LECT. 1. METEOROLOGY – AGRICULTURAL METEOROLOGY – DEFINITION, THEIR IMPORTANCE TO CROP PRODUCTION AND FUTURE SCOPE.

Meteorology

Greek word "Meteoro" means 'above the earth's surface' (atmosphere)
"logy" means "indicating science"

- Branch of science dealing with that of atmosphere is known as meteorology
- Lower atmosphere extending up to 20km from earth's surface where frequent physical process takes place
- Meteorology is a combination of both physics and geography

Meteorology is a combination of both physics and geography. This science utilizes the principles of Physics to study the behaviour of air. It is concerned with the analysis of individual weather elements for a shorter period over a smaller area. In other words, the physical state of the atmosphere at a given place and time is referred to as "weather". The study of weather is called 'meteorology'. It is often quoted as the "physics of atmosphere".

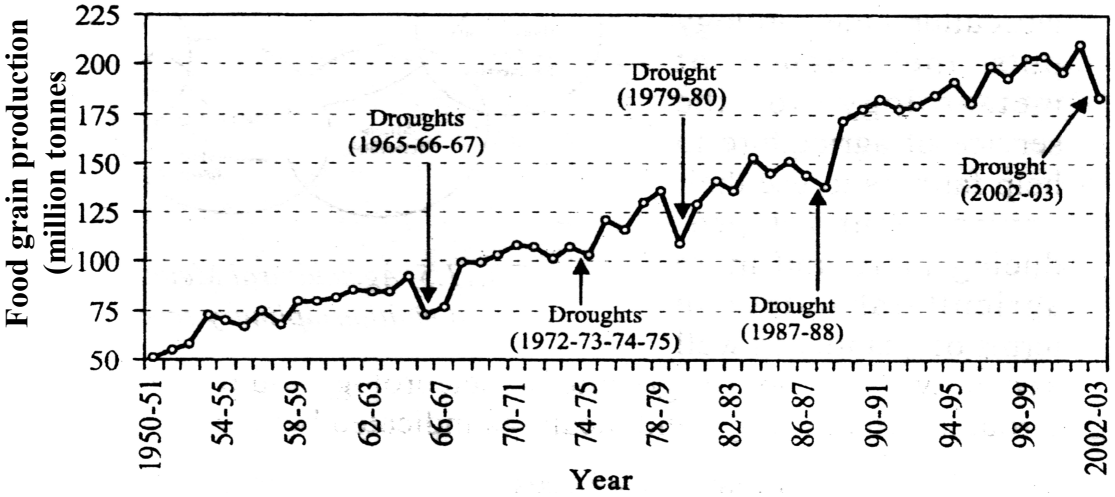
Weather: Physical state of the atmosphere at a given place and given time
Climate: Long term regime of atmospheric variables of a given place or area

Agricultural meteorology:

1. A branch of applied meteorology which investigates the physical conditions of the environment of growing plants or animal organisms
2. An applied science which deals with the relationship between weather/climatic conditions and agricultural production.
3. An applied science which deals with the relationship between weather/climatic conditions and agricultural production.
4. A science concerned with the application of meteorology to the measurement and analysis of the physical environment in agricultural systems. The word 'Agro meteorology' is the abbreviated form of agricultural meteorology.
5. To study the interaction between meteorological and hydrological factors on the one hand and agriculture in the widest sense, including horticulture, animal husbandry and forestry on the other (WMO)

Meteorology	Agricultural meteorology
Branch of atmospheric physics	Branch of applied meteorology or a branch of agriculture as it deals with agriculture
It is a weather science	It is a product of agriculture and meteorology
It is a physical science	It is a biophysical science
It aims at weather forecasting	It aims at improving quantity and quality of crop production through meteorological skills
Weather service is the concern	Agro advisory service to the farmers is the concern based on weather forecast
It is a linking science to the society	It is a linking science to the farming community

IMPORTANCE TO CROP PRODUCTION



1. Helps in planning cropping patterns/systems.
2. Selection of sowing dates for optimum crop yields.
3. Cost effective ploughing, harrowing, weeding etc.
4. Reducing losses of applied chemicals and fertilizers.
5. Judicious irrigation to crops.
6. Efficient harvesting of all crops.
7. Reducing or eliminating outbreak of pests and diseases.
8. Efficient management of soils which are formed out of weather action.
9. Managing weather abnormalities like cyclones, heavy rainfall, floods, drought etc. This can be achieved by
   (a) Protection: When rain is forecast avoid irrigation. But, when frost is forecast apply irrigation.
   (b) Avoidance: Avoid fertilizer and chemical sprays when rain is forecast
   (c) Mitigation: Use shelter belts against cold and heat waves.
10. Effective environmental protection.
11. Avoiding or minimizing losses due to forest fires.

FUTURE SCOPE

1. To study climatic resources of a given area for effective crop planning.
2. To evolve weather based effective farm operations.
3. To study crop weather relationships in all important crops and forecast crop yields based on agro climatic and spectral indices using remote sensing.
4. To study the relationship between weather factors and incidence of pests and diseases of various crops.
5. To delineate climatic/agro ecological/agro climatic zones for defining agro climatic analogues so as to make effective and fast transfer of technology for improving crop yields.
6. To prepare crop weather diagrams and crop weather calendars.
7. To develop crop growth simulation models for assessing/obtaining potential yields in different agro climatic zones.
8. To monitor agricultural droughts on crop-wise for effective drought management.
9. To develop weather based agro advisories to sustain crop production utilizing various types of weather forecast and seasonal climate forecast.
10. To investigate microclimatic aspects of crop canopy in order to modify them for increased crop growth
11. To study the influence of weather on soil environment on which the crop is grown
12. To investigate the influence of weather in protected environment (eg. Glass houses) for improving their design aiming at increasing crop production.

Lect 2. **COORDINATES OF INDIA AND TAMIL NADU, ATMOSPHERE – COMPOSITION OF ATMOSPHERE - VERTICAL LAYERS OF ATMOSPHERE BASED ON TEMPERATURE DIFFERENCE / LAPSE RATE.**

Coordinates of India

Lies between	º N and	º N latitude
	ºE and	º E longitude

Coordinates of Tamil Nadu

Lies between	08º 05’ N and	13º 35’ N latitude
	76º 15’ E and	80º 20’ E longitude

Earth is elliptical in shape and has three spheres

Hydrosphere - the water portion
Lithosphere - the solid portion
Atmosphere - the gaseous portion

Atmosphere : The atmosphere is the colourless, odourless and tasteless physical mixture of gasses which surrounds earth on all sides. It is mobile, compressible and expandable. It contains huge number of solid and liquid particles called aerosol. Some gases are permanent atmospheric constituents in fixed proportions to the total gas volume. Others very from place and time to time.

The lower atmosphere where the chemical composition of gas is uniform is called homosphere. At higher levels the chemical composition of air changes considerably and known as heterosphere.

Uses of atmosphere

1. Provides oxygen which is useful for respiration in crops
2. Provides carbon-dioxide to build biomass in photosynthesis.
3. Provides nitrogen which is essential for plant growth.
4. Acts as a medium for transportation of pollen.
5. Protects crops plants on earth from harmful U.V.rays.
6. Maintains warmth to plant life and
7. Provides rain to field crops as it is a source of water vapour, cloud, etc.

Composition of atmosphere

The following all the different gases that are present in percentage by volume approximately.

Nitrogen (N_2)	= 78.08	Oxygen (O_2)	= 20.95
Argon (Ar)	=0.93	CO_2	=0.03
Neon (Ne)	= 0.0018	Helium(He)	=0.0005
Ozone(O_3)	=0.00004	Hydrogen(H_2)	=0.00006
Methane (CH_4)	=0.00017		

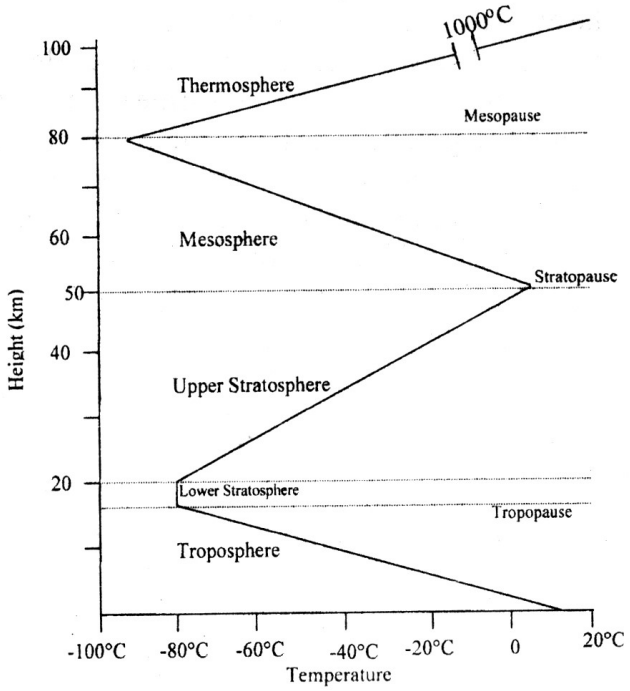
Vertical Layers of atmosphere based on temperature

On the basis of vertical temperature variation the atmosphere is divided into different spheres or layers.

A. Troposphere

1. The word “Trop” means mixing or turbulence and “sphere” means region.
2. The average height o this lower most layer of the atmosphere is about 14 km above the men sea level; at the equator it is 16 km and 7-8 km at the poles.

3. Under normal conditions the height of the troposphere changes from place to place and season to season.
4. Various types of clouds, thunderstorms, cyclone and anticyclones occur in this sphere because of the concentration of almost all the water vapour and aerosols in it. So, this layer is called as "seat of weather phenomena".
5. The wind velocities increase with height and attain the maximum at the top of this layer.
6. Another striking feature of the troposphere is that there is a decrease of temperature with increasing elevation at a mean lapse rate of about 6.5°C per km.
7. Most of the radiation received from the sun is absorbed by the earth's surface. So, the troposphere is heated from below.
8. In this layer, about 75 per cent of total gases and most of the moisture and dust particles present.
9. A the top of the troposphere there is a shallow layer separating it from the stratosphere which is known as the "Tropopasue ".
10. The tropospause layer is thin and its height changes according to the latitudes and it is a transitional zone and distinctly characterized by no major movement of air.



B). Stratosphere

1). This layer exists above the tropopause (around 20 km onwards) and extends to altitudes of about 50-55 km.

2). This layer is called as "Seat of photochemical reactions"

3). The temperature remains practically constant at around 20 km and is characterized as isothermal because air is thin, clear, cold and dry near tropopause.

4). The temperature of this layer increases with height and also depends upon the troposphere because the troposphere is higher at the equator than at the poles.

5). In the upper parts of the stratosphere the temperatures are almost as high as those near the earth's surface, which is due to the fact that the ultra-violet radiation from the sun is absorbed by ozone in this region. The air density is so much less that even limited absorption of solar radiation by the atmospheric constituents notably ozone produces a temperature increase.

6). Less convection takes place in the stratosphere because it is warm at the top and cold at the bottom.

7). There is also persistence of circulation patterns and high wind speeds.

8). The upper boundary of the stratosphere is called the stratopause.

C). Mesosphere/Ozonosphere

1. There is a maximum concentration of ozone between 30 and 60 km above the surface of the earth and this layer is known at the ozonosphere.
2. A property of the ozone is that it absorbs UV rays. Had there been no layer of the ozone in the atmosphere, the ultraviolet rays might have reached the surface of the earth and no life can exist.
3. Temperature of the ozonosphere is high (warm) due to selective absorption of U.V radiation by ozone.
4. Because of the preponderance of chemical process this sphere is called as the "chemosphere"
5. In this layer the temperature increases with height at the rate of 5°C per km.
6. According to some leading scientists the ionosphere is supposed to start at a height of 80 km above the earth's surface. The layer between 50 and 80 km is called as "Mesosphere". In this layer the temperature decreases with height. The upper boundary of this layer is called the "Mesospause".
7. Mesosphere is the coldest region in the atmosphere with temperature reaching the lowest value of nearly -95°C at the mesopause (80km)

D). Thermosphere(Ionosphere)

1) The thermosphere layer lies beyond the ozonosphere (mesosphere) at a height of about 80 km above the earth's surface and extends upto 400 km.
2) The atmosphere in the ionosphere is partly ionised enriched ion zones exist in the form of distinct ionised layers. So, this layer is called as the ionosphere.
3) Above the mesosphere the temperature increases again and is in the order of 1000°C.
4) The ionosphere reflects the radio waves because of one or multiple reflections of shortwave radio beams from the inoised shells. So, long distance radio communication is possible de to this layer.

E). Exosphere.

1) The outer most layer of the earth's atmosphere is named as the exosphere and this layer lies between 400 and 1000 km.
2) At such a greater height the density of atoms in the atmosphere is extremely low.
3) Hydrogen and Helium gases predominate in this outer most region.
4) At an altitude of about 500 to 600 km the density of the atmosphere becomes so low that collisions between the natural particles become extremely rare.

Lapse rate

The decrease in air temperature with height is known as the normal / environmental lapse rate and it is 6.5°C/km.

Adiabatic lapse rate

The rate of change of temperature in an ascending or descending air mass through adiabatic process is called as adiabatic lapse rate.

The thermodynamic transformation which occurs without exchange of heat between a system and its environment is known as adiabatic process. In adiabatic process, adiabatic cooling accompanies expansion, and adiabatic warming accompanies compression.

Lect. 3. CLIMATE AND WEATHER – FACTORS AFFECTING CLIMATE AND WEATHER. MACRO CLIMATE – MESO CLIMATE – MICRO CLIMATE – DEFINITION AND THEIR IMPORTANCE – DIFFERENT CLIMATES OF INDIA AND TAMILNADU AND THEIR CHARACTERIZATION

Weather

i) 'A state or condition of the atmosphere at a given place and at a given instant of time'.
ii) 'The daily or short term variations of different conditions of lower air in terms of temperature, pressure, wind, rainfall, etc'.
iii) State of atmosphere at a particular time as defined by the various meteorological elements. (WMO)

The aspects involved in weather include small areas and duration, expressed in numerical values, etc. The different weather elements are solar radiation, temperature, pressure, wind, humidity, rainfall evaporation, etc. is highly variable. It changes constantly sometimes from hour to hour and at other times from day to day.

Climate

i) 'The generalized weather or summation of weather conditions over a given region during comparatively longer period'.
ii) 'The sum of all statistical information of weather in a particular area during a specified interval of time, usually, a season or a year or even a decade'.
iii) Synthesis of weather conditions in a given area, characterized by long-term statistics (mean values, variances, probabilities of extreme values, etc,) of the meteorological elements in that area. (WMO)

The aspects involved are larger areas like a zone, a state, a country and is described by normal. The climatic normals are generally worked out for a period of 30 years.

Differences between weather and climate:

Weather	Climate
1. A typical physical condition of the atmosphere.	1. Generalized condition of the atmosphere which represents and describes the characteristics of a region.
2. Changes from place to place even in a small locality	2. Different in different large region
3. Changes according to time (every moment)	3. Change requires longer (years) time.
4. Similar numerical values of weather of different places usually have same weather	4. Similar numerical values of climate of different places usually have different climates.
5. Crop growth, development and yield are decided by weather in a given season.	5. Selection of crops suitable for a place is decided based on climate of the region.
6. Under abnormal weather conditions planners can adopt a short-term contingent planning.	6. Helps in long-term agricultural planning.

Factors affecting climate

i) Latitude: The distance from the equator, either south or north, largely creates variations in the climate. Based on the latitude, the climate has been classified as

i) Tropical ii) Sub-tropical iii) Temperate & iv) Polar.

ii) Altitude(elevation): The height from the MSL creates variation in climate. Even in the tropical regions, the high mountains have temperate climate. The temperature decreases by 6.5 ºC/Km from the sea level. Generally, there is also a decrease in pressure and increase in precipitation and wind velocity. The above factors alter the kind of vegetation, soil types and the crop production.

iii) Precipitation: The quantity and distribution of rainfall decides the nature of vegetation and the nature of the cultivated crops. The crop regions are classified on the basis of average rainfall which is as follow.

Rainfall(mm)	Name of the climatic region
Less than 500	Arid
500-750	Semi-arid
750-1000	Sub-arid
More than 1000	Humid

iv) Soil type: Soil is a product of climatic action on rocks as modified by landscape and vegetation over a long period of time. The colour of the soil surface affects the absorption, storage and re-radiation of heat. White colour reflects while black absorbs more radiation. Due to differential absorption of heat energy, variations in temperature are created at different places. In black soil areas, the climate is hot while in red soil areas, it is comparatively cooler due to lesser heat absorption.

v) Nearness to large water bodies: The presence of large water bodies like lakes and sea including its current affect the climate of the surrounding areas, eg. Islands and coastal areas. The movement of air from earth's surface and from water bodies to earth modify the climate. The extreme variation in temperature during summer and winter is minimized in coastal areas and island.

vi) Topography: The surface of landscape (leveled or uneven surface areas) produces marked change in the climate. This involves the altitude of the place, steepness of the slope and exposure of the slope to light and wind.

vii) Vegetation: Kinds of vegetation characterize the nature of climate. Thick vegetation is found in tropical regions where temperature and precipitation are high. General types of vegetations present in a region indicate the nature of the climate of that region.

Scales of climate and their importance

i) Microclimate: Microclimate deals with the climatic features peculiar to small areas and with the physical processes that take place in the layer of air very near to the ground. Soil-ground conditions, character of vegetation cover, aspect of slopes, and state of the soil surface, relief forms – all these may create special local conditions of temperature, humidity, wind and radiation in the layer of air near the ground which differ sharply from general climatic conditions. One of the most important tasks of agricultural meteorology is to study the properties of air near the ground and surface layer of soil, which falls under the micro climate.

ii) Meso climate: The scale of meso climate falls between micro and macro climates. It is concerned with the study of climate over relatively smaller areas between 10 & 100 km across.

iii) Macro climate: Macro climate deals with the study of atmosphere over large areas of the earth and with the large scale atmospheric motions that cause weather. The scales of air motion in different climates are given in the Table below.

Type of climate	Horizontal scale (km)	Vertical scale(km)	Time Scale(hrs)
A. Macro climate			
1. Planetary scale	2000-5000 & more	10	200 to 400
2. Synoptic scale	500-2000	10	100
B. Meso climate	1 to 100	1-10	1-10
C. Micro climate	<100m	200 m	6-12 minutes

If any weather system develops under different types of climate, it persists longer periods under the macroclimate while smaller periods under micro climates.

CLIMATES OF INDIA AND TAMILNADU AND THEIR CHARACTERIZATION

Climate classification was tried by many scientists from beginning of 19th century using many parameters. Thornthwaite during 1931 and 1948 classified the climate using precipitation and evaporation /Potential evaporation and was subsequently modified by Mathur (1955) for the Moisture Index (Im) and is give below

Im = 100 [(P-PE)/PE]

Where P = Precipitation, PE = Potential evapo-transpiration

Using the moisture Index (**Im**) the following classification was made

Im Quantity	Climate classification
100 and above	Per humid
20 to 100	Humid

0 to 20	Moist sub humid
-33.3 to 0	Dry sub humid
-66.7 to -33.3	Semi arid
-100 to -66.7	Arid

Another classification by Troll (1965) based on number of humid months, said to be of more agricultural use was modified by ICRISAT for India. Humid month is one having mean rainfall exceeding the mean Potential evapo transpiration.

Climate	Number of humid months	% geographical area of India
Arid	<2.0	17.00
Semiarid-dry	2.0-4.5	57.17
Semiarid-wet	4.5-7.0	12.31
Humid	>7.0	1.10

The ICAR under All India Coordinated Research Project on Dryland Agriculture adopted classification based Moisture Deficit Index (MDI)

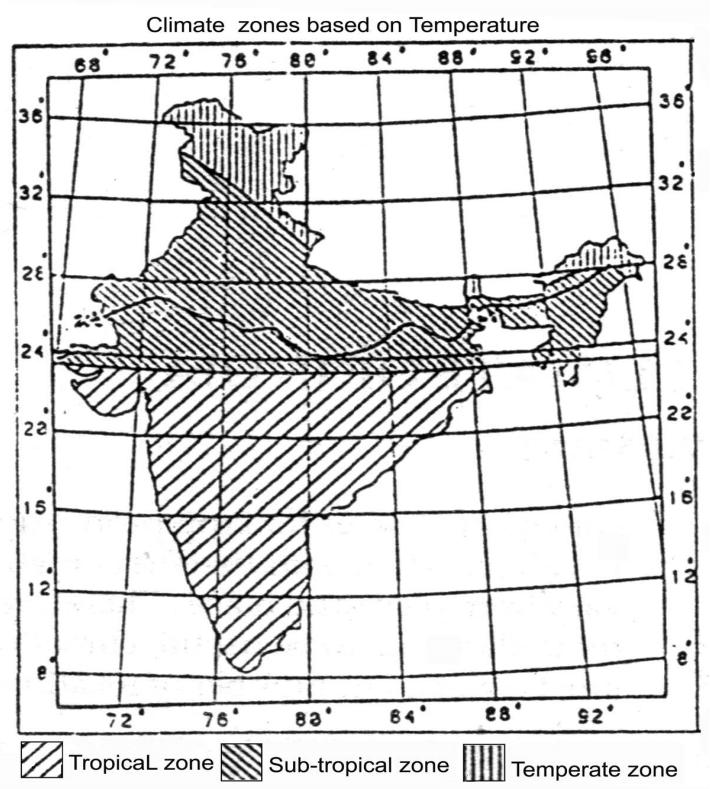
$$MDI = \frac{P - PET}{PET} \times 100$$

Where P is annual precipitation (cm) and PET is Potential Evapotranspiration. Based on MDI the climate is divided into three regions as below.

Type of climate	MDI
Subhumid	0.0 to 33.3
Semiarid	-33.3 to -66.6
Arid	> -66.6

Temperature based classification

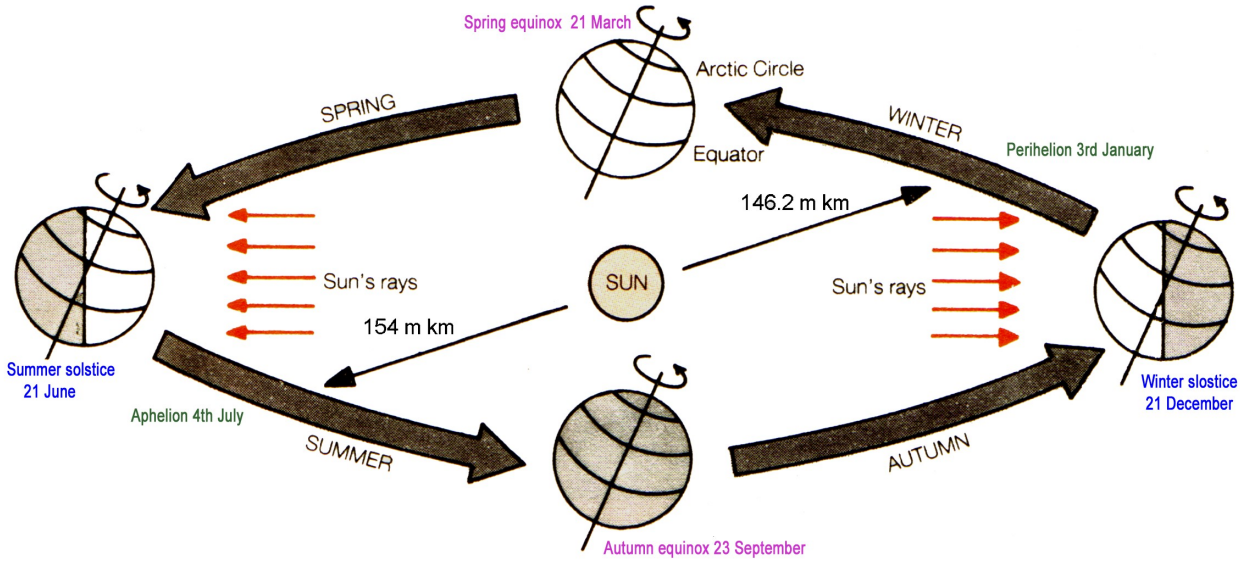
The tropic of cancer, which passes through the middle of the country, divides it into two distinct climates. The tropical climate in the South where all the 12 months of the year have mean daily temperature exceeding 20°C; and in the North where a sub-tropical climate prevails. In sub-tropics during the winter months, it is cool to cold. Frosts occur sometime during the months of December and January. Some areas in the Northern India have a temperate climate. Here it snows during the winter months and freezing temperatures may extend to two months or more during the year. Three main climatic zones of India based on temperature are shown in the map below.



Lect. 4. Solar radiation – Spectrum of radiation – Characteristics of different wave lengths and their effect on crop production.

Sun

- Sun is the prime source of energy
- Sun is the nearest star to the planet earth
- Diameter of the sun is 1.39 X 10^6 km
- It rotates on its axis about once every four weeks(27 days near equator & 30 days –polar)
- Sun is on an average 1.5 X 10^8 km away from the earth (149.64 M km deviation is 2.41 M km)
- Surface temperature of the sun is 5462° K
- Every minute, the sun radiates approximately 56 X 10^{26} calories of energy.
- The interior mass of the sun has a density of 80 to 100 times that of water.
- Energy is due to the fusion, Hydrogen is transformed to helium.
- 99% of the energy to biosphere is only from the sun and the rest one percent is from stars, lightning discharge, sun's radiation reflected from the moon, re-radiation from the earth etc.



Insolation

Electro magnetic energy radiated into the space by the sun

Factors affecting insolation

1. The solar constant which depends on
   a. Energy output of the sun
   b. Distance from earth to sun
2. Transparency of the atmosphere
3. Duration of daily sunlight period
4. Angle at which sun's noon rays strike the earth.

Transfer of heat

All mater, at a temperature above the absolute zero, imparts energy to the surrounding space. Three processes viz. conduction, convection and radiation are involved in heat flow or heat transfer.

Conduction

Heat transfer through matter without the actual movement of the substances or matter. Heat flows from the warmer to cooler part of the body so that the temperatures between them are equalized.

Eg. The energy transmission through an iron rod which is made warmer at one end.

Convection

Processes of transmission of heat through actual movement of molecules of the medium. This is predominant form of energy transmission on the earth as all the weather related processes involve this process. Eg. Boiling of water in a beaker

Radiation.

Transfer of energy from one body to another without the aid of the material medium (solid, liquid or gas). Radiation is not heat, only when radiation is absorbed by surface of a body heat is produced.

Eg. The energy transmission through space from the sun to the earth.

Solar radiation

The flux of radiant energy from the sun is solar radiation.

Heavenly bodies emit – short wave radiation
Near surfaces including earth emit - long wave radiation

Radiation flux

The amount of radiant energy emitted, received, transmitted across a particular area is known as radiant flux.

Radiant flux density

The radiant flux divided by the area across which the radiation is transmitted is called radiant flux density.

Emissive power

The radiant flux density emitted by a source is called its emissive power.

Energy measurement

Units	Cal cm^{-2} min^{-1}	J cm^{-2} mi^{-1}	W cm^{-2}
Cal cm^{-2} min^{-1}	1	4.1868	0.069
J cm^{-2} mi^{-1}	0.238	1	0.00165
W cm^{-2}	14.3	60.6	1

Spectrum of Radiation

Band	Spectrum	Wavelength (μ)	Importance
Ultra violet	Cosmic rays	< 0.005	Shorter wave lengths of spectrum & Chemically active, unless filtered there is danger of life on earth
	Gamma rays and X-rays	0.005 – 0.20	
	Ultraviolet rays	0.20 – 0.39	
Visible	Violet	0.39 – 0.42	Visible spectrum known as Light essential for all plant processes
	Blue	0.42 – 0.49	
	Green	0.49 – 0.54	
	Yellow	0.54 – 0.59	
	Orange	0.59 – 0.65	
	Red	0.65 – 0.76	
Infra red	Infrared rays	> 0.76	Essential for thermal energy of the plant (Source of heat)

Units of measurements of wavelength

Micron 1μ = 10^{-6} m = 10^{-4} cm
Milli micron 1 mμ = 10^{-9} m = 10^{-7} cm
Angstrom Å = 10^{-10} m = 10^{-8} cm

Solar radiation and crop plants

❖ Crop production is exploitation of solar radiation

❖ Three broad spectra

1. **Shorter than visible range**: Chemically very active
   - ➢ When plants are exposed to this radiation the effects are detrimental.
   - ➢ Atmosphere acts as regulator for this radiation and none of cosmic, Gamma and X-rays reaches to the earth.
   - ➢ The UV rays of this segment reaching to the earth are very low and it is normally tolerated by the plants.
2. **Higher than visible wavelength**
   - ⌖ Referred to IR radiation
   - ⌖ It has thermal effect on plants
   - ⌖ In the presence of water vapour, this radiation does not harm plants, rather it supplies the necessary thermal energy to the plant environment.
3. **Visible spectrum**
   - ☞ Between UV & IR radiation and also referred as light
   - ☞ All plant parts are directly or indirectly influenced by the light
   - ☞ Intensity, quality and duration are important for normal plant growth
   - ☞ Poor light leads to plant abnormalities
   - ☞ Light is indispensable to photosynthesis
   - ☞ Light affect the production of tillers, the stability, strength and length of culms
   - ☞ It affects the yield, total weight of plant structures, size of the leaves and root development.
   - ☞ Critical stages of plant growth for light
     - Radiation intensity during the third month of Maize plant
     - Rice – 25 days prior to flowering
     - Barley – flowering period

and	Wavelength(nm)	Specific effect on plant
.	Radiation within 1000 and more	No specific effect on plant activity. Radiation absorbed by plants are transformed into heat. This radiation does not interfere with bio-chemical processes.
.	1000-720	Radiation in this band helps in plant elongation, can be accepted as an adequate measure of plant elongation activity. The far red region (700-920 nm) has important role on photo-periodism, germination of seeds, flowering and colouration of fruits.
.	720-510	In this spectral region light is strongly absorbed by chlorophylls. It generates strong photosynthetic and photo-periodic activity.
.	610-510	This is green-yellow region. Absorption in this spectral region has low photosynthetic effectiveness and weak formative activity.
.	510-400	It is the strongest chlorophyll and yellow pigment absorption region. In the blue-violet range, photosynthetic activity becomes very strong. This region has very strong effect on formation of tissues.
.	400-315	Radiation in this band produces formative effects. It has dwarfing effect on plants and thickening effect on plant leaf.
.	315-280	Radiation in this band has detrimental effect on most plants
.	Less than 280	Lethal effect most of the plants get killed due to radiation in this band UV ranges have germicidal action.

Lect. 5. Radiation balance – Solar constant – albedo – Sensible heat – Heat energy – Latent heat

A part of the incident radiation on the surface is absorbed, while a part is reflected and the remaining is transmitted.

Absorptivity

Absorptivity of a substance is defined as the ratio of the amount of radiant energy absorbed to the total amount incident upon that substance. The absorptivity of a blackbody is unity. Natural bodies like sun and earth are near perfect black bodies

Reflectivity

Reflectivity is defined as the ratio of the radiant energy reflected to the total incident radiation upon that surface. If it is expressed in percentage it becomes albedo.

Transmittivity

Transmittivity is defined as ratio of the transmitted radiation to the total incident radiation upon the surface.

Emissivity

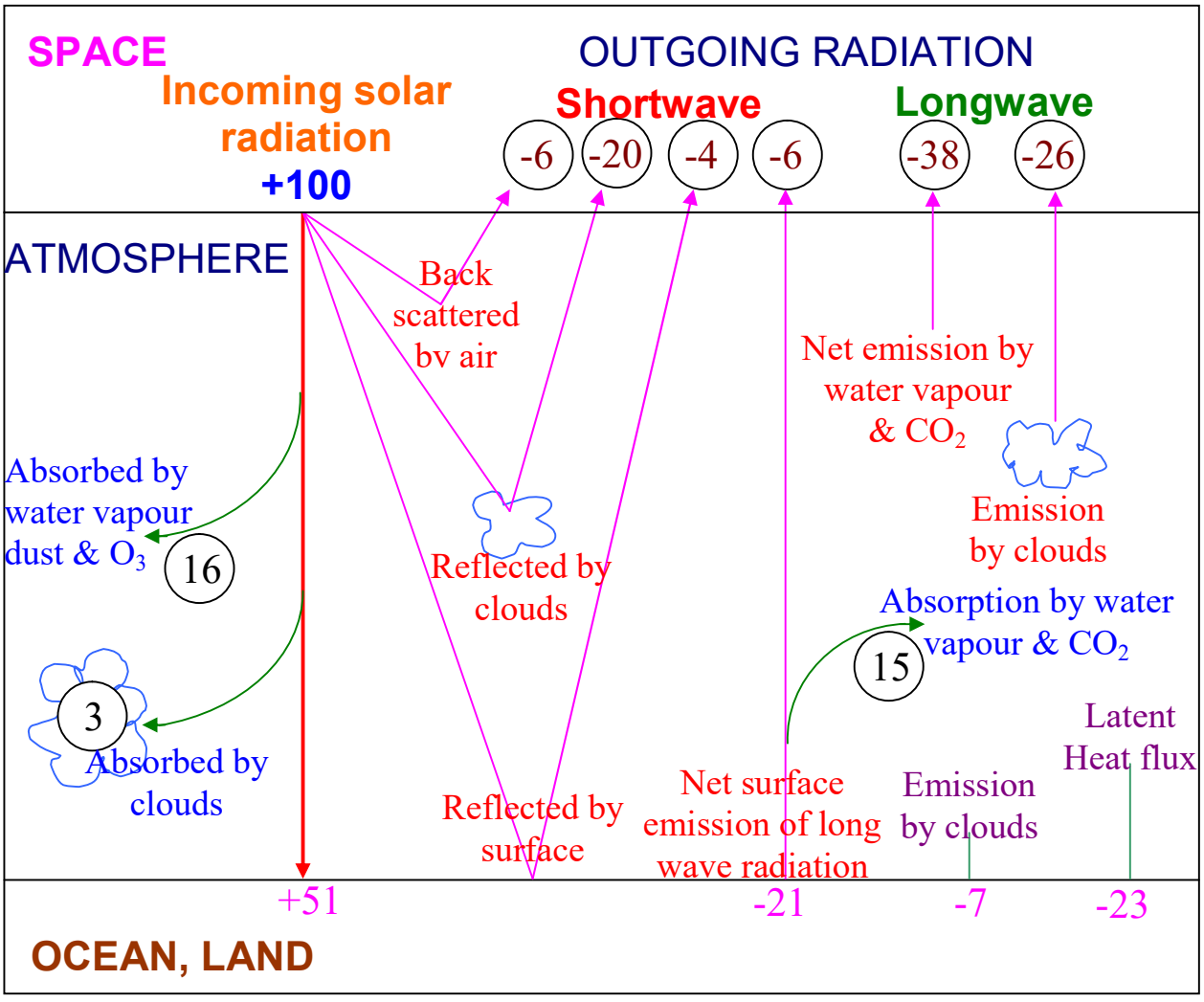
Emissivity is defined as the ratio of the radiant energy emitted by a given surface to the total heat energy emitted by a black body. The emissivity of a black body is unity.

Blackbody radiation

A Blackbody is defined as a body, which completely absorbs all the heat radiations falling on it without reflecting and transmitting any of it. It means reflectivity and transmittivity become zero. When such a black body is heated it emits radiation of all wavelengths depending upon its temp.

Radiation balance

The difference between all incoming and outgoing radiation at the earth's surface and top of the atmosphere is known as radiation balance at the earth's surface.



Solar constant

Solar constant is the energy received on a unit area at the outer most boundary of the earth (atmosphere) surface held perpendicular to the sun's direction, at the mean distance between the sun and the earth.

- Solar constant is not a true constant. It fluctuates by as much as ± 3.5 % about its mean value depending upon the distance of the earth from the sun.
- Value is 2 cal / cm^2 / min. (1.92 and 2.02) Recent measurements indicate value of 1.94 cal / cm^2 / min (133 wm^{-2}) [1 Langley = 1cal]
- 35% of the energy is contributed by U.V. and visible parts and 65% by Infra Red.

Albedo

It is the percentage of reflected radiation to the incident radiation. (Varies with colour and composition of the earth's surface, season, angle of the sun rays). Value is Highest in winter and at sunrise and sunset. Pure water – 5-20%, Vegetation 10-40%, Soils 15-50%, Earth 34-43% and clouds 55%. High albedo indicates that much of the incident solar radiation is reflected rather than absorbed.

Depends up on

1. Angle of incidence of radiation. Albedo increase with decreasing elevation of sun with minimum during noon.
2. Physical characteristics of surface
3. Season
4. Time of the day

For plant community albedo depends upon

1. Age of the crop
2. Percentage of ground cover
3. Colour and reflectivity of the foliage

Outgoing long wave radiation

- After being heated by solar radiation, the earth becomes source of radiation.
- Average temperature of the earth's surface 285º k (12º C)
- 99% of radiation is emitted in the farm of IR range (4 to 120 µ)
- About 90% of the outgoing radiation is absorbed by the atmosphere.
  Water vapour absorb in wavelengths of 5.3 to 7.7 µ and beyond 20µ.
  Ozone 9.4 to 9.8 µ.
  CO_2 – 13.1 to 16.9 µ
  Clouds – in all wavelengths
- Long wave radiation escapes to the space between 8.5 and 11 µ and this is known as the **atmospheric window.** Atmosphere for this spectrum acts as transparent medium instead of absorbing. This spectral region is used in microwave remote sensing to monitor the features of the sky in case of overcast sky.
- A large part of the radiation absorbed by the atmosphere is sent back to the earth's surface as counter – radiation. This counter radiation prevents the earth's surface from excessive cooling at night.

Radiation laws

The direct transfer of heat from the sun to the earth through the space and atmosphere indicates that radiation of heat from one place to other occurs in the form of electromagnetic waves in the same manner and with same speed of as light. The wavelength of electromagnetic radiation is given by the equation

$$\lambda = \frac{C}{V}$$

Where λ = Wavelength (The shortest distance between consecutive crests in the wave trance)
C = Velocity of light ($3x10^{10}$ cm sec^{-1})
V = Frequency means number of vibrations of cycles per second

Plank's law

Plank introduced the 'particle concept'. The electromagnetic radiation consists of a stream or flow of particles or quanta, each quantum having energy content E determined by of each quantum is proportional to the frequency given by the equation.

E= h v where
h= Plank's constant ($6.62x10^{-34}$ J sec^{-1}
V= Frequency

The law states that greater the frequency (shorter wave length) greater is the energy of quantum.

Kirchoff's law

A good absorber of radiation is a good emitter, in similar circumstances. This law states that the absorptivity 'a' of an object for radiation of a specific wavelength is equal to the emissivity 'e' for the same wavelength. The equation of the law is :

$$a(\lambda) = e(\lambda)$$

Stefan-Boltzmann's law

The intensity of radiation emitted (E) by a radiating body is directly proportional to the fourth power of the absolute temperature of that body. (Emissivity of black body = 1)

$E = \sigma T^4$

Where,

T= (273+°C) because temperature is in Kelvins
= Stefan-Boltzmann's constant which is equal to 5.673 x 10^{-8} W m^{-2} K^{-4}

Wein's Displacement laws

The wavelength of the maximum intensity of emission (λ_{max}) from a radiating black body is inversely proportional to its absolute temperature

$\lambda_{max} = 2897\ T^{-1}\ \mu = 2897/T\ \mu$ Where T is in ºK

If the temperature of a body is high, radiation maximum is displaced towards shorter wavelengths. For the sun's surface temperature of 5793°K, the λ_{max} is 0.5µ (2897/5793). The most intense solar radiation occurs in the blue-green range of visible light. The wavelength of maximum intensity of radiation for the earth's actual surface temperature of 14°C or 287°K is about 10.0 (2897/287) microns, which is in the infrared band.

Energy balance or heat balance

The net radiation is the difference between total incoming and outgoing radiations and is a measure of the energy available at the ground surface. It is the energy available at the earth's surface to drive the processes of evaporation, air and soil heat fluxes as well as other smaller energy consuming processes such as photosynthesis and respiration. The net radiation over crop is as follows.

$R_n = G + H + LE + PS + M$

R_n is net radiation, G is surface soil heat flux, H is sensible heat flux, LE is laten heat flux, PS and M are energy fixed in plants by photosynthesis and energy involved in respiration, respectively. The PS and M are assumed negligible due to their minor contribution (about 1-2% of R_n). The net radiation is

the basic source of energy for evapotranspiration (LE), heating the air (H) and soil (S) and other miscellaneous M including photosynthesis.

Temperature

It is defined as the measure of the average speed of atoms and molecules

Kinetic energy

Energy of motion.

Heat

It is the aggregate internal energy of motion and molecules of a body. It is often defined as energy in the process of being transferred from one object to another because of the temperature between them.

Sensible heat

It is the heat that can be measured by a thermometer and thus sensed by humans. Normally measured in Celsius, Fahrenheit and Kelvin.

Latent heat

It is the energy required to change a substance to a higher state of matter. This same energy is released on the reverse process. Change of state through Evaporation and condensation is known as latent heat of evaporation and latent heat of condensation. From water to water vapour takes 600 calories and water to ice takes 80 calories.

Blue colour of the sky

If the circumference of the scattering particle is less than about 1/10 of the wavelength of the incident radiation, the scattering co-efficient is inversely proportional to the fourth power of the wavelength of the incident radiation. This is known as **Rayleigh scattering**. This is the primary cause of the blue colour of the sky.

For larger particles with circumference >30 times of wavelength of the incident radiation, scattering is independent of the wavelength (i.e) white light is scattered. This is known as **Mei scaring**

Red Colour of the sky at sunset & sunrise.

It is because of increased path length in the atmosphere. % of solar energy in the visible part decreases. With in the visible part, the ratio of the blue to the red part decreases with increased path length.

Disposition of Solar radiation

a. 25% of solar radiation is reflected back to the space by clouds (more by middle and high latitudes and less in the sub tropics)
b. 6% reflected back by air, dust and water vapour.
c. 30% scatted downwards (more in the form of shorter wavelengths able) them that in longer wave length (red).
d. 17% of solar radiation is absorbed by the atmosphere. (Mostly by Oxygen, O_3, CO_2 & H_2O vapour).

O_2	– absorb the extreme UV wavelengths (0.12 to 0.6 μ)
O_3	– UV (0.2 to 0.32 μ) and Visible part of radiation (0.44 to 0.7 μ)
H_2O vapour	– Near infra red (0.93, 1.13, 1.42 μ)
CO_2	- IR band 2.7 μ.

e. About 50% of solar radiation reaches earth's surface, after reflection, scattering and absorption.

Lect. 6. LIGHT – EFFECT OF LIGHT INTENSITY, QUALITY, DIRECTION AND DURATION ON CROP PRODUCTION – AIR TEMPERATURE – FACTORS AFFECTING TEMPERATURE.

Light:

Light is the visible portion of the solar spectrum with wavelength range is from 0.39 to 0.76µ.

- ❖ Light is one of the important climatic factors for many vital functions of the plant.
- ❖ It is essential for the synthesis of the most important pigment ie. Chlorophyll, Chlorophyll absorbs the radiant energy and converts it into potential energy of carbohydrate.
- ❖ The carbohydrate thus formed is the connecting link between solar energy and living world.
- ❖ In addition, it regulates the important physiological functions.
- ❖ The cahrateristics of light viz. intensity, quality, duration and direction are important for crops.

Light intensity

The intensity of light is measured by comparing with a standard candle. The amount of light received at a distance of one metre from a standard candle is known as "Metre candle or Lux". The light intensity at one foot from a standard candle is called 'foot candle' or 10.764 luxes and the instrument used is called as lux metre.

- ➢ About one percent of the light energy is converted into biochemical energy.
- ➢ Very low light intensity reduces the rate of photosynthesis resulting in reduced growth.
- ➢ Similarly, very high intensity is detrimental to plant in many ways as below.
  - ▪ It increases the rate of respiration.
  - ▪ It also causes rapid loss of water (ie) increases the transpiration rate of water from the plants.
  - ▪ The most harmful effect of high intensity light is that it oxidises the cell contents which is termed as 'Solarisation'. This oxidation is different from respiration and is called as photo-oxidation.
- ➢ Under field conditions the light is not spread evenly over the crop canopy but commonly passed by reflection and transmission through several layers of leaves.
- ➢ The intensity of light falls at exponential rate with path length through absorbing layers according to Beer's law. ie the relative radiation intensity decreases exponentially with increasing leaf area.
- ➢ At ground level the light intensity is below the light compensation point (The light intensity at which the gas exchange resulting from photosynthesis is equal to that resulting from respiration)

Based on the response to light intensities the plants are classified as follows.

(i) Sciophytes (shade loving plants): The plants grow better under partially shaded conditions. (eg) Betel vine, buck wheat etc.

(ii) Hetrophytes (Sun loving): Many species of plants produce maximum dry matter under high light intensities when the moisture is available at the optimum level. (eg) Maize, sorghum, rice etc.

Quality of Light

When a beam of white light is passed through a prism, it is dispersed into wavelengths of different colours. This is called the visible part of the solar spectrum. The different colours and their wave length are as follows:

Violet	400 – 435 m µ	Blue	435 – 490 m µ
Green	490 – 574 m µ	Yellow	574 – 595 m µ
Orange	595 – 626 m µ	Red	626 – 750 m µ

- The principal wavelength absorbed and used in photosynthesis are in the violet – blue and the orange - red regions.
- Among this, short rays beyond violet such as X rays, gamma rays and larger rays beyond red such as infrared, are detrimental to plant growth.

- Red light is the most favourable light for growth followed by violet – blue.
- Ultra – violet and shorter wave lengths kill bacteria and many fungi.

c) Duration of light:

- The duration of light has greater influence than the intensity for canopy development and final yield.
- It has a considerable importance in the selection of crop varieties.
- The response of plants to the relative length of the day and night is known as phtoperiodism. The plants are classified based on the extent of response to day length which is as follows.
  - **(i) Long day plants:** The plants which develop and produce normally when the photoperiod is greater than the critical minimum (greater than 12 hours). eg. Potato, Sugarbeet, Wheat, Barley etc.
  - **(ii) Short day plants:** The plants which develop normally when the photoperiod is less than the critical maximum (less than 12 hours). Rice, Sorghum, cotton, Sunflower
  - **(iii) Day neutral plants / Indeterminate:** Those plants which are not affected by photoperiod. (eg) Tomato, Maize

The photoperiodism influences the plant character such as floral initiation or development, bulb and rhizome production etc. In long day plant, during periods of short days, the growth of internodes are shortened and flowering is delayed till the long days come in the season. Similarly when short day plants are subjected to long day periods, there will be abnormal vegetative growth and there may not be any floral initiation.

Direction of light

- The direction of sunlight has a greater effect on the orientation of roots and leaves.
- In temperate regions, the southern slopes plants produce better growth than the northern slopes due to higher contribution of sunlight in the southern side.
- The change of position or orientation of organs of plants caused by light is usually called as phototropism ie the leaves are oriented at right angles to incidence of light to receive maximum light radiation.

Photomorphogenesis: Change in the morphology of plants due to light. This is mainly due to U.V and violet ray of the sun.

AIR TEMPERATURE

Temperature is defined as, "The measure of speed per molecule of all the molecules of a body". Where as heat is, "the energy arising from random motion of all the molecules of a body'. (Degree of molecular activity). It is the intensity aspect of heat energy.

Conduction: Heat transfer when two bodies of unequal temperatures come into contact. Heat passes from point to point by means of adjacent molecules.

Convection: Transfer through movement of particles (part of mass) in fluids and gasses. These ar able to circulate internally and distribute heated part of the mass.

Radiation: It is the process of transmission of energy by electromagnetic waves between two bodies without the necessary aid of an intervening material medium.

Factors affecting air temperature

i. Latitude
ii. Altitude
iii. Distribution of land and water
iv. Ocean currents
v. Prevailing winds
vi. Cloudiness
vii. Mountain barriers

viii. Nature of surface
ix. Relief
x. Convection and turbulence etc.

1. Latitude:

The time of occurrence of maximum monthly mean temperature and minimum monthly mean temperature also depends on latitude of a place. (eg.) The coldest month is January in northern regions of India while December in the south. Similarly, the warmest month is May in the south while June in the north across the country.

2. Altitude:

The surface air temperature decreases with increasing altitude from the mean sea level as the density of air decreases. Since the density of air is less at higher altitudes, the absorbing capacity of air is relatively less with reference to earth's longwave radiation.

3. Distribution of land and water:

Land and water surfaces react differently to the insolation. Because of the great contrasts between land and water surfaces their capacity for heating the atmosphere varies. Variations in air temperature are much greater over the land than over the water. The differential heating process between land and sea surfaces are due to their properties. It is one of the reasons for Indian monsoon.

4. Ocean currents:

The energy received over the ocean surface carried away by the ocean currents from the warm areas to cool areas. This results in temperature contrast between the equator and poles. The occurrence of El-Nino is due to change in sea surface temperature between two oceanic regions over the globe.

5. Prevailing winds:

Winds can moderate the surface temperature of the continents and oceans. In the absence of winds, we feel warm in hot climates. At the same time, the weather is pleasant if wind blows.

6. Cloudiness:

The amount of cloudiness affects the temperature of the earth's surface and the atmosphere. A thick cloud reduces the amount of insolation received at a particular place and thus the day time temperature is low. At the same time, the lower layers in the atmosphere absorb earth's radiation. This results in increasing atmospheric temperature during night. That is why, cloudy nights are warmer. This is common in the humid tropical climates.

7. Mountain barriers:

Air at the top of the mountain makes little contact with the ground and is therefore cold while in the valley at the foothills makes a great deal of contact and is therefore warm. That is, the lower region of the earth's atmosphere is relatively warmer when compared to hillocks.

Lect. 7. DIURNAL AND SEASONAL VARIATION IN AIR TEMPERATURE– ISOTHERM. HEAT UNIT DEFINITION AND ITS USE – HEAT AND COLD WAVES – ROLE OF TEMPERATURE IN CROP PRODUCTION.

Diurnal and seasonal variation of air temperature

- The minimum air temperature occurs at about sunrise, after which there is a constant rise till it reaches to maximum.
- The maximum air temperature is recorded between 1300 hrs and 1400 hrs although the maximum solar radiation is reaches at the moon.
- A steady fall in temperature till sunrise is noticed after is attains maximum. Thus the daily March displays one maximum and one minimum. The difference between the two is called the diurnal range of air temperature.
- The diurnal range of air temperature is more on clear days while cloudy weather sharply reduces daily amplitudes.
- The diurnal range of temperature is also influenced by soils and their coverage in addition to seasons.
- Addition of daily maximum and minimum temperature divided by two is nothing but daily mean / average temperature.
- In northern hemisphere winter minimum occurs in January and summer maximum in July.

Horizontal air temperature distribution

The lines connecting points of equal temperature is called as **isotherm**

- ✓ It is largely depends latitude. A general decrease in temperature from equator towards poles is one of the most fundamental factors of climatology.
- ✓ Irregular distribution of land and water on earth's surface breaks the latitudinal variation in temperature.
- ✓ Land areas warm and cool rapidly than water bodies
- ✓ Mountain barriers influence horizontal distribution of temperature by restricting movement of air masses.
- ✓ On local scale topographic relief exerts an influence on temperature distribution.

Vertical air temperature distribution

Decrease in temperature with increase in height

Temperature inversion

Occasionally at some altitude the temperature abruptly increases instead of decreasing. This condition in which this abrupt rise instead of fall in temperature occurs in the air is known as the temperature inversion. This may occurs under the following conditions.

- When the air near the ground cools off faster than the overlying layer, because of heat loss during cooling nights.
- When an actual warm layer passing over a lower cold layer
- Cold air from hill tops and slopes tend to flow downward and replaced by warm air.

Significance of Temperature inversion

- ❖ Cloud formation, precipitation and atmospheric visibility are greatly influenced by inversion phenomenon
- ❖ Fog formation may take place near the ground which may affect the visibility to both human beings and animals. Affects air navigation.
- ❖ Diurnal temperature is affected by temperature inversions.

The incoming solar radiation and its conversion in to heat is affected.

Heat Units

It is a measure of relative warmth of growing season of a given length. Normally it is indicated as Growing Degree Days (GDD). A heat unit is the departure from the mean daily temperature above the minimum threshold temperature.

The minimum threshold temperature is the temperature below which no growth takes place. Usually ranges from 4.5 to 12.5 ºC for different crops (Most commonly used value is 6.0ºC)

Degree Day

A degree day is obtained by subtracting the threshold temperature from daily mean temperature. Summation of the daily values over the growth period gives degree days of the crops.

$$GDD = \Sigma \left\{ \frac{T_{max} + T_{min}}{2} \right\} - T_b$$

Where

T_{max} – Maximum air temperature of the day

T_{min} – Minimum air temperature of the day

T_b - Base temperature of the crop

The base temperature is the threshold temperature.

Advantages / Importance of growing degree Day Concept

1. In guiding the agricultural operations and planting land use.
2. To forecast crop harvest dates, yield and quality
3. In forecasting labour required for agricultural operations
4. Introduction of new crops and new varieties in new areas
5. In predicting the likelihood of successful growth of a crop in an area.

HEAR INJURIES

'Thermal death point" – the temperature at which the plant cell gets killed when the temperature ranges from 50-60°C. This varies with plant species. The aquatic and shade loving plants are killed at comparatively lower temperature (40°C).

High temperature

- results in desiccation of plants
- disturbs the physiological activities like photosynthesis and respiration
- increases respiration leading to rapid depletion of reserve food.

Sun clad

Injury caused on the barks of stem by high temperature during day time and low temperature during the night time.

Stem griddle

The stem at ground level scorches around due to high soil temperature. It causes death of plant by destroying conductive tissues. Eg. This type of injury is very common in young seedlings of cotton in sandy soil when soil temperature exceeds 60°C.

COLD INJURY

(i) Chilling injury: Plants which are adapted to hot climate, if exposed to low temperature for sometime, are found to be killed or severely injured or development of chloratic condition (yellowing) (eg.) cholratic bands on the leaves of sugarcane, sorghum and maize in winter months when the night temperature is below 20°C.

(ii) Freezing injury: This type of injury is commonly observed in plants of temperate regions. When the plants are exposed to very low temperature, water freezes into ice crystals in the intercellular spaces of plants. The protoplasm of cell is dehydrated resulting in the death of cells.

(eg.) Frost damage in potato, tea etc.

(iii) Suffocation: In temperature regions, usually during the winter season, the ice or snow forms a thick cover on the soil surface. As a result, the entry of oxygen is prevented and crop suffers for want of oxygen. Ice coming in contact with the root prevents the diffusion of CO_2 outside the root zone. This prevents the respiratory activities of roots leading to accumulation of harmful substances.

(iv) Heaving: This is a kind of injury caused by lifting up of the plants along with soil from its normal position. This type of injury is commonly seen in temperate regions. The presence of ice crystals increases the volume of soil. This causes mechanical lifting of the soil.

Role of temperature in crop production:

1. Temperature influences distribution of crop plants and vegetation.
2. The surface air temperature is one of the important variables, which influences all stages of crop during its growth development and reproductive phase.
3. Air temperature affects leaf production, expansion and flowering.
4. The diffusion rates of gases and liquid changes with temperature.
5. Solubility of different substances is dependent on temperature.
6. Biochemical reactions in crops (double or more with each 10°C rise) are influenced by air temperature.
7. Equilibrium of various systems and compounds is a function of temperature.
8. Temperature affects the stability of enzymatic systems in the plants.
9. Most of the higher plants grow between 0°C – 60°C and crop plants are further restricted from 10 – 40°C, however, maximum dry matter is produced between 20 and 30°C
10. At high temperature and high humidity, most of the crop plants are affected by pests and diseases.
11. High night temperature increases respiration and metabolism.
12. A short duration crop becomes medium duration or long duration crop depending upon its environmental temperature under which it is grown.
13. Most of the crops have upper and lower limits of temperature below or above which, they may not come up and an optimum temperature when the crop growth is maximum. These are known as cardinal temperatures and different crops have different temperatures.

Sl No	Crop	Minimum	Optimum	Mximum
1	Wheat and Barley	0 – 5	25 – 31	31 – 37
2	Sorghum	15 – 18	31 – 36	40 – 42

Thermo periodic response

Response of living organism to regular changes in temperature either day or night or seasonal is called thermoperiodism.

Lect. 8. SOIL TEMPERATURE – THEIR IMPORTANCE IN CROP PRODUCTION. FACTORS AFFECTING SOIL TEMPERATURE. DIURNAL AND SEASONAL VARIATION IN SOIL TEMPERATURE.

Soil temperature:

The soil temperature is one of the most important factors that influence the crop growth. The sown seeds, plant roots and micro organisms live in the soil. The physio-chemical as well as life processes are directly affected by the temperature of the soil. Under the low soil temperature conditions signification is inhibited and the intake of water by roof is reduced. In a similar way extreme soil temperatures injures plant and its growth is effected.

Eg. On the sunny side, plants are likely to develop faster near a wall that stores and radiates heat. If shaded by the wall, however, the same variety may mature later. In such cases soil temperature is an important factor.

Importance of soil temperature on crop plants:

The soil temperature influences many process.

1. Governs uptake of water, nutrients etc needed for photosynthesis.
2. Controls soil microbial activities and the optimum range is 18-30°C.
3. Influences the germination of seeds and development of roots.
4. Plays a vital role in mineralization of organic forms of nitrogen.(inc with inc in temp)
5. Influences the presence of organic matter in the soil.(more under low soil temperature)
6. Affects the speed of reactions and consequently weathering of minerals.
7. Influences the soil structure (types of clay formed, the exchangeable ions present, etc.)

Factors affecting soil temperature:

Heat at ground surface is propagated downward in the form of waves. The amplitude deceases with depth. Both meteorological and soil factors contribute in bringing about changes of soil temperature.

I) Meteorological factors:

1. Solar radiation:

a) The amount of solar radiation available at any given location and point of time is directly proportional to soil temperature.
b) Even though a part of total net radiation available is utilised in evapotranspiration and heating the air by radiation (latent and sensible heat fluxes) a relatively substantial amount of solar radiation is utilized in heating up of soil (ground heat flux) depending up on the nature of surface.
c) Radiation from the sky contributes a large amount of heat to the soil in areas where the sun's rays have to penetrate the earth's atmosphere very obliquely.

2. Wind:

Air convection or wind is necessary to heat up the soil by conduction from the atmosphere. (eg.) The mountain and valley winds influence the soil temperature.

3. Evaporation and condensation:

a) The greater the rate of evaporation the more the soil is cooled. This is the reason for coolness of moist soil in windy conditions.
b) On the other hand whenever water vapour from the atmosphere or from other soil depths condenses in the soil it heats up noticeably. Freezing of water generates heat.

4. Rainfall (Precipitation):

Depending on its temperature, precipitation can either cool or warm the soil.

II. Soil factors:

1. Aspect and slope:

a) In the middle and high latitudes of the northern hemisphere, the southern slopes receive more insolation per unit area than the northern exposure.
b) The south west slopes, are usually warmer than the south east slopes. The reason is that the direct beam of sunshine on the south east slope occur shortly after prolonged cooling at night, but the evaporation of dew in the morning also requires energy.

2. Soil texture

a) Because of lower heat capacity and poor thermal conductivity, sandy soils warm up more rapidly than clay soils. The energy received by it is concentrated mainly in a thin layer resulting in extraordinary rise in temperature.
b) Radiational cooling at night is greater in light soils than in heavy soils. In the top layer, sand has the greatest temperature range, followed by loam and clay.
c) The decrease of range with depth is more rapid in light soils than heavy soils when they are dry but slower when they are wet.
d) A soil with rough surface absorbs more solar radiation than one with a smooth surface.

3. Tillage and Tilth:

a) By loosening the top soil and creating a mulch, tillage reduces the heat flow between the surface and the sub soil.
b) Since, the soil mulch has a greater exposure surface than the undisturbed soil and no capillary connection with moist layers below, the cultivated soil dries up quickly by evaporation, but the moisture in the sub-soil underneath the dry mulch is conserved.
c) In general soil warms up faster than air. The diurnal temperature wave of the cultivated soil has a much larger amplitude than that of the uncultivated soil.
d) The air 2-3 cm above the tilled soil is often hotter (10°C or above) than that over an untilled soil.
e) At night loosened ground is colder and more liable to frost than the uncultivated soil.

4. Organic matter:

a) The addition of organic matter to a soil reduces the heat capacity and thermal conductivity. But, the water holding capacity increases.
b) The absorbtivity of the soil increases because of the dark colour of the organic matter.
c) At night, the rapid flow of heat from sub-soil by radiation is reduced with the addition of organic matter because of its low thermal conductivity.
d) The darker the colour, the smaller the fraction of reflected radiation.
e) The dark soils and moist soils reflect less than the light coloured and dry soils.

5. Soil moisture:

a) Moisture has an effect on heat capacity and heat conductivity.
b) Moisture at the soil surface cools the soil through evaporation.
c) Therefore, a moist soil will not heat up as much as a dry one.
d) Moist soil is more uniform in temperature throughout its depth as it is a better conductor of heat than the dry soil.

Variations in soil temperature:

There are two types of soil temperature variations; daily and seasonal variation of soil temperature

1. Daily variations of soil temperature:

a) These variations occur at the surface of the soil.
b) At 5 cm depth the change exceeds 10°C. At 20 cm the change is less and at 80 cm diurnal changes are practically nil.
c) On cooler days the changes are smaller due to increased heat capacity as the soils become wetter on these days.
d) On a clear sunny day a bare soil surface is hotter than the air temperature.
e) The time of the peak temperature of the soil reaches earlier than the air temperature due to the lag of the air temperature.
f) At around 20 cm in the soil the temperature in the ground reaches peak after the surface reaches its maximum due to more time the heat takes to penetrate the soil. The rate of penetration of heat wave within the soil takes around 3 hours to reach 10 cm depth.
g) The cooling period of the daily cycle of the soil surface temperature is almost double than the warming period.
h) Undesirable daily temperature variations can be minimised by scheduling irrigation.

2. Seasonal variations of soil temperature:

a) Seasonal variations occur much deeper into the soil.
b) When the plant canopy is fully developed the seasonal variations are smaller.
c) In winter, the depth to which the soil freezes depends on the duration and severeness of the winter.
d) In summer the soil temperature variations are much more than winter in tropics and sub tropics.

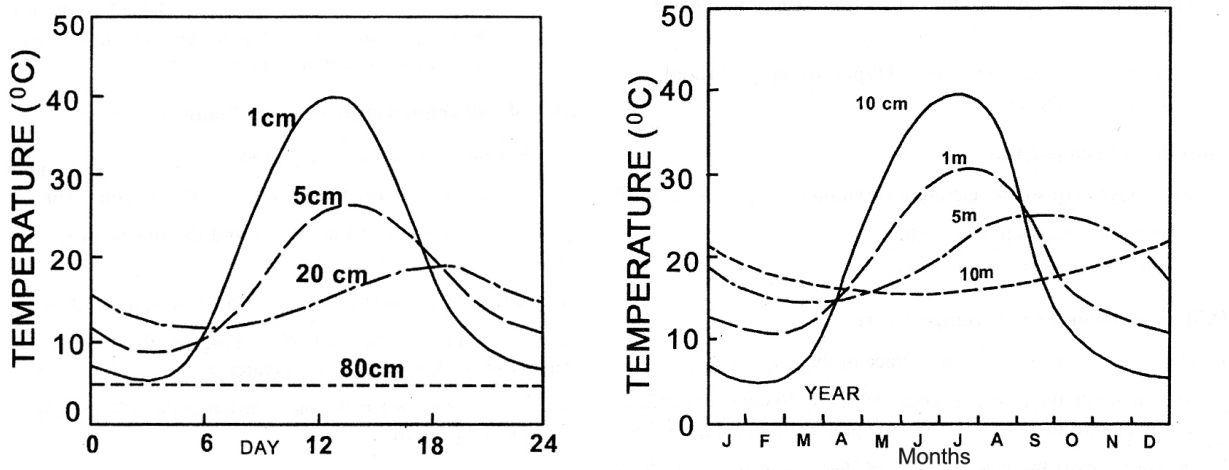


Fig. Daily and monthly variation of soil temperature

LECT.10 ATMOSPHERIC PRESSURE – DIURNAL AND SEASONAL VARIATION – PRESSURE SYSTEMS OF THE WORLD – CAUSES OF VARIATION – ISOBAR – LOW, DEPRESSION, ANTICYCLONE, TORNADO, HURRICANE AND STORMS.

Atmospheric pressure

The atmospheric pressure is the weight of the air, which lies vertically above a unit area centered at a point. The weight of the air presses down the earth with the pressure of 1.034 gm / cm^2. It is expressed in millibar (mb) equal to 100 N/m^2 or 1000 dynes/cm^2. Unequal heating of the earth and its atmosphere by the sun and rotation of the earth bring about differences in atmospheric pressure.

Isobars: The distribution of pressure is represented on maps by 'isobars'. Isobars are defined as the imaginary lines drawn on a map to join places having the same atmospheric pressure.

Diurnal and seasonal variation

(a) Diurnal pressure variation

a. There is a definite rhythm in the rise and fall of the pressure in a day.
b. Radiational heating (air expansion) and radiational cooling (air contraction) are the main reasons for diurnal variation in the air pressure.
c. Diurnal variation is more prominent near the equator than at the mid latitudes.
d. The areas closer to sea level record relatively larger amount of variation than in land areas.
e. Equatorial regions absorbs more heat than it loses while the polar region gives up more heat than they receive

b) Seasonal pressure variation

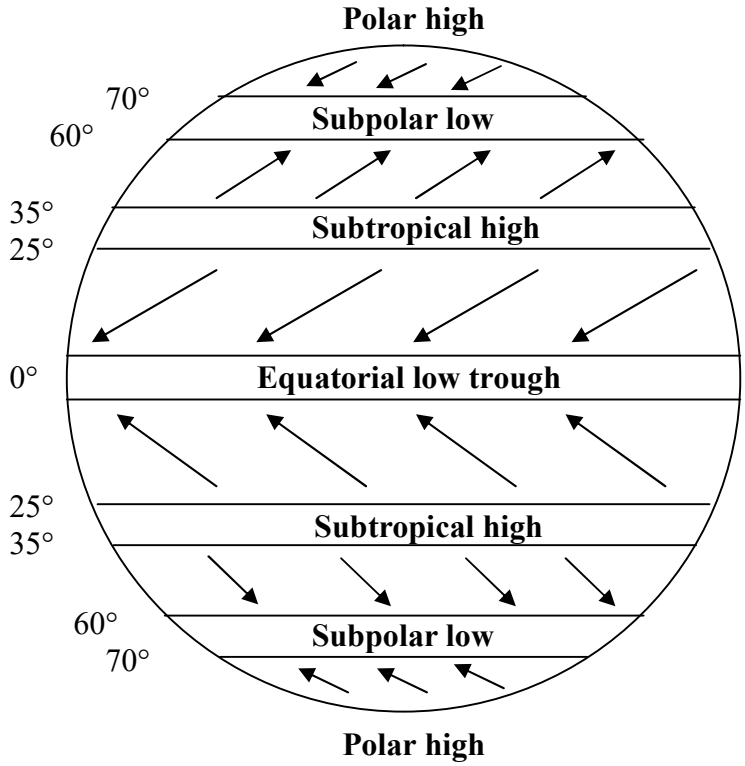
a. Due to the effect caused by annual variation in the amount of insolation, distinct seasonal pressure variations occur.
b. These variations are larger in the tropical region than the mid latitude and polar regions.
c. Usually, high pressures are recorded over the continents during the cold season and over the oceans during the warm season.

Pressure systems of the world

The shape of the earth is not uniform and subjected to uneven distribution of solar radiation, when it revolves around the sun. The uneven distribution of solar radiation over different regions of the globe leads to contrast in surface air temperature. This results in variations of surface atmospheric pressure systems, which are known as standard atmospheric pressure systems / belts. There are altogether seven alternating low and high pressure belts on the earth's surface. They are as follows:

i. Equatorial trough of low pressure (between 5°N and 5°S)
ii. Subtropical high pressure belt (Northern hemisphere) (25° and 35°N)
iii. Subtropical high pressure belt (Southern hemisphere) (25° and 35°S)
iv. Subpolar low pressure belt (Northern hemisphere) (60° and 70°N)
v. Subpolar low pressure belt (Southern hemisphere) (60° and 70°S)
vi. Polar high (Northern hemisphere)
vii. Polar high (Southern hemisphere)

The equatorial region receives more solar radiation and thus the surface air temperature is high, which creates lighter air near the ground compared to higher latitudes. The above condition leads to low atmospheric pressure over the equatorial region while sub tropical high pressure belts develop in both the hemispheres between 25 and 35 degree latitudes due to relatively low surface air temperature. It is due to low solar radiation received due to inclined sun's rays over the subtropical region when compared to the equatorial belt. Like wise alternate low and high atmospheric pressure belt systems are developed across the globe from the equator to the poles.



Causes of variation
The atmospheric pressure changes continuously due to several factors. The most important factors are changes with temperature, altitude, water vapour content and rotation of earth.

a) Temperature
Hot air expands and exerts low pressure. Cold air contracts and exerts high pressure. So the equator has a low pressure due to prevalence of high temperature but poles have a high pressure.

b) Altitude
At sea level, the air column exerts its full pressure, but when we stand on a hill or when we go in the upper layers of atmosphere, we leave a portion of air which cannot exert its full pressure. At sea level, a coastal town enjoys high pressure but on high altitude one will register a low pressure. For every 10 m of ascend, the pressure get reduced by 1 hPa.

c) Water vapour
The water vapour content is lighter in cold area than in air which is dry with the result that moist air of a high temperature exerts a less pressure when compared to cold air.

d) Rotation of the earth
On account of rotation of the earth, the pressure at 60-70°N and S becomes low. The rotation of the earth near sub-polar belts, makes the air to escape from these belts which move towards the horse latitude (30° - 35°N and 30 – 35°S). These latitudes absorb the air from sub polar belts making the pressure high. G.D.Coriolis (1844) a French Mathematician indicated that air is deflected towards right in the Northern Hemisphere and Left in the Southern hemisphere due to rotation of earth and this was termed after him as Coriolis force. Coriolis force is not actually a force but it is effect created by rotation of earth.

Low / Depression: When the isobars are circular or elliptical in shape, and the pressure is lowest at the centre, such a pressure system is called ‘Low’ or ‘Depression’ or ‘Cyclone’. The movement will be anti-clockwise in the Northern hemisphere while it is clockwise in the southern hemisphere. Wind spped hardly exceeds 40 km per hour.

Anticyclone: When isobars are circular, elliptical in shape and the pressure is highest at the centre such a pressure system is called ‘High’ or ‘Anticyclone’. When the isobars are elliptical rather than

circular the system is called as ‘Ridge’ or ‘Wedge’. The movement will be clockwise in the Northern hemisphere while it is anti-clockwise in the southern hemisphere.

Storm: Low pressure centre surrounded by winds having their velocities in the range of 40 to 120 km/hour. A more favourable atmosphere condition for their occurrence exists during the summer season. The Bay of Bengal and Arabian sea offer ideal condition for origin and growth of the storms. These storms produce heavy precipitation and bring about a change in the existing weather. It occurs very rarely. It causes wide spread damage.

Hurricane: A severe tropical cyclone with wind speed exceeding 120 km per hour. The name hurricane is given to the tropical cyclones in the North Atlantic and the eastern North Pacific Ocean. The tropical cyclones of Hurricane force in the western North pacific are known as typhoons. In Australia this type of storm is given the name willy-willy, whereas in the Indian Ocean they are called as Cyclones. Hurricanes are fueled by water vapour (i.e.) pushed up from the warm ocean surface, so they can last longer and sometimes move much further over water than over land. A combination of heat and moisture along with the right wind conditions can create a new hurricane.

Thunderstorms: Storms produced by cumulonimbus clouds and always accompanied by lightening and thunder. They are usually of short duration, seldom over 2 hours. They are also accompanied by strong wind gusts, heavy rain and sometimes hail.

Tornadoes: Defined as a violently rotating column of air attended by a funnel-shaped or tubular cloud extending downward from the base of cumulonimbus cloud. Tornadoes are the most violent storms of lower troposphere. They are very small in size and of short duration. They mostly occur during spring and early summer. They have been reported at widely scattered locations in the mid latitudes and tropics. Crop losses are heavy due to this event. Unknown in other parts of the world.

Waterspouts: It is column of violently rotating air over water having a similarity to a dust devil of tornado. In other words, tornadoes are weak visible vortices occurring over water are called waterspouts. They are formed over tropical and subtropical oceans.

Lect. 11. WIND – WIND SYSTEMS OF THE WORLD – INTER TROPICAL CONVERGENCE ZONES (ITCZ) – WIND SPEED IN DIFFERENT SEASONS – EFFECT OF WIND ON CROP PRODUCTION.

Wind: Air in horizontal motion is known as wind. Vertical movement is noticed but negligibly small compared to horizontal movement as the height of the atmosphere is only for few kilometers. However vertical movement or uplift of air only causes significant weather changes in cloud formation and rain.

Wind systems of the world

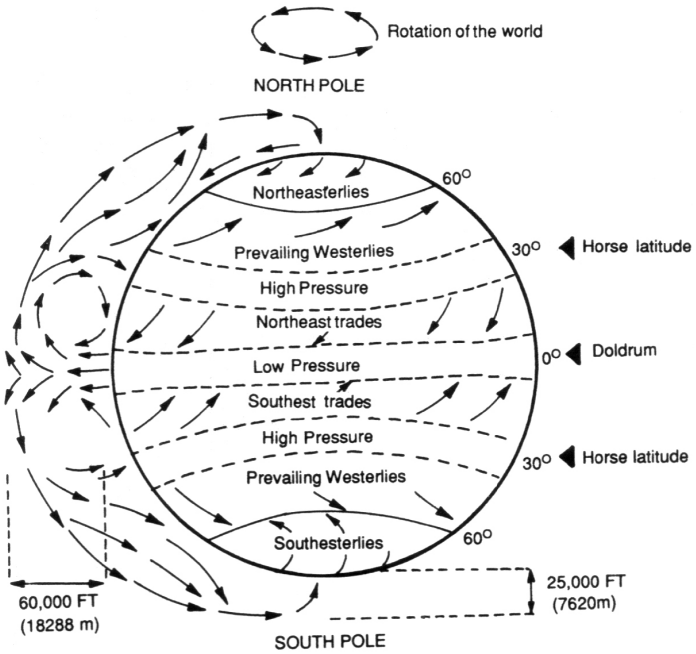
The wind belts found on earth's surface in each hemisphere are:

a. Doldrums
b. Trade wind belt
c. Prevailing westerlies
d. Polar easterlies

1. Doldrums

Owing to continuous heating of the earth by insolation, pressures are low and winds converge and rise near the equator. This intertropical convergent zone is known as 'Doldrums'.

a) These are the equatorial belts of calms and variable winds.
b) The location is 5°S and 5°N latitudes.
c) Wind is light due to negligible pressure gradient.
d) Mostly, there are vertical movements in the atmosphere.
e) The atmosphere is hot and sticky.



GLOBAL WIND CIRCULATION

2. Trade winds (Tropical Easterlies)

a) The regular high temperature at the equator results in a high pressure forming in the upper levels of the equator.
b) Then, the air is transferred to the northward and southward directions until 35° North and South in both the hemisphere.
c) Due to this reduction in surface pressure on the equator (doldrums) there is an increase in pressure at 35°N and 35°S which are known as horse latitude (sub-tropical high).
d) As a result, the winds flow from the horse latitude to the equatorial region.
e) While moving, these winds are deflected by Coriolis force to the right in northern hemisphere and to the left in southern hemisphere.
f) These winds flow from 35°N to the equator in NE direction in the northern hemisphere and from 35°S to the equator in SE direction in the southern hemisphere. These are known as 'Trade winds'. These are known as 'Tropical easterlies'.
g) These are most constant winds in force and direction and flow over nearly half the globe.

3. Anti-trade winds

a) This is a supplementary wind system of the earth which is effective at higher levels.
b) This system works in opposite direction to the surface winds.
c) The anti-trade winds mostly flow from land to ocean and brings no rain.

4. Prevailing Westerlies

a) The winds that flow from sub-tropical high to the low-pressure area about 60-70° latitudes in both the hemispheres are known as 'Prevailing westerlies'.
b) In the northern hemisphere the direction of Prevailing westerlies is SW and in southern hemisphere NW.

c) These winds are forceful and are irregular as compare to the trade winds in the tropical regions.
d) High precipitation zone

5. Polar Easterlies / Polar winds

b) A permanent high pressure exists on the poles.
c) From these high pressure polar regions, cold winds flow to areas at about 60-65° latitudes in both the hemispheres.
d) The winds flow in NE direction in the northern hemisphere and in SE direction in the southern hemisphere.

Mountain winds

a) Blows from mountain up slope to base
b) Occurs during night time
c) Cooling of air close to slope takes place
d) Adiabatic heating decreases this phenomenon
e) Also known as 'Katabalic winds'

Valley winds

a) Blow from valley base to up slope.
b) Occurs during day time
c) Over heating of air adjacent to slope takes place
d) Adiabatic cooling decreases this phenomenon
e) Also known as 'Anabatic winds'

Sea breeze

During the daytime, more so in summer, land is heated more than the adjacent body of water. As a result warmed air over the land expands producing an area of low pressure. The isobaric surfaces bend upward as a result of which the cooler air starts moving across the coast line from sea to land. This is the 'Sea breeze; or 'On shore breeze'.

Land breeze

At night because of nocturnal radiation land is colder than adjacent sea and the pressure gradient is directed from land to sea. There is a gentle flow of wind from land to sea. This 'off-share' wind is called 'Land breeze'.

Sl.	Sea Breeze	Land Breeze
1.	Occurs in day time	Occurs in night time
2.	Flows from sea	Flows from land
3.	Have more moisture than land breeze	Do not have more moisture
4.	Occurrence depends on topography of coast to grater extent	Occurrence depends on topography of land to little extent
5.	Modifies weather on hot summer afternoon	Produces cooler winters and warmer summers
6.	Stronger than land breeze	Weaker than sea breeze

Effect of wind on crop plants

1) Transports heat in either sensible or latent heat form from lower to higher altitudes
2) Wind affects the plant directly by increasing transpiration and the intake of CO_2 and also causes several types of mechanical damage.
3) Wind helps in pollination and dispersal of seeds.
4) Light and gentle winds are helpful for cleaning the agricultural produce.
5) Hot dry winds frequently do much damage to vegetation in the growing crops by promoting excessive water loss.
6) Wind has powerful effect on humidity.
7) Long, continued warm, dry winds injured blossoms by evaporating the secretion of the stigma.

8) Provides moisture which is necessary for precipitation
9) Wind prevents frost by disrupting atmospheric inversion
10) Causes soil erosion

Wind speed in different season

Winds represent air in motion. The primary cause of all winds is regional differences in temperature, producing regional differences in pressure. When these pressure differences persist for several hours, the rotation of the earth modifies the direction of motion, till the winds blow along lines of equal pressure. Wind direction and speed are modified frequently due to seasonal variation in solar radiation and differential heating of the earth's surface.

Wind Speed The winds are generally measured over level, open terrain at 3 meters above ground. Yet, a general idea of the distribution of the mean daily wind speed, on an annual basis as well as on a monthly basis, would be useful. The mean daily wind speed is the value obtained by averaging the wind speed (irrespective of direction) for a whole day. This averaged for all the days of a month is the mean daily wind speed for that month. The daily values averaged for all the 365 days of the year is the annual mean daily wind speed.

Wind Direction Winds are always named after the direction they come from. Thus, a wind from the south, blowing towards north is called south wind. The wind vane is an instrument used to find out the direction of the wind. Windward refers to the direction wind comes from, and leeward refers to the direction it blows to. When a wind blows more frequently from one direction than from any other, it is called a prevailing wind.

South West Monsoon wind direction: During South West Monsoon period of June to September, the westerly winds prevail on the west of Kerala and south winds on the west of northern Circars, Orissa and Bengal. During April and May the region of high temperature is shifted to north viz., upper Sind, lower Punjab and Western Rajasthan. This area becomes the minimum barometric pressure area to which monsoon winds are directed.

North East Monsoon wind direction: During North East Monsoon period of October to December, on account of the increase in barometric pressure in Northern India, there is a shift in the barometric pressure to the South East and North Easterly winds begin to flow on the eastern coast, by the end of September. These changes bring on heavy and continue rainfall to the Southern and South Eastern India.

Average wind speed for different seasons at Coimbatore.
Month wise wind speed (KMPH)

Month	Wind speed (KMPH)	
	Monthly	Season
January	5.4	Winter - 5.5
February	5.5	
March	7.6	
April	4.6	Summer - 5.3
May	3.7	
June	13.4	
July	12.7	SWM - 10.8
August	11.2	
September	6.0	
October	2.8	
November	2.5	NEM - 2.7
December	2.8	

Lect. 12. HUMIDITY –ABSOLUTE HUMIDITY – SPECIFIC HUMIDITY –RELATIVE HUMIDITY – MIXING RATIO, DEW POINT TEMPERATURE – VAPOUR PRESSURE DEFICIT -DIURNAL VARIATION IN RELATIVE HUMIDITY AND ITS EFFECT ON CROP PRODUCTION.

Humidity: The amount of water vapour that is present in atmosphere is known as atmospheric moisture or humidity.

Absolute humidity: The actual mass of water vapour present in a given volume of moist air. It is expressed as grams of water vapour per cubic meter or cubic feet.

Specific humidity: Weight of water vapour per unit weight of moist air. It is expressed as grams of water vapour per kilogram of air (g/kg).

Mixing ratio: The ratio of the mass of water vapour contained in a sample of moist air to the mass of dry air. It is expressed as gram of water vapour per kilogram dry air.

Relative Humidity: The ratio between the amount of water vapour present in a given volume of air and the amount of water vapour required for saturation under fixed temperature and pressure. There are no units and this is expressed as percentage. In other terms it is the ratio of the air's water vapour content to its maximum water vapour capacity at a given temperature expressed in percentage. The relative humidity gives only the degree of saturation of air. The relative humidity of saturated air is 100 per cent.

Dew Point temperature: The temperature to which a given parcel of air must be cooled in order to become saturation at constant pressure and water vapour content. In this case, the invisible water vapour begins to condense into visible form like water droplets.

Vapour Pressure deficit: The difference between the saturated vapour pressure (SVP) and actual vapour pressure (AVP) at a given temperature. This is an another measure of moisture in the atmosphere which is useful in crop growth studies. When air contains all the moisture that it can hold to its maximum limit, it is called as saturated air, otherwise it is unsaturated air, at that temperature. The vapour pressure created at this temperature under saturated conditions is vapour pressure or saturated vapour pressure (SVP).

Importance of Humidity on crop plants

The humidity is not an independent factor. It is closely related to rainfall, wind and temperature. It plays a significant role in crop production.

1. The humidity determines the crops grown in a given region.
2. It affects the internal water potential of plants.
3. It influences certain physiological phenomena in crop plants including transpiration
4. The humidity is a major determinant of potential evapotranspiration. So, it determines the water requirement of crops.
5. High humidity reduces irrigation water requirement of crops as the evapotranspiration losses from crops depends on atmospheric humidity.
6. High humidity can prolong the survival of crops under moisture stress. However, very high or very low relative humidity is not conducive to higher yields of crops.
7. There are harmful effects of high humidity. It enhances the growth of some saprophytic and parasitic fungi, bacteria and pests, the growth of which causes extensive damage to crop plants. Eg: a. Blight disease on potato. b. The damage caused by thrips and jassids on several crops.
8. High humidity at grain filling reduces the crop yields.
9. A very high relative humidity is beneficial to maize, sorghum, sugarcane etc, while it is harmful to crops like sunflower and tobacco.
10. For almost all the crops, it is always safe to have a moderate relative humidity of above 40%.

Variation in Humidity:

1. Absolute humidity is highest at the equator and minimum at the poles.
2. Absolute humidity is minimum at sunrise and maximum in afternoon from 2 to 3 p.m. The diurnal variations are small in desert regions.
3. The relative humidity is maximum at about the sunrise and minimum between 2 to 3 p.m.
4. The behaviour of relative humidity differs a lot from absolute humidity. At the equator it is at a maximum of 80 per cent and around 85 per cent at the poles. But, near horse latitudes it is around 70 per cent.

Lect. 13 CLOUDS AND THEIR CLASSIFICATION – PRECIPITATION – FORMS OF PRECIPITATION – ISOHYETS – MONSOON RAINFALL VARIABILITY – DROUGHT AND FLOOD - CONCEPTS OF CLOUD SEEDING.

Clouds

"An aggregation of minute drops of water suspended in the air at higher altitudes". The rising air currents tend to keep the clouds from falling to the ground.

WMO cloud classification

The World Meteorological Organisation (WMO) classified the clouds according to their height and appearance into 10 categories. From the height, clouds are grouped into 4 categories (viz., family A, B, C and D) as stated below and there are sub- categories in each of these main categories.

Family A

The clouds in this category are high. The mean lower level is 7 kilometers and the mean upper level is 12 kilometers in tropics and sub-tropics. In this family there are three sub-categories.

1. Cirrus (Ci)
   - ❖ In these clouns ice crystals are present.
   - ❖ Looks like wispy and feathery. Delicate, desist, white fibrous, and silky appearance.
   - ❖ Sun rays pass through these clouds and sunshine without shadow.
   - ❖ Does not produce precipitation.

2. Cirrocumulus (Cc)
   - ❖ Like cirrus clouds ice crystals are present in these clouds also.
   - ❖ Looks like rippled sand or waves of the sea shore.
   - ❖ White globular masses, transparent with no shading effect.
   - ❖ Meckerel sky.

3. Cirrostraturs (Cs)
   - ❖ Like the above two clouds ice crystals are present in these clouds also.
   - ❖ Looks like whitish veil and covers the entire sky with milky white appearance.
   - ❖ Produces "Halo".

Family B

The clouds in this category are middle clouds. The mean lower level is 2.5 kilometers and the mean upper level is 7 kilometers in tropics and sub-tropics. In this family there are 2 sub-categories as details below:

1. Altocumulus (Ac)
   - ❖ In these clouds ice water is present.
   - ❖ Greyish or bluish globular masses.
   - ❖ Looks like sheep back and also known as flock clouds or wool packed clouds.

2. Alto-stratus (As)
   - ❖ In these clouds water and ice are present separately.
   - ❖ Looks like fibrous veil or sheet and grey or bluish in colour.
   - ❖ Produces coronos and cast shadow.
   - ❖ Rain occurs in middle and high latitudes.

Family C

The clouds in this category are lower clouds. The height of these clouds extends from ground to upper level of 2.5 kilometers in tropics and sub-tropics. In this family, like high clouds, there are 3 sub-categorises.

1. Strato cumulus (Sc)

- These clouds are composed of water.
- Looks soft and grey, large globular masses and darker than altocumuls.
- Long parallel rolls pushed together or broken masses.
- The air is smooth above these clouds but strong updrafts occur below.

2. Stratus (St)

- These clouds are also composed of water.
- Looks like for as these clouds resemble grayish white sheet covering the entire portion of the sky (cloud near the ground).
- Mainly seen in winter season and occasional drizzle occurs.

3. Nimbostratus (Ns)

- These clouds are composed of water or ice crystals.
- Looks thick dark, grey and uniform layer which reduces the day light effectively.
- Gives steady precipitation.
- Sometimes looks like irregular, broken and shapeless sheet like.

Family D

These clouds form due to vertical development i.e., due to convection. The mean low level is 0.5 and means upper level goes up to 16 kilometers.

In this family two sub-categories are present.

1. Cumulus (Cu)

These clouds are composed of water with white majestic appearance with flat base.

Irregular dome shaped and looks like cauliflower with wool pack and dark appearance below due to shadow.

These clouds usually develop into cumuolo-nimbus clouds with flat base.

2. Cumulonimbus (Cb)

- The upper levels of these clouds possess ice and water is present at the lower levels.
- These clouds have thunder head with towering envil top and develop vertically.
- These clouds produces violent winds, thunder storms, hails and lightening, during summer.

Forms of Precipitation

Rain: It is precipitation of liquid water particles either in the form of drops having diameter greater than 0.5 mm or in the form of smaller widely scattered drops. When the precipitation process is very active, the lower air is moist and the clouds are very deep, rainfall is in the form of heavy downpour. On occasions, falling raindrops completely evaporate before reaching the ground.

Drizzle: It is fairly uniform precipitation composed of fine drops of water having diameter less than 0.5 mm small and uniform size and seems to be floated in the air, it is referred as drizzle. If the drops in a drizzle completely evaporates before reaching the ground, the condition is referred to as ‘mist’.

Snow: It is the precipitation of white and opaque grains of ice. Snow is the precipitation of solid water mainly in the form of branched hexagonal crystals of stars. In winter, when temperatures are below freezing in the whole atmosphere, the ice crystals falling from the Altostratus do not melt and reach the ground as snow.

Sleet: It refers to precipitation in the form of a mixture of rain and snow. It consists of small pellets of transparent ice, 5 mm or less in diameter. It refers to a frozen rain that forms when rain falling to the earth passing through a layer of cold air and freezes. This happens when temperature is very low. It is not commonly seen in India expect high ranges, that too in winter, in extreme north and northeast India.

Hail: Precipitation of small pieces of ice with diameter ranging from 5 to 50 mm or something more is known as hail. Hailstorms are frequent in tropics. In India, the period from March to May offers the ideal condition for hailstorms. It is the most dreaded and destructive form of precipitation produced in thunderstorms or cumulonimbus clouds.

Isohyets: Isohyets are the lines connecting various locations, having an equal amount of precipitation.

Monsoon Rainfall Variability

Indian continent receives its annual rainfall by the peculiar phenomenon known as monsoon. It consists of series of cyclones that arise in India Ocean. These travel in northeast direction and enter the Peninsular India along its west coast. The most important of these cyclones usually occur from June to September resulting in summer monsoon or southwest monsoon. This is followed by a second rainy season from October to December. A third and fourth rainy seasons occur from January to February and from March to May respectively. Of the four rainy seasons, southwest monsoon is the most important as it contribute 80 – 95% of the total rainfall of the country.

Two types of monsoon systems are a) South West Monsoon, b) North East Monsoon.

(a) South West Monsoon

Beginning of the year temperature of the Indian Peninsular rapidly rises under the increasing heat of the sun. A minimum barometric pressure is established in the interior parts of the Peninsular by the month of March. Westerly winds prevail on the west Kerala and south winds on the west of northern Circars, Orissa and Bengal. During April and May the region of high temperature is shifted to north viz., upper Sind, lower Punjab and Western Rajasthan. This area becomes the minimum barometric pressure area to which monsoon winds are directed.

The western branch of South West monsoon touches North Karnataka, Southern Maharastra and then it make its way to Gujarat. When the South West Monsoon is fully operating on the Western India, another branch of the same is acting in the Bay of Bengal. It carries rains to Burma, Northern portions of the east coast of India, Bengal, Assam and the whole of North India in general.

b) North east Monsoon

During September end, the South West Monsoon penetrates to North Western India but stays on for a full month in Bengal. On account of the increase in barometric pressure in Northern India, there is a shift of the barometric pressure to the South East and North Easterly winds begin to flow on the eastern coast. These changes bring on heavy and continuous rainfall to the Southern and South Eastern India.

c) Winter Rainfall

It is restricted more to Northern India and is received in the form of snow on the hills and as rains in the plains of Punjab, Rajasthan and central India. Western disturbance is a dominant factor for rainfall during these months in northwestern India.

d) Summer Rainfall:

The summer Rainfall is received from March to May as local storms. It is mostly received in the South East of Peninsular and in Bengal. Western India does not generally receive these rains.

Rainfall distribution in Tamilnadu in different seasons

Rainfall season	Quantity (mm)	Percentage share
South West monsoon	311.7	32
North East Monsoon	457.8	47
Cold weather period	48.7	5
Hot weather period	155.9	16

Drought: The term drought can be defined by several ways.

1. The condition under which crops fail to mature because of insufficient supply of water through rains.
2. The situation in which the amount of water required for transpiration and evaporation by crop plants in a defined area exceeds the amount of available moisture in the soil.
3. A situation of no precipitation in a rainy season for more than 15 days continuously. Such length of non-rainy days can also be called as dry spells.

Classification of Drought

Droughts are broadly divided into 3 categories based on the nature of impact and spatial extent.

i. **Meteorological Drought**

If annual rainfall is significantly short of certain level (75 per cent) of the climatologically expected normal rainfall over a wide area, then the situation is called meteorological drought. In every state each region receives certain amount of normal rainfall. This is the basis for planning the cropping pattern of that region or area.

ii. **Hydrological drought**

This is a situation in which the hydrological resources like streams, rivers, reservoirs, lakes, wells etc dry up because of marked depletion of surface water. The ground water table also depletes. The industry, power generation and other income generating major sources are affected. If Meteorological drought is significantly prolonged, the hydrological drought sets in.

iii. **Agricultural Drought**

This is a situation, which is a result of inadequate rainfall and followed by soil moisture deficit. As a result, the soil moisture falls short to meet the demands of the crops during its growth. Since, the soil moisture available to a crops insufficient, it affects growth and finally results in the reduction of yield. This is further classified as early season drought, mid season drought and late season drought.

Flood: Years in which actual rainfall is 'above' the normal by twice the mean deviation or more is defined as years of floods or excessive rainfall. Like droughts, the definition of floods also varies one situation to another and form one region to other. Some of the flood years characterized based on the spatial damage due to high and intense rainfall in India are as follows.

India: 1878,1872,1917,1933,1942,1956,1959,1961,1970,1975,1983,1988.

Principles of rainmaking: Clouds are classified into warm and cold clouds based on cloud top temperature. If the cloud temperature is positive these clouds are called warm clouds and if it is negative they are called as cold clouds. The nucleus needed for precipitation differs with type of clouds. Hygroscopic materials are necessary as nucleus for warm clouds

Cloud seeding: Cloud seeding is one of the tools to mitigate the effects of drought. It is defined as a process in which the precipitation is encouraged by injecting artificial condensation nuclei through aircrafts or suitable mechanism to induce rain from rain bearing cloud. The rain drops are several times heavier than cloud droplets. These mechanisms are different for cold and warm clouds.

Seeding of cold clouds

This can be achieved by two ways (1. Dry ice seeding and 2. Silver Iodide seeding).

1.Dry ice seeding

- Dry ice (solid carbon-dioxide) has certain specific features. It remains as it is at –80°C and evaporates, but does not melt. Dry ice is heavy and falls rapidly from top of cloud and has no persistent effects due to cloud seeding.
- Aircrafts are commonly used for cloud seeding with dry ice.
- Aircraft flies across the top of a cloud and 0.5 – 1.0 cm dry ice pellets are released in a steady stream.
- While falling through the cloud a sheet of ice crystals is formed.
- From these ice crystals rain occurs.

This method is not economical as 250 kg of dry ice is required for seeding one cloud. To carry the heavy dry ice over the top of clouds special aircrafts are required, which is an expensive process.

2. Silver Iodide seeding

Minute crystals of silver iodide produced in the form of smoke acts as efficient ice-farming nuclei at temperatures below –5°C. When these nuclei are produced from the ground generators, these particles are fine enough to diffuse with air currents. Silver iodide is the most effective nucleating substance because; its atomic arrangement is similar to that of ice. The time for silver iodide smoke released from ground generator to reach the super cooled clouds was offer some hours, during which it would draft a long way and decay under the sun light. The appropriate procedure for seeding cold clouds would be to release silver iodide smoke into super cooled cloud from an aircraft. In seeding cold clouds silver iodide technique is more useful than dry ice techniques, because, very much less of silver iodide is required per cloud. There is no necessity to fly to the top of the cloud, if area to be covered is large.

Seeding of warm clouds

1) Water drop Technique

Coalescence process is mainly responsible for growth of rain drops in warm cloud. The basic assumption is that the presence of comparatively large water droplets is necessary to initiate the coalescence process. So, water droplets or large hygroscopic nuclei are introduced in to the cloud. Water drops of 25 mm are sprayed from aircraft at the rate of 30 gallons per seeding on warm clouds.

2) Common salt technique

Common salt is a suitable seeding material for seeding warm clouds. It is used either in the form of 10 per cent solution or solid. A mixture of salt and soap avoid practical problems. The spraying is done by power sprayers and air compressors or even from ground generators. The balloon burst technique is also beneficial. In this case gun powder and sodium chloride are arranged to explode near cloud base dispersing salt particles.

Lect. 14. EVAPORATION – TRANSPIRATION, EVAPOTRANSPIRATION – POTENTIAL EVAPOTRANSPIRATION – DEFINITION AND THEIR IMPORTANCE IN AGRICULTURAL PRODUCTION.

Evaporation: A physical process in which liquid water is converted into its vapour. Evaporation is the most important water loss term in water balance equation.

Importance of Evaporation in crop plants

1) Evaporation is an important process of hydrologic cycle.
2) The evaporation from the soil is an important factor deciding the irrigation water requirements of a crop
3) In modifying the microclimate of a crop the evaporation from the soils is an important factor for consideration.
4) Evaporation is the most important of all the factors in the heat budget, after radiation.
5) The evaporation is also one of the most important factors in the water economy.
6) Since, a certain amount of evaporation also demands a definite amount of heat, it provides a link between water budget and heat budget.

Factors affecting evaporation

The evaporation from a fully exposed water surface is the function of several environmental factors

1. Environmental factors
   a. Water temperature
      With an increase of temperature the kinetic energy of water molecules increases and surface tension decreases which increases evaporation.
   b. Wind
      The evaporation from fully exposed surface is directly proportional to the velocity of wind and vice-versa, because dry wind replaces the moist air near water. The process of evaporation takes place continuously when there is a supply of energy to provide latent heat of evaporation (540 calories / gram of water).
   c. Relative humidity
      The evaporation is greater at low RH than at high RH.
   d. Pressure
      The evaporation is more at low pressure and less at high pressure.

2. Water factors
   a. Composition of water
      The dissolved salts and other impurities decreases the rate of evaporation. The evaporation is inversely proportional to the salinity of water.
   b. Area of evaporation
      The larger the area of exposure, greater will be the evaporation.

Transpiration: This is a physiological phenomenon, which takes place only in living plants. The loss of water from living parts of the plant is known as Transpiration. The loss of water through stomatal openings of the leaves is termed as stomatal transpiration. The loss of water through cuticle is known as cuticular transpiration and from lenticels is known as lenticular transpiration.

Importance of transpiration on crop plants

1. Dissipation of radiant energy by plant parts
2. Translocation of water in the plants
3. Translocation of minerals in the plant

Factors affecting transpiration

I. Environmental factors

1. Light: By directly opening and closing the of stomata there is periodicity in the transpiration rate. Indirectly by increasing the temperature of leaf cells the transpiration is increased.

2. Atmospheric humidity: The rate of transpiration is almost inversely proportional to atmospheric humidity.
3. Air Temperature: Increase in Temperature results in opening of stomata which in turn increases transpiration.
4. Wind velocity: The higher the wind speed higher the transpiration

II. Plant factors

1. Plant height: Water need of the crop varies with height.
2. Leaf characteristics: Reduction in leaf area brings reduction in transpiration.
3. Availability of water to the plant: If there is little water in the soil the tendency for dehydration of leaf causes stomatal closure and a consequent fall in transpiration.

Differences between evaporation and transpiration

Sl	Evaporation	Transpiration
1.	Controlled by meteorological factors	Controlled by both meteorological and plant factors
2.	Diffusive resistant is absent	Diffusive resistance occurs due to internal leaf geometry and presence of stomata.
3.	Also occurs in night due to advective heat transportation.	Reduced in the night due to closure of stomata.
4.	This is purely a physical phenomenon which takes place from any exposed surface with moisture.	This is physiological phenomenon which takes place only in living plants.
5.	This takes place through any openings or pores	This takes place through guard cells of stomata, cuticle and lenticules etc.

Evapotranspiration: Evapotranspiration denotes the quantity of water transpired by plants or retained in the plant tissue plus the moisture evaporated from the surface of the soil. As long as the rate of root uptake of soil moisture balances the water losses from the canopy, evapotranspiration continues to occur at its potential rate. When the rate of root water uptake falls below the transpiration demand, actual transpiration begins to fall below the potential rate. This is either because the soil cannot supply water to roots quickly or the plant can no longer extract water to meet the evaporational demand.

Reference Evapotranspiration (ET_0): This represents the maximum rate of evapotranspiration from an extended surface of 8 to 10 centimeters tall green grass cover, actually growing and completely shading the ground under limited supply of water.

Potential Evapotranspiration (PET): Potential evapotranspiration (PET) for any crop is obtained from reference evapotranspiration and crop factors (Kc) when water supply is unlimited.

$$PET = Kc \times ET_0$$

Importance of Evapotranspiration and Potential Evapotranspiration for crop plants

1. Estimation of the soil moisture there by planning irrigation schedule of crops.
2. Understanding relationship between the crop yield and irrigation water.
3. Guiding for the production of a crop with a fully developed canopy.
4. The evapotranspiration can also help to demarcate soil climatic zones including the drought prone areas.
5. These will form the base for developing suitable soil and crop management practices, crop varieties, water conservation techniques, cropping pattern and ways to improve productivity rainfed crops.

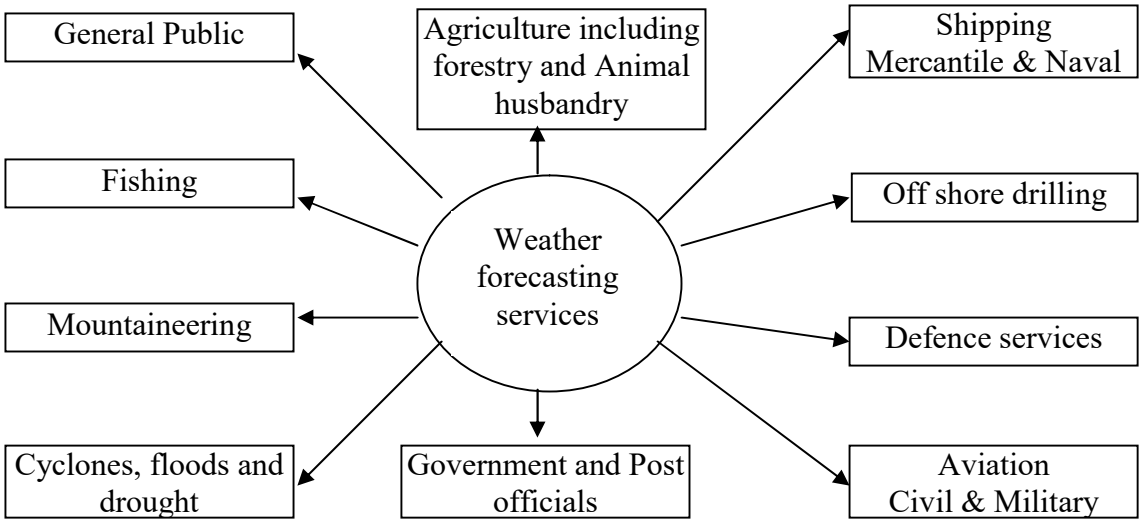
Lect. 15. AGROCLIMATIC NORMALS, WEATHER FORECASTING – TYPES, IMPORTANCE – SYNOPTIC CHART – CROP WEATHER CALENDAR.

Climatic normals

The climatic normals are the average value of 30 years of a particular weather element. The period may be week, month and year. The crop distribution, production and productivity depend on the climatic normals of a place. If the crops are selected for cultivation based on the optimum climatic requirements it is likely that the crop production can be maximized.

Weather forecast

The prediction of weather for the next few days to follow. The Figure below depicts different weather forecasting services normally practiced in a country.



NEED / IMPORTANCE OF FORECAST

- Basically weather has many social and economic impacts in a place.
- Among different factors that influence crop production, weather plays a decisive role as aberrations in it alone explains up to 50 per cent variations in crop production
- The rainfall is the most important among the required forecast, which decides the crop production in a region and ultimately the country's economy.
- The planning for moisture conservation under weak monsoon condition and for flood relief under strong monsoon condition is important in a region.
- A reliable weather forecasting when disseminated appropriately will pave way for the effective sustainability.
- One can minimize the damage, which may be caused directly or indirectly by unfavourable weather.
- The recurring crop losses can be minimized if reliable forecast on incidence of pest and diseases is given timely based on weather variables.
- Help in holding the food grain prices in check through buffer stock operations. This means that in good monsoon years when prices fall, the government may step in and buy and in bad years when price tend to rise, it may unload a part of what it had purchased.
- Judicious use of water can be planned in a region depending up on the forecast.

Type of weather forecast

	Types of forecast	Validity period	Main users	Predictions
1	Short range a) Now casting	Up to 72 hours 0-2 hours	Farmers marine agencies, general public	Rainfall distribution, heavy rainfall, heat and cold wave conditions, thunder storms etc.
	b) Very short range	0-12 hours		
2	Medium range	Beyond 3 days and upto 10 days.	Farmers	Occurrence of rainfall, Temperature.
3	Long range	Beyond 10 days upto a month and a season.	Planners	This forecasting is provided for Indian monsoon rainfall. The out looks are usually expressed in the form of expected deviation from normal condition.

Synoptic charts

An enormous volume of meteorological data is being collected from all over the world continuously round the clock through various telecommunication channels. To assess, assimilate and analyse the vast data, they have to be suitably presented. For this purpose, the observations are plotted on maps in standard weather codes. These maps are called 'Synoptic maps or charts'.

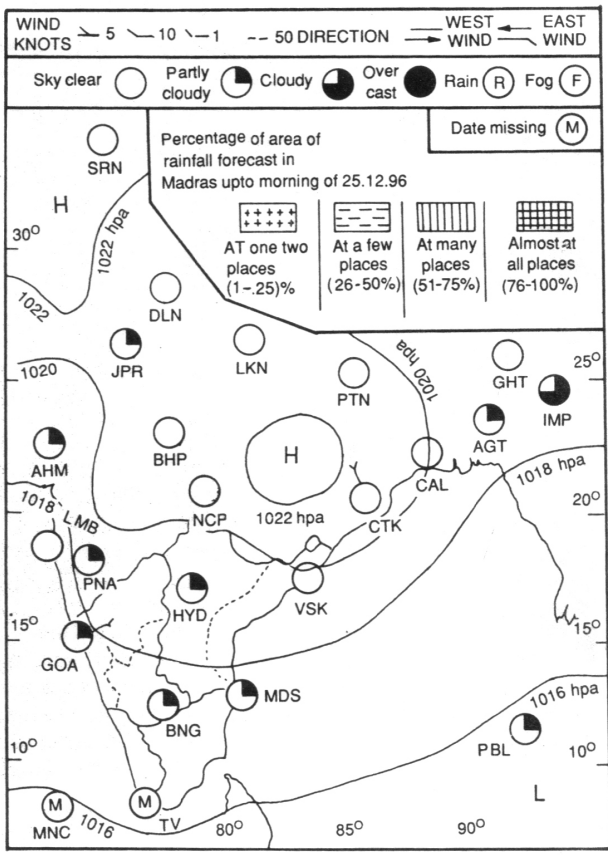
Synoptic charts display the weather conditions at a specified time over a large geographical area. The surface synoptic charts plotted for different synoptic hours (00, 03, 06, 09, 12, 15, 18, 21 UTC) depict the distribution of pressure, temperature, dew point, clouds, winds, present and past weather. In place of GMT, UTC (Universal Time Co-ordinate) is used. The upper air charts are also prepared at the standard pressure levels of the atmosphere (different heights) of the atmosphere wherein the pressure, wind and temperature are plotted. The surface charts together with the upper air charts provide a composite three-dimensional weather picture pertaining to a given time. Thus it gives a birds eye view of the state of atmosphere at a time over a large area and is a important tool used by operational meteorologists and scientists.

The surface synoptic charts are the most used charts. It contains the maximum number of observations with the largest number of parameters plotted and often forms the base on which the pressure level charts are built up. The pattern of the pressure distribution is brought out by drawing isobars, troughs, ridges, lows, highs, depressions, cyclones, cols, fronts and discontinuities. These systems are clearly marked and labeled using appropriate symbols and colours.

In synoptic charts different weather phenomena and atmospheric characters are marked with different symbols as mentioned below.

S.No	Symbols	Weather element/character/phenomenon
1.	Narrow black lines	lsobars
2.	Numbers at ends of isobars	Pressure values in hPa
3.	Shading	Precipitation
4.	Arrows	Wind direction
5.	Feathers in the arrows	Wind velocity
6.	Small circles with shading	Amount of clouds

In addition to the above, different symbols are used for recording weather phenomena.



Sample daily weather report

	SQUALL		DEW		SHOWERS OF LIGHT SNOW
	GALE		FROST		CONTINUOUS HEAVY SNOW
	DUST STORM		SOLAR HALO		SOFT HAIL
	DUST DEVIL		LUNAR HALO		HAIL
	LIGHTNING		RAINBOW		MOIST HAZE
	THUNDERSTORM		LIGHT THUNDERSTORM WITH RAIN		SEVERE DUST STORM
	SHOWERS		SHOWER OF LIGHT RAIN		INDUSTRIAL SMOKE
	DRIZZLE		INTERMITTENT MODERATE DRIZZLE		SOLAR CORONA
	CONTINUOUS LIGHT DRIZZLE		CONTINUOUS MODERATE DRIZZLE		CLEAR SKY
	RAIN		CONTINUOUS HEAVY RAIN		FOG
	CONTINUOUS LIGHT RAIN		CONTINUOUS LIGHT SNOW		MIST

SYMBOLS FOR RECORDING WEATHER PHENOMENA

Weather calendar

In order to provide the farmers with an efficient weather service, it is essential that the weather forecaster should be familiar with the crops that are grown in a particular agroclimatic zone. The type of forewarnings to be given depend on the stages of the crop. In case of farmers, they should become familiar with weather bulletins and learn how to interpret. To meet the above requirement, the detailed information collected from the agricultural departments has been condensed by the IMD and presented in a pictorial form known as crop weather calendar. This calendar has three parts as follows.

a) Bottom part
b) Middle part
c) Top part

a) Bottom part provides the activities related to crop or information related to phenological stages of the crop and the months.

b) Middle part gives information regarding normal weather condition required for active crop growth. It is divided into different sections according to rainfall, rainy days, minimum temperature, maximum temperature, pan evaporation and sunshine hours.

c) Top part gives information related to the weather abnormalities or to take precautionary measures. Top part is divided into different sections according to dry spell length, high wind, heavy rainfall and cloudy weather.

Sample crop weather calendar prepared for cotton in Tamilnadu for South Arcot district

CROP WEATHER CALENDAR

STATE : TAMILNADU **CROP :** COTTON **VARIETY** : LRA-5166, MCU-7 **IRRIGATED**

DISTRICTS : SOUTH-ARCOT **DURATION :** 150 DAYS **SOIL :** RED LOAM

Weather warnings	*Rain*	> 100 MM/DAY		
	Duration of wet spell	> 30 MM FOR 10 DAYS		
	Cloudy weather			
	Drought	40 DAYS	35 DAYS	35 DAYS
	High winds			> 30 KM/HOUR
	Temperature			
	Hail storm			
Weather conditions favourable for incidence of pests and diseases	*Pests*	STEM WEEVIL, BOLL WORMS	STEM WEEVILS, BOLL WORMS	STEM WEEVILS, BOLL WORMS
	Weather			
	Diseases	WILT	WILT	
	Weather			

| Normal phase wise water requirement (mm) | | | |

WEATHER NORMALS FOR AGRICULTURAL CROPS

Sl. No.	Crops	Optimum Temperature ° C		Day length	Rainfall (mm)	Altitude above MSL (m)
		Germination	Growth stage			
1	Rice	Min 10 ° C	22-25 (flowering) 20-21(grain formn) 20-25(ripening)		1500	<3000
2	Maize	35-44 ° C				
3	Sorghum	7-10	25-30	Short day		
4	Pearl millet		28-32		400-750	
5	Finger millet				500-1000	
6	Kodo millet				400-500	
7	Wheat	20-22	16-22		250-1800	<3500
8	Barley		12-15 (growth) 30(reproduction)	Long day	400-500	
9	Oats	15-25			380-1140	
10	Ground nut	27-30	24-27		500-1250	
11	Sesame	25-27		Short day	500-650	<1250
12	Castor	20-26		Long day	500-600	<3000
13	Sunflower	20-25			500-700	<2500
14	Rape seed and Mustard	18-25		Long day	300-400	
15	Safflower	15-16	25-30	Day neutral	600-900	
16	Soybean	15-32	30-33		600-650	1200-2000
17	Pigeon pea	20-30				
18	Green gram	15	20-40	Short day	600-1000	
19	Black gram					1500
20	Cow pea	12-15	21-35	Short day	600	
21	Bengal gram		15-25		600-1000	
22	Cotton	18	21-27	Day neutral	500	
23	Jute		27-40	Short day	1500	
24	Tobacco	28	25-35		500-1000	
25	Sugar cane		24-30	Long day	2000-2500	
26	Sugar beet	12-15	22-30	Long day		
27	Potato	18-20	18-20			

Lect. 16. **DEFINITION AND USES OF REMOTE SENSING AND CROP WEATHER MODELING – CLIMATE CHANGE AND VARIABILITY – EL- NINO, LA- NINA**

Definition: Remote sensing is defined as the art and science of gathering information about objects or areas from a distance without having physical contact with objects area being investigated.

Uses: Remote sensing techniques are used in agricultural and allied fields.

1. Collection of basic data for monitoring of crop growth
2. Estimating the cropped area
3. Forecasting the crop production
4. Mapping of wastelands
5. Drought monitoring and its assessment
6. Flood mapping and damage assessment
7. Land use/cover mapping and area under forest coverage
8. Soil mapping
9. Assessing soil moisture condition, irrigation, drainage
10. Assessing outbreak of pest and disease
11. Ground water exploration

Remote Sensing platforms:

Three platforms are generally used for remote sensing techniques. They are ground based, air based and satellite based. Infrared thermometer, Spectral radiometer, Pilot-Balloons and Radars are some of the ground based remote sensing tools while aircrafts air based remote sensing tools. Since the ground based and air based platforms are very costly and have limited use, space based satellite technology has become handy for wider application of remote sensing techniques. The digital image processing, using powerful computers, is the key tool for analyzing and interpretation of remotely sensed data. The advantages of satellite remote sensing are:

- Synoptic view – Wide area can be covered by a single image/photo (One scene of Indian Remote Sensing Satellite IRS series cover about 148 x 178 sq.km area).
- Receptivity – Can get the data of any area repeatedly (IRS series cover the same area every 16-22 days).

Coverage – Inaccessible areas like mountains, swampy areas and thick forests are easily covered.

Space based remote sensing is the process of obtaining information about the earth from the instruments mounted on the Earth Observation Satellites. The satellites are subdivided into two classes and the types of satellite are as follows:

Polar orbiting satellites: These satellites operate at an altitude between 550 and 1,600 km along an inclined circular plane over the poles. These satellites are used for remote sensing purposes. LANDSAT (USA), SPOT (FRANCE), and IRS (INDIA) are some of the Remote Sensing Satellites.

Geostationary satellite: These have orbits around the equator at an altitude of 36,000 km and move with the same speed as the earth so as to view the same area on the earth continuously. They are used for telecommunication and weather forecasting purposes. INSAT series are launched from India for the above purposes. All these satellites have sensors on board operating in the visible and near infrared regions of the electromagnetic spectrum. INSAT-3A was launched on 10^{th} April, 2003.

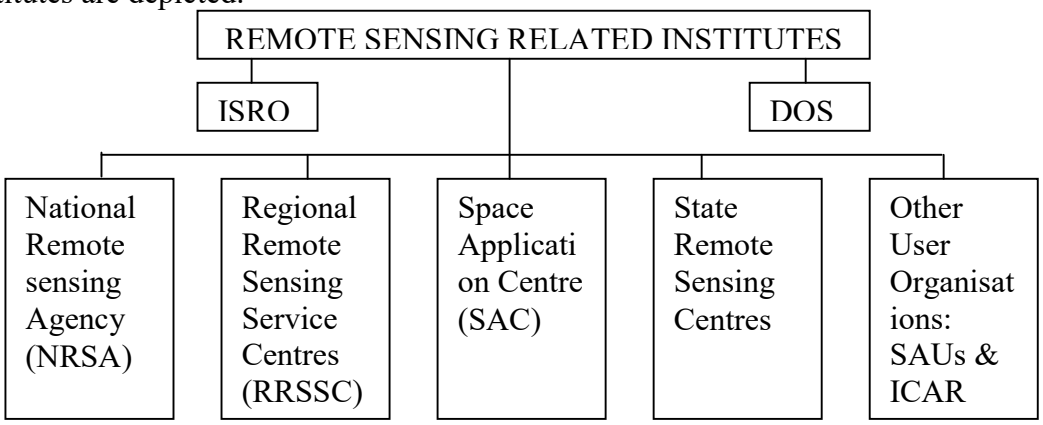
Role of Remote Sensing in agriculture

Agricultural resources are important renewable dynamic natural resources. In India, agriculture sector alone sustains the livelihood of around 70 percent of the population and contributes nearly 35 percent of the net national product. Increasing agricultural productivity has been the main concern since scope for increasing area under agriculture is rather limited. This demands judicious and optimal management of both land and water resources. Hence, comprehensive and reliable information on land use/cover, forest area,

soils, geological information, extent of wastelands, agricultural crops, water resources both surface and underground and hazards/natural calamities like drought and floods is required. Season-wise information on crops, their acreage, vigour and production enables the country to adopt suitable measures to meet shortages, if any, and implement proper support and procurement policies. Remote Sensing systems, having capability of providing regular, synoptic, multi-temporal and multi-spectral coverage of the country, are playing an important role in providing such information. A large number of experiments have been carried out in developing techniques for extracting agriculture related information from ground borne, air borne and space borne data.

Indian Remote Sensing programme:

India, with the experience gained from its experimental remote sensing satellite missions BHASKARA-I and II, has now established satellite based operational remote sensing system in the country with the launch of Indian Remote Sensing Satellite IRS-IA in 1988, followed by IRS-IB (1992), IRS-IC (1995) and IRS-ID (1997). The Department of Space (DOS) / Indian Space Research Organisation (ISRO) as the nodal agency for establishing an operation remote sensing system in the country initiated efforts in the early 1970s for assessing the potentials of remotely sensed data through several means. In order to meet the user requirement of remote sensing data analysis and interpretation, ISRO/DOS has set up a system to launch remote sensing satellites once in three or four years to maintain the continuity in data collection. The remote sensing and some of its related institutes are depicted.



Crop weather modeling

Crop model: It is a representation of a crop through mathematical equations explaining the crops interaction with both above ground and below ground environment.

The increase in dry matter of the crop is referred to as growth. The rate of growth of a healthy crop depends on the rate at which radiation is intercepted by foliage and / or on the rate at which water and nutrients are captured by root systems and therefore on the distribution of water and nutrients in the soil profile. The crop development is described in terms of various phenophases through which the crop completes its lifecycle. That is the progress of the crop from seeding or primordial initiation to maturity. Finally the yield of crop stand is expresses as a product of three components, viz., the period over which dry matter is accumulated (the length of the growing period), the mean rate at which dry matter is accumulated and the fraction of dry matter treated as yield when the crop is harvested.

It is understood that the crop growth, development and yield depend upon the mean daily temperature (DTT), the length of the day and the amount of solar radiation (PAR) received by the crop.

$$DTT = \frac{\text{Max daily temperature} + \text{Min daily temperature}}{2} - \text{base temperature}$$

Where, DTT = Daily thermal time accumulation.

The time needed for the crop to reach a development stage depends upon temperature measured above a base value (DTT) and for photo periodically sensitive phases such as flowering, the

day length above a fixed base. In the absence of stress, the harvest index does not vary much from year to year for a specified cultivar / variety. Therefore, crop weather modeling is based on the principles that govern the development of crop and its growing period based on temperature and / or day length. They are used to quantify the rate of crop growth in terms of radiation interception, water use and nutrient supply which moderate harvest index when the crops experience stress condition.

The basic information required to be generated for crop weather modeling includes.

a) Crop phonology in relation to the temperature and day length
b) Water use by the crop during different phenophases of crop growth
c) The relationship between radiation interception, crop water use and total dry matter production
d) Partitioning of dry matter into various plant components as influenced by water and nutrient availability, and
e) The effect of weather parameters on biotic interference to crop growth.

Types of models

a) Statistical models
These models express the relationship between the yield or yield components and the weather parameters. The relationships are measured in a system using statistical techniques. Simple regression techniques explaining weather crop relationships are also considered as models.

b) Mechanistic model
These models explain not only the relationships between the weather parameters and the yield, but explain the relationship of influencing dependent variables.

c) Deterministic models
These models estimate the exact value of the yield or dependent variable. These models also have defined co-efficient.

d) Stochastic models
A probability element is attached to each output. For each set of inputs different outputs are given along with probabilities. These models define the yield or state of dependent variable at a given rate.

e) Dynamic models
Time is included as a variable. Both dependent and independent variables are having values which remain constant over a given period of time. Over a period of time these variables are changing due to change in rate of increment.

f) Static models
Time is not included as a variable. The dependent and independent variables having values remain constant over a given period of time.

g) Simulation models
Computer models in general, are a mathematical representation of a real world system. One of the main goals of crop simulation models is to estimate agricultural production as a function of weather and soil conditions as well as crop management. These models use one or more sets of differential equations over time, normally from planting until harvest maturity or final harvest.

h) Descriptive models
A descriptive model defines the behaviour of a system in a simple manner. The model reflects little or none of the mechanisms that are the causes of phenomena but consists of one or more mathematical equations. An example of such an equation is the one derived from successively measured weights quickly the weight of the crop where no observation was made.

i) Explanatory models
This model consists of quantitative description of the mechanisms and process that cause the behaviour of the system. To create this model, a system is analyzed and its process and mechanisms are quantified separately. The model is built by integrating these descriptions for the entire system. It

contains descriptions of distinct processes such as leaf area expansion, tiller production etc. Crop growth is a consequence of these processes.

Climate change and variability

Climate change: Any permanent change in weather phenomena from the normals of a long period average is referred as climate change. Eg. The global temperature has increased by 2.0 to 3.0 C and increase in CO2 from 180ppm to 350ppm.

Climate variability: The temporal changes in weather phenomena which is part of general circulation of atmosphere and occurs on a yearly basis on a global scale.

Climate change and climate variability are the concern of human kind in recent decades all over the world. The recurrent drought and desertification seriously threaten the livelihood of over 1-2 billion people who depend on the land for most of their needs. The weather related disasters viz. drought and floods, ice storms, dust storms, land slides, thunder clouds associated with lightening and forest fires are uncommon over one or other region of the world. The year 1998 was one of the recent weather related disaster years, which caused hurricane house in Central America and floods in China, India and Bangladesh. Canada and New England in the U.S. suffered heavily due to ice storm in January while Turkey, Argentina and Paraguay with floods in June 1998. Vast fires in Siberia burned over three million acres of forests. Human and crop losses are the worst phenomena in such weather disasters, affecting global economy to a considerable extent.

The 1997-'98 El-Nino events, the strongest of the last century is estimated to have affected 110 million people and cost the global economy nearly US $ 100 billion. Statistics compiled from insurance companies for the period 1950-1999. Show that major natural catastrophes which are mainly weather and climate related caused estimated economic losses of US $ 960 billion. Most of the losses were recorded in recent decades. Increase in aerosols due to emission of green house gases including black carbon and chlorofluorocarbons (CFCS), ozone depletion, UV-B filtered radiation, cold and heat waves, global cooling and warming and "human hand" in the form of deforestation and loss of wetlands in the process of imbalanced development for betterment of human kind may be caused factors for climate variability and climate change.

Causes of climatic variability

A. External causes

i) Solar output: An increase in solar output by 0.3%when compared to 1650 -1700AD data.
ii) Orbital variation: 1. Earth orbit varies form almost a complete circle to marked ellipse (Eccentricity). 2. Wobble of earth's axis (Precession of equinox) 3. Tilt of the earth's axis of rotation relative to the plane of the orbit varies between 21.8º and 24.4º.

B. Internal causes

i) Changes in the atmospheric composition. Change in the green house gases especially CO_2
ii) Land surface changes particularly the afforestation and deforestation
iii) The internal dynamics of southern oscillation – changes in the sea surface temperature in western tropical Pacific (El-Nino/La-Nina) coupled with Southern Oscillation Index, the Tahiti minus Darwin normalized pressure index leading to the ENSO phenomena
iv) Anthropogenic causes of climate variation in green house gases and aerosols.

Effects of climate change

1. The increase concentration of CO_2 and other green house gases are expected to increase the temperature of the earth.
2. Crop production is weather dependant and any change will have major effects on crop production and productivity.

3. Elevated CO_2 and temperature affects the biological process like respiration, photosynthesis, plant growth, reproduction, water use etc. Depending on the latitude the CO_2 may either offer beneficial effect or may behave otherwise also.

El-Nino and La-Nina

El-Nino is a Spanish word meaning “the boy child” (‘Child Christ’) because El-Nino occurs around Christmas time each year when the waters off the Peruvian coast warm slightly. In every three to six years, the waters become unusually warm. 'El Niño' is now used more widely to refer to this abnormal warming of the ocean and the resulting effects on weather. 'El Niño' is often coupled with 'Southern Oscillation' as the acronym ENSO. 'La Niña' is used popularly to signify the opposite of El Niño, occurring when the waters of the eastern Pacific are abnormally cold. La Niña episodes are associated with more rainfall over eastern Australia, and continuing drought in Peru. Peruvian meteorologists have objected to term La Niña-the Girl Child-because Christ is not known to have had a sister, and the term anti-ENSO is sometimes preferred.

The El-Nino event is due to decrease in atmospheric pressure over the South East Pacific Ocean. At the same time, the atmospheric pressure over Indonesia and North Australia increases. Once the El-Nino event is over, the atmospheric pressure over the above regions swings back. This sea-saw pattern of atmospheric pressure is called Southern Oscillation. Since El-Nino and Southern Oscillation are linked they often termed as ENSO.

It is most important one, which represents a tendency for high atmospheric pressure over the Pacific Ocean, represents to be associated with low pressure over the Indian Ocean and vice-versa. A measure of the monsoon low pressure is the Southern Oscillation Index (SOI) represented by the difference in sea level pressure over Tahiti, an Island in South central pacific and Darwin in North Australia, which represents the northern part of the Indian Ocean. The positive SOI denotes high pressure over the central pacific and low over Indonesia, North Australia and Northern Indian Ocean. Above average rainfall is expected over India, India and Indonesia and North Australia if the SOI is positive. Drought or deficit rainfall is expected in the above countries if the SOI is negative, indicating high atmospheric pressure over Indonesia and low in the central pacific.

Lect. 17. DIFFERENT SEASON OF INDIA – EFFECT OF WEATHER AND CLIMATE ON CROP PRODUCTION, SOIL FERTILITY AND INCIDENCE OF PEST AND DISEASE.

Different season of India

Based on the rainfall pattern and temperature distribution, the India Meteorological Department, Government of India has divided the whole year into four seasons viz.

1. South west monsoon (June – September)
2. Post Monsoon (October – November)
3. Winter (December – February)
4. Summer or Pre monsoon (March / April – May / June)

The above seasons coincide with the agricultural seasons viz.

1) Kharif
2) Rabi and
3) Summer

The Kharif season is nothing but the Southwest monsoon or autumn. The Rabi coincides with post monsoon and winter seasons. In summer, the cultivable land under seasonal crops is kept in many regions of the country. Wherever water is plenty, vegetables are grown in some parts of the country during summer. Spring falls between January and March. Based on temperatures, ranges, there are three distinct crops seasons in India. They are

1) Hot weather (Mid February – Mid June)
2) Kharif or rainy season (Mid June – Mid October)
3) Rabi (Mid October – Mid February)

In Tamil Nadu there is a slight variation in the seasons based on rainfall duration as

2) Winter – January and February
3) Summer – March to May
4) Rainy seasons
   a) South west monsoon (June – September)
   b) North east monsoon (October – December)

The criteria for division of growing seasons are broadly based on monthly precipitation and temperature. The pattern followed as

a) Hot month – if the average temperature is above 20°C
b) Cold month – if the mean temperature is between 0-10°C
c) Warm month – if the mean temperature is 15-20°C

Incidence of pest and disease

Considerable crop losses caused due to pests and diseases in the humid and sub humid tropics. Many of the restrictions on productivity and geographical distribution of plants and animals are imposed by pests and diseases. The geographical distribution of pests is mainly based on climatic factors. The climatic conditions show a gradient from place to place and there is a related gradient in the abundance of a particular pest / disease. The periodic or seasonal nature of incidence and out breaks of several pests and diseases of many crops can be ascribed to weather conditions as the triggering factors. These epidemics of diseases are principally weather dependent, either in terms of local weather conditions being favourable for growth and development of the casual organisms or the prevailing winds helping to disseminate airborne pathogens or spores of diseases such as mildew, rusts, scabs and blights.

The migration and dispersion of insect pests depend on the wind speed and direction besides the nature of air currents. Some plant pathogenic viruses suitable for the development of these vectors favour the transmission of such diseases. A surfeit of pests and diseases, which infest plants are kept in chock by seasonal fluctuations in atmospheric temperature or relative humidity and other weather factors. Insect pest outbreaks occur as a result of congenial weather conditions, which facilitate their un-interrupted multiplication. The weather and climate greatly influence the quantity and quality of food provided by the host crops to the associated species of pests. The abundance or otherwise of the pestiferous species is thus dependent on climatic conditions, indirectly also.

The surface air temperature, relative humidity, dew fall, sunshine, cloud amount, wind, rainfall and their pattern and distribution are the primary weather factors influencing the incidence or

outbreaks of pests and diseases of crops. In the humid tropics, the weather variables namely air temperature, intermittent rainfall, cloudy weather and dewfall may play a crucial role in the outbreaks of pests and diseases. The impact of various weather components on pests and diseases is experienced in a location and crop specific manner.

Among the major pests associated with crops, insect, mite and nematode species are of a serious nature in terms of their abundance and damage potential. If the occurrence of pest / disease in time and space can be predicted in advance with reasonable accuracy on the basis of relevant weather parameters, appropriate and timely control measures can be programmed. Appropriate insecticide / fungicide interventions can certainly reduce the pesticide load in the environment and the related pollution and health hazards.

Effect of weather and climate on Soil Fertility

Red Soil (Alfisol)

Red soils are agriculturally important found in major portion of drylands. They are generally low in organic matter, available N and P. Soil pH ranges from 5.8 to 6.7. Rooting depth of crops is limited by the presence of compact subsoil. Many crops are susceptible to even moderate droughts. These soils are having the characteristics of rapidly sealing the surface after the rainfall. Water supply in the soil is reduced by limited infiltration due to lower conductivity. Problem of crusting affects the crop establishment. Soil moisture deficit is the major factor related to rainfall climatology affecting crop production. Soil erosion is the major factor reducing the fertility due to highly variable seasonal rainfall pattern.

Black Soil (Vertisol)

Black soils in India cover an area of about 72.9 m. ha which accounts for 22.2% of the total geographical area of the country. These are generally rainfed and experience considerable fluctuations in crop production due to climate variability. The clay content of the soil ranges from 40 to 60%, occasionally going to as high as 80%. Organic carbon content remains low ranging from 0.3 to 0.7%, pH of the soil normally ranges from 7.5 to 8.6%. The cation exchange capacity is 35-50 meq/100g. Inversion takes unique feature of the vertisols or deep black soils. Vertisols are necessarily deep. The soils invariably have wide and deep shrinkage cracks on the surface that changes with variation in the soil moisture regime. The cracks remain open depending on soil moisture and evaporation. The deep black soils, because of their high clay content, expanding nature of clay and depth, have a very high water holding capacity enabling crops to with stand drought at different stages of the crop.

Laterite Soils

The texture of the topsoil is loamy or clayey with many concretions. Laterite soils are generally associated with undulating topography in regions with a relatively high annual rainfall. These soils cover 13 m. ha in India. These soils are mostly dominated in hilly and high rainfall regions and slightly acidic in nature due to leaching of bases. They are rich in Iron and Alluminium.

Alluvial soil

They are generally loamy sands or sandy loams, very deep with moderate clay content. These soils are having firmly high water holding capacity. The drainage characteristics are highly varying. Water stagnation is the major problem affecting crop productivity during heavy rainfall seasons.

Sierozemic soil

These soils are sand, loamy sand and sandy loam in texture. Soil erosion through winds is common. Since these soils are light textured, water and nutrient holding capacity is less. Sub-soil Salinity is common due to extreme aridity. Kharif or Rabi cropping is possible in deep soils. But in loamy sands and sand, only the Kharif crops can be raised.

Submontane Soil

The soils are silty loam in texture and are medium to deep. Landslides and soil erosion are common. High rainfall lead to heavy soil erosion and major portion of top fertile soils are lost.

CENTRE OF ORIGIN , DISTRIBUTION OF SPECIES, WILD RELATIVES IN DIFFERENT CEREALS:-

CENTRE OF ORIGIN: The centre of origin is the geographical area where a particular plant (either domesticated or wild) is first originated on earth. The concept of centre of origin was given by N.I Vavilow . He proposed eight centre of origin:-

Chinese centre , Indo- Malayan centre , Central Asiatic centre , Near eastern centre , Mediterranean centre , Abyssinian centre , South Mexican & central American centre And South American centre.

SPECIES DISTRIBUTION: Species distribution is manner in which a biological taxon is spatially arranged . The geographical limits of a particular taxon's distribution is its range .

CROP WILD RELATIVES: A crop wild relative is a wild plant closely related to a domesticated plant, whose geographical origins can be traced to regions known as Vavilow centres. It may be a wild ancestor of the domesticated plant .

CEREALS :

CROP	FAMILY	C.N NO	ORIGIN	DISTRIBUTION OF SPECIES	WILD RELATIVE
WHEAT *Triticum aestivum*	poaceae	2n= 42	South asia	57 N -47 S latitude. China, india , Russia, usa, france , Canada, Pakistan, Australia and turkey	*T.aethiopicum, T. araraticum, T. compactum*
OAT *Avena sativa*	poaceae	2n = 42	Asian minor	Russian federation , usa, Canada , Poland, China , france , Australia.	*A.abyssinica, A. sterilis, A.brevis A. ludoviciana Culivated species: A.chenesis, A. Fatua A.byzantina*
BARLEY *Hordeum vulgare*	Poaceae	2n = 14	Asia (Ethiopia)	Europe, china , france , canada , usa ,spain ,uk , india , russia	*Cultivated : 2 row- H.distichum 6 row barley – H. vulgare Wild species- H. spontaneum,*

Pulses :-

Crop	Family	Chromo Number	Origin	Distribution of Species	Wild Relative
Chickpea *Cicer arietinum* L.	Legumin-oseae	2n = 16	Southwest Asia	India, Burma, Pakistan, Euthopia, Turkey	*Cicer reticulatum*, Other related species :- *C. bijugum* *C. pinnatifidum*, *C. songaricum* *C. ecticulatum*
Lentil *Lens esculenta* Moench.	Legumin-oseae	2n = 14	Eastern Mediterran-ean region.	India, spain, Pakistan, Bangladesh, Turkey, syria	*Lens ervoides*, *L. nigricans*
Pea *Pisum sativum*	Legumin-oseae		Mediterra-nean region	China, India, Pakistan, USA, Euthopia, Russian Fed, Greece, Spain France.	*Pisum fulvum* *P. sativum* subsp *elatius*

Oilseeds.

Crop	Family	Ch. No	Origin	Distribution of Species	Wild Relative.
Sunflower *Helianthus annus* L.	Compositae	2n = 34	America	Rusian Fed, Canada, Mexico, Spain, Turkey, South America.	*Helianthus* eg *argophyllus*, *H. mollis*, *Helianthus tuberosus*, *H. resinosus*
Mustard *Brassica juncea*	Brassicaceae	2n = 18	Ancient Egypt and china.	China, Canada, India, Poland, Bangladesh.	*Brassica elongata*, *Sinapis arvenis*
Rapeseed *Brassica napus*	Brassicaceae	2n = 38	Eastern Afganis-tan.	Europe, Asia, Africa	*Brassica rapa* L. *Sinapis arvenis* *Brassica oleracea*

Scanned with OKEN Scanner

Fodder

Crop	Family	CN.	Origin	Distribution of species	Wild relative.
Bajra Pennisetum glaucum L.	Poaceae	2n = 14	India or W. Africa	Asia and Africa. India, China, Nigeria, Pakistan, Egypt, Arabia.	P. pedicellatum, P. orientale, P. mezianum P. purpureum
Sorghum Sorghum bicolor L.	Poaceae	2n = 20	Northeastern Africa or Egyptian	Nigeria, sudan, north America, Ethiopia.	Sorghum halepense, Sorghum nitidum, Sorghum angustum
Berseem Trifolium alexandrium L.	leguminosae	2n = 16	Asian Minor.	USA, Australia, Egypt, India, Pakistan	T. resupinatum T. repens T. pratense T. incarnatum T. hybridum

Cash. crop.

Crop	Family	CN	Origin	Distribution of species	Wild relative.
Sugarcane Saccharum officinarum L.	Poaceae	2n = 80	India	India, Brazil cuba, China, USA, Mexico, France, Australia.	cultivated :- Saccharum barberi S. sinense wild :- Saccharum spontaneum, saccharum robustum
Sugarbeet Beta vulgaris L.	~~Amaranthaceae~~ Chenopodiaceae	2n = 18	Mediterranean region	Russian Fed, France, Germany Turkey, Poland	Beta vulgaris L. ssp maritima Beta vulgaris L. ssp vulgaris

Scanned with OKEN Scanner

Horticulture.

Crop	Family	CN.	Origin	Distribution	Wild relative.
Mango Mangifera indica L.	Anarcardaceae	2n = 40	Indo-Burma region	India, Burma East & west Africa.	M. laurina, M. gedebe, M. minor M. odorata.
Guava Psidium guajava	Myrtaceae	2n = 22	Tropical America	America, Canada, Australia, India, Burma, Indonesia	Psidium amplexicaule Psidium littorale
~~Anola~~ Aonla Phyllanthus emblica	Euphorbiaceae.	2n = 28	Indo-China.	India, China, Jalaysia, Ceylon.	~~E. fischeri~~, Emblica fisheri, Emblica acidus

Vegetables

crop	Family	CN	Origin	Distribution of species	Wild relative
Potato Solanum tuberosum L.	solanaceae	2n = 48	~~South America~~ OR Peru.	America, Europe, Brazil, Argentina, Germany	Solanum malmeanum, ~~Solan~~ Solanum ~~acaule~~, acaule Solanum boliverse, S. demissum
Onion Allium cepa L.	Amaryllidacea	2n = 16	Central Asia.	Afganistan, Uzbekistan, Tajistan, western asia.	Allium bisceptrum, Allium canadense
Tomato. Solanum lycopersicum	Solanaceae	2n = 12	South America	Bolivia, Mexico, Chile, Colombia, Peru. Central America	Solanum cheesmaniae Solanum galapagense
Cauliflower Brassica oleracea var. botrytis	Brassicaceae	2n = 18	Northeast Mediterranean Region	Romania, Greece, ~~Russi~~ Italy, France, Mexico, Taiwan.	Brassica oleracea, Brassica cretica.

Scanned with OKEN Scanner

a) Cultivated Germplasm
It can be used in three main ways: (1) as a variety, (2) as a parent in the hybridization, and (3) as a variant in the gene pool.
b) Wild Germplasm
it is used to transfer resistance to biotic and abiotic stresses, wider adaptability and sometimes quality such as fibre strength in cotton.

Organizations associated with Germplasm:
IPGRI – International Plant Genetic Resources Institute
NBPGR – National Bureau of Plant Genetic Resources

Study of genetics of Qualitative and Quantitative characters

The phenotype of any individual can be classified into two types:
1) Qualitative characters and 2) Quantitative characters

1. Qualitative characters: The characters that show discontinuous variation and which cannot be measured easily are known as qualitative characters. These are also known as classical mendelian traits.
Eg: Corolla colour – Red white or pink no continuous variation
Seed shape – Round wrinkled variation is not continuous
2. Quantitative characters are those showing continuous variation and which can be measured easily. These characters are also known as metric traits. The data obtained from such characters is known as quantitative data. This data can be subjected to statistical analysis and the branch of science which deals with such analysis is known as quantitative genetics or biometrical genetics.
Eg: Yield, Plant height

Differences between quantitative and qualitative characters

	Quantitative characters	**Qualitative characters**
Deals with	Traits of degree Eg: Plant height, seed weight, yield etc.	Traits of kind Eg: Corolla colour, seed shape, appearance etc
Variation	Continuous	Discontinuous
Effect of individual gene	Small and undetectable	Large and detectable
No. of genes involved	Several (polygenic)	one or few (mono /oligogenic)
Grouping into distinct Classes	Not possible	Possible
Effect of environment	High	Low
Metric measurement	Possible	Not Possible
Statistical analysis	Based on mean, variance, standard deviation etc	Based on ratios and frequencies
Stability	Low	High
Transgressive segregation of F 2	Yes	No
Dominance effect	No	Yes

PLANT GENETIC RESOURCES, ITS UTILIZATION AND CONSERVATION

PLANT GENETIC RESOURCES:

The sum total of genes in a crop species is referred to as genetic resources. Or
Gene pool refers to a whole library of different alleles of a species. or
Germplasm may be defined as the sum total of hereditary material i.e., all the alleles of various genes present in a crop species and its wild relatives.

Important features of plant genetic resources are -

- Gene pool represents the entire genetic variability or diversity available in a crop specie
- Germplasm includes both cultivated and wild species or relatives of crop plants.
- Germplasm is collected from the centres of diversity, gene banks, gene sanctuaries, farmers fields, markets and seed companies.
- Germplasm is the basic material for launching a crop improvement programme.
- Germplasm may be indigenous (collected with in country) or exotic (collected from foreign countries)

KINDS OF GERMPLASM

The germplasm consists of various plant materials of a crop such as
land races , advanced (homozygous), breeding materials, obsolete cultivars, wild forms of cultivated species , modern cultivars, wild relatives, mutants These are briefly discussed below:

1. Land races

These are nothing but primitive cultivars which were selected and cultivated by the farmers for many generations without systematic plant breeding efforts. Land races have broad genetic base which again provides them wider adoptability.

2. Obsolete Cultivars

These are the varieties developed by systematic breeding effort which were popular earlier and now have been replaced by new varieties. Improved varieties of recent past are known as obsolete cultivars. Obsolete varieties have several desirable characters they constitute an important part of gene pool. Example : Wheat varieties K65, K68, pb 591 were most popular traditional tall varieties before introduction of high yielding dwarf Mexican wheat varieties. Now these varieties are no more cultivated.

3. Modern cultivars

The currently cultivated high yielding varieties are referred to as modern cultivars. They are also known as improved cultivars or advanced cultivars. These varieties have high yield potential and uniformity as compared to obsolete varieties land races.However, these have narrow genetic base and low adoptability as compared to land races

4. Advanced breeding lines

These are pre -released plants which have been developed by plant breeders in modern scientific breeding programmes. These are known as advanced lines, cultures and stocks.This group includes, nearly homozygous lines, lines derived from biotechnology programmes i.e. transgenic plants and mutant lines etc. These lines which are not yet ready for release to farmers.

5. Wild forms of cultivated species

Wild forms of cultivated species are available in many crop plants. Such plants have generally high degree of resistance to biotic and abiotic stresses and are utilized in breeding programmes. They can easily cross with cultivated species. Wild forms of many crop species are extinct.

6. Wild Relatives

Those naturally occurring plant species which have common ancestry with crops and can cross with crop species are referred to as wild relatives or wild species. Wild relatives include all other species, which are related to the crop species by descent during their evolution. Both these groups are sources of valuable genes for biotic and abiotic stress and for quality traits and yield.

7. Mutants

Mutation breeding is used when the desired character is not found in the genetic stocks of cultivated species and their wild relatives. Mutations do occur in nature as well as can be induced through the use of physical and chemical mutagens. The germplasm includes those carrying gene mutations, chromosomal aberrations and markers genes etc. are considered special genetic stocks. They are useful in breeding programmes.

The gene pool system of classification

The pool of a crop includes all cultivars, wild species and wild relatives containing all the genes available for breeding use.

1. Primary gene pool
2. Secondary Gene pool
3. Tertiary gene pool

These are briefly discussed below:

1. Primary gene pool (GP1) : This is also known as gene pool one (GP1). The gene pool in which intermating is easy and leads to production of fertile hybrids is known as primary gene pool. In such gene pool, genes can be exchanged between lines simply by making normal crosses. This is the material of prime breeding importance.
2. Secondary gene pool (GP2) : This type of gene pool is also known as gene pool two (GP2). The genetic material that leads to partial fertility on crossing with GP1 is referred to as secondary gene pool. It includes plants that belong to related species. Such material can be crossed with primary gene pool, but usually the hybrids are sterile and some of the progeny to some extent are fertile.
3. Tertiary gene pool (GP3) : The genetic material which leads to production of sterile hybrids on crossing with primary gene pool is termed as tertiary gene pool or gene pool three (GP3). It includes material which can be crossed with GP1, but the hybrids are sterile.

Types of seed collections

Based on the use and duration of conservation, seed collections are of three types

1. Base Collection
2. Active Collection
3. Working collection

Base collections: It is also known as principal collection. These consist of all the accessions present in the germplasm of a crop. They are stored at about -18C or -20C with 5 + 1% moisture content; they are disturbed only for regeneration. For reasons of safety, duplicates of base collections should be conserved in other germplasm banks as well. High quality orthodox seeds can maintain good viability upto 100 years.

Active collections : The accessions in an active collection are stored at temperatures below 15C (often near 0C), and the seed moisture is kept at 5%. The storage is for medium duration, i.e., 10-15 years. These collections are actively utilized in breeding programme. These collections are used for evaluation, multiplication and distribution of the accessions. Germination test is carried out after every 5-10 years to assess the reduction in seed viability

. **Working collections** : The accessions being actively used in crop improvement programmes constitute working collection. Their seeds are stored for 3-5 years at less than 15C and they usually contain about 10% moisture. These collections are maintained by the breeders using them.

Core collection

The concept of core collection was proposed by Franked it refers to a subset of base collection which represents the large collection. Or a limited set of accessions derived from an existing germplasm collections.

Germplasm activities

There are six important activities related to plant genetic resources

1. Exploration and collection
2. Conservation
3. Evaluation
4. Documentation
5. Multiplication and Distribution
6. Utilization

Exploration & Collection :-

Exploration refers to collection trips and collection refer to tapping of genetic diversity from various sources and assembling the same at one place. The exploration and collection is a highly scientific process. This process takes into account six important items, viz, (1) sources of collection, (2) priority of collection, (3) agencies of collection, (4) methods of collection, (5) methods of sampling and (6) sample size.

2. Germplasm Conservation

Conservation refers to protection of genetic diversity of crop plants from genetic erosion. There are two important methods of germplasm conservation or preservation. or

Germplasm conservation refers to maintain the collected germplasm in such a state that there is minimum risk for its loss and that either it can be planted directly in the field or it can be prepare for planting with relative ease when ever necessary. There are two important methods of germplasm conservation or preservation viz.,1. In situ conservation 2. Ex situ conservation

i. In situ conservation

Conservation of germplasm under natural habitat is referred to as in situ conservation. This is achieved by protecting this area from human interference : such an area is often called as natural park, biosphere

reserve or gene sanctuary. A gene sanctuary is best located within the centre of origin of crop species concerned, preferably covering the microcenter with in the centre of origin. NBPGR, New Delhi is making attempts to establish gene sanctuaries in Meghalaya for Citrus and in the North-Eastern region for Musa, Citrus, Oryza, Saccharum and Megifera.

This method of preservation has following main disadvantages

Each protected area will cover only ve ry small portion of total diversity of a crop species, hence several areas will have to be conserved for a single species.

The management of such areas also poses several problems.

This is a costly method of germplasm conservation

Merits : Gene sanctuaries offer the following two advantages.

A gene sanctuary not only conserves the existing genetic diversity present in the population, it also allows evolution to continue. As a result, new alleles and new gene combinations would appear with time.

The risks as sociated with ex situ conservation are not operative. ii. **Ex situ conservation**

Conservation of germplasm away from its natural habitat is called ex situ germplasm conservation. This method has following three advantages.

It is possible to preserve entire genetic diversity of a crop species at one place.

Handling of germplasm is also easy

This is a cheap method of germplasm conservation

Preservation in the form of seed is the most common and easy method, relatively safe, requires minimum space and easy to maintain. Glass, tin or plastic containers are used for preservation and storage of seeds. The seed can be conserved under long term, medium term and short term storage conditions.

Roberts in 1973 classified seeds on the basis of their storability, into two major groups.viz.,

1. Orthodox seeds 2. Recalcitrant seeds

1. Orthodox Seeds:

   Seeds of this type can be dried to low moisture content of 5% and stored at a low temperature without losing their viability are known as orthodox seeds. Most crop seeds belong to this category. Such seeds can be easily stored for long periods; their longevity increases in response to lower humidity and storage temperature. Eg. Wheat, Rice, Corn, Chickpea, Cotton, Sunflower

2. Recalcitrant Seeds:

   The viability of this group of seeds drops drastically if their moisture content is reduced below 12-30%. Seeds of many forest and fruit trees, and of several tropically crops like Citrus, cocoa, coffee, rubber, oil palm, mango, jackfruit, etc. belong to this group. Such seeds present considerable difficulties in storage. They require in situ conservation.

3. **Evaluation**

   Evaluation refers to screening of germplasm in respect of morphological, genetical, economic, biochemical, physiological, pathological and entomological attributes. Evaluation requires a team of specialists from the disciplines of plant breeding, physiology, biochemistry, pathology and

entomologys. The evaluation of germplasm is down in three different places, viz., (1) in the field, (2) in green house, and (3) in the laboratory.

4. **Documentation**

It refers to compilation, analysis, classification storage and dissemination of information. In plant genetic resources, documentation means dissemination of information about various activities such as collection, evaluation, conservation, storage and retrieval of data. Now the term documentation is more appropriately known as information system

Distribution

▪ The specific germplasm lines are supplied to the users on demand for utilization in the crop improvement programmes.

▪ Distribution of germplasm is the responsibility of the gene bank centres

▪ The germplasm is usually supplied to the workers who are engaged in research work of a particular crop species.

▪ Proper records are maintained about the distribution of material.

5. **Utilization**

It refers to use of germplasm in crop improvement programmes. The germplasm can be utilized in various ways. The uses of cultivated and wild species of germplasm are briefly discussed below:

a) Cultivated Germplasm

It can be used in three main ways: (1) as a variety, (2) as a parent in the hybridization, and (3) as a variant in the gene pool.

Wild Germplasm: it is used to transfer resistance to biotic and abiotic stresses, wider adaptability and sometimes quality such as fibre strength in cotton.

Organizations associated with germplasm

IPGRI – International Plant Genetic Resources Institute

NBPGR – National Bureau of Plant Genetic Resources

Cryopreservation: Cryopreservation is a technique that ensures safe, long-term conservation of genetic resources of plant species with recalcitrant seeds, of vegetatively propagated species and of biotechnology products such as somatic embryos, cell lines and genetically transformed material.

LECTURE NO. 12

ADAPTABILITY AND STABILITY

Adaptability & Stability –

The success of crop improvement activities largely depend on the identification of superior varieties for mass propagation. A variety can be considered superior if it has potential for high yield under favourable environment and the same time great deal of phenotypic stability. Stability of a genotype refers to its performance with respect to changing environment factor over time within a given location.

Adaptation and Adaptability:

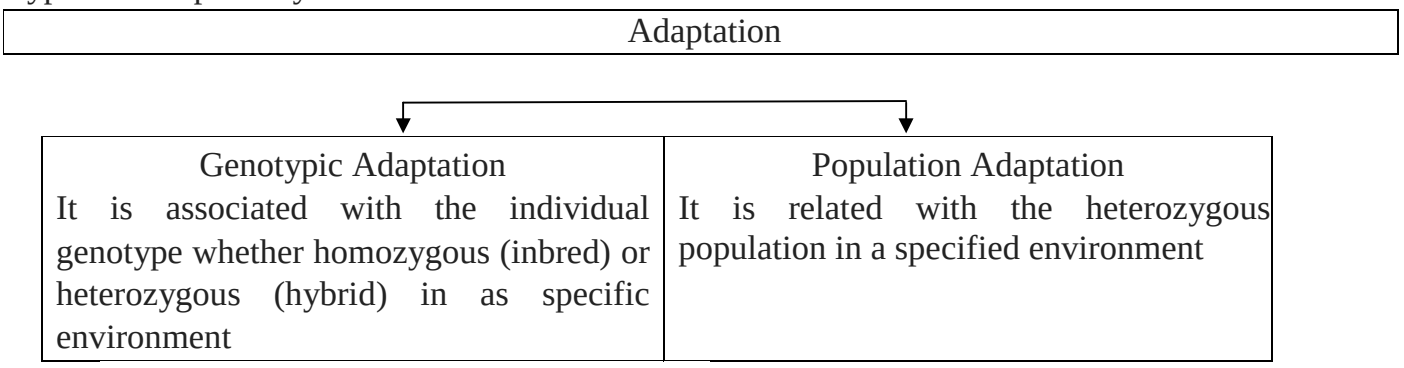
Adaptation:-

It refers to those changes in structure or function of an individual/population which lead to better survival in a given environment is known as adaptation.

Adaptability:

Ability to genotype to exhibit relatively stable performance in different environment or capacity of a genotype or population for genetic change in adaptation.

Types of Adaptability –



1. Specific genotype adaptation
2. General genotypic adaptation

1. Specific population adaptation
2. General population adaptation

1. Specific genotype adaptation – It is the close adaptation of genotype to a limited environment.
2. General genotypic adaptation – It is refers to the capacity of a genotype to produce a wide range of phenotypes compatible with a wide range of environmental conditions.
3. Specific Population adaptation – It refers to the capacity of heterogeneous population to adapt to specific environment.
4. General population adaptation – It is the capacity of heterogeneous population to adapt to the variety of environment.

FACTOR AFFECTING ADAPTABILITY-

1. Heterogeneity – The heterogeneous population have broad genetic base, Such population have greater capacity to stabilize production over a wide range of changing environment.
2. Heterozygosity – It has been observed that heterozygous individual such as F1 hybrids are more stable than their homozygous parents to environmental variation.

3. Genetic polymorphism – The regular occurrence of several phenotypes in a genetic population is known as genetic polymorphism.
4. Mode of Pollination – The cross pollination species have better buffering capacity that self pollination species because of more heterozygosity.

STABILITY ANALYSIS

It refers to the suitability of variety for general cultivation over wide range of environments.

- Stability refers to the performance with respective changing environmental factors overtime within given location.
- Selection for stability is not possible until a biometrical model with suitable parameters is available to provide criteria necessary to rank varieties / breeds for stability.
- Low magnitude of G.E interaction involves the consistent performance of a population over variable environments.
- It consists of following steps: Location / environment wise analysis of variance. pooled analysis of variance for all the locations/ environments.
- If G.E interaction is found significant ,stability analysis can be carried out using one of the four methods:

1.Finlay and Wilkinson model (1963)
2.Eberhat and Russell model(1966)
3.Perkins and Jinks model(1968)
4.Freeman and Perkins model (1971)

1. Finlay and Wilkinson model (1963)

- Used two parameters

1)Mean performance over environments.
2)Regression performance in different environments.
The following inferences can be drawn:
1)The regression coefficient of unity indicates average stability.
2)If the regression coefficient is >1,it means below average stability. 3) If the regression coefficient is <1, it means above average stability 4) Regression coefficient of 0 would express absolute stability.

MERITS

- Analysis of this model is simple.
- 2 parameters- mean yield over locations and regression coefficient are used to asses the phenotypic stability.

DEMERITS

- The deviations from the regression line are not estimated which are important for the stability analysis.
- Greater emphasis is given on mean performance over environments than regression coefficients.

2. Eberhat and Russell model(1966)

- It is the most popular and useful model.
- In 1966 both made further improvement in stability analysis by partitioning the G.E interaction of each variety into 2 parts. one is slope of the regression line , second is deviation from regression line.

- In this model total variance is first divided into 2 components: -genotypes -environment plus interaction (E+G*E)
- The second component is further divided in to 3 components.
  I. Environment linear
  II. G.E linear
  III. Pooled deviations
- Sum of squares due to pooled deviations are further divided into sum of squares due to individual genotype.

MAIN FEATURES OF THIS MODEL

- This model consists of three parameters
  a) mean yield over locations
  b)regression coefficient =bi
  C)Deviation from regression =s^2di
- Analysis of stability parameters is simple as compared to other models of stability analysis.
- The degree of freedom for environment is 1.
- It requires less area hence less expensive when compared to other models.
- It does not provide independent estimation for mean performance and environmental index

ANOVA TABLE

Source of variation	Degrees of freedom
Genotypes	g-1
E+ G*E interaction	g(e-1)
environment (linear)	1
G.E linear	g-1
pooled deviations	g(e-2)
genotype-1	e-2
genotype-2	e-2
Pooled error	ge(r-1)

Merits:

It measures three parameters of stability

A=mean yield over environments

B=regression coefficient

C=deviation from regression line

- It provides more reliable information on stability than Finlay and Wilkinson model.
- Analysis is simple. Demerits:
- Estimation of mean performance and environment index is not independent.
- There is a combined estimation of sum of squares of environment and interactions which is not proper.

LECTURE NO. 13 & 14

Hybrid seed production technology in Rabi crops -Sunflower

1. HYBRID SEED PRODUCTION IN SUNFLOWER

- Hybrids are produced by employing cytoplasmic genetic male sterility.
- The male sterile female and male parents are raised in BSH 3, 1:6, KBSH 1,1:4 ratio under 400 m isolation.
- Seeds are produced by transferring the pollen of male parent to the female parent with the help of honeybees reared at 5 hives / ha.

HYBRIDS

BSH -1 = CMS 234 A x RHA 274

TCSH 1 = CMS 234 A x RHA 272

Season: June - July, October - November

Isolation distance: Foundation seed Certified seed Hybrids 600 m 400 m respectively

Seed and sowing

Seeds are sown in ridges and furrows

Seed rate: Female 12 kg /ha and Male 4 kg/ha.

Spacing 60 x 30 cm (hybrids)

Planting ratio : 8:1 or 4:1

Border row : two

Manures and fertilizers

Compost : 12.5t/ha

NPK : 60:45:45 kg /ha

Supplementary pollination

1. As in varieties In hybrids, the palm is first gently rubbed on the male parent flowers and then on the female line to transfer the pollen.
2. Keeping of bee hives 5 ha-1 .

ROGUING

Plants are rogued based on plant height, head size and colour of seeds during pre-flowering stage upto harvest.

Field standards

	Foundation seeds	Certified seeds
Off types	0.1 %	0.2%

Harvesting

The change of head colour from green to lemon yellow is the indication of physiological maturity. The heads are harvested separately first in male and then in female.

Drying, processing and others – as in varieties

Seed standards

The graded seed should possess the following characters for certification and sale as certified/ truthfully labelled seeds

Parameter	FS	CS
Physical purity (min) %	98	98
Inert matter (max) %	2	2
Germination (min)%	60	60
Moisture content (max)%		
(a) Open storage	8	8
(b) Moisture vapour proof Storage	5	5

LECTURE 15 & 16

Ideotype concept and climate resilient crop varieties for future

IDEOTYPE CONCEPT

Crop Ideotype :-

Crop ideotype refers to model plants or ideal plant type for a specific environment.

"In broad sense an ideotype is a biological model which is expected to perform or behave in a predictable manner within a defined environment".

- More specifically, crop ideotype is a plant model which is expected to yield greater quantity of grains, fibre, oil or other useful product when developed as a cultivar.
- The term ideotype was first proposed by Donald in 1968 working on wheat.

Ideotype Breeding :-

Ideotype breeding can be defined as a method of crop improvement which is use to enhance genetic yield potential through genetic manipulation of individual plant character.

Main features of ideotype breeding are:- 1. Emphasis on individual trait
2. Includes yield enhancing traits
3. Exploits physiological variation
4. Slow progress
5. Selection
6. Designing of model
7. Interdisciplinary approach
8. A continuous process

Differences between traditional and ideotype breeding

Sr. No.	Traditional	Ideotype
1	The main objective is defined before initiating the breeding work.	The conceptual theoretical model is prepared before initiation of breeding work
2	Selection is focused on yield and some other characters	Selection is focused on individual plant characters.
3	It usually includes various morphological and economic characters.	It includes various morphological, physiological and biochemical plant characters
4	Value of each character is not fixed in advance	Value of each trait is defined in advance.

5	This is a simple and rapid method of cultivar development	This is a difficult and slow method of cultivar development
6	The phenotypic of a new variety is not specified in advance	Phenotype of new variety to be developed is specified in advance

Features of crop ideotypes

- The crop ideotype consists of several morphological and physiological traits which contribute for enhanced yield or higher yield than currently prevalent crop cultivars.
- The morphological and physiological features of crop ideotype differ from crop to crop and sometimes within the crop also depending upon whether the ideotype is required for irrigated cultivation or rainfed cultivation.
- Ideal plant types or model plants have been discussed in several crops like wheat, rice, maize, barley, cotton and beans.

The important features of ideotype from some crops are

WHEAT

The term ideotype was coined by Donald in 1968 working on wheat. He proposed ideotype of wheat with following main features:

- A short strong stem. It imparts lodging resistance and reduces the losses due to lodging.
- Erect leaves. Such leaves provide better arrangement for proper light distribution resulting in high photosynthesis or CO2 fixation.
- Few small leaves. Leaves are the important sites of photosynthesis, respiration and transpiration. Few and small leaves reduce water loss due to transpiration.
- Larger ear. It will produce more grains per ear.
- An erect ear. It will get light from all sides resulting in proper grain development.
- Presence of awns. Awns contribute towards photosynthesis.
- A single culm.

SORGHUM

IN Dr. Swaminathan 1972 proposed ideal plant type of Sorghum.

- High grain yield.
- Harvest index greater than 30.
- High ear head exertion. Panical DM of total Dm: >50% Higher relative water content.

Climate resilient crop varieties for future → Crop varieties that have enhanced tolerance to biotic and abiotic stresses.

At present India is facing two problems, first increasing population and second is to protect agriculture from adverse impact of climate.

Impact of climate change :- It have direct and indirect effect on crop, soil, water and pest. Change in temp reduce crop duration, alter photosynthesis, affects survival and distribution of pest populations, develop new equilibrium btw crop and pests, hasten nutrient mineralization in soils, increase evaporational losses.

Strategies for Climate change Adaptation :-

(1) Develop climate resilient varieties. (2) Promote water saving technologies
(3) Conserve agriculture (4) Improved nutrient management.
(5) Integrated farming system (6) Pest forecasting
(7) weather forecasting.

Climate resilient varieties → They give consistently higher yields under diff abiotic stress conditions. Understand photoperiod sensitivity, thermo tolerance meachanisms, genetic variation for transpiration efficiency will help identifying short duration high yielding varieties that escape terminal drought and terminal heat stress as well as tackle abiotic and biotic stresses.

Abiotic stress commonly occur :-

- Drought stress - changing behaviour of monsoon lead to drought conditions in the country where whose agriculture depend on rain. No. of adaptive traits are used to improve drought tolerance like osmotic adjustment, reduce leaf area, lipid deposition on leaves and by roots.
- Heat stress → Rise in temp beyond threshold level for a period to cause irreversible loss to plant growth. It can be done by developing thermo-tolerant varieties.
- salinity stress → High salinity cause both hyper-ionic and high-osmotic stress lead to plant death.

Crop and resilient varieties.

(1) Pigeonpea	→ IPH 09-5	Early maturity <150 day, resistant to wilt.
(2) Chickpea	Pusa chickpea 4005	drought tolerant developed through marker assisted selection.
(3) Pearlmillet	PB 1887	Summer pearlmillet rich in Fe and Zn
(4) Sorghum	CSH 47	High biomass variety suitable for 2G biofuel and silage making.
(5) Wheat	DBW 332	High yielding wheat with 78.3 q/ha grain yield with high protein content (12.2%) and zinc (40.6 ppm)
(6) Wheat	DBW 337	HYV with high zince (44.4 ppm)

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* Procedures including conventional and modern innovative approaches :-

Plant breeding is science of changing the traits of plants in order to produce desired characteristics.

Conventional breeding → Process of developing new plant cultivars without the use of futuristic molecular breeding technologies. They do not violate the natural law of inheritance. Variability is created through hybridization. selection based on phenotype is done to identify important genotype. It is longer process. It is dependent on phenotypic expressions of cultivars for identifying superior one.

Modern breeding → technologies like genomic selection, environmics and Highput phenotyping (HTP) are practiced to improve genetic gain of cultivars.

* Conventional Method :-

(1) Pedigree method → when individual plant progenies are grown and their records are kept safe.

(2) Bulk method → when segregation population are grown as commercial crop and seeds of all plants are collected into mass is called bulk method.

(3) Single seed decent method → It is simple and efficient conversion of bulk method. when segregating populations are grown as commercial crop and one seed from each plant is taken and collected as mass, it is called SSD.

(4) Back cross method → The hybrid and progenies are crossed with one of its parents.

(5) Pure-line selection → Selecting and breeding progeny from superior organisms for a no. of generation until pure line of organism with only desired characteristics is established.

(6) Recurrent selection → A no. of plants are selected based on their phenotype and open pollinated seed from them are bulked together to raise next generation. selection cycle is repeated one or more times to increase the frequency of favourable alleles.

Modern method →

Marker assisted selection (MAS) → MAS is process of using morphological biochemical or DNA markers as indirect selection criteria for selecting agriculturally important traits in crop breeding.

Genomic selection → It is a form of MAS in which genetic markers covering whole genome are used so that all quantitive loci (QTL) are in linkage disequilibrium with at least one marker.

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Table 1. Differences between conventional and modern plant breeding methods.

Conventional plant breeding	Modern plant breeding
• The breeding method is based more on phenotype which creates unreliability in determining pure line of genes.	• It is genotype based method of breeding which is more accurate in determining the pure gene line.
• It is more time consuming to release a new variety.	• It is comparatively less time consuming to release a new variety.
• Variability in conventional breeding is created through hybridization.	• Newly used technologies like Genomic selection, enviromics and High Throughput Phenotyping (HTP) are practiced to improve genetic gain of cultivars.
• Generally, dominant genes are only selected. The selection of recessive alleles needs to undergo a long procedure.	• The recessive alleles can be selected through the use of markers and identification of specific sites of gene which is quite shorter procedure than of the conventional.
• It is less effective since it depends more on skills, arts and subjective analysis of breeder. This makes the result less reliable.	• Modern Plant Breeding is more effective and trusted since it is based on scientific research and findings.
• Conventional plant breeding demands less technical skills and scientific knowledge of genetics	• In the same place, modern plant breeders are required with more technical skills and genetic science knowledge.
• It is less expensive as it can be carried with local techniques and tools.	• It is highly expensive as it requires high tech machineries and methodologies.

ADVANTAGE OF MODERN PLANT BREEDING OVER CONVENTIONAL

From Neolithic age, first initiation of domestication of crop, to twenty-first century, the golden age of plant breeding, people have applied various strategies for crop improvement. The extensive use of conventional breeding in correspondence with other disciplines of science has certainly made modern plant breeding more reliable and effective. In comparison with traditional breeding, modern plant breeding has following advantages:

a. By using some techniques like Marker Assisted Breeding and Quantitative Trait Loci Mapping, selections of superior plant can be done even at seedling stage. The later occurring unwanted genes can be removed by using different markers.

b. Since conventional selection is dependent on phenotypic expression, only dominant genes are expressed on. Thus, case of conventional breeding only dominant genes can be selected. In order to select recessive alleles, test cross and selfing are done which is lengthy procedure. However with modern breeding several recessive alleles can also be selected by use of markers and identification of specific sites of the gene.

c. In traditional breeding, phenotypic selection is difficult because of presence of masking effects. Some of the quantitative traits which are governed by multiple alleles are difficult to select because their phenotypic expression varies. However, with new breeding technologies like gene editing and genomic selection it is easier.

d. Although constant breeding are conducted through conventional breeding, the results has not been very fruitful. Genetic gains of quantitative traits have not been effective as they are largely affected by genotype by environment (G × E) interaction. But, modern breeding is based on stable genotypes which are less affected by G × E interaction. This makes the breeding program effective and efficient.

e. Conventional breeding is more dependent on skills, art and subjective analysis of breeder (Anderson 2013). However, modern breeding is more of a science than art. It is based on scientific research and findings. Thus, it is more trustworthy and effective.

Plant Breeding- Objective of Plant breeding

Plant breeding can be defined as an art, a science, and technology of improving the genetic make up of plants in relation to their economic use for the man kind.

or

Plant breeding is the art and science of improving the heredity of plants for the benefit of mankind.

or

Plant breeding deals with the genetic improvement of crop plants also known as science of crop improvement.

or

Science of changing and improving the heredity of plants.

Aim :

Plant breeding aims to improve the characteristics of plants so that they become more desirable agronomically and economically. The specific objectives may vary greatly depending on the crop under consideration.

Objectives of Plant Breeding :

1. Higher yield : The ultimate aim of plant breeding is to improve the yield of economic produce. It may be grain yield, fodder yield, fibre yield, tuber yield, cane yield or oil yield depending upon the crop species. Improvement in yield can be achieved either by evolving high yielding varieties or hybrids.

2. Improved quality: Quality of produce is another important objective in plant breeding. The quality characters vary from crop to crop. Eg. grain size, colour, milling and backing quality in wheat. Cooking quality in rice, malting quality in barley, size, colour and size of fruits, nutritive and keeping quality in vegetables, protein content in pulses, oil content in oilseeds, fibre length, strength and fineness in cotton.

3. Abiotic resistance : Crop plants also suffer from abiotic factors such as drought, soil salinity, extreme temperatures, heat, wind, cold and frost, breeder has to develop resistant varieties for such environmental conditions.

4. B iotic resistance : Crop plants are attacked by various diseases and insects, resulting in considerable yield losses. Genetic resistance is the cheapest and the best method of minimizing such losses. Resistant varieties are developed through the use of resistant donor parents available in the gene pool.

5. Change in maturity Duration / Earliness : Earliness is the most desirable character which has several advantages. It requires less crop management period, less insecticidal sprays, permits new crop rotations and often extends the crop area. Development of wheat varieties suitable for late planting has permitted rice-wheat rotation. Thus breeding for early maturing crop varieties, or varieties suitable for different dates of planting may be an important objective. Maturity has been reduced from 270 days to 170 days in cotton, from 270 days to 120 days in pigeonpea, from 360 days to 270 days in sugarcane.

6. Determinate Growth : Development of varieties with determinate growth is desirable in crops like Mung, Pigeon Pea (*Cajanus cajan*), Cotton (*Gossypium sp.*), etc.

7. Dormancy : In some crops, seeds germinate even before harvesting in the standing crop if there are rains at the time of maturity, e.g., Greengram, Blackgram, Barley and Pea, etc. A period of dormancy has to be introduced in these crops to check loss due to germination. In some other cases, however, it may be desirable to remove dormancy.

8. Desirable Agronomic Characteristics: It includes plant height, branching, tillering capacity, growth habit, erect or trailing habit etc., is often desirable. For example, dwarf ness in cereals is generally associated with lodging resistance and better fertilizer response. Tallness, high tillering and profuse branching are desirable characters in fodder crops.

9. Elimination of Toxic Substances : It is essential to develop varieties free from toxic compounds in some crops to make them safe for human consumption. For example, removal of neurotoxin in Khesari (*Lathyruys sativus*) which leads to paralysis of lower limbs, erucic acid from *Brassica* which is harmful for human health, and gossypol from the seed of cotton is necessary to make them fit for human consumption. Removal of such toxic substances would increase the nutritional value of these crops.

10.Non-shattering characteristics: The shattering of pods is serious problem in green gram. Hence resistance to shattering is an important objective in green gram.

11.Synchronous Maturity : It refers to maturity of a crop species at one time. The character is highly desirable in crops like Greengram, Cowpea, and Cotton where several pickings are required for crop harvest.

12.Photo and Thermo insensitivity: Development of varieties insensitive to light and temperature helps in crossing the cultivation boundaries of crop plants. Photo and thermo-insensitive varieties of wheat and rice has permitted their cultivation in new areas. Rice is now cultivated in Punjab, while wheat is a major *rabi* crop in West Bengal.

13.Wider adaptability : Adaptability refers to suitability of a variety for general cultivation over a wide range of environmental conditions. Adaptability is an important objective in plant breeding because it helps in stabilizing the crop production over regions and seasons.

14.Varieties for New Seasons : Traditionally Maize is a *kharif* crop. But scientists are now able to grow Maize as *rabi* and *zaid* crops. Similarly, mung is grown as a summer crop in addition to the main *kharif* crop.

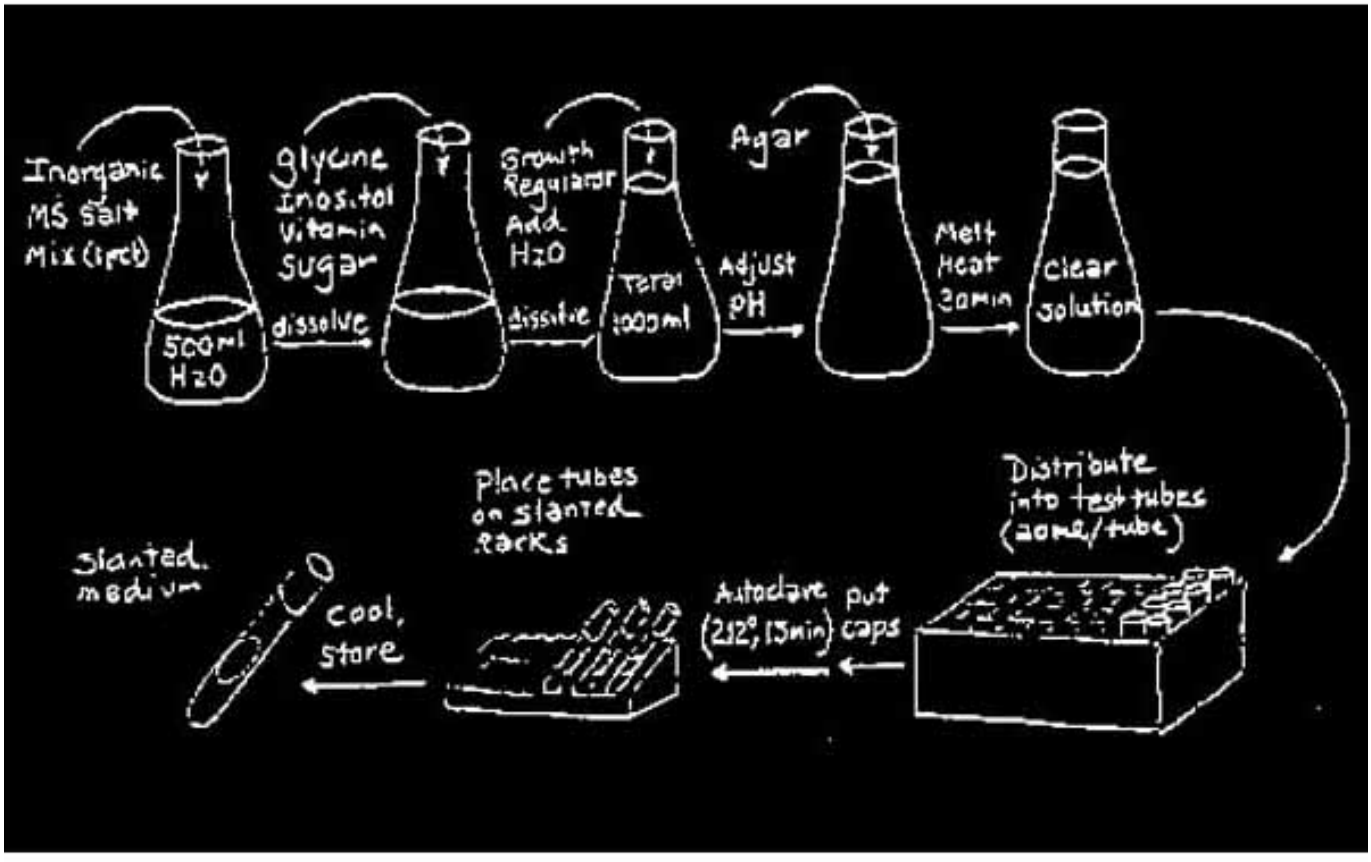
Scope of plant breeding (Future Prospects)

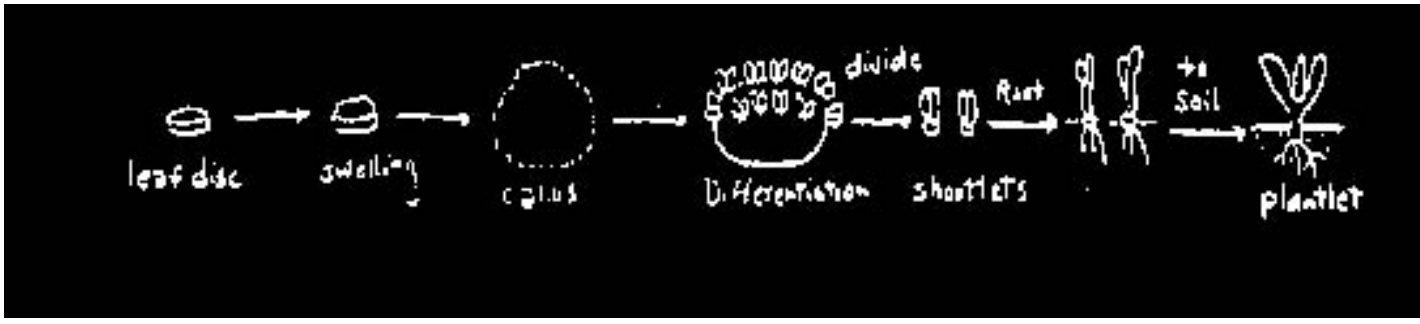
From times immemorial, the plant breeding has been helping the mankind. With knowledge of classical genetics, number of varieties have been evolved in different crop plants. In order to combat the global alarm created by population explosion, the food front has to be strengthened which is serious challenge to those scientists concerned with agriculture. Advances in molecular biology have sharpened the tools of the breeders, and brighten the prospects of confidence to serve the humanity. The application of biotechnology to field crop has already led to the field testing of genetically modified crop plants. Genetically engineered Rice, Maize, Soybean, Cotton, Oilseeds Rape, Sugar Beet and Alfalfa cultivars are expected to be commercialized before the close of 20th century. Genes from varied organisms may be expected to boost the performance of crops especially with regard to

PLANT TISSUE CULTURE

Plant tissue culture may be defined as a process whereby small pieces of living tissues explants are isolated from an organism and grown aseptically on a nutrient medium under controlled conditions

Two concepts viz., plasticity and totipotency are important for understanding plant cell culture and regeneration.





TOTIPOTENCY

It is the genetic potential of a plant cell to produce the entire plant and the ability of a plant cell to perform all the functions of development which are characteristic of zygote

PLASTICITY

It is the ability of the plants to adapt to environmental conditions by altering their metabolism, growth and development to t suit their environment.

When plant cell and tissues are cultured *in vitro* they generally exhibit a very high degree of plasticity which allows one type of tissue or organ to be initiated from another type .

History of plant tissue culture

The history of plant tissue culture begins with the concept of the cell theory given independently by Schleiden 1838 and Schwann 1839 which implied.that the cell is a functional unit. The first plantlet formation *in vitro* was reported as early in 1940s Ernest Bell (1946) reported it in Tropaeolum and Lupinus. It was only during 1960s that Morel reported plantlets formation in orchids , which became commercially viable programme

1838 & 1839	Schleiden and Schwann	Cell theory, cell is the functional unit of living organisms
1839	Habertland (Father of tissue culture)	
1939	Nobecourt	Cultivating plant tissues for unlimited period
Gautheret	1955	Totipotency Establishment of habituated cultures, , tumour cells, importance of light and

		temperature for the root growth Two important functions 1. the meristem of plant tissue cultures 2. plant tissue culture
Georges Morel		First to culture monocotyledonous tissue, meristem tip culture for elimination of virus disease of orchids, discovered two unique opines of crown gall tissues, Established about protocom
1934	White	First reported for the first time successful continuous cultures of tomato root tips in liquid culture and obtained indefinite growth., in vitro cultivation of viruses on excised roots and growth of tumour tisues, Important publication 1.the cultivation of animal and plant cells
Caplin and Steward	1948	Use of coconut milk for the first time, cell cultures of single cells, various types of vessels for culture work like rotating nipple flasks,
Steward and Ammirto	1969	Somatic embryogenesis in carrot for the first time, , completely established the totipotency, Important publication
		Volumes in “plant physiology”
Reinert	1959	Bipolar embryo formation in carrot and showed embryogenesis, , cryopreservation of cells, regeneration of plantlets, Important publication First state of art in plant tissue culture “Plant cell, tissue and organ culture”
Vasil and Vasil	1965	Land mark work on single isolated cells of tobacco which

		paved way for cells cuttures in genetics, morphogenesis and vegetative propagation and proved totipotency in cells, has contributed significantly for cells culture, protoplast, somatic embryogenesis of cerals
Maheswari	1964-1967	Experimental embryology Important publication An introduction to the embryogenesis Phytomorphology
Guha and Meheswari		Development of haploids through anther and pollen culture for the first time

ORGANOGENESIS

Organogenesis means the development of adventitious organs or primordial from undifferentiated cell mass in tissue culture by the process of differentiation. This is the process by which cells and tissues are forced to undergo changes which lead to the production of a unipolar structure, namely a shoot or root primordium, whose vascular system is often connected to the parent tissue. Morphological changes in the callus leading to the *denovo* organ formation from undifferentiated tissues are termed as organogenesis.

.This system is commonly produced in callus cultures, but can be produced directly from the *explant.* It is effected through a balance between the levels of auxins and cytokinins. A relatively a higher proportions of auxins are required for root induction and for the shoot induction a higher level of cytokinins are required. It is usual to induce shoot formation by increasing the cytokinin to auxn ratio of the culture medium. These shoots can then be rooted in auxin rich medium.

Organic connection between shoot and root primordial is essential for the regeneration of complete plantlet from the same culture. Shoot formation followed by rooting is the general characteristic of organogenesis . Organogenesis is unipolar in structure and there is vascular connection with explant and not easily separated unless cut off.

de novo It literally means “arise a new”. New plants arising from unorganized cells or tissues to form unorganized cells and tissues

Cytodifferentiation

In plant tissue culture during growth and maturation of the callus tissue or free cells in suspension culture few dedifferentiated cells undergo cytosenescence and redifferentiated to vascular tissues. The development process is termed as cytodifferentiaton.

Caulogenesis

It is a type of organogenesis by which only adventitious shoot bud initiation takes place in the callus culture

Rhizogenesis

It is a type of organogenesis by which only adventitious root formation takes place in the callus tissue

Organoids

In some cultured tissues , an error occurs in the development programming for organogenesis and an anomalous structure is formed. Such anomalous organ like structures are called organoids

Meristemoids

Meristemoid is a localized group of meristamic cells that arise in the callus tissue and may give rise to shoots and or roots

Explant

The tissue taken from a plant or seed and transferred to a culture medium to establish a tissue culture system or regenerate a plant

Precocious germination

Premature germination of the embryo radicle prior to completion of embryogenic development.

Dedifferentiation

The phenomenon of the conversion of mature cells into the meristematic state leading to the formation of callus is called dedifferentiation

Protocom

In nature, little differentiated structures developing naturally on orchid embryo which help in propagating the orchids. Through *in vitro* culture also, from cymbidium shoot tip cultures , protocoms could be produced which again could be sectioned into quarters and subculutred, each section regenerating a new protocom, within a few weeks which, in turn , could be divided. The so obtained protocom subsequently evolved in to young plantlets.

Adventitious buds:

Shoot buds originating from other than existing meristem are known as adventitious shoot buds.

.

Differentiation

The process of biochemical and structural changes by which cells especially the unroganised cells becoming specialized in form and function

Redifferentiation

The component cells of callus have the ability to form a whole plant is called redifferentiation

These two phenonmenons of dedifferentiation and redifferentiation are inherent in the capacity described as cellular totipotency . This property is found only in plant cells and not in animal cells

Xylogenesis

It is the differentiation of parenchyma into cells that have localized secondary wall thickeninings as seen in the xylem and vascular plants

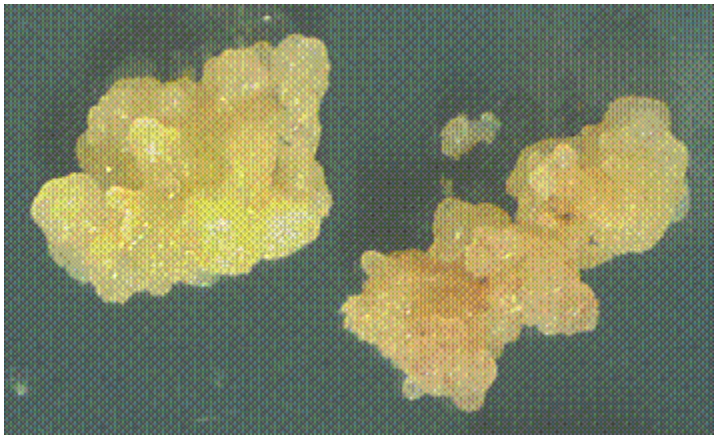
Factors affecting Regeneration

- source of explant
- nutrient media and constituents
- plant growth regulators

CALLUS INDUCTION AND MAINTANANCE

What is a callus?

It is an unorganized or undifferentiated mass of proliferative cells produced either in culture or in nature



What is callus culture ?

Tissues and cells cultured on an agar medium form an unorganized mass of cells i.e., callus

Callus formation from explant involves the development of progressively more random planes of cell division , less frequent specialization of cells and loss of organized structures.

Callus culture is often performed in the dark and the light can encourage differentiation of the callus.

Micro callus

The initial colony of cells visible but too small to transfer by direct manipulation recovered from cultured of protoplasts single cells or very small aggregate cells.

Induction and maintenance

When freshly cut pieces of surface sterilized plant tissues are grown in agar medium with appropriate nutrients with suitable proportion of auxin and cytokinin they exhibit callusing at cut ends, which gradually extends to the entire surface of the tissue. Callus cultures need to be subcultured every 3 – 5 weeks in view of cell growth , nutrient depletion and medium drying. Repeated subculture on an agar medium improves the friability of the callus

Habituation of callus tissue

In some plant species the callus tissue is able to grow on a standard maintenance medium or basal medium which is devoid of growth hormones. This property of the callus tissue is known as habituation and the callus tissue is known as habituated callus tissue.

During the long term culture, the culture may lose the requirement for auxin and or cytokinin.

What is subculture?

Subcluture is the transfer of cultures with or without dilution from one culture vessel to another containing fresh culture medium . It is also known as passage.

The callus tissue in many cases shows a high potential for organogenesis when first initiated but gradually a decline sets in as subculture proceeds with eventual loss of organogenic response. The genetic effects in a callus tissue are reflected in changes of chromosomal structure or number such as aneuploidy , polyploidy , cryptic chromosomal rearrangements.

Callus culture are extremely important in plant biotechnology. Manipulation of the auxin to cytokinin ratio in the medium can lead to the development of shoots, roots or somatic embryos from

which whole plants can subsequently be produced. Callus cultures can also be used to initiate cell suspensions, which are used in a variety of ways in plant regeneration studies.

Applications of callus culture

1. to study nutrition requirement of plants
2. to study cell and organ differentiation and morphogenesis
3. somaclonal variations and its exploitation
4. developing cell suspension cultures and protoplasts cultures
5. genetic transformation using ballistic particle gun technology
6. in the production of secondary metabolism and regulation

SELECTION OF EXPLANTS

Appropriate selection of explants is very important for rapid *in vitro* propagation

The genotype, age and physiological state of the explant respond differently to cultures.

Selection of mother plant

It is necessary to select the mother tree/plant with the care. The explants should be taken from mother plants possessing superior phenotypes such as disease resistance , stress tolerance , high yield and product quality. Explants should proliferate readily. Even materials with strong ability to proliferate should be screened continuously

The following aspects decide the size of explant

1. the surface size
2. volume
3. cell number

. Shoot tips of 2mm size only respond well in *Manihot esculenta* whereas in *Dianthus caryophyllus* if the shoot tip size is too small i.e.., 2mm , there is lesser response or only the root are induced and not the shoots When eradication of viral infection is the main objective, very small meristem should be used

location of explants

Position of explants i.e., developmental stage is very important. In shoot tip culture of *Rosa rugosa* the success rate of terminal bud culture was higher than the using the lateral buds

season and time of explant collection

the season during which the bud is collected is another factor to be considered. In general buds about to sprout are suitable for culture. For embryo culture the dormancy state of seeds should be considered

CELL SUSPENSION CUTURE

How single cells are produced?

Callus cultures fall into two types viz., compact and friable. In compact callus the cells are compactly and densely arranged and in friable type the callus cells are loosely arranged and they are soft and breaks apart easily. Friable callus provides inoculum for cell suspension culture when friable callus is placed in liquid medim and agitated single cells are released in the medium.

What is a cell suspension culture?

It a type of culture in which single cells or small aggregates of cells multiply while suspended in agitated liquid medium . It is also referred to cell culture or cell suspension culture

What is plant cell culture?

It is an *in vitro culture* of single or relatively small groups of plant cells i.e., the callus culture

Why plant cell suspension culture?

Establishment of single cell cultures provides and excellent opportunity to investigate the properties and potentialities of plant cells and for mutation induction.

Spatial heterogeneity

The individual cells within a population of cultured cells invariably show cytogenetical and metabolic variations depending on the stage and growth cycle and culture conditions, such variables is termed as spatial heterogenity.

Critical Initial Density (CID)

The particular initial cell density that is able to grow in liquid medium is called critical initial density.

Different categories of suspension culture

Broadly speaking there are three types of suspension cultures

1. batch culture
2. continuous culture
3. immobilized cell cultures

Batch culture

It is a suspension culture where the cell cultures are maintained in a definite volume of agitaged liquid with repeated subculturing of a small aliquot of cell culture to a fresh medium at regular intervals. Generally cell suspensions are grown in flasks (100 – 250 ml) containing 20 –75 mil of the culture medium incubated on orbital platform shakers at the speed of 8- 120 rpm..

After subculture the cells divide and the biomass of the culture increases in a characteristic fashion, until nutrients in the medium are exhausted and/or toxic by - products build up. . The cell number of a batch culture exhibits a typical sigmoidal curve containing

1. a lag phase (during which period the cell or biomass remains unchanged
2. a log phase , an exponential phase which includes rapid increase in cell numberdue to active cell division
3. stationary period during which period the cell number does not changedue to the depletion of nutrients in the media and or by toxic substances

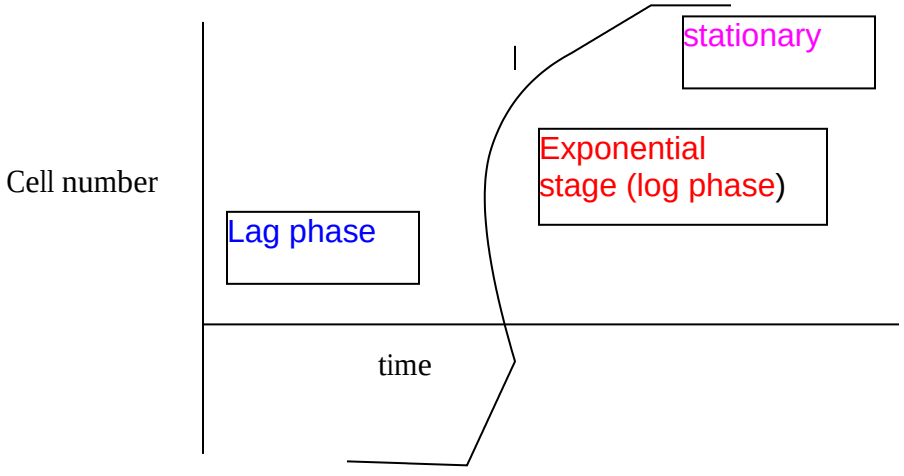


figure:. Model curve showing different growth phases in batch culture

Batch cultures are characterized by a constant change in the pattern of cell gwoth and metabolism.

Uses of batch culture

a) for cloning

b) for cell suspension

Continuous culture / mass culture

In continuous culture, the cell population is maintained in a steady state by regularly replacing a portion of the used or spent medium by fresh medium

There are two types of continuous culture types

a. closed continuous culture
b. open continous culture

closed continuous culture

cells are separated from the used medium taken out for replacement and added back to the culture so that the cell biomass keeps on increasing

open continuous cultures

both cells and the used medium are taken out from open continuous cultures are replaced by equal volume of fresh medium . Here, the steady state of suspension culture is maintained

immobilized cell cultures

plant cells and groups may be encapsulated in a suitable material or entrapped in membranes or stainless screens. To provide the nutrients to the cells, liquid medium is continuously run through the column where the immobilized cells are packed and sufficient aeration is also provided.

Assessment of cells in suspension

1. cell count

   cell count (at the beginning of culture and after certain days of incubation) , is a relatively more accurate measure adopted to determine the growth and cultures Increase in cell number depends on Mitotic Index (MI) of cells in suspension cultures

   Mitotic Index refers to the percentage of cells undergoing mitosis.

$$MI = \frac{\text{total number of divided cells}}{\text{total observed cells}} \times 100$$

2. packed cell volume (PCV) = (Biomass volume) ml / g of culture
3. cell fresh weight (gm / ml)
4. cell dry weight(gm / ml)
5. by measuring the optical density of the liquid medium the turbidity level could be estimated which is directly proportional to cell number

Test for viability of cell

using Fluoresein Di Acetate (FDA), Evans blue stains the viable cell count could be made

applications of cell culture

1. it helps in understanding of an organ formation or embryoid formation starting from single cell or small cell aggregate
2. suspension culture derived from medicinally important plants can be studied for the production of secondary metabolites such as alkaloid
3. it helps in mutant selection in relation to crop improvement
4. to produce valuable products including secondary metbolites through bio transformation a technique utilized with the help of microbes

   (eg) Datura cell culture possess ability to convert hydroquinone into arbutin
5. single cell cultures are also being used for production of Single Cell Proteins (SCP)

   SCP are any microbial biomass from both uni and multicellular bacteria, yeasts, filamentous fungi or algae which can be used as food or feed additives.

(eg) Spirulina

comparison of callus and cell suspension cultures

Parameters	Callus	Cell suspension
Growth	Slow	Fast
Cell or cell content	Cells in contact	Dissociated
Medium	Only lower layer is in contact with the medium	All cells are in direct contact with the medium
Precursors	Not available to all cells	Available to cells
Subculture period	Long, 4-8 weeks	Short , 7-21 days
Accumulation of metabolites	Higher than cell suspension	Lower than callus culture
Scale up in bioreactor	Not possible	Cell suspension ar grown in bioreactor

Applications of cell culture

- cell culture offers enormous opportunities in the study of single cells and group oc cells
- in the isolation of protoplasts
- in cell cloning by the plating technique with or without specific treatment like mutagens,
- development of cell lines for various types of resistance like salt or drought tolerance, toxin resistant lines
- in scale up technology using bioreactors of various types

PRODUCTION OF SECONDARY METABOLITES

WHAT IS SECONDARY METABOLITE?

The secondary metabolites are those cell constituents which are not essential for their survival and not involved in primary metabolic activities like photosynthesis, respiration, protein synthesis etc.. These secondary metabolites include alkaloids , glycosides (steroids, phenolics), terpenoids and a variety of flavours , perfumes , agrochemicals etc.

Plants are the chief source of a wide range of biochemicals which are of medicinal importance . It has been found that the cells of the respective plants when cultured in specific medium *in vitro* , they produce the secondary metabolites which can be conveniently harvested and further processed.

Why synthesis of secondary metabolites through cell culture?

1. the yield and quality of the product is more consistent in cell cultures because it is not influenced by the environment
2. the production schedule can be predicted and controlled in the laboratory or industry

A list of some groups of biochemicals obtained from plants

Group	Examples
Alkaloids	Morphine, codeine, quinine, nicotine, cocaine, hyoscyamine, lysergic acid etc
Terpenoids	Menthol, camphor, carotenoid, polyterpenes
Phenylpropanoids	Anthocyanin, coumarins, flavonoids, isoflavonoids,
Quinines	Anthraquinone, nebzoquinones
Steroid	sterols

A list of some pharmaceutically valuable biochemicals obtained from plants

Compound	Plant species	Medicinal value
Shikonin	*Lithospermum erythrorhizon*	Antiseptic
Berberine	*Coptis japonica*	Antibacterial
Quinine	*cinchona*	Antimalarial
Taxol	*Taxus sp.*	Breast and ovarian cancer treatment

What is a bioreactor?

It is a culture vessel generally of a large volume which has provisions for aeration, stirring to achieve medium and cell mixing , contamination control, replacement of used medium and or cells

Four types of bioreactors are

1) 1.batch bioreactors
2) continuous bioreactors
3) multistage bioreactors
4) immobilized cell bioreactors

commercial production of shikonin

Shikonin was the first commercial product from cell culture of *Lithospermum erythrorhizon* .

Steps involved in the production of shikonin

1. the high producing clone cells to be used as inoculum i.e., stock or seed clutres and maintained in jar fermentors
2. the inoculum is first added to a 200 lit fermentor containing the MG5 medium for culture growth
3. after 9 days the cells are filtered out and inoculated into a 750 lit fermentors with M 9 medium and incubate for 14 days
4. the cells are harvested by simple filteration techniques and shikonin derivatives are extracted from the cells

A 750 lit bioreactor with 600 lit medium would yield 1.2 kg Shikonin in 2 weeks . In contrast *Lithospermum erythrorhizon* roots from one hectare land would yield about 9kg Shikonin after 4 years . Shikonin is used for making cosmetics, lotion and soap in Japan

Advantages of secondary metabolite synthesis

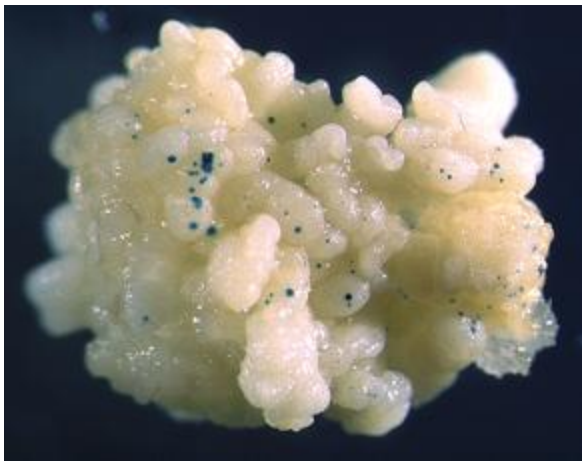
1. threat on endangered or extinct species could be eliminated (eg. *Lithospermum erythrorhizon)*
2. when the target plant is limited in supply (Trichosanthes sp.) or slow in growth (L.erythrorhizon) cell culture is highly useful for faster and continuous supply
3. cell cultures produce more secondary metabolites than the plant tissues in the field (20% more production of shikonin in cell culture)
4. cells can be stored

SOMATIC EMBRYOGENESIS

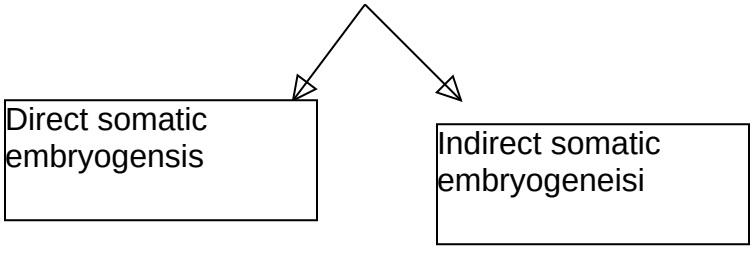
What is somatic embryogenesis?

It is the process of a single cell or a group of cells initiating the developmental pathways that lead to reproductive regeneration of non zygotic embryos capable of germinating to form complete plants.

Embryogeneic cultures are compact dry, amorphous, and white in colour as compared to non embryogenic cultures which are watery dirty white to light brown in colour and soft in nature.



SOMATIC EMBRYOGENESIS



In direct embryogenesis the embryo is formed directly from a cell or group of cells without the production of an intervening callus

In indirect somatic embryogenesis callus is first produced from the explant. Embryos are then produced from the callus

Embryoid

It is a small well organized structure comparable of the sexual embryo, which is produced in tissue culture of dividing somatic cells.which are embryogenically potential,

Embryogenic potential

The capability of the somatic plant cell of a culture to produce embryoids is known as embryogenic potential

Embryogenic callus (EC)

In somatic embryogenesis small compact cells divide asymemetrically and their daughter cells stick together to produce cell masses called proembryogenic masses or embryogenic clumps

Characters of somatic embryo

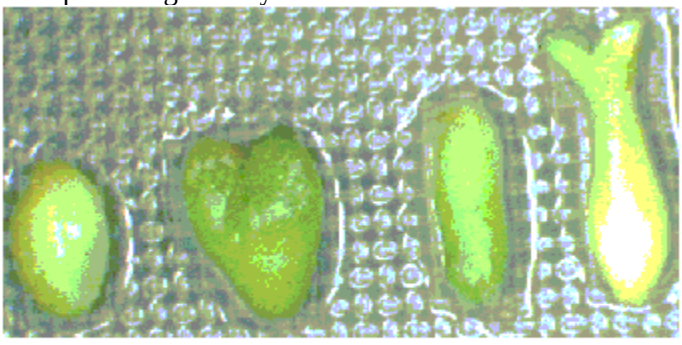
1.the origin is single cell
2.bipolar i.e., both shoot and root primordia present
3.vascular connection between the somatic embryos and the explant is absent
4. the somatic embryos are easily separated from the explant tissue

explants for initiation of SE

1.embryonic or young seedling tissues
2.excised small tissues from young inflorescence
3.scutellum
4.young roots
5.petioles
6.immature leaf
7.immature hypocotyls

Distinct stages in development of Somatic Embryogenesis

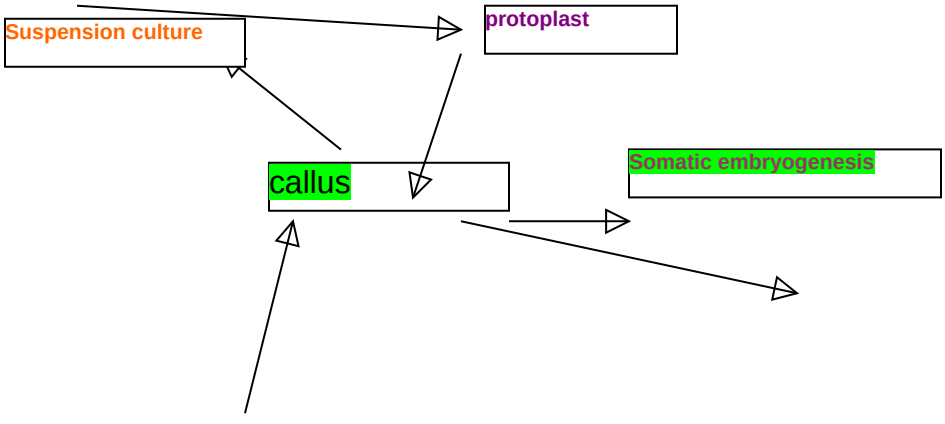
1. .single cells
2. .group of cells
3. globular stage
4. .heart shaped embryo
5. .torpedo stage embryo

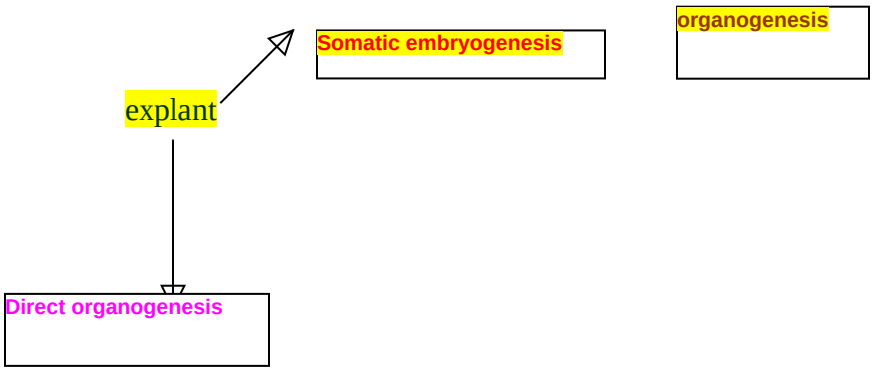


DRAW THE DIAGRAM

somatic embryogenesis may develop from single cells or from a small group of cells. Repeated cell divisions lead to the production of a group of cells that develop into an organized structure known as "globulin"stage embryo. Further development results in heart and torpedo stage embryos from which plants can be regenerated Signs of tissue differentiation become apparent at the globular stage and apical meristem are apparent in heart shaped embryo.

Somatic embryogenesis usually proceeds in two distinct stages. In the initial stage (embryo initiation) , a high concentration of 2,4 D is used. In the second stage (embryo production) embryos are produced in a medium with no or very low level of 2,4D In many systems it has been found that somatic embryogenesis is improved by supplying a source of reduced nitrogen, such as specific amino acids or casein hydrolysate.





Indirect somatic embryogenesis in carrot

A callus can be established from explants from a wide range of carrot tissues by placing the explants on solid medium containing 2,4D 91 mg)/lit) . This callus can be used to produce a cell suspension by placing it in agitated liquid MS medium containing 2,4D (1mg/lit). this cell suspension can be maintained by repeated subculturing into 2,4D containing medium. Removal of old 2,4D containing
medium and replacement with fresh medium containing absicic acid (0.025 mg / lit) results in the production of embryos

Direct somatic embryogenesis form alfalfa

Young trifoliate leaves are used as the *explant* . These are removed from the plant and chopped into small pieces. The pieces are washed in a plant growth regulator free medium and placed in liquid medium (B5) supplemented with 2,4D (4mg / lit) , kinetin (0.2 mg /lit) , adenine (1mg / lit) and glutarthione (10mg /lit) . The cultures are maintained in agitated liquid medium for about 10 – 15 days . Transferring the culture to maltose and PEG supplemented media results in the development of somatic embryos. These somatic embryos mature on solid medium containing absicic acid.

Importance of somatic embryogenesis

1.clonal propagation:- the mass production of adventitious embryos in cell culture is one of the ways of clonal propagation
2.for genetic transformation
3.raising somaclonal variation in tree species with the help of mutation
4synthesis of artificial seeds
5.synthesis of metabolites

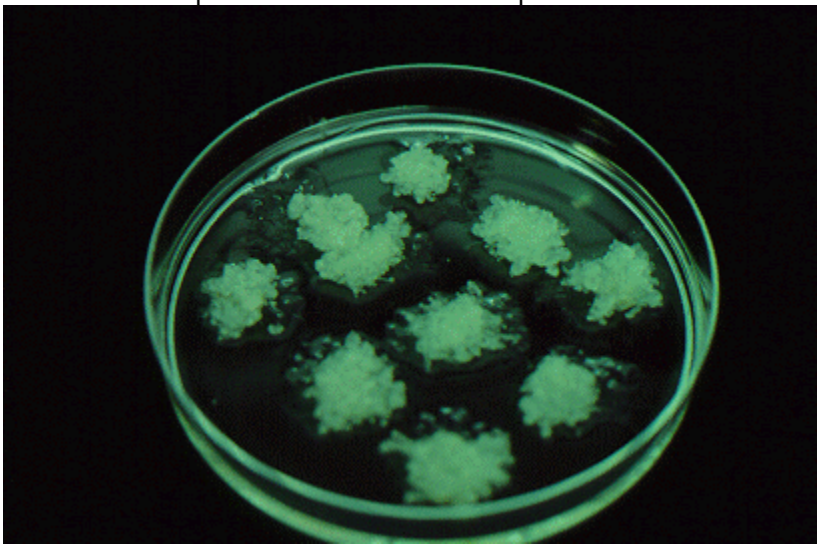
Differences / comparison between organogenesis and embryogenesis

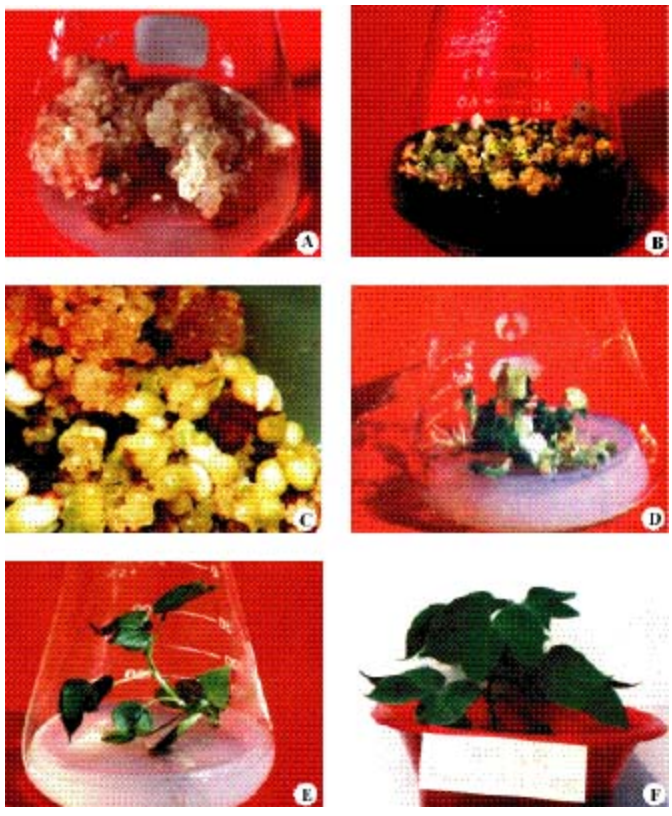
Charactersistc	Organogenesis	embryogenesis
Origin	Many cells , usually superficial	Single cell, usually superficial
Polarity	Unipolar	Bipolar
	Present; vascular strands	Absent; there is no vascular

Vascular connection with callus / explant	connected with those present in callus / explant	connection with callus/ explant
Separation from callus/ explant	Not easity separated unless cut off	Easily separated since the radicular end is cutinized

Applications of somatic embryogenesis

1. somatic embryogenesis provides potential plantlets in the form of somatic seeds. These are available in enormous number once the culture is established. The somatic embryos can be used for the production of synthetic seeds for direct sowing in the field.
2. somatic embryo provides organized culture system comparable to intact plant in sterile liquid cultures. Such cultures produce organ specific or differentiation related compounds in higher amount compared to cell culture of the species




A
B
C
D
E
F

ARTIFICIAL SEEDS OR SYNTHETIC SEEDS

When somatic embryoids derived from plant tissue culture are encapsulated by a hydrogel and such encapsulated embryoids behave like true seeds if grown in soil and can be used as substitutes of natural seeds

Methods of artificial seeds production

1.gel complexation
2.molding

Gel complexation: in this method isolated somatic embryoids are mixed with 0.5 to 5% (W/V) Sodium alginate and dropped into 30 – 100 μM Calcium nitrate solution. Surface comlexation begins immediately and the drops are gelled completely within 30 seconds

molding method:- In this method isolated somatic embryos are mixed in a temperature dependent – gel such as gelrite and placed in the well of a microtiter plate and it formsgel when the temperature is cooled down.

Four types of synthetic seeds have been proposed on the basis of embryos and its encapsulation

- uncoated desiccated somatic embryos eg orchard grass
- coated desiccated somatic embryos eg. Carrot
- encapsulated coated hydrated somatic embryos eg. Alfalfa
- uncoated hydrated embryos (in a fluid drilling gel) eg. Carrot

plants produced from synthetic seeds sown in vitro and in soil

- in vitro – Apium graveiolens, Brassica sp. Carrot, cotton, alfalfa, rice, maize
- in soil – Apium graveolens, carrot, alfalfa
-

Importance of artificial seeds

1. they canbe stored upto a year without loss in viability
2. they are easy to handle and useful as units of delivery
3. they can be directly sown in the field without hardening
4. artificial seeds are available within a short time
5. season / time independent
6. no dormancy
7. artificial seed coating also has the potential to hold and deliver beneficial adjuvants such as growth promoting thiozobacteria, plant nutrients and growth control agents and pesticidies for precise placement
8. artificial seeds help to study the role of endosperm and seed coat formation

limitation

1. when the artificial seeds are stored at low temperature the embryos show a characteristic drop in conversion

2. cost of production is high

Common hydrogel used for encapsulation

Sl.no	Gel	Complexing agent
1	Sodium alginate	Calcium salts
2	Sodium alginate with gelatin	Calcium chloride
3	Carnagenan with locust beam gun	Potassium or ammonium chloride
4	Gelrite	Temperature lowered

SOMACLONAL VARIATION

Somaclonal variation is the genetic variability which is regenerated during tissue culture . Such variations manifests themselves as heritable mutation and present in the plant population even after transplantation to the field. Larkin and Scowcroft (1981) proposed the term somaclone to describe the plants originating from any type of tissue culture. The somaclonal variation may be attributed to either I) pre existing variation in the somatic cells of the explants) or ii) variation generated during tissue culture)

Mechanisms causing somaclonal variation

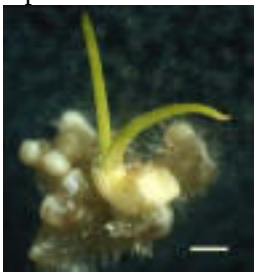
1.endomitosis

2.chromosomal abberation

3.DNA amplification

4.transposable elements

5.point mutation



why or how these chromosomal changes occur?

1. alterations in DNA methylation

a decrease in methylation causes the genes more active

2.lack of nucleic acid precursors due to very rapid cell division

3.role of growth regulators like 2,4D and sometimes kinetin in inducing variation

4.nutrient composition

KNO3 influences the albino plants from wheat cultures , level of organic N_2 chelating agents and other micro nutrients

5.Culture conditions: temperature , method of culture

6. duration of culture (longer the duration of culture more the variation)

SELECTION OF SOMACLONAL VARIATION

1.analysis of phenotypic characters

the morphological characters of somaclones are compared with the parental types for three tof four generations and finally the genetic variability is assessed

2.cytological study of variants

3.mesurement of DNA content of the variants

4.gel electrophoresis of proteins and enzymes

5. by exerting selection pressure using particular chemicals in the media
    a) selection for disease resistance - the toxin produced by the pathogen can be used in the media (phytophthora resistance in potato)
    b) herbicide resistance - by adding interested herbicide in the media (tobacco)
    c) salt tolerance - by adding NaCl (tobacco)
    d) drought/water logging tolerance - by adding PEG (tomato)
    e) mineral toxicity/deficiency tolerance - adding and reducing the quantity of interested nutrient in the media (tomato, sorghum)
    f) temperature stress / chilling response - exposing the culture to very high or low temperature (tobacco for chilling response, pear for temperature stress)

Somaclonal variation among regenerated plants from callus and protoplast culture has been presented to a lot of significant contributions to plant science. Somaclonal variation among regenerated plants from

Callus and protoplasts culture has been suggested as a useful source of potentially valuable germplasm for plant breeding and improvement. The major benefit of somaclonal variation is to create variation in adapted genotype.

List of crop species where desirable and heritable somaclonal variation has been reported

Species	Characters which were modified
Allium sativa	Bulb size, shape, clove no. aerial bulbil
Avena sativa	Plant height, heading date, awns
Hordeum spp	Plant ht, tillering
Oryza sativa	Plant ht, heading date , seed fertility, grain no., wt
Saccharam officinarum	Disease (eye spot, fiji disease, downey mildew)
Triticum aestivum	Plant and ear morphology, awns, gliadins, amylase, grain wt., yield
Zea mays	T toxin resistance, male fertility , Mt DNA
Lycopersicon esculentum	Leaf morphology, branching habit, fruit colour, pedicel, male fertility, growth
Medicago sativa	Multifoliate leaves, elongated petioles, growth branch number plant height, dry matter yield
Solanum tuberosum	Tuber shape, maturity date, plant morphology, resistance for early andlate blight,

	photoperiod, leaf color, vigour, height, skin colour

.problems with somoclonal variation

- variation is cultivar dependent
- frequencies of change vary
- many changes are undesirable
- some changes are unstable
- many changes are not novel
- characters of interest may not change

methods of assessment of somaclonal variation

- phenotypic parameters(quantitative (leaf size, plant height, qualitative, branching pattern, flowercolour)
- physiological parameters(protein patterns by electrophoresis, secondary products formation)
- genetic parameters (chromosome number and structure, banding pattern)

MICROPROPAGATION / CLONAL PROPAGATION

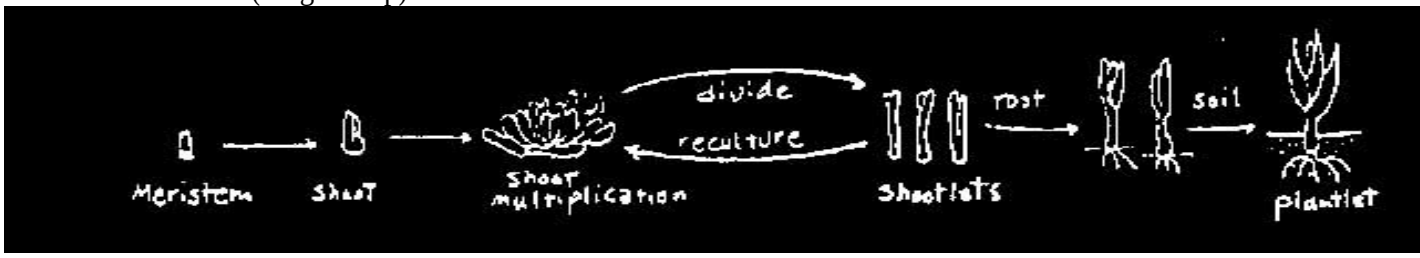
What is a micropropagation?

It is the *in vitro* regeneration of plants from organs, tissues , cells or protoplasts and the true to type propagation of a selected genotype using *in vitro* culture technique

A variety of plants species can be conveniently propagated through the techniques of cell , tissue or organ culture. This is particularly described as clonal propagation or micropropagation

Explants for micropropagation

- apical shoots
- axillary buds
- adventitious shoots
- bulbs
- leaf size (Begonia sp)



stages in micropropagation

in vitro clonal propagation is a complicated process requiring many steps or stages . Murashige proposed four distinct stages that can be adopted for overall production technology of clones commercially. Stages I to III are followed under in vitro conditions, whereas stage IV is accomplished in a green house environment

stage 0 – Preparative stage

This step involves selection of mother plant to provide a suitable *explant* of good quality for initiation of aseptic cultures. Selection of suitable *explant* is essential to the success of in vitro propagation Wherever possible mother plants should be grown under protected environment like

glasshouse, greenhouse etc. while taking *explant* from the field age of the mother plant, yield potential and healthiness should be considered

Stage 1 initiation of aseptic culture

This step is meant for obtaining an aseptic culture of the plant which is under investigation. The culture may be initiated from shoot tips , buds, stem root explants, flowers, sterile plantlets, callus etc. At this stage it is absolutely essential that the explant to be cultured should be totally free from microbial infection and that a high percentage of the explants survive and show rapid growth. This depends on the correct development of medium

Stage II shoot proliferation stage

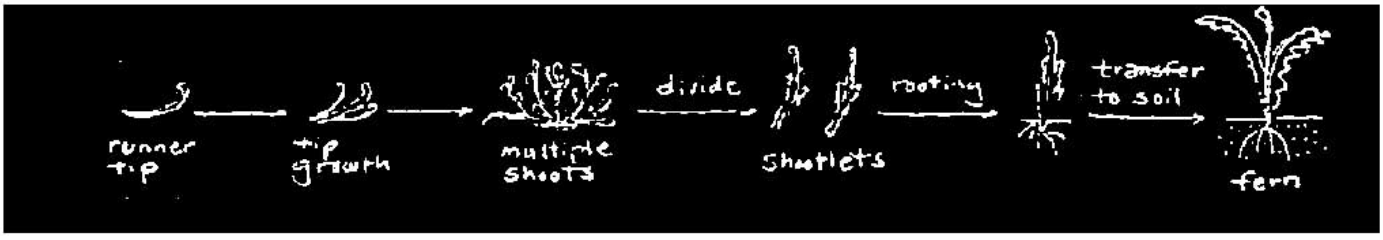
6. This stage aims at obtaining a rapid increase in the number of shoots or asexual embryos which can utilimately be used to provide the large number of plants. This cycle generally lasts for 4 – 10 weeks The cytokinin in the media stimulates pre existing shoot buds present in the explants (apical meristems in shoot tips, and axillary buds in nodal explants) to develop into shoots. After sometime (4-6 weeks) the axillary branching in a culture reaches the maximum. The individual shoots are then excised and subcultured onot fresh medium to initiate a new cycle of multiplication by axillary branching with a final yield of $5^{10} - 6^{12}$ plants in one year.

Stage III root development

This stage involves preparation of shoots for rooting. The proliferated shoots are transferred to a rooting medium. Sometimes shoots are directly established in soil as micro cuttings to develop roots.

Stage IV hardening

An important and critical stage in this process is when the plantlets under aseptic conditions of laboratories have to be shifted to galssshouse or greenhouse . The sterile plants are hardened or acclimatized to their new surroundings .



Advantages of micropropagation

1) rapid multiplication of superior clones and maintenance of uniformity
2) multiplication of disease free plants
3) multiplication of sexually derived sterile hybrids
4) supplies planting material irrespective of season
5) facilitates storage of a large scale
6) eases the transportation of planting material
7) stocks of germplasm can be maintained for many years
8) multiplication of cloning dioecious species
9) requires minimum growing space in commercial nurseries
10) in case of forest trees mature elite trees can be identified and rapidly cloned by this technique
11) in ornamentals tissue culture plants give better growth , more flowers,
12) very valuable when limited tissue is available as explant

limitations

- high investment cost
- requirement of more skill
- high electricity consumption
- presence of traces of somaclonal variation
- possibility of loss of rare genetic material when there is a severe contamination
- suitable techniques of micropropagation are not available for many valuable speices
- vitrification may be a problem in some species

Explants used in micropropagation of some of the economically important ornamental and horticultural platns

Group	Plant	Explant
Bulbs and corms	Allium, lilium, tulips, narcissus,	Scale leaves, leaf blades, stems
	Gladiolus	Corms, stem
Houseplants	Petunia	Small leaf pieces
Orchard crops	Musa	Shoot tip
Conifers	Picea abies	Needles
Field crops	Sugarcane,	Meristem tip culture and shoot tip culture

PRODUCTION OF VIRUS FREE PLANTS

Mersitem culture is often useful in recovering virus free plants from virus infected plants or clones

Eg. (potato, sugarcane)

What is a meristem?

A localized group of actively dividing cells from which permenant tissue system, i.e., root, shoot, leaf , and flower are derived. Thye contain only one pair of subtending leaves

Apical meristem?

The apical meristem is a group of cells , situated at the extreme tip of the shoot or root in the shape of dome. This shoot meristem measures approximately 0.1 mm in diameter and 2.5 to 3 mm in length covered by developing leaf primordial. The apical meristem remain in an active state during the vegetative growth phase and they are in a permanent embryonic stage.

How meristem tip culture useful for micropropagation ?

The cells constituting the meristems are highly conservative and hence genetically stable so the plants regenerated from the plants are genetically identical.

Why plants derived from meristem tip culture are free from virus?

Since, the rate of cell division is higher the virus is not able to cope up with the same and get eliminated. Further the absence of plasmodesmata and vascular elements in the meristem greatly hinders the transport of virus particles leading to very low concentration in meristem.

Meristem culture

In vitro culture of a generally shiny, domelike structure measuring less than 0.1 mm in length when excised , most often excised from the shoot apex

First application of meristem was to obtain virus free plants of Dhalias. Considerable expertise is required to dissect out the shoot apical meristem with only one or two leaf primordia.

Meristem tips are carefully dissected away from the apical or lateral shoot buds under a steremicroscope under aseptic condition. After this though most mersitems can be directly on suitable culture medium without surface sterilization . Meristem can be directly inoculated on a suitable culture medium without surface sterilization . Meristems are usually cultured on solid medium occasionally on liquid media supplemented with a low concentration of cytokinins and a moderate level of auxins. Further, transferred to root development media for improving root growth. After a period of 2-6 months the plants are transferred to green house and sample plants are tested for the presence of virus by ELISA and PAGE techniques

Sometimes mersitem tip cuture have failed to eliminate virus infection because the explant contains shoot apices with vascular tissue instead of true meristem. Meristem tip culture combined with heat treatment (thermo therapy) or chemical treatment (chemotherapy) has proved to be very effective in virus eradication.

Thermo therapy

Explants are exposed to the incidence of higher temperature which are not lethal for plant cells, but they are lethal for viruses. Mostly used temperature range is 50 – 52 ° C with exposition about 10 30 minutes. In case of whole plant, lower temperature has to be used (32 – 40 °with exposure for 4 to 30 days

Chemotherapy

By using some of the chemicals viz., malchite green, ribavirin or 2 thiouracil when added to the medium it kills the virus in the explants

Shoot tip grafting *in vitro* and micrografting

Shoot tip grafting (STG) in vitro, also known as micrografting is extremely beneficial with woody species . This method involves micrografting of aseptically isolated, very small shoot tips consisting of meristems with 2 – 3 leaf primordia to in vitro grown virus free seedling (root stock) . This method is employed in citurs, apple, prunus plants.

Virus indexing

It may be emphasized that all the plants obtained through meristem culture with or without chemo or thermotherapy are not virus free. Therefore, such plants have to be tested for the presence of the concerned virus. This is called virus indexing.

- The simplest method for virus indexing is to score the plants for the presence of specific symptoms produced by the relevant virus
- The saps from test plant may be used to inoculate highly sensitive and healthy indicator plants
- A highly sensitive and precise technique for virus indexing embryos is ELISA test (Enzyme Linked Immuno Sorbant Assay) It is more convenient, rapid and efficient when a large number of plants are handled
- DNA and RNA probes can also be used for virus detection

  Virus have eliminated form a number of economically important plant species including the following:
  - Ø Mottle virus free from cassava
  - Ø Cauliflower mosaic virus from cauliflower
  - Ø Other crop spp include garlic, pineapple, dahlia, cymbidium, orchid, carnation, straw berry, iris, lily, apple, cassava, banana, raspberry, sugarcane, grape, potato, ginger

ANTHER CUTLURE AND MICROSPORE CULTURE

By carefully selection of developing anthers at a precise and critical stage it is possible to establish the anther culture that will give rise to haploid plants.

Guha and Maheswari (1964) first reported the direct development of embryos form pollen grains of Datura by anther culture

What is androgenesis?

Androgenesis is the *in vitro* development of haploid plants originating from totipotent pollen grains through a series of cell division and differentiation.

Direct androgenesis

Microspores behave like a zygote and undergoes change to form embryoid which ultimately gives rise to a plantlet.

Indirect androgenesis

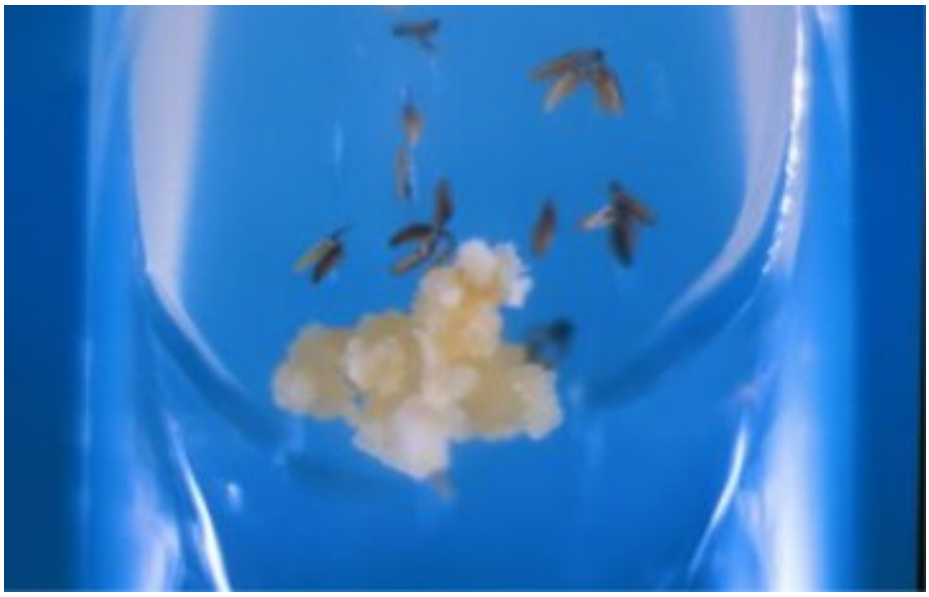
In contrast to the direct androgenesis the microspore instead of undergoing embryogenesis divide repeatedly to form a callus tissue which differentiates into haploid plantlet.

Principle of anther culture

The basic principle of anther and pollen culture is the production of haploid plants exploiting the totipotency of microspore and the occurrence of single set of chromosome (n) in microspore. The principle behind the anther culture is that without disturbing the natural habitat and environment of the enclosed anther, pollen can be grown by culturing the intact anther. In culture condition, the diploid tissue of anther will remain living without proliferation at the selective medium and at the same

time it will encourage the development of pollen by nursing and providing nutrient. In anther culture the gametophytic pathway of pollen is broken and it undergoes sporophytic pathway.

Flower buds of the appropriate developmental stage are collected, surface sterilized and their anthers are excised and placed horizontally on culure medium. Flower buds with small anthers may themselves be cultured and in some case, the entire inflorescence has been cultured. Care should be taken to avoid injury to anthers since it may induce callus formation from anther walls. Alternatively pollen grain may be separated from anthers and cultured on a suitable medium



Pathways of development of pollen

The early divisions in responding pollen grains may occur in one of the following four ways.

Pathway I

The uninucleate pollen grain may divide symmetrically to yield two equal darughter cells called vegetative and generative nuclei both of which undergo further divisions

Eg. Datura innoxia

Pathway II

The uninucleate pollen divides unequally. The generative cell degenerates immediately or after undergoing one or two divisions. The callus / embryo originates due to successive division of vegetative cells

Eg. Barley, wheat, triticale, chillies, tobacco

Pathway III

Here the the vegetative cell degenerates and the generative cell divide repeatedly to form multinucleate pollen

Eg. Hyoscyamus niger

Pathway IV

In some species, the uninucleate pollen grain divide unequally producing generative and vegetative cells, but both these cells divide repeatedly to contribute to the developing embryo callus

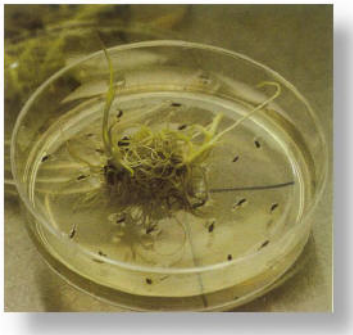
Eg. Datura innoxia

Pretreatment

Low temperature 3 – 5 °C for 2 days ----tobacco

High temperature 35°C for 24 hours ----- brassica

Prolonged low temperature 4 – 10 °C for 3 – 28 days -- cereals



MICROSPORE CULTURE OR POLLEN CULTURE

Isolated pollen grains when cultured in vitro gives rise to haploid embryos or callus and this approach is called pollen culture. Pollen may be isolated either by squeezing or float culture of anthers.

Squeeze culture

About 50 anthers may be placed in 20 ml of medium and squeezed with a glass rod; the solution is filtered through a nylon mesh of suitable pore size and centrifuged at 500 – 800 RPM for 5 minutes. The pollen pellet is collected washed twice and suspended at a final density of $10^3 – 10^4$ pollen /ml

Float culture:

Excised anthers are floated on a shallow liquid medium in petridishes; the anthers dehisce in a few days releasing their pollen grains into the medium

Initially isolated pollen grains were cultured either in hanging drops or on a filter paper raft placed on cultured anthers. Subsequently Nitsch and Co Workers first replaced the nurse tissue by an extract of cultured anthers and finally devised a completely synthetic medium for pollen culture the crucial ingredients of which were glutamine, L-Serine, and inositol

Slit technique

Cutting the anther wall to release the microspore calluses/embryos rather than relying on natural dehiscence but this is a time consuming process eg. Tobacco, pennisetum

Advantages of haploids / anther culture / pollen culture

1) Haploid are useful in cytogenetic studies
2) Production of homozygous inbreds / isogenic diploids within a year as compared to the long inbreeding method which takes 4-6 years
3) To trace the parents of the hybrids
4) Haploids are valuable for mutation studies
5) By comparing the heterozygous diploid with haploid or homozygous diploid population recessive phenotypic characters can be identified
6) Development of pure lines and 100% male plants in Asparagus
7) Recovery of sexual inter specific hybrids between wild and domestic species (tomato)
8) For understanding the phylogenetic relationship between species the study of meiotic behaviour of haploid provide clues for chromosome duplication within a species

9) To study the inheritance pattern
10) Use of haploids in the production of monosomics, nullisomics, and other anueploids
11) Double haploid, that are homozygous and fertile are readily obtained enabling the selection of desirable gene combination

How to double the chromosomes in haploid?

Spontaneous duplication

Homozygous diploid callus or embryoids may be formed by the spontaneous fusion of two similar nuclei of cultured pollen after first division. Haploid cells are unstable in culture and have a tendency to undergo endomitosis.

Induced duplication

Colchicines treatment:- the young plantlets regenerated through anther culture are treated with 0.5% colchicines solution for 24 – 48 hours. Treated plantlets are replanted in the medium after through washing. In case of mature haploid plantlets , 4% colchicines paste may be applied to the axil of the leaves

OVARY CULTURE

GYNOGENESIS

Culture of unfertilized ovaries to obtain haploid plants from egg cell or other haploid cells of embryo sac is called ovary culture and the process is known as Gynogeneis

- Ø The first report on gynogenesis was by San Noem in 1976 in case of barley

During induction of ovaries are floated on a liquid medium having low auxin and kept in dark while for regeneration they are transferred to an agar medium with higher auxin concentration and incubated in light.

In vitro parthenogenesis

Haploid plants generally originate from egg cell in most of species (rice)

In vitro apogamy

When haploid plants originate from other than egg cell called synergid (rice) or antipodal(Allium tuberosum)

Limitation

- Ø The frequency of responding ovaries (1 – 5%) and the number of plants / ovary (1-2) is low
- Ø It has been successful only in lesser number of plant species

Advantages of ovary culture

1) Ovary/ ovule culture may be useful when there is male sterility in crop species
2) For in vitro pollination and fertilization or for embryo rescue
3) To produce parthenogenetic haploids (wheat, barley,)
4) To understand the physiology of fruit development
5) Reduction in the frequency of albino plants

Following pollination , whole flower buds are excised (2-15 days pollination) Calyx, corolla and stamen are removed. Ovaries are then surface sterilized and inoculated. To obtain unpollinated ovaries, flower buds are removed 24-48 hours prior to anthesis

Ovule culture

Flowers are sterilized inoculated on pre culture medium. After 10 to 14 days ovules are removed from flowers and plated on medium. Ovule requires exclusive skill . Ovule culture is

mainly tried only in those cases where embryo aborts very early, and embryo culture is not possible due to difficulty of its excision at a very early stage.

EMBRYO CULTURE

Embryo culture is the aseptic isolation and growth of sexually produced embryos *in vitro* with the objective of obtaining viable plants.

In 1904, Hanning published the first report on embryo culture in cruciferae.

Types of embryo culture

1) Culture of immature embryos (hybrid seed0
2) Culture of mature embryos (to avoid inhibition in germination)

Isolation of embryo

The embryo excision operation is performed aseptically in a laminar flow hood. A stereomicroscope equipped with a coolary fluorescent lamp is required for excision of small embryos . Soaking a hard coat seed in water facilitates easy excision. The excision of smaller or immature embryos require careful dissection

Culture strategies

Sometimes young embryos may prove difficult to culture directly on the medium . In such cases, embryos may be placed onto or implanted into developing endosperm that are cultured in vitro. This technique is known as embryo-nurse endosperm technique

Precocious germination

When excised immature plant embryos are grown in vitro , they do not proceed further for its maturation and start germinate . This phenomenon without completing normal embryogenic development is known as precocious germination

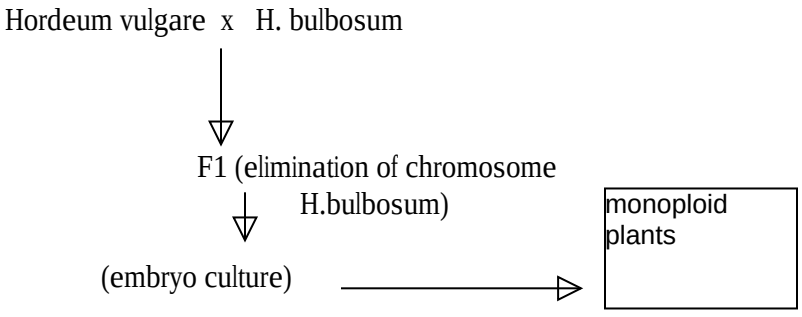
Practical applications of embryo culture

1. rescuing embryos from incompatible crosses
   in interspecific and intergeneric hybridization programmes, incompatability barriers often prevent normal seed development and production of hybrids due to post zygotic barriers and causes embryo abortion. . In such cases isolating the embryo and culturing in vitro may give useful results
2. overcoming dormancy and shortening breeding cycle
   a) the life cycle of Iris was reduced from 2 – 3 years to less than one year. It is possible to obtain two generations of flowering against one in Rosa spp.
   b)germination of the immature embryos of orchid seeds

c) dry storage wild oat (Avena fatua)

3. overcoming seed sterility
   in early ripening fruit cultivars seeds do not germinate because their embryos are still immature
   eg. Peach, apricot, plum , coconut
4. production of monoploids
   bulbosum technique
   In interspecific hybridization between Hordeum vulgare and Hordeum bulbosum the zygote is formed but during the development of embryo subsequently the chromosomes of H.bulbosum are eliminated and monoploid embryos of H.vulgare are formed . However the monoploid embryos are weak and show slow growth and on the other hand when these

monoploids are dissected and cultured in vitro they develop into monoploid plants are produced.



5. clonal micropropagation
   eg. Pinus elliotti, graminae, coniferae
6. seed testing : rapid means of determining viability of particular lot of seeds eg. Seeds of conifers, shrubs, vines and fruit trees

other application

a) to study some fundamental problems in experimental embryogenesis
b) host pathogen interaction, eg.formation of ergot by infection of rye embryos by *Claviceps purpurea* and fusarium wilt of seedlings. In later cases , incorporation of fungal toxin fusaric acid into culture medium interfere with water uptake by germinated embryos of Phaseolus vulgaris and induce characteristics wilting of embryonic leaves
c) cultured embryos have been used as test objects to evaluate the mutagenic ability of irradiated substrates on living tissue. For this embryos of certain cereals were plated on X irradiated nutrient medium for evaluation

PROTOPLAST ISOLATION,PROTOPLAST FUSION AND SOMATIC HYBRDISATION

WHAT IS A PROTOPLAST?

The entire plant cell without its cellulosic cell wall and protoplasts are functional individual cell with plasma membrane as outermost layer .

What is protoplast culture?

In vitro culture of protoplast

Sources of protoplast

a) mesophyll cells of leaves
b) cultured suspension cells
c) callus culture
d) preconditioned plant material

Isolation of protoplast

methods of protoplast isolation can be classifed into two main groups

1) mechanical method (non enzymatic)

2) enzymatic → sequential method (two step method)

→ mixed method (single step method)

Mechanical method:

It is done by cutting plasmolysed cells with a sharp edged micro scalpel or knife after keeping the material under microscope. The protoplasts are released and and the cells are deplamolysed. This method is useful for isolation of protoplasts from vacuolated cells (eg. Onion bulbs, scales, radish roots) this method gives poor yield of protoplasts and is not suitable for isolating protoplasts from meristematic and less vacuolated cells. The mechanical method though was used as early as 1982, in now only rarely used for isolation of protoplasts

Enzymatic method

Commercially available enzymes

a) pectolyase Y 23
b) cellulase =onozyka R10
c) meicelase
d) rhozyme
e) macerozyme R 10
f) hemicellulase
g) pectinase
h) drieselase

the role of enzymes is to dissolve middle lamella and dissolving cell wall. A combination of these enzymes in a concentration of 0.5 to 20% is used . In many cases the macerozyme and cellulase are sufficient to obtain protoplast in significant umber. The enzyme solution is prepared in 10-15% sorbitol or mannitol containing small amount of $CaCl_2$ (7mM) for membrance stability.

Sequential method:

This involves initial incubation of macerated plant tissue with pectinase (macroenzyme) which inturn are then converted into protoplasts by cellulase treatment.

Mixed enzymatic

Plant tissue are plasmolysed in the presence of a mixture of pectinase and cellulases thus inducing simultaneous separation of cells and degradation of cell wall to release protoplast directly.

After enzyme treatment protoplast suspensions are collected by centrifugation (60 –100 rpm) for 2 – 5 minutes. Then washed in medium without enzyme. Cell debries are removed and the protoplasts are placed in a medium with appropriate concentration of sucrose or mannitol..

This method is widely used since

1) large quantities of protoplasts can be obtained
2) the cells are not broken as in case of mechanical isolation
3) Osmotic shrinkage is less
4) Takes reduced time
5) Lesser contamination

Osmoticum

Osmoticum is a solution causing changes in osmatic pressure. During isolation and culture , protoplasts require osmotic protection until they regenerate a strong wall. Inclusion of an osmoticum in both isolation and culture media prevents rupture of protoplasts. The most widely used osmotica are sorbitol, mannitol, glucose, or sucrose.

Subprotoplasts

Subprotoplast do not contain the entire contents of plant cells and include the following

Cytoplast

The protoplasts lacking a nucleus and each contains entire cytoplasm of a cell

Miniprotoplast / karyoplast

Isolated protoplasts contain a nucleus surrounded by some cytoplasm and the original outer plasma membrane

Microplast

The protoplast contain only a fraction of cytoplasm and outer membrane

Microprotoplast

The protoplats containing only a few of all chromosomes and a fraction of the cytoplasm

Viability of protoplast

The viability of protoplast is tested by

1) Observing the presence of cytoplasmic streaming
2) Exclusion of Evans Blue dye
3) Change in protoplast size due to change in the level of osmoticum
4) Presence of photosynthetic and respiratory activity
5) FDA (Fluorescein DiAcetate) or CFW Calcofluor white (CFW) test.

Minimum plating density

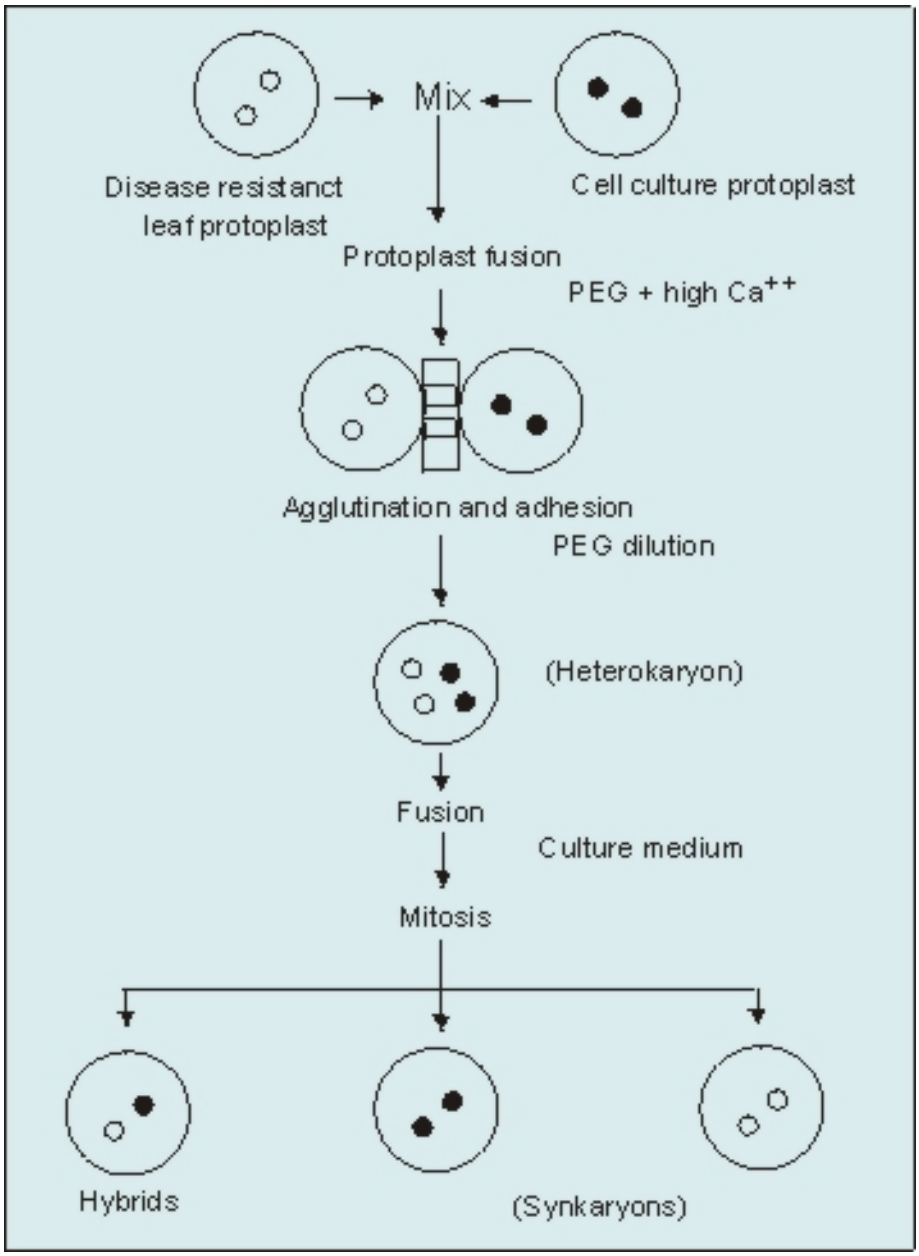
A minimum plating density of protoplasts is requied for growth to begin eg. 5×10^3.to 1×10^5protoplast / cm^3 for tobacco

Culture of protoplast

The first step in the protoplast culture is the development of a cell wall around the membrane of isolated protoplast. This is followed by induction of division in the protoplast derived new cell giving rise to a small cell colony. By manipulation of the nutritional and physiological conditions in the nutrient media, cell colonies may be induced to grow callus continuously or to regenerate whole plants

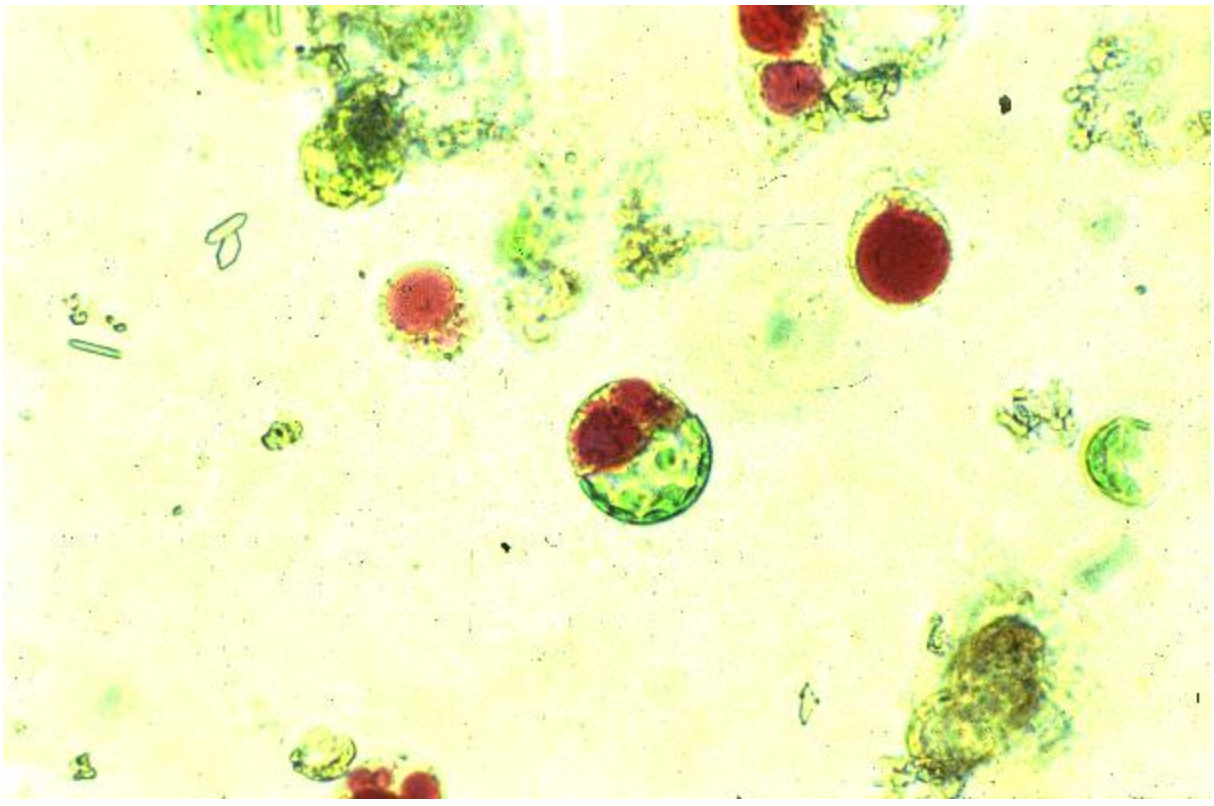
Protoplast fusion

Protoplasts fusion or somatic hybridization is one of the most important uses of protoplast culture. This is particularly significant for hybridization between species or genera, which can not be made to cross by conventional method of sexual hybridization.



Somatic hybridization

In vitro fusion of plant protoplasts derived either from somatic cell of somatic plant or from two genetically different plant is called somatic hybridization



Methods of protoplasts fusion

1) Spontaneous fusion
2) Induced fusion

Spontaneous fusion

Protoplasts during isolation often fuse spontaneously and this phenomenon is called spontaneous fusion. Simply physical contact is sufficient to bring about the spontaneous fusion among similar parental protoplasts. The occurrence of multinucleate fusion bodies is common when cells are prepared from actively dividing cells. Spontaneous fusion usually gives rise to homokaryon usually intraspecific. Protoplasts of young leaves undergo spontaneous fusion frequently. This type of fusion can be done with the help of micromanipulators or micropipettes.

Induced fusion

Induced fusion

For achieving interspecific and intergeneric fusion the following methods are followed

1) Chemical method
2) Electric method
3) Mechanical method

The induced fusion requires a suitable agent called fusogen. The inducing agents first brings the protoplasts together and then causes them to adhere to one another for bringing about fusion.

Chemofusion

The following chemicals are used as fusogens

1) $NaNO_3$ (isolated protoplasts are suspended in an aggregation mixture of 5.5% $NaNO_3$ in 10% sucrose solution)

2) Poly Ethylene Glycol (PEG)(1 ml of protoplasts suspended in a culture medium with 1ml of 56% of PEG and tube shaken for 5 seconds. The protoplasts are allowed to sediment for 10 minutes washed with growth medium and examined for successful agglutination and fusion)

When the quantity of protoplast is less drop cultures can be used. Protoplasts are placed as microdrops in petriplates to which PEG (50µl each)are added to each drop and kept for 5-10 minutes.

3) Calcium ions (Ca^{++})(spinning the protoplasts in a fusion inducing solution (0.05M $CaCl_2 2H_2O$ in 0.4M Mannitol at high pH of 10.5)
4) Proteins: (Gelatin and early products of its degradation at a concentration of 2.5% induced aggregation at high frequency within one hour (eg. Vicia, glycine, allium).

Electric fusion

If protoplasts are placed into a small vessel containing electrodes and a potential difference is applied then the protoplasts will line up between the electrodes. Afterwards an extremely short square wave electric shock is applied protoplasts can be induced to fuse.

Mechanical fusion

The isolated protoplasts are brought into intimate physical contact mechanically under microscope using micromanipulatorand perfusion micropipette.

Selection of somatic hybrids

The protoplasts suspension recovered after a treatment with fusogens consists of following types

1. unfused prototplasts of two species/strains
2. products of fusion between two or more protoplasts of the same (homokaryon)
3. hybrid protoplast produced by fusion between protoplasts of two species(heterokaryon)

effective strategy has to be employed for the identification somatic hybrids of heterokaryon in nature and they should be isolated. This step is called selection of hybrid cells.

Methods of selection of somatic hybrids

1. Somatic visual markers

   Hybrids of Petunia parodii (green) with P.hybrida (white) could be isolated in the form of green callus which represented only hybrid cells.
2. biochemical basis for complementation

   This selection strategy exploits thse natural properties of the two parental species which show complementation in the hybrid cells and at same time permit their selection.
   a. auxin autotrophy: the parental protoplasts of Nicotina glauca and Nicotiana longsdorffi requires an auxin compound in order to proliferate, whereas hybrid callus tissue needs no such requirement since the hybrid cells are auxin autotrophic
   b. protoplast of Petunia hybrida form calli on the MS medium while those of P.parodii produce only small cell colonies. Further actinomycin (1µg/ml) inhibits cell division of P.hybrida protoplasts, but it has no effect on those of P.parodii, Thus protoplasts of both these Petunia species fail to produce macroscopic colonies on MS medium supplemented with 1µg/ml actinomycin D whereas hybrid cells divide normally and produce macroscopic calli.
3. to culture the entire protoplast population
4. labeLling: protoplasts of two parents may be labeled by different fluorescent agents, which will then enable the selection of hybrids
   i. octadeconyl amino fluorescent
   ii. octadecyl palamine

5. Fluorescent Assorted Cell Sorter (FACS)

Symmetric hybrids:

Some somatic hybrid plants retain the full or nearly full somatic complements of the two parental species ; they are called symmetric hybrids.

Asymmetric hybrids

Many somatic hybrids exhibit the full somatic complement of one parental species are lost during the preceding mitotic divisions; such hybrids are referred to as asymmetric hybrids.

CYBRIDS

Cybrids or cytoplasmic hybrids are cells or plants containing nucleus of one species but cytoplasm from both the parental species.

Cybrids can be produced in the following methods

1. fusion of normal protoplasts from one parent with enucleated protoplasts from the other parent. Enucleated protoplasts can be obtained by high speed centrifugation (20,000 – 40,000g for 45 – 90 minutes) of protoplasts or by irradiation treatment
2. fusion of normal protoplasts form one parent and protoplasts containing non viable nuclei from the other
3. selective elimination of one of the nuclei from the heterokaryon
4. selective elimination of chromosomes of one parent at a later stage after fusion of the nuclei

Major application of cybrids

- to transfer the cytoplasmic male sterility (tobacco, tomato)
- to transfer antibiotic resistance character(tobacco)
- to transfer herbicide resistance (brassica)

Production of cytoplsmically male sterile lines in tomato

i. Mesophyll protoplasts of tomato (Lycopersicon esculentum) were treated with iodoacetamide (IOA) to inactivate mitochondria and

ii. Mesophyll protoplast of Solanum acaule (S.tuberosum) wre irradiated with ϒ or X rays to inactivate nuclei. The protoplast were mixed in 1:1 ratio and induced to fuse using $Ca^{++}$and PEG, leading to the production of heterologous hybrids. Among the fusion from the original cultivars with respect to morphology, physiology and chromosome number (2n = 24), but exhibited various degrees of male sterility

iii. The nuclear genotype of cultivar remains unaffected

iv. 100% probability of getting somatic hybrids

Applications of somatic hybridisation and cybridisation

i. For effecting wide hybridization

Interspecific hybrids

in genus Daucus and its relatives

in genus Nicotiana and Brasscia

Intergeneric

Rice + Echnichloa = oryzochloa

Raphanus sativus + B.oleracea = raphanobrassica

N.tabacum + Lycopersicon esculentum = solanopersicon

Solanum tuberosum + L.esculentum = solanopersicon

ii. To create recombinants in asexually propagated crops or sterile plants
Eg. Potato

iii. Overcoming the barriers of self incompatability
Eg. Nicotiana tabacum x N.nesophila (disease resistant)

iv. Production of cms lines

v. Production of herbicide tolerant plants (brassica)

CRYOPRESERVATION / IN VITRO GERMPLASM PRESERVATION

Modes of conservation of germplasm

i. In situ conservation

The method of conserving land races and other genotypes in their own habitat. This mode of conservation has some limitations . Due to environmental hazards some of the material may be lost. The cost of maintaining a large proportion of available genotypes in nurseries or fields is very high and tedious

ii. Ex situ conservation

This is a modern method of preserving germplasm.. Seeds or *in vitro* maintained plant cells, tissues and organs are preserved under appropriate conditions for long term storage as gene banks

Advantages of this type of conservation

- large amount of material can be preserved in small area
- it overcomes the destruction due to environmental hazards
- it provides large amounts of plant material for culturing

What is cryopreservation?

Preservation of seeds, cells , tissues and organs in liquid nitrogen is called cryopreservation It is based on the reduction and subsequent arrest of metabolic functions of biological material by imposition of ultra low temperature. At the temperature of liquid nitrogen (-196C) almost all the metabolic activities of cells are ceased and the sample can then be preserved in such state for extended periods. However, only few biological materials in their natural state, can be frozen to sub freezing temperatures without adversely affecting the cell viability . However, it requires efficient regeneration protocols through tissue culture of the species.

What materials can be used for cryopreservation?

Embryos, embryoids(conifers, pollen embryos in tobacco), shoot tips (carnation, solanum sp.), callus cultures (chrysanthemum sp) , cell suspension (capsicum), protoplast (carrot)

Strategies

- Normal growth (short to medium storage0
- Slow growth;

the growth rate can be smothered by using different enclosures for culture vessels, reduction in temperature, inclusion of osmoticum, growth retardants, modification of gaseous environment , induction of storage organs, minimal growth media

- Suspension growth:

Cryo storage / cryopreservation of cells, protoplasts etc.

what is a cryoprotection?

It is a process that prevents the formation of ice crystals in cells and protect them from toxic solution effect due to water loss from the cytoplasm

Cryoprotectants

Several chemicals such as dimethyl sulphoxide (DMSO) , glycerol, various sugars and sugar alcohol protect living cells against damage during freezing and thawing i.e. they make the storage material not to become frozen . These compounds lower the temperature at which freezing first occurs and can alter the crystal habit of ice when it separates. The colligative properties of the cryoprotectants minimizes the harmful action of electrolytes concentration resulting from conversion of water into ice. High solubility in aqueous phase and low toxicity to the cells are the two essential characteristics for cryoprotectants.

Two types of cryoprotectants are permeating and non permeating

What is permeating cryoprotectant

cryoprotectant that can permeate are called permeating cryoprotectant eg. DMSO, methanol, glycerol

what is non permeating cryoprotectant?

Not able to permeate eg. Sucrose, mannitol, sugar alcohol, dextran, polyvinyl pyrrolidone, hydroxy ethyl starch

Steps in cryopreservation

1) Freezing
2) Storage
3) Thawing
4) Reculture

Freezing and storage:

a. slow freezing method

initially the temperature is frozen at the rate of 0.5 to 4°C per minute from the temperature of 0° C till it reaches -100°C and finally transferred to liquid medium

b.rapid freezing method

the material is frozen rapidly by or by pouring plunginig into liquid nitrogen

c. droplet freezing: In this method the cryoprotectant treated meristems are dispensed in droplets of 2-3 microlit on an aluminium foil in a petriplate. The specements are frozen by slow cooling (0.5 C /min) to a subzero temperature between –20C to 40C prior to immersion in liquid nitrogen.

stepwise method

slow freezing rate initially (1 to 5 °C per minute) for 30 minutes and afterwards rapidly cooled by pluning into liquie N_2

dry freezing method

materials dehydrated by drying in an oven or under vacuum

a cryoprotectant like DMSO (5-8%), Glycerol (10%) must be added to the culture medium to protect the cells from ice injury. The frozen cells and tissues are stored in a liquid nitrogen refrigerators.

Thawing

Thawing of the frozen materials is achieved by plunging vials into warm water (37 – 40 °C for 90 seconds , washed several times to remove the cryoprotectant and preserved in ice bath

Reculturing

The cells/tissue/shoot tips may be transferred to the required fresh medium after thawing for regeneration

Slow growth culture

Slow growth of cultures may be achieved by maintaining the plantlets either at low temperature (4-9°C) or on a suitable medium having high osmotic concentration. In addition the nutritional status may be lowered down to restrict the growth.

Advantages of in vitro conservation

- Ø within a little space , a large number of plants can be maintained
- Ø pathogen free condition is maintained
- Ø protection against natural disorders
- Ø easy movement of planting material across the countries beacuase it ensures appropriate quarantine measures
- Ø storage of pollen for enhancing longevity
- Ø establishment of germplasm banks
- Ø conservation of cell lines producing medicines
- Ø conservation of somaclonal and gametoclonal variation in culture

Vitrification: It involves a freeze induced cell dehydration step prior to liquid nitrogen storage. The efficiency of this method depends on the ability of highly concentrated solutions of cryoprotectants to supercool to very low temperature with rapid coolingto become viscous at sufficiently low temperatures, and solidify without the formation of ice.

Encapsualtion:

This technique is used in synthetic seed technology by coating somatic embryos in alginate beads.

Applications of cryopreservation

1. conservation of genetic uniformity
2. preservation of rare genomes
3. freeze storage of cell cultures and cell lines
4. maintenance of disease free material
5. cold acclimation and frost resistance
6. retention of morphogenetic potential in long term cultures.

Organizations involved in cryopreservation

IBPGR – International Board for Plant Genetic Resources
CIAT – Centro International de Agricultura Tropical
IRRI – International Rice Research Institute
NBPGR – National Bureau of Plant genetic Resources

ਵੱਧਣਾ ਦੇ ਕਾਰੋਬਾਰ ਵਿੱਚ ਗਾਹਕਾਂ ਦੀ ਭੂਮਿਕਾ :- Buying House

ਇਹ ਸਿਫ਼ਾਰਿਸ਼ ਕੀਤੀ ਜਾਂਦੀ ਹੈ ਕਿ ਦੀਗਲਾਰੇਸ ਦਾ ਮਾਰਕੀਟਿੰਗ ਮੈਕਟਰ ਉਸੇ ਵੱਧਣ ਨਿਰਮਾਤਾ ਦੇਸ਼ ਨਾਲੋਂ ਘੱਟ ਕੀਮਤ ਤੇ ਉੱਚ ਗੁਣਵੱਤਾ ਵਾਲੇ ਉਪਾਦ ਦਾ ਉਪਾਦਨ ਕਰ ਸਕਦਾ ਹੈ। ਨਤੀਜੇ ਵਜੋਂ, ਦੀਗਲਾਰੇਸ ਨੇ ਵਿਸ਼ਵ ਦੇ ਵੱਧਣਾ / ਖਰੀਦਦਾਰੀ ਦੀ ਸਾਖ ਵਿੱਚ ਇੱਕ ਵਿਸ਼ਾਲ ਸਥਾਨ ਪ੍ਰਾਪਤ ਕੀਤਾ ਹੈ, ਜੋ ਕਿ ਕੱਪੜੇ ਖਰੀਦਣ ਵਾਲੇ ਘਰ ਦੇ ਸੰਤੁਲਨ ਕੋਣ ਨਾਲ ਵੀ ਸੰਬੰਧਿਤ ਹੈ।

ਘਰ ਖਰੀਦਣਾ [Buying House]:-

ਇੱਕ ਖਰੀਦਦਾਰ ਘਰ ਖਰੀਦਦਾਰ ਅਤੇ ~~ਨਿਰਮਾ~~ ਨਿਰਮਾਤਾ ਵਿਚਕਾਰ ਇੱਕ ਮੀਡੀਆ ਹੈ। ਇਹ ਇੱਕ ਖਰੀਦਦਾਰੀ ਏਜੰਸੀ ਜਾਂ ਖਰੀਦਦਾਰੀ ਦਫ਼ਤਰ ਹੈ। ਏਹ ਸਥਾਨ ਦੇ ਵੱਖ ਵੱਖਰੇ ਅਤੇ ਹਨ। ਖਰੀਦ ਏਜੰਸੀ ਇੱਕ ਸੁਤੰਤਰ ਖਰੀਦਦਾਰ ਦੇ ਖੇਤਰੀ ਦਫ਼ਤਰ ਹੈ, ਜਿਥੇ ਹਰ ਉਸ ਦੇ ਖੇਤਰੀ ਪੂਰਤੀ ਕੀਤੀ ਗਈ ਹੈ। ਵੱਖ ਵੱਖ, ਇੱਕ ਦਫ਼ਤਰ ਖਰੀਦਦਾਰ ਉਹ ਹੈ, ਜੋ ਵੱਖ ਵੱਖ ਖਰੀਦਦਾਰ ਅਤੇ ਬ੍ਰਾਂਡ ਨਾਮ ਇੱਕ ਸਥਾਨ ਤੇ ਕੰਮ ਕਰਦਾ ਹੈ। ਇਸ ਕੋਲ ਇਹ

ਸਾਰੀਆਂ ਕੈਟੇਗਰੀਆਂ ਖਰੀਦਦਾਰ ਤੇ ਨਿਰਭਰ
ਹਨ, ਹਰ ਖਰੀਦਦਾਰ ਤੇ ਨਹੀਂ।

ਗਾਰਮੈਂਟਸ ਵਰੇਹਾਊਸ ਦਿਓ ਪੂਰਾ Buying House ਖਰੀਦਦਾਰ ਦੀ ਪਰਿਭਾਸ਼ਾ

ਇਹ ਨਾਮ ਸਾਰਾ ਦਿਨ, ਇਹ Buying ਖਰੀਦਦਾਰ ਸਾਰੀਆਂ ਸਾਰੀਆਂ ਗਤੀਵਿਧੀਆਂ ਦੇ ਸੁਮੇਲ ਨੂੰ ਹੈ, ਜੋ ਕਿ ਸਿਰਫ ਇਕੋਸੀ ਕੰਪਨੀਆਂ ਦੇ ਖਰੀਦਦਾਰਾਂ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ, ਨਿਰਮਾਤਾਵਾਂ ਲਈ ਸਾਰਥਕ ਇਕੱਠ ਹਰੇਕ ਮੀਟਿੰਗ ਲਈ ਸਥਾਪਤ ਹੈ, ਸਗੋਂ ਸਥਾਨਕ ਕੰਪਨੀ ਖਰੀਦਦਾਰ ਫੈਕਟਰੀਆਂ ਨੂੰ ਸਾਰਥਕ ਦੇਣ ਲਈ ਉਹ ਕੈਟੇਗਰੀ ਸਾਰਿਤ ਪੁਰਸ਼ ਹਰ ਨਾਲ ਹੀ ਸਥਾਪਤ ਹੈ। ਖਰੀਦਦਾਰ ਅਤੇ ਨਿਰਮਾਤਾ।

ਦੀਗਲਾਹੋਣ ਦੇ ਕੰਪਨੀ ਨਿਰਮਾਣ ਵੇਲੇ ਇਕ Buying ਖਰੀਦਦਾਰ ਸਤੰਤਰਤਾ ਨੂੰਸਰ ਨਿਰਯਾਤ ਹੈ। ਕਿਉਂਕਿ ਗਾਰਮੈਂਟਸ ਸੈਕਟਰ ਚਲੇ ਹੁਣ ਇਕੋਸੀ ਖਰੀਦਦਾਰ ਨਾਲ ਸਥਾਪਤ ਹੈ, ਹਰ ਇਕੋ ਖਰੀਦਦਾਰ ਹਰ ਖਰੀਦਦਾਰ ਲਈ ਕੰਪਨੀਆਂ ਨੂੰ ਹਰ ਸਿਸਟਮ ਨਿਰਯਾਤ ਹਨ। ਕਿਉਂਕਿ ਉਨ੍ਹਾਂ ਨੂੰ ਇਹੋ ਸਾਰਥਕ ਅਤੇ ਅੰਤਰਰਾਸ਼ਟਰੀ ਦੇਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦੇ ਹਨ, ਜਦੋਂ ਕਿ Buying ਖਰੀਦਦਾਰ ਇਕੋ ਉਨ੍ਹਾਂ ਦੀ ਸੰਗ ਅਨੁਸਾਰ ਗਾਰਮੈਂਟਸ ਉਤਪਾਦਨ ਸਥਾਪਤੀ

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ਕਰਕੇ ਉਨ੍ਹਾਂ ਨੂੰ ਸਮਾਜਿਕ ਸਹਾਇਤਾ ਪ੍ਰਦਾਨ ਕਰਦੇ
ਹਨ। ਇਕੱਲੀ ਬਜ਼ੁਰਗ ਔਰਤ ਬਜ਼ੁਰਗ ਮਰਦ ਵਾਂਗ
ਹੀ ਚੰਗੇ ਹੋਣ ਦੀ ਸੰਭਾਵਨਾ ਹੁੰਦੀ ਹੈ, ਜੋ ਬਜ਼ੁਰਗਾਂ
ਵਿਚ ਇਕ-ਇਕ ਵਧ ਜਾਂਦੇ ਹਨ, ਜਿਸ ਨਾਲ ਪਿਛਲੇ
ਸਾਲ ਪੀੜਤ ਵਿਚ ਬਜ਼ੁਰਗ ਹਲੇ ਤੋਂਮੋਟੇਰ
3-4 ਰਾਤੇ ਅੱਜੇ ਵਧੇ ਸਮਾਜ ਸਨ।

ਇਸ ਤੋਂ ਇਸਤੀਰੇ ਇਹ, ਇਹ ਔਰਤਾਂ ਜਿਸ
ਦੇ ਨਾਲ ਰਾਤੇ ਜਿਸਤਾ ਹੀ ਵਧ ਬਜ਼ੁਰਗ ਨੂੰ
ਚਲੀ ਤਾਂ ਜਿਤਰ ਹਨ, ਇਤਿਹਾਸ ਉਨ੍ਹਾਂ ਨੂੰ ਇਕ
ਨੇ ਨਾਰਕ ਨੇਤਾ ਦੱਸ ਹੈ। ਸਾਰਸਟ ਉਹਨਾਂ
ਨੂੰ ਜਿਤਰਾ ਵਰਨ ਇਹ ਸਾਰਨੀਕਾ ਤੋਂ ਦੇਖ ਤੇ
ਵਧ ਸਾਰੇ ਪਰਾਜ ਸਾਮਨ ਹੋਏ ਹਨ, ਜੋ ਜਿਸੇ
ਇਹ ਸਾਰ ਪੁਰਸ਼ ਪਿੱਛੇ ਵਰਨ ਸੰਤਰ ਨਹੀਂ ਹੈ।

ਸਮਾਜ ਤੋਂ, ਤੇ ਇਹ ਬਜ਼ੁਰਗ ਵਧ ਨੂੰ ਤੇਹਾਂ
ਕਿਤੇ ਕਾਰਜ ਕਰਨੇ ਚੰਦੇ ਹਨ:

1. ਬਜ਼ੁਰਗ ਤੋਂ ਨਾਰਕ ਸੇਵਾਨ।
2. ਨਾਰਕ ਨੂੰ ਪੁਰਾ ਕਰ ਨਵੀ ਚੰਗੇ ਸਮਾਜਿਕ
(ਸਮਾਜਕ ਫੈਕਟਰੀ) ਸੰਤਰ।
3. ਸਮਾਜਕ ਫੈਕਟਰੀਆਂ ਤੋਂ ਨਾਰਕ ਪ੍ਰੋਗਰਾਮਿੰਗ।
4. ਬਜ਼ੁਰਗਾਂ ਨਵੀ ਉਪਾਰ ਇਕਸਾਰ ਦੇ ਸਾਮੂਹ ਚਾਹੀਦਾ
5. ਸੋਸੀਅਲਾਂ ਪਹਾਨਗੀਆਂ ਨਵੀ ਬਜ਼ੁਰਗਾਂ ਨਾਲ ਸੰਪਰਕ
ਕਰਨ।
6. ਫੈਕਟਰੀਆਂ ਨੂੰ ਸਾਰੀਆਂ ਇੱਛਾਵਾਂ ਅਤੇ ਪਹਾਨਗੀਆਂ ਨੂੰ

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ਅੱਗੇ ਕੈਮਰੇ ਹੋਏ।
1. ਬਰੀਦਰ ਦੀ ਸੀਰ ਦੇ ਅਨੁਸਾਰ ਢਾਲੇ - ਸਾਧ
ਸਾਰਤ ਕੋਸੀਸਿੰਗ।
2. ਸਾਮੂਨੇ ਤੇ ਉਪਰਨ ਤੱਕ ਨੈਰੀਦੇ ਉਪਰ ਦੀ
ਗਾਹਕ ਚਹਦੀ ਰੱਖੋ।
3. ਬਰੀਦਰ ਦੀ ਸੀਰ ਦੇ ਅਨੁਸਾਰ ਸਿਰੀਦ ਸਿਰਾ
ਜੋ ਸਰਤ ਦੀ ਪਾਸਦ ਕੰਨੀ ਚਰੀਦੀ ਹੈ।
ਸਾਫ਼ ਦੀ ਸਿਪਿੰਗ।

Buying House ਦਾ ਸਿਫ਼ ਨਾਮਦਰ ਫੈਕਟਰੀਆਂ ਨਾਲ
ਕੰਮ ਕਰਦਾ ਹੈ, ਬਲਕਿ ਇਹ ਛੋਟੀਆਂ ਫੈਕਟਰੀਆਂ
ਨੂੰ ਵੀ ਸਦਰ ਕਰਦਾ ਹੈ। ਇਸ ਲਈ ਬਹੁਤ ਸਾਰੀਆਂ
ਛੋਟੀਆਂ ਫੈਕਟਰੀਆਂ ਵਧ ਗਈਆਂ ਹਨ, ਜਿਸ ਨਾਲ
ਬਾਸ ਬਰੀਦਰ ਨਹੀਂ ਹੈ। ਹਰ ਬਰੀਦਰ ਉਹ
ਨੂੰ ਕੱਪੜੇ ਦਾ ਸਾਰਤ ਪੂਰਾ ਕਰੇ ਇਸੀਲਈ
ਸੈਂਕ ਪੂਰਾ ਕਰਦਾ ਹੈ ਜੇਕਰ ਉਹ ਬਰੀਦਰ ਦੀ
ਸੀਰ ਨੂੰ ਟੀਮ ਕੱਚ ਦੇ ਸਾਰਤ ਪਰ ਹਨ ਦੀ
ਸਮਝ ਕੱਪੜੇ ਹਨ। ਨਤੀਜੇ ਵਜੋਂ, ਸਾਰੇ ਉਹਨੀ
ਗਾਰਮੈਂਟਸ ਫੈਕਟਰੀ ਚੋਣ ਦੇ ਗਾਰਮੈਂਟ ਮੈਕਟਰ ਹਿੰ
ਸਿਰਫ਼ ਕਲ ਨਵੀ ਡਿਜਾਰ ਹਨ, ਜੋ ਕਿ ਸਾਰਾ
ਨਵੀ ਬਾਸ ਕਰੇ ਕੱਪੜਿਆਂ ਦੇ ਵਾਂਗਾਰ ਨਹੀਂ
ਚਾਹੁ ਹੁੰਦੀਆਂ ਹੈ।

ਇੱਥੇ ਅਸੀ ਕੀਤ ਸਕਦੇ ਹਾਂ ਕਿ ਸਿਲਾਈ
ਜੋ ਬਰੀਦਰ ਹਰ ਹਿਸਦਾ ਸਬੰਧ ਇੱਕ
ਚੁਣੇ ਤੇ ਨਿਰਭਰ ਹਨ। ਇੱਕ ਦੀ ਹੋਰ ਦੇ

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ਤੇ ਚਿਨ੍ਹ ਸਾਇਜ਼ ਤੀ ਸੈਂਡ ਤੋ। ਨਤੀਜ਼ ਵੀ, ਪਰ ~~ਕਲੀਅਰ~~ ਨਾਲ ਕਵੇਰਾਨ ਅਤੇ ਨਿਸ਼ਾਨ ਵਿਚਾਰ ਦੂਰੀ ਚੱਟ ਸੱਚੀ ਤੋ।

ਜਾ ਸੱਚ, ਸੇਵਰ ਚੈਗਨਾਲੇਸ ਵਿਚ ਪਰ ਚਰੀਦ ਵਾਲੇ ਕੱਪੜੇ ਲੀ ਜਾ, ਤਾਂ ਸਾਡੇ ਦੱਖੇ ਕਪੜਿਆਂ ਦੇ ਚੇਤਰ ਵਿਚ ਕੀ ਤੋਇਆ ਤੋਵੇਗਾ। ਪਰੇ ਕਪੜਿਆਂ ਦਾ ਕਾਂਟੇਕਾਰ ਡਿੱਗ ਗਿਆ। ਫੈਕਟਰੀਆਂ ਨੇ ਕੱਪੜੇ ਦਾ ਕੋਈ ਸਾਰਥਕ ਨਤੀ ਮਿਲਦਾ, ਇਕੋਸੀ ਚਰੀਦਦਾ ਵੀ ਇਥੇ ਸਿੱਖੇ ਤੋਂ, ਤੇ ਕੋਈ ਸਾਰਥਕ ਨਤੀਂ ਦੇ ਸਕਦੇ ਜਾ।

ਚੈਗਨਾਲੇਸ ਦੇ ਸੈਕਟਰ ਦਾ ਨਵਾਂ ਨਾਮਕਰਨ ਤੋ: "ਫਰਾ ਫੋਰ RMG ਕਿਲੀਮਨ।" ਇਹ ਸਾਡੇ ਲਈ ਕੋਈ ਸਮਾਨ ਨਤੀ $50 ਤੋ। ਸਾਡੇ ਕੋਲ ਇਸ ਟੀਚੇ ਨੂੰ ਕੋਰ ਦੀ ਕਾਫੀ ਸਮਾਨਤਾ ਤੋ। ਸਾਡੀ ਚੈਗਨਾਲੇਸ ਸਾਫਟਵੇਅਰ ਦੀ ਵੀ ਵੇਖੇਲੋਚ, ਫਰਾ ਦੇ ਨਿਰਯਾਤ ਵਿਚ $50 ਕਿਲੀਮਨ ਦੇ ਚੈਪਟਰ ਦੀ ਵੀਸਰੇ $0 ਦਾ ਸੀ ਤਾਂ। ਇਸ ਸੀਨ ਪੱਧਰ ਨੂੰ ਹਾਸਿਲ ਕਰ ਲਈ ਚਾਹਿਦਾ ਹੁਨਿਮ ਸੁਰੀਮਾ ਦੇ ਛੋਟੇ ਦੇ ਕਪੜਿਆਂ ਦੇ ਚਰੀਦਦਾਰਾਂ ਤੋਂ ਚਰਤ ਸਾਡੇ ਸਾਰਥਕ ਵਿਕਰੇ ਕਰਕੇ ਸਤੋਂਤਦਪੂਰਨ ਕੋਸਲ ਮਿਤਦੇਗਾ।

ਉਪਰੋਕਤ ਤਰੀਕਿਆਂ ਨਾਲ, ਕੱਪੜੇ ਚਰੀਦਦਾਰ ਵਾਲੇ ਪਰ ਕਪੜਿਆਂ ਦੇ ਕਾਂਟੇਕਾਰ ਦੇ ਸੀਤੀਕਰਨ ਅਤੇ ਵੱਡੇ ਰਕਮਾਂ ਨੂੰ

ਕਰਨ ਅਤੇ ਸਹਿਯੋਗ ਭਾਵਨਾ ਪੈਦਾ ਹੁੰਦੀ ਹੈ।

ਮੈਨੇਜਮੈਂਟ ਅਤੇ ਵਰਕਰਾਂ ਦੇ ਵਿਚਕਾਰ ਸਹੀ ਸੰਬੰਧ ਹੋਣ ਨਾਲ ਹੀ ਉਦਯੋਗ ਦੀ ਉੱਨਤੀ ਹੁੰਦੀ ਹੈ। ਇਸ ਲਈ ਮੈਨੇਜਮੈਂਟ ਨੂੰ ਵਰਕਰਾਂ ਦੀਆਂ ਜਾਇਜ਼ ਮੰਗਾਂ ਨੂੰ ਮੰਨਣਾ ਚਾਹੀਦਾ ਹੈ ਅਤੇ ਉਨ੍ਹਾਂ ਦੀਆਂ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਹੱਲ ਕਰਨਾ ਚਾਹੀਦਾ ਹੈ।

ਕਾਰਜ

1. ਵਰਕਰਾਂ ਦੀ ਉਪਾਦਨ ਵਿਕਾਸ ਅਤੇ ਸਮੱਸਿਆ ਬਣਾਓ।
2. ਆਪਣੇ ਨੇੜੇ ਦੀ ਕੋਈ ਸਹਯੋਗਿਕ ਇਕਾਈ Buying ਦਾ ਦੌਰਾ ਕਰੋ ਅਤੇ ਉਨ੍ਹਾਂ ਦੀ ਸਮੱਸਿਆ ਦਿਖਾਓ।
3. ਵਰਕਰਾਂ ਨਾਲ ਸੰਪਰਕ ਕਰਨ ਅਤੇ ਉਨ੍ਹਾਂ ਦੀਆਂ ਸਮੱਸਿਆਵਾਂ ਦੇ ਪੂਰਤੀ ਲਈ ਸੁਝਾਅ ਦਿਓ।
4. ਵਰਕਰਾਂ ਨਾਲ ਸੰਪਰਕ ਕਰਨ ਅਤੇ ਉਨ੍ਹਾਂ ਦੀਆਂ ਸਮੱਸਿਆਵਾਂ ਦੇ ਪੂਰਤੀ ਲਈ ਸੁਝਾਅ ਦਿਓ।
5. ਵਰਕਰਾਂ ਦੀ ਸਮੱਸਿਆਵਾਂ ਅਤੇ ਵਰਕਰਾਂ ਦੀਆਂ ਮੰਗਾਂ ਤੇ ਵਰਕਰਾਂ ਦੀਆਂ ਟਿੱਪਣੀਆਂ ਨੂੰ ਲਿਖੋ।

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fashion designing

Apparal sector → ਇਸ ਵਿੱਚ ਉਹ ਕੰਪਨੀਆਂ ਸ਼ਾਮਿਲ ਹਨ ਜੋ ਕੱਪੜੇ, ਜੁੱਤੀਆਂ ਅਤੇ ਸਹਾਇਕ ਉਪਕਰਣ ਨੂੰ ਵੇਚਦੀਆਂ ਅਤੇ ਦੇਖਦੀਆਂ ਹਨ ਜਿਨ੍ਹਾਂ ਵਿੱਚ Design ਤੋਂ ਲੈ ਕੇ ਮਾਰਕੀਟਿੰਗ ਤਕ underwear ਸ਼ਾਮਲ ਹਨ। Luxury

- ਸਾਰੇ Retail Apparal Industry [ਪ੍ਰਚੂਨ ਲਿਬਾਸ ਉਦਯੋਗ] ਜਾਂ ਗੱਲ ਕੀਤੀ ਜਾਂਦੀ ਹੈ ਤਾਂ ਸਾਡੇ ਮੰਨ ਵਿੱਚ ਇਹ ਆਉਂਦਾ ਹੈ ਕੱਪੜੇ, ਸਾਡੇ ਦੇ ਸੂਟ, ਪਰਸ ਅਤੇ Underwear, Sleepwear ਜਾਂ ਇਹਦੇ ਵਰਗਾ ਸ਼ਾਮਿਲ ਹੈ ਅਤੇ Accessory ਇੱਥੇ ਉਦਾਹਰਣ - ਜੈਵੀ ਚੀਜ਼ ਚੀਜ਼ ਵੀ ਸ਼ਾਮਿਲ ਹਨ। Luxury

* Exporting → ਜਿਹਨਾਂ ਇੱਕ ਦੇਸ਼ ਵਿਚ ਪੈਦਾ ਕੀਤੇ ਗਏ ਉਤਪਾਦ ਜਾਂ ਸੇਵਾ ਨੂੰ ਦੂਸਰੇ ਦੇਸ਼ ਵਿਚ ਖਰੀਦਣ ਨੂੰ ਵੇਚਿਆ ਜਾਂਦਾ ਹੈ। ਜਿਸਨੂੰ ਆਖਿਰ ਉਦਾਹਰਣ ਦੇ ਤਰ ਤੇ ਦੂਜੇ ਮੁਲਕ ਵਿੱਚ ਇੱਕ ਸਾਧਨ ਨੂੰ ਅਤੇ

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ਦੇਸ਼ ਵਿਚਕਾਰ ਵੱਖੋ ਵੱਖਰ ਤੇ ਨਿਰ ਹੈ।

Advantages and disadvantages of exporting

ਹਰੇਕ ਅਰਥਵਿਵਸਥਾ ਤੋਂ ਬਾਹਰ ਨਿਰਯਾਤ ਕਰਨ ਨਾਲ ਕਾਰੋਬਾਰ ਨੂੰ ਵਧਣ ਸਕਦਾ ਹੈ। ਨਵੇਂ ਦੇਸ਼ਾਂ ਵਿਚ ਵਿਕਰੀ ਵਿੱਚ ਵਿਸਤਾਰ ਕਰਨ ਦੇ ਮੌਕੇ ਵਿੱਚ ਕਿਸੇ ਵੀ ਕੰਪਨੀ ਲਈ ਮਹੱਤਵਪੂਰਨ ਹੋ ਸਕਦੇ ਹਨ, ਮੌਜੂਦਾ ਦੇ ਨਾਲ-ਨਾਲ ਨਾਲ ਹੀ ਹਰ ਨਵੇਂ ਬਾਜ਼ਾਰ ਨੂੰ ਵਿਚਾਰ ਕਰਨ ਚਾਹੀਦਾ ਹੈ। ਹਾਲਾਂਕਿ ਇਹਨਾਂ ਫਾਇਦਾ ਵਿੱਚ ਮਦਦ ਤੋਂ ਪਹਿਲਾ ਉਨ੍ਹਾਂ ਨੂੰ ਜੋਖਮ ਚਾਹੀਦਾ ਹੈ।

Advantages of exporting [ਨਿਰਯਾਤ ਦੇ ਫਾਇਦੇ]

- ਤੁਸੀਂ ਆਪਣੇ ਫਾਇਦਾ ਨੂੰ ਸੰਤੁਲਨ ਤੋਂ ਤੇ ਵਧਾ ਸਕਦੇ ਹੋ, ਜਿਸ ਨਾਲ ਤੁਸੀਂ ਵਿੱਚ ਤੇ ਘੱਟ ਨਿਰਭਰ ਹੋ।
- ਵੱਖ ਉਪਾਦਨ ਪੈਮਾਨੇ ਅਤੇ ਵਿਹਤਰ ਸਾਰੀਆਂ ਚੀਜ਼ਾਂ ਵੱਡੀਆਂ ਅਰਥਵਿਵਸਥਾਵਾਂ ਦੀ ਅਗਵਾਈ ਕਰ ਸਕਦਾ ਹੈ।
- ਹਾਰ ਬੋਸ ਅਤੇ ਵਿਕਾਸ ਦਰਜ ਸਕਦਾ ਹੈਸਹਯੋਗ ਕਰ ਸਕਦਾ ਹੈ ਜਿਹੜਾ ਤੁਸੀਂ ਨਵੇਂ ਫਾਇਦਾ ਦੇ ਸਮਰਥਨ ਮੌਸਮ ਉਪਾਦ

ਨੂੰ ਚਲਾ ਸਕਦੇ ਹੋ।

Disadvantages of exporting [ਨਿਰਯਾਤ ਦੇ ਨੁਕਸਾਨ]

ਜੇਕਰ ਤੁਸੀਂ ਸਹਯਾਨ ਨਹੀਂ ਹੋ, ਤੁਸੀਂ ਆਪਣੇ ਪਰਦੇਸ਼ ਦਾਸਤਾਂ ਲਈ ਮੌਸੂਦਾ ਗਾਹਕਾਂ ਤੇ ਵਿਸ਼ਾਲ ਬ੍ਰਾਜ਼ ਸਕਦੇ ਹੋ।
ਤੁਹਾਡੇ ਬ੍ਰਸ਼ਾਸਨ ਦੇ ਬਰਤੇ ਵਧ ਸਕਦੇ ਹਨ ਕਿਉਂਕਿ ਤੁਹਾਨੂੰ ਜ਼ੁਰੀਅਨ ਜ਼ੁਰੀਅਨ ਤੋਂ ਦਾਤਰ ਵਧਾਰ ਰਖਦੇ ਸਮੇਂ ਨਿਰਯਾਤ ਨਿਯਮਾਂ ਨਾਲ ਨਸਿੱਠਣਾ ਪੈ ਸਕਦਾ ਹੈ।
ਤੁਸੀਂ ਹੋ ਸਿਸੇ ਸਿਸਤਿਆ ਦਾ ਸ਼ੁਧੀਪਨ ਕਰ ਰਹੇ ਹੋਵੋਗੇ, ਵਹੀ ਵਾਰ ਹਜ਼ਾਰ ਮੀਲ ਦੂਰ।
ਵਿਦੇਸ਼ੀ ਦਾਸਤਾਂ ਵਿੱਚ ਤੁਸੀਂ ਕੁਝ ਨਿਯੰਤਰਣ ਗੁਆ ਸਕਦੇ ਹੋ ਜਿਸਦੇ ਤੁਸੀਂ ਘਰ ਵਿੱਚ ਹਕਦੇ ਰਖਦੇ ਹੋ।
ਤੁਹਾਨੂੰ ਆਪਣੇ ਸਵੈ ਦਾਸਤਾਰ ਚਾਰੇ ਪਰਦੇਸ਼ ਦਾਸਤਾਰ ਨਾਲੋਂ ਵੱਖਰੇ ਢੰਗ ਨਾਲ ਸੋਚਣ ਦੀ ਲੋੜ ਹੋਵੇਗੀ। ਇਹ ਤੁਹਾਡੇ ਉਤਪਾਦਾਂ ਨੂੰ ਸਮੇਤਰਣ ਦੇ ਆਪਣੇ ਕਾਰਨਾਂ ਨਾਲ ਵੱਖਰੇ ਗਾਹਕ ਹੋਣਗੇ।

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what is Exporting? [ਨਿਰਯਾਤ ਕੀ ਹੈ?]

ਨਿਰਯਾਤ, ਸਧਾਰਨ ਸ਼ਬਦਾਂ ਵਿੱਚ, ਇੱਕ ਦੇਸ਼ ਵਿਚ ਨਿਰਮਿਤ ਚੀਜ਼ਾਂ ਅਤੇ ਉਤਪਾਦਾਂ ਨੂੰ ਦੇਖਣ ਦਾ ਕੰਮ ਹੈ ਪਰ ਫਿਰ ਦੂਜੇ ਵਿੱਚ ਵੇਚਿਆ ਜਾਂਦਾ ਹੈ। ਨਿਰਯਾਤ ਦਾ ਟੀਚਾ ਨਵੇਂ ਬਾਜ਼ਾਰਾਂ ਵਿੱਚ ਵਿਸਤਾਰ ਕਰਨਾ ਅਤੇ ਆਪਣੇ ਘਰੇਲੂ ਦੇਸ਼ ਦੇ ਸੁਰੱਖਿਅਤ ਬਿਸਤਰ ਕੁਝ ਸਾਰਥਿਕ ਪ੍ਰਾਪਤ ਕਰਨਾ ਹੈ।

ਦੁਨੀਆ ਭਰ ਦੇ ਅਜਾਰਾ ਹਰ ਕਾਰੋਬਾਰ ਲਈ, ਨਿਰਯਾਤ ਉਹ - ਨ ਦੇ ਕਾਰੋਬਾਰ ਨੂੰ ਵਧਾਉਣ ਅਤੇ ਵਧਾਉਣ ਲਈ ਸਭ ਤੋਂ ਮਹੱਤਵਪੂਰਨ ਹੈ। ਨਿਰਯਾਤ ਕਾਰੋਬਾਰ ਦੇ ਮਾਲੀਏ ਵਿੱਚ ਵਿਭਿੰਨਤਾ ਅਤੇ ਇਸਨੂੰ ਸੁਰੱਖਿਅਤ ਕਰਨ ਵਿੱਚ ਵੀ ਮਦਦ ਕਰਦਾ ਹੈ।

The challenges of Exporting [ਨਿਰਯਾਤ ਦੀਆਂ ਚੁਣੌਤੀਆਂ]

ਕਿਸੇ ਵੀ ਕਿਸਮ ਦੇ ਕਾਰੋਬਾਰ ਵਾਂਗ ਵਿੱਚ ਖਾਸ ਚੁਣੌਤੀਆਂ ਅਤੇ ਸੁਸਤਪਣਾ ਹੈ। ਹੇਠਾਂ ਕੁਝ ਚੁਣੌਤੀਆਂ ਹਨ ਜਿਨ੍ਹਾਂ ਦਾ ਤੁਸੀਂ ਇੱਕ ਨਿਰਯਾਤਕ ਵਜੋਂ ਸਾਹਮਣਾ ਕਰ ਸਕਦੇ ਹੋ:

(1.) Finding new Potential buyers [ਨਵੇਂ ਸੰਭਾਵੀ ਖਰੀਦਦਾਰਾਂ ਨੂੰ ਲੱਭਣਾ]

ਇਹੋ ਜਹੀ ਚੀਜ਼ਾਂ ਨੂੰ ਨਿਰਮਾਤ ਕਰਨ ਲਈ ਚੀਜ਼ਾਂ ਤੋਲਣਦੀਆਂ ਅਤੇ ਇਸਤੇਮਾਲ ਦੀ ਲੋੜ ਹੁੰਦੀ ਹੈ। ਉਦਾਹਰਨ ਲਈ, ਤੁਹਾਨੂੰ ਉਪਾਰਾਂ ਲਈ ਗਲੋਬਲ ਬਜ਼ਾਰਾਂ ਨੂੰ ਸਮਾਨੀ ਨਾਲ ਲੱਭਣ ਸਮਾਨ ਲੱਭਣ ਲਈ ਤੋਂ ਕਿਉਂਕਿ ਤੁਹਾਨੂੰ ਕੋਲ ਅਜਿਹੇ ਚਾਹਵਾਨ ਇੱਕ ਕੋਈ ਹਦਾਸ ਲੱਭਣ ਤੋਂ ਸਕਦਾ ਹੈ। ਤੁਹਾਨੂੰ ਇੱਕ ਰਣਨੀਤੀ ਦੀ ਚਣਉਂਦੀ ਪਵੇਗੀ ਜਿਸ ਦਿੱਤੇ ਸੌਂਤਆਲਰ ਅੰਤ ਤੁਹਾਡੇ ਰਾਂਮਚਾਰ ਨੂੰ ਖਰੀਦ ਕਰ ਦੇ ਗਾ ਦਿੱਤੇ ਨਾ ਆਵੇ।

ਸਹੀ ਬਜ਼ਾਰਾਂ ਲੱਭਣ ਦੀ ਕੋਈ ਕੋਰ ਵਾਂਗ ਨਹੀਂ ਹੈ। ਹਾਲਾਂਕਿ ਵਰਗੇ ਟੂਲਸ ਨਾਲ, ਤੁਸੀਂ Trademo Intel ਉਪਾਰ ਸੂਚੀਆਂ ਲਈ ਭਰੋਸੇਮੰਦ ਅਤੇ ਉੱਭਰ ਰਹੇ ਬਜ਼ਾਰਾਂ ਨੂੰ ਲੱਭ ਸਕਦੇ ਹੋ ਅਤੇ ਸੰਭਾਵੀ ਬਜ਼ਾਰਾਂ ਦੀ ਸੂਚੀ ਬਣਾ ਸਕਦੇ ਹੋ। ਤੁਸੀਂ ਲੱਭਣ ਅਤੇ ਪਲੇਟਫਾਰਮ ਲਈ ਇੱਕ ਤੁੱਸੇ ਦੀ ਚੋਣੀ ਕਰ ਸਕਦੇ ਹੋ।

(9.) Finding the right market for a specific product

ਕਿਸੇ ਖਾਸ ਉਤਪਾਦ ਲਈ ਸਹੀ ਬਾਜ਼ਾਰ ਲੱਭਣਾ :-

ਕਿਸੇ ਖਾਸ ਬਾਜ਼ਾਰ ਨੂੰ ਨਿਰਮਾਤ ਕਰਨ ਲਈ ਸਹੀ ਉਤਪਾਦ ਦੀ ਲੋੜ ਕਰਨ

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ਗਲੋਬਲ ਵਪਾਰ ਵਿੱਚ ਦੇਸ਼ਾਂ ਚੁਣੌਤੀਆਂ ਵਿੱਚ ਇੱਕ ਹੈ। ਹਰ ਮਾਰਕੀਟ ਦੀਆਂ ਵੱਖੋ ਵੱਖਰੀਆਂ ਲੋੜਾਂ ਅਤੇ ਲੋੜਾਂ ਹੁੰਦੀਆਂ ਹਨ। ਉਸ ਖੇਤਰ ਦੀ ਚੋਣ ਕਰਨ ਲਈ ਮਹੱਤਵਪੂਰਨ ਹੈ ਜਿਸ ਨੂੰ ਤੁਸੀਂ ਸਮਝ ਦਾ ਟੀਚਾ ਰੱਖ ਰਹੇ ਹੋ, ਵੱਖ ਵੱਖ ਖੇਤਰਾਂ ਵਿੱਚ ਬਰੀਦਾਰਾਂ ਦਾ ਧਿਆਨ, ਅਤੇ ਉਹਨਾਂ ਲਈ ਉਪਯੋਗ ਨੂੰਹਾਂ ਨੂੰ ਨੋਟ ਕਰੋ।

ਮੰਨ ਲਓ ਕਿ ਹਰ ਨਿਰਯਾਤ ਸਲਾਹਕਾਰ ਚਾਹੁੰਦਾ ਹੈ ਕਿ ਤੁਸੀਂ ਇਸਨੂੰ ਵਿਸ਼ਵ ਦੇ ਵੱਖ-ਵੱਖ ਖੇਤਰਾਂ ਵਿੱਚ ਕਿਵੇਂ ਸਫਲਤਾ ਪੂਰਵਕ ਮਾਰਕੀਟ ਕਰਦੇ ਹੋ। ਸਹੀ ਧਿਆਨ ਖੁੰਝੇ ਵਪਾਰ ਮਾਰਕ ਨੂੰ ਵਧ ਜਾਂ ਹੇਠਾਂ ਸਕਦੇ ਹਨ। ਸਹੀ ਧਿਆਨ ਦੇ ਵੱਲ ਵਲ ਸਹੀ ਤੁਹਾਨੂੰ ਵਿੱਚ ਸਫਲਤਾ ਦੇਸ਼ ਹੇਠ ਅਤੇ ਚੰਗ ਪੈਕੇਟਾਂ ਦੇ ਸੈਟ ਹੈ ਜੋ ਹੇਠ - ਅਧਾਰਿਤ ਵਪਾਰ ਟੈਸਟ ਸੈਟ ਵਿੱਚ ਤੁਹਾਡੀ ਸਫਲ ਕਰੇਗਾ।

3. Import / export duties & tariffs [ਆਯਾਤ / ਨਿਰਯਾਤ ਡਿਊਟੀ ਅਤੇ ਟੈਰਿਫ :—

ਦੁਸ਼ਾਰ ਵਰਤ ਉਪਾਵਾਂ ਤੇ ਨਿਰਯਾਤ ਡਿਊਟੀਜ਼ ਅਸਾਈਨਮੈਂਟਾਂ ਸੰਦੀਆਂ ਹਨ। ਨਿਰਯਾਤ ਡਿਊਟੀਜ਼

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ਤੇ ਇਲਾਵਾ ਦਰਮਦ ਟੈਗਿਟ ਵੀ ਹਨ ਜੋ ਨਿਰਜਾਤ ਨੂੰ ਪ੍ਰਭਾਵਿਤ ਕਰਦੇ ਹਨ। ਇੱਕ ਆਵਾਜ਼ ਟੈਗਿਟ ਇੱਕ ਟੈਗਿਟ ਹੈ ਜੋ ਇੱਕ ਦੇਸ਼ ਆਜ਼ਾਦ ਵੀ ਇੱਕ ਯੂਨਿਟ 'ਤੇ ਅਭਿਆਸ ਕਰਦਾ ਹੈ।

ਇਸ ਲਈ, ਇਹ ਉਨ੍ਹਾਂ ਗਾਹਕਾਂ ਲਈ ਵੱਲ ਨਾਗਰ ਨੂੰ ਦਖਾਏਗਾ ਜੋ ਹੁਣੇ ਉਤਪਾਦ ਨੂੰ ਖਰੀਦ / ਆਜ਼ਾਦ ਕਰਨ ਜਾ ਰਹੇ ਹਨ। ਸੇਵਰ ਹੁਣਾ ਨਿਸ਼ਾਨ ਦੇਸ਼ ਆਵਾਜ਼ ਟੈਗਿਟ ਨੂੰ ਦਖਾਉਂਦਾ ਹੈ, ਤਾਂ ਇਹ ਹੁਣੇ ਉਤਪਾਦ ਨੂੰ ਖਰੀਦ ਲਈ ਹੁਣੇ ਗਾਹਕਾਂ ਦੀ ਦਿਲਚਸਪੀ ਨੂੰ ਪ੍ਰਭਾਵਿਤ ਕਰ ਸਕਦਾ ਹੈ।

ਇਸ ਚੁਣੌਤੀ ਨੂੰ ਦੂਰ ਕਰਨ ਲਈ, ਤਾਨੂੰ ਆਜ਼ਾਦ ਅਤੇ ਨਿਰਜਾਤ ਟੈਗਿਟਾਂ ਨੂੰ ਧਿਆਨ ਵਿੱਚ ਰੱਖਦੇ ਹੋਏ ਆਪਣੇ ਉਤਪਾਦਨ ਦੀ ਕੀਮਤ ਨਿਰਧਾਰਤ ਕਰਨ ਦੇ ਯੋਗ ਹੋਣ ਦੀ ਲੋੜ ਹੈ। ਇਹ ਸੁਨਿਸ਼ਚਿਤ ਕਰੋ ਕਿ ਤੁਸੀਂ ਇਸਦੀ ਕੀਮਤ ਨੂੰ ਆਪਣੇ ਗਾਹਕਾਂ ਨੂੰ ਇੱਕ ਸੁਵਿਧਾਜਨਕ ਵਾਪਸੀ ਕੀਮਤ 'ਤੇ ਭੇਜਣ ਦੇ ਯੋਗ ਹੋ। ਤੁਹਾਡੀ ਸਥਲਾਈ ਨੂੰ ਚੁਣੌਤੀਪੂਰਨ ਤੌਰ 'ਤੇ ਕੀਮਤ ਦੇਣ ਦਾ ਇੱਕ ਤਰੀਕਾ ਹੈ ਇੱਕ ਸਾਲ ਫਾਰਵਰਡ ਦੀ ਵਰਤੋਂ ਕਰਨਾ।

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(4) Quality Standards [ਗੁਣਵੱਤਾ ਦੇ ਮਿਆਰ]

ਆਧਾਰ, ਨਿਰਯਾਤ ਟੀਚਿਆਂ ਤੋਂ ਇਲਾਵਾ, ਵਿਦੇਸ਼ੀ ਗੁਣਵੱਤਾ ਦੇ ਮਾਪਦੰਡਾਂ ਨੂੰ ਪੂਰਾ ਕਰਨ ਦੀ ਜ਼ਰੂਰਤ ਚਰਾਸਦਕਾਰਾਂ ਲਈ ਇੱਕ ਵੱਡੀ ਚੁਣੌਤੀ ਹੋ ਸਕਦੀ ਹੈ। ਉਦਾਹਰਨ ਲਈ, ਜਦੋਂ ਕੋਈ ਅਜਿਹੇ ਦੇਸ਼ ਵਿਚ ਚਰਾਗਾਹਾਂ ਦੇ ਨਿਰਯਾਤ ਦੀ ਗੱਲ ਆਉਂਦੀ ਹੈ ਤਾਂ ਸਖਤ ਨਿਯਮ ਹੁੰਦੇ ਹਨ ਜਿਨ੍ਹਾਂ ਨੂੰ ਚਰਾਹ ਸਾਰੇ ਕਾਰੋਬਾਰ ਨਵੇਂ ਚਾਰਾਗਾਹਾਂ ਲਈ ਪੂਰਾ ਕਰਨ ਵਿੱਚ ਅਸਫਲ ਰਹਿੰਦੇ ਹਨ। ਉਦਾਹਰਨ ਲਈ ਪੂਰਾ ਕਰਨ ਵਿੱਚ ਅਸਫਲ ਰਹਿੰਦੇ ਹਨ ਲਈ, ਜਦੋਂ ਸਮਾਨਿਆਂ ਦੀ ਗੱਲ ਆਉਂਦੀ ਹੈ ਤਾਂ (ਅਮਰੀਕਨ ਸਯਾਈਸ ਟੇਬਲ ਐਸੋਸੀਏਸ਼ਨ ASTA), ਦੁਆਰਾ ਤੈਅ ਕੀਤੇ ਗਏ ਮਾਪਦੰਡਾਂ ਦੇ ਚਰਾਹ ਸਾਰੇ ਜਿੰਮਿਆਂ ਵਿੱਚ ਉਮੀਦ ਕੀਤੇ ਜਾਂਦੇ ਹਨ।

ਹਾਲਾਂਕਿ, ਇਥੇ ਕੁਝ ਅੰਤਰ ਗੁਣਵੱਤਾ) ਸਿਆਰ ਵੀ ਹੈ ਜੋ FAO ਤੋਂ ਜਿੰਮਿਆਂ ਵਿੱਚ ਵੀ ਸਵੀਕਾਰ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਗੁਣਵੱਤਾ ਦੇ ਮਾਪਦੰਡਾਂ ਨੂੰ ਪੂਰਾ ਕਰਨ ਤੋਂ ਇਲਾਵਾ, ਉਨ੍ਹਾਂ ਨੂੰ ਚੁਣੌਤੀ, ਪੈਕਜਿੰਗ ਅਤੇ ਲੇਬਲਿੰਗ, ਤੇ ਵੀ ਧਿਆਨ ਦੇਣ ਦੀ ਲੋੜ ਹੈ ਕਿ ਉਹ ਅੰਤਰਰਾਸ਼ਟਰੀ ਮਿਆਰਾਂ ਨੂੰ

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(5.) The currency exchange rate [ਮੁਦਰਾ ਵਟਾਂਦਰਾ ਦਰ]

ਵਟਾਂਦਰਾ ਦਰ ਇੱਕ ਮੁਦਰਾ ਨੂੰ ਦੂਜੀ ਵਿੱਚ ਬਦਲਣ ਦੇ ਹਿਸਾਬ ਨਾਲ ਮੁੱਲ ਹੈ। ਅਰਥਸ਼ਾਸਤਰੀ ਮੁਲਾਂਕਣ ਕਰਦੇ, ਕਿਉਂ ਅਕਸਰ ਅਮਰੀਕੀ ਡਾਲਰ ਦੀਆਂ ਸਮਰੂਪ ਮੁਦਰਾਵਾਂ ਦੀ ਵਰਤੋਂ ਕਰਦੇ ਹਨ। ਜੇਕਰ ਕਿਸੇ ਵਿਦੇਸ਼ੀ ਮੁਦਰਾ ਦਾ ਮੁੱਲ ਸਥਾਨਕ ਮੁਦਰਾ ਦੇ ਬਰਾਬਰ ਵਧਦਾ ਹੈ, ਤਾਂ ਨਿਰਯਾਤ ਕਰਦੀਆਂ ਨੂੰ ਫਾਇਦਾ ਹੁੰਦਾ ਹੈ।

ਇਸ ਦੇ ਉਲਟ, ਜੇ ਵਿਦੇਸ਼ੀ ਮੁਦਰਾ ਦਾ ਮੁੱਲ ਘਟਦਾ ਹੈ, ਤਾਂ ਇਹ ਨਿਰਯਾਤ ਕਰਦੀਆਂ ਦੇ ਵਿਰੁੱਧ ਹੈ। ਉਦਾਹਰਨ ਵਜੋਂ, ਯੂਐੱਸ - ਚੀਨ ਵਪਾਰ ਯੁੱਧ ਦੇ ਕਾਰਨ ਯੁਆਨ ਦਾ ਮੁੱਲ ਦੇ ਮੁਕਾਬਲੇ ਘਟਿਆ ਹੈ। ਇਸ ਨੇ ਸ਼ਾਂਕਿ USD, ਯੂਐੱਸ ਸਰਕਾਰ ਨੂੰ ਅੱਗੇ ਦੀ ਮਾਰ ਗਏ ਭਾਰੀ ਟੈਰਿਫ ਦੇ ਬਾਵਜੂਦ, ਚੀਨ ਨੂੰ ਚੀਨ ਤੋਂ ਅਮਰੀਕਾ ਵਿੱਚ ਸਸਤੇ ਉਤਪਾਦਾਂ ਨੂੰ ਨਿਰਯਾਤ ਕਰਨ ਵਿੱਚ ਮਦਦ ਕੀਤੀ।

(6.) Pricing Strategy [ਕੀਮਤ ਦੀ ਰਣਨੀਤੀ]

ਕੀਮਤ ਉਹਨੇ ਰਣਨੀਤੀਆਂ ਨੂੰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਜੋ ਕੀਤੀ ਗਈ ਕੀਮਤ ਤੇ ਅਧਾਰਤ ਹੈ। ਹਰ ਸਾਲ

ਨਿਰਮਾਤਾਵਾਂ ਲਈ ਕੀਮਤ ਦੀ ਸਹੀਤੀ ਬਣਾਉਣ ਅਤੇ ਮਾਰਕੀਟ ਦੀ ਚੋਣ ਕਰਨ ਵਿੱਚ ਅਸਰ ਵਿੱਚ ਸਹਾਇਤਾ ਲਈ ਹਨ ਜੋ ਗਲੋਬਲ ਬਾਜ਼ਾਰ ਵਿੱਚ ਉਨ੍ਹਾਂ ਦੀ ਸੁਰੱਖਿਆਤਮਕ ਨੂੰ ਪ੍ਰਭਾਵਤ ਕਰਦੇ ਹਨ।

ਨਿਰਮਾਤ ਅਤੇ ਆਪਣੇ ਉਤਪਾਦਾਂ ਦੀ ਕੀਮਤ ਨਿਰਧਾਰਤ ਕਰਦੇ ਸਮੇਂ, ਆਯਾਤ ਅਤੇ ਨਿਰਯਾਤ ਟੈਰਿਫ ਨੂੰ ਵੀ ਧਿਆਨ ਵਿੱਚ ਰੱਖਦੇ ਸਹਿਤਵਪੂਰਨ ਹੈ। ਕੀਮਤ ਵਿੱਚ ਆਪਣੇ ਪ੍ਰਤੀਯੋਗੀਆਂ ਨੂੰ ਘੱਟ ਕਰਨ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰੋ। ਜੇ ਅਸੀਂ ਸੋਚਦੇ ਹਾਂ ਕਿ ਤੁਹਾਡੇ ਸੁਰੱਖਿਆਤਮਕ ਤੁਹਾਡੀਆਂ ਕੀਮਤਾਂ ਨੂੰ ਵਿਦੇਸ਼ੀ ਘਟਾ ਰਹੇ ਹਨ, ਤਾਂ ਇਸਲਿਹ ਸਿਯਮੈਂਟ ਡੰਪਿੰਗ ਦਾ ਸਹਿਮਤੀ ਕਰਨ ਤੁਹਾਨੂੰ ਇਸ ਨੂੰ ਦੂਰ ਕਰਨ ਵਿੱਚ ਸਕਦਾ ਹੈ ਕਰ ਸਕਦਾ ਹੈ।

Trademe Intel ਸਹਯੋਗਿਤਾ ਨੂੰ ਦੁਨੀਆ ਭਰ ਦੇ ਸਿਯਮੈਂਟ ਦੇ ਮੁਹਾਨ ਕਰਦਾ ਹੈ ਜੋ ਤੁਹਾਨੂੰ ਤੁਹਾਡੇ ਮੁਕਾਬਲੇ ਨੂੰ ਸੱਭਤ, ਨਿਗਰਾਨੀ ਕਰਨ ਅਤੇ ਚੋਣ ਕਰਨ ਦੀ ਇਜਾਜ਼ਤ ਦਿੰਦਾ ਹੈ।

(7.) Compliance and Documentation (ਪਾਲਣਾ ਅਤੇ ਦਸਤਾਵੇਜ਼)

ਪਾਲਣਾ ਦਾ ਬੁਨਿਆਦੀ ਸਮੂਹ ਅੱਜ ਵਰਤਮਾਨ

ਸਹੀ ਸਭ ਤੋਂ ਵੱਡੀ ਚੁਣੌਤੀਆਂ ਵਿੱਚੋ ਇੱਕ ਹੈ। ਧਾਸਣ ਪ੍ਰਤਿਭਿਆ ਵਧੀ ਗਈ ਸੁਸਕਲ ਪੂਰੀ ਹੈ ਅਤੇ ਸਧਸਟਤ ਦੀ ਘਾਟ ਪੂਰੀ ਹੈ। ਇਸ ਤੋਂ ਇਲਾਵਾ, ਸਿੱਖਿਅਤ ਅਧਿਕਾਰੀ ਅਤੇ ਨੌਕਰਸ਼ਾਹੀ ਵੀ ਵਧ ਨਿਰਯਾਤ ਕਾਰੋਬਾਰ ਨੂੰ ਅੱਗੇ ਲੈਜਾ ਅਤੇ ਸੁਸਕਲ ਬਣ ਸਕਦੇ ਹਨ।

The Advantages of Exporting [ਨਿਰਯਾਤ ਦੇ ਫਾਇਦੇ]

ਤੁਹਾਡੀਆਂ ਦਸਤੁਆਂ ਨੂੰ ਨਿਰਯਾਤ ਕਰਨ ਤੁਹਾਡੇ ਕਾਰੋਬਾਰ ਲਈ ਚਹੁ ਲਾਭਦਾਇਕ ਹੋ ਸਕਦਾ ਹੈ। ਹਰ ਕਾਰੋਬਾਰ ਸੇ ਵਧਣ ਚਾਹੁੰਦਾ ਹੈ, ਅਤੇ ਇੱਥੇ ਗਲੋਬਲ ਮੋਡ ਲਈ ਸਭਤੋ ਵਰਤ ਦੀ ਜਰੂਰਤ ਪੈਂਦੀ ਹੈ। ਨਿਰਯਾਤ ਕਰਨ ਦੇ ਫਾਇਦੇ ਅਤੇ ਫਾਇਦੇ ਹਰ ਇੱਕ ਚੁਣੌਤੀ ਤੋਂ ਵੱਧ ਹਨ ਜਿਸਦਾ ਤੁਹਾਡੇ ਕਾਰੋਬਾਰ ਦਾ ਸਾਹਮਣਾ ਹੋ ਸਕਦਾ ਹੈ।

① A good Product will always sell
[ਇੱਕ ਚੰਗਾ ਉਤਪਾਦ ਹਮੇਸ਼ਾ ਵਿਕੇਗਾ]:-

ਨਿਰਯਾਤ ਦੇ ਪਹਿਲੇ ਫਾਇਦਿਆਂ ਵਿੱਚੋ ਇੱਕ ਇਹ ਹੈ ਕਿ ਇੱਕ ਚੰਗਾ ਉਤਪਾਦ ਹਮੇਸ਼ਾ ਵੇਚਦਾ ਹੈ। ਨਿਰਯਾਤ ਇੱਕ ਅਜਿਹਾ ਕਾਰੋਬਾਰ ਹੈ ਜੋ ਕਿਸੇ ਵੀ ਵਿਅਕਤੀ ਦੁਆਰਾ ਇੱਕ ਚੰਗੇ ਵਿਚਾਰ ਅਤੇ

ਉਪਾਰ ਨਾਲ ਸ਼ੁਰੂ ਕੀਤਾ ਜਾ ਸਕਦਾ ਹੈ। ਆਪਣੇ ਨਿਰਯਾਤ ਵਪਾਰ ਸ਼ੁਰੂ ਕਰਨ ਲਈ ਤੁਸੀਂ ਵਾਸਤਵ ਵੀ ਲਿਗੀ ਪੂੰਜੀ ਕਰਨ ਜਾਂ ਵਪਾਰ ਸਫ਼ਲ ਤੋਂ ਜਾਣ ਵੀ ਲੋੜ ਨਹੀਂ ਹੈ। ਤੁਸੀਂ ਸਿਰਫ ਇਕ ਸਫਲਤਾ ਵਾਲੀ ਰੀਸਰਚ ਨੂੰ ਵੀ ਉਪਾਰ ਵੀ ਲੋੜ ਹੈ।

ਤੁਹਾਡਾ ਉਪਾਰ ਕੀ ਕੁਸ਼ਲਤਾ ਦਾ ਹੋਣ ਚਾਹੀਦਾ ਹੈ ਅਤੇ ਤੁਹਾਨੂੰ ਗਾਹਕਾਂ ਵੀਸਾ ਲੋਕਾਂ ਨੂੰ ਧਰਾ ਕਰਨ ਦੇ ਯੋਗ ਹੋਣ ਚਾਹੀਦਾ ਹੈ। ਸਭ ਤੋਂ ਸਫਲਤਾਪੂਰਕ, ਸਸਤਾ ਚੀਜ਼ਾਂ ਨਾਲੋਂ ਕਿਤੇ ਜ਼ਿਆਦਾ ਚੰਗਾ ਅਤੇ ਲੰਮਾ ਹੋਣਾ ਚਾਹੀਦਾ ਹੈ।

(2) ਸੀਮਤ ਬਾਜ਼ਾਰ (ਨਿਰਯਾਤ ਦਾ ਮੁੱਖ ਫਾਇਦਾ):-
Limitless market (The main advantage of exporting)

ਤੁਸੀਂ ਅੱਜ ਦੁਨੀਆ ਦੇ ਸਾਰੇ ਦੇਸ਼ਾਂ ਵਿੱਚ ਆਪਣੇ ਉਪਾਰ ਦੇਖ ਸਕਦੇ ਹੋ ਭਾਵ ਮਾਰਕੀਟ ਅਸੀਮਤ ਹੈ। ਆਪਣੇ ਸੂਝ ਦੇਸ਼ ਵਿੱਚ ਆਪਣੇ ਉਪਾਰ ਨੂੰ ਦੇਖਦੇ ਹੋਏ ਤੁਹਾਡੇ ਬਾਜ਼ਾਰ ਦੇ ਆਕਾਰ ਨੂੰ ਸਥਾਨਕ ਬਾਜ਼ਾਰ ਤੱਕ ਸੀਮਤ ਕਰ ਸਕਦਾ ਹੈ। ਹਾਲਾਂਕਿ, ਵਿਦੇਸ਼ਾਂ ਵਿੱਚ ਉਪਾਰਾਂ ਦਾ ਨਿਰਯਾਤ ਕਰਨ ਤੁਹਾਨੂੰ ਆਪਣੀ ਪ੍ਰੋਡਕਟ ਦਾ ਦੂਰਦਰਸ਼ਨ ਕਰਨ ਅਤੇ ਵੱਡੀ ਕਮਾਈ ਕਰਨ ਦੇ

ਅਸੀਮਤ ਸੌਦੇ ਪੂਰਨ ਕਰਦਾ ਹੈ।

ਆਪਣੇ ਉਤਪਾਦਾਂ ਨੂੰ ਹਿਸਦ ਪੱਧਰ 'ਤੇ ਦੇਖਣ ਤੁਹਾਡੀ ਪੂਂਡ ਦੀ ਸਾਖ ਨੂੰ ਵਧਾਉਣ ਅਤੇ ਤੁਹਾਡੀ ਆਮਦਨੀ ਨੂੰ ਵਧਾਉਣ ਵਿੱਚ ਤੁਹਾਡੀ ਮਦਦ ਕਰ ਸਕਦਾ ਹੈ। ਸਦੇਂ ਕਿ ਕੁਝ ਦਹਾਕੇ ਪਹਿਲਾਂ ਦੁਨੀਆਂ ਦੇ ਲਗਭਗ ਸਾਰੇ ਦੇਸ਼ਾਂ ਨੂੰ ਤੁਹਾਡੇ ਉਤਪਾਦਾਂ ਨੂੰ ਦੇਖਣ ਲਈ ਖੁੱਲ੍ਹੇ ਨਹੀਂ ਸੀ, ਅੱਜ ਇਹ ਹੈ।

ਤੁਸੀਂ ਦੇ ਨਾਲ ਆਪਣੇ ਨਵੇਂ ਬਾਜ਼ਾਰ Trademo Intel ਖਰੀਦਦਾਰਾਂ ਨੂੰ ਜ਼ਰੂਰ ਦਰਸਾਏ ਤੇ! ਅੱਜ ਹੀ ਇਸਨੂੰ ਅਜ਼ਮਾਓ।

③ ਵਿਦੇਸ਼ੀ ਬਾਜ਼ਾਰ ਉੱਚੀਆਂ ਕੀਮਤਾਂ ਦੀ ਪੇਸ਼ਕਸ਼ ਕਰ ਸਕਦੇ ਹਨ:- [Foreign markets can offer higher prices]

ਵਿਦੇਸ਼ੀ ਬਾਜ਼ਾਰ 'ਤੇ ਤੁਹਾਡੇ ਉਤਪਾਦਾਂ ਦੀਆਂ ਕੀਮਤਾਂ ਸਥਾਨਕ ਬਾਜ਼ਾਰਾਂ ਨਾਲੋਂ ਵਧੀ ਜਿਆਦਾ ਤੇ ਸਕਦੀਆਂ ਹਨ ਕਿਉਂਕਿ ਉਹਨਾਂ ਕੋਲ ਵਿਲੱਖਣ ਅਤੇ ਅਣਉਪਲਬਧ ਹੈ। ਬੇਸ਼ੱਕ, ਇਹ ਉਹਨਾਂ ਬਾਜ਼ਾਰਾਂ 'ਤੇ ਹੀ ਨਿਰਭਰ ਕਰਦਾ ਹੈ ਜਿਨ੍ਹਾਂ ਵਿੱਚ ਤੁਸੀਂ ਉੱਦਮ ਕਰਦੇ ਤੇ ਅਤੇ ਤੁਹਾਡੀਆਂ ਉਤਪਾਦ ਸ਼੍ਰੇਣੀਆਂ। ਇਹ ਅਕਸਰ ਸੱਚ ਵਰਗਾ ਹੁੰਦਾ ਹੈ ਕਿ ਕਾਰੋਬਾਰ ਹਿਸਦ ਪੱਧਰ 'ਤੇ ਨਿਰਯਾਤ ਕਰਨ ਸ਼ੁਰੂ ਕਰਦੇ ਹਨ।

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(4.) ਬਰਾਮਦਕਾਰਾਂ ਲਈ ਸਰਕਾਰੀ ਲਾਭ [About benefit for exporters] :- ਇਹਨਾਂ ਵਿਚ ਕਸਟਮ ਜਾਂ ਮੋਟਾਂ ਦਾ ਨਿਰਯਾਤ ਕਰਨਾ ਸੱਭ ਗਤੀਵਿਧੀਆਂ ਵਿੱਚ ਇੱਕ ਹੈ, ਜੋ ਤੁਹਾਨੂੰ ਇਸ ਵਿੱਚ ਵਿਦੇਸ਼ੀ ਮੁਦਰਾ ਨਿਸ਼ਾਨਿਤ ਹੈ ਜਾਂ ਸਾਨੂੰ ਵਿਦੇਸ਼ੀ ਮੁਦਰਾ ਕਮਾਉਣ ਵਾਲਾ ਵਿੱਚ ਸਹਾਇਤਾ ਹੈ। ਇਸੇ ਲਈ ਸਰਕਾਰ ਬਰਾਮਦਕਾਰਾਂ ਨੂੰ ਚਹੁ ਸਾਰੇ ਵਿਸ਼ਾਵਾਂ ਲਈ ਲਾਭ ਦਿੰਦੀ ਹੈ।

ਸਰਕਾਰ ਨਿਰਯਾਤਕਾਂ ਨੂੰ ਸੇਵਾ ਟੈਕਸ ਅਤੇ (ਵੈਲਯੂ ਐਡਿਡ ਟੈਕਸ) ਵਿੱਚ ਛੋਟ ਪ੍ਰਦਾਨ ਕਰਦੀ ਹੈ। ਡਿਊਟੀ ਡਰਾਅਬੈਕ ਲਈ, ਭਾਰਤ ਵਿੱਚ, ਨਿਰਯਾਤਕਾਂ ਨੂੰ ਸੂਚੀਆਂ ਦੇ ਅਧੀਨ ਡਿਊਟੀਆਂ ਦੇ ਨਿਰਯਾਤ ਲਈ ਸਰਲ ਪ੍ਰਕਿਰਿਆ ਦੀ ਪੇਸ਼ਕਸ਼ ਕੀਤੀ ਜਾਂਦੀ ਹੈ। ਨਾਲ ਹੀ, ਚੋਟੀਦਾ ਸੇਵਾਵਾਂ ਸਮਰਪਿਤ ਵਪਾਰਕ ਮਿਸ਼ਨਾਂ ਦੇ ਨਾਲ ਬਰਾਮਦਕਾਰਾਂ ਨੂੰ ਵਿਸ਼ੇਸ਼ ਵਰਤੋਂ ਵਿਚ ਹਨ। ਜਿਸ ਨਿਸ਼ਾਨਾ ਤੁਸੀਂ ਨਿਰਯਾਤ ਕਰਦੇ ਹੋ, ਉਸੇ ਹੀ ਨਿਸ਼ਾਨਾ ਅਤੇ ਤੁਸੀਂ ਖਾਸ ਕਰਦੇ ਹੋ।

(5.) ਭੁਗਤਾਨ ਸਥਾਨਕ ਬਾਜ਼ਾਰ ਨਾਲੋਂ ਤੇਜ਼ੀ ਨਾਲ ਪ੍ਰਾਪਤ ਹੋਏ [Payments received faster than in local market]

ਵਲੀ ਦਾ, ਸਧਾਰਨ ਧਾਗਾ ਵਿਚ, ਜੋਰਨ ਸੁਰਾਖਸ਼ ਸੰਤੁਲਨ ਸਿਸਟਮ ਹੁੰਦਾ ਹੈ, ਤਾਂ ਦਖਾਰੀਆਂ ਨੂੰ ਮਸੀਨਿਸਟਾਂ ਧਾਗਾ ਮਾਸ ਦੇਖ ਸਾਹ ਤੋਂ 2-3 ਧਾਗਾ ਜਰਾਇਜੀ ਮਿਲਦੀ ਹੈ। ਇਹਨਾਂ ਨੂੰ ਨਿਰਯਤ ਕਰੇ ਸਮੇਂ, ਕੋਈ ਵੀ ਮਾਲ ਦੇ ਨਿਰਯਤ ਤੋਂ ਪਹਿਲਾਂ ਗੀ ਭੁਗਤਾਨ ਦੀ ਇਕ ਤਿਮੀਰ ਰਾ ਸਕਦਾ ਹੈ।

ਚੇਸੱਕ, ਇਹ ਸਭ ਭੁਗਤਾਨ ਦੀਆਂ ਸਰਤਾਂ ਅਤੇ ਖਰੀਦਦਾਰ ਨਾਲ ਗੱਲਬਾਤ 'ਤੇ ਨਿਰਭਰ ਕਰਦਾ ਹੈ। ਹਾਲਾਂਕਿ, ਅੰਤਰਰਾਸ਼ਟਰੀ ਖਰੀਦਦਾਰਾਂ ਦੇ ਨਾਲ, ਭੁਗਤਾਨਾਂ ਨੂੰ ਵੱਖ-ਵੱਖ ਕਾਨੂੰਨਾਂ ਦੁਆਰਾ ਸੁਰੱਖਿਅਤ ਕੀਤਾ ਜਾਂਦਾ ਹੈ ਅਤੇ ਤੁਸੀਂ ਆਮ ਤੌਰ 'ਤੇ ਆਪਣੇ ਉਤਪਾਦਾਂ ਨੂੰ ਉਦੋਂ ਹੀ ਭੇਜਦੇ, 'ਤੇ ਦੇਖ ਸਕਦੇ ਹੋ।

ਸਿੱਟਾ:- ਇੱਕ ਨਿਰਯਤ ਕਾਰੋਬਾਰ ਸ਼ੁਰੂ ਕਰਨ ਦੀ ਸਾਰੀਆਂ ਚੁਣੌਤੀਆਂ ਅਤੇ ਫਾਇਦੇ ਹਨ। ਹਾਲਾਂਕਿ, ਇਨ੍ਹਾਂ ਚੁਣੌਤੀਆਂ ਅਤੇ ਰੁਕਾਵਟਾਂ ਨੂੰ ਸਹੀ ਯੋਜਨਾਬੰਦੀ ਦੁਆਰਾ ਦੂਰ ਕੀਤਾ ਜਾ ਸਕਦਾ ਹੈ। ਇਸੇ ਕਾਰਨ ਨੂੰ ਨਿਰਯਾਤ ਕਰਨ ਦੇ ਫਾਇਦੇ ਅਤੇ ਦਖਾਰੀ ਮੌਕਿਆਂ ਨਾਲ ਇਹ ਸਪੱਸ਼ਟ ਤੌਰ 'ਤੇ ਚੁਣੌਤੀਆਂ ਤੋਂ ਵੱਧ ਹੈ।

ਗਲੇਧਲ ਘਲਾਰ ਤੁਹਾਨੂੰ ਚੋਲਤ ਸੀਵੇ ਪੁਦਨ
ਰਹਸਗੇ, ਸੇ ਤੁਹਾਨੂੰ ਸਮਾਸ ਤੌਰ ,ਤੇ ਨਹੀਂ
ਸਿਲਦੇ ਸੇਕਰ ਤੁਸੀਂ ਸਥਾਨਕ ਤੌਰ ,ਤੇ
ਰਾਬੋਧਾਰ ਕਰ ਗੇ ਹੋ। ਇਸ ਲਈ ਅੱਗੇ
ਵਧੋ ਅਤੇ ਅੱਜ ਹੀ ਆਪਣਾ ਰਾਬੋਧਾਰ
ਦਯਾਓ!

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Fashion Careers [ਫੈਸ਼ਨ ਕੈਰੀਅਰ]

ਫੈਸ਼ਨ ਦੀ ਦਿਲਚਸਪ ਦੁਨੀਆ ਪ੍ਰਤਿਭਾਸ਼ੀ ਅਤੇ ਸਾਹਕਾਰ ਪੇਸ਼ੇਵਰ ਲਈ ਚਮਤਕਾਰੀ ਮੌਕੇ ਦੀ ਪੇਸ਼ਕਸ਼ ਕਰਦੀ ਹੈ। ਫੈਸ਼ਨ ਪ੍ਰੋਗਰਾਮ ਆਮ ਤੌਰ 'ਤੇ ਡਿਜ਼ਾਈਨ ਅਤੇ ਕੱਪੜੇ ਦੇ ਨਿਰਮਾਣ ਜਾਂ ਕਾਰੋਬਾਰ ਅਤੇ ਮਾਰਕੀਟਿੰਗ 'ਤੇ ਕੇਂਦਰਿਤ ਹੁੰਦੇ ਹਨ। ਇਹ ਪੈਸਾ ਇਹਨਾਂ ਦੋਵਾਂ ਦਿਲਚਸਪ ਖੇਤਰਾਂ ਵਿੱਚ ਉਪਲਬਧ ਚਮਤਕਾਰੀ ਫੈਸ਼ਨ ਕੈਰੀਅਰ ਦੀ ਪੜਚੋਲ ਕਰਦਾ ਹੈ।

ਫੈਸ਼ਨ ਵਿੱਚ ਕੈਰੀਅਰ ਕਿਉਂ ਚਮਤਕਾਰ ਹੈ

ਫੈਸ਼ਨ ਦੀ ਦੁਨੀਆ ਵਿੱਚ ਰਾਸ਼ਟਰਪਤੀ ਹੋਣ ਲਈ, ਚਾਹਵਾਨ ਪੇਸ਼ੇਵਰ ਨੂੰ ਕਈ ਵੱਖ-ਵੱਖ ਵਾਧਾਕੀਆਂ ਅਤੇ ਸਥਾਨਾਂ ਦੇ ਵਿਚਕਾਰ ਤੇਜ਼ ਰਫ਼ਤਾਰ ਦੀ ਲੋੜ ਹੁੰਦੀ ਹੈ ਅਤੇ ਫੈਸ਼ਨ ਦੀ ਦੁਨੀਆ ਵਿੱਚ ਸਫਲਤਾ ਪ੍ਰਾਪਤ ਕਰਨ ਲਈ ਆਪਣੇ ਆਪ ਨੂੰ ਸਥਾਪਿਤ ਕਰਨ ਅਤੇ ਖੇਤਰ ਵਿੱਚ ਅੱਗੇ ਵਧਣ ਲਈ ਆਪਣੇ ਆਪ ਨੂੰ ਅਤੇ ਪੇਸ਼ੇਵਰ ਵਿਕਾਸ ਲਈ ਇੱਕ ਮਜ਼ਬੂਤ ਵਚਨਬੱਧਤਾ ਦੀ ਲੋੜ ਹੋਵੇਗੀ।

ਫੈਸ਼ਨ ਕੈਰੀਅਰ ਆਰਟੀਕਲ [Fashion Career article]

ਇੱਕ ਫੈਸ਼ਨ ਡਿਜ਼ਾਈਨਰ ਜਾਂ ਉੱਦਮੀ ਵਜੋਂ ਇਸ ਨੂੰ ਸਫਲ ਬਣਾਉਣ ਵਿਅਕਤੀ ਪ੍ਰਤਿਭਾਸ਼ੀ ਅਤੇ ਉੱਚ

ਪ੍ਰੋਗਰਾਮ ਵਿਦਿਆਰਥੀ ਨਹੀਂ ਸੰਤੁਸ਼ਟ ਦੇ ਪੇਤਰ ਵਿਚ ਹੋਵੀ ਹਨ, ਪਰ ਫੈਸ਼ਨ ਵਿਚ ਜ਼ਿਆਦਾਤਰ ਕੀਮਤ ਕੋਰਸ ਅਗੇਪਰ ਹਰੀਕਾਂ ਨੂੰ ਦਰਸਾਉਂਦੇ ਹਨ। ਜ਼ਿਆਦਾਤਰ ਫੈਸ਼ਨ ਪੇਸ਼ਾਵਰ ਹਫ਼ਤਾਵਾਰ ਕਮਾਉਂਦੇ ਹਨ ਜੋ ਕਿ ਕੋਰਸ ਸੰਤੁਸ਼ਟ ਉਦਯੋਗਾਂ ਨਹੀਂ ਆਮ ਔਸਤ ਨਾਲ ਮੇਲ ਖਾਂਦਾ ਹੈ।

ਫੈਸ਼ਨ ਕਰੀਅਰ ਦੇ ਮਾਰਗ [Fashion career paths]

ਚਾਹੁ ਸਾਰੇ ਫੈਸ਼ਨ ਪ੍ਰੋਗਰਾਮ ਵਿਦਿਆਰਥੀਆਂ ਨੂੰ ਵਿਸ਼ੇਸ਼ ਕੈਰੀਅਰ ਮਾਰਗਾਂ ਨਾਲ ਸਬੰਧਤ ਹੋਣੇ ਚਾਹੀਦੇ ਹਨ ਵਿਕਾਸ ਦੀ ਸਪੱਸ਼ਟ ਰਸਤੇ ਆਪਣੇ ਸਿੱਖਿਆ ਨੂੰ ਵਿਸ਼ੇਸ਼ ਵਿਦਿਆਰਥੀ ਚਾਹੁੰਦੇ ਦੀ ਵਿਆਖਿਆ ਦਿਓ ਹਨ। ਸਕੂਲ ਵਿਚ ਪੇਸ਼ਕਸ਼ਾਂ ਵੱਖਰੀਆ ਹੈਂਦਾ ਹਨ, ਪਰ ਜ਼ਿਆਦਾਤਰ ਫੈਸ਼ਨ ਪ੍ਰੋਗਰਾਮ ਵਿਦਿਆਰਥੀਆਂ ਨੂੰ ਉਹਨਾਂ ਨੌਕਰੀ ਵਿਕਲਪ ਪੂਰਾ ਕਰੇ ਹਨ। ਇਸ ਵਿਚ ਉਹਨਾਂ ਦੇ ਦਫ਼ਤਰ, ਬਰੀਦਾਰੀ ਅਤੇ ਡਿਜ਼ਾਈਨ ਪੱਖਾਂ ਨਾਲ ਸਬੰਧਤ ਕੋਰਸ ਸ਼ਾਮਲ ਹੋ ਸਕਦੇ ਹਨ।

ਫੈਸ਼ਨ ਵਿਚ ਆਪਣਾ ਕੈਰੀਅਰ ਕਿਵੇਂ ਸ਼ੁਰੂ ਕਰੀਏ

ਉਹਨਾਂ ਫੈਸ਼ਨ ਸੋਚਣਾ ਨਹੀਂ ਚਾਹੁ ਸਾਰੇ ਆਕਰਸ਼ਕ ਕੈਰੀਅਰ ਦਾ ਸਮਾਨਾਰਥਕ ਕਰਦਾ ਹੈ। ਡਿਜ਼ਾਈਨ ਦੇ ਉਪਰਾਲੇ ਦੇ ਪੱਖ ਹੋਂ, ਤੁਸੀਂ ਇੱਕ ਸ਼ੀਤ ਡਿਜ਼ਾਈਨਰ, ਗਾਰਮੈਂਟ ਟੈਕਨੋਲੋਜਿਸਟ (Garment technologist)

fashion illustrator or fashion Stylist ਵਜੋਂ ਸਫਲ ਹੋ। ਇਹਨਾਂ ਅਹੁਦਿਆਂ ਲਈ ਮਾਰਕੀਟਿੰਗ ਸਾਥੀ ਵਜੋਂ ਉਨ੍ਹਾਂ ਦੇ ਕੈਰੀਅਰ ਮਾਰਗ ਦੀ ਪੇਸ਼ਕਸ਼ ਵੀ ਕਾਫ਼ੀ ਹਿੱਸਾ ਇਕੱਠੀ, ਪੂਰਨ ਬਰੀਕਣ retail buyers, inventory Planners, marketing Specialists, and Public relations Specialists ਅਤੇ ਸਹਾਇਤਾ-ਪੱਧਰ ਦੀਆਂ ਅਹੁਦਿਆਂ ਦੇ ਨਾਮ ਸਨ।

ਟੈਕਸ ਇਕ ਆਪਣੇ ਕਰੀਅਰ ਨੂੰ ਕਿਵੇਂ ਅੱਗੇ ਵਧਾਇਆ ਜਾਵੇ :-

ਸਿੱਖਿਆ ਨੂੰ ਜਾਰੀ ਰੱਖਣ ਲਈ ਵਿਅਕਤੀਗਤ ਉਦਯੋਗ ਦੇ ਰੁਝਾਨਾਂ ਦੇ ਸਿਖਰ 'ਤੇ ਰਹਿਣ ਅਤੇ ਵਿਕਾਸ ਦੇ ਮੌਕਿਆਂ ਵਜੋਂ ਦੀ ਇੱਕ buying ਦੀਆਂ ਤਰੀਕਾਂ ਪੇਸ਼ ਕਰਦੀ ਹੈ ਜੋ ਤੁਹਾਡੇ ਕਾਰੋਬਾਰ ਦੀਆਂ ਸੰਭਾਵਨਾਵਾਂ ਨੂੰ ਬੁਰਾਈ ਕਰ ਸਕਦੀ ਹੈ। ਜੇਕਰ ਇੱਕ ਸੰਸਥਾ ਦੁਆਰਾ ਵਜਾਂ ਦਾਰੇ ਸਰਗਰਮਤ ਦੀ ਪੂਰਨ ਕਰਦਾ ਹੈ ਜੋ ਤੁਸੀਂ ਟੈਕਸ ਉਦਯੋਗ ਵਿੱਚ ਆਪਣੀ ਪੇਸ਼ੇਵਰ ਯਾਤਰਾ ਨੂੰ ਅੱਗੇ ਵਧਾਇਆ ਸਕਦੇ ਹੋ।

Continuing Education :- ਟੈਕਸ ਵਿਚ ਚੁਣੌਤੀਪੂਰਨ ਉਦਯੋਗ ਵਿੱਚ, ਇਹੋ ਜਿਹਾ ਕਿ ਕੋਈ ਉਨ੍ਹਾਂ ਸਥਾਪਿਤ

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ਪੇਸ਼ਵਾ ਦੀ ਆਪਣੇ ਰਸੋਈ ਦੇ ਵਿਕਾਸ ਨੂੰ ਤੇਜ਼ ਕਰਨ ਅਤੇ ਆਪਣੇ ਗਿਆਨ ਨੂੰ ਦਖਾਉਣ ਲਈ ਸਿਰਫ ਸਿੱਖਿਆ ਦਾ ਪੱਛ ਕਰਦੇ ਹਨ। ਕਈ ਵਿਅਕਤੀ ਦਖ ਟੈਸਟ ਡਿਗਰੀਆਂ ਕਮਾਉਂਦੇ ਹਨ, ਹਰ ਸਿਮਾਰਤ ਲੋਕ ਆਪਣੀ ਸੈਸ਼ਨ ਸਿੱਖਿਆ ਨੂੰ ਪੇਸ਼ਵਾ ਪ੍ਰੋਗਰਾਮਾਂ ਨਾਲ ਪੂਰਕ ਕਰਨ ਦੀ ਚੋਣ ਕਰਦੇ ਹਨ ਜੋ ਸਰਟੀਫਿਕੇਟ ਪ੍ਰਾਪਤ ਕਰਦੇ ਹਨ। ਇਹ ਪ੍ਰੋਗਰਾਮ ਵਿੱਚ ਮੌਸਮਾਈਨ ਅਤੇ ਕਲਾਸਰੂਮ ਅਧਾਰਿਤ ਡਿਪਲੋਮੇ ਤੋਂ ਸਕਦੇ ਹਨ।

ਆਪਣੇ ਕੈਰੀਅਰ ਨੂੰ fashion ਵਿੱਚ ਕਿਵੇਂ ਬਦਲਣਾ

ਚਾਹੇ ਸਾਡੇ ਤਜਰਬੇਕਾਰ ਪੇਸ਼ੇਵਰ ਦੇ ਅਨੁਸਾਰ ਵਿੱਚ ਚਾਹੇ ਸਮਰਪਣ ਹੁੰਦਾ ਹੈ ਪਰ fashion ਦੇ ਵਿਸ਼ਿਆਂ ਤੋਂ ਬਦਲਣਾ ਹੈ। ਸਫਲਤਾ ਅਤੇ ਸੋਚ ਵਾਲੇ ਵਿਆਪਕ ਆਰਥਿਕ ਸਿਧਾਂਤ ਤੋਂ ਬਣੇ, ਚਾਹੇ ਘੱਟ ਪਰਿਪਰਾਗਤ ਸੱਭਾਈਆਂ ਵੱਲ ਮੁੜਦਾ ਹੈ, ਤੇ ਸਫਲ ਹੁੰਦਾ ਹੈ।

ਇਸ ਤਰ੍ਹਾਂ, ਸਿਆਸੀ ਕਾਲੇਜੀ ਸੰਭਾਲਾਂ ਦੇ ਸਹਾਰੇ ਆਮ ਕੈਮਰਾਮੈਨ ਗਿਆਨ ਵਾਲੇ ਉੱਚ ਗਿਆਨਵਾਨ ਪੇਸ਼ੇਵਰ ਵੀ ਹੋਣ ਲੋਕ ਸਮਸੀਆਂ ਦੇ ਆਸਰੇ ਹੋਣ ਲਈ ਸਥਾਪਤ ਕਰਦੇ ਹਨ। ਫੈਸਲ ਵਿੱਚ ਸਭਿਆ ਵਾਂ ਹੀ ਹੈ

ਸਮੇਂ ਸਿਮੇਟਰੀਜ਼ ਸੈਂਪਣ ਨਾਲ ਸਿੱਖਣ ਦੇ ਸੈਕਿਲ ਨੂੰ
ਸੁਮਾਇਜ਼ ਜਾ ਸਕਦਾ ਹੈ, ਕਿਉਂਕਿ ਚਹੁ ਸਾਰੇ ਕੰਮੀਲਾਂ
ਸਾਰਾ ਦਿਮਾਗ ਅਨੁਭਵ ਨੂੰ ਚਹੀਦੇ ਹਨ।

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ਰਿਟੇਲ ਕੀ ਹੈ?

ਪ੍ਰਚੂਨ ਵੰਡ ਦਾ ਅੰਤਮ ਚੈਨਲ ਹੈ ਜਿੱਥੇ ਛੋਟੀ ਮਾਤਰਾ ਵਿੱਚ ਵਸਤੂਆਂ (ਜਾਂ ਸੇਵਾਵਾਂ) ਸਿੱਧੇ ਉਪਭੋਗਤਾ ਨੂੰ ਉਹਨਾਂ ਦੀ ਵਰਤੋਂ ਲਈ ਵੇਚੀਆਂ ਜਾਂਦੀਆਂ ਹਨ।

ਇਸ ਪਰਿਭਾਸ਼ਾ ਦੇ ਦੋ ਮੁੱਖ ਵਾਕਾਂਸ਼ ਜੋ ਪ੍ਰਚੂਨ ਨੂੰ ਥੋਕ ਤੋਂ ਵੱਖ ਕਰਦੇ ਹਨ-

ਵਸਤੂਆਂ ਦੀ ਛੋਟੀ ਮਾਤਰਾ :- ਨਿਰਮਾਣ ਜਾਂ ਥੋਕ ਦੇ ਉਲਟ ਪ੍ਰਚੂਨ ਸੌਦੇ ਵਿੱਚ ਵਸਤੂਆਂ ਦੀ ਗਿਣਤੀ ਬਹੁਤ ਘੱਟ ਹੈ।

ਸਿੱਧੇ ਤੌਰ ਤੇ ਉਪਭੋਗਤਾ ਨੂੰ :- ਪ੍ਰਚੂਨ ਵਿਕਰੇਤਾ ਦੇ ਸਾਰੇ ਚੈਨਲ ਜੋ ਸਿੱਧੇ ਗਾਹਕ ਨੂੰ ਅੰਤਮ ਵਿਕਰੀ ਹੈ।

ਰਿਟੇਲਿੰਗ ਕੀ ਹੈ?

ਪ੍ਰਚੂਨ ਵਿਕਰੇਤਾ ਅੰਤ (ਜਾਂ ਤਾਂ ਨਿਰਮਾਤਾ, ਥੋਕ ਵਿਕਰੇਤਾ ਜਾਂ ਏਜੰਟ ਤੋਂ) ਪ੍ਰਾਪਤ ਕਰਨ ਅਤੇ ਅੰਤਮ ਵਰਤੋਂ ਲਈ ਗਾਹਕਾਂ ਨੂੰ ਵੇਚਣ

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ਦੀ ਇਕ ਪ੍ਰਤਿਭਾ ਹੈ।
ਸਾਧਨ ਸਥਾਨ ਇੱਕ, ਪੁਰਸ਼ ਦਿਖਦੇ ਇੱਕ
ਪੁਰਸ਼ ਦਿਖਦੇ ਅਤੇ ਗਾਹਕ ਦੇ ਦਿਖਦੇ
ਮਾਲਕ ਦੀ ਛੋਟੀ ਮਾਤਰ ਦਾ ਸੌਦਾ ਦੇ
ਹੈ ਜਿੱਥੇ ਦੁਕਾਨ ਦਿਖਦੀ ਦੇ ਉਹਨਾਂ ਨੂੰ
ਚੰਗਾ ਲਗੀ ਬਰੀਦਿਆ ਜਾਂਦਾ ਹੈ।

ਇੱਕ ਮਿਟੇਸ਼ ਕੀ ਹੈ?

ਇੱਕ ਪੁਰਸ਼ ਦਿਖਦੇ ਇੱਕ ਦਿਮਾਗੀ ਜਾਂ ਰੋਬੋਟ
ਤੇ ਹੈ ਜੋ ਸਮਾਨ ਵਰਤੋਂ ਨਹੀਂ ਗਾਹਕਾਂ
ਨੂੰ ਚੰਗੀ ਮਾਤਰ ਇੱਕ ਸਮਾਨ ਦੇਣਾ ਹੈ।
ਹਾਰ ਰੱਖਣ -
ਪੁਰਸ਼ ਦੋ ਦਾ ਇੱਕ ਚੰਗਾ ਹੈ।
ਮਿਟੇਸ਼ਿੰਗ ਇੱਕ ਦੁਕਾਨ ਬਰੀਦਿਆ ਹੈ।
ਪੁਰਸ਼ ਇੱਕ ਵਰੋਚਾਰ ਜਾਂ ਦਿਮਾਗੀ ਹੈ।

ਪੁਰਸ਼ ਸਟੋਰ ਉਹ ਸਥਾਨ ਹੈ ਜਿਥੇ ਗਾਹਕ
ਨੂੰ ਸਿਮਾਰਤਰ ਸਮਾਨ ਦਿਖਦੇ ਹੈ
ਹੈ। ਉਹ ਚੁਣੇ ਨਹੀਂ ਇੱਕ ਮਾਰਕੀਟਿੰਗ
ਟੂਲ ਅਤੇ ਗਾਹਕ ਨਹੀਂ ਸਹੀ ਦੁਕਾਨ
ਸਾਫਟਵੇਅਰ ਦਾ ਸਮਾਨ - ਪੁਰਾਣ ਅਤੇ
~~ਸੇਲਰ~~ ਸੇਲਰ ਵਰਤ ਨਹੀਂ ਇੱਕ ਸਾਫਟ
ਟੂਲ ਦੇਸੋ ਵੇਸ ਕਰੇ ਹਨ।

ਇਸ ਤੋਂ ਇਲਾਵਾ, ਪੂਰਨ ਰੁਜ਼ਗਾਰ ਅਰਥਵਿਵਸਥਾ ਲਈ ਇੱਕ ਵੱਡੀ ਸੀਮਾਂਤ ਹੈ। ਇਹ ਮੌਜੂਦਾ ਪੂਰਨ ਰੁਜ਼ਗਾਰ ਹੈ, ਇੱਥੇ ਵਾਧਾ ਰੁਜ਼ਗਾਰ ਹੈ, ਅਤੇ ਛੁਟੀਆ GDP ਦੇ ਸੀਮਤ ਵੱਧਣ ਇੱਕ ਤਕਨੀਕੀ ਬੇਰੋਜ਼ਗਾਰੀ ਵੀਅਨ ਵੀਅ ਰੋਜ਼ ਰੁਜ਼ਗਾਰ ਹੈ।

ਗਿਣਤੀ ਕਿਵੇਂ ਕੰਮ ਕਰਦਾ ਹੈ?

ਪੂਰਨ ਸਾਰ :-

ਅੱਧ ਦੇ ਇੱਕ ਸਧਾਰਨ ਸਾਲ ਸਾਰਨ, ਤੇ ਕੰਮ ਕਰਦਾ ਹੈ। ਪੂਰਨ ਇਕਰੇਤ ਸਾਰਨ ਸੱਲ, ਤੇ ਵਸਤੂਆਂ ਨੂੰ ਬਰੀਦੇ ਹਨ, ਪੈਂਡੀਂਦੇ ਸੁਸਾਂਢੇ ਦੇ ਸਾਰਨਿਕ ਦੇ ਨਾਲ ਸੇਚਰ, ਸਾਂਦੇ - ਸਸਾਨ ਅਤੇ ਇਸ ਦੀ ਸਾਰਨ ਨੂੰ ਸੋਂਦੇ ਹਨ, ਅਤੇ ਇਸ ਨੂੰ ਉੱਚ ਰੀਸਦ, ਤੇ ਵੇਚਦੇ ਹਨ।

ਗਿਣਤੀਕਰਨ ਦੀਆਂ ਕਿਸਮਾਂ :- ਗਿਣਤੀਕਰਨ ਨੂੰ ਪੰਜ ਕਿਸਮਾਂ ਵਿੱਚ ਵੰਡਿਆ ਜਾ ਸਕਦਾ ਹੈ। ਇੱਥੇ ਗਿਣਤੀਕਰਨ ਦੀਆਂ ਉਹ ਕਿਸਮਾਂ ਹਨ ਜੋ ਸੱਚ ਸੋਂਦੇ ਹਨ -

ਸਟੈਂਡ ਗਿਣਤੀਕਰਨ :- ਇਸ ਵਿੱਚ ਵੱਖ-ਵੱਖ ਕਿਸਮਾਂ

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ਦੇ ਖੁਰਾਕ ਸਟੋਰ ਸਾਮਲ ਹਨ ਜਿਵੇਂ ਕਿ ਡਿਪਾਰਟਮੈਂਟ ਸਟੋਰ, ਸਪੈਸਲਿਟੀ ਸਟੋਰ, ਸੁਪਰਮਾਰਕੀਟ, ਸੁਵਿਧਾ ਸਟੋਰ, ਕੈਟਾਲਾਗ ਸੋਲਮ, ਹਾਰਡ ਸਟੋਰ, ਸੁਪਰਸਟੋਰ ਡਿਸਕਾਊਂਟ ਸਟੋਰ, ਅਤੇ ਸੁੱਕ ਦਾਖੇ ਸਟੋਰ ਸਾਮਲ।

(2) ਗੈਰ-ਸਟੋਰ ਰਿਟੇਲਿੰਗ :- ਗੈਰ ਸਟੋਰ ਰਿਟੇਲਿੰਗ ਰਿਟੇਲਿੰਗ ਦੀ ਇੱਕ ਕਿਸਮ ਹੈ ਜਿੱਥੇ ਦੁਕਾਨਦਾਰ ਰਵਾਇਤੀ ਦੁਕਾਨਾਂ ਜਾਂ ਸਟੋਰਾਂ ਤੋਂ ਬਾਹਰ ਹੁੰਦੀ ਹੈ, ਇਸ ਨੂੰ ਅੱਗੇ ਦੋ ਕਿਸਮਾਂ ਵਿੱਚ ਵੰਡਿਆ ਗਿਆ ਹੈ - ਸਿੱਧੀ ਵਿਕਰੀ (ਜਿੱਥੇ ਫੇਰੀ ਕਰਨ ਵਾਲਾ ਵਿਅਕਤੀ ਹਰੇਕ ਉਪਭੋਗਤਾ ਦੀ ਹਰੇਕ ਲੋੜ ਨੂੰ ਸਮਝਦਾ ਹੈ) ਅਤੇ ਸਵੈਚਲਿਤ ਵੇਚਿੰਗ (ਆਟੋਮੈਟਿਕ ਵੇਚਿੰਗ ਮਸ਼ੀਨਾਂ ਨੂੰ ਸਥਾਪਤ ਕਰਨ ਜਾਂ ਜਨਤਕ ਰਿਟੇਲਰ ਦੀ ਮਦਦ ਤੋਂ ਬਿਨਾਂ ਵੀ ਉਤਪਾਦਾਂ ਦੀ ਪੇਸ਼ਕਸ਼ ਕਰਦੇ ਹਨ)।

(3) ਕਾਮਬੋਰੇਟ ਰਿਟੇਲਿੰਗ :- ਇਸ ਵਿੱਚ ਕਾਮਬੋਰੇਟ ਚੇਨਜ਼ ਜਿਵੇਂ ਕਿ ਚੇਨ ਸਟੋਰ.

ਰਿਟੇਲਿੰਗ ਦੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ

ਪ੍ਰਚੂਨ ਵਿਕਰੇਤਾ ਨੂੰ ਚੋਰ ਜਾਂ ਨਿਰਮਾਤਾ ਤੋਂ ਵੱਖ ਕੀਤਾ ਜਾ ਸਕਦਾ ਹੈ ਕਿਉਂਕਿ ਇਸ ਦੀ

ਵੱਖ ਵਿਸ਼ੇਸ਼ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ ਵਿੱਚ ਸ਼ਾਮਲ ਹਨ :-

* ਗਾਹਕ ਨਾਲ ਸਿੱਧਾ ਸੰਪਰਕ :-

ਵਿੱਚ ਔਨਲਾਈਨ ਗਾਹਕ ਨਾਲ ਸਿੱਧਾ ਸੰਪਰਕ ਸ਼ਾਮਲ ਹੈ ਪਰ ਅਜੇ ਵੀ ਦਬੇ ਗਏ ਵਿਕਰੇਤਾ ਵੈਬਸਾਈਟ ਦੇ ਸਹਾਰੇ ਤੇ ਚੋਟੀ ਵਿਕਰੇਤਾ ਅਤੇ ਗਾਹਕ ਜਾਂ ਨਿਰਮਾਤਾ ਅਤੇ ਗਾਹਕ ਵਿਚਕਾਰ ਇੱਕ ਵਿਚੋਲਾ ਹੈ।

* ਗਾਹਕਾਂ ਨਾਲ ਗਿਣਤੀ :-

ਪੂਰਨ ਵਿਕਰੇਤਾ ਗਾਹਕਾਂ ਨਾਲ ਇੱਕ ਚੰਗਾ ਚਰਿੱਤਰ ਬਣਾਉਂਦੇ ਹਨ ਅਤੇ ਉਹਨਾਂ ਨੂੰ ਇਹ ਫੈਸਲਾ ਕਰਨ ਵਿੱਚ ਮਦਦ ਕਰਦੇ ਹਨ ਕਿ ਉਹਨਾਂ ਨੂੰ ਆਪਣੇ ਅਤੀ ਕਿਹੜੇ ਉਤਪਾਦਾਂ ਅਤੇ ਸੇਵਾਵਾਂ ਦੀ ਕੇਹ ਕਰਨੀ ਚਾਹੀਦੀ ਹੈ।

* ਉਤਪਾਦਾਂ ਦੀ ਛੋਟੀ ਸਾਰ ਦਾ ਸਟਾਕ ਰੱਖੋ :-

ਪੂਰਨ ਵਿਕਰੇਤਾ ਆਮ ਤੌਰ 'ਤੇ ਨਿਰਮਾਤਾਵਾਂ ਅਤੇ ਚੋਟੀ ਵਿਕਰੇਤਾਵਾਂ ਦੀ ਤੁਲਨਾ ਵਿੱਚ ਸਾਰ ਦੀ ਛੋਟੀ ਸਾਰ ਦਾ ਸਟਾਕ ਰੱਖਦੇ ਹਨ।

* ਵੱਖ-ਵੱਖ ਚੁਣਾਂ ਦੇ ਸਟਾਕ ਸਾਰ :-

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ਪੂਰਨ ਹਿਰਦੇਤਾ ਆਸ ਤੈਂ ਤੇ ਚਾਸ਼ਨ ਕਿ
ਸੰਗ ਦੇ ਅਹਸਾਤ ਦੱਖ - ਦੱਖ ਖੁਣ ਦੇ
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Trade Show

ਫੈਸ਼ਨ ਇਵੈਂਟ ਉਹ ਜਿੱਥੇ Fashion Trade Show ਟੈਕਸ ਡਿਜ਼ਾਈਨਰ ਅਤੇ ਚੰਡ ਦੇ ਮਾਲਕ ਸੰਭਾਵੀ ਗਾਹਕਾਂ ਅਤੇ ਰਿਟੇਲਰਾਂ ਨੂੰ ਆਪਣੇ ਨਵੇਂ ਟੈਕਸ ਦਿਖਾਉਂਦੇ ਹਨ, ਅਤੇ ਇਹ ਸਮਾਗਮ ਪੂਰੀ ਦੁਨੀਆ ਵਿੱਚ ਆਯੋਜਿਤ ਕੀਤੇ ਜਾਂਦੇ ਹਨ।

ਇੱਕ ਟੈਕਸ ਟਰੇਡ ਸ਼ੋਅ ਦੇ ਹੈ

ਇੱਕ ਵਪਾਰਕ ਸ਼ੋਅ ਨੂੰ Enterpreneur com ਇੱਕ ਖਾਸ ਉਦਯੋਗ ਵਿੱਚ ਕੰਪਨੀਆਂ ਲਈ ਉਤਪਾਦ ਦੇ ਨਵੇਂ ਡਿਜ਼ਾਈਨ ਅਤੇ ਸੇਵਾਵਾਂ ਨੂੰ ਪ੍ਰਦਰਸ਼ਿਤ ਕਰਨ ਅਤੇ ਪ੍ਰਦਰਸ਼ਿਤ ਕਰਨ ਲਈ ਇੱਕ ਪ੍ਰਦਰਸ਼ਨੀ "ਵਜੋਂ ਪਰਿਭਾਸ਼ਿਤ ਕਰਦਾ ਹੈ। ਇਹ ਸ਼ਬਦ ਇਹ ਦਰਸਾਉਂਦਾ ਹੈ ਕਿ ਵਿਸ਼ਵਵਿਆਪੀ ਵਪਾਰਕ ਸ਼ੋਅ ਸਿਰਫ ਨਵੀਂ ਖੋਜ ਨਹੀਂ ਹਨ, ਅਤੇ ਸਿਰਫ ਕੰਪਨੀ ਦੇ ਪ੍ਰਤੀਨਿਧਾਂ ਅਤੇ ਖੁਸ਼ ਸੰਸਥਾਵਾਂ ਨੂੰ ਪੇਸ਼ ਕਿਤੇ ਜਾਂਦੇ ਹਨ। ਟੈਕਸ ਟਰੇਡ ਸ਼ੋ (Fashion Trade Show) ਫੈਸ਼ਨ ਇਵੈਂਟ ਹੈ ਜਿੱਥੇ ਟੈਕਸ ਡਿਜ਼ਾਈਨਰ ਅਤੇ ਚੰਡ ਮਾਲਕ ਸੰਭਾਵੀ ਗਾਹਕਾਂ ਅਤੇ ਪ੍ਰੈਸ ਦਿਖਾਉਂਦੇ ਹਨ ਆਪਣੇ ਨਵੇਂ ਟੈਕਸ ਦਿਖਾਉਂਦੇ ਹਨ ਅਤੇ ਇਹ ਸਮਾਗਮ ਪੂਰੀ ਦੁਨੀਆ ਵਿੱਚ ਆਯੋਜਿਤ

ਕੀਤੇ ਜਾਂਦੇ ਹਨ।

ਸਿਜ਼ਨਰਜ਼ ਸਾਮਗਿਆਂ ਵਿੱਚ, ਟੈਕਸ ਟਰੇਡ ਸ਼ੋਅ ਦੇ ਸਹਿਪਾਰਜ਼ਾਂ ਦੇਂ ਪੁਰਜ਼ਸ਼ੀ ਹਨ ਨੂੰ ਵਿਸ਼ਦੇ, ਤੇ ਇਹੇ ਹਨ ਜਿੱਥੇ ਡਿਜ਼ਾਈਨਰ ਪਿਛਲੇ ਸਾਲ ਦੌਰਾਨ ਕੰਮ ਗਏ ਸਭੇ ਟੈਸਟ ਨੂੰ ਦਿਖਾਉਂਦੇ ਹਨ। ਇਸ ਕਿਸਮ ਦੇ ਦਫ਼ਤਰ ਪੁਰਜ਼ਸ਼ਾਂ ਵਿੱਚ ਸਥਾਨ ਸੱਤਰਦਫ਼ਤਰ ਹੈ ਜੋ ਅਤੇ ਡਿਜ਼ਾਈਨਰ ਚੁਣ ਸਥਾਨ ਲਈ ਦੇਣ ਅਤੇ ਨੂੰ ਸਾਲ ਨਹੀਂ ਹਨ ਜੋ ਉਹਨਾਂ ਨੂੰ ਸਭ ਤੋਂ ਦਖੀਜ਼ ਮੌਕਸਪੋਜ਼ਰ ਪੂਰਾ ਕਰਨਗੇ।

List of Top Fashion Trade Shows

- ਚੋਟੀ ਦੇ ਟੈਕਸ ਦਫ਼ਾਰ ਸੋ ਟੀ ਸਭੀ ਪ੍ਰਸਿੱਧ ਸਭੀ ਮੌਰਗੀਰੋਧ ਦੇ ਅਨੁਸਾਰ 10 ਦਾ
- ਮੌਸਿਰ ਲਾਸ ਏਗਾਸ
- Texworld Paris ਸਿਪਾਨੇ
- MIC A M ਮੈਡਰਸਟੀ ਸਿਧਾਬ ਅਤੇ ਟੈਕਸਟਾਈਲ ਮੇਲਾ
- Texworld USA ਇੰਟਰਟੈਕਸਟਾਇਲ ਸੀਜ਼ਨੀ ਅਪੈਰਲ
- ਟੈਂਚਿੰਗ
- ਉਤੀਗੜ੍ਹ ਸੈਂਟਾ ਮੌਕਸਪੋ
- ਪਸ਼ਮੀ ਲੈਨ ਮੇਲਾ
- ਸੱਪ ਸ਼ੋਅ

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ਭਾਰਤ ਅੰਤਰਰਾਸ਼ਟਰੀ ਵਪਾਰ ਮੇਲਾ

ਇੰਡੀਆ ਟਰੇਡ ਪ੍ਰੋਮੋਸ਼ਨ ਇਕ ਦਿੱਲੀ ਸਥਿਤ Trade fare ਹੈ ਜੋ 1980 ਤੋਂ ਹਰ ਸਾਲ ਨਵੰਬਰ ਵਿਚ ਪ੍ਰਗਤੀ ਮੈਦਾਨ ਵਿਚ ਆਯੋਜਿਤ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਇਹ ਭਾਰਤ ਦੀ ਸਭ ਤੋਂ ਵੱਡਾ ਵਪਾਰ ਪ੍ਰਮੋਸ਼ਨ ਏਜੰਸੀ ਹੈ ਜਿਸਦਾ ਨਾਮ India Trade promotion organisation ਹੈ। ਇਹ ਪ੍ਰਮੋਸ਼ਨ ਸਮਾਗਮ ਹੈ। ਇਹ ਸਮਾਗਮ 14 ਨਵੰਬਰ ਤੋਂ 27 ਤੱਕ ਹੁੰਦਾ ਹੈ ਜਿਸ ਵਿਚ ਆਯੋਜਿਤ ਦੇਸ਼ ਭਰ ਦੇ ਵਪਾਰ ਹਿੱਸਾ ਲੈਂਦੇ ਹਨ। ਇਹ ਮੇਲਾ ਵਿਚ ਦੇ ਨਾਲ ਨਾਲ ਵਿਦੇਸ਼ ਤੋਂ ਵੀ ਵਪਾਰੀ ਆਉਂਦੇ ਹਨ। IITF 2013 ਵਿਚ ਅਤੇ ਜਾਪਾਨ ਨੂੰ ਸਾਂਝੀ ਦੇਸ਼ ਦਾ ਦਰਜਾ ਦਿੱਤਾ ਗਿਆ ਸੀ।

उपन्यास

हिंदी-उपन्यास साहित्य के संदर्भ में आलोच्य युग को 'प्रेमचंद-युग' की संज्ञा लगभग निर्वि रूप में मिल चुकी है, क्योंकि 'सेवासदन' (1918) का प्रकाशन न केवल प्रेमचंद (1880-193 के साहित्यिक जीवन की, वरन् हिंदी-उपन्यास की भी एक महत्त्वपूर्ण घटना थी। 'सेवासद पूर्ववर्ती कथा-साहित्य का अभूतपूर्व विकास था—इससे पहले कथा-साहित्य में या तो अजीबोग घटनाओं के द्वारा कुतूहल और चमत्कार की सृष्टि रहती थी अथवा आर्यसमाज और तत्समान अ सामाजिक आंदोलनों से प्रभावित समाज-सुधारों का प्रचार ही उसकी उपलब्धि रह गयी थी। जीव की सही अभिव्यक्ति का साधन वह नहीं बन पाया था। देवकीनंदन खत्री, गोपालराम गहमर हरिकृष्ण जौहर आदि पहली कोटि के कथाकार थे तो गौरीदत्त, श्रद्धाराम, फिल्लौरी, श्रीनिवासदास बालकृष्ण भट्ट, मेहता लज्जाराम शर्मा, ब्रजनंदन सहाय आदि दूसरी कोटि के कथाकार थे किशोरीलाल गोस्वामी की स्थिति कुछ-कुछ बीच की थी, यद्यपि उनका झुकाव भी 'मनोरंजन' की ओर ही अधिक था। उस काल के केवल एक उपन्यासकार भुवनेश्वरप्रसाद मिश्र की रचनादृष्टि अपने समकालीनों से भिन्न थी। 'मनोरंजन' और 'प्रचार' से ऊपर उठ कर उन्होंने उपन्यास को जीवन की अभिव्यक्ति के साधन के रूप में प्रतिष्ठित करने का प्रयास किया। 'घराऊ घटना' (1893) और 'बलवंत भूमिहार' (1896) उनकी ऐसी ही कृतियां थीं। वैसे प्रेमचंद ने भी 1918 के पूर्व उर्दू में कई उपन्यासों की रचना की थी, जिनमें से 'प्रेमा अर्थात दो सखियों का विवाह' ('हसखुर्मा व हमसवाब' का रूपांतर) 1907 में हिंदी में प्रकाशित हो चुका था। उनके अन्य आरंभिक उपन्यास 'असरारे मआबिद उर्फ़ देवस्थान रहस्य', 'किसना', 'रूठी रानी', 'जलवए ईसार' आदि थे। इनमें प्रेमचंद ने भी उपन्यास को मनोरंजन से ऊपर उठा कर जीवन के सीधे संपर्क में लाने का प्रयत्न किया था। उन्होंने आर्यसमाज से प्रेरणा अवश्य ग्रहण की थी, पर उनकी अपनी विशिष्ट जीवनदृष्टि भी निर्मित हो चुकी थी, जो इन उपन्यासों में अभिव्यक्ति पाना चाह रही थी। किंतु हिंदी में 'उपन्यास' की कोई परंपरा न होने के कारण प्रेमचंद को उसका समुचित ढांचा (फार्म) नहीं मिल रहा था। संभवत: अपने लिए सही भाषा की तलाश भी वे नहीं कर पाये थे। परिणामत: इस काल में लिखित उनके सभी उपन्यास एक प्रतिभाशाली लेखक के 'बचकाने प्रयास' जैसे लगते हैं। 'सेवासदन' उनकी पहली प्रौढ़ कृति है जहां से उनके नये औपन्यासिक जीवन का ही नहीं, बल्कि हिंदी उपन्यास के एक नये युग का भी प्रादुर्भाव हुआ।

'सेवासदन' के बाद प्रेमचंद के 'प्रेमाश्रम' (1922), 'रंगभूमि' (1925), 'कायाकल्प' (1926), 'निर्मला' (1927), 'ग़बन' (1931), 'कर्मभूमि' (1933) और 'गोदान' (1935) शीर्षक सात मौलिक उपन्यास प्रकाशित हुए। इस बीच उन्होंने अपने दो पुराने उर्दू उपन्यासों को भी हिंदी में रूपांतरित और परिष्कृत करके प्रकाशित किया। 'जलवए ईसार' का रूपांतर 'वरदान' 1921 में प्रकाशित हुआ तथा 'हमखुर्मा व हमसवाब' के पूर्व प्रकाशित हिंदी-रूपांतर 'प्रेमा अर्थात दो सखियों का विवाह' को परिष्कृत कर उन्होंने 'प्रतिज्ञा' (1929) शीर्षक से उसे सर्वथा नये रूप में प्रकाशित कराया। एक उल्लेखनीय तथ्य यह है कि आरंभ में प्रेमचंद अपने उपन्यास पहले उर्दू में लिखते थे और फिर स्वयं उनका हिंदी-रूपांतर करते थे। 'सेवासदन', 'प्रेमाश्रम' और 'रंगभूमि' क्रमश: 'बाज़ारे-हुस्न', 'गोशए-आफ़ियत' और 'चौगाने-हस्ती' नाम से उर्दू में लिखे गये थे, किंतु प्रकाशित पहले ये हिंदी में ही हुए। वैसे, मूल रूप से हिंदी में लिखित उनका पहला उपन्यास 'कायाकल्प' है। इसके बाद उन्होंने सभी उपन्यासों की रचना हिंदी में ही की, उर्दू की बैसाखी की ज़रूरत उन्हें अब नहीं रह गयी थी।

हिंदी-उपन्यास को प्रेमचंद की देन अनेकमुखी है। प्रथमतः उन्होंने हिंदी-कथासाहित्य को 'मनोरंजन' के स्तर से उठा कर जीवन के साथ सार्थक रूप में जोड़ने का काम किया। चारों ओर फैले हुए जीवन और अनेक सामयिक समस्याओं—पराधीनता, ज़मींदारों, पूंजीपतियों और सरकारी कर्मचारियों द्वारा किसानों का शोषण, निर्धनता, अशिक्षा, अंधविश्वास, दहेज की कुप्रथा, घर और समाज में नारी की स्थिति, वेश्याओं की ज़िंदगी, वृद्ध-विवाह, विधवा-समस्या, सांप्रदायिक वैमनस्य, अस्पृश्यता, मध्यमवर्ग की कुंठाएं आदि ने उन्हें उपन्यास-लेखन के लिए प्रेरित किया था। प्रेमचंद ने एक-एक कर बड़ी बेसब्री से इन समस्याओं और जीवन के विभिन्न पहलुओं को अपने उपन्यासों में स्थान दिया। 'सेवासदन' में उनका ध्यान मुख्यतः विवाह से जुड़ी समस्याओं—तिलक-दहेज की प्रथा, कुलीनता का प्रश्न, विवाह के बाद घर में पत्नी का स्थान और समाज में वेश्याओं की स्थिति पर रहा। 'निर्मला' में दहेजप्रथा और वृद्धविवाह से होने वाले पारिवारिक विघटन तथा विनाश का चित्रण है। कृषक-जीवन की समस्याओं के चित्रण का प्रथम प्रयास 'प्रेमाश्रम' में लक्षित हुआ और उसे पूर्णता प्राप्त हुई 'गोदान' में। वैसे प्रेमचंद ने मान्य रूप से अपने प्रायः सभी उपन्यासों में, और विशेषरूप से 'रंगभूमि' और 'कर्मभूमि' में, ग्रामीणों की स्थिति का बेबाक चित्रण किया है, पर 'गोदान' को तो ग्रामीण जीवन और कृषि-संस्कृति का महाकाव्य ही कहा जा सकता है। ग्रामीण जीवन का इतना सच्चा, व्यापक और प्रभावशाली चित्रण हिंदी के किसी अन्य उपन्यास में नहीं हुआ है, संभवतः वह संसार के साहित्य में बेजोड़ है।

महात्मा गांधी से प्रभावित होने के कारण ही नहीं, बल्कि अपनी मानवतावादी दृष्टि के कारण भी देश की सांप्रदायिक समस्या प्रेमचंद की चिंता का मुख्य विषय थी। इस समस्या को 'सेवासदन' और विशेषरूप से 'कायाकल्प' में प्रस्तुत किया गया है। 'सेवासदन', 'रंगभूमि', 'प्रतिज्ञा', 'कर्मभूमि' और 'गोदान' में अंतर्जातीय विवाह के प्रश्न को उठाया गया है। उच्चवर्गीय और मध्यमवर्गीय समाज में नारी की स्थिति तथा अपने अधिकारों के प्रति उसकी क्रमशः उभरती गयी जागरूकता तो प्रायः उनके सभी उपन्यासों में चित्रित है। विधवा-विवाह का प्रश्न 'प्रतिज्ञा' में उठाया गया है। मध्यमवर्ग की कुंठाओं का सबसे अच्छा चित्रण 'ग़बन' और 'निर्मला' में है, यद्यपि 'सेवासदन' और 'कर्मभूमि' में भी इसकी झलक देखी जा सकती है। समाज में हरिजनों की स्थिति और उनकी समस्याओं का चित्रण 'कर्मभूमि' में मिलता है। बड़े पैमाने पर फैलने वाले उद्योगधंधों के फलस्वरूप ग्रामीण जीवन और पुराने मूल्यों में विघटन तथा पूंजीवाद के बढ़ते हुए प्रभाव का चित्रण 'रंगभूमि' में देखा जा सकता है। देश की पराधीनता के अहसास से पैदा हुआ दर्द 'प्रेमाश्रम', 'रंगभूमि', 'कायाकल्प', 'ग़बन' और 'कर्मभूमि' में स्थान-स्थान पर व्यक्त हुआ है। सामान्य जीवन की धड़कन तो उनके सभी उपन्यासों में मिलती है। इसका अर्थ यह नहीं है कि उन्होंने क़िस्सागोई से बिलकुल ही नाता तोड़ लिया था, बल्कि यह कहना ज़्यादा ठीक होगा कि वे अंत तक क़िस्सागोई से जुड़े रहे। यही कारण है कि उनके उपन्यासों को इतनी लोकप्रियता प्राप्त हुई। उन्नीसवीं शताब्दी के अंतिम दशक में देवकीनंदन खत्री ने कौतूहलोत्पादक चौंकाने वाली नयी-नयी घटनाओं की सृष्टि करके कथा में रोचकता पैदा की थी, जबकि प्रेमचंद ने सहज-सामान्य मानवीय व्यापारों को मनोवैज्ञानिक स्थितियों से जोड़ कर उनमें एक सहज तीव्र मानवीय रुचि पैदा कर दी। उनके आरंभिक उपन्यासों में 'घटनाओं' की सृष्टि का भी प्रयास लक्षित होता है, पर धीरे-धीरे वे इस पुराने रोग से मुक्त होते गये और 'गोदान' में पहुंच कर उन्होंने क़िस्सागोई की उस कला को प्रस्तुत करने में सफलता प्राप्त की जो 'घटनाओं' पर नहीं, मनोवैज्ञानिक स्थितियों से दीप्त सहज-सामान्य मानवीय व्यापारों पर जीती है। उनका वैशिष्ट्य इस बात में

निहित है कि उन्होंने सामयिक समस्याओं को अपने उपन्यासों का आधार बनाने के बावजूद जीवन की सहज-सामान्य धारा को उचित महत्त्व दिया। उनके उपन्यासों में समस्याओं और उनके आदर्शवादी समाधानों का महत्त्व उत्तरोत्तर कम होता गया और जीवनधारा की ताज़गी तथा यथार्थता क्रमशः प्रमुख तथा व्यापक होती गयी। अपने अंतिम उपन्यास 'गोदान' में भी वे आदर्शों से मुक्त नहीं हो सके हैं, पर 'गोदान' में सामान्य जीवनधारा की अत्यंत सशक्त अभिव्यक्ति हुई है। अपने अन्य उपन्यासों में भी उन्होंने समाज के विभिन्न वर्गों के व्यक्तियों की सामान्य ज़िंदगी को उसकी संपूर्ण मार्मिकता में प्रस्तुत किया है। विशेषता यह है कि सामान्य ज़िंदगी के ये ब्यौरे मनोवैज्ञानिक स्थितियों से संकलित हैं, जिनकी पृष्ठभूमि में जीवन का गहरा और व्यापक अनुभव तथा तीव्र संवेदना विद्यमान है।

प्रेमचंद ने अपने उपन्यासों में समाज के विभिन्न वर्गों का चित्रण किया है। इनमें सबसे प्रमुख वर्ग है—किसानों का, जो मुख्यतः गांवों में रहता था और जो देश की समूची आबादी का लगभग 85 प्रतिशत था। इसके बाद उन्होंने मध्यवर्ग को अपने उपन्यासों का विषय बनाया। अभिजातवर्ग और नागरिक जीवन का चित्रण उन्होंने बहुत कम किया है, और जहां ऐसे स्थल आये हैं, वहां उनका मन रमा नहीं है। 'गोदान' में नागरिक जीवन के चित्रण की संभावनाएं तो थीं, किंतु उसका प्रामाणिक और पर्याप्त चित्रण वहां भी नहीं है। उपन्यास में कुछ नागरिक पात्रों के दर्शन अवश्य होते हैं, पर वे किसी विशेष अर्थ में नागरिक जीवन का प्रतिनिधित्व नहीं करते। नगर-जीवन की विशेषताओं, जैसे—कोलाहल, दौड़-धूप, तंगी, भीड़, घुटन, गंदगी, बेकारी, होटल, रेस्तरां, शुष्क औपचारिकता, भयानक जीवन-संघर्ष आदि का बहुत प्रामाणिक चित्रण 'गोदान' में कहीं दिखायी नहीं देता। 'गोदान' की तथाकथित नगरकथा के पात्र प्रेमचंद के नारी-विषयक, प्रेम-विषयक और देशसेवा-विषयक आदर्शों के प्रतिपादन के निमित्त खड़े किये गये हैं, न कि वे नगर-जीवन के अंग हैं। लगभग यही बात उनके अन्य उपन्यासों में आये नागरिक पात्रों के विषय में भी कही जा सकती है। हां, उनके उपन्यासों में शोषक वर्ग—ज़मींदारों, साहूकारों, सरकारी कर्मचारियों (विशेषतः पुलिस-विभाग) तथा पुरोहितों का यथार्थ और प्रामाणिक चित्रण हुआ है। इनमें ज़मींदार-वर्ग के प्रति प्रेमचंद की सहानुभूति उन्हें उच्चकोटि का कलाकार ही नहीं, संतुलित दृष्टि-संपन्न सामाजिक आलोचक भी सिद्ध करती है। तत्कालीन ज़मींदार एक ओर किसानों का शोषण करता था, तो दूसरी ओर वह बैंकरों, दलालों और अंगरेज़-सरकार के शोषण का शिकार भी था। तत्कालीन सामंती ढांचा भव्य और डरावना दिखायी पड़ने पर भी भीतर से बिलकुल खोखला हो चुका था। प्रगतिवाद या साम्यवाद के प्रति दुराग्राही लेखकों की दृष्टि इस खोखलेपन की ओर नहीं जा सकती, किंतु प्रेमचंद ने अपनी सूक्ष्म अवलोकन-क्षमता से न केवल इसे लक्ष्य किया, अपितु सहानुभूति के साथ इसे अपने उपन्यासों में प्रस्तुत भी किया।

प्रेमचंद यद्यपि राष्ट्रप्रेमी और देशभक्त लेखक थे, पर अपने उपन्यासों में वे राष्ट्रीय भावना को सशक्त अभिव्यक्ति न दे सके। जगह-जगह ऐसा लगता है कि वे इस ओर बढ़ना तो चाहते हैं, पर उनकी व्यावहारिक बुद्धि जैसे रास्ता रोक देती है। वे सामाजिक सुधारों तथा प्राकृतिक विपत्तियों में सहायता-कार्य करने वाली 'सेवा-समितियों' के गठन और उनकी गतिविधियों का तो वर्णन करते हैं, पर सत्याग्रह-आंदोलन या स्वतंत्रताप्राप्ति के निमित्त किये गये आंदोलन के चित्रण से बचते हैं। यह बात 'प्रेमाश्रम', 'रंगभूमि', 'ग़बन' और 'कर्मभूमि' सब में देखी जा सकती है। इसी प्रकार कतिपय सामाजिक समस्याओं को सही संदर्भ में उठाने पर भी वे उन्हें उचित तर्कसंगत परिणति नहीं दे पाये हैं। कई उपन्यासों में अंतर्जातीय विवाह की समस्या उठायी गयी है। दो

विभिन्न जातियों के युवक-युवतियों में प्रेम-संबंध स्थापित होता है, पर प्रेमचंद उस संबंध को विवाह में बदलने के पूर्व ही प्रेमी-प्रेमिका को मृत्यु या किसी अन्य बहाने से एक-दूसरे से अलग कर देते हैं। सोफ़िया-विनय, अमरकांत-सकीना, चक्रधर-मनोरमा आदि प्रेमी-युगलों की कहानी इसका प्रमाण है। इसी प्रकार 'प्रतिज्ञा' में विधवा-विवाह की समस्या को उठा कर भी वे अमृतराय और पूर्णा का विवाह संपन्न नहीं करा पाते। केवल 'गोदान' में मातादीन और सिलिया का विवाह दिखाने का साहस उन्होंने किया है। संभवत: सामाजिक आलोचना के भय से प्रेमचंद समाजसुधार की दिशा में क्रांतिकारी क़दम उठाने से रह गये थे।

शिल्प और भाषा की दृष्टि से भी प्रेमचंद ने हिंदी-उपन्यास को विशिष्ट स्तर प्रदान किया। यों सुघठित और चारों ओर से दुरुस्त कथानक गढ़ने का कौशल देवकीनंदन खत्री भी दिखा चुके थे, पर चित्रणीय विषय के अनुरूप शिल्प के अन्वेषण का प्रयोग हिंदी उपन्यास में पहली बार प्रेमचंद ने ही किया। उनकी विशेषता यह है कि उनके द्वारा प्रस्तुत किये गये दृश्य अत्यंत सजीव, गतिमान और नाटकीय हैं। उनके उपन्यासों की भाषा की खूबी यह है कि शब्दों के चुनाव तथा वाक्य-योजना की दृष्टि उसे 'सरल' और 'बोलचाल की भाषा' कहा जा सकता है। पर भाषा की इस सरलता को निर्जीवता, एकरसता और अकाव्यात्मकता का पर्याय नहीं समझा जाना चाहिए। प्रेमचंद के उपन्यासों में, विशेषत: 'गोदान' में, भाषा का वैविध्य जितने स्तरों पर दिखायी पड़ता है, वह हिंदी के उपन्यास-साहित्य में अब तक दुर्लभ है। इतनी 'सरल' भाषा को एक साथ इतने स्तरों पर काम में लाना, प्रेमचंद जैसे उपन्यासकार द्वारा ही संभव था। भाषा के सटीक, सार्थक और व्यंजनापूर्ण प्रयोग में वे अपने समकालीन ही नहीं, बल्कि बाद के उपन्यासकारों को भी पीछे छोड़ जाते हैं। वस्तुत: प्रेमचंद ने ही हिंदी-उपन्यास को अभिव्यक्ति का सशक्त माध्यम प्रदान किया।

प्रेमचंद के समकालीन उपन्यासकारों की संख्या दो-ढाई सौ के लगभग है, किंतु सबका उल्लेख न यहां संभव है और न आवश्यक। फिर भी इस काल के कम-से-कम दस-बारह उपन्यासकार ऐसे अवश्य हैं, जिन्होंने किसी-न-किसी रूप में अपनी पहचान कायम की है। **विश्वंभरनाथ शर्मा 'कौशिक'** (1891-1946) ने 'मां' और 'भिखारिणी' लिख कर प्रेमचंद का सफल अनुकरण किया था, पर संभवत: इसी कारण लिखने की योग्यता होते हुए भी वे अपनी अलग पहचान नहीं बना सके। प्रेमचंद के अन्य अनुकरणकर्ताओं में चतुरसेन शास्त्री और प्रतापनारायण श्रीवास्तव प्रमुख हैं। **चतुरसेन शास्त्री** ने आलोच्य अवधि में 'हृदय की परख' (1918), 'हृदय की प्यास' (1932), 'अमर अभिलाषा' (1932) और 'आत्मदाह' (1937) शीर्षक उपन्यासों की रचना की, किंतु प्रेमचंद की रचनाशैली से प्रभावित होने पर भी उन्होंने उसे कौशिक जी की भांति एकांतत: ग्रहण नहीं किया है। यही कारण है कि परवर्ती युग में उनकी उपन्यासकला पर्याप्त रूप से भिन्न आयाम ग्रहण कर सकी। **प्रतापनारायण श्रीवास्तव**-कृत 'विदा' (1929) और 'विजय' (1937) आदर्शवादी उपन्यास हैं। 'विदा' में नागरिक उच्चवर्गीय समाज का चित्रण है और 'विजय' में अभिजातवर्गीय विधवा-जीवन की समस्याएं चित्रित हैं। रचनाशैली की दृष्टि से ये उपन्यास प्रेमचंद के कहीं अधिक समीप हैं। देवनारायण द्विवेदी (जन्म 1897) के 'कर्तव्याघात', 'प्रणय', 'पश्चात्ताप' और 'दहेज़' तथा अनूपलाल मंडल-कृत 'निर्वासिता' (1929) भी प्रेमचंद की परंपरा में लिखित औपन्यासिक रचनाएं हैं। वैसे, इस धारा के अन्य उपन्यासकारों में प्रफुल्लचंद्र ओझा 'मुक्त' और जगदीश झा 'विमल' का भी उल्लेख किया जा सकता है।

कालक्रम की दृष्टि से देखें तो विवेच्य काल में सबसे पहले **शिवपूजन सहाय** (1893-1963) ने हिंदी-उपन्यास को प्रेमचंद से भिन्न मार्ग पर ले जाने का प्रयास किया। उनका 'देहाती

दुनिया' (1926) शीर्षक उपन्यास प्रचलित रूढ़ि को तोड़ने की दिशा में एक साहसिक क़दम था, किंतु शायद यह क़दम समय से पहले उठा लिया गया। इसीलिए इस उपन्यास का समुचित मूल्यांकन 1950 के लगभग आंचलिक उपन्यासों का आविर्भाव होने पर हुआ। प्रेमचंद-युग के सबसे अक्खड़ और इसीलिए सबसे बदनाम उपन्यासकार हुए **बेचन शर्मा 'उग्र'**, जिन्होंने 'चंद हसीनों के खुतूत' (1927), 'दिल्ली का दलाल' (1927), 'बुधुआ की बेटी' (1928), 'शराबी' (1930) आदि उपन्यासों में समाज की बुराइयों को, उसकी नंगी सचाई को, बिना किसी लाग-लपेट के बड़े ही साहस के साथ, किंतु सपाटबयानी के रूप में प्रस्तुत किया। उन्होंने समाज के उस वर्ग को अपने उपन्यासों का विषय बनाया, जिसे दलित या पतित वर्ग कहते हैं, और उसके चित्रण में उन्होंने किसी प्रकार के 'शील' या 'अभिजात शिष्टता' का परिचय नहीं दिया। इस कारण उनके उपन्यासों में एक ओर सच्चाई अपने नग्न रूप में आयी है, तो दूसरी ओर वह 'परचेबाज़ी' के निकट पहुंच जाती है जो किसी कृति को कलारूप में परिणत नहीं होने देती। उग्र के सभी उपन्यास सुधारवादी दृष्टिकोण से लिखे गये हैं, इसलिए भी वे श्रेष्ठ कलारूप में परिणत नहीं हो पाये हैं। दूसरी ओर उनकी सपाटबयानी अधकचरे और कम उम्र पाठकों की रुचि को विकृत करने के ख़तरे से भी युक्त है, जिससे उनका सुधारवादी उद्देश्य भी पूरा नहीं हो पाता। वैसे यह उल्लेखनीय है कि 'चंद हसीनों के खुतूत' पत्रात्मक प्रविधि में लिखा गया हिंदी का पहला उपन्यास है। 'उग्र' के अनुकरणकर्ताओं में विषय की दृष्टि से ऋषभचरण जैन और शिल्प की दृष्टि से अनूपलाल मंडल उल्लेखनीय हैं। **ऋषभचरण जैन** ने उग्र की भांति तत्कालीन समाज के 'वर्जित विषयों' पर 'दिल्ली का कलंक', 'दिल्ली का व्यभिचार', 'वेश्यापुत्र', 'रहस्यमयी' आदि उपन्यासों की रचना की और **अनूपलाल मंडल** ने पत्रात्मक प्रविधि में 'समाज की वेदी पर' और 'रूपरेखा' शीर्षक उपन्यासों का प्रणयन किया।

प्रेमचंद के समकालीनों में **जयशंकर प्रसाद** इसलिए उल्लेखनीय हैं कि वे न केवल कविता और नाटक के क्षेत्र में, वरन् 'कंकाल' (1929) और 'तितली' (1934) की रचना द्वारा उपन्यासकार के रूप में भी चर्चा के विषय बने। इनमें से 'कंकाल' ही विशेष उल्लेखनीय है। 'तितली' में ग्रामीण और कृषक-जीवन का सामान्य औपन्यासिक फैलाव मात्र है। 'कंकाल' ही विशिष्टता यह है कि इसमें प्रसाद ने समाज की त्याज्य, अवैध और अज्ञात-कुलशील संतानों की कथा कही है। विषय के चुनाव की दृष्टि से वे घोर प्रकृतिवादी लगते हैं, पर पात्रों की रचना में उनका वही रोमांटिक रूप सामने आता है, जो उनके नाटकों और कविताओं में देखने को मिलता है। यद्यपि प्रसाद की भी दृष्टि प्रेमचंद, उग्र आदि की तरह सामाजिक थी, किंतु संयोगवश 'कंकाल' में कुछ व्यक्ति ही प्रधान बन गये हैं। ये व्यक्ति समाज में अकेले हैं, इनका कोई वर्ग नहीं है, इस प्रकार के कई पात्र मिल कर भी किसी वर्ग का निर्माण नहीं करते। स्वभावतः ऐसे पात्र असामान्य होते हैं और यदि प्रसाद ने असामान्य मनोविज्ञान के सिद्धांतों के अनुरूप अपने पात्रों को गढ़ा होता तो उन्हें बहुत दूर तक सफलता मिली होती। पर वे 'उग्र' की तरह समाज के इन उपेक्षित और लांछित व्यक्तियों के मसीहा बन कर उपस्थित होते हैं, और इनको केंद्र में रख कर ऐसी कहानी गढ़ते हैं, जो इनके प्रति पाठक की करुणा जगाने में एक हद तक समर्थ तो है, पर वह कहानी 'घटनाओं', संयोगों और 'चमत्कारों' पर आधृत होने के कारण कृत्रिम और अविश्वसनीय हो जाती है। उपन्यासकार के रूप में प्रसाद की असफलता का एक अन्य कारण यह है कि उनकी भाषा बिलकुल भी उपन्यासोचित नहीं है। भाषा को अलंकृत करने, उसे लक्षणा शक्ति और अलंकारों से सजाने का मोह उनमें इतना अधिक है कि वह विषय से सर्वथा अलग

पड़ जाती है। इस प्रकार प्रसाद प्रतिभा-संपन्न लेखक होते हुए भी हिंदी-उपन्यास को कोई नया आयाम नहीं दे सके।

हिंदी-उपन्यास को प्रेमचंद-युग में ही नयी दिशा देने का सफल प्रयास किया जैनेंद्र (1905-1988) ने। विवेच्य काल में उनके तीन उपन्यास प्रकाशित हुए—'परख' (1929), 'सुनीता' (1935) और 'त्यागपत्र' (1937)। हिंदी-उपन्यास को उनसे जो पाना था, वह इन्हीं कृतियों में मिल गया। 'परख' में समकालीन सामाजिक उपन्यासों की परंपरा से (जिसके प्रेमचंद सर्वश्रेष्ठ लेखक थे) अलग लीक पर चलने का प्रयास किया गया है। लेखक ने व्यापक सामाजिक जीवन को अपने उपन्यासों का विषय न बना कर व्यक्ति-मानस की शंकाओं, उलझनों और गुत्थियों का चित्रण किया है। उनके उपन्यासों की कहानी अधिकतर एक परिवार की कहानी होती है और वे 'शहर की गली और कोठरी की सभ्यता' में ही सिमट कर व्यक्तिपात्रों की मानसिक गहराइयों में प्रवेश करने की कोशिश करते हैं। जैनेंद्र की अगर कोई त्रुटि है, तो केवल यह कि वे अपने पात्रों को पहेली बना कर छोड़ देते हैं और पाठक उस मनोवैज्ञानिक पहेली को सुलझाने के असफल प्रयत्न में उलझा रह जाता है। जो हो, उन्होंने हिंदी-उपन्यास को असंदिग्ध रूप से नयी दिशा प्रदान की और उपन्यास को सामाजिक यथार्थ ही नहीं, बल्कि मनोवैज्ञानिक यथार्थ के क्षेत्र में भी प्रवेश करने की राह सुझायी। इस प्रकार उन्हें हिंदी में मनोवैज्ञानिक उपन्यासों की परंपरा का पुरस्कर्ता माना जा सकता है। वैसे उन्होंने हिंदी-उपन्यास को नये शिल्प और नयी भाषा से भी समृद्ध किया है। 'परख' में यद्यपि उन्होंने प्रेमचंद की दृश्यात्मक और परिदृश्यात्मक पद्धति को मिश्रित रूप में अपनाया है, पर सिलसिलेवार कहानी कहने की ज़रूरत जितनी प्रेमचंद समझते थे, उतनी जैनेंद्र ने नहीं समझी। 'परख' की भांति 'सुनीता' और 'त्यागपत्र' भी वयस्क और संवेदनशील पाठकों के लिए लिखे गये उपन्यास हैं, विषय और शिल्प दोनों दृष्टियों से। 'त्यागपत्र' में समूची कथा एक पात्र विशेष के अवलोकनबिंदु से प्रस्तुत की गयी है, जो निश्चय ही नाटकीकरण की विकसित पद्धति है। कथ्य के अनुरूप उनकी भाषा में भी नवीनता है। 'सादगी' उनकी भाषा की भी विशेषता है, पर वह प्रेमचंद की भाषा की सादगी से भिन्न है। जैनेंद्र की भाषा स्वगतालाप अथवा ख़ुद से या बहुत हुआ तो किसी आत्मीय से चुप-चुप की जाने वाली बातचीत की भाषा है। इसलिए भाषा सरल होने पर भी आंतरिक मनोभावों को व्यक्त करने की उसमें अद्‌भुत क्षमता है। इसमें संदेह नहीं कि हिंदी-उपन्यास को जैनेंद्र की देन महत्त्वपूर्ण है, प्रेमचंद के बाद उन्होंने ही हिंदी-उपन्यास को विशेष व्यक्तित्व प्रदान किया।

इस काल के अन्य प्रमुख उपन्यासकारों में भगवतीचरण वर्मा, राधिकारमणप्रसाद सिंह, सियारामशरण गुप्त, भगवतीप्रसाद वाजपेयी, वृंदावनलाल वर्मा, राहुल सांकृत्यायन, सूर्यकांत त्रिपाठी 'निराला' आदि उल्लेखनीय हैं। भगवतीचरण वर्मा ने 'चित्रलेखा' (1934) की रचना कर पाठकों के बीच पर्याप्त लोकप्रियता प्राप्त की थी, पर उपन्यास में जीवन की धड़कन न होने के कारण इसका कोई स्थायी मूल्य न हो सका। 1936 में इनका 'तीन वर्ष' नामक उपन्यास छपा, जो अपनी 'अश्रुपंकिल' भावुकता के कारण पाठकों में काफ़ी लोकप्रिय हुआ। राधिकारमणप्रसाद सिंह ने 'राम-रहीम' (1937) में कतिपय सामाजिक पहलुओं का उद्‌घाटन किया, पर उनका लगभग सारा ध्यान भाषा को 'चुलबुलाहट' से युक्त बनाने में ही लगा रहा। सियारामशरण गुप्त-कृत 'गोद' (1932), 'अंतिम आकांक्षा' (1934) और 'नारी' (1937) गांधी-दर्शन पर आधारित मनोवैज्ञानिक सामाजिक उपन्यास हैं, जिनमें क्रमशः लांछनाग्रस्त निरपराध व्यक्तियों की मनोव्यथा, घरेलू नौकरों की अनुकरणीय मर्यादा और नारी-समस्याओं के निराकरण के लिए नये-

पुराने मूल्यों के समन्वय पर बल दिया गया है। भगवतीप्रसाद वाजपेयी के उपन्यासों—'प्रेमपथ', 'मीठी चुटकी', 'अनाथ पत्नी', 'त्यागमयी', 'लालिमा' आदि—में मध्यवर्गीय पारिवारिक सामाजिक जीवन का मनोविश्लेषणपरक चित्रण मिलता है। अपने पात्रों के संदर्भ में जीवन की उपलब्धि-अनुपलब्धियों का तटस्थ, व्यावहारिक और कहीं-कहीं भावुकतापूर्ण प्रस्तुतिकरण उनकी उल्लेखनीय विशेषताएं हैं। वृंदावनलाल वर्मा (1889-1969)-कृत 'संगम' (1928), 'लगन' (1929), 'प्रत्यागत' (1929) और 'कुंडलीचक्र' (1932) सामाजिक उपन्यास हैं तथा 'गढ़कुंडार' (1929) और 'विराटा की पद्मिनी' (1936) की रचना ऐतिहासिक पृष्ठभूमि में हुई है। जहां लेखक का अभीष्ट विभिन्न सामाजिक समस्याओं के संदर्भ में जीवन का आदर्शात्मक यथार्थ-निरूपण प्रतीत होता है, वहां शुद्ध ऐतिहासिक उपन्यासों की रचना-परंपरा को आरंभ करने का श्रेय भी उन्हीं को प्राप्त है। राहुल सांकृत्यायन (19893-1963) ने इस काल में मौलिक उपन्यासों के स्थान पर 'शैतान की आंख' (1923), 'विस्मृति के गर्भ में' (1923), 'सोने की ढाल' (1923) प्रभृति अनूदित उपन्यासों की रचना की, जिनमें ऐतिहासिक-रोमानी कथानकों को स्थान प्राप्त हुआ है। इस काल में स्वच्छंदतावादी पद्धति के प्रेममूलक उपन्यासों की रचना का श्रेय सूर्यकांत त्रिपाठी 'निराला' को है। उनके द्वारा रचित 'अप्सरा' (1931), 'अलका' (1933), 'प्रभावती' (1936) और 'निरुपमा' (1936) उपन्यास भले ही प्रसाद के कथा-साहित्य की भांति विषय-निरूपण और शैली दोनों की दृष्टि से उनकी कवि-चेतना से प्रभावित हैं, किंतु इनके उल्लेख के बिना इस काल के उपन्यास-साहित्य का विश्लेषण अधूरा रहेगा।

निष्कर्ष रूप में विवेच्य काल को हिंदी-उपन्यास का स्थापनाकाल कह सकते हैं। जहां प्रेमचंद ने हिंदी-उपन्यास को प्रथम बार साहित्य का दर्जा प्रदान किया और जैनेंद्र ने उसे 'आधुनिक' बनाया, वहीं प्रसाद, कौशिक, उग्र, भगवतीचरण वर्मा, भगवतीप्रसाद वाजपेयी, निराला आदि ने भी अपने-अपने ढंग से उसे समृद्धि प्रदान कर परवर्ती उपन्यासकारों का मार्गदर्शन किया।

कहानी

हिंदी-कहानी का प्रकार और परिमाण दोनों ही दृष्टियों से वास्तविक विकास विवेच्य काल में ही हुआ, यह एक निर्विवाद तथ्य है। जिस प्रकार प्रेमचंद इस काल के उपन्यास-साहित्य के एकच्छत्र सम्राट् बने रहे, उसी प्रकार कहानी के क्षेत्र में भी उनका स्थान अद्वितीय रहा। इस अवधि में उन्होंने लगभग दो सौ कहानियां लिखीं। उनके कहानी-लेखन की सबसे बड़ी विशेषता यह है कि स्वयं उनकी ही कहानियों में हिंदी-कहानी के विकास की प्रायः सभी अवस्थाएं दृष्टिगोचर हो जाती हैं। उनकी आरंभिक कहानियों में क़िस्सागोई, आदर्शवाद और सोद्देश्यता की मात्रा अधिक है। यद्यपि व्यावहारिक मनोविज्ञान का पुट दे कर मानवचरित्र के सूक्ष्म उद्घाटन की क्षमता के फलस्वरूप प्रेमचंद ने अपनी कहानियों को विशिष्ट बना दिया है, पर उनकी आरंभिक कहानियों का कच्चापन और यथार्थ की उनकी कमज़ोर पकड़ अत्यंत स्पष्ट है। इन कहानियों में हम एक अत्यंत प्रबुद्ध कलाकार को कहानी के सही ढांचे या शिल्प की तलाश में संघर्षरत पाते हैं। 'बलिदान' (1918), 'आत्माराम' (1920), 'बूढ़ी काकी' (1921), 'विचित्र होली' (1921), 'गृहदाह' (1922), 'हार की जीत' (1922), 'परीक्षा' (1923), 'आपबीती' (1923), 'उद्धार' (1924), 'सवा सेर गेहूं' (1924), 'शतरंज के खिलाड़ी' (1925), 'माता का हृदय' (1925), 'कजाकी' (1926), 'सुजान भगत' (1927), 'इस्तीफा' (1928), 'अलग्योझा' (1929), 'पूस की रात' (1930), 'तावान' (1931), 'होली का उपहार' (1931), 'ठाकुर

का कुआं' (1932), 'बेटों वाली विधवा' (1932), 'ईदगाह' (1933), 'नशा' (1934), 'बड़े भाई साहब' (1934), 'कफ़न' (1936) आदि कहानियों में इस तलाश की रेखाएं स्पष्ट देखी जा सकती हैं।

प्रेमचंद की कहानियां अपने आसपास की ज़िंदगी से जुड़ी हुई हैं। वे ग्रामीण जीवन से अधिक संबद्ध थे, अतः उनकी अधिकतर कहानियों का विषय गांव की ज़िंदगी से निःसृत है। पर उनकी बहुतेरी कहानियां क़स्बाई, ज़िंदगी, सत्याग्रह-आंदोलन, स्कूल और कॉलेज के वातावरण तथा ज़मींदारों, साहूकारों, क्लर्कों एवं उच्च पदाधिकारियों की समस्याओं और परिवेश की उपज हैं। इससे उनके अनुभवक्षेत्र के वैविध्य और विस्तार का पता चलता है। यद्यपि कलात्मक विकास की दृष्टि से प्रेमचंद के कथा-रचनाकाल को उपखंडों में बांटना बहुत संगत प्रतीत नहीं होता, फिर भी 1930 को एक अस्पष्ट विभाजक-रेखा के रूप में रखा जा सकता है। इसके पूर्व की कहानियां अपने संदर्भों से गहरे रूप में जुड़ी रहने के बावजूद प्रभाव की दृष्टि से कमज़ोर हैं। बहुधा प्रेमचंद का आदर्शवादी दृष्टिकोण, परंपरागत मूल्यों में उनकी आस्था और उनका इच्छित विश्वास, यहां तक कि उनका अंधविश्वास, उनकी पूर्ववर्ती कहानियों पर हावी रहे हैं। पर प्रेमचंद अपनी कमज़ोरियों को आलोचकों द्वारा चेताये जाने के पूर्व ही समझ चुके थे और हर अगली कहानी में उन्हें दूर करने की कोशिश करते थे। इसका सबसे अच्छा उदाहरण 'बूढ़ी काकी', 'शतरंज के खिलाड़ी', 'कजाकी' और 'इस्तीफ़ा' जैसी कहानियां मानी जा सकती हैं। इनमें आदर्शवादी समाधान, पुराने मूल्यों के प्रति आस्था की अभिव्यक्ति, समाज की आलोचना आदि कम है और कुछ मार्मिक स्थितियों को उनकी पूरी मनोवैज्ञानिकता और यथार्थता में उभारने की कोशिश अधिक। प्रेमचंद की 1930 के बाद की कहानियां उनकी पूर्ववर्ती कहानियों से नितांत भिन्न हैं। यद्यपि इनमें भी कुछ निहायत कमज़ोर कहानियां मिल जाती हैं, पर इस काल की अधिकतर कहानियों का स्वर और तेवर पहले से बदला हुआ प्रतीत होता है। उदाहरण के लिए, 'पूस की रात', 'ईदगाह', 'बड़े भाई साहब', 'ठाकुर का कुआं', 'तावान', 'ज्योति', 'क़ायर', 'होली का उपहार' और 'कफ़न' का उल्लेख किया जा सकता है। प्रेमचंद की इस काल की कहानियों में सचाई को उसके नग्नतम रूप में ही देखने का प्रयास नहीं, उसके उस पहलू को भी पकड़ने की चेष्टा है, जिसकी ओर साधारणतः दृष्टि नहीं जाती। 'पूस की रात', 'तावान' और 'कफ़न' तो प्रेमचंद की ही नहीं, हिंदी की बेजोड़ कहानियां हैं। कोई आश्चर्य नहीं कि आधुनिक हिंदी-कहानी को इन्हीं कहानियों से जोड़ने की चेष्टा आज हो रही है। इस अवधि की कहानियों में प्रेमचंद का आदर्शवादी दृष्टिकोण भी है, पर वह अधिकतर छिपा हुआ ही नहीं, कहानियों के साथ घुला हुआ भी है। प्रेमचंद की इस काल की कहानियां निस्संदेह हिंदी-कहानी को एक कसौटी देने में समर्थ हो सकी हैं।

इस काल के दूसरे प्रमुख कहानीकार हैं जयशंकर प्रसाद। यद्यपि उनकी पहली कहानी 'ग्राम' सन् 1911 में ही 'इंदु' में छप चुकी थी, तथापि उनके महत्त्वपूर्ण कहानी-संग्रह—'प्रतिध्वनि' (1926), 'आकाशदीप' (1929), 'आंधी' (1931), 'इंद्रजाल' (1936) आदि विवेच्य काल में ही प्रकाश में आये। कहानी-लेखक के रूप में उनकी प्रकृति प्रेमचंद से बिलकुल अलग है। जहां प्रेमचंद का रुझान जीवन के चारों ओर फैले यथार्थ में था, वहीं प्रसाद रूमानी स्वभाव के व्यक्ति थे। उनकी कहानियों में जीवन के सामान्य यथार्थ को कम और स्वर्णिम अतीत के गौरव, मसृण भावुकता, कल्पना की ऊंची उड़ान तथा काव्यात्मक चित्रण को अधिक महत्त्व मिला है। उनकी कुछ कहानियां तो आधुनिक कहानी की तुलना में संस्कृत-गद्यकाव्य के निकट हैं। 'चक्रवर्ती का स्तंभ', 'खंडहर

की लिपि', 'पत्थर की पुकार', 'उस पार का योगी', 'प्रतिमा' आदि कहानियों में यह बात देखी जा सकती है। यद्यपि प्रसाद की कहानियों में प्रेम और करुणा का, त्याग और बलिदान का, दार्शनिकता और काव्यात्मकता का, भावुकता और चित्रात्मकता का प्राधान्य है, तथापि उनकी परवर्ती कहानियों में भावुकता और चित्रमयता की प्रवृत्तियां थोड़ी छंटी हैं और इनका स्थान मनोविज्ञान ने लिया है। 'आकाशदीप', 'कला', 'देवदासी', 'आंधी', 'मधुवा', 'इंद्रजाल', 'सालवती' आदि कहानियों में उलझनपूर्ण मन:स्थितियों तथा मानसिक द्वंद्व के चित्रण में प्रसाद को पूरी सफलता मिली है। एक ख़ास प्रकार के नारी पात्रों की सृष्टि में प्रसाद जी अद्वितीय हैं, जो अपने निश्छल प्रेम, त्याग और बलिदान से पाठकों के मन पर अमिट प्रभाव छोड़ जाती हैं। 'आकाशदीप' की चंपा, 'देवरथ' की सुमाता, 'पुरस्कार' की मधूलिका आदि प्रसाद की अनुपम नारी सृष्टि है। नियति और समाज से एक साथ संघर्षरत नारी का ऐसा चित्रण अन्यत्र दुर्लभ है। इसके बावजूद प्रसाद की कहानियां आधुनिक कहानी से सही रूप में नहीं जुड़ पातीं। उनकी जीवनदृष्टि ही नहीं, भाषा भी आधुनिक कहानी की प्रकृति के प्रतिकूल है। यही कारण है कि जहां प्रेमचंद को आधुनिक हिंदी-कहानी का जनक माना जाता है, वहीं प्रसाद को यह श्रेय नहीं मिलता।

विवेच्य काल के अन्य कहानी लेखकों में विश्वंभरनाथ शर्मा 'कौशिक' और सुदर्शन विशेष उल्लेखनीय हैं। ये दोनों ही प्रेमचंद की परंपरा के कहानीकार माने जाते हैं। कौशिक जी की 'रक्षाबंधन' कहानी यद्यपि 1912 में ही छप चुकी थी, पर उनकी कहानी-कला में विशेष निखार 1918 के बाद ही आया। 'गल्पमंदिर', 'चित्रशाला' (दो भाग), 'प्रेम-प्रतिमा', 'मणिमाला', 'कल्लोल' आदि में उनकी दो सौ से ऊपर कहानियां संगृहीत हैं। प्रेमचंद की भांति उन्होंने अपने आसपास की ज़िंदगी से कहानियों के विषय चुने हैं और पारिवारिक जीवन की अनेक समस्याओं—बाल-विवाह, परदा-प्रथा, दहेज़-प्रथा आदि का अंकन किया है। ग्रामीण जीवन की अपेक्षा उन्होंने नगर-जीवन का अधिक चित्रण किया है। सुदर्शन के कहानी-संग्रहों में 'सुदर्शन-सुधा', 'सुदर्शन-सुमन', 'तीर्थयात्रा', 'पुष्पलता', 'गल्पमंजरी', 'सुप्रभात', 'परिवर्तन', 'पनघट' आदि उल्लेखनीय हैं। विषय-चयन की दृष्टि से उन्होंने भी तत्कालीन जीवन की ज्वलंत समस्याओं को आधार बनाया है। कौशिक और सुदर्शन ने यद्यपि कुछ अच्छी कहानियां लिखी हैं, जैसे कौशिक की 'ताई' और 'पगली' तथा सुदर्शन की 'हार की जीत', 'कवि की स्त्री' आदि, पर उनमें प्रेमचंद की तरह विकास की संभावनाएं नहीं दीखतीं। फिर भी, प्रेमचंद की आरंभिक कहानियों तथा कौशिक और सुदर्शन की कहानियों में पर्याप्त समानता है वही संयोग के आधार पर कथानक की योजना, किसी आदर्श को केंद्र में रख कर कथा की बुनावट, हृदय-परिवर्तन के नुस्खे से सामाजिक समस्याओं का समाधान, हर जगह पुण्य की विजय और परंपरागत मूल्यों की स्थापना। विकास के दूसरे चरण में इनकी कहानियों में मनोविज्ञान का प्रवेश हुआ, संयोगाधृत कथानकों में कमी आयी और दोनों ने ही कुछ ऐसी कहानियों की रचना की, जो प्रेमचंद की समकक्षता करती हैं। किंतु अपने विकास के तीसरे चरण में प्रेमचंद ने जिस कोटि की विशुद्ध, यथार्थवादी कहानियां लिखीं, वैसी कहानियां कौशिक और सुदर्शन नहीं लिख पाये।

आलोच्य युग के कुछ कहानी लेखकों—चतुरसेन शास्त्री, राय कृष्णदास और विनोदशंकर व्यास—ने प्रसाद की कथालेखन-शैली को अपनाया। चतुरसेन शास्त्री ने विभिन्न युगों के ऐतिहासिक प्रसंगों पर आधारित अनेक मार्मिक कहानियां लिखीं, जिनमें 'दुखवा मैं कासों कहूं मोरी सजनी' अत्यंत प्रसिद्ध हुई, पर बाद में पता चला और अब यह सिद्ध हो चुका है कि यह कहानी बंगला-कथाकार हरिसाधन मुखोपाध्याय की 'सेलिना बेग़म' कहानी का रूपांतर है।

उनकी अन्य कहानियों में 'अंबपालिका', 'प्रबुद्ध', 'भिक्षुराज', 'बावर्चिन', 'हल्दीघाटी में', 'मालवधू' आदि उल्लेखनीय हैं, जिनमें भारतीय इतिहास के विभिन्न प्रसंगों का मर्मस्पर्शी चित्रण हुआ है। राय कृष्णदास ने प्रसाद की तरह भावप्रधान कहानियों की रचना की। कवित्वपूर्ण वातावरण की सृष्टि और नाटकीय शिल्प-योजना में वे प्रसाद की भांति सिद्धहस्त हैं। 'अंत:पुर का आरंभ' और 'रमणी का रहस्य' जैसी कहानियों में यह बात स्पष्टत: देखी जा सकती है। विनोदशंकर व्यास की कहानियों में प्रसाद की करुणा, प्रेम आदि भावनाओं का प्राधान्य है। 'कल्पनाओं का राजा', 'विधाता', 'अपराध' आदि कहानियां इस दृष्टि से उल्लेखनीय हैं।

विवेच्यकाल के कहानीकारों में पांडेय बेचन शर्मा 'उग्र', जैनेंद्र और अज्ञेय अलग-अलग कारणों से उल्लेखनीय हैं। उग्र की कहानियां 'चिनगारियां' (1923), 'शैतान-मंडली' (1924), 'इंद्रधनुष' (1927), 'बलात्कार' (1927), 'चॉकलेट' (1928), 'दोज़ख की आग' (1929), 'निर्लज्जा' (1929) आदि कृतियों में संकलित हैं। प्रेमचंद की तरह 'उग्र' भी सामाजिक चेतना के लेखक थे, और वे आदर्शवादी भी प्रेमचंद से कम न थे, पर समाज के नग्न यथार्थ को उन्होंने ऐसे कच्चे रूप में पेश किया कि तत्कालीन पाठकों और विशेषकर समीक्षकों ने उन्हें पश्चिमी प्रकृतिवाद का अनुगामी समझ लिया। उनकी कहानियों में अनुभूति की तीव्रता कुछ कम है और सामाजिक शोषण, अनाचार एवं कुप्रथाओं के प्रति आक्रोश तनिक ज़्यादा है। यही कारण है कि उनकी कहानियां उतना बेधती नहीं, जितना चौंकाती और झकझोरती हैं। 'चिनगारियां' में उन्होंने अपनी विद्रोहपूर्ण राष्ट्रीय चेतना को वाणी देने का प्रयास किया, जिसके फलस्वरूप यह कहानी-संग्रह सरकार द्वारा जब्त कर लिया गया। अन्य कहानियों में उन्होंने समाज पर चौतरफ़ा प्रहार किया। व्यंग्य का जैसा पैनापन उनकी कहानियों में मिलता है, वैसा बहुत कम लेखकों में सुलभ होता है। 'उग्र' विशुद्ध समाजद्रोही थे, कला की उन्होंने कभी चिंता ही नहीं की, फलत: उनकी कहानियां कलात्मक दृष्टि से कभी भी शिखर पर न पहुंच सकीं। फिर भी अपने अक्खड़ व्यक्तित्व, बेलौस भाषा और पैनी दृष्टि के लिए वे सदैव स्मरण किये जायेंगे।

प्रेमचंद के बाद हिंदी-कहानी को नवीन आयाम देने वालों में जैनेंद्र प्रमुख हैं। उन्होंने प्रेमचंद के निकट संपर्क में रहने पर भी उनका अनुसरण नहीं किया, वरन् अपने लिए नयी दिशा की खोज की। उन्होंने कहानी को 'घटना' के स्तर से उठा कर 'चरित्र' और 'मनोवैज्ञानिक सत्य' पर लाने का प्रयास किया। यद्यपि स्वयं प्रेमचंद ने भी 1930 ई. तक इस उपलब्धि को पा लिया था, पर जैनेंद्र की एक और खूबी यह रही कि उन्होंने कथावस्तु को सामाजिक धरातल से समेट कर व्यक्तिगत और मनोवैज्ञानिक भूमिका पर प्रतिष्ठित किया। उसकी 'हत्या' (1927) शीर्षक कहानी में इन प्रवृत्तियों की झलक देखी जा सकती है। बाद की कहानियों में—जैसे 'खेल', 'अपना-अपना भाग्य', 'बाहुबली', 'वातायन', 'नीलम देश की राजकन्या', 'दो चिड़ियां', 'ध्रुवयात्रा', 'पाजेब', 'एक दिन' आदि में—जैनेंद्र ने व्यक्ति-मन की शंकाओं, प्रश्नों तथा गुत्थियों का अंकन किया है। उनकी कहानियों का मुख्य विषय नारी है, ऐसी नारी जो घर ही नहीं, पातिव्रत्य की चारदीवारी से भी बाहर निकलकर मुक्ति की सांस लेना चाहती है। जैनेंद्र प्रेमचंद से इस अर्थ में विशिष्ट हैं कि वे कहानी कहने से भागते हैं। घटनाओं को प्राय: छोड़ते जाते हैं या उनकी जगह संकेतों से काम लेना पसंद करते हैं। अनुभूति की गहरी प्रेरणा उनकी कहानियों को वैशिष्ट्य प्रदान करती हैं, यहां तक कि कथानक, पात्र, परिस्थिति आदि की विरलता भी तीव्र अनुभूति के संस्पर्श से अत्यंत प्रभावोत्पादक हो जाती है।

हिंदी-कहानी के विकास में अज्ञेय (1911-1987) का स्थान लगभग वही है जो जैनेंद्र

का। किंतु जहां जैनेंद्र मनःसंसार को छोड़ कर वास्तविक दुनिया में आना पसंद नहीं करते और जहां उनके पात्र समाज से लड़ने का हौसला न रख कर अपने मन की दुर्बलताओं से ही उलझते रहते हैं, वहीं अज्ञेय के पात्र बहिर्मुखी हैं जो समाज तथा अपने आसपास की परिस्थितियों से जूझने के लिए सदैव प्रस्तुत रहते हैं। भारतीय समाज की रूढ़िप्रियता शोषण, वर्तमान विश्व में व्याप्त संघर्ष आदि को ले कर उन्होंने अनेक मार्मिक कहानियां लिखी हैं। उनका प्रथम कहानी-संग्रह 'विपथगा' 1931 में प्रकाशित हुआ था। 'विपथगा' कहानी में आधुनिक विश्व में होने वाले युद्ध के कारणों की खोज की गयी है और नारी का चित्रण क्रांति की अग्रदूत के रूप में किया गया है। इसी प्रकार 'कड़ियां', 'अमर वल्लरी', 'मैना', 'सिगनेलर', 'रेल की सीटी', 'रोज', 'हरसिंगार' आदि कहानियों में आज की स्वीकृत शासन-व्यवस्था तथा परंपरागत मान-मूल्यों को नकारा गया है। एक ओर प्रेम और कर्तव्य तथा दूसरी ओर आदर्श और सहज वृत्ति के संघर्ष का मार्मिक चित्रण इन कहानियों में देखा जा सकता है। इनमें अज्ञेय ने व्यक्ति मन की ग्रंथियों, प्रेरणाओं तथा अंतर्द्वंद्वों का सूक्ष्म विश्लेषण किया है। अज्ञेय की कहानियां मनोवैज्ञानिक होने पर भी सामाजिक संघर्ष और विद्रोह के तीखेपन से युक्त हैं, जैनेंद्र के कथा-साहित्य की तुलना में वे अधिक ठोस और विश्वसनीय हैं।

विवेच्यकाल के कहानीकारों में कुछ और नाम गिनाये जा सकते हैं, जैसे राधिकारमणप्रसादसिंह, भगवतीप्रसाद वाजपेयी, निराला, सुमित्रानंदन पंत, राहुल सांकृत्यायन, सुभद्राकुमारी चौहान, शिवरानी देवी, उषादेवी मित्रा, चंद्रगुप्त विद्यालंकार, विष्णु प्रभाकर आदि। राधिकारमणप्रसाद सिंह बहुत पहले 'कानों में कंगना' लिख कर प्रसिद्धि प्राप्त कर चुके थे। विवेच्यकाल में उन्होंने अपनी विशिष्ट चुभती शैली में 'दरिद्रनारायण', 'पैसे की घुघनी' आदि प्रसिद्ध कहानियों की रचना की, जो 'गांधी टोपी' (1938) में संकलित हैं। उनकी कहानियां अधिकतर समाज-सुधार और आदर्श-स्थापन की प्रेरणा से युक्त हैं। भगवतीप्रसाद वाजपेयी की 'मधुपर्क', 'दीपमालिका', 'हिलोर', 'मिठाईवाला', 'हद्‌गति', 'तारा', 'स्वप्नमयी', 'शबनम' आदि कहानियां विवेच्य अवधि में प्रकाशित हुईं। इनकी सबसे प्रसिद्ध कहानी है—'निंदिया लागी', जिसमें मध्यवर्गीय समाज की विसंगतियों का बड़ा अच्छा चित्रण हुआ है। **भगवतीचरण वर्मा** ने भी विवेच्य काल में कुछ कहानियां लिखी थीं, जो 'इन्सटालमेंट' (1936) में संगृहीत हैं। उन्होंने जीवन की कुरूपताओं का पर्दाफ़ाश करते हुए वर्तमान सभ्यता और आधुनिक समाज के खोखलेपन का चित्रण किया है। आधुनिक युग में नारी-पुरुष के संबंधों के विघटन का यथार्थ अंकन भी उनकी कहानियों में मिलता है।

छायावाद के प्रसिद्ध कवि-द्वय—निराला और पंत—ने भी कहानियां लिखने का प्रयास किया था। निराला ने 'श्रीमती गजानंद शास्त्रिणी', 'पद्मा' और 'लिली' जैसी कहानियां लिखीं, जिनमें काव्यात्मक वातावरण की सृष्टि ही प्रमुख है। पंत की 'पानवाला' नामक कहानी इसी काल में लिखी गयी थी, जिसमें अनुभूति-पक्ष की ही प्रधानता है। पंत और निराला की कहानियों पर युगीन चिंतन की छाप नहीं मिलती। वस्तुतः ये दोनों रूमानी कवि थे और रूमानियत कहानी के लिए अनुकूल नहीं पड़ती। विवेच्य काल में राहुल सांकृत्यायन ने भी कुछ कहानियों की रचना की जो 'सतमी के बच्चे' (1935) में संकलित हैं। इनमें भारत की तत्कालीन सामाजिक एवं आर्थिक परिस्थितियों का यथार्थ अंकन हुआ है। आर्थिक विषमता की घुटन इन कहानियों में बहुत ही सशक्त रूप में अभिव्यक्त हुई है। ये कहानियां चरित्रप्रधान हैं, पर राहुल जी का झुकाव मनोविज्ञान की ओर उतना नहीं है जितना कि वर्ग-संघर्ष की ओर है।

इस युग की नारी-लेखिकाओं में **सुभद्राकुमारी चौहान** की कहानियां सामाजिक-पारिवारिक जीवन के व्यावहारिक चित्रण के लिए विशेष प्रसिद्ध हैं। 'बिखरे मोती' (1932) और 'उन्मादिनी' (1934) में संगृहीत कहानियों में उन्होंने अधिकतर भारतीय नारी की परिस्थितियों, समस्याओं तथा भावनाओं का सजग चित्रण किया है। उनकी 'पापी पेट' शीर्षक प्रसिद्ध राष्ट्रीय कहानी भी इसी अवधि की रचना है। प्रेमचंद की अर्द्धांगिनी **शिवरानी देवी** ने भी प्रायः उन्हीं की शैली को अपनाते हुए कुछ सामाजिक कहानियों की रचना की थी, जो 'कौमुदी' (1937) में प्रकाशित हैं। **उषादेवी मित्रा** की भावुकता-भरी कल्पनामयी सामाजिक कहानियां भी 1933 के आसपास तत्कालीन पत्रिकाओं में प्रकाशित होने लगी थीं—'पिउ कहां', 'मूर्त मृदंग', 'गोधूलि', 'देवदासी', 'मन का मोह' आदि की रचना उन्होंने इसी अवधि में की थी। चंद्रगुप्त विद्यालंकार और विष्णु प्रभाकर के कहानीकार-जीवन का आरंभ इसी काल के अंतिम चरण में हुआ। **चंद्रगुप्त विद्यालंकार** की इस अवधि की कहानियों में 'गोरा', 'बचपन', 'संदेह', 'आंसू', 'शराबी', 'भय का राज्य', 'पगली', 'ताड़ का पत्ता', 'मास्टर जी' आदि प्रमुख हैं। **विष्णु प्रभाकर** (जन्म 1912) की कुछ कहानियां 1931 और 1934 के बीच 'हंस' और 'अलंकार' में प्रकाशित हुई थीं। इन दोनों ही लेखकों ने परवर्ती युग में कहानी-लेखन के क्षेत्र में अपना विशेष स्थान बनाया।

कुल मिला कर हिंदी-कहानी के विकास की दृष्टि से विवेच्य काल का उल्लेखनीय महत्त्व है। प्रेमचंद ने हिंदी-कहानी को मज़बूत नींव ही नहीं दी, बल्कि उसे कलात्मक ऊंचाई भी प्रदान की। कौशिक, सुदर्शन, उग्र, राहुल आदि ने कहानी को सामाजिक पीड़ा की अभिव्यक्ति का सफल माध्यम बनाया। जैनेंद्र और अज्ञेय ने मनोविश्लेषण को आधार बना कर नवीन प्रयोग किये, जहां से हिंदी-कहानी की एक नवीन धारा का सूत्रपात हुआ। तात्पर्य यह है कि इस युग में हिंदी-कहानी अपने विकास की प्रारंभिक अवस्थाओं को पार कर वहां पहुंच गयी, जहां से हमें इसके श्रेष्ठ रूप के दर्शन होने लगते हैं।

निबंध

हिंदी में 'निबंध' शब्द का प्रयोग एक ओर तो 'एस्से' के पर्याय रूप में ललित या व्यक्तिगत निबंधों के लिए होता है, और दूसरी ओर उन रचनाओं के लिए भी होता है जिनमें किसी विषय का सुसंबद्ध विवेचन प्रस्तुत किया जाता है। यहां इनमें से प्रथम वर्ग की रचनाओं, अर्थात विषय के स्थान पर 'व्यक्ति' और 'लालित्य' को प्रधानता देने वाले निबंधों का विवेचन ही अभीष्ट है। इस युग के सबसे प्रमुख निबंधकार आचार्य रामचंद्र शुक्ल हैं, पर इस मान्यता का आधार उनके वे सभी निबंध हैं, जो 'चिंतामणि' के दोनों खंडों में संकलित हैं। इन निबंधों में प्रौढ़ चिंतन, सूक्ष्म विश्लेषण और तर्कपूर्ण सुसंबद्ध विवेचन का चरम आदर्श लक्षित होता है और इस कसौटी पर शुक्ल जी को हिंदी का सर्वश्रेष्ठ निबंधकार मानना सर्वथा उचित भी है। किंतु यह ध्यान रखना आवश्यक है कि 'चिंतामणि' के दूसरे भाग में संकलित 'काव्य में प्राकृतिक दृश्य', 'काव्य में रहस्यवाद' और 'काव्य में अभिव्यंजनावाद' निबंध न हो कर विस्तृत आलोचनात्मक लेख हैं। प्रथम भाग में भी तीन प्रकार के निबंध हैं—मनोविकार विषयक, साहित्य-सिद्धांत विषयक और साहित्यालोचन विषयक। इनमें अंतिम दो प्रकार निश्चित रूप से साहित्यालोचन से संबद्ध हैं, अतः ये 'आलोचना' के अंतर्गत आयेंगे, 'निबंध' के अंतर्गत नहीं। शेष रह जाते हैं मनोविकार संबंधी निबंध, जिन्हें प्रस्तुत प्रसंग में विचारणीय होने पर भी शुद्ध 'ललित' या 'व्यक्तिगत' निबंध नहीं कहा जा सकता। इनमें अत्यंत गंभीर मुद्रा में उत्साह, श्रद्धा, भक्ति, करुणा, लज्जा, ग्लानि, लोभ,

प्रीति, ईर्ष्या, भय आदि भावों अथवा मनोविकारों का स्वरूप निर्धारण तथा इनका तुलनात्मक विवेचन किया गया है। इस संदर्भ में शुक्ल जी का विशद पांडित्य, प्रौढ़ चिंतन, सूक्ष्म विश्लेषण, व्यापक अनुभव सब कुछ अपने उत्कर्ष पर पहुंचा दिखायी देता है और वे एक आचार्य तथा दार्शनिक के रूप में हमारे सामने आते हैं। इन निबंधों में पर्यवेक्षण, विवेचन और निष्कर्ष तीनों की सुसंबद्ध शृंखला है। फिर भी ये दर्शनशास्त्र और मनोविज्ञान की संपत्ति न हो कर साहित्य की संपत्ति हैं, क्योंकि इनमें गंभीर मुद्रा त्याग कर शुक्ल जी बीच-बीच में सहज बातचीत, हास्य-व्यंग्य और मधुर संभाषण की अनौपचारिक मुद्रा अपनाते दीखते हैं, जिसके फलस्वरूप इनमें व्यक्तिगत तत्त्व का समावेश हो गया है। उदाहरणार्थ, 'लोभ और प्रीति' निबंध का यह अंश द्रष्टव्य है :

> *"लोभियों का दमन योगियों के दमन से किसी प्रकार कम नहीं होता। लोभ के बल से वे काम और क्रोध को जीतते हैं, सुख की वासना का त्याग करते हैं, मान-अपमान में समान भाव रखते हैं...लोभियो, तुम्हारा अक्रोध, तुम्हारा इंद्रिय-निग्रह, तुम्हारी मानापमान-समता, तुम्हारा तप अनुकरणीय है : तुम्हारी निष्ठुरता, तुम्हारी निर्लज्जता, तुम्हारा अविवेक, तुम्हारा अन्याय विगर्हणीय है। तुम धन्य हो, तुम्हें धिक्कार है!"*

किसी विषय के वैज्ञानिक विवेचन में ऐसे भावोद्गार के लिए कोई स्थान नहीं होता। मनोविज्ञान के ग्रंथ में इस प्रकार का विषयांतर दोष माना जायेगा। इसी प्रकार अपनी बात को स्पष्ट करने के लिए शुक्ल जी ने कहीं-कहीं अंतर्कथा की भी सहायता ली है, जो ललित निबंध का तो गुण है, पर वैज्ञानिक विवेचन में जिसका कोई महत्त्व स्वीकार नहीं किया जा सकता। इस तरह की 'ललित उड़ान' ही 'निबंध' को 'लेख' से भिन्न करती है, और शुक्ल जी के निबंधों में इस 'ललित उड़ान' के दर्शन यत्र-तत्र होते हैं।

शुक्ल जी के निबंधों की एक अन्य विशेषता है प्रांजल साहित्यिक भाषा का प्रयोग, जो इनको विषय के शुष्क विवेचन से भिन्न धरातल पर ला खड़ा करती है। वैज्ञानिक विवेचन की भाषा का सारा बल अर्थ की 'निश्चयात्मकता' पर होता है, जबकि शुक्ल जी ने अर्थ की निश्चयात्मकता का ध्यान रखने पर भी उसे अधिक बोधगम्य, व्यंजक और प्रतीतिपूर्ण बनाने के लिए भाषा की उन सभी शक्तियों का प्रयोग किया है, जिनके कारण ही कोई कथन 'काव्य' की संज्ञा प्राप्त करता है। शब्दचयन, वाक्यरचना, सादृश्य-विधान—सब में उन्होंने अपनी काव्यात्मक रुचि का परिचय दिया है। 'प्रथम पुरुष' की शैली का प्रयोग भी उनके निबंधों को 'ललित निबंध' के निकट पहुंचाने वाला तत्त्व है। इस प्रकार उनके मनोविकार विषयक निबंधों में भी ललित निबंधों की आत्मीयता, काव्य-गुण प्रभृति अनेक विशेषताएं विद्यमान हैं, फिर भी गंभीर चिंतन, सूक्ष्म विश्लेषण और तर्क की प्रधानता के कारण इन्हें सही अर्थों में 'ललित निबंध' नहीं कहा जा सकता।

'ललित निबंध' की दृष्टि से **गुलाबराय** (1888-1963) की कुछ रचनाएं उल्लेखनीय हैं। 'ठलुआ-क्लब', 'फिर निराशा क्यों', 'मेरी असफलताएं' आदि संग्रहों में उनके कुछ श्रेष्ठ व्यक्तिगत निबंध संकलित हैं। 'मेरा मकान', 'मेरे नापिताचार्य', 'मेरी दैनिकी का एक पृष्ठ', 'प्रीतिभोज' आदि निबंध ललित निबंध की सभी विशेषताओं से युक्त हैं। इनमें उन्होंने अपनी गंभीर आलोचकीय पांडित्य वाली मुद्रा का त्याग कर सर्वथा अनौपचारिक बातचीत-शैली में अपने व्यक्तिगत जीवन तथा आसपास की तुच्छ दीख पड़ने वाली वस्तुओं के संबंध में भावपूर्ण उद्गार

और चलती हुई प्रतिक्रियाएं व्यक्त की हैं। इनमें 'विषय' को प्रधानता न दे कर लेखक के व्यक्तित्व, उसकी निजी प्रतिक्रियाओं और उल्लास तथा व्यंग्यपूर्ण क्षणों की अभिव्यक्ति मिलती है। लेखक की भाषा सरल, स्वच्छ, स्पष्ट और भावव्यंजक है। उदाहरणस्वरूप, 'मेरी दैनिकी का एक पृष्ठ' की कुछ पंक्तियां देखिए :

> *"ख़ैर, आजकल उस (भैंस) का दूध कम हो जाने पर भी और अपने मित्रों को छाछ भी नहीं पिला सकने की विवशता की झुंझल के होते हुए भी (सुरराज इंद्र की तरह मुझे भी मट्ठा दुर्लभ हो जाता है—तक्रं शक्रस्य दुर्लभम्) उसके लिए भुस लाना अनिवार्य हो जाता है। कहां साधारणीकरण और अभिव्यंजनावाद की चर्चा और कहां भुस का भाव। भुस ख़रीद कर मुझे भी गधे के पीछे ऐसे ही चलना पड़ता है, जैसे बहुत से लोग अक्ल के पीछे लाठी ले कर चलते हैं। कभी-कभी गधे के साथ क़दम मिला के रखना कठिन हो जाता है। लेकिन मुझे गधे के पीछे चलने में उतना ही आनंद आता है जितना कि पलायनवादी को जीवन से भागने में।"*

समीक्ष्य काल में **पदुमलाल पुन्नालाल बख्शी** ने भी कतिपय व्यक्तिगत निबंध लिखे, जो 'पंचपात्र' में संगृहीत हैं। इसमें संकलित 'अतीत स्मृति', 'उत्सव', 'रामलाल पंडित', 'श्रद्धांजलि के दो फूल' आदि निबंधों में लेखक की भावुकता, आत्मीयता तथा व्यंग्यपूर्ण प्रतिक्रिया का सुंदर समन्वय मिलता है। कहीं-कहीं अंतर्कथाओं का प्रयोग भी उन्होंने सफलता के साथ किया है। बख्शी जी की भाषा में गति की सजीवता और चित्रात्मकता पर्याप्त मात्रा में दिखायी पड़ती है। इस काल के अन्य ललित निबंधकारों में शांतिप्रिय द्विवेदी, शिवपूजन सहाय, बेचन शर्मा 'उग्र', रघुवीर सिंह और माखनलाल चतुर्वेदी के भी नाम लिये जा सकते हैं। **शांतिप्रिय द्विवेदी** ने निजी जीवन और व्यक्तिगत समस्याओं पर निबंध लिखने के अतिरिक्त 'कवि और काव्य' (1936), 'साहित्यिकी' (1938) प्रभृति आलोचनात्मक निबंध-संग्रहों में भी भावुकता और आत्मीयता का परिचय दिया है। भाषा की काव्यमयता, सुकुमार शब्दयोजना और भावोच्छ्वासों की तरल अभिव्यक्ति उनके निबंधों की सहज विशेषताएं हैं। **शिवपूजन सहाय** 'भाषा के जादूगर' के रूप में ख्यात हैं। उनकी मस्ती और ज़िंदादिली अनेक व्यक्तिगत निबंधों में फूटी-सी पड़ती है। 'कुछ' शीर्षक निबंध-संग्रह में उन्होंने तुच्छ से तुच्छ विषय को अपनी रोचक रचना प्रणाली से मोहक बना दिया है। उनके निबंध संख्या में अधिक नहीं हैं, पर जो हैं, वे उनकी आत्माभिव्यंजना, शिष्ट हास्य, मार्मिक व्यंग्य और औपचारिक किंतु परिष्कृत-परिमार्जित शैली के कारण हिंदी-निबंध-साहित्य में अपना विशेष स्थान रखते हैं।

बेचन शर्मा 'उग्र' के अधिकतर निबंध भावात्मक हैं। 'बुढ़ापा', 'गाली' आदि निबंधों में उन्होंने सामाजिक और आर्थिक विषमताओं का भावपूर्ण शैली में प्रतिपादन किया है, यत्र-तत्र व्यंग्य के समावेश में भी वे दक्ष हैं। उनके निबंधों की भाषा अत्यंत चित्रात्मक, गतिशील और नाटकीय तीव्रता से युक्त है। वे अपने पाठकों से बिना किसी औपचारिकता के बात करते हुए आगे बढ़ते हैं, पर उनके निबंधों में वह शालीनता, माधुर्य और आभिजात्य नहीं है, जो गुलाबराय अथवा शिवपूजन सहाय के निबंधों में है। फलतः उनके निबंध 'ललित' निबंध न बन कर जोशीले भाषण बन गये हैं। **रघुवीर सिंह** ने ऐतिहासिक प्रसंगों को आधार बना कर कुछ अच्छे भावात्मक निबंधों

की रचना की है। मुग़लकालीन इतिहास की घटनाओं और इमारतों पर उन्होंने अनेक ललित-निबंध लिखे हैं। उनकी भाषा में चित्रात्मकता, सांकेतिकता और अर्थसंपन्नता पूरे तौर पर दिखायी देती हैं। माखनलाल चतुर्वेदी ने भी आलोच्य-युग में कतिपय भावप्रधान निबंधों की रचना की थी। उनके निबंधों में भावुकता की प्रधानता है, पर वे चिंतन से बिलकुल शून्य नहीं हैं। उनके निबंधों की सबसे बड़ी शक्ति है—उनकी भाषा, जिसमें कथन का बांकपन, ओज, प्रतीकात्मकता, लाक्षणिकता और प्रवाह सब कुछ का अत्यंत सुंदर समन्वय हुआ है।

संक्षेप में, विवेच्य युग में निबंधों की रचना तो पर्याप्त मात्रा में हुई, किंतु ललित निबंधों के क्षेत्र में उल्लेखनीय उपलब्धियां अधिक नहीं हैं, इस दिशा में जिन लेखकों ने योगदान किया है, उन्होंने एक अभाव की पूर्ति भले ही की है, कोई मानदंड स्थापित नहीं किया। इस काल के निबंध-साहित्य के संबंध में शुक्ल जी का यह कथन सर्वथा उचित है : "अर्थ-वैचित्र्य और भाषा-शैली का नूतन विकास जैसा कहानियों के भीतर प्रकट हुआ है वैसा निबंध के क्षेत्र में नहीं देखने में आ रहा है।"

समालोचना

उपन्यास, कहानी, नाटक और कविता की भांति विवेच्यकाल में समालोचना-साहित्य भी एक नये युग में प्रवेश करता दिखायी देता है। द्विवेदी-युग में आचार्य महावीरप्रसाद द्विवेदी तथा उनके समकालीन समीक्षकों ने समालोचना ग्रंथों की रचना आरंभ तो कर दी थी, पर उनके द्वारा आरंभ किये गये आलोचना-साहित्य को सम्यक् आकार देने का श्रेय विवेच्य काल के समालोचकों, विशेषकर आचार्य रामचंद्र शुक्ल को है। इस काल तक आते-आते समालोचना हिंदी-साहित्य की अनिवार्य आवश्यकता बन गयी थी। विश्वविद्यालयों में हिंदी-साहित्य के अध्ययन-अध्यापन के संदर्भ में एक ओर तो काव्यशास्त्र विषयक ग्रंथों की रचना की आवश्यकता का अनुभव किया जा रहा था, और दूसरी ओर हिंदी में कतिपय ऐसी साहित्यविधाएं विकसित हो रही थीं, जिनके विवेचन-विश्लेषण में संस्कृत-काव्यशास्त्र से कोई सहायता नहीं मिल सकती थी, जैसे उपन्यास और कहानी। काव्य और नाट्यरचना में भी ऐसी नवीन काव्यप्रवृत्तियां दिखायी देने लगी थीं, जिनका संस्कृत-काव्यशास्त्र से कोई संबंध नहीं जुड़ता था। ये नवीन प्रवृत्तियां अंग्रेज़ी के माध्यम से पाश्चात्य साहित्य से आयी थीं, अतः पाश्चात्य काव्यशास्त्र की ओर भी लेखकों का ध्यान जाने लगा था। छायावाद के पक्ष-विपक्ष में पुस्तकों और अधिकतर निबंधों के रूप में आलोचना का एक ऐसा रूप विकसित हुआ, जो अपने युग के लिए नया तो था ही, वह भावी आलोचना की पीठिका भी बना।

इस काल के जिन लेखकों ने संस्कृत-काव्यशास्त्र का परिचय देने के लिए सिद्धांत या लक्षण-ग्रंथों की रचना की, उनमें जगन्नाथप्रसाद 'भानु' (रस-रत्नाकर, 1919, अलंकार-दर्पण, 1936), गुलाबराय (नवरस—1921), विश्वनाथप्रसाद मिश्र (काव्यांग-कौमुदी—1924), भगवानदीन (व्यंग्यार्थ-मंजूषा, 1927), रामशंकर शुक्ल 'रसाल' (अलंकार-पीयूष, 1929, नाट्य-निर्णय, 1930), अर्जुनदास केडिया (भारतीभूषण, 1930), किशोरीदास वाजपेयी (रस और अलंकार, 1931), श्यामसुंदरदास (रूपक-रहस्य, 1932), कन्हैयालाल पोद्दार (रस-मंजरी, 1934, अलंकार-मंजरी, 1936) आदि प्रमुख हैं। हरिऔध-कृत 'रसकलस' (1935) की भूमिका में रस और नायिकाभेद का विवेचन भी इस संदर्भ में महत्त्वपूर्ण है। पाश्चात्य साहित्यशास्त्र संबंधी पुस्तकों में कन्हैयालाल गुप्त-कृत 'चरित्रचित्रण' (1923), पदुमलाल पुन्नालाल बख्शी-कृत 'विश्व-

वाणी मेरी चाहिए, क्या तुम

प्र०- छायावादी काव्य → प्रवृत्तियाँ और उपलब्धि

उ०- छायावादी रूप - स्वरूप :-

सामान्य रूप से 1918 ई० के आस-पास हिन्दी कविता जो अपनी अभिनव छवि बना रही थी, इसके लिए आलोचकों ने 'छायावाद' संज्ञा प्रदान की, जिन समालोचकों ने यह नाम प्रदान किया, उसकी दृष्टि से 'रहस्य' शब्द का प्रयोग इस कविता धारा का उपजीव्य स्थान नहीं था उन्होंने इस शब्द का प्रयोग उपहास और निन्दा अर्थ में किया था लेकिन स्वच्छन्द काव्यधारा के इन युवा कवि ने इस विद्रूपणा युक्त अभिधान को स्वतन्त्रता से स्वीकार कर लिया और छायावादी कवि के रूप में अपनी एक विशिष्ट पहचान बनायी।

शाब्दिक निर्वचन की दृष्टि से यदि 'छायावाद' का विश्लेषण करें तो ज्ञात हो जायेगा कि इससे छायावाद का तात्विक स्वरूप पर प्रकाश नहीं

पड़ता है। 'छायावाद' छाया + वाद से बनता है। वाद एक विशिष्ट और निश्चित धारा से संबंधित है और छाया अर्थ की वर्ण-वर्ण की छवियों से आच्छादित है। 'प्रसाद' जी 'छाया' शब्द को कुन्तक और आनन्दवर्धन की स्थापनों से स्वसंपित करने का प्रयास करते हैं। प्रसाद ने कुन्तक की वक्रोक्ति से भी इस 'छाया' का संबंध जोड़ने का प्रयास किया है— शब्द और अर्थ की यह स्वाभाविक वक्रता, छाया और क्रान्ति की सर्जना करती है। आचार्य रामचन्द्र शुक्ल इसे अंग्रेजी के 'केंट-समेट' से जुड़ा मानते हैं।

किसी भी साहित्य का स्वरूप निर्धारण तत्कालीन परिवेश से प्रतिबद्ध होता है। युग की चेतना साहित्य को नियामक होती है। वर्तमान राजनीतिक, सामाजिक एवं साहित्यिक परिस्थितियां आगत साहित्य को एक अभिनव दृष्टि और दिशा प्रदान करती हैं। वास्तविकता तो यह है कि 'छायावाद' अपने युग की उपज है। सीमांकन से यह सुस्पष्ट हो गया है कि छायावाद दो विश्वयुद्धों के मध्य का साहित्य है। यह समय प्रथम विश्वयुद्ध की समाप्ति तथा द्वितीय विश्वयुद्ध के प्रारम्भ का था। राजनीति में इस समय गाँधीवाद का प्रभाव था और साहित्य में छायावाद का। कोनों अलग-अ

क्षेत्रों में अपनी प्रगति [illegible]
प्रसारित कर रहे हैं] छायावाद का
साहित्य पृष्ठाधार लिये द्विवेदीयुगीन साहित्य
है द्विवेदीयुगीन काव्यधारा इतिवृत्तात्मक
स्थूलता से सम्पन्न होने के कारण
शुष्क और नीरस है। द्विवेदीयुग में
शृंगार तथा अभिव्यंजना का सम्यक्
बहिष्कार है इन सब बातों की
प्रतिक्रिया के कारण अवसर पाकर
छायावादी कविता नयी संवेदना रूप
शिल्प को लेकर गतिशील हुई।

छायावाद की परिभाषा :-

छायावादी कवि
को छायावाद नाम अनायास प्राप्त हो
गया है, लेकिन इसकी परिभाषा
सायास साध्य है हिन्दी साहित्य के
विद्वानों ने इसे भिन्न-भिन्न प्रकार
से परिभाषित करने का प्रयास किया
जो निम्नलिखित है :-

1. आचार्य रामचन्द्र शुक्ल :-
"छायावाद शब्द का
प्रयोग दो अर्थों में समझना चाहिए।
एक तो रहस्यवाद के अर्थ में
छायावाद का ~~दूसरा~~ प्रयोग काव्यवस्तु
या व्यापक अर्थ के रूप में"

2. डॉ० नगेन्द्र छायावाद को स्थूल के प्र
सूक्ष्म का विद्रोह मानते हैं और साथ
ही यह स्वीकार करते हैं "छायावा

एक विशेष प्रकार की भाव पद्धति है जीवन के प्रति एक विशेष ~~प्रकार की~~ भावात्मक दृष्टिकोण है।"

3. आचार्य गुलाब राय के अनुसार, "छायावाद की अभिव्यक्ति का अपना ढंग है वह उपदेशात्मक नहीं, वरन व्यंजनात्मक है।"

4. डा० राम कुमार वर्मा भी शुक्ल की भाँति छायावाद को रहस्यवाद से अभिन्न मानते हैं उनका कथन है, "परमात्मा की छाया आत्मा पर पड़ने लगती है, और आत्मा की छाया परमात्मा में यही छायावाद है।"

छायावाद के आलोचकों और छायावादी कवियों की छायावाद विषयक उक्त मान्यताओं से छायावाद के स्वरूप, प्रेरणा, परिवेश तथा प्रवृत्ति का सहज-सूत्रात्मक परिचय प्राप्त हो जाता है। उक्त समस्त विचार बिन्दुओं को मिलाकर छायावाद की अवधारणा के सम्बन्ध में निम्नलिखित महत्वपूर्ण तथ्य प्रतिपादित किये जा सकते हैं—

1. छायावादी कविता में स्थूलता के स्थान पर सूक्ष्म सौन्दर्य सत्ता की प्रतिष्ठा प्राप्त हुई।
2. छायावाद में आत्मीय व्यंजना की प्रधानता है।
3. अतिशय लाक्षणिकता, प्रतीकात्मकता आदि छायावाद की शैल्पिक प्रवृत्तियाँ हैं।
4. छायावाद और रहस्यवाद में स्वरूप गत

अन्तर है। वे दोनों एक नहीं हैं।
रहस्यवाद छायावाद के आगे की वस्तु है
वस्तुत: छायावाद द्विवेदी युगीन कवि
की स्थूलता का विद्रोह है वह अनेक
प्रकार की भाव-भूमियों और विचार-
भूमियों की सुन्दर शरणस्थली है। उसमें
लोक के उदात्त और मंगल विधायक
भावों का निरूपण है और वह
शिल्पगत अनेकानेक नव्य पटलों से
अलावरण से भी सम्पन्न है।
छायावादी कविता की प्रवृत्तियां
1. आत्माभिव्यक्ति की प्रधानता:-
द्विवेदी युगीन
कविता में विषय की प्रधानता थी,
इसलिए छायावादी कविता विषयप्रधान
बनी और उसमें व्यक्ति (कवि) के निज
की सुखद: मयी अनुभूतियों की
अभिव्यंजना हुई। 'प्रसाद' जी ने काव्य
को संकलपात्मक अनुभूति माना है
और छायावाद का उद्भव का कारण
स्वानुभूतिमयी अभिव्यक्ति को स्वीकार
किया है, वे लिखते हैं कि कविता के
क्षेत्र में पौराणिक युग की किसी घटना
अथवा देश-विदेश की सुन्दरी के
बाह्य वर्णन से भिन्न जब वेदना के
आधार पर स्वानुभूतिमयी अभिव्यक्ति
होने लगी तब हिन्दी में उसे छायावाद
के नाम से अभिहित किया गया।

छायावादी कवियों की भावनायें यदि उनके विशिष्ट वैयक्ति तक दुःखों के रोने-धोने तक ही सीमित रहती, उनके भाव यदि केवल आत्मकेन्द्रित ही होते तो उनमें इतनी व्यापक प्रेषणीयता कदापि न आ पाती। निराला ने लिखा—

"मैंने मैं शैली अपनाई,
देखा एक दुःखी निज भाई।
दुख की छाया पड़ी हृदय में,
झट उमड़ वेदना आई।"

कामायनी में सन्दर्भ में यह कथित-व्यथित निराश हताश मनु का परिचय है छायावादी कवियों का आत्म निवेदन नितान्त व्यक्तिमूलक नहीं है वह समष्टि संपृक्त है उनका आत्माभिव्यंजन युगीन परिवेश से सम्पृक्त है।

2. प्रकृति-सौन्दर्य और प्रेम व्यंजना :—

प्रकृति-विधान की दृष्टि से छायावादी कविता अत्यन्त कोमल और कमनीय है प्रकृति अपने समग्र रूप में छायावादी कविता में विद्यमान है छायावादी कवियों ने प्रकृति को काव्य में संजीव बना दिया है प्रकृति-सौन्दर्य और प्रेम की अत्याधिक व्यंजना के कारण ही डॉ० देवराज छायावादी काव्य को 'प्रकृति-काव्य' कहते हैं छायावादी काव्य में प्रकृति सौन्दर्य के चित्रण के अनेक रूप मिलते हैं जैसे :—

प्रकृति का सहारा लेकर

(क) आलम्बन रूप में प्रकृति चित्रण (ख) उद्दीपन रूप में प्रकृति चित्रण (ग) प्रकृति का मानवीकरण (घ) नामी रूप में प्रकृति का चित्रण (ङ) आलंकारिक चित्रण (च) प्रकृति का वातावरण और पृष्ठभूमि के रूप में चित्रण। इस प्रकार छायावादी कवि में प्रकृति अपनी पूर्ण गरिमा के साथ विराजमान है। पन्त की कविता से प्रकृति चित्रण का एक उदाहरण —

"बाँधो का झुरमुट,
संध्या का झुरमुट।
है चहक रही चिड़िया,
टी.वी. टी. टुवा-टुवा॥

3. कमनीय कल्पना :- द्विवेदी युगीन हिन्दी कविता में स्थूलता और इतिवृत्तात्मकता की प्रधानता थी। इसी प्रवृत्ति के विरोध स्वरूप छायावादी कवियों ने अपनी कविताओं में कल्पना का अतिशय कलात्मक रूप प्रस्तुत किया है। छायावादी कवियों का कल्पनालोक अपने पूर्ववर्ती कवियों से अलग और विशिष्ट है। प्रसाद अपनी उर्वरा और नित्य कल्पना विधान का परिचय देते हुए लिखते हैं —

"नील परिधान बीच सुकुमार,
खिल रहा मृदुल अधखुला अंग।
खिला हो ज्यों बिजली का फूल
मेघ वन बीच गुलाबी रंग।

प्रस्तुत अवतरण में प्रसाद जी ने बिल्कुल नूतन कल्पना का विधान किया है। बिजली का फूल विशेष है।

4. रहस्य भावना :-

छायावादी कवियों ने ब्रह्म और जीव के सजल अन्तः सम्बन्धों को लेकर बहुत सी कविताओं को लिखा। ऐसी ही व्यथा के कारण छायावादी कविता में रहस्यभाव का समावेश मिलता है। रहस्यभावना छायावादी कविता की विशिष्ट प्रवृत्ति है छायावादी कविता में रहस्यात्मकता को विशेष मानकर इसे रहस्यवाद का पर्याय मान लिया है परन्तु उनकी मान्यता बहुत संगत नहीं है, क्योंकि छायावाद रहस्यवादमयी नहीं है वह छायावाद से आगे का सोपान है प्रसाद, पन्त, निराला, महादेवी वर्मा आदि समस्त कवियों ने इस परम ब्रह्म के प्रति कौतूहल, जिज्ञासा, आश्चर्य, विस्मय आदि भावों से आभूषित होकर वर्णन भी है इन कवियों की रहस्य चेतना भावात्मक है

महादेवी वर्मा की कविता में रहस्यवाद की नाना स्थितियों की अभिव्यक्ति हुई -

क्या पूजा क्या अर्चना रे?
उस असीम का सुन्दर मन्दिर
मेरा लघुतम जीवन रे
मेरी श्वासों करती रहती नितप्रिय

5. शृंगार भावना :-
छायावादी काव्य में शृंगार भावना की प्रधानता है परन्तु यह शृंगार रीतिकालीन स्थूल एवं वासना से भिन्न है छायावादी शृंगार-भावना मानसिक सूक्ष्म एवं अतीन्द्रिय है यह शृंगार-भावना दो रूपों में व्यक्त हुई है (क) नारी के अतीन्द्रिय सौन्दर्य चित्रण द्वारा (ख) प्रकृति एवं नारी भावना के आरोप के माध्यम से। पन्त और प्रसाद से अद्भुती कैलाश से नारी के सौन्दर्य का चित्रण किया है- "तुम्हारे छूने में था प्राण
संग में पावन गंगा स्नान।
तुम्हारी वाणी में कल्याणि,
त्रिवेणी की लहरों का गान

6. वेदना की विकृति :-
वेदना ही कविता की जननी मानी गयी है और वियोग को कवि की संज्ञा प्रदान की गई है पन्त कहते है :-
"वियोगी होगा पहला कवि
आह से उपजा होगा गान
उमड़ कर आँखों से चुपचाप,
बही होगी कविता अनजान।"
महादेवी वर्मा की कविता में वियोग भावना आत्मा और परमात्मा के ____ के रूप में वर्णित है।

काव्य में
है परन्तु वह
स्थूल एवं
अतीन्द्रिय है
कथा में व्यक्त
अतीन्द्रिय
त पर नारी
माध्यम से।
अद्भुती कल्पना
का चित्रण किया
था प्राण
गंगा स्नान।
नों का कल्याण,
लहरों का गान।

दना ही कविता
है और वियोगी
ान की गई है

ला कवि
गा गान
ो चुपचाप,
ता अनजान।"
कविता में
और परमात्मा

प्रसाद जी की कविता में भी वियोग के अनेक रूप प्रस्फुटित हुए हैं। उनकी यह वेदना भावना मानु के साथ अधिक सादृश्य ग्रहण करते हुए दिखाई पड़ती है। वेदना और विरह छायावादी कविता का प्रेम तत्व है। इन कवियों की यह वेदना उनकी निज की वेदना नहीं रह गई है। यह युगानुरूप संदर्भों से जुड़कर पूरे समाज से जुड़ गई है।

4. मानवतावाद:-

छायावादी कवि अपने भिन्न-भिन्न परिवेशों और संस्कारों के बावजूद जिस विचार भूमि पर पहुँचते हैं उसे मानवतावाद कहा जा सकता है। छायावाद हिन्दी साहित्य का ऐसा काल खण्ड है जिसमें मानव जीवन अपनी सम्पूर्ण विराटता के साथ प्रकट हुआ है। जो आलोचक छायावादी कवियों पर आत्म लीनता का आरोप लगाते हैं वह पक्ष के अनुकूल नहीं है। छायावादी कवियों का काव्य तत्कालीन मानव-जीवन का सजीव चित्र है। प्रसाद, पन्त, निराला महादेवी वर्मा आदि सभी रचनाकारों के काव्य में उपेक्षित दीन-हीन व्यक्तियों के प्रति सहानुभूति, शोषकों के प्रति घृणा तथा समस्त मानव के कल्याण के लिए मंगल प्रस्फुटित हुई है। प्रसाद जी लिखते हैं:-

"आँसू को हँसते देखो मनु
हँसो और सुख पाओ,
[illegible] विकसित कमलों"

8. राष्ट्रीयता की भव्य भावना :-
कोई भी रचनाकार देशकाल से प्रभावित और अनुप्रेरित होकर काव्य-सर्जना करता है। छायावादी कवियों ने अपनी युग की उथल-पुथल से आन्दोलित होकर ही रचनाएँ की है। जबकि छायावादी कविता दो महायुद्धों के बीच की कविता है तथा उस समय भारतीय स्वतन्त्रता आन्दोलन अपने चरम रूप में व्याप्त था। इसलिए राष्ट्रीयता की भावना से आपूरित होकर काव्य रचना करना इन कवियों के लिए सहज अनिवार्य था। निराला की कविता में राष्ट्रीयता का भाव अनेक रूपों में अभिव्यक्त हुआ है। भगवती चरण चतुर्वेदी 'पुष्प की अभिलाषा' नाम कविता में लिखते हैं-

"मुझे तोड़ लेना वन माली,
इस पथ पर देना तुम फेंक
मातृभूमि पर शीश चढ़ाने
जिस पथ जायें वीर अनेक।"

9. अलंकार विधान :-
छायावादी कवियों ने अलंकारों का प्रयोग चमत्कार प्रदर्शन के लिए नहीं किया। वरन वहाँ पर अलंकार स्वाभिव्यक्ति की सहज उच्छल धारा में नैसर्गिक रूप विधा

10. नारी के

कवि क
शालील
प्राय
होने के
में जा
और नि
निराला
"दोनो
भिन्न

इनके
नहीं है
नारी
करते
पर ब
चित्रण

पड़ता है लेकिन वे सिद्धान्त
में अलंकारों को काव्य का उत्पादन
नहीं स्वीकार करते इस सन्दर्भ में
पन्त जी लिखते हैं:—
"तुम वहन कर सको जन-मन में मेरे विचार
वाणी मेरी चाहिए तुम्हें क्या अलंकार।"
अलंकार विषयक ऐसा दृष्टिकोण होने
के बावजूद भी इन कवियों ने अलंकारों का
प्रचुर प्रयोग किया है। उपमा, उत्प्रेक्षा और
रूपक इनके सर्वाधिक प्रिय अलंकार है

10. नारी के सौन्दर्य एवं प्रेम का चित्रण:—

छायावादी
कवि का नारी चित्रण अपेक्षाकृत सूक्ष्म और
ज्यादा लील है इसमें स्थूलता और नग्नता
प्रायः न के बराबर है स्वच्छन्दतावादी
होने के नाते इस कवि को प्रेम के क्षेत्र
में जाति, वर्ण, सामाजिक रीति-नीति, रूढ़ियाँ
और मिथ्या मान्यताएँ मान्य नहीं है
निराला जी लिखते हैं:—
"दोनों हम भिन्न वर्ण, भिन्न जाति, भिन्न कुल
भिन्न धर्म-भाव, पर केवल उपनाम से
प्राणों से एक थे।"

इनके प्रेम चित्रण में कोई दुराव-छिपाव
नहीं है, इसमें कवि की वैयक्तिकता है इन्होंने
नारी सम्बन्धी सौन्दर्य एवं प्रेम का चित्रण
करते समय स्थूल क्रिया-व्यापारों के चित्रण
पर बल दिया है भाव-दिशाओं का
चित्रण अधिक है

प्रा॰ प्रयोगवादी काव्य प्रवृत्तियाँ और उपलब्धि
आ॰ आधुनिक हिन्दी कविता में प्रयोगवाद का
काव्यान्दोलन प्रगतिवादी हिन्दी कविता के
भूमि से अंकुरित हुआ। प्रगतिवाद एक
प्रकार से मार्क्सवाद का ही साहित्यिक
संस्करण है यह भारतीय परम्परा के
अनुकूल नहीं। शिल्प-सौन्दर्य के प्रति
भी प्रगतिवादी कवियों में उदासीनता
वर्तमान थी। अतएव प्रगतिवाद को छो
तथा प्रयोगवाद का जन्म हुआ। इधर
द्वितीय महायुद्ध के परिणामस्वरूप जीव
अपनी सहज सबलता खो चुका था, मा
मूल्यों में अविश्वता आने लगी थी।
पुरानी मान्यताएँ और आस्थाएँ टू
रही थी। चारों ओर विखराव नजर आ
रहा था। यह विखराव आधुनिक युग
की समस्या थी, जिसे आधुनिक कवि
तथा लेखकों ने अनुभव किया। सन
1943 में प्रकाशित 'तार सप्तक'
में इन्हीं नए भाव-बोध के स
तथा यथार्थ के नए धरातल की
अभिव्यक्ति मिली है। 'तार सप्तक'
से ही प्रयोगवाद का प्रारम्भ होता
है। प्रयोगशीलता की प्रवृत्ति पन
और निराला में भी मिलती है, पर
सोद्देश्य प्रयोगशीलता का सामूहिक
प्रयास 'तार सप्तक' से ही प्रा
होता है

प्रयोगवादी कविता की प्रवृत्तियां :-

प्रयोगवादी कविता के वस्तु विन्यास को ध्यान में रखते हुए उसकी प्रवृत्तियों को इस प्रकार प्रस्तुत किया जा सकता है—

1. गहन वैयक्तिकता :—

प्रयोगवादी कविता में वैयक्तिकता की अभिव्यंजना अनेक रूपों में हुई है सामान्य रूप में, रचनाकार की यही आत्मानुभूति सर्वानुभूति बनकर साहित्य की सत्ता धारण करती थी. और करती है लेकिन सबसे पहले प्रयोगवाद में इस वैयक्तिकता को समाजोन्मुख से काटकर बिलकुल एकांकी कर दिया गया। परिणामतः- प्रयोगवादी काव्य में नितान्त व्यक्ति की अपनी अनुभूति और भावना अभिव्यंजित हुई है कवि नरेश कुमार कहते है :—

विश्व के इस खेत-वन पथ
मैं अंह का मेघ हूँ।

2. अतिशय बौद्धिकता :—

अतिशय बौद्धिकता प्रयोगवादी काव्य की अत्यन्त विशेषता है। प्रयोगवादी कवि सारे तथ्यों का दर्शन बुद्धि के आलोक में करते है। प्रयोगवादी कवियों में आक्रोश, झुंझलाहट, व्यंग्य, विद्रोह, आत्मगोपन, स्व विश्लेषण, पर-विश्लेषण तथा तथ्य-निरूपण में अपने बौद्धिक उत्कर्ष का परिचय

दिया है। धर्मवीर भारती इस कविता
बौद्धिकता का समर्थन करते हुए लि
है— "प्रयोगवादी कविता में भावना
है, किन्तु हर भावना के आगे एक
प्रश्न चिन्ह लगा है। इसी प्रश्न-चि
को आप बौद्धिकता कह सकते हैं"

3. व्यापक अनास्था की भावना :—

अतिशय
बौद्धिकता के कारण ही प्रयोगवादी कवि
में अनास्था की भावना उत्पन्न हुई
है। इसी अनास्था के कारण प्रयोगव
कवियों के मन में निराशा, कुण्ठा, पी
बोध, टूटना और पराजय की भावना
को स्थान मिला है।

4. आस्था की भावना :—

प्रयोगवादी कवि
ने अपनी कविता में अनास्था और
शंका को ही नहीं, आस्था और वि
को भी स्थान दिया है। उनकी यह
आस्था उनकी अनास्था से ज्यादा
और शक्तिमान लगती है। प्रयोगवाद
सम्पूर्ण भाव-बोध को देखकर कह
जा सकता है कि प्रयोगवादी कवि
की पराजय और अनास्था की भाव
एक सीमा तक है उसके बाद उन
समस्त क्षण मानसिकता आस्था
सजल संवेदना

के प्रति कृतज्ञता और उसकी सुदृढ़ता की कामना व्यक्त करते हुए लिखते हैं कि –

"आत्मा न खोये
मानव फिर मिट्टी का भी देवता हो जाता है।"

5. सामाजिक यथार्थवाद :–

सामान्य रूप से, यह माना जाता है कि प्रगतिवाद में समाजवाद की और प्रयोगवाद में व्यक्तिवाद की प्रतिष्ठा हुई है लेकिन जहाँ तक दोनों के तात्विक स्वरूप का प्रश्न है दोनों में कोई विशेष अन्तर नहीं है समाजवाद के अन्तर्गत व्यक्ति का अध्ययन समाज से शुरू होकर व्यक्ति तक पहुँचता है और प्रयोगवाद के अन्तर्गत व्यक्ति का अध्ययन समाज से शुरू होकर व्यक्ति तक पहुँचता है और प्रयोगवाद के अन्तर्गत यही अध्ययन व्यक्ति से शुरू होकर समाज तक पहुँचता है।

6. क्षणवाद :–

हिन्दी के प्रयोगवादी कवियों ने क्षणवाद को बड़ी व्यापकता के साथ ग्रहण किया है। अज्ञेय तो इस क्षण की जोरदार वकालत करते ही हैं और धर्मवीर भारती भी इससे ग्रस्त दिखाई पड़ते हैं। क्षण की इसी पकड़ ने प्रयोगवादी कवियों को अस्तित्व का भी बोध कराया। अज्ञेय की 'नदी के द्वीप' गिरिजा कुमार माथुर के 'पृथ्वीकल्प' मुक्तिबोध का 'चाँद का मुँह टेढ़ा है'

और भारती का 'द्रुत महिमा' नामक
कविताओं में मुक्तिबोध का यह
भाव विद्यमान है वह क्षण में ही
सम्पूर्णता का दर्शन करता है
एक क्षण क्षण में प्रवहमान,
व्याप्त सम्पूर्णता।
इससे कथमपि बड़ा नहीं था महत्वपूर्ण
पिया था अगस्त्य ने — अक्षय

7. मानवतावाद :-

मानव और मानतावाद
को उपेक्षा करके कोई भी साहित्य रचा
नहीं जा सकता है रचनाकार का
परिवेश उसकी रचना में विद्यमान रहता
है परिवेश रचनाकार को विषयवस्तु
देता है साथ सुखद और दुखद भाव
उछलती और कुदती जिन्दगी अपनी
सर्वांगीणता के साथ रचना को अभि
रचनात्मक उपादान होते हैं अज्ञेय के
'इन्द्र धनुष रौंदे हुये ये', मुक्तिबोध
का 'चाँद का मुँह टेढ़ा है' भारती
की 'सात गीत वर्ष' आदि रचनाएँ
मानवतावादी दृष्टिकोण से पूर्ण पूरित है

8. शृंगार का उन्मुक्त चित्रण :-

प्रयोगवादी
कवियों ने फ्रायड के मनो-विश्लेषण
से क्या कामी कुछ ग्रहण किया है
इसलिए इनकी रचनाओं में जहाँ
एक तरफ मांसल शृंगार और

9. व्यंग्य

ने व्यं
और
की का
पूर्णिक
की कि
का चि
बोली
की क
पर क
"सांप
नगर
एक
कि
कि

10. प्रकृति

जिस
है, वह

भोग-भावना का भी व्यापक चित्रण हुआ है प्रयोगवादी कवियों ने शृंगार को जिस रूप में लिया है, उसको देखकर यह कहना पड़ता है कि उन्होंने इसको प्रकृत रूप में ही ग्रहण किया है। इन रचनाकारों ने प्रतीकों और बिम्बों के माध्यम से अपनी कुण्ठित और दमित संवेदनाओं को वाणी प्रदान किया।

9. व्यंग्यात्मकता :—

अधिकांश प्रयोगवादी कवियों ने व्यंग्य का सहारा लेकर आज के जीवन और सभ्यता का मार्मिक वर्णन किया है। श्री कान्त वर्मा की 'नगर हीन मन' शीर्षक कविता में आज के नागरिक-जीवन की रिक्तता, स्वार्थपरता एवं छल-कपट का चित्रण बड़ी सफलतापूर्वक व्यंग्यात्मक शैली में प्रस्तुत किया गया है। अज्ञेय की कविता 'साँप' में भी शहरी सभ्यता पर करारा व्यंग्य है—

"साँप तुम सभ्य तो हुए नहीं, न होगे।
नगर में बसना भी तुम्हें नहीं आया।
एक बात पूछूँ? उत्तर दोगे।
फिर कैसे सीखा डसना
विष कहाँ पाया।"

10. प्रकृति का चित्रण :—

छायावादी कवि ने प्रकृति जिस बहुरंगी आभा के साथ प्रस्तुत हुई है, वह अत्यन्त विलक्षण है। प्रयोगवादी

कविता में वैसा रूप नहीं दिखाई पड़ता है जैसे छायावादी कविता में है इस कविता में कवि मनुष्य के जीवन की विसंगतिपूर्ण स्थिति को शब्दायित करने में सचेत और संलग्न है। प्रयोगवादी कवियों में अज्ञेय गिरिजा कुमार माथुर, धर्मवीर भारती आदि की रचनाओं में प्रकृति का सुन्दर और हृदयकर्षी रूप दिखाई पड़ता है।

6. काव्य भाषा :-

प्रयोगवादी कवियों ने भाषा को भावाभिव्यक्ति के माध्यम के रूप में अंगीकार किया है वे शब्द चयन में अत्यन्त उदार हैं। कहने की आवश्यकता नहीं है कि प्रयोगवादी कवि भाषा में सुस्पष्टता, सहजता और सुबोधता के पक्षधर रहे हैं इसलिए उन्होंने अंग्रेजी उर्दू, हिन्दी के तत्सम तथा ग्रामीण बोलचाल के शब्दों का निसंकोच व्यवहार किया प्रयोगवादी कवियों की भाषा भावानुकूल है भावानुकूल शब्दों का व्यवहार करके उन्होंने अपनी अपूर्व क्षमता का परिचय दिया है उनके ऐसे शब्द बिम्बात्मकता तथा भाव-सम्बन्धन में विशेष सहायक सिद्ध हुए हैं।

12. छन्द योजना :-

कविता के अन्य क्षेत्रों में

समान प्रयोगवादी कलाकार प्रायः छन्द आदि के बन्धन को स्वीकार न करके मुक्तक परम्परा में विश्वास रखता है और उसने इसका प्रयोग किया है कहीं-कहीं इन्होंने लोक-गीतों के आधार पर अपने गीतों की रचना की है कुछ ऐसी भी प्रयोगवादी कविताएँ हैं जिनमें न लय है और न गति, उनमें गद्य की नीरसता और शुष्कता है इस प्रकार कहा जा सकता है कि छन्द और लय की दृष्टि से भी प्रयोगशील कविता अत्यन्त सम्पन्न है।

13. बिम्ब व प्रतीक योजना :-

प्रयोगवादी कवियों ने सर्वथा नवीन और विविध बिम्बों का प्रयोग किया है प्रयोगवादी कवियों की रचनाओं में प्राकृतिक बिम्ब, पौराणिक बिम्ब, कलात्मक बिम्ब, दृश्यात्मक बिम्ब आदि दिखाई पड़ते हैं।

प्रयोगवादी कवियों ने व्यापक धरातल पर प्रतीकों की नियोजना अपने साहित्य के अन्तर्गत की है मुख्य रूप से प्रयोगवादी रचना कलात्मक, प्राकृतिक पौराणिक, वैज्ञानिक और यौन प्रतीकों का व्यवहार किया गया है

प्र- भारतेन्दु युग की प्रवृत्तियाँ और विशेषताएँ लिखिए।

उ- आधुनिक काल को पुनर्जागरण का भी कहा जाता है। भारतेन्दु हरिश्चन्द्र को आधुनिक युग का प्रवर्तक कहा जाता है इसका कारण यह है कि भारतेन्दु जी ने हिन्दी साहित्य तथा काव्य में आधुनिक जीवन दर्शन सम्बन्धित आत्मा की प्रतिष्ठा की। भारतेन्दु युग का समय सम्वत 1925 से लेकर 1950 तक का है भारतेन्दु जी बहुमुखी प्रतिभा के रचनाकार थे उन्होंने गद्य व पद्य दोनों में समान रूप से लिखा। हिन्दी कविता को नए विषयों में प्रवृत्त करने और गद्य के नवीन विधाओं के विकास में उनका अभूतपूर्व योगदान था। उनसे प्रेरणा प्राप्त कर साहित्य सर्जन में सक्रिय होने वाले उस समय के अन्य साहित्यकारों में प्रतापनारायण मिश्र, बालकृष्ण भट्ट, बदरीनारायण चौधरी 'प्रेमघन' राधाचरण गोस्वामी आदि का नाम लिया जा सकता है तत्कालीन हिन्दी साहित्य पर भारतेन्दु के व्यक्तित्व और कृतित्व का असाधारण प्रभाव पड़ा। इसीलिए हिन्दी साहित्य के इतिहास में इस काल खण्ड को भारतेन्दु युग की संज्ञा से अभिहित

किया गया है

प्रवृत्तियाँ

6. आधुनिक भाव-बोध के परिणाम स्वरूप भारतेन्दु युगीन हिन्दी काव्य में जिन नवीन प्रवृत्तियों का समावेश हुआ है उनका संक्षिप्त विवरण इस प्रकार है

1. राष्ट्रीयता अथवा देश भक्ति :-

भारतेन्दु और उनके सहयोगियों ने रीतिकालीन काव्य परम्परा से हटकर आधुनिक हिन्दी कविता को जिन नवीन प्रवृत्तियों की ओर मोड़ा, उनमें राष्ट्रीयता अथवा देश भक्ति का स्वर सर्वप्रमुख और सर्वोच्च था। देश भक्ति की जिस भावना का विकास आगे चलकर मैथिलीशरण गुप्त की 'भारत भारती' के माध्यम से हुआ उसका प्रारम्भिक रूप भारतेन्दु हरीश-चन्द्र, प्रताप नारायण मिश्र, प्रेमघन और राधा कृष्ण दास आदि की कविताओं में परिलक्षित होता है। इन कवियों ने देश के उत्कर्ष के लिए उत्तरदायी परिस्थिति पर प्रकाश डालकर जन-मानस में राष्ट्रीय भावना जगाने का महत्वपूर्ण कार्य किया।

अंग्रेजों की शोषण नीति, भारत की आर्थिक दुर्दशा तथा किसान मजदूरों की दीन हीन दशा के यथार्थ चित्रों में तत्कालीन कवियों की

के अनुसार नए-नए विषयों की ही प्रधानता रही। किन्तु कविता के पुराने विषयों का भी पूरी तरह निर्वाह नहीं किया जा सका। इनके भारतेन्दु तथा उनके अन्य सहयोगियों ने ईश्वर भक्ति विषयक अनेक सरस रचनाएँ प्रस्तुत की। इन रचनाओं में कहीं तो निर्गुण उपासक सन्तों की सी विरक्ति भावना देखने को मिलती है और कहीं वैष्णव भक्तों की तन्मयता मिलती है। ऐसी कविताओं में भारत को उसकी दुर्व्यवस्था से मुक्त करने के लिए ईश्वर से प्रार्थनाएँ की गई हैं। उदाहरण के लिए -

"बन के लता पता मोहि कीजै,
गोपी पद पंकज पावन की
रज जामें सिर भीजै।"

— भारतेन्दु हरिश्चन्द्र

4. शृंगार विकता :-

भारतेन्दु और उनके सहयोगियों ने रीतिकालीन कवियों का अनुसरण करते हुए प्रेम और सौंदर्य की भावना से युक्त शृंगार प्रधान रचनाएँ भी प्रस्तुत की। भारतेन्दु की प्रेम सरोवर, प्रेमाश्रु, प्रेम फुलवारी, प्रेमघन की युगलमंगल-स्तोत, वर्षाबिन्दु, अम्बिकादत्त व्यास की पावस-पचासा आदि इसी प्रकार की रचनाएं हैं। इस युग की कुछ कविताओं में घनानन्द की सी सरसता और भावुकता पाई जाती है

5. प्रकृति चित्रण :-
भारतेन्दु युग के कुछ कवियों ने स्वतन्त्र रूप से प्रकृति के सौन्दर्य का वर्णन किया है। किन्तु रीतिकालीन कवियों के प्रभाव स्वरूप वे परम्परा निर्वाह की प्रवृत्ति से मुक्त नहीं हो सके। भारतेन्दु ने सत्य हरिश्चन्द्र और चन्द्रावली में कर्मशः गंगा और यमुना की स्वतन्त्र छवि का अंकण करने का प्रयास किया है। किन्तु अलंकार भार से दब जाने के कारण इन कविताओं ने सहजता की अपेक्षा कृत्रिमता अधिक आ गई है।

6. मातृ भाषा का उद्धार :-
भारतेन्दु युगीन काव्य ने मातृ भाषा हिन्दी के गौरव को पुनः स्थापित करने का प्रयास किया। उन्होंने निज भाषा गौरव सम्बन्धी विचारों से लोगों में हिन्दी के प्रति अनुराग उत्पन्न कर मातृ भाषा का उद्धार किया। भारतेन्दु जी का निम्नलिखित दोहा इसका प्रमाण है :-
"निज भाषा उन्नति अहै, सब उन्नति को मूल
बिन निज भाषा ज्ञान के, मिटत न हिय को सूल

7. सामाजिक कुप्रथाओं का विरोध :-
भारतेन्

युग में आर्य समाज, सनातन धर्म, ब्रह्म समाज और महाराष्ट्र समाज ने जो समाज सुधार का आन्दोलन चलाया था उसका प्रभाव भारतेन्दु युग के कवियों पर भी पड़ा। उन्होंने बाल-विवाह, वृद्ध-विवाह आदि कुप्रथाओं के विरुद्ध अपनी कविता द्वारा आवाज उठाई। वृद्ध विवाह पर लिखी गई एक कविता का उदाहरण इस प्रकार है

"हाय शादी हुई थी
बेहोशी में जब थी
मैं सोलह बरस की
वह अस्सी बरस के
देख मैं उनको रोती
देख हमको वह हंसते।"

8. हास्य व्यंग्य :-

भारतेन्दु युग में पत्र-पत्रिकाओं के प्रचार-प्रसार से हिन्दी काव्य को जनमानस के अत्यधिक निकट लाने में पर्याप्त सफलता प्राप्त हुई। कविता को सामान्य पाठकों की दृष्टि से आकर्षक और उपयोगी बनाने के लिए साहित्यकारों को उसमें रोचकता का समावेश करना पड़ा। हास्य-व्यंग्य इसी रोचकता का एक महत्वपूर्ण अंग बन कर काव्य में समाविष्ट हुआ। पश्चिम सभ्यता, विदेशी शासन, सामाजिक अन्धविश्वासों पर किए गए चुभते व्यंग्य को सुनकर अनायास हंसी आ जाती है।

9. समस्या पूर्ति :-

भारतेन्दु युग में कवियों की प्रतिभा और रचना कौशल को परखने के लिए कवि गोष्ठियों और कवि समाजों में कठिन से कठिन विषयों पर समस्याओं की पूर्ति करवाई जाती थी। इन समस्या पूर्तियों में पुराने कवि निसंकोच रूप से भाग लेते थे और नए कवियों का उत्साहवर्धन होता था। कानपुर के 'रसिक समाज' में प्रतापनारायण मिश्र द्वारा की गई समस्या पूर्ति कितनी हृदयग्राही बन गई "बनि बैठी है मान की मूरति सी, मुख खोलत बोलै न नाही न हाँ। तुम ही मनोहरि कहै हारि कै हरि सखियन की कौन चलाई तहाँ।"

निष्कर्ष :- निष्कर्ष रूप में हम कह सकते हैं कि भारतेन्दु युग साहित्य के समाजीकरण का युग था। जिसमें जनवादी विचारधारा विकसित हुई, साथ ही प्राचीन और नवीन का मिश्रण मिलता है सुधारात्मक व उपदेशात्मक प्रवृत्ति के कारण इस युग का काव्य हितैषी उद्देश्य बन गया था।

प्र॰ द्विवेदी युग की कृतियाँ और विशेषताएँ लिखिए।

उ॰ आधुनिक हिन्दी साहित्य का दूसरा चरण द्विवेदी युग कहलाता है। इसका समय संवत 1950 से लेकर 1975 तक का है। भारतेन्दु युग के समाप्त होते ही हिन्दी साहित्य ने फिर करवट ली। भारतेन्दु युग में कविताओं के नए-नए विषयों का समावेश तो हुआ। किन्तु काव्य की भाषा और अभिव्यक्ति के अन्य उपादानों में कोई परिवर्तन नहीं हो सका। नवीन विषयों के अन्तर्गत राष्ट्रीय अथवा देश भक्ति की जिस भावना को सर्वाधिक महत्व मिला था उसका भी बहुत बड़ा अंश महारानी विक्टोरिया की प्रशंसा करने में समाप्त हो गया। राष्ट्रीयता और देश-भक्ति की भावना से अनुप्राणित जितना साहित्य द्विवेदी युग में लिखा गया, उतना किसी काल खण्ड में नहीं। कवियों को नवीन काव्य चेतना से अनुप्राणित कर उन्हें एक निश्चित दिशा प्रदान करने में पंडित महावीर प्रसाद द्विवेदी ने महत्वपूर्ण भूमिका निभाई। हिन्दी साहित्य में द्विवेदी जी का महत्व इस लिए है कि उन्होंने तत्कालीन साहित्य में प्रचलित रूढ़ियों का संगठित और जबरदस्त विरोध किया। सन 1903 में द्विवेदी जी ने सरस्वती का संपादन अपने हाथों में संभाला

और उसके माध्यम से खड़ी बोली हिंदी भाषा को परिष्कृत परिमार्जित करने में विशेष योगदान दिया। इस युग के कवियों ने अयोध्या सिंह उपाध्याय 'हरिऔध', मैथिली शरण गुप्त, रामनरेश त्रिपाठी, माखन लाल चतुर्वेदी आदि प्रमुख हैं। अयोध्या पाठक ने खड़ी बोली में काव्य रचना करते हुए प्रकृति को आलम्बन रूप में ग्रहण करने का आग्रह किया। द्विवेदी युग की प्रमुख विशेषताएं इस प्रकार हैं:-

1. राष्ट्रीयता अथवा देश भक्ति :-

द्विवेदी युगीन कवियों की राष्ट्रीय भावना भारतेन्दु युगीन कवियों की भावना से कुछ भिन्न और अपेक्षाकृत अधिक स्पष्ट एवं मुखर है। भारतेन्दु युगीन काव्य में देश भक्ति के साथ-साथ राज भक्ति का स्वर भी सुनाई पड़ता है, किन्तु द्विवेदी युगीन काल शुद्ध राष्ट्रीयता और देश भक्ति की भावना से अनुप्राणित है। उनमें अंग्रेजी शासन के प्रति आक्रोश एवं विद्वेष की भावना तथा भारतीय जनता को स्वतन्त्रता प्राप्ति के लिए प्रेरित करने वाला क्रान्तिकारी स्वर सुनाई पड़ता है। इसका एक उदाहरण इस प्रकार है

"देश-भक्ति वीरों मरने से नेक नहीं डरते
प्राणों का बलिदान देश की वेदी पर

2. आदर्श एवं नैतिकता की प्रधानता:-

भारतेन्दु युग के कवियों ने अपनी कविताओं में यद्यपि नए-नए विषयों का समावेश किया फिर भी वे रीतिकालीन शृंगारी भावना का परित्याग न कर सके। द्विवेदी युग में आचार्य महावीर प्रसाद द्विवेदी के नेतृत्व ने रीतिकालीन शृंगारिकता का स्पष्ट विरोध किया गया और कविता के भीतर आदर्श एवं नैतिकता की प्रतिष्ठा हुई।

कविता के माध्यम से मनुष्य के हृदय में स्वार्थ त्याग, कर्तव्य पालन, आत्म गौरव आदि उच्च आदर्शों की स्थापना का प्रयास किया गया।

3. सामाजिक रूढ़ियों का विरोध:-

आधुनिक काल से पूर्व भारतीय समाज में जाति, धर्म, सम्प्रदाय, आदि आधारों पर भेदभाव की अनेक दीवारें खड़ी की गई थी। आधुनिक काल में बौद्धिक और वैज्ञानिक दृष्टिकोण के प्रभाव से मानव मात्र की समानता का भाव विकसित हुआ। स्त्रियों को भी पुरुषों के समान अधिकार देने की बात सोची जाने लगी। धीरे-धीरे परम्परागत धर्म का स्थान मानवता ने ले लिया।

द्विवेदी युग में आर्य समाज का सुधार वादी आन्दोलन अत्यन्त तीव्र और

प्रखर हो गया था। इस युग के काव्य में हमें अछूतों, किसानों और मजदूरों विधवा तथा भिक्षुकों आदि के कई चित्र अंकित किए गए। निराला जी की 'भिक्षुक' और 'विधवा' कविताएं इसी युग में लिखी गई थीं। इस युग का कवि सामाजिक अन्याय व वैषम्य की पीड़ा को सहन न कर सका।

4. इतिवृत्तात्मकता :— द्विवेदी युग में कुछ ऐसे कवियों को छोड़ दीजिए जिन्होंने रीतिकालीन अभिव्यक्ति प्रणाली का विरोध किया अर्थवाद की प्रधानता के कारण इस युग के कवियों ने वर्णन प्रधान इतिवृत्तात्मक शैली को अपनाया। यह शैली सैद्धान्तिक एवं ऐतिहासिक आख्यानों के लिए अत्यन्त उपयुक्त थी। किन्तु इससे काव्य में नीरसता आ गई तथा अनुभूति की गहराई का समावेश न हो सका।

5. बौद्धिकता की प्रधानता :— इस युग के कवि और उसका काव्य दोनों पाश्चात्य संस्कृति के बौद्धिकतावाद से अत्यधिक प्रभावित हैं। प्रस्तुत युग के कवि ने हिन्दू जागरण के लिए भारत के अतीत के गौरव और सांस्कृतिक उच्चता का प्रतिष्ठापन करना

अभिशाप था क्योंकि इसके बिना अंग्रेजी शासन में अंग्रेजी सभ्यता के रंग ~~अंधत्व~~ अन्धत्व वाले भारतवासी के मन से हीनता की भावना का निराकरण असंभव था, अतः इस युग के कवि ने अपनी प्राचीन भारतीय संस्कृति की बौद्धिक व्याख्या की। गुप्त के राम अवतारी राम न होकर आदर्श मानव हैं, जो कि कोई दिव्य संदेश नहीं लाए हैं वह निज कर्म से इस भूमि को स्वर्ग बनाने आए हैं।

6. नवीन तथा साधारण विषय:-

आचार्य शुक्ल इस सम्बन्ध में लिखते हैं- "खड़ी बोली का प्रसार बढ़ता दिखाई देता था और काव्य के प्रवाह के लिए कुछ नई भूमियाँ भी दिखाई पड़ती थीं, देश दशा, समाज सुधार, स्वदेश-प्रेम, आचरण, सम्बन्धी उपदेश आदि ही तक नई धारा की कविता न रहकर जीवन के कुछ और पक्षों की ओर भी बढ़ी। परन्तु गद्य के साथ नहीं। त्याग, वीरता, उदारता इत्यादि के अनेक पौराणिक और ऐतिहासिक प्रसंग पद्य बद्ध हुए, जिनके बीच-बीच में जन्म भूमि प्रेम, स्वजाति गौरव, आत्म सम्मान की व्यंजना करते

वाले जोशीले भाषण, ववे. गाए।

7. देश का अतीत गौरव और संस्कृति :- युगीन कविता में लोक सेवा, विश्व प्रेम, लोक रक्षा, कर्तव्य, त्याग नेतृत्व, संगठन आदि की अनेक भावनाएं मिलती है। खुबी इस बात की है कि उक्त तत्व भारत के अतीत में भी मिलते है। इस तक इस युग के कवि ने अपने अती राम और कृष्ण आदि की कथाओं में विविध तत्वों का समावेश करके उनकी बुद्धि संत व्याख्या की। इस युग के कवि वे अतीत के दर्शन, कला, साहित्य विज्ञान और समृद्धि सबका विस्तृत गान किया है। वह पुकार उठा है। —

"संसार को पहले हमीं ने ज्ञान
विद्या दान

8. अनुवाद कार्य :- इस काल में देशी और विदेशी भाषाओं के साहित्य की कविताओं का हिन्दी खड़ी बोली में अनुवाद भी हुआ। आचार्य द्विवेदी के उद्देश्य हिन्दी भाषा और साहित्य को समृद्ध बनाना था। अतः उन्हों अनुवाद की प्रवृत्ति को भी प्रोत्साहि दिया। द्विवेदी जी ने हिन्दी कविता में

लिए मराठी की वर्ण प्रधान इति-
वृत्तात्मक शैली को वरताया। क्योंकि
यह उनके मन के अनुकूल पड़ती
थी। उस काल के अन्य कवियों ने
भी इसी शैली को अपनाया। मैथिली
शरण गुप्त ने माइकेल मधुसूदन के
दो काव्यों 'मेघनाद वध', 'विरहिणी-
ब्रजांगना' का सुन्दर अनुवाद किया।
इस काल में अंग्रेजी साहित्य की
कविताओं के अनुवाद की भी परम्परा
खूब चली। सत्य यह है कि इस काल
में यह अनुवाद कार्य हिन्दी साहित्य
के पद्य और गद्य दोनों क्षेत्रों में
बराबर चलता रहा है।

9. काव्य भाषा :-

द्विवेदी युग में खड़ी बोली
के समर्थकों को सफलता मिली। गद्य
के क्षेत्र में ~~[illegible]~~ प्रतिष्ठित होने के
साथ-साथ पद्य के क्षेत्र में भी खड़ी बोली
की व्यापक प्रतिष्ठा द्विवेदी युगीन
हिन्दी कविता की सर्वाधिक महत्वपूर्ण
उपलब्धी है। आचार्य महावीर प्रसाद
द्विवेदी के महान प्रत्यनों से उनके
समय में खड़ी बोली के प्रतिष्ठित
स्वरूप की स्थापना हुई। और पहले
से चली आने वाली व्यावहारिक
असमानताएँ समाप्त हो गई।

द्विवेदी युग की कविता में

बड़ी बोली के दो स्वरूप दिखाई पड़ते हैं — एक उसका वह स्वरूप जिसमें बोलचाल के सीधे सरल शब्दों का प्रयोग हुआ है और दूसरा उसका वह रूप है जिसमें संस्कृत निष्ठ समास प्रधान शब्दावली देखने को मिलती है।

निष्कर्ष :-

निष्कर्ष रूप में कहा जा सकता है कि द्विवेदी युगीन हिन्दी कविता अहम दायित्व से अनुप्राणित कविता है। उसमें मात्र मनोरंजन ही नहीं है वरन् उसमें गहन उपदेश समाहित है जो उस युग की आवश्यकता थी।

निष्कर्ष :-

द्विवेदी युग में तत्कालीन राजनीतिक, धार्मिक तथा सामाजिक आन्दोलनों का तीव्रतम मूल्यांकन हुआ है इस युग में काव्य में नवीन जीवन बोध के प्रति आकर्षण भी व्यक्त हुआ है। साथ ही इस युग के कवियों ने काव्य-शैली अभिव्यक्ति भाषा का भी नूतन परिष्कार किया

History

1857 ਈ: ਦਾ ਵਿਦਰੋਹ

ਅੰਗਰੇਜ਼ੀ ਰਾਜ ਤੋਂ ਪਹਿਲਾਂ

ਬੰਗਾਲ ਦੇ ਨਵਾਬ ਦੀ ਹਾਰ (ਪਲਾਸੀ ਦੀ ਲੜਾਈ) 1757 ਈ:

ਬਕਸਰ ਦੀ ਲੜਾਈ 1764 ਈ:

ਦੋਹਰੀ ਸ਼ਾਸਨ ਪ੍ਰਣਾਲੀ 1765 ਈ:

20 ਮਾਰਚ, 1857 ਨੂੰ ਗਵਰਨਰ ਜਨਰਲ ਲਾਰਡ ਕੈਨਿੰਗ ਦੁਆਰਾ ਨਵੇਂ ਕਾਰਤੂਸਾਂ ਦੀ ਵਰਤੋਂ ਦਾ ਹੁਕਮ ਦਿੱਤਾ ਗਿਆ।

ਕਾਰਤੂਸ ਵਿਚ ਸੂਰ ਅਤੇ ਗਾਂ ਦੀ ਚਰਬੀ ਦੀ ਵਰਤੋਂ ਦੀ ਅਫਵਾਹ ਫੈਲ ਗਈ।

ਮੰਗਲ ਪਾਂਡੇ ਦੁਆਰਾ ਅਫਸਰ ਦੀ ਹੱਤਿਆ

ਕਾਰਤੂਸ ਵਿਚ ਸੂਰ ਅਤੇ ਗਾਂ ਦੀ ਚਰਬੀ ਦੀ ਵਰਤੋਂ ਦੀ ਅਫਵਾਹ ਫੈਲ ਗਈ।

ਮੰਗਲ ਪਾਂਡੇ ਨੂੰ 8 ਅਪ੍ਰੈਲ ਨੂੰ ਫਾਂਸੀ ਦੇ ਦਿੱਤੀ ਗਈ।

ਕਾਰਤੂਸ ਵਿਚ ਸੂਰ ਅਤੇ ਗਾਂ ਦੀ ਚਰਬੀ ਦੀ ਵਰਤੋਂ ਦੀ ਅਫਵਾਹ ਫੈਲ ਗਈ।

ਮੰਗਲ ਪਾਂਡੇ ਨੂੰ 8 ਅਪ੍ਰੈਲ ਨੂੰ ਫਾਂਸੀ ਦੇ ਦਿੱਤੀ ਗਈ।

ਮੇਰਠ ਵਿਚ ਵਿਦਰੋਹ 10 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਕਾਰਤੂਸ ਵਿਚ ਸੂਰ ਅਤੇ ਗਾਂ ਦੀ ਚਰਬੀ ਦੀ ਵਰਤੋਂ ਦੀ ਅਫਵਾਹ ਫੈਲ ਗਈ।

ਮੰਗਲ ਪਾਂਡੇ ਨੂੰ 8 ਅਪ੍ਰੈਲ ਨੂੰ ਫਾਂਸੀ ਦੇ ਦਿੱਤੀ ਗਈ।

ਮੇਰਠ ਵਿਚ ਵਿਦਰੋਹ 10 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਬਹਾਦਰ ਸ਼ਾਹ ਜ਼ਫਰ ਨੂੰ ਭਾਰਤ ਦਾ ਸਮਰਾਟ ਐਲਾਨਿਆ ਗਿਆ।

ਕਾਰਤੂਸ ਵਿਚ ਸੂਰ ਅਤੇ ਗਾਂ ਦੀ ਚਰਬੀ ਦੀ ਵਰਤੋਂ ਦੀ ਅਫਵਾਹ ਫੈਲ ਗਈ।

ਮੰਗਲ ਪਾਂਡੇ ਨੂੰ 8 ਅਪ੍ਰੈਲ ਨੂੰ ਫਾਂਸੀ ਦੇ ਦਿੱਤੀ ਗਈ।

ਮੇਰਠ ਵਿਚ ਵਿਦਰੋਹ 10 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਬਹਾਦਰ ਸ਼ਾਹ ਜ਼ਫਰ ਨੂੰ ਭਾਰਤ ਦਾ ਸਮਰਾਟ ਐਲਾਨਿਆ ਗਿਆ।

ਵਿਦਰੋਹ ਦੀ ਖ਼ਬਰ ਸੁਣੀ ਗਈ।

ਕਾਰਤੂਸ ਵਿਚ ਸੂਰ ਅਤੇ ਗਾਂ ਦੀ ਚਰਬੀ ਦੀ ਵਰਤੋਂ ਦੀ ਅਫਵਾਹ ਫੈਲ ਗਈ।

ਮੰਗਲ ਪਾਂਡੇ ਨੂੰ 8 ਅਪ੍ਰੈਲ ਨੂੰ ਫਾਂਸੀ ਦੇ ਦਿੱਤੀ ਗਈ।

ਮੇਰਠ ਵਿਚ ਵਿਦਰੋਹ 10 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਬਹਾਦਰ ਸ਼ਾਹ ਜ਼ਫਰ ਨੂੰ ਭਾਰਤ ਦਾ ਸਮਰਾਟ ਐਲਾਨਿਆ ਗਿਆ।

ਵਿਦਰੋਹ ਦੀ ਖ਼ਬਰ ਸੁਣੀ ਗਈ।

ਦਿੱਲੀ ਤੇ ਕਬਜ਼ਾ 11 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਕਾਰਤੂਸ ਵਿਚ ਸੂਰ ਅਤੇ ਗਾਂ ਦੀ ਚਰਬੀ ਦੀ ਵਰਤੋਂ ਦੀ ਅਫਵਾਹ ਫੈਲ ਗਈ।

ਮੰਗਲ ਪਾਂਡੇ ਨੂੰ 8 ਅਪ੍ਰੈਲ ਨੂੰ ਫਾਂਸੀ ਦੇ ਦਿੱਤੀ ਗਈ।

ਮੇਰਠ ਵਿਚ ਵਿਦਰੋਹ 10 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਬਹਾਦਰ ਸ਼ਾਹ ਜ਼ਫਰ ਨੂੰ ਭਾਰਤ ਦਾ ਸਮਰਾਟ ਐਲਾਨਿਆ ਗਿਆ।

ਵਿਦਰੋਹ ਦੀ ਖ਼ਬਰ ਸੁਣੀ ਗਈ।

ਦਿੱਲੀ ਤੇ ਕਬਜ਼ਾ 11 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਵਿਦਰੋਹ ਦੀ ਅਗਵਾਈ ਵਿਅਕਤੀਆਂ ਨੂੰ ਅਧੀਨ ਕੀਤੀ ਜਾ ਰਹੀ ਸੀ।

ਕਾਰਤੂਸ ਵਿਚ ਸੂਰ ਅਤੇ ਗਾਂ ਦੀ ਚਰਬੀ ਦੀ ਵਰਤੋਂ ਦੀ ਅਫਵਾਹ ਫੈਲ ਗਈ।

ਮੰਗਲ ਪਾਂਡੇ ਨੂੰ 8 ਅਪ੍ਰੈਲ ਨੂੰ ਫਾਂਸੀ ਦੇ ਦਿੱਤੀ ਗਈ।

ਮੇਰਠ ਵਿਚ ਵਿਦਰੋਹ 10 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਬਹਾਦਰ ਸ਼ਾਹ ਜ਼ਫਰ ਨੂੰ ਭਾਰਤ ਦਾ ਸਮਰਾਟ ਐਲਾਨਿਆ ਗਿਆ।

ਵਿਦਰੋਹ ਦੀ ਖ਼ਬਰ ਸੁਣੀ ਗਈ।

ਦਿੱਲੀ ਤੇ ਕਬਜ਼ਾ 11 ਮਈ, 1857 ਈ: ਨੂੰ ਹੋਇਆ

ਵਿਦਰੋਹ ਦੀ ਅਗਵਾਈ ਵਿਅਕਤੀਆਂ ਨੂੰ ਅਧੀਨ ਕੀਤੀ ਜਾ ਰਹੀ ਸੀ।

ਵਿਦਰੋਹ ਦੀ ਖ਼ਬਰ ਸੁਣੀ ਗਈ

East India Company Britis

ਹਰੀ ਵਾਲ਼ ਗਰਤੁਸ

ਓਹ ਆਰੰਦੇ ਗਓ ਨੇ ਸੰਦ ਲੈ ਲਿਆ ਸੀ।
1853 → ਡਾਂਸੀ ਨੇ ਆਯਰੇ ਹਾਜ਼ ਹਿੰਤ ਔਰਤਾਂ ਖਿਲਾ ਲਿਆ।

5. ਅਵੱਧ ਨੂੰ ਮਿਲਾਉਣਾ:- (1856)
ਅਵੱਧ ਦੇ ਉੱਧਰ ਮਾੜੇ ਸ਼ਾਸਨ ਪ੍ਰਬੰਧ ਦੇ ਦੋਸ਼
ਅਵੱਧ ਦਾ ਨਵਾਬ → ਵਾਜਿਦ ਅਲੀ ਸ਼ਾਹ →

ਸਮਾਜਿਕ ਅਤੇ ਧਾਰਮਿਕ ਕਾਰਨ:-

ਸਮਾਜਿਕ ਸੁਧਾਰ:- → ਅੰਧ ਵਿਸ਼ਵਾਸ → ਕੁੜੀਆਂ ਨੂੰ ਮਾਰਨਾ
ਸਤੀ ਪ੍ਰਥਾ
ਨਰ ਬਲੀ
ਵਿਧਵਾ ਦਾ ਵਿਆਹ ਨਾ ਕਰਨ ਦੀ ਆਗਿਆ ਦੇਣੀ।
ਪਰ ਹਿੰਦੂਆਂ ਨੇ ਇਸਨੂੰ ਆਪਣਾ ਧਰਮ ਸਮਝਿਆ। ਜਿਸ ਕਾਰਨ ਬਗ਼ਾਵਤ ਕੀਤੀ ਗਈ।

6. ਈਸਾਈ ਧਰਮ ਦਾ ਪ੍ਰਚਾਰ:- ਸਕੂਲਾਂ, ਕਾਲਜਾਂ, ਹਸਪਤਾਲਾਂ, ਮੁਦਰਕਾਂ, ਦਫ਼ਤਰਾਂ ਜੇਲ੍ਹਾਂ → ਈਸਾਈ ਧਰਮ ਦਾ ਪ੍ਰਚਾਰ ਕਰਨਾ ਸ਼ੁਰੂ ਕਰ ਦਿੱਤਾ।
→ ਸਾਸ਼ਣ, ਸਕੂਲਾਂ / ਅੱਕਟ → 1850 ਦਾ ਇੱਕ ਨਵਾਂ ਅੱਕਟ
ਜੇ ਤੁਸੀਂ ਕਿਸੇ ਮੰਦਰ ਜੋ ਤੁਹਾਡੀਆਂ ਨਸੀਹਤਾਂ ਨਹੀਂ ਸੁਣੀਆਂ ਜਾਣਗੀਆਂ। ਹਿੰਦੂ - ਮੁਸਲਿਮ → ਖ਼ਤਰਾ ਸਮਝਣ ਲੱਗੇ।

7. ਰੇਲ ਅਤੇ ਤਾਰ ਦਾ ਆਰੰਭ → ਆਵਾਜਾਈ ਦੇ ਸਾਧਨਾਂ ਨੂੰ ਸੌਖਾ ਕਰਨ ਲਈ
→ ਰੇਲ → ਯਾਤਾਯਾਤ ਸੌਖੀ ਕਰਨ ਲਈ → ਤਾਰ ਦਾ ਪ੍ਰਬੰਧ।
ਪਰ ਅੰਧ-ਵਿਸ਼ਵਾਸਾਂ ਦੇ ਕਾਰਨ ਉਹ ਨਿਰਾਸ਼ੀ ਹੋ ਗਏ।

8. ਤਰੱਕੀਆਂ ਨਾਲ਼ ਦੁਰਵਿਹਾਰ, ਵਿਤਕਰਾ ਅਤੇ ਸਿਆਸੀ ਨਿਰਾਸ਼ਤਾ ਹੋਣ ਕਰਕੇ ਵਿਦਰੋਹ ਕੀਤਾ ਗਿਆ।
ਉਹ ਅਫ਼ਸਰ ਉੱਪਰ ਤਿਲਕਦਾ। ਸੂਰ, ਕੁੱਤੇ, ਗਾਂ ਕਹਿ ਕੇ ਉਹ ਨਾਲ਼ ਵਿਤਕਰਾ

ਚਾਂਦਾ ਸੀ, ਅਤੇ ਕਈਆਂ ਵਿਰੋਧ ਨਾਲ ਦੀਆਂਗਿਆ ਨਹੀਂ ਸੀ ਕਿ
ਕਰਕੇ ਭਾਰਤੀ ਵਿਅਕਤੀ ਗਏ।

ਆਰਥਿਕ ਕਾਰਣ:

1. ਦੇਸ਼ ਦਾ ਆਰਥਿਕ ਸ਼ੋਸ਼ਣ → ਭਾਰਤੀ ਉਦਯੋਗਾਂ → ਤਬਾਹ
ਭਾਰਤੀਆਂ ਨੂੰ ਰੋਜ਼ਗਾਰ → ਮਹਿੰਗੀ।
ਭੁੱਖਮਰੀ → ਗਰੀਬੀ

2. ਜ਼ਮੀਨ ਮਾਲਕਾਂ ਦਾ ਵਿਨਾਸ਼: → ਜ਼ਮੀਨਾਂ ਖੋਹ ਲਈਆਂ ਗਈਆਂ।

3 ਖੇਤੀ ਦੀ ਸਮੱਸਿਆ → ਕਿਸਾਨਾਂ → ਤੇ ਅਧਿਕਾਰ ਅੰਗਰੇਜ਼ਾਂ ਨੇ Shaft ਕੀਤਾ
ਕਰ ਲਿਆ।
ਲਗਾਨ → ਹੱਥ ਪੈਸਾ ਦਿਆਜ
ਖੇਤੀਯੋਗ → ਚੰਦਾ।

4. ਨੌਕਰੀਆਂ ਵਿਚ ਅਸਮਾਨਤਾ → ਭਾਰਤੀਆਂ → ਉੱਚੇ ਅਹੁਦਿਆਂ ਤੇ ਹਾਨ →
ਛੋਟੇ ਅਹੁਦਿਆਂ ਤੇ ਹੀ ਨਿਯੁਕਤ।
1833 → ਚਾਰਟਰ ਐਕਟ → ਨੌਕਰੀ ਵੱਲੇ ਯੋਗਤਾ ਵੱਲੋ
ਜਾਵੇਗੀ, ਪਰ ਹਕੀਕਤ ਵਿਚ ਅਜਿਹਾ ਨਹੀਂ ਹੋਇਆ ਸਕੇ

ਸੰਸਕ੍ਰਿਤਕ ਕਾਰਣ:

1. ਭਾਰਤੀ ਸੰਸਕ੍ਰਿਤਕ ਵਿਰਸੇ ਨੂੰ ਸੱਟ: → ਘੱਟ ਤਰੱਕੀ ਨੂੰ ਵੇਖ ਕੇ ਵੇਖ ਸਮਝੇ ਕਰ
ਦੀ ਅਗਵਾਈ → ਘੱਟ ਤਕਨੀਕ →
ਪੱਛਮੀ ਤਰੀਕਾ। ਤੇ ਸਾਡੇ ਪੁਰਾਣੇ ਸੰਸਕਾਰਾਂ ਦਾ ਤਰੱਕੀ
ਅਪਮਾਨ ਕਰਨ ਲਗ ਪਏ ਵਿਦਵਾਨ
ਦਾ ਕਾਰਨ ਬਣਿਆ।

1. ਪਹਿਲੀ ਐਂਗਲੋ-ਅਫ਼ਗਾਨ ਲੜਾਈ ਦਾ ਪ੍ਰਭਾਵ:-

ਪਹਿਲੀ ,, ,, ,, ਅੰਗਰੇਜ਼ਾਂ ਤੇ ਅਫ਼ਗਾਨਾਂ 1839-42 ਵਿਚ
ਹੋਈ ਸੀ। ਇਹਨਾਂ ਨੂੰ ਅਜਿਹਾ ਕਿਹਾ ਜਾਣ ਲੱਗਾ। ਹਰ ਕਿਸ
ਲੜਾਈ ਵਿਚ ਉਹ ਹਮੇਸ਼ਾ ਜਿੱਤ ਹਾਸਲ ਕਰਦੀ ਰਹੀ
ਵਿਚ ਹਿੰਮਤ ਅਤੇ ਬਹਾਦਰੀ ਕਿਉਂਕਿ ਉਹ ਕਈ ਵਾਰ
ਅਫ਼ਗਾਨਾਂ ਨੂੰ ਹਰਾ ਚੁੱਕੀ ਸਨ।

2. ਭਾਰਤੀ ਅਤੇ ਅੰਗਰੇਜ਼ੀ ਔਰਤਾਂ ਦੀ ਸਿਥਤੀ ਵਿਚ ਅੰਤਰ:
→ ਅੰਗਰੇਜ਼ਾਂ ਦੀ ਸਿਥਤੀ ਜ਼ਿਆਦਾ ਚੰਗੀ ਸੀ। ਉਹ
ਵੀ ਇਕ ਕਾਰਨ ਸੀ।

3. ਸਮਾਜ ਵਿਚ ਭਾਰਤੀ ਔਰਤ:-
ਇਸ ਔਰਤ ਤੋਂ → ਜਥਮਾਂ ਤੇ ਸੁੱਟ →
ਧਾਰਮਿਕ ਕੈਦੀ
ਸਿਧਾਂਤ ਅਨੁਸਾਰ → ਹਾਰ ਲੜਾਈ ਲੋਕ ਨੂੰ ਭਾਰਤੀਆਂ
ਨੂੰ ਅੰਗਰੇਜ਼ੀ ਔਰਤ ਦੇਖੇ ਜਾਣ ਯਤਨ ਕਰ ਚਾਹੇ ਤਿਆਰ
ਅਪਮਾਨ ਸਮਝਦੇ ਸਨ।

4. ਅਫ਼ਗ਼ ਤੇ ਸਿਥਤੀ:-
ਧਾਰਮਿਕ ਤਬਦੀਲੀ ਤੇ ਔਰਤ ਵਿਚ
1856 → ਔਰਤਾਂ ਦੀ ਸਥਿਤੀ ਵਿਚ
ਸੁਧਾਰ ਲਈ ਕਾਨੂੰਨ ਬਣਾਏ ਗਏ।
ਵਿਧਵਾ ਦੇ ਮੁਬਿਆ ਨੂੰ ਕਾਨੂੰਨ 50,000
ਅਫ਼ਗ਼ ਵਿਚ ਵਿਆਹ ਦੀ ਉਮਰ ਵਧਾਈ ਗਈ,

5. ਇਕ ਉੱਭਰਦੀ ਹੋਈ ਅਫ਼ਗ਼ਾਨ → 1856 → ਔਰਤਾਂ ਨੂੰ ਸਿਖਿਆ
ਅਫ਼ਗ਼ਾਨ ਔਰਤ ਦੀ ਸਥਿਤੀ ਵਿਚ ਵੀ ਸੁਧਾਰ ਕੀਤੇ ਗਏ।

ਉਪਰੋਕਤ ਕਾਰਨ:-

ਇਸ → "ਅੰਤਰਰਾਸ਼ਟਰੀ" → ਇਸ ਤਰ੍ਹਾਂ ਦੀ ਤਰਜ਼ੀ ਸੰਸਥਾਵਾਂ ਦੀ
ਸਥਾਪਨਾ ਕੀਤੀ ਗਈ।

ਪ੍ਰਾਚੀਨ ਸਮਾਰਕ ਦਾ ਅੰਤ → 1596 - 1857

ਸਥਾਪਨਾ ਪੱਤੇ → 24 ਸਾਵਣ, 1857 ਈ: → ਮੇਰਠ

1857 ਈ: ਦੇ ਵਿਦਰੋਹ ਦੇ ਕਾਰਣ: / ਸਿੱਟੇ

ਰਾਜਨੀਤਕ ਸਿੱਟੇ:-

1. ਕੰਪਨੀ ਦੇ ਸਾਸ਼ਨ ਦਾ ਅੰਤ:- 1857 ਈ: ਤੋਂ ਚੱਲੀ ਆ ਰਹੀ ਦੋਸਤ ਇੰਡੀਆ ਕੰਪਨੀ 1858 ਈ: ਦੇ ਅੱਖਰ ਦਾ ਅੰਤ ਹੋ ਗਿਆ। ਬਣੀ

2. ਭਾਰਤ ਦਾ ਸਾਸ਼ਨ ਇੰਗਲੈਂਡ ਦੇ ਅਧੀਨ:- 1858 ਈ: → ਅੱਖਰ ਗਈ
ਭਾਰਤ ਦਾ ਸਾਸ਼ਨ ਇੰਗਲੈਂਡ ਦੇ ਹੱਥ ਵਿਚ ਆ ਗਿਆ। ਸਾਸ਼ਨ ਚਲਾਉਣ ਲਈ → 15 ਮੈਂਬਰ ਨਿਯੁਕਤ ਕੀਤੇ ਗਏ। ਮੰਤਰੀ ਮੰਡਲ ਦੀ ਨਿਯੁਕਤੀ ਕੀਤੀ ਗਈ। ਮੁ

3. ਮੁਗ਼ਲ ਵੰਸ਼ ਦਾ ਅੰਤ:- 1707 - 1857 ਤੱਕ ਮੁਗ਼ਲ ਬਾਦਸ਼ਾਹ

ਬਹਾਦਰ ਸ਼ਾਹ ਦੂਜਾ (ਆਖ਼ਰੀ ਸ਼ਾਸ਼ਕ) → ਸਿਪਾਹੀ ਵਿਦਰੋਹ ਵਿਚ ਹਿੱਸਾ ਲਿਆ ਅਤੇ ਸਿਪਾਹੀ ਦੱਦ ਕਰਕੇ ਮੁਗ਼ਲ ਭੇਸ ਵਿਚ ਰੰਗੂਨ ਅਤੇ 1862 ਈ: ਉਸਦੀ ਮੌਤ ਹੋ ਗਈ ਹੈ। (ਜਾਂ)

4. ਸੰਸਕ੍ਰਿਤ ਦੇ ਅਰਥ ਦਾ ਬਦਲਾਅ:- ਸਤਾਰ → (ਰਾਜ) → ਬਦਲ ਗਿਆ
(ਧਰਮ)
ਦੱਖਣ-ਪੂਰਬ

ਤਾਲ ਸਾਹਿਬ ਦੇ ਨਿਯਮ ਵਿਚ ਜਾਂ ਤਾਲ ਵਿਚ ਅਰਥ ਬਦਲ ਹੋ ਗਿਆ।

5. ਦੇਸੀ ਰਾਜਾਂ ਦੇ ਪ੍ਰਤੀ ਨਵੀਂ ਨੀਤੀ:-
ਹਰ ਇਕ ਰਾਜ ਦੇ ਰਾਜਾ ਨੂੰ ਇਹ ਵਿਸ਼ਵਾਸ ਦਿਵਾਇਆ ਕਿ ਜਮਾਂਦ ਜਾਇਦਾਦ ਸ਼ਰਤ ਨਹੀਂ ਕੀਤੀ ਜਾਵੇਗੀ।

6. ਗਲਤਫ਼ਹਿਮੀਆਂ ਦਾ ਦੂਰ:- ਵਿਦਰੋਹ ਅਸਫ਼ਲ ਹੋਣ ਦੇ ਬਾਵਜੂਦ ਵੀ ਇਕ ਵਿਚ ਸਤੰਤਰਤਾ ਸ਼ਕਤੀ ਪੈਦਾ ਕੀਤੀ ਅਤੇ ਉਹ ਇਕਜੁੱਟ ਹੋਣ ਲੱਗ ਪਏ।

7. ਸਾਸ਼ਤ ਵਿਚ ਭਾਰਤੀਆਂ ਨੂੰ ਸਾਮਿਲ ਕੁਰਨਾ:- ਭਾਰਤੀ ਲੋਕਾਂ ਦੀ ਸਹਾਇਤਾ ਲੈਣ ਲਈ ਕੁਝ ਭਾਰਤੀਆਂ ਨੂੰ ਸਾਮਿਲ ਕੀਤਾ ਗਿਆ।

important

ਮੌਤਕ ਨੁਸਖੇ:

1. ਸੌਣ ਵਿਚ ਅੰਗਰੇਜ਼ੀ ਸੌਣ ਦਾ ਹਵਾਲਾ → ਵਿਦਵਾਨ ਤੋਂ ਪਹਿਲਾਂ ਸੌਣ ਵਿਚ ਆਹਤੀ ਲੋਕਾਂ ਦੀ ਗਿਣਤੀ ਤਿਆਰ ਹੋਣ ਕਰਕੇ ਉਹ ਵਿਦਵਾਨ ਵਿਚ ਸ਼ਿਆ ਨੂੰ ਗਏ। ਜਿਥੇ ਕਰਕੇ ਅੰਗਰੇਜ਼ੀ ਸੌਣ ਵਿਚ ਹਵਾਲਾ ਦਿੱਤਾ ਗਿਆ।
2. ਤੇਹਬਾਤ ਅੰਗਰੇਜ਼ੀ ਸੌਂਤਕਾਂ ਤੇ ਸੌਂਹਣ → ਆਹਤੇ ਲੋਕਾਂ ਨੂੰ ਸਿਖ ਹਾਰੇ ਤਾ ਦੱਸਿਆ ਗਿਆ।
3. ਦੁੱਖ ਦੇ ਚਾਂਤਾਂ ਦੇ ਸਿਧਾਹੀਆਂ ਦਾ ਸੌਣ → ਵਿਦਵਾਨ ਤੋਂ ਪਹਿਲਾਂ ਜਿਹੜੇ ਚਾਤ ਦੇ ਲੋਕ ਤਿਆਰ ਹੋਣ ਕਰਕੇ ਸਵੀਕਰਤ ਦਖ ਗਿਆ ਸੀ। ਜਿਥੇ ਕਾਰਨ ਉਹਨਾਂ ਦਾ ਸੌਣ - ਦੁੱਖ ਪਾਏ ਕਰਨ ਲਈ ਅਜਿਹਾ ਕਿਹਾ ਗਿਆ।
4. ਗੁਰਤੀ ਸੌਂਤਾ ਦਾ ਖੁਰਦ ਗਰਤ → ਸੁੱਖ, ਸਿਖ, ਧਰਾਤ → ਬਣਾਉ ਜਾਣ ਅੱਖਾਂ ਕਰ ਦਿਤੇ।
ਗੁੰਮ-ਬਣਾਉ ਅਣਦਖ, ਖਿਲਾਰ, ਮੱਖ ਭਾਰਤ → ਤਰਤੀ ਖੋਰ ਕਰ ਦਿਤੀ ਗਈ।
ਸ਼ਾਮਲਿਤ ਕਰਨਾ ਅਤੇ ਪਾਰਸ਼ਦ ਵਿਚ ਕਿਉਂਕਿ ਲਿਹਤਾਂ ਦੀ ਗਿਣਤੀ ਵਿਦਵਾਨ ਸਮੇਂ ਤਿਆਰ ਸੀ।
5. ਭਾਰਤੀਆਂ ਤੇ ਤੋਕਰੀਆਂ ਦੇਣ ਦਾ ਵਿਤਰਨ → ਖੁਰਦ → ਅੱਕਵ → ਤੋਕਰੀਆਂ ਦੇ ਉਤੇ ਅਹੁਦੇ → ਕੁੱਲੀ ਵਿਤਕਰ ਤਹੀਂ ਪਰ ਹਕੀਕਤ ਵਿਚ ਅਜਿਹਾ ਤਹੀਂ ਹੋਇਆ।
6. ਭਾਰਤੀਆਂ ਅਤੇ ਅੰਗਰੇਜ਼ਾਂ ਦੇ ਸੰਬੰਧਾਂ ਵਿਚ ਤਣਾਅ → ਸੌਂਤਾ ਵਿਚ ਆਹਤੀ ਅਤੇ ਅੰਗਰੇਜ਼ੀ ਸੌਂਤ ਦੇ ਲੋਕਾਂ ਤੇ ਕਦ ਵੀ ਵਿਚਕ ਦੁਤੇ ਉਪਰ ਹਕੀਮ ਦਾ ਰੋਕ।
7. ਸੋਅਪ → ਛੋਟੇ ਧਾਓ ਤੇ ਵਾਹ ਕਰੂ ਦੀ ਨੀਤੀ ਨ ਅੰਗਰੇਜ਼ਾਂ ਤੇ ਜਿਨ੍ਹਾਂ ਨੂੰ ਸੁਖਧਾਤ ਦੇ ਖਿਲਾਫ਼ ਤੇ ਸੁਖਧਾਮਾਂ ਨੂੰ ਜਿਨ੍ਹਾਂ ਦੇ ਖਿਲਾਫ਼ ਭੜਕਾਰੇ ਕੰਮ ਕਰਨ ਲਿਆ
8. ਧਾਰਮਿਕ ਆਜ਼ਾਦੀ → ਅੰਗਰੇਜ਼ ਸਰਕਾਰ ਵੱਲੋਂ ਦਖਲ-ਅੰਦਾਜ਼ੀ ਨਹੀਂ ਕਰੇਗੀ।

ਆਰਥਿਕ ਸਿੱਟੇ:

1. ਈਸਟ ਇੰਡੀਆ ਕੰਪਨੀ ਦਾ ਖ਼ਾਤਮਾ → ਅਸਿਮਿਆ ਚੱਤਰ ਵਿਧੀ ਦਾ ਕੰਮੀ ਪੂਰੇ, ਹਥਾਰ, ਵਿਜਤਮਾ ਕਾਬਾ ਉਦ ਰੁਪਈਆ ਟੁੱਟਿਆ/ ਤੱਕਸ਼ਾ/ ਤੱਕਸ਼ ਘਟਾਏ ਗਏ

ਪਹਿਲਾ ਵਿਸ਼ਵ ਯੁੱਧ → 1914

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ਕਿਉਂਕਿ ਹਰ ਕੋਈ ਬੁਰ ਸਮੇਂ ਉਹਨਾਂ ਤੋਂ ਹੱਲਾਂ ਦੇ ਆਧਾਰ ਬਣਾਉਣ ਭਰਤਾ ਸ਼ੁਰੂ ਕਰ ਦਿੱਤੇ।

ਸਮੂਹ) Very Important

ਪਹਿਲਾ ਵਿਸ਼ਵ ਯੁੱਧ → ਮੌਲਿਕ ਵਿਦਵਾਨ:

ਪ੍ਰਮੁੱਖ ਇਤਿਹਾਸਕਾਰ → ਸਰ ਜੋਨ ਸ਼ਾਰਮੈਂ
ਮਾਰਸ਼ਮੈਂਟ
ਸੀ. ਈ.,
ਪੀਟੀ, ਗਰਹਰਸ
ਸਾਬੀਕਰ ਔਂਡਰਹਰਸ

1. ਅੰਗਰੇਜ਼ ਭਾਰਤੀ ਮੌਲਿਕਾਂ ਤਾਂ ਬੁਰਾ ਸਲੂਕ ਕਰਦੇ ਸਨ।
2.

ਦੂਸਰਾ ਹਿੱਸਾ → ਆਜ਼ਾਦੀ ਦੀ ਪਹਿਲੀ ਲੜਾਈ

29 ਮਾਰਚ → 1857 ਈ.

ਭਾਰਤੀ ਇਤਿਹਾਸਕਾਰ → ਵੀਰ ਸਾਵਰਕਰ
ਅਸ਼ੋਕ ਮਹਿਤਾ
ਤਾਰਾ ਚੰਦ।

1. ਆਮ ਲੋਕਾਂ ਨੇ ਹਿੱਸਾ ਲਿਆ।
2. ਅੰਗਰੇਜ਼ਾਂ ਦੇ ਅੱਤਿਆਚਾਰ।
3. ਹਿੰਦੂਓ ਦੀ ਧਰਤ ਪਹਿਲਾਂ ਹੀ ਤਿਆਰ ਸੀ।
4. ਹੋਰ ਵੀ ਕਈ ਰਜਵਾੜੇ, ਮੁਗਲ ਬਾਦਸ਼ਾਹ ਤਿਆਰ ਸਨ।
5. ਹਿੰਦੂਆਂ ਅਤੇ ਮੁਸਲਮਾਨਾਂ ਦਾ ਮਿਲਵਰਤਣ।
6. ਹਿੰਦੂਓ ਸੰਤਾ ਤੱਕ ਸੀਮਿਤ ਨਹੀਂ ਸੀ → ਧਰਮ, ਇਸਤਰੀ, ਬੱਚੇ, ਗਰੀਬ ਕਿਸਾਨ।
7. ਆਮ ਜਨਤਾ ਤੇ ਅੱਤਿਆਚਾਰ ਕਿਆਦਾ।

→ ਆਲੋਚਨਾ (ਅੰਗਰੇਜ਼ੀ ਇਤਿਹਾਸਕਾਰ)

1. ਇਹਨਾਂ ਦੇ ਹਿਸਾਬ ਸੀਮਿਤ ਇਕਦੀ। ਮੁੱਠ ਭੁਰ ਹਿੰਦ ਫੌਜਿਆ ਕੋਲ ਲੜਾਕਿਆ ਤੋਂ ਵਧ ਦੇਖਣੀ ਸਹੁ ਨੇ ਇਸ ਹਿੱਤ ਹਿੱਸਾ ਲਿਆਹੀ ਨਹੀਂ।
2. ਸਤ ਦੇ ਆਪਣੇ ਸਵਾਰਥ ਹਿੱਤ। ਲੋਕਾਂ ਦੀ ਘਾਟ।
3. ਦੇਸੀ ਰਾਜਿਆਂ ਨੇ ਅੰਗਰੇਜ਼ਾਂ ਦਾ ਸਾਥ ਦਿੱਤਾ।
4. ਭਾਰਤੀਆਂ ਹਿੱਤ ਲੋਕਾਂ ਦੀ ਘਾਟ।

ਸਿੱਟਾ → 1857 ਈ. ਦਾ ਵਿਦਰੋਹ ਮੁਕੰ ਸੱਤਾ ਤੇ ਕੀਤ ਪਰ ਇਹ ਇਕ ਤੇ ਇਸ ਹਿੱਤ ਚੋਸ਼ਾ ਲਿਆਮਣੇ ਵਿਚ ਵੱਡੇ ਹਿਸਾ ਇਸ ਵਿਦਰੋਹ ਨੇ ਆਜ਼ਾਦੀ ਦੀ ਤਾਹਨਾ ਪੱਕਾ ਕਰ ਦਿੱਤੇ ਗਏ। ਮਿਲੀ-ਜੁਲੀ ਕੋਸ਼ਿਸ਼ ਅੰਗਰੇਜ਼ਾਂ ਨੂੰ ਭਜਣ ਵਿੱਚ ਕੋਹਨਾਮੀ।

Chapter → 10 पँछमी ऐशीमां हिँस ग्रमरहार रा उडाग

* रमाल थामा रे ग्रमपीठ उग्रवी रे ग्रमपुरिवीकरग रीग्रां हिग्रेमउाहां

प्रीमबा :- 1914 ही: हिँस थिगिला मग्रां - पँच्च मग् वेग्रिग्रमा मिग हिँस उग्रवी रे टिगलिउ ग्रगउे ढगांस हिग्रय वरमदी, ग्रमउे ग्रमाग्रटगेग्रमा रा खाष दिँउा। हिग पँच्च हिस उग्रवी रे उव गेउ एसड्ड थिग्रमा। 1919 ही: हिँस घग्रमाद्द री मेयी रेगल गेडे उँद्द, ऐसां हाल मेयीग्रमां वीउीग्रमां गद्दीग्रमां मां ग्रघरग्रमउो मिगसेरव रुग्हाद्दे गए। उग्रवी हाल ही 10 ग्रगामउ 1920 ही: रे मेहग्रम मेयी वीउी गद्दी।

① मेहगम री मेयी :- 10 ग्रगामउ 1920 ही: रे हिउ मेयी उद्दी मी। उग्रवी रे मिमड उेउ टिगलिउ रा ग्रमपूराग रुहाल रव सिग्रमा। उग्रवी रे ग्रमाग्रमीलीग्रमां रे मुउेउ गक री अहालुवी रे दिँउी। उग्रवी री मेला री मीषग्रमा 50 उमाद उेम्म रव दिँउी गद्दी। ढग्रमाद री पृग्रवी हुसं गमी रेडी ही रुहाल रव दिँउी। उग्रवी रे गलउाल वेल मेयीग्रमां से रीग्रमां मगडां मिलद्द उं चिलां उव वेदी साग सवं मी। उग्रवी रे डवां रा ग्रमपमाद्द उीदग्रमा। उि उाउेद्द मी वि वेदी वुमिग्रा मिद्दे मिग ताल उग्रवी रा उेयाल उँद्द। मिटे हुसं उग्रवी हिँस रमाल थामा री मदडी रा उेडाग उीदग्रमा।

② उग्रवी हिँस रमाल थामा री मदडी रा उेडाग :- रमाल थामा हिँस उेग उे हिद्ध दिगरे हाला ढेंसी ग्रदमग मी। महाली

ਦੇ ਦਿਨਾਂ ਵਿੱਚ ਉਹ ਬੁੱਢੀਵਾਲ ਇਲਾਕੇ ਤੋਂ ਬਹੁਤ ਅਗਾਂਹ ਤੋਂ ਪਹੁੰਚਾ ਸੀ ਅਤੇ ਉਹ ਤੁਰਦੀ ਵਿੱਚ ਸਥਾਪਤ ਵਿਚ ਗਾਹਕ ਬੁੱਢੀਵਾਲੇ ਸੱਥ ਦਾ ਸੰਘਣ ਸ਼ਬਦੀ ਦਾ ਅਤੇ ਕਰਨ ਵਾਲਾ ਸੀਵਾਪਸ ਸਰਕਾਰ ਦੀ ਸਥਾਪਤਾ ਕਲਾ ਸਾਰੇ ਦੀ ਸੀ। ਰਮਾਲ ਧਾਮਾ ਨੇ ਤੁਰਦੀ ਤੁਰਦਾਂ ਦਾ ਹੈ' ਦਾ ਲਾਮਬਾ ਬਣਿਆ ਕਰਨ ਤੁਰਦੀ ਨੂੰ ਵਿਦੇਸ਼ੀ ਅਗਾਹ ਤੋਂ ਸ਼ਰਤ ਕਰਦੇ ਵਿੱਚ ਸ਼ਲਤਾਨ ਦੇ ਦੀ ਤੁਰਮਾਰੀ ਦਾ ਅਤੇ ਕਰਨ ਦਾ ਤਿਸੇਲਾ ਕੀਤਾ। ਪਹਿਲੇ ਸਾਲ - ਜੁਧ ਦੇ ਰਮਾਲ ਸਾਲ ਰਮਾਲ ਧਾਮਾ ਨੇ ਪਹਿਲਾਂ ਤੁਰਦੀ ਦੇ ਜੁਧ ਵਿਚ ਸ਼ਾਮਲ ਤੇ ਜਿੱਤਾ ਹੋਇ ਦਾ ਵਿਰੋਧ ਕੀਤਾ ਪਰੰਤੂ ਅਤੇ ਤੁਰਦੀ ਜੁਧ ਵਿੱਚ ਸ਼ਾਮਲ ਤੇ ਜਿੱਤਾ ਤਾਂ ਉਸਦੇ ਜੁਧ ਦੇ ਮੈਦਾਨ ਵਿੱਚ ਸਾ ਦੇ ਤੁਰਦਾ ਮੈਦਾਨਾਂ ਦੀ ਧੁਰੀ ਜੋਗਤਾ ਨਾਲ ਅਗਵਾਈ ਕੀਤੀ। ਜੁਧ ਦੇ ਅੰਤ ਤੇ ਧਾਮਲ ਵਿਚ ਸੱਥਦਾ ਤੇ ਕਿ ਇਹ ਤੁਰਦੀ ਦਾ ਰਕਬਾ ਚਾਲਕ ਰਹੇਗਾ।

(3) <u>ਸ਼ਲਤਾਨ ਦੀ ਸ਼ਰਤੀ ਦੀ ਸਮਾਪਤੀ</u>:- ਮਿੱਤਰ ਦੇਸ਼ਾਂ ਨੇ ਅਤੇ ਤੁਰਦੀ ਦੇ ਸ਼ਲਤਾਨ ਦੇਸ਼ਾਂ ਨੂੰ ਵਿੱਚ ਦੀ ਗਲਬਾ ਲਈ ਬੁਲਾਇਆ। ਮਿੱਤਰ-ਦੇਸ਼ਾਂ ਦੁਆਰਾ ਰਮਾਲ ਧਾਮਾ ਅਤੇ ਸ਼ਲਤਾਨ ਦੇਸ਼ਾਂ ਨੂੰ ਸਾਲਤਾ ਦਿਤੇ ਬਾਦ ਦੀ ਸੀਧਤੀ ਨੇ ਗਸ਼ਟਰੀ, ਸਮਝੌਤੀ ਨੂੰ ਤੁਰਦੀ ਵਿਚ ਸ਼ਲਤਾਨਤਾ ਦੀ ਸੁਧਾ ਸਮਾਪਤੀ ਦਾ ਫੈਸਲਾ ਕਰ ਲਈ ਸਮਝੌਤਾ ਕਰ ਦਿਤਾ। ਪੈਰਿਸ ਸਮਝੌਤਾ, 1920 ਈ: ਨੇ ਗੈਸ਼ਟਰੀ ਸਮਝੌਤੀ ਤੇ ਤੁਰਦੀ ਵਿਚ ਸ਼ਲਤਾਨਤਾ ਦੀ ਸਥਾ ਲਈ ਸਮਾਪਤੀ ਦਾ ਸ਼ਲਾਨ ਕਰ ਦਿਤਾ। ਇਸ ਵਿਚ ਪਿਛੇ ਸਮੀਰਾ ਦੀ ਗਸ਼ਟਰੀ ਸਰਕਾਰ ਨੇ ਕਮਤੁਲਤੀਸ਼ਾ ਉਤੇ ਰਹਸ਼ਾ ਕਰ ਲਿਆ ਕਮਤੇ ਤੁਰਦੀ ਦਾ ਸ਼ਲਤਾਨ ਸ਼ਤਿਸਰ ਹੋਏ ਨੇ ਮਾਲਟਾ ਦੇ ਟਾਪੂ ਵਿਚ ਬਾ ਦੇ ਸ਼ਰਤ ਲਈ। ਤੁਰਦੀ ਦੇ ਸ਼ਲਤਾਨ ਤੁਰਦ ਸਾਸਤਾਕ ਦਾ ਸ਼ਾਸਨ ਤੋਂ ਦੇ

ਇਲਾਹਾ ਸੀਮਾ ਅਤ ਤਰ ਦੇ ਮੁਸਲਮਾਨਾਂ ਦਾ ਖਲੀਫ਼ਾ ਮੁਸਤਫ਼ਾ ਕਮਾਲ ਅਤਾਤੁਰਕ ਦੀ ਸਮਾਪਤੀ ਦੇ ਨਾਲ-ਨਾਲ ਖਲੀਫ਼ਾ ਦੇ ਪਦ ਦੀ ਵੀ ਸਮਾਪਤੀ ਕਰਨੀ ਚਾਹੀਦੀ ਸੀ। ਪਰੰਤੂ ਉਸਨੇ ਤਾਂ ਸੀ ਕਿ ਤਮਾਮ ਕਲ ਸਾਰੇ ਮੁਸਲਮਾਨਾਂ ਲਈ ਸਾਂਝਾ ਧਾਰਮਿਕ ਜਾਇਦਾਦਾਂ ਅਤੇ ਪੈਤ੍ਰਕਾਂ ਦਿਸ ਲਈ ਉਸਨੇ ਕੌਮ ਸਾਰੇ ਖਲੀਫ਼ਾ ਦਾ ਪਦ ਕਾਇਮ ਰਖਣ ਦਾ ਫ਼ੈਸਲਾ ਕੀਤਾ। ਉਸਮਾਨ ਦੇ ਖ਼ਾਨਦਾਨ ਦੇ ਸਭ ਤੋਂ ਨੇੜਲੇ ਕਰੀਬੀ ਸ਼ਾਹਜ਼ਾਦੇ ਅਬਦੁਲਮਜੀਦ ਨੂੰ ਖਲੀਫ਼ਾ ਦਾ ਪਦ ਪ੍ਰਦਾਨ ਕੀਤਾ ਗਿਆ ਜਿਸ ਨੂੰ ਸਾਰੇ ਧਾਰਮਿਕ ਅਤੇ ਰਾਜਨੀਤਿਕ ਅਧਿਕਾਰ ਦਿੱਤੇ ਗਏ।

(4) **ਲੌਜ਼ੈਨ ਦੀ ਸੰਧੀ** :- ਸਾਲ ਪਾਸ ਦੇ ਦਰਮਿਆਨ 1922 ਈ: ਵਿੱਚ ਇਸਤਾਂਬੁਲ ਅਤੇ ਅੰਗੋਰਾ ਦੀ ਸਰਕਾਰ ਦੇ ਨੁਮਾਇੰਦੇ ਮੈਸੋਪੋਟੇਮੀਆ ਵਿੱਚ ਸੰਧੀ ਦੇ ਸੰਬੰਧ ਵਿੱਚ ਗੱਲਬਾਤ ਕਰਦੇ ਰਹੇ। ਅੰਤ 24 ਜੁਲਾਈ, 1923 ਈ: ਨੂੰ ਲੌਜ਼ੈਨ ਦੀ ਸੰਧੀ ਉੱਤੇ ਹਸਤਾਖ਼ਰ ਕੀਤੇ ਗਏ ਜਿਸ ਦੀਆਂ ਸ਼ਰਤਾਂ ਬਹੁਤ ਹੱਦ ਤਕ ਅੰਗੋਰਾ ਦੇ ਪੱਖ ਵਿੱਚ ਸਨ। ਤੁਰਕੀ ਦੀ ਰਾਸ਼ਟਰੀ ਸਰਕਾਰ ਨੂੰ ਅਜ਼ਾਦ ਪ੍ਰਭੁਸੱਤਾ ਸੰਪੰਨ ਰਾਜ ਮਿਲ ਗਿਆ, ਸਗੋਂ ਸੰਮਰਨਾ ਦੀ ਸੀਮਾ ਉੱਤੇ ਵੀ ਕੁਝ ਇਲਾਕੇ ਉਸ ਨੂੰ ਮਿਲ ਗਏ। ਸੁਆਰਸੀਆਂ ਦਾ ਤੁਰਕੀ ਤੇ ਕੁਝ ਵਿੱਚ ਹਟਵਾਂ ਕਰ ਦਿੱਤਾ ਗਿਆ। ਵਿਦੇਸ਼ੀਆਂ ਨੂੰ ਤੁਰਕੀ ਵਿੱਚ ਇਸ ਤੋਂ ਪਹਿਲਾਂ ਦਿੱਤੇ ਗਏ ਸਾਰੇ ਵਿਸ਼ੇਸ਼ ਅਧਿਕਾਰ ਸਮਾਪਤ ਕਰ ਦਿੱਤੇ ਗਏ। ਤੁਰਕੀ ਵਿੱਚ ਘੱਟ-ਗਿਣਤੀਆਂ ਨੂੰ ਮੁਸਲਮਾਨਾਂ ਦੇ ਬਰਾਬਰ ਧਾਰਮਿਕ ਸਮਾਜਿਕ ਤੇ ਰਾਜਨੀਤਿਕ ਅਧਿਕਾਰ ਪ੍ਰਦਾਨ ਕੀਤੇ ਗਏ। ਪਰੰਤੂ ਤੁਰਕੀ ਨੂੰ ਜ਼ਰਾਈ-ਸਰਹੱਦਾਂ ਦੇ ਸੰਬੰਧ ਵਿੱਚ ਕਈ ਖਲ- ਰੁਕਾਵਟਾਂ ਦਾ ਵਿਸ਼ੇਸ਼ - ਦੀਆਂ ਕਲ ਦਾ ਅਧਿਕਾਰ ਨਹੀਂ ਦਿੱਤਾ ਗਿਆ। ਇਸ ਤਰ੍ਹਾਂ ਪਹਿਲੇ ਸਾਰੇ ਜਿਹੜੇ ਗਏ ਰਾਸ਼ਟਰ ਇਸ ਤੁਰਕੀ ਨੂੰ ਵਿਸ਼ੇਸ਼ ਅਧਿਕਾਰ ਰਾਸ਼ਟਰ ਸੀ ਦੇ ਸੰਬੰਧ ਦੀ ਸੰਧੀ ਕਰ ਕਲ ਉਪਰੰਤ ਸਾਰੇ ਨਵੰਬਰ ਸਾਲ ਸਮਾਨਤਾ ਦੇ ਆਧਾਰ ਉੱਤੇ ਸੰਧੀ ਕਰਨ ਇੱਛਕ ਹੋਇਆ।"

⑤ ਗੁਰਦੁਆਰਾ ਦੀ ਸਥਾਪਨਾ :- ਜੈਸੇ ਹੀ ਸੰਧੂ ਕਲਾਂ ਦੀ ਸੰਗਤ ਨੂੰ ਬਾਬਾ ਰਾਮ ਦਾਸ ਅਤੇ ਉਨ੍ਹਾਂ ਦੇ ਪਰਿਵਾਰ ਦਾ ਸਤਿਕਾਰ ਪਤਾ ਲੱਗਾ ਤਾਂ ਉਨ੍ਹਾਂ ਨੇ ਇਸ ਸਥਾਨ ਦੀ ਸੇਵਾ-ਸੰਭਾਲ ਆਪਣੇ ਹੱਥ ਲੈ ਲਈ। ਸ਼ਰਧਾਲੂ ਅਤੇ ਸੇਵਾਦਾਰ ਦੂਰ-ਦੂਰ ਤੋਂ ਆਉਣ ਲੱਗ ਪਏ ਅਤੇ ਗੁਰਦੁਆਰਾ ਸਾਹਿਬ ਦੀ ਸਥਾਪਨਾ ਹੋ ਗਈ। ਇਸ ਤੋਂ ਬਾਅਦ ਬਾਬਾ ਰਾਮ ਦਾਸ ਨੇ ਆਪਣਾ ਧਿਆਨ ਖੇਤੀਬਾੜੀ ਵੱਲ ਲਗਾਇਆ। ਉਨ੍ਹਾਂ ਦੀ ਮਿਹਨਤ ਸਦਕਾ ਉਨ੍ਹਾਂ ਦੀ ਜ਼ਮੀਨ ਬਹੁਤ ਉਪਜਾਊ ਬਣ ਗਈ। ਉਨ੍ਹਾਂ ਦੇ ਖੇਤ ਵਿੱਚ ਫਸਲ ਦੇ ਨਾਲ-ਨਾਲ ਫਲਾਂ ਦੇ ਰੁੱਖ ਵੀ ਲਹਿ-ਲਹਾਉਣ ਲੱਗ ਪਏ। ਉਨ੍ਹਾਂ ਦੇ ਖੇਤ ਵਿੱਚ ਕੰਮ ਕਰਨ ਵਾਲੇ ਮਜ਼ਦੂਰ ਵੀ ਖੁਸ਼ ਸਨ ਕਿਉਂਕਿ ਉਨ੍ਹਾਂ ਨੂੰ ਵੀ ਚੰਗੀ ਮਜ਼ਦੂਰੀ ਮਿਲਦੀ ਸੀ।

⑥ ਉਮਰੀ ਦਾ ਸ਼ਾਦੀਸ਼ੁਦਾ ਜੀਵਨ :- ਬਾਬਾ ਰਾਮ ਦਾਸ ਨੇ 1928 ਈ: ਤੋਂ 1938 ਈ: ਤੱਕ ਉਮਰੀ ਦਾ ਗੁਜ਼ਾਰਾ ਕੀਤਾ। ਇਸ ਸਮੇਂ ਦੌਰਾਨ ਇੱਕ ਉਮਰੇ ਉਮਰੀ ਦੇ ਸਾਰਥ-ਅਰਥੀ ਇੱਕ ਸੁੰਦਰੀ ਸੁਹਾਗ ਬੀਤੇ। ਇਸ ਸੁਹਾਗ ਦਾ ਉਮਰੇ ਉਮਰੀ ਦਾ ਸ਼ਾਦੀਸ਼ੁਦਾ ਕਹਿਣਾ ਸੀ। ਰਾਮ ਦਾਸ ਨੇ ਕਿਹਾ ਸੀ, "ਤੇਰੇ ਮਾਤਾ ਸਰੀਰ ਪੰਜ ਇੰਚ ਹਨ, ਇਕ ਦੀ ਮਾਤਾ ਘਰ ਪੰਜਾਂ ਹਨ ਤਾਂ ਸਾਰੇ ਸ਼ਾਦੀਸ਼ੁਦਾ ਕਹਿਣਾ ਸੀ ਕਿ ਤੇਰੇ ਸ਼ਾਦੀਸ਼ੁਦਾ ਜੀਵਨ ਦੀ ਸ਼ੁਰੂਆਤ ਕਰੇ ਗਾ।" ਉਮਰੇ ਉਮਰੀ ਦੇ ਸ਼ਾਦੀਸ਼ੁਦਾ ਜੀਵਨ ਬਾਰੇ ਹੇਠ ਲਿਖੇ ਮੁੱਖ ਸੁਹਾਗ ਬੀਤੇ:-

ⓘ ਸੀਵਾਲਰ ਸੁਹਾਗ :- ਬਾਬਾ ਰਾਮ ਦਾਸ ਨੇ 1928 ਈ: ਇੱਕ ਉਮਰੀ ਇੱਕ ਸਥਾਨ ਦਾ ਸ਼ਾਦੀਸ਼ੁਦਾ ਕਰ ਦਿੱਤਾ ਅਤੇ ਅਗਸਤ 1930 ਈ: ਇੱਕ ਉਮਰੀ ਇੱਕ ਗੁਰਦੁਆਰਾ ਦੀ ਸਥਾਪਨਾ ਕਰ ਦਿੱਤੀ। 20 ਅਗਸਤ, 1934 ਈ: ਨੂੰ ਉਮਰੀ ਦਾ ਕਹਾਂ ਸੀਵਾਲ ਸਾਹਿਬ ਬੀਤਾ ਗਿਆ ਜੋ 1960 ਈ: ਤਕ ਅਬਾਦਿਤ ਰਿਹਾ।

ਇਸ ਸੀਵਧਾਨ ਸਮਰਮਾਰ ਲੋਕਾਂ ਦੇ ਰਾਈਨ ਸਾਰਸਵੇ ਸਮਾਲਤਾ, ਆਸ਼ਵ, ਸ਼ੈਲੀ, ਅਤੇ ਸ਼ੁੱਧ ਚਾਵਾਰੀਵ ਦੀ ਸੁਤੰਤਰਤਾ ਆਦਿ ਦੇ ਪ੍ਰਸਾਰ ਦਿੱਤੇ ਗਏ। 1924 ਈ: ਵਿਚ ਸਮਾਜ ਸਮਾਲ ਦੇ 'ਗਵਰਨਮੈਂਟ ਲਾਅ ਏਜ', ਦੀ ਸਥਾਪਨਾ ਕੀਤੀ।

(ii) ਧਰਮ ਨਿਰਪੇਖਤਾ :- ਸਮਾਜ ਸਮਾਲ ਦੇ ਸ਼ੀਰਸ਼ਸ਼ ਕੀਤਾ ਕਿ ਸਮਾਪਤਿਕ ਝੰਡਾਂ ਦੇ ਸਮਾਜਾਂ ਤੇ ਵਿਸ਼ਵਾਸਾਂ ਦੇ ਪ੍ਰਭਾਵ ਕਰਨ ਲਈ ਇਸਲਾਮ ਧਰਮ ਦੇ ਚੌਧਰੀ ਦੇ ਉਭਰਨ ਚਾਹੁੰਦੇ ਹੈ। ਇਸ ਲਈਵ ਇਸ ਸਭ ਤੋਂ ਪਹਿਲਾਂ ਉਸ ਦੇ ਖ਼ਲੀਫ਼ਾ ਦਾ ਪਦ ਸਮਾਪਤ ਕਰਨ ਦਾ ਨਿਸ਼ਚਾ ਕੀਤਾ। ਉਸ ਦੇ ਸਮਰੱਥਕਾਂ ਦੇ ਜ਼ੋਰਦਾਰ ਵਿਰੋਧ ਕਿ ਇਹ ਇਕ 'ਪੁਰਾਣੀ ਤੇ ਵਿਸ਼ਵਸ਼ ਸੰਸਥਾ ਹੈ', ਅਤੇ ਤ ਮਾਰਚ, 1924 ਈ: ਨੂੰ ਖ਼ਲੀਫ਼ਾ ਦੇ ਪਦ ਦੇ ਸਮਾਪਤ ਕਰਨ ਸੰਬੰਧੀ ਕਾਨੂੰਨ ਪਾਸ ਕਰ ਦਿੱਤਾ ਗਿਆ। ਇਹ ਧਰਮ ਨਿਰਪੇਖਤਾ ਵੱਲ ਇਕ ਵਿਸ਼ਵ ਮਹੱਤਵਪੂਰਨ ਕਦਮ ਸੀ। ਇਸ ਪਿੱਛੇ ਕਮਾਲ ਪਾਸ਼ਾ ਉੱਤੇ ਸਮਾਜਿਕ ਸਮੂਹ ਪੁਰਾਣੇ ਕਾਨੂੰਨਾਂ ਦੀ ਥਾਂ ਉੱਤੇ ਪੱਛਮੀ ਦੇਸ਼ਾਂ ਤੋਂ ਨਵੀਨ ਕਾਨੂੰਨ ਲਾਗੂ ਕੀਤੇ ਗਏ ਸਮਾਪਤਿਕ ਝੰਡਾਂ ਦੇ ਸਿੱਖਿਆ, ਵਿਆਹ ਤੇ ਤਲਾਕ ਬਾਰੇ ਨਵੇਂ ਕਾਨੂੰਨ ਲਾਗੂ ਕੀਤੇ ਗਏ। ਧਾਰਮਿਕ ਸੰਸਥਾਵਾਂ ਤੇ ਕਾਨੂੰਨਾਂ ਦੀ ਥਾਂ ਧਰਮ ਨਿਰਪੇਖਤਾ ਦੇ ਸਿਧਾਂਤ ਉੱਤੇ ਸਮਾਪਤਿਕ ਸਮੀਕਰਨਾਂ ਸਿੱਖਿਆਕ ਸੰਸਥਾਵਾਂ ਸਥਾਪਤ ਕੀਤੀਆਂ ਗਈਆਂ। 1928 ਈ: ਵਿਚ ਸਮਾਜਵਾਦੀ ਸਮੂਹਾਂ ਦੇ ਸੀਵਧਾਨ ਵਿਚੋਂ ਇਹ ਧਾਰਾ ਹਟਾ ਦਿੱਤੀ ਕਿ ਵਿਚ ਇਸਲਾਮ ਨੂੰ ਰਾਜ ਦਾ ਧਰਮ ਕਿਹਾ ਗਿਆ ਸੀ।

(iii) ਸਮਾਜਿਕ ਕੁਰੀਤੀਆਂ ਅਤੇ ਰੀਤੀ ਰਿਵਾਜਾਂ ਵਿੱਚ ਸੁਧਾਰ:- ਕਮਾਲ ਪਾਸ਼ਾ ਨੇ ਤੁਰਕੀ ਦੇ ਤੁਰਕੀ ਸਮਾਜਿਕ ਰਿਵਾਜਾਂ, ਆਦਤਾਂ, ਰੀਤੀ-ਰਿਵਾਜਾਂ ਅਤੇ ਕੁਰੀਤੀਆਂ ਵਿਚ ਵੀ ਸਮਾਪਤਿਕ ਢੰਗ ਦੇ ਪਰਿਵਰਤਨ ਲਿਆਉਣ ਦੇ ਯਤਨ ਕੀਤੇ। ਉਸ ਦਾ ਵਿਚਾਰ ਸੀ ਕਿ ਸਭ

ਤੇ ਪਹਿਲਾਂ ਦੇਖਾਂ ਦੇ ਪੀਤਮਦੇ ਦਾ ਰੁਮਾਪਤਿਕੀ ਕਰਨ ਤੇਜ਼ ਲਾਗੀਆ ਤੇ। ਇਸ ਉਦੇਸ਼ ਲਾਲ ਉਸ ਦੇ ਪਹਿਲਾ ਸਿਧਾਰੀਆ ਦੇ ਫੈਸ ਕਰ ਦੇ ਨਹੀਂ ਪਛਮੀ ਦੇਸ਼ ਦੀ ਟਯੋ ਦੀ ਹਰਦੇ ਕੁਰਤ ਦਾ ਸਮਾਇਸ ਦਿਤਾ। ਇਸ ਪਿਛੇ ਸਾਸ ਦੇਸ਼ਾਂ ਦੇ ਦੀ ਪਛਮੀ ਦੇਸ਼ ਦੀ ਤੋਰ ਸਮਤੇ ਦੇਪੀਸਾਂ ਸੁਰੂਤ ਕਰਨ ਲਗੇ ਸਿਤ ਸਿਸਮਾ। ਰਮਾਲ ਦੇ ਸਮਸੰਘਲੀ ਤੇ ਗਰੇਨ ਪਾਸ ਕਰਦਾ ਮੁਦਤਾ ਸਿਸ ਸਰੀਂ ਦੇਸ਼ ਦੀ ਦਰਤੇ ਦੇ ਇਕ ਸਰਸ ਰਸਾਰ ਦੇ ਦਿਤਾ ਸਿਸਮਾ। ਰਮਾਲ ਦੇ ਸਮਸੰਘਲੀ ਤੇ ਗਰੇਨ ਦਿਸਤਰੀਸਾਂ ਦੇ ਦੀ ਪਛਮੀ ਦੇਸ਼ ਦੇ ਰਪੜੇ ਪੀਤਮਦ ਦਾ ਸਮਾਇਸ ਦਿਤਾ ਸਿਸਮਾ।

(iv) ਸਿੱਖਿਆ ਦਾ ਇਤਿਹਾਸ :- ਮੱਦੇ ਰਮਾਲ ਪਾਸਾ ਸਸਤਨਯੁਤੀ ਚਹਿਸਾ ਤੇ ਉਸ ਸਮੇਂ ਤੁਰਕੀ ਦੇ ਦੇਸ਼ਾਂ ਦੀ ਚਰਸੀਖਸਾ ਦ ਸਮਲਪਤ ਸੀ। ਉਸਦਾ ਵਿਸਾਸ ਸੀ ਕਿ ਇਸ ਦਾ ਗਰਦ ਸਰਕਾਂ ਦੀ ਪਾਰ ਲਗੇਂ ਸਗੇਂ ਸਸਲੀ ਦਰਦਸਾਸਾ ਦਾ ਤੋਤ ਸੀ ਤਿਸ ਦੇ ਚਹਿਸਾਂ ਦਰੀ ਸਸਲਿਕ ਸਸੰਧਾ ਸੀ। ਰਮਾਲ ਪਾਸਾ ਦੇ 1924 ਈ: ਵਿਚ ਤਹਾਤੀਨੀ ਦੇਸ਼ ਦੀ ਦਰੀ ਦਰਦਸਾਸਾ ਅਧੀਨ ਗਰਦ ਸੰਦੀਯੀ ਦਿਤ ਸੰਸਥਾਵਾਂ ਦੀ ਲਿਜਰਤੀ ਕੀਤੀ ਸਸੰਤ ਸਸਤਨਯੁਤੀ ਸਸਸੰਘਲੀ ਦੇ ਸਿਤੀ ਤਿਸਾਵਿਤ ਕਰ ਦਿੱਤੀ ਸਿਸ ਉਪਰੋਤ ਪੁਰਾਣੀ ਦਰਦਸਾਸਾ ਦੀ ਦਰਤੇ ਦੇਸ਼ਾਂ ਕੀਤੇ ਸਾ ਸਕਦੇ ਸੀ। ਰੁਸਿਧਸਾਧਕਾਂ ਦੇ ਇਸ ਦਰਦਸਾਸਾ ਦਿਤ ਸਿੱਖਿਆ ਦੇਣ ਦੀ ਟਰੇਨਿੰਗ ਦਿਤੀ ਗਈ। ਸਾਰੇ ਦੇਸ਼ ਦਿਤ ਦਰਦਸਾਸਾ ਦਿਤ ਤੀ ਸਿੱਖਿਆ ਦੇਣ ਲਈ ਸਕਤ ਖੁਲ੍ਹ ਗਏ। ਦਿਨਾਂ ਜਤਨਾਂ ਦੇ ਫਲਸਰੂਪ ਦਸ ਸਾਲਾਂ ਦਿਤ ਦੇਸ਼ ਦੀ ਬਾਲਗ ਸਰ-ਸਿੱਖਿਆ ਦੇ 50 ਪ੍ਰਤੀਸ਼ਤ ਤੋਂ ਵਧੇਰੇ ਵਿਦਿਆਰਥੀ-ਸਿਖਣ ਦੇ ਜੋਗ ਹੋ ਗਏ। ਰਮਾਲ ਸਸਸੰਘਲੀ ਦੇ ਸਰ ਸਾਲਾਂ ਤੋਂ ਵਧ ਉਸਰ ਦੇ ਚਹਿਸਾਂ ਦਰੀ ਸਸਲਿਕ ਸਿੱਖਿਆ ਲਾਜਸੀ ਕਰ ਦਿੱਤਾ। ਇਹ ਸਸਲਾਲ ਲਗਾਇਆ ਗਿਆ ਹੈ ਕਿ 1935 ਈ: ਤਕ ਤੁਰਕੀ ਦਿਚ 7 ਤੋਂ 12 ਸਾਲ ਦੀ ਉਸਰ ਦੇ 50 ਫ਼ੀਸਦੀ ਚਹਿਸੇ ਸਸਲਿਕ ਸਕੂਲਾਂ ਦਿਚ ਪੜ੍ਹਦੇ ਸਨ। ਰਮਾਲ

ਪਾਸ਼ ਦੇ ਸਭਨੇਕਾਂ ਹਿਵਸਾਇਕ ਸਕ੍ਰਲਾਂ ਦੀ ਸਸਾਧਨਾ ਹੀ ਕੀਤੀ।

(v) ਹਿਸਤੀਮਾਂ ਦੀ ਸੀਧਤੀ ਹਿੱਸ ਸ੍ਰਧਾਰ :- ਤੁਸਲ ਧਾਸ਼ਾ ਦਾ ਇੱਕ ਸਭੱਤਵਪੂਰਨ ਸ੍ਰਧਾਰ ਹਿਸਤੀਮਾਂ ਦੀ ਸੀਧਤੀ ਹਿੱਸ ਪਰਿਵਰਤਨ ਸੀ। ਉਸਨੇ ਤੁਰਕੀ ਦੇਸ਼ਾਂ ਹਿਸਤੀਮਾਂ ਹਿੱਸ ਬੁਨਿਆ ਸਾਂ ਪਰਦਾ ਅਥਾ ਸਸਾਧਨ ਕਰਨ ਦੇ ਜਤਨ ਕੀਤੇ ਅਤੇ ਉਨ੍ਹਾਂ ਨੂੰ ਤੁਰਖੀ ਦੇਸ਼ ਦਾ ਪਰਿਸ਼ਾਦਾ ਸਸਾਧਨਾਤਿਮ ਰਾਸ਼ੀ ਬੋਸ਼ਿਤ ਕੀਤਾ। 1926 ਈ: ਵਿੱਚ ਮਿਸਰ ਦੇਸ਼ ਸਭਨੁਸਾਰ ਹਿਸਤੀਮਾਂ ਨੂੰ ਹਿਸਾਬ ਦੇ ਸਾਸਕ ਹਿੱਸ ਸਸਾਧਨਾਂ ਦੇ ਸ੍ਰਧਾਰ ਦਿੱਤੇ ਗਏ। ਇਸ ਹਿਸਤੀ ਨਾਲ ਸਸਾਧਨ ਪਤੀ ਦੇ ਉਦਾਰ ਦੇਸ਼ਾ ਹੁਦੇ ਸੰਕਟ ਸੀ ਹਾਇਤ ਪ੍ਰਸਾਂ ਨਾਲ ਪਤੀ ਦੀ ਤਸਾਮੀਦੇ ਤੇ ਜਿਥਾਂ ਉਸਨੇ ਉਦਾਰ ਦੇਸ਼ ਅਪਣਾ ਸੀ। ਇਸੇ ਤਰ੍ਹ ਸਭਨੁਸਾਰ ਹਿਸਤੀਮਾਂ ਨੂੰ ਸਾਇਦਾਦ ਤੇ ਹੋਰ ਸਾਰੇ ਕਾਨੂੰਨੀ ਸਾਮਲਿਆਂ ਵਿੱਚ ਬੁਨਿਆਦ ਸ੍ਰਧਾਰ ਆਏ ਤੇ ਗਏ। 1930 ਈ: ਵਿੱਚ ਹਿਸਤੀਮਾਂ ਨੂੰ ਵੋਟ ਦਾ ਸ੍ਰਧਾਰ ਦਿੱਤਾ ਗਿਆ। ਤੁਰਕੀ ਦੀਆਂ ਚਰਤੁ ਸਾਰੀਆਂ ਹਿਸਤੀਮਾਂ ਸਸਾਧਨਾਪਰ, ਸੁਵਟਰ, ਵਕੀਲ ਅਤੇ ਵੱਡੇ ਅੱਸ ਦੀ ਚੁਣ ਗਈਆਂ ਅਤੇ ਦੇਸ਼ਾਂ ਤੇ ਦਬਾਰ ਸਸਦਾਇਕਾ ਵਿੱਚ ਵੀ ਚਰਤੁ ਸਾਰੀਆਂ ਹਿਸਤੀਮਾਂ ਵੇਸ ਕਰ ਰਹੀਆਂ ਸਨ।

(vi) ਸਫ਼ਾਈ ਤੇ ਸਿਤ੍ਰ ਸੈਹਿਆ ਸ੍ਰਧਾਰ :- ਤੁਰਕੀ ਵਿੱਚ ਚਰਤੁ ਪਾਸੇ ਵੱਡਾ ਸਭਾਈ ਸਫ਼ਾਈ ਤੇ ਸਿਤ੍ਰ ਸੈਹਿਆ ਦੀ ਸਮੱਸਿਆ ਸੀ। ਉਹ ਇਹ ਸਾਮਲਿਆਂ ਪਾਸੇ ਲੋਕਵਾਹ ਵੀ ਸਨ। ਸਭਾਤੁਰਕ ਦੀ ਸਹਾਇਤਾ ਦੇ ਲੋਕਾਂ ਦੇ ਸਫ਼ਾਈ ਤੇ ਸਿਤ੍ਰ ਸੈਹਿਆ ਦੀ ਪਾਸੇ ਬਾਰੇ ਜਾਗਰੂਕਤਾ ਪੈਦਾ ਕੀਤੀ। ਉਨ੍ਹਾਂ ਦੇ ਵੇਸ਼ ਤੇ ਹੋਰ ਸਿਮਾਰੀਆਂ ਤੇ ਚਰਤੁ ਕਾਰੀ ਕੈਂਪ ਲਗਾਏ ਅਤੇ ਹੋਰ ਉਪਾਅ ਕਰ ਦੇ ਸੁਝਾਅ ਦਿੱਤੇ ਗਏ। ਸਹਰਾਂ ਵਿੱਚ ਲੋਕਾਂ ਦੇ ਸਾਫ਼ ਪਾਣੀ ਸਪਲਾਈ ਕਰਨ, ਗਲੀਆਂ ਦੀ ਉਸਤ ਹਿਵਸਥਾ ਕਰਨ ਅਤੇ ਸਿਮਾਰੀਆਂ ਦੀ

ਤੇਰਬਾਸ ਵਰਲ ਮੀਹੀਧੀ ਛਤੀਰੇ ਜਤਨ ਵੀਤੇ ਗਏ।

(vii) ਹੱਖ-ਹੱਖ ਰਖਾ ਟੂ ਉਤਮਾਗ :- ਤੁਰਕੀ ਇੱਕ ਮਹੁਤਾਲਾਂ ਦੇ ਸਾਮਨ ਸਮਾਧੀਨ ਇਤਰ-ਰਾਸ਼ਟਰੀਤ ਅਧਿਦ ਦਾ ਕੋਈ ਇਕਸ਼ਾਸ ਕਰੀਂ ਤੇ ਸੀਰਿਆ ਮੀ ਕਿਉਂਕਿ ਅਮੀਰੀਕਾਂ ਕਰਾਹਾਂ ਇਸਲਾਸ ਦੇ ਸਿਧਾਂਤਾਂ ਦੇ ਇਕੱਧ ਸਮਝੌਤਾਂ ਕਾਂਈਆਂ ਸਨ। ਰਮਾਫ਼ ਪਾਸ਼ਾ ਟੂ ਅਕੀ ਇਸ ਇਸਲਾਸ ਧਰਸ ਦੇ ਬੀਪਲ ਉਤੇ ਇਤੇ ਸਨ। ਉਸ ਦੇ ਜਤਨਾਂ ਵਜੋਂ ਦੇਤੇ-ਵਤੇ ਸੀਰਿਆਂ ਇਸ ਪੱਛਮੀ ਦੇਸ਼ਾਂ ਦੇ ਸੀਰਿਆਸਤਾਰ ਵੇਖ ਪੈਦੇ ਗਏ ਜਿਸ ਦੇ ਸਿੱਟੇ ਵਜੋਂ ਪੱਛਮੀ ਦਸ਼ਾਂ ਤੇ ਸੀਰਿਆ ਟੂ ਵਧਾ ਉਤਮਾਗ ਕਾਇਮ ਹੋਇਆ। ਉਸਦੇ ਰਾਸ਼ਟਰਤਾਂਤਰਿਕ ਸਮਾਂ ਸਮਾਂਤਰ ਇਹ ਸਮਾਧੀਨ ਹੋ ਦੇ ਵਾਂਤ ਵਜਾਂ ਦੇ ਪੈਦੇ ਰਾਸ਼ ਦੇ ਸਮੇਂ ਇਸ ਤੁਸੀਂ ਉਸਦੇ ਇਸਲਾਸ ਦੇ ਸੀਰਿਆਂ ਦਾ ਘਤਾਰਿਤ ਦੇ ਸਿਧਾਂਤ ਹੀ ਉਲੇਖਯੋਗ ਵੁਰੋਕ ਕਰਾਂ ਸਾਰੂਸੇ ਸਮਸਾਲੀ ਸਿਸਾਫ਼ ਗਈ। ਉਸ ਦੇ ਪੱਛਮੀ ਸੀਰਿਆਂ ਤੇ ਸੀਰਿਆਂ ਰਾਸ਼ਾਂ ਟੂ ਉਤਮਾਗ ਦਿਤਾ। ਏਸ਼ਾ ਇਸ ਪੱਛਮੀ ਦੇਸ਼ਾਂ ਦੇ ਕਈ ਰਾਸ਼ - ਰਸ਼ਾ ਦੇ ਸਮਰਥਕ ਵੀ ਪੈਦੇ ਗਏ।

(viii) ਸਮਾਰੀਧਰ ਇਰਾਸ :- ਰਮਾਫ਼ ਪਾਸ਼ਾ ਦੀ ਸਮਰਥੀ ਦੇ ਉਤਰ ਟੂ ਪਾਂਤਲਾਂ ਸਮਾਰੀਧਰ ਪੱਸ਼ ਤੇ ਤੁਰਕੀ ਇੱਕ ਪਲੀਕੁਸਾ ਹੋਇਆ ਏਸ਼ ਸੀ। ਇਹ ਇੱਕ ਬੁਸ਼ੀ ਸੁਪਾਫ਼ ਏਸ਼ ਸੀ ਜਿਸਦੇ ਸਾਂਧ ਪੈਰਾਫ਼ਾਫ਼ ਅਸ਼ਾਫ਼, ਵਫ਼ਾ, ਸੇ, ਵੁਸੀਸ਼ਾ ਰਮਤੇ ਸੀਰਿਆ ਸੀ। ਖੇਤੀਹਾਰੀ ਦੇ ਸਾਧਨ ਪ੍ਰਯੁਫ਼ ਵੇਸ਼ ਦੇ ਸਮ ਰਮਤੇ ਪੈਰਾਫ਼ਾਫ਼ ਚਾਰ ਪਾਂਚ ਹੋਏ ਸੀ। ਏਸ਼ ਦਾ ਉਦਯੋਗੀਕਰਨ ਦਾ ਤੇਜ਼ ਦੇ ਬੁਰਾਫ਼ਾਫ਼ ਸੀ ਰਮਤੇ ਇਹ ਸਸ ਰੂਪ ਇਸ ਵੇਸ਼ਾ ਸਾਫ਼ ਵੇਖਣ ਰਮਤੇ ਉਸਾਫ਼ ਸੀਰਿਆਂ ਸੁਧੀਆਂ ਚੀਜ਼ਾਂ ਸਗੀਰਫ਼ ਹਾਲਾ ਏਸ਼ ਸੀ। ਰਮਾਫ਼ ਪਾਸ਼ਾ ਦੇ ਜਤਨਾਂ ਵਜੋਂ ਤੁਰਕੀ ਦੀ ਬੁਸ਼ੀ, ਉਦਯੋਗਾਂ ਸਮਾਰਿ ਦਾ ਸਮਸਾਧਾਰਨ ਇਰਾਸ ਹੋਇਆ।

* * * * *

(1) सीट री राउी 1945

पिछड़ा

जैड चाग्गी 16 घीमदी हिछ आम्उ मभेउ
राघव रेहा मुद्द रा, डे सीट हिछ
पोग्फा, पम्उगाल्लीम्पा ते सीट हिछ पुद्दम
रीउा मैंव रेम सीट हिछ दपाठ वग्वे
आम्घर मोकिउी दे मानधउ वग्टा छाड़ रे
मी। 17 दी मद्दी हिछ प्युटेक रम्माग
सीट हिछ मद्दीम रा ठिअपारक मुद्द
री मीग दपी। तिम वग्वे 1934-42
प्युटेक मपउ, सीट रे माद्द गानद्दीम
हिअराठ जेंय जेंग्मा। प्युटेक तिउ
रागमा। घाम्पर हिछ प्युटेक री
राघव मीरासी तिम्मारा घेंय ग्वाद्दी।
सीट, रे छोर माद्द वानद्दीम उ दुघ
उ गाद्द म। हेवां हिछ गामठी गोद्दा
माद्दी मुद्द उ गाद्दी।

19। री सीट राउी दे माद्द गानद्दीम
रा मडि वद रिउा, गद्दउअ री मबापकाग्रेा
पेटिम प्पटका रे उठ माद्द पठं
उद्द रांडी ग्याद्दी तिम हिछ हिछ मि-मे-
उग री अगादाद्दी हिछ मामद्दारी मेंगोद्दा
दे ग्वामुव्वद्दारोमा हिछ सीट वेठ रे
ठाठमा रे टापू उे रेअट रद्दी
मानधउ वद रिउा।

बारडी मद्दिद्दी 1945 री राउी रे दक्कमद्दप
मा गद्दी प देघनी रे विमम री
जी।

माउ-मे-उ्ग रे क्रमश "गान्धीउर नउ चेइव री तसी छ' लिखिये 5"

पहटी राम वां गामटी छे रह।	वमिउ सिमटा वां मामहारी माउ-मे-उ्ग।
तेउा उ्ग-मिंग-ग्रि उा. मतनउ-मेरा छिमांग-वाधी-मेव	आउ-मेंह-याधी।

वाइट 1949 री रा्ड

(1) 1911 ही री वा्ड

माइ गान्हीम रा 1911 री रा्ड। ह गादउ्उव मठराठ री मवापरा उ वाही। हिम रे घाह्नर घारगी मरउीमा छीक हिव एमह्र रे रगीमा मता एमा छीक उ्व। मम गान्धीइन रह उ्व्त वे माउमह्र मा व रगे मह, सिरा हिव मामहारी रह पुमिंम मी।

(2) छाव मही मनिरक्ख

म्राउी मैमेरा हिव छीक दी गाव। विगामा रा, मेउ रेमह्र पिमा मी, मेउव रेमा मउे, ताघाउ रा छीक। क्रे पुगाह ह्रीक्रे घेवा उ घरराम, तगे छीक्रे रे घेवा रीमा गामठी छीक रे घेवा रीमा गामठी वाहमाह। उ्उव क्रेठीमा।

५ मई १९१७ ही ही चीरिंग हिचे ३००० हिहिमागधीभा मने मनीषभाषदा ने हिव ગાંધી મહાત્મા કીધા. મગવાર ને કીધ ને સાથ પાર્ટિ સ્થી થવડી રી હતે વીડી. हिव ध्यटका डाव मही हिदम हते पुनिय. हिम ध्यटका ने १९५५ री राडी स्थी ગમડા માટ વ્ય દેરડા.

③ हार्मिंगटका वाशदर्गेम १९२१-२२री:

washing ने जउडां हत हार्मिंगटका हिम ६६ध० ton १९२। हिव हिव मडिउगमुरथी मेम्बरा जीहमा. हिम हिछ के पुनिय रेमाने डाग हिमा.

हिम हिछ जैव ममारे मने डीम तरु मोधिपिउ जॅमभिमादा ने हिंडाव रीउ गिभ्या. मडा।

① के रेमा ने डीक री हेरउ, मभेडउ, मेंउउभउ वहाटी, गेमद हिछ मरर वक्ष गाह।

② माठे रेमा हुं डीक हिछ चगधिव रीभा हुधाव ने उरजगिव मडरडा पराड रीउभा मादगीभा.

नेमेश्वर रे धादर हुं डीक री मव्याव ना५ाड रीभा मामगाहरी. हडीभ. हा वेर मरी. ८

हाउं ध मडि १९५९ री हाउं छी. हिछ वाभ किंध

(५)

(५) बउमितउंग ना गामटगी ईव एक राडिगम

बाडीवागी मेगाठम, उंग - मिंग - ग्रेहि
ते वाडी स्थिमाईद हिठ जिमा आहिमा
हिर एक हा गाठम वीआ गिमा
बउमितउंग ना गामटगे ईव एक वाप
पेनिंप गेहिमा। हिम एक ते बैंटम
दिघ ग. मत जाउ मेम रे मगाहरी ते
1921 ही हिठ गाहउउठ री मबापमा वीडी,
सैम हिठ गेहरिमाठेघी हिम एक रे
मैंघ घहम ईगे। पिग री गमी राडी
उ घामट हिर चॅपोनेघिमा ते मामहारी
पाठरी हा दिठमाह व स्थिमा।
गामटहार्य अउ मामहार्य स्थिर एते ह
तेते माईंह ईगे।

वठहाईह एरी ग. मेम ते नेहरमी नरडीमा उ मअउ
मंगी। एम जिमाठ ज गिमा।
पठ गामटहरी उ मामहारी दिउवाठ
मउईर पॅरा वेर उ गाहे।
गामटहारी एम हे तमारा ईव
दिप दिग। एते घपामे मामहारीमा रे
आहिमा। च 1925 हिठ ग. मत जाउ ईम
री मेउ उ गाहे। 1925 उ 1927
उव मामहार एक ते वाढी
नेहराम वठ स्थिमा।

5 વિમાંગ વાદી કોર્ટ અપીલ ગમટ્ઠદારીમા દા. મૈંવિંગ ફેડે અપવાદ —

1920 ટી ડેર વિમાંગ દિમદામજેગા ઇરિમા દિલ્લ દિર વદ્દ ગિમા, ગા મેસ રી મેડ રિપેડ ગમટ્ઠી વદ્દ રા કેડા વદ્દ ગિમ્પા। 1928 ટી દિલ્લ વિમાંગ રી ~~મમત્વી~~ ગમટ્ઠદારી ગૅસા કે ચીરિંગ ડેડે વધ્યા વર્ષ રિમ્પા। દિમ પુરાઠ માગ રીમ ગમટ્ઠદારી મઠરાઠ રે અપીલ મેપા ગિમા। માઠ રેમ રી ગત્પામી વધ્યા રિમ્પા ગિમા, કે વિમાંગ રી દિમ મઠરાઠ રી અપીલ કે દિગાર્ડ મમ્ડ માઠ પેઠમી રેમા કે માદ્ડા રે રિડે।

(6) ગમટ્ઠદારીમા અને મામદારીમા દિલ્લ નિપગમે

ગમટ્ઠદારીમા રથી મામદારી મત। મઠ દ્વેં ડેદ્વે વદ્દ ડેર રી મરવી ચડમ વર્ણ રથી ચરડ જડક રીડે ચઠ ગમટ્ઠદારીમા દે મદ્દરા દા મિસ્રા। 1934 ટી દિલ્લ મામદારીમા કે વિમાંગમી ચેડ્ઠ દિલ્લ રિડે પામે ચઠ રિમ્પા, મામદારીમા દે વદ્દ દિલ્લ રીમે કે વર્ણ્ય માગ્ગા દેર ~~મદ્દ~~ રથી મતધૂઠ વર્ણ રિડે। 20 ગ્રામ માબદારી 370 રિલા દિલ્લ 6 ગ્રામ મીક્સ રા વમટ્મદી પગલી ગમડા 3/6 વર્ણ મૈમી ચરડે।

(6)

हिंदू अल्पसंख्यक और द्विराष्ट्र सिद्धांत (हिंदू महासभा) के संस्थापक थे। 1937 के चुनाव में हिंदू महासभा ने सावरकर के नेतृत्व में भाग लिया। द्विराष्ट्र सिद्धांत के प्रतिपादक सावरकर थे।

(7) साम्प्रदायिक उभार और मीडिया की भूमिका

1931 के दंगे साम्प्रदायिक तनाव और हिंसा का परिणाम थे। इन दंगों में मीडिया की भूमिका महत्वपूर्ण रही। मीडिया ने दंगों की रिपोर्टिंग की और लोगों को जागरूक किया। मीडिया ने दंगों के कारणों और परिणामों पर चर्चा की। मीडिया ने दंगों के समाधान के लिए सुझाव दिए।

(8) कांग्रेस-मुस्लिम लीग संघर्ष 1937-45

1937 के चुनाव में कांग्रेस को बहुमत मिला। मुस्लिम लीग को कम सीटें मिलीं। कांग्रेस ने मुस्लिम लीग को सरकार में शामिल नहीं किया। मुस्लिम लीग ने कांग्रेस पर मुस्लिम विरोधी होने का आरोप लगाया। इस संघर्ष ने भारत के विभाजन में महत्वपूर्ण भूमिका निभाई।

(9) मठदुरुडा स्ही निप्पठम मत्तु मामदरीमा री
नेडु

तागामारी डुंडे मोटम धेव रे उम्पे डु
पिडे 14 अगमउ 1945 दी त्तापाउ ते उंदुमाउ
मेट रिडे त्तापाउ इमागा धारी रीडु
दिक्कारिमा दी ४ रे रामदधारीमा मत्तु
मामदरीमा दिक्कार दिडराम निप्पठम मत्त
पिमा। मर दिद रामदधरीमा दे मकरउ
तिरी। धामर दिद मामदरीमा ते
दिमाका, मत्तु पाम डेवा ७ ताल निपम्र
धद वे निप्पठम उंत वठ रिडु।।
1949 दी दिद मामदधरीमा ते
रामदधरीमा री रातपाडी वेंटा डुंडे
मरिपराम वठ रिमा। दिल्लागु मत्तु
उम रे मामदधरां ते दागमेमा रे
राप दिद मठद स्ही, मापदी मेउ
उर दिधे गे मामर रीडु।

(10) रीम दिद देव-गदडेउ री मत्रापका

पठिकी मरुधठ 1949
दे माडि-मे-उंगा ते गदडेउ मठराठ
रा मॉरास वठ रिडु। माडि-मे-उंगा
रामदठपडी मत्तु डाडि-मॉक-राधी रेम
रे पुपाद मडुडी धद।

दुंत रेमा दे
* 1तद मठ डे पठिरा रेम 67
गाउउ मार्ट रेमा दे रीम री
दिम मठराम दे माडउा रे रिडेडे।

Chapter → 9 ਦੂਸਾ ਸਗਂ ਯੁੱਧ ਕਲੌਤ ਚਾਮਦ ਦੀਆਂ ਘਟਨਾਵਾਂ

ਭੂਮਿਕਾ :- ਪਹਿਲੇ ਸਗਂਯੁੱਧ ਦੀ ਸਮਾਪਤੀ ਦਾ ਮੈਮਾਰ ਦੇ ਮੂਹੇ ਦੂਰਾਂ ਦੇ ਮਹਾਗਾਰ ਰੀਤਾ ਸੀ। ਪਹਿਲੇ ਸਗਂਯੁੱਧ ਦੇ ਸਰਾਂ ਦੇਸਾਂ ਨੂੰ ਦਿਨੀਆਂ ਸਮੱਸਿਆਂ ਦਾ ਸੁਮਾਮਣਾ ਕਰਨਾ ਪਿਆ ਸੀ ਕਿ ਦੂਰ ਰਹਿਣ ਵਿਚ ਉਹ ਯੁੱਧ ਦੀ ਗੱਲ ਸੱਚ ਹੀ ਲਗੀ ਸਰਦੇ ਸਨ। ਉਹ ਸਾਰੇ ਦੁਨੀਆ ਇਕ ਸਮਾਨੀ ਸਾਂਤੀ ਚਾਹੁੰਦੇ ਸਨ। ਪਰੰਤੂ ਸਾਂਤੀ ਕੁੱਝ ਹੀ ਸਾਲਾਂ ਤਕ ਰਹਿ ਸਕੀ।

1939 ਈ: ਵਿਚ ਪੈਰਸਾਈਯੂਸਾਂ ਦੇ ਕਮੀਸਨ ਨੂੰ ਯਾਰਨ ਕਰ ਦਿਸਾ ਕਿ ਦੂਸਾ ਸਗਂਯੁੱਧ ਸਰੂਹੀ ਲਗਭਗ ਲੱਗਾ।

ਦੂਸੇ ਸਗਂਯੁੱਧ ਦੇ ਕਾਰਨ -

① ਦਰਸਾਇ ਦੀ ਸੰਧੀ :- ਪਹਿਲੇ ਸਗਂਯੁੱਧ ਦਾ ਮੁੱਖ ਸਰਸੂਲੀ ਦੀ ਗਰੂ ਸੀ ਦਰਸਾਇ ਦੀ ਸੰਧੀ ਦੇ ਤਾਰ ਉਹਿਰਮਾ ਸੀ। ਸ਼ੁਰਸ਼ ਇੱਕ ਇਸ ਸੰਧੀ ਵਿਚ ਹੀ ਦੂਸੇ ਵਿਸ਼ਵ ਯੁੱਧ ਦੇ ਬੀਜ ਮੌਜੂਦ ਸਨ। ਸਰਸਾਈ ਨੇ ਸਾਪਣੀ ਇੱਛਾ ਨਾਲ ਇਸ ਸੰਧੀ ਨੂੰ ਸਵੀਕਾਰ ਨਹੀਂ ਕੀਤਾ ਸੀ ਬਲਕਿ ਇਹ ਸੰਧੀ ਉਸ ਉੱਤੇ ਜ਼ਬਰਦਸਤੀ ਥੋਪੀ ਗਈ ਸੀ। ਇਸ ਸੰਧੀ ਦਾ ਸ਼ੁਰੂ ਤੋਂ ਹੀ ਜਰਮਨੀ ਵਿਚ ਜ਼ੋਰਦਾਰ ਵਿਰੋਧ ਹੋਇਆ ਸੀ। ਜਰਮਨੀ ਨੂੰ ਇਕ ਬੁਰਾ ਹਰ ਦੇਸ਼ ਸਮਝਦਾ ਸੀ। ਉਸ ਦੀ ਸੈਨਿਕ ਸਾਕਤੀ ਨੂੰ ਕਮਜ਼ੋਰ ਬਣਾ ਦਿਤਾ ਗਿਆ। ਉਸ ਦੇ ਅਨੇਕਾਂ ਪ੍ਰਦੇਸ਼ ਅਤੇ ਬਸਤੀਆਂ ਉਸ ਤੋਂ ਖੋ ਲਈਆਂ ਗਈਆਂ। ਇਸ ਦੇ ਇਲਾਵਾ ਉਸਤੇ ਦੇ ਰਿਤੇ ਦੇ ਕਈ ਸਰਸਾਈ ਦੇ ਦੇ ਟੁੱਕੜੇ ਕਰ ਦਿਤੇ ਗਏ। ਉਸ ਦੇ ਸਾਰ ਵਾਲੀ ਦੇ ਕਲਾ ਖੋਹ ਲਏ, ਤੇ ਸਿਰ ਦੇਸਾਂ ਦਾ ਸਾਂਪਵਾਰ ਤੇ ਰੋਕ ਲਾ ਦਿਤੀ। ਸੰਧੀ ਦੀ ਜੁੰਮੇ ਸਮਝੌਤੇ ਦੀ ਧਾਰਾ ਸਾਂ ਸਰਸਾਈ ਦੇ ਸਥੇ, ਤੇ ਕਲੇਰ ਸੀ ਕਿ ਸੁਸ ਨੂੰ ਚੇਤ ਦੇ ਰਖੇ ਤੇਰੇ ਸਰਸਾਈ ਉਤਾਹਲਾ ਸੀ। ਸਮੀਸਾ ਸੀਧੀ ਇੱਕ

ਇੱਕ ਹੋਰ ਯੁੱਧ ਜ਼ਰੂਰੀ ਸੀ।

② ਗਸ਼ਟਰੀ ਭਾਵਨਾ ਦਾ ਪ੍ਰਲਰ - ਉਭਾਰ :- ਗਸ਼ਟਰੀ ਭਾਵਨਾ ਦਾ ਉਭਾਰ ਵੀ ਸੰਘਰਸ਼ ਦਾ ਇੱਕ ਮਹੱਤਵਪੂਰਨ ਕਾਰਨ ਬਣਿਆ। ਪਹਿਲੇ ਸੰਸਾਰ ਯੁੱਧ ਤੋਂ ਬਾਅਦ ਜਿਨਾਂ ਦੇਸ਼ਾਂ ਦੇ ਸੰਬੰਧ ਜਰਮਨੀ ਦੇ ਨਾਲ ਸਨ ਉਹਨਾਂ ਦੇ ਇਸ ਗੱਲ ਤੇ ਜ਼ੋਰ ਦਿੱਤਾ ਕਿ ਵਿਸ਼ਵ ਵਿੱਚ ਸਥਾਈ ਸ਼ਾਂਤੀ ਸਥਾਪਤ ਕਰਨ ਲਈ ਸਾਮਰਾਜਵਾਦ ਨੂੰ ਖਤਮ ਕਰਨਾ ਜ਼ਰੂਰੀ ਹੈ। ਪਰੰਤੂ 1939 ਈ: ਵਿੱਚ ਸਥਾਈ ਸ਼ਾਂਤੀ ਸਥਾਪਤ ਕਰਨ ਦੀ ਬਜਾਏ ਸਾਮਰਾਜਵਾਦੀ ਦੇਸ਼ਾਂ ਨੇ ਸਾਮਰਾਜਵਾਦ ਦੀ ਭਾਵਨਾ ਨੂੰ ਹੋਰ ਵੀ ਤੇਜ਼ ਕਰ ਦਿੱਤਾ। ਜੋਰ ਜੋਰ ਨਾਲ ਸਥਾਪਤ ਸਾਮਰਾਜਵਾਦ ਖਿਲਾਫ ਦੀ ਸਥਾਪਨਾ ਦੇ ਨਾਲ ਨਾਲ ਸਥਾਪਤ ਸਾਮਰਾਜਵਾਦ ਦੀ ਨੀਤੀ ਸਥਾਪਤ ਹੋਈ। ਇਟਲੀ ਵਿੱਚ ਮੁਸੋਲਿਨੀ ਸਥਾਪਤ ਸਰਕਾਰ ਵਿੱਚ ਫਿਟਲਰ ਦੇ ਗਸ਼ਟਰੂਹਾਰ ਨੂੰ ਚੁਣੌਤੀ ਦੇਣ ਦੇ ਚੁੱਪ ਚੁਪੀਤੇ ਯਤਨ ਕੀਤੇ। ਉਨ੍ਹਾਂ ਨੇ ਸਥਾਪਤ ਦੇਸ਼ ਦੇ ਲੋਕਾਂ ਵਿੱਚ ਉਹ ਦੇਸ਼ਾਂ ਦੇ ਲੋਕਾਂ ਦੇ ਹਾਰੇ ਵਿੱਚ ਇਹ ਦਿੱਤੀ ਕਿ ਉਹ ਤਰੱਕੀ ਕਰ ਰਹੇ ਹਨ ਕਿ ਇਸ ਨੇ ਸਾਰੇ ਵਿਸ਼ਵ ਨੂੰ ਜੰਗ ਦਾ ਮੈਦਾਨ ਬਣਾ ਦਿੱਤਾ ਸੀ।

③ ਸਥਾਪਤ ਸਥਾਪਤਾਵਾਦ :- 1939 ਈ: ਦੇ ਸਥਾਪਤ ਸਾਰੇ ਨੂੰ ਵਿਸ਼ਵ ਦੇ ਉੱਤੇ ਦੇਸ਼ ਨੂੰ ਸਥਾਪਤ ਕਰਨ ਵਿੱਚ ਇੱਕ ਮਹੱਤਵਪੂਰਨ ਸਥਾਪਤ ਸੀ। ਇਸ ਕਾਰਨ ਜ਼ਰੂਰ ਦੇ ਦੇਸ਼ਾਂ ਨੂੰ ਸਮੁੱਚ ਦੇਸ਼ਾਂ ਨੂੰ ਅੱਗੇ ਸਥਾਪਤ ਸੰਕਟ ਦਾ ਸਾਹਮਣਾ ਕਰਨਾ ਪਿਆ। ਉਨ੍ਹਾਂ ਦੇ ਸਾਹਮਣੇ ਰਾਜਧਾਨੀਆਂ ਵਿੱਚ ਤਿਆਰ ਸਥਾਪਤ ਨੂੰ ਦੇਖਣ ਦੀ ਸਮੱਸਿਆ ਸੀ। ਉਹ ਸਥਾਪਤ ਸਥਾਪਤ ਦੇ ਲਈ ਕਈ ਮੁਸੀਬਤਾਂ ਵਿੱਚ ਸਥਾਪਤ ਸਥਾਪਤ ਦੇ ਲਈ ਸਥਾਪਤ ਸਥਾਪਤ ਦੇ ਲਈ ਕਈ ਸਥਾਪਤ ਸਥਾਪਤ ਦੇ ਲ

ਵੀਰੂਪੀਅਮ ਦੇ ਅਮਾਪਣੇ ਅਧਿਕਾਰ ਹਿਤ ਵੇ ਤਿਅਮਾ
ਸਮਤੇ ਸਾਧਨਾਂ ਦੇ ਮੈਦਾਨੀਅਮ, ਤੇ ਅਧਿਕਾਰ ਕਰ
ਲਿਆ। ਇਹਨਾਂ ਮੌਲਿਕ ਸੁਧਿਆਂ ਦੇ ਕਾਰਨ ਵੀ
ਸਾਮਰਾਜ ਦਾ ਹਾਰਵਰਡ ਤਿਆਗ ਤੇ ਗਿਆ।

(4) ਗੰਧਮਾਰ ਦੇ ਸੀਮਿਤ ਰਾਜ:- 1919 ਈ: ਦੀ ਵਰਸਾਇ ਦੀ
ਸੰਧੀ ਦੇ ਅਨੁਸਾਰ ਇਹ
ਨਿਸ਼ਚਿਤ ਹੋਇਆ ਕਿ ਜਰਮਨ ਰਾਜਦੂਤ ਨਿਸ਼ਸਤ੍ਰੀਕਰਨ ਦੀ
ਨੀਤੀ ਦਾ ਪਾਲਣ ਕਰਨਗੇ। ਸਿੱਟੇ ਵਜੋਂ ਜਰਮਨੀ ਦੀ
ਸਭ ਤੋਂ ਵੱਡੀ ਸੈਨਾ ਵਿਚ ਕੇਵਲ 4 ਲੱਖ ਸੈਨਿਕ ਹੀ
ਹਿੱਸਾ ਲੈ ਸਕਣਗੇ, ਤੇ ਨਿਸ਼ਸਤ੍ਰੀਕਰਨ ਦੀਆਂ ਸ਼ਰਤਾਂ ਦਾ
ਸਖ਼ਤੀ ਨਾਲ ਪਾਲਣ ਕਰਵਾਇਆ। ਇਸ ਤੋਂ ਇਲਾਵਾ ਉਹ
ਦੇਸ਼ ਵਿਚ ਸੈਨਾ ਦੇ ਸੰਗਠਨ ਦੇ ਲਈ ਤਿਆਰ ਨਹੀਂ ਸੀ।
ਉਨ੍ਹਾਂ ਦੇ ਅਧਿਕਾਰ ਗੰਧਮਾਰ ਵਿਚ ਵਧਾ ਕਰਨ ਦੇ ਕੰਮ
ਨੂੰ ਸਾਰੀ ਗੰਧਮਾਰ ਸਮਝ ਦੇ ਵਿਰੋਧ ਕੀਤਾ। ਗਲਤ ਸਥਾਨ
ਦੇ ਚਾਹਵਾਦ ਸਮਝੌਤਾ ਦਾ ਵੀ ਇਹੀ ਮੰਤਵ ਸੀ ਕਿ
ਗੰਧਮਾਰ ਨੂੰ ਘੱਟ ਕਰਨ ਦੇ ਲਈ ਤਿਆਰ ਨਹੀਂ ਸੀ। ਮਿਤੇ
ਵਿਚ ਸਥਿਰਤਾ ਲਿਆਉਣ ਵਿਚ ਅਧਿਕਾਰ ਤੇ ਤਿਆਰ ਨਹੀਂ
ਹੀ ਅਧਿਕਾਰ, ਦੀ ਸੰਧੀ ਦੀਆਂ ਸ਼ਰਤਾਂ ਨੂੰ ਮੰਨਣ ਤੇ
ਸਹਮਤ ਹੋ ਗਿਆ। ਤਿਆਰ ਦੇ ਸਮਝੌਤੇ ਵਿਚ ਮੌਲਿਕ ਸੰਧੀ
ਸਥਾਨ ਨੂੰ ਵਿਚਾਰ ਤੇ ਗਿਆ ਅਤੇ ਗੰਧਮਾਰ ਦਾ ਨਿਸ਼ਸਤ੍ਰੀਕਰਨ
ਤੇ ਜ਼ੋਰ ਦਿੱਤਾ ਗਿਆ। ਸਮਝੌਤਾ ਦੀ ਵੱਖ-ਵੱਖ ਤੇ
ਵੱਖਰਾਂ ਨੇ ਹੀ ਅਸਫਲ ਤੇ ਗਿਆ। ਸਿੱਟੇ ਵਜੋਂ ਵੱਖ-ਵੱਖ
ਵੱਖਾਂ ਵਿਚ ਗੰਧਮਾਰ ਦੇ ਨਿਰਮਾਣ ਦੀ ਦੌੜ ਲੱਗ
ਗਈ ਉਸ ਦੇ ਵਾਸੇ ਹਿਟਲਰ ਨੇ ਵਾਰਸਾ ਸੰਧੀ ਨੂੰ ਤੋੜ
ਦਿੱਤਾ।

(5) ਬਸਤੀਵਾਦੀ ਅਤੇ ਸਾਮਰਾਜੀ ਰਾਜ:- ਇੰਗਲੈਂਡ, ਫਰਾਂਸ ਤੇ ਸੰ.
ਰਾਜ. ਦੇ. ਸਮਝਦੇ ਸਨ ਕਿ
ਉਨ੍ਹਾਂ ਦੇ ਪਹਿਲਾ ਸਥਾਨ ਉੱਚ ਸਾਮਰਾਜੀ ਹਿਤਾਂ ਦੇ ਕਾਰਨ
ਹੀ ਗੰਧਮਾਰ ਚੁਣੀ ਲੀਤਾ ਸੀ। ਸਾਰੀ ਸਮਝੌਤੇ ਤੇ
ਹਸਤਾਖਰ ਕਰਦੇ ਵੇਲੇ ਇਹ ਗਲਤੀ ਤੇ ਬਸਤੀਵਾਦੀ ਤੇ

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ਕਾਮਣ ਸਮਾਧਯਤ ਕੀਤੇ ਗਏ ਸਨ। ਪਰੰਤੂ ਸਮਾਂ ਦੇ ਵਿਕਾਸ ਦੇ ਨਾਲ ਸਮਾਜ ਵਿਚ ਸਮਾਧੀ ਦੀ ਮਹੱਤਤਾ ਘੱਟ ਹੋ ਗਈ ਅਤੇ ਸਮਾਧੀ ਦਾ ਉਪਯੋਗ ਸੀਮਿਤ ਹੋ ਗਿਆ। ਇਹ ਵੀ ਸਮਾਂ ਦੇ ਨਾਲ ਹੀ ਹੋਇਆ ਕਿ ਸਮਾਧੀ ਦੇ ਸਥਾਨ ਤੇ ਸਮਾਰਕ ਬਣਾਏ ਜਾਣ ਲੱਗੇ। ਸਮਾਰਕ ਬਣਾਉਣ ਦੀ ਪਰੰਪਰਾ ਦੀ ਸ਼ੁਰੂਆਤ ਕਦੋਂ ਅਤੇ ਕਿਵੇਂ ਹੋਈ ਇਸ ਦੇ ਬਾਰੇ ਵਿਚ ਕੋਈ ਵੀ ਨਿਸ਼ਚਿਤ ਰੂਪ ਨਾਲ ਕੁਝ ਨਹੀਂ ਕਿਹਾ ਜਾ ਸਕਦਾ। ਇਸ ਦੇ ਬਾਰੇ ਵਿਚ ਕਈ ਮਤ ਪ੍ਰਚਲਿਤ ਹਨ। ਕੁਝ ਵਿਦਵਾਨਾਂ ਦਾ ਮੰਨਣਾ ਹੈ ਕਿ ਸਮਾਰਕ ਬਣਾਉਣ ਦੀ ਪਰੰਪਰਾ ਦੀ ਸ਼ੁਰੂਆਤ ਬੁੱਧ ਧਰਮ ਦੇ ਪ੍ਰਭਾਵ ਦੇ ਕਾਰਨ ਹੋਈ ਹੈ। ਬੁੱਧ ਧਰਮ ਦੇ ਅਨੁਯਾਈਆਂ ਨੇ ਮਹਾਤਮਾ ਬੁੱਧ ਦੇ ਅਵਸ਼ੇਸ਼ਾਂ ਤੇ ਸਤੂਪ ਬਣਾਏ ਸਨ। ਇਸ ਲਈ ਇਹ ਸੰਭਵ ਹੈ ਕਿ ਸਤੂਪਾਂ ਦੀ ਤਰ੍ਹਾਂ ਹੀ ਸਮਾਰਕ ਬਣਾਏ ਜਾਣ ਲੱਗੇ ਹੋਣ। ਕੁਝ ਵਿਦਵਾਨਾਂ ਦਾ ਮੰਨਣਾ ਹੈ ਕਿ ਸਮਾਰਕ ਬਣਾਉਣ ਦੀ ਪਰੰਪਰਾ ਦੀ ਸ਼ੁਰੂਆਤ ਸਿਕੰਦਰ ਦੇ ਭਾਰਤ ਤੇ ਆਕ੍ਰਮਣ ਦੇ ਬਾਅਦ ਹੋਈ ਹੈ। ਸਿਕੰਦਰ ਦੇ ਸਾਥੀ ਯੂਨਾਨ ਵਾਪਸ ਜਾਣ ਤੇ ਆਪਣੇ ਨਾਲ ਭਾਰਤ ਦੀ ਕਈ ਵਸਤੂਆਂ ਲੈ ਗਏ ਸਨ ਅਤੇ ਉਨ੍ਹਾਂ ਨੇ ਉਥੇ ਭਾਰਤੀ ਵਸਤੂਆਂ ਦੇ ਸਮਾਰਕ ਬਣਾਏ ਸਨ। ਇਸ ਲਈ ਇਹ ਸੰਭਵ ਹੈ ਕਿ ਭਾਰਤ ਵਿਚ ਵੀ ਸਮਾਰਕ ਬਣਾਉਣ ਦੀ ਪਰੰਪਰਾ ਦੀ ਸ਼ੁਰੂਆਤ ਹੋਈ ਹੋਵੇ। ਪਰੰਤੂ ਇਹ ਸਾਰੇ ਵਿਚਾਰ ਕੇਵਲ ਅਨੁਮਾਨ ਤੇ ਆਧਾਰਿਤ ਹਨ। ਇਸ ਲਈ ਇਨ੍ਹਾਂ ਵਿਚੋਂ ਕਿਸੇ ਨੂੰ ਵੀ ਪੂਰੀ ਤਰ੍ਹਾਂ ਸਹੀ ਨਹੀਂ ਕਿਹਾ ਜਾ ਸਕਦਾ।

(6) <u>ਘੱਟ ਗਿਣਤੀ ਦੀਆਂ ਸਭਾਵਾਂ ਦੀ ਸਥਾਪਨਾ:-</u> ਘੱਟ-ਗਿਣਤੀਆਂ ਦੀ ਸਥਾਪਨਾ ਦਾ ਮੁੱਖ ਕਾਰਨ ਸਮਾਜ ਵਿਚ ਆਪਣੀ ਵੱਖਰੀ ਪਹਿਚਾਣ ਬਣਾਉਣਾ ਸੀ। ਇਹ ਸਭਾਵਾਂ ਆਪਣੇ ਸਮਾਜ ਦੇ ਵਿਕਾਸ ਦੇ ਲਈ ਕਾਰਜ ਕਰਦੀਆਂ ਸਨ। 1919 ਈ: ਵਿਚ ਪਹਿਲੇ ਸਿਖ ਜੱਥੇ ਵਿਚ ਸ਼ਾਮਲ ਸਾਰੇ ਮੈਂਬਰਾਂ ਨੇ ਮਿਲ ਕੇ ਅਕਾਲੀ ਦਲ ਦੀ ਸਥਾਪਨਾ ਕੀਤੀ ਸੀ। ਇਸ ਦਲ ਦਾ ਮੁੱਖ ਉਦੇਸ਼ ਗੁਰਦੁਆਰਿਆਂ ਦੀ ਪ੍ਰਬੰਧਕ ਕਮੇਟੀ ਦੀ ਚੋਣ ਕਰਵਾਉਣਾ ਸੀ। ਇਸ ਦਲ ਦੇ ਮੈਂਬਰਾਂ ਨੇ ਸਿਖ ਗੁਰਦੁਆਰਾ ਐਕਟ ਪਾਸ ਕਰਵਾਉਣ ਵਿਚ ਵੀ ਮਹੱਤਵਪੂਰਨ ਭੂਮਿਕਾ ਨਿਭਾਈ ਸੀ। ਇਸ ਤਰ੍ਹਾਂ ਘੱਟ-ਗਿਣਤੀਆਂ ਦੀ ਸਥਾਪਨਾ ਦਾ ਮੁੱਖ ਉਦੇਸ਼ ਆਪਣੇ ਸਮਾਜ ਦੀ ਉਨਤੀ ਲਈ ਕਾਰਜ ਕਰਨਾ ਹੁੰਦਾ ਹੈ। ਇਸ ਲਈ ਇਹ ਸਭਾਵਾਂ ਆਪਣੇ ਸਮਾਜ ਦੇ ਵਿਕਾਸ ਲਈ ਕਾਰਜ ਕਰਦੀਆਂ ਹਨ। ਇਹ ਸਭਾਵਾਂ ਆਪਣੇ ਸਮਾਜ ਦੇ ਲੋਕਾਂ ਨੂੰ ਸਿਖਿਆ ਦੇਣ ਦਾ ਪ੍ਰਬੰਧ ਕਰਦੀਆਂ ਹਨ। ਇਸ ਤਰ੍ਹਾਂ ਘੱਟ-ਗਿਣਤੀਆਂ ਦੀ ਸਥਾਪਨਾ ਦਾ ਇਕ ਮੁੱਖ ਉਦੇਸ਼ ਆਪਣੇ ਸਮਾਜ ਦੇ ਲੋਕਾਂ ਨੂੰ ਸਿਖਿਆ ਦੇਣਾ ਹੁੰਦਾ ਹੈ। ਇਸ ਤਰ੍ਹਾਂ ਘੱਟ-ਗਿਣਤੀਆਂ ਦੀ ਸਥਾਪਨਾ ਦਾ ਇਕ ਮੁੱਖ ਉਦੇਸ਼ ਆਪਣੇ ਸਮਾਜ ਦੇ ਲੋਕਾਂ ਨੂੰ ਸਿਖਿਆ ਦੇਣਾ ਹੁੰਦਾ ਹੈ। ਇਸ ਤਰ੍ਹਾਂ ਘੱਟ-ਗਿਣਤੀਆਂ ਦੀ ਸਥਾਪਨਾ ਦਾ ਇਕ ਮੁੱਖ ਉਦੇਸ਼ ਆਪਣੇ ਸਮਾਜ ਦੇ ਲੋਕਾਂ ਨੂੰ ਸਿਖਿਆ ਦੇਣਾ ਹੁੰਦਾ ਹੈ।

(7) ਗਲਟਰੀ ਸੈਂਪ ਦੀ ਸਮਸਥਾ :- ਗਲਟਰ ਸੈਂਪ ਦੀ ਸਥਾਪਨਾ 1920 ਵਿੱਚ ਹੋਈ। ਇਸ ਦੀ ਸਥਾਪਨਾ ਤੋਂ ਬਾਅਦ ਇਸ ਨੂੰ ਕਈ ਵਾਰ ਵਧਾਇਆ ਗਿਆ ਹੈ। ਇਸ ਦਾ ਮੁੱਖ ਉਦੇਸ਼ ਉਦਯੋਗਾਂ ਨੂੰ ਪ੍ਰਤੀ ਦਾ ਵਧ ਸਕੀ। ਇਸ ਦਾ ਇੱਕ ਹੋਰ ਮੰਤਵ ਇਹ ਵੀ ਹੈ ਕਿ ਇਸ ਦੇ ਵਿਚ ਸਥਾਪਤੀ ਵਾਲੀ ਸੈਂਨਾ ਨਹੀਂ ਸੀ। ਇਸ ਦਾ ਮੁੱਖ ਉਦੇਸ਼ ਸਥਾਪਤੀ ਵਿਚ ਨੂੰ ਉਤਸ਼ਾਹਿਤ ਕਰਨਾ ਸੀ ਤਾਂ ਜੋ ਉਦਯੋਗਾਂ ਨੂੰ ਪ੍ਰਤੀ ਦਾ ਵਧ ਸਕੀ। ਸਥਾਪਤੀ ਵਿਚ ਨੂੰ ਉਤਸ਼ਾਹਿਤ ਕਰਨਾ ਸੀ ਤਾਂ ਜੋ ਉਦਯੋਗਾਂ ਨੂੰ ਪ੍ਰਤੀ ਦਾ ਵਧ ਸਕੀ। ਗਲਟਰ ਸੈਂਪ ਇਸ ਲਈ ਹੀ ਸਥਾਪਤ ਕੀਤਾ ਗਿਆ ਸੀ। ਗਲਟਰ ਇਸ ਦੇ ਮੁੱਖ ਸੰਯੋਜਕ ਲਈ ਇੱਕ ਸਥਾਨ ਹੈ। ਸਥਾਪਤੀ ਉਤਪਾਦਨ ਵਿਚ ਵਾਧਾ ਕਰਨਾ ਸੀ। ਸਥਾਪਤੀ ਮਹਾਰਾਸ਼ਟਰ ਸਿੱਧੀ ਦਾ ਸਥਾਪਤੀ ਸੀਮਾ, ਤੇ, ਸੂਰਜਮੁਖੀ ਦੇ ਸਥਾਪਤੀ ਵਿਚ ਮੁੱਖ ਸਥਾਪਤੀ ਵਿਚ ਸਿਖਾ ਤੇ ਗਲਟਰ ਸੈਂਪ ਦੇ ਸੰਯੋਜਕ ਵਿਚ ਤਾ ਵਧ ਸਕੇ। ਇਸ ਤੋਂ ਗਲਟਰ ਸੈਂਪ ਦੀ ਵਸਤੂਆਂ ਦਾ ਨਾਮ ਖੁੱਲ੍ਹ ਗਿਆ ਸਥਾਪਤੀ ਤੇ ਗਲਟਰ ਦਾ ਇਸ ਤੇ ਵਿਸ਼ਵਾਸ ਹੋ ਗਿਆ। ਸਥਾਪਤੀ ਸ੍ਰੰਖਿਆ ਦੇ ਚੁਣੀ ਹੋ ਜੋ ਸਥਾਪਤੀ ਦੇ ਉਤਪਾਦਨ ਵਿਚ ਪਿਆਰ ਦੇਵ ਚਾਹੇ। ਇਸ ਤੋਂ ਗਲਟਰ - ਸੈਂਪ ਦੀ ਵਸਤੂਆਂ ਵਿਚ ਸਥਾਪਤੀ ਦਾ ਇੱਕ ਸਥਾਪਤੀਕਰਨ ਵਾਲਾ ਹੋਈ।

(8) ਇੰਗਲੈਂਡ ਸਥਾਪਤੀ ਹਿੱਸ ਸਥਾਪਤੀ :- ਪਹਿਲੇ ਸਥਾਪਤੀ - ਯੁੱਧ ਇੰਗਲੈਂਡ ਤੇ ਜਰਮਨ ਵਿਚਲੇ ਲੜੇ ਸਥਾਪਤੀ ਪਰ ਯੁੱਧ ਦੀ ਸਥਾਪਤੀ ਪਿੱਛੋਂ ਦੋਵਾਂ ਵਿਚ ਸਥਾਪਤੀ ਹੋ ਗਏ। ਇੰਗਲੈਂਡ ਯੁੱਧ ਵਿਚ ਸਥਾਪਤੀ-ਸਥਾਪਤੀ ਦੀ ਸਥਾਪਤੀ ਵਿਚ ਸਥਾਪਤੀ ਸੀ। ਇਸ ਨੇ ਜਿੱਤ ਜਰਮਨ ਸਥਾਪਤੀ ਦੇ ਵਧ ਤੋਂ ਵਧ ਲਾਲ ਸਥਾਪਤੀਆਂ ਤੇ ਯੁੱਧ ਦਾ ਸਥਾਪਤੀ ਦੇ ਸਥਾਪਤੀ ਤੇ ਸਥਾਪਤੀ ਦੀ ਸਥਾਪਤੀ ਸੀ। ਇਸ ਤੋਂ ਸਥਾਪਤੀ ਦੇ ਸਥਾਪਤੀ ਦੇ ਸਥਾਪਤੀ ਦੇ

ਵਿੱਚ ਸ਼ਾਮਲ ਕੀਤਾ ਗਿਆ। ਇਸ ਤਰ੍ਹਾਂ ਇਹ ਸਾਰੇ ਦੇਸ਼ ਵਿੱਚ ਸਭ ਤੋਂ ਵੱਡਾ ਸਹਿਕਾਰੀ ਬੈਂਕ ਬਣ ਗਿਆ।

(9) ਸਰਮਲੀ ਦਾ ਪੈਲੈਂਡ ਉੱਤੇ ਹਮਲਾ:- ਉਪਰੋਕਤ ਕਾਰਜਾਂ ਤੋਂ ਸਪੱਸ਼ਟ ਹੈ ਕਿ 1939 ਈ: ਦੇ ਅੰਤ ਤਕ ਜਰਮਨ ਨੇ ਆਪਣੀ ਸਾਮਰਾਜੀ ਵਿਸਥਾਰ ਦੀ ਨੀਤੀ ਤਹਿਤ ਪੋਲੈਂਡ ਉੱਤੇ ਹਮਲਾ ਕਰ ਦਿੱਤਾ ਅਤੇ ਪਹਿਲੀ ਸਤੰਬਰ 1939 ਈ: ਨੂੰ ਪੋਲੈਂਡ ਉੱਤੇ ਹੱਲਾ ਬੋਲ ਦਿੱਤਾ। ਤੇ ਸਤੰਬਰ ਦੇ ਦਿਨਾਂ ਤੇ ਜਰਮਨ ਦੇ ਸਰਮਲੀ ਨੇ ਜੰਗ ਸਮਾਪਤ ਹੋਣ ਦੀ ਘੋਸ਼ਣਾ ਕਰ ਦਿੱਤੀ। ਸਰਮਲੀ ਦੁਆਰਾ ਇਸ ਨੂੰ ਖੋਹ ਲਿਆ ਗਿਆ ਤੇ ਜੰਗ ਨੇ ਜੰਗ ਦਾ ਨਾਮੋਨਿਸ਼ਾਨ ਕਰ ਦਿੱਤਾ। ਦੇਖਦੇ ਹੀ ਦੇਖਦੇ ਇਸਦੇ ਦੇ ਕਈ ਦੇਸ਼ ਇਸ ਦੀ ਲਪੇਟ ਵਿੱਚ ਆ ਗਏ ਅਤੇ ਜੰਗ ਇੱਕ ਭਿਆਨਕ ਜੰਗ ਦਾ ਰੂਪ ਧਾਰਨ ਕਰ ਗਿਆ।

(10) ਵਿਸ਼ਵ ਦੀ ਦੂਜੀ ਮਹਾਂ ਜੰਗ:- ਪਹਿਲੇ ਜੰਗ-ਜੰਗ ਦੇ ਸਮਾਪਤ ਤੋਂ ਪਹਿਲਾਂ ਹੀ ਜੰਗ ਦੀ ਦੂਜੀ ਜੰਗ ਦੇ ਵਿਚਾਰ ਪੈਦਾ ਹੋਣ ਲੱਗ ਪਏ ਸਨ। ਦੂਜੀ ਜੰਗ-ਜੰਗ ਦੇ ਕਾਰਨ ਵੀ ਪਹਿਲੀ ਜੰਗ ਦੇ ਕਾਰਨਾਂ ਵਿੱਚ ਹੀ ਲੁਕੇ ਹੋਏ ਸਨ। 1938 ਈ: ਤਕ ਜਰਮਨ ਤਾਨਾਸ਼ਾਹ ਹਿਟਲਰ ਦੇ ਸਾਮਰਾਜੀ ਮਨਸੂਬੇ ਕਾਫੀ ਹੱਦ ਤਕ ਸਪੱਸ਼ਟ ਹੋ ਚੁੱਕੇ ਸਨ। ਉਸ ਨੇ ਆਸਟਰੀਆ, ਚੈਕੋਸਲਵਾਕੀਆ ਅਤੇ ਪੋਲੈਂਡ ਨੂੰ ਆਪਣੇ ਅਧੀਨ ਕਰ ਲਿਆ ਸੀ। ਉਸ ਦੀ ਨਜ਼ਰ ਫਰਾਂਸ ਅਤੇ ਰੂਸ ਉੱਤੇ ਸੀ। ਉਹ ਇਹਨਾਂ ਦੇਸ਼ਾਂ ਨੂੰ ਆਪਣੇ ਅਧੀਨ ਕਰਨ ਲਈ ਯਤਨਸ਼ੀਲ ਸੀ। ਉਸ ਨੇ ਇਹਨਾਂ ਦੇਸ਼ਾਂ ਨੂੰ ਆਪਣੇ ਅਧੀਨ ਕਰਨ ਲਈ ਯਤਨਸ਼ੀਲ ਸੀ। ਉਸ ਨੇ ਇਹਨਾਂ ਦੇਸ਼ਾਂ ਨੂੰ ਆਪਣੇ ਅਧੀਨ ਕਰਨ ਲਈ ਯਤਨਸ਼ੀਲ ਸੀ।

ਇਸਲੰਡ ਸਮਾਰੋ ਕਰਾਂਸ, ਜੋ ਮਿੰਨ੍ਹ ਵੇਸ ਸਮਾਪਤਿਵੇ ਸਟ,
ਦਾ ਸਾਰਯੋ ਸਾਲੀ ਗੋਟ ਗਇਸ ਤੇ ਗਿਆ। ਸਤੰਬਰ 1939
ਦੀ: ਇਹ ਸਦੇ ਸਰਸਤੀ ਦੇ ਪਹਿਲ ਦਿਨ ਚਮਕਾ ਕੀਤਾ ਤਾਂ
ਮਿੰਨ੍ਹ - ਵੇਸਾਂ ਦੇ ਪਹਿਲ ਦਾ ਸਾਲ ਇੰਨਾ ਸਿਸ ਹੈ
ਕਲਸਵ੍ਰਯ ਵੇਸੇ ਸਗਾਂ - ਜੁੱਧ ਦਾ ਸਮਾਰਿਭ ਹੋਇਆ।

ਵੇਸੇ ਵਿਸ਼ਵ ਜੁੱਧ ਦੇ ਨਤੀਜੇ -

① ਸਾਰੀ ਸਾਲੀ ਤੇ ਸਾਲੀ ਨਕਸਾਲ:- ਵੇਸਾ ਸਗਾਂ - ਜੁੱਧ ਸਾਰਵ
ਵਿਨਾਸ਼ਕਾਰੀ ਸਿੱਧ ਹੋਇਆ। ਇਸ ਜੁੱਧ ਵਿਚ ਤੇਵੇ ਸਾਲੀ
ਤੇ ਸਾਲੀ ਨਕਸਾਲ ਦਾ ਸਮੇਂਕਾ ਢਾਂਚਾ ਸਮੇਂਕਾ ਹੈ।
ਇੱਕ ਅਮਾਨਸਾਲ ਪੁਰਸਕਾਰ ਇਸ ਵਿਚ ਕਈ ਵਿਕ ਦੇਸ਼
ਤੇ ਵੱਧ ਸੈਨਿਕ ਸਮੇਂ ਲਗਭਗ 2 ਕਰੋੜ ਨਾਗਰਿਕਾਂ ਦੀ
ਸੌਂ ਹੋਈ। ਇਸ ਤੇ ਵਿਨਾਸ਼ ਕਈ ਦੇ ਲਵ ਸਪਤੀ
ਤੇ ਲਗਾਤ ਹੋ ਗਏ। ਧਨ ਸਾਰੇ ਸੰਸਾਰਸਾ ਵਿਚ ਲਵ
ਜੁੱਧ ਤੇ ਪਿੱਛ ਫੈਲੀਆਂ ਬਿਮਾਰੀਆਂ ਦਾ ਸਿਕਾਰ ਹੋਏ।
ਸਾਲੀ ਨਕਸਾਲ ਤੇ ਵਿਚਾਰ ਇਸ ਜੁੱਧ ਵਿਚ ਸਾਰੇ ਸਾਲੀ
ਨਕਸਾਲ ਦੀ ਹੋਇਆ। ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਕਿ ਜੁੱਧ ਵਿਚ ਲਵ
ਵੀਰ ਗਏ ਸਮਝਾਂ ਸਾਲਰ ਤੇ ਵਿਨਾਸ਼ 300 ਤੇ 400
ਮਿਲੀਅਨ ਡਾਲਰ ਹੋਰ ਦੀ ਸੰਪੱਤੀ ਦੀ ਹਾਨਿ ਹੋ ਗਈ।
ਇਸ ਤੇ ਪਹਿਲਾਂ ਸੰਸਾਰ ਦੇ ਕਿਸੇ ਜੁੱਧ ਵਿਚ ਸਮਸਿਤ
ਸਾਰੀ ਨਕਸਾਲ ਕਦੀ ਨਹੀਂ ਹੋਈ ਸੀ।

② ਸਭਸਤੀ ਦੇ ਦੇ ਟੁੱਟੇ:- ਇਸ ਜੁੱਧ ਦਾ ਸਭਸਤੀ ਤੇ
ਵੱਡਾ ਉਸਾਰੂ ਨਤੀਜਾ ਨਿਕਲਿਆ।
ਇਸ ਤੇ ਦਾ ਵੇਹਲ ਨਿਹਚਾ ਸਾਰੇ ਸਿਤ ਗਏ ਖਤਮ ਹੋ
ਹਾਪਸ ਹੋ ਗਏ ਸਾਰੇ ਇਸ ਦੇ ਟੁੱਟੇ ਹੀ ਰਹਿ ਗਏ
ਸਮੇਂ ਇਸ ਦੇ ਸੈਨਿਕ ਪੱਖ ਤੇ ਸਦਾ ਹਾਵੀ
ਸਹਯੋਗੀ ਰਹ ਗਿਆ। ਹਾਰ ਸਮੇਂ ਸੇਤੇ
ਸਹਯੋਗੀ ਦੇ ਸਾਰ ਤੇ ਸਭਸਤੀ ਦੇ ਸਾਰ ਤੇ ਸਿਸਮਾਂ ਵਿਚ ਵੱਡੇ

Shot on Y11

ਇੱਕ ਸਮੇਂ ਇਹ ਰਹੀ ਦੀਵੇਮਾਂ ਹਰ ਸਮਾਪਤੀ ਸਮਾਪਬਾਣ ਹੋਰ ਬੁੱਧਮਾ। ਚਾਮਦ ਇੱਕ ਪੁਸ਼ਦੀ ਸਰਮਾਂ ਇੱਕ ਤੁਮ ਦੇ ਸਮਾਪਤ ਕੀਮਤੀਲਸੂਦ ਸਾਮਲ ਸਬਾਪਤਾ ਹੋ ਗਾਮਾ ਸਮੇਤ ਪੱਛਮੀ ਸਰਮਲੀ ਇੱਕ ਸਮਾਰੰਗਾ ਤੇ ਉਹ ਦੇ ਸਾਬੀਮਾਂ ਦੇ ਮੁਕਾਦ ਸਮਾਪਤ ਚੋਰ ਹੋਣੀ ਸਾਮਦ ਸਬਾਪਤਾ ਰਰ ਇੱਕ ਗਿਆ। ਸਰਮਲੀ ਦੀ ਰਾ ਸਮਾਤੀ ਚਰਸਿਲ ਤੇ ਦੀ ਦੇ ਭਾਗਾਂ ਇੱਕ ਦੇਤੂ ਇੱਕ ਗਿਆ। ਇਸ ਤਰ੍ਹਾਂ ਚਿਸਮਾਸਤ ਦੀ ਜੰਗਤਾ ਤੇ ਜਤਲਾ ਤੁਸੀਂ ਸਬਾਪਤਾ ਹੋਈ ਗਏ ਸੋਜ਼ਰਤ ਸਰਮਲ ਗਸ਼ਟਰ ਦੇ ਏਟੇ ਤੇ ਗਏ।

(3) ਇਟਲੀ ਤੇ ਭਾਗੀ ਮੱਟ:- ਤੁਸੀਂ ਸਗ-ਜੱਯ ਦੇ ਸਿੱਟੇ ਇਸੀਂ ਇਟਲੀ ਤੇ ਭਾਗੀ ਮੱਟ ਹਸੀ। ਇਸ ਜੱਯ ਤੇ ਪਹਿਲਾਂ ਸਮੁੱਚਿਲੀ ਦੇ ਇਟਲੀ ਤੇ ਸ਼ਰਤੀ ਸਾਹੀ ਚੜ੍ਹਾਉਣ ਦੇ ਸਫ਼ਲ ਜਤਲ ਵੀਤੇ ਸਲ ਅੰਤ ਇਟਲੀ ਸੋਤਰ ਇੱਕ ਦੀ ਰਹੀ ਸਿਤਾਂ ਪ੍ਰਾਪਤ ਕੀਤੀਆਂ ਸਲ। ਪਰੰਤੂ ਇਸ ਜੱਯ ਦੇਗਲ ਇਟਲੀ ਦੀ ਚੜ੍ਹੀ ਤਰ੍ਹਾਂ ਰਰ ਹੋਈ। ਉਸ ਤੇ ਲਿਖੀਆਂ, ਦੇਗੀਦੀਆਂ, ਸੋਮਾਚੀ-ਕਰ ਤੇ ਇਤਿਹਾਸੀਆਂ ਸਮਾਇ ਸਾਰੀਆਂ ਸਮਤੰਤਰੀ ਚਸਤੀਆਂ ਚਰ ਚਤੀਆਂ, ਗਈਆਂ। ਇਸ ਤੇ ਇਤਿਹਾਸ ਉਸ ਦੇ ਜ਼ਰਤਾਰ, ਫ਼ਰਾਸ ਤੇ ਜੰਗੇ ਸਹਤਾਰੀਆਂ ਦੇ ਦੀ ਰਰ ਸਬੇਸ ਦੇਤੂ ਹਹੇ। ਉਸ ਦੀ ਸੈਲਿਕ ਸ਼ਰਤੀ ਦੀ ਸੀਸ਼ਤ ਰਰ ਇੱਤੀ ਗਈ ਸਸੇ ਉਸ ਉਤੇ ਜੱਯ ਦੇ ਤਸਤਾਰ ਇਸੀਂ ਭਾਗੀ ਧਲ-ਗਸ਼ੀ ਚੋਪੀ ਗਈ। ਜੱਯ ਪਿੱਛੇ ਰਹੀ ਦੀਵੇਮਾਂ ਤਰ ਸਿੱਤਰ-ਦੇਸਾਂ ਦੀ ਸੈਲਿਕ ਸੋਸਿਲ ਇਟਲੀ ਉਤੇ ਸ਼ਾਸਤ ਰਸ਼ੀ ਗਈ। ਇਟਲੀ ਇੱਕ ਫ਼ਾਸਿਜ਼ਸ ਦਾ ਹੀ ਸਸੇ ਰਰ ਇੱਤਾ ਗਿਆ।

(4) ਸਾਪਾਤ ਦਾ ਸ਼ਰਤੀਰੋਤ ਤੇਤਾ:- ਇਸ ਜੱਯ ਦੇ ਸਿੱਟੇ ਇਸੀਂ ਸਾਪਾਤ ਸ਼ਰਤੀ ਰੋਤ ਤੇ ਗਿਆ। ਜੱਯ ਤੇ ਪਹਿਲਾਂ ਸਾਪਾਤ ਦੀ ਸਾਰੀ ਚਰਤ ਹਰ ਗਈ ਦੀ ਸਸੇ ਉਤ ਦੇਸੀਆਂ ਦੀ ਇਰ ਸਮੁੱਖ

Shot on Y11
Vivo AI camera

ਸਾਮਗਲਵਾਲੀ ਤਾਕੁਤ ਹਾਵ ਗਿਆ। ਇਸ ਕੁੱਯ ਵਿੱਚ ਉਸ ਦੇ ਬਚੀ ਹੁਈ ਗਾਂ ਤੇਈ ਸਮੇਤ ਉਸ ਦੇ ਵਧੇ ਸੀਸ਼ਯ ਤਕਾ (ਗੋਰੂਸੀਮਾ ਤੇ ਨਾਗਾਸਾਕੀ ਸਮਾਵਿ) ਬਚੀ ਹੁਈ ਹੁਆ ਹੁਆਰ ਹੁਏ ਗਏ। ਵਧੀ ਵੀਰਤਮਾ ਤਕ ਸ਼ਾਪਾਨ ਉੱਤੇ ਮਿਤਰ-ਦੇਸ਼ਾਂ ਵਲਸਗੀਰੀ ਸਾਹਸਕ ਸੰਵਿਧਾਨਵਾਦ ਦਾ ਬਚਸਾ ਗਿਆ। 1951 ਈ: ਦੇ ਸੰਧੀ ਸਮੁਲਮਾਰ ਸ਼ਾਪਾਨ ਤੁੰ ਵੇਸੇਸਮਾ, ਫਾਰੂਸਮਾ, ਸੰਘਾਸਿਤ ਤੇ ਵਧੀ ਹਰ ਅਦੇਸ਼ ਹਟ ਚਲੇ ਗਏ। ਇਸ ਪਿਛੋਂ ਸ਼ਾਪਾਨ ਨੂੰ ਕੁਮਾਰੀਧਰ ਪੱਖ ਤੇ ਪੁਨਰਵਿਕਾਸ ਵਿੱਚ ਵਧੀ ਵਧੇ ਲਗ ਗਏ।

(5) ਰੂਸ ਦੀ ਸਰਤੀ ਤੇ ਸੁਲਝਾਉ ਵਿੱਚ ਹਾਯਾ:- ਰੂਸਾ ਸਮਾਜੁੱਯ ਸਾਤਰਾਨੀ ਸਿੱਯ ਪੈਦਿਸਮਾ। ਇਸ ਕੁੱਯ ਵਿੱਚ ਦੇ ਸਿਟੇ ਰੂਸ ਤੇ ਵਧੀ ਅਦੇਸ਼ ਆਪਤ ਹੁਏ। ਦੇਸੁਰਤੀਸਮਾ, ਸਟਹੀਸਮਾ, ਲਿਥੁਆਸੀਸਮਾ, ਪੱਲਿਤ ਦਾ ਵਰਤ ਭਾਗ ਸਮੇਤ ਫਿਨਲੈਂਤ ਦੇ ਵੱਖ ਅਦੇਸ਼ ਰੂਸ ਵਿੱਚ ਸਾਸਲ ਹਟ ਚਲੇ ਗਏ। ਇਸ ਤੁੰ ਇਲਾਵਾ ਪੂਰਬੀ ਜਰਮਨੀ ਦੇ ਸਮਾਧਿਕਾਰ ਤੇਤ ਵਸਾ ਗਿਆ। ਜਰਮਨੀ ਦੇ ਹਗਤੇਤ ਭਾਗਤ ਤੁੰਸ ਦਾ ਸੰਤਤ-ਸੁਸ਼ਤਰਾ ਖੇਤਰ ਵਿੱਚ ਸੁਲਝਾਉ ਹਾਯ ਗਿਆ। ਰੂਸ ਵਿੱਚ ਸਰਾਸਿਤ ਦੀ ਵਿੱਚਤ ਵਿੱਚ ਹਾਯਾ ਪੈਦਿਸਮਾ ਸਮੇਤ ਉਸੇਂ ਦੇ ਕੀਸਤੋਤਿਸਟ ਸਾਸਤ ਨੂੰ ਵਿਸ਼ੇਸ਼ ਸਰਤੀ ਪ੍ਰਧਾਨ ਤੋਈ। ਰੂਸ ਤੁੰ ਬਾਹਰ ਵੁਸੇ ਦੇਸ਼ਾਂ ਵਿੱਚ ਦੀ ਰੂਸੀ ਅਸਰ ਵਧਾਵ ਵਧਤ ਚੱਲਾ ਸਮੇਤ ਉਹੀ-ਉਹੀ ਵਧੀ ਦੇਸ਼ਾਂ ਦੇ ਕੀਸਤੋਤਿਸਟ ਸਾਸਤ ਅਵਾਜੀ ਨੂੰ ਸਮਧਵਾ ਦਿਸਮਾ।

(6) ਪ੍ਰ. ਸਮੈਸ. ਦੇ. ਦਾ ਸੈਸਾਰ ਦੀ ਸਗਤ ਸਰਤੀ ਵਜੋਂ ਉਭਾਰ:- ਇਸ ਕੁੱਯ ਦੇ ਕਲਸਵ੍ਰਯ ਪ੍ਰ. ਸਮੈਸ. ਦੇ. ਦਾ ਸੈਸਾਰ ਦੀ ਸਗ ਤੁੰ ਸਗਤ ਸੁਰਤੀ ਵਜੋਂ ਉਭਾਰ ਹੋਇਸਮਾ। ਪ੍ਰਧਾਨੀ ਦੇਸ਼ਾਂ ਦੇ ਸ਼ੁਰਾਵਤੇ ਵਿੱਚ ਉਸ ਦਾ ਇਸ ਕੁੱਯ ਵਿੱਚ ਚੁਹਤ ਪੱਧਰ ਤੁਸਾਲ ਹੋਇਸਮਾ। ਸਿਤਰ-ਦੇਸ਼ਾਂ ਦੀਸਮਾਂ ਸਮਲੇਸਾਂ ਸਿੱਤਾ

Shot on Y11

ਇਕ ਪ੍ਰਮੁੱਖ ਦੇਸ਼ ਹੈ ਜੋ ਸਯੁੰਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦਾ ਸੰਸਥਾਪਕ ਹੈ ਅਤੇ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸੁਰੱਖਿਆ ਪਰਿਸ਼ਦ ਦਾ ਸਥਾਈ ਮੈਂਬਰ ਹੈ। ਇਸ ਦੇਸ਼ ਦੀ ਰਾਜਧਾਨੀ ਮਾਸਕੋ ਹੈ। ਇਸ ਦੀ ਮੁਦਰਾ ਰੂਬਲ ਹੈ। ਇਸ ਦੇਸ਼ ਦੀ ਭਾਸ਼ਾ ਰੂਸੀ ਹੈ। ਇਸ ਦੇਸ਼ ਦੀ ਰਾਜਨੀਤਿਕ ਵਿਵਸਥਾ ਸੰਘਾਤਮਕ ਸੰਸਦੀ ਲੋਕਤੰਤਰ ਹੈ। ਇਸ ਦੇਸ਼ ਦੀ ਸੰਸਦ ਨੂੰ ਫੈਡਰਲ ਅਸੈਂਬਲੀ ਕਹਿੰਦੇ ਹਨ। ਇਸ ਦੇਸ਼ ਦੀ ਸੰਸਦ ਦੇ ਦੋ ਸਦਨ ਹਨ। ਇਸ ਦੇਸ਼ ਦੀ ਸੰਸਦ ਦੇ ਉੱਪਰੀ ਸਦਨ ਨੂੰ ਫੈਡਰੇਸ਼ਨ ਕੌਂਸਲ ਕਹਿੰਦੇ ਹਨ। ਇਸ ਦੇਸ਼ ਦੀ ਸੰਸਦ ਦੇ ਹੇਠਲੇ ਸਦਨ ਨੂੰ ਸਟੇਟ ਡੂਮਾ ਕਹਿੰਦੇ ਹਨ। ਇਸ ਦੇਸ਼ ਦੀ ਸੰਸਦ ਦੇ ਹੇਠਲੇ ਸਦਨ ਦੇ ਮੈਂਬਰਾਂ ਦੀ ਗਿਣਤੀ 450 ਹੈ। ਇਸ ਦੇਸ਼ ਦੀ ਸੰਸਦ ਦੇ ਹੇਠਲੇ ਸਦਨ ਦੇ ਮੈਂਬਰਾਂ ਦਾ ਕਾਰਜਕਾਲ 5 ਸਾਲ ਹੈ। ਇਸ ਦੇਸ਼ ਦੀ ਸੰਸਦ ਦੇ ਹੇਠਲੇ ਸਦਨ ਦੇ ਮੈਂਬਰਾਂ ਦੀ ਚੋਣ ਪ੍ਰਣਾਲੀ ਅਨੁਪਾਤਿਕ ਪ੍ਰਤੀਨਿਧਿਤਵ ਹੈ।

(7) ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ :- ਦੂਜੇ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ ਦੀ ਤਿਆਰੀ ਵੀ ਉਸੇ ਸਮੇਂ ਸ਼ੁਰੂ ਹੋ ਗਈ ਸੀ। ਇਸ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ ਹੋਈ। ਇਸ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ ਦੇ ਸਮੇਂ ਕੁੱਲ 51 ਸੰਸਥਾਪਕ ਦੇਸ਼ ਸਨ। ਇਸ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ ਦੇ ਸਮੇਂ ਭਾਰਤ ਦੀ ਪ੍ਰਤੀਨਿਧਤਾ ਸਰ ਰਾਮਾਸਵਾਮੀ ਮੁਦਲਿਆਰ ਨੇ ਕੀਤੀ ਸੀ। ਇਸ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ 24 ਅਕਤੂਬਰ 1945 ਈ: ਨੂੰ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੇ ਚਾਰਟਰ ਦੇ ਲਾਗੂ ਹੋਣ ਤੋਂ ਬਾਅਦ ਹੋਈ। ਇਸ ਦੀ ਸਥਾਪਨਾ ਤੋਂ ਬਾਅਦ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੇ ਮੁੱਖ ਦਫ਼ਤਰ ਨੂੰ ਨਿਊਯਾਰਕ ਵਿੱਚ ਸਥਾਪਿਤ ਕੀਤਾ ਗਿਆ। ਇਸ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ ਦੇ ਸਮੇਂ ਇਸ ਦੇ ਮੈਂਬਰ ਦੇਸ਼ਾਂ ਦੀ ਗਿਣਤੀ 51 ਸੀ। ਇਸ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ ਦੇ ਸਮੇਂ ਇਸ ਦੇ ਮੈਂਬਰ ਦੇਸ਼ਾਂ ਦੀ ਗਿਣਤੀ ਵਧ ਕੇ ਹੁਣ 193 ਹੋ ਗਈ ਹੈ। ਇਸ ਸੰਯੁਕਤ ਰਾਸ਼ਟਰ ਸੰਘ ਦੀ ਸਥਾਪਨਾ ਦੇ ਸਮੇਂ ਇਸ ਦੇ ਮੈਂਬਰ ਦੇਸ਼ਾਂ ਦੀ ਗਿਣਤੀ ਵਧ ਕੇ ਹੁਣ 193 ਹੋ ਗਈ ਹੈ।

(8) ਵਰਸੇਲਜ਼ ਦੀ ਸੰਧੀ :- ਇਹ ਵਰਸੇਲਜ਼ ਦੀ ਸੰਧੀ ਜਰਮਨੀ ਅਤੇ ਮਿੱਤਰ ਰਾਸ਼ਟਰਾਂ ਵਿਚਕਾਰ ਹੋਈ ਸੀ। ਇਸ ਵਰਸੇਲਜ਼ ਦੀ ਸੰਧੀ ਤੇ ਜਰਮਨੀ ਅਤੇ ਮਿੱਤਰ ਰਾਸ਼ਟਰਾਂ ਦੇ ਨੁਮਾਇੰਦਿਆਂ ਨੇ ਦਸਤਖ਼ਤ ਕੀਤੇ ਸਨ

Chapter 18 ब्रमी शुंडी ममे सैलिल ममीत ब्रम दा पृतग - लिममाइ

(1) शीमवा→
ज्रमपे दे उँउड पृगुध हिंस मीसड ब्रम ध्लीमा दा शेड उ हशा ध्लम ऐं। 18वीं मयी उद ब्रम ही हिमंह दे गमसीउ हिंस देवी शिछमयी लगें मी। दिउ हिंस पलीछमा जीटमा देव मीठमा सांछा मी। ब्रम दे दिउगम हिंस मुंयाग दा वागद ब्रमलगमेंउड ब्रमे दे गमगयी उँउ छेठड साल बूमाडेड जीटमा। उम दे ममपेड मामल वाल दे पड़िछे 10 मालां हिंस ममलां मउडूहपृगद मृपूग बैंउ। पगेड 1866 हिंस उमले ममपेड शादी मांग मुंयाग हापूम ले छटे। दिमंदे गमसवाड हिंस ब्रम हिंस 'लाजी किसम' लामी शुंडी-वाली ममेंछद छीछमा सिम के ही मेंस साछीद मांमंह मंदाशे देड मछ उं उंधाड दे मेंर देखा मी। ममलिगमेंउड ध्लमे दे दिम ममेंछद दे वसछड छटी मछउ वांठहाटी वैंडे पगेड 1881 ई: हिंस उड ममप शुंडीवागीममां दे हीघ दा मिंगाड उ० गिममा। ममेंदांकेंद ध्लमे दे उंउंगापिवागी ममलिगमेंउड उमे (1881 ई उं 1894 ई: उँउ) दे मछउ शीडी ममपेड्डी ममेंउ शुंडीवागीममां दे दिंगेय वछेद वांठहाटी वैंडी। दिम दी मेंउ पिड़ दिम दा पूंउड लिवछम हुआ ब्रम दा ममगट छीछमा। दिम दे ममपेड पिता दी दमलगी शीडी दे मागी गीछमा। दिमंद मामल-वाल हिंस मुमांवहाटी उंवूंउंगी एछ दी मसायछा 1898 ई: हिंस वैंडी। सिम के गमदूंग दी ज्ञालउ दे मुंयाग छटी ब्रुग-गेंग साल ममेंछद उछीदिममा। 1904-05 ई: हिंस ब्रम-मयाल जेंयू ध्स जीटमा। सिम हिंस ब्रम दी जंग दा वागद ब्रम दे लेव ममपेड मामल दे सिलाफ उछव दिंडा। 1905 हिंस ब्रम हिंस शुंडी ज्ञादी पल मड़क ता उ थाड़ी। छेंसं

ए वॅमा हयरा गिमा। 1914 ही: हिंस थीज्ञा मगं-
ॅंय गंद ॅंहिमा, सिम हिंस वूम ही मसाल ॅं गुममती
ॅं ॅिममलस गुग ॅंहे, ममउ ॅंवा ए मधुव इर
गिमा। 1917 हि ही: हिंस ॅंवां वे हिस्टॅंग वग
हिंउ, सिमरे वूंडी ए वूय थाग्ड वग ॅिमा,
सिंद ये ॅंसमवूय वूम हिंस ॅिवॅंवूम ॅंगमुठ ए
ममउ ॅंहिमा ममॅं गमसीॅंस मंवरे ॅिवगॅंममं
वे ॅंया हिंस ममा गाटी।

वूम ही वूंडी वे वाग्ड —

1917 ही: ही वूमी वूंडी ए वाबूल वूम ए थीज्ञे हिमाह
ॅंय हिंस ॅंकमहहा मी। वूम ये हिंडूंवूम हिंस 18वी
ही: ॅं 1917 गी: ॅंव ए ममुं ॅंहे हिसाग ममउ
थवुॅंस मामॅंउहाये ममुंसिव ॅंसे हिसंवाव ॅंगेंहाग
ॅंथवूम ॅंसही ॅंमॅंस ॅं। वूमी मामसा ये डूंवॅंवूमा,
ॅंहुं ये ॅंमुंसागे ॅंडी, ॅंहाग्हाये हिसाग वे ॅंसुंाव,
ॅिमासा ॅं ममवूवं ही ॅंवममॅंजेग गसॅंउ वूममुं
वूम ही हिंवेमी मंवरॅंममं ॅं गव वे वूम वे ॅंसवां
ॅं 1917 ही: हिंस हिंस्टॅंग वग्ड ॅंसही ॅंगिंउ वग
हिंउं।

① <u>वूमी गवमां ही ॅंसाममागे ॅं ममॅंजेगाउ</u>:— वूमी वूंडी ए
वाबूल वूमी गवमां ए ॅंसाममागे ॅं ममॅंजेगाउ मी। वूम वे हिमाॅंस
मामगम ए गॅंमी ॅंाव वेंय मी। मे थग्ड वूय हिंस
ॅंसाममागे ममगाट मी ममउ ॅंवूम वे हिमी ममले ममं
ममाहेम ही मामगम हसी वाहेल ॅंहे मला ममॅंजेगाॅंउव
ही गुॅंउ थिहं ॅंवूम ए ॅंवा हिंस्हुम थीज्ञा गवमगॅंही
ॅंहुं ॅंहेहा मिवू वे ॅंिसॅंउ ही। ॅं 1800 ही: ॅंव गम
ॅंहाउ। ॅंवूम वे हिंवेंवूम ॅंगमुठ वे ॅंसाथला ॅंहाउं।

ਉਸ ਦੇ ਨਾਮਨ ਵਿੱਚ ਮੈਂ ਉਹੋ ਸਬਤ ਪਾਈਨੀਅਮਾਂ ਲਗਾ ਦਿੱਤੀਆਂ ਗਈਆਂ ਅਤੇ ਉਪਰਵਾਲੇ ਹਿੱਸਾ ਦਾ ਅਲਗ ਕਰਨ ਵਾਲਿਆਂ ਵਿਚ ਕੁਦਰਤੀ ਸਾਧਨਾਂ ਦੀ ਸਾਂਭ ਚਲੀ। ਸਤੰਬਰ ਦੀ ਸ਼ੁਰੂਆਤ ਵਿਚ ਵਾਸ਼ਿੰਗਟਨ ਦੇ ਉਹਨਾਂ ਨੇ ਦੇਸ਼-ਵਿਦੇਸ਼ ਦੇ ਦਿੱਤਾ ਸਾਂਝ ਕੀਤੀ। ਉਸ ਦੇ ਸਾਥੀਆਂ ਵਿਚ 150,000 ਵਿਦਿਆਰਥੀਆਂ ਨੂੰ ਦੇਸ਼-ਵਿਦੇਸ਼ ਦੇ ਦਿੱਤਾ ਗਿਆ ਅਤੇ ਇਸ ਤਰ੍ਹਾਂ ਹੀ ਹੋਇਆ, ਗਿਣਤੀ ਵਿਚ ਕੋਈ ਵੀ ਸੱਚ ਵਿਚ ਸੱਚ ਦਿੱਤਾ ਗਿਆ।

(2) ਸਮਲਿੰਗਕਤਾ ਦੇ ਸਮਾਜਿਕ ਕਾਰਨ :- ਸਮਲਿੰਗਕਤਾ ਦੇ ਸਮਾਜਿਕ ਕਾਰਨ ਵਿਚ ਪਰਿਵਾਰ ਦੇ ਪਰਿਵਾਰ ਦੇ ਇਕ ਵੀ ਮੈਂਬਰ ਦਾ ਸਮਲਿੰਗਕਤਾ ਦਾ ਸ਼ਿਕਾਰ ਹੋਣਾ ਹੈ। ਇਸ ਤੋਂ ਇਲਾਵਾ ਸਮਾਜ ਵਿਚ ਵਿਚਰਦੇ ਸਮੇਂ ਵਿਅਕਤੀ ਦਾ ਸਮਲਿੰਗਕਤਾ ਦਾ ਸ਼ਿਕਾਰ ਹੋਣਾ ਵੀ ਸਮਲਿੰਗਕਤਾ ਦੇ ਕਾਰਨਾਂ ਵਿਚ ਸ਼ਾਮਲ ਹੈ। ਪਰੰਤੂ ਕਈ ਵਾਰ ਤਾਂ ਉਹਨਾਂ ਦੀ ਸਮਲਿੰਗਕਤਾ ਦਾ ਕਾਰਨ ਵਿਅਕਤੀ ਦਾ ਆਪਣਾ ਨਿਰਣਾ ਵੀ ਹੁੰਦਾ ਹੈ। ਸਮਲਿੰਗਕਤਾ ਦੇ ਕਾਰਨਾਂ ਵਿਚ ਉਹਨਾਂ ਦੀ

मिंय उंदी।

(3) 'लाईब्रेरियन' मां ममाउंवहारी ममैंख्लत:- ममलैंगमेंउव ह्वे ह्वे नामलवाह हिंस ममाउंवहारी ममैंख्लत या उंग्राह जैंटमा भिम है लाईब्रेरियन विंग थाया है। 'लाईब्रेरियन' या मंग्रयी ममगस विमे हो सीस उं हिमंहाम का वीउ थाह भिम का 'उंग्र' ममगखल का वेंव। हिम ममैंख्लत है थ्रमैंय हिखावंव उं हिंउ ह्वम है प्रगउंल ब्रमाम्राख्र डांसे है मंउ उं उंधूंव ह्वा थाईंह मंत। 1875 यी: उं घाम्मर लाईब्रेरियनमां है ह्वे मंग्रसा उं नमाहेंव वीउ ममंउ ममापद्धीमां हिमंव राहहाद्धीमां गगें ह्वे मंग्वावू ममीपरागीमां का ममंउ है प्यार उंउंग दिंउ। उंतुं ले थाबू है मोहंल माव्रू 1882 यी: हिंस उंम यी जैंउंमा वूंस हिंस मूंख्ल उं गई। थाहें हिम बूंउंवागे, ममैंख्लत है मंग्वावू है मंग्वावू है हिंस पैंया वीउंमां गद्यैंमां बूंउंवागे थाहसाहां का ममंउ का वीउ का मीवमां। मंगं या वे ममीमंगेमां थाहसाहां मेंग दंउ गद्यैंमां मिसुं का 1917 यी: यी बूंउं गगें 'मंगराहा' जैंटमां।

(4) ममलैंगमेंउव उंमे यी मूंउंबूम्माहारी उं ममलवावी तीउं:-

ममलैंगमेंउव ह्वे थिंह उंम का पंउंबू ममलैंगमेंउव उंमा ह्वम का थाममव द्यांडमां। थिंउं वे वंउंह है ममलैंगमेंउव उंमे का मूंउंबूम्माहारी मियूंउं हिंस हिंमंहाम जैंव हिंस वह दिंउ ममंउ उंम है वेंवा हिंस बूंउंवागे उं उंग्राह हिंसावां है ह्वंसंड का लिंमंसा

वह किस्मा। उस की सैडी या माग उस वर्मेंग
अडी शिकाहार। चमल उे वमी वह हिंस रिंडा मांग
उस उस के मागलराग हिंस पुलीहुगीटीमां हिंस
मंडिव मिंधक्षा या वमेंउ वह रिंडा गिक्षा वमेंउ
हिंदुस्तानीमां चीनमां मंडियोमां उंउे उेक
सगा रिंडीमां गडीमां, मगासाग-पंउग उंउे ही
मंडउ पाहियोमां सगा रिंडीमां शाडीमां मंसाकर
मामह उंउे रेंदगी मंडगाग या लिंडुउगह उेग ही हिंस
वह रिंडा गिक्षा। चंडउ गिंडडी हिंस शांडी वागेमां
है वेंद वह लिक्षा गिक्षा मां वेंउे यी मक्षा रे रिंडी
गूडी। वेंह-वमी लेवां उंउे वमी गाम: वमी शुक्ष
वमेंउ वमी मीउक्षमडा सेपडह रे जउत वेंउे गडे।

⑤ लिंडिंक्षम ह्वे से ही लिंगिक्षमडा:- 1894 ही: हिंस लिंडिंक्षम
एका गमगॅयी उंउे वेंग
वमेंउ उस के क्षाय गी क्षमेंलाह वीउा कि उेग क्षायपेंह
रिंडा हांग लिंगिक्षमडा से लीडी यी हिंदुडा लाह
पालहा वेंगा। उेग चंडा क्षमडीक्षाल विमर्म या
मामक मी वमेंउ उस हिंस गमलीडिंक मंह-घंह ही
ही घाट मी। उेग चंडा छाटीलग मी वमेंउ गंक
वाक या माग वेंम क्षायपेंह मलागरागं उे पीगहाग
रे सीडिंस सीक्षमां रे रीगड क्षमलमाग वगडा मी।
उस उंउे उस ही चउडी मगंगडी क्षमेंडा मेंडगं या
चंडा धूगाह मी। उेग रंटड हिंडागं हाडी टिमउडी
मी वमेंउ उेग क्षायपेंह चंडी रे मंडा उलाक्षागे डेग
लाह मामंस वंस ही धूंगडा रिंडी गगे।

⑥ रिमाडा ही उग्मनेग मीचडी:- गूंदं 1861 ही. रे मागी
क्षायेंग क्षमेंलमाह रिमाल
रामां रे मंउेउह वह रिंडा गिक्षा मी वमेंउ चंडउ मांगे
रिमाल रे कमीलां रे मांडव ही चंडा रिंडा गिक्षा

ਸੀ, ਫਿਰ ਵੀ ਕਿਸਾਨਾਂ ਦੀ ਸਥਿਤੀ ਦੇਖਣਯੋਗ ਨਹੀਂ ਸੀ। ਇਕ ਤਾਂ ਉਨ੍ਹਾਂ ਨੂੰ ਬਹੁਤ ਥੋੜ੍ਹੇ ਮਾਤਰਾ ਵਿਚ ਜ਼ਮੀਨਾਂ ਮਿਲੀਆਂ ਸਨ ਅਤੇ ਜਨਸੰਖਿਆ ਵਿਚ ਵਾਧਾ ਹੋਣ ਕਾਰਨ ਇਹ ਜ਼ਮੀਨ ਵੀ ਵੰਡੀ ਜਾਂਦੀ ਸੀ। ਦੂਜੇ ਪਾਸੇ ਉਨ੍ਹਾਂ ਨੂੰ ਭਾਰੀ ਦਰ ਦਾ ਲਗਾਨ ਦੇਣਾ ਪੈਂਦਾ ਸੀ। ਉਨ੍ਹਾਂ ਦੇ ਇਸ ਦੁੱਖ ਨੂੰ ਸਮਝਣ ਲਈ ਹੀ ਵਡੀ ਸਮਤਾ ਰਾਏ ਨੂੰ ਸੀ ਰੇਆ। ਛੋਟੇ ਕਿਸਾਨ ਸਿਰਫ਼ ਉਨ੍ਹਾਂ ਜ਼ਮੀਨਾਂ ਉੱਤੇ ਖੇਤੀ ਕਰਦੇ ਸਨ ਜੋ ਕਿ ਉਨ੍ਹਾਂ ਦੇ ਆਪਣੇ ਪਰਿਵਾਰ ਦੇ ਗੁਜ਼ਾਰੇ ਲਈ ਹੀ ਕਾਫ਼ੀ ਹੁੰਦੀ ਸੀ। ਇਸ ਕਿਸਾਨ ਵਰਗ ਦੀ ਹਾਲਤ ਵੀ ਬਹੁਤ ਤਰਸਯੋਗ ਸੀ। ਇਸ ਕਿਸਾਨ ਵਰਗ ਨੂੰ ਵੀ ਸਾਹੂਕਾਰ ਵਿਚੋਲੇ ਅਤੇ ਜ਼ਿਮੀਦਾਰ ਆਪਣੇ ਸ਼ਿਕੰਜੇ ਵਿਚ ਫਸਾ ਕੇ ਰੱਖਦੇ ਸਨ

मढ़ल ब्रांडी उँदी।

(8) ममासहारी एक री मसायठा:- ऊिदेगिर ब्रांडी पिछे मुसद्रग री गछउ ग्रयागल रे उिरेम लाल ग्रम हिछ ममासहारी मिपांउ रा ध्रुयाग उेह छेगा। 1898 री: हिछ गसायुग रे ममासहारी छेवउेउगे एक री मसायुला उे गयी। 1903 री: हिछ हिग एक मेलमोहिव ब्रांउ घोलमोहिव लामी रे ब्रागां हिछ हीिममा गिग्मा, मेलमोहिव घोर गिहउी रे मेघगं री माषा मी मे ग्रम हिछ उेकी-उेकी मोहयालिव मापुला गूगें मुगासहाय सिग्मांउेहा साउेरी मी। हिम रा ध्रमिंयु छेउा वेडेंमगे मी। घोलमोहिव हेंप गिहउी रे मेघगं री माषा ब्रांडीमगी स्कीम मी सिम रा ध्रमेंस छेउा हौंसिल मी। हिग माषा ब्रांडीमगी छेग लाल ग्रम हिछ ममासहाय सिग्मांउेह रे पंस हिछ मी। हिम रा ममेउम उिरेम ग्रम हिछ विठ्ठी हग्ग री मेठा मसायुु वग्रा मी। ममासहारी छेवउेउगे एक रे मसद्रगं हिछ घूली मांगुडी सिग्मारे, उिलुं रा ग्रमाल छेग लाल मेगढ़ल वौउ, उिलुं री गछउ ग्रयागल लखे उछउालां वग्रहालीमां ग्रमेउ 1903 री: रे ब्रांडीब्रागी ग्रमेंसिल हिछ रा-छद्रु रे गाग सिग्मा।

हौसिल री जेग ममगहारी उेउ हिम एक री घोलमोहिव माषा ले जी ग्रमेउ लहिग्रउ 1917 री: हिछ मढ़ल ब्रांडी सिग्मारी।

(9) ग्रम-मधाल जुँय:- हिम जुँय हिछ ग्रम रे मधाल पामे मागी गग उेदी। छेंदे सिउे देमीमा-री देम उँछे उेदी हिम ममुपमाल मसर उाग रागल ग्रमी लेर माठ रे उालाकागे मागल हिग्रु ब्रडर उेदु। मुद हिछ उिउ मधाल रे गमटगी ग्रममुद ममलरे उँदे ग्रमी मरवाग रे पूग ममगवल देरे मे

ਸੁਣ ਪਰੀਤੂ ਰੂਸ ਦੀ ਸਾਧਾਰ ਤੇ ਹਾਰ ਦੇ ਸਿੱਟੇ ਵਜੋਂ ਉਸਨੂੰ ਇਸ ਦਿਨ ਗਹਿਰਾ ਸਦਮਾ ਹੋਇਆ ਕਿ ਉਸਨੂੰ ਦੂਰ ਅਮਰੀਕੀ ਏਸ਼ਾਮਦ ਰੂਸ ਤੇ ਜਾਪਾਨ ਦੀ ਜਿੱਤ ਬਰਦਾਸ਼ਤ ਨਾ ਹੋ ਸਕਿਆ। ਇਹ 1905 ਈ: ਦੇ ਬੋਲਸ਼ਵਿਕ ਇਨਕਲਾਬ ਦਾ ਤਤਕਾਲੀਨ ਕਾਰਨ ਸਿੱਧ ਹੋਇਆ।

(10) 1905 ਈ: ਦਾ ਬੋਲਸ਼ਵਿਕ ਇਨਕਲਾਬ :- ਰੂਸ ਵਿਚ ਮਜ਼ਦੂਰਾਂ ਦੀ ਦਯਨੀਯ ਸਥਿਤੀ ਸੀ। ਉਨ੍ਹਾਂ ਦੇ ਕੰਮ ਕਰਨ ਦੇ ਸਮੇਂ ਅਤੇ ਉਜਰਤ ਬਾਰੇ ਕੋਈ ਕਾਨੂੰਨ ਨਹੀਂ ਸੀ। ਜਨਵਰੀ, 1905 ਈ: ਨੂੰ ਸੇਂਟ ਪੀਟਰਸਬਰਗ ਦੇ ਇਕ ਕਾਰਖਾਨੇ ਦੇ ਮਜ਼ਦੂਰਾਂ ਨੇ ਹੜਤਾਲ ਕਰ ਦਿੱਤੀ। ਉਨ੍ਹਾਂ ਦੀਆਂ ਮੰਗਾਂ ਸਨ- ਕੰਮ ਦੇ ਘੰਟੇ ਘਟਾ ਕੇ 8 ਘੰਟੇ ਕੀਤੇ ਜਾਣ, ਜ਼ਿਆਦਾ ਮਜ਼ਦੂਰੀ, ਰੋਜ਼ ਵਰਤੋਂ ਵਾਲੀਆਂ ਵਸਤੂਆਂ ਤੇ ਟੈਕਸ ਘਟਾਇਆ ਜਾਵੇ, ਕਾਰਖਾਨਿਆਂ ਵਿਚ ਸੁਰੱਖਿਆ ਦੇ ਪ੍ਰਬੰਧ ਕੀਤੇ ਜਾਣ। ਜਦੋਂ ਇਹ ਹੜਤਾਲ ਲਗਭਗ 1½ ਹਫ਼ਤੇ ਮਜ਼ਦੂਰ ਨੇਤਾਵਾਂ ਦੀ ਗ੍ਰਿਫ਼ਤਾਰੀ ਕਾਰਨ ਬੰਦ ਰਹੀ ਤਾਂ ਹੜਤਾਲੀ ਮਜ਼ਦੂਰਾਂ ਦੀਆਂ ਮੰਗਾਂ ਨੂੰ ਮਨਵਾਉਣ ਦੇ ਲਈ ਜ਼ਾਰ ਦੇ ਮਹਿਲ ਵਿੰਟਰ ਪੈਲੇਸ ਅੱਗੇ ਸ਼ਾਂਤਮਈ ਜਲੂਸ ਕੱਢਣ ਦਾ ਫ਼ੈਸਲਾ ਕੀਤਾ ਗਿਆ। ਇਸ ਜਲੂਸ ਵਿਚ ਲਗਭਗ ਦੋ ਲੱਖ ਮਜ਼ਦੂਰਾਂ ਨੇ ਹਿੱਸਾ ਲਿਆ ਸੀ। ਇਸ ਜਲੂਸ ਦੀ ਅਗਵਾਈ ਫਾਦਰ ਗੈਪਨ ਨਾਂ ਦਾ ਇਕ ਪਾਦਰੀ ਕਰ ਰਿਹਾ ਸੀ। ਜਲੂਸ ਵਿਚ ਔਰਤਾਂ ਅਤੇ ਬੱਚੇ ਵੀ ਸ਼ਾਮਲ ਸਨ। ਜਲੂਸ ਵਿਚ ਸ਼ਾਮਲ ਲੋਕ ਜ਼ਾਰ ਦੇ ਹੱਕ ਵਿਚ ਨਾਅਰੇ ਲਾ ਰਹੇ ਸਨ। ਜਦੋਂ ਜਲੂਸ ਵਿੰਟਰ ਪੈਲੇਸ ਦੇ ਨੇੜੇ ਪਹੁੰਚਿਆ ਤਾਂ ਜ਼ਾਰ ਦੇ ਸੈਨਿਕਾਂ ਨੇ ਜਲੂਸ ਉੱਤੇ ਗੋਲੀ ਚਲਾ ਦਿੱਤੀ। ਇਸ ਕਾਰਨ ਇਕ ਅੰਦਾਜ਼ੇ ਅਨੁਸਾਰ 4000 ਮਜ਼ਦੂਰ ਮਾਰੇ ਗਏ ਅਤੇ ਹਜ਼ਾਰਾਂ ਹੋਰ ਜ਼ਖ਼ਮੀ ਹੋ ਗਏ। ਇਸ ਭਿਆਨਕ ਖ਼ੂਨ-ਖ਼ਰਾਬੇ ਦੇ ਕਾਰਨ ਇਸ ਐਤਵਾਰ ਨੂੰ ਖ਼ੂਨੀ ਐਤਵਾਰ ਵਿਚ ਜਾਣਿਆ ਜਾਂਦਾ ਹੈ।

(11) ਪੀਟਰ ਮਹਾਨ ਅਤੇ ਇਸ ਦੇ ਰੂਸ ਦੀ ਤਰੱਕੀ :- ਪੀਟਰ ਮਹਾਨ ਦਾ ਇਸ ਰੂਸ ਦੀ ਤਰੱਕੀ ਵਿਚ ਬਹੁਤ ਵੱਡਾ ਹੱਥ ਹੈ। ਇਸ ਨੇ ਰੂਸੀ ਫ਼ੌਜ ਨੂੰ ਯੂਰਪੀਅਨ ਢੰਗ ਨਾਲ ਸੰਗਠਿਤ ਕੀਤਾ। ਇਸ ਨੇ ਰੂਸ ਦੀ ਸਮੁੰਦਰੀ ਸ਼ਕਤੀ ਨੂੰ ਵਧਾਉਣ ਲਈ ਬਹੁਤ ਯਤਨ ਕੀਤੇ। ਇਸ ਨੇ ਰੂਸ ਦੀ ਰਾਜਧਾਨੀ ਮਾਸਕੋ ਤੋਂ ਬਦਲ ਕੇ ਸੇਂਟ ਪੀਟਰਸਬਰਗ ਕਰ ਦਿੱਤੀ। ਇਸ ਨੇ ਰੂਸ ਦੀ ਸਮੁੰਦਰ ਤੱਕ ਪਹੁੰਚ ਬਣਾਉਣ ਲਈ ਬਹੁਤ ਯਤਨ ਕੀਤੇ। ਇਸ ਨੇ ਰੂਸ ਦੀ ਸਮੁੰਦਰ ਤੱਕ ਪਹੁੰਚ ਬਣਾਉਣ ਲਈ ਬਹੁਤ ਯਤਨ ਕੀਤੇ। ਇਸ ਨੇ ਰੂਸ ਦੀ ਸਮੁੰਦਰ ਤੱਕ ਪਹੁੰਚ ਬਣਾਉਣ ਲਈ ਬਹੁਤ ਯਤਨ ਕੀਤੇ।

हिलाम ममउ लिगाम्ग़ा उया ईंड ऐयूहा पिम्मा। 1915 ग्रीः उव उम ऐ लखा मैंदिर माउ गाए मत। ममिगो मंथिउ हिंछ ब्रुगवाउ ले घुरुउ मिग्गाए मुंथिम्मा हिंछ विमाल ममउ ब्रसद्रुगं ऐ मघरुयमउ मैंला हिंछ अदुं वग्वे उसु ऐ हंस-हंस उंया मंगीए ममं 'उे उम पिछा। उंया या बंदी ब्रांउम्मामु ला उह ऐ राग्ल उंदुं ऐ आगे ग्रवाछां ऐ मघरुयमउ मैंला हिंछ अग्वे वग्वे उंदुं ऐ हंस-हंस उंया मंगीएमं 'उे उम पिछा। उंसुं या मूरुमहा वग्ला पिम्मा। हंदी मंथिम्म हिंछ माउ ला गंए ग्रमो मैंलिवां ऐ वाग्ल उंदुं या उंमला ऐंद गिम्मा। ग्रमेउ थामे विमाल ममउ ब्रसद्रुगं ग्रीवमो उे माछ ऐ वाग्ल उंद उंदुथाएल हिंछ घाग्रु गिमंद्रुट ममा गाछी मिम वाग्ल छेवां ले आगे ममाग्रीवल मंवट या माउमहा वग्ला पिम्मा। हमउग्मां ग्रीवमो ऐ वाग्ल वीमाउ घुरुउ हंछ गाथिम्मां। दिदुं वाग्ला वग्वे छेवा आगे ममंमंउम्म ढेंछिम्मा।

ग्रम ग्रीवमो ऐ ब्रुगह —

1917 ग्रीः ग्रीवमो हिब्रह दिंउगाम्ग़ ग्रीवमो मंउ उे हंयू मंउंहयूग्ल ब्रूंटला मैंलो थाग्रीउे। हिम ले ला वंद्रह ग्रम घलांद्रि माउ मैंमाउ 'उे ग्रंगामी ब्रुगह याए।

① लिंग्रिंग्रम गमउंउंउ या ममंउ:- 1917 ग्रीः ग्रीवमो ग्रम ग्रीवमो मिंग्रा हिंउ लिंग्रिंछिम्मा कि ग्रम हिंछ लिंग्रिंग्रम गमुंउंउ या ममंउ ऐ गिम्मा। ग्रम ऐ ब्रुव लिंग्रिंग्रम ग्रममेंउ ऐ वामल उं घुरुउ उंग्रा ममाए उंद मत। उंदुं ले उम ऐ ग्रमगंग्रीं वंद्रह 'उे मममघुव मैंउा। घामंग्रंग्र हिंछ लिंग्रिंग्रम ममंउ उंमग्रीं घाउंसे ग्रीवमो गंछिम्मा वंग्रिंग्रीं गंए ग्रीं। हिम उंग्रां ग्रम हिंछ पिंछले उंद मैं माछां उं

ਪੰਜੇ ਸਮਾ ਨੇ ਵੇਸਾਂਦੇਵ ਸਾਸਤ ਦਾ ਸਮੀਤ ਤੇ ਲਿਸਮਾ।

(2) ਰੂਸ ਵਿੱਚ ਸਮਾਜਵਾਦੀ ਸਾਸਨ ਦੀ ਸਥਾਪਨਾ:- 1917 ਈ: ਦੀ ਬਾਂਤੀ ਦਾ ਮੁੱਖ ਮਸਾਪਨਾ ਸੀ। ਲੈਨਿਨ ਰਾਜਨੀਤਿਕ ਦੇ ਸਮਾਜਵਾਦੀ ਸਿਧਾਂਤਾਂ ਦਾ ਉਤਸਾਹੀ ਸਮਰਥਕ ਸੀ ਅਤੇ ਉਸ ਦੀ ਸਹਾਇਤਾ ਦੇ ਸਮਾਜਵਾਦੀ ਸਿਧਾਂਤਾਂ ਨੂੰ ਰੂਪ ਦੇਣ ਦਾ ਨਿਸਚਾ ਕੀਤਾ। ਇਸ ਦੇ ਸਾਥੀ ਉਤਸਾਹਤ ਹੋਏ ਸਾਥੀ ਸਰਕਾਰ ਦੀ ਸਥਾਪਨਾ ਕੀਤੀ। ਲੈਨਿਨ, ਸਟਾਲਿਨ, ਟਰਾਟਸਕੀ ਅਤੇ ਟਰੋਟਸਕੀ ਸਮੇਤ ਸਾਥੀ ਸਰਕਾਰ ਦੇ ਮੈਂਬਰ ਨਿਯੁਕਤ ਕੀਤੇ ਗਏ। ਸਾਰੇ ਦੇਸ਼ ਦੀ ਭੂਮੀ ਦਾ ਰਾਸ਼ਟਰੀਕਰਨ ਕੀਤਾ ਗਿਆ। ਸਮਾਜ ਦੇ ਸਮਾਜਿਕ ਢਾਂਚੇ ਦਾ ਨਿਰਮਾਣ ਕੀਤਾ ਗਿਆ। ਰੂਸ ਵਿੱਚ ਸਾਥੀ ਸਰਕਾਰ ਦੀ ਸਥਾਪਨਾ ਕਾਰਨ ਸਮਾਜਵਾਦ ਦੀ ਸਥਾਪਨਾ ਕੀਤੀ ਗਈ।

(3) ਰੂਸ ਦਾ ਜੁੱਧ ਵਿੱਚੋਂ ਨਿਕਲਣਾ:- ਰੂਸ ਦੀ 1917 ਈ: ਦੀ ਬਾਂਤੀ ਪਿਛੋਂ ਸੋਵੀਅਤ ਸਰਕਾਰ ਜੁੱਧ ਵਿੱਚੋਂ ਰੂਸ ਦੀ ਰੱਖਿਆ ਕਰਨ ਦੀ ਸਿੱਖਿਆ ਦੀ। ਇਸ ਨਿਮਾਨਤਰ ਜੁੱਧ ਵਿੱਚ ਰੂਸ ਦੇ ਲੱਖੀ 20 ਲੱਖ ਸੈਨਿਕ ਮਾਰੇ ਗਏ ਅਤੇ ਲਗਭਗ 50 ਲੱਖ ਸੈਨਿਕ ਜਖਮੀ ਹੋਏ। ਇਸ ਨਿਮਾਨਤਰ ਵਿਦੇਸ਼ ਦੇ ਕਾਰਨ ਰੂਸ ਦੀ ਆਰਥਿਕ ਦਸਾ ਬਹੁਤ ਖਰਾਬ ਹੋ ਗਈ ਸੀ। ਸੋਵੀਅਤ ਦੀ ਜੁੱਧ ਦੇ ਕਾਰਨ ਦੇ ਕਈ ਉਦਯੋਗ ਬੰਦ ਹੋ ਗਏ। ਇਸ ਕਾਰਨ ਬੋਲਸ਼ੇਵਿਕ ਸਰਕਾਰ ਨੇ ਰਾਸ਼ਟਰ ਸੰਕਟ ਤੋਂ ਮੁਕਤੀ ਪਾਉਣ ਦੀ ਜੁੱਧ ਸਮਾਪਤੀ ਦੀ ਘੋਸ਼ਣਾ ਕਰ ਦਿੱਤੀ ਅਤੇ ਜਰਮਨੀ ਨਾਲ ਸਾਂਤੀ ਸਮਝੌਤਾ ਕੀਤਾ।

(4) ਉਦਯੋਗਾਂ ਦਾ ਰਾਸ਼ਟਰੀਕਰਨ:- 1917 ਈ: ਦੀ ਬਾਂਤੀ ਤੋਂ ਪਹਿਲਾਂ

ਰੁਮ ਉਦਯੋਗਿਕ ਇਕਾਈ ਤੋਂ ਬਹੁਤ ਪਿਛੋਕੜ ਸੀ ਮਾ। ਭਵਿੱਖ ਰੁਮ ਇਸ ਨਿਰੰਕਰ ਨਾਮਕ ਦੇ ਉਦਯੋਗਿਕ ਵਿਕਾਸ ਦੇ ਲਈ ਵਰਤ ਜੁਹਰ ਕੀਤੇ ਸਨ, ਜਿਸ ਦੀ ਉਦਯੋਗਿਕ ਇਕਾਈ ਤੋਂ ਰੁਮ ਜੁਰਮੀ ਦਸ਼ਾ ਤੋਂ ਬਹੁਤ ਪਿਛੇ ਸੀ। ਸਰ-ਬਾਲਿਆਂ ਦਾ ਮਖੀਆ ਮਜ਼ਦੂਰਾਂ ਹੋਲਸੀਹਰ ਕੁਰੀ ਦੇ ਕਾਰਖਾਨੇ ਉਦਯੋਗਿਕ ਵਿਕਾਸ ਦੇ ਮਾਰੇ ਸਾਧਨਾਂ ਤੇ ਮਹਤਵਾਰੀ ਵੱਧਣ ਮੁਹਾਧਤ ਤੇ ਗਿਆ। ਕਾਰਖਾਨਿਆਂ ਦਾ ਮੁਖੀਆ ਮਜ਼ਦੂਰਾਂ ਦੇ ਤਰਾਂ ਇਸ ਰਾਹ ਮਜ਼ਦੂਰ ਹੁਣ ਇਸ ਇਕ ਲਹਾਂ ਉਤਪਾਦ ਪੈਦਾ ਕੀਤਾ। ਸਿਰ ਇਸ ਉਤਪਾਦ ਦੇ ਵੇਚ ਇਸ ਉੱਤੇ ਪੈਦ ਲਗੀ। ਰੁਮਾਇ ਇਸ ਰੁਮ ਜੁਰਮ ਦਾ ਇਕ ਸਹਾ ਉਦਯੋਗਿਕ ਵਿਕਾਸ ਹੁਣ ਗਿਆ ਸਮੇਤ ਰੁਮ ਇਸ ਤੁਮਾਰ ਸਾਮਾਨ ਸੀਮਾ ਦੇ ਹਰ-ਇਸ ਅਗਾਂ ਇਸ ਸਾਦ ਲਗਾ।

⑤ <u>ਮਜ਼ਦੂਰਾਂ ਸਮੇਤ ਕਿਸਾਨਾਂ ਦੀ ਹਾਲਤ ਸੁਧਾਰ:-</u> 1917 ਈ: ਦੇ ਪਹਿਲਾਂ ਮਜ਼ਦੂਰਾਂ ਸਮੇਤ ਕਿਸਾਨਾਂ ਦੀ ਹਾਲਤ ਤਸੱਲੀਬਖਸ਼ ਨਹੀਂ ਸੀ। ਮਜ਼ਦੂਰਾਂ ਨੂੰ ਬਹੁਤ ਘੱਟ ਤਨਖਾਹ ਮਿਲਦੀ ਸੀ। ਉਨ੍ਹਾਂ ਦੇ ਕਾਰਖਾਨਿਆਂ ਦੀਆਂ ਭਿਆਨਕ ਹਾਲਤਾਂ ਵਿਚ ਇਸ 10 ਘੰਟਿਆਂ ਤੋਂ ਲਗਾਤਾਰ ਕੰਮ ਕਰਨਾ ਪੈਂਦਾ ਸੀ। ਇਸੇਪਤੀ ਉਨ੍ਹਾਂ ਦੇ ਰਹਿਣ ਲਈ ਕੋਈ ਚੰਗੇ ਮਕਾਨ ਨਹੀਂ ਸਨ। ਇਸੇ ਤਰ੍ਹਾਂ ਇਸ ਕਿਸਾਨਾਂ ਦੀ ਹਾਲਤ ਵੀ ਤਸੱਲੀਬਖਸ਼ ਨਹੀਂ ਸੀ। ਉਨ੍ਹਾਂ ਦੇ ਵੱਲ ਹਾਲਤ ਦੇ ਕਾਰਨ ਬਹੁਤ ਘੱਟ ਜ਼ਮੀਨ ਸੀ ਅਤੇ ਉਹ ਵੀ ਬਹੁਤ ਵੱਡੇ ਵੱਡੇ ਜ਼ਿਮੀਂਦਾਰਾਂ ਪਾਸ ਗਹਿਣੇ ਪਈ ਸੀ। 1917 ਈ: ਦੀ ਬੋਲਸ਼ੀਵਿਕ ਕ੍ਰਾਂਤੀ ਦੇ ਫਲਸਰੂਪ ਕਿਸਾਨਾਂ ਅਤੇ ਮਜ਼ਦੂਰਾਂ ਦੀ ਸਥਾਨ ਦੀ ਇਕ ਨਵੀਂ ਸਰਕਾਰ ਹੋਂਦ ਵਿਚ ਆਈ। ਮਜ਼ਦੂਰਾਂ ਦੇ ਕਾਰਖਾਨਿਆਂ ਦਾ ਮੁਖੀਆ ਮੈਂਬਰ ਇਕ ਗਿਆ ਅਤੇ ਉਨ੍ਹਾਂ ਦੀ ਭਲਾਈ ਦੇ ਲਈ ਅਨੇਕਾਂ ਕਾਨੂੰਨਾਂ ਦਾ ਨਿਰਮਾਣ ਹੋਇਆ। ਮਜ਼ਦੂਰਾਂ ਦੇ ਕੰਮ ਦੇ ਘੰਟਿਆਂ ਦੀ ਸਿਰਫ਼ ਦਾ ਮੁਖੀਆ ਸਰਕਾਰੀ ਦੇਖ-ਰੇਖ ਵਿਚ ਕੀਤਾ ਗਿਆ। ਇਸੇ ਤਰ੍ਹਾਂ ਕਿਸਾਨਾਂ ਤੋਂ ਜ਼ਮੀਨਾਂ ਖੋਹ ਕੇ ਕਿਸਾਨਾਂ ਵਿਚ ਵੰਡ

ਵਿਤੀਆਂ ਗਈਆਂ। ਉਹ ਤੇ ਲਗਾਏ ਗਏ ਰਾਜ ਦੇ ਪੱਖ ਵਿਚ ਵੋਟ ਪਾਉਂਦੇ ਸਨ। ਸਵਾਲਿਕ ਅਮਾਮਲ ਇੱਥੇ ਹੀ ਖਿਮਾਸ਼ ਹੁਮਾਉ ਸੁਸਤਾਵਾਂ ਤੇ ਪ੍ਰੈਸਿਡ ਸਵਾਦ ਵਿੱਚ ਸਿਆਸੀ ਗਿਆ। ਚਿਲੇ ਸਮੇਂ ਵਿਚ ਹੁਸੀ ਕੁੰਡੀ ਦੀ ਵਿੱਚ ਸਤੰਤਰ-ਪੂਰਵ ਅਾਧਤੀ ਸੀ।

(6) ਸਮਾਸ ਵਿੱਚ ਵਰਗ-ਸੰਪਰਕ ਦਾ ਸਮੀਕ:- ਉਪਜੀਵਕ ਕੁੰਡੀ ਪਿੱਛੋਂ ਹੁਸੀ ਸਮਾਸ ਵਿੱਚ ਪ੍ਰੈਸੀਪਤੀ ਸਮੇਂ ਸਮਾਜਕ ਵਰਗ ਦੇ ਸੰਦਰਭ ਵਿਚ ਸਮਾਜ ਵਿਗਿਆਨੀਆਂ ਦਾ ਸਿਆਸੀ ਅਧਿਐਨ ਦਾ ਕੇਂਦਰ ਰਹੀ ਹੈ। ਪ੍ਰੈਸੀਪਤੀ ਸਮੇਂ ਸਮਾਜਕ ਵਰਗ ਦੇ ਸਮਾਜੀ ਆਧਾਰ ਦੇ ਸਬੰਧ ਵਿਚ ਕਈ ਸਿਧਾਂਤ ਦਾ ਨਿਰਮਾਣ ਕੀਤਾ ਗਿਆ ਹੈ। ਇਸ ਦੀ ਕੁੰਡੀ ਪਿੱਛੋਂ ਰਾਜਸ਼ਾਲਿਕਾਂ ਤੇ ਉਤਪਾਦਨ ਦੇ ਸਾਧਨਾਂ ਦਾ ਅਾਗਾਂ ਦਾ ਸਮਤੀ ਕਰਦੇ ਹਨ। ਸਮੇਂ ਪ੍ਰੈਸੀਪਤੀ ਵਰਗ ਦਾ ਅਧਿਐਨ ਕਰਦੇ ਹਨ ਸਮੇਂ ਇਸ ਦੇ ਨਾਲ ਹੀ ਵਰਗਾਂ ਵਿੱਚ ਸੰਘਰਸ਼ ਦਾ ਸਿਧਾਂਤ ਵੀ ਸਮਾਜਕ ਹੀ ਸਮਾਪਤ ਹੋ ਗਿਆ।

(7) ਸਮਾਨਤਾ ਸਮੇਂ ਸਮਾਸ ਵਿਸ਼ਮਤਾ:- 1917 ਈ: ਦੀ ਕੁੰਡੀ ਦੇ ਬਲਸ਼ਵਿਕ ਹੁਸੀ ਵਿੱਚ ਪ੍ਰੈਸੀਪਤੀਆਂ, ਵਰੀਆਂ ਸਮੇਂ ਹੁਸੀ-ਪਤੀਆਂ ਦਾ ਸਮੇਂ ਹੋਣਾ। ਵਿਸ਼ਾਲ ਤੇ ਵਿਕਤੀਆਂ ਦਾ ਸਮਾਸ ਵਿੱਚ ਅਤਿਅੰਤ ਸਮਾਪਤ ਹੋਣਾ। ਸਾਰੇ ਨਾਗਰਿਕਾਂ ਨੂੰ ਵਿਅਕਤੀਗਤ ਸਮੇਂ ਸਮਾਜਕ ਵੀਆਂ ਸਹੂਲਤਾਂ ਮੁਹੱਈਆ ਕਰਾਉਣਾ। ਸਾਰੀਆਂ ਤੇ ਕਾਨੂੰਨ ਸਮਾ ਰਾਜੀ ਉਚ-ਨੀਚ ਦੀ ਭਾਵਨਾ ਦਾ ਸਮੇਂ ਹੋਣਾ ਅਤੇ ਸਮਾਸ ਵਿੱਚ ਸਮਾਨਤਾ ਦੀ ਭਾਵਨਾ ਦਾ ਕਰਮ ਹੋਣਾ। ਸੁਸਤਾਵਾਂ ਤੇ ਵਿਸਾਸ ਦੀ ਸਰਕਾਰ ਦੇ ਸਮਾਸ-ਵਿਸ਼ਮਤਾ ਕਈ ਕਾਰਨਾਂ ਕਰਕੇ ਹੈ

ममेउ मियांउां मुमासहाये उुँउे ममापाविउ रहें मनाम
हा लिममाइ बीउा।

⑧ पैम माक्षा जैमलाहां हा ममैउ :- वुम हिँछ पैम माक्षा जैमलाहा हा ममाविउ
ही 1917 ही: वीवूंडी हा जीमिंरा मी। 1924 ही: हिछ
कौलल ले रहीं ममागीयव सौंडी छावा बीउी। हिउ
सौंडी मुमासहाये उे पैमहाये उउा रे मिसाछ उुँउे
ममापाविउ मी। चहुँउ वुमी ममागीयव उिम ले
ममागीयव चेउठ हिँछ वुम दे ममाउम-लिम्बउ
चहाउिइ छटी पैम माक्षा जैमलाहां हा मिछीमिक्षा
मइ बीउा सिम रे छुममइय वुम हा लवमा जेघरछ
गिममा।

⑨ वुम हा हिँव मवडीमाछी रेम हसें उुउाव :- 19 हीं मदी उँव
जगय रे मवडीमाछी रेमां हिँछ लहीं उिये मी। 1904-
05 ही: हिछ मापाल हुग्गो हिँछ सिंगे रेम ले वुम दे
उग रे मोव मेमाव ले उेगहो हिँछ पा पिउा: मी।
वुम रे मामल ची हिम वमसंगे ले वम रे छुवा दे
वूंडी रे छटी सेवला पिँउे मी। 1917 ही: रे
घाममय वुम हिछ मवडीमाछी मववाव हा लिममाइ
जोयिममा। हिम ले ममागीयव ममेउ मवागिसव
चेउठा हिछ मउउहपुरुल घापडीममां बीउीममां। हिमां
जउसं रे वालल वुम सा वेहछ जगय हा घछीव
हिमाह हा हिँव चहउ मवडीमाछी रेम घह गिममा।

⑩ मेमाव ची रे गुँरां हिँछ हेउ :- वुमी बूंडी ले मेमाव रे
घाममय रे हिउवम उुँउे
ही मउँउहपुरुल घछाइ पोइममा। हिम रे लउीछी
हमें उँछे-उँछी मेमाव हिछ ममभछी वृथ हिछ

ਦੇ ਗੁੱਰ ਸ਼ਬਦਮ ਤੇ ਸਾਂਝੇ - ਇੱਕ ਨੂੰ ਸਮਝੇ ਉਸ ਦੇ ਸਮਸਖਾਂ ਦਾ ਸਮਹਾਰੀ ਗੁੱਰ ਸਮਝੇ ਵਾਂ ਇਸ ਤਿਗਲੰਘ ਦੁਸਮਸਖਾ ਨੂੰਸਮੇ ਉਨ੍ਹਾਂ ਦੇ ਸਮਸਖਾਂ ਦਾ ਪਸੀਹਾਰੀ ਗੁੱਰ। ਇੰਸਾਰ ਦੇ ਬਹੁਤ ਸਾਂਝੇ ਇੱਸ ਵੀਲਾਂ ਇਹ ਕਿਸੇ ਸਾ ਕਿਸੇ ਗੁੱਰ ਨਾਲ ਸੰਬੰਧਿਤ ਤੇ ਸਾਂਝੇ। ਪਰੰਤੂ ਇਨਾਂ ਦੇ ਸਮਾਪਤੀ ਇਤਿਹਾਸਾ ਸਾਰਤ ਸਾਰੇ ਸਮੇ ਤੇ ਦੇਸ਼ਾ ਦਾ ਇਕ ਐਸਾ ਗੁੱਰ ਹੀ ਤੇ ਇਸ ਸਮਾਪਤੀ।

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"Hardeep Singh Deepu" Section-A . (Diff. equation) 1

Introduction:

Existence of Solutions:- let I be an open interval on the real line $(-\infty < t < \infty)$ i.e. then the set of all real t satisfying $a < t < b$ for some real constants a and b.

The set of all complex-valued functions having k cont derivatives on I is denoted by $C^k(I)$.

The set $C^1(I)$ = all complex-valued functions having 1st order cont. derivatives.

If right hand kth derivative of f exist at a and it is cont. from right at a the f is said to the class C^k on $[a, b)$

Hly. if kth derivative is cont. from left at b then $f \in C^k$ on $(a, b]$.

Open connected set:- Firstly, we discuss about open set A set which have no boundary that is called open set e.g. $|z| < 1$

but $|z| \leq 1$ it is not open set ∵ it contains boundary.

Connected set: If two elements of a set joined by a line is said to be connected set.

e.g. circle is not a connected whereas sphere is a connected set.

Def: if D is open connected set in the real (t, x) plane then the set of all complex-valued function f defined on D s.t. all kth order partial

derivative $\frac{\partial^k f}{\partial t^p \partial x^q}$ exist where $k = p+q$ and are cont. on D is denoted by $C^k(D)$.

Initial value Problem :- If a function f have some initial value, then it is called IVP.

e.g. $f(x,y) = x^2 y$, $y(0) = 1$, ...

Ordinary diff. eq :- If a function have diff. Initial values then it is called ordinary diff. eq.

e.g. $f(x,y) = x^2 y$, $y'(0) = 2$

To find diff. function ϕ defined on a real t interval I s.t

(i) $(t, \phi(t)) \in D$ where $t \in I$

(ii) $\phi'(t) = f(t, \phi(t))$

This problem is called an ordinary diff. eq. of Ist order and it is denoted by $x' = f(t,x)$

If such an interval I and function ϕ exist then ϕ is called a solution of diff. eq.

$\phi'(t) = f(t, \phi(t))$ on the interval I.

then $\phi \in C^1(I)$

e.g. $x' = 1 \Rightarrow \frac{dx}{dt} = 1 \Rightarrow x = t + c$

then there exist an infinite many solutions.

If $x(0) = 1 \Rightarrow c = 1$

so $x = t + 1$, then there is a unique solution

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Initial value problem:- To find an interval I containing τ and a solution ϕ of the diff. eq.

$x' = f(t,x)$ on I satisfying $\phi(\tau) = \xi$

Suppose ϕ is a sol. which exist on an interval I then by integrating both sides we get

$$\phi(t) = \int_\tau^t f(s,\phi(s))\,ds + \phi(\tau)$$

$$= \xi + \int_\tau^t f(s,\phi(s))\,ds$$

This is an integral eq. of the diff. eq.

Conversely:- Suppose $\phi \in C$ is a function satisfy the above integral eq. on I.

So $\phi(t) = \int_\tau^t f(s,\phi(s))\,ds + \xi$

If $t=\tau \Rightarrow \phi(\tau) = \xi$ and diff. the integral eq. we get

$$\phi'(t) = f(s,\phi(s))$$

$\Rightarrow \phi$ is a sol. of the given diff equation on Interval I.

i.e. there is correspondence between solutions ϕ of the diff. eq. on I satisfying $\phi(\tau) = \xi$ and Cont. function ϕ satisfying integral eq. on I)

eg:- let $x' = x^2 \Rightarrow \frac{dx}{dt} = x^2$

$$\frac{dx}{x^2} = dt \Rightarrow -\frac{1}{x} = t + c$$

Goal $\quad x = \frac{-1}{t+c}$

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If sol. of diff. eq. passes through the pt $(1,-1)$

$$-1 = \frac{-1}{1+c} \Rightarrow 1+c=1 \Rightarrow c=0$$

So $x = -\frac{1}{t}$

but this doesn't exist at $t=0$, Although $f(t,x) = x^2$ is cont. there.

Def. — approximate solution! — Def! — let f be a real valued continuous on a Domain D in (t,x) plane and ϵ-app. sol. of the diff. eq. on t Interval I is a sol. function $\phi \in C$ on I s.t.

(i) $(t, \phi(t)) \in D \quad \forall\, t \in I$

(ii) $\phi \in C'$ on I except possible for a finite set of pts. S on I where ϕ is not cont or simple discont. (i.e. L.H.L $\neq$ R.H.L)

(iii) $|\phi'(t) - f(t, \phi(t))| < \epsilon$

Any function $\phi \in C$ satisfying property (ii) on I is said to have a piecewise cont. on I and it is denoted by $\phi \in C_p'(I)$

(Any function f is said to be piecewise cont on I iff it is cont on a interval as well as its sub-intervals)

From above three conditions it is clear that $\phi(t)$ is an ϵ-app. Sol. of the given Initial value Problem.

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Note! If $f \in C$ on rectangle R, $|t-\tau| \le a$, $|x-\xi| \le b$ about the pt. (τ, ξ) it is bounded there let $M = \max(f(t,x))$, $t,x \in R$ Here R is the rectang on (t,x) plane and α is $\min\left(a, \frac{b}{M}\right)$

Lipschitz Condition!: let f be a function defined for $(x,$ in a set S then we say that f satisfy Lipschitz Condition on S if $\exists$ k constant s.t

$|f(x,y_1) - f(x,y_2)| \le k|y_1 - y_2|$ for each $(x,y_1), (x_2,y_2) \in S$ the constant k is called Lipchitz constant.

e.g. let $f(x,y) = xy^2$, $|x| \le 1$, $|y| \le 1$

1st Method!: $|f(x,y_1) - f(x,y_2)| = |xy_1^2 - xy_2^2|$

$= |x|\,|y_1 - y_2|\,|y_1 + y_2|$

$\le |x|\,|y_1 - y_2|\,(|y_1| + |y_2|)$

$= 2|y_1 - y_2|$

$\Rightarrow |f(x,y_1) - f(x,y_2)| \le 2|y_1 - y_2|$

Here $k = 2$ is known as L.C.

IInd method!: If f is real valued function defined on S s.t. $\frac{\partial f}{\partial y}$ exist and is cont. on S.

Also $\left|\frac{\partial f}{\partial y}\right| < k$ for some $k > 0$ then f satisfy Lipchitz condition.

$\left|\frac{\partial f}{\partial y}\right| = |2xy| = 2|x||y| \le 2$

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So $K=2$ is Lipchitz constant.

e.g. $f(x,y) = 4x^2+y^2$; $|x| \le 1$, $|y| \le 1$

$$|f(x,y_1) - f(x,y_2)| = |4x^2+y_1^2 - 4x^2 - y_2^2|$$

$$= |y_1^2 - y_2^2| = |y_1 - y_2|\,|y_1 + y_2|$$

$$\le (|y_1| + |y_2|)\,|y_1 - y_2| = 2\,|y_1 - y_2|$$

Ex:- Give an example of a cont. function that doesn't satisfy a Lipschitz condition on a rectangle

Sol:- let $f(x,y) = y^{2/3}$ on $|x| \le 1$, $|y| \le 1$

$f(x,y)$ is a polynomial in y, so it is cont.

But $\left|\frac{\partial f}{\partial y}\right| = \left|\frac{2}{3y^{1/3}}\right|$ which doesn't exist at $y=0$

So L.C. is not satisfied.

Ex:- Show that $f(x,y) = \sqrt{|y|}$ doesn't satisfy the L.C in any interval containing the origin.

Ex:- $f(x,y) = x^2|y|$ satisfies the L.C on $R = \{(x,y) : |x| \le 1, |y| \le 1\}$ for which $\frac{\partial f}{\partial y}$ doesn't exist in R.

Sol:-

$$|f(x,y_1) - f(x,y_2)| = x^2\,||y_1| - |y_2|| \le x^2\,|y_1 - y_2|$$

$$\Rightarrow |f(x,y_1) - f(x,y_2)| \le |y_1 - y_2|$$

So f satisfies L.C.

$\frac{\partial f}{\partial y} = x^2$ if $y > 0$ and $\frac{\partial f}{\partial y} = -x^2$ if $y < 0$.

Hence $\frac{\partial f}{\partial y}$ doesn't exist.

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Thm: Let $f \in C$ on the rectangle R. Given any $\epsilon > 0$ there exist an ϵ-app. solution ϕ of the given initial value problem on $|t-\tau| \le \alpha$ s.t. $\phi(\tau) = \xi$

Sol: let $\epsilon > 0$ be given we will prove the thm on $[\tau, \tau+\alpha]$ the same will work for $[\tau-\alpha, \tau]$.

The combined result we will get. Construct a polygonal path joined end to end by a finite no. of pair of st. lines.

$f(t,x)$ is cont. on R and rectangle R is closed.

$\therefore f(t,x)$ is uniformly cont. on R.

$\exists\ \epsilon > 0$ however small $\delta_\epsilon > 0$ s.t.

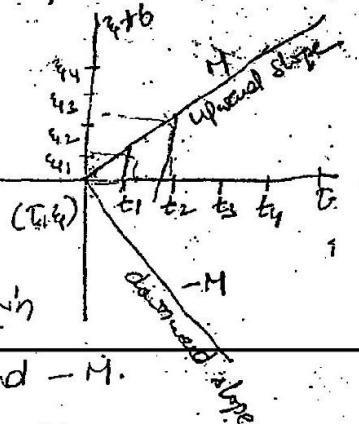
$|f(t,x) - f(\bar{t},\bar{x})| \le \epsilon \quad \forall\ |t-\bar{t}| \le \delta_\epsilon$ and $|x-\bar{x}| < \epsilon$ ——— (1)

where (t,x) and $(\bar{t},\bar{x}) \in R$

Now we divide the interval $[\tau, \tau+\alpha]$ into n parts as $\tau = t_0 < t_1 < t_2 \cdots t_{k-1} < t_k < t_{k+1} \cdots t_n = \tau+\alpha$

s.t. $\max |t_k - t_{k-1}| \le \min\left(\delta_\epsilon, \frac{\epsilon}{M}\right)$ for $k = 1, 2, \cdots n$

Now from pt to $= \tau$, draw a line segment right to the pt. (τ, ξ) which will meet at some pt. on the line $t = t_1$ at some pt. (t_1, x_1).



The line segment will be entirely within the region t bounded by the line M and $-M$.

by the def of α $|f(t,x)| \le M$ where $\alpha = \min\left(a, \frac{b}{M}\right)$

Now from pt (t_1, x_1) draw another line segment which will meet the line $t = t_2$ at some pt (t_2, x_2).

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and cont in this way, we get a piecewise cont function lying entirely with in the region t and we have

$\phi(t) = \xi$

$\frac{f(b)-f(a)}{b-a} = f'(c)$

$\phi(t) = \phi(t_{k-1}) + f(t_{k-1}, \phi(t_{k-1}))\,(t - t_{k-1})$ ——(2).

$\phi'(t) = f(t, \phi(t))$

$\forall\ k = 1,2\cdots n, \quad t_{k-1} \le t \le t_k$

Now $|\phi(t) - \phi(t_{k-1})| = |f(t_{k-1}, \phi(t_{k-1}))|\,|t - t_{k-1}|$

$\le M\,|t - t_{k-1}|$

also $\max |t_k - t_{k-1}| \le \min\left(\delta\epsilon, \frac{\delta\epsilon}{M}\right) = \frac{\delta\epsilon}{M}$

so $|\phi(t) - \phi(t_{k-1})| \le M \cdot \frac{\delta\epsilon}{M} = \delta\epsilon$

Now diff. (3) w.r.t. t

$\phi'(t) = f(t_{k-1}, \phi(t_{k-1}))$

Now $|\phi'(t) - f(t, \phi(t))| = |f(t_{k-1}, \phi(t_{k-1})) - f(t, \phi(t))|$

$\le \epsilon$ by (i)

So ϕ is an ϵ-app. solution of the given IVP.

(P) (*) Equi-Continuous function:- A set of function $F = \{f\}$ defind on a real interval I is said to be equi-cont. on I if given any $\epsilon > 0$ $\exists\ \delta\epsilon > 0$ independent of f on F and also $t, \bar{t} \in I$ s.t. $|f(t) - f(\bar{t})| < \epsilon$ $\forall\ |t - \bar{t}| < \delta$

(*) (P) (*) (P) Ascoli's lemma:- On a bounded interval I and let $F = \{f\}$ be an infinite uniformly bounded, equicont. set of functions on I then F contains a seq. $\{f_n\}$ where $n = 1,2\cdots$ which is uniformly cont convergent on I.

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Proof: let $\{r_k\}$ where $k \in N$ be rational no. on interval I in some order. The set of no. $\{f(r_1)\}$ where $f \in F$ is bounded and f is equicont Hence $\exists$ a sequences of distinct functions in $\{f_n\}$ where $f_{n_i} \in F$ s.t. seq. $\{f_{n_1}(r_1)\}$ is convergent. Also the set of no. $\{f_{n_1}(r_2)\}$ is convergent. So the set of no. $\{f_{n_1}(r_1)\}$ has cgt seq. $\{f_{n_2}(r_2)\}$ which is a sub-seq. Continuing in this way an infinite set of functions $f_{n_k} \in F$ where $n, k \in N$ which have the property that $\{f_{n_k}\}$ converges at $r_1, r_2 \dots r_k$. Define f_n to be the functions f_{nn} then $\{f_n\}$ is seq. sequence which is uniformly convergent on I;

Clearly the set $\{f_n\}$ converges at each of rational no. on I then given any $\epsilon > 0$ and rational no. $r_k \in I$ $\exists$ an integer $N_k(r_k)$ s.t.

$|f_n(r_k) - f_m(r_k)| < \epsilon$ — (1) $\forall\ n, m \geq N_k(r_k)$

Also F is equi cont. So given $\epsilon > 0$ $\exists$ a $\delta_\epsilon > 0$ independent of t, E and $f \in F$ s.t.

$|f(t) - f(E)| < \epsilon$ $\forall$ $|t - E| < \delta_\epsilon$ — (2)

Divide the interval I into finite no. of sub-interval $I_1, I_2 \dots I_k$ s.t. length of largest subinterval is less than δ. Now for each I_k

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Choose a rational no: $r_k \in I_k$. If $t \in I$ $\exists$ $t \in I_k$

Now $|f_n(t) - f_m(t)| = |f_n(t) - f_n(r_k) + f_n(r_k) + f_m(r_k) - f_m(r_k) - f_m(t)|$

$\forall\ n, m \geq \max(N_1(r_1), N_2(r_2), \ldots N_k(r_k))$

$\leq |f_n(t) - f_n(r_k)| + |f_n(r_k) - f_m(r_k)| + |f_m(r_k) - f_m(t)|$
(2) (1) (1)

$< \epsilon + \epsilon + \epsilon = 3\epsilon = \epsilon'$

$\Rightarrow |f_n(t) - f_m(t)| < \epsilon'$ $\forall\ n, m \geq \max(N_1(r_1), N_2(r_2), \ldots N_k(r_k))$

$\Rightarrow \{f_n\}$ is the seq. uniformly cgt seq. which converges uniformly on I.

Cauchy-peano existence thm] Prove

Thm 12.1 If $f \in C$ on the rectangle R, then there exist a solution $\phi \in C^1$ on the diff. eq. $x' = f(t,x)$ $\forall$ $(t,x) \in D$ on $|t - \tau| \leq a$ for which $\phi(\tau) = \xi_0$

Sol: let the seq. $\{\epsilon_n\}$ for $n = 1, 2, \ldots$ be a monotonically decreasing seq. of the real no. tending to zero as $n \to \infty$

For each ϵ_n $\exists$ an ϵ_n-app. solution ϕ_n of $x' = f(t,x)$ on $|t - \tau| \leq \alpha$ s.t. $\phi_n(\tau) = \xi_0$

Choose one such solution ϕ_n for each ϵ_n

it follows that $|\phi_n(t) - \phi_n(t_{k-1})| \leq M |t - t_{k-1}|$ ——(1)

putting $t_{k-1} = \tau$

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also $|t-\tau| \le \frac{b}{M}$

$\therefore |\phi_n(t) - \phi_n(\tau)| \le M|t-\tau| \le M \cdot \frac{b}{M} = b$

$\Rightarrow |\phi_n(t) - \phi_n(\tau)| \le b$ $\quad |x|-|y| \le |x-y|$

$\Rightarrow |\phi_n(t)| \le b + |\phi_n(\tau)| = b + |\xi_1|$

the seq. $\{\phi_n(t)\}$ is uniformly bounded by $b+|\xi_1|$. Moreover eq. (1) implies that $\{\phi_n\}$ is an equicont. set. So By Ascoli's lemma $\exists$ a subseq. $\{\phi_{n_k}\}$ of $\{\phi_n\}$ converging uniform on $[\tau-\alpha, \tau+\alpha]$ to a limit function ϕ which must be cont. Since each $\{\phi_n\}$ is continuous

$$\therefore \phi_n(t) = \xi + \int_\tau^t f(s, \phi_n(s))\,ds + \Delta_n(s)\,ds \qquad (2)$$

where $\Delta_n(t) = \phi_n'(t) - f(t, \phi_n(t))$

at those pts where $\phi_n'(t)$ exists and $\Delta_n(t) = 0$ otherwise

$\because \phi_n$ is an ε-app. solution

$\therefore |\phi_n'(t) - f(t, \phi_n(t))| \le \varepsilon_n$

$\Rightarrow \Delta_n(t) \le \varepsilon_n$

Since f is cont. on R

$\Rightarrow f$ is U.C. on R and ϕ_{n_k} converges uniformly on $[\tau-\alpha, \tau+\alpha]$

So $\phi_{n_k} \to \phi$ uniformly on $[\tau-\alpha, \tau+\alpha]$ as $k \to \infty$

$\Rightarrow f(t, \phi_{n_k}(t)) \to f(t, \phi(t))$ converges uniformly on $[\tau-\alpha, \tau+\alpha]$ as $k \to \infty$

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Replacing η by η_k in eq. (2) and let $k \to \infty$

$$\phi(t) = \xi + \int_\tau^t f(s, \phi(s))\, ds \quad \text{---(3)} \quad (\because \phi_{\eta_k} \to \phi)$$

Take $t = \tau$ in (3) we get

$$\phi(t) = \xi.$$

and diff. (3) we get $\phi'(t) = f(t, \phi(t))$

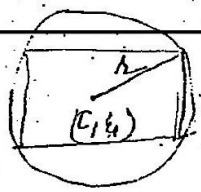
Here $f(t, \phi(t))$ is a cont. function, ϕ is a solution of $x' = f(t,x)$ on $|t-\tau| \le \alpha$ on C'. #

Thm (*) Let $f \in C$ on a domain D in the (t,x) plane and Suppose that (τ, ξ) is any pt. in D. Then there exist a solution ϕ of the initial value problem on some t interval containing τ in its interior.

Sol:- Since D is open connected so $\exists$ an $r > 0$ s.t. all pts whose distance from (τ, ξ) is less than r i.e.,

$$|(\tau, \xi) - (x, y)| < r \quad \forall\ (x,y) \in D$$

Let R_1 be any rectangle containing (τ, ξ) and contained in this open circle of radius r. then by above thm on R we get the required result.



[$f \in (C, Lip)$ Nagumo
$\Rightarrow$ Cauchy Lip exn

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Note1. A simple condition which gives one solution passing through a given pt is the Lipschitz condition.

Thm 2.1 Suppose $f \in (C, Lip)$ in D with Lipschitz constant K. let ϕ_1, ϕ_2 be ϵ_1 and ϵ_2 app. solutions of the diff. eq $x' = f(t,x)$ of C^1 on some τ, $a < \tau < b$ s.t. $|\phi_1(\tau) - \phi_2(\tau)| \le \delta$ where $\delta > 0$ — (1).

If $\epsilon = \epsilon_1 + \epsilon_2$ then for all $t \in (a,b)$

$$|\phi_1(t) - \phi_2(t)| \le \delta e^{K|t-\tau|} + \frac{\epsilon}{K}\left(e^{K|t-\tau|} - 1\right) \quad — (2)$$

Sol:- Consider the case where $\tau \le t < b$, a corresponding proof holds for $a < t \le \tau$. Since ϕ_1, ϕ_2 are ϵ_1 and ϵ_2 app. Sol. of $x' = f(t,x)$

$$|\phi_i'(s) - f(s, \phi_i(s))| \le \epsilon_i \quad \text{for } i = 1,2 \quad — (3)$$

[by ϵ-app. sol.]

at all but a finite no. of pts. on $\tau \le s \le b$

Integrating from τ to t where $\tau \le t \le b$

$$\left|\phi_i(t) - \phi_i(\tau) - \int_\tau^t f(s, \phi_i(s))\,ds\right| \le \epsilon_i (t-\tau)$$

using the fact that $|\alpha - \beta| \le |\alpha| + |\beta|$

put $i = 1$ and $i = 2$

$$\left|\phi_1(t) - \phi_1(\tau) - \int_\tau^t f(s, \phi_1(s))\,ds\right| \le \epsilon_1 (t-\tau)$$

$$\left|\phi_2(t) - \phi_2(\tau) - \int_\tau^t f(s, \phi_2(s))\,ds\right| \le \epsilon_2 (t-\tau)$$

Now $\left|\phi_1(t) - \phi_2(t) - (\phi_1(\tau) - \phi_2(\tau)) - \int_\tau^t f(s,\phi_1(s))\,ds - \int_\tau^t f(s,\phi_2(s))\,ds\right|$

$$\le \epsilon_1 (t-\tau) + \epsilon_2 (t-\tau)$$

$$= \epsilon (t-\tau) \quad — (4)$$

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let r be the function defined on $[\tau, b]$ by

$$r(t) = |\phi_1(t) - \phi_2(t)|$$

from (4) we get, using $|x| - |y| \le |x-y|$

$$r(t) - r(\tau) \le \int_\tau^t |f(s,\phi_1(s)) - f(s,\phi_2(s))|\, ds \le \epsilon(t-\tau)$$

$$\Rightarrow r(t) \le r(\tau) + \int_\tau^t |f(s,\phi_1(s)) - f(s,\phi_2(s))|\, ds + \epsilon(t-\tau)$$

$$\le r(\tau) + k\int_\tau^t |\phi_1(s) - \phi_2(s)|\, ds + \epsilon(t-\tau)$$

$$\le r(\tau) + k\int_\tau^t r(s)\, ds + \epsilon(t-\tau) \qquad \text{——— (5)}$$

Define the function R by $R(t) = \int_\tau^t r(s)\, ds$

$$\Rightarrow R'(t) = r(t)$$

(5) $\Rightarrow$ $R'(t) \le |\phi_1(\tau) - \phi_2(\tau)| + kR(t) + \epsilon(t-\tau)$

$$= \delta + kR(t) + \epsilon(t-\tau)$$

$$\Rightarrow R'(t) - kR(t) \le \delta + \epsilon(t-\tau)$$

Multiplying by $e^{-k(t-\tau)}$ and integrating from τ to t:

$$\int_\tau^t R'(t)\, e^{-k(t-\tau)}\, dt - k\int_\tau^t e^{-k(t-\tau)} R(t)\, dt$$

$$\le \delta\int_\tau^t e^{-k(t-\tau)}\, dt + \epsilon\int_\tau^t (t-\tau)\, e^{-k(t-\tau)}\, dt$$

$$\Rightarrow R(t)\, e^{-k(t-\tau)}\Big]_\tau^t - \int_\tau^t R(t)\, e^{-k(t-\tau)}(-k)\, dt - k\int_\tau^t e^{-k(t-\tau)} R(t)\, dt$$

$$\le \delta\left(\frac{e^{-k(t-\tau)}}{-k}\right)_\tau^t + \epsilon(t-\tau)\frac{e^{-k(t-\tau)}}{-k} + \frac{\epsilon}{k}\int_\tau^t e^{-k(t-\tau)}\, dt$$

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$$\Rightarrow R(t)\,e^{-k(t-\tau)} - R(\tau) \le \delta\left(\frac{e^{-k(t-\tau)}}{-k} + \frac{1}{k}\right) + \epsilon(t-\tau)\frac{e^{-k(t-\tau)}}{-k} \le 0 + \frac{\epsilon}{k}\left[\frac{e^{-k(t-\tau)}}{-k} + \frac{1}{k}\right]$$

$$\Rightarrow R(t)\,e^{-k(t-\tau)} - 0 \le \frac{\delta}{k}\left[1 - e^{-k(t-\tau)}\right] + \epsilon\left[\frac{(t-\tau)\,e^{-k(t-\tau)}}{-k} - \frac{1}{k^2}\left(e^{-k(t-\tau)} - 1\right)\right]$$

$$\le \frac{\delta}{k}\left[1 - e^{-k(t-\tau)}\right] - \frac{\epsilon}{k^2}\left[e^{-k(t-\tau)}\left(k(t-\tau)+1\right)\right]$$

$$\Rightarrow R(t) \le \frac{\delta}{k}\left[e^{k(t-\tau)} - 1\right] - \frac{\epsilon}{k^2}\left[1 + k(t-\tau)\right] + \frac{\epsilon}{k^2}e^{k(t-\tau)} \quad \text{---(6)}$$

By (5) and (6) we get

$$r(t) - r(\tau) - \epsilon(t-\tau) \le kR(t)$$

$$\Rightarrow r(t) - r(\tau) - \epsilon(t-\tau) \le k\left[\frac{\delta}{k}\left(e^{k(t-\tau)} - 1\right) - \frac{\epsilon}{k^2}\left(1 + k(t-\tau)\right) + \frac{\epsilon}{k^2}e^{k(t-\tau)}\right]$$

$$\Rightarrow r(t) \le r(\tau) + \epsilon(t-\tau) + \delta\left(e^{k(t-\tau)} - 1\right) - \frac{\epsilon}{k}\left(1 + k(t-\tau)\right) + \frac{\epsilon}{k}e^{k(t-\tau)}$$

$$\Rightarrow r(t) \le \delta + \epsilon(t-\tau) + \delta e^{k(t-\tau)} - \delta - \frac{\epsilon}{k} - \epsilon(t-\tau) + \frac{\epsilon}{k}e^{k(t-\tau)}$$

$$= \delta e^{k(t-\tau)} + \frac{\epsilon}{k}\left(e^{k(t-\tau)} - 1\right)$$

$$\Rightarrow |\phi_1(t) - \phi_2(t)| \le \delta e^{k(t-\tau)} + \frac{\epsilon}{k}\left(e^{k(t-\tau)} - 1\right)$$

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Thm 2.2 let $f \in (C, Lip)$ in D and $(\tau, \xi) \in D$. If ϕ_1 and ϕ_2 are any two solutions of the diff. eq. $x' = f(t,x)$ on (a,b), $a < \tau < b$ such that $\phi_1(\tau) = \phi_2(\tau) = \xi$ then $\phi_1 = \phi_2$

Solution:- firstly we prove the thm 2.1.

we have

$$x(t) \le \delta e^{k(t-\tau)} + \frac{\epsilon}{k^2}\left(e^{k(t-\tau)} - 1\right)$$

$$|\phi_1(t) - \phi_2(t)| \le \delta e^{k(t-\tau)} + \frac{\epsilon}{k^2}\left(e^{k(t-\tau)} - 1\right) \quad \text{---(1)}$$

$\forall\ \tau < t < .$

apply the same for $a < t < \tau$

$$|\phi_1(t) - \phi_2(t)| \le \delta e^{k(\tau - t)} + \frac{\epsilon}{k^2}\left(e^{k(\tau - t)} - 1\right) \quad \text{---(2)}.$$

Combining (1) and (2)

$$|\phi_1(t) - \phi_2(t)| \le \delta e^{k|t-\tau|} + \frac{\epsilon}{k^2}\left(e^{k|t-\tau|} - 1\right)$$

$$\Rightarrow |\phi_1(t) - \phi_2(t)| \le \frac{\epsilon}{k^2}\left(e^{k|t-\tau|} - 1\right) \quad \text{as } \delta \to 0$$

$\therefore |\phi_1(t) - \phi_2(t)| \to 0$ as $\epsilon \to 0$ as ϵ is very small.

$\Rightarrow \phi_1(t) = \phi_2(t)\ \forall\ t \in (a,b)$

$\therefore \phi_1 = \phi_2$ / Hence Proved.

Thm 2.3 Suppose $f \in (C, Lip)$ on the rectangle

$R: |t-\tau| \le a$, $|x-\xi| \le b$ and let

$M = \max |f(t,x)|$ and $\alpha = \min\left(a, \frac{b}{M}\right)$

Then $\exists$ a unique solution $\phi \in C^1$ of $x' = f(t,x)$ on $|t-\tau| \le \alpha$ for which $\phi(\tau) = \xi$

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Sol: let $\{\varepsilon_n\}$ be the monotonically decreasing seq. of +ve real no.'s tend to zero as $n \to \infty$

For each ε_n an ε_n-app. sol. ϕ_n. These functions satisfy the relation

$$\phi_n(t) = \xi + \int_\tau^t f(s, \phi_n(s))\,ds + \Delta_n(s)\,ds \quad \text{——(1)}$$

where $\Delta_n(t) = \phi_n'(t) - f(t, \phi_n(t))$ at those pts where $\phi_n'(t)$ exist and $\Delta_n(t) = 0$ otherwise. Now $\Delta_n(t) \to 0$ as $n \to \infty$ uniformly on $|t-\tau| \le \alpha$.

Now by the 2.1 thm

$$|\phi_1(t) - \phi_2(t)| \le \delta e^{k(t-\tau)} + \frac{\varepsilon}{k}(e^{k(t-\tau)} - 1) \quad \text{——(2)}$$

so eq. (2) applied for ϕ_n and ϕ_m on $|t-\tau| \le \alpha$

i.e. $|\phi_n(t) - \phi_m(t)| \le \frac{(\varepsilon_n + \varepsilon_m)}{k}(e^{k\alpha} - 1)$ for δ is very sma

thus the seq. $\{\phi_n\}$ is U.C. on the interval $|t-\tau| \le \alpha$ and therefore there exist a continuous limit function ϕ on this interval such that $\phi_n(t) \to \phi(t)$ as $n \to \infty$ uniformly on $|t-\tau| \le \alpha$.

we know that every Lip function is U.C.

~~to f is U.C. on R~~

$\Rightarrow f(t, \phi_n(t))$ is U.C. to $f(t, \phi(t))$ as $n \to \infty$ on $|t-\tau| \le \alpha$ ——(3)

Hence $\lim_{n\to\infty} \int_\tau^t f(s, \phi_n(s))\,ds + \Delta_n(s)\,ds = \int_\tau^t f(s, \phi(s))\,ds$

by (2) and (3)

$$\lim_{n\to\infty} \phi_n(t) = \lim_{n\to\infty} \xi + \lim_{n\to\infty} \int_\tau^t f(s,\phi_n(s))\,ds + \varepsilon_n$$

$$\Rightarrow \quad \phi(t) = \xi + \int_\tau^t f(s,\phi(s))\,ds \quad \text{by (4)}$$

which proves the existence of solution $\phi \in C^1$ of $x' = f(t,x)$ on $|t-\tau| \le \alpha$

It is unique by thm 2.2.

$$|\phi(t) - \phi_n(t)| \le \frac{\varepsilon_n}{k}\left(e^{k(t-\tau)} - 1\right)$$

$$\le \frac{\varepsilon_n}{k}\left(e^{k\alpha} - 1\right) = \frac{\varepsilon_n}{k}\left(1 + k\alpha + \tfrac{(k\alpha)^2}{2!} + \cdots - 1\right).$$

$$\le \varepsilon_n \alpha \qquad \text{(neglect higher)}$$

Ques

Method of Successive approximation.

If $f \in C$ on R, then f is bounded there. let $\max|f| = M$ on R and $\alpha = \min\left(a, \frac{b}{M}\right)$. It is clear that a sol. ϕ of $x' = f(t,x)$ on $|t-\tau| \le \alpha$ for which $\phi(\tau) = \xi$ must satisfy the integral eq.

$$\phi(t) = \xi + \int_\tau^t f(s,\phi(s))\,ds \qquad \text{---(1)}$$

and conversely if ϕ satisfies (1) it satisfies the diff eq. $x' = f(t,x)$ and $\phi(\tau) = \xi$

The successive app. for $x' = f(t,x)$ are defined to be the functions $\phi_0, \phi_1, \cdots$

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are given by the formula $\phi_0(t) = \xi$

and $\phi_{k+1} = \xi + \int_\tau^t f(s, \phi_k(s))\, ds$ for $k = 0, 1, 2 \ldots$

on $|t - \tau| \le \alpha$.

Ex:- Paper ~~Some~~ the initial value problem upto third order

app. solution:-

$x' = 2x - 2t^2 - 3 = f(t, x)$

given $x(0) = 2$ or $\phi_0(t) = 2$

Sol:- $\frac{dx}{dt} = 2x - 2t^2 - 3$

$\phi_{k+1} = \xi + \int_\tau^t f(s, \phi_k(s))\, ds$ Put $k = 0$

$\phi_1(t) = \xi + \int_0^t f(s, \phi_0(s))\, ds$

$= 2 + \int_0^t (4 - 2s^2)\, ds = 2 + \left[4s - \frac{2s^3}{3}\right]_0^t$

$= 2 + t - \frac{2t^3}{3}$

IInd app. Put $k = 1$

$\phi_2(t) = \xi + \int_0^t f(s, \phi_1(s))\, ds$

$= 2 + \int_0^t \left[2\left(2 + s - \frac{2s^3}{3}\right) - 2s^2 - 3\right] ds$

$= 2 + \int_0^t \left(1 + 2s - 2s^2 - \frac{4s^3}{3}\right) ds$

$= 2 + t + t^2 - \frac{2t^3}{3} - \frac{t^4}{3}$

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3rd app!: Put $k=2$

$$\phi_3(t) = \xi + \int_0^t f(s, \phi_2(s))\,ds$$

$$= 2 + \int_0^t \left[2\left(2 + s + s^2 - \frac{2s^3}{3} - \frac{s^4}{3}\right) - 2s^2 - 3\right] ds$$

$$= 2 + \int_0^t \left(1 + 2s - \frac{4s^3}{3} - \frac{2s^4}{3}\right) ds$$

$$= 2 + t + t^2 - \frac{t^4}{3} - \frac{2t^5}{15} \quad \text{Ans}$$

Gronwall's Inequality:- let $f(t)$ and $g(t)$ be the non-negat functions on the interval $\alpha \le t \le \beta$ and λ is a non-negative constant. If $f(t) \le \lambda + \int_\alpha^t f(s)g(s)\,ds$ $\forall\ t \in [\alpha, \beta]$ then $f(t) \le \lambda \exp \int_\alpha^t g(s)\,ds$

Sol: Define $h(t) = \lambda + \int_\alpha^t f(s)\,g(s)\,ds$

Replace t by α we get $h(\alpha) = \lambda$

$$f(t) \le \lambda + \int_\alpha^t f(s)\,g(s)\,ds$$

$$\Rightarrow f(t) \le h(t)$$

again $h(t) = \lambda + \int_\alpha^t f(s)\,g(s)\,ds$

$$h'(t) = f(t)\,g(t) \quad \forall\ t \in [\alpha, \beta]$$

$\because f(t) \ge 0$, $g(t) \ge 0$

so $h'(t) \ge 0$

$$h'(t) = f(t)\,g(t) \le h(t)\,g(t)$$

$$\Rightarrow \frac{h'(t)}{h(t)} \le g(t)$$

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Integrating from α to t w.r.t t

$$\int_\alpha^t \frac{h'(t)}{h(t)}\,dt \le \int_\alpha^t g(t)\,dt$$

$$[\log h(t)]_\alpha^t \le \int_\alpha^t g(t)\,dt$$

$$\log h(t) - \log h(\alpha) \le \int_\alpha^t g(t)\,dt$$

$$\log \frac{h(t)}{h(\alpha)} \le \int_\alpha^t g(t)\,dt$$

$$\Rightarrow \log \frac{h(t)}{\lambda} \le \int_\alpha^t g(s)\,ds \Rightarrow \frac{h(t)}{\lambda} \le \exp \int_\alpha^t g(s)\,ds$$

but $f(t) \le h(t)$

$$f(t) \le h(t) \le \lambda \exp \int_\alpha^t g(s)\,ds$$

$$\Rightarrow f(t) \le \lambda \exp \int_\alpha^t g(s)\,ds \quad \text{H.P.}$$

Thm Picard - Lindelof Thm for Existence and Uniqueness :-

Statement: If $f \in (C, Lip)$ on R, then the successive app. ϕ_k exists such that $\phi_0(t) = \xi$ and

$$\phi_{k+1} = \xi + \int_\tau^t f(t, \phi_k(t))\,dt \quad \text{on } |t-\tau| \le \alpha$$

is cont. function and converges uniformly on $|t-\tau| \le \alpha$ where $\alpha = \min\left(a, \frac{b}{M}\right)$ to the unique sol. of ϕ of the initial value problem $x' = f(t,x)$, —(1) such that $x(\tau) = \xi$ on I.

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Solution: Consider the interval $[\tau, \tau+\alpha]$ a similar argument will hold for $[\tau-\alpha, \tau]$

we shall divide its proof into five main steps as

(i) The functions $\{\phi_n\}$ actually exist have cont. derivatives and satisfy the inequality $|\phi_n(t) - \phi_0(t)| \le b$ on $|t-\tau| \le \alpha$ and thus $f(t, \phi_n(t))$ is defined on this interval.

(ii) The function $\{\phi_n\}$ satisfy the inequality.

$$|\phi_n(t) - \phi_{n-1}(t)| \le \frac{M}{k} \frac{(k\alpha)^n}{n!} \text{ on } |t-\tau| \le \alpha$$

(iii) As $n \to \infty$ the seq. of functions $\{\phi_n\}$ converges uniformly to a cont. function ϕ on $|t-\tau| \le \alpha$

(iv) The limit function ϕ satisfies the diff. eq.

$$\frac{d\phi}{dt} = f(t, \phi(t)) \text{ on } |t-\tau| \le \alpha \text{ s.t. } \phi(\tau) = \xi$$

(v) This function ϕ is the only diff. function on $|t-\tau| \le \alpha$ which satisfies the diff. eq.

$$\frac{d\phi}{dt} = f(t, \phi(t)) \text{ with } \phi(\tau) = \xi$$

we shall prove the result by M.I.

Part I: Now $\phi_1(t) = \xi + \int_\tau^t f(s, \phi_0(s))\, ds$

$$|\phi_1(t) - \xi| \le \int_\tau^t |f(s, \phi_0(s))|\, ds = M \int_\tau^t ds$$

$$= M|t-\tau| = M\alpha \le M \cdot \frac{b}{M} = b$$

$$\Rightarrow |\phi_1(t) - \xi| \le b \text{ on } t \in [\tau, \tau+\alpha]$$

for $n=1$, result is true.

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∴ Assume that result is true for $n-1$ i.e. ϕ_{n-1} exist s.t. $|\phi_{n-1} - \xi| \le b \quad \forall \; t \in [\tau, \tau+\alpha]$

So $f(s, \phi_{n-1}(s))$ defined and satisfies $|f(s, \phi_{n-1}(s))| \le M$

Now $$\phi_n(t) = \xi + \int_\tau^t f(s, \phi_{n-1}(s))\, ds$$

$$|\phi_n(t) - \xi| \le \int_\tau^t |f(s, \phi_{n-1}(s))|\, ds \le \int_\tau^t M\, dt$$

$$= M|t-\tau| \le M\alpha = M \cdot \frac{b}{M} \le b$$

Thus $\{\phi_n\}$ exist and have cont. derivative on $[\tau, \tau+\alpha]$

So $(t, \phi_n(t)) \in R$

$\Rightarrow f(t, \phi_n(t))$ is defined in this interval.

II (n) Again we use M.I. to prove

$$|\phi_n(t) - \phi_{n-1}(t)| \le \frac{M}{k} \frac{(k\alpha)^n}{n!}$$

Put $n=1$, $|\phi_1(t) - \phi_0(t)| \le M\alpha \le M \cdot \frac{b}{M} = b$

this result is true

let us suppose that result is true for $n-1$

$$|\phi_{n-1}(t) - \phi_{n-2}(t)| \le \frac{M}{k} \frac{(k\alpha)^{n-1}}{(n-1)!}$$

for n $\quad |\phi_n(t) - \phi_{n-1}(t)|$

$$= \left| \xi + \int_\tau^t f(s, \phi_{n-1}(s))\, ds - \xi - \int_\tau^t f(s, \phi_{n-2}(s))\, ds \right|$$

$$= \left| \int_\tau^t f(s, \phi_{n-1}(s))\, ds - \int_\tau^t f(s, \phi_{n-2}(s))\, ds \right|$$

using Lipschitz condition

$$|f(s, \phi_{n-1}(s)) - f(s, \phi_{n-2}(s))| \le k |\phi_{n-1}(s) - \phi_{n-2}(s)|$$

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So we have

$$|\phi_n(t) - \phi_{n-1}(t)| \le k \int_\tau^t |\phi_{n-1}(s) - \phi_{n-2}(s)|\, ds$$

using assumption

$$\le k \int_\tau^t \frac{M}{k} \frac{(k\alpha)^{n-1}}{(n-1)!}\, ds$$

$$\le \frac{M k^{n-1}}{(n-1)!} \int_\tau^t (s-\tau)^{n-1} ds$$

$$= \frac{M k^{n-1}}{(n-1)!} \cdot \frac{(t-\tau)^n}{n} = \frac{M(k\alpha)^n}{k\, n!}$$

(II) Convergence of $\{\phi_n\}$

Consider the series

$$\phi_p = \phi_0(t) + (\phi_1(t) - \phi_0(t)) + (\phi_2(t) - \phi_1(t)) + \cdots + (\phi_p(t) - \phi_{p-1}(t))$$

let ϕ_p be the partial sum of the series ($p = 1, 2, 3 \ldots$ put and add 2nd)

$$\therefore \phi_n(t) = \phi_0(t) + \sum_{p=1}^{\infty} (\phi_p(t) - \phi_{p-1}(t)) \quad \text{---(i)}$$

Now we have to show that the series in eq. (i) is cgt

$$|\phi_n(t)| = \left|\phi_0(t) + \sum_{p=1}^{\infty} (\phi_p(t) - \phi_{p-1}(t))\right|$$

$$\le |\phi_0(t)| + \sum_{p=1}^{\infty} |\phi_p(t) - \phi_{p-1}(t)|$$

from II step

$$\le |\xi_0| + \sum_{p=1}^{\infty} \frac{M}{k} \frac{(k\alpha)^p}{p!}$$

$\sum \frac{M}{p=0^k} \left(\frac{(k\alpha)^p}{p!} - \frac{M}{k}\right)$

$$\le |\xi_0| + \frac{M}{k}\left(\sum_{p=0}^{\infty} \frac{(k\alpha)^p}{p!} - 1\right)$$

$\frac{k\alpha}{1!} + \frac{(k\alpha)^2}{2!} + \cdots = 1$

$1 + \frac{k\alpha}{1!} + \frac{(k\alpha)^2}{2!} + \cdots = e^{k\alpha}$

$(e^{k\alpha} - 1)$

$$\le |\xi_0| + \frac{M}{k}(e^{k\alpha} - 1)$$

$\sum \frac{x^n}{n!}$

$1 + \frac{x}{1!} + \frac{x^2}{2!} + \cdots = e^x$

bounded sequence

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Right hand side of this series is U.C.

by W-M. Test $|\phi_n(t)|$ is uniformly convergent

$\leftarrow |\phi_n(t)|$ is absolutely cgt.

$\Rightarrow \phi_n(t)$ is cgt and converges uniformly on $[\tau, \tau+\alpha]$ on $\phi(t)$.

Step IV Estimate for ϕ converges ϕ [Diff. eq. solution]

Firstly we estimate $|\phi(t) - \phi_n(t)|$ Diff equation solution (ϕ_n)

Defining $\phi(t) = \xi + \sum_{p=1}^{\infty} [\phi_p(t) - \phi_{p-1}(t)]$

$\phi_n(t) = \xi + \sum_{p=1}^{n} [\phi_p(t) - \phi_{p-1}(t)]$ $|\phi(t) - \phi_n(t)| < \varepsilon$

n terms cancel

$$|\phi(t) - \phi_n(t)| = \sum_{p=n+1}^{\infty} |\phi_p(t) - \phi_{p-1}(t)| \leq \sum_{p=n+1}^{\infty} \frac{M}{K} \frac{(K\alpha)^p}{p!}$$

$$\leq \sum_{p=n+1}^{\infty} \frac{M}{K} \frac{(K(t-\tau))^p}{p!} \leq \frac{M}{K} \left[\frac{(K\alpha)^{n+1}}{(n+1)!} + \frac{(K\alpha)^{n+2}}{(n+2)!} + \cdots \right]$$

Comm

$$\leq \sum_{p\geq 1}^{\infty} \frac{M}{K} \frac{(K\alpha)^p}{p!} = \frac{M}{K} \frac{(K\alpha)^{n+1}}{(n+1)!} \sum_{n\geq 0}^{\infty} \frac{(K\alpha)^n}{n!}$$

$$\leq \frac{M}{K} \frac{(K\alpha)^{n+1}}{(n+1)!} \sum_{n\geq 0}^{\infty} \frac{(K\alpha)^n}{n!} \leq \frac{M}{K} \frac{(K\alpha)^{n+1}}{(n+1)!} e^{K\alpha}$$

$$\leq \frac{(K\alpha)^{n+1}}{(n+1)!} \left[1 + \frac{K\alpha}{n+1} + \frac{(K\alpha)^2}{(n+1)(n+2)} + \cdots \right]$$

$$\leq \frac{(K\alpha)^{n+1}}{(n+1)!} \left[1 + \frac{K\alpha}{1!} + \frac{(K\alpha)^2}{2!} + \cdots \right]$$

let $\varepsilon_n = \frac{M}{\alpha} \frac{(K\alpha)^{n+1}}{(n+1)!}$ $\Rightarrow |\phi(t) - \phi_n(t)| \leq \varepsilon_n e^{K\alpha} \to 0$ as $n \to \infty$

$\Rightarrow |\phi(t) - \phi_n(t)| \to 0$ as $n \to \infty$

$\phi_n(t) \Rightarrow \phi(t)$

$\frac{K\alpha}{n+1} < \frac{K\alpha}{1}$

$\frac{1}{1+2} < \frac{1}{2}$

Now $\phi(t) = \lim_{n\to\infty} \phi_n(t)$ → solution of Diff Eq $\phi\phi$

$$= \xi + \lim_{n\to\infty} \int_{\tau}^{t} f(s, \phi_{n-1}(s))\, ds$$

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Now we have to prove that

$$\lim_{n\to\infty} \int_\tau^t f(s, \phi_n(s))\,ds = \int_\tau^t f(s, \phi(s))\,ds$$

Consider $\left| \int_\tau^t f(s,\phi_n(s))\,ds - \int_\tau^t f(s,\phi(s))\,ds \right|$ $\quad f \in (r, \text{Lip.})$

$$\leq \int_\tau^t |f(s,\phi_n(s)) - f(s,\phi(s))|\,ds$$

$$\leq k \int_\tau^t |\phi_n(s) - \phi(s)|\,ds \quad \text{(by Lipschitz condition)}$$

$$\int \varepsilon_n e^{kx}\,dx$$

$$\leq k \int_\tau^t \varepsilon_n e^{k(s-\tau)}\,ds \qquad \frac{e^{k(s-\tau)}}{k}$$

$$\leq k\varepsilon_n \frac{1}{k}\left[e^{k(s-\tau)}\right]_\tau^t$$

$$\leq k \int_\tau^t \varepsilon_n e^{k(s-\tau)}\,ds$$

$$\leq \varepsilon_n (e^{k(t-\tau)} - 1)$$

$$\leq \varepsilon_n \left[e^{k(t-\tau)}\right]_\tau^t = \varepsilon_n \left[e^{k(t-\tau)} - 1\right]$$

$$\leq \varepsilon_n e^{k(t-\tau)} \to 0 \quad \text{as } n \to \infty$$

So $\lim_{n\to\infty} \int_\tau^t f(s,\phi(s))\,ds = \int_\tau^t f(s,\phi_n(s))\,ds$

Also we have $\phi_{n+1} = \xi + \int_\tau^t f(s,\phi_n(s))\,ds$

Taking limit $n\to\infty$ both sides

$$\lim_{n\to\infty} \phi_{n+1} = \xi + \lim_{n\to\infty} \int_\tau^t f(s,\phi_n(s))\,ds$$

$$\Rightarrow \quad \phi(t) = \xi + \int_\tau^t f(s,\phi(s))\,ds$$

$\Rightarrow$ $\phi(t)$ is a solution of $\frac{dx}{dt} = f(t,x)$

Step V Uniqueness: We assume that ψ is another diff. eq. defined on $[\tau, \tau+\alpha]$ s.t.

Two solutions of 2 equal theorems

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$\frac{d\varphi}{dt} = f(t, \varphi(t))$ s.t. $\varphi(\tau) = \xi$ from (I) part

Then steady assume $|\varphi(t) - \xi| \le b$ on $[\tau, \tau+\alpha]$

Suppose $\nexists\ t_1$ s.t. $|\varphi(t_1) - \xi| = b$ Suppose $t_1 < \tau + \alpha$

and using Mean value Thm $\exists M_1$ s.t. $\tau \le t_1 \le \tau + \alpha$

$M_1 = |\varphi'(x)| = \left| \frac{\varphi(t_1) - \xi}{t_1 - \tau} \right| \quad \frac{f(b)-f(a)}{b-a}$, t_1 a point $|t_1 - \tau| \le \alpha$

$\therefore \varphi' \uparrow, \varphi \uparrow \Rightarrow \ge \frac{b}{\alpha} \quad \alpha = \min\left[a, \frac{b}{M}\right] \quad \frac{1}{|t_1 - \tau|} \ge \frac{1}{\alpha}$

$M_1 \ge M$

and $M_1 = |\varphi'(x)| = |f(x, \varphi(x))| \le M$

$M_1 \le M_0$ which is contradiction.

$\Rightarrow (t, \varphi(t)) \in R$ and $\tau + \alpha \le t_1$

$\therefore \varphi(t)$ is sol. of the IVP.

$\therefore \varphi(t) = \xi + \int_\tau^t f(s, \varphi(s))\, ds \quad -(1)$

Now suppose the seq. $\phi_1, \phi_2, \dots, \phi_n$ be s.t.

$\phi_n(t) = \xi + \int_\tau^t f(s, \phi_{n-1}(s))\, ds \quad (2)$

Now we have to show that $|\varphi(t) - \phi_n(t)| \le \frac{(k\alpha)^n b}{n!}$

we will prove this by M.I. for $n \ge 0$

$|\varphi(t) - \xi| \le b = b\frac{(k\alpha)^0}{0!} = b \le b$

$\varphi(t)$

the result is true for $n = 0$

let it be true for $n-1$

$\therefore |\varphi(t) - \phi_{n-1}(t)| \le b\frac{(k\alpha)^{n-1}}{(n-1)!}$ from (1) & (2).

Now $|\varphi(t) - \phi_n(t)| = \left| \int_\tau^t f(s, \varphi(s))\, ds - \int_\tau^t f(s, \phi_{n-1}(s))\, ds \right|$

$\le \left| \int_\tau^t k\, |\varphi(s) - \phi_{n-1}(s)|\, ds \right| \le k \left| \int_\tau^t f(s, \phi_{n-1}(s))\, ds \right|$

$$\leq \int_\tau^t |f(s,\psi(s)) - f(s,\phi_{n-1}(s))|\,ds$$

$f \in C(\bar{C}, Up)$

$$\leq k \int_\tau^t |\psi(s) - \phi_{n-1}(s)|\,ds \Rightarrow \leq k \int_\tau^t \frac{k(t-\tau)}{(n-1)!}\,dt$$

$$\leq k \int_\tau^t \frac{b\,k^{n-1}\alpha^{n-1}}{(n-1)!}\,ds = k \int_\tau^t \left(\frac{b\,k^{n-1}(s-\tau)^{n-1}}{(n-1)!}\,ds \right.$$

$$= k^n b \frac{(t-\tau)^n}{n!} = \frac{b(k\alpha)^n}{n!} \leq \frac{k^n b}{n!}\alpha^n \leq \frac{(k\alpha)^n}{n!} b \to 0 \text{ as } n \to \infty$$

$$|\psi(t) - \phi_n(t)| \leq \frac{b(k\alpha)^n}{n!} \to 0 \quad \text{as } n \to \infty$$

$$\lim_{n\to\infty} \phi_n(t) = \psi(t) \quad \text{on } |t-\tau| \leq \alpha$$

$$\text{but } \lim_{n\to\infty} \phi_n(t) = \phi(t) \quad \text{on } |t-\tau| \leq \alpha$$

$$\Rightarrow \psi(t) = \phi(t) \quad \text{on } |t-\tau| \leq \alpha$$

So the solution is unique.

Continuation of solutions:

Ex: Discuss the existence and uniqueness of solution of the initial value problem.

$$\frac{dy}{dx} = y^{1/3}, \quad y(0) = 0$$

Sol: Here $f(x,y) = y^{1/3}$, $x_0 = 0$, $y_0 = 0$

The function $f(x,y) = y^{1/3}$ is cont. at $R: |x| \leq a, |y| \leq b$ about the origin.

$\therefore$ $\exists$ at least one sol of $\frac{dy}{dx} = y^{1/3}$ on $|x-a| \leq \alpha$ $|x| \leq h$ where h is +ve and s.t. $y(0) = 0$

So existence of a sol. is assured.

Now we have to examine the uniqueness. If f

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satisfie a Lipschitz condition on R; then by existence and Uniqueness thm, Uniqueness is also proved.

Now $\left|\frac{f(x,y_2)-f(x,y_1)}{|y_2-y_1|}\right| = \left|\frac{y_2^{1/3}-y_1^{1/3}}{|y_2-y_1|}\right|$

let $y_1 = -\delta$, $y_2 = \delta$. $\quad y_2=\delta,\ y=0 \ \left|\frac{\delta^{1/3}}{\delta}\right| = \frac{1}{\delta^{2/3}}$ as $\delta \to 0$

so $\left|\frac{f(x,y_2)-f(x,y_1)}{y_2-y_1}\right| = \left|\frac{\delta^{1/3}-(-\delta)^{1/3}}{\delta-(-\delta)}\right| = \frac{1}{\delta^{2/3}} \to \infty$ as $\delta \to 0$

$\therefore$ f doesn't satisfy a Lip. condition w.r.t. y throughout any domain containing $y=0$

So we can't apply existence and uniqueness thm to obtain a solution.

Remark: Notice that thm 3.1 is both an existence and Uniqueness thm. It tells us that

If f is cont. and f satisfies a Lip. Condition on rectangle R.

then there exist a sol. ϕ of $\frac{dy}{dx} = f(x,y)$ defined on $|x-x_0| \le h$ s.t. $\phi(x_0) = y_0$

and this sol. ϕ is the unique sol.

2. Ex: Discuss the existence and Uniqueness of the sol. of the initial value problem

$$\frac{dy}{dx} = y^{4/3}, \quad y(x_0) = y_0$$

3. Ex: Examine the existence and uniqueness of the sol. of the initial value problem

$$\frac{dy}{dx} = \sqrt{|y|}, \quad y(0) = 0$$

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Sol:- Here $f(x,y) = \sqrt{|y|}$ $x_0 = 0$, $y_0 = 0$

$\therefore$ $f(x,y)$ is cont. in any finite domain D of xy-plane

Consider the rectangle $R: |x| \le a, |y| \le b$

So $f(x,y)$ is cont. for all $(x,y) \in R$

Thus $\exists$ at least one sol of the given problem

Now $\left| \dfrac{f(x,y_1) - f(x,y_2)}{y_1 - y_2} \right| \le k$

let $y_1 = \delta$ and $y_2 = 0$

So we have $\dfrac{\sqrt{\delta}}{\delta} \le k \Rightarrow \dfrac{1}{\delta^{1/2}} \le k$

which can't be satisfy as it is unbounded when $\delta \to 0$ So $f(x,y)$ doesn't satisfy the Lips. condition.

Ex:- Examine the existence and uniqueness of the sol. of the initial value problem

$$\frac{dy}{dx} = y^2, \quad y(1) = -1$$

Sol:- $f(x,y) = y^2$, $x_0 = 1$, $y_0 = -1$

Here $f(x,y)$ is cont. for all.

we consider the rectangle $R: |x-1| \le a, |y+1| \le b$

In this rectangle, we have

$$|f(x,y_2) - f(x,y_1)| = |y_2^2 - y_1^2| = |y_2 - y_1||y_2 + y_1|$$

$$\le 2b|y_2 + y_1|$$

$\left| \dfrac{y_2^2 - y_1^2}{y_2 - y_1} \right|$ This Lip. condition is satisfied in R.

$\left| \dfrac{(y_2 - y_1)(y_2 + y_1)}{(y_2 - y_1)} \right|$ let $M = \max |f(x,y)|$ and $h = \min\left(a, \dfrac{b}{M}\right)$

$= |y_2 + y_1|$

$\le 2b$

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$|y+(-1)| \le b$ $|y-(-1)| \le b$ $|y+1| \le b$ If $|y|+|1| \le b$
$|y|-|-1| \le b$ $|y| \le b-1$
$y \le b+1$

... So the given problem has a unique sol. for $|x-1| \le h$

$M = \max |f(x,y)| = \max |y^2| = |(-1-b)^2| = (1+b)^2$

$h = \min\left(a, \frac{b}{M}\right) = \left(a, \frac{b}{(1+b)^2}\right)$

let $\phi(b) = \frac{b}{(1+b)^2} \Rightarrow \phi'(b) = \frac{1-b}{(1+b)^3}$, $\phi''(b) = \frac{2b-4}{(1+b)^4}$

for max or min of $\phi(b)$ put $\phi'(b) = 0$

then $b = 1$ and $\phi''(b) < 0$

and max of $\phi(b) = \phi(1) = \frac{1}{4}$

Then if $a \ge \frac{1}{4}$, $\phi(b) = \frac{b}{(1+b)^2} \le a$

So $h = \frac{b}{(1+b)^2} \le \frac{1}{4}$

and if $a < \frac{1}{4}$ then $h < \frac{1}{4}$

max $\frac{b}{(1+b)^2}$ is $\frac{1}{4}$ so we have $h \le \frac{1}{4}$

for $b = 1$, $a \ge \frac{1}{4}$

$h = \min\left[a, \frac{b}{(1+b)^2}\right] = \min\left[a, \frac{1}{4}\right] = \frac{1}{4}$

$\Rightarrow h \le \frac{1}{4}$

Hence the given problem has a unique sol. when $|x-1| \le \frac{1}{4}$

$-\frac{1}{4} \le x-1 \le \frac{1}{4}$

$\frac{3}{4} \le x \le \frac{5}{4}$

Ex: $\frac{dy}{dx} = \frac{y}{\sqrt{x}}$, $y(1) = 2$

Sol: Here $f(x,y) = \frac{y}{\sqrt{x}}$ is cont. everywhere except for $x = 0$.

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Consider $R = |x-1| \le \frac{1}{2}$ and $|y-2| \le \frac{1}{2}$

So that $f(x,y)$ is cont. for all $(x,y) \in R$

Thus $\exists$ at least one sol. of the given problem in a small neighbourhood of $x=1$

Also $\frac{\partial f}{\partial y} = \frac{1}{\sqrt{x}}$ and $\left|\frac{\partial f}{\partial y}\right| \le \sqrt{2}$ $\because \frac{1}{\sqrt{2}} = \sqrt{.}$

$\therefore$ The Up. condition is satisfied by $f(x,y)$

Also $a = b = \frac{1}{2}$, and $M = \max |f(x,y)| = \sqrt{2}$

$\therefore h = \min\left(a, \frac{b}{M}\right) = \left(\frac{1}{2}, \frac{1}{2\sqrt{2}}\right) = \frac{1}{2}$

Thus, there exist a unique sol. of the given problem on $|x-1| \le \frac{1}{2}$

6. Ex: Examine the existence of the sol. of the problem $(x^2-x-6)\frac{d^2y}{dx^2} + (x^2+4)\frac{dy}{dx} + \frac{1}{2x+3}y = e^{-x}$

$y(2) = 0, \; y'(2) = 4$

If it exists, is it unique and over what interval

Sol: In the given problem, the coeff of y is cont except at $x = \frac{3}{2}$ and all other coeff. are cont. for all real values of x

Now $x^2 - x - 6 = 0 \Rightarrow x = -2, 3$

This $f(x)$ is cont. in every closed interval $a \le x \le b$ s.t. $\frac{3}{2} < a < x = 2 < b < 3$

$\therefore$ The given IVP has a unique sol. and this sol. is defined over every such closed interval $a < x < b$.

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Continuation of solutions :- Suppose that $f \in C$ in some Domain D of the (t,x) plane and $x' = f(t,x)$ has a solution ϕ which exist on a finite interval (a,b) and passes through some pt. $(\tau, \xi) \in D$ and $a < \tau < b$. If $|f|$ is bounded by some constant $M < \infty$ on D then it is easy to see that both the limits

$$\phi(a+0) = \lim_{t \to a+0} \phi(t), \qquad \phi(b-0) = \lim_{t \to b-0} \phi(t)$$

exist. Also $\phi(t) = \xi + \int_{\tau}^{t} f(s, \phi(s))\, ds$

if $a < t_1 < t_2 < b$

$$|\phi(t_1) - \phi(t_2)| \leq \left| \int_{\tau}^{t_2} f(s,\phi(s))\, ds - \int_{\tau}^{t_1} f(s,\phi(s))\, ds \right|$$

$$\leq \int_{t_1}^{t_2} |f(s,\phi(s))|\, ds \leq M(t_2 - t_1)$$

Thus as t_1 and $t_2 \to a+0$, $\phi(t_1) - \phi(t_2) \to 0$ which implies by the cauchy criterion for convergence that $\phi(a+0)$ exist. Similarly $\phi(b-0)$ exist. Suppose that the point $(b, \phi(b-0))$ is in D. If $\bar{\phi}$ is the function defined by

$$\bar{\phi}(t) = \phi(t) \quad \forall\ t \in (a,b)$$

$$\bar{\phi}(t) = \phi(b-0) \quad \text{if } t = b$$

then $\bar{\phi}$ is a sol. of $x' = f(t,x)$ of class C^1 on $(a,b]$

So $\bar{\phi}(t) = \xi + \int_{\tau}^{t} f(s, \bar{\phi}(s))\, ds \quad \forall\ t \in (a,$

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which implies that the left hand derivative ϕ'_- of ϕ at b exist.

$\therefore \phi'_-(b) = \phi'(b-0) = f(b, \phi(b))$

The function $\bar{\phi}$ is called a continuation of the sol. ϕ to $(a, b]$.

Note:- The eq. $x' = x^2$ has a sol. $\phi(t) = -\frac{1}{t}$ which passes through $(-1, 1)$ which exist on $(-1, 0)$ but can't be continued to $(-1, 0]$. So ϕ doesn't exist in a region D.

Thm 4.1 let $f \in C$ in a Domain D of the (t,x) plane and suppose f is bounded. If ϕ is a solution of eq. $x' = f(t,x)$ on (a, b) then the limits $\phi(a+0)$ and $\phi(b-0)$ exist. If $(a, \phi(a+0))$ or $(b, \phi(b-0))$ in D, then the sol. ϕ may be continued to the left of a (or to the right of b).

Proof:- ϕ is a sol. of $x' = f(t,x)$ on (a,b) then it will satisfy the integral equation

$\phi(t) = \xi + \int_\tau^t f(s, \phi(s))\,ds$ and ϕ passes through a pt. $(\tau, \xi) \in D$ s.t. $\phi(\tau) = \xi$ also $\phi \in C(D)$.

~~as ϕ is diff on (a,b)~~

So it is easy to see that both limits

$\phi(a+0) = \lim_{t \to a^+} \phi(t)$ and

$\phi(b-0) = \lim_{t \to b^-} \phi(t)$ exist. [$\because \phi$ is cont.

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Take $a < t_1 < t_2 < b$

$$|\phi(t_2) - \phi(t_1)| = \left| \xi + \int_{\tau}^{t_2} f(s, \phi(s))\,ds - \xi - \int_{\tau}^{t_1} f(s, \phi(s))\,ds \right|$$

$$= \left| \int_{t_1}^{t_2} f(s, \phi(s))\,ds + \int_{\tau}^{t_1} f(s, \phi(s))\,ds - \int_{\tau}^{t_1} f(s, \phi(s))\,ds \right|$$

$$= \left| \int_{t_1}^{t_2} f(s, \phi(s))\,ds \right| \leq \int_{t_1}^{t_2} |f(s, \phi(s))|\,ds$$

$$\leq M(t_2 - t_1) \to 0 \quad \text{as } t_1 \to a^+,\ t_2 \to a^+$$

$\Rightarrow \phi(t_2) - \phi(t_1) \to 0$

So by cauchy criterion for convergence $\phi(a+0)$ exist

Illy $\phi(b-0)$ exist

given $(b, \phi(b-0)) \in D$

Define $\bar{\phi}(t)$ on $(a, b]$ when we extend the interval from b to forward.

$$\bar{\phi}(t) = \begin{cases} \phi(t) & \text{if } a < t < b \\ \phi(b-0) & \text{if } t = b \text{ or } t \in (a, b] \end{cases}$$

we will show that $\bar{\phi}(t)$ will be a sol of $x' = f(t, x)$ we have to prove it will satisfy the integral eq.

Case I: when $a < t < b$ then $\bar{\phi}(t) = \phi(t)$ and $\phi(t)$ is already a sol. of $x' = f(t, x)$ on (a, b) so $\bar{\phi}(t)$ will be.

Case II:- when $t = b$

then $\bar{\phi}(t) = \phi(b-0) = \xi + \int_{\tau}^{t} f(s, \bar{\phi}(s))\,ds$

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$\Rightarrow \phi(t) = \xi + \int_{\tau}^{b} f(s, \phi(s))\, ds$

$\therefore$ Left hand derivative exist of ϕ i.e. ϕ' exist at $(b-0)$ s.t

$\phi'(b) = \phi'(b-0) = f(b, \phi(b))$

from (i) it is clear that at $t = b$ also it will satisfy the integral equation and $\phi(t) \in C^1$ and ϕ is a solution of $x' = f(t,x)$ on $(a,b]$ so ϕ is called continuation of sol. ϕ to $(a,b]$.

Actually the process can be carried further by the eqn. $x' = f(t,x)$ has sol.

$\psi \in C^1$ on $[b, b+\beta]$; $\beta > 0$

i.e. $\phi \in C^1$ on (a,b) has sol. $\phi \in C^1$ on $(a,b]$

$\psi \in C^1$ on $[b, b+\beta]$

Define $\hat{\phi}(t)$ on $(a, b+\beta]$

$$\hat{\phi}(t) = \begin{cases} \phi(t) & \text{if } t \in (a,b] \\ \psi(t) & \text{if } t \in [b, b+\beta] \end{cases}$$

Case I. when $t \in (a,b]$

then $\hat{\phi}(t) = \phi(t)$

$\phi(t)$ is sol. on $(a,b]$ so $\hat{\phi}(t)$ is also a sol. of $x' = f(t,x)$

Case II :- $t > b$ it follows from def of $\hat{\phi}(t)$

$\hat{\phi}(t) = \phi(b-0) + \int_{b}^{t} f(s, \hat{\phi}(s))\, ds$

$\because \psi$ passes through $[b, \phi(b-0)]$

so $\hat{\phi}(t) = \psi(t)$: $\psi(b) = \phi(b-0) = \xi$

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But $\varphi(t) = \phi(b-0) + \int_b^t f(s, \varphi(s))\,ds$

as $\hat{\phi}(t) = \varphi(t) = \phi(b-0) + \int_b^t f(s, \varphi(s))\,ds$

$\therefore \hat{\phi}(t) = \phi(b-0) + \int_b^t f(s, \hat{\phi}(s))\,ds$ $\quad \varphi(s) = \phi(s)$ $\forall t > b$

Hence $\hat{\phi}(t)$ satisfy integral eqn when $t > b$

So by combining both cases

$\hat{\phi}'(t) = f(t, \hat{\phi}(t)) \quad \forall \; t \in (a, b+\beta]$.

So $\hat{\phi}(t)$ is a sol. of $x' = f(t,x)$

$\hat{\phi}(t)$ is called the continuation of ϕ on $(a, b+\beta]$.

also continuation of sol. for the left in $t \in [a-\beta, b)$.

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Proof of (iv) → Since each $\phi_n(t)$ satisfies $|\phi_n(t) - \phi_0(t)| \le b$ also $|\phi(t) - \phi_0| \le b$ on $[\tau, \tau+\alpha]$

Thus $f(s, \phi(s))$ defined

by lip. condition, we have

$|f(t,\phi(t)) - f(t,\phi_n(t))| \le K |\phi_0(t) - \phi_n(t)|$

But $K|\phi(t) - \phi_n(t)| < K\left(\frac{\epsilon}{K}\right) \le \epsilon$ as $\phi_n(t) \to \phi(t)$ as $n \to \infty$

for all $n \in N$

as the seq. $\phi_n(t) \to \phi(t)$

Hence the seq. of functions $|f(t, \phi_n(t))|$ defined for $n = 1, 2, 3, \ldots$ converges uniformly to a function defined by $f(t, \phi(t))$ on $x \in [\tau, \tau+\alpha]$

Also $f(t, \phi_n(t))$ is continuous on this interval

Therefore $\lim_{n\to\infty} \phi_{n+1}(t) = \xi + \lim_{n\to\infty} \int_\tau^t f(t, \phi_n(t))\,dt$

$$= \xi + \int_\tau^t \lim_{n\to\infty} |f(t, \phi_n(t))|\,dt$$

$$\phi(t) = \xi + \int_\tau^t f(t, \phi(t))\,dt$$

so $\phi(t)$ satisfies the diff. eq

$x' = f(t, x)$ on $[\tau, \tau+\alpha]$

$s.t.\ \phi(\tau) = \xi$

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System of Diff. equations:-

Def: System of an ordinary diff. eq. of 1st order. Suppose n is +ve integer and $f_1, f_2 \cdots f_n$ are real cont. function defined on some domain D of the real $(t, x_1, x_2 \cdots x_n)$ space.

Now to find n diff. functions $\phi_1, \phi_2 \cdots \phi_n$ defined on a real t interval I such that

(i) $(t, \phi_1(t), \cdots \phi_n(t)) \in D \quad \forall\ t \in I$

(ii) $\phi_i'(t) = f_i(t, \phi_1(t) \cdots \phi_n(t))$

This problem is called a system of n ordinary diff. eq. of the 1st order and is denoted by

$$x_i' = f_i(t, x_1, \cdots x_n) \quad \forall\ i = 1, 2 \cdots n$$

If such an interval I and functions $(\phi_1, \phi_2 \cdots \phi_n)$ exist then the set of functions $(\phi_1, \phi_2 \cdots \phi_n)$ is called a solution of $x_i' = f_i(t, x_1, \cdots x_n)$ on I.

Now let $(\tau, \xi_1, \cdots \xi_n) \in D$. Then the initial value problem consists of finding a sol. $(\phi_1, \cdots \phi_n)$ of $x_i' = f(t, x_1, \cdots x_n)$ on I containing τ s.t. $\phi_i(\tau) = \xi_i$. Let X denote the n-dimensional space with pts x having co-ordinates $(x_1, \cdots x_n)$. Then the functions f_i defined on the $(t, x_1, \cdots x_n)$ space give rise to the function $\tilde{f}_i$ on the (t, x) space defined by $\tilde{f}_i(t, x) = f_i(t, x_1, \cdots x_n)$.

Also associated with any pt x in the x space is the one-column matrix

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$\hat{x} = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}$ called the vector associated with x

x_i is called the ith component of $\hat{x}$

Clearly f_i defines a function $\hat{f}_i$ of t and vector $\hat{x}$ by

$$\hat{f}_i(t, \hat{x}) = f_i(t, x)$$

Associated with the pt. (t, x) in the (t, x) space one has the vector $\hat{f}(t, \hat{x}) = \begin{pmatrix} f_1(t,x) \\ f_2(t,x) \\ \vdots \\ f_n(t,x) \end{pmatrix}$ and this gives rise to a vector $\hat{f}(t, \hat{x})$ defined by $\hat{f}(t, \hat{x}) = \begin{pmatrix} \hat{f}_1(t, \hat{x}) \\ \vdots \\ \hat{f}_n(t, \hat{x}) \end{pmatrix}$

If the x_i are diff. functions of t, then $\hat{x}'$, the der. of $\hat{x}$, is defined by $\hat{x}' = \begin{pmatrix} x_1' \\ \vdots \\ x_n' \end{pmatrix}$

Then the eq. $x_i' = f_i(t, x_1 \dots x_n)$ may be written as

$$\hat{x}' = \hat{f}(t, \hat{x})$$

so the diff. eq. $x_i' = f_i(t, x_1 \dots x_n)$ may be written as $x' = f(t, x)$ where

$$x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \text{ and } f(t, x) = \begin{bmatrix} f_1(t, x) \\ f_2(t, x) \\ \vdots \\ f_n(t, x) \end{bmatrix}$$

So the sol. of diff. eq. on I interval becomes a vector function ϕ with component $\phi_1, \phi_2 \dots \phi_n$ defined on I satisfying

(i) $(t, \phi(t)) = (t, \phi_1(t), \phi_2(t) \dots \phi_n(t)) \in D$

(ii) $\phi'(t) = f(t, \phi(t))$; $t \in I$

Note: (i) $\|\ \|$ → is called norm and it is used diff

$|\ |$ → is called mode and it is used for Integral

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Inventory Control

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Inventory:- It consists of usable but idle resources. It contains material or goods. It is also known as 'stock'. It is almost essential to maintain some inventory for the smooth functioning of an enterprise.

It is viewed as necessary evils as too little of it causes costly interruptions and too much of it results in idle capital.

Forms:- It may be of following forms:-

i) **Raw material inventory:-** It contains raw material which is ~~used~~ kept for using in the production of goods.

ii) **Work in process Inventory:-** It contains semi finished goods or goods which are ready to use in further process.

iii) **Finished good inventory:-** It contains the items that are finished and (ready) waiting for shipment from the factory.

Categories:- It is divided in two categories:-

i) **Direct inventory:-** which are directly used to do production, are termed in direct inventories

i) **Raw material:-** reasons

i) for economical bulk purchasing

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iii) to enable rate changes
iii) to prevent delay.
iv) for seasonal fluctuations

b) Work-in-process :=
i) to enable economical lot production
ii) for replacement of wastages
iii) to maintain uniform production even if amount of sales may vary.

c) Finished goods := i) to promote products
ii) to allow stablization of production level

d) Spare parts

ii) Indirect Inventories := It contains the items that are necessary but are not the compotenent of finished goods. for ex. oil, grease, petrol etc.

Types :=
i) Movement := These are arise due to shipment of inventory items to distribution centres and from various production centres. The amount of this inventory depends upon the time consumed in transportation and nature of demand. e.g. := coal, when transhipped can't provide any service

ii) Buffer := These are maintained to meet the uncertainities of demand and supply. These 'buffer' inventories are to meet the demand

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during lead time when for protection against fluctuations in demand. It is known as safety stock

iii) Anticipation:= These are known as seasonal inventories. These are held for future demands for the product is anticipated e.g. demand of crackers before Diwali.
This is done to smooth the production process for a longer duration on a continuous scale rather than operating with excessive overtime in one period and let the system to be idle in another period.

Three types of costs are associated in inventory:
i) Holding Cost (C_1) := It is denoted by C_1.
It is the cost which is reqd. to hold the inventory.
for ex. ⇒ to keep raw material, we need space, to holding cost contain rent of that space & similarly other things as interest on money, insurance of stored equipment, taxes and depreciation of equipment

ii) Shortage Cost (C_2) := denoted by C_2.
It is the penalty cost for running out of the stock. It includes permanent loss of customers and its associated lost profit in future sales.

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iii) Set-up Cost (C_2):= It is the cost of setting up the machinery before starting production. It is generally independent of quantity ordered for or produced as it contains necessary items whether you produced no items or so many units and so many

Factors:=

i) Demand:= The no. of units required in a period is called demand. It may be deterministic or probabilistic.

ii) Lead time:= The time gap between placing an order and its actual arrival in inventory. It contains two components:
I administrative lead time ⇒ from initiation of procurement action until placing an order
II delivery lead time ⇒ placing an order until delivery of ordered material.

iii) Order Cycle:= The time period b/w two successive orders is referred as an order cycle. The order may be placed in two types of inventory review:
I Continuous Review:= The record of inventory is checked cont. until a specified point, called reorder level, is reached, where we place a new order. It is referred to as two bin system. Inventory is divided in two parts and places in two bins (physically or on paper). Items

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are drawn from one bin and when it is empty, order is placed. Demand in this lead time is satisfied with second bin. Again we repeat this process.

2) Periodic Review :- In this system, inventory levels are viewed at fixed time intervals and orders are placed at such intervals. Quantity ordered each time depends on the inventory level at the time of review.

* Re-order level :- The level b/w max. and min. stock, at which purchasing activities must start.

* Reasons for carrying inventories :-

i) to ensure of an adequate supply of items to customers and avoid shortage
ii) To reduce the risk of loss due to the changes in price of items stocked at the time of making stock.
iii) to take advantage of quantity discount on bulk purchases.
iv) To carry buffer stocks in case of delayed deliveries
v) To help minimizing the loss.
vi) To use available capital, ~~the~~ storage space.

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x The Inventory Decisions:- The two most important questions occur about the inventory :=

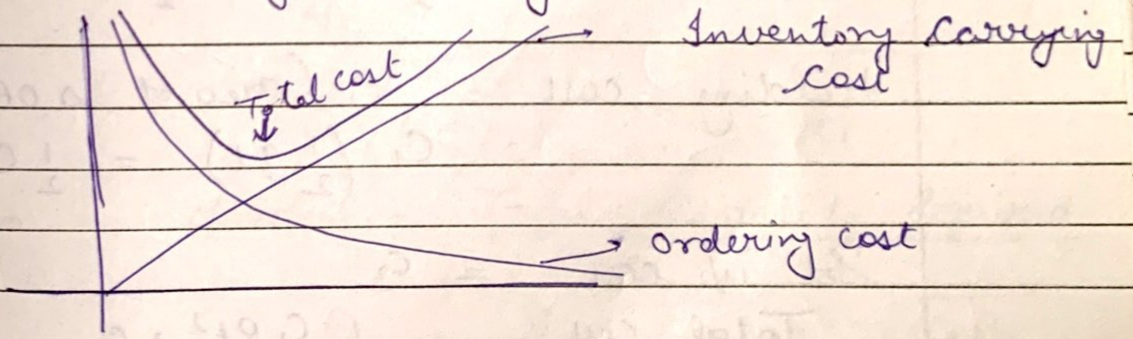
i) How much to order? optimum quantity of an item to be orderd.

ii) When should the order be placed?

The answer of first question is EOQ (Economic order Quantity) which we ~~have~~ set to minimize the total cost

The second answer depends upon the system that we are using cont or periodic system.

EOQ :- By the order quantity, we mean the quantity procured during one period or one production cycle. When the size of order increases, the ordering cost decrease and ~~when size of~~ order holding cost will increase and vice versa. So, in this we have two opposite cost, one encourage increase in order size and other discourage. EOQ is the size of order which minimize total annual cost of carring inventory and order cost.



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Model I (a) Wilson Haris Model

(EOQ Model with no shortage) Uniform

Assumptions: i) Demand is uniform at a rate of R units per unit time.

ii) Lead time is zero.

iii) Production rate is infinite.

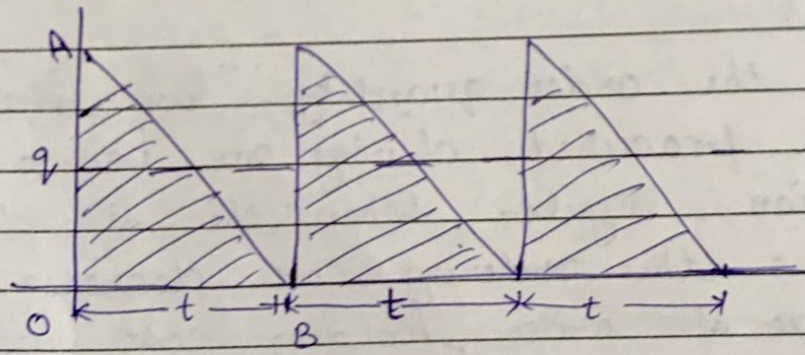
iv) Shortage costs are not allowed.

v) Holding cost is C_1 per quantity

vi) Set up cost is C_3 per set-up

Let each production cycle be made at fixed interval 't', therefore, the quantity q already present in the beginning is:

$q = Rt$



Average inventory

Since the stock in small time dt is $Rt\,dt$ ∴ for time 't' we get:-

$$\int_0^t Rt\,dt = \frac{Rt^2}{2}\Big|_0^t$$

$$= \frac{Rt^2}{2} = \frac{(Rt)t}{2} = \frac{1}{2}qt$$

Holding cost = C_1 (area of $\triangle OAB$)

$$= C_1\left(\frac{1}{2}qt\right) = \frac{1}{2}C_1(Rt^2)$$

Set up cost = C_3

∴ Total Cost = $\frac{1}{2}C_1Rt^2 + C_3$

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A(t) Avg. cost = $\frac{\text{Total cost}}{t}$

$$\frac{1}{2} C_1 R t + \frac{C_3}{t}$$

To min Avg. cost $A(t)$ let $\frac{d}{dt} A(t) = 0$

$$\frac{d}{dt}(A(t)) = \frac{1}{2} C_1 R - \frac{C_3}{t^2}$$

$$\Rightarrow \frac{1}{2} C_1 R - \frac{C_3}{t^2} = 0$$

$$\frac{C_3}{t^2} = \frac{1}{2} C_1 R$$

$$t^2 = \frac{2 C_3}{C_1 R} \qquad t = \sqrt{\frac{2 C_3}{C_1 R}}$$

Now $\frac{d^2}{dt^2} A(t) = \frac{2 C_3}{t^3} > 0$

$\therefore$ at $t = \sqrt{\frac{2 C_3}{C_1 R}}$ we get min. value

$\therefore$ Avg. min. cost is $= \frac{1}{2} C R \sqrt{\frac{2 C_3}{C_1 R}} + C_3 \sqrt{\frac{C_1 R}{2 C_3}}$

$$= \frac{1}{2} \sqrt{2 C_3 C_1 R} \sqrt{\frac{C_1 C_3 R}{2}} + \sqrt{\frac{C_1 C_3 R}{2}}$$

$$= 2 \sqrt{\frac{C_1 C_3 R}{2}} = \sqrt{2 C_1 C_3 R}$$

EOQ & $q = Rt = R \sqrt{\frac{2 C_3}{C_1 R}} = \sqrt{\frac{2 C_3 R}{C_1}}$

optimum no. of orders = $\frac{\text{Total Quantity Required}}{EOQ}$

$$= \frac{R}{q} = \frac{R \sqrt{C_1}}{\sqrt{2 C_3 R}} = \sqrt{\frac{C_1 R}{2 C_3}}$$

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* Optimum length of time b/w orders t = $\frac{\text{Total time period}}{\text{No. of orders}}$.

Cor:- In this problem, if the set-up cost is $C_3 + bq$ instead of being fixed. Show that there is no change in EOQ due to change in set-up cost.

Ans:- Here we get;

$$TC = \frac{1}{2} C_1 R t^2 + C_3 + bq$$

$$AC = \frac{1}{2} C_1 R t + \frac{C_3 + bq}{t} =$$

$$\frac{d}{dt} AC = 0 \Rightarrow \frac{1}{2} C_1 R - \frac{(C_3 + bq)}{t^2} = 0$$

$$\frac{1}{2} C_1 R t + \frac{C_3 + bRt}{t}$$

$$\frac{1}{2} C_1 R t + \frac{C_3}{t} + bR$$

$$\frac{d}{dt} AC = 0 \Rightarrow \frac{1}{2} C_1 R - \frac{C_3}{t^2} = 0$$

$$\Rightarrow t = \sqrt{\frac{2C_3}{C_1 R}}$$

$$q = Rt = R\sqrt{\frac{2C_3}{C_1 R}} = \sqrt{\frac{2C_3 R}{C_1}}$$

which is same as in model. So, it doesn't change.

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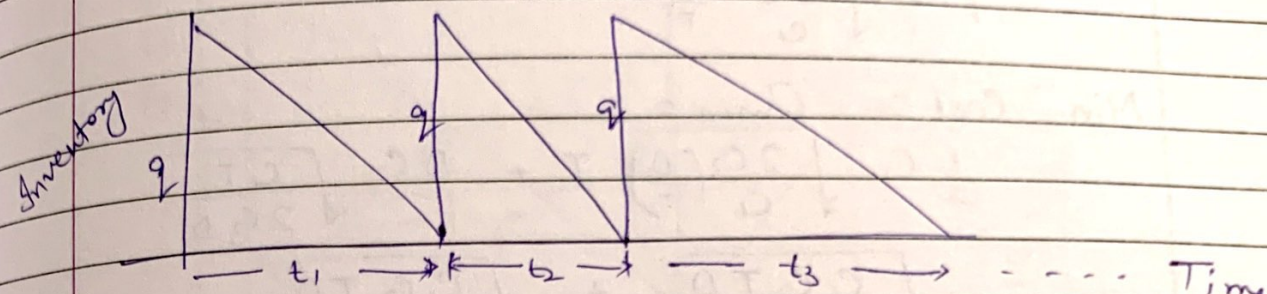
Model I (b)

* EOQ with several production runs of unequal length.

This model is same as (a) but here the demand rate is diff in diff cycles.



Let q denote the fixed quantity produced in each cycle. Let D is the total Demand over the entire period T.

Then no. of production cycles will be $n = \frac{D}{q}$

&

$T = t_1 + t_2 + \dots + t_n$, where $t_1, t_2, \dots$ t_n are successive production runs.

Holding cost $\Rightarrow C_1\left[\frac{1}{2} q t_1 + \frac{1}{2} q t_2 + \dots + \frac{1}{2} q t_n\right]$

$= \frac{1}{2} q C_1 T$

Set up cost $= \frac{D}{q} C_3$

Total cost $= \frac{1}{2} q C_1 T + \frac{D}{q} C_3$

~~Avg. cost~~ We've to min Total cost :-

$\therefore \frac{d}{dq} TC = 0$

$\frac{1}{2} C_1 T - \frac{D}{q^2} C_3 = 0$

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$$\frac{1}{2} C_1 T = \frac{D}{q^2} C_3$$

$$q^2 = \frac{2DC_3}{C_1 T}$$

$$q = \sqrt{\frac{2C_3}{C_1} \frac{D}{T}}$$

Min. Cost :- $C_{min} =$

$$\frac{1}{2} C_1 \sqrt{\frac{2C_3\left(\frac{D}{T}\right)}{C_1}} T + DC_3 \sqrt{\frac{C_1 T}{2C_3 D}}$$

$$= \sqrt{\frac{C_1 C_3 T D}{2}} + \sqrt{\frac{C_1 C_3 T D}{2}}$$

$$= 2\sqrt{\frac{C_1 C_3 T D}{2}} = \sqrt{2 C_1 C_3 T D}$$

Min. Avg. cost $= \frac{TC}{T}$

$$= \sqrt{\frac{2 C_1 C_3 T D}{T}} = \sqrt{\frac{2 C_1 C_3 D}{T}}$$

E(c) Problem of EOQ with finite replenishment Production :-

In this model, all assumptions are same, as (a) but except the instantaneous production, here it is finite.

The production run is of length 't' consists of two parts t_1 & t_2 as:-

i) t_1 is the time period during which the stock is growing up at the a rate of (K-R) per unit time, $K > R$

ii) t_2 is the time period during which there is no replishment but there is only a constant demand R

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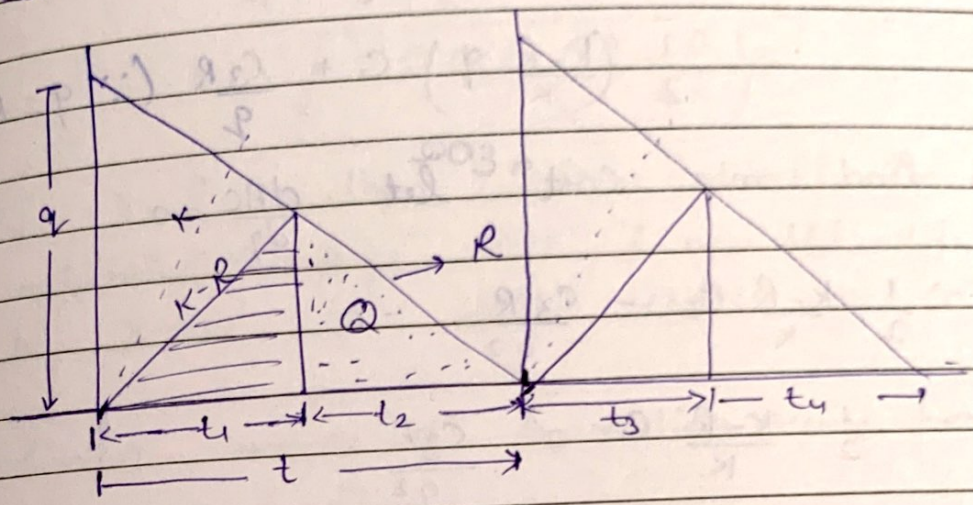
Q is the stock available at the end of t_1, which is consumed in t_2. It can be represented by following figure



$q = Rt$

We know $t_1 = \frac{Q}{K-R}$

& $t_2 = \frac{Q}{R}$

Again $Q = q - Rt_1$

$= q - R\left(\frac{Q}{K-R}\right)$

$Q = \frac{(K-R)q - RQ}{K-R}$

$(K-R)Q + RQ = (K-R)q$

$KQ = (K-R)q$

$Q = \frac{(K-R)q}{K}$

Holding cost will be on Q quantity which is in the stock.

$\therefore$ Holding Cost $= \frac{1}{2} Q t C_1$

Set up cost $= C_3$

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Total cost = $\frac{1}{2} Q t C_1 + C_3$

Avg. cost = $\frac{1}{2} Q C_1 + \frac{C_3}{t}$

$= \frac{1}{2}\left(\frac{K-R}{K} q\right) C_1 + \frac{C_3 R}{q}$ $(\because q = Rt)$

To find min. cost & EOQ let $\frac{dAC}{dq} = 0$

$$\frac{1}{2} \frac{K-R}{K} C_1 - \frac{C_3 R}{q^2} = 0$$

$$\Rightarrow \frac{1}{2} \frac{K-R}{K} C_1 = \frac{C_3 R}{q^2}$$

$$q^2 = \frac{2 C_3 R K}{(K-R) C_1}$$

$$q^* = \sqrt{\frac{2 R K C_3}{(K-R) C_1}}$$

$$\frac{d^2 AC}{dq^2} = \frac{2 C_3 R}{q^3} > 0$$

$\therefore$ at q^*, the value of q will be min.

Since $q = Rt$

$$\therefore t = \frac{q}{R} = \sqrt{\frac{2 R K C_3}{(K-R) C_1}} \cdot \frac{1}{R}$$

$$= \sqrt{\frac{2 K C_3}{R C_1 (K-R)}}$$

Min. cost = $\frac{1}{2} Q t C_1 + \frac{C_3}{t}$

$$\frac{1}{2} \frac{K-R}{K} q C_1 + \frac{C_3 R}{q}$$

$$\frac{1}{2} \frac{K-R}{K} C_1 \sqrt{\frac{2 R K C_3}{(K-R) C_1}} + C_3 R \sqrt{\frac{R C_1 (K-R)}{2 K C_3}}$$

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$$\sqrt{\frac{(k-R)C_1RC_3}{2k}} + \sqrt{\frac{RC_1C_3(k-R)}{2k}}$$

$$= 2\sqrt{\frac{RC_1C_3(k-R)}{2k}}$$

$$= \sqrt{2C_1C_3R\left(1-\frac{R}{k}\right)}$$

i) If $k = R$, then there will be no carrying cost & no set up cost & $C_{min} = 0$

ii) If, $k \to \infty$ it will reduce to (a) model.

* Optimum no. of production runs per year.

$$n = \frac{D}{q}$$

* Deterministic inventory problems with shortage

Model II (a) :- EOQ with constant demand and scheduling time constant.

Assumptions :- i) C_1 is the holding cost per unit per unit time.

ii) C_2 is the shortage cost per unit / time.

iii) R = Demand Rate

iv) t_p → scheduling period which is fixed

v) I is the order level to which inventory is raised at the beginning of each scheduling period

vi) Lead time is zero.

vii) Production rate is infinite.

viii) q_p is fixed size i.e. $q_p = Rt_p$

The graphical representation can be done in the way:

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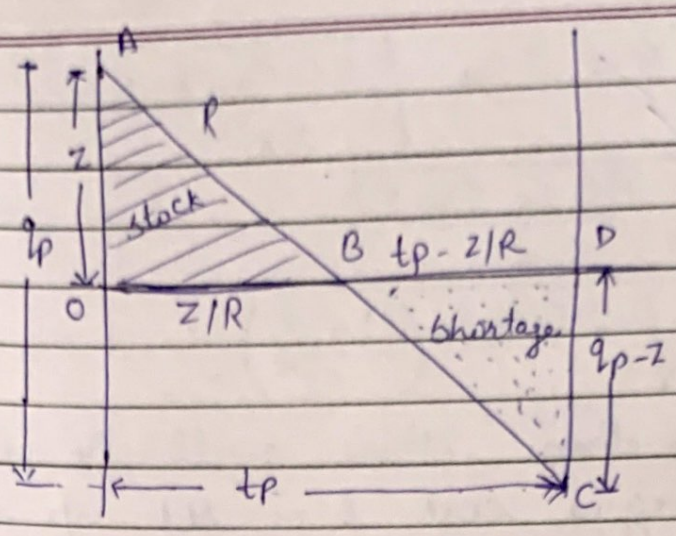

clearly $0 \leq Z \leq q_p$

Holding Cost = C_1 (area of $\triangle OAB$)

$$C_1\left(\frac{1}{2} Z \cdot \frac{Z}{R}\right) = \frac{C_1}{2}\frac{Z^2}{R}$$

Shortage cost = C_2 (area of $\triangle BCD$)

$$= C_2\left(\frac{1}{2}(q_p - Z)\left(t_p - \frac{Z}{R}\right)\right)$$

$$C_2\left(\frac{1}{2}(q_p - Z)\left(\frac{Rt_p - Z}{R}\right)\right)$$

$$C_2\left(\frac{1}{2}\frac{(q_p - Z)(q_p - Z)}{R}\right)$$

$$C_2\left(\frac{1}{2}\frac{(q_p - Z)^2}{R}\right)$$

Total Cost = $\frac{C_1}{2}\frac{Z^2}{R} + C_2\left(\frac{1}{2}\frac{(q_p - Z)^2}{R}\right)$

Avg. cost = $\frac{T.C}{t_p}$

$$= \frac{C_1 Z^2}{2 q_p} + \frac{C_2}{2}\frac{(q_p - Z)^2}{q_p} \quad \text{— (1)}$$

To min. it let $\frac{dA}{dZ} = 0$

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$$\frac{1}{2}\frac{2zC_1}{q_p} + \frac{C_2}{2}\frac{2(q_p - z)(-1)}{q_p} = 0$$

$$\Rightarrow \frac{C_1 z}{q_p} = \frac{C_2(q_p - z)}{q_p}$$

$$C_1 z = C_2(q_p - z)$$

$$= C_2 q_p - C_2 z$$

$$(C_1 + C_2) z = C_2 q_p$$

$$z = \frac{C_2 q_p}{C_1 + C_2}$$

Again $\frac{d^2A}{dz^2} = \frac{C_1}{q_p} + \frac{C_2}{q_p} > 0$

So, it will give min. value.

$$C_{min} = \frac{1}{2}\frac{C_1}{q_p}\left[\frac{C_2 q_p}{C_1 + C_2}\right]^2 + \frac{C_2}{2q_p}\left[q_p - \frac{C_2 q_p}{C_1 + C_2}\right]^2$$

$$= \frac{1}{2}\frac{C_1 C_2^2 q_p^2}{q_p (C_1 + C_2)^2} + \frac{C_2}{2q_p (C_1 + C_2)^2}\left((C_1 + C_2) q_p - C_2 q_p\right)$$

$$= \frac{1}{2}\frac{C_1 C_2^2 q_p}{(C_1 + C_2)^2} + \frac{C_2 C_1^2 q_p^2}{2q_p (C_1 + C_2)^2}$$

$$= \frac{1}{2}\frac{C_1 C_2 q_p}{(C_1 + C_2)^2}(C_2 + C_1)$$

$$\frac{1}{2}\frac{C_1 C_2 q_p}{(C_1 + C_2)}$$ Ans.

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Model II (b) := EOQ with constant rate of demand and scheduling time variable

Assumptions := All the assumptions are same except that time is not fixed for each production run. Therefore, we need set up cost C_3 also.

Cost ~~equation~~ & ~~are~~ graphical representations ~~are~~ is same. So

Cost eq. $C(t,z) = \frac{C_1 z^2}{2Rt} + \frac{1}{2} C_2 \frac{(Rt-z)^2}{Rt} + \frac{C_3}{t}$ — (1)

Here, we've replaced $q_p = Rt$

To min. this cost eq. ; let

$\frac{\partial C}{\partial t} = 0$ & $\frac{\partial C}{\partial z} = 0$

As t & z both are variable here:

$\frac{\partial C}{\partial z} = 0$

$\frac{C_1 z}{Rt} - \frac{C_2 (Rt-z)}{Rt} = 0$

$\frac{z}{Rt}(C_1 + C_2) = C_2$

$z = \frac{C_2 Rt}{C_1 + C_2}$

$\frac{\partial C}{\partial t} = 0$

$-\frac{C_1 z^2}{2Rt^2} + \frac{1}{2} C_2 \frac{(Rt-z)^2}{R}\left(\frac{-1}{t^2}\right) + \frac{1}{2}\frac{C_2}{Rt} 2(Rt-z)R - \frac{C_3}{t^2} = 0$

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$$\frac{-C_1 z^2}{2Rt^2} - \frac{1}{2Rt^2} C_2 (Rt - z)^2 + \frac{C_2 (Rt - z)}{t} - \frac{C_3}{t^2} = 0$$

$$\Rightarrow \frac{-C_1}{2Rt^2}\left[\frac{C_2^2 R^2 t^2}{(C_1+C_2)^2}\right] - \frac{1}{2Rt^2} C_2 \left[Rt - \frac{C_2 Rt}{C_1+C_2}\right]^2 + \frac{C_2}{t}\left[Rt - \frac{C_2 Rt}{C_1+C_2}\right] - \frac{C_3}{t^2} = 0$$

$$\Rightarrow \frac{-C_1 C_2^2 R}{2(C_1+C_2)^2} - \frac{1}{2}\frac{C_2}{Rt^2}\left[R^2t^2 + \frac{C_2^2 R^2 t^2}{(C_1+C_2)^2} - \frac{2C_2 R^2 t^2}{C_1+C_2}\right] + C_2 R - \frac{C_2^2 R}{C_1+C_2} - \frac{C_3}{t^2} = 0$$

$$\Rightarrow \frac{-C_1 C_2^2 R}{2(C_1+C_2)^2} - \frac{1}{2} C_2 R - \frac{1}{2}\frac{C_2^3 R}{(C_1+C_2)^2} + \frac{C_2^2 R}{C_1+C_2} + C_2 R - \frac{C_2^2 R}{C_1+C_2} - \frac{C_3}{t^2} = 0$$

$$\Rightarrow \frac{-C_1 C_2^2 R}{2(C_1+C_2)^2} - \frac{1}{2}\frac{C_2^3 R}{(C_1+C_2)^2} + \frac{1}{2} C_2 R - \frac{2C_2^2 R}{C_1+C_2} - \frac{C_3}{t^2} = 0$$

$$\Rightarrow \frac{-C_1 C_2^2 R}{2(C_1+C_2)^2} - \frac{1}{2}\frac{C_2^3 R}{(C_1+C_2)^2} + \frac{C_1 C_2 R - C_2^2 R - 4C_2^2 R}{2(C_1+C_2)}$$

$$\frac{-C_1 C_2^2 R}{2(C_1+C_2)^2} - \frac{C_2 R}{2}\left[1 - \frac{C_2}{C_1+C_2}\right]^2 + C_2 R\left[1 - \frac{C_2}{C_1+C_2}\right] - \frac{C_3}{t^2} = 0$$

$$\Rightarrow \frac{-C_1 C_2^2 R}{2(C_1+C_2)^2} - \frac{R C_1^2 C_2}{2(C_1+C_2)^2} + \frac{C_1 C_2 R}{C_1+C_2} - \frac{C_3}{t^2} = 0$$

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$$\frac{-C_1C_2R}{2(C_1+C_2)^2}(C_1+C_2)' + \frac{C_1C_2R}{C_1+C_2} = \frac{C_3}{t^2}$$

$$-\frac{C_1C_2R}{2(C_1+C_2)} + \frac{C_1C_2R}{(C_1+C_2)} = \frac{C_3}{t^2}$$

$$\Rightarrow \frac{C_1C_2R}{2(C_1+C_2)} = \frac{C_3}{t^2}$$

$$t^2 = \frac{2C_3(C_1+C_2)}{C_1C_2R}$$

$$t = \sqrt{\frac{2C_3(C_1+C_2)}{C_1C_2R}}$$

$$q = Rt = R\sqrt{\frac{2C_3(C_1+C_2)}{C_1C_2R}} = \sqrt{\frac{2RC_3(C_1+C_2)}{C_1 \cdot C_2}}$$

$$C_{min} = \frac{C_1z^2}{2Rt} + \frac{1}{2}\frac{C_2}{Rt}(Rt-z)^2 + \frac{C_3}{t}$$

$$\Rightarrow \frac{C_1C_2^2R^2t^2}{2Rt(C_1+C_2)^2} + \frac{1}{2}\frac{C_2}{Rt}\left(Rt - \frac{C_2Rt}{C_1+C_2}\right)^2 + \frac{C_3}{t}$$

$$\Rightarrow \frac{C_1C_2^2Rt}{2(C_1+C_2)^2} + \frac{1}{2}\frac{C_2 \cdot C_1^2Rt}{(C_1+C_2)^2} + \frac{C_3}{t}$$

$$\Rightarrow \frac{C_1C_2Rt}{2(C_1+C_2)^2}[C_1+C_2)] + \frac{C_3}{t}$$

$$\Rightarrow \frac{C_1C_2Rt}{2(C_1+C_2)} + C_3\sqrt{\frac{C_1C_2R}{2C_3(C_1+C_2)}}$$

$$\Rightarrow \frac{C_1C_2R}{2(C_1+C_2)}\sqrt{\frac{2C_3(C_1+C_2)}{C_1C_2R}} + \sqrt{\frac{C_3C_1C_2R}{2(C_1+C_2)}}$$

$$\Rightarrow \sqrt{\frac{C_1C_2RC_3}{2(C_1+C_2)}} + \sqrt{\frac{C_3C_1C_2R}{2(C_1+C_2)}} = \sqrt{\frac{2C_1C_3RC_2}{(C_1+C_2)}}$$

$$\Rightarrow \sqrt{2C_1C_3R}\sqrt{\frac{C_2}{C_1+C_2}}$$

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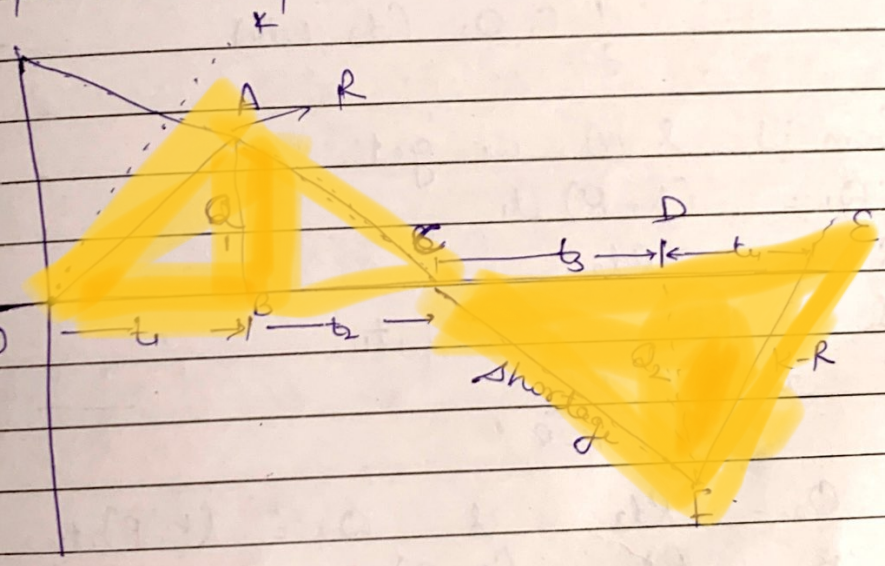
Model II (c) :- EOQ model with finite replenishment :-

Assumptions :- i) Demand Rate is R per unit time
ii) Lead time is zero.
iii) production rate is finite.
iv) Inventory carrying cost is C_1 per quantity per unit time
v) Shortages are allowed. & C_2 - - -
vi) Set up cost is C_3 per quantity / unit time.
vii) each production run consists of two parts ~~t_0 & t_2~~ which are again divided into two parts, so we've four parts :- t_1, t_2, t_3 & t_4.

graphical representation is :-



i) During time period as $K > R$, production is more than demand so, inventory is growing at the rate $(K-R)$ units ~~of~~ / time.
ii) In time t_2, inventory is decreasing at the rate of R unit / unit time as there is no production. The inventory growing upto in t_1 is consumed in t_2 so both are equal.

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Holding cost = C_1 (ΔOAC)

$$= \frac{1}{2} C_1 Q_1 (t_1 + t_3) \quad \text{— (1)}$$

iii) Again, In time t_3 there is shortage which is growing upto Q_2 units.

iv) In time period t_4, shortages are filled immediately at the rate (K-R) units/time.

So, shortage in t_3 are same that are filled in t_4.

Shortage cost = C_2 (area of Δ CEP)

$$= C_2 \frac{1}{2} Q_2 (t_3 + t_4)$$

$$\frac{1}{2} C_2 Q_2 (t_3 + t_4) \quad \text{— (2)}$$

From iii) & iv) we get:

$Q_1 = (K-R) t_1$

& $Q_1 = Rt_2$

So $Rt_2 = (K-R) t_1$

$$t_1 = \frac{Rt_2}{K-R} \quad \text{— (3)}$$

$Q_2 = Rt_3$ & $Q_2 = (K-R) t_4$

So $Rt_3 = (K-R) t_4$ —

$$t_4 = \frac{Rt_3}{K-R} \quad \text{— (4)}$$

Since we know $q = Rt$

$q = R(t_1 + t_2 + t_3 + t_4)$

$$= R\left(\frac{Rt_2}{K-R} + t_2 + t_3 + \frac{Rt_3}{K-R}\right)$$

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$$= \frac{RK}{K-R}(t_2 + t_3)$$

Total cost = Holding cost + Shortage cost + Set up

$$= \frac{1}{2} C_1 Q_1 (t_1 + t_2) + \frac{1}{2} C_2 Q_2 (t_3 + t_4) + C_3$$

Avg. cost = T. Cost / Time

$$= \frac{\frac{1}{2} C_1 Q_1 (t_1 + t_2) + \frac{1}{2} C_2 Q_2 (t_3 + t_4) + C_3}{t_1 + t_2 + t_3 + t_4}$$

Put values of Q_1, Q_2, t_1, t_4 in this eqn:-

$$AC = \frac{\frac{1}{2} C_1 (Rt_2)\left[\frac{Rt_2}{K-R} + t_2\right] + \frac{1}{2} C_2 Rt_3 \left[t_3 + \frac{Rt_3}{K-R}\right] + C_3}{\frac{Rt_2}{K-R} + t_2 + t_3 + \frac{Rt_3}{K-R}}$$

$$\Rightarrow \frac{\frac{1}{2}\left[\frac{C_1 RK t_2^2}{K-R} + \frac{C_2 RK t_3^2}{K-R}\right] + C_3}{\frac{K(t_2 + t_3)}{K-R}}$$

$$= \frac{1}{2}\left[\frac{RK(C_1 t_2^2 + C_2 t_3^2) + 2C_3(K-R)}{K(t_2 + t_3)}\right]$$

$$\frac{\partial C}{\partial t_2} = 0 \quad \& \quad \frac{\partial C}{\partial t_3} = 0$$

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$$\frac{K(t_2+t_3)\left[\frac{1}{2}2C_1t_2\right]RK - \left[\frac{1}{2}(C_1t_2^2+C_2t_3^2)RK + C_3(K-R)\right]K}{K^2(t_2+t_2)^2} = 0$$

$$\Rightarrow C_1t_2RK(t_2+t_3) - \left[\frac{1}{2}(C_1t_2^2+C_2t_3^2)RK + C_3(K-R)\right] = 0$$

$$\frac{\partial C}{\partial t_3} = 0$$

$$\frac{K(t_2+t_3)\left[C_2t_3^{RK}\right] - \left[\frac{1}{2}(C_1t_2^2+C_2t_3^2)RK + C_3(K-R)\right]K}{K^2(t_2+t_3)^2} = 0$$

$$\Rightarrow C_2t_3RK(t_2+t_3) - \left[\frac{1}{2}(C_1t_2^2+C_2t_3^2)RK + C_3(K-R)\right] = 0$$

from here, we get:-

$$t_2^* = \sqrt{\frac{2C_3C_2(1-R/K)}{RC_1(C_1+C_2)}}$$

$$t_3^* = \sqrt{\frac{2C_3C_1(1-R/K)}{RC_2(C_1+C_2)}}$$

Also $q = R\left(\frac{Rt_2}{K-R} + t_2 + t_3 + \frac{Rt_3}{K-R}\right)$

$$= \frac{RK}{K-R}(t_2+t_3)$$

$$= \frac{RK}{K-R}\left(\sqrt{\frac{2C_3C_2(1-R/K)}{RC_1(C_1+C_2)}} + \sqrt{\frac{2C_3C_1(1-R/K)}{RC_2(C_1+C_2)}}\right)$$

$$= \frac{RK}{K-R}\sqrt{\frac{2C_3(1-R/K)}{R(C_1+C_2)}}\left(\sqrt{\frac{C_2}{C_1}} + \sqrt{\frac{C_1}{C_2}}\right)$$

$$= \frac{RK}{K-R}\sqrt{\frac{2C_3(K-R)}{RK(C_1+C_2)}}\sqrt{\frac{C_2^2+C_1^2}{C_1C_2}}\;\frac{C_2+C_1}{\sqrt{C_1}\sqrt{C_2}}$$

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$$\sqrt{\frac{2C_3RK}{(K-R)(C_1+C_2)} \cdot \frac{C_1^2+C_2^2}{C_1C_2}}$$

$$\sqrt{\frac{2C_3RK(C_1+C_2)}{(K-R)C_1C_2}}$$ Ans.

Also, we can find min. cost.

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MECHANICS OF SOLIDS

M.A./M.Sc. Mathematics (Final)

MM-504 & MM 505
(Option-A_1)

Directorate of Distance Education
Maharshi Dayanand University
ROHTAK – 124 001

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M.A./M.Sc. Mathematics (Final)

MECHANICS OF SOLIDS

MM-504 & 505 (A_1)

Max. Marks : 100

Time : 3 Hours

Note: Question paper will consist of three sections. Section I consisting of one question with ten parts covering whole of the syllabus of 2 marks each shall be compulsory. From Section II, 10 questions to be set selecting two questions from each unit. The candidate will be required to attempt any seven questions each of five marks. Section III, five questions to be set, one from each unit. The candidate will be required to attempt any three questions each of fifteen marks.

Unit I

Analysis of Strain: Affine transformation. Infinite simal affine deformation. Geometrical interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariants. General infinitesimal deformation. Saint-Venant's equations of Compatibility. Finite deformations.

Unit II

Equations of Elasticity: Generalized Hooke's law. Homogeneous isotropic media. Elasticity moduli for isotropic media. Equilibrium and dynamic equations for an isotropic elastic solid. Strain energy function and its connection with Hooke's law. Uniquness of solution. Beltrami-Michell compatibility equations. Saint-Venant's principle.

Unit III

Two – dimensional Problems: Plane stress. Generalized plane stress. Airy stress function. General solution of Biharmonic equation. Stresses and displacements in terms of complex potentials. Simple problems. Stress function appropriate to problems of plane stress. Problems of semi-infinite solids with displacements or stresses prescribed on the plane boundary.

Unit IV

Torsional Problem: Torsion of cylindrical bars. Tortional rigidity. Torsion and stress functions. Lines of shearing stress. Simple problems related to circle, elipse and equilateral triangle.

Variational Methods: Theorems of minimum potential energy. Theorems of minimum complementary energy. Reciprocal theorem of Betti and Rayleigh. Deflection of elastic string, central line of a beam and elastic membrane. Torsion of cylinders. Variational problem related to biharmonic equation. Solution of Euler's equation by Ritz, Galerkin and Kantorovich methods.

Unit V

Elastic Waves: Propagation of waves in an isotropic elastic solid medium. Waves of dilatation and distortion Plane waves. Elastic surface waves such as Rayleigh and Love waves.

Chapter-1
Cartesian Tensors

1.1 INTRODUCTION

There are physical quantities which are independent or invariant of any particular coordinate system that may be used to describe them. Mathematically, such quantities are represented by tensors. That is, a tensor is a quantity which describes a physical state or a physical phenomenon.

As a mathematical entity, a tensor has an existence independent of any coordinate system. Yet it may be specified in a particular coordinate system by a certain set of quantities, **known as its components**. Specifying the components of a tensor in one coordinate system determines the components in any other system according to some definite law of transformation.

In dealing with general coordinate transformations between arbitrary curvilinear coordinate systems, the tensors defined are known as **general tensors**. When one is dealing with cartesian rectangular frames of reference only, the tensor involved are referred to as **cartesian tensors**. **From now onwards, the word "tensor" means "cartesian tensors"** unless specifically stated otherwise.

1.2 COORDINATE TRANSFORMATIONS

Let us consider a right handed system of rectangular cartesian axes x_i with a fixed origin O. Let P be a general point whose coordinates with respect to this system O $x_1x_2x_3$ are (x_1, x_2, x_3).

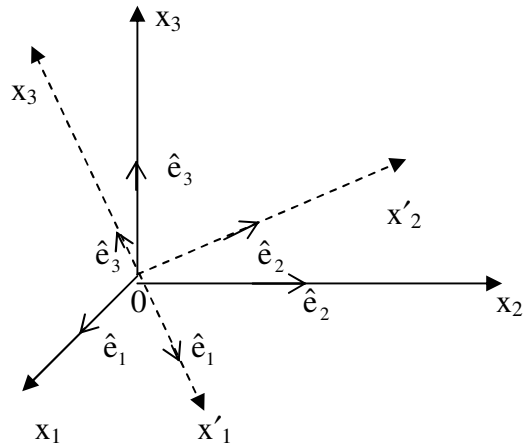


Fig (1.1)

Let $\bar{r}$ be the position vector of P w.r.t. O.

Then

$$\bar{r} = x_1 \hat{e}_1 + x_2 \hat{e}_2 + x_3 \hat{e}_3 \qquad (1)$$

and (x_1, x_2, x_3) are the components of the vector $\overline{OP}$. Here, $\hat{e}_1$, $\hat{e}_2$, $\hat{e}_3$ are unit vectors along axes.

Let a new system $Ox_1'x_2'x_3'$ of axes be obtained by rotating the "**old system**" of axes about some line in space through O. The position vector $\bar{r}$ of P has the following representation in the new system

$$\bar{r} = x_1' \hat{e}_1' + x_2' \hat{e}_2' + x_3' \hat{e}_3' \qquad (2)$$

where $\hat{e}_i$ is the unit vector directed along the positive x_i'-axis, and

$$\hat{e}_i' . \hat{e}_j' = \begin{cases} 1 & \text{for } i = j \\ 0 & \text{for } i \neq j \end{cases}$$

and

$$\hat{e}_1' \times \hat{e}_2' = \hat{e}_3', \text{ etc.}$$

and (x_1', x_2', x_3') are the new components of $\overline{OP} = \bar{r}$ relative to the new axes $Ox_1'x_2'x_3'$. Let a_{pi} be the direction cosines of new x_p'-axis w.r.t. the old x_i-axis.

That is,

$a_{pi} = \cos(x_p', x_i)$ = cosine of the angle between the positive x_p'-axis (new axis) and the positive x_i-axis (old axis)

$$= \bar{e}_p' . \bar{e}_i \qquad (3)$$

Form (2), we write

$$\bar{r} . \hat{e}_p' = x_p'$$

$$\Rightarrow x_p' = \bar{r} . \hat{e}_p' = (x_1 \hat{e}_1 + x_2 \hat{e}_2 + x_3 \hat{e}_3) . \hat{e}_p' ,$$

$$\Rightarrow x_p' = a_{p1} x_1 + a_{p2} x_2 + a_{p3} x_3 = a_{pi} x_i . \qquad (4)$$

Here p is the free suffix and i is dummy.

In the above, the following **Einstein summation convection** is used.

"Unless otherwise stated specifically, whenever a suffix is repeated, it is to be given all possible values (1, 2,3) and that the terms are to be added for all".

Similarly

$$x_i = \bar{r} . \hat{e}_i$$

$$= (x_1' \hat{e}_1' + x_2 \hat{e}_2' + x_3 \hat{e}_3') . \hat{e}_i ,$$

$$= a_{1i} x_1' + a_{2i} x_2' + a_{3i} x_3'$$

$$= a_{pi}\, x'_p \,. \qquad (5)$$

Here i is a free suffix and p is dummy. When the orientations of the new axes w.r.t. the old axes are known, the coefficients a_{pi} are known. Relation (4) represent the law that transforms the old triplet x_i to the new triplet x'_p and (5) represent the inverse law, giving old system in terms of new system.

Remark 1. The transformation rules (4) and (5) may be displaced in the following table

	x_1	x_2	x_3
x'_1	a_{11}	a_{12}	a_{13}
x'_2	a_{21}	a_{22}	a_{23}
x'_3	a_{31}	a_{32}	a_{33}

(6)

Remark 2. The transformation (4) is a linear transformation given by

$$\begin{bmatrix} x'_1 \\ x'_2 \\ x'_3 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \qquad (7)$$

The matrix

$$[L] = (a_{ij})_{3\times 3} \qquad (8)$$

may be thought as an operator operating on the vector $\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ and giving the vector $\begin{bmatrix} x'_1 \\ x'_2 \\ x'_3 \end{bmatrix}$.

Remark 3. Since this transformation is rotational only, so the matrix L of the transformation is non-symmetric.

Remark 4. Relations (4) and (5) yield

$$\frac{\partial x'_p}{\partial x_i} = a_{pi} \qquad (9)$$

and

$$\frac{\partial x_i}{\partial x'_p} = a_{pi} \,. \qquad (10)$$

1.3. THE SYMBOL δ_{ij}

It is defined as

$$\delta_{ij} = \begin{matrix} 1 \text{ if } i = j \\ 0 \text{ if } i \neq j \end{matrix} \,. \qquad (1)$$

That is,

$$\delta_{11} = \delta_{22} = \delta_{33} = 1,$$

$$\delta_{12} = \delta_{21} = \delta_{31} = \delta_{23} = \delta_{32} = 0 \ .$$

The symbol δ_{ij} is known as the Kronecker δ symbol, named after the **German mathematician** Leopold Kronecker (1827-1891). The following property is inherent in the definition of δ_{ij}

$$\delta_{ij} = \delta_{ji} \ .$$

By summation convention

$$\delta_{ii} = \delta_{11} + \delta_{22} + \delta_{33} = 3 \ . \qquad (2)$$

The unit matrix of order 3 is

$$I_3 = (\delta_{ij}) \text{ and } \det(\delta_{ij}) = 1.$$

The orthonormality of the base unit vectors $\hat{e}_i$ can be written as

$$\hat{e}_i . \hat{e}_j = \delta_{ij} \ . \qquad (3)$$

We know that

$$\frac{\partial x_i}{\partial x_j} = \begin{cases} 1 \text{ if } i = j \\ 0 \text{ if } i \neq j \end{cases} .$$

Therefore,

$$\frac{\partial x_i}{\partial x_j} = \delta_{ij} \ . \qquad (4)$$

Theorem 1.1. Prove the following (**known as substitution properties of δ_{ij}**)

(i) $u_j = \delta_{ij} u_i$

(ii) $\delta_{ij} u_{jk} = u_{ik}, \ \delta_{ij} u_{ik} = u_{jk}$

(iii) $\delta_{ij} u_{ij} = u_{11} + u_{22} + u_{33} = u_{ii}$

Proof. (i) Now $\delta_{ij} u_i = \delta_{1j} u_1 + \delta_{2j} u_2 + \delta_{3j} . u_3$

$$= u_j + \sum_{\substack{i=1 \\ i \neq j}}^{3} \delta_{ij} u_i$$

$$= u_j$$

(ii) $$\delta_{ij} u_{jk} = \sum_{j=1}^{3} \delta_{ij} u_{jk}$$

$= \delta_{ii} u_{ik}$ (for $j \neq i$, $\delta_{ij} = 0$), here summation over i is not taken

$$= u_{ik}$$

(iii) $$\delta_{ij}u_{ij} = \sum_i \left[\sum_j \delta_{ij} u_{ij} \right]$$

$$= \sum_i (1.u_{ii}) \ , \quad \text{in } u_{ii} \text{ summation is not being taken}$$

$$= \sum_i u_{ii}$$

$$= u_{ii} = u_{11} + u_{22} + u_{33} \ .$$

Question. Given that

$$a_{ij} = \alpha\delta_{ij}b_{kk} + \beta b_{ij}$$

where $\beta \neq 0$, $3\alpha+\beta \neq 0$, find b_{ij} in terms of a_{ij} .

Solution. Setting j = i and summing accordingly, we obtain

$$a_{ii} = \alpha.3.b_{kk} + \beta b_{ii} = (3\alpha + \beta)b_{kk}$$

$$\Rightarrow \qquad b_{kk} = \frac{1}{3\alpha+\beta} \ a_{kk} \ .$$

Hence

$$b_{ij} = \frac{1}{\beta}\left[a_{ij} - \alpha\delta_{ij}b_{kk}\right]$$

$$\Rightarrow \qquad b_{ij} = \frac{1}{\beta}\left[a_{ij} - \frac{\alpha}{3\alpha+\beta}\delta_{ij}a_{kk} \right] \ .$$

Theorem 1.2. Prove that

(i) $a_{pi}a_{qi} = \delta_{pq}$

(ii) $a_{pi}a_{pj} = \delta_{ij}$

(iii) $|a_{ij}| = 1, \quad (a_{ij})^{-1} = (a_{ij})' \ .$

Proof. From the transformation rules of coordinate axes, we have

$$x'_p = a_{pi} \, x_i \qquad (1)$$

$$x_i \ = a_{pi} \, x'_p \qquad (2)$$

where

$$a_{pi} = \cos(x'_p, x_i) \qquad (3)$$

(i) Now

$$x'_p = a_{pi} \, x_i$$

$$= a_{pi}(a_{qi}\, x'_q)$$

$$= a_{pi}\, a_{qi}\, x'_q \qquad (4)$$

Also

$$x'_p = \delta_{pq} x'_q \qquad (5)$$

Therefore,

$$(a_{pi}a_{qi} - \delta_{pq})x'_q = 0$$

or

$$a_{pi}a_{qi}\ \delta_{pq} = 0$$

or

$$a_{pi}\ a_{qi} = \delta_{pq} \qquad (6)$$

This proves that (i).

(ii) Similarly, $x_i = a_{pi}\, x'_p$

$$= a_{pi}a_{pj}x_j \qquad (7)$$

Also

$$x_i = \delta_{ij}x_j \qquad (8)$$

Hence,

$$a_{pi}a_{pj} = \delta_{ij}\ . \qquad (9)$$

(iii) Relation (6) gives, in the expanded form,

$$a_{11}^2 + a_{12}^2 + a_{13}^2 = 1,$$

$$a_{21}^2 + a_{22}^2 + a_{23}^2 = 1,$$

$$a_{31}^2 + a_{32}^2 + a_{33}^2 = 1$$

$$a_{11}a_{21}+a_{12}a_{22}+a_{13}a_{23} = 0\ ,$$

$$a_{21}a_{31}+a_{22}a_{32} + a_{23}a_{33} = 0\ ,$$

$$a_{31}a_{11}+a_{32}a_{12} + a_{33}a_{13} = 0\ . \qquad (10)$$

The relations (6) and (9) are referred to as the orthonormal relations for a_{ij}. In matrix notation, relations (6) and (9) may be represented respectively, as follows

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} a_{11} & a_{21} & a_{31} \\ a_{12} & a_{22} & a_{32} \\ a_{13} & a_{23} & a_{33} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad (11)$$

$$\begin{bmatrix} a_{11} & a_{21} & a_{31} \\ a_{12} & a_{22} & a_{32} \\ a_{13} & a_{23} & a_{33} \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad (12)$$

or

$$LL' = L'L = 1\ . \qquad (13)$$

These expressions show that the matrix $L = (a_{ij})$ is non-singular and that

$$(a_{ij})^{-1} = (a_{ij})' \text{ and } |a_{ij}| = 1 . \qquad (14)$$

The transformation matrix $L = (a_{ij})$ is called the **proper orthogonal matrix**. For this reason, the transformation laws (3) and (4), determined by the matrix $L = (a_{ij})$, are called **orthogonal transformations**.

Example. The x'_i-system is obtained by rotating the x_i-system about the x_3-axis through an angle θ in the sense of right handed screw. Find the transformation matrix. If a point P has coordinates (1,1, 1) in the x_i-system, find its coordinate in the x'_i-system. If a point Q has coordinate (1, 1,1) in the x'_i-system, find its coordinates in the x_i-system.

Solution. The figure (1.2) shows how the x'_i-system is related to the x_i-system. The table of direction cosines for the given transform is

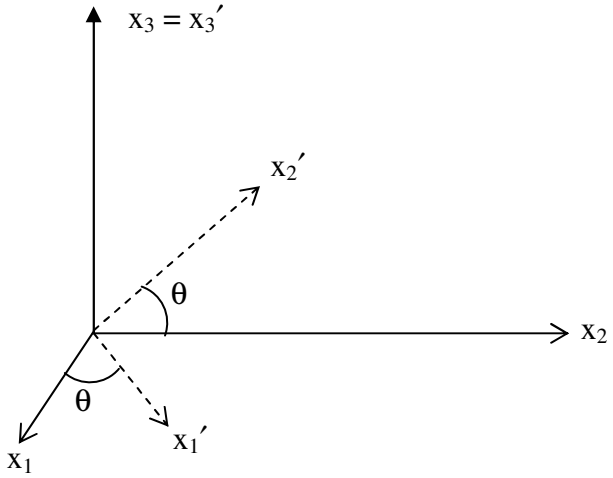


Fig. (1.2)

	$\hat{e}_1$	$\hat{e}_2$	$\hat{e}_3$
$\hat{e}'_1$	$\cos\theta$	$\sin\theta$	0
$\hat{e}'_2$	$-\sin\theta$	$\cos\theta$	0
$\hat{e}'_3$	0	0	1

Hence, the matrix of this transformation is

$$(a_{ij}) = \begin{pmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} . \qquad (1)$$

The transformation rules for coordinates are

$$x'_p = a_{pi}x_i, \qquad (2)$$

$$x_i = a_{pi}\, x'_p . \qquad (3)$$

The coordinates $P(x'_1, x'_2, x'_3)$ of the point P(1, 1, 1) in the new system are given by

$$x'_1 = a_{1i}x_i = a_{11}x_1 + a_{12}x_2 + a_{13}x_3 = \cos\theta + \sin\theta$$

$$x'_2 = a_{2i}x_i = a_{21}x_1 + a_{22}x_2 + a_{23}x_3 = \cos\theta - \sin\theta$$

$$x'_3 = a_{3i}x_i = a_{31}x_1 + a_{32}x_2 + a_{33}x_3 = 1. \qquad (4)$$

Therefore, coordinates of P in the x'_i-system are $(\cos\theta + \sin\theta, \cos\theta - \sin\theta, 1)$.

The coordinates (x_1, x_2, x_3) of a w.r.t. old system are given as

$$x_1 = a_{p1}x'_p = a_{11}x'_1 + a_{21}x'_2 + a_{31}x'_3 = \cos\theta - \sin\theta$$

$$x_2 = a_{p2}x'_p = a_{12}x'_1 + a_{22}x'_2 + a_{32}x'_3 = \cos\theta + \sin\theta$$

$$x_3 = a_{p3}x_p = a_{13}x'_1 + a_{23}x'_2 + a_{33}x'_3 = 1\ . \qquad (5)$$

Hence, the coordinates of the point Q in the old x_i-system are $(\cos\theta-\sin\theta, \cos\theta + \sin\theta, 1)$.

1.4 SCALARS AND VECTORS

Under a transformation of certesian coordinate axes, a scalar quantity, such as the **density or the temperature**, remains unchanged. This means that a scalar is an invariant under a coordinate transformation. Scalaras are called **tensors of zero rank.**

We know that a scalar is represented by a single quantity in any coordinate system. Accordingly, a tensor of zero rank (or order) is specified in any coordinate system in three-dimensional space by one component or a single number.

All physical quantities having magnitude only are tensors of zero order.

Transformation of a Vector

Let $\bar{u}$ be any vector having components (u_1, u_2, u_3) along the x_i-axes and components (u'_1, u'_2, u'_3) along the x'_i-axes so that vector $\bar{u}$ is represented by three components/quantities. Then we have

$$\bar{u} = u_i\ \hat{e}_i \qquad (1)$$

and $$u = u'_i\ \hat{e}'_i \qquad (2)$$

where $\hat{e}_i$ is the unit vector along x_i-direction and $\hat{e}'_i$ is the unit vector along x'_i-direction.
Now

$$u'_p = \bar{u}\ .\ \hat{e}'_p$$

$$= (u_i\ \hat{e}_i)\ .\ e'_p$$

$$= (\hat{e}'_p\ .\ \hat{e}_i)u_i$$

$$\Rightarrow \quad u'_p = a_{pi}\ u_i\ . \qquad (3)$$

where

$$a_{pi} = \hat{e}'_p\ .\ \hat{e}_i = \cos(x'_p, x_i)\ . \qquad (4)$$

Also

$$u_i = \bar{u}\ .\ \hat{e}_i$$

$$= (u'_p\ \hat{e}'_p)\ .\ \hat{e}_1$$

$$= (\hat{e}'_p\ .\hat{e}'_i)\ u'_p$$

$$= a_{pi}\ u'_p\ , \qquad (5)$$

where (a_{pi}) is the proper orthogonal transformation matrix.
Relations (3) and (5) are the rules that determine u'_p in terms of u_i and vice-versa. Evidently, these relations are analogous to rules of transformation of coordinates.

Definition (Tensor of rank one)

A cartesian tensor of rank one is an entity that may be represented by a set of three quantities in every cartesian coordinate system with the property that its components u_i relative to the system $ox_1x_2x_3$ are related/connected with its components u'_p relative to the system $ox'_1x'_2x'_3$ by the relation

$$u'_p = a_{pi}u_i$$

where the law of transformation of coordinates of points is

$$x'_p = a_{pi}x_i \quad \text{and } a_{pi} = \cos(x'_p, x_i) = \hat{e}'_p.\hat{e}_i\ .$$

Note: We note that **every vector in space is a tensor of rank one.** Thus, physical quantities possessing both magnitude and direction such as **force**, **displacement, velocity, etc.** are all tensors of rank one. In three-dimensional space, 3 real numbers are needed to represent a tensor of order 1.

Definition (Tensor of order 2)

Any entity representable by a set of 9 (real) quantities relative to a system of rectangular axes is called a tensor of rank two if its components w_{ij} relative to system $ox_1x_2x_3$ are connected with its components w'_{pq} relative to the system $ox'_1x'_2x'_3$ by the transformation rule

$$w'_{pq} = a_{pi}\, q_{qj}\, w_{ij}$$

when the law of transformation of coordinates is

$$x'_p = a_{pi}x_i\ ,$$

$$a_{pi} = \cos(x'_p, x_i) = \hat{e}'_p . \hat{e}_i \, .$$

Note : Tensors of order 2 are also called **dyadics**. For example, strain and stress tensors of elasticity are, each of rank 2. In the theory of elasticity, we shall use tensors of rank 4 also.

Example. In the x_i-system, a vector $\bar{u}$ has components $(-1, 0, 1)$ and a second order tensor has the representation

$$(w_{ij}) = \begin{pmatrix} 0 & 1 & 0 \\ -1 & 0 & 2 \\ 0 & -2 & 0 \end{pmatrix} .$$

The x'_i-system is obtained by rotating the x_i-system about the x_3-axis through an angle of 45^o in the sense of the right handed screw. Find the components of the vector $\bar{u}$ and the second ordered tensor in the x'_i-system.

Solution. The table of transformation of coordinates is

	x_1	x_2	x_3
x'_1	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	0
x'_2	$-\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	0
x'_3	0	0	1

If u'_p are the components of vector in the new system, then

$$u'_p = a_{pi} u_i \, , \quad a_{pi} = \hat{e}'_p . \hat{e}_i \, . \tag{1}$$

This gives $\quad u'_1 = -\frac{1}{\sqrt{2}}$

$$u'_2 = \frac{1}{\sqrt{2}} \, ,$$

$$u'_3 = 1 \, .$$

Let w'_{pq} be the components of the given second order tensor in the x'_i-system. Then the transformation law for second order tensor yields

$$w'_{pq} = a_{pi} a_{qj} w_{ij} \tag{2}$$

We find (left an exercise to readers)

$$w'_{pq} = \begin{pmatrix} 0 & 1 & \sqrt{2} \\ -1 & 0 & \sqrt{2} \\ -\sqrt{2} & -\sqrt{2} & 0 \end{pmatrix} \tag{3}$$

Definition 1. A second order tensor u_{ij} is said to be symmetric if

$$u_{ij} = u_{ji} \quad \text{for all i and j .}$$

Definition 2. A second order tensor u_{ij} is said to be skew-symmetric if

$$u_{ij} = - u_{ji} \text{ for all i and j .}$$

Tensors of order n

A tensor of order n has 3^n components. If u_{ijk}…..are components of a tensor of order n , then, the transformation law is

$$u'_{pqr} \ldots\ldots = a_{pi}\, a_{qj}\, a_{rk} \ldots\ldots u_{ijk} \ldots\ldots$$

where the law of transformation of coordinates is

$$x'_p = a_{pi}\, x_i,$$

and

$$a_{pi} = \cos\,(x'_p, x_i) \,.$$

Importance of the Concept of Tensors

(a) Tensors are quantities describing the same phenomenon regardless of the coordinate system used. Therefore, tensors provide an important guide in the formulation of the correct forms of physical laws.

(b) The tensor concept gives us a convenient means of transforming an equation from one system of coordinates to another.

(c) An advantage of the use of cartesian tensors is that once the properties of a tensor of order n have been established, they hold for all such tensors regardless of the physical phenomena they present.

Note : For example, in the study of strain, stress, inertia properties of rigid bodies, the common bond is that they are all symmetric tensors of rank two.

(d) With the use of tensors, equations are condensed, such as

$$\tau_{ij\,,\,j} + f_i = 0,$$

is the equation of equilibrium in tensor form. It consists of 3 equations and each equation has 4 terms.

(e) Equations describing physical laws must be tensorially homogeneous, which means that every term of the equation must be a tensor of the same rank.

1.5 PROPERTIES OF TENSORS

Property 1 : If all components of a tensor are 0 in one coordinate system, then they are 0 in all coordinate systems.

Proof : Let $u_{ijkl}\ldots.$ and $u'_{pqrs}\ldots..$be the components of a nth order tensor in two systems $0x_1x_2x_3$ and $0x_1'x_2'x_3'$, respectively.

Suppose that

$$u_{ijkl}\ldots.. = 0 .$$

Then, the transformation rule yields

$$u'_{pqrs}\ldots.. = a_{pi}\, a_{qj}\, a_{rk}\, a_{sm}\ldots.u_{ijkl}\ldots.$$

giving

$$u'_{pqrs}\ldots.= 0 .$$

This proves the result.

Zero Tensor

A tensor whose all components in one Cartesian coordinates system are 0 is called a zero tensor.

A zero tensor may have any order n.

Property 2 : If the corresponding components of two tensors of the same order are equal in one coordinate system, then they are equal in all coordinate systems.

Corollary : A tensor equation which holds in one Cartesian coordinate system also holds in every other Cartesian coordinate system.

Equality of Tensors

Two tensors of the same order whose corresponding components are equal in a coordinate system (and hence in all coordinates) are called equal tensors.

Note : Thus, in order to show that two tensors are equal, it is sufficient to show that their corresponding components are equal in any one of the coordinate systems.

Property 3 (Scalar multiplication of a tensor)

If the components of a tensor of order n are multiplied by a scalar α, then the resulting components form a tensor of the same order n.

Proof : Let $u_{ijk}\ldots$ be a tensor of order n. Let $u'_{pqr}\ldots$ be the corresponding components in the dashed system 0 x_1' x_2' x_3'. The transformation rule for a tensor of order n yields

$$u'_{pqrs}\ldots = a_{pi}\, a_{qj}\, \ldots u_{ijkl}\ldots \qquad (1)$$

where $$a_{pi} = \cos(x_p', x_i)\ . \qquad (2)$$

Now $$(\alpha\, u'_{pqr}\ldots) = (a_{pi}\, a_{qj}\ldots)\ (\alpha\, u_{ijk}\ldots) \qquad (3)$$

This shows that components $\alpha\, u_{ijk}\ldots$ form a tensor of rank n.

Tensor Equations

An equation of the form

$$\alpha_{ijk} - \beta_{ij}\, u_k = 0$$

is called a **tensor equation.**

For checking the correctness of a tensor equation, there are following two rules :

Rule (i) In a correctly written tensor equation, no suffix shall appear more than twice in a term, otherwise, the operation will not be defined. For example, an equation

$$u_j' = \alpha_{ij}\, u_j\, v_j$$

is not a tensor equation.

Rule (ii) If a suffix appears only once in a term, then it must appear only once in the remaining terms also. For example, an equation

$$u_j' - l_{ij}\, u_j = 0$$

is not a tensor equation.

Here j appears once in the first term while it appears twice in the second term.

Property 4 (Sum and Difference of tensors)

If $u_{ijk}\ldots$ and $v_{ijk}\ldots$ are two tensors of the same rank n then the sums

$$(u_{ijk}\ldots + v_{ijk}\ldots)$$

of their components are components of a tensor of the same order n.

Proof : Let

$$w_{ijk}\ldots. = u_{ijk}\ldots. + v_{ijk}\ldots. \qquad (1)$$

Let $u'_{pqr}\ldots.$ and $v'_{pqr}\ldots.$ be the components of the given tensors of order n relative to the new dashed system $0\ x_1'\ x_2'\ x_3'$. Then, transformation rules for these tensors are

$$u'_{pqr}\ldots. = a_{pi}\ a_{qj}\ \ldots.u_{ijk}\ldots. \qquad (2)$$

and

$$v'_{pqrs}\ldots. = a_{pi}\ a_{qj}\ \ldots.v_{ijkl}\ldots. \qquad (3)$$

where

$$a_{pi} = \cos\ (x_p'\ ,\ x_i). \qquad (4)$$

Let

$$w'_{pqr}\ldots\ldots = u'_{pqr}\ldots\ldots v'_{pqr}\ldots. \qquad (5)$$

Then equations (2) – (5) give

$$w'_{pqr}\ldots. = a_{pi}\ a_{ij}\ \ldots.\ w_{ijk}\ldots\ldots. \qquad (6)$$

Thus quantities $w_{ijk}\ldots.$ obey the transformation rule of a tensor of order n. Therefore, they are components of a tensor of rank n.

Corollary : Similarly, $u_{ijk}\ldots - v_{ikl}\ldots.$ are components of a tensor of rank n.

Property 5 (Tensor Multiplication)

The product of two tensors is also a tensor whose order is the sum of orders of the given tensors.

Proof : Let $u_{ijk}\ldots.$ and $v_{pqr}\ldots.$ be two tensors of order m and n respectively. We shall show that the product

$$w_{ijk}\ldots.{}_{pqr}\ldots. = u_{ijk}\ldots.\ v_{pqr}\ldots. \qquad (1)$$

is a tensor of order m + n.

Let $u'_{i_1 j_1}\ \ldots.$ and $v'_{p_1 q_1}\ \ldots..$ be the components of the given tensors of orders m and n relative to the new system $0\ x_1'\ x_2'\ x_3'$. Then

$$u'_{i_1 j_1}\ \ldots. = a_{i_1 i}\ \ a_{j_1 j}\ldots\ldots.\ u_{ijk}\ldots\ldots\ldots \qquad (2)$$

$$v'_{p_1q_1} \ldots\ldots = a_{p_1p}\ a_{q_1q}\ \ldots\ldots\ v_{pqr}\ldots\ldots \qquad (3)$$

where

$$a_{pi} = \cos\ (x_p', x_i)\ . \qquad (4)$$

Let

$$w'_{i_1j_1} \ldots\ldots_{p_1q_1} \ldots\ldots = u'_{i_1j_1} \ldots\ldots v'_{p_1q_1} \ldots\ldots \qquad (5)$$

Multiplying (2) an (3), we get

$$w'_{i_1j_1} \ldots\ldots_{p_1q_1} \ldots\ldots = (a_{i_1i}\ a_{j_1j} \ldots)\ a_{p_1p}a_{q_1q} \ldots\ldots)w_{ijk}\ldots\ldots pqr\ldots\ldots \qquad (6)$$

This shows that components $w_{ijk}\ldots\ldots_{pqr}\ldots\ldots$ obey the transformation rule of a tensor of order (m + n). Hence $u_{ijk}\ldots\ldots v_{pqr}\ldots\ldots$ are components of a (m + n) order tensor.

Exercise 1 : If u_i and v_i are components of vectors, then show that $u_i\ v_j$ are components of a second – order tensor.

Exercise 2 : If a_{ij} are components of a second – order tensor and b_i are components of a vector, show that $a_{ij}\ b_k$ are components of a third order tensor.

Exercise 3 : If a_{ij} and b_{ij} are components of two second – order tensors show that $a_{ij}\ b_{km}$ are components of fourth – order tensor.

Exercise 4 : Let u_i and v_i be two vectors. Let $w_{ij} = u_i\ v_j + u_j\ v_i$ and $\alpha_{ij} = u_i\ v_j - u_j\ v_i$. Show that each of w_{ij} and α_{ij} is a second order tensor.

Property 6 (Contraction of a tensor)

The operation or process of setting two suffices equal in a tensor and then summing over the dummy suffix is called a contraction operation or simply a contraction.

The tensor resulting from a contraction operation is called a contraction of the original tensor.

Contraction operations are applicable to tensor of all orders (higher than 1) and each **such operation reduces the order of a tensor by 2.**

Theorem : Prove that the result of applying a contraction to a tensor of order n is a tensor of order n – 2.

Proof : Let $u_{ijk}\ldots\ldots$ and $u'_{pqr}\ldots\ldots$ be the components of the given tensor of order n relative to two cartesian coordinate systems 0 $x_1\ x_2\ x_3$ and 0 $x_1'\ x_2'\ x_3'$. The rule of transformation of tensors is

$$u'_{pqr} \ldots\ldots = a_{pi}\, a_{qj}\, a_{rk} \ldots\ldots u_{ijk} \ldots\ldots \quad (1)$$

where

$$a_{pi} = \cos (x_p', x_i) . \quad (2)$$

Without loss of generality, we contract the given tensor by setting j = i and using summation convention . Let

$$v_{kl} \ldots = u_{iikl} \ldots\ldots \quad (3)$$

Now $u'_{pqr} \ldots = (a_{pi}\, a_{qj})\, a_{rk} \ldots\ldots u_{iikl} \ldots\ldots$

$$= \delta_{pq}\, a_{rk} \ldots u_{kl} \ldots$$

This gives

$$u'_{pprs} \ldots = a_{rk}\, a_{sl} \ldots v_{kl} \ldots\ldots$$

or

$$v'_{rs} \ldots\ldots = a_{rk} \ldots v_{kl} \ldots \quad (4)$$

Property 7 (Quotient laws)

Quotient law is the partial converse of the contraction law.

Theorem : If there is an entity representable by the set of 9 quantities u_{ij} relative to any given system of cartesian axes and if $u_{ij}\, v_j$ is a vector for an arbitrary vector v_i, then show that u_{ij} is second order tensor.

Proof : Let

$$w_i = u_{ij}\, v_j \quad (1)$$

Suppose that u'_{pq}, u'_p, w'_p be the corresponding components in the dashed system 0 x_1' x_2' x_3'. Then

$$v'_q = a_{qj}\, v_j, \quad (2)$$

$$w'_p = a_{pi}\, w_i, \quad (3)$$

where

$$a_{pi} = \cos (x_p', x_i) . \quad (4)$$

Equation (1) in the dashed system is

$$w'_p = u'_{pq}\, v'_q . \quad (5)$$

Inverse laws of (2) and (3) are

$$v_j = a_{qj}\, v'_q, \quad (6)$$

$$w_i = a_{pi}\, w'_p. \quad (7)$$

Now $u'_{pq}\, v_q' = w_p'$

$= a_{pi}\, w_i$

$= a_{pi}\, (u_{ij}\, v_j)$

$= a_{pi}\, (a_{qj}\, v_q')\, u_{ij}$

$= a_{pi}\, a_{qj}\, u_{ij}\, v_q'$.

This gives

$$(u'_{pq} - a_{pi}\, a_{qj}\, u_{ij})\, v_q' = 0, \qquad (8)$$

for an arbitrary vector v_q'. Therefore, we must have

$$u'_{pq} = a_{pi}\, a_{qj}\, u_{ij}. \qquad (9)$$

This rule shows that components u_{ij} obey the tensor law of transformation of a second order.

Hence, u_{ij} is a tensor of order two.

Question : Show that δ_{ij} and a_{ij} are tensors, each of order two.

Solution : Let u_i be any tensor of order one.

(a) By the substitution property of the Kronecker delta tensor δ_{ij}, we have

$$u_i = \delta_{ij}\, u_j. \qquad (1)$$

Now u_i and v_j are, each of tensor order 1. Therefore, by quotient law, we conclude that δ_{ij} is a tensor of rank two.

(b) The transformation law for the first order tensor u_i is

$$u_p' = a_{pi}\, u_i, \qquad (2)$$

where

$$a_{pi} = \cos\,(x_p', x_i). \qquad (3)$$

Now u_i is a vector and $a_{pi}\, u_i$ is a vector by contraction property. Therefore, by quotient law, the quantities a_{pi} are components of a second order tensor.

Hence the result.

Note (1) The tensor δ_{ij} is called **a unit tensor** or an **identity tensor** of order two.

Note (2) We may call the tensor a_{ij} as the **transformation tensor of rank two.**

Exercise 1 : Let a_i be an ordered triplet and b_i be a vector, referred to the x_i – axis. If $a_i\ b_i$ is a scalar, show that a_i are components of a vector.

Exercise 2 : If there is an entity representable by a set of 27 quantities u_{ijk} relative to o $x_1\ x_2\ x_3$ system and if $u_{ijk}\ v_{jk}$ is a tensor of order one for an arbitrary tensor v_{jk} of order 2, show that u_{ijk} is a tensor of order 3.

Exercise 3 : If $u_{ijk}\ v_k$ is a tensor of order 2 for an arbitrary tensor v_k of order one, show that u_{ijk} is tensor of order 3.

1.6 THE SYMBOL $\in_{ijk}$

The symbol $\in_{ijk}$ is known as the Levi – civita $\in$ - symbol , named after the Italian mathematician Tullio Levi – civita (1873 – 1941).

The $\in$ - symbol is also referred to as the **permutation symbol / alternating symbol** or **alternator.**

In terms of mutually orthogonal unit vectors $\bar{e}_1, \bar{e}_2, \bar{e}_3$ along the cartesian axes , it is defined as

$$\bar{e}_i \,.\, (\bar{e}_j \times \bar{e}_k) = \in_{ijk},$$

for i , j , k = 1 , 2 , 3. Thus, the symbol $\in_{ijk}$ gives

$$\in_{ijk} = \begin{cases} 1 & \text{if i, j, k take values in the cyclic order} \\ -1 & \text{if i, j, k takes value in the acyclic order} \\ 0 & \text{if two or all of i, j, k take the same value} \end{cases}$$

These relations are 27 in number.

The $\in$ - symbol is useful in expressing the vector product of two vectors and scalar triple product.

(i) We have

$$\bar{e}_i \times \bar{e}_j = \in_{ijk}\ \bar{e}_k.$$

(ii) For two vectors a_i and b_i , we write

$$\bar{a} \times \bar{b} = (a_i\ e_i) \times (b_j\ e_k) = a_i\ b_j\ (e_i \times e_j) = \in_{ijk} a_i\ b_j\ e_k.$$

(iii) For vectors

$$a = a_i\ e_i\ ,\ b = b_j\ e_j\ ,\ c = c_k\ e_k,$$

we have

$$[\bar{a}, \bar{b}, \bar{c}\,] = (\bar{a} \times \bar{b}) \,.\, \bar{c}$$

$$= (\in_{ijk} a_i\, b_j\, e_k) \,.\, (c_k\, e_k)$$

$$= \in_{ijk} a_i\, b_j\, c_k$$

$$= \begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix}.$$

Question: Show that $\in_{ijk}$ is a tensor of order 3.

Solution: Let $\bar{a} = a_i$ and $\bar{b} = b_j$ be any two vectors. Let

$$\bar{c} = c_i = \bar{a} \times \bar{b}\,.$$

Then

$$c_i = \in_{ijk} a_j\, b_k. \qquad \text{(i)}$$

Now $a_j\, b_k$ is a tensor of order 2 and $\in_{ijk} a_j\, b_k$ is a tensor of order one. Therefore , by quotient law, $\in_{ijk}$ is a tensor of order 3.

Note (1) Due to tensorial character of the $\in$ - symbol , it is called an **alternating tensor** or **permutation tensor.**

Note (2) The symbols δ_{ij} and $\in_{ijk}$ were introduced earlier to simplifying the writing of some equations.

Vector of a Second Order Tensor

Let u_{ij} be a second order tensor. The vector

$$\in_{ijk} u_{jk}$$

is called the vector of the tensor u_{jk}.

Example 1: Show that $w_{ij} = \in_{ijk} u_k$ is a skew – symmetric tensor, where u_k is a vector and $\in_{ijk}$ is an alternating tensor.

Solution: Since $\in_{ijk}$ is a tensor of order 3 and u_k is a tensor of order one , so by contraction , the product $\in_{ijk} u_k$ is a tensor of order 2 . Further

$$w_{ji} = \in_{jik} u_k$$

$$= - \in_{ijk} u_k$$

$$= - w_{ji}.$$

This shows that w_{ij} is a tensor which is skew – symmetric.

Example 2: Show that u_{ij} is symmetric iff $\in_{ijk} u_{ij} = 0$.

Solution: We find

$$\in_{ij1} u_{ij} = \in_{231} u_{23} + \in_{321} u_{32} = u_{23} - u_{32}$$

$$\in_{ij2} u_{ij} = u_{31} - u_{13} \, , \in_{ij3} u_{ij} = u_{12} - u_{21}$$

Thus, u_{ij} is symmetric iff

$$u_{ij} = u_{ji}$$

or

$$u_{23} = u_{32} \, , u_{13} = u_{31} \, , u_{12} = u_{21}.$$

1.7 ISOTROPIC TENSORS

Definition: A tensor is said to be an isotropic tensor if its components **remain unchanged / invariant** however the axes are rotated.

Note (1) An isotropic tensor possesses no directional properties. Therefore a non – zero vector (or **a non – zero tensor of rank 1) can never be an isotropic tensor.**

Tensors of higher orders , other than one , can be isotropic tensors.

Note (2) Zero tensors of **all orders** are isotropic tensors.

Note (3) By definition , a scalar (or a tensor of rank zero) is an isotropic tensor.

Note (4) A scalar multiple of an isotropic tensor is an isotropic tensor.

Note (5) The sum and the differences of two isotropic tensors is an isotropic tensor.

Theorem: Prove that substitution tensor δ_{ij} and alternating tensor $\in_{ijk}$ are isotropic tensors.

Proof: Let the components δ_{ij} relative to x_i system are transformed to quantities δ'_{pq} relative to x_i' - system. Then , the tensorial transformation rule is

$$\delta'_{pq} = a_{pi} \, a_{qj} \, \delta_{ij} \qquad (1)$$

where

$$a_{pi} = \cos(x_p' \, , x_i) \, . \qquad (2)$$

Now

$$\text{RHS of (1)} = a_{pi}\,[a_{qj}\,\delta_{ij}]$$

$$= a_{pi}\,a_{qi}$$

$$= \delta_{pq}$$

$$= \begin{cases} 0 & if \;\; p \neq q \\ 1 & if \;\; p = q \end{cases}. \qquad (3)$$

Relations (1) and (3) show that the components δ_{ij} are transformed into itself under all co-ordinate transformations. Hence , by definition , δ_{ij} is an isotropic tensor.

We know that $\in_{ijk}$ is a system of 27 numbers. Let

$$\in_{ijk} = [\bar{e}_i\,,\ \bar{e}_j\,,\ \bar{e}_k] = \bar{e}_i\,.\,(\bar{e}_j \times \bar{e}_k), \qquad (4)$$

be related to the x_i axes. Suppose that these components are transformed to $\in'_{pqr}$ relative to x_i' - axis. Then , the third order tensorial law of transformation gives

$$\in'_{pqr} = a_{pi}\,a_{qj}\,a_{rk} \in_{ijk} \qquad (5)$$

where l_{pi} is defined in (2)

we have already checked that (exercise)

$$\in_{ijk} a_{pi}\,a_{qj}\,a_{rk} = \begin{vmatrix} a_{p1} & a_{p2} & a_{p3} \\ a_{q1} & a_{q2} & a_{q3} \\ a_{r1} & a_{r2} & a_{r3} \end{vmatrix} \qquad (6)$$

and

$$[\bar{e}_p'\,,\ \bar{e}_q'\,,\ \bar{e}_r'] = \begin{vmatrix} a_{p1} & a_{p2} & a_{p3} \\ a_{q1} & a_{q2} & a_{q3} \\ a_{r1} & a_{r2} & a_{r3} \end{vmatrix} \qquad (7)$$

From (5) – (7) , we get

$$\in'_{pqr} = [\bar{e}_p'\,,\ \bar{e}_q'\,,\ \bar{e}_r']$$

$$= \bar{e}_p'\,.\,(\bar{e}_q' \times \bar{e}_r')$$

$$= \begin{cases} 1 & if\ p,q,r\ are\ in\ cyclic\ order \\ -1 & if\ p,q,r\ are\ in\ cyclic\ order \\ 0 & if\ any\ two\ or\ all\ suffices\ are\ equal \end{cases} \quad (8)$$

This shows that components $\in_{ijk}$ are transformed into itself under all coordinate transformations. Thus, the third order tensor $\in_{ijk}$ is an isotropic tensor.

Theorem: If u_{ij} is an isotropic tensor of second order , then show that

$$u_{ij} = \alpha\, \delta_{ij}$$

for some scalar α.

Proof: As the given tensor is isotropic , we have

$$u_{ij}' = u_{ij} \ , \quad (1)$$

for all choices of the x_i' - system. In particular , we choose

$$x_1' = x_2 \ , \ x_2' = x_3 \ , \ x_3' = x_1 \quad (2)$$

Then

$$a_{ij} = \begin{vmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{vmatrix} \quad (3)$$

and

$$u'_{pq} = a_{pi}\, a_{qj}\, u_{ij} \ . \quad (4)$$

Now

$$u_{11} = u_{11}' = a_{1i}\, a_{1j}\, u_{ij}$$
$$= a_{12}\, a_{12}\, u_{23} = u_{22} \ ,$$
$$u_{22} = u_{22}' = a_{2i}\, a_{2j}\, u_{ij}$$
$$= a_{23}\, a_{23}\, u_{33} = u_{33} \ ,$$
$$u_{12} = u_{12}' = a_{1i}\, a_{2j}\, u_{ij}$$
$$= a_{12}\, a_{23}\, u_{23} = u_{23} \ ,$$
$$u_{23} = u_{23}' = a_{2i}\, a_{3j}\, u_{ij}$$
$$= a_{23}\, a_{31}\, u_{31} = u_{31} \ ,$$
$$u_{13} = u_{13}' = a_{1i}\, a_{3j}\, u_{ij}$$

$$= a_{12}\, a_{31}\, u_{21} = u_{21} ,$$

$$u_{21} = u_{21}' = a_{2i}\, a_{1j}\, u_{ij}$$

$$= a_{23}\, a_{12}\, u_{32} = u_{32} \ .$$

Thus

$$u_{11} = u_{22} = u_{33} ,$$

$$u_{12} = u_{23} = u_{31} ,$$

$$u_{21} = u_{32} = u_{13} . \qquad (5)$$

Now , we consider the transformation

$$x_1' = x_2 , x_2' = -x_1 , x_3' = x_3 . \qquad (6)$$

Then

$$(a_{ij}) = \begin{pmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix} , \qquad (7)$$

$$u'_{pq} = a_{pi}\, a_{qj}\, u_{ij} \qquad (8)$$

This gives

$$u_{13} = u'_{13} = a_{1i}\, a_{3j}\, u_{ij}$$

$$= a_{12}\, a_{33}\, u_{23} = u_{23} ,$$

$$u_{23} = u'_{23} = a_{2i}\, a_{3j}\, u_{ij}$$

$$= a_{21}\, a_{33}\, u_{13} = -u_{13} .$$

Thus

$$u_{13} = u_{23} = 0. \qquad (9)$$

From (5) and (9), we obtain

$$a_{ij} = \alpha\, \delta_{ij} , \qquad (10)$$

where

$$\alpha = a_{11} = a_{22} = a_{33}. \qquad (11)$$

Note 1: If a_{ijk} are components of an isotropic tensor of third order, then

$$a_{ijk} = \alpha \, . \in_{ijk}$$

for some scalar α.

Note 2: If a_{ijkm} are components of a fourth – order isotropic tensor , then

$$a_{ijkm} = \alpha \, \delta_{ij} \, \delta_{km} + \beta \, \delta_{ik} \, \delta_{jm} + \gamma \, \delta_{im} \, \delta_{jk}$$

for some scalars α , β , γ .

Definition: (Gradient)

If $u_{pqr...}(x_1 , x_2 , x_3)$ is a tensor of order n , then

$$v_{spqr\ldots\ldots} = \frac{\partial}{\partial x_s} u_{pqr.....}$$

$$= u_{pqr\ldots., s}$$

is defined as the gradient of the tensor field $u_{pqr....}(x_1 , x_2 , x_3)$.

Theorem: Show that the gradient of a scalar point function is a tensor of order 1.

Proof: Suppose that $U = U(x_1 , x_2 , x_3)$ be a scalar point function and

$$v_i = \frac{\partial U}{\partial x_i} = U_{,i} = \text{gradient of U.} \qquad (1)$$

Let the components of the gradient of U in the dashed system o $x_1' \, x_2' \, x_3'$ be v_p', so that,

$$v_p' = \frac{\partial U}{\partial x_{p'}}, \qquad (2)$$

where the transformation rule of coordinates is

$$x_p' = a_{pi} \; x_i \, , \qquad (3)$$

$$x_i = a_{pi} \; x_p' \qquad (4)$$

$$a_{pi} = \cos (x_p' , x_i) \, . \qquad (5)$$

By chain rule

$$v_p' = \frac{\partial U}{\partial x_{p'}}$$

$$= \frac{\partial U}{\partial x_i} \frac{\partial x_i}{\partial x_{p'}}$$

$$= a_{pi} \frac{\partial U}{\partial x_i}$$

$$= a_{pi} v_i ,$$

which is a transformation rule for tensors of order 1.

Hence gradient of the scalar point function U is a tensor of order one.

Theorem: Show that the **gradient of a vector** u_i is a tensor of order 2. Deduce that δ_{ij} is a tensor of order 2.

Proof: The **gradient of the tensor** u_i is defined as

$$w_{ij} = \frac{\partial u_i}{\partial x_j} = u_{i,j}. \qquad (1)$$

Let the vector u_i be transformed to the vector u_p' relative to the new system o $x_1' x_2' x_3'$. Then the transformation law for tensors of order 1 yields

$$u_p' = a_{pi} u_i, \qquad (2)$$

where the law of transformation of coordinates is

$$x_q' = a_{qj} x_j, \qquad (3)$$

$$x_j = a_{qj} x_q', \qquad (4)$$

$$a_{pi} = \cos (x'_p, x_i). \qquad (5)$$

Suppose that the 9 quantities w_{ij} relative to new system are transformed to w'_{pq}. Then

$$w'_{pq} = \frac{\partial u'_p}{\partial x'_q}$$

$$= \frac{\partial}{\partial x_q'} (a_{pi} u_i)$$

$$= a_{pi} \frac{\partial u_i}{\partial x_q'}$$

$$= a_{pi} \frac{\partial u_i}{\partial x_j} \frac{\partial x_j}{\partial x_q'}$$

$$= a_{pi}\, a_{qj} \frac{\partial u_i}{\partial x_j}$$

$$= a_{pi}\, a_{qj}\, w_{ij}, \qquad (6)$$

which is the transformation rule for tensors of order 2.

Hence , w_{ij} is a tensor of order 2. Consequently , the gradient of the vector u_i is a tensor of order 2.

Deduction : We know that

$$\delta_{ij} = \frac{\partial x_i}{\partial x_j},$$

and that x_i is a vector. So , δ_{ij} is a gradient of the vector x_i. It follows that 9 quantities δ_{ij} are components of a tensor of order 2.

1.8 EIGENVALUES AND EIGEN VECTORS OF A SECOND ORDER SYMMETRIC TENSOR.

Definition: Let u_{ij} be a **second order** symmetric tensor. A scalar λ is called an **eigenvalue of** the tensor u_{ij} if there exists a **non – zero vector v_i** such that

$$u_{ij}\, v_j = \lambda\, v_i, \qquad \text{for } i = 1 , 2 , 3.$$

The **non – zero vector v_i** is then called an eigenvector of tensor u_{ij} corresponding to the eigen vector λ.

We observe that every (**non - zero**) scalar multiple of an eigenvector is also an eigen vector.

Article: Show that it is always possible to find three mutually orthogonal eigenvectors of a second order symmetric tensor.

Proof: Let u_{ij} be a second order symmetric tensor and λ be an eigen value of u_{ij} . Let v_i be an eigenvector corresponding to λ.

Then $u_{ij}\, v_j = \lambda\, v_i$

or

$$(u_{ij} - \lambda\, \delta_{ij})\, v_j = 0 . \qquad (1)$$

This is a set of three homogeneous simultaneous linear equations in three unknown v_1 , v_2 , v_3. These three equations are

$$\left.\begin{aligned} (u_{11}-\lambda)v_1 + u_{12}v_2 + u_{13}v_3 &= 0 \\ u_{21}v_1 + (u_{22}-\lambda)v_2 + u_{23}v_3 &= 0 \\ u_{31}v_1 + u_{32}v_2 + (u_{33}-\lambda)v_3 &= 0 \end{aligned}\right\} . \qquad (2)$$

This set of equations possesses a non – zero solution when

$$\begin{vmatrix} u_{11}-\lambda & u_{12} & u_{13} \\ u_{21} & u_{22}-\lambda & u_{23} \\ u_{31} & u_{32} & u_{33}-\lambda \end{vmatrix} = 0,$$

or

$$| u_{ij} - \lambda\, \delta_{ij} | = 0. \qquad (3)$$

Expanding the determinant in (3) , we find

$$(u_{11} - \lambda)\,[(u_{22} - \lambda)\,(u_{33} - \lambda) - u_{32}\,u_{23}]$$

$$- \quad u_{12}\,[u_{21}\,(u_{33} - \lambda) - u_{31}\,u_{23}] + u_{13}\,[u_{21}\,u_{32} - u_{31}\,(u_{22} - \lambda)] = 0$$

or

$$-\lambda^3 + (u_{11} + u_{22} + u_{33})\,\lambda^2 - (u_{11}\,u_{22} + u_{22}\,u_{33} + u_{33}\,u_{11} - u_{23}\,u_{32} - u_{31}\,u_{13} - u_{12}\,u_{21})\,\lambda + [u_{11}\,(u_{22}\,u_{33} - u_{23}\,u_{32}) - u_{12}\,(u_{21}\,u_{33} - u_{31}\,u_{23})$$

$$+ u_{13}(u_{21}\,u_{32} - u_{31}\,u_{22})] = 0 . \qquad (4)$$

We write (4) as

$$-\lambda^3 + \lambda^2\,I_1 - \lambda\,I_2 + I_3 = 0 , \qquad (5)$$

where

$$I_1 = u_{11} + u_{22} + u_{33}$$

$$= u_{ii}, \qquad (6)$$

$$I_2 = u_{11}\,u_{22} + u_{22}\,u_{33} + u_{33}\,u_{11} - u_{12}\,u_{21} - u_{23}\,u_{32} - u_{31}\,u_{13}$$

$$= \frac{1}{2}[u_{ii}\, u_{jj} - u_{ij}\, u_{ji}], \qquad (7)$$

$$I_3 = |\, u_{ij}\,|$$

$$= \in_{ijk} u_{i1}\, u_{j2}\, u_{k3}\,. \qquad (8)$$

Equation (5) is a cubic equation in λ. Therefore , it has three roots , say , λ_1 , λ_2 , λ_3 which may not be distinct (real or imaginary). These roots (which are scalar) are the three eigenvalues of the symmetric tensor u_{ij} .

Further

$$\lambda_1 + \lambda_2 + \lambda_3 = I_1 \qquad (9)$$

$$\lambda_1\, \lambda_2 + \lambda_2\, \lambda_3 + \lambda_3\, \lambda_1 = I_2 \qquad (10)$$

$$\lambda_1\, \lambda_2\, \lambda_3 = I_3 \qquad (11)$$

Each root λ_i , when substituted in equation (2) , gives a set of three linear equations (homogeneous) which are not all independent. By discarding one of equations and using the condition

$$v_1^{\,2} + v_2^{\,2} + v_3^{\,2} = 1$$

for unit vectors , the eigenvector $\overline{v}_i$ is determined.

Before proceeding further, we state and prove two important lemmas.

Lemma 1: Eigenvalues of a real symmetric tensor u_{ij} are **real**.

Proof: Let λ be an eigenvalue with corresponding eigenvector u_i.

Then $$u_{ij}\, v_j = \lambda\, v_i. \qquad (I)$$

Taking the complex conjugate on both sides of (I) , we find

$$\overline{u_{ij} v_j} = \overline{\lambda\, v_i} \qquad \overline{u_{ij}}\,\overline{v_j} = \overline{\lambda}\,\overline{v_i}$$

$$u_{ij}\, \overline{v_j} = \overline{\lambda}\, \overline{v_i} \qquad (II)$$

since u_{ij} is a real tensor. Now

$$u_{ij}\, \overline{v_j}\, v_i = (u_{ij}\, \overline{v_j})\, v_i$$

$$= (\overline{\lambda}\, \overline{v_i})\, v_i$$

$$= \overline{\lambda}\, \overline{v_i}\, v_i. \qquad (III)$$

Also $$\overline{u_{ij}\, \overline{v_j}\, v_i} = \overline{u_{ij}}\, v_j\, \overline{v_i}$$

$$= u_{ij}\, v_j\, \overline{v_i}$$

$$= u_{ji}\, v_i\, \overline{v_j}$$

$$= u_{ij}\, \overline{v_j}\, v_i.$$

This shows that quantity $u_{ij}\ \overline{v}_j\ v_i$ is real. Hence $\overline{\lambda}\ \ \overline{v}_i\ v_i$ is real.

Since $\overline{v}_i\ v_i$ is always real, it follows that $\overline{\lambda}$ is real.

Therefore λ is real.

Lemma 2: Eigen vector corresponding to two distinct eigen values of the symmetric tensor u_{ij} are orthogonal.

Proof: Let $\lambda_1 \neq \lambda_2$ be two distinct eigenvalues of u_{ij}. Let A_i and B_i be the corresponding non – zero eigenvectors. Then

$$u_{ij}\ A_j = \lambda_1\ A_i,$$

$$u_{ij}\ B_j = \lambda_2\ B_i. \qquad \text{(I)}$$

We obtain

$$u_{ij}\ A_j\ B_i = \lambda_1\ A_i\ B_i,$$

$$u_{ij}\ B_j\ A_i = \lambda_2\ A_i\ B_i\ . \qquad \text{(II)}$$

Now

$$u_{ij}\ A_j\ B_i = u_{ji}\ A_i\ B_j$$

$$= u_{ij}\ B_j\ A_i\ . \qquad \text{(III)}$$

From (II) & (III) , we get

$$\lambda_1\ A_i\ B_i = \lambda_2\ A_i\ B_i$$

$$(\lambda_1 - \lambda_2)\ A_i\ B_i = 0$$

$$A_i\ B_i = 0. \qquad (\Theta\ \lambda_1 \neq \lambda_2)$$

Hence , eigenvectors A_i and B_i are mutually orthogonal.

This completes the proof of lemma 2.

Now we consider various possibilities about eigenvalues λ_1 , λ_2 , λ_3 of the main theorem.

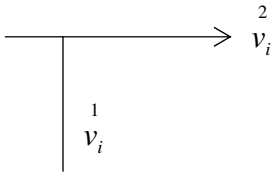
Case 1: If $\lambda_1 \neq \lambda_2 \neq \lambda_3$, i . e. , when all eigenvalues are different and real.

Then , by lemma 2 , three eigenvectors corresponding to λ_i are mutually orthogonal. Hence the result holds.

Case 2: If $\lambda_1 \neq \lambda_2 = \lambda_3$. Let $\overset{1}{v}_i$ be the eigenvector of the tensor u_{ij} corresponding to the

eigenvalue λ_1 and $\overset{2}{v}_i$ be the eigenvector corresponding to λ_2. Then

$$\overset{1}{v}_i \ \overset{2}{v}_i = 0.$$



Let p_i be **a** vector orthogonal to both $\overset{1}{v}_i$ and $\overset{2}{v}_i$. Then

$$p_i \ \overset{1}{v}_i = p_i \ \overset{2}{v}_i = 0 \ , \tag{12}$$

and

$$u_{ij} \ \overset{1}{v}_j = \lambda_1 \ \overset{1}{v}_i \quad ,$$

$$u_{ij} \ \overset{2}{v}_j = \lambda_2 \ \overset{2}{v}_i \ . \tag{13}$$

Let

$$u_{ij} \ p_j = q_i = \text{a tensor of order 1} \tag{14}$$

we shall show that q_i and p_i are parallel.

Now

$$\begin{aligned} q_i \ \overset{1}{v}_i &= u_{ij} \ p_j \ \overset{1}{v}_i \\ &= u_{ji} \ \overset{1}{v}_j \ p_i \\ &= u_{ij} \ \overset{1}{v}_j \ p_i \\ &= \lambda_1 \ \overset{1}{v}_i \ p_i \\ &= 0. \end{aligned} \tag{15}$$

Similarly

$$q_i \overset{2}{v}_i = 0. \tag{16}$$

Thus q_i is orthogonal to both orthogonal eigenvectors $\overset{1}{v}_i$ and $\overset{2}{v}_i$.

Thus q_i must be parallel to p_i. So , we may write

$$u_{ij}\, p_j = q_i = \alpha\, p_i \ , \tag{17}$$

for some scalar α .

Equation (10) shows tha α must be an eigenvalue and p_i must be the corresponding eigenvector of u_{ij}.

Let

$$\overset{3}{v}_i = \frac{p_i}{|\, p_i \,|} \ . \tag{18}$$

Since u_{ij} has only three eigenvalues λ_1 , $\lambda_2 = \lambda_3$, so α must be equal to $\lambda_2 = \lambda_3$.

Thus $\overset{3}{v}_i$ is an eigenvector which is orthogonal to both $\overset{1}{v}_i$ and $\overset{2}{v}_i$ where $\overset{1}{v}_i \perp \overset{2}{v}_i$.

Thus, there exists three mutually orthogonal eigenvectors.

Further , let w_i be any vector which lies in the plane containing the two eigenvectors $\overset{2}{v}_i$ and $\overset{3}{v}_i$ corresponding to the repeated eigenvalues. Then

$$w_i = k_1 \overset{2}{v}_i + k_2 \overset{3}{v}_i$$

for some scalars k_1 and k_2 and

$$w_i \overset{1}{v}_i = 0 \ ,$$

and

$$u_{ij}\, w_j = u_{ij}(k_1 \overset{2}{v}_j + k_2 \overset{3}{v}_j)$$

$$= k_1\, u_{ij} \overset{2}{v}_j + k_2\, u_{ij} \overset{3}{v}_j$$

$$= k_1\, \lambda_2 \overset{2}{v}_i + k_2\, \lambda_3 \overset{3}{v}_i$$

$$= \lambda_2 (k_1 \overset{2}{v_i} + k_2 \overset{3}{v_i}) \qquad (\Theta\ \lambda_2 = \lambda_3)$$

$$= \lambda_2 w_i . \qquad (19)$$

Thus w_i is orthogonal to $\overset{1}{v_i}$ and w_i is an eigenvector corresponding to λ_2.

Hence , any two orthogonal vectors that lie on the plane normal to $\overset{1}{v_i}$ can be chosen as the other two eigenvectors of u_{ij}.

Case 3: If $\lambda_1 = \lambda_2 = \lambda_3$.

In this case , the cubic equation in λ becomes

$$(\lambda - \lambda_1)^3 = 0,$$

or

$$\begin{vmatrix} \lambda_1 - \lambda & 0 & 0 \\ 0 & \lambda_1 - \lambda & 0 \\ 0 & 0 & \lambda_1 - \lambda \end{vmatrix} = 0 . \qquad (20)$$

Comparing it with equation (3) , we find

$$u_{ij} = 0 \text{ for } i \neq j$$

and

$$u_{11} = u_{22} = u_{33} = \lambda_1.$$

Thus

$$\mathbf{u_{ij} = \lambda_1\ \delta_{ij}} \qquad (21)$$

Let v_i be any **non – zero vector.** Then

$$u_{ij}\ v_j = \lambda_1\ \delta_{ij}\ v_j \ ,$$

$$= \lambda_1\ v_i. \qquad (22)$$

This shows that v_i is an eigenvector corresponding to λ_1. Thus , **every non – zero vector in space is an eigenvector which corresponds to the same eigenvalue λ_1.** Of these vectors , we can certainly chose (at least) there vectors $\overset{1}{v_i}$, $\overset{2}{v_i}$, $\overset{3}{v_i}$ that are mutually orthogonal.

Thus , in every case , there exists (at least) three mutually orthogonal eigenvectors of u_{ij}.

Example: Consider a second order tensor u_{ij} whose matrix representation is

$$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 2 & 1 \\ 2 & 2 & 3 \end{bmatrix}.$$

It is clear , the tensor u_{ij} is not symmetric. We shall find eigenvalues and eigenvectors of u_{ij}.

The characteristic equation is

$$\begin{vmatrix} 1-\lambda & 0 & -1 \\ 1 & 2-\lambda & 1 \\ 2 & 2 & 3-\lambda \end{vmatrix} = 0$$

or

$$(1 - \lambda)\,[(2 - \lambda)\,(3 - \lambda) - 2] - 1\,[2 - 2(2 - \lambda)] = 0$$

or

$$(1 - \lambda)\,(2 - \lambda)\,(3 - \lambda) = 0\ .$$

Hence , eigenvalues are

$$\lambda_1 = 1\ ,\ \lambda_2 = 2\ ,\ \lambda_3 = 3$$

which are all different.

We find that an unit eigenvector corresponding to $\lambda = 1$ is

$$v_i^{(1)} = \left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0\right),$$

an unit eigenvector corresponding to $\lambda = 2$ is

$$v_i^{(2)} = \left(\frac{2}{3}\ ,\ -\frac{1}{3}\ ,\ -\frac{2}{3}\right),$$

and an unit eigenvector corresponding to $\lambda = 3$ is

$$\overset{3}{v}_i = \left(\frac{1}{\sqrt{6}}, -\frac{1}{\sqrt{6}}, -\frac{2}{\sqrt{6}} \right) .$$

We note that

$$\overset{1}{v}_i \overset{2}{v}_i \neq 0, \ \overset{2}{v}_i \overset{3}{v}_i \neq 0, \ \overset{1}{v}_i \overset{3}{v}_i = 0.$$

This happens due to non – symmetry of the tensor u_{ij}.

Example 2: Let the matrix of the components of the second order tensor u_{ij} be

$$\begin{bmatrix} 2 & 2 & 0 \\ 2 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

Find eigenvalues and eigenvectors of it.

We note that the tensor is symmetric. The characteristic equation is

$$\begin{vmatrix} 2-\lambda & 2 & 0 \\ 2 & 2-\lambda & 0 \\ 0 & 0 & 1-\lambda \end{vmatrix} = 0$$

or

$$\lambda(\lambda - 1)\ (\ \lambda - 4) = 0 .$$

Thus eigenvalues are

$$\lambda_1 = 0 , \lambda_2 = 1 , \lambda_3 = 4 ,$$

which are all different.

Let $\overset{1}{v}_i$ be the unit eigenvector corresponding to eigenvalue $\lambda_1 = 0$. Then , the system of homogegeous equations is

$$\begin{bmatrix} 2 & 2 & 0 \\ 2 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \overset{1}{v}_1 \\ \overset{1}{v}_2 \\ \overset{1}{v}_3 \end{bmatrix} = 0 .$$

This gives $\overset{1}{v}_1 + \overset{1}{v}_2 = 0$, $\overset{1}{v}_1 + \overset{2}{v}_2 = 0$, $\overset{1}{v}_3 = 0$.

we find

$$\overset{1}{v}_i = \left(\frac{1}{\sqrt{2}} , \frac{-1}{\sqrt{2}} , 0 \right) .$$

Similarly

$$\overset{2}{v}_i = (0\ ,\ 0\ ,\ 1)\ \ ,$$

and

$$\overset{3}{v}_i = \left(\frac{1}{\sqrt{2}}\ ,\ \frac{1}{\sqrt{2}}\ ,\ 0\right)\ ,$$

are eigen vectors corresponding to $\lambda_2 = 1$ and $\lambda_3 = 4$, respectively.

Moreover, these vector are mutually orthogonal.

Books Recommended

1. Y.C. Fung — Foundations of Solid Mechanics, Prentice Hall, Inc., New Jersey, 1965

2. T.M. Atanackovic, A. Guran — Theory of Elasticity for Scientists and Engineers, Birkhauser , Boston, 2000

3. Saada, A.S. — Elasticity – Theory and Applications, Pergamon Press, Inc., NY, 1974.

4. Sokolnikoff, I.S. — Mathematical Theory of Elasticity, Tata McGraw Hill Publishing Company, Ltd., New Delhi, 1977.

5. Garg, N.R. and Sharma, R.K. — Generation of Displacements and Stresses in a Multilayered Half-Space due to a Strip-Loading, Journal ISET, Vol 28, 1991, pp 1-26.

Chapter-2
Analysis of Stress

2.1 INTRODUCTION

Deformation and motion of an elastic body are generally caused by external forces such as surface loads or internal forces such as earthquakes, nuclear explosions, etc. When an elastic body is subjected to such forces , its behaviour depends upon the **magnitude of the forces ,** upon **their direction** , and upon the inherent **strength of the material** of which the body is made. Such forces **give rise to interactions between neighbouring portions** in the interior parts of the elastic solid. Such interactions **are studied** through the **concept of stress.** The concepts of stress vector on a surface and state of stress at a point of the medium shall be discussed.

An approach to the solution of problems in elastic solid mechanics is to examine deformations initially , and then consider stresses and applied loads. Another approach is to establish relationships between applied loads and internal stresses first and then to consider deformations. Regardless of the approach selected , it is necessary to derive the component relations individually.

2.2. BODY FORCES AND SURFACE FORCES

Consider a continuous medium. We refer the points of this medium to a rectangular cartesian coordinate system. Let τ represents the region occupied by the body in the deformed state. A deformable body may be acted upon by two different types of external forces.

(i) Body forces : These forces are those forces **which act on every volume element of the body and hence on the entire volume** of the body. For example , **gravitational force** is a body force **(magnetic forces** are also body forces). Let ρ denotes the density of a volume element $\Delta\tau$ of the body τ. Let g be the gravitational force / acceleration. Then , the force acting on the mass $\rho\Delta\tau$ contained in volume $\Delta\tau$ is $g.\rho\Delta\tau$.

(ii) Surface forces : These forces are those which act upon every surface element of the body. Such forces are **also called contact forces. Loads applied** over the exterior surface or bounding surface are examples of surface forces. **A hydrostatic pressure** acting on the surface of a body **submerged in a liquid /** water is a surface force.

Internal forces : In addition to the external forces , there are internal forces (such **as earthquakes , nuclear explosions**) which arise **from the mutual interaction between various parts** of the elastic body.

Now , we consider an elastic body in its undeformed state with no forces acting on it. Let a system of forces be applied to it. Due to these forces , the body is deformed and **a system of internal forces is set up to oppose this deformation.** These internal forces **give rise to stress within the body**. It is therefore necessary to consider **how external forces are transmitted through the medium.**

2.3 STRESS VECTOR ON A PLANE AT A POINT

Let us consider an elastic body in equilibrium under the action of a system of external forces. Let us pass a fictitious plane π through a point $P(x_1 , x_2 , x_3)$ in the interior of this body. The body can be considered as consisting of two parts , say , A
and B and these parts are in welded contact at the interface π. Part A of the body is in equilibrium under forces (external) and the effect of part B on the plane π. We assume that this effect is continuously distributed over the surface of intersection.

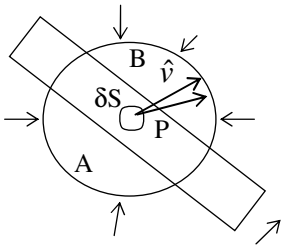


Fig. (2.1)
Around the point P , let us consider a small surface δS (on the place π) and let $\hat{v}$ be an outward unit normal vector (for the part A of the body). The effect of part B on this small surface element can be reduces to a force $\overline{Q}$ and a vector couple $\overline{C}$. Now, let δS shrink in size towards zero in a manner such that the point P always remain inside δS and $\hat{v}$ remains the normal vector.

We assume that $\frac{\overline{Q}}{\delta S}$ tends to a definite limit $\overline{T}\,(x_1 , x_2 , x_3)$ and that $\frac{\overline{C}}{\delta S}$ tends to zero as δS tends to zero. Thus

$$\lim_{\delta S \to 0} \frac{\overline{Q}}{\delta S} = \overline{T}\,(x_1 , x_2 , x_3) ,$$

$$\lim_{\delta S \to 0} \frac{\overline{C}}{\delta S} = 0 .$$

Now $\overline{T}$ is a surface force per unit area.

This force , $\overline{T}$, is called **the stress vector** or **traction on the plane π at P.**

Note 1: Forces acting over the surface of a body are never idealized point forces , they are, in reality, forces per unit area applied over some finite area. These external forces per unit area are called also tractions.

Note 2: Cauchy's stress postulate

If we consider another oriented plane π' containing the same point $P(x_i)$, then the stress vector is likely to have a different direction. For this purpose, Cauchy made the following postulated – known as Cauchy's stress postulate.

"The stress vector $\underset{\sim}{T}$ depends on the orientation of the plane upon which it acts".

Let $\hat{v}$ be the unit normal to plane π through the point P. This normal characterize the orientation of the plane upon which the stress vector acts. For this reason , we write the **stress vector as** $\underset{\sim}{T}^{\hat{v}}$, indicating its dependence on the orientation $\hat{v}$.

Cauchy's Reciprocal relation

When the plane π is in the interior of the elastic body , the normal $\hat{v}$ has two possible directions that are opposite to each other and we choose one of these directions.

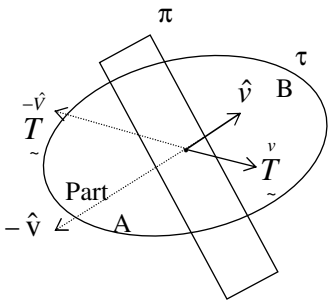


Fig. (2.2)

For a chosen $\hat{v}$, the stress vector $\underset{\sim}{T}^{\hat{v}}$ is interpreted as the internal surface force per unit area acting on plane π due to the action of part B of the material / body which $\hat{v}$ is directed upon the part A across the plane π.

Consequently , $\underset{\sim}{T}^{-\hat{v}}$ is the internal surface force per unit area acting on π due to the action of part A for which $\hat{v}$ is the outward drawn unit normal. By Newton's third law of motion , vector $\underset{\sim}{T}^{-\hat{v}}$ and $\underset{\sim}{T}^{\hat{v}}$ balance each other as the body is in equilibrium. Thus

$$\underset{\sim}{T}^{-\hat{v}} = -\underset{\sim}{T}^{\hat{v}} ,$$

which is known as Cauchy's reciprocal relation.

Homogeneous State of Stress

If π and π' are any two parallel planes through any two points P and P′ of a continuous elastic body , and if the stress vector on π at P is equal to the stress on π' at P′ , then the state of stress in the body is said to be a homogeneous state of stress.

2.4 NORMAL AND TANGENTIAL STRESSES

In general , the stress vector $\underset{\sim}{T}^{v}$ is inclined to the plane on which it acts and need not be in the direction of unit normal $\hat{v}$. The projection of $\underset{\sim}{T}^{v}$ on the normal $\hat{v}$ is called **the normal stress.** It is denoted by σ or σ_n. The projection of $\underset{\sim}{T}^{v}$ on the plane π , in the plane of $\underset{\sim}{T}^{\hat{v}}$ and $\hat{v}$, is called the **tangential** or **shearing stress.** It is denoted by τ or σ_t.

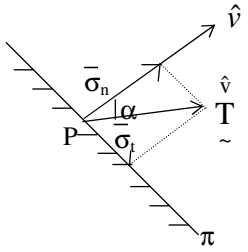


Fig. (2.3)

Thus,

$$\sigma = \sigma_n = \underset{\sim}{T}^{v} \cdot \hat{v} \quad , \quad \tau = \sigma_t = \underset{\sim}{T}^{\hat{v}} \cdot \hat{t} , \qquad (1)$$

$$| \underset{\sim}{T}^{\hat{v}} |^2 = \sigma_n^2 + \sigma_t^2 \qquad (2)$$

where $\hat{t}$ is a unit vector normal to $\hat{v}$ and lies in the place π.

A stress in the direction of the outward normal is considered positive (i.e. $\sigma > 0$) and is called a **tensile stress**. A stress in the opposite direction is considered negative ($\sigma < 0$) and is called a **compressible stress.**

If $\sigma = 0$, $\underset{\sim}{T}^{\hat{v}}$ is perpendicular to $\hat{v}$. Then , the stress vector $\underset{\sim}{T}^{\hat{v}}$ is called a **pure shear stress** or a **pure tangential stress.**

If $\tau = 0$, then $\underset{\sim}{T}^{\hat{v}}$ is parallel to $\hat{v}$. The stress vector $\underset{\sim}{T}^{\hat{v}}$ is then called **pure normal stress.**

When $\underset{\sim}{T}^{\hat{v}}$ acts opposite to the normal $\hat{v}$, then the pure normal stress is called **pressure** ($\sigma < 0, \tau = 0$).

From (1) , we can write

$$\underset{\sim}{T}^{\hat{v}} = \sigma\ \hat{v} + \tau\ \hat{t} \qquad (3)$$

and $$\tau = \sqrt{|\underset{\sim}{T}^{\hat{v}}|^2 - \sigma^2} \qquad (4)$$

Note : $\sigma_t = \tau = |\underset{\sim}{T}^{v}| \sin\alpha \ \Rightarrow\ |\sigma| = |\underset{\sim}{T}^{\hat{v}} \times \hat{v}|$, as $|\hat{v}| = 1$.

This τ in magnitude is given by the magnitude of vector product of $\underset{\sim}{T}^{\hat{v}}$ and $\hat{v}$.

2.5 STRESS COMPONENTS

Let $P(x_i)$ be any point of the elastic medium whose coordinates are (x_1 , x_2 , x_3) relative to rectangular cartesian system o x_1 x_2 x_3.

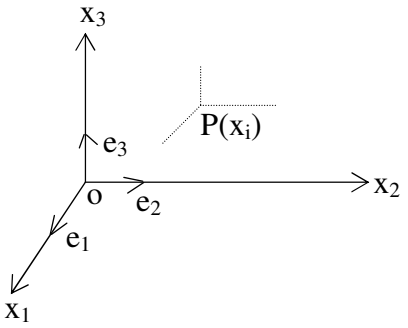


Fig. (2.4)

Let $\underset{\sim}{T}^{1}$ denote the stress vector on the plane , with normal along x_1 – axis , at the point P. Let the stress vector $\underset{\sim}{T}^{1}$ has components τ_{11} , τ_{12} , τ_{13} , i.e. ,

$$\underset{\sim}{T}^{1} = \tau_{11}\ \hat{e}_1 + \tau_{12}\ \hat{e}_2 + \tau_{13}\ \hat{e}_3$$

$$= \tau_{1j}\ \hat{e}_j\ . \qquad (1)$$

Let $\underset{\sim}{T}^{2}$ be the stress vector acting on the plane || to $x_1\ x_3$ – plane at P. Let

$$\underset{\sim}{T}^{2} = \tau_{21}\ \hat{e}_1 + \tau_{22}\ \hat{e}_2 + \tau_{23}\ \hat{e}_3$$

$$= \tau_{2j}\ \hat{e}_j\ . \qquad (2)$$

Similarly

$$\underset{\sim}{T}^{3} = \tau_{31}\ \hat{e}_1 + \tau_{32}\ \hat{e}_2 + \tau_{33}\ \hat{e}_3$$

$$= \tau_{3j}\ \hat{e}_j\ . \qquad (3)$$

Equations (1) – (3) can be condensed in the following form

$$\underset{\sim}{T}^{i} = \tau_{ij}\ \hat{e}_j\ . \qquad (4)$$

Then $$\underset{\sim}{T}^{i}\ .\ \hat{e}_k = (\tau_{ij}\ \hat{e}_j)\ .\ \hat{e}_k$$

$$= \tau_{ij}\ \delta_{jk}$$

$$= \tau_{ik}. \qquad (5)$$

Thus , for given i & j , the quantity τ_{ij} represent the jth components of the stress vector $\underset{\sim}{T}^{i}$ acting on a plane **having** $\hat{e}_i$ as the unit normal. Here , the first suffix i indicates the direction of the normal to the plane through P and the second suffix j indicates the direction of the stress component. In all , we have 9 components τ_{ij} at the point $P(x_i)$ in the o $x_1\ x_2\ x_3$ system. These quantities are called **stress – components.** The matrix

$$(\tau_{ij}) = \begin{bmatrix} \tau_{11} & \tau_{12} & \tau_{13} \\ \tau_{21} & \tau_{22} & \tau_{23} \\ \tau_{31} & \tau_{32} & \tau_{33} \end{bmatrix},$$

whose rows are the components of the three stress vectors, is called the matrix of the state of stress at P. The dimensions of stress components are $\frac{force}{(Length)^2}$ $= M\ L^{-1}\ T^{-2}$.

The stress components τ_{11} , τ_{22} , τ_{33} are called **normal stresses** and other components τ_{12} , τ_{13} , τ_{21} , τ_{23} , τ_{31} , τ_{32} are called **shearing stresses** ($\Theta \overset{1}{\underset{\sim}{T}} . \hat{e}_1 = e_{11}$, $\overset{1}{\underset{\sim}{T}} . \hat{e}_2 = e_{12}$, etc)

In CGS system , the stress is measured in **dyne per square centimeter**.

In English system , it measured in **pounds per square inch** or **tons per square inch.**

Dyadic Representation of Stress

It may be helpful to consider the stress tensor as a vector – like quantity having a magnitude and associated direction (s) , specified by unit vector. The dyadic is such a representation. We write the **stress tensor** or **stress dyadic** as

$$\overline{\overline{\tau}} = \tau_{ij}\ \hat{e}_i\ \hat{e}_j$$

$$= \tau_{11}\ \hat{e}_1\ \hat{e}_1 + \tau_{12}\ \hat{e}_1\ \hat{e}_2 + \tau_{13}\ \hat{e}_1\ \hat{e}_3 + \tau_{21}\ \hat{e}_2\ \hat{e}_1 + \tau_{22}\ \hat{e}_2\ \hat{e}_2$$

$$+ \tau_{23}\ \hat{e}_2\ \hat{e}_3 + \tau_{31}\hat{e}_3\ \hat{e}_1 + \tau_{32}\hat{e}_3\ \hat{e}_2 + \tau_{33}\hat{e}_3\ \hat{e}_3 \qquad (1)$$

where the juxtaposed double vectors are called **dyads.**

The stress vector $\overset{i}{\underset{\sim}{T}}$ acting on a plane having normal along $\hat{e}_i$ is evaluated as follows :

$$\overset{i}{\underset{\sim}{T}} = \overline{\overline{\sigma}} \ . \ \hat{e}_i$$

$$= (\tau_{jk}\ \hat{e}_j\ \hat{e}_k)\ .\ \hat{e}_i$$

$$= \tau_{jk}\ \hat{e}_j\ (\delta_{ki})$$

$$= \tau_{ji}\ \hat{e}_j$$

$$= \tau_{ij}\ \hat{e}_j\ .$$

2.6 STATE OF STRESS AT A POINT–THE STRESS TENSOR

We shall show that the state of stress at any point of an elastic medium on an oblique plane is completely characterized by the stress components at P.

Let $\underset{\sim}{\overset{v}{T}}$ be the stress vector acting on an oblique plane at the material point P , the unit normal to this plane being $\hat{v} = v_i$.

Through the point P , we draw three planar elements parallel to the coordinate planes. A fourth plane ABC at a distance h from the point P and parallel to the given oblique plane at P is also drawn. Now, the tetrahedron PABC contains the elastic material.

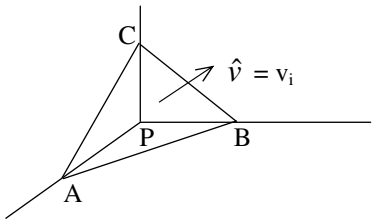


Fig. (2.5)

Let τ_{ij} be the components of stress at the point P. Regarding the signs (negative or positive) of scalar quantities τ_{ij} , we adopt the following convention.

If one draws an exterior normal (outside the medium) to a given face of the tetrahedron PABC ,then the positive values of components τ_{ij} are associated with forces acting in the positive directions of the coordinate axes. On the other hand , if the exterior normal to a given face is pointing in a direction opposite to that of the coordinate axes , then the positive values of τ_{ij} are associated with forces directed oppositely to the positive directions of the coordinate axes.

Let σ be the area of the face ABC of the tetrahedron in figure. Let σ_1 , σ_2 , σ_3 be the areas of the plane faces PBC , PCA and PAB (having normals along x_1 - , x_2 - & x_3 – axes) respectively.

Then

$$\sigma_i = \sigma \cos(x_i , \hat{v}) = \sigma v_i \qquad (1)$$

The volume of the tetrahedron is

$$v = \frac{1}{3} h \sigma. \qquad (2)$$

Assuming the continuity of the stress vector $\underset{\sim}{\overset{v}{T}} = \overset{v}{T_i}$, the x_i – component of the stress force acting on the face ABC of the tetrahedron PABC (made of elastic material) is

$$(\overset{v}{T_i} + \in_i) \sigma , \qquad (3)$$

provided $\lim_{h\to 0} \in_i = 0$. (3a)

Here , $\in_i$'s are inserted because the stress force act at points of the oblique plane ABC and not on the given oblique plane through P. Under the assumption of continuing of stress field , quantities $\in_i$'s are infinitesimals.

We note that the plane element PBC is a part of the boundary surface of the material contained in the tetrahedron. As such , the unit outward normal to PBC is $-\hat{e}_1$. Therefore , the x_i – component of force due to stress acting on the face PBC of area σ_1 is

$$(-\tau_{1i} + \in_{1i})\, \sigma_1 \qquad (4a)$$

where $\lim_{h\to 0} \in_{1i} = 0.$

Similarly forces on the face PCA and PAB are

$$\left.\begin{aligned}(-\tau_{2i} + \in_{2i})\, \sigma_2 \,,\\ (-\tau_{3i} + \in_{3i})\, \sigma_3\end{aligned}\right]$$

with $\lim_{h\to 0}$

$$\in_{2i} = \lim_{h\to 0} \in_{3i} = 0. \qquad (4b)$$

On combining (4a) and (4b) , we write

$$(-\tau_{ji} + \in_{ji})\, \sigma_j, \qquad (5)$$

as the x_i – component of stress force acting on the face of area σ_j provided

$$\lim_{h\to 0} \quad \in_{ji} = 0.$$

In equation (5) , the stress components τ_{ij} are taken with the negative sign as the exterior normal to a face of area σ_j is in the negative direction of the x_j – axis.

Let F_i be the body force per unit volume at the point P. Then the x_i – component of the body force acting on the volume of tetrahedron PABC is

$$\frac{1}{3} h\, \sigma(F_i + \in_i') \qquad (6)$$

where $\in_i$'s are infinitesimal and

$$\lim_{h\to 0} \in_i' = 0.$$

Since the tetrahedral element PABC of the elastic body is in equilibrium, therefore , the resultant force acting on the material contained in PABC must be zero. Thus

$$(\overset{v}{T}_i + \in_i)\,\sigma + (-\tau_{ji} + \in_{ji})\sigma_j + \frac{1}{3}(F_i + \in_i')h\,\sigma = 0.$$

Using (1) , above equation (after cancellation of σ) becomes

$$(\overset{v}{T}_i + \in_i) + (-\tau_{ji} + \in_{ji})v_j + \frac{1}{3}(F_i + \in_i')\,h = 0. \qquad (7)$$

As we take the limit $h \to 0$ in (7) , the oblique face ABC tends to the given oblique plane at P. Therefore , this limit gives

$$\overset{v}{T}_i - \tau_{ji}\, v_j = 0$$

or

$$\overset{v}{T}_i = \tau_{ji}\, v_j \qquad (8)$$

This relation connecting the stress vector $\underset{\sim}{\overset{v}{T}}$ and the stress components τ_{ij} is known as **Cauchy's law or formula**.

It is convenient to express the equation (8) in the matrix notation. This has the form

$$\begin{bmatrix} \overset{v}{T}_1 \\ \overset{v}{T}_2 \\ \overset{v}{T}_3 \end{bmatrix} = \begin{bmatrix} \tau_{11} & \tau_{21} & \tau_{31} \\ \tau_{12} & \tau_{22} & \tau_{32} \\ \tau_{13} & \tau_{23} & \tau_{33} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} \qquad (8a)$$

As $\overset{v}{T}_i$ and v_i are vectors. Equation (8) shows , by quotient law for tensors , that new **components τ_{ij} form a second order tensor**.

This stress tensor is called the CAUCHY'S STRESS TENSOR.

We note that , through a given point , there exists infinitely many surface plane elements. On every one of these elements we can define a stress vector. The totality of all these stress vectors is called the **state of stress** at the point. The relation (8) enables us to find the stress vector on any surface element at a point by knowing the stress tensor at that point. As such , the state of stress at a point is completely determined by the stress tensor at the point.

Note : In the above , we have assumed , first , that stress can be defined everywhere in a body , and , second , that the stress field is continuous. These are the basic assumptions of continuum mechanics. Without these assumptions

, we can do very little. However , in the further development of the theory , certain mathematical discontinuities will be permitted / allowed.

2.7 BASIC BALANCE LAWS

(A) Balance of Linear Momentum :

So far , we have discussed the state of stress at a point. If it is **desired to move from one point to another ,** the stress components will change. Therefore, it is necessary to investigate the equations / conditions which control the way in which they change.

While the strain tensor e_{ij} has to satisfy six compatibility conditions , the components of stress tensor must satisfy three linear **partial differential equations of the first order**. The principle of balance of linear momentum gives us these differential equations. This law , consistent with the **Newton's second law of motion** , states that **the time rate of change of linear momentum** is equal to the **resultant force on the elastic body**.

Consider a continuous medium in equilibrium with volume τ and bounded by a closed surface σ. Let F_i be the components of the **body force per unit volume** and $\overset{v}{T}_i$ be the component of the surface force in the x_i – direction. For equilibrium of the medium , the resultant force acting on the matter within τ must vanish . That is

$$\int_{\tau} F_i \, d\tau + \int_{\sigma} \overset{v}{T}_i \, d\sigma = 0, \qquad \text{for } i = 1, 2 , 3. \tag{1}$$

We know the following Cauchy's formula

$$\overset{v}{T}_i = \tau_{ji} \, v_j, \qquad (i = 1 , 2 , 3), \tag{2}$$

where τ_{ij} is the stress tensor and v_j is the unit normal to the surface. Using (2) into equation (1) , we obtain

$$\int_{\tau} F_i \, d\tau + \int_{\sigma} \tau_{ji} \, v_j \, d\sigma = 0, \qquad (i = 1 , 2 , 3). \tag{3}$$

We assume that stresses τ_{ij} and their first order partial derivatives are also continuous and single valued in the region τ. Under these assumptions , Gauss – divergence theorem can be applied to the surface integral in (3) and we find

$$\int_{\sigma} \tau_{ji}\, v_j \, d\sigma = \int_{\tau} \tau_{ji\,,\,j} \, d\,\tau. \tag{4}$$

From equations (3) and (4) , we write

$$\int_{\tau} (\tau_{ji\,,\,j} + F_i)\, d\tau = 0, \tag{5}$$

for each i = 1, 2 , 3. Since the region τ of integration is arbitrary (every part of the medium is in equilibrium) and the integrand is continuous, so , we must have

$$\tau_{ji\,,\,j} + F_i = 0, \tag{6}$$

for each i = 1, 2 , 3 and at every interior point of the continuous elastic body. These equations are

$$\begin{aligned}
&\frac{\partial \tau_{11}}{\partial x_1} + \frac{\partial \tau_{21}}{\partial x_2} + \frac{\partial \tau_{31}}{\partial x_3} + F_1 = 0 \ , \\
&\frac{\partial \tau_{12}}{\partial x_1} + \frac{\partial \tau_{22}}{\partial x_2} + \frac{\partial \tau_{32}}{\partial x_3} + F_2 = 0 \ , \\
&\frac{\partial \tau_{13}}{\partial x_1} + \frac{\partial \tau_{23}}{\partial x_2} + \frac{\partial \tau_{33}}{\partial x_3} + F_3 = 0 \ .
\end{aligned} \tag{7}$$

These equations are referred to as **Cauchy's equations of equilibrium.** These equations are also called **stress equilibrium equations.** These equations are associated with undeformed cartesian coordinates.

These equations were obtained by Cauchy in **1827.**

Note 1 : In the case of motion of an elastic body , these equations (due to balance of linear momentum) take the form

$$\tau_{ji,j} + F_i = \rho\, \ddot{u}_i, \tag{8}$$

where $\ddot{u}_i$ is the acceleration vector and ρ is the density (mass per unit volume) of the body.

Note 2 : When body force F_i is absent (or negligible) , equations of equilibrium reduce to

$$\tau_{ji,j} = 0. \tag{9}$$

Example: Show that for zero body force, the state of stress for an elastic body given by

$$\tau_{11} = x^2 + y + 3z^2 \, , \, \tau_{22} = 2x + y^2 + 2z \, , \, \tau_{33} = -2x + y + z^2$$

$$\tau_{12} = \tau_{21} = -xy + z^3 \, , \, \tau_{13} = \tau_{31} = y^2 - xz \, , \, \tau_{23} = \tau_{32} = x^2 - yz$$

is possible.

Example: Determine the body forces for which the following stress field describes a state of equilibrium

$$\tau_{11} = -2x^2 - 3y^2 - 5z \, , \, \tau_{22} = -2y^2 + 7 \, , \, \tau_{33} = 4x + y + 3z - 5$$

$$\tau_{12} = \tau_{21} = z + 4xy - 6 \, , \, \tau_{13} = \tau_{31} = -3x + 2y + 1 \, , \, \tau_{23} = \tau_{32} = 0.$$

Example: Determine whether the following stress field is admissible in an elastic body when body forces are negligible.

$$[\tau_{ij}] = \begin{bmatrix} yz + 4 & z^2 + 2x & 5y + z \\ . & xz + 3y & 8x^3 \\ . & . & 2xyz \end{bmatrix}$$

(B) Balance of Angular momentum

The principle of balance of angular momentum for an elastic solid is –

"The time rate of change of angular momentum about the origin is equal to **the resultant moment about of origin of body and surface forces."**

This law assures the symmetry of the stress tensor τ_{ij}.

Let a continuous elastic body in equilibrium occupies the region τ bounded by surface σ. Let F_i be the body force acting at a point $P(x_i)$ of the body. Let the position vector of the point P relative to the origin be $\vec{r} = x_i \, \hat{e}_i$. Then , the moment of force $\vec{F}$ is $\vec{r} \times \vec{F} = \in_{ijk} x_j F_k$, where $\in_{ijk}$ is the alternating tensor.

As the elastic body is in equilibrium , the resultant moment due to body and surface forces must be zero. So ,

$$\int_{\tau} \in_{ijk} x_j F_k \, d\tau + \int_{\sigma} \in_{ijk} x_j \, \overset{v}{T}_k \, d\sigma = 0, \qquad (1)$$

for each i = 1, 2 , 3.

Since , the body is in equilibrium , so the Cauchy's equilibrium equations gives

$$F_k = -\tau_{lk,l}. \tag{2a}$$

The stress vector $\overset{v}{T}_k$ in terms of stress components is given by

$$\overset{v}{T}_k = \tau_{lk}\, v_l \tag{2b}$$

The Gauss – divergence theorem gives us

$$\int_\sigma \in_{ijk} x_j\, \tau_{lk}\, v_l\, d\sigma = \int_\tau [\in_{ijk} x_j\, \tau_{lk}]_{,l}\, d\tau$$

$$= \int_\tau \in_{ijk} [x_j\, \tau_{lk,l} + \delta_{jl}\, \tau_{lk}]\, d\tau$$

$$= \int_\tau \in_{ijk} [x_j\, \tau_{lk,l} + \tau_{jk}]\, d\tau. \tag{3}$$

From equations (1) , (2a) and (3) ; we write

$$\int_\tau \in_{ijk} x_j\, (-\tau_{lk,l})\, d\tau + \int_\tau \in_{ijk} [x_j\, \tau_{lk,l} + \tau_{jk}]\, d\tau = 0.$$

This gives

$$\int_\tau \in_{ijk} \tau_{jk}\, d\tau = 0, \tag{4}$$

for i = 1 , 2 , 3. Since the integrand is continuous and the volume is arbitrary , so

$$\in_{ijk} \tau_{jk} = 0, \tag{5}$$

for i = 1 , 2 , 3 and at each point of the elastic body. Expanding (5) , we write

$$\in_{123} \tau_{23} + \in_{132} \tau_{32} = 0$$

$$\Rightarrow \quad \tau_{23} - \tau_{32} = 0,$$

$$\in_{213} \tau_{13} + \in_{231} \tau_{31} = 0$$

$$\Rightarrow \quad \tau_{13} = \tau_{31}, \tag{6}$$

$$\in_{312} \tau_{12} + \in_{321} \tau_{21} = 0$$

$$\Rightarrow \quad \tau_{12} = \tau_{21}.$$

That is

$$\tau_{ij} = \tau_{ji} \qquad \text{for } i \neq j \qquad (7)$$

at every point of the medium.

This proves the symmetry of stress tensor.

This law is also referred to as **Cauchy's second law.** It is due to **Cauchy** in **1827.**

Note 1 : On account of this symmetry , the state of stress at every point is specified by six instead of nine functions of position.

Note 2 : In summary , the six components of the state of the stress must satisfy three partial differential equations ($\tau_{ji,j} + F_i = 0$) within the body and the three relations ($\overset{v}{T}_i = \tau_{ji}\, v_j$) on the bounding surface. The equations $\overset{v}{T}_i = \tau_{ji}\, v_j$ are called the boundary conditions.

Note 3 : Because of symmetry of the stress – tensor , the equilibrium equations may be written as

$$\tau_{ij,j} + F_i = 0.$$

Note 4 : Since $\overset{i}{T}_j = \tau_{ij}$, equations of equilibrium (using symmetry of τ_{ij}) may also be expressed as

$$\overset{i}{T}_{j,j} = -F_i$$

or

$$\text{div } \underset{\sim}{\overset{i}{T}} = -F_i.$$

Note 5 : Because of the symmetry of τ_{ij} , the boundary conditions can be expressed as

$$\overset{v}{T}_i = \tau_{ij}\, v_j$$

Remark : It is obvious that the three equations of equilibrium do not suffice for the determination of the six functions that specify the stress field. This may be expressed by the statement that the stress field is statistically indeterminate. To determine the stress field , the equations of equilibrium must be supplemented by other relations that can't be obtained from static considerations.

2.8 TRANSFORMATION OF COORDINATES

We have defined earlier the components of stress τ_{ij} with respect to cartesian system o x_1 x_2 x_3. Let Ox_1' x_2' x_3' be any other cartesian system with the

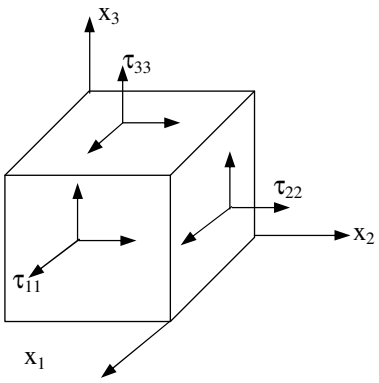
same origin but oriented differently. Let these coordinates be connected by the linear relations

$$x_p' = a_{pi}\, x_i \quad , \tag{1}$$

where a_{pi} are the direction cosines of the x_p' - axis with respect to the x_i – axis. That is ,

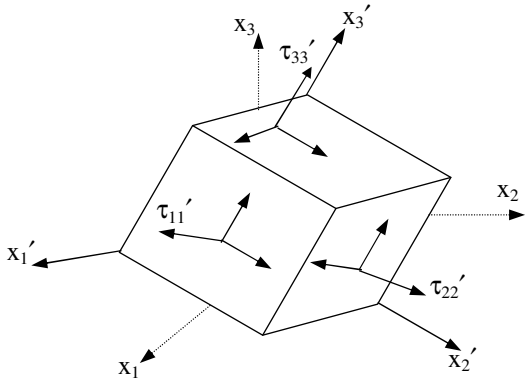
$$a_{pi} = \cos(x_p' , x_i) \, . \tag{2}$$

Let τ'_{pq} be the components of stress in the new reference system (Fig.).



Given stresses

Fig. (2.6)



Desired stresses

Fig. (2.7) Transformation of stress components under rotation of co-ordinates system.

We shall now obtain a general formula ,in the form of the theorem given below , which enables one to compute the component in any direction $\hat{v}$ of the stress vector acting on any given element with $\hat{v}'$.

Theorem: let the surface element $\Delta\sigma$ and $\Delta\sigma'$, with unit normals $\hat{v}$ and $\hat{v}'$, pass through the point P. Show that the component of the stress vector $\underset{\sim}{\overset{\hat{v}}{T}}$ acting on $\Delta\sigma$ in the direction of $\hat{v}'$ is equal to the component of the stress vector $\underset{\sim}{\overset{\hat{v}'}{T}}$ acting on $\Delta\sigma'$ in the direction of $\hat{v}$.

Proof: In this theorem , it is required to show that

$$\underset{\sim}{\overset{\hat{v}}{T}} \cdot \hat{v}' = \underset{\sim}{\overset{\hat{v}'}{T}} \cdot \hat{v} \tag{3}$$

The Cauchy's formula gives us

$$\overset{v}{T}_i = \tau_{ji}\, v_j \tag{4}$$

and

$$\overset{v'}{T}_i = \tau_{ij}\, v_j', \tag{5}$$

due to symmetry of stress tensors as with

$$\hat{v} = v_j \text{ and } \hat{v}' = v_j'.$$

Now $$\underset{\sim}{\overset{v'}{T}} \cdot \hat{v} = \overset{v'}{T}_i\, v_i$$

$$= (\tau_{ij}\, v_j')\, v_i$$

$$= \tau_{ji}\, v_i'\, v_j$$

$$= (\tau_{ij}\, v_j)\, v_i'$$

$$= \overset{v}{T}_i\, v_i'$$

$$= \underset{\sim}{\overset{v}{T}} \cdot \hat{v}'. \tag{6}$$

This completes the proof of the theorem.

Article : Use the formula (3) to derive the formulas of transformation of the components of the stress tensor τ_{ij}.

Solution : Since the stress components τ'_{pq} is the projection on the x'_q – axis of the stress vector acting on a surface element normal to the x'_p – axis (by definition) , we can write

$$\tau'_{pq} = \overset{p}{T}_q = \overset{\hat{v}'}{T} , \hat{v} \tag{7}$$

where

$$\left.\begin{aligned} &\hat{v}' \text{ is parallel to the } x'_p \text{ – axis ,} \\ &\hat{v} \text{ is parallel to the } x'_q \text{ – axis.} \end{aligned}\right\} \tag{8}$$

Equations (6) and (7) imply

$$\tau'_{pq} = \tau_{ij} \nu_i' \nu_j.. \tag{9}$$

Since

$$\left.\begin{aligned} \nu_i' &= \cos(x'_p , x_i) = a_{pi} \\ \nu_j &= \cos(x'_q , x_j) = a_{qj}. \end{aligned}\right\} \tag{10}$$

Equation (9) becomes

$$\tau'_{pq} = a_{pi} a_{qj} \tau_{ij}. \tag{11}$$

Equation (11) and definition of a tensor of order 2 show that the stress components τ_{ij} transform like a cartesian tensor of order 2. Thus , the physical concept of stress which is described by τ_{ij} agrees with the mathematical definition of a tensor of order 2 in a Euclidean space.

Theorem: Show that the quantity

$$\theta = \tau_{11} + \tau_{22} + \tau_{33}$$

is invariant relative to an orthogonal transformation of cartesian coordinates.

Proof: Let τ_{ij} be the tensor relative to the cartesian system o x_1 x_2 x_3. Let these axes be transformed to o x_1' x_2' x_3' under the orthogonal transformation

$$x'_p = a_{pi} x_i , \tag{1}$$

where

$$a_{pi} = \cos(x'_p , x_i). \tag{2}$$

Let τ'_{pq} be the stress components relative to new axes. Then these components are given by the rule for second order tensors ,

$$\tau'_{pq} = a_{pi}\, a_{qj}\, \tau_{ij}. \qquad (3)$$

Putting q = p and taking summation over the common suffix , we write

$$\begin{aligned} \tau'_{pp} &= a_{pi}\, a_{pj}\, \tau_{ij} \\ &= \delta_{ij}\, \tau_{ij} \\ &= \tau_{ij}. \end{aligned}$$

This implies

$$\tau'_{11} + \tau'_{22} + \tau'_{33} = \tau_{11} + \tau_{22} + \tau_{33} = \theta \qquad (4)$$

This proves the theorem.

Remark: This theorem shows that whatever be the orientation of three mutually orthogonal planes passing through a given point , the sum of the normal stresses is independent of the orientation of these planes.

Exercise 1 : Prove that the tangential traction , parallel to a line l , across a plane at right angles to a line l′ , the two lines being at right angles to each other , is equal to the tangential traction , parallel to the line l′ , across a plane at right angles to l.

Exercise 2 : Show that the following two statements are equivalent.

(a) The components of the stress are symmetric.

(b) Let the surface elements $\Delta\sigma$ and $\Delta\sigma'$ with respective normals $\hat{v}$ and $\hat{v}'$ pass through a point P. Then $\underset{\sim}{T}^{v} \cdot \hat{v}' = \underset{\sim}{T}^{v'} \cdot \hat{v}$.

Hint : (b) $\Rightarrow$ (a). Let $\hat{v} = \hat{i}$ and $\hat{v}' = \hat{j}$

Then $\underset{\sim}{T}^{v} \cdot \hat{v}' = \underset{\sim}{T}^{i} \cdot \hat{j} = T^{i}_{j} = \tau_{ij}$

and $\underset{\sim}{T}^{v'} \cdot \hat{v} = \underset{\sim}{T}^{j} \cdot \hat{i} = T^{j}_{i} = \tau_{ji}$

by assumption , $\underset{\sim}{T}^{v} \cdot \hat{v}' = \underset{\sim}{T}^{v'} \cdot \hat{v}$, therefore $\tau_{ij} = \tau_{ji}$

This shows that τ_{ij} **is symmetric**.

Example 1: The stress matrix at a point P in a material is given as

$$[\tau_{ij}] = \begin{bmatrix} 3 & 1 & 4 \\ 1 & 2 & -5 \\ 4 & -5 & 0 \end{bmatrix}$$

Find
(i) the stress vector on a plane element through P and parallel to the plane $2x_1 + x_2 - x_3 = 1$,
(ii) the magnitude of the stress vector , normal stress and the shear stress ,
(iii) the angle that the stress vector makes with normal to the plane.

Solution: (i) The plane element on which the stress – vector is required is parallel to the plane $2x_1 + x_2 - x_3 = 1$. Therefore , direction ratios of the normal to the required plane at P are < 2 , 1 , -1>. So, the d.c.'s of the unit normal $\hat{v} = v_i$ to the required plane at P are

$$v_1 = \frac{2}{\sqrt{6}} \ , \ v_2 = \frac{1}{\sqrt{6}} \ , \ v_3 = -\frac{1}{\sqrt{6}} \ .$$

Let $\underset{\sim}{\overset{v}{T}} = \overset{v}{T}_i$ be the required stress vector. Then , Cauchy's formula gives

$$\begin{bmatrix} \overset{v}{T}_1 \\ \overset{v}{T}_2 \\ \overset{v}{T}_3 \end{bmatrix} \begin{bmatrix} 3 & 1 & 4 \\ 1 & 2 & -5 \\ 4 & -5 & 0 \end{bmatrix} \begin{bmatrix} 2/\sqrt{6} \\ 1/\sqrt{6} \\ -1/\sqrt{6} \end{bmatrix},$$

or

$$\overset{v}{T}_1 = \sqrt{3/2} \ , \ \overset{v}{T}_2 = 3\sqrt{3/2} \ , \ \overset{v}{T}_3 = \sqrt{3/2} \ .$$

So , the required stress vector at P is

$$\underset{\sim}{\overset{v}{T}} = \sqrt{\frac{3}{2}}(\hat{e}_1 + 3\hat{e}_2 + \hat{e}_3)$$

and

$$| \underset{\sim}{\overset{v}{T}} | = \sqrt{\frac{33}{2}} \ .$$

(ii) The normal stress σ is given by

$$\sigma = \underset{\sim}{\overset{v}{T}} \cdot \hat{v} = \sqrt{\frac{3}{2}} \cdot \frac{1}{\sqrt{6}} (2 + 3 - 1) = \frac{1}{2} \times 4 = 2,$$

and the shear stress τ is given by

$$\tau = \sqrt{|\underset{\sim}{\overset{v}{T}}|^2 - \sigma^2} = \sqrt{\frac{33}{2} - 4} = \frac{5}{\sqrt{2}}.$$

(As $\tau \neq 0$, so the stress vector $\underset{\sim}{\overset{v}{T}}$ need not be along the normal to the plane element)

(iii) Let θ be the angle between the stress vector $\underset{\sim}{\overset{v}{T}}$ and normal $\hat{v}$.

Then

$$\cos\theta = \frac{\underset{\sim}{\overset{v}{T}} . \hat{v}}{|\underset{\sim}{\overset{v}{T}}| \, |\hat{v}|} = \frac{2}{\sqrt{\frac{33}{2}}} = \sqrt{\frac{8}{33}}.$$

This determines the required inclination.

Example 2: The stress matrix at a point $P(x_i)$ in a material is given by

$$[\tau_{ij}] = \begin{bmatrix} x_3 x_1 & x_3^{\,2} & 0 \\ x_3^{\,2} & 0 & -x_2 \\ 0 & -x_2 & 0 \end{bmatrix}.$$

Find the stress vector at the point Q (1 , 0 , -1) on the surface $x_2^{\,2} + x_3^{\,2} = x_1$.

Solution: The stress vector $\underset{\sim}{\overset{v}{T}}$ is required on the surface element

$$f(x_1 , x_2 , x_3) = x_1 - x_2^{\,2} - x_3^{\,2} = 0 ,$$

at the point Q(1 , 0 , -1).

We find $\nabla f = \hat{e}_1 + 2\hat{e}_3$ and $|\nabla f| = \sqrt{5}$ at the point Q.

Hence , the unit outward normal $\hat{v} = v_i$ to the surface f = 0 at the point Q(1 , 0 , −1) is

$$\hat{v} = \frac{\nabla f}{|\nabla f|} = \frac{1}{\sqrt{5}}(\hat{e}_1 + 2\hat{e}_3).$$

giving

$$v_1 = \frac{1}{\sqrt{5}}\ , v_2 = 0\ , v_3 = \frac{2}{\sqrt{5}}\ .$$

The stress matrix at the point $Q(1\ ,\ 0\ ,\ -1)$ is

$$[\tau_{ij}] = \begin{bmatrix} -1 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}.$$

Let $\underset{\sim}{\overset{v}{T}} = \overset{v}{T}_i$ be the required stress vector at the point Q. Then , by Cauchy's law

$$\begin{bmatrix} \overset{v}{T}_1 \\ \overset{v}{T}_2 \\ \overset{v}{T}_3 \end{bmatrix} = \begin{bmatrix} -1 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 1/\sqrt{5} \\ 0 \\ 2/\sqrt{5} \end{bmatrix}.$$

We find $\overset{v}{T}_1 = \frac{-1}{\sqrt{5}}\ ,\quad \overset{v}{T}_2 = \frac{1}{\sqrt{5}}\ ,\quad \overset{v}{\mathrm{T}}_3 = 0\ .$

Hence , the required stress vector at Q is

$$\underset{\sim}{\overset{v}{T}} = \frac{1}{\sqrt{5}}(-\hat{e}_1 + \hat{e}_2).$$

Example 3: The stress matrix at a certain point in a material is given by

$$[\tau_{ij}] = \begin{bmatrix} 3 & 1 & 1 \\ 1 & 0 & 2 \\ 1 & 2 & 0 \end{bmatrix}.$$

Find the normal stress and the shear stress on the octahedral plane element through the point.

Solution: An octahedral plane is a plane whose normal makes equal angles with positive directions of the coordinate axes. Hence , the components of the unit normal $\hat{v} = \hat{v}_i$ are

$$v_1 = v_2 = v_3 = \frac{1}{\sqrt{3}}.$$

Let $\underset{\sim}{\overset{v}{T}} = \overset{v}{T}_i$ be the stress vector through the specified point. Then , Cauchy's formula gives

$$\begin{bmatrix} \overset{v}{T}_1 \\ \overset{v}{T}_2 \\ \overset{v}{T}_3 \end{bmatrix} = \frac{1}{\sqrt{3}} \begin{bmatrix} 3 & 1 & 1 \\ 1 & 0 & 2 \\ 1 & 2 & 0 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = \frac{1}{\sqrt{3}} \begin{bmatrix} 5 \\ 3 \\ 3 \end{bmatrix}$$

The magnitude of this stress vector is

$$|\underset{\sim}{\overset{v}{T}}| = \sqrt{\frac{43}{3}}.$$

Let σ be the normal stress and τ be the shear stress. Then

$$\sigma = \underset{\sim}{\overset{v}{T}} \cdot \hat{v} = \frac{1}{3}(5 + 3 + 3) = \frac{11}{3},$$

and

$$\tau = \sqrt{\frac{43}{3} - \frac{121}{9}} = \sqrt{\frac{129 = 121}{9}} = \sqrt{\frac{8}{9}} = \frac{2\sqrt{2}}{3}.$$

Since $\sigma > 0$, the normal stress on the octahedral plane is tensile.

Example 4: The state of stress at a point P in cartesian coordinates is given by

$\tau_{11} = 500$, $\tau_{12} = \tau_{21} = 500$, $\tau_{13} = \tau_{31} = 800$, $\tau_{22} = 1000$,

$\tau_{33} = -300$, $\tau_{23} = \tau_{32} = -750.$

Compute the stress vector $\underset{\sim}{T}$ and the normal and tangential components on the plane passing through P whose outward normal unit vector is

$$\hat{v} = \frac{1}{2}\hat{e}_1 + \frac{1}{2}\hat{e}_2 + \frac{1}{\sqrt{2}}\hat{e}_3 .$$

Solution: The stress vector

$$\underset{\sim}{T} = \mathrm{T_i}\ \hat{e}_i$$

is given by

$$\mathrm{T_i} = \tau_{ji}\ v_j.$$

We find

$$\mathrm{T_1} = \tau_{11}\ v_1 + \tau_{21}\ v_2 + \tau_{31}\ v_3 = 250 + 250 + 400\sqrt{2}$$

$$= 500 + 400 \times (1.41)$$

$$= 500 + 564 = 1064, \quad \text{approx.}$$

$$\mathrm{T_2} = \tau_{12}\ v_1 + \tau_{22}\ v_2 + \tau_{32}\ v_3 = 250 + 250 + \frac{750}{\sqrt{2}}$$

$$= 221, \quad \text{App.}$$

$\mathrm{T_3} = \tau_{13}\ v_1 + \tau_{23}\ v_2 + \tau_{33}\ v_3 = 400 - 375 - 150\sqrt{2} = 25 - 150(1.41)$

$$= -187, \text{ app.}$$

2.9 STRESS QUADRIC

In a trirectangular cartesian coordinate system o $x_1\ x_2\ x_3$, consider the equation

$$\tau_{ij}\ x_i\ x_j = \pm\ k^2 \qquad (1)$$

where (x_1 , x_2 , x_3) are the coordinates a point P relative to the point P^o whose coordinates relative to origin O are $(x_1^{\,o} , x_2^{\,o} , x_3^{\,o})$, τ_{ij} is the stress tensor at the point $P^o(x_i^{\,o})$, and **k is a real constant** .

The sign + or – is so chosen that the quadric surface (1) is real.
The quadric surface (1) is known as the **stress quadric of Cauchy** with its centre at the point $P^o(x_i^{\,o})$.

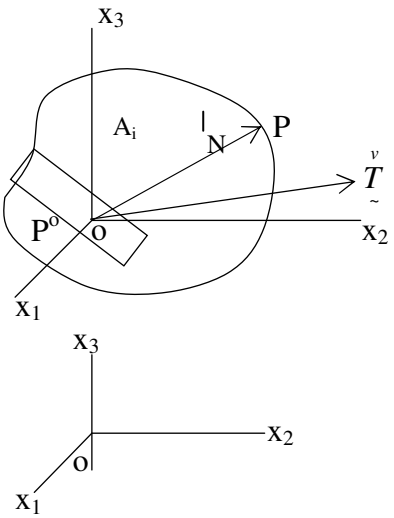


Fig. (2.8)

Let A_i be the radius vector , of magnitude A , on this stress quadric surface which is normal on the plane π through the point P^o having stress tensor τ_{ij}. Let $\hat{v}$ be the unit vector along the vector A_i. Then

$$v_i = A_i / A = x_i / A. \qquad (2)$$

Let $\underset{\sim}{\overset{v}{T}}$ denote the stress vector on the plane π at the point P^o. Then , the normal stress N on the plane π is given by

$$N = \underset{\sim}{\overset{v}{T}} . \hat{v} = \overset{v}{T}_i \; v_i = \tau_{ij} \, v_j \, v_i = \tau_{ij} \, v_i \, v_j. \qquad (3)$$

From equations (1) and (2) , we obtain

$$\tau_{ij} \, (A \, v_i) \, (A \, v_j) = \pm k^2$$

$$\tau_{ij} \, v_i \, v_j = \pm k^2 / A^2$$

$$\mathbf{N = \pm k^2 / A^2.} \qquad (4)$$

This gives the **normal stress acting on the plane π** with orientation $\hat{v} = v_i$ **in terms of the length of the radius vector** of the stress quadric from the point (centre) P^o along the vector v_i.

The relation (4) shows that the normal stress N on the plane π through P^o with orientation along A_i is inversely proportional to the square of that radius vector $A_i = \overline{P^o P}$ of the stress quadric.

The positive sign in (1) or (4) is chosen whenever the normal stress N represents tension (i.e., N > 0) and negative sign when N represents compression (i.e. , N < 0).

The Cauchy's stress quadric (1) possesses another interesting property. This property is

"The normal to the quadric surface at the end of the radius vector A_i is parallel to the stress vector $\underset{\sim}{\overset{v}{T}}$ acting on the plane π at P^o."

To prove this property , let us write equation (1) in the form

$$G(x_1 , x_2 , x_3) \equiv \tau_{ij}\, x_i\, x_j\ \mu\ k^2 = 0. \qquad (5)$$

Then the direction of the normal to the stress quadric surface is given by the gradient of the scalar point function G. The components of gradient are

$$\frac{\partial G}{\partial x_n} = \tau_{ij}\,(\delta_{in})\, x_j + \tau_{ij}\, x_i(\delta_{jn}) = 2\,\tau_{nj}\, x_j$$

$$= 2\, A\, \tau_{nj}\, v_j$$

$$= 2\, A\, \underset{\sim}{\overset{v}{T}}_n . \qquad (6)$$

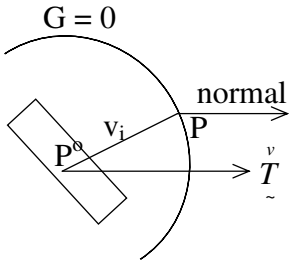


Fig. (2.9)

Equation (6) shows that vectors $\underset{\sim}{\overset{v}{T}}_n$ and $\frac{\partial G}{\partial x_n}$ are parallel. Hence the stress vector $\underset{\sim}{\overset{v}{T}}$ on the plane π at P^o is directed along the normal to the stress quadric at P, P being the end point of the radius vector $A_i = \overline{P^O P}$.

Remark 1: Equation (6) can be rewritten as

$$\underset{\sim}{\overset{v}{T}} = \frac{1}{2A}(\underset{—}{\nabla} G) . \qquad (7)$$

This relations gives an easy way of constructing the stress vector $\underset{\sim}{\overset{v}{T}}$ from the knowledge of the quadric surface $G(x_1 , x_2 , x_3)$ = constant and the magnitude A of the radius vector A_i.

Remark 2: Taking principal axes along the coordinate axes , the stress quadric of Cauchy assumes the form

$$\tau_1 x_1^2 + \tau_2 x_2^2 + \tau_3 x_3^2 = \pm k^2 \qquad (8)$$

Here the coefficients τ_1 , τ_2 , τ_3 are the principal stresses. Let the axes be so numbered that $\tau_1 \geq \tau_2 \geq \tau_3$.

If $\tau_1 > \tau_2 > \tau_3 > 0$, then equation (8) represents an ellipsoid with plus sign. Then , the relation $N = k^2/A^2$ implies that the force acting on every surface element through P^o is tensile (as $N < 0$).

If $0 > \tau_1 > \tau_2 > \tau_3$, then equation (8) represents an **ellipsoid** with a negative sign on the right and $N = -k^2/A^2$ indicates that the normal stress is compressive ($N > 0$).If $\tau_1 = \tau_2 \neq \tau_3$ or $\tau_1 \neq \tau_2 = \tau_3$ or $\tau_1 = \tau_3 \neq \tau_2$, then the Cauchy's stress quadric is an **ellipsoid of revolution**.

If $\tau_1 = \tau_2 = \tau_3$, then the stress quadric is a sphere.

2.10 PRINCIPAL STRESSES

In a general state of stress , the stress vector $\underset{\sim}{\overset{v}{T}}$ acting on a surface with outer normal $\hat{v}$ depends on the direction of $\hat{v}$.

Let us see in what direction $\hat{v}$ the stress vector $\underset{\sim}{\overset{v}{T}}$ becomes normal to the surface , on which the shearing stress is zero. Such a surface shall be called a **principal plane** , its normal a **principal axis** , and the value of normal stress acting on the principal plane shall be called a **principal stress.**

Let $\hat{v}$ define a principal axis at the point $P^o(x_i^o)$ and let τ be the corresponding principal stress and τ_{ij} be the stress tensor at that point. Let $\underset{\sim}{\overset{v}{T}}$ be the stress vector. Then

$$\underset{\sim}{\overset{v}{T}} = \tau \hat{v},$$

or

$$\overset{v}{T}_i = \tau v_i. \qquad (1)$$

Also $\overset{v}{T}_i = \tau_{ij}\, v_j$ (2)

Therefore $\tau_{ij}\, v_j = \tau v_i = \tau\, \delta_{ij}\, v_j$

or $(\tau_{ij} - \tau\, \delta_{ij})\, v_j = 0.$ (3)

The three equations , i = 1 , 2 , 3 , are to be solved for v_1 , v_2 , v_3. Since $\hat{v}$ is a unit vector , we must find a set of non – trivial solutions for which

$$v_1^2 + v_2^2 + v_3^2 = 1 .$$

Thus , equation (3) poses an eigenvalue problem. Equation (3) has a set of non – vanishing solutions v_1 , v_2 , v_3 iff the determinant of the coefficients vanishes , i.e. ,

$$| \tau_{ij} - \tau\, \delta_{ij} | = 0,$$

or
$$\begin{bmatrix} \tau_{11} - \tau & \tau_{12} & \tau_{13} \\ \tau_{12} & \tau_{22} - \tau & \tau_{23} \\ \tau_{13} & \tau_{23} & \tau_{33} - \tau \end{bmatrix} = 0. \qquad (3a)$$

On expanding (2) , we find

$$-\tau^3 + \theta_1\, \tau^2 - \theta_2\, \tau + \theta_3 = 0, \qquad (3b)$$

where

$$\theta_1 = \tau_{11} + \tau_{22} + \tau_{33}$$
(4a)

$$\theta_2 = \begin{vmatrix} \tau_{22} & \tau_{23} \\ \tau_{23} & \tau_{33} \end{vmatrix} + \begin{vmatrix} \tau_{11} & \tau_{13} \\ \tau_{31} & \tau_{33} \end{vmatrix} + \begin{vmatrix} \tau_{11} & \tau_{12} \\ \tau_{21} & \tau_{22} \end{vmatrix}, \qquad (4b)$$

$$\theta_3 = \in_{ijk} \tau_{1i}\, \tau_{2j}\, \tau_{3k} = \det.(\tau_{ij}). \qquad (4c)$$

Equation (3) is a cubic equation in τ. Let its roots be τ_1 , τ_2 , τ_3. Since the matrix of stress , (τ_{ij}) is real and symmetric , the roots τ_i of (3) are all real. Thus , τ_1 , τ_2 , τ_3 are the principal stresses.

For each value of the principal stress , a unit normal vector $\hat{v}$ can be determined.

Case I : When $\tau_1 \neq \tau_2 \neq \tau_3$, let $\overset{1}{v}_i$, $\overset{2}{v}_i$, $\overset{3}{v}_i$ be the unit principal axes corresponding to the principal stresses τ_1 , τ_2 , τ_3 , respectively. Then principal axes are mutually orthogonal to each other.

Case II : If $\tau_1 = \tau_2 \neq \tau_3$ are the principal stresses , then the direction $\overset{3}{v}_i$ corresponding to principal stress τ_3 is a principal direction and any two mutually perpendicular lines in a plane with normal $\overset{3}{v}_i$ may be chosen as the other two principal direction of stress.

Case III : If $\tau_1 = \tau_2 = \tau_3$, then any set of orthogonal axes through P^o may be taken as the principal axes.

Remark : Thus , for a symmetric real stress tensor τ_{ij} , there are three principal stresses which are real and a set of three mutually orthogonal principal directions.

If the reference axes x_1 , x_2 , x_3 are chosen to coincide with the principal axes , then the matrix of stress components becomes

$$[\tau_{ij}] = \begin{bmatrix} \tau_1 & 0 & 0 \\ 0 & \tau_2 & 0 \\ 0 & 0 & \tau_3 \end{bmatrix}. \qquad (5)$$

Invariants of the stress – tensor :

Equation (3) can be written as

$$(\tau - \tau_1)\,(\tau - \tau_2)\,(\tau - \tau_3) = 0, \qquad (6)$$

and we find

$$\left.\begin{aligned} \theta_1 &= \tau_1 + \tau_2 + \tau_3 \\ \theta_2 &= \tau_1\,\tau_2 + \tau_2\,\tau_3 + \tau_3\,\tau_1 \\ \theta_3 &= \tau_1\,\tau_2\,\tau_3 \end{aligned}\right\}. \qquad (7)$$

Since the principal stress τ_1 , τ_2 , τ_3 characterize the physical state of stress at point , they are independent of any coordinates of reference.

Hence , coefficients θ_1 , θ_2 , θ_3 of equation (3) are invariant w.r.t. the coordinate transformation. Thus θ_1 , θ_2 , θ_3 are the three scalar invariants of the stress tensor τ_{ij}.

These scalar invariants are called the **fundamental stress invariants.**

Components of stress τ_{ij} in terms of τ_α's

Let X_α be the principal axes. The transformation law for axes is

$$X_\alpha = a_{i\alpha}\, x_i$$

or

$$x_i = a_{i\alpha}\, X_\alpha\,, \tag{8}$$

where

$$a_{i\alpha} = \cos(x_i\,,\, X_\alpha). \tag{9}$$

The stress – matrix relative to axes X_α is

$$\tau'_{\alpha\beta} = \mathrm{diag}(\tau_1\,,\, \tau_2\,,\, \tau_3). \tag{10}$$

Let τ_{ij} be the stress – matrix relative to x_i – axis. Then transformation rule for second order tensor is

$$\tau_{ij} = a_{i\alpha}\, a_{i\beta}\, \tau'_{\alpha\beta}$$

$$= \sum_{\alpha=1}^{3} a_{i\alpha}\, (a_{j\alpha}\, \tau_\alpha).$$

This gives

$$\tau_{ij} = \sum_{\alpha=1}^{3} a_{i\alpha}\;\; a_{j\alpha}\, \tau_\alpha. \tag{11}$$

Definition (Principal axes of Stress)

A system of coordinate axes chosen along the principal directions of stress is referred to as principal axes of stress.

Question: Show that , as the orientation of a surface element at a point P varies , the normal stress on the surface element assumes an extreme value when the element is a principal plane of stress at P and that this extremum value is a principal stress.

Solution: Let τ_{ij} be the stress tensor at the point P. Let τ be the normal stress on a surface element at P having normal in the direction of unit vector $\hat{v} = v_i$. Then , we know that

$$\tau = \tau_{ij}\, v_i\, v_j \tag{1}$$

we have to find $\hat{v} = v_i$ for which τ is an extremum. Since $\hat{v} = v_i$ is a unit vector , we have the restriction

$$v_k \, v_k - 1 = 0 \qquad (2)$$

We use the method of lagrange's multiplier to find the extremum values of τ. The extreme values are given by

$$\frac{\partial}{\partial v_i} \{\tau_{ij} \, v_i \, v_j - \lambda(v_k \, v_k - 1)\} = 0 \qquad (3)$$

where λ is a Lagrange's multiplier. From (3) , we find

$$\tau_{ij} \, \{v_j + \delta_{ij} \, v_i\} - \lambda\{2v_k \, \delta_{ik}\} = 0$$

$$\Rightarrow \qquad 2 \, \tau_{ij} \, v_j - 2 \, \lambda \, v_i = 0$$

$$\Rightarrow \qquad \tau_{ij} \, v_j - \lambda \, \delta_{ij} \, v_j = 0$$

$$\Rightarrow \qquad (\tau_{ij} - \lambda \, \delta_{ij}) \, v_j = 0 \, . \qquad (4)$$

These conditions are satisfied iff $\hat{v} = v_j$ is a principal direction of stress and $\tau = \lambda$ is the corresponding principal stress.

Thus , τ assumes an extreme value on a principal plane of stress and a principal stress is an extreme value of τ given by (1).

2.11 MAXIMUM NORMAL AND SHEAR STRESSES

Let the co-ordinate axes at a point P^o be taken along the principle directions of stress. Let τ_1 , τ_2 , τ_3 be the principal stresses as P^o. Then

$$\tau_{11} = \tau_1 \, , \, \tau_{22} = \tau_2 \, , \, \tau_{33} = \tau_3 \, ,$$

$$\tau_{12} = \tau_{23} = \tau_{31} = 0.$$

Let $\underset{\sim}{\overset{v}{T}}$ be the stress vector on a planar element at P^o having the normal $\hat{v} = v_i$. Let N be the normal stress and S be the shearing stress. Then

$$| \underset{\sim}{\overset{v}{T}} |^2 = N^2 + S^2. \qquad (1)$$

The relation

$$\overset{v}{T}_i = \tau_{ij} \, v_j$$

gives

$$\overset{v}{T}_1 = \tau_1 v_1 , \overset{v}{T}_2 = \tau_2 v_2 = \overset{v}{T}_3 = \tau_3 v_3 , \qquad (1a)$$

so that

$$N = \underset{\sim}{\overset{v}{T}} . \hat{v} = \overset{v}{T}_i v_i = \tau_1 v_1^2 + \tau_2 v_2^2 + \tau_3^2 . \qquad (1b)$$

N is a function of three variables v_1 , v_2 , v_3 connected by the relation

$$v_k v_k - 1 = 0. \qquad (2)$$

From (1) & (2) , we write

$$N = \tau_1(1 - v_2^2 - v_3^2) + \tau_2 v_2^2 + \tau_3 v_3^2$$

$$= \tau_1 + (\tau_2 - \tau_1)v_2^2 + (\tau_3 - \tau_1) v_3^2 \qquad (3)$$

The extreme value of N are given by

$$\frac{\partial N}{\partial v_2} = 0 \quad , \quad \frac{\partial N}{\partial v_3} = 0 ,$$

which yield

$$v_2 = 0 , v_3 = 0 \text{ for } \tau_2 \neq \tau_1 \ \& \ \tau_3 \neq \tau_1.$$

Hence

$$v_1 = \pm 1 , v_2 = v_3 = 0 \ \& \ N = \tau_1 .$$

Similarly , we can find other two directions

$$v_1 = 0 , v_2 = \pm 1 , v_1 = 0 , N = \tau_2$$

$$v_1 = 0 , v_2 = 0 , v_3 = \pm 1 , N = \tau_3$$

Thus , we find that the extreme values of the Normal stress N are along the principal directions of stress and the extreme values are themselves principal stresses. So , the absolute maximum normal stress is the maximum of the set $\{\tau_1 , \tau_2 , \tau_3\}$. Along the principal directions , the shearing stress is zero (i.e. , the minimum).

Now $S^2 = (\tau_1^2 v_1^2 + \tau_2^2 v_2^2 + \tau_3^2 v_3^2) - (\tau_1 v_1^2 + \tau_2 v_2^2 + \tau_3 v_3^2)^2$ (3a)

To determine the directions associated with the maximum values of |S|. We maximize the function $S(v_1 , v_2 , v_3)$ in (3) subject to the constraining relation $v_i v_i = 1$.

For this , we use the method of Lagrange multipliers to find the free extremum of the functions

$$F(v_1 , v_2 , v_3) = S^2 - \lambda(v_i\, v_i - 1) \qquad (4)$$

For extreme values of F. We must have

$$\frac{\partial F}{\partial v_1} = \frac{\partial F}{\partial v_2} = \frac{\partial F}{\partial v_3} = 0. \qquad (5)$$

The equation $\frac{\partial F}{\partial v_1} = 0$ gives

$$2\,\tau_1^2\, v_1 - 4\,\tau_1\, v_1(\tau_1\, v_1^2 + \tau_2\, v_2^2 + \tau_3\, v_3^2) - 2\,\lambda\, v_1 = 0$$

or
$$\lambda = \tau_1^2 - 2\,\tau_1(\tau_1\, v_1^2 + \tau_2\, v_2^2 + \tau_3\, v_3^2) . \qquad (6)$$

Similarly from other equations ,we obtain

$$\lambda = \tau_2^2 - 2\tau_2\,(\tau_1\, v_1^2 + \tau_2\, v_2^2 + \tau_3\, v_3^2) , \qquad (7)$$

$$\lambda = \tau_3^2 - 2\tau_3\,(\tau_1\, v_1^2 + \tau_2\, v_2^2 + \tau_3\, v_3^2) \quad . \qquad (8)$$

Equations (6) & (7) yield

$$\tau_2^2 - \tau_1^2 = 2(\tau_2 - \tau_1)\,(\tau_1\, v_1^2 + \tau_2\, v_2^2 + \tau_3\, v_3^2)$$

For $\tau_1 \neq \tau_2$, this leads to

$$\tau_2 + \tau_1 = 2(\tau_1\, v_1^2 + \tau_2\, v_2^2 + \tau_3\, v_3^2)$$

or
$$(2v_1^2 - 1)\,\tau_1 + (2v_2^2 - 1)\,\tau_2 + 2\,v_3^2\,\tau_3 = 0 .$$

This relation is identically satisfied if

$$v_1 = \pm\,\frac{1}{\sqrt{2}} \;,\; v_2 = \frac{1}{\sqrt{2}} \;,\; v_3 = 0. \qquad (9)$$

From equations (1b) , (3a) and (9) , the corresponding maximum value of | S | is

$$\left.\begin{aligned} |\,S\,|_{max} &= \frac{1}{2}\,|\,\tau_2 - \tau_1\,| \\ \text{and} \qquad |\,N\,| &= \frac{1}{2}\,|\,\tau_1 + \tau_2\,| \end{aligned}\right\} \qquad (10)$$

For this direction

$$S^2 = \frac{1}{2}(\tau_1^2 + \tau_2^2) - \left(\frac{\tau_1 + \tau_2}{2}\right)^2$$

$$= \frac{1}{4}[2\tau_1^2 + 2\tau_2^2 - (\tau_1^2 + \tau_2^2 + 2\tau_1\,\tau_2)]$$

$$= \frac{1}{4}(\tau_1^2 + \tau_2^2 - 2\tau_1\,\tau_2)\,.$$

This implies

$$|\,S\,|_{max} = \frac{1}{2}|\,\tau_1 - \tau_2\,|.$$

Similarly , for the directions

$$v_1 = \pm\frac{1}{\sqrt{2}}\ ,\ v_2 = 0\ ,\ v_3 = \pm\ \frac{1}{\sqrt{2}}\ ,$$

we have

$$|\,S\,|_{max} = \frac{1}{2}\ |\,\tau_3 - \tau_1\,|\ ,$$

$$|\,N\,| = \frac{1}{2}\ |\,\tau_3 + \tau_1\,|.$$

Also, for the direction

$$v_1 = 0\ ,\ v_2 = \pm\frac{1}{\sqrt{2}}\ ,\ v_3 = \pm\frac{1}{\sqrt{2}}\ ,$$

the corresponding values of $|\,S\,|_{max}$ and $|\,N\,|$ are , respectively ,

$$\frac{1}{2}|\,\tau_2 - \tau_3\,| \text{ and } \frac{1}{2}|\,\tau_2 + \tau_3\,|.$$

These results can recorded in the following table

v_1	V_2	v_3	$\|S\|_{max/min}$	$\|\,N\,\|$
0	0	±1	Min S = 0	$\|\,\tau_3\,\|$ = Max.
0	±1	0	0 (Min.)	$\|\,\tau_2\,\|$ = Max.

± 1	0	0	0(Min.)	$\lvert \tau_1 \rvert$ = Max.
0	$\pm\frac{1}{\sqrt{2}}$	$\pm\frac{1}{\sqrt{2}}$	$\frac{1}{2}\lvert \tau_2 - \tau_3 \rvert$ Max.	$\frac{1}{2}\lvert \tau_2 + \tau_3 \rvert$ Min.
$\pm\frac{1}{\sqrt{2}}$	0	$\pm\frac{1}{\sqrt{2}}$	$\frac{1}{2}\lvert \tau_3 - \tau_1 \rvert$ Max.	$\frac{1}{2}\lvert \tau_3 + \tau_1 \rvert$ Min.
$\pm\frac{1}{\sqrt{2}}$	$\pm\frac{1}{\sqrt{2}}$	0	$\frac{1}{2}\lvert \tau_1 - \tau_2 \rvert$ Max.	$\frac{1}{2}\lvert \tau_1 + \tau_2 \rvert$ Min.

If $\tau_1 > \tau_2 > \tau_3$, then **τ_1 is the absolute maximum** values of N and **τ_3** is its **minimum** value, and the maximum value of $\lvert S \rvert$ is

$$\lvert S \rvert_{max} = \frac{1}{2}(\tau_3 - \tau_1).$$

and the maximum shearing stress acts on the surface element containing the x_2 principal axis and bisecting the angle between the x_1 – and x_3 – axes. Hence the following theorem is proved.

Theorem : Show that the maximum shearing stress is equal to **one – half** the difference between the greatest and least normal stress and acts on the plane that bisects the angle between the directions of the largest and smallest principal stresses.

2.12 MOHR'S CIRCLE (GEOMETRICAL PROOF OF THE THEOREM AS PROPOSED BY O.(OTTO) MOHR(1882))

We know that

$$N = \tau_1 v_1^2 + \tau_2 v_2^2 + \tau_3 v_3^2 \qquad (1)$$

and $$S^2 + N^2 = \tau_1^2 v_1^2 + \tau_2^2 v_2^2 + \tau_3^2 v_3^2 \ . \qquad (2)$$

Also $$v_1^2 + v_2^2 + v_3^2 = 1 \ . \qquad (3)$$

Solving equations (1) – (3) , by Cramer's rule , for v_1^2 , v_2^2 , v_3^2 ; we find

$$v_1^2 = \frac{S^2 + (N - \tau_2)(N - \tau_3)}{(\tau_1 - \tau_2)(\tau_1 - \tau_3)} \ , \qquad (4)$$

$$v_2^2 = \frac{S^2 + (N - \tau_3)(N - \tau_1)}{(\tau_2 - \tau_1)(\tau_2 - \tau_3)} \quad , \tag{5}$$

$$v_3^2 = \frac{S^2 + (N - \tau_1)(N - \tau_2)}{(\tau_3 - \tau_1)(\tau_3 - \tau_2)} \quad , \tag{6}$$

Assume that $\tau_1 > \tau_2 > \tau_3$ so that $\tau_1 - \tau_2 > 0$ and $\tau_1 - \tau_3 > 0$. Since v_1^2 is non – negative. We conclude from equation (4) that

$$S^2 + (N - \tau_2)(N - \tau_3) \geq 0.$$

or $$S^2 + N^2 - N(\tau_2 + \tau_3) + \tau_2 \tau_3 \geq 0$$

or $$S^2 + \left(N - \frac{\tau_2 + \tau_3}{2}\right)^2 \geq \left(\frac{\tau_2 - \tau_3}{2}\right)^2 . \tag{7}$$

This represents a region outside the circle

$$S^2 + \left(N - \frac{\tau_2 + \tau_3}{2}\right)^2 = \left(\frac{\tau_2 - \tau_3}{2}\right)^2 ,$$

in the (N , S) plane.

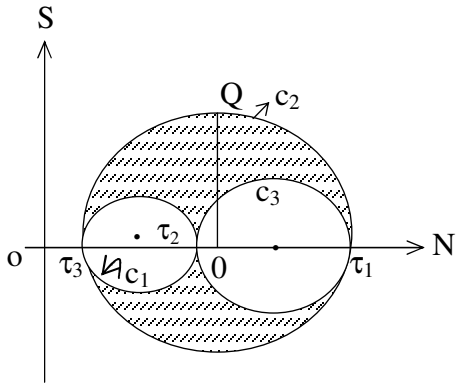


Fig. (2.10) Mohr's Circles

This circle , say C_1 , has centre $\left(\frac{\tau_2 + \tau_3}{2}, 0\right)$ and radius $\frac{\tau_2 - \tau_3}{2}$ in the cartesian SN-plane with the values of N as abscissas and those of S as ordinates.

Since $\tau_2 - \tau_3 > 0$ and $\tau_2 - \tau_1 < 0$, we conclude from (5) that

$$S^2 + (N - \tau_3)(N - \tau_1) \leq 0 . \tag{8}$$

Thus , the region defined by (8) is a closed region , interior to the circle c_2 , whose equation is

$$S^2 + (N - \tau_3)(N - \tau_1) = 0 . \qquad (8a)$$

The circle C_2 passed through the points $(\tau_3 , 0)$, $(\tau_1 , 0)$ and have centre on the N – axis.

Finally , equation (6) yields

$$S^2 + (N - \tau_1)(N - \tau_2) \geq 0 , \qquad (9)$$

since

$$\tau_3 - \tau_1 < 0 \text{ and } \tau_3 - \tau_2 < 0.$$

The region defined by (9) is exterior to the circle c_3 , with centre on the N –axis and passing through the points $(\tau_1 , 0)$, $(\tau_2 , 0)$.

It follows from inequalities (7) to (9) that the admissible values of S and N lie in the shaded region bounded by the circles as shown in the figure.

From figure , it is clear that the maximum value of shearing stress S is represented by the greatest ordinate O^1Q of the circle C_2.

Hence $$S_{max} = \frac{\tau_1 - \tau_3}{2} \qquad (10a)$$

The value of N , corresponding to S_{max} is OO′ where

$$OO' = \tau_3 + \frac{\tau_1 - \tau_3}{2} = \frac{\tau_1 + \tau_3}{2} \qquad (10b)$$

Putting the values of S & N from equations (10a , b) into equations (4) – (6). We find

$$v_1^2 = v_3^2 = \frac{1}{2} , v_2^2 = 0.$$

or

$$v_1 = \pm \frac{1}{\sqrt{2}} , v_3 = \pm \frac{1}{\sqrt{2}} , v_2 = 0. \qquad (11)$$

Equation (11) determines the **direction of the maximum shearing stress.** Equation (11) shows that the maximum shearing stress acts on the plane that

bisects the angle between the directions of the largest and smallest principal stresses.

2.13 OCTAHEDRAL STRESSES

Consider a plane which is equally inclined to the principal directions of stress. Stresses acting on such a plane are known as octahedral stresses. Assume that coordinate axes coincide with the principal directions of stress. Let τ_1 , τ_2 , τ_3 be the principal stresses. Then the stress matrix is

$$\begin{bmatrix} \tau_1 & 0 & 0 \\ 0 & \tau_2 & 0 \\ 0 & 0 & \tau_3 \end{bmatrix}.$$

A unit normal $\hat{v} = v_i$ to this plane is

$$v_1 = v_2 = v_3 = \frac{1}{\sqrt{3}}.$$

Then the stress vector $\underset{\sim}{\overset{v}{T}}$ on a plane element with normal $\hat{v}$ is given by

$$\overset{v}{T}_i = \tau_{ij}\, v_j \ .$$

This gives

$$\overset{v}{T}_1 = \tau_1\, v_1 \ , \quad \overset{v}{T}_2 = \tau_2\, v_2 \ , \quad \overset{v}{T}_3 = \tau_3\, v_3 \ .$$

Let N be the normal stress and S be the shear stress. Then

$$\mathrm{N} = \underset{\sim}{\overset{v}{T}} \ . \ \hat{v} = \tau_1\, v_1^2 + \tau_2\, v_2^2 + \tau_3\, v_3^2 = \frac{1}{3}(\tau_1 + \tau_2 + \tau_3) \ ,$$

and

$$\mathrm{S}^2 = | \underset{\sim}{\overset{v}{T}} |^2 - \mathrm{N}^2$$

$$= (\tau_1^2\, v_1^2 + \tau_2^2\, v_2^2 + \tau_3^2\, v_3^2) - \frac{1}{9}(\tau_1 + \tau_2 + \tau_3)^2$$

$$= \frac{1}{3}(\tau_1^2 + \tau_2^2 + \tau_3^2) - \frac{1}{9}(\tau_1 + \tau_2 + \tau_3)^2$$

$$= \frac{1}{9}[3(\tau_1^2 + \tau_2^2 + \tau_3^2) - (\tau_1^2 + \tau_2^2 + \tau_3^2 + 2\,\tau_1\tau_2 + \tau_2\tau_3 + \tau_3\tau_1)]$$

$$= \frac{1}{9}[(\tau_1^2 + \tau_2^2 - 2\tau_1\tau_2) + (\tau_2^2 + \tau_3^2 - 2\tau_2\tau_3) + (\tau_3^2 + \tau_1^2 - 2\tau_1\tau_3)]$$

$$= \frac{1}{9}[(\tau_1 - \tau_2)^2 + (\tau_2 - \tau_3)^2 + (\tau_3 - \tau_1)^2] ,$$

giving

$$S = \frac{1}{3}\sqrt{(\tau_1 - \tau_2)^2 + (\tau_2 - \tau_3)^2 + (\tau_3 - \tau_1)^2} \ .$$

Example : At a point P , the principal stresses are $\tau_1 = 4$, $\tau_2 = 1$, $\tau_3 = -2$. Find the stress vector , the normal stress and the shear stress on the octahedral plane at P.

[**Hint :** N = 1 , S = $\sqrt{6}$, $\underset{\sim}{T}^{\hat{v}} = \frac{1}{\sqrt{3}}(4\ \hat{e}_1 + \hat{e}_2 - 2\hat{e}_3)$.]

2.14. STRESS DEVIATOR TENSOR

Let τ_{ij} be the stress tensor. Let

$$\sigma_0 = \frac{1}{3}(\tau_{11} + \tau_{22} + \tau_{33}) = \frac{1}{3}(\tau_1 + \tau_2 + \tau_3)$$

Then the tensor

$$\tau^{(d)}_{ij} = \tau_{ij} - \sigma_0 \, \delta_{ij}$$

is called the stress deviator tensor. It specifies the deviation of the state of stress from the mean stress σ_0.

Chapter-3

Analysis of Strain

3.1 INTRODUCTION

Rigid Body

A rigid body is an ideal body such that the **distance between every pair of its points remains unchanged under the action of external forces.**

The possible displacements in a **rigid body** are **translation and rotation**. These displacements are called rigid displacements. In translation , each point of the rigid body moves a fixed distance in a fixed direction. In rotation about a line , every point of the body (rigid) moves in a circular path about the line in a plane perpendicular to the line.

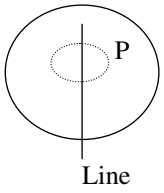


Fig. (3.1)

In a rigid body motion , there is a uniform motion throughout the body.

Elastic Body

A body is called **elastic** if it possesses the property of **recovering its original shape and size when the forces causing deformation are removed**.

Continuous Body

In a continuous body , the atomistic structure of matter can be **disregarded** and the body is replaced by a **continuous mathematical region of the space** whose geometrical points are **identified with material points** of the body.

The **mechanics of such continuous elastic bodies** is called mechanics of continuum. This branch covers a vast range of problems of **elasticity , hydromechanics , aerodynamics , plasticity ,** and **electrodynamics , seismology** , etc.

Deformation of Elastic Bodies

The change in the relative position of points in a continuous is called deformation **,** and the body itself is then called a strained body. The study of deformation of an elastic body is known as the **analysis of strain.** The deformation of the body is due to relative movements or distortions within the body.

3.2 TRANSFORMATION OF AN ELASTIC BODY

We consider the undeformed and deformed both positions of an elastic body. Let $Ox_1x_2x_3$ be mutually orthogonal cartesian coordinates fixed in space. Let a continuous body B , referred to system $Ox_1x_2x_3$, occupies the region R in the undeformed state. In the deformed state, the points of the body B will occupy some region ,say R′.

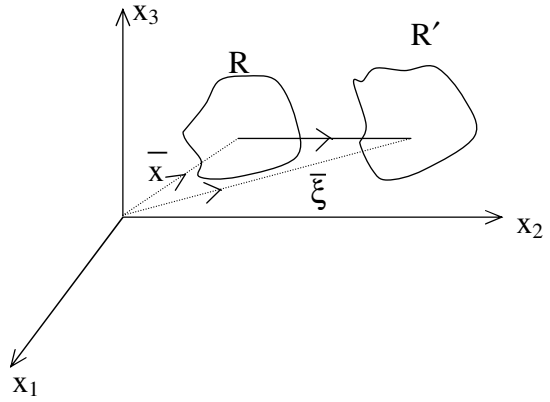


Fig. (3.2)

Let $P(x_1 , x_2 , x_3)$ be the coordinates of a material point P of the elastic body in the initial or unstained state. In the transformation or deformed state , let this material point occupies the geometric point $P'(\xi_1 , \xi_2 , \xi_3)$. We shall be concerned only with continuous deformations of the body from region R into the region R′ and we assume that the deformation is given by the equation

$$\xi_1 = \xi_1(x_1 , x_2 , x_3) ,$$

$$\xi_2 = \xi_2(x_1 , x_2 , x_3) ,$$

$$\xi_3 = \xi_3(x_1 , x_2 , x_3) . \qquad (1)$$

The **vector** $\overline{PP'}$ **is called the displacement vector** of the point P and is denoted by u_i.

Thus

$$u_i = \xi_i - x_i \quad ; \quad i = 1 , 2 , 3 \qquad (2)$$

or

$$\xi_i = x_i + u_i . \quad i = 1 , 2 , 3 \qquad (3)$$

Equation (1) expresses the coordinates of the points of the body in the transformed state in terms of their coordinates in the initial undeformed state. This type of description of deformation is known as the **Lagrangian method** of describing the transformation of a continuous medium.

Another method , known as **Euler's method** expresses the coordinates in the undeformed state in terms of the coordinates in the deformed state.

The transformation (1) is invertible when

$$J \neq 0.$$

Then , we may write

$$x_i = x_i(\xi_1 , \xi_2 , \xi_3) \quad , \quad i = 1 , 2 , 3. \qquad (4)$$

In this case , the transformation from the region R into region R′ is one – to – one.

Each of the above description of deformation of the body has its own advantages. It is however, more convenient in the study of the mechanics of solids to use **Lagrangian approach because the undeformed state of the body often possesses certain symmetries which make it convenient to use a simple system of coordinates.**

A part of the transformation defined by equation (1) may represent rigid body motions

(i.e. , translations and rotations) of the body as a whole. This part of the deformation leaves unchanged the length of every vector joining a pair of points within the body and is of no interest in the analysis of strain.

The remaining part of transformation (1) will be called **pure deformation.**

Now , we shall learn how to distinguish between pure deformation and rigid body motions when the latter are present in the transformation equations (1).

3.3 LINEAR TRANSFORMATION OR AFFINE TRANSFORMATION

Definition: The transformation

$$\xi_i = \xi_i(x_1 , x_2 , x_3)$$

is called a linear transformation or affine transformation when the functions ξ_i are **linear functions** of the coordinates x_1 , x_2 , x_3.

In order to distinguish between rigid motion and pure deformation , we consider the simple case in which the transformation (1) is linear.

We assume that the general form of the linear transformation (1) is of the type

$$\left.\begin{aligned} \xi_1 &= \alpha_{10} + (\alpha_{11} + 1)\, x_1 + \alpha_{12}\, x_2 + \alpha_{13}\, x_3 , \\ \xi_2 &= \alpha_{20} + \alpha_{21}\, x_1 + (1 + \alpha_{22})\, x_2 + \alpha_{23}\, x_3 , \\ \xi_3 &= \alpha_{30} + \alpha_{31}\, x_1 + \alpha_{32}\, x_2 + (1 + \alpha_{33})\, x_3 , \end{aligned}\right\} \qquad (5)$$

or

$$\xi_i = \alpha_{i0} + (\alpha_{ij} + \delta_{ij})\, x_j , \qquad (6)$$

where the coefficients α_{ij} are **constants** and are well known.

Equation (5) can written in the matrix form as

$$\begin{bmatrix} \xi_1 - \alpha_{10} \\ \xi_2 - \alpha_{20} \\ \xi_3 - \alpha_{30} \end{bmatrix} = \begin{bmatrix} 1+\alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & 1+\alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & 1+\alpha_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} , \qquad (7)$$

or

$$\begin{bmatrix} u_1 - \alpha_{10} \\ u_2 - \alpha_{20} \\ u_3 - \alpha_{30} \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} . \qquad (8)$$

We can look upon the matrix $(\alpha_{ij} + \delta_{ij})$ as an operator acting on the vector $\overline{x} = x_i$ to give the
vector α_{i0}.

If the matrix $(\alpha_{ij} + \delta_{ij})$ is non – singular , then we obtain

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = (\alpha_{ij} + \delta_{ij})^{-1} \begin{bmatrix} \xi_1 - \alpha_{10} \\ \xi_2 - \alpha_{20} \\ \xi_3 - \alpha_{30} \end{bmatrix} , \qquad (9)$$

which is also linear as inverse of a linear transformation is linear.

Infact, matrix algebra was developed basically to express linear transformations in a concise and lucid manner.

Result (1) : Sum of two linear transformations is a linear transformation.

Result (2) : Product of two linear transformations is a linear transformation which is not commutative.

Result (3) : Under a linear transformation , a plane is transformed into a plane.

Proof of (3) : Let

$$a\,x_1 + b\,x_2 + c\,x_3 + d = 0\,,$$

be an equation of a plane in the undeformed state. Let

$$\begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix} = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix},$$

be the linear transformation of points. Let its inverse be

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 & C_1 \\ A_2 & B_2 & C_2 \\ A_3 & B_3 & C_3 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix}.$$

Then the equation of the plane is transformed to

$$a(A_1\,\xi_1 + B_1\,\xi_2 + C_1\,\xi_3) + b(A_2\xi_1 + B_2\,\xi_2 + C_2\,\xi_3)$$

$$+ c(A_3\,\xi_1 + B_3\,\xi_2 + C_3\,\xi_3) + d = 0$$

or

$$\alpha_1\,\xi_1 + \beta_1\,\xi_2 + \gamma_1\,\xi_3 + d = 0\,,$$

which is again an equation of a plane in terms of new coordinates (ξ_1 , ξ_2 , ξ_3).

Hence the result.

Result (4) : A linear transformation carries line segments into line segments.

Thus , it is the linear transformation that allows us to assume that a line segment is transformed to a line segment and not to a curve.

3.4 SMALL/ INFINITESIMAL LINEAR DEFORMATIONS

Definition (Small / Infinitesimal Deformations)

A linear transformation of the type

$$\xi_i = \alpha_{i0} + (\alpha_{ij} + \delta_{ij})\, x_j$$

is said to be a small linear transformation of the coefficients α_{ij} are so small that their products can be neglected in comparison with the linear terms.

Result (1) : The product of two small linear transformations is a small linear transformation which is **COMMUTATIVE** and the product transformation is obtained by superposition of the original transformations and the result is independent of the order in which the transformations are performed.

Result (2) : In the study of finite deformations (as compared to the infinitesimal affine deformation), the principle of superposition of effects and the independence of the order of transformations are no longer valid.

Note : If a body is subjected to large linear transformations , a straight line element seldom remains straight. A curved element is more likely to result. The linear transformation then expresses the transformation of element $P_1\, P_2$ to the tangent $P_1' T_1'$ to the curve at P_1' for the curve itself.

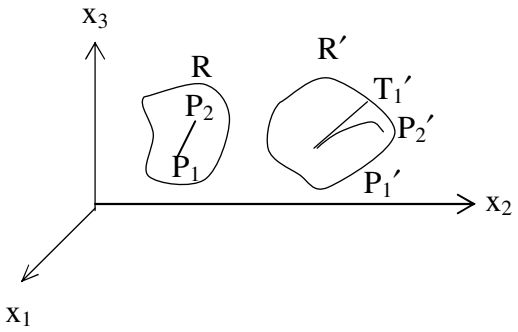


Fig. (3.3)

For this reason , a linear transformation is sometimes called **linear tangent transformation.**
It is obvious that the smaller the element $P_1\, P_2$, the better approximation of $P_1'P_2'$ by its tangent $P_1'T_1'$.

3.5 HOMOGENEOUS DEFORMATION

Suppose that a body B , occupying the region R in the undeformed state , is transformed to the region R′ under the linear transformation.

$$\xi_i = \alpha_{i0} + (\alpha_{ij} + \delta_{ij})\, x_j \qquad (1)$$

referred to orthogonal cartesian system $Ox_1x_2x_3$. Let $\hat{e}_1, \hat{e}_2, \hat{e}_3$ be the unit base vectors directed along the coordinate axes x_1 , x_2 , x_3 (Fig. 3.4)

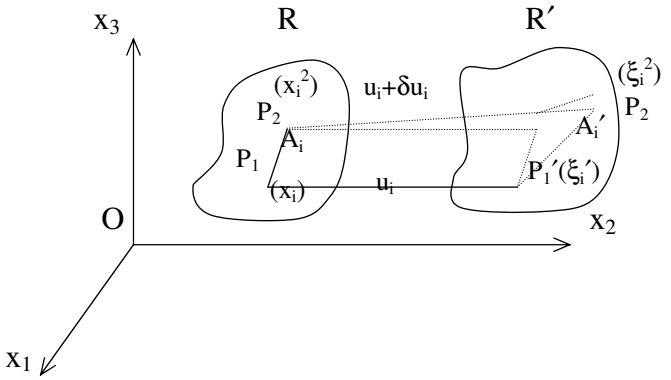


Fig. (3.5)

Let $P_1(x_1^1, x_2^1, x_3^1)$ and $P_2(x_1^2, x_2^2, x_3^2)$ be two points of the elastic body in the initial state. Let the positions of these points in the deformed state , due to linear transformation (1) , be $P_1'(\xi_1^1, \xi_2^1, \xi_3^1)$ and $P_2'(\xi_1^2, \xi_2^2, \xi_3^2)$.

Since the transformation (1) is linear , so the line segment $\overline{P_1P_2}$ is transformed into a line segment $\overline{P_1'P_2'}$.

Let the vector $\overline{P_1P_2}$ has components A_i and vector $\overline{P_1'P_2'}$ has components A_i'. Then

$$\overline{P_1P_2} = A_i\ \hat{e}_i \quad , \qquad A_i = x_i^2 - x_i^1 \, , \tag{2}$$

and

$$\overline{P_1'P_2'} = A_i'\ \hat{e}_i \quad , \qquad A_i' = \xi_i^2 - \xi_i^1 \, . \tag{3}$$

Let $$\delta A_i = A_i' - A_i \quad , \tag{4}$$

be the change in vector A_i .

The vectors A_i and A_i' , in general , differ in direction and magnitude.

From equations (1) , (2) and (3) , we write

$$A_i' = \xi_i^2 - \xi_i^1$$

$$= [\alpha_{i0} + (\alpha_{ij} + \delta_{ij})\ x_j^2\ ] - [\alpha_{i0} + (\alpha_{ij} + \delta_{ij})\ x_j^1\ ]$$

$$= (\overset{2}{x}_i - \overset{1}{x}_i) + \alpha_{ij}(\overset{2}{x}_j - \overset{1}{x}_j)$$

$$= A_i + \alpha_{ij} A_j .$$

This implies

$$A_i' - A_i = \alpha_{ij} A_j$$

$$\boldsymbol{\delta A_i = \alpha_{ij} A_j} \quad . \tag{5}$$

Thus , the linear transformation (1) changes the vector A_i into vector A_i' where

$$\begin{bmatrix} A_1' \\ A_2' \\ A_3' \end{bmatrix} = \begin{bmatrix} 1+\alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & 1+\alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & 1+\alpha_{33} \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \\ A_3 \end{bmatrix}, \tag{6}$$

or

$$\begin{bmatrix} \delta A_1 \\ \delta A_2 \\ \delta A_3 \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \\ A_3 \end{bmatrix}. \tag{7}$$

Thus , the linear transformation (1) or (6) or (7) are all equivalent.

From equation (6) , it is clear that two vectors A_i and B_i whose components are equal transform into two vectors A_i' and B_i' whose components are again equal. Also two parallel vectors transformation into parallel vectors.

Hence,two equal and similarly oriented rectilinear polygons located in different parts of the region R will be transformed into equal and similarly oriented polygons in the transformed region R′ under the linear transformation (1).

Thus , the different parts of the body B , when the latter is subjected to the linear transformation (1) , **experience the same deformation independent of the position of the parts of the body.**

For this reason , the linear deformation (1) is called a homogeneous deformation.

Theorem: Prove that the necessary and sufficient condition for an infinitesimal affine transform

$$\xi_{ij} = \alpha_{i0} + (\alpha_{ij} + \delta_{ij})\, x_j$$

to represent a rigid body motion is that the matrix α_{ij} is skew – symmetric

Proof: With reference to an orthogonal cartesian system o x_1 x_2 x_3 fixed in space , let the line segment $\overrightarrow{P^oP}$ of the body in the undeformed state be transferred to the line segment $\overline{P^{0'}P'}$ in the deformed state due to infinitesimal affine transformation

$$\xi_i = \alpha_{i0} + (\alpha_{ij} + \delta_{ij})\, x_j \ , \qquad (1)$$

in which α_{ij} are known constants. Let A_i be vector $\overline{P^oP}$ and A_i' be the vector $\overline{P^{0'}P'}$

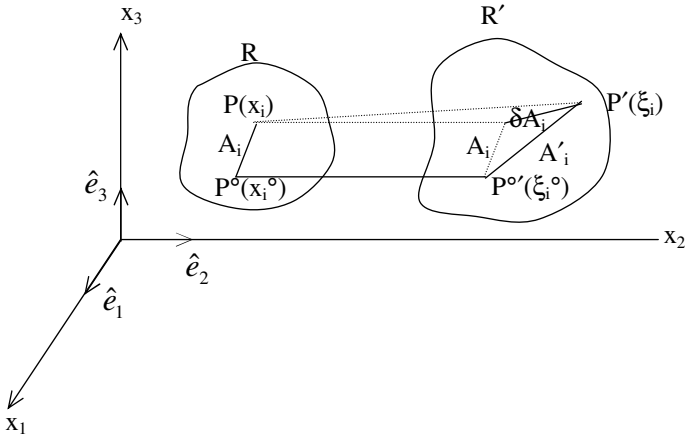


Fig. (3.6)

Then

$$A_i = x_i - x_i^\circ \ , \quad A_i' = \xi_i - \xi_i^\circ \ . \qquad (2)$$

Let $$\delta A_i = A_i' - A_i \ . \qquad (3)$$

From (1) and (2) , we find

$$\begin{aligned} A_i' &= \xi_i - \xi_i^\circ \\ &= (\alpha_{i0} + \alpha_{ij}\, x_j + x_i) - (\alpha_{i0} + \alpha_{ij}\, x_j^\circ + x_i^\circ) \\ &= (x_i - x_i^\circ) + \alpha_{ij}\, (x_j - x_j^\circ) \\ &= A_i + \alpha_{ij}\, A_j \ . \end{aligned}$$

This gives

$$\delta A_i = A_i' - A_i = \alpha_{ij}\, A_j \ . \qquad (4)$$

Let A denote the length of the vector. Then

$$\mathbf{A} = |\, \mathbf{A_i}\, | = \sqrt{A_i\ A_i} = \sqrt{A_1^{\,2} + A_2^{\,2} + A_3^{\,2}} \ . \qquad (5)$$

Let δA denote the change in length A due to deformation. Then

$$\mathbf{\delta A} = |\, A_i' \,| - |\, A_i \,| \,. \qquad (6)$$

It is obvious hat $\delta A \neq |\, \delta A_i \,|$, but

$$\delta A = \sqrt{(A_i + \delta A_i)(A_i + \delta A_i)} - \sqrt{A_i A_i} \,.$$

This imply

$$(A + \delta A)^2 = (A_i + \delta A_i)\,(A_i + \delta A_i) \,,$$

or

$$(\delta A)^2 + 2\, A\, \delta A = (\delta A_i)\,(\delta A_i) + 2\, A_i\,(\delta A_i) \,. \qquad (7)$$

Since the linear transformation (1) or (4) is small , the terms $(\delta A)^2$ and (δA_i) (δA_i) are to be neglected in (7). Therefore , after neglecting these terms in (7) , we write

$$2\, A\, \delta A = 2\, A_i\, \delta A_i \,,$$

or

$$\mathbf{A\ \delta A = A_i\ \delta A_i} = A_1\, \delta A_1 + A_2\, \delta A_2 + A_3\, \delta A_3 \,. \qquad (8)$$

Using (4) , equation (8) becomes

$$A\, \delta A = A_i\, (\alpha_{ij}\, A_j)$$

$$= \alpha_{ij}\, A_i\, A_j$$

$$= \alpha_{11}\, A_1^{\,2} + \alpha_{22}\, A_2^{\,2} + \alpha_{33}\, A_3^{\,2} + (\alpha_{12} + \alpha_{21})\, A_1\, A_2$$

$$+ (\alpha_{13} + \alpha_{31}) A_3\, A_1 + (\alpha_{23} + \alpha_{32})\, A_2\, A_3. \qquad (9)$$

Case 1: Suppose that the infinitesimal linear transformation (1) represents a rigid body motion.

Then , the length of the vector A_i before deformation and after deformation remains unchanged.

That is

$$\delta A = 0 \,, \qquad (10)$$

for all vectors A_i.

Using (9) , we then get

$$\alpha_{11}\, A_1^{\,2} + \alpha_{22}\, A_2^{\,2} + \alpha_{33}\, A_3^{\,2} + (\alpha_{12} + \alpha_{21})\, A_1 A_2 + (\alpha_{23} + \alpha_{32})\, A_2\, A_3$$

$$+ (\alpha_{13} + \alpha_{31})A_1A_3 = 0 , \qquad (11)$$

for all vectors A_i.

This is possible only when

$$\alpha_{11} = \alpha_{22} = \alpha_{33} = 0 ,$$

$$\alpha_{12} + \alpha_{21} = \alpha_{13} + \alpha_{31} = \alpha_{23} + \alpha_{32} = 0 ,$$

i.e. , $$\alpha_{ij} = - \alpha_{ji} , \quad \text{for all i \& j} \qquad (12)$$

i.e. , the matrix α_{ij} is skew – symmetric.

Case 2: Suppose α_{ij} is skew – symmetric. Then , equation (9) shows that

$$A\ \delta A = 0 , \qquad (13)$$

for all vectors A_i. This implies

$$\delta A = 0 \qquad (14)$$

for all vectors A_i

This shows that the transformation (1) represents a rigid body linear small transformation.

This completes the proof of the theorem.

Remark: When the quantities α_{ij} are skew – symmetric , then the linear infinitesimal transformation

$$\delta A_i = \alpha_{ij}\ A_j \ ,$$

equation (11) takes the form

$$\delta A_1 = - \alpha_{21}\ A_2 + \alpha_{13}\ A_3 ,$$

$$\delta A_2 = \alpha_{21}\ A_1 - \alpha_{32}\ A_3 ,$$

$$\delta A_3 = - \alpha_{13}\ A_1 + \alpha_{32}\ A_2 . \qquad (15)$$

Let $$w_1 = \alpha_{32} = - \alpha_{23} ,$$

$$w_2 = \alpha_{13} = - \alpha_{31} ,$$

$$w_3 = \alpha_{21} = - \alpha_{12} . \qquad (16)$$

Then , the transformation (15) can be written as the vector product

$$\overline{\delta A} = \overline{w} \times \overline{A} \ , \qquad (17)$$

where $\overline{w} = w_i$ is the infinitesimal rotation vector. Further

$$\begin{aligned} \delta A_i &= A_i' - A_i \\ &= (\xi_i - \xi_i^\circ) - (x_i - x_i^\circ) \\ &= (\xi_i - x_i) - (\xi_i^\circ - x_i^\circ) \\ &= \delta x_i - \delta x_i^\circ . \end{aligned} \qquad (18)$$

This yields

$$\delta x_i = \delta x_i^\circ + \delta A_i \ ,$$

or

$$\delta x_i = \delta x_i^\circ + (\overline{w} \times \overline{A}) \ . \qquad (19)$$

Here , the quantities

$$\delta x_i^\circ = \xi_i^\circ - x_i^\circ$$

are the components of the displacement vector representing the **translation** of the point P° and the remaining terms of (19) represent **rotation of the body** about the point P°.

3.6 PURE DEFORMATION AND COMPONENTS OF STRAIN TENSOR

We consider the infinitesimal linear transformation

$$\delta A_i = \alpha_{ij} A_j \quad . \qquad (1)$$

Let $$w_{ij} = \frac{1}{2} (\alpha_{ij} - \alpha_{ji}) \ , \qquad (2)$$

and

$$e_{ij} = \frac{1}{2} (\alpha_{ij} + \alpha_{ji}) \ . \qquad (3)$$

Then the matrix w_{ij} is **antisymmetric** while e_{ij} is **symmetric** .

Moreover ,

$$\alpha_{ij} = e_{ij} + w_{ij} , \qquad (4)$$

and this decomposition of α_{ij} as a sum of a symmetric and skew – symmetric matrices is unique.

From (1) and (4) , we write

$$\delta A_i = e_{ij} A_j + w_{ij} A_j \quad . \qquad (5)$$

This shows that the transformation of the components of a vector A_i given by

$$\delta A_i = w_{ij} A_j \quad , \qquad (6)$$

represents rigid body motion with the components of rotation vector w_i given by

$$w_1 = w_{32} \ , w_2 = w_{13} , w_3 = w_{21} , \qquad (7)$$

and the transformation

$$\mathbf{\delta A_i = e_{ij} A_j ,} \qquad (8)$$

with $$\mathbf{e_{ij} = e_{ji}} \ , \qquad (9)$$

represents a **pure deformation**.

Strain Components

The symmetric coefficients , e_{ij} , in the pure deformation

$$\delta A_i = e_{ij} A_j$$

are called the **strain components.**

Note (1) : These components of strain characterize **pure deformation** of the elastic body. Since A_j and δA_i are vectors (each is a tensor of order 1) , therefore , by quotient law , the strain components $\mathbf{e_{ij}}$ **form a tensor of order 2.**

Note (2) : For most materials / structures , the strains are of the order **of** $\mathbf{10^{-3}}$. Such strains certainly **deserve to be called small**.

Note (3) : The strain components e_{11} , e_{22} , e_{33} are called **normal strain components** while e_{12} , e_{13} , e_{23} , e_{21} , e_{31} , e_{32} are called **shear strain components**.

Example : For the deformation defined by the linear transformation

$$\xi_1 = x_1 + x_2 , \xi_2 = x_1 - 2x_2 , \xi_3 = x_1 + x_2 - x_3 ,$$

find the inverse transformation , components of rotation and strain tensor , and axis of rotation.

Solution : The given transformation is expresses as

$$\begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 \\ 1 & -2 & 0 \\ 1 & 1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}, \qquad (1)$$

and its inverse transformation is

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 \\ 1 & -2 & 0 \\ 1 & 1 & -1 \end{bmatrix}^{-1} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix}$$

$$= \frac{1}{3} \begin{bmatrix} 2 & 1 & 0 \\ 1 & -1 & 0 \\ 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix}, \qquad (2)$$

giving

$$x_1 = \frac{1}{3}(2\,\xi_1 + \xi_2),$$
$$x_2 = \frac{1}{3}(\xi_1 - \xi_2),$$
$$x_3 = \xi_1 - \xi_3 \quad . \qquad (3)$$

Comparing (1) with

$$\xi_i = (\alpha_{ij} + \delta_{ij})\, x_j \quad , \qquad (4)$$

we find

$$(\alpha_{ij}) = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -3 & 0 \\ 1 & 1 & -2 \end{bmatrix}. \qquad (5)$$

Then

$$w_{ij} = \frac{1}{2}(\alpha_{ij} - \alpha_{ji}) = \frac{1}{2} \begin{bmatrix} 0 & 0 & -1 \\ 0 & 0 & -1 \\ 1 & 1 & 0 \end{bmatrix}, \qquad (6)$$

and

$$e_{ij} = \frac{1}{2}(\alpha_{ij} + \alpha_{ji})$$

$$= \begin{bmatrix} 0 & 1 & \frac{1}{2} \\ 1 & -3 & \frac{1}{2} \\ \frac{1}{2} & \frac{1}{2} & -2 \end{bmatrix}, \qquad (7)$$

and

$$\alpha_{ij} = w_{ij} + e_{ij} \ , \qquad (8)$$

The axis of rotation is

$$\overline{w} = w_i \ \hat{e}_i$$

where

$$w_1 = w_{32} = \frac{1}{2} \ ,$$

$$w_2 = w_{13} = -\frac{1}{2} \ ,$$

$$w_3 = w_{21} = 0. \qquad (9)$$

3.7 GEOMETRICAL INTERPRETATION OF THE COMPONENTS OF STRAIN

Normal Strain Component e_{11}

Let e_{ij} be the components of strains. The pure infinitesimal linear deformation of a vector A_i is given by

$$\delta A_i = e_{ij} \ A_j \quad , \qquad (1)$$

with $e_{ij} = e_{ji}$.

Let e denote the extension (or change) in length per unit length of the vector A_i with magnitude A. Then , by definition ,

$$e = \frac{\delta A}{A} \ . \qquad (2)$$

we note that e is positive or negative depending upon whether the material line element A_i experiences an **extension** or a **contraction**.

Also e = 0 iff the vector A retains its length during a deformation.

This number e is referred to **as the normal strain of the vector A_i**.

Since the deformation is linear and infinitesimal , we have (proved earlier)

$$A\ \delta A = A_i\ \delta A_i \qquad (3)$$

or $$\frac{\delta A}{A} = \frac{A_i\ \delta A_i}{A^2} \ .$$

Now from (1) – (3) , we write

$$e = \frac{\delta A}{A} = \frac{A_i\ \delta A_i}{A^2}$$

$$= \frac{1}{A^2}\ A_i\ e_{ij}\ A_j \ .$$

This implies

$$e = \frac{1}{A^2}\ [e_{11}\ A_1{}^2 + e_{22}\ A_2{}^2 + e_{33}\ A_3{}^2 + 2e_{12}\ A_1\ A_2 + 2e_{13}\ A_1\ A_3 + 2e_{23}\ A_2\ A_3]\backslash \qquad (4)$$

since $e_{ij} = e_{ji}$.

In particular , we consider the case in which the vector A_i in the undeformed state is parallel to the x_1- axis. Then

$$A_1 = A \ , A_2 = A_3 = 0 \qquad (5)$$

Using (5) , equation (4) gives

$$e = e_{11} \ . \qquad (6)$$

Thus , the component e_{11} of the strain tensor represents , to a good approximation the **extension or change in length per unit initial length** of a material line **segment** (or fibre of the material) **originally placed parallel to the x_1 – axis** in the **undeformed state**.

Similarly , normal strains e_{22} and e_{33} are to be interpreted.

Illustration : Let $e_{ij} = \begin{bmatrix} e_{11} & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$.

Then all unit vectors parallel to the x_1 – axis will be extended by an amount e_{11}. In this case , one has a homogeneous deformation of material in the direction of the x_1 – axis. A cube of material whose edges before deformation are '*l*' units long will become (after deformation due to e_{ij}) a rectangular parallelopiped whose dimension in the x_1 – direction is $l\ (1 + e_{11})$ units and whose dimensions in the direction of the x_2 – and x_3 – axes are unchanged.

Remark: The vector

$$\overline{A} = A_i = (A\ ,\ 0\ ,\ 0)$$

is changed to (due to deformation)

$$\overline{A}' = (A + \delta A_1)\ \hat{e}_1 + \delta A_2 \hat{e}_2 + \delta A_3 \hat{e}_3$$

in which

$$\delta A_i = e_{ij}\ A_j = e_{il}\ A_1$$

give

$$\delta A_1 = e_{11}\ A\ ,\ \delta A_2 = e_{12}\ A\ ,\ \delta A_3 = e_{13}\ A.$$

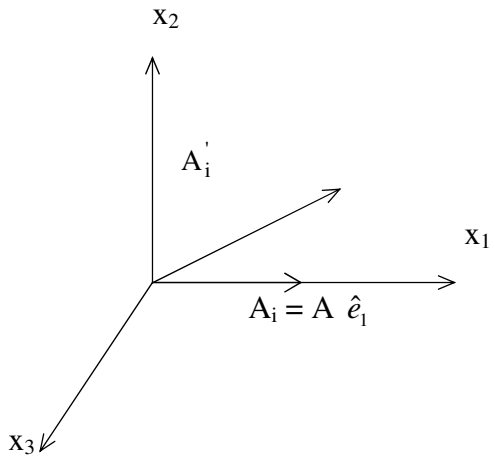


Fig. (3.7)

Thus

$$\overline{A}' = (A + e_{11}\ A\ ,\ e_{12}\ A\ ,\ e_{13}\ A)\ .$$

This indicates that vector $A_i = (A , 0 , 0)$ upon deformation , in general , **changes its orientation also**.

The length of the vector due to deformation becomes $(1 + e_{11})\, A$.

Question : From the relation $\delta A_i = e_{ij}\, A_j$, find δA and δA_i for a vector lying initially along the x – axis (i.e. , $\overline{A} = A\,\hat{e}_1$) and justify the fact that $\frac{\delta A}{A} = e_{11}$. Does δA_i lie along the x – axis ?

Answer : It is given that $A_i = (A , 0 , 0)$. The given relation

$$\delta A_i = e_{ij}\, A_j \qquad (1)$$

gives

$$\delta A_1 = e_{11}\, A \,,\ \delta A_2 = e_{12}\, A \,,\ \delta A_3 = e_{13}\, A \,. \qquad (2)$$

Thus , in general , **the vector δA_i does not lie along the x – axis.**

Further

$$(A + \delta A) = \sqrt{[A(1+e_{11})^2 + (e_{12}A)^2 + (e_{13}A)^2}$$

$$= A\ \sqrt{1 + 2e_{11} + e_{11}{}^2 + e_{12}{}^2 + e_{13}{}^2}\ . \qquad (3)$$

Neglecting square terms as deformation is small, equation (3) gives

$$(A + \delta A)^2 = A^2\,(1 + 2\, e_{11}) \ ,$$

$$\Rightarrow \qquad \cancel{A^2} + 2\, A\, \delta A = \cancel{A^2} + 2\, A^2\, e_{11} \ ,$$

$$2\, A\, \delta A = 2\, A^2\, e_{11}$$

$$\frac{\delta A}{A} = e_{11}. \qquad (4)$$

This shows that e_{11} gives the extension of a vector (A , 0 , 0) per unit length due to deformation.

Remark : The strain components e_{ij} refer to the chosen set of coordinate axes. If the axes are changed , the strain components e_{ij} will , in general , change as per tensor transformation laws.

Geometrical Interpretation of Shearing Stress e_{23}

The shearing strain component e_{23} may be interpreted by considering **intersecting vectors initially parallel to two coordinate** axes – x_2 – and x_3 – axes.

Now , we consider in the undeformed state two vectors.

$$\overline{A} = A_2 \, \hat{e}_2 \ ,$$

$$\overline{B} = B_3 \, \hat{e}_3 \ , \qquad (1)$$

directed along x_2 – and x_3 – axis , respectively.

The relations of small linear deformation are

$$\delta A_i = e_{ij} \, A_j \ ,$$

$$\delta B_i = e_{ij} \, B_3 \ , \qquad (2)$$

Further , the vectors A_i and B_i due to deformation become (Figure)

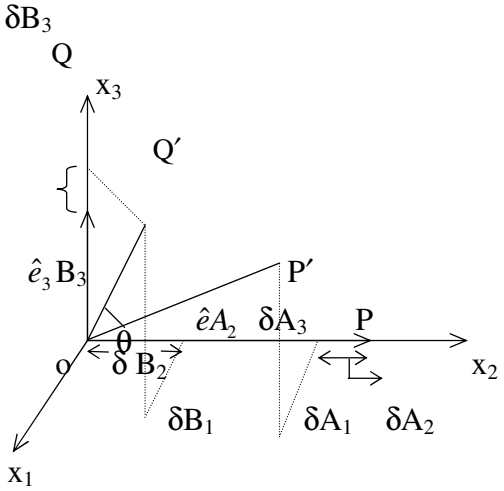


Fig. (3.8)

$$\left.\begin{aligned} \overline{A}' &= \delta A_1 \, \hat{e}_1 + (A_2 + \delta A_2) \, \hat{e}_2 + \delta A_3 \, \hat{e}_3 \, , \\ \overline{B}' &= \delta B_1 \, \hat{e}_1 + \delta B_2 \, \hat{e}_2 + (B_3 + \delta B_3) \, \hat{e}_3 \, . \end{aligned}\right\} \qquad (3)$$

Deformed vectors $\overline{A}'$ and $\overline{B}'$ need not lie in the x_2 x_3 – plane. Let θ be the angle between $\overline{A}'$ and $\overline{B}'$. Then

$$\cos\theta = \frac{\overline{A}'.\overline{B}'}{A'B'} = \frac{\delta A_1\delta B_1 + (A_2+\delta A_2)\delta B_2 + \delta A_3(B_3+\delta B_3)}{\sqrt{(\delta A_1)^2+(A_2+\delta A_2)^2+(\delta A_3)^2}\sqrt{(\delta B_1)^2+(\delta B_2)^2+(B_3+\delta B_3)^2}}\,. \tag{4}$$

Since , the deformation is small , we may neglect the products of the changes in the components of the vector A_i and B_i. Neglecting these products , equation (4) gives

$$\cos\theta = (A_2\,\delta B_2 + B_3\,\delta A_3)\,(A_2+\delta A_2)^{-1}\,(B_3+\delta B_3)^{-1}$$

$$= \frac{A_2\delta B_2 + B_3\,\delta A_3}{A_2\,B_3}\left(1+\frac{\delta A_2}{A_2}\right)^{-1}\left(1+\frac{\delta B_3}{B_3}\right)^{-1}$$

$$= \left(\frac{\delta B_2}{B_3}+\frac{\delta A_3}{A_2}\right)\left(1-\frac{\delta A_2}{A_2}\right)\left(1-\frac{\delta B_3}{B_3}\right)\quad ,$$

neglecting other terms. This gives

$$\cos\theta = \frac{\delta B_2}{B_3}+\frac{\delta A_3}{A_2}\qquad , \tag{5}$$

neglecting the product terms involving changes in the components of the vectors A_i and B_i.

Since in formula (5) , all increments in the components of initial vectors A_i and B_i have been neglected except δA_3 and δB_2 , the deformation of these vectors on assuming (w.l.o.g)

$$\delta A_1 = \delta A_2 \equiv 0\ ,$$

and $$\delta B_1 = \delta B_3 \equiv 0\ ,$$

can be represented as shown in the figure below (It shows that vectors A_i' and B_i' lie in the $x_2\,x_3$ – plane). We call that equations (3) now may be taken as

$$\overline{A}' = A_2\ \hat{e}_2\ + \delta A_3\,\hat{e}_3\ ,$$

$$\overline{B}' = \delta B_2\ \hat{e}_2\ + B_3\,\hat{e}_3\,. \tag{6}$$

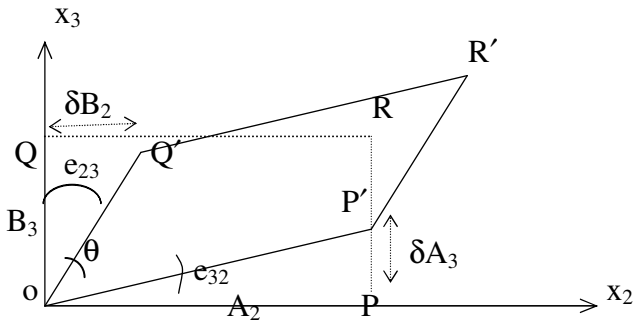


Fig. (3.9)

From equations (1) and (2) ,we obtain

$$\delta A_3 = e_{32}\, A_2 \quad ,$$

$$\delta B_2 = e_{23}\, B_3 \tag{7}$$

This gives

$$e_{32} = \frac{\delta A_3}{A_2} = \tan \angle P'O\,P \tag{8}$$

and

$$e_{23} = \frac{\delta B_2}{B_3} = \tan \angle Q'O\,Q\,. \tag{9}$$

Since strains $e_{23} = e_{32}$ are small , so

$$\angle P'O\,P = \angle Q'O\,Q \cong e_{23} \quad ,$$

and hence

$$2e_{23} \cong 90° - \theta = \pi/2 - \theta \quad . \tag{10}$$

Thus , a **positive value** of $2e_{23}$ represents a **decrease** in the right angle between the vectors A_i and B_i due to **small linear deformation** which were initially directed along the positive x_2 – and x_3 –axes. The quantity /strain component e_{23} **is called the shearing strain.**

A similar interpretation can be made for the shear strain components e_{12} and e_{13}.

Shear strain components represent the changes in the relative orientations of material arcs.

Remark 1: By rotating the parallelogram R′OP′Q′ through an angle e_{23} about the origin (in the $x_2\ x_3$ – plane) , we obtain the following configurations (Figure)

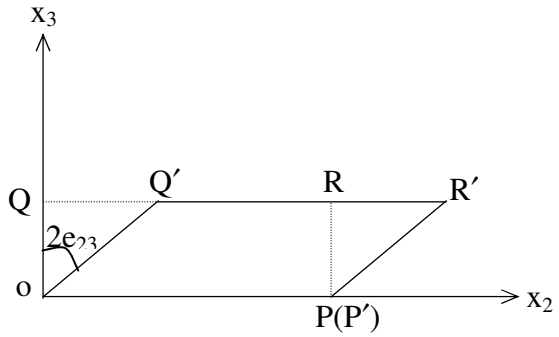


Fig. (3.10)

This figure shows a slide or a shear of planar elements parallel to the $x_1\ x_2$ – plane.

Remark 2: Figure shows that the areas of the rectangle OQRP and the parallelogram OQ′R′P′ are equal as they have the same height and same base in the $x_2\ x_3$ – plane.

Remark 3: For the strain tensor $\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & e_{23} \\ 0 & e_{32} & 0 \end{bmatrix}$,

a cubical element is deformed into a parallelopiped and the volumes of the cube and parallelopiped remain the same.

Such a small linear deformation is called a **pure shear.**

3.8 NORMAL AND TANGENTIAL DISPLACEMENTS

Consider a point $P(x_1 , x_2 , x_3)$ of the material. Let it be moved to Q under a small linear transformation. Let the components of the displacement vector $\overline{PQ}$ be u_1 , u_2 , u_3. In the plane OPQ , let $\overline{PN} = \bar{n}$ be the projection of $\overline{PQ}$ on the line OPN and let $\overline{PT} = \bar{t}$ be the tangential component of $\overline{PQ}$ in the plane of OPQ or PQN.

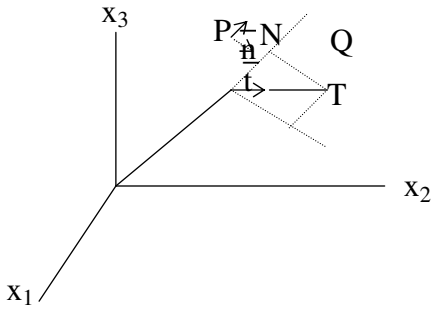


Fig. (3.11)

Definition: Vectors $\bar{n}$ and $\bar{t}$ are , respectively , called **the normal and the tangential components of the displacement of P.**

Note: The magnitude n of normal displacement $\bar{n}$ is given by the dot product of vectors

$$\overline{OP} = (x_1 , x_2 , x_3) \text{ and } \overline{PQ} = (u_1 , u_2 , u_3).$$

The magnitude t of tangential vector $\bar{t}$ is given the vector product of vectors $\overline{OP}$ and $\overline{PQ}$ (This does not give the direction of $\bar{t}$).

Thus

$$n = PQ \cos \angle NPQ = \frac{\overline{OP}.\overline{PQ}}{|\overline{OP}|} ,$$

$$t = PQ \sin \angle NPQ = \frac{(OP)(PQ)\sin(NPQ)}{OP} = \frac{|\overline{OP} \times \overline{PQ}|}{|\overline{OP}|} ,$$

and

$$n^2 + t^2 = u_1^2 + u_2^2 + u_3^2.$$

3.9 STRAIN QUADRIC CAUCHY

Let $P°(x_1° , x_2° , x_3°)$ be any but fixed point of a continuous medium , with reference axes o x_1 x_2 x_3 fixed in space.

We introduce a local system of axes with origin at the point P° and with axes parallel to the fixed axes (figure).

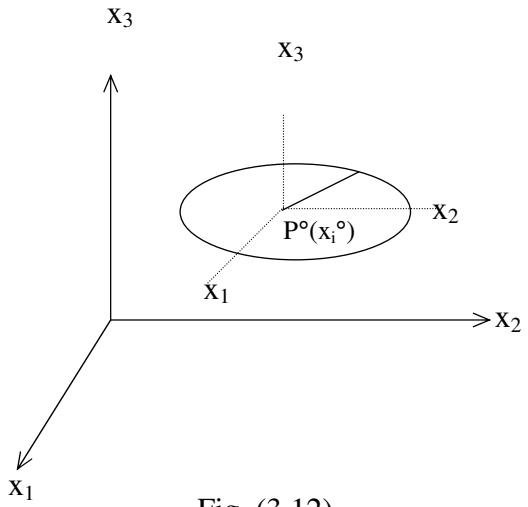


Fig. (3.12)

With reference to these local axes , consider the equation

$$e_{ij}\, x_i\, x_j = \pm k^2 \quad , \qquad (1)$$

where k is a real constant and e_{ij} is the strain tensor at P°. This equation represents a quadric surface with its centre at P°.

This quadric is called the **quadric surface of deformation** or **strain quadric** or **strain quadric of Cauchy.**

The sign + or – in equation (1) be chosen so that the quadric surface (1) becomes a real one.

The nature of this quadric surface depends on the value of the strains e_{ij} .

If $|e_{ij}| \neq 0$, the quadric is either an ellipsoid or a hyperboloid.

If $|e_{ij}| = 0$, the quadric surface degenerates into a cylinder of the elliptic or hyperbolic type or else into two parallel planes symmetrically situated with respect to the origin P° of the quadric surface.

This strain quadric is completely determined once the strain components e_{ij} at point P° are known.

Let $\overline{P^oP}$ be the radius vector A_i of magnitude A to any point P(x_1 , x_2 , x_3) , referred to local axis , on the strain quadric surface (1). Let e be the extension of the vector A_i due to some linear deformation characterized by

$$\delta A_i = e_{ij}\, A_j \quad . \qquad (2)$$

Then , by definition ,

$$e = \frac{\delta A}{A} = \frac{A\delta A}{A^2} = \frac{A_i \delta A_i}{A^2} .$$

This gives

$$e = \frac{e_{ij}\, A_i\, A_j}{A^2} \quad , \qquad (3)$$

using (2).

Since $\overline{P^oP} = A_i$ and the coordinate of the point P , on the surface (1) , relative to P° are (x_1 , x_2 , x_3) , it follows that

$$A_i = x_i \quad . \qquad (4)$$

From equations (1) , (3) and (4) ; we obtain

$$e\,A^2 = e_{ij}\,A_i\,A_j = e_{ij}\,x_i\,x_j = \pm k^2$$

or $$e\,A^2 = \pm k^2$$

or $$\mathbf{e = \pm}\,\frac{k^2}{A^2}\ . \qquad (5)$$

Result (I) : Relation (5) shows that the **extension or elongation of any radius vector A_i of the strain quadric of Cauchy** , given by equation (1) , is inversely proportional to the square of the length A of that radius vector. **This determines the elongation of any radius vector of the strain quadric at the point $P°(x_i°)$**.

Result (II) : We know that the length A of the radius vector A_i of strain quadric (1) at the point $P°(x_i°)$ has maximum and minimum values **along the axes of the quadric.** In general , axes of the strain quadric (1) differs from the coordinate axes through $P°(x_i°)$.

Therefore , the maximum and minimum extensions /elongations of radius vectors of strain quadric (1) **will be along its axes.**

Result (III) : Another interesting property of the strain quadric (1) is that **normal ν_i to this surface** at the end point P of the vector $\overline{P^oP} = A_i$ is parallel to the displacement vector δA_i.

To prove this property , let us write equation (1) in the form

$$G = e_{ij}\,x_j\,x_i\ \mu\,k^2 = 0\ . \qquad (6)$$

Then the direction of the normal $\hat{v}$ to the strain quadric (6) is given by the gradient of the scalar function G. The components of the gradient are

$$\frac{\partial G}{\partial x_k} = e_{ij}\,\delta_{ik}\,x_j + e_{ij}\,x_i\,\delta_{kj}$$

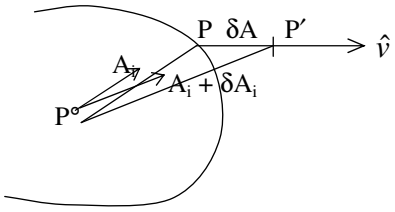
$$= e_{kj}\,x_j + e_{ik}\,x_i$$

$$= 2\,e_{kj}\,x_j\ ,$$

or

$$\frac{\partial G}{\partial x_k} = 2\,\delta A_k\ . \qquad (7)$$

This shows that vector $\frac{\delta G}{\delta x_k}$ and δA_k are parallel.



$\delta A_i \parallel v_i$

Fig. (3.13)

Hence , the vector $\overline{\delta A}$ is directed along the normal at P to the strain quadric of Cauchy.

3.10 STRAIN COMPONENTS AT A POINT IN A ROTATION OF COORDINATE AXES

Let new axes o x_1' x_2' x_3' be obtained from the old reference system o x_1 x_2 x_3 by a rotation (figure).

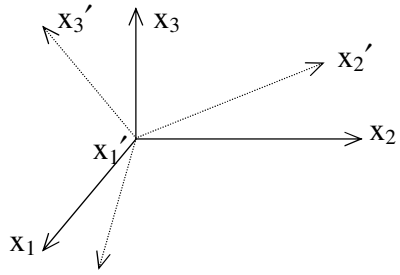


Fig. (3.14)

Let the directions of the new axes x_i' be specified relative to the old system x_i by the following table of direction cosines in which a_{pi} is the cosine of the angle between the x_p' - and x_i – axis.

That is ,

$$a_{pi} = \cos (x_p' , x_i) .$$

Thus

	x_1	x_2	x_3
x_1'	a_{11}	a_{12}	a_{13}
x_2'	a_{21}	a_{22}	a_{23}
x_3'	a_{31}	a_{32}	a_{33}

Then the transformation law for coordinates is

$$x_i = a_{pi}\, x_p' ,$$

or

$$x_p' = a_{pi}\, x_i . \tag{2}$$

The well – known orthogonality relation are

$$a_{pi}\, a_{qi} = \delta_{pq} , \tag{3}$$

$$a_{pi}\, a_{pj} = \delta_{ij} , \tag{4}$$

with reference to new x_p' system , a new set of strain components e'_{pq} is determined at the point O while e_{ij} are the components of strain at O relative to old axes O x_1 x_2 x_3.

Let

$$e_{ij}\, x_i\, x_j = \pm k^2 \quad , \tag{5}$$

be the equation of the strain quadric surface relative to old axis. The equation of quadric surface with reference to new prime system becomes

$$e'_{pq}\, x'_p\, x'_q = \pm k^2 , \tag{6}$$

as we know that quadric form is invariant w.r.t. an orthogonal transformation of coordinates.

Further , equations (2) to (6) together yield

$$\begin{aligned} e'_{pq}\, x'_p\, x'_q &= e_{ij}\, x_i\, x_j \\ &= e_{ij}\, (a_{pi}\, x'_p)\, (a_{qj}\, x'_q) \\ &= (e_{ij}\, a_{pi}\, a_{qj})\, x'_p\, x'_q , \end{aligned}$$

or

$$(e'_{pq} - a_{pi}\, a_{qj}\, e_{ij})\, x'_p\, x'_q = 0. \tag{7}$$

Since equation (7) is satisfied for arbitrary vector x'_p , we must have

$$e'_{pq} = a_{pi}\, a_{qj}\, e_{ij} . \tag{8}$$

Equation (8) is the law of transformation for a second order tensor.

We , therefore , conclude that the components of strain form a second order tensor.

Similarly , it can be verified that

$$e_{ij} = a_{pi}\, a_{qj}\, e'_{pq} \,. \qquad (9)$$

Question : Assuming that e_{ij} is a tensor of order 2 , show that quadratic form $\mathbf{e_{ij}\, x_i\, x_j}$ **is an variant.**

Solution : We have

$$e_{ij} = a_{pi}\, a_{qj}\, e'_{pq} \,,$$

so

$$e_{ij}\, x_i\, x_j = a_{pi}\, a_{qj}\, e'_{pq}\, x_i\, x_j$$

$$= e'_{pq}\, (a_{pi}\, x_i)\, (a_{qj}\, x_j)$$

$$= e'_{pq}\, x'_p\, x'_q \,.$$

Hence the result.

3.11 PRINCIPAL STRAINS AND INVARIANTS

From a material point $P°(x_i°)$ there emerges infinitely many material arcs /filaments , and each of these arcs generally changes in length and orientation under a deformation.

We seek now the lines through $P°(x_i°)$ **whose orientation** is left unchanged by the small linear deformation given by

$$\delta\, A_i = e_{ij}\, A_j \quad , \qquad (1)$$

where the strain components e_{ij} are small and constant.

In this situation , **vectors $\mathbf{A_i}$ and $\mathbf{\delta A_i}$ are parallel** and , therefore ,

$$\delta A_i = e\, A_i \quad , \qquad (2)$$

for some **constant e.**

Equation (2) shows that the constant **e represents the extension**

$$\left(e = \frac{|\, \delta\, A_i \,|}{|\, A_i \,|} = \frac{\delta A}{A} \right)$$

of **vector $\mathbf{A_i}$.**

From equations (1) and (2) , we write

$$e_{ij} A_j = e A_i$$

$$= e \delta_{ij} A_j . \qquad (3)$$

This implies

$$(e_{ij} - e \delta_{ij}) A_j = 0. \qquad (4)$$

We know that e_{ij} is a real symmetric tensor of order 2. The equation (3) shows that the scalar e is an eigenvalue of the real symmetric tensor e_{ij} with corresponding eigenvector A_i. Therefore , we conclude that there are precisely three mutually orthogonal directions whose orientations are not changed on account of deformation and these directions coincide with the three eigenvectors of the strain tensor e_{ij}.

These directions are known as **principal directions** or **invariant directions** of strain.

Equation (4) gives us a system of three homogeneous equations in the unknowns A_1 , A_2 , A_3. This system possesses a non – trivial solution iff the determinant of the coefficients of the A_1 , A_2 , A_3 is equal to zero , i.e. ,

$$\begin{vmatrix} e_{11} - e & e_{12} & e_{13} \\ e_{21} & e_{22} - e & e_{23} \\ e_{31} & e_{32} & e_{33} - e \end{vmatrix} = 0 , \qquad (5)$$

which is a cubic equation in e.

Let e_1 , e_2 , e_3 be the three roots of equation (5). These are known as **principal strains**.

Evidently , the principal strains are the eigenvalues of the second order real symmetric strain tensor e_{ij} . Consequently , these principal strains are all real (not necessarily distinct).

Physically , the principal strains e_1 , e_2 , e_3 (all different) are the extensions of the vectors , say $\underset{\sim}{\overset{i}{A}}$, in the principal /invariant directions of strain. So, vectors $\underset{\sim}{\overset{i}{A}}$, $\underset{\sim}{\overset{i}{\delta A}}$, $\underset{\sim}{\overset{i}{A}} + \underset{\sim}{\overset{i}{\delta A}}$ are collinear.

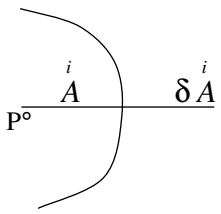


Fig. (3.15)

At the point P° , consider the strain quadric

$$e_{ij}\, x_i\, x_j = \pm k^2 . \qquad (6)$$

For every principal direction of strain $\overset{i}{\underset{\sim}{A}}$, we know that $\delta \overset{i}{A}$ is normal to the quadric surface (6). Therefore , the principal directions of strain are also normal to the strain quadric of Cauchy. Hence, principal direction of strain must be the three principal axes of the strain quadric of Cauchy.

If some of the principal strains e_i are equal , then the associated directions become indeterminate but one can always select three directions that all mutually orthogonal (already proved).

If $e_1 \neq e_2 = e_3$, then the quadric surface of Cauchy is a surface revolution and our principal direction,
say $\overset{1}{\underset{\sim}{A}}$, will be directed along the axis of revolution.

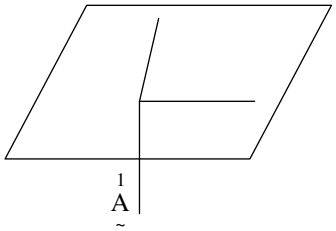


Fig. (3.16)

In this case , any two mutually perpendicular vectors lying in the plane normal to $\overset{1}{\underset{\sim}{A}}$ may be taken as the other two principal directions of strain.

If $e_1 = e_2 = e_3$, then strain quadric of Cauchy becomes a sphere and any three orthogonal directions may be chosen as the principal directions of strain.

Result 1 : If the principal directions of strain are taken as the coordinate axes , then

$$e_{11} = e_1 , e_{22} = e_2 , e_{33} = e_3$$

and

$$e_{12} = e_{13} = e_{23} = 0 ,$$

as a vector initially along an axis remains in the same direction after deformation (so changes in right angles are zero). In this case , the strain quadric of Cauchy has the equation

$$e_1 x_1^2 + e_2 x_2^2 + e_3^2 x_3^2 = \pm k^2. \tag{7}$$

Result 2: Expanding the cubic equation (5) , we write

$$-e^3 + \nu_1 e^2 - \nu_2 e + \nu_3 = 0.$$

where

$$\nu_1 = e_{11} + e_{22} + e_{33}$$

$$= e_{ii} = tr(E) , \tag{8}$$

$$\nu_2 = e_{11} e_{22} + e_{22} e_{33} + e_{33} e_{11} - e_{23}^2 - e_{13}^2 - e_{12}^2$$

$$= tr(E^2) = \frac{1}{2} (e_{ii} e_{jj} - e_{ij} e_{ji}) , \tag{9}$$

$$\nu_3 = \in_{ijk} e_{1i} e_{2j} e_{3k}$$

$$= | e_{ij} | = tr(E^3) . \tag{10}$$

Also , e_1 , e_2 , e_3 are roots of the cubic equation (8) , so

$$\left.\begin{aligned} \nu_1 &= e_1 + e_2 + e_3 \\ \nu_2 &= e_1 e_2 + e_2 e_3 + e_3 e_1 \\ \nu_3 &= e_1 e_2 e_3 \end{aligned}\right\} \tag{11}$$

We know that eigenvalues of a second order real symmetric tensor are independent of the choice of the coordinate system.

It follows that ν_1 , ν_2 , ν_3 are , as given by (10) , **three invariants of the strain tensor e_{ij} with respect to an orthogonal transformation of coordinates**.

Geometrical Meaning of the First Strain Invariant $\nu = e_{ii}$

The quantity $\nu = e_{ii}$ has a simple geometrical meaning. Consider a volume element in the form of a rectangular parallelepiped whose edges of length l_1 , l_2 , l_3 are parallel to the principal directions of strain.

Due to small linear transformation /deformation , this volume element becomes again a rectangular parallelepiped with edges of length $l_1(1+e_1)$, $l_2(1+e_2)$, $l_3(1+e_3)$, where e_1 , e_2 , e_3 are principal strains.

Hence , the change δV in the volume V of the element is

$$\delta V = l_1 l_2 l_3 (1 + e_1) (1 + e_2) (1 + e_3) - l_1 l_2 l_3$$

$= l_1\, l_2\, l_3\, (1 + e_1 + e_2 + e_3) - l_1\, l_2\, l_3$, ignoring small strains e_i.

$= l_1\, l_2\, l_3\, (e_1 + e_2 + e_3)$

This implies

$$\frac{\delta V}{V} = e_1 + e_2 + e_3 = \nu_1$$

Thus , the first strain invariant ν_1 **represents the change in volume per unit initial volume due to strain produced in the medium**.

The quantity ν_1 is called the **cubical dilatation** or simply the **dilatation**.

Note : If $e_1 > e_2 > e_3$ then e_3 is called the **minor principal strain** , e_2 is called the **intermediate principal strain** , and e_1 is called the **major principal strain**.

Question : For small linear deformation , the strains e_{ij} are given by

$$(e_{ij}) = \alpha \begin{bmatrix} x_2 & (x_1 + x_2)/2 & x_3 \\ (x_1 + x_2)/2 & x_1 & x_3 \\ x_3 & x_3 & 2(x_1 + x_2) \end{bmatrix} , \quad \alpha$$

= constant.

Find the strain invariants , principal strains and principal directions of strain at the point P(1 , 1 , 0).

Solution : The strain matrix at the point P(1 , 1 , 0) becomes

$$(e_{ij}) = \begin{bmatrix} \alpha & \alpha & 0 \\ \alpha & \alpha & 0 \\ 0 & 0 & 4\alpha \end{bmatrix} ,$$

whose characteristic equation becomes

$$e(e - 2\alpha)\,(e - 4\alpha) = 0 .$$

Hence , the principle strains are

$$e_1 = 0 , e_2 = 2\alpha , e_3 = 4\alpha.$$

The three scalar invariants are

$$\nu_1 = e_1 + e_2 + e_3 = 6\alpha , \nu_2 = 8\alpha^2 , \nu_3 = 0$$

The three principal unit directions are found to be

$$\overset{1}{A}_i = \left(\frac{1}{\sqrt{2}} , \frac{-1}{\sqrt{2}} , 0 \right) \quad , \qquad \overset{2}{A}_i = \left(\frac{1}{\sqrt{2}} , \frac{1}{\sqrt{2}} , 0 \right) \quad ,$$

$$\overset{3}{A}_i = (0 \ , 0 \ , 1)$$

Exercise : The strain field at a point P(x , y , z) in an elastic body is given by

$$e_{ij} = \begin{bmatrix} 20 & 3 & 2 \\ 3 & -10 & 5 \\ 2 & 5 & -8 \end{bmatrix} \times 10^{-6} .$$

Determine the strain invariants and the principal strains.

Question : Find the principal directions of strain by finding the extremal value of the extension e.

OR

Find the directions in which the extension e is stationary.

Solution: Let e be the extension of a vector A_i due to small linear deformation

$$\delta A_i = e_{ij} A_j \quad . \tag{1}$$

Then

$$e = \frac{\delta A}{A} . \tag{2}$$

We know that for an infinitesimal linear deformation (1) , we have

$$A \, \delta A = A_i \, \delta A_i . \tag{3}$$

Thus

$$e = \frac{A \, \delta A}{A^2} = \frac{A_i \, \delta A_i}{A^2} = \frac{e_{ij} A_i \, A_j}{A^2} . \tag{4}$$

Let

$$\frac{A_i}{A} = a_i . \tag{5}$$

Then

$$a_i \, a_i = 1 , \tag{6}$$

and equation (4) then gives

$$e(a_1 , a_2 , a_3) = e_{ij} \, a_i \, a_j \ . \tag{7}$$

Thus , the extension e is a function of a_1 , a_2 , a_3 which are not independent because of relation (6). The extreme/stationary(or Max/Min) values of the extension e are to be found by making use of Lagrange's method of multipliers.

For this purpose , we consider the auxiliary function

$$F(a_1 , a_2 , a_3) = e_{ij}\, a_i\, a_j - \lambda(a_i\, a_i - 1) , \qquad (8)$$

where λ is a constant.

In order to find the values of a_1 , a_2 , a_3 for which the function (7) may have a maximum or minimum, we solve the equations

$$\frac{\partial F}{\partial a_k} = 0 \qquad , k = 1 , 2 , 3. \qquad (9)$$

Thus , the stationary values of e are given by

$$e_{ij}\, (\delta_{ik}\, a_j + a_i\, \delta_{jk}) - \lambda\, 2\, a_i\, \delta_{ik} = 0$$

or $$e_{kj}\, a_j + e_{ik}\, a_i - 2\, \lambda\, a_k = 0$$

or $$2\, e_{ki}\, a_i - 2\, \lambda\, a_k = 0$$

or $$e_{ki}\, a_i = \lambda\, a_k . \qquad (10)$$

This shows that λ is an eigenvalue of the strain tensor e_{ij} and a_i is the corresponding eigenvector. Therefore , equations in (10) determine the principal strains and principal directions of strain.

Thus , the extension e assumes the stationary values along the principal directions of strain and the stationary/extreme values are precisely the principal strains.

Remark : Let M be the square matrix with eigenvectors of the strain tensor e_{ij} as columns. That is

$$M = \begin{bmatrix} \overset{1}{A}_1 & \overset{2}{A}_1 & \overset{3}{A}_1 \\ \overset{1}{A}_2 & \overset{2}{A}_2 & \overset{3}{A}_2 \\ \overset{1}{A}_3 & \overset{2}{A}_3 & \overset{3}{A}_3 \end{bmatrix}$$

Then $$e_{ij}\ \overset{1}{A}_j = e_1\ \overset{1}{A}_i ,$$

$$e_{ij} \overset{2}{A}_j = e_2 \overset{2}{A}_i ,$$

$$e_{ij} \overset{3}{A}_j = e_3 \overset{3}{A}_i$$

The matrix M is called the **modal matrix** of strain tensor e_{ij}.

Let

$$E = (e_{ij}) , D = dia(e_1 , e_2 , e_3).$$

Then , we find

$$E M = M D$$

or $$M^{-1} E M = D .$$

This shows that the matrices E and D are similar.

We know that two similar matrices have the same eigenvalues. Therefore , the characteristic equation associated with $M^{-1}EM$ is the same as the one associated with E. Consequently , eigenvalues of E and D are identical.

Question : Show that , in general , at any point of the elastic body there exists (at least) three mutually perpendicular principal directions of strain due to an infinitesimal linear deformation.

Solution : Let e_1 , e_2 , e_3 be the three principal strains of the strain tensor e_{ij}. Then , they are the roots of the cubic equation

$$(e - e_1) (e - e_2) (e - e_3) = 0 ,$$

and $$e_1 + e_2 + e_3 = e_{11} + e_{22} + e_{33} = e_{ii} ,$$

$$e_1 e_2 + e_2 e_3 + e_3 e_1 = \frac{1}{2} (e_{ii} e_{jj} - e_{ij} e_{ji}) ,$$

$$e_1 e_2 e_3 = | e_{ij} | = \in_{ijk} e_{1i} e_{2j} e_{3k} .$$

We further assume that coordinate axes coincide with the principal directions of strain. Then , the strain components are given by

$$e_{11} = e_1 , e_{22} = e_2 , e_{33} = e_3 ,$$

$$e_{12} = e_{13} = e_{23} = 0 ,$$

and the strain quadric of Cauchy becomes

$$e_1 x_1^2 + e_2 x_2^2 + e_3 x_3^2 = \pm k^2. \qquad (1)$$

Now , we consider the following three possible cases for principal strains.

Case 1 : When $e_1 \neq e_2 \neq e_3$. In this case , it is obvious that there exists three mutually orthogonal eigenvectors of the second order real symmetric strain tensor e_{ij}. These eigenvectors are precisely the three principal directions that are mutually orthogonal.

Case 2 : When $e_1 \neq e_2 = e_3$.

Let $\overset{1}{A}_i$ and $\overset{2}{A}_i$ be the corresponding principal orthogonal directions corresponding to strains (distinct) e_1 and e_2 , respectively. Then

$$e_{ij} \overset{1}{A}_j = e_1 \overset{1}{A}_i \ ,$$

$$e_{ij} \overset{2}{A}_j = e_2 \overset{2}{A}_i \qquad (2)$$

Let p_i be a vector orthogonal to both $\overset{1}{A}_i$ and $\overset{2}{A}_i$. Then

$$p_i \overset{1}{A}_i = p_i \overset{2}{A}_i = 0. \qquad (3)$$

Let $$e_{ij} p_i = q_j \ . \qquad (4)$$

Then $$q_j \overset{1}{A}_j = (e_{ij} p_i) \overset{1}{A}_j = (e_{ij} \overset{1}{A}_j) p_i = e_1 \overset{1}{A}_i p_i = 0 \qquad (5a)$$

Similarly $$q_j \overset{2}{A}_j = 0 \ . \qquad (5b)$$

This shows that the vector q_j is orthogonal to both $\overset{1}{A}_j$ and $\overset{2}{A}_j$. Hence , the vectors q_i and p_i must be parallel. Let

$$q_i = \alpha p_i \ , \qquad (6)$$

for some scalar α. From equations (4) and (6) , we write

$$e_{ij} p_j = q_i = \alpha p_i \ , \qquad (7)$$

which shows that the scalar α is an eigenvalue/principal strain of the strain tensor e_{ij} with corresponding principal direction p_i .

Since e_{ij} has only three principal strains e_1 , e_2 , α and two of these are equal , so α must be equal to $e_2 = e_3$.

We denote the normalized form of p_i by $\overset{3}{A}_i$.

This shows the existence of three mutually orthogonal principal directions in this case.

Further , let v_i be any vector normal to $\overset{1}{A}_i$. Then v_i lies in the plane containing principal directions $\overset{2}{A}_i$ and $\overset{3}{A}_i$. Let

$$v_i = k_1 \overset{2}{A}_i + k_2 \overset{3}{A}_i \qquad \text{for some scalars } k_1 \text{ and } k_2 \qquad (8)$$

Now
$$e_{ij} v_j = e_{ij} (k_1 \overset{2}{A}_j + k_2 \overset{3}{A}_j)$$

$$= k_1(e_{ij} \overset{2}{A}_j) + k_2(e_{ij} \overset{3}{A}_j)$$

$$= k_1(e_2 \overset{2}{A}_i) + k_2(e_3 \overset{3}{A}_i)$$

$$= e_2[k_1 \overset{2}{A}_i + k_2 \overset{3}{A}_i] \qquad (\Theta\, e_2 = e_3)$$

$$= e_2 v_i$$

This shows that the direction v_i is also a principal direction corresponding to principal strain e_2. Thus, in this case , any two orthogonal(mutually) vectors lying on the plane normal to $\overset{1}{A}_i$ can be chosen as the other two principal directions. In this case , the strain quadric surface is a surface of revolution.

Case 3: When $e_1 = e_2 = e_3$, then the strain quadric of Cauchy is a sphere with equation

$$e_1(x_1^2 + x_2^2 + x_3^2) = \pm k^2 ,$$

or
$$x_1^2 + x_2^2 + x_3^2 = \pm \frac{k^2}{e_1}$$

and any three mutually orthogonal directions can be taken as the coordinate axes which are coincident with principal directions of strain.

Hence , the result.

3.12 GENERAL INFINITESIMAL DEFORMATION

Now we consider the general functional transformation and its relation to the linear deformation. Consider an arbitrary material point $P°(x_i°)$ in a continuous medium. Let the same material point assume after deformation the point $Q°(\xi_i°)$. Then

$$\xi_i° = x_i° + u_i(x_1° , x_2° , x_3°) , \qquad (1)$$

where u_i are the components of the displacement vector $\overline{P^oQ^o}$. We assume that u_1 , u_2 , u_3 , as well as their partial derivatives are continuous functions.

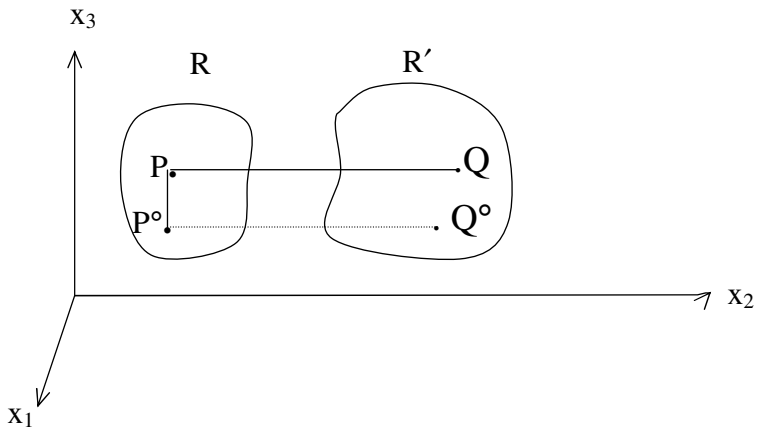


Fig. (3.17)

The **nature of the deformation in the neighbourhood of the point P° can be determined by considering the change** in the vector $\overline{P^oP} = A_i$ in the undeformed state , where $P(x_1 , x_2 , x_3)$ is an arbitrary **neighbouring** point of P°.

Let $Q(\xi_1 , \xi_2 , \xi_3)$ be the deformed position of P. Then the displacement u_i at the point P is

$$u_i(x_1 , x_2 , x_3) = \xi_i - x_i. \qquad (2)$$

The vector $A_i = x_i - x_i° , \qquad (3)$

has now deformed to the vector

$$\xi_i - \xi_i° = A_i′ \text{ (say)}. \qquad (4)$$

Therefore , $\delta A_i = A_i′ - A_i$

$$= (\xi_i - \xi_i°) - (x_i - x_i°)$$

$$= (\xi_i - x_i) - (\xi_i^\circ - x_i^\circ)$$

$$= u_i(x_1 , x_2 , x_3) - u_i(x_1^\circ , x_2^\circ , x_3^\circ)$$

$$= u_i(x_1^\circ + A_1 , x_2^\circ + A_2 , x_3^\circ + A_3) - u_i(x_1^\circ , x_2^\circ , x_3^\circ)$$

$$= \left(\frac{\partial u_i}{\partial x_j} \right)_o A_j \quad , \tag{5}$$

plus the higher order terms of Taylor's series. The subscript ∘ indicates that the derivative is to be evaluated at the point P°.

If the region in the nbd. of P° is chosen sufficiently small , i.e. , if the vector A_i is sufficiently small , then the product terms like A_i A_j may be ignored.

Ignoring the product terms and dropping the subscript ∘ in (5) , we write

$$\delta A_i = u_{i,j} A_j \quad , \tag{6}$$

where the symbol $u_{i,j}$ has been used for $\frac{\partial u_i}{\partial x_j}$.

Result (6) holds for small vectors A_i.

If we further assume that the **displacements u_i as well as their partial derivatives are so small that their products can be neglected ,** then the transformation (which is linear) given by (4) becomes infinitesimal in the nbd of the point (P°) under consideration and

$$\delta A_i = \alpha_{ij} A_j \quad , \tag{7}$$

with

$$\alpha_{ij} = u_{i,j}. \tag{8}$$

Hence , all results discussed earlier are immediately applicable.

The transformation (6) can be splitted into pure deformation and rigid body motion as

$$\delta A_i = u_{i,j} A_j = \left(\frac{u_{i,j} + u_{j,i}}{2} + \frac{u_{i,j} - u_{j,i}}{2} \right) A_j$$

$$= e_{ij} A_j + w_{ij} A_j \ , \tag{9}$$

where $$e_{ij} = \frac{1}{2}(u_{i,j} + u_{j,i}) , \tag{10}$$

$$w_{ij} = \frac{1}{2}(u_{i,j} - u_{j,i}) . \tag{11}$$

The transformation

$$\delta A_i = e_{ij} A_j \quad , \tag{12}$$

represents pure deformation and

$$\delta A_i = w_{ij} A_j \quad , \tag{13}$$

represents rotation . In general , the transformation (9) is no longer homogeneous as both the strain components e_{ij} and components of rotation w_{ij} are functions of the coordinates. We find

$$\nu = e_{ii} = \frac{\partial u_i}{\partial x_i} = u_{i,i} = \text{div } \bar{u}. \tag{14}$$

That is , the cubic dilatation is the divergence of the displacement vector $\bar{u}$ and it differs , in general , from point to point of the body.

The rotation vector w_i is given by

$$w_1 = w_{32} , w_2 = w_{13} , w_3 = w_{21} . \tag{15}$$

Question : For the small linear deformation given by

$$\bar{u} = \alpha x_1 x_2(\hat{e}_1 + \hat{e}_2) + 2\alpha(x_1 + x_2) x_3 \hat{e}_3 , \alpha = \text{constant}.$$

find the strain tensor , the rotation and the rotation vector.

Solution: We find

$$u_1 = \alpha x_1 x_2 , u_2 = \alpha x_1 x_2 , u_3 = 2\alpha(x_1 + x_2)x_3 ,$$

$$e_{11} = \frac{\partial u_1}{\partial x_1} = \alpha x_2 , e_{22} = \frac{\partial u_2}{\partial x_2} = \alpha x_1 , e_{33} = \frac{\partial u_3}{\partial x_3} = 2\alpha(x_1 + x_2)$$

$$e_{12} = \frac{1}{2}\left(\frac{\partial u_1}{\partial x_1} + \frac{\partial u_2}{\partial x_2}\right) = \frac{\alpha}{2}(x_1 + x_2) ,$$

$$e_{13} = \frac{1}{2}\left(\frac{\partial u_1}{\partial x_3} + \frac{\partial u_3}{\partial x_1}\right) = \alpha x_3 , e_{23} = \alpha x_3$$

Hence

$$(e_{ij}) = \alpha \begin{bmatrix} x_2 & (x_1 + x_2)/2 & x_3 \\ (x_1 + x_2)/2 & x_1 & x_3 \\ x_3 & x_3 & 2(x_1 + x_2) \end{bmatrix}.$$

We know that

$$w_{ij} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} - \frac{\partial u_j}{\partial x_i}\right)$$

We find

$$w_{11} = w_{22} = w_{33} = 0 ,$$

$$w_{12} = \frac{\alpha}{2}[x_1 - x_2] = -w_{21} ,$$

$$w_{13} = -\alpha x_3 = -w_{31} ,$$

$$w_{23} = -\alpha x_3 = -w_{32} ,$$

Therefore

$$(w_{ij}) = \alpha \begin{bmatrix} 0 & (x_1 - x_2)/2 & -x_3 \\ -(x_1 - x_2)/2 & 0 & -x_3 \\ x_3 & x_3 & 0 \end{bmatrix}. \qquad (2)$$

The rotation vector $\bar{w} = w_i$ is given by $w_i = \in_{ijk} u_{k,j}$. We find

$$w_1 = w_{32} = \alpha x_3 , \; w_2 = w_{13} = -\alpha x_3 , \; w_3 = w_{21} = \frac{\alpha}{2}(x_2 - x_1) .$$

So $$\bar{w} = \alpha x_3(\hat{e}_1 - \hat{e}_2) + \frac{\alpha}{2}(x_2 - x_1)\,\hat{e}_3 .$$

Exercise 1: For small deformation defined by the following displacements , find the strain tensor , rotation tensor and rotation vector.

(i) $u_1 = -\alpha x_2 x_3$, $u_2 = \alpha x_1 x_2$, $u_3 = 0$.

(ii) $u_1 = \alpha^2(x_1 - x_3)^2$, $u_2 = \alpha^2(x_2 + x_3)^2$, $u_3 = -\alpha x_1 x_2$, α = constant.

Exercise 2: The displacement components are given by

$$u = -yz\ ,\ v = xz\ ,\ w = \phi(x\ ,\ y)$$

calculate the strain components.

Exercise 3: Given the displacements

$$u = 3\ x^2\ y\ ,\ v = y^2 + 6\ xz\ ,\ w = 6z^2 + 2\ yz\ ,$$

calculate the strain components at the point (1 , 0 , 2). What is the extension of a line element (parallel to the x – axis) at this point ?

Exercise 4: Find the strain components and rotation components for the small displacement components given below

(a) Uniform dilatation – $u = e\ x\ ,\ v = e\ y\ ,\ w = e\ z\ ,$

(b) Simple extension - $u = e\ x\ ,\ v = w = 0\ ,$

(c) Shearing strain - $u = 2\ sy\ ,\ v = w = 0\ ,$

(d) Plane strain - $u = u(x\ ,\ y)\ ,\ v = v(x\ ,\ y)\ ,\ w = 0.$

3.13 SAINT-VENANT'S EQUATIONS OF COMPATIBILITY

By definition , the strain components e_{ij} in terms of displacement components u_i are given by

$$\mathbf{e_{ij} = \frac{1}{2}\,[u_{i,j} + u_{j,i}]} \qquad (1)$$

Equation (1) is used to find the components of strain if the components of displacement are given. However , if the components of strain , e_{ij} , are given then equation (1) is a set of 6 partial differential equations in the three unknowns u_1 , u_2 , u_3. Therefore , the **system (1) will not have a single – valued solution for u_i unless given strains e_{ij} satisfy certain conditions which are known as the conditions of compatibility or equations of compatibility.**

Geometrical meaning of Conditions of Compatibility

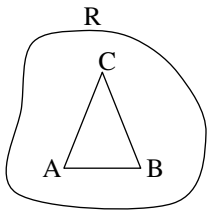
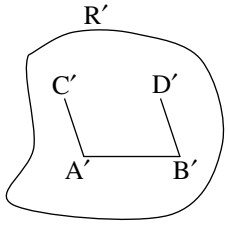


fig 1



fig(2a)

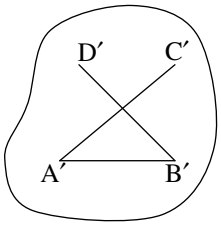


fig (2b)

Fig (1) shows a portion of the material of the body in the undeformed state in the form of a continuous triangle ABC. If we deform the body by an arbitrarily specified strain field then we might end up at the points C′ and D′ with a gap between them , after deformation , as shown in fig(2a) or with overlapping material as shown in fig(2b).

For a single valued continuous solution to exist the points C′ and D′ must be the same in the strained state. This cannot be guaranteed unless the specified strain components satisfy certain conditions , known as the conditions (or relations or equations) of compatibility.

Equations of Compatibility

We have $$e_{ij} = \frac{1}{2}(u_{i,j} + u_{j,i}) . \qquad (1)$$

So , $$e_{ij,kl} = \frac{1}{2}(u_{i,jkl} + u_{j,ikl}) \quad . \qquad (2)$$

Interchanging i with k and j with *l* in equation (2) , we write

$$e_{kl,ij} = \frac{1}{2}(u_{k,lij} + u_{l,kij}) \quad . \qquad (3)$$

Adding (2) and (3) , we get

$$e_{ij,kl} + e_{kl,ij} = \frac{1}{2}[u_{i,jkl} + u_{j,ikl} + u_{k,lij} + u_{l,kij}] . \qquad (4)$$

Interchanging i and *l* in (4) , we get

$$e_{lj,ki} + e_{ki,lj} = \frac{1}{2}[u_{l,jki} + u_{j,lki} + u_{k,lij} + u_{i,ljk}] . \qquad (5)$$

From (4) and (5) , we obtain

$$e_{ij,kl} + e_{kl,ij} = e_{lj,ki} + e_{ki,lj} ,$$

or $$e_{ij,kl} + e_{kl,ij} - e_{ik,jl} - e_{jl,ik} = 0 . \qquad (6)$$

These equations are known as equations of compatibility.

These equations are **necessary conditions** for the existence of a single valued continuous displacement field. These are 81 equations in number. Because of symmetry in indicies i , j, and k , *l*; some of these equations are identically satisfied and some are repetitions.

Only 6 out of these 81 equations are essential. These equations were first obtained by **Saint – Venant in 1860**.

A strain tensor e_{ij} that satisfies these conditions is referred to as a possible strain tensor.

Show that the conditions of compatibility are sufficient for the existence of a single valued continuous displacement field.

Let $P°(x_i°)$ be some point of a simply connected region at which the displacements $u_i°$ and rotations $w_{ij}°$ are known. The displacements u_i of an arbitrary point $P'(x_i')$ can be obtained in terms of the known functions e_{ij} by means of a line integral along a continuous curve C joining the points P_o and P'.

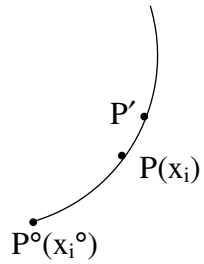


Fig. (3.18)

$$u_j(x_1', x_2', x_3') = u_j°(x_1°, x_2°, x_3°) + \int_{P^o}^{P'} du_j \quad . \qquad (7)$$

If the process of deformation does not create cracks or holes , i.e. , if the body remains continuous , the displacements u_j' should be independent of the path of integration.

That is , u_j' should have the same value regardless of whether the integration is along curve C or any other curve. We write

$$du_j = \frac{\partial u_j}{\partial x_k}\, dx_k = u_{j,k}\, dx_k = (e_{jk} + w_{jk})\, dx_k \, . \qquad (8)$$

Therefore ,

$$u_j' = u_j° + \int_{P^o}^{P'} e_{jk}\, dx_k + \int_{P^o}^{P'} w_{jk}\, dx_k \, , \quad (P(x_k) \text{ being point the joining curve}).$$

(9)

Integrating by parts the second integral , we write

$$\int_{P^o}^{P'} w_{jk}\, dx_k = \int_{P^o}^{P'} w_{jk}\, d(x_k - x_k') \qquad \text{(The point P}'(x_k') \text{ being fixed so } dx_k'=0)$$

$$= \{(x_k - x_k')\, w_{jk}\}_{P^o}^{P'} - \int_{P^o}^{P'} (x_k - x_k')\, w_{jk,l}\, dx_l$$

$$= (x_k' - x_k^o) w_{jk}^o + \int_{P^o}^{P'} (x_k' - x_k)\, w_{jk,l}\, dx_l \quad . \qquad (10)$$

From equations (9) and (10) , we write

$$u_j(x_1', x_2', x_3') = u_j^o + (x_k' - x_k^o) w_{jk}^o + \int_{P^o}^{P'} e_{jk}\, dx_k + \int_{P^o}^{P'} (x_k' - x_k)\, w_{jk,l}\, dx_l$$

$$= u_j^o + (x_k' - x_k^o)\, w_{jk}^o + \int_{P^o}^{P'} [e_{jl} + (x_k' - x_k)\, w_{jk,l}]\, dx_l \ , \qquad (11)$$

where the dummy index k of e_{jk} has been changed to *l*.

But $$w_{jk,l} = \frac{1}{2} \frac{\partial}{\partial x_l} [u_{j,k} - u_{k,j}]$$

$$= \frac{1}{2} [u_{j,kl} - u_{k,jl}]$$

$$= \frac{1}{2} [u_{j,kl} + u_{l,jk}] - \frac{1}{2} [u_{l,jk} + u_{k,jl}]$$

$$= e_{jl,k} - e_{lk,j} \qquad (12)$$

Using (12) , equation (11) becomes

$$u_j(x_1', x_2', x_3') = u_j^o + (x_k' - x_k^o)\, w_{jk}^o + \int_{P^o}^{P'} [e_{jl} + \{x_k' - x_k\}\, \{e_{jl,k} - e_{kl,j}\}]\, dx_l$$

$$= u_j^o + (x_k' - x_k^o)\, w_{jk}^o + \int_{P^o}^{P'} U_{jl}\, dx_l \quad , \qquad (13)$$

where for convenience we have set

$$U_{jl} = e_{jl} + (x_k' - x_k)\, (e_{jl,k} - e_{kl,j}) \ , \qquad (14)$$

which is a known function as e_{ij} are known.

The first two terms in the right side of equation (13) are independent of the path of integration. From the theory of line integrals, the third term become independent of the path of integration when the integrands $U_{jl}\, dx_l$ must be exact differentials.

Therefore , if the displacements $u_i(x_1' , x_2' , x_3')$ are to be independent of the path of integration , we must have

$$\frac{\partial U_{jl}}{\partial x_l} = \frac{\partial U_{ji}}{\partial x_l} \ , \qquad \text{for i , j , } l = 1 , 2 , 3. \tag{15}$$

Now

$$U_{jl,i} = e_{jl,i} + (x_k' - x_k)\,(e_{jl,ki} - e_{kl,ji}) - \delta_{ki}\,(e_{jl,k} - e_{kl,j})$$

$$= e_{jl,i} - e_{jl,i} + e_{il,j} + (x_k' - x_k)\,(e_{jl,ki} - e_{kl,ji}) \ , \tag{16a}$$

and

$$U_{ji,l} = e_{ji,l} + (x_k' - x_k)\,(e_{ji,kl} - e_{ki,jl}) - \delta_{kl}(e_{ji,k} - e_{ki,j})$$

$$= e_{ji,l} - e_{ji,l} + e_{li,j} + (x_k' - x_k)\,(e_{ji,kl} - e_{ki,jl}) \ . \tag{16b}$$

Therefore , equations (15) and (16 a , b) yields

$$(x_k' - x_k)\,[e_{jl,ki} - e_{kl,ji} - e_{ji,kl} + e_{ki,jl}] = 0 \ .$$

Since this is true for an arbitrary choice of $x_k' - x_k$ (as P′ is arbitrary) , it follows that

$$e_{ij,kl} + e_{kl,ij} - e_{ik,jl} - e_{jl,ki} = 0 \ , \tag{17}$$

which is true as these are the compatibility relations.

Hence , the displacement (7) independent of the path of Integration. Thus , the compatibility conditions (6) are sufficient also.

Remark 1: The compatibility conditions (6) are necessary and sufficient **for the existence of a single valued continuous displacement field** when the strain components are prescribed.

In detailed form , these 6 conditions are

$$\frac{\partial^2 e_{11}}{\partial x_2 \partial x_3} = \frac{\partial}{\partial x_1}\left(\frac{-\partial e_{23}}{\partial x_1} + \frac{\partial e_{31}}{\partial x_2} + \frac{\partial e_{12}}{\partial x_3} \right) ,$$

$$\frac{\partial^2 e_{22}}{\partial x_3 \partial x_1} = \frac{\partial}{\partial x_2}\left(\frac{-\partial e_{31}}{\partial x_2} + \frac{\partial e_{12}}{\partial x_3} + \frac{\partial e_{23}}{\partial x_1}\right),$$

$$\frac{\partial^2 e_{33}}{\partial x_1 \partial x_2} = \frac{\partial}{\partial x_3}\left(\frac{-\partial e_{12}}{\partial x_3} + \frac{\partial e_{23}}{\partial x_1} + \frac{\partial e_{31}}{\partial x_2}\right),$$

$$\frac{2\partial^2 e_{12}}{\partial x_1 \partial x_2} = \frac{\partial^2 e_{11}}{\partial x_2^{\,2}} + \frac{\partial^2 e_{22}}{\partial x_1^{\,2}},$$

$$\frac{2\partial^2 e_{23}}{\partial x_2 \partial x_3} = \frac{\partial^2 e_{22}}{\partial x_3^{\,2}} + \frac{\partial^2 e_{33}}{\partial x_2^{\,2}},$$

$$\frac{2\partial^2 e_{31}}{\partial x_3 \partial x_1} = \frac{\partial^2 e_{33}}{\partial x_1^{\,2}} + \frac{\partial^2 e_{11}}{\partial x_3^{\,2}}.$$

These are the necessary and sufficient conditions for the strain components e_{ij} to give single valued displacements u_i for a simply connected region.

Definition : A region space is said to be **simply connected** if an arbitrary closed curve lying in the region can be **shrunk to a point** , **by continuous deformation , without passing outside of the boundaries.**

Remark 2: The specification of the strains e_{ij} only does not determine the displacements u_i uniquely because the strains e_{ij} characterize only the pure deformation of an elastic medium in the neighbourhood of the point x_i.

The displacements u_i may involve rigid body motions which do not affect e_{ij}.

Example 1 : (i) Find the compatibility condition for the strain tensor e_{ij} if e_{11} , e_{22} , e_{12} are independent of x_3 and $e_{31} = e_{32} = e_{33} = 0$.

(ii) Find the condition under which the following are possible strain components.

$$e_{11} = k(x_1^{\,2} - x_2^{\,2}) \text{ , } e_{12} = k' x_1 x_2 \text{ , } e_{22} = k x_1 x_2 \text{ ,}$$

$$e_{31} = e_{32} = e_{33} = 0 \text{ , } k \text{ \& } k' \text{ are constants}$$

(iii) when e_{ij} given above are possible strain components , find the corresponding displacements , given that $u_3 = 0$.

Solution : (i) We verify that all the compatibility conditions except one are obviously satisfied. The only compatibility condition to be satisfied by e_{ij} is

$$e_{11,22} + e_{22,11} = 2\, e_{12,12} \,. \qquad (1)$$

(ii) Five conditions are trivially satisfied. The remaining condition (1) is satisfied iff

$$k' = k$$

as $e_{11\,22} = -2k$, $e_{12,12} = k'$, $e_{22,11} = 0$.

(iii) We find

$e_{11} = u_{1,1} = k(x_1^2 - x_2^2)$, $u_{2,2} = k\ x_1\ x_2$, $u_{1,2} + u_{2,1} = -2k\ x_1\ x_2$, ($\Theta\ k' = -k$)

$$u_{2,3} = u_{1,3} = 0.$$

This shows that the displacement components u_1 and u_2 are independent of x_3. We find (exercise)

$$u_1 = \frac{1}{6}(2x_1^3 - 6x_1\ x_2^2 + x_2^3) - c\ x_2 + c_1\ ,$$

$$u_2 = \frac{1}{2}k\ x_1\ x_2^2 + c\ x_1 + c_2\ ,$$

where c_1 , c_2 and c are constants.

Example 2: Show that the following are not possible strain components

$$e_{11} = k(x_1^2 + x_2^2)\ ,\ e_{22} = k(x_2^2 + x_3^2)\ ,\ e_{33} = 0\ ,$$

$$e_{12} = k'\ x_1\ x_2\ x_3\ ,\ e_{13} = e_{23} = 0\ ,\ k\ \&\ k' \text{ being constants.}$$

Solution : The given components e_{ij} are possible strain components if each of the six compatibility conditions is satisfied. On substitution , we find

$$2k = 2k'\ x_3.$$

This can't be satisfied for $x_3 \neq 0$.

For $x_3 = 0$, this gives $k = 0$ and then all e_{ij} vanish.

Hence , the given e_{ij} are not possible strain components.

Exercise 1: Consider a linear strain field associated with a simply connected region R such that $e_{11} = A\ x_2^2$, $e_{22} = A\ x_1^2$, $e_{12}\ B\ x_1\ x_2$, $e_{13} = e_{23} = e_{33} = 0$. Find the relationship between constant A and B such that it is possible to obtain a single – valued continuous displacement field which corresponds to the given strain field.

Exercise 2: Show by differentiation of the strain displacement relations that the compatibility conditions are necessary conditions for the existence of continuous single – valued displacements.

Exercise 3: Is the following state of strain possible ? (c = constant)

$e_{11} = c(x_1^2 + x_2^2)\, x_3$, $e_{22} = c\, x_2^2\, x_3$, $e_{12} = 2c\, x_1\, x_2\, x_3$, $e_{31} = e_{32} = e_{33} = 0$.

Exercise 4: Show that the equations of compatibility represents a set of necessary and sufficient conditions for the existence of single – valued displacements. Derive the equations of compatibility for plane strain.

Exercise 5: If $e_{11} = e_{22} = e_{12} = e_{33} = 0$, $e_{13} = \phi_{,2}$ and $e_{23} = \phi_{,1}$; where ϕ is a function of x_1 and x_2 , show that ϕ must satisfy the equation

$$\nabla^2 \phi = \text{constant}$$

Exercise 6: If e_{13} and e_{23} are the only non – zero strain components and e_{13} and e_{23} are independent of x_3 , show that the compatibility conditions may be reduced to the following single condition

$$e_{13,2} - e_{23,1} = \text{constant}.$$

Exercise 7: Find which of the following values of e_{ij} are possible linear strains.

(i) $e_{11} = \alpha(x_1^2 + x_2^2)$, $e_{22} = \alpha x_2^2$, $e_{12} = 2\alpha\, x_1\, x_2$, $e_{31} = e_{32} = e_{33} = 0$, α = constant.

(ii) $$(e_{ij}) = \begin{bmatrix} x_1 + x_2 & x_1 & x_2 \\ x_1 & x_2 + x_3 & x_3 \\ x_2 & x_3 & x_1 + x_3 \end{bmatrix}$$

compute the displacements in the case (i).

3.14 FINITE DEFORMATIONS

All the results reported in the preceding sections of this chapter were that of the classical theory of infinitesimal strains. Infinitesimal transformations permits the application of the principle of superposition of effects.

Finite deformations are those deformations in which the displacements u_i together with their derivatives are no longer small.

Consider an aggregate of particles in a continuous medium. We shall use the same reference frame for the location of particles in the deformed and undeformed states.

Let the coordinates of a particle lying on a curve C_o , before deformation , be denoted by (a_1 , a_2 , a_3), and let the coordinates of the same particle after deformation (now lying on some curve C) be (x_1 , x_2 , x_3).

Then the elements of arc of the curve C_o and C are given , respectively , by

$$d s_o^2 = d a_i \, d a_i , \tag{1}$$

and

$$ds^2 = d x_i \, d x_i. \tag{2}$$

We consider first the Eulerian description of the strain and write

$$a_i = a_i (x_1 , x_2 , x_3). \tag{3}$$

Then

$$da_i = a_{i,j} \, d x_j = a_{i,k} \, dx_k . \tag{4}$$

Substituting from (4) into (1) , we write

$$ds_o^2 = a_{i,j} \, a_{i,k} \, dx_j \, dx_k . \tag{5}$$

Using the substitution tensor , equation (2) can be rewritten as

$$d s^2 = \delta_{jk} \, dx_j \, dx_k . \tag{6}$$

we know that the measure of the strain is the difference $ds^2 - ds_o^2$.

From equations (5) and (6) , we get

$$\begin{aligned} ds^2 - ds_o^2 &= (\delta_{jk} - a_{i,j} \, a_{i,k}) \, dx_j \, dx_k \\ &= 2\eta_{jk} \, dx_j \, dx_k , \end{aligned} \tag{7}$$

where

$$2\eta_{jk} = \delta_{jk} - a_{i,j} \, a_{i,k}. \tag{8}$$

We now write the strain components η_{jk} in terms of the displacement components u_i , where

$$u_i = x_i - a_i. \tag{9}$$

This gives

$$a_i = x_i - u_i.$$

Hence

$$a_{i,j} = \delta_{ij} - u_{i,j} , \tag{10}$$

$$a_{i,k} = \delta_{ik} - u_{i,k} . \tag{11}$$

Equations (8) , (10) and (11) yield

$$\begin{aligned} 2\eta_{jk} &= \delta_{jk} - (\delta_{ij} - u_{i,j})\,(\delta_{ik} - u_{i,k}) \\ &= \delta_{jk} - [\delta_{jk} - u_{k,j} - u_{j,k} + u_{i,j}\,u_{i,k}] \\ &= (u_{j,k} + u_{k,j}) - u_{i,j}\,u_{i,k}. \end{aligned} \tag{12}$$

The quantities η_{jk} are called the Eulerian strain components.

If , on the other hand , Lagrangian coordinates are used , and equations of transformation are of the form

$$x_i = x_i\,(a_1 , a_2 , a_3) , \tag{13}$$

then

$$dx_i = x_{i,j}\,da_i = x_{i,k}\,da_k , \tag{14}$$

and

$$ds^2 = x_{i,j}\,x_{i,k}\,da_j\,da_k , \tag{15}$$

while

$$ds_o{}^2 = \delta_{jk}\,da_j\,da_k. \tag{16}$$

The Lagrangian components of strain $\in_{jk}$ are defined by

$$ds^2 - ds_o{}^2 = 2\in_{jk}\,da_j\,da_k . \tag{17}$$

Since

$$x_i = a_i + u_i , \tag{18}$$

therefore ,

$$x_{i,j} = \delta_{ij} + u_{i,j} \ ,$$

$$x_{i,k} = \delta_{ik} + u_{i,k} .$$

Now

$$ds^2 - ds_o^2 = (x_{i,j}\, x_{i,k} - \delta_{jk})\, da_j\, da_k$$

$$= [(\delta_{ij} + u_{i,j})\,(\delta_{ik} + u_{i,k}) - \delta_{jk}]\, da_j\, da_{k=}$$

$$= (u_{j,k} + u_{k,j} + u_{i,j}\, u_{i,k})\, da_j\, da_k. \qquad (19)$$

Equations (17) and (19) give

$$2\in_{jk} = u_{j,k} + u_{k,j} + u_{i,j}\, u_{i,k}. \qquad (20)$$

It is mentioned here that the differentiation in (12) is carried out with respect to the variables x_i , while in (20) the a_i are regarded as the independent variables.

To make the difference explicitly clear , we write out the typical expressions η_{jk} and $\in_{jk}$ in unabridged notation,

$$\eta_{xx} = \frac{\partial u}{\partial x} - \frac{1}{2}\left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial x}\right)^2 + \left(\frac{\partial w}{\partial x}\right)^2\right]. \qquad (21)$$

$$2\eta_{xy} = \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right) - \left(\frac{\partial u}{\partial x}\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\frac{\partial v}{\partial y} + \frac{\partial w}{\partial x}\frac{\partial w}{\partial y}\right), \qquad (22)$$

$$\in_{xx} = \frac{\partial u}{\partial a} + \frac{1}{2}\left[\left(\frac{\partial u}{\partial a}\right)^2 + \left(\frac{\partial v}{\partial b}\right)^2 + \left(\frac{\partial w}{\partial a}\right)^2\right], \qquad (23)$$

$$2\in_{xy} = \left(\frac{\partial u}{\partial b} + \frac{\partial v}{\partial a}\right) + \left(\frac{\partial u}{\partial a}\frac{\partial u}{\partial b} + \frac{\partial v}{\partial a}\frac{\partial v}{\partial b} + \frac{\partial w}{\partial a}\frac{\partial w}{\partial b}\right). \qquad (24)$$

When the strain components are large , it is no longer possible to give simple geometrical interpretations of the strains $\in_{jk}$ and η_{jk}.

Now , we consider some particular cases.

Case I: Consider a line element with

$$ds_o = d\, a_1 \text{ , } d\, a_2 = 0 \text{ , } d\, a_3 = 0 \text{ .} \qquad (25)$$

Define the extension E_1 of this element by

$$E_1 = \frac{ds - ds_o}{ds_o}.$$

Then

$$ds = (1 + E_1)\, ds_o \text{ ,} \qquad (26)$$

and consequently

$$ds^2 - ds_o^2 = 2 \in_{jk} d\, a_j\, d\, a_k$$

$$= 2 \in_{11} d\, a_j^2 . \qquad (27)$$

Equations (25) to (27) yield

$$(1 + E_1)^2 - 1 = 2 \in_{11}$$

or

$$E_1 = \sqrt{1 + 2 \in_{11}} - 1 . \qquad (28)$$

When the strain $\in_{11}$ is small , (28) reduces to

$$E_1 \cong \in_{11} ,$$

as was shown in the discussion of infinitesimal strains.

Case II: Consider next two line elements

$$ds_o = da_2 , da_1 = 0 , da_3 = 0 , \qquad (29)$$

and

$$d\bar{s}_o = d\ \bar{a}_3 , d\ \bar{a}_1 = d\ \bar{a}_2 = 0. \qquad (30)$$

These two elements lie initially along the a_2 – and a_3- axes.

Let θ denote the angle between the corresponding deformed elements dx_i and $d\bar{x}_i$, of lengths ds and $d\bar{s}$, respectively. Then

$$ds\ \ d\bar{s}\ \cos\theta = dx_i\ d\bar{x}_i$$

$$= x_{i,\alpha}\ \ \bar{x}_{i,\beta}\, da_\alpha\ d\bar{a}_\beta$$

$$= x_{i,2}\ \ \bar{x}_{i,3}\, da_2\ d\bar{a}_3$$

$$= 2 \in_{23} da_2\ d\bar{a}_3 . \qquad (31)$$

Let

$$\alpha_{23} = \frac{\pi}{2} - \theta , \qquad (32)$$

denotes the change in the right angle between the line elements in the initial state. Then , we have

$$\sin \alpha_{23} = 2 \in_{23} \left(\frac{da_2}{ds} \right) \left(\frac{d\bar{a}_3}{d\bar{s}} \right). \tag{33}$$

$$= \frac{2 \in_{23}}{\sqrt{1+2 \in_{22}} \sqrt{1+2 \in_{33}}} \ , \tag{34}$$

using relations in (26) and (28).

Again , if the strains $\in_{ij}$ are so small that their products can be neglected , then

$$\alpha_{23} \cong 2 \in_{23} , \tag{35}$$

as proved earlier for infinitesimal strains.

Remark: If the displacements and their derivatives are small , then it is immaterial whether the derivatives of the displacements are calculated at the position of a point before or after deformation. In this case , we may neglect the nonlinear terms in the partial derivatives in (12) and (20) and reduce both sets of formulas to

$$2\eta_{jk} = u_{j,k} + u_{k,j} = 2 \in_{jk} ,$$

which were obtained for an infinitesimal transformation.

It should be emphasized that the transformations of finite homogeneous strain are not in general commutative and that the simple superposition of effects is no longer applicable to finite deformation.

Chapter-4

Constitutive Equations of Linear Elasticity

4.1. INTRODUCTION

It is a fact of experience that deformation of a solid body induces stresses within. The relationship between stress and deformation is expressed as a constitutive relation for the material and depends on the material properties and also on other physical observables like temperative and , perhaps , the electromagnetic field.

An elastic deformation is defined to be one in which the stress is determined by the current value of the strain only , and not on rate of strain or strain history : $\tau = \tau(e)$.

An elastic solid that undergoes only an **infinitesimal** deformation and for which the governing material is **linear** is called **a linear elastic solid or Hookean solid**.

From experimental observations , it is known that , under normal loadings , many structural materials such as metals , concrete , wood and rocks behave as linear elastic solids.

The classical theory of elasticity (or linear theory) serves as an excellent model for studying the mechanical behaviour of a wide variety of such solid materials.

Hook's law : In 1678 , Robert Hook , on experimental grounds , stated that the extension is proportional to the force. Cauchy in 1822 generalized Hook law for the deformation of elastic solids. According to Cauchy , " Each component of stress at any point of an elastic body is a linear function of the components of strain at the point".

This law is now known as **Generalized Hooke's Law.** Here , linearity means that stress – strain relations are linear.

4.2. GENERALIZED HOOKE'S LAW

In general , we write the following set of linear relations

$$\tau_{11} = c_{1111}\, e_{11} + c_{1112}\, e_{12} + \ldots\ldots\ldots + c_{1133}\, e_{33} \quad ,$$

$$\tau_{12} = c_{1211}\, e_{11} + c_{1212}\, e_{12} + \ldots\ldots\ldots + c_{1233}\, e_{33} \quad ,$$

$$\tau_{33} = c_{3311}\, e_{11} + c_{3312}\, e_{12} + \ldots\ldots\ldots + c_{3333}\, e_{33} \quad ,$$

or

$$\tau_{ij} = c_{ijkl}\, e_{kl} \quad , \qquad (1)$$

where τ_{ij} is the stress tensor and e_{kl} is the strain tensor. The coefficients , which are $81 = 3^4$ in number , are called elastic moduli.

In general , these coefficients depend on the physical properties of the medium and are independent of the strain components e_{ij}.

We suppose that relations (1) hold at every point of the medium and at every instant of time and are solvable for e_{ij} in terms of τ_{ij}.

From (1) , it follows that τ_{ij} are all zero whenever all e_{ij} are 0.

It means that in the initial unstrained state the body is unstressed. From quotient law for tensors , relation (1) shows that c_{ijkl} are components of a fourth – order tensor.

This tensor is called **elasticity tensor.** Since e_{ij} are dimensionless quantities , it follows that elastic moduli c_{ijkl} have the same dimensions as the stresses (force/Area).

If , however , c_{ijkl} do not change throughout the medium for all time , we say that the **medium is (elastically) homogeneous**.

Thus , for a homogeneous elastic solid , the elastic moduli are constants so that the mechanical properties remain the same throughout the solid for all times. The tensor equation (1) represents the generalized Hooke's law in the x_i – system.

Since τ_{ij} is symmetric and e_{kl} is symmetric , there are left 6 independent equations in relation (1) and each equation contains 6 independent elastic moduli.

So, the number of independent elastic coefficients are , in fact , 36 for a generalized an anisotropic medium.

For simplicity , we introduce the following (engineering) notations

$$\left.\begin{aligned} &\tau_{11} = \tau_1 \,,\ \tau_{22} = \tau_2 \,,\ \tau_{33} = \tau_3 \,,\ \tau_{23} = \tau_4 \,,\ \tau_{31} = \tau_5 \,,\ \tau_{12} = \tau_6 \quad , \\ &e_{11} = e_1 \,,\ e_{22} = e_2 \,,\ e_{33} = e_3 \,,\ 2e_{23} = e_4 \,,\ 2e_{31} = e_5 \,,\ 2e_{12} = e_6 \,. \end{aligned}\right\} \qquad (2)$$

Then , the generalized Hooke's law may be written in the form

$$\tau_i = c_{ij}\, e_j \qquad ; \qquad i \,, j = 1 \,, 2 \,, \ldots\ldots \,, 6 \,, \qquad (3)$$

or in the matrix form

$$\begin{bmatrix} \tau_1 \\ \tau_2 \\ \tau_3 \\ \tau_4 \\ \tau_5 \\ \tau_6 \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \ldots\ldots\ldots\ldots & c_{16} \\ c_{21} & c_{22} \ldots\ldots\ldots\ldots & c_{26} \\ c_{31} \ldots\ldots\ldots\ldots\ldots\ldots & & \\ c_{41} \ldots\ldots\ldots\ldots\ldots\ldots & & \\ c_{51} \ldots\ldots\ldots\ldots\ldots\ldots & & \\ c_{61} & c_{62} \ldots\ldots\ldots\ldots & c_{66} \end{bmatrix} \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ e_4 \\ e_5 \\ e_6 \end{bmatrix} . \qquad (4)$$

If the elastic properties (or mechanical properties) of a medium at a point are independent of the orientation (i.e. $c'_{ij} = c_{ij}$) of the coordinate axes , then we say that the medium under consideration is isotropic.

If at a point of the medium , properties of medium (i.e. , c_{ij}'s) depend upon the orientation , then medium is called an **Anisotropic** or **Aelotropic** medium.

The 6×6 matrix (c_{ij}) in (4) is called **stiffness matrix.**

4.3. HOMOGENEOUS ISOTROPIC MEDIA

When the elastic coefficients c_{ijkl} in the generalized Hooke's law are constants throughout the medium and they are independent of the orientation of the coordinate axes , the elastic media is termed as homogeneous isotropic media.

We know that the generalized Hooke's law is

$$\tau_{ij} = c_{ijkl}\, e_{kl} \qquad (1)$$

where τ_{ij} and e_{kl} are symmetric strain and stress tensor , respectively , and c_{ijkl} are the components of a tensor of order 4.

Since the media is isotropic , therefore , the tensor c_{ijkl} is an isotropic tensor. Hence , it can be represented in the form

$$c_{ijkl} = \alpha\, \delta_{ij}\, \delta_{kl} + \beta\, \delta_{ik}\, \delta_{jl} + \gamma\, \delta_{il}\, \delta_{jk} \qquad (2)$$

where α , β , γ are some scalars. From equations (1) and (2) , we obtain

$$\begin{aligned} \tau_{ij} &= (\alpha\, \delta_{ij}\, \delta_{kl} + \beta\, \delta_{ik}\, \delta_{jl} + \gamma\, \delta_{il}\, \delta_{jk})\, e_{kl} \\ &= \alpha\, \delta_{ij}\, e_{kk} + \beta\, \delta_{ik}\, e_{kj} + \gamma\, \delta_{il}\, e_{jl} \\ &= \alpha\, \delta_{ij}\, e_{kk} + \beta e_{ij} + \gamma\, e_{ji} \\ &= \alpha\, \delta_{ij}\, e_{kk} + (\beta + \gamma)\, e_{ij} \quad , \end{aligned} \qquad (3)$$

since $e_{ij} = e_{ji}$. On redesignating α by λ and $(\beta + \gamma)$ by 2μ , relation (3) yields

$$\tau_{ij} = \lambda\, \delta_{ij}\, e_{kk} + 2\mu\, e_{ij} \quad . \tag{4}$$

The two elastic coefficients λ and μ are known as Lame constants. δ_{ij} is the substitution tensor.

Let

$$v = e_{kk} \, , \; \theta = \tau_{ii} \, . \tag{5}$$

Taking j = i in (4) and using summation convention according , we find

$$\begin{aligned} \theta &= 3\lambda\, v + 2\, \mu\, v \\ &= (3\, \lambda + 2\, \mu)\, v \\ &= 3\, k\, v \, , \end{aligned} \tag{6}$$

where

$$k = \lambda + \frac{2}{3}\, \mu \, , \tag{7}$$

is the bulk modulus.

From (4) , we write

$$\begin{aligned} e_{ij} &= \frac{\lambda}{2\mu}\, \delta_{ij}\, v + \frac{1}{2\mu}\, \tau_{ij} \\ &= \frac{-\lambda}{2\mu(3\lambda + 2\mu)}\, \delta_{ij}\, \tau_{kk} + \frac{1}{2\mu}\, \tau_{ij} \, . \end{aligned} \tag{8}$$

This relation expresses the strain components as a linear functions of components of stress tensor.

Question : Show that if the medium is isotropic , the principal axes of stress are coincident with the principal axes of strain.

Solution : Let the x_i-axes be directed along the principal axes of strain.

Then

$$e_{12} = e_{13} = e_{23} = 0. \tag{1}$$

The stress – strain relations for an isotropic medium are

$$\tau_{ij} = \lambda\, \delta_{ij}\, e_{kk} + 2\, \mu\, e_{ij} \quad . \tag{2}$$

Combining (1) & (2) , we find

$$\tau_{12} = \tau_{13} = \tau_{23} = 0 \ . \qquad (3)$$

This shows that the coordinates axes x_i are also the principal axes of stress.

This proves the result. Thus, there is no distinction between the principal axes of stress and of strain for isotropic media.

4.4. PHYSICAL MEANINGS OF ELASTIC MODULI FOR AN ISOTROPIC MEDIUM

We have already introduced two elastic moduli λ and μ in the generalized Hooke's law for an isotropic medium. We introduce three more elastic moduli defined below

$$E = \frac{\mu(3\lambda + 2\mu)}{\lambda + \mu} \ , \qquad \sigma = \frac{\lambda}{2(\lambda + \mu)} \ , \quad k = \lambda + \frac{2}{3}\mu \ . \qquad (1)$$

The quantity σ is dimensionless and is called the **Poisson ratio**. It was introduced by Simon D. Poisson in 1829.

The quantity E is called **Young's modulus** after Thomas Young who introduced it in the early 19th century , probably in 1807. Its dimension is that of a stress (force/area).

The elastic modulus k is called the modulus of compression or the bulk modulus.

Solving the first two equations for λ and μ (in terms σ and E) , we find

$$\lambda = \frac{E\sigma}{(1+\sigma)(1-2\sigma)} \ , \qquad \mu = \frac{E}{2(1+\sigma)} \ . \qquad (2)$$

From (2) , we find the following relations

$$\left.\begin{aligned} \lambda + 2\mu &= \frac{E(1-\sigma)}{(1+\sigma)(1-2\sigma)} \ , \ \frac{\lambda+\mu}{\mu} = \frac{1}{1-2\sigma} \ , \\ \frac{\lambda+2\mu}{\mu} &= \frac{2(1-\sigma)}{1-2\sigma} \ , \ \frac{\lambda}{\lambda+2\mu} = \frac{\sigma}{1-\sigma} \ . \end{aligned}\right\} \qquad (3)$$

Generalized Hooke's Law in terms of Elastic Moduli σ and E

We know that the generalized Hooke's law (giving strain components in terms of stresses) in terms of Lame's constants λ and μ is

$$e_{ij} = \frac{-\lambda}{2\mu(3\lambda + 2\mu)} \delta_{ij} \tau_{kk} + \frac{1}{2\mu} \tau_{ij} \quad . \qquad (4)$$

Substituting the values of λ and μ in terms of E and σ from (2) into (4) , we find

$$e_{ij} = \frac{-\sigma}{E} \delta_{ij} \tau_{kk} + \frac{1+\sigma}{E} \tau_{ij} \quad . \qquad (5)$$

Note : (1) Out of five elastic moduli (namely ; λ , μ , E , σ , k) only two are independent.

Note : (2) The Hooke's law , given in (5) , is frequently used in engineering problems.

Remark : The following three experiments give some insight into the physical significance of various elastic moduli for isotropic media.

(I) Simple Tension :

Consider a right cylinder with its axis parallel to the x_1 – axis which is subjected to longitudinal forces applied to the ends of the cylinder. These applied forces give rise to a uniform tension T in every cross – section of the cylinder so that the stress tensor τ_{ij} has only one non – zero component $\tau_{11} = T$. That is

$$\tau_{11} = T \ , \ \tau_{22} = \tau_{33} = \tau_{12} = \tau_{23} = \tau_{31} = 0 \quad . \qquad (1)$$

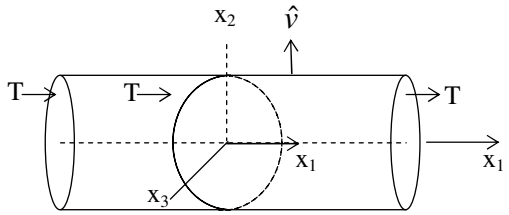


Fig. (4.1)

Since the body forces are absent ($f_i = 0$) , the state of stress given by (1) satisfies the equilibrium equation $\tau_{ij,j} = 0$ in the interior of the cylinder.

A normal $\hat{v}$ to the lateral surface lies in the plane parallel to x_2 x_3 plane , so $\hat{v} = (0 , v_2 , v_3)$.

The relation $\overset{v}{T}_i = \tau_{ij} v_j$ implies that $\overset{v}{T}_1 = \overset{v}{T}_2 = \overset{v}{T}_3 = 0$.

Hence $\underset{\sim}{\overset{v}{T}} = 0.$

This shows that the lateral surface of the cylinder is free from tractions.

The generalized Hooke's law giving strains in terms of stresses is

$$e_{ij} = \frac{-\lambda}{2\mu(3\lambda+2\mu)}\,\delta_{ij}\,\tau_{kk} + \frac{1}{2\mu}\,\tau_{ij} \quad . \tag{2}$$

We find from equations (1) & (2) that

$$e_{11} = \frac{\lambda+\mu}{\mu(3\lambda+2\mu)}\,T \quad ,$$

$$e_{22} = e_{33} = \frac{-\lambda}{2\mu(3\lambda+2\mu)}\,T \quad ,$$

$$e_{12} = e_{23} = e_{31} = 0 \quad . \tag{3}$$

Since $\dfrac{\lambda+\mu}{\mu(3\lambda+2\mu)} = \dfrac{1}{E}$ and $\dfrac{\sigma}{E} = \dfrac{\lambda}{2\mu(3\lambda+2\mu)}$, (4)

Therefore

$$\left.\begin{aligned} e_{11} &= \frac{T}{E}\ , \\ e_{22} = e_{33} &= -\frac{\sigma}{E}\,T = -\sigma\, e_{11} \quad , \\ \text{and} \qquad e_{12} &= e_{13} = e_{23} = 0 \quad . \end{aligned}\right\} \tag{5}$$

These strain components obviously satisfies the compatibility equations

$$e_{ij,kl} + e_{kl,ij} - e_{ik,jl} - e_{jl,ik} = 0 \ ,$$

and therefore , the state of stress given in (1) actually corresponds to one which can exist in a deformed elastic body. From equation (5) , we write

$$\frac{\tau_{11}}{e_{11}} = E \quad , \quad \frac{e_{22}}{e_{11}} = \frac{e_{33}}{e_{11}} = -\sigma \ . \tag{6}$$

Experiments conducted on most naturally occurring elastic media show that a tensile longitudinal stress produces a longitudinal extension together with a contraction in a transverse directions. According for $\tau_{11} = T > 0$, we take

$$e_{11} > 0 \text{ and } e_{22} < 0 \ , \ e_{33} < 0 \ .$$

It then follows from (6) that

$$E > 0 \text{ and } \sigma > 0 \quad . \tag{7}$$

From equation (6) , we see that E represents the ratio of the longitudinal stress τ_{11} to the corresponding longitudinal strain e_{11} produced by the stress τ_{11}.

From equation (6) , we get

$$\left| \frac{e_{22}}{e_{11}} \right| = \left| \frac{e_{33}}{e_{11}} \right| = \sigma \quad . \tag{8}$$

Thus , the Poisson's ratio σ represents the numerical value of the ratio of the **contraction e_{22}** (or e_{33}) **in a transverse direction** to the corresponding **extension e_{11} in the longitudinal direction.**

(II) Pure Shear

From generalized Hooke's law for an isotropic medium , we write

$$2\mu = \frac{\tau_{12}}{e_{12}} = \frac{\tau_{13}}{e_{13}} = \frac{\tau_{23}}{e_{23}} \quad . \tag{9}$$

The constant 2μ is thus the **ratio** of a shear stress component to the corresponding shear strain component. It is , therefore , related to the **rigidity** of the elastic material.

For this reason , the coefficient μ is called the **modulus of rigidity** or the **shear modulus**.

The other lame constant λ has no direct physical meaning.

The value of μ in terms of Young's modulus E and Poisson ratio σ is given by

$$\mu = \frac{E}{2(1+\sigma)} \quad . \tag{10}$$

Since $E > 0$, $\sigma > 0$, it follows that $\mu > 0$ (11)

(III) Hydrostatic Pressure

Consider an elastic body of arbitrary shape which is put in a large vessel containing a liquid. A hydrostatic pressure p is exerted on it by the liquid and the elastic body experience all around pressure. The stress tensor is given by $\tau_{ij} = -p\,\delta_{ij}$. That is ,

$$\tau_{11} = \tau_{22} = \tau_{33} = -p \text{ , } \tau_{12} = \tau_{23} = \tau_{31} = 0.$$

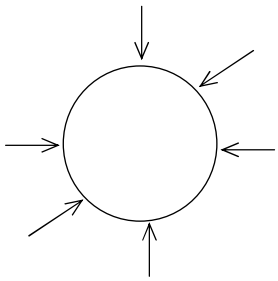


Fig. (4.2)

These stress components satisfy the equilibrium equations for zero body force. We find

$$\tau_{kk} = -3p \ ,$$

and the generalized Hooke's law giving strains in terms of stresses

$$e_{ij} = \frac{1}{2\mu}\left[\frac{-\lambda}{3\lambda+2\mu}\delta_{ij}\,\tau_{kk} + \tau_{ij}\right] \ , \qquad (13)$$

gives

$$e_{12} = e_{23} = e_{31} = 0 \ ,$$

$$e_{11} = e_{22} = e_{33} = \frac{1}{2\mu}\left[\frac{3\lambda\, p}{3\lambda+2\mu} + (-p)\right] = -\frac{p}{3\lambda+2\mu} \ , \qquad (14)$$

which obviously satisfy the compatibility equations. We find

$$e_{kk} = \frac{-3p}{3\lambda+2\mu} = \frac{-p}{\lambda+\frac{2}{3}\mu} = \frac{-p}{k} \ .$$

That is ,

$$v \text{ (cubical dilatation)} = \frac{-p}{k} \ . \qquad (15)$$

From experiments , it has been found that **a hydrostatic pressure tends to reduce the volume of the elastic material**. That is , if $p > 0$, then

$$e_{kk} = v < 0.$$

Consequently , it follows from (15) that $k > 0$.

Relation (15) also shows that the constant k represents the **numerical value** of the **ratio** of the **compressive stress** to the dilatation.

Substituting the value of λ and μ in terms of E and σ , we find

$$k = \frac{E}{3(1-2\sigma)} \quad . \tag{16}$$

Since k > 0 and E > 0 , it follows that $\mathbf{o < \sigma < \frac{1}{2}}$ for all physical substances.

Since

$$\lambda = \frac{E\sigma}{(1+\sigma)(1-2\sigma)} \quad , \tag{17}$$

and E > 0 , $0 < \sigma < \frac{1}{2}$, it follows that $\boldsymbol{\lambda > 0.}$

Remark : The solutions of many problems in elasticity are either exactly or approximately independent of the value chosen for Poisson's ratio. This fact suggests that approximate solutions may be found by so choosing Poisson's ratio as to simplify the problem. Show that , if one take $\sigma = 0$, then

$$\lambda = 0 \, , \, \mu = \frac{E}{2} \, , \, k = \frac{1}{3}E \quad ,$$

and Hooke's law is expressed by

$$\tau_{ij} = E\, e_{ij} = \frac{1}{2} E\, (u_{i,j} + u_{j\,,\,i}) \quad .$$

Note 1: The elastic constants μ , E , σ , k have definite physical meanings. These constants are called engineering elastic modulus.

Note 2: The material such as steel , brass , copper , lead , glass , etc. are isotropic elastic medium.

Note 3: We find

$$e_{kk} = \frac{\tau_{kk}}{3k} = \frac{1-2\sigma}{E}\, \tau_{kk} \quad .$$

Thus $e_{kk} = 0$ iff $\sigma = \frac{1}{2}$, provided E and τ_{kk} remain finite.

When $\sigma \to \frac{1}{2}$, $\lambda \to \infty$, $k \to \infty$, $\mu = \frac{E}{3}$, $v = e_{ii} = u_{i,i} = 0$,

This limiting case corresponds to which is called an incompressible elastic body.

Question : In an elastic beam placed along the x_3 – axis and bent by a couple about the x_2–axis , the stresses are found to be

$$\tau_{33} = -\frac{E}{R}\, x_1 \ , \ \tau_{11} = \tau_{22} = \tau_{12} = \tau_{13} = \tau_{23} = 0 \ , \ R = \text{constant}$$

Find the corresponding strains.

Solution : The strains in terms of stresses & elastic moduli E and σ are given by the Hooke's law

$$e_{ij} = -\frac{\sigma}{E}\, \delta_{ij}\, \tau_{kk} + \frac{1+\sigma}{E}\, \tau_{ij} \quad . \qquad (1)$$

Here

$$\tau_{kk} = -\frac{E}{R}\, x_1 .$$

Hence , (1) becomes

$$e_{ij} = \frac{\sigma}{R} x_1\, \delta_{ij} + \frac{1+\sigma}{E}\, \tau_{ij} \quad . \qquad (2)$$

This gives $e_{11} = e_{22} = \frac{\sigma}{R}\, x_1$, $e_{33} = -\frac{1}{R}\, x_1$, $e_{12} = e_{23} = e_{13} = 0$.

Question : A beam placed along the x_1 – axis and subjected to a longitudinal stress τ_{11} at every point is so constrained that $e_{22} = e_{33} = 0$ at every point. Show that $\tau_{22} = \sigma\tau_{11}$, $e_{11} = \frac{1-\sigma^2}{E}\, \tau_{11}$, $e_{33} = \frac{-\sigma(1+\sigma)}{E}\, \tau_{11}$.

Solution : The Hooke's law giving the strains in terms of stresses is

$$e_{ij} = -\frac{\sigma}{E}\, \delta_{ij}\, \tau_{kk} + \frac{1+\sigma}{E}\, \tau_{ij} \quad . \qquad (1)$$

It gives

$$e_{22} = -\frac{\sigma}{E}(\tau_{11} + \tau_{22} + \tau_{33}) + \frac{1+\sigma}{E}\, \tau_{22}$$

$$= \frac{1}{E}\ \tau_{22} - \frac{\sigma}{E}(\tau_{11} + \tau_{33}) \quad . \tag{2}$$

Putting $e_{22} = e_{33} = 0$ in (2) , we get

$$\tau_{22} = \sigma\ \tau_{11} \quad . \tag{3}$$

Also , from (1) , we find

$$e_{11} = -\frac{\sigma}{E}(\tau_{11} + \tau_{22} + \tau_{33}) + \frac{1+\sigma}{E}\ \tau_{11}$$

$$= -\frac{\sigma}{E}(\tau_{11} + \sigma\ \tau_{11}) + \frac{1+\sigma}{E}\ \tau_{11}$$

$$= \frac{1}{E}[-\sigma - \sigma^2 + 1 + \sigma]\ \tau_{11} = \frac{1-\sigma^2}{E}\tau_{11} \quad . \tag{4}$$

Also , from (1) , we get

$$e_{33} = -\frac{\sigma}{E}(\tau_{11} + \tau_{22}) + \frac{1+\sigma}{E}\tau_{33}$$

$$= -\frac{\sigma}{E}(\tau_{11} + \sigma\ \tau_{11}) = \frac{-\sigma(1+\sigma)}{E}\tau_{11} \quad . \tag{5}$$

Exercise 1: Find the stresses with the following displacement fields :

(i) $u = k\ y\ z$, $v = k\ z\ x$, $w = k\ x\ y$

(ii) $u = k\ y\ z$, $v = k\ z\ x$, $w = k\ (x^2 - y^2)$

where k = constant.

Exercise 2 : A rod placed along the x_1 – axis and subjected to a longitudinal stress τ_{11} is so constrained that there is no lateral contraction. Show that

$$\tau_{11} = \frac{(1-\sigma)E}{(1+\sigma)(1-2\sigma)}e_{11}$$

4.5. EQUILIBRIUM AND DYNAMIC EQUATIONS FOR AN ISOTROPIC ELASTIC SOLID

We know that Cauchy's equation's of equilibrium in term of stress components are

$$\tau_{ij,j} + F_i = 0 \quad , \tag{1}$$

where F_i is the body force per unit volume and i , j = 1, 2, 3 .

The generalized Hooke's law for a homogeneous isotropic elastic body is

$$\tau_{ij} = \lambda\, \delta_{ij}\, e_{kk} + 2\mu\, e_{ij}$$

$$= \lambda\, \delta_{ij}\, u_{k,k} + \mu(u_{i,j} + u_{j,i}) \ , \qquad (2)$$

where λ and μ are Lame constants. Putting the value of τ_{ij} from (2) into equation (1) , we find

$$\lambda\, \delta_{ij}\, u_{k,kj} + \mu(u_{i,jj} + u_{j,ij}) + F_i = 0$$

$$\lambda\, u_{k,ki} + \mu\ \nabla^2 u_i + \mu\, u_{k,ki} + F_i = 0$$

$$(\lambda + \mu)\frac{\partial \theta}{\partial x_i} + \mu\ \nabla^2\ u_i + F_i = 0 \quad , \qquad (3)$$

where $\theta = u_{k,k} = \text{div}\ \bar{u}$ = cubical dilatation and i = 1 , 2 , 3.

Equations in (3) form a synthesis of the analysis of strain, analysis of stress and the stress – strain relation.

These fundamental partial differential equations of the elasticity theory are known as Navier's equations of equilibrium , after **Navier (1821).**

Equation (3) can be put in several different forms.

Form (A) : In vector form , equation (3) can be written as

$$(\lambda + \mu)\ \text{grad div}\ \bar{u} + \mu\ \nabla^2\ \bar{u} + \bar{F} = \bar{0} \quad . \qquad (4)$$

Form (B) : We know the following vector identity :

$$\text{curl curl}\ \bar{u} = \text{grad div}\ \bar{u} - \nabla^2\ \bar{u} \ . \qquad (5)$$

Putting the value of $\nabla^2\ \bar{u}$ from (5) into (4) , we obtain

$$(\lambda + \mu)\ \text{grad div}\ \bar{u} + u\ [\text{grad div}\ \bar{u} - \text{curl curl}\ \bar{u}] + \bar{F} = \bar{0}$$

or

$$(\lambda + 2\mu)\ \text{grad div}\ \bar{u} - \mu\ \text{curl curl}\ \bar{u} + \bar{F} = 0. \qquad (6)$$

Form (C) : Putting the value of grad div $\bar{u}$ from (5) into (4) , we get

$$(\lambda + \mu)\ [\nabla^2\ \bar{u} + \text{curl curl}\ \bar{u}] + \mu \nabla^2\ \bar{u} + \bar{F} = \bar{0}$$

or

$$(\lambda + 2\mu)\ \nabla^2\ \bar{u} + (\lambda + \mu)\ \text{curl curl}\ \bar{u} + \bar{F} = \bar{0} \qquad (7)$$

Form D : We know that

$$\frac{\lambda + \mu}{\mu} = \frac{1}{1 - 2\sigma} \quad . \qquad (8)$$

From (8) and (4) , we find

$$\nabla^2\ \bar{u} + \frac{1}{1 - 2\sigma}\ \text{grad div}\ \bar{u} + \frac{1}{\mu}\ \bar{F} = \bar{0}\ . \qquad (9)$$

Dynamical Equations for an Isotropic Elastic Solid

Let ρ be the density of the medium. The components of the force (mass $\times$ acceleration/volume) per unit volume are $\rho \frac{\partial^2 u_i}{\partial t^2}$.

Hence , the dynamical equations in terms of the displacements u_i become

$$(\lambda + \mu)\frac{\partial \theta}{\partial x_i} + \mu \nabla^2 u_i + F_i = \rho \frac{\partial^2 u_i}{\partial t^2} \quad ,$$

for i = 1 , 2 , 3.

Various form of it can be obtained as above for equilibrium equations.

Question : In an isotropic elastic body in equilibrium under the body force $\underline{f} = a\, x_1\, x_2\, \hat{e}_3$, where a is a constant , the displacements are of the form

$$u_1 = A\, x_1^2\, x_2\, x_3\ ,\ u_2 = B\, x_1\, x_2^2\, x_3\ ,\ u_3 = C\, x_1\, x_2\, x_3^2$$

where A , B , C are constants. Find A , B , C. Evaluate the corresponding stresses.

4.6. BELTRAMI-MICHELL COMPATIBILITY EQUATIONS IN TERMS OF THE STRESSES FOR AN ISOTROPIC SOLID

The strain – stress relations for an isotropic elastic solid are

$$e_{ij} = \frac{1 + \sigma}{E}\tau_{ij} - \frac{\sigma}{E}\delta_{ij}\,\theta, \qquad \theta = \tau_{ij} \quad , \qquad (1)$$

in which σ is the Poisson's ratio and E is the Young's modulus.

The Saint – Venant's compatibility equations in terms of strain components are

$$e_{ij,kl} + e_{kl,ij} - e_{ik,jl} - e_{jl,ik} = 0 \ , \qquad (2)$$

which impose restrictions on the strain components to ensure that given e_{ij} yield single – valued continuous displacements u_i .

When the region τ is simply connected, using (1) in (2) , we find

$$\frac{1+\sigma}{E}\{\tau_{ij,kl} + \tau_{kl,ij} - \tau_{ik,jl} - \tau_{jl,ki}\} = \frac{\sigma}{E}\{\delta_{ij}\,\theta_{,kl} + \delta_{kl}\,\theta_{,ij} - \delta_{ik}\,\theta_{,jl} - \delta_{jl}\,\theta_{,ik}\}$$

$$\tau_{ij\,,\,kl} + \tau_{kl\,,\,ij} - \tau_{ik\,,\,jl} - \tau_{jl\,,\,ki} = \frac{\sigma}{1+\sigma}(\delta_{ij}\,\theta_{\,,\,kl} + \delta_{kl}\,\theta_{\,,\,ij} - \delta_{ik}\,\theta_{\,,\,jl} - \delta_{jl}\,\theta_{\,,\,ik}) \ , \quad (3)$$

with $\tau_{ij,kl} = \dfrac{\partial^2 \tau_{ij}}{\partial x_k \, \partial x_l}$, $\theta_{,ij} = \dfrac{\partial^2 \theta}{\partial x_i \, \partial x_j}$.

These are equations of compatibility in stress components. These are $81(=3^4)$ in number but all of them are not independent. If i & j or k & *l* are interchanged , we get same equations. Similarly for i = j = k = *l* , equations are identically satisfied. Actually , the set of equations (3) contains only six independent equations obtained by setting

k = *l* = 1 , i = j = 2

k = *l* = 2 , i = j = 3

k = *l* = 3 , i = j = 1

k = *l* = 1 , i = 2 , j = 3

k = *l* = 2 , i = 3 , j = 1

k = *l* = 3 , i = 1 , j = 2.

Setting k = *l* in (3) and then taking summation over the common index , we get

$$\tau_{ij,kk} + \tau_{kk,ij} - \tau_{ik,jk} - \tau_{jk,ik} = \frac{\sigma}{1+\sigma}(\delta_{ij}\,\theta_{,kk} + \delta_{kk}\,\theta_{,ij} - \delta_{ik}\,\theta_{,jk} - \delta_{jk}\,\theta_{,ik}) \ ,$$

Since $\theta_{,kk} = \nabla^2 \theta$, $\tau_{ij,kk} = \nabla^2 \tau_{ij}$,

$\tau_{kk,ij} = \theta_{,ij}$, $\delta_{kk} = 3$,

therefore , above equations become

$$\nabla^2 \tau_{ij} + \theta_{,ij} - \tau_{ik,jk} - \tau_{jk,ik} = \frac{\sigma}{1+\sigma} [\delta_{ij} \nabla^2 \theta + 3\theta_{,ij} - 2\theta_{,ij}]$$

or

$$\nabla^2 \tau_{ij} + \frac{1}{1+\sigma} \theta_{,ij} - \tau_{ik,jk} - \tau_{jk,ik} = \frac{\sigma}{1+\sigma} \delta_{ij} \nabla^2 \theta. \qquad (4)$$

This is a set of 9 equations and out of which only 6 are independent due to the symmetry of i & j. In combining equations (3) linearly , the number of independent equations is not reduced.

Hence the resultant set of equations in (4) is equivalent to the original equations in (3).

Equilibrium equations are

$$\tau_{ik,k} + F_i = 0 \quad ,$$

where F_i is the body force per unit volume.

Differentiating these equations with respect to x_j , we get

$$\tau_{ik,kj} = -F_{i,j} \quad . \qquad (5)$$

Using (5) , equation (4) can be rewritten in the form

$$\nabla^2 \tau_{ij} + \frac{1}{1+\sigma} \theta_{,ij} - \frac{\sigma}{1+\sigma} \delta_{ij} \nabla^2 \theta = -(F_{i,j} + F_{j,i}) \quad . \qquad (6)$$

Setting j = i in (6) and adding accordingly, we write

$$\nabla^2 \theta + \frac{1}{1+\sigma} \nabla^2 \theta - \frac{3\sigma}{1+\sigma} \nabla^2 \theta = -2F_{i,i}$$

$$\left(1 + \frac{1}{1+\sigma} - \frac{3\sigma}{1+\sigma}\right) \nabla^2 \theta = -2F_{i,i}$$

$$\frac{2(1-\sigma)}{1+\sigma} \nabla^2 \theta = -2F_{i,i} = -2\, div \vec{F} \quad ,$$

giving

$$\nabla^2 \theta = -\frac{1+\sigma}{1-\sigma} div \vec{F} \quad . \qquad (7)$$

Using (7) in (6) , we find the final form of the compatibility equations in terms of stresses.

We get

$$\nabla^2 \tau_{ij} + \frac{1}{1+\sigma}\theta_{,ij} = -\frac{\sigma}{1-\sigma}\delta_{ij}\, div\vec{F} - (F_{i,j} + F_{j,i}) \quad . \qquad (8)$$

These equations in cartesian coordinates (x , y , z) can be written as

$$\left.\begin{aligned}
\nabla^2 \tau_{xx} + \frac{1}{1+\sigma}\frac{\partial^2\theta}{\partial x^2} &= -\frac{\sigma}{1-\sigma}\, div\vec{F} - 2\frac{\partial F_x}{\partial x} \\
\nabla^2 \tau_{yy} + \frac{1}{1+\sigma}\frac{\partial^2\theta}{\partial y^2} &= -\frac{\sigma}{1-\sigma}\, div\vec{F} - 2\frac{\partial F_y}{\partial y} \\
\nabla^2 \tau_{zz} + \frac{1}{1+\sigma}\frac{\partial^2\theta}{\partial z^2} &= -\frac{\sigma}{1-\sigma}\, div\vec{F} - 2\frac{\partial F_z}{\partial z}
\end{aligned}\right\}$$

$$\left.\begin{aligned}
\nabla^2 \tau_{yz} + \frac{1}{1+\sigma}\frac{\partial^2\theta}{\partial y\,\partial z} &= -\left(\frac{\partial F_y}{\partial z} + \frac{\partial F_z}{\partial y}\right) \\
\nabla^2 \tau_{zx} + \frac{1}{1+\sigma}\frac{\partial^2\theta}{\partial z\,\partial x} &= -\left(\frac{\partial F_z}{\partial x} + \frac{\partial F_x}{\partial z}\right) \\
\nabla^2 \tau_{xy} + \frac{1}{1+\sigma}\frac{\partial^2\theta}{\partial x\,\partial y} &= -\left(\frac{\partial F_x}{\partial y} + \frac{\partial F_y}{\partial x}\right)
\end{aligned}\right\} \quad (9)$$

In 1892 , Beltrami obtained these equations for $\vec{F} = \vec{0}$ and in 1900 Michell obtained then in form as given in (9).

These equations in (9) are called the **Beltrami – Michell** compatibility equations.

Definition : A function V of class C^4 is called a biharmonic function when

$$\nabla^2\, \nabla^2 V = 0 \ .$$

Theorem : When the components of the body $\vec{F}$ are constants , show that the stress and strain invariants θ and v are harmonic functions and the stress components τ_{ij} and strain components e_{ij} are biharmonic functions.

Proof : The Beltrami – Michell compatibility equations in terms of stress are

$$\nabla^2 \tau_{ij} + \frac{1}{1+\sigma} \theta_{,ij} = -\frac{\sigma}{1-\sigma} \delta_{ij} \; div\vec{F} - (F_{i,j} + F_{j,i}) \quad , \tag{1}$$

in which $\vec{F}$ is the body force per unit volume.

It is given that the vector $\vec{F}$ is constant. In this case, equations in (1) reduce to

$$\nabla^2 \tau_{ij} + \frac{1}{1+\sigma} \theta_{,ij} = 0 \; . \tag{2}$$

Setting j = i in (2) and taking summation accordingly , we get

$$\nabla^2 \tau_{ii} + \frac{1}{1+\sigma} \theta_{,ii} = 0$$

$$\nabla^2 \theta + \frac{1}{1+\sigma} \nabla^2 \theta = 0$$

$$\left(1 + \frac{1}{1+\sigma}\right) \nabla^2 \theta = 0$$

$$\nabla^2 \theta = 0 \; . \tag{3}$$

This shows that the stress invariant $\theta = \tau_{kk}$ is a harmonic function.

The standard relation between the invariants θ and v is

$$\theta = (3\lambda + 2\mu)\, v \quad , \tag{4}$$

and equation (3) implies that

$$\nabla^2 v = 0 \quad , \tag{5}$$

showing that the strain invariant $v = e_{kk}$ is also a harmonic function.

Again

$$\nabla^2 \nabla^2 \tau_{ij} = \nabla^2 \left(-\frac{1}{1+\sigma} \theta_{,ij} \right) \quad ,$$

$$= -\frac{1}{1+\sigma} \nabla^2 (\theta_{,ij})$$

$$= -\frac{1}{1+\sigma} (\nabla^2 \theta)_{,ij} \quad ,$$

giving $$\nabla^2 \nabla^2 \tau_{ij} = 0 \ . \qquad (6)$$

This shows that the stress components τ_{ij} are biharmonic functions.

The following strain – stress relations

$$e_{ij} = \frac{-\lambda}{2\mu(3\lambda + 2\mu)} \delta_{ij}\, \theta + \frac{1}{2\mu} \tau_{ij}$$

give

$$\nabla^2 \nabla^2 e_{ij} = \frac{-\lambda}{2\mu(3\lambda + 2\mu)} \delta_{ij}\, \nabla^2 \nabla^2\, \theta + \frac{1}{2\mu}\, \nabla^2 \nabla^2\, \tau_{ij}$$

$$\nabla^2 \nabla^2\, e_{ij} = 0 \ . \qquad (7)$$

Equation (7) shows that the strain components e_{ij} are also biharmonic functions.

Theorem 2: If the body force $\vec{F}$ is derived from a **harmonic potential** function , show that the strain and stress invariants e_{kk} & τ_{kk} are harmonic functions and the **strain and stress** components are **biharmonic function**.

Proof : Let ϕ be the potential function and $\vec{F}$ is derived from ϕ so that

$$\vec{F} = \underline{\nabla}\, \phi \qquad \text{or} \qquad F_j = \phi_{,j} \ . \qquad (1)$$

Then

$$\text{div}\, \vec{F} = \phi_{,jj} = \nabla^2 \phi = 0 \ , \qquad (2)$$

since ϕ is a harmonic function (given). Further

$$F_{i\,,\,j} = F_{j\,,\,i} = \phi_{,\,ij} \qquad (3)$$

The Beltrami – Michell compatibility equations in terms of stresses , in this case , reduce to

$$\nabla^2 \tau_{ij} + \frac{1}{1+\sigma} \theta_{,\,ij} = -2\phi_{,\,ij} \ . \qquad (4)$$

Putting j = i in (4) and taking the summation accordingly , we obtain

$$\nabla^2\, \tau_{ii} + \frac{1}{1+\sigma} \theta_{,ii} = -2\phi_{,ii}$$

$$= -2\nabla^2 \phi$$

$$= 0 \quad ,$$

giving

$$\nabla^2 \theta = 0 \, , \qquad (5)$$

This shows that θ is harmonic.

The relation $\theta = (3\lambda + 2\mu)\, v$ immediately shows that v is also harmonic.

From equation (4) , we write

$$\nabla^2 \, \nabla^2 \tau_{ij} + \frac{1}{1+\sigma} \, \nabla^2 \theta_{,ij} = -2(\nabla^2 \phi)_{,ij}$$

$$= 0$$

This gives

$$\nabla^2 \, \nabla^2 \tau_{ij} = 0 \quad , \qquad (6)$$

as $\nabla^2 \theta = \nabla^2 \phi = 0.$

It shows that the components τ_{ij} are biharmonic.

The strain – stress relations yields that the strain components are also biharmonic function.

Question : Find whether the following stress system can be a solution of an elastostatic problem in the absence of body forces :

$$\tau_{11} = x_2 \, x_3 \, , \, \tau_{22} = x_3 \, x_1 \, , \, \tau_{12} = x_3^{\,2} \, , \, \tau_{13} = \tau_{33} = \tau_{32} = 0.$$

Solution : In order that the given stress system can be a solution of an elastostatic problem in the absence of body forces , the following equations are to be satisfied :

(i) Cauchy's equations of equilibrium with $f_i = 0$, i.e. ,

$$\tau_{11,1} + \tau_{12,2} + \tau_{13,3} = 0 \quad ,$$

$$\tau_{12,1} + \tau_{22,2} + \tau_{23,3} = 0 \quad ,$$

$$\tau_{13,1} + \tau_{23,2} + \tau_{33,3} = 0 \quad . \qquad (1)$$

(ii) Beltrami – Michell equations with $f_i = 0$, i.e. ,

$$\nabla^2 \tau_{11} + \frac{1}{1+\sigma}(\tau_{11} + \tau_{22} + \tau_{33})_{,11} = 0 ,$$

$$\nabla^2 \tau_{22} + \frac{1}{1+\sigma}(\tau_{11} + \tau_{22} + \tau_{33})_{,22} = 0 ,$$

$$\nabla^2 \tau_{33} + \frac{1}{1+\sigma}(\tau_{11} + \tau_{22} + \tau_{33})_{,33} = 0 ,$$

$$\nabla^2 \tau_{12} + \frac{1}{1+\sigma}(\tau_{11} + \tau_{22} + \tau_{33})_{,12} = 0 ,$$

$$\nabla^2 \tau_{13} + \frac{1}{1+\sigma}(\tau_{11} + \tau_{22} + \tau_{33})_{,13} = 0 ,$$

$$\nabla^2 \tau_{23} + \frac{1}{1+\sigma}(\tau_{11} + \tau_{22} + \tau_{33})_{,23} = 0 . \qquad (2)$$

It is easy to check that all the equilibrium equations in (1) are satisfied.

Moreover, all except the fourth one in (2) are satisfied by the given stress system.

Since the given system does not satisfy the Beltrami – Michell equations fully , it can not form a solution of an elastostatic problem.

Remark : The example illustrates the important fact that a stress system may not be a solution of an elasticity problem even though it satisfies Cauchy's equilibrium equations.

Exercise 1: Show that the stress – system $\tau_{11} = \tau_{22} = \tau_{13} = \tau_{23} = \tau_{12} = = 0$, $\tau_{33} = \rho g\, x_3$, where ρ and g are constants ,satisfies that equations of equilibrium and the equations of compatibility for a suitable body force.

Exercise 2: Show that the following stress system can not be a solution of an elastostatic problem although it satisfies cauchy's equations of equilibrium with zero body forces :

$$\tau_{11} = x_2^2 + \sigma(x_1^2 - x_2^2) , \tau_{22} = x_1^2 + \sigma(x_2^2 - x_1^2) , \tau_{33} = \sigma(x_1^2 + x_2^2)$$

$$\tau_{12} = -2\sigma\, x_1\, x_2 , \tau_{23} = \tau_{31} = 0$$

where σ is a constant of elasticity.

Exercise 3: Determine whether or not the following stress components are a possible solution in elastostatics in the absence of body forces :

$$\tau_{11} = a\, x_2\, x_3\ ,\ \tau_{22} = b\, x_3\, x_1\ ,\ \tau_{33} = c\, x_1\, x_2\ ,\ \tau_{12} = d\, x_3^2$$
$$\tau_{13} = e\, x_2^2\ ,\ \tau_{23} = f\, x_1^2\ ,$$

where a , b , c , d , e , f are all constants.

Exercise 4: In an elastic body in equilibrium under the body force $\underline{f} = a\, x_1\, x_2\, \hat{e}_3$, where a is a constant , the stresses are of the form

$$\tau_{11} = a\, x_1\, x_2\, x_3\ ,\ \tau_{22} = b\, x_1\, x_2\, x_3\ ,\ \tau_{33} = c\, x_1\, x_2\, x_3$$
$$\tau_{12} = (a\, x_1^2 + b\, x_2^2)\, x_3\ ,\ \tau_{23} = (b\, x_2^2 + c\, x_3^2)\, x_1\ ,\ \tau_{13} = (c\, x_3^2 + a\, x_1^2)\, x_2$$

where a , b , c are constants. Find these constants.

Exercise 5: Define the stress function S by

$$\tau_{ij} = S_{,ij} = \frac{\partial^2 S}{\partial x_i\, \partial x_j}$$

and consider the case of zero body force. Show that , if $\sigma = 0$, then the equilibrium and compatibility equations reduce to

$$\nabla^2\ S = \text{Constant.}$$

4.7. UNIQUENESS OF SOLUTION

The most general problem of the elasticity theory is to determine the **distribution of stresses** and **strains** as well as displacements at all points of a body when certain boundary conditions and certain initial conditions are specified (under the assumption that the body force $\underline{f}$ is known before hand).

In the linear elasticity , the displacements , strains and stresses are governed by the following equations

(I) $e_{ij} = \frac{1}{2}(u_{i,j} + u_{j,i})$ strain – displacement relations (1)

(II) $\tau_{ij} = \lambda\delta_{ij}\, e_{kk} + 2\mu\, e_{ij} = \lambda\delta_{ij}\, u_{k,k} + \mu(u_{i,j} + u_{j,i})$ material law (2)

or

$$e_{ij} = -\frac{\sigma}{E}\delta_{ij}\, \tau_{kk} + \frac{1+\sigma}{E}\tau_{ij}$$

(III) $\tau_{ij,j} + f_i = 0$ Cauchy's equation of equilibrium

or (3)

$(\lambda + \mu)$ grad div $\bar{u} + \mu\, \nabla^2\ \bar{u} + \bar{f} = \bar{0}$ Navier equation of equilibrium

Accordingly , solving a problem in linear elasticity generally amounts **to solving these equations for u_i , e_{ij} and τ_{ij}** under certain specified boundary conditions and initial conditions.

Let a body occupying a region V has the boundary S.

Initially , It is assumed that the body is in the **undeformed state.** That is,

$$\mathbf{u_i = 0 \quad for \quad e_{ij} = 0 \quad in\ V\ .} \quad (\text{at time } t = 0) \qquad (4)$$

The boundary conditions specified are usually of one of following three kinds :

(i) **The stress vector is specified at every point of boundary S for all times**, i.e. ,

$$\underset{\sim}{T}^{v} = \underset{\sim}{s} \qquad \text{on S}$$

where $\underset{\sim}{s}$ is a known vector point function.

(ii) the displacement vector is specified at every point of S and for all times , i.e. ,

$$\underset{\sim}{u} = \underset{\sim}{u}^{*} \qquad \text{on S} \qquad (6)$$

when $\underset{\sim}{u}^{*}$ is a known function.

(ii) the stress vector is specified at every point of a part S_τ of S and the displacement vector is specified at every point of the remaining part $S_u = S - S_\tau$; i.e. ,

$$\left.\begin{aligned} \underset{\sim}{T}^{v} &= \underset{\sim}{s} && \text{on } S_\tau \\ \underset{\sim}{u} &= \underset{\sim}{u}^{*} && \text{on } S_u = S - S_\tau \end{aligned}\right\} \quad . \qquad (7)$$

The problem of solving equations (1) , (2) , (3) under the initial condition(4) and **one of the boundary** conditions in (5) – (7) to determine u_i , e_{ij} , τ_{ij} is known as **boundary value problem in elastostatics.**

A set $\{u_i , e_{ij} , \tau_{ij}\}$ so obtained / determined , if it exists , is called **a solution of the problem**.

When the boundary condition is of the form (5) , the problem is referred to as the traction **(or stress) boundary value problem** ; and when the boundary condition of the form (6) , the problem is referred to as the **displacement BV problem** ; and when the boundary condition is of the form (7) , the problem is referred to **as mixed BV problem**.

The three problems are together called the **fundamental boundary value problems**. The boundary conditions valid for all the three problems can be written down in the form of (7). For the traction problem $S_\tau = S$ and $S_u = \phi$, for the displacement problem $S = S_u$ and $S_\tau \neq \phi$, and for mixed problem $S_u \neq S \neq S_\tau$.

Uniqueness : The solutions of an elastostatic problem governed by equations (1) – (3) and the boundary condition (7) is **unique** within a rigid body displacement.

Remark 1: The displacement boundary value problem is completely solved if one obtains a solution of the Navier equation subject to the boundary condition (6). Note that we need not adjoin the compatibility equations

$$e_{ij,kl} + e_{kl,ij} - e_{ik,jl} - e_{jl,ik} = 0 \,, \qquad (8)$$

for the only purpose of the latter is to impose restrictions on the strain components that shall ensure that the e_{ij} yield single – valued continuous displacements u_i , when the region is simply connected. From the knowledge of functions u_i , one can determine the strains , and hence stresses by making use of Hooke's law in (2).

Remark 2: The **stress boundary value problem** suggests the desirability of expressing all the differential equations entirely in terms of **stress**. The compatibility equations (Betrami – Michell compatibility equations) in terms of stresses are

$$\nabla^2 \tau_{ij} + \frac{1}{1+\sigma} \tau_{kk,ij} = -\frac{\sigma}{1-\sigma} \delta_{ij} \operatorname{div} \overline{F} - (F_{i,j} + F_{j,i}) \quad . \qquad (9)$$

In order to determine the state of stress in the interior of an elastic body , one must solve the system of equations consisting of Cauchy's equations of equilibrium (3) and B–M compatibility equations subject to the boundary conditions in (5).

4.8. ST. VENANT'S PRINCIPAL

In the analysis of actual structures subjected to external loads , it can be invariably found that the distributions of surface forces are so complex as to define them more accurately for solving the appropriate governing equations. It is true that the solutions obtained for such problems using the elasticity equations are exact only if the external loads are applied in a specific manner. However , in many cases it is possible to predict the net effect of the external surface tractions without worrying about the precise manner in which they are distributed over the boundary.

In 1853 in his "Memoire Sur la Torsion des Prismes" , Saint – Vanant developed solutions for the torsion of prismatic bars which gave the same stress distribution for all cross – sections. He attempted to justify the usefulness of his formulation by the following : " **The fact is that the means of application and distribution of the forces towards the extremities of the prisms is immaterial to the perceptible effects produced on the rest of the length , so that one can always , in a sufficiently similar manner , replace the forces applied with equivalent static forces or with those having the same total moments and the same resultant forces"**.

St. Venant's Principal : If a certain distribution of forces acting on a portion of the surface of a body is replaced by different distribution of forces acting on

the same portion of the body ,then the effects of the two different distributions on the parts sufficiently far removed (large compared to linear dimensions of the body) from the region of application of forces , are essentially the same , provided that the two distributions of forces are statically equivalent (that is , the same resultant forces and the same resultant moment).

St . Venant principal is profitable when solving problems in rigid – body mechanics to employ the concept of a point force when we had a force distribution over a small area. At other times , we employed the rigid – body resultant force system of some distribution in the handling of a problem. Such replacements led to reasonably accurate and direct solutions. From the viewpoint of rigid – body mechanics , **this principal states that** the stresses reasonably distant from an applied load on a boundary are not significantly altered if this load is changed to another load which is equivalent to it. We may call such a second load the **statically equivalent load.**

This principal is actually summarized by one of its more detailed names, “The principal of the elastic equivalence of statically equipollent systems of load”.

St. Venant’s principal is very convenient and useful in obtaining solutions to various problems in elasticity. However , the statements are in general vague. They do not specifically state either the extent of the region within which the effects of two different statically equivalent force systems are not quite the same or the magnitude of the error.

Therefore , St. Venant’s principal is only qualitative and expresses only a trend.

Nevertheless , St. Venant’s principal has many important implications with respect to many practical problems. For instance , in many structures , the overall deflections are not unduly affected by the local changes in the distribution of forces or localized stress concentrations due the holes , cracks , etc. But it should be realized that the presence of defects in a region , or a non – uniform application of load will cause changes in stress distribution.

This principle is mainly used in elasticity to solve the problems of extension/bending/torsion of elastic beams. Under this technique , certain assumptions about the components of stress , strain and displacements are made , while leaving enough degree of freedom , so that the equations of equilibrium and compatibility are satisfied . The solution so obtained will be unique by the uniqueness of solution of the general boundary – value problems of linear elasticity.

Table for various elastic coefficients for an isotropic media

λ	$\frac{2\mu\sigma}{1-2\sigma}$	$\frac{\mu(E-2\mu)}{3\mu-E}$	$k-\frac{2}{3}\mu$	$\frac{E\sigma}{(1+\sigma)(1-2\sigma)}$	$\frac{3k\sigma}{1+\sigma}$	$\frac{3k(3k-E)}{(9k-E)}$	–	–	–
μ	–	–	–	$\frac{E}{2(1+\sigma)}$	$\frac{3k(1-2\sigma)}{2(1+\sigma)}$	$\frac{3kE}{9k-E}$	–	$\frac{\lambda(1-2\sigma)}{2\sigma}$	$\frac{3}{2}(k-\lambda)$
σ	–	$\frac{E}{2\mu}-1$	$\frac{3k-2\mu}{2(3k+\mu)}$	–	–	$\frac{3k-E}{6k}$	$\frac{\lambda}{2(\lambda+\mu)}$	–	$\frac{\lambda}{3k-\lambda}$
E	$2\mu(1+\sigma)$	–	$\frac{9k\mu}{3k+\mu}$	–	$3k(1-2\sigma)$	–	$\frac{\mu(3\lambda+2\mu)}{\lambda+\mu}$	$\frac{\lambda(1+\sigma)(1-2\sigma)}{\sigma}$	$\frac{9k(k-\lambda)}{3k-\lambda}$
k	$\frac{2\mu(1+\sigma)}{3(1-2\sigma)}$	$\frac{\mu E}{3(3\mu-E)}$	–	$\frac{E}{3(1-2\sigma)}$	–	–	$\lambda+\frac{2}{3}\mu$	$\frac{\lambda(1+\sigma)}{3\sigma}$	–

Chapter-5

Strain-Energy Function

5.1. INTRODUCTION

The energy stored in an elastic body by virtue of its deformation is called the **strain energy**. This energy is acquired by the body when the body forces and surface tractions do some work. This is also termed as **internal energy**. It depends upon the shape and temperature of the body.

5.2. STRAIN – ENERGY FUNCTION

Let τ_{ij} be the stress tensor and e_{ij} be the strain tensor for an infinitesimal affine deformation of an elastic body. We write

$$\left.\begin{aligned} &\tau_{11} = \tau_1 \ , \ \tau_{22} = \tau_2 \ , \ \tau_{33} = \tau_4 \\ &\tau_{23} = \tau_4 \ , \ \tau_{31} = \tau_5 \ , \ \tau_{12} = \tau_6 \end{aligned}\right\} \ , \qquad (1)$$

and

$$\left.\begin{aligned} &e_{11} = e_1 \ , \ e_{22} = e_2 \ , \ e_{33} = e_3 \\ &2e_{23} = e_4 \ , \ 2e_{13} = e_5 \ , \ 2e_{12} = e_6 \end{aligned}\right\} \ , \qquad (2)$$

in terms of engineering notations.

We assume that the deformation of the elastic body is isothermal or adiabatic. **Love(1944)** has proved that , under this assumption there exists a function of strains

$$W = W(e_1 \ , \ e_2 \ , \ e_3 \ , \ \ldots\ldots, \ e_6) \ , \qquad (3)$$

with the property

$$\frac{\partial W}{\partial e_i} = \tau_i \quad , \quad \text{for } i = 1 \ , \ 2 \ , \ \ldots.. \ , \ 6. \qquad (4)$$

This function W is called the strain energy function.

W represents strain energy , per unit of undeformed volume , stored up in the body by the strains e_i.

The units of W are $\frac{\text{force}\times \text{L}}{\text{L}^3} = \frac{\text{force}}{\text{L}^2}$, **that of a stress**.

The existence of W was first introduced by George Green (1839).

Expanding the strain energy function W , given in (3) in a power series in terms of strains e_i , we write

$$2W = d_0 + 2\, d_i\, e_i + d_{ij}\, e_i\, e_j \qquad , i , j = 1, 2 , \ldots . ,6 \ . \tag{5}$$

after discarding all terms of order 3 and higher in the strains e_i as strains e_i are assumed to be **small**. In second term , summation of i is to be taken and in 3rd term , summation over dummy sufficies i & j are to be taken.

In the **natural state , $e_i = 0$, consequently** $W = 0$ **for $e_i = 0$**.

This gives

$$d_0 = 0 \ . \tag{6}$$

Even otherwise , the constant term in (5) can be neglected since we are interested only in the partial derivatives of W. Therefore ,equations (5) and (6) yield

$$2W = 2d_i\, e_i + d_{ij}\, e_i\, e_j \quad . \tag{7}$$

This gives

$$\frac{\partial W}{\partial e_k} = d_i\, \delta_{ik} + \frac{1}{2}\, \frac{\partial}{\partial e_k} \{d_{ij}\, e_i\, e_j\}$$

$$= d_k + \frac{1}{2} \{d_{ij}\, \delta_{ki}\, e_j + d_{ij}\, e_i\, \delta_{kj}]$$

$$= d_k + \frac{1}{2} [d_{kj}\, e_j + d_{ki}\, e_i]$$

$$= d_k + \frac{1}{2} (d_{kj} + d_{kj})\, e_j$$

$$= d_k + (d_{kj}\, e_j)\, e_j \quad .$$

This gives

$$\tau_i = d_i + c_{ij}\, e_j \ , \tag{8}$$

where

$$c_{ij} = \frac{1}{2}(d_{ij} + d_{ji}) = c_{ji} \quad . \tag{9}$$

We observe that **c_{ij} is symmetric.**

We further assume that the stresses $\tau_i = 0$ in the undeformed state , when $e_i = 0$.

This assumption , using equation (8) , gives

$$\mathbf{d_i = 0} \quad , \qquad i = 1 , 2 , \ldots , 6 \quad . \tag{10}$$

Equations (7) , (8) and (10) give

$$\tau_i = c_{ij}\, e_j \tag{11}$$

and

$$W = \frac{1}{2}\, c_{ij}\, e_i\, e_j = \frac{1}{2}\, e_i\, \tau_i \quad , \tag{12}$$

since , two quadric homogeneous forms for W are equal as

$$d_{ij}\, e_i\, e_j = c_{ij}\, e_i\, e_j \quad . \tag{13}$$

Equation (12) shows that the strain energy function W **is a homogeneous function of degree 2** in strains e_i , i = 1 , 2 , ….., 6 , and coefficients c_{ij} are symmetric.

The generalized Hooke's law under the conditions of existence of strain energy function is given in equations (9) and (11).

In matrix form , it can be expressed as

$$\begin{bmatrix} \tau_{11} \\ \tau_{22} \\ \tau_{33} \\ \tau_{23} \\ \tau_{13} \\ \tau_{12} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} & c_{15} & c_{16} \\ c_{12} & c_{22} & c_{23} & c_{24} & c_{25} & c_{26} \\ c_{13} & c_{23} & c_{33} & c_{34} & c_{35} & c_{36} \\ c_{14} & c_{24} & c_{34} & c_{44} & c_{45} & c_{46} \\ c_{15} & c_{25} & c_{35} & c_{45} & c_{55} & c_{56} \\ c_{16} & c_{26} & c_{36} & c_{46} & c_{56} & c_{66} \end{bmatrix} \begin{bmatrix} e_{11} \\ e_{22} \\ e_{33} \\ 2e_{23} \\ 2e_{13} \\ 2e_{12} \end{bmatrix} . \tag{14}$$

This law contains 21 independent elastic constants.

Result 1: From equation (2) ; we write

$$W = \frac{1}{2}[\tau_1 e_1 + \tau_2 e_2 + \tau_3 e_3 + \tau_4 e_4 + \tau_5 e_5 + \tau_6 e_6]$$

$$= \frac{1}{2}[\tau_{11} e_{11} + \tau_{22} e_{22} + \tau_{33} e_{33} + 2\tau_{23} e_{23} + 2\tau_{13} e_{13} + 2\tau_{12} e_{12}]$$

$$= \frac{1}{2}\tau_{ij} e_{ij} \quad , \; i, j = 1, 2, 3 . \tag{15}$$

This **result in (14) is called Claperon formula.**

Result II : For an isotropic elastic medium , the Hooke's law gives

$$\tau_{ij} = \lambda \delta_{ij} e_{kk} + 2\mu e_{ij} \quad , \quad i, j = 1, 2, 3. \tag{16}$$

This gives

$$W = \frac{1}{2} e_{ij}[\lambda\delta_{ij} e_{kk} + 2\mu e_{ij}]$$

$$= \frac{1}{2}\lambda e_{kk} e_{kk} + \mu e_{ij} e_{ij} .$$

$$= \frac{1}{2}\lambda e_{kk}^2 + \mu e_{ij}^2$$

$$= \frac{1}{2}\lambda(e_{11} + e_{22} + e_{33})^2 + \mu(e_{11}^2 + e_{22}^2 + e_{33}^2 + 2e_{12}^2 + 2e_{13}^2 + 2e_{23}^2) . \tag{17}$$

Result 3: Also , we have

$$e_{ij} = -\frac{\sigma}{E} \delta_{ij} \tau_{kk} + \frac{1+\sigma}{E}\tau_{ij} . \tag{18}$$

Hence

$$W = \frac{1}{2} \tau_{ij} [-\frac{\sigma}{E}\delta_{ij} \tau_{kk} + \frac{1+\sigma}{E} \tau_{ij}]$$

$$= -\frac{\sigma}{2E}\tau_{ii} \tau_{kk} + \frac{1+\sigma}{2E} \tau_{ij} \tau_{ij} . \tag{19}$$

Result 4: From equation (12) , we note that in the value of W , we may interchange e_i and τ_i . Consequently , interchanging e_i and τ_i in equation (4) , we obtain

$$\frac{\partial W}{\partial \tau_i} = e_i \quad , \quad \text{for } i = 1 , 2 , 3 , \ldots\ldots 6. \qquad (20)$$

This result is due to **Castigliano (1847 – 1884).**

It follows from the assumed linear assumed linear stress – strain relations.

Result 5: We know that the elastic moduli λ and μ are both positive for all physical elastic solids. The quadratic form on the right side of (17) takes only positive values for every set of values of the strains.

This shows that the strain energy function W is a positive definite form in the strain components e_{ij} , for an isotropic elastic solid.

Question : Show that the strain – energy function W for an isotropic solid **is independent** of the **choice of coordinate** axes.

Solution : We know that the strain energy function W is given by

$$W = \frac{1}{2} \tau_{ij} e_{ij}$$

$$= \frac{1}{2} e_{ij} (\lambda \delta_{ij} e_{kk} + 2\mu e_{ij})$$

$$= \frac{1}{2}\lambda(e_{11} + e_{22} + e_{33})^2 + \mu (e_{11}^2 + e_{22}^2 + e_{33}^2 + 2e_{12}^2 + 2e_{13}^2 + 2e_{23}^2] \quad . (1)$$

Let

$$I_1 = e_{ii} = e_{11} + e_{22} + e_{33} , \qquad (2)$$

$$I_2 = e_{ii} e_{jj} – e_{ij} e_{ji} \quad . \qquad (3)$$

be the first and second invariants of the strain tensor e_{ij}. As the given medium is isotropic , the elastic moduli λ and μ are also independent of the choice of coordinate axes. We write

$$W = \frac{1}{2}\lambda I_1^2 + \mu [(e_{11} + e_{22} + e_{33})^2 – 2 e_{11} e_{22} – 2 e_{22} e_{33}$$

$$– \quad 2 e_{33} e_{11} + 2e_{12}^2 + 2e_{13}^2 + 2e_{23}^2]$$

$$= \frac{1}{2} \lambda I^2 + \mu [I_1^2 – 2\{(e_{11} e_{22} – e_{12}^2) + (e_{22} e_{33} – e_{23}^2) + (e_{11} e_{33} – e_{13}^2\}]$$

$$= \frac{1}{2}\ \lambda\, I_1^2 + \mu\, I_1^2 - 2\,\mu\, I_2$$

$$= \left(\frac{\lambda}{2} + \mu\right) I_1^2 - 2\mu\, I_2 \,. \qquad (4)$$

Hence , equation (4) shows that the strain energy function W is invariant relative to all rotations of cartesian axes.

Question : Evaluate W for the stress field (for an isotropic solid)

$$\tau_{11} = \tau_{22} = \tau_{33} = \tau_{12} = 0$$

$\tau_{13} = -\mu\,\alpha\, x_2$, $\tau_{23} = \mu\,\alpha\, x_1$, $\alpha \neq 0$ is a constant and μ is the Lame's constant

Solution : We find

$$\tau_{kk} = \tau_{11} + \tau_{22} + \tau_{33} = 0.$$

Hence , the relation

$$e_{ij} = \frac{1}{2\mu}\left[\tau_{ij} - \frac{\lambda}{3\lambda + 2\mu}\,\delta_{ij}\,\tau_{kk}\right] \qquad ;\quad i\,,\, j = 1\,,\, 2\,,\, 3.$$

gives

$$e_{ij} = \frac{1}{2\mu}\,\tau_{ij}$$

That is , $e_{11} = e_{22} = e_{33} = e_{12} = 0$, (1)

$$e_{13} = -\frac{1}{2}\,\alpha\, x_2 \ , e_{12} = \frac{1}{2}\,\alpha\, x_1 \,. \qquad (2)$$

The energy function W is given by

$$W = \frac{1}{2}\,\tau_{ij}\, e_{ij}$$

$$= \frac{1}{4\mu}\,\tau_{ij}\,\tau_{ij}$$

$$= \frac{1}{4\mu}\left[\tau_{13}^2 + \tau_{23}^2\right]$$

$$= \frac{1}{4}\mu\alpha^2(x_1^2 + x_2^2).$$

Exercise : Show that the strain energy function W is given by

$$W = W_1 + W_2 \ ,$$

where $W_1 = \frac{1}{2}\ k\ e_{ii}\ e_{ii} = \frac{1}{18k}\ \tau_{ii}\ \tau_{ii}$, $\quad k$ = bulk modulus ,

and $W_2 = \frac{1}{3}\mu[(e_{11} - e_{22})^2 + (e_{22} - e_{33})^2 + (e_{33} - e_{11})^2 + 6(e_{12}^2 + e_{23}^2 + e_{31}^2)]$

$$= \frac{1}{12\mu}[(\tau_{11} - \tau_{22})^2 + (\tau_{22} - \tau_{33})^2 + (\tau_{33} - \tau_{11})^2 + 6(\tau_{12}^2 + \tau_{23}^2 + \tau_{31}^2)] \ .$$

Question : If $W = \frac{1}{2}[\lambda\ e_{kk}^2 + 2\mu\ e_{ij}\ e_{ij}]$, prove the following ,

(i) $\dfrac{\partial W}{\partial e_{ij}} = \tau_{ij}$

(ii) $W = \frac{1}{2}\tau_{ij}\ e_{ij}$

(iii) W is a scalar invariant.

(iv) $W \geq 0$ and $W = 0$ iff $e_{ij} = 0$

(v) $\dfrac{\partial W}{\partial \tau_{ij}} = e_{ij}$.

Solution : We note that W is a function of e_{ij}. Partial differentiation of this function w.r.t. e_{ij} gives

$$\frac{\partial W}{\partial e_{ij}} = \frac{1}{2}[\lambda.2e_{kk}\ \frac{\partial e_{kk}}{\partial e_{ij}} + 4\mu\ e_{ij}]$$

$$= [\ \lambda\ e_{kk}\ \delta_{ij} + 2\ \mu\ e_{ij}]$$

$$= \tau_{ij} \ . \qquad (1)$$

(ii) We write

$$W = \frac{1}{2}[\lambda\ e_{kk}\ e_{kk} + 2\ \mu\ e_{ij}\ e_{ij}]$$

$$= \frac{1}{2}[\lambda\ e_{kk}\{\delta_{ij}\ e_{ij}\} + 2\ \mu\ e_{ij}\ e_{ij}]$$

$$= \frac{1}{2} (\lambda \, \delta_{ij} \, e_{kk} + 2 \, \mu \, e_{ij}) \, e_{ij}$$

$$W = \frac{1}{2} \, \tau_{ij} \, e_{ij} \quad . \qquad (2)$$

(iii) Since τ_{ij} and e_{ij} are components of tensors , each of order 2 , respectively. So by contraction rule, $W = \frac{1}{2} \tau_{ij} \, e_{ij}$ is a scalar invariant.

(iv) Since $\lambda > 0$, $\mu > 0$, $e_{kk}^2 \geq 0$ and $e_{ij} \, . \, e_{ij} \geq 0$, if follows that $W \geq 0$.

Moreover $W = 0$ iff $e_{kk} = 0$ and $e_{ij} = 0$. Since $e_{ij} = 0$ automatically implies that $e_{kk} = 0$. Hence $W = 0$ holds iff $e_{ij} = 0$.

(v) Putting

$$e_{ij} = \frac{1+\sigma}{E} \, \tau_{ij} - \frac{\sigma}{E} \tau_{kk} \, \delta_{ij}$$

into (2) , we find

$$W = \frac{1}{2} [\frac{1+\sigma}{E} \, \tau_{ij} \, \tau_{ij} - \frac{\sigma}{E} \tau_{kk} \, \delta_{ij} \, \tau_{ij}] = \frac{1}{2} [\frac{1+\sigma}{E} \, \tau_{ij} \, \tau_{ij} - \frac{\sigma}{E} \tau_{kk}^2] \quad .$$

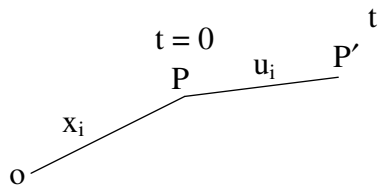
This implies

$$\frac{\partial W}{\partial \tau_{ij}} = \frac{1+\sigma}{E} \tau_{ij} - \frac{\sigma}{E} \, \tau_{kk} \, \frac{\partial \tau_{kk}}{\partial \tau_{ij}} \Rightarrow \frac{\partial W}{\partial \tau_{ij}} = \frac{1+\sigma}{E} \tau_{ij} - \frac{\sigma}{E} \tau_{kk} \, \delta_{ij} = e_{ij} \quad . \; (3)$$

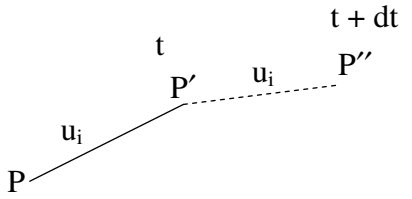
Theorem : Show that the total work done by the external forces in altering (changing) the configuration of the **natural state** to the state at **time t** is equal to the sum of the **kinetic energy** and the **strain energy**.

Proof : the natural / unstrained state of an elastic body is one in which there is a uniform temperature and zero displacement with reference to which all strains will be specified.

Let the body be in the natural state when $t = 0$. Let $(x_1 \, , \, x_2 \, , \, x_3)$ denote the coordinate of an arbitrary material point of the elastic body in the undeformed / unstrained state.



If the elastic body is subjected to the action of external forces , then it may produce a deformation of the body and at any time 't' , the coordinate of the same material point will be $x_i + u_i(x_1 , x_2 , x_3 , t)$.



The displacement of the point P in the interval of time (t , t + dt) is given by

$$\frac{\partial u_i}{\partial t}\,dt = \dot{u}_i\,dt \quad ,$$

where

$$\dot{u}_i = \frac{\partial u_i}{\partial t} \quad .$$

The work done by the body forces F_i acting on the volume element $d\tau$, in time 'dt' sec , located at the material point P is

$$(F_i\,d\tau)\,(\dot{u}_i\,dt) = F_i\,\dot{u}_i\,d\tau\,dt \quad ,$$

and the work performed by the external surface forces $\overset{v}{T}_i$ in time interval (t , t + dt) is

$$\overset{v}{T}_i\,\dot{u}_i\,d\sigma\,dt \quad ,$$

where $d\sigma$ is the element of surface.

Let E denote the work done by the body and surface forces acting on the elastic body.

Then , the rate of doing work on the body originally occupying some region τ (by external forces) is

$$\frac{dE}{dt} = \int_{\tau} F_i\,\dot{u}_i\,d\tau + \int_{\Sigma} \overset{v}{T}_i\,\dot{u}_i\,d\sigma \quad , \qquad (1)$$

where Σ denotes the original surface of the elastic body.

Now $\int_{\Sigma} \overset{v}{T}_i \, \dot{u}_i \, d\sigma = \int_{\Sigma} (\tau_{ij} \, v_j) \, \dot{u}_i \, d\sigma$

$$= \int_{\Sigma} (\tau_{ij} \, \dot{u}_i) \, v_j \, d\sigma$$

$$= \int_{\tau} (\tau_{ij} \, \dot{u}_i)_{,j} \, d\tau \quad ,$$

$$= \int_{\tau} [\, \tau_{ij,j} \, \dot{u}_i + \tau_{ij} \, \dot{u}_{i,j} \,] \, d\tau$$

$$= \int_{\tau} \tau_{ij,j} \, \dot{u}_i \, d\tau + \int_{\tau} \tau_{ij} \, \dot{\varepsilon}_{ij} \, d\tau + \int_{\tau} \tau_{ij} \, \dot{w}_{ij} \, d\tau \quad , \qquad (2)$$

where

$$\dot{\varepsilon}_{ij} = (\dot{u}_{i,j} + \dot{u}_{j,i})/2 \quad ,$$

$$\dot{w}_{ij} = (\dot{u}_{i,j} - \dot{u}_{j,i})/2 \quad . \qquad (3)$$

Since

$$\dot{w}_{ij} = -\dot{w}_{ji} \quad \text{and} \quad \tau_{ij} = \tau_{ji} \, ,$$

so

$$\tau_{ij} \, \dot{w}_{ij} = 0 \quad , \qquad (4a)$$

From dynamical equations of motion for an isotropic body , we write

$$\tau_{ij,j} = \rho \, \ddot{u}_i - F_i \quad .$$

Therefore, $\tau_{ij,j} \, \dot{u}_i = \rho \, \ddot{u}_i \, \dot{u}_i - F_i \, \dot{u}_i \quad .$ (4b)

Using results (4a ,b) ; we write from equations (3) and (1) ,

$$\frac{dE}{dt} = \int_{\tau} F_i \, \dot{u}_i \, d\tau + \int_{\tau} [\rho \, \ddot{u}_i \, \dot{u}_i - F_i \, \dot{u}_i] \, d\tau + \int_{\tau} \tau_{ij} \, \dot{\varepsilon}_{ij} \, d\tau$$

$$= \int_{\tau} \rho \, \ddot{u}_i \, \dot{u}_i \, d\tau + \int_{\tau} \tau_{ij} \, \dot{\varepsilon}_{ij} \, d\tau \quad . \qquad (5)$$

The kinetic energy K of the body in motion is given by

$$K = \frac{1}{2}\int_{\tau} \rho\, \dot{u}_i \dot{u}_i \, d\tau \qquad (6)$$

Then

$$\frac{dK}{dt} = \int_{\tau} \rho\, \ddot{u}_i \dot{u}_i \, d\tau \,. \qquad (7)$$

We define the engineering notation

$$\left.\begin{aligned} &\tau_{11} = \tau_1 \,,\ \tau_{22} = \tau_2 \,,\ \tau_{33} = \tau_3 \\ &\tau_{23} = \tau_4 \,,\ \tau_{13} = \tau_5 \,,\ \tau_{12} = \tau_6 \\ &e_{11} = e_1 \,,\ e_{22} = e_2 \,,\ e_{33} = e_3 \\ &2e_{23} = e_4 \,,\ 2e_{13} = e_5 \,,\ 2e_{12} = e_6 \end{aligned}\right\} \,. \qquad (8)$$

Then $$\int_{\tau} \tau_{ij}\, \dot{e}_{ij} \, d\tau = \int_{\tau} \tau_i \frac{\partial e_i}{\partial t} \, d\tau \quad , \qquad (9)$$

for i = 1 , 2 , 3, … , 6, and under isothermal condition , there exists a energy function

$$W = W(e_1 \,,\, e_2 \,,\ldots\ldots \,,\, e_6) \quad ,$$

with the property that

$$\frac{\partial W}{\partial e_i} = \tau_i \quad , \qquad (10)$$

$1 \le i \le 6$. From equations (9) and (10) , we write

$$\int_{\tau} \tau_{ij}\, \dot{e}_{ij} d\tau = \int_{\tau} \left(\frac{\partial W}{\partial e_i} \frac{\partial e_i}{\partial t} \right) d\tau = \frac{d}{dt} \int_{\tau} W \, d\tau$$

$$= \frac{dU}{dt} \quad , \qquad (11)$$

where

$$U = \int_{\tau} W \, d\tau \quad . \qquad (12)$$

From equations (5) , (7) and (11) , we write

$$\frac{dE}{dt} = \frac{dK}{dt} + \frac{dU}{dt} \quad . \tag{13}$$

Integrating equation (13) w.r.t. 't' between the limits t = 0 and t = t , we obtain

$$E = K + U \ , \tag{14}$$

since both E and K are zero at t = 0.

The equation (14) proves the required result.

Note 1: If the elastic body is in equilibrium instead of in motion , then K = 0 and

consequently E = U.

Note 2: U is called the total strain energy of the deformation.

5.3. CLAPEYRON'S THEOREM

Statement. If an elastic body **is in equilibrium** under a given system of body forces F_i and surface forces $\overset{v}{T}_i$, then the **strain energy of deformation** is equal to **one – half** the work that would be **done by the external forces** (of the equilibrium state) acting through the **displacements u_i** form the **unstressed state** to the **state of equilibrium**.

Proof : We are required to prove that

$$\int_{\tau} F_i \, u_i \, d\tau + \int_{\Sigma} \overset{v}{T}_i \, u_i \, d\sigma = 2 \int_{\tau} W \, d\tau \quad , \tag{1}$$

where Σ denotes the original surface of the unstressed region τ of the body and W is the energy density function representing the strain every per unit volume. Now

$$\int_{\Sigma} \overset{v}{T}_i \, u_i \, d\sigma = \int_{\Sigma} \tau_{ij} \, u_i \, v_j \, d\sigma$$

$$= \int_{\tau} (\tau_{ij} \, u_i)_{,\,j} \, d\tau$$

$$= \int_{\tau} \{\tau_{ij\,,\,j} \, u_i + \tau_{ij} \, u_{i\,,\,j}\} \, d\tau$$

$$= \int_{\tau} \tau_{ij\,,\,j}\, u_i \, d\tau + \int_{\tau} \tau_{ij} \left\{ \frac{u_{i,j} + u_{j,i}}{2} + \frac{u_{i,j} - u_{j,i}}{2} \right\} d\tau$$

$$= \int_{\tau} \tau_{ij\,,\,j}\, u_i \, d\tau + \int_{\tau} \tau_{ij}\, (e_{ij} + w_{ij})\, d\tau$$

$$= \int_{\tau} (\tau_{ij\,,\,j}\, u_i + \tau_{ij}\, e_{ij})\, d\tau \qquad (2)$$

since

$$w_{ij} = - w_{ji} \text{ and } \tau_{ij} = \tau_{ji} .$$

Again from (2)

$$\int_{\Sigma} \overset{v}{T}_i \, u_i \, d\sigma = \int_{\tau} (-F_i \, u_i + 2W)\, d\tau \ , \qquad (3)$$

since

$$\tau_{ij\,,\,j} + F_i = 0 \ ,$$

being the equilibrium equations and

$$W = \frac{1}{2} \tau_{ij}\, e_{ij} \ .$$

From (3) , we can write

$$\int_{\tau} F_i \, u_i \, d\tau + \int_{\Sigma} \overset{v}{T}_i \, u_i \, d\sigma = 2 \int_{\tau} W \, d\tau \ , \qquad (4)$$

proving the theorem.

5.4 RECIPROCAL THEOREM OF BETTI AND RAYLEIGH

Statement : If an elastic body is subjected to two systems of body and surface forces producing two equilibrium states , show that the work done by the system of forces in acting through the displacements of the second system is equal to the work done by the second system of forces in acting through the displacements of the first system.

Proof : Let the first system of body and surface forces $\{F_i \ , \ \overset{v}{T}_i \}$ produces the displacement u_i and the second system $\{F_i' \ , \ \overset{v}{T}_i' \}$ produces displacements u_i'. Let

W_1 = work done by the first system of forces in acting through the displacement of the second system.

Then

$$W_1 = \int_V F_i \, u_i' \, dv + \int_S T_i^{v} \, u_i' \, ds$$

$$= \int_V F_i \, u_i' \, dv + \int_S \tau_{ij} \, \nu_j \, u_i' \, ds$$

$$= \int_V F_i \, u_i' \, dv + \int_V (\tau_{ij} \, u_i')_{,j} \, dv$$

$$= \int_V F_i \, u_i' \, dv + \int_V \tau_{ij,j} \, u_i' \, dv + \int_V \tau_{ij} \, u'_{i,j} \, dv$$

$$= \int_V (\tau_{ij,j} + F_i) u_i' \, dv + \int_V \tau_{ij} \, e'_{ij} \, dv \quad ,$$

$$= \int_V \tau_{ij} \, e'_{ij} \, dv \quad , \qquad (1)$$

using equations of equilibrium

$$\tau_{ij,j} + F_i = 0 \quad .$$

Hence

$$W_1 = \int_V [\lambda \, \delta_{ij} \, e_{kk} + 2\mu \, e_{ij}] \, e'_{ij} \, dv$$

$$= \int_V [\lambda \, e_{kk} \, e'_{kk} + 2 \, \mu \, e_{ij} \, e'_{ij}] \, dv. \qquad (2)$$

This expression is symmetric in primed and unprimed quantities.

We conclude that $W_1 = W_2$ where W_2 is the workdone by the forces of the second system in acting through the displacements u_i of the first system.

This completes the proof of the theorem.

Corollary : Let $\overset{(1)}{\tau}_{ij}$ be the stresses corresponding to the strains $\overset{(1)}{e}_{ij}$ and $\overset{(2)}{\tau}_{ij}$ be the stresses corresponding to the strains $\overset{(2)}{e}_{ij}$, in an elastic body. Prove that

$$\overset{(1)}{\tau}_{ij}\ \overset{(2)}{e}_{ij} = \overset{(2)}{\tau}_{ij}\ \overset{(1)}{e}_{ij} .$$

Remark 1: Reciprocal theorem relates the equilibrium states of an elastic solid under the action of different applied loads.

Remark 2: An alternative form of the reciprocal theorem is

$$\int_{\Sigma} T_i\, u_i' \, d\sigma + \int_{\tau} F_i\, u_i' \, d\tau = \int_{\tau} \tau_{ij}\, e'_{ij} \, d\tau .$$

5.5. THEOREM OF MINIMUM POTENTIAL ENERGY

Now, we introduce an important functional , **called the potential energy of deformation ,** and prove that this functional attains an absolute minimum when the displacements of the elastic body are those of the equilibrium configuration.

Statement : Of all displacements satisfying the given boundary conditions, those which satisfy the equilibrium equations make the potential energy an absolute minimum.

Proof : Let a body τ be in equilibrium under the action of specified body and surface forces. Suppose that the surface forces T_i are prescribed only over a portion Σ_T of the surface Σ , and over the remaining surface Σ_u the displacements are known.

We denote the displacements of the equilibrium state by u_i. We consider a class of arbitrary displacements $u_i + \delta u_i$, consistent with constraints imposed on the elastic body. This means that

$$\delta u_i = 0 \quad , \qquad \text{on } \Sigma_u \qquad (1)$$

but δu_i are arbitrary over the part Σ_T , except for the condition that they belong to class C^3 and are of the order of magnitude of displacements admissible in linear elasticity.

Displacements δu_i are called **virtual displacements** .

We know that the strain energy U is given by the formula

$$U = \int_{\tau} W \, d\tau \ , \qquad (2)$$

where the strain energy function W is given by the formula

$$W = \frac{1}{2}\ \lambda\, e_{kk}\, e_{kk} + \mu\, e_{ij}\, e_{ij} \quad , \tag{3}$$

λ and μ being Lame constants , and e_{ij} strain tensor.

The strain energy U is equal to the work done by the external forces on the elastic body in the process of bringing the body from the natural state to the equilibrium state characterized by the displacements u_i.

The **virtual work δU** performed by the external force F_i and T_i during the virtual displacements δu_i is defined by the equation

$$\delta U = \int_{\tau} F_i\, \delta u_i\, d\tau + \int_{\Sigma} T_i\, \delta u_i\, d\sigma \ . \tag{4}$$

Since the volume τ is fixed and the forces F_i and T_i do not vary when the arbitrary variations δu_i are considered , equation (4) can be written in the form

$$\delta U = \delta\left(\int_{\tau} F_i\, u_i\ d\tau + \int_{\Sigma} T_i\, u_i\, d\sigma \right) \quad . \tag{5}$$

From equation (2) , we have

$$\delta U = \delta\left(\int_{\tau} W\ d\tau \right) \ . \tag{6}$$

Equations (5) and (6) provide

$$\delta\left(\int_{\tau} W\ d\tau \ - \int_{\tau} F_i\, u_i\ d\tau \ - \int_{\Sigma} T_i\, u_i\, d\sigma \right) = 0 \ . \tag{7}$$

The potential energy V is defined by the formula

$$V = \int_{\tau} W\ d\tau \ - \int_{\tau} F_i\, u_i\ d\tau \ - \int_{\Sigma} T_i\, u_i\, d\sigma \quad . \tag{8}$$

In view of equation (8) , relation (7) reads

$$\delta\, V = 0. \tag{9}$$

This formula shows that the potential energy functional V has a stationary value in a class of admissible variations δu_i of the displacements u_i of the equilibrium state.

We shall finally show that the functional V assumes a minimum value when the displacements u_i are those of the equilibrium state.

To show this , we demonstrate that the **increment** ΔV produced in V by replacing the equilibrium displacements u_i by $u_i + \delta u_i$ is positive for all non – vanishing variations δu_i.

First , we calculate the increment ΔW in W. From (3)

$$\Delta W = \left(\frac{\lambda}{2} v^2 + \mu e_{ij}\, e_{ij}\right)\Big|_{u_i+\delta u_i} - \left(\frac{\lambda}{2} v^2 + \mu e_{ij}\, e_{ij}\right)\Big|_{u_i} . \qquad (10)$$

Now

$$e_{ij}\,|_{u_i+\delta u_i} = \frac{1}{2}(u_{i,j} + u_{j,i})\,|_{u_i+\delta u_i}$$

$$= \frac{1}{2}\,(u_{i,j} + u_{j,i}) + \frac{1}{2}\,[(\delta u_i)_{,j} + (\delta u_j)_{,i}]$$

$$= e_{ij} + \frac{1}{2}\,(\delta u_i)_{,j} + \frac{1}{2}\,(\delta u_j)_{,i} \qquad (11)$$

and

$$v|_{u_i+\delta u_i} = e_{kk}\,|_{u_i+\delta u_i}$$

$$= e_{ii} + (\delta u_i)_{,\,i}$$

$$= v + (\delta u_i)_{,\,i} \qquad (12)$$

Therefore , equations (10) to (12) yield

$$\Delta W = \left(\frac{\lambda}{2}\right)[v + (\delta u_i)_{,i}]\,[v + (\delta u_i)_{,\,i}] + \mu[e_{ij} + \frac{1}{2}(\delta u_i)_{,i} + \frac{1}{2}(\delta u_j)_{,i}]$$

$$\times [e_{ij} + \frac{1}{2}(\delta u_i)_{,j} + \frac{1}{2}(\delta u_i)_{,i}] - \left(\frac{\lambda}{2}\right) v^2 - \mu\, e_{ij}\, e_{ij}$$

$$= \lambda\, v\, (\delta u_i)_{,\,i} + 2\mu\, e_{ij}\, (\delta u_i)_{,\,j} + P \quad , \qquad (13)$$

where

$$P = \left(\frac{\lambda}{2}\right)[(\delta u_i)_{,\,i}]^2 + \left(\frac{\mu}{4}\right)[(\delta u_i)_{,\,j} + (\delta u_j)_{,i}]^2 \geq 0 \quad . \qquad (14)$$

Equation (13) can be rewritten in the form

$$\Delta W = \lambda \nu \delta_{ij} (\delta u_i)_{,j} + 2 \mu e_{ij} (\delta u_i)_{,j} + P$$

$$= (\lambda \nu \delta_{ij} + 2 \mu e_{ij}) [(\delta u_i)_{,j}] + P$$

$$= \tau_{ij} [(\delta u_i)_{,j}] + P. \qquad (15)$$

The increment ΔU in strain energy is , therefore ,

$$\Delta U = \int_{\tau} \Delta W \, d\tau$$

$$= \int_{\tau} \tau_{ij} (\delta u_i)_{,j} \, d\tau + \int_{\tau} P \, d\tau$$

$$= \int_{\tau} [(\tau_{ij} \delta u_i)_{,j} - \tau_{ij,j} \delta u_i] \, d\tau + Q$$

$$= \int_{\tau} (\tau_{ij} \delta u_i)_{,j} \, d\tau - \int_{\tau} \tau_{ij,j} \delta u_i \, d\tau + Q$$

$$= \int_{\Sigma} \tau_{ij} v_j \delta u_i \, d\sigma - \int_{\tau} \tau_{ij,j} \delta u_i \, d\tau + Q \quad . \qquad (16)$$

In equation (16) , we have used divergence theorem and

$$Q = \int_{\tau} P \, d\tau \geq 0 \quad . \qquad (17)$$

Since $P \geq 0$ by virtue of (14).

If the body is in equilibrium , then we have

$$\tau_{ij,j} = - F_i \quad , \quad \text{in } \tau \qquad (18)$$

$$\tau_{ij} \nu_j = \overset{\nu}{T}_i \quad , \quad \text{on } \Sigma \qquad (19)$$

and , therefore , equation (16) becomes

$$\Delta U = \int_{\Sigma} \overset{\nu}{T}_i \delta u_i \, d\sigma + \int_{\tau} F_i \delta u_i \, d\tau + Q. \qquad (20)$$

Using the definition (8) for potential energy. we get

$$\Delta V = \Delta U - \int_{\tau} F_i \, \delta u_i \, d\tau - \int_{\Sigma} \overset{v}{T_i} \, \delta u_i \, d\sigma \ . \qquad (21)$$

Substituting (20) in (21) , we obtain

$$\Delta V = \left[\int_{\Sigma} \overset{v}{T}_i \, \delta u_i \, d\sigma + \int_{\tau} F_i \, \delta u_i \, d\tau + Q \right] - \int_{\tau} F_i \, \delta u_i \, d\tau - \int_{\Sigma} \overset{v}{T_i} \, \delta u_i \, d\sigma$$

$$= Q \ . \qquad (22)$$

Since

$$Q \geq 0 \ ,$$

(Q = 0 in the case of equilibrium only as P = 0 in this case), we find

$$\Delta V \geq 0. \qquad (23)$$

This completes the proof of the theorem.

Converse : Assume that there is a set of admissible functions $u_i + \delta u_i$ which satisfy the prescribed boundary conditions and such that

$$\Delta V = [\Delta U - \int_{\Sigma} \overset{v}{T_i} \, \delta u_i \, d\sigma - \int_{\tau} F_i \, \delta u_i \, d\tau \ ] \geq 0 \ , \qquad (24)$$

on this set of functions.

From equation (16) , we write

$$\Delta U = \int_{\Sigma} \tau_{ij} \, \nu_j \, \delta u_i \, d\sigma - \int_{\tau} \tau_{ij \, , j} \, \delta u_i \, d\tau + Q \quad ,$$

where Q is given in (17). Inserting this value of ΔU in (24) , we obtain

$$\left[- \int_{\tau} (\tau_{ij \, , j} + F_i) \, \delta u_i \, d\tau + \int_{\Sigma} \tau_{ij} \, \nu_j - \overset{v}{T_i}) \, \delta u_i \, d\sigma + Q \right] \geq 0 \ . \qquad (25)$$

On the part Σ_T of Σ , where T_i are assigned ,

$$\tau_{ij} \, \nu_j - T_i = 0 \quad , \qquad (26)$$

and over the remaining part Σ_u of Σ ,

$$\delta u_i = 0 \quad . \tag{27}$$

Therefore ,

$$\int_{\Sigma} (\tau_{ij}\, v_j - \overset{v}{T}_i)\, \delta u_i \, d\sigma = 0. \tag{28}$$

Hence , equation (25) reduces to

$$\left[-\int_{\tau} (\tau_{ij\,,j} + F_i)\, \delta u_i \, d\tau + Q \right] \geq 0. \tag{29}$$

Since Q is essentially positive and the displacements δu_i **are arbitrary** , the inequality (29) implies that

$$\tau_{ij,j} + F_i = 0 \quad , \tag{30}$$

for every point interior to τ.

Thus , the equations of equilibrium are satisfied for every interior point in τ. This proves the converse part.

5.6. THEOREM OF MINIMUM COMPLEMENTARY ENERGY

Definition : The complementary energy V* is defined by the formula

$$V^* = U - \int_{\Sigma u} T_i\, u_i \, d\sigma = \int_{\tau} W \, d\tau - \int_{\Sigma u} T_i\, u_i \, d\sigma \quad ,$$

where U is the strain energy and W is the strain energy function.

Statement : The complementary energy V* has an absolute minimum when the stress tensor τ_{ij} is that of the equilibrium state and the varied states of stress fulfill the following conditions :

(i) $(\delta\tau_{ij})_{\,,j} = 0$ in τ ,

(ii) $(\delta\, \tau_{ij}) v_j = 0$ on Σ_T ,

(iii) $\delta\tau_{ij}$ are arbitrary on Σ_u .

Proof : Let a body τ be in equilibrium under the action of body forces F_i and surface forces T_i assigned over a part Σ_T of the surface Σ. On the remaining part Σ_u of Σ , the displacements u_i are assumed to be known.

If the τ_{ij} are the stress components of the equilibrium state , then we have

$$\left.\begin{aligned} \tau_{ij\,,\,j} + F_i = 0 \quad &\text{in } \tau\,, \\ \tau_{ij}\, \nu_j = T_i \quad &\text{on } \Sigma_T\,, \\ u_i = f_i \quad &\text{on } \Sigma_u\,. \end{aligned}\right\} \qquad \begin{aligned} &(1)\\ &(2)\\ &(3) \end{aligned}$$

We introduce a set of functions $\overset{1}{\tau}_{ij}$ of class C^2 the body τ , which we shall also write as

$$\overset{1}{\tau}_{ij} = \tau_{ij} + \delta\tau_{ij}\,, \qquad (4)$$

satisfying the conditions :

(i) $\overset{1}{\tau}_{ij\,,\,j} + F_i = 0$, in τ (5)

(ii) $\overset{1}{\tau}_{ij}\, \nu_j = T_i$, on Σ_T (6)

(iii) $\overset{1}{\tau}_{ij}$ are arbitrary on the surface Σ_u .

From equations (4) and (5) at each point of τ ; we write

$$(\tau_{ij} + \delta\,\tau_{ij})_{\,,\,j} + F_i = 0$$

$$(\tau_{ij\,,\,j} + F_i)\ (\delta\tau_{ij})_{\,,\,j} = 0$$

$$(\delta\,\tau_{ij})_{,j} = 0 \qquad \text{in } \tau \quad . \qquad (7)$$

Also from equations (4) and (6) , we have

$$(\tau_{ij} + \delta\,\tau_{ij})\, \nu_j = T_i \qquad \text{on } \Sigma_T$$

$$\tau_{ij}\, \nu_j + (\delta\tau_{ij})\, \nu_j = T_i \qquad \text{on } \Sigma_T\,,$$

$$(\delta\tau_{ij})\, \nu_j = 0 \qquad \text{on } \Sigma_T \quad . \qquad (8)$$

Since $\overset{1}{\tau}_{ij}$ are arbitrary on Σ_u , so the variations $\delta\tau_{ij}$ are arbitrary on Σ_u.

As the stresses τ_{ij} are associated with the equilibrium state of the body , so τ_{ij} satisfy the Biltrami – Michell compatibility equations. Let W denote the strain – energy density function. It is given by the formula

$$W = \left(\frac{1+\sigma}{2E}\right)\tau_{ij}\ \tau_{ij} - \left(\frac{\sigma}{2E}\right)\tau_{ii}\ \tau_{ii} \quad , \qquad (9)$$

where σ = Poisson ration and E = Young's modulus.

The increment ΔU in the strain energy U is given by the formula

$$\Delta U = \int_{\tau} \Delta W \, d\tau \quad , \tag{10}$$

where the increment ΔW in W is produced by replacing τ_{ij} in (9) by $\overset{1}{\tau}_{ij} = \tau_{ij} + \delta \tau_{ij}$. That is ,

$$W + \Delta W = \left(\frac{1+\sigma}{2E}\right)(\tau_{ij} + \delta\tau_{ij})\,(\tau_{ij} + \delta\,\tau_{ij}) - \left(\frac{\sigma}{2E}\right)(\tau_{ii} + \delta\tau_{ii})^2$$

$$= W + \left(\frac{1+\sigma}{2E}\right)[2\tau_{ij}(\delta\,\tau_{ij}) + (\delta\,\tau_{ij})] - \left(\frac{\sigma}{2E}\right)[2\,\tau_{ii}\,(\delta\,\tau_{ii}) + (\delta\,\tau_{ii})^2] \quad .$$

Hence ,

$$\Delta W = \left(\frac{1+\sigma}{E}\right)\tau_{ij}\,(\delta\,\tau_{ij}) - \frac{\sigma}{E}\tau_{ii}(\delta\,\tau_{ii}) + W(\delta\,\tau_{ij}) \, , \tag{11}$$

where

$$W(\delta\,\tau_{ij}) = \left[\left(\frac{1+\sigma}{2E}\right)(\delta\tau_{ij})(\delta\tau_{ij}) - \left(\frac{\sigma}{2E}\right)(\delta\tau_{ii})^2\right] \geq 0 \, , \tag{12}$$

since the strain energy function W is a positive definite quadric form in its variables.

From Hooke's law for isotropic solids , we have

$$e_{ij} = \left(\frac{1+\sigma}{E}\right)\tau_{ij} - \left(\frac{\sigma}{E}\right)\tau_{kk}\,\delta_{ij} \, . \tag{13}$$

From equations (11) to (12) , we write

$$\Delta W = \left[\left(\frac{1+\sigma}{2E}\right)\tau_{ij} - \left(\frac{\sigma}{E}\right)\tau_{kk}\,\delta_{ij}\right](\delta\,\tau_{ij}) + W\,(\delta\,\tau_{ij})$$

$$= (e_{ij})\,(\delta\,\tau_{ij}) + W(\delta\,\tau_{ij})$$

$$= \left(\frac{u_{i,j} + u_{j,i}}{2}\right)(\delta\,\tau_{ij}) + W(\delta\,\tau_{ij})$$

$$= (u_{i,j})\ (\delta\ \tau_{ij}) + W(\delta\ \tau_{ij})$$

$$= [(u_i\ \delta\ \tau_{ij})_{,j} - u_i(\delta\ \tau_{ij})_{,j}] + W(\delta\ \tau_{ij}). \qquad (14)$$

Since the stress components τ_{ij} were assumed to satisfy the Beltrami – Michell compatibility equations , therefore, the displacements u_i appearing in (14) are those of the actual equilibrium state of the body.

Using (14) in (10) , the increment ΔU in the strain energy becomes

$$\Delta U = \int_{\tau} [(u_i\ \delta\ \tau_{ij})_{,j} - u_i\ (\delta\ \tau_{ij})_{,j} + W(\delta\tau_{ij})]\ d\tau$$

$$= \int_{\tau} (u_i\ \delta\tau_{ij})_{,j}\ d\tau - \int_{\tau} u_i(\delta\tau_{ij})_{,j}\ d\tau + \int_{\tau} W(\delta\tau_{ij})\ d\tau$$

$$= \int_{\Sigma_u} (u_i\ \delta\tau_{ij})\ v_j\ d\sigma + P\ , \qquad (15)$$

using the Gauss divergence theorem and equations (7) and (8). In equation (15) ,

$$P = \int_{\tau} W(\delta\ \tau_{ij})\ d\tau\ \geq 0. \qquad (16)$$

As the variations $\delta\tau_{ij}$ are arbitrary on the surface Σ_u , we write

$$(\delta\tau_{ij})\ v_j = \Delta T_i\ , \qquad \text{on } \Sigma_u \qquad (17)$$

then , equation (15) reads as

$$\Delta U = \int_{\Sigma_u} u_i\ \Delta T_i\ d\sigma + P\ . \qquad (18)$$

Since the displacements u_i are assigned on the surface Σ_u , we can write (18) as

$$\Delta(\ U - \int_{\Sigma_u} u_i\ \ T_i\ ) = P \geq 0\ ,$$

or

$$\Delta V^* \geq 0. \qquad (19)$$

That is , the increment ΔV^* in the complementary energy V^* (for the equilibrium state) is essentially positive.

Hence , the complementary energy functional V* has an absolute minimum in the case of an equilibrium state of the body.

This completes the proof.

5.7. THEOREM OF MINIMUM STRAIN ENERGY

Statement : The strain energy U of an elastic body in equilibrium under the action of prescribed surface forces is an absolute minimum on the set of all values of the functional U determined by the solutions of the system

$$\tau_{ij,j} + F_i = 0 \quad \text{in } \tau \quad , \qquad \tau_{ij}\, \nu_j = T_i \quad \text{on } \Sigma \ .$$

Proof : Continuing from the previous theorem on complementary energy , we write

$$(\delta\, \tau_{ij})\, \nu_j = 0 \quad \text{on } \mathbf{\Sigma} = \Sigma_T \cup \Sigma_u \ ,$$

and equation (15) reduces to

$$\Delta U = P \geq 0 \ ,$$

showing that the increment ΔU in the strain energy U of a body in equilibrium state is positive. Therefore , U is an absolute minimum.

Hence the result.

Chapter-6
Two-Dimensional Problems

6.1 INTRODUCTION

Many physical problems regarding the deformation of elastic solids are reducible to two-dimensional elastostatic problems. This reduction facilitates an easy solution.

6.2 PLANE STRAIN DEFORMATION

An elastic body is said to be in the state of plane strain deformation, parallel to the $x_1\ x_2$-plane, if the displacement component u_3 vanishes identically and the other two displacement components u_1 and u_2 are function of x_1 and x_2 coordinates only and independent of x_3 coordinate.

Thus, the state of plane strain deformation (parallel to x_1x_2-plane) is characterised by the displacement components of the following type

$$u_1 = u_1(x_1, x_2),\ u_2 = u_2(x_1, x_2),\ u_3 = 0. \qquad \ldots(1)$$

The plane strain deformation is a two-dimensional approximation.

A plane strain state is used for a body in which one dimension is much larger than the other two.

For example, a long pressurized pipe or a dam between two massive end walls is a suitable case of plane strain deformation.

The maintenance of a state of plane strain requires the application of tension or pressure over the terminal sections, adjusted so as to keep constant the lengths of all the longitudinal filaments.

The states of plane strain deformation can be maintained in bodies of cylindrical form by suitable forces. We take the generators of the cylindrical bounding surface to be parallel to the x_3-axis. We further suppose that the terminal sections are at right angles to this axis. The body force, if any, must be at right angles to the x_3-axis and independent of it.

The strain components, e_{ij} are given by the following strain-displacement relation

$$e_{ij} = \frac{1}{2}(u_{i,j} + u_{j,i})\ . \qquad \ldots(2a)$$

We find, for plane strain deformation parallel to x_1x_2-plane,

$$e_{13} = e_{23} = e_{33} = 0, \qquad \ldots(3)$$

and

$$e_{11} = \frac{\partial u_1}{\partial x_1},\ e_{22} = \frac{\partial u_2}{\partial x_2},$$

$$e_{12} = \frac{1}{2}\left(\frac{\partial u_1}{\partial x_2} + \frac{\partial u_2}{\partial x_1}\right), \qquad \ldots(4)$$

which are independent of x_3.

It shows that all non-zero strains are on the x_1x_2-plane and x_3-axis is strain-free/extension-free.

The strain matrix is, thus

$$(e_{ij}) = \begin{pmatrix} \dfrac{\partial u_1}{\partial x_1} & \dfrac{1}{2}\left(\dfrac{\partial u_1}{\partial x_2} + \dfrac{\partial u_2}{\partial x_1}\right) & 0 \\ \dfrac{1}{2}\left(\dfrac{\partial u_1}{\partial x_2} + \dfrac{\partial u_2}{\partial x_1}\right) & \dfrac{\partial u_2}{\partial x_2} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

The stress components τ_{ij} in terms of strains components e_{ij} are governed by generalized Hooke's law for isotropic elastic solids

$$\tau_{ij} = \lambda\, \delta_{ij}\, e_{kk} + 2\mu\, e_{ij}\ . \qquad \ldots(5a)$$

We find, for plane strain deformation parallel to x_1x_2-plane,

$$\tau_{11} = \lambda(e_{11} + e_{22}) + 2\mu\, e_{11} = (\lambda + 2\mu)\, e_{11} + \lambda\, e_{22}, \qquad \ldots(5b)$$

$$\tau_{22} = \lambda(e_{11} + e_{22}) + 2\mu\, e_{22} = \lambda\, e_{11} + (\lambda + 2\mu) e_{22}, \qquad \ldots(5c)$$

$$\tau_{12} = 2\mu\, e_{12}, \qquad \ldots(5d)$$

$$\tau_{13} = \tau_{23} = 0, \qquad \ldots(6a)$$

$$\tau_{33} = \lambda(e_{11} + e_{22}) = \sigma\,(\tau_{11} + \tau_{22})$$

$$= \frac{\lambda}{2(\lambda+\mu)}(\tau_{11} + \tau_{22}). \qquad \ldots(6b)$$

where

$$\sigma = \frac{\lambda}{2(\lambda+\mu)} ,$$

is the Poisson's ratio.

These relations shows all stress components are also independent of x_3 coordinate.

Since stress

$$\tau_{13} = \tau_{23} = 0, \text{ but } \tau_{33} \neq 0,$$

so the strain-free axis (x_3-axis) is not stress-free, in general.

The Cauchy's equilibrium equations for an elastic solid are

$$\tau_{ij,j} + f_i = 0, \qquad \ldots(7)$$

where $\underline{f} = f_i$ is the body force per unit volume.

In the case of plane strain deformation parallel to x_1x_2-plane, these equations reduce to, using equations (6),

$$\tau_{11,1} + \tau_{12,2} + f_1 = 0,$$

$$\tau_{12,1} + \tau_{22,2} + f_2 = 0,$$

$$f_3 = 0. \qquad \ldots(8)$$

It shows that, for a plane strain deformation parallel to x_1x_2-plane, the body force is also independent of x_3 coordinate and the body force must be perpendicular to x_3-direction.

In general, there are 6 Saint-Venant compatibility conditions for infinitesimal strain components. In the state of plane strain deformation five out of these 6 conditions are identically satisfied and the only compatibility condition to be considered further, for plane strain deformation parallel to x_1x_2-plane, is

$$e_{11,22} + e_{22,11} = 2\, e_{12,12} . \qquad \ldots(9)$$

Remark :- To distinguish plane strain case from the general case, we shall use subscripts α, β instead of i , j. We shall also assume that α, β vary form 1 to 2.

From equations (5a) and (8a, b); we write as follows:

$$\tau_{\alpha\beta,\beta} + f_\alpha = 0 , \qquad \text{for } \alpha = 1, 2 ,$$

$$\lambda\, \delta_{\alpha\beta}(e_{11} + e_{22})_{,\beta} + \mu\, (u_{\alpha,\beta\beta} + u_{\beta,\alpha\beta}) + f_\alpha = 0,$$

$$\lambda(e_{11} + e_{22})_{,\alpha} + \mu\, [\nabla^2 u_\alpha + (e_{11} + e_{22})_{,\alpha}] + f_\alpha = 0$$

$$(\lambda + \mu)\, \frac{\partial}{\partial x_\alpha}(e_{11} + e_{22}) + \mu\, \nabla^2 u_\alpha + f_\alpha = 0 \qquad \ldots(10)$$

for $\alpha = 1, 2$ and

$$\nabla^2 = \frac{\partial^2}{\partial x_1{}^2} + \frac{\partial^2}{\partial x_2{}^2} . \qquad \ldots(10a)$$

These are the equations of equilibrium (or Navier equations) for plane strain deformation, parallel to x_1x_2-plne.

Beltrami – Michell Conditions of Compatibility for Plane Strain Deformation Parallel to x_1x_2-Plane.

Solving equations (5b, c, d) for strain components in terms of stresses, we write

$$e_{11} = \frac{(\lambda + 2\mu)\tau_{11} - \lambda\tau_{22}}{4\mu(\lambda + \mu)},$$

$$e_{22} = \frac{(\lambda + 2\mu)\tau_{22} - \lambda\tau_{11}}{4\mu(\lambda + \mu)},$$

$$2e_{12} = \frac{1}{\mu}\tau_{12} . \qquad \ldots(11)$$

Substituting the values of these strain components into Saint-Venant compatibility condition (9), we obtain

$$\frac{1}{4\mu(\lambda + \mu)} [(\lambda+2\mu)\, \tau_{11,22} - \lambda\, \tau_{22,22} + (\lambda+2\mu)\, \tau_{22,11} - \lambda\, \tau_{11,11}] = \frac{1}{\mu}\, \tau_{12,12}$$

$$(\lambda+2\mu)\, (\tau_{11,22} + \tau_{22,11}) - \lambda\, (\tau_{11,11} + \tau_{22,22}) = 4(\lambda + \mu)\, \tau_{12,12} \qquad \ldots(12)$$

Differentiating the equilibrium equations

$$\tau_{\alpha\beta,\beta} + f_\alpha = 0 ,$$

w.r.t. x_α and adding under summation convention, we find

$$\tau_{\alpha\beta,\alpha\beta} + f_{\alpha,\alpha} = 0 ,$$

$$\tau_{11,11} + \tau_{22,22} + 2\,\tau_{12,12} + f_{\alpha,\alpha} = 0 . \qquad \ldots(13)$$

Eliminating $\tau_{12,12}$ from (12) and (13), we get

$$(\lambda+2\mu)\,(\tau_{11,22} + \tau_{22,11}) - \lambda(\tau_{11,11} + \tau_{22,22}) + 2(\lambda+\mu)\,[\tau_{11,11} + \tau_{22,22} + f_{\alpha,\alpha}] = 0$$

$$(\lambda + 2\mu)\,[\tau_{11,22} + \tau_{22,11} + \tau_{11,11}\ \ \tau_{22,22}] + 2(\lambda+\mu)\, f_{\alpha,\alpha} = 0$$

$$\left(\frac{\partial^2}{\partial {x_1}^2} + \frac{\partial^2}{\partial {x_2}^2}\right)(\tau_{11} + \tau_{22}) + \frac{2(\lambda+\mu)}{\lambda+2\mu}(f_{1,1} + f_{2,2}) = 0$$

$$\left(\frac{\partial^2}{\partial {x_1}^2} + \frac{\partial^2}{\partial {x_2}^2}\right)(\tau_{11} + \tau_{22}) + \frac{1}{1-\sigma}\ \text{div}\ \bar{f} = 0 . \qquad \ldots(14)$$

When the body force is constant or absent, then the Beltrami-Michell compatibility condition (14) for plane strain deformation (parallel to x_1x_2-plane) reduces to

$$\left(\frac{\partial^2}{\partial {x_1}^2} + \frac{\partial^2}{\partial {x_2}^2}\right)(\tau_{11} + \tau_{22}) = 0 . \qquad \ldots(15)$$

Equation (15) shows that the stress $\tau_{11} + \tau_{22}$ is harmonic, when the body force is either absent or constant, and consequently $(e_{11} + e_{22})$ is harmonic.

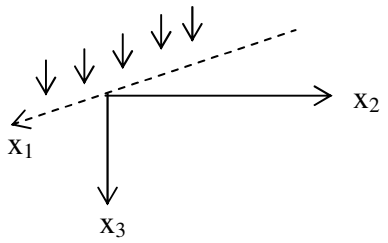
Note :- The generalized Hooke's law

$$\tau_{ij} = \frac{E}{1+\sigma}\left[e_{ij} + \frac{\sigma}{1-2\sigma}\delta_{ij}\, e_{kk}\right] ,$$

may also be used to calculate the stress components for plane strain deformation parallel to x_1x_2-plane is term of elastic modulli E, σ instead of λ , μ.

Examples of Plane strain deformations

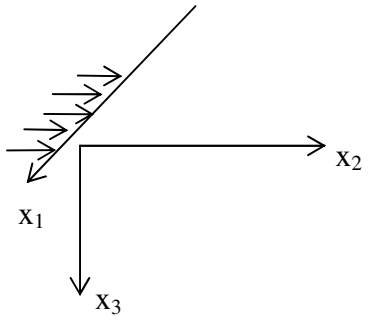
(A) The problem of stresses in an elastic semi-infinite medium subjected to a vertical line-load is a plane strain problem.



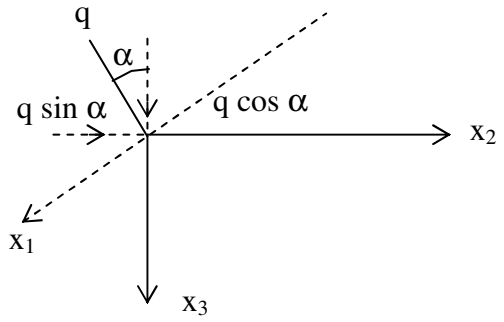
Here, the line-load extends to infinity on both sides of the origin. The displacement components are of the type

$$u_1 = 0,\ u_2 = u_2(x_2, x_3),\ u_3 = u_3(x_2, x_3)\ ,$$

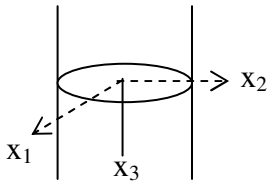
(B) The problem of determination of stresses resulting from a tangential line-load at the surface of a semi-infinite medium is a plane strain problem.



(C) The stresses and displacements in a semi-infinite elastic medium subjected to **inclined loads** can be obtained by **superposition** of the vertical and horizontal cases. If the components of the line-load are q cosα and q sinα, the stresses can be determined.



(D) The problem of deformation of an infinite cylinder by a force in the x_1x_2-plane is a plane strain problem.



In Cartesian coordinates

$$u_1 = u_1(x_1, x_2),\ u_2 = u_2(x_1, x_2),\ u_3 = 0.$$

In cylindrical coordinates

$$u_r = u(r, \theta),\ \ u_\theta = v(r, \theta)\ ,\ u_z = \ 0,$$

Principal Strains And Directions For Plane Strain Deformation

A deformation for which the strain components e_{11}, e_{22} and e_{12} are independent of x_3 and $e_{13} = e_{23} = e_{33} \equiv 0$ is called a plane strain deformation parallel to the x_1x_2-plane.

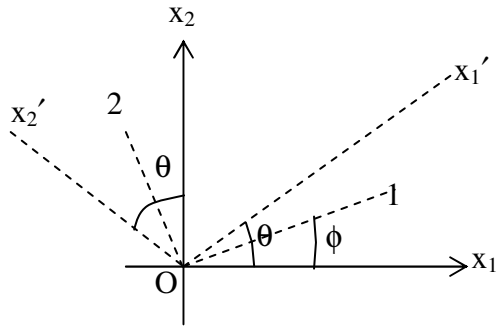
For such a deformation, the principal strain in the direction of x_3-axis is zero and the strain quadric of Cauchy

$$e_{ij}\, x_i\, x_j = \pm k^2\ , \qquad \ldots(1)$$

becomes

$$e_{11}\, x_1^{\,2} + 2\, e_{12}\, x_1x_2 + e_{22}\, x_2^{\,2} = \pm k^2\ , \qquad \ldots(2)$$

which represents a cylinder in three-dimensions. Let the axes be rotated about x_3-axis through an angle θ to get new axes $Ox_1'\, x_2'\, x_3'$.



Let

$$a_{ij} = \cos(x_i', x_j) . \qquad \ldots(3)$$

Then

	x_1	x_2	x_3
x_1'	$\cos\theta$	$\sin\theta$	0
x_2'	$-\sin\theta$	$\cos\theta$	0
x_3'	0	0	1

$\ldots(4)$

The strains e'_{pq} relative to primed system are given by the law

$$e'_{pq} = a_{pi}\, a_{qj}\, e_{ij} , \qquad \ldots(5)$$

for (ij) = (11), (22), (12), (21). We find

$$e'_{11} = a_{1i}\, a_{1j}\, e_{ij} = a_{11}^2\, e_{11} + a_{12}^2\, e_{22} + a_{11}\, a_{12}\, e_{12} + a_{12}\, a_{11}\, e_{12}$$

$$= \cos^2\theta .\, e_{11} + \sin^2\theta\, e_{22} + 2 \sin\theta \cos\theta\, e_{12}$$

$$= e_{11}\left(\frac{1+\cos 2\theta}{2}\right) + e_{22}\left(\frac{1-\cos 2\theta}{2}\right) + e_{12} \sin 2\theta$$

$$= \frac{1}{2}(e_{11} + e_{22}) + \frac{1}{2}(e_{11} - e_{22}) \cos 2\theta + e_{12} \sin 2\theta, \quad \ldots(6a)$$

Similarly

$$e'_{22} = \frac{1}{2}(e_{11} + e_{22}) - \frac{1}{2}(e_{11} - e_{22}) \cos 2\theta - e_{12} \sin 2\theta, \quad \ldots(6b)$$

$$e'_{12} = -\frac{1}{2}(e_{11} - e_{22}) \sin 2\theta + e_{12} \cos 2\theta \qquad \ldots(6c)$$

$$e'_{31} = e'_{32} = e'_{33} = 0 . \qquad \ldots(6d)$$

The principal directions in the x_1x_2-plane are given by

$$e'_{12} = 0$$

This gives

$$\frac{\sin 2\theta}{e_{12}} = \frac{\cos 2\theta}{\frac{1}{2}(e_{11} - e_{22})} = \frac{1}{\sqrt{e_{12}^2 + \frac{1}{4}(e_{11} - e_{22})^2}}\ , \qquad \ldots(7a)$$

and

$$\tan 2\theta = \frac{e_{12}}{\frac{1}{2}(e_{11} - e_{22})} = \frac{2e_{12}}{e_{11} - e_{22}}\ . \qquad \ldots(7b)$$

Let ϕ be the angle which the principal directions O_1 and O_2 make with the old axes in the x_1x_2-plane. Then

$$\tan 2\phi = \frac{2e_{12}}{e_{11} - e_{22}}\ . \qquad \ldots(8)$$

The principal strains e_1 and e_2 given by equations (6a, b) and (7a). We find ($e_1 = e_{11}^1$, $e_2 = e_{22}^1$)

$$e_1, e_2 = \frac{1}{2}(e_{11} + e_{22}) \pm \sqrt{\frac{1}{4}(e_{11} - e_{22})^2 + e_{12}^2}\ , \qquad \ldots(9)$$

the shearing strain e'_{12} will be maximum when

$$\frac{d}{d\theta} e'_{12} = 0$$

$$-(e_{11} - e_{22}) \cos 2\theta - 2\, e_{12} \sin 2\theta = 0$$

$$\frac{\cos 2\theta}{e_{12}} = \frac{\sin 2\theta}{-\frac{1}{2}(e_{11} - e_{22})} = \frac{1}{\sqrt{e_{12}^2 + \frac{1}{4}(e_{11} - e_{22})^2}} \qquad \ldots(10a)$$

This gives the direction in which the shearing strain e'_{12} is maximum and maximum value of e'_{12} is given by equations (6c) and (10a). We find

$$\left(e'_{12}\right)_{max} = \sqrt{e_{12}^2 + \frac{1}{4}(e_{11} - e_{22})^2} \quad . \qquad \ldots(10b)$$

From equations (9) and (10b), we obtain

$$\frac{e_1 - e_2}{2} = \left(e'_{12}\right)_{max.} \qquad \ldots(11)$$

This shows that maximum value of shearing strain is half of the difference of two principal strains in the x_1x_2 plane.

6.3 ANTIPLANE STRAIN DEFORMATION PARALLEL TO x_1x_2-PLANE

This deformation is characterised by

$$u_1 = u_2 \equiv 0, \; u_3 = u_3(x_1, x_2) \; .$$

The strains are

$$e_{11} = 0, \; e_{22} = e_{12} = e_{33} = 0 \; , \qquad \ldots(1)$$

$$e_{13} = \frac{1}{2}\frac{\partial u_3}{\partial x_1}, \; e_{23} = \frac{1}{2}\frac{\partial u_3}{\partial x_2} \; . \qquad \ldots(2)$$

Thus, only shear strains in the x_3-direction are non-zero we can now find stresses from the Hooke's law

$$\tau_{ij} = \lambda v. \, \delta_{ij} + 2\mu \, e_{ij} \; ,$$

giving $$\tau_{11} = \tau_{22} = \tau_{33} = 0, \; \tau_{12} = 0 \; , \qquad \ldots(3)$$

and non-zero shear stresses are

$$\tau_{13} = \mu\frac{\partial u_3}{\partial x_1}, \tau_{23} = \mu\frac{\partial u_3}{\partial x_2} \; . \qquad \ldots(4)$$

The equations of equilibrium are

$$\tau_{ij,j} + F_i = 0.$$

Using the above values of stresses, we see that for i = 1, 2, we must have

$$F_1 = F_2 = 0, \qquad \ldots(5)$$

and for i = 3,

$$\tau_{31,1} + \tau_{32,2} + \tau_{33,3} + F_3 = 0$$

$$\frac{\partial \tau_{31}}{\partial x_1} + \frac{\partial \tau_{32}}{\partial x_2} + F_3 = 0 \, . \qquad \ldots(6)$$

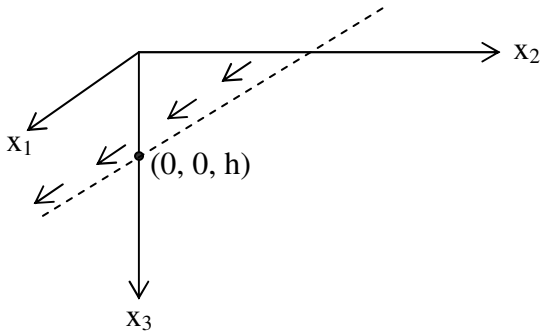
In term of u_3, this may be written as

$$\mu \left(\frac{\partial^2 u_3}{\partial {x_1}^2} + \frac{\partial^2 u_3}{\partial {x_2}^2} \right) + F_3 = 0.$$

$$\mu \, \nabla^2 u_3 + F_3 = 0 \, .$$

Example of Anti-plane Deformation

Suppose that a force is applied along the line which is parallel to x_1-axis and is situated at a depth h below the free-surface of an elastic isotropic half-space.



The resulting deformation is that of anti-plane strain deformation with

$$u_1 = u_1(x_2, x_3), \; u_2 = u_3 = 0.$$

Remark :- Two-dimensional problems in acoustics are antiplane strain problems.

6.4 PLANE STRESS

An elastic body is said to be in a state of plane stress parallel to the x_1x_2-plane if

$$\tau_{31} = \tau_{32} = \tau_{33} = 0 \, , \qquad \ldots(1)$$

and the remaining stress components τ_{11}, τ_{22}, τ_{12} are independent of x_3.

The equilibrium equations

$$\tau_{ij,j} + f_i = 0 ,$$

for the case of plane stress reduce to

$$\tau_{11,1} + \tau_{12,2} \ f_1 = 0 , \qquad \ldots(2a)$$

$$\tau_{12,1} + \tau_{22,2} + f_2 = 0 , \qquad \ldots(2b)$$

$$f_3 = 0 \ , \qquad \ldots(2c)$$

which are the same as for the case of plane strain deformation parallel to x_1x_2-plane. In the state of plane stress, the body force $\overline{f} = (f_1, f_2, 0)$ must be **independent of x_3** as various stress components in Cauchy's equilibrium equations in (2) are independent of x_3.

The strain components e_{ij} and stresses components τ_{ij} are connected by the Hooke's law

$$\tau_{ij} = \lambda \, \delta_{ij} \, e_{kk} + 2\mu \, e_{ij} \quad . \qquad \ldots(3)$$

This gives

$$e_{12} = \frac{1}{2\mu} \ \tau_{12}, \ e_{13} = 0, \ e_{23} = 0 ,$$

and

$$\tau_{33} = \lambda(e_{11} + e_{22} + e_{33}) + 2\mu \, e_{33}$$

$$e_{33} = -\frac{\lambda(e_{11} + e_{22})}{\lambda + 2\mu} \neq 0. \qquad \ldots(5a)$$

Hence

$$e_{kk} = e_{11} + e_{22} + e_{33} = (e_{11} + e_{22}) - \frac{\lambda(e_{11} + e_{22})}{\lambda + 2\mu}$$

$$= \frac{2\mu}{\lambda + 2\mu}(e_{11} + e_{22}). \qquad \ldots(5b)$$

This shows that strain component e_{13} and e_{23} are zero but e_{33} is not zero.

Hence, a state of plane stress does not imply a corresponding state of plane strain.

In view of Hooke's law (3), the strain components also do not depend upon x_3.

Let

$$\bar{\lambda} = \frac{2\lambda\mu}{\lambda + 2\mu} \qquad \ldots(6)$$

From (3), we write

$$\tau_{11} = \lambda \frac{2\mu}{\lambda + 2\mu}(e_{11} + e_{22}) + 2\mu e_{11} = (\bar{\lambda} + 2\mu) e_{11} + \bar{\lambda} e_{22} \qquad \ldots(7a)$$

$$\tau_{22} = \bar{\lambda}(e_{11} + e_{22}) + 2\mu e_{22} = \bar{\lambda} e_{11} + (\bar{\lambda} + 2\mu) e_{22} \qquad \ldots(7b)$$

comparing equations (7a, b) with the corresponding relations for plane strain deformation parallel to x_1x_2-plane, it is evident that solutions of plane stress problems can be obtained from the solutions of corresponding plane strain problems on replacing the true value of λ by the apparent value $\bar{\lambda} = \frac{2\lambda\mu}{\lambda + 2\mu}$.

Strain Components in terms of Stress Components

Solving equations (7a, b) for e_{11} and e_{22}, we find

$$e_{11} = \frac{2(\lambda + \mu)\tau_{11} - \lambda\tau_{22}}{2\mu(3\lambda + 2\mu)},$$

$$e_{22} = \frac{2(\lambda + \mu)\tau_{22} - \lambda\tau_{11}}{2\mu(3\lambda + 2\mu)}. \qquad \ldots(8)$$

Substituting these values of e_{11} and e_{22} into equation (5a), we find

$$e_{33} = \frac{-\lambda(\tau_{11} + \tau_{22})}{2\mu(3\lambda + 2\mu)}. \qquad \ldots(9)$$

Other strain components have been obtained in equation (4) already. All strain components are independent of x_3 by Hooke's law.

In this plane stress problem, two compatibility equations are identically satisfied and the remaining four are

$$e_{11,22} + e_{22,11} = 2e_{12,12} \ , \qquad \ldots(10a)$$

$$e_{33,11} = e_{33,22} = e_{33,12} = 0. \qquad \ldots(10b)$$

Since e_{33} is independent of x_3 and satisfies all conditions in (10b), so e_{33} must be of the type

$$e_{33} = c_1 + c_2 x_2 + c_3 x_1 \ , \qquad \ldots(11)$$

where c_1, c_2, c_3 are constants.

In most problems, equation (10a) is taken into consideration and requirement of equations in (10b) is ignored. This is possible, although approximately, when the dimension of the elastic body in the x_3-direction is small.

In the plane stress state, strain components e_{11}, e_{22}, e_{33} are independent of x_3 but the displacements may depend upon x_3.

Hence, plane stress problems are not truly two-dimensional.

Compatibility Equation in terms of Stresses

From equations (4), (8) and (10a), we write

$$\frac{1}{2\mu(3\lambda + 2\mu)} [2(\lambda+\mu)\tau_{11,22} - \lambda\, \tau_{22,22} + 2(\lambda+\mu)\, \tau_{22,11} - \lambda\, \tau_{11,11}] = \frac{2}{2\mu} \tau_{12,12}$$

$$2(\lambda+\mu)(\tau_{11,22}+\tau_{22,11}) - \lambda(\tau_{22,22} \ \tau_{11,11}) = 2(3\,\lambda+2\mu)\, \tau_{12,12} \ . \qquad \ldots(12)$$

From equation in (2), we write

$$\tau_{11,11} + \tau_{12,12} + f_{1,1} = 0, \ \tau_{12,12} + \tau_{22,22} + f_{2,2} = 0$$

$$(\tau_{11,11} + \tau_{22,22}) + (f_{1,1} + f_{2,2}) = -2\, \tau_{12,12} \ . \qquad \ldots(13)$$

From (12) and (13) , we have

$$2(\lambda+\mu)\,(\tau_{11,22} + \tau_{22,11}) - \lambda(\tau_{22,22} + \tau_{11,11}) = -(3\lambda + 2\mu)\,[\tau_{11,11} + \tau_{22,22} + f_{1,1} + f_{2,2}]$$

$$2(\lambda+\mu)\,(\tau_{11,22} + \tau_{22,11} + (2\lambda+2\mu)(\tau_{22,22} + \tau_{11,11}) + (3\lambda+2\mu)\,(f_{1,1}+f_{2,2}) = 0$$

$$2(\lambda+\mu)\,[(\tau_{11,22} + \tau_{22,22}) + (\tau_{11,11}+\tau_{22,11})] + (3\lambda + 2\mu)\,(f_{1,1} + f_{2,2}) = 0$$

$$\left(\frac{\partial^2}{\partial x_1{}^2} + \frac{\partial^2}{\partial x_2{}^2}\right)(\tau_{11} + \tau_{22}) + \frac{3\lambda + 2\mu}{2(\lambda + \mu)}\,(f_{1,1} + f_{2,2}) = 0\,, \qquad \ldots(14)$$

which is the same as obtained from the corresponding equation for plane strain deformation parallel to x_1x_2-plane on replacing λ by $\dfrac{2\lambda\mu}{\lambda + 2\mu}$.

Remark :- Since $\tau_{31} = \tau_{32} = 0$, so x_3-axis a principal axis of stress and the corresponding principal stress τ_3 is zero because

$$\tau_{31} = \tau_{32} = \tau_{33} = 0\,.$$

In the state of plane stress, one principal stress is zero or when one of the principal stress is zero, the state of stress is known as plane stress state.

Note :- A state of plane stress is obviously a possibility for bodies with one dimension much smaller than the other two. This type of state appears in the study of the deformation of a thin sheet plate when the plate is loaded by force applied at the boundary.

When the lengths of the generators in a cylindrical body are small in comparison with the linear dimensions of the cross-section, the body becomes a plate and the terminal sections are its faces.

The maintenance in a plate of a state of plane stress does not require the application of traction to the faces of the plate, but it required the body forces and tractions at the edge (or curved boundary) to be distributed in certain special ways.

In such a state, the stress components in the direction of the thickness of the plate are zero on both faces of the plate.

Question :- Discuss the principal stresses and principal directions of stress in a state of plane stress.

Answer :- Let an elastic body be in the state of plane stress parallel to the x_1x_2-plane. Then the stress components τ_{31}, τ_{32}, τ_{33} vanishes, i.e.,

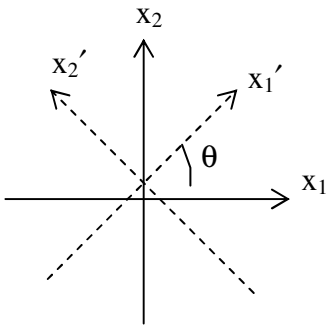
$$\tau_{31} = \tau_{32} = \tau_{33} = 0.$$

The equation of stress quadric in the state of

plane stress becomes

$$\tau_{11}\, x^2 + \tau_{22}\, y^2 + 2\tau_{12}\, xy = \pm k^2.$$

Let us rotate the $0x_1\, x_2\, x_3$ system about $0x_3$-axis by an amount θ .



Then

$$a_{11} = \cos(x_1', x_1) = \cos\theta,$$

$$a_{12} = \cos(x_1', x_2) = +\sin\theta\ ,$$

$$a_{13} = 0$$

$$a_{21} = \cos(x_2', x_1) = -\sin\theta,$$

$$a_{22} = \cos(x_2', x_2) = \cos\theta,$$

$$a_{23} = \cos(x_2', x_3) = 0$$

$$a_{31} = 0,\ a_{32} = 0,\ a_{33} = 1\ .$$

Let τ'_{pq} be the stresses relative to new system. Then

$$\tau'_{pq} = a_{pi}\, a_{qj}\, \tau_{ij}.$$

This gives

$$\tau'_{11} = a_{1i}\, a_{1j}\, \tau_{ij}$$

$$= \tau_{11}\cos^2\theta + \tau_{22}\sin^2\theta + 2\,\tau_{12}\cos\theta\sin\theta.$$

$$= \frac{1}{2}(\tau_{11} + \tau_{22}) + \frac{1}{2}(\tau_{11} - \tau_{22})\cos 2\theta + \tau_{12}\sin 2\theta$$

Similarly,

$$\tau'_{22} = \frac{1}{2}(\tau_{11} + \tau_{22}) - \frac{1}{2}(\tau_{11} - \tau_{22}) \cos 2\theta - \tau_{12} \sin 2\theta,$$

$$\tau'_{12} = -\frac{1}{2}(\tau_{11} - \tau_{22}) \sin 2\theta + \tau_{12} \cos 2\theta,$$

$$\tau'_{31} = \tau'_{32} = \tau'_{33} = 0.$$

To obtain the other two principal directions of stress, we put

$$\tau'_{12} = 0.$$

This gives $\frac{1}{2}(\tau_{11} - \tau_{22}) \sin 2\theta = \tau_{12} \cos 2\theta$

$$\frac{\cos 2\theta}{\frac{1}{2}(\tau_{11} - \tau_{22})} = \frac{\sin 2\theta}{\tau_{12}} = \frac{1}{\sqrt{\frac{1}{4}(\tau_{11} - \tau_{22})^2 + \tau_{12}^2}}$$

$$\tan 2\theta = \frac{2\tau_{12}}{\tau_{11} - \tau_{22}}.$$

This determines θ and hence the directions of two principal stresses $0x'_1$ and $0x'_2$.

Let τ_1 and τ_2 be the principal stresses in the directions $0x'_1$ and $0x'_2$ respectively. Then

$$\tau_1 = \frac{1}{2}(\tau_{11} + \tau_{22}) + \frac{1}{4}\frac{(\tau_{11} - \tau_{22})^2}{\sqrt{\frac{1}{4}(\tau_{11} - \tau_{22})^2 + \tau_{12}^2}} + \frac{\tau_{22}{}^2}{\sqrt{\frac{1}{4}(\tau_{11} - \tau_{22})^2 + \tau_{12}^2}}$$

$$= \frac{1}{2}(\tau_{11} - \tau_{22}) + \sqrt{\frac{1}{4}(\tau_{11} - \tau_{22})^2 + \tau_{12}^2},$$

and

$$\tau_2 = \frac{1}{2}(\tau_{11} - \tau_{22}) - \sqrt{\frac{1}{4}(\tau_{11} - \tau_{22})^2 + \tau_{12}^2}.$$

The principal stress in the direction $0x_3$ or ox_3' is

$$\tau_3 = 0 .$$

The stress quadric with respect to principal axes becomes

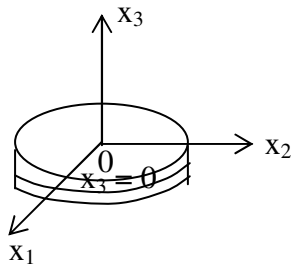
$$\tau_1 \, x_1'^2 + \tau_2 \, x_2'^2 = \pm k^2 ,$$

which is a cylinder whose base is a conic (where may be called stress conic); its plane contains the directions of the two principal stresses which do not vanish.

Note : (The stress of plane stress is also defined as the one in which one principal stress is zero).

6.5 GENERALIZED PLANE STRESS

Consider a thin flat plate of thickness 2h. We take the middle plane of the plate as $x_3 = 0$ plane so that the two faces of the plate are $x_3 = h$ and $x_3 = -h$. We make the following assumptions :



(a) The faces of plate are free from applied loads.

(b) The surface forces acting on the edge (curved surface) of the plate lie in planes, parallel to the middle plane ($x_3 = 0$), i.e., parallel to x_1x_2-plane and are symmetrically distributed w.r.t the middle plane $x_3 = 0$.

(c) $f_3 = 0$ and components f_1 and f_2 of the body force are symmetrically distributed w.r.t the middle plane.

Under these assumptions, the points of the middle plane will not undergo any deformation in the x_3-direction. Let

$$\bar{u}_3(x_1, x_2) = \frac{1}{2h} \int_{-h}^{h} u_3(x_1, x_2, x_3) \, dx_3 , \qquad \ldots(1)$$

denote the mean value of u_3 over the thickness of the plate. Then $\bar{u}_3(x_1, x_2)$ is independent of x_3. The symmetrical distribution of external forces w.r.t. the middle plane implies that

$$\overline{u}_3(x_1, x_2) = 0 \ . \qquad \ldots(2)$$

Since the faces $x_3 = \pm h$ of the plate are free from applied loads (as assumed in (a), so

$$\tau_{31}(x_1, x_2, \pm h) = \tau_{32}(x_1, x_2, \pm h) = \tau_{33}(x_1, x_2, \pm h) = 0 \ , \qquad \ldots(3a)$$

for all admissible values of x_1 and x_2. Hence

$$\tau_{31,1} = \tau_{32,2} = 0 \ , \qquad \text{at } x = \pm h \ . \qquad \ldots(3b)$$

Third equilibrium equation (with $f_3 = 0$) is

$$\tau_{31,1} + \tau_{32,2} + \tau_{33,3} = 0 \ . \qquad \ldots(4)$$

Using (2b), equation (4) reduce to

$$\tau_{33,3}(x_1, x_2, \pm h) = 0 \ . \qquad \ldots(5)$$

We note that τ_{33} and its derivative w.r.t. x_3 vanish on the faces of the plate. Since the thickness of plate is assumed to be very small, the stress component τ_{33} is small throughout of plate. Therefore we make assumption that

$$\tau_{33} = 0 \ , \qquad \ldots(6)$$

throughout the plate.

Now, we make the following definition.

Definition :- The stressed state of a thin plate for which $\tau_{33} = 0$ everywhere and τ_{31}, τ_{32} vanish on the two faces of the plate is known as generalized plane stress.

The remaining equilibrium equations for an elastic body are

$$\tau_{\alpha 1,1} + \tau_{\alpha 2,\,2} + \tau_{\alpha 3,3} + f_\alpha = 0 \quad \text{for } \alpha = 1, 2 \ .$$

Integrating w.r.t x_3 between the limits $-h$ and $+h$, we obtain

$$\frac{1}{2h} \int_{-h}^{h} [\tau_{\alpha 1,1} + \tau_{\alpha 2,\,2} + \tau_{\alpha 3,3} + f_\alpha] \, dx_3 = 0$$

$$\overline{\tau}_{\alpha 1,1} + \overline{\tau}_{\alpha 2,2} + \overline{f}_{\alpha} = 0 \ , \qquad \ldots(7)$$

for $\alpha = 1, 2$, because,

$$\int_{-h}^{h} \tau_{\alpha 3,3}\, dx_3 = \tau_{\alpha 3}(x_1, x_2, h) - \tau_{\alpha 3}(x_1, x_2, -h)$$

$$= 0 - 0 = 0 \ , \qquad \ldots(7a)$$

as τ_{31} and τ_{32} vanish on the two faces of the plate.

Equations in (7) are the equilibrium equations for the mean values of the stresses and forces. Here $\overline{\tau}_{\alpha 1}$ etc. represents mean values.

When a plate is thin, the determination of the mean values of the components of displacement, strain and stress, taken over the thickness of the plate, may lead to knowledge nearly as useful as that of the actual values at each point. The actual values of the stresses, strains and displacements produced in the plate are determined in the case of plane stress state.

We note that the mean values of the displacements and stresses (which are independent of x_3) for the generalized plane stress problem satisfy the same set of equations that govern the plane strain problem, the only difference being is that we have to replace λ by $\dfrac{2\lambda\mu}{\lambda + 2\mu}$.

The state of generalized stress is purely two-dimensional and similar to the plane strain deformation, parallel to x_1x_2-plane.

We introduce the average field quantities $\overline{u_i}, \overline{e_{ij}}, \overline{\tau_{ij}}$ as defined in equation (1) for u_3. Then

$$\overline{u}_1 = \overline{u}_1(x_1, x_2), \quad \overline{u}_2 = \overline{u}_2(x_1, x_2), \quad \overline{u}_3 = 0 \qquad \ldots(8)$$

Since $\tau_{33} = 0$, so

$$\lambda(e_{11} + e_{22} + e_{33}) + 2\mu\, e_{33} = 0$$

$$e_{33} = \frac{-\lambda}{\lambda + 2\mu}(e_{11} + e_{22}) \qquad \ldots(8a)$$

$$e_{11} + e_{22} + e_{33} = \left(1 - \frac{\lambda}{\lambda + 2\mu}\right)(e_{11} + e_{22}) = \frac{2\mu}{\lambda + 2\mu}(e_{11} + e_{22}) \ . \quad \ldots(8b)$$

The generalized Hooke's law gives

$$\tau_{\alpha\beta} = \lambda\, \delta_{\alpha\beta}\, (e_{11} + e_{22} + e_{33}) + 2\mu\, e_{\alpha\beta} \quad \text{for } \alpha,\ \beta = 1, 2$$

$$\tau_{\alpha\beta} = \frac{2\lambda\mu}{\lambda + 2\mu} \,.\, \delta_{\alpha\beta} .\, (e_{11} + e_{22}) + 2\mu\, e_{\alpha\beta} \ .$$

Integrating over x_3 and taking mean value over the thickness, we find

$$\bar{\tau}_{\alpha\beta} = \frac{2\lambda\mu}{\lambda + 2\mu}\ \delta_{\alpha\beta}(\ \bar{e}_{11} + \ \bar{e}_{22}) + 2\mu\ \bar{e}_{\alpha\beta} \ , \qquad \ldots(9)$$

for $\alpha, \beta = 1, 2$.

The five equations consisting of equations in (6) and (9) serve to determine the five unknown mean values $\bar{u}_1$, $\bar{u}_2$, $\bar{\tau}_{11}$, $\bar{\tau}_{22}$, $\bar{\tau}_{12}$.

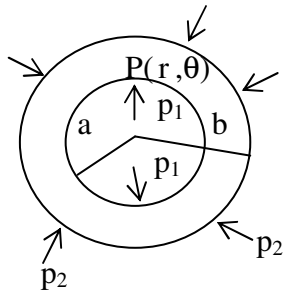
The substitution from (9) into (6) yields two equations of the Navier type

$$(\ \bar{\lambda} + \mu)\frac{\partial}{\partial x_\alpha}(\ \bar{e}_{11} + \ \bar{e}_{22}) + \mu\ \nabla^2\ \bar{u}_\alpha + \ \bar{F}_\alpha(x_1, x_2) = 0 \ , \quad \ldots(10)$$

from which the average displacements $\bar{u}_\alpha$ can be determined when the values of the $\bar{u}_\alpha$ are specified on the contour. Here $\bar{\lambda} = 2\lambda\mu/(\lambda+2\mu)$.

Example 1 :- Thick-walled Tube Under External and Internal Pressures

We consider a cross-section of a thick-walled cylindrical tube whose inner radius is a and external radius b. We shall determine the deformation of the tube due to uniform internal pressure p_1 and external pressure p_2 acting on it.



We shall use the cylindrical coordinates (r, θ, z) to solve the problem and axis of cylinder tube is taken as z-axis.

This problem is a plane strain problem and due to symmetry, the cylindrical components of displacement are of the type

$$u_r = u(r),\ u_\theta = 0,\ u_z = 0\ . \qquad \ldots(1)$$

We know that for an isotropic elastic medium, the Stoke's Navier equation of equilibrium for zero body force is

$$(\lambda + 2\mu)\ \text{grad div}\ \bar{u} - \mu\ \text{curl curl}\ \bar{u} = \bar{0}\ . \qquad \ldots(2)$$

We find

$$\text{curl}\ \bar{u} = \frac{1}{r}\begin{vmatrix} \hat{e}_r & r\hat{e}_\theta & \hat{e}_z \\ \partial/\partial r & \partial/\partial\theta & \partial/\partial z \\ u_r & 0 & 0 \end{vmatrix} = \bar{0}, \qquad \ldots(3)$$

and

$$\text{div}\ \bar{u} = \frac{1}{r}\left[\frac{d}{dr}(r\,u)\right] = \frac{du}{dr} + \frac{u}{r}\ ,$$

as u is a function f r only. We have used $\frac{d}{dr}$ instead of $\frac{\partial}{\partial r}$.

From equations (2)–(4), we find

$$\text{grad div}\ \bar{u} = \bar{0}$$

$$\text{div}\ \bar{u} = \text{constt.}\ \ 2A\ \text{(say)}$$

$$\frac{1}{r}\frac{d}{dr}(r\,u) = 2A$$

$$\frac{d}{dr}(r\,u) = 2Ar$$

$$ru = Ar^2 + B,\ B = \text{constt.}$$

$$U = Ar + B/r\ , \qquad \ldots(5)$$

where A and B are constants to be determined from the boundary conditions.

The strains in cylindrical coordinates (r, θ, z), using (1) and (5), are found to be

$$\left.\begin{aligned} e_{rr} &= u,r = A - B/r^2 \\ e_{\theta\theta} &= \frac{u}{r} = A + B/r^2 \\ e_{r\theta} &= e_{\theta z} = e_{rz} = e_{zz} = 0 \\ \text{div } \bar{u} &= e_{rr} + e_{\theta\theta} = 2A\,. \end{aligned}\right\} \qquad \ldots(6)$$

The generalized Hooke's law for an isotropic material gives the expressions for stresses. We find

$$\begin{aligned} \tau_{rr} &= \lambda \text{ div } \bar{u} + 2\mu\, e_{rr} = 2A\lambda + 2\mu\,(A - B/r^2) = 2(\lambda+\mu)A - 2\mu\frac{B}{r^2}\,, \\ \tau_{\theta\theta} &= \lambda \text{ div } \bar{u} + 2\mu\, e_{\theta\theta} = 2(\lambda+\mu)\,A + 2\mu\, B/r^2\,, \\ \tau_{zz} &= \lambda \text{ div } \bar{u} + 2\mu\, e_{zz} = 2A\lambda = \sigma\,(\tau_{rr} + \tau_{\theta\theta}), \qquad \ldots(7) \\ \tau_{r\theta} &= \tau_{\theta z} = \tau_{rz} = 0. \end{aligned}$$

Here,

$$\sigma = \frac{\lambda}{2(\lambda+\mu)}\,.$$

Boundary conditions : The boundary conditions on the curved surface of the tube (or cross-section) are

$$\left.\begin{aligned} \tau_{rr} &= -p_1 \quad \text{at } r = a \\ \tau_{rr} &= -p_2 \quad \text{at } r = b \end{aligned}\right\} \qquad \ldots(8)$$

From equations (7) and (8), we write

$$-p_1 = 2(\lambda+\mu)\,A - 2\mu\, B/a^2\,,$$

$$-p_2 = 2(\lambda+\mu)\,A - 2\mu\, B/b^2\,.$$

Solving these equations for A and B, we find

$$A = \frac{p_1 a^2 - p_2 b^2}{2(\lambda+\mu)(b^2 - a^2)},$$

$$B = -\frac{a^2b^2(p_2 - p_1)}{2\mu(b^2 - a^2)} \ . \qquad \ldots(9)$$

Putting these values of A and B in (5) and (7), we obtain the expressions for the displacement and stress which are

$$u_r = u(r) = \frac{p_1a^2 - p_2b^2}{2(\lambda + \mu)(b^2 - a^2)}.r - \frac{(p_2 - p_1)a^2b^2}{2\mu(b^2 - a^2)}.\frac{1}{r} \ , \qquad \ldots(10)$$

This gives the displacement

$$\bar{u} = u\,\hat{e}_r$$

that occurs at a point distance r from the axis of the tube ($a < r < b$) .

The stresses are

$$\tau_{rr} = \frac{p_1a^2 - p_2b^2}{b^2 - a^2} + \frac{a^2b^2(p_1 - p_2)}{(b^2 - a^2)}.\frac{1}{r^2} \ , \qquad \ldots(11a)$$

$$\tau_{\theta\theta} = \frac{p_1a^2 - p_2b^2}{b^2 - a^2} - \frac{a^2b^2(p_2 - p_1)}{(b^2 - a^2)}.\frac{1}{r^2} \ , \qquad \ldots(11b)$$

$$\tau_{zz} = \sigma(\tau_{rr} + \tau_{\theta\theta}) = \frac{\lambda}{\lambda + \mu}\left(\frac{p_1a^2 - p_2b^2}{b^2 - a^2}\right). \qquad \ldots(11c)$$

Equation (11c) show that τ_{zz} is constant. Hence, there is a uniform extension | contraction in the direction of the axis of the tube. Moreover, cross-sections perpendicular to this axis remain plane after deformation.

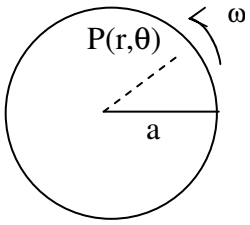
Rotating Shaft

Suppose that a solid long right circular cylinder (without an axle-hole) of radius a is rotating about its axis with uniform (constant) angular velocity ω.

We assume that the cylinder is not free to deform longitudinally.

We shall be using the cylindrical co-ordinate system (r, θ, z) to determine the displacement and stresses at any point of the cylinder.

We consider a cross-section of long right circular cylinder of radius a. This cross-section is a circle with radius a. Consider a point P(r, θ) at a distance r from the origin.



Due to symmetry, the displacement components are dependent on r only and

$$u_r = u(r),\ u_\theta = u_z = 0 \quad . \qquad \ldots(1)$$

This problem is a plane strain problem.

We know that radial and transverse components of acceleration are

$$\ddot{r} - r\,\dot{\theta}^2,\ 2\,\dot{r}\dot{\theta} + r\,\ddot{\theta}\ .$$

Since

$$\dot{r} = 0,\ \dot{\theta} = \omega,\ \ddot{r} = \ddot{\theta} = 0,$$

so the components of acceleration are

$$-r\,\omega^2,\ 0\ .$$

Hence equation of motion is

$$(\lambda + 2\mu)\ \text{grad div}\ \bar{u} - \mu\ \text{curl curl}\ \bar{u} = -\rho\, r\, \omega^2\ \hat{e}_r\ , \qquad \ldots(2)$$

where ρ is the density of the shaft. In view of (1),

$$\text{curl curl}\ \bar{u} = \bar{0},\ \text{div}\ \bar{u} = \frac{du}{dr} + u/r\ . \qquad \ldots(3)$$

From (2) and (3), we find

$$(\lambda + 2\mu)\ \text{grad}\left(\frac{du}{dr} + u/r\right) + \rho r\,\omega^2\,\hat{e}_r = 0$$

$$\frac{d}{dr}\left(\frac{du}{dr}+u/r\right)+\frac{\rho\omega^2}{\lambda+2\mu}\ r=0\ .$$

Integrating, we obtain

$$\frac{du}{dr}+u/r+\frac{\rho\omega^2}{\lambda+2\mu}.\frac{r^2}{2}=2A$$

$$\frac{1}{r}\frac{d}{dr}(u.r)+\frac{\rho\omega^2}{\lambda+2\mu}.\frac{r^2}{2}=2A$$

$$\frac{d}{dr}(u.r)+\frac{\rho\omega^2}{\lambda+2\mu}.\frac{r^3}{2}=2Ar$$

$$u.\ r+\frac{\rho\omega^2}{\lambda+2\mu}.\frac{r^4}{8}=Ar^2+B$$

$$u(r)=A\ r+\frac{B}{r}-\frac{\rho\omega^2}{\lambda+2\mu}.\frac{r^3}{8}\ , \qquad \ldots(4)$$

where A and B are constants to be determined from boundary conditions.

Since cylinder is a solid cylinder, we must take

$$B=0,$$

since, otherwise, $|u|\to\infty$ as $r\to 0$. So (4) reduces to

$$u(r)=Ar-\frac{\rho\omega^2}{\lambda+2\mu}\left(\frac{r^3}{8}\right). \qquad \ldots(5)$$

We know that the generalized Hooke's law in term of cylindrical coordinates gives

$$\tau_{rr}=\lambda\ \text{div}\ \bar{u}+2\mu\ e_{rr}=\lambda\ \text{div}\ \bar{u}+2\mu\ \frac{du}{dr}$$

$$=\lambda\left[\frac{du}{dr}+\frac{u}{r}\right]+2\mu\frac{du}{dr}$$

$$= \lambda\left[2A - \frac{\rho\omega^2}{\lambda+2\mu}.\frac{r^2}{2}\right] + 2\mu\left[A - \frac{\rho\omega^2}{\lambda+2\mu}.\frac{3r^2}{8}\right]$$

$$= 2(\lambda+\mu)\,A - \frac{\rho\omega^2}{\lambda+2\mu}(2\lambda+3\mu)\frac{r^2}{4} \quad . \qquad \ldots(6)$$

The surface r = a of the shaft is traction free, so the boundary condition is

$$\tau_{rr} = 0 \text{ at } r = a \qquad \ldots(7)$$

From equations (7) and (8); we find

$$A = \frac{\rho\omega^2(2\lambda+3\mu)}{(\lambda+\mu)(\lambda+2\mu)}.\frac{a^2}{8} \qquad \ldots(8)$$

Hence, at any point P(r, θ) of the shaft, the displacement and stress τ_{rr} due to rotation with angular velocity ω is

$$\bar{u} = u(r)\,.\,\hat{e}_r = \frac{\rho\omega^2 r}{8(\lambda+2\mu)}\left[\frac{2\lambda+3\mu}{\lambda+\mu}a^2 - r^2\right]\hat{e}_r \ , \qquad \ldots(9)$$

$$\tau_{rr} = \frac{\rho\omega^2}{4}\left(\frac{2\lambda+3\mu}{\lambda+2\mu}\right)\,[a^2 - r^2] \ . \qquad \ldots(10)$$

The other non-zero stresses are

$$\tau_{\theta\theta} = \lambda \text{ div } \bar{u} + 2\mu e_{\theta\theta} = \lambda \text{div } \bar{u} + 2\mu.\left(\frac{u}{r}\right)$$

$$= \frac{\rho\omega^2}{4(\lambda+2\mu)}\,[(2\lambda+3\mu)\,a^2 - (2\lambda+\mu)\,r^2] \ , \qquad \ldots(11a)$$

$$\tau_{zz} = \sigma(\tau_{rr} + \tau_{\theta\theta}) = \lambda \text{ div } \bar{u} = \lambda\left[2A - \frac{\rho\omega^2}{\lambda+2\mu}.\frac{r^2}{2}\right]$$

$$= \frac{\lambda\rho\omega^2}{2(\lambda+2\mu)}\left[\frac{2\lambda+3\mu}{2(\lambda+\mu)}a^2 - r^2\right]. \qquad \ldots(11b)$$

6.6 AIRY'S STRES FUNCTION FOR PLANE STRAIN PROBLEMS

In plane elastostatic problems, it is convenient to use the standard notation x, y, z instead of x_1, x_2, x_3 for Cartesian system.

The **plane strain** Cauchy's equilibrium equations on the xy-plane are

$$\tau_{xx,x} + \tau_{xy,y} + f_x = 0\,, \qquad \ldots(1)$$

$$\tau_{xy,x} + \tau_{yy,y} + f_y = 0\,. \qquad \ldots(2)$$

Assume that the external body force is conservative, so that

$$\underline{f} = -\underline{\nabla}\, V,$$

where V is the force potential. This gives

$$f_x = -V_{,x} \text{ and } f_y = -V_{,y}.$$

Using this, equations (1) and (2) can be put in the form

$$(\tau_{xx} - V)_{,x} + \tau_{xy,y} = 0 \qquad \ldots(3)$$

$$\tau_{xy,x} + (\tau_{yy} - V)_{,y} = 0\,. \qquad \ldots(4)$$

Equations (3) and (4) can be satisfied identically through the introduction of a stress function $\Phi = \Phi(x, y)$ such that

$$\tau_{xx} = \frac{\partial^2\phi}{\partial y^2} + V,$$

$$\tau_{yy} = \frac{\partial^2\phi}{\partial x^2} + V,$$

$$\tau_{xy} = \frac{-\partial^2\phi}{\partial x\partial y}\,. \qquad \ldots(5)$$

The function Φ is know as Airy's stress function, after the name of a British astronomer G. B. Airy. The function ϕ is called a stress function as ϕ generates stresses.

The Beltrani–Michell compatibility equation for plane strain deformation (in term of stresses) is

$$\nabla^2(\tau_{xx} + \tau_{yy}) + \frac{2(\lambda+\mu)}{\lambda+2\mu}\{\text{div } \rho \mathbf{f}\} = 0 \ ,$$

which now in the case of conservative body force and stress function Φ becomes, using (5),

$$\nabla^2 \{\nabla^2\phi + 2V\} + \frac{2(\lambda+\mu)}{\lambda+2\mu} \{-\nabla^2 V\} = 0$$

$$\nabla^2 \nabla^2\phi + \left(\frac{2\mu}{\lambda+2\mu}\right) \nabla^2 V = 0 \ , \qquad \ldots(6)$$

where $$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}.$$

Equation (6) shows that the stress-function Φ is a biharmonic function whenever V is harmonic.

If the body force is absent/vanish, then for plane strain problem, the stress function Φ satisfies the biharmonic equation

$$\nabla^2 \nabla^2 \phi = 0 \qquad \ldots(7)$$

i.e. $$\frac{\partial^4\phi}{\partial x^4} + 2\frac{\partial^4\phi}{\partial x^2 \partial y^2} + \frac{\partial^4\phi}{\partial y^4} = 0. \qquad \ldots(7a)$$

The formula's for displacements in terms of stress function ϕ can be obtained by integrating the stress-strain relations for plane strain, which are

$$\tau_{11} = \phi_{,22} = (\lambda + 2\mu)e_{11} + \lambda\, e_{22} \ , \qquad \ldots(8)$$

$$\tau_{22} = \phi_{,11} = \lambda\, e_{11} + (\lambda+2\mu)\, e_{22} \ , \qquad \ldots(9)$$

$$\tau_{12} = -\phi_{,12} = 2\mu\, e_{12} = \mu(u_{1,2} + u_{2,1}) . \qquad \ldots(10)$$

Solving equations (8) and (9), for e_{11} and e_{22}, we get

$$2\mu\, u_{1,1} = 2\mu\, e_{11} = -\phi_{,11} + \frac{\lambda + 2\mu}{2(\lambda + \mu)}\, \nabla^2\phi , \qquad \ldots(11)$$

$$2\mu\, u_{2,2} = 2\mu\, e_{22} = -\phi_{,22} + \frac{\lambda + 2\mu}{2(\lambda + \mu)}\, \nabla^2\phi . \qquad \ldots(12)$$

The integration of equations (11) and (12) yields

$$2\mu\, u_1 = -\phi_{,1} + \frac{\lambda + 2\mu}{2(\lambda + \mu)} \int \nabla^2\phi\, dx + f(y) , \qquad \ldots(13)$$

$$2\mu\, u_2 = -\phi_{,2} + \frac{\lambda + 2\mu}{2(\lambda + \mu)} \int \nabla^2\phi\, dy + g(x) , \qquad \ldots(14)$$

where f and g are arbitrary functions. Substituting the values of u_1 and u_2 from (13) and (14) into equation (10),, we find that

$$f'(y) + g'(x) = 0$$

$$f'(y) = -g'(x) = \text{constt} = \alpha(\text{say})$$

$$f(y) = \alpha y + \beta ,$$

$$g(x) = -\alpha x + \gamma ,$$

where α, β, γ are constants.

The form of f and g indicates that they represent a rigid body displacement and can thus be ignored in the analysis of deformation.

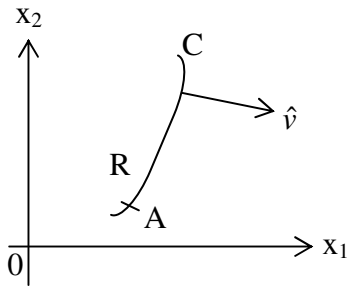
Thus, whenever ϕ becomes knows; the displacements, strains and stresses can be obtained for the plane strain problem.

Biharmonic Boundary-Value Problems

Let the body occupies the region bounded by the curve C. Then the boundary conditions are of the form

$$\tau_{\alpha\beta}\, v_\beta = T_\alpha(s) \ , \qquad \ldots(1)$$

where $T_\alpha(s)$ are known functions of the are parameter s on C, the are length s being measured along C from a fixed point, say A.



The direction cosines of a tangent are $\left(\frac{dx_1}{ds}, \frac{dx_2}{ds}\right)$, so the d. c'.s of a normal to the curve is

$$\left(\frac{dx_2}{ds}, -\frac{dx_1}{ds}\right).$$

Choosing

$$v_1 = \frac{dx_2}{ds}, \quad v_2 = -\frac{dx_1}{ds},$$

equation (1) can be written as

$$\left.\begin{aligned} \tau_{11}\,\frac{dx_2}{ds} - \tau_{12}\,\frac{dx_1}{ds} = T_1(s) \end{aligned}\right\}$$

$$\tau_{21}\frac{dx_2}{ds} - \tau_{22}\frac{dx_1}{ds} = T_2(s)\,. \qquad \ldots(2)$$

The Airy stress function ϕ generates the stresses as given below

$$\tau_{11} = \frac{\partial^2\phi}{\partial x_2^2},\ \tau_{22} = \frac{\partial^2\phi}{\partial x_1^2},\ \tau_{12} = -\frac{\partial^2\phi}{\partial x_1 \partial x_2}\ . \qquad \ldots(3)$$

From (2) and (3), we write

$$\phi_{,22}\ \frac{dx_2}{ds} + \phi_{,12}\frac{dx_1}{ds} = T_1(s)$$

$$\Rightarrow \frac{\partial}{\partial x_2}\left\{\frac{\partial \phi}{\partial x_2}\right\}\frac{dx_2}{ds} + \frac{\partial}{\partial x_1}\left\{\frac{\partial \phi}{\partial x_2}\right\}\frac{dx_1}{ds} = T_1(s)\,,$$

and

$$-\phi_{,12}\ \frac{dx_2}{ds} - \phi_{,11}\frac{dx_1}{ds} = T_2(s)$$

$$\Rightarrow \quad \frac{\partial}{\partial x_2}\left\{\frac{\partial \phi}{\partial x_1}\right\}\frac{dx_2}{ds} + \frac{\partial}{\partial x_1}\left\{\frac{\partial \phi}{\partial x_1}\right\}\frac{dx_1}{ds} = -T_2(s)\,.$$

Using chain rule, we write

$$\frac{d}{ds}\left(\frac{\partial \phi}{\partial x_2}\right) = T_1(s),$$

$$\frac{d}{ds}\left(\frac{\partial \phi}{\partial x_1}\right) = -\,T_2(s)\,.$$

Integrating these equations along C, we get

$$\frac{\partial \phi}{\partial x_1} = -\int T_2(s)\,ds = f_1(s)\,,$$

…(4a)

$$\frac{\partial \phi}{\partial x_2} = \int T_1(s)\,ds = f_2(s)\,. \qquad \ldots(4b)$$

Hence, the stress boundary problem of elasticity is related to the boundary value problem of the type

$$\nabla^2\,\nabla^2\,\phi = 0 \quad \text{in R}\,,$$

$$\phi_{,\alpha} = f_\alpha(s) \quad \text{on } C , \qquad \ldots(5)$$

where $f_\alpha(s)$ are known functions.

The boundary value problem (5) is know as the fundamental biharmonic boundary-value problem.

This boundary-value problem can be phrased in the following form.

Normal derivative of $\phi = \dfrac{\partial \phi}{\partial \nu} = \underline{\nabla}\, \phi .\ \hat{\nu}$

$$= \phi_{,\alpha}\, u_\alpha$$

$$= f_1(s)\, \frac{dx_2}{ds} - f_2(s) \frac{dx_1}{ds}$$

$$\equiv g(s), \text{ say} , \qquad \ldots(6)$$

on C,

Since $d\phi = \phi_{,\alpha}\, dx_\alpha$

$$= f_\alpha\, dx_\alpha ,$$

so $\phi = \int f_\alpha\, dx_\alpha$

$$= \int \left(f_\alpha \frac{dx_\alpha}{ds} \right) ds$$

$$= f(s) \text{ say.} \qquad \ldots(7)$$

on C.

Thus, the knowledge of the $\phi_{,\alpha}(s)$ on C leads to compute the value of $\phi(s)$ and its normal derivative $\dfrac{\partial \phi}{\partial \nu}$ on C .

Conversely, if ϕ and $\dfrac{\partial \phi}{\partial \nu}$ are know on C, we can compute $\phi_{,\alpha}(s)$.

Consequently, the boundary value problem in (5) can be written in an equivalent form

$$\left.\begin{aligned} &\nabla^2\nabla^2\phi = 0 \text{ in R} \\ &\phi = f(s) \text{ and } \frac{d\phi}{d\nu} = g(s) \text{ on C}. \end{aligned}\right\} \qquad \ldots(8)$$

The boundary value problem in (8) is more convenient in some problems.

6.7 STRESS FUNCTION FOR PLANE STRESS PROBLEM

For plane stress case, the Airy stress function ϕ is defined in the same way as for the plane strain problem. The generalized Hooke's law gives

$$e_{11} = \frac{1}{E}(\tau_{11} - \sigma\,\tau_{22}),$$

$$e_{22} = \frac{1}{E}\,(\tau_{22} - \sigma\,\tau_{11}),$$

$$e_{12} = \frac{1+\sigma}{E}\tau_{12}.$$

$$e_{11} = \frac{1}{E}[\phi_{,22} - \sigma\,\phi_{,11} + (1-\sigma)V],$$

$$e_{22} = \frac{1}{E}[\phi_{,11} - \sigma\,\phi_{,22} + (1-\sigma)V],$$

$$E_{12} = -\frac{1+\sigma}{2}\phi_{,12}\,.$$

Substitution into the Cauchy's compatibility equation, we find

$$\nabla^2\nabla^2\,\phi + (1-\sigma)\,\nabla^2\,V = 0.$$

For zero body forces, the stress function ϕ in plane stress problems, satisfies the biharmonic equation

$$\nabla^2\,\nabla^2\,\phi\, = 0.$$

Exercise :- Show that, when body force is absent, the stress function ϕ is a biharmonic function for both elasto-static problems-plane strain problem and plane stress state of the body

Airy Stress Function in Polar Coordinate

(for both cases of plane stress and plane strain)

For zero body force, components f_r, f_θ; the equilibrium equations in terms of 2–D polar coordinates (r, θ)

$$\frac{1}{r}\frac{\partial}{\partial r}(r\,\tau_{rr}) + \frac{1}{r}\frac{\partial}{\partial \theta}\tau_{r\theta} - \frac{\tau_{\theta\theta}}{r} = 0,$$

$$\frac{1}{r^2}\frac{\partial}{\partial r}(r^2\,\tau_{\theta r}) + \frac{1}{r}\frac{\partial}{\partial \theta}\tau_{\theta\theta} = 0,$$

are identically satisfied if the stresses are derived from a function $\phi = \phi(r, \theta)$

$$\tau_{rr} = \frac{1}{r}\frac{\partial \phi}{\partial r} + \frac{1}{r^2}\frac{\partial^2 \phi}{\partial \theta^2},$$

$$\tau_{\theta\theta} = \frac{\partial^2 \phi}{\partial r^2},$$

$$\tau_{r\theta} = -\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial \phi}{\partial \theta}\right).$$

The function $\phi(r, \theta)$ is the Airy stress function.

In this case, the compatibility equation shows that $\phi(r, \theta)$ satisfies the biharmonic equation

$$\nabla^2 \nabla^2 \phi = 0,$$

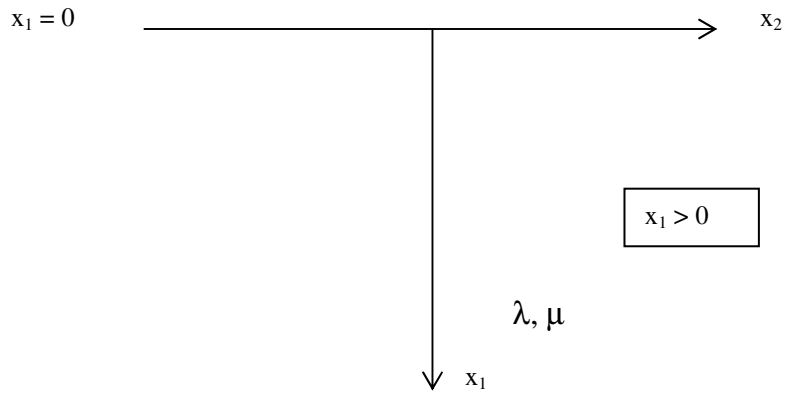
$$\left(\frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r} + \frac{1}{r^2}\frac{\partial^2}{\partial \theta^2}\right)\left(\frac{\partial^2 \phi}{\partial r^2} + \frac{1}{r}\frac{\partial \phi}{\partial r} + \frac{1}{r^2}\frac{\partial^2 \phi}{\partial \theta^2}\right) = 0. \quad \ldots(*)$$

which is know as the compatibility equation to be satisfied by the Airy stress function $\phi(r, \theta)$.

If one can find a solution of $(*)$ that also satisfies the given boundary conditions, then the problem is solved, since by uniqueness theorem (called Kirchoff's uniqueness theorem), such a solution is unique.

6.8. DEFORMATION OF A SEMI-INFINITE ELASTIC ISOTROPIC SOLID WITH DISPLACEMENTS OR STRESSES PRESCRIBED ON THE PLANE BOUNDARY

We consider a semi-infinite elastic medium with x_1-axis pointing into the medium so that the medium occupies the region $x_1 > 0$ and $x_1 = 0$ is the plane boundary.



($x_3 = 0$ cross-section of the medium)

We consider the plane strain deformation parallel to x_1x_2-plane. Then, the displacements are of the type

$$u_1 = u_1(x_1, x_2)\ ,\ \ u_2 = u_2(x_1, x_2)\ ,\ \ u_3 = 0\ . \qquad (1)$$

The stresses are generated by the Airy stress function $\phi = \phi(x_1, x_2)$ such that

$$\tau_{11} = \frac{\partial^2\phi}{\partial x_2^2}\ ,\ \ \tau_{22} = \frac{\partial^2\phi}{\partial x_1^2}\ ,\ \ \tau_{12} = -\frac{\partial^2\phi}{\partial x_1 \partial x_2}\ , \qquad (2)$$

where ϕ satisfies the biharmonic equation

$$\frac{\partial^4\phi}{\partial x_1^4} + 2\,\frac{\partial^4\phi}{\partial x_1^2 \partial x_2^2} + \frac{\partial^4\phi}{\partial x_2^4} = 0\ . \qquad (3)$$

For convenience, we write

$$(x_1, x_2, x_3) \equiv (x, y, z) , \ (u_1, u_2, u_3) = (u, v, w) . \qquad (4)$$

We use the Fourier transform method to solve the biharmonic equation (4). We use $\bar{f}(x, k)$ to denote the Fourier transform of f(x,y). Then

$$\bar{f}(x, k) = F[f] = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(x, y) \exp\{-iky\} \, dy . \quad (5)$$

If f(x, y) satisfies the Dirichlet conditions then at the points where it is continuous, we have the inverse transformation

$$f(x, y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \bar{f}(x, k) \exp(iky) \, dk , \qquad (6)$$

for $-\infty < y < \infty$. Also if

$$\frac{\partial^n f}{\partial y^n} \to 0 , \qquad \text{when } y \to \pm \infty$$

for the case n = 0, 1,2,…., r −1, then

$$F\left[\frac{\partial^r f}{\partial y^r}\right] = (-ik)^r \ \bar{f}(x, k) . \qquad (7)$$

Taking the Fourier transform of equation (3) w.r.t. the variable y, we obtain

$$\frac{d^4\Phi}{dx^4} - 2k^2 \frac{d^4\Phi}{dx^2} + k^4 \Phi = 0 , \qquad (8)$$

where $\Phi(x, k)$ is the Fourier transform of $\phi(x,y)$. Equation (8) is an ODE of fourth order. Its solution is

$$\Phi(x, k) = (A + Bx) \exp(-|k| x) + (C + Dx) \exp(|k| x) , \qquad (9)$$

where A, B, C, D are constants and they may depend upon k also.

Since we require that (9) is bounded as $x \to \infty$, we conclude that

$$C = D = 0 , \qquad (10)$$

so that (9) becomes

$$\Phi(x, k) = (A + Bx) \exp(-|k| x) . \tag{11}$$

Inverting (11) with the help of (6), we write

$$\phi(x, y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} [(A+Bx) \exp(-|k|x)] \exp(iky)\, dk . \tag{12}$$

From equations (2) and (12), the stresses are found to be

$$\tau_{11} = \frac{-1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} k^2[(A + Bx) \exp(-|k| x)] \exp(iky)\, dk , \tag{13}$$

$$\tau_{12} = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} |k| [|k| A + B(|k| x-2)] \exp(-|k| x) \exp(iky)\, dk , \tag{14}$$

$$\tau_{12} = -\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} ik [|k|A - B(1-|k| x)] \exp(-|k| x) \exp(iky)\, dk . \tag{15}$$

We know that the displacements u(x,y) and v(x, y) are given by

$$2\mu u = -\frac{\partial \phi}{\partial x} + \frac{1}{2\alpha} \int \nabla^2 \phi\, dx , \tag{16}$$

$$2\mu v = -\frac{\partial \phi}{\partial x} + \frac{1}{2\alpha} \int \nabla^2 \phi\, dy , \tag{17}$$

after neglecting the rigid body displacements, and

$$\alpha = \frac{\lambda + \mu}{\lambda + 2\mu} . \tag{18}$$

we find

$$\nabla^2 \phi = \tau_{11} + \tau_{22}$$

$$= \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} (-2B) |k| \exp(-|k|x) \exp(iky)\, dk . \tag{19}$$

Hence, we find

$$2\mu u(x,y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} [\, + |k|A + B(-1 + \frac{1}{\alpha} + |k|x\,) \exp(-|k|x) \exp(iky)\, dk\,, \tag{20}$$

$$2\mu v\,(x,y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} [(-ik)A + B(-ikx - \frac{i\,|\,k\,|}{k\alpha})]\ \exp(-|k|x) \exp(iky)\, dk\,. \tag{21}$$

Case I. When stresses are prescribed on x = 0.

Let the boundary conditions be

$$\tau_{11}(0,y) = h(y), \tag{22}$$

$$\tau_{12}(0, y) = g(y), \tag{23}$$

where h(y) and g(y) are known functions of y. Then

$$\bar{\tau}_{11} = \ \bar{g}(k) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} g(y) \exp(-iky)\, dy, \tag{24}$$

$$\bar{\tau}_{12} = \ \bar{h}(k) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} h(y) \exp(-iky)\, dy, \tag{25}$$

so that

$$\tau_{11}(0,y) = h(y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \bar{h}(k) \exp(iky)\, dk\,, \tag{26}$$

$$\tau_{12}(0,y) = g(y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \bar{g}(k) \exp(iky)\, dk\,. \tag{27}$$

Putting x = 0 in equations (13) and (15), and comparing with respective equations (26) and (27), we obtain

$$-k^2\,[\,A] = \ \bar{h}(k)\,, \tag{28}$$

$$ik\,[|k|\,A - B\,] = \ \bar{g}(k)\,. \tag{29}$$

Solving these equations for A and B, we obtain

$$A = -\frac{[\bar{h}(k)]}{k^2}, \tag{30}$$

$$B = -\left(|k|\frac{\bar{h}(k)}{k^2} + \frac{\bar{g}(k)}{ik}\right). \tag{31}$$

Putting the values of coefficients A and B from equations (30) and (31) into (13) – (15) and (20) and (21), we obtain the integral expressions for displacements and stresses.

$$2\mu\, u(x,y) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}\left[\left(\frac{1}{ik} - \frac{1}{i\alpha k} - \frac{|k|x}{ik}\right)\bar{g}(k) + \left(-\frac{1}{\alpha|k|}x\right)\bar{h}(k)\right],$$

$$\exp(-|k|x)\exp(iky)dk \tag{32}$$

$$2\mu v(x,y) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}\left[\left(\frac{-1}{\alpha|k|} + x\right)\bar{g}(k) + \left(\frac{i}{k} + \frac{ikx}{|k|} - \frac{i}{k\alpha}\right)\bar{h}(k)\right].$$

$$\exp(-|k|x)\exp(iky)dk \tag{33}$$

$$\tau_{11}(x,y) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}[(-ikx)\ \bar{g}(k) + (1+x|k|)\ \bar{h}(k)]\exp(-|k|x)\exp(iky)\,dk,$$

(34)

$$\tau_{22}(x,y) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}\left[\left(ixk - \frac{2|k|}{k}\right)\bar{g}(k) + (1-x|k|)\bar{h}(k)\right],$$

$$\exp(-|k|x)\exp(iky)dk \tag{35}$$

$$\tau_{12}(x,y) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}\left[(1-x|k|)\bar{g}(k) + (-ixk)\bar{h}(k)\right]\exp(-|k|x)\exp(iky)dk.$$

(36)

Now we consider two particular situations in which specific surface stresses are known.

Particular Cases

(a) Normal line-load :- In this particular case, a normal line-load, P, per unit length acts on the z-axis, then

$$h(y) = -P\delta(y), \tag{37}$$

$$g(y) = 0 . \tag{38}$$

Consequently,

$$\bar{h}(k) = \frac{-P}{\sqrt{2\pi}} . \tag{39}$$

$$\bar{g}(k) = 0 . \tag{40}$$

Putting the values of $\bar{h}(k)$ and $\bar{g}(k)$ from equations (39) and (40) into equations (34) to (36), we find the following integral expressions for stresses at any point of isotropic elastic half-space due to a normal line-load acting on the z-axis.

$$\tau_{11}(x,y) = \frac{-P}{2\pi}\int_{-\infty}^{\infty} (1 + x\,|k|\,) \exp(-|k|x) \exp(iky)\, dk , \tag{41}$$

$$\tau_{22}(x,y) = \frac{-P}{2\pi}\int_{-\infty}^{\infty} (1-x\,|k|\,) \exp(-|k|\,x) \exp(iky)\, dk , \tag{42}$$

$$\tau_{12}(x,y) = \frac{-P}{2\pi}\int_{-\infty}^{\infty} (-ixk) \exp(-\,|k|\,x) \exp(iky)\, dk . \tag{43}$$

We shall evaluate the integrals (41) to (43). We find

$$\tau_{11}(x,y) = \frac{-P}{2\pi}\left[\frac{2x}{(y^2 + x^2)} + \frac{2x(x^2 - y^2)}{(x^2 + y^2)^2}\right]$$

$$= \frac{-2P}{\pi}\left[\frac{x^3}{(x^2 + y^2)^2}\right], \tag{44}$$

$$\tau_{22}(x,y) = \frac{-P}{2\pi}\left[\frac{2x}{y^2+x^2} - \frac{2x(x^2-y^2)}{(x^2+y^2)^2}\right]$$

$$= \frac{-2P}{\pi}\left[\frac{xy^2}{(x^2+y^2)^2}\right], \tag{45}$$

$$\tau_{12}(x, y) = \frac{-P}{2\pi}\left[-ix\left\{\frac{4ixy}{(x^2+y^2)^2}\right\}\right]$$

$$= \frac{-2P}{\pi}\left[\frac{x^2y}{(x^2+y^2)^2}\right], \tag{46}$$

using the following standard integrals.

(1) $$\int_{-\infty}^{\infty} e^{+ik(y)}\, dk = 2\pi\, \delta(-y)$$

(2) $$\int_{-\infty}^{\infty} (|k|)^{-1} e^{-|k|x} e^{iky}\, dk = -\log(y^2 + x^2)$$

(3) $$\int_{-\infty}^{\infty} k^{-1} e^{-|k|x} e^{iky}\, dk = 2i \tan^{-1}\left(\frac{y}{x}\right)$$

(4) $$\int_{-\infty}^{\infty} e^{-|k|x} e^{iky}\, dk = \frac{2x}{y^2+x^2}$$

(5) $$\int_{-\infty}^{\infty} \frac{k}{|k|} e^{-|k|x} e^{iky}\, dk = \frac{-2i(-y)}{y^2+x^2} = \frac{2iy}{x^2+y^2}$$

(6) $$\int_{-\infty}^{\infty} k\, e^{-|k|x} e^{iky}\, dk = \frac{4iyx}{(y^2+x^2)^2}$$

$$(7) \qquad \int_{-\infty}^{\infty} |k|\, e^{-|k|x}\, e^{iky}\, dk = \frac{2(x^2 - y^2)}{(x^2 + y^2)^2}$$

$$(8) \qquad \int_{-\infty}^{\infty} k^2\, e^{-|k|x}\, e^{iky}\, dk = \frac{4x(x^2 - 3y^2)}{(x^2 + y^2)^3}$$

$$(9) \qquad \int_{-\infty}^{\infty} k|k|\, e^{-|k|x}\, e^{iky}\, dk = \frac{4iy(3x^2 - y^2)}{(x^2 + y^2)^3}$$

The corresponding displacements can be found from equations (32), (33), (39) and (40). We find

$$2\mu u = \frac{-P}{2\pi} \int_{-\infty}^{\infty} \left(-x - \frac{1}{\alpha |k|} \right) \exp(-|k|x) \exp(iky)\, dk$$

$$= \frac{P}{\pi} \left[\frac{x^2}{y^2 + x^2} - \frac{\log(x^2 + y^2)}{2\alpha} \right], \qquad (47)$$

$$2\mu v = \frac{-P}{2\pi} \int_{-\infty}^{\infty} \left(\frac{i}{k} + \frac{ixk}{|k|} + \frac{1}{i\alpha k} \right) \exp(-|k|x) \exp(iky)\, dk$$

$$= \frac{P}{\pi} \left[\frac{xy}{x^2 + y^2} + \left(\frac{\alpha - 1}{\alpha} \right) \tan^{-1}\left(\frac{y}{x} \right) \right]. \qquad (48)$$

(b) Normal pressure : Suppose that a uniform normal pressure p_0 acts over the strip $-a \le y \le a$ on the surface $x = 0$ in the positive x-direction. The corresponding boundary conditions give

$$h(y) = \begin{cases} -p_0 & |y| \le a \\ 0 & |y| > a \end{cases}, \qquad (49)$$

$$g(y) = 0\,. \qquad (50)$$

We find

$$\bar{h}(k) = -2p_0 \left(\frac{\sin ka}{k} \right), \quad \bar{g}(k) = 0 . \tag{51}$$

Proceeding as in the previous case, we find the following integral expressions for the stresses and displacements at any point of an isotropic elastic half-space due to normal pressure.

$$\tau_{11}(x, y) = -\frac{2p_0}{\sqrt{2\pi}} \int_{-\infty}^{\infty} (1 + x\,|\,k\,|) \left(\frac{\sin ka}{k} \right) \exp(-|k|x) \exp(iky)\, dk , \tag{52}$$

$$\tau_{22}(x,y) = \frac{-2p_0}{\sqrt{2\pi}} \int_{-\infty}^{\infty} (1 - x\,|\,k\,|) \left(\frac{\sin ka}{k} \right) \exp(-|k|x) \exp(iky) , \tag{53}$$

$$\tau_{12}(x,y) = \frac{-2p_0}{\sqrt{2\pi}} \int_{-\infty}^{\infty} (-ixk) \left(\frac{\sin ka}{k} \right) \exp(-|k|x) \exp(iky)\, dk , \tag{54}$$

$$2\mu u(x,y) = \frac{-2p_0}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \left(-x - \frac{1}{\alpha\,|\,k\,|} \right) \left(\frac{\sin ka}{k} \right) \exp(-|k|x) \exp(iky)\, dk , \tag{55}$$

$$2\mu v(x,y) = \frac{-2p_0}{\sqrt{2\pi}} \int_{-\infty}^{\infty} i \left(\frac{1}{k} + \frac{xk}{|\,k\,|} - \frac{1}{\alpha k} \right) \left(\frac{\sin ka}{k} \right) \exp(-|k|x) \exp(iky)\, dk . \tag{56}$$

The earlier case of the normal line-load, P per unit length, becomes the particular case of the above uniform normal strip-loading case, by taking

$$P_0 = \frac{P}{2a} , \tag{57}$$

and using the relation

$$\lim_{a \to 0} \left(\frac{\sin ka}{ka} \right) = 1 . \tag{58}$$

Case 2. When surface displacements are prescribed on the boundary x = 0.

Let the boundary conditions be

$$u(0, y) = h_1(y) , \tag{59}$$

$$v(0, y) = g_1(y) . \tag{60}$$

Then, we write, as before,

$$u(0, y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \bar{h}_1(k) \exp(iky)\, dk , \tag{61}$$

$$v(0, y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \bar{g}_1(k) \exp(iky)\, dk . \tag{62}$$

Proceeding as earlier, we shall get the result.

6.9 GENERAL SOLUTION OF THE BIHARMONIC EQUATION

The biharmonic equation in two-dimension is

$$\nabla^2 \nabla^2 \phi (x_1, x_2) = 0 \quad \text{in R} . \qquad \ldots(1)$$

Here R is a region of x_1x_2-plane.

Let $$\nabla^2 \phi = P_1(x_1, x_2) . \qquad \ldots(2)$$

Then

$$\nabla^2 P_1 = 0, \qquad \ldots(3)$$

showing that $P_1(x_1, x_2)$ is a harmonic function. Let $P_2(x_1, x_2)$ be the conjugate harmonic function. Then, the function

$$F(z) = P_1 + i P_2 , \qquad \ldots(4)$$

is an analytic function of the complex variable

$$z = x_1 + ix_2$$

satisfying the Cauchy-Riemann equations

$$P_{1,1} = P_{2,2},$$

$$P_{2,1} = -P_{1,2}. \qquad \ldots(5)$$

Let $$G(z) = \frac{1}{4} \int F(z)\, dz = p_1 + ip_2. \qquad \ldots(6)$$

Then G(z) is also an analytic function such that

$$G'(z) = \frac{1}{4} F(z) , \qquad \ldots(7)$$

and by virtue of CR-equations for G(z),

$$p_{1,1} = p_{2,2} ,$$

$$p_{1,2} = -p_{2,1} , \qquad \ldots(8)$$

we find $$\frac{\partial p_1}{\partial x_1} + \frac{i\partial p_2}{\partial x_1} = \frac{1}{4}(P_1 + iP_2) . \qquad \ldots(9)$$

This gives $$p_{1,1} = p_{2,2} = \frac{1}{4} P_1,$$

$$P_{1,2} = -p_{2,1} = \frac{-1}{4} P_2 . \qquad \ldots(10)$$

Now $$\nabla^2(p_1 . x_1) = p_1 \nabla_2 x_1 + x_1 \nabla^2 p_1 + 2 \nabla p_1 . \nabla x_1$$

$$= 0 + 0 + 2\left[\frac{\partial p_1}{\partial x_1}\frac{\partial x_1}{\partial x_1} + \frac{\partial p_1}{\partial x_2}.\frac{\partial x_1}{\partial x_2}\right]$$

$$= 2[p_{1,1} + 0]$$

$$= 2p_{1,1} \qquad \ldots(11)$$

Similarly, $$\nabla^2(p_2. x_2) = 2\, p_{2,2} . \qquad \ldots(12)$$

As p_1 and p_2 are harmonic functions therefore,

$$\nabla^2(\phi - p_1 x_1 - p_2 x_2) = \nabla^2\phi - 2(p_{1,1} + p_{2,2})$$

$$= P_1 - 2\left[\frac{1}{4}P_1 + \frac{1}{4}P_1\right].$$

This implies

$$\nabla^2 (\phi - p_1 x_1 - p_2 x_2) = 0 \text{ in } R \qquad \ldots(13)$$

Let $$\phi - p_1 x_1 - p_2 x_2 = q_1 (x_1, x_2), \text{ say} . \qquad \ldots(14)$$

Then $q_1(x_1, x_2)$ is a harmonic function in R. Let $q_2(x_1, x_2)$ be a conjugate function of $q_1(x_1, x_2)$ and let

$$H(z) = q_1 + iq_2. \qquad \ldots(15)$$

Then H(z) is an analytic function of z.

From (14), we write

$$\phi(x_1, x_2) = p_1x_1 + p_2x_2 + q_1$$

$$\mathbf{\phi(x_1, x_2) = Re\ [\ \bar{z}\, G(z) + H(z)].} \qquad \ldots(16)$$

Here, $\bar{z} = x_1 - i\, x_2$ and Re denotes the real part of the bracketed expression. The representation (16) of the biharmonic function $\phi(x_1, x_2)$ in terms of two analytic functions G(z) and H(z) was first obtained by GOURSAT.

Deduction : From (16), we write

$$\phi = p_1x_1 + p_2x_2 + q_1$$

$$\phi_{(z,\ \bar{z})} = \frac{1}{2}[\ \bar{z}\, G(z) + z\,\overline{G(z)} + H(z) + \overline{H(z)}]\ , \qquad \ldots(17)$$

since $H(z) + \overline{H(z)} = 2q_1$ and $G(z) = p_1 + ip_2$, $\overline{G(z)} = p_1 - ip_2$.

Some Terminology Involving Conjugate of Complex Functions

Suppose that t is a real variable and

$$f(t) = U(t) + iV(t)\ . \qquad \ldots(1)$$

is a complex valued function of the real variable t, where U(t) and V(t) are functions of t with real coefficients. The conjugate $\bar{f}(t)$ of f(t) is defined

$$\bar{f}(t) = U(t) - iV(t) \qquad \ldots(2)$$

If we replace the real variable t by the complex variable z(= x + iy), then f(z) and $\bar{f}(z)$ are defined to be

$$\left.\begin{aligned} f(z) &= U(z) + iV(z) \\ \bar{f}(z) &= U(z) - iV(z)\ . \end{aligned}\right\} \qquad \ldots(3)$$

Similarly $f(\bar{z})$ and $\bar{f}(\bar{z})$, functions of the complex variable $\bar{z} = \overline{x+iy} = x - iy$, are defined to be

$$\left.\begin{aligned} f(\bar{z}) &= U(\bar{z}) + i\,V(\bar{z}) \\ \bar{f}(\bar{z}) &= U(\bar{z}) - i\,V(\bar{z}) \end{aligned}\right\} \quad \ldots(4)$$

Now $\overline{f(z)}$ = conjugate of $f(z)$

= conjugate of $\{U(z) + iV(z)\}$

$= U(\bar{z}) - i\,V(\bar{z})$ (on changing $i \to -i$ and z to $\bar{z}$)

$= \bar{f}(\bar{z})$, using (4)

(i) Thus $\overline{f(z)} = \bar{f}(\bar{z})$. $\ldots(5)$

(ii) $$\frac{d}{dz}[\overline{f(\bar{z})}] = \frac{d}{dz}[U(z) - iV(z)], \text{ using (4a)}$$

$$= U'(z) - i\,V'(z)$$

$$= U'(\bar{z}) + i\,V'(\bar{z})$$

$$= \overline{[U(\bar{z}) + iV(\bar{z})]'}$$

$$= \overline{f'(\bar{z})}. \quad \ldots(6)$$

Similarly

$$\frac{d}{d\bar{z}}[\overline{f(z)}] = U'(\bar{z}) - iV'(\bar{z}) = [\overline{f'(z)}]. \quad \ldots(7)$$

Stresses and Displacements in terms of Analytic Functions G(z) and H(z).

The stresses in terms of Airy stress function $\phi = \phi(x_1, x_2)$ are given by

$$\tau_{11} = \phi_{,22},\ \tau_{22} = \phi_{,11},\ \tau_{12} = -\phi_{,12}. \qquad \ldots(1)$$

This gives

$$\tau_{11} + i\,\tau_{12} = \phi_{,22} - i\,\phi_{,12}$$

$$= -i\frac{\partial}{\partial x_2}[\phi_{,1} + i\,\phi_{,2}]\ , \qquad \ldots(2)$$

$$\tau_{22} - i\,\tau_{12} = \phi_{,11} + i\,\phi_{,12}$$

$$= \frac{\partial}{\partial x_1}\ [\phi_{,1} + i\,\phi_{,2}]\ . \qquad \ldots(3)$$

We have

$$z = x_1 + i\,x_2,\quad \overline{z} = x_1 - i\,x_2$$

$$x_1 = \frac{1}{2}(z + \overline{z}),\ x_2 = \frac{1}{2i}(z - \overline{z}). \qquad \ldots(4)$$

By chain rule

$$\frac{\partial}{\partial x_1} = \frac{\partial}{\partial z} + \frac{\partial}{\partial \overline{z}},\ .$$

$$\frac{\partial}{\partial x_2} = i\left(\frac{\partial}{\partial z} - \frac{\partial}{\partial \overline{z}}\right). \qquad \ldots(5)$$

Now
$$\frac{\partial \phi}{\partial x_1} + i\frac{\partial \phi}{\partial x_2} = \left(\frac{\partial}{\partial x_1} + i\frac{\partial}{\partial x_2}\right)\phi$$

$$= \left[\frac{\partial}{\partial z} + \frac{\partial}{\partial \overline{z}} - \left(\frac{\partial}{\partial z} - \frac{\partial}{\partial \overline{z}}\right)\right]\phi$$

$$= 2\ \frac{\partial \phi}{\partial \overline{z}}\ . \qquad \ldots(6)$$

Since

$$\phi = \frac{1}{2}[\overline{z}\ G(z) + z\ \overline{G(z)} + H(z) + \overline{H(z)}] \qquad \ldots(7)$$

where G and H are analytical functions, we find

$$2\frac{\partial \phi}{\partial \overline{z}} = G(z) + z\frac{\partial}{\partial \overline{z}}\{\overline{G(z)}\} + 0 + \frac{\partial}{\partial \overline{z}}\{\overline{H(z)}\}$$

$$= G(z) + z\overline{G'(z)} + \overline{H'(z)}$$

$$= G(z) + z\ \overline{G'(z)} + \overline{K(z)}\ , \qquad \ldots(8)$$

where

$$K(z) = H'(z)\ . \qquad \ldots(9)$$

From equations (2), (3), (5), (6) and (8), we find

$$\tau_{11} + \ i\ \tau_{12} = \left(\frac{\partial}{\partial z} - \frac{\partial}{\partial \bar{z}}\right)[G(z) + z\overline{G'(z)} + \overline{K(z)}]$$

$$= \{G'(z) + 1\ \overline{G'(z)}\} - \{z.\overline{G''(z)}\ + \overline{K'(z)}\}$$

$$= G'(z) + \overline{G'(z)} - z.\overline{G''(z)}\ - \overline{K'(z)}\,, \qquad \ldots(10)$$

because

$$\frac{\partial}{\partial \bar{z}}\overline{G'(z)} = \overline{\frac{\partial}{\partial z}(G'(z)} = \overline{G''(z)}\ . \qquad \ldots(11)$$

Also

$$\tau_{22} - i\ \tau_{12} = \left(\frac{\partial}{\partial z} + \frac{\partial}{\partial \bar{z}}\right)[G(z) + z.\overline{G'(z)} + \overline{K(z)}]$$

$$= G'(z) + \ \overline{G'(z)} + z.\overline{G''(z)} + \overline{K'(z)}\,. \qquad \ldots(12)$$

Adding and subtracting (10) from (10a), we obtain

$$\tau_{11} + \tau_{22} = 2[G'(z) + \overline{G'(z)}\ ]$$

$$= 2.2\ \mathrm{Re}\ \{G'(z)\}$$

$$= 4\ \mathrm{Re}[G'(z)], \qquad \ldots(13)$$

$$\tau_{22} - \tau_{11} - 2i\ \tau_{12} = 2\ [\overline{zG''(z)} + \overline{K'(z)}]$$

On taking conjugate both sides, we obtain

$$\tau_{22} - \tau_{11} + 2i\,\tau_{12} = 2\,[z\,G''(z) + K'(z)]. \qquad \ldots(14)$$

Equations (13) and (14) provide expressions for stresses for plane strain deformation in terms of analytic functions G(z) and H(z).

Expressions for Displacements :- We know that, for plane strain deformation parallel to x_1x_2-plane,

$$\tau_{11} = \phi_{,22} = (\lambda+2\mu)\,u_{1,1} + \lambda\,u_{2,2}\,, \qquad \ldots(15)$$

$$\tau_{22} = \phi_{,11} = \lambda u_{1,1} + (\lambda + 2\mu)\,u_{2,2}\,, \qquad \ldots(16)$$

$$\tau_{12} = -\phi_{,12} = \mu\,(u_{1,2} + u_{2,1})\,. \qquad \ldots(17)$$

Solving equations (15) and (16) for $u_{1,1}$ and $u_{2,2}$ in terms of $\phi_{,11}$ and $\phi_{,22}$, we find

$$2\mu\,u_{1,1} = \phi_{,11} + \frac{\lambda+2\mu}{2(\lambda+\mu)}\,\nabla^2\phi, \qquad \ldots(18)$$

$$2\mu\,u_{2,2} = -\phi_{,22} + \frac{\lambda+2\mu}{2(\lambda+\mu)}\,\nabla^2\phi\,. \qquad \ldots(19)$$

We know that

$$\nabla^2\phi = P_1 = 4\,p_{1,1} = 4\,p_{2,2}\,. \qquad \ldots(20)$$

Putting the values of $\nabla^2\,\phi$ from equations (20) into equations (18) and (17), we obtain

$$2\mu\,u_{1,1} = -\,\phi_{,11} + \frac{2(\lambda+2\mu)}{(\lambda+\mu)}\,p_{1,1}, \qquad \ldots(21)$$

$$2\mu\,u_{2,2} = -\phi_{,22} + \frac{2(\lambda+2\mu)}{\lambda+\mu}\,p_{2,2}. \qquad \ldots(22)$$

The integration of these equations yields,

$$2\mu\, u_1 = -\phi_{,1} + \frac{2(\lambda+2\mu)}{\lambda+\mu}\, p_1 + f(x_2), \qquad \ldots(23)$$

$$2\mu\, u_2 = -\phi_{,2} + \frac{2(\lambda+2\mu)}{\lambda+\mu}\, p_2 + g(x_1). \qquad \ldots(24)$$

where $f(x_2)$ and $g(x_1)$ are, as yet, arbitrary functions. Equation (17) serves to determine f and g.

Since $p_{1,2} = -p_{2,1}$, we easily obtain from equations (17), (23) and (24) that

$$f'(x_2) + g'(x_1) = 0$$

$$f'(x_2) = -g'(x_1) = \text{constt} = \alpha \text{ (say)}.$$

Hence $$f(x_2) = \alpha x_2 + \beta,$$

$$g(x_1) = -\alpha x_1 + \gamma\,. \qquad \ldots(25)$$

where α, β and γ are constants.

From equations (23), (24) and (25), we note that f and g represent a rigid body displacements and therefore can be neglected in the analysis of deformation.

Setting f = g = 0 in (23) and (24), we write

$$2\mu\, u_1 = -\phi_{,1} + \frac{2(\lambda+2\mu)}{\lambda+\mu} p_1, \qquad \ldots(26)$$

$$2\mu\, u_2 = -\phi_{,2} + \frac{2(\lambda+2\mu)}{\lambda+\mu}\, p_2. \qquad \ldots(27)$$

This implies, in compact form,

$$2\mu\,(u_1 + iu_2) = -(\phi_{,1} + i\,\phi_{,2}) + \frac{2(\lambda+2\mu)}{\lambda+\mu}\,(p_1 + i\,p_2)$$

$$= -[G(z) + z\overline{G'(z)} + \overline{H'(z)}] + \frac{2(\lambda+2\mu)}{\lambda+\mu} G(z)$$

$$= \left[\frac{2(\lambda+2\mu)}{\lambda+\mu} - 1\right] G(z) - z\overline{G'(z)} - \overline{H'(z)}$$

$$= k_0\, G(z) - z\overline{G'(z)} - \overline{H'(z)}, \qquad \ldots(28)$$

where

$$k_0 = \frac{\lambda + 3\mu}{\lambda + \mu} = 3 - 4\sigma. \qquad \ldots(29)$$

The quantity k_0 is called the Muskhelishvile's constant.

The formulas given by (13), (14) and (28) are called Kolosov-Muskhelishvilli formulas. This result corresponds to the state of plane strain.

Remark :- In the generalized plane-stress problem, λ must be replaced by $\bar{\lambda} = \frac{2\lambda\mu}{\lambda + 2\mu}$ and if k_0 is the corresponding value of in (29). We find

$$k_0 = \frac{\bar{\lambda} + 3\mu}{\bar{\lambda} + \mu} = \frac{5\lambda + 6\mu}{3\lambda + 2\mu} = \frac{3 - \sigma}{1 + \sigma}.$$

We note that both k and k_0 are greater than 1.

First and Second Boundary Values Problem of Plane Elasticity

We first consider the first boundary-value problem in which the stress component $\tau_{\alpha\beta}$ must be such that

$$\tau_{\alpha\beta}\, \nu_\beta = T_\alpha(s), \quad \alpha, \beta = 1, 2, \qquad \ldots(1)$$

where the stress vector $T_\alpha(s)$ is specified on the boundary.

In terms of Airy stress function $\phi = \phi(x_1, x_2)$, the condition (1) is equivalent to

$$\phi_{,1}(s) = -\int T_2(s)\, ds, \qquad \ldots(2)$$

$$\phi_{,2}(s) = \int T_1(s)\, ds,$$

on C. Now, we write

$$\phi_{,1} + i\,\phi_{,2} = i \int [T_1(s) + iT_2(s)]\, ds \text{ on C.} \qquad \ldots(3)$$

we know that

$$\phi_{,1} + i\,\phi_{,2} = G(z) + z\,\overline{G'(z)} + \overline{H'(z)}, \qquad \ldots(4)$$

where G and H are analytic functions. Thus, the boundary condition in terms of G and H is

$$G(z) + z\,\overline{G'(z)} + \overline{H'(z)} = i \int [T_1(s) + i\,T_2(s)]\,ds \text{ on C.} \qquad \ldots(5)$$

The determination of the corresponding boundary conditions in the second boundary-value problem is as follows.

In this type of boundary value problem, boundary conditions are

$$u_\alpha = g_\alpha(s), \text{ on C,} \qquad \ldots(6)$$

where the functions $g_\alpha(s)$ are know functions. Equation (6) yields

$$2\mu(u_1 + i\,u_2) = 2\mu\,[g_1(s) + ig_2(s)], \text{ on C,}$$

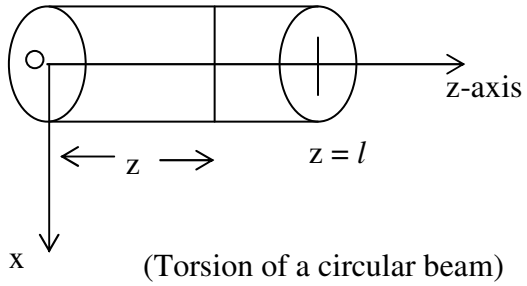
This implies

$$\Rightarrow \qquad k_0\,G(z) - z\,\overline{G'(z)} - \overline{H'(z)} = 2\mu\,[g_1(s) + i\,g_2(s)], \text{ on C .} \qquad \ldots(7)$$

Chapter-7
Torsion of Bars

7.1 TORSION OF A CIRCULAR SHAFT

Let us consider an elastic right circular beam of length *l*. We choose the z-axis along the axis of the beam so that its ends lie in the planes z = 0 and z = l, respectively. The end z = 0 is fixed in the xy-plane and a couple of vector moment $\vec{M} = M\hat{e}_3$ about the z-axis is applied at the end z = *l* . The lateral surface of the circular beam is stress-free and body forces are neglected.



(Torsion of a circular beam)

The problem is to compute the displacements, strains and stresses developed in the beam because of the twist (or torsion) it experiences due to the applied couple.

Because of the symmetry of the cross-section of the beam by planes normal to the z-axis, these sections will remain planes even after deformation.

That is, if (u, v, w) are the displacements, then

$$w = 0, \qquad \ldots.(1)$$

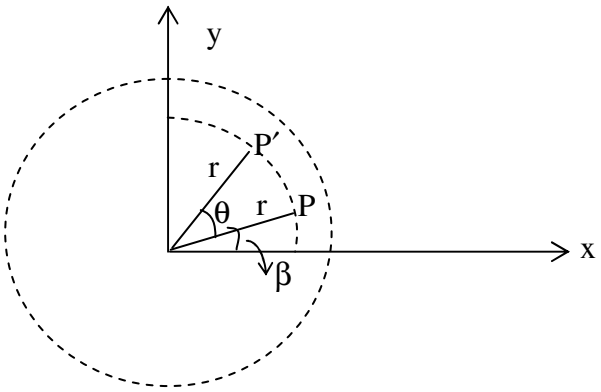
However, these plane sections will get rotated about the z-axis through some angle θ. The rotation θ will depend upon the distance of the cross-section from the fixed end z = 0 of the beam. For small deformations, we assume that

$$\theta = \alpha z \qquad \ldots.(2)$$

where α is a constant.

The constant α represents the twist per unit length (for z = 1).

Now, we consider a cross-section of the right circular beam. Let P(x, y) be a point on it before deformations and P′ (x′, y′) be the same material point after deformation.



(Rotation of a section of the circular shaft)

Then

$$u = x' - x$$

$$= r\,[\cos(\theta+\beta) - r\cos\beta]$$

$$= r\,[\cos\theta\cos\beta - \sin\theta\sin\beta] - r\cos\beta$$

$$= r\cos\beta\,(\cos\theta - 1) - y\sin\theta$$

$$= x\,(\cos\theta - 1) - y\sin\theta\,. \qquad \ldots.(3)$$

Since θ is small, so

$$\cos\theta \approx 1\,,\ \sin\theta \approx \theta\,.$$

Therefore

$$u = -y\theta = -\alpha yz\,. \qquad \ldots.(4)$$

Similarly

$$v = y' - y$$

$$= r\sin(\beta + \theta) - r\sin\beta$$

$$= x\sin\theta + y\,(\cos\theta - 1)\,. \qquad \ldots.(5)$$

For small deformations, θ is small, so

$$v = x\,\theta = \alpha\,xz\,. \qquad \ldots.(6)$$

Thus, the displacement components at any point (x, y, z) of the beam due to twisting are

$$u = -\alpha\,yz, \qquad v = \alpha\,xz, \qquad w = 0, \qquad \ldots.(7)$$

where α is the twist per unit length. Therefore, the displacement vector $\bar{u}$ is

$$\bar{u} = -\alpha z\ (y\hat{i} - x\hat{j})\ . \qquad \ldots.(8)$$

Then

$$\bar{u} \cdot \bar{r} = -\alpha z\,(y\hat{i} - x\hat{j}) \cdot (x\hat{i} + y\hat{j}) = 0\,, \qquad \ldots.(9)$$

and

$$|\bar{u}| = \alpha z\sqrt{x^2 + y^2} = \alpha z r\,, \qquad \ldots(10)$$

in polar coordinates (r, θ).

That is, the displacement vector is in the tangential direction and is of magnitude αrz.

The corresponding strains are

$$e_{xx} = 0,\ e_{yy} = 0,\ e_{zz} = 0,$$

$$e_{xy} = 0,\ e_{yz} = \frac{1}{2}\alpha x,\ e_{zx} = -\frac{1}{2}\alpha y\,. \qquad \ldots(11)$$

The stress-strain relations

$$\tau_{ij} = \lambda\,\delta_{ij}\,e_{kk} + 2\mu e_{ij},$$

yield

$$\tau_{xx} = \tau_{yy} = \tau_{zz} = \tau_{xy} = 0\,,$$

$$\tau_{yz} = \mu\alpha x\,,\quad \tau_{xz} = -\mu\alpha y\,. \qquad \ldots.(12)$$

This system of stresses clearly satisfies the equations of equilibrium (for zero body)

$$\tau_{ij\,,\,j} = 0\ .$$

Also the Beltrami-Michell compatibility conditions for zero body force

$$\nabla^2\tau_{ij} + \frac{1}{1+\sigma}\,\tau_{kk,\,ij} = 0\ , \qquad \ldots(13)$$

are obviously satisfied.

Since the lateral surface is stress-free, so the boundary conditions to be satisfied on the lateral surface are

$$\tau_{ij}\,v_{j=0}\,, \qquad \text{for } i = 1, 2, 3\ . \qquad \ldots(14)$$

Since the normal is perpendicular to z-axis, so

$$v_3 = 0\,, \qquad \ldots(15)$$

on the lateral surface of the beam. The first two conditions are identically satisfied. The third condition becomes

$$\tau_{xz}\,v_x + \tau_{yz}v_y = 0\,. \qquad \ldots(16)$$

Let 'a' be the radius of the cross-section. Let (x, y) be a point on the boundary C of the cross-section. Then

$$x^2 + y^2 = a^2$$

and

$$v_x = \cos(\hat{\nu}, x) = x/a,$$

$$\nu_y = \cos(\hat{\nu}, y) = y/a .$$

Therefore, on the boundary C,

$$\tau_{xz}\, v_x + \tau_{yz} v_y = -\mu\,\alpha y.(x/a) + \mu\alpha x.(y/a) = 0. \qquad ..(17)$$

That is, the lateral surface of the circular beam is stress-free.

On the base $z = l$, let

$$\overline{F} = (F_x, F_y, F_z),$$

be the resultant force. Then

$$F_x = \iint_R \tau_{zx}\, dx\, dy$$

$$= -\mu\alpha \iint_R y\ dx\, dy$$

$$= 0, \qquad ..(18)$$

since the y coordinate of the C. G. is zero. Also,

$$F_y = \iint_R \tau_{zy} dx\, dy = \alpha x \iint_R x\ dx\, dy = 0, \qquad ..(19)$$

$$Fz = \iint_R \tau_{zz} dx\, dy = 0, \qquad ...(20)$$

because the x coordinate of the C. G. is zero as the C. G. lies on the z-axis.

Thus, on the base $z = l$, the resultant force $\overline{F}$ is zero.

Let $\overline{M} = (M_x, M_y, M_z)$ be the resultant couple on the base $z = l$. Then

$$\overline{M} = \iint_R (x\hat{e}_1 + y\hat{e}_2 + l\hat{e}_3) \times (\tau_{xz}\hat{e}_1 + \tau_{zy}\hat{e}_2 + \tau_{zz}\hat{e}_3) dxdy. \qquad ..(21)$$

This gives

$$M_x = \iint_R (y\tau_{zz} - l\tau_{zy}) dxdy = \mu\alpha l \iint_R yx\, dxdy = 0, \qquad ..(22)$$

$$M_y = \iint_R (l\tau_{xz} - x\tau_{zz}) dxdy = -\mu\alpha l \iint_R y\, dxdy = 0, \qquad ...(23)$$

$$M_z = \iint_R (x\tau_{zy} - y\tau_{zx})dxdy$$

$$= \mu x \iint_R (x^2 + y^2)dxdy$$

$$= \mu\alpha x \text{ [moment of inertia of the cross-section z = } l \text{ about the z-axis]}$$

$$= \mu\alpha \frac{\pi a^4}{2}. \qquad ...(24)$$

As $\overline{M} = M\hat{e}_3$, so we write

$$M = M_z = \frac{\pi\mu\alpha a^4}{2} \quad , \qquad ...(25)$$

where a is the radius of the circular cross-section at z =λ.

This gives

$$\alpha = \frac{2M}{\mu\pi a^4} \ , \qquad ...(26)$$

which determines the constant α in term of moment of the applied couple M, radius of the cross-section 'a' and rigidity μ of the medium of the beam.

The constant α is the twist per unit length. With α given by (26), the displacements, strains and stresses at any point of the beam due to applied twist became completely known by equations (7), (11), (12).

Stress -Vector

The stress vector at any point P(x, y) in any cross-section (z = constant) is given by

$$\underset{\sim}{T}^{z} = \tau_{zx}\hat{i} + \tau_{zy}\hat{j} + \tau_{zz}\hat{k} \ . \qquad ..(27)$$

Using (12), we find

$$\underset{\sim}{T}^{z} = \tau_{zx}\hat{i} + \tau_{zy}\hat{j}$$

$$= \mu\alpha(-y\hat{i} + x\hat{j}) \ , \qquad ...(28)$$

which lies in the cross-section itself, i.e., the stress-vector is tangential.

Moreover, we note that the stress-vector $\underset{\sim}{T}^{z}$ is perpendicular to the radius vector $\underset{\sim}{r} = x\hat{i} + y\hat{j}$ as

$$\underset{\sim}{T}^{z} . \underset{\sim}{r} = 0.$$

The magnitude τ of the shier vector $\underset{\sim}{T}^{z}$ is given by

$$\tau = \sqrt{\tau^2_{zx} + \tau^2_{zy}} = \mu\alpha\sqrt{x^2 + y^2} = \mu\alpha r, \qquad ...(29)$$

which is maximum when r = a , and

$$\tau_{max} = \mu\alpha a = \frac{2M}{\pi a^3}. \qquad ...(30)$$

Note:- The torsinal rigidity of the beam, denoted by D_0, is defined by

$$D_0 = \frac{M}{\alpha} = \mu . \frac{\pi a^4}{2} . \qquad ...(31)$$

The constant D_0 provides a measure of the rigidity of the beam. It depends on the modulus of rigidity μ and the shape of the cross-section of the beam only. The constant D_0 (which is equal to $\frac{M}{\alpha}$) represents the moment of the couple required to produce a unit angle of twist per unit of length.

It is also called the torsinal stiffness of the beam.

Example: Consider a circular shaft of length *l*, radius a, and shear modulus μ, twisted by a couple M. Show that the greatest angle of twist θ and the maximum shear stress

$$\tau = \sqrt{\tau^2_{zx} + \tau^2_{zy}}$$

are given by

$$\theta_{max} = \frac{2Ml}{\pi . \mu a^4}, \qquad \tau_{max} = \frac{2M}{\pi a^3}$$

Solution: We know that

$$\theta = \alpha z, \qquad M = \frac{\mu\alpha\pi a^4}{2}, \qquad T = \mu\alpha r . \qquad ....(1)$$

We find

$$\alpha = \frac{2M}{\mu\pi a^4} \qquad ....(2)$$

Now

$$\theta_{max} = \alpha.(z)_{max} = \alpha l = \frac{2M}{\mu\pi a^4} ,$$

and

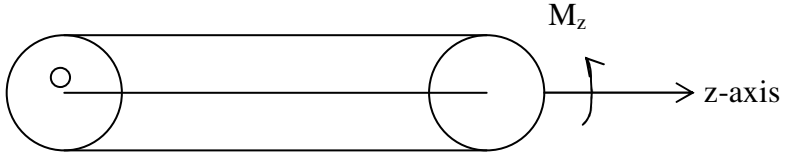
$$\tau_{max} = \mu\alpha\,(r)_{max} = \mu\alpha a = \frac{2M}{\pi a^3} .$$

7.2. TORSION OF BARS OF ARBITRARY CROSS-SECTION

Consider an elastic beam of length *l* of uniform but arbitrary cross-section. The lateral surface is stress free and body forces are absent. Suppose that a couple of vector moment $\vec{M}$ about the axis of the beam is applied at one end and the other end is fixed.

The problem is to compute the displacements, strains and stresses developed in the beam.

We choose z-axis along the axis of the beam. Let the end z = 0 be fixed and the end z = λ be applied the vector couple of moment $\vec{M}$.



(Torsion of a beam of arbitrary cross-section)

Let (u, v, w) be the components of the displacement. In the case of a circular cross-section, a plane cross-section remains plane even after the deformation. However, when the cross-section is arbitrary, a plane cross-section will not remain plane after deformation, it gets warped (curved surface).

This phenomenon is known as warping.

We assume that each section is warped in the same way, i.e., warping is independent of z . We write

$$w = \alpha\,\phi\,(x, y) \ , \qquad ...(1)$$

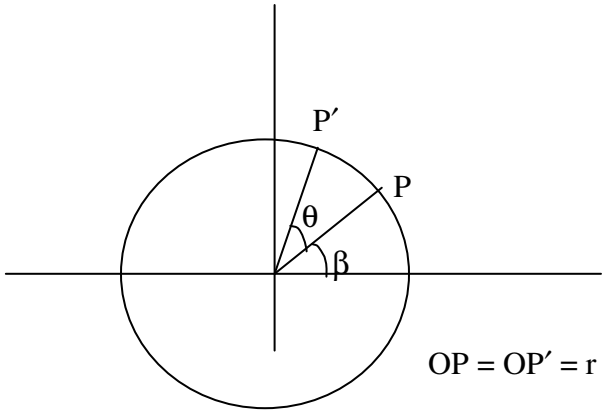
which is the same for all sections. Here α is the angle of twist per unit length of the beam.

The function $\phi = \phi\,(x, y)$ is called the Saint-Venant's warping function or torsion function.

Due to twisting, a plane section get rotated about the axis of the beam. The angle θ of rotation depends upon the distance of the section from the fixed end. For small deformations, we assume that

$$\theta = \alpha z \ . \qquad ..(2)$$

Let P (x, y) be any point on a cross section before deformations P′ (x′, y′) be the same material point after deformation.



Then

$$\begin{aligned} u = x' - x &= r\cos(\theta + \beta) - r\cos\beta \\ &= r\cos\theta\cos\beta - r\sin\theta\sin\beta - r\cos\beta \\ &= x(\cos\theta - 1) - y\sin\theta \\ &= -y\,\theta \ . \qquad ..(3) \end{aligned}$$

Similarly

$$v = x\,\theta \ . \qquad ..(4)$$

Hence, for small deformations, the displacement components are given by the relations

$$\begin{aligned} u &= -\alpha yz \ , \\ v &= \alpha xz \ , \\ w &= \alpha\phi\,(x, y) \ . \qquad ..(5) \end{aligned}$$

The strain components are

$$e_{xx} = \frac{\partial u}{\partial x} = 0,$$

$$e_{yy} = \frac{\partial v}{\partial y} = 0,$$

$$e_{zz} = \frac{\partial w}{\partial z} = 0 \ , \qquad ..(6)$$

and

$$e_{xy} = \frac{1}{2}\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right) = \frac{1}{2}(-\alpha z + \alpha z) = 0,$$

$$e_{yz} = \frac{1}{2}\alpha\left[x + \frac{\partial \phi}{\partial y}\right],$$

$$e_{zx} = \frac{1}{2}\alpha\left[-y + \frac{\partial \phi}{\partial x}\right] . \qquad ..(7)$$

The stresses are to be found by using the Hooke's law

$$\tau_{ij} = \lambda\, \delta_{ij}\, e_{kk} + 2\, \mu\, e_{ij}. \qquad ..(8)$$

We find

$$\tau_{xx} = \tau_{yy} = \tau_{zz} = \tau_{xy} = 0, \qquad \ldots(9)$$

$$\tau_{yz} = \mu\, \alpha\left(x + \frac{\partial \phi}{\partial y}\right), \qquad ..(10)$$

$$\tau_{zx} = \mu\, \alpha\left(-y + \frac{\partial \phi}{\partial x}\right) . \qquad ...(11)$$

These stresses must satisfy the following equilibrium equations for zero body force

$$\tau_{i\,j,\,j} = 0 \ , \qquad ..(12)$$

for i = 1, 2, 3 in R. First two equations are identically satisfied. The third equation gives

$$\tau_{zx,\,x} + \tau_{zy,\,y} = 0 \qquad \text{in R}$$

or
$$\mu\alpha\, \frac{\partial}{\partial x}\left[-y + \frac{\partial \phi}{\partial x}\right] + \mu\alpha \frac{\partial}{\partial y}\left[x + \frac{\partial \phi}{\partial y}\right] = 0$$

or
$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0, \qquad ...(13)$$

in the region R of the cross-section.

This shows that the torsion function ϕ is a harmonic function.

Let C be the boundary curve of the region R representing the cross-section of the beam. Since the lateral surface is stress free, so the boundary conditions to be satisfied are

$$\tau_{ij}\, v_j = 0\,, \qquad \text{on C} \qquad ...(14)$$

for i = 1, 2, 3. The first two conditions are identically satisfied as $v_3 = 0$. The third condition is

$$\tau_{zx}\, v_x + \tau_{zy}\, v_y = 0 \qquad \text{on C.}$$

or

$$\left(-y + \frac{\partial\phi}{\partial x}\right)\nu_x + \left(x + \frac{\partial\phi}{\partial y}\right)\nu_y = 0 \qquad \text{on C}$$

or

$$\frac{\partial\phi}{\partial x}\nu_x + \frac{\partial\phi}{\partial y}\nu_y = y\, v_x - x\, v_y \qquad \text{on C}$$

or

$$\frac{d\phi}{dv} = y\, v_x - x\, v_y \qquad \text{on C.} \qquad ...(15)$$

since

$$\frac{d\phi}{dv} = \text{normal derivative of } \phi$$

$$= \nabla\phi . \hat{v}$$

$$= \frac{\partial\phi}{\partial x}\nu_x + \frac{\partial\phi}{\partial y}v_y\,. \qquad ...(16)$$

Thus, the torsion function/ warping functions ϕ must be a solution of the two dimensional following Neumann boundary value problem.

$$\nabla^2\phi = 0 \quad , \qquad \text{in R} \ ,$$

$$\frac{d\phi}{dv} = \text{normal derivations of } \phi = (y.\, v_x - x.\, v_y) \qquad \text{on C .} \qquad ...(17)$$

So, we solve the torsion problem as a Neummann problem (17).

On the base $z = l$, let $\overline{F}$ be the resultant force. Then

$$F_x = \iint_R \tau_{zx}\, dx\, dy = \mu\alpha \iint_R \left(\frac{\partial\phi}{\partial x} - y\right) dx\, dy$$

$$= \mu\alpha \iint_R \left[\frac{\partial}{\partial x}\left\{ x\left(\frac{\partial \phi}{\partial x} - y\right)\right\} + \frac{\partial}{\partial y}\left\{ x\left(\frac{\partial \phi}{\partial y} + x\right)\right\}\right] dx\, dy$$

$$= \mu\alpha \int_C \left[-x\left(\frac{\partial \phi}{\partial y} + x\right)dx + x\left(\frac{\partial \phi}{\partial x} - y\right)dy \right], \qquad \ldots(18)$$

using Green's theorem

$$\int_C (P dx + Q dy) = \iint_R \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right) dx\, dy \ , \qquad \ldots(19)$$

which converts surface integral into a line integral.

In case of two-dimensional curve C, directions cosines of the tangent are $< \frac{dx}{ds}, \frac{dy}{ds} >$, and therefore, d. c.'s of the normal are $< + \frac{dy}{ds}, - \frac{dx}{ds} >$, i. e.,

$$\nu_x = dy/ds, \qquad \nu_y = -dx/ds. \qquad \ldots(20)$$

From equations (18) and (20), we write

$$F_x = \mu\alpha \int_C x\left[\left(-x - \frac{\partial \phi}{\partial y}\right)\frac{dx}{ds} + \left(\frac{\partial \phi}{\partial x} - y\right)\frac{dy}{ds}\right] ds$$

$$= \mu\alpha \int_C x\left[\frac{\partial \phi}{\partial x}.\nu_x + \frac{\partial \phi}{\partial y}\nu_y + (x\nu_y - y\nu_x)\right] ds$$

$$= \mu\alpha \int_C x\left[\frac{\partial \phi}{\partial \nu} + (x\nu_y - y\nu_x)\right] ds$$

$$= 0, \qquad \ldots(21)$$

since, on the boundary C, the integrand is identically zero.

Similarly

$$F_y = F_z = 0 \ .$$

Thus, the resultant force $\overline{F}$ on the cross-section R of the beam vanishes.

On the base $z = l$, let $\overline{M}$ be the resultant couple. Then

$$M_x = \iint_R (y\tau_{zz} - z\tau_{zy})\, dx\, dy$$

$$= -l \iint_R \tau_{zy}\, dx dy \quad ; \qquad (\Theta z = l)$$

$$= -l\, F_y$$

$$= 0\ . \qquad ...(23)$$

Similarly

$$M_y = 0. \qquad ...(24)$$

Now

$$M_z = \iint_R \left(x\tau_{zy} - y\tau_{zx}\right) dx\, dy = \mu\alpha \iint_R \left[x^2 + y^2 + x\frac{\partial \phi}{\partial y} - y\frac{\partial \phi}{\partial x} \right] dx\, dy\ ,$$

This gives

$$M = \mu\alpha \iint_R \left[x^2 + y^2 + x\frac{\partial \phi}{\partial y} + y\frac{\partial \phi}{\partial z} \right] dx\, dy\ , \qquad ...(25)$$

as it is given that M is the moments of the torsion couple about z-axis.

We write

$$M = \alpha D \qquad ...(26)$$

where M is applied moment, α is the twist per unit length and D is the torsinal rigidity given by

$$D = \mu \iint_R \left[x^2 + y^2 + x\frac{\partial \phi}{\partial y} - y\frac{\partial \phi}{\partial x} \right] dx\, dy\ , \qquad ...(27)$$

which depends upon μ (i. e., the material of the beam) and the shape of the cross-section R (i. e., the geometry of the beam).

For given M, α can be determined from equation (26).

However, when α is given, then we can calculate the required moment M, from equation (27), to produce the twist α per unit length.

After finding ϕ (by solving the Neumann boundary value problem) the torsion function ϕ becomes know and consequently the torsinal rigidity D becomes known.

7.3. DIRICHLET BOUNDARY VALUE PROBLEM

Let ψ (x, y) be the conjugate harmonic function of the harmonic function ϕ(x, y). Then

$$\frac{\partial \phi}{\partial x} = \frac{\partial \psi}{\partial y}, \frac{\partial \phi}{\partial y} = -\frac{\partial \psi}{\partial x}, \qquad ..(28)$$

and the function $\phi + i\psi$ is an analytic function of the complex variable $x + iy$.

Now

$$\frac{d\phi}{d\nu} = \frac{\partial \phi}{\partial x}\nu_x + \frac{\partial \phi}{\partial y}\nu_y$$

$$= \frac{\partial \phi}{\partial x}\frac{dy}{ds} - \frac{\partial \phi}{\partial y}\frac{dx}{ds}$$

$$= \frac{\partial \psi}{\partial y}\frac{dy}{ds} + \frac{\partial \psi}{\partial x}\frac{dx}{ds},$$

$$= \frac{d\psi}{ds}. \qquad ….(29)$$

On the boundary C, the boundary condition (15) now becomes

$$\frac{d\psi}{ds} = y\nu_x - x\nu_y \qquad \text{on C},$$

or

$$\frac{d\psi}{ds} = y\frac{dy}{ds} + x\frac{dx}{ds} \qquad \text{on C},$$

or

$$\psi = \frac{1}{2}\left(x^2 + y^2\right) + \text{constt}, \qquad \text{on C}. \qquad …..(30)$$

Thus, the determination of the function $\psi = \psi(x, y)$ is the problem of solving the Dirichlet problem

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0 \qquad \textbf{in R}$$

$$\psi = \frac{1}{2}\left(x^2 + y^2\right) + \textbf{constt.} \qquad \textbf{on C} \qquad \textbf{...(31)}$$

whose solution is unique.

Once ψ becomes known, the torsion function $\phi = \phi(x, y)$ can be obtained from relations in (28).

We generally, take, constt. = 0 in (31).

The Dirichlet problem of potential theory can be solved by standard techniques.

7.4. STRESS- FUNCTION

Stress-Function: The stress function, denoted by Ψ, is defined as

$$\Psi(x,y) = \psi(x, y) - \frac{1}{2}\left(x^2 + y^2\right) \qquad ...(32)$$

where $\psi(x, y)$ is the solution of the Dirichlet problem (31).

We know that $\psi(x, y)$ is also the conjugate function of the harmonic torsion function $\phi(x, y)$.

The stress $\Psi(x,y)$ was introduced by Prandtl.

From equation (32), we find

$$\frac{\partial \Psi}{\partial x} = \frac{\partial \psi}{\partial x} - x \quad ,$$

or

$$\frac{\partial \psi}{\partial x} = \frac{\partial \Psi}{\partial x} + x \quad , \qquad ..(33)$$

and

$$\frac{\partial \Psi}{\partial y} = \frac{\partial \psi}{\partial y} - y$$

or

$$\frac{\partial \psi}{\partial y} = \frac{\partial \Psi}{\partial y} + y \quad . \qquad ..(34)$$

Further, we find

$$\nabla^2 \Psi = \frac{\partial^2 \Psi}{\partial x^2} + \frac{\partial^2 \Psi}{\partial y^2}$$

$$= \left(\frac{\partial^2 \psi}{\partial x^2} - 1\right) + \left(\frac{\partial^2 \psi}{\partial y^2} - 1\right)$$

$$= -2 \qquad \text{in R.} \qquad ..(35)$$

From equations (31) and (32), we find

$$\Psi = \text{constt on } C \, . \qquad ..(36)$$

The differential equation in (35) is called Poisson's equation.

Thus, the stress function $\Psi(x, y)$ is a solution of the boundary value problem consists of equations (35) and (36).

The shear stresses τ_{zx} and τ_{zy}, given in (11), can also be expressed in terms of stress function Ψ. We find

$$\tau_{zx} = \mu\alpha\left(\frac{\partial\phi}{\partial x} - y\right)$$

$$= \mu\alpha\left(\frac{\partial\psi}{\partial y} - y\right)$$

$$= \mu\alpha\,\frac{\partial\Psi}{\partial y}, \qquad ..(37)$$

$$\tau_{zy} = \mu\alpha\left(\frac{\partial\phi}{\partial y} + x\right)$$

$$= \mu\alpha\left(-\frac{\partial\psi}{\partial x} + x\right)$$

$$= -\mu\alpha\,\frac{\partial\Psi}{\partial x}\,. \qquad ...(38)$$

The torsional rigidity D in term of stress function $\Psi(x, y)$ can be found.

We know that

$$D = \frac{1}{\alpha}\int\int_R \left(x\tau_{zy} - y\tau_{zx}\right)dx\,dy$$

$$= \frac{1}{\alpha}\int\int_R \left[x\left\{-\mu\alpha\frac{\partial\Psi}{\partial x}\right\} - y\left\{\mu\alpha\frac{\partial\Psi}{\partial y}\right\}\right]dx\,dy$$

$$= -\mu\int\int_R \left[x\frac{\partial\Psi}{\partial x} + y\frac{\partial\Psi}{\partial y}\right]dx\,dy$$

$$= -\mu\int\int_R \left[\frac{\partial}{\partial x}(x\Psi) + \frac{\partial}{\partial y}(y\Psi)\right]dx\,dy + 2\mu\int\int_R \Psi dx\,dy$$

$$= -\mu\int_C \Psi\left[x\nu_x + y\nu_y\right]ds + 2\mu\iint_R \Psi dx\,dy\,, \qquad ..(39)$$

using the Green theorem for plane.

On the boundary, C,

$$\Psi = \text{constt.}$$

We choose

$$\Psi = 0 \text{ on } C . \qquad ..(40)$$

Then

$$D = 2\mu \iint_R \Psi dxdy , \qquad ..(41)$$

which is the expression for torsinal rigidity D in terms of stress function Ψ .

7.5. LINES OF SHEARING SHEER

Consider the family of curves in the xy-plane given by

$$\Psi = \text{constt.} \qquad ...(42)$$

Then

$$\frac{\partial \Psi}{\partial x} + \frac{\partial \Psi}{\partial y}\frac{dy}{dx} = 0 .$$

This gives

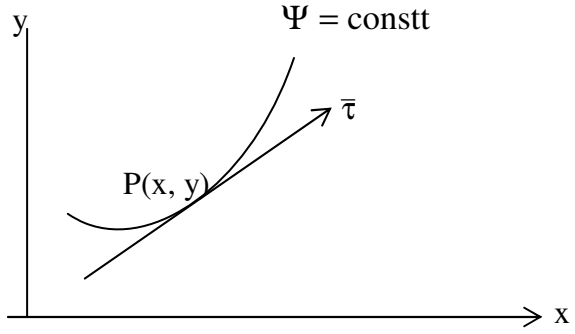
$$\frac{dy}{dx} = -\frac{\Psi x}{\Psi y} .$$

$$= \frac{\mu\alpha\Psi x}{\mu\alpha\Psi y}$$

$$= \frac{\tau_{zy}}{\tau_{zx}} . \qquad ..(43)$$

This relation shows that at each of the curve, Ψ = constt, the stress vector

$$\bar{\tau} = \tau_{zx}\,\hat{i} + \tau_{zy}\,\hat{j} \qquad ..(44)$$



is defined along the tangent to the curve Ψ = constt. at that point.

The curves

$$\Psi = \text{constt}$$

are called lines of shearing stress.

7.6. SPECIAL CASES OF BEAMS : TORSION OF AN ELLIPTIC BEAM

Let the boundary C of the cross-section be

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1 \ . \qquad ..(A1)$$

We assume that the solution of the Dirichlet boundary values problem (31) is of the type

$$\psi\,(x, y) = c^2\,(x^2 - y^2) + k^2 \ , \qquad ..(A2)$$

for constants c^2 and k^2.

It is obvious that

$$\nabla^2\,\psi = 0 \ . \qquad ..(A3)$$

At each point (x, y) on the boundary C, we must have

$$c^2\,(x^2 - y^2) + k^2 = \frac{1}{2}(x^2 + y^2)$$

or

$$x^2(\tfrac{1}{2} - c^2) + y^2(\tfrac{1}{2} + c^2) = k^2 \qquad ..(A4)$$

which becomes the ellipse (A1) if

$$c^2 < \tfrac{1}{2}$$

and

$$a = \frac{k}{\sqrt{\frac{1}{2}-c^2}}, \qquad b = \frac{k}{\sqrt{\frac{1}{2}+c^2}} \ ,$$

or

$$a^2 = \frac{k^2}{\left(\frac{1}{2}-c^2\right)}, \qquad b^2 = \frac{k^2}{\frac{1}{2}+c^2}$$

or

$$c^2 = \tfrac{1}{2}\left(\frac{a^2-b^2}{a^2+b^2}\right), \qquad k^2 = \frac{a^2b^2}{a^2+b^2} \ . \qquad ..(A5)$$

Therefore, solution of the Dirichlet problem (31) for this particular type of elliptic beam is

$$\psi(x, y) = \frac{a^2 - b^2}{2(a^2 + b^2)}(x^2 - y^2) + \frac{a^2 b^2}{a^2 + b^2}. \qquad ..(A6)$$

The torsion function ϕ is given by the formula

$$\begin{aligned}\phi(x,y) &= \int\left(\frac{\partial\phi}{\partial x}dx + \frac{\partial\phi}{\partial y}dy\right)\\ &= \int\left[\frac{\partial\psi}{\partial y}dx - \frac{\partial\psi}{\partial x}dy\right]\\ &= -\frac{a^2 - b^2}{a^2 + b^2}\int(y\,dx + x\,dy)\\ &= -\frac{a^2 - b^2}{a^2 + b^2}xy. \qquad ..(A7)\end{aligned}$$

The stress function $\Psi(x,y)$ is given by the formula

$$\begin{aligned}\Psi &= \psi(x, y) - \tfrac{1}{2}(x^2 + y^2)\\ &= \frac{-a^2 b^2}{a^2 + b^2}\left(\frac{x^2}{a^2} + \frac{y^2}{b^2} - 1\right), \qquad ..(A8)\end{aligned}$$

using (A6).

To calculate the torsional rigidity D_e and twist α.

The non-zero shear stresses are

$$\begin{aligned}\tau_{zx} &= \mu\alpha\left(\frac{\partial\psi}{\partial y} - y\right)\\ &= \mu\alpha\left[-\frac{a^2 - b^2}{a^2 + b^2}y - y\right]\\ &= \frac{-2\mu\alpha a^2 y}{a^2 + b^2}, \qquad ..(A9)\end{aligned}$$

and

$$\tau_{zy} = \mu\alpha\left(-\frac{\partial\psi}{\partial x} + x\right)$$

$$= \mu\alpha \left[-\frac{a^2 - b^2}{a^2 + b^2} x + x \right]$$

$$= \frac{2\mu\alpha b^2 x}{a^2 + b^2}. \qquad ..(A10)$$

Let M be the torsion moment of the couple about z-axis. Then

$$M = \iint_R \left(x\,\tau_{zy} - y\,\tau_{zx} \right) dxdy$$

$$= \frac{2\mu\alpha}{a^2 + b^2} \left[b^2 \iint_R x^2 dxdy + a^2 \iint_R y^2 dxdy \right]$$

This implies

$$M = \frac{2\mu\alpha}{a^2 + b^2} \left[b^2 I_y + a^2 I_x \right], \qquad \ldots(A11)$$

where I_x and I_y are the moments of inertia of the elliptic cross-section about x− and y−axis, respectively.

We know that

$$I_x = \frac{\pi a b^3}{4}, \qquad I_y = \frac{\pi a^3 b}{4} \qquad \ldots(A12)$$

Putting these values in (A11), we find

$$M = \frac{\pi\mu\alpha a^3 b^3}{a^2 + b^2}. \qquad ..(A13)$$

The torsional rigidity D_e is given by the formula

$$M = D_e \alpha. \qquad \ldots(A14)$$

Hence, we find

$$D_e = \frac{\pi\mu a^3 b^3}{a^2 + b^2}, \qquad ..(A15)$$

$$\alpha = \frac{M(a^2 + b^2)}{\pi\mu a^3 b^3}. \qquad \ldots(A16)$$

Equations (A9) , (A10) and (A16) imply

$$\tau_{zx} = \frac{-2My}{\pi a b^3}, \qquad 1 \qquad \ldots(A17)$$

$$\tau_{zy} = \frac{-2Mx}{\pi a^3 b}. \qquad \ldots(A18)$$

Lines of shearing stress: The line of shearing stress are given by the formula

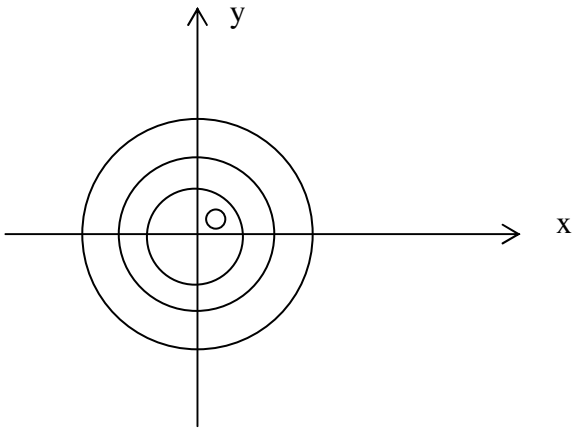
$$\Psi = \text{constt.} \qquad \ldots(A19)$$

Equations (A8) and (A19) imply

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = \text{constt.} \qquad \ldots(A20)$$

as the lines the shearing stress.

This is a family of concentric ellipses, similar to the given ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1.$



Displacements. The displacements at any point of the given elliptic beam are now given by the formulas

$$u = -\alpha\, yz, \qquad v = \alpha\, xz, \qquad w = \alpha\,\phi = -\left(\frac{a^2 - b^2}{a^2 + b^2}\right)\alpha\, xy \qquad \ldots(A21)$$

with the twist per unit length, α, as given by equation (A16).

Maximum shear stress: The shear stress τ is given by

$$\tau = \sqrt{\tau^2_{zx} + \tau^2_{zy}} \quad .$$

$$= \frac{2\mu\alpha}{a^2 + b^2}\sqrt{a^4 y^2 + b^4 x^2}\,. \qquad \ldots(A22)$$

We know that the maximum shear stress occurs on the boundary C

$$C: \qquad \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1.$$

So, on the boundary C , the shear stress becomes

$$\tau = \frac{2\mu\alpha}{a^2+b^2}\sqrt{a^4b^2\left(1-\frac{x^2}{a^2}\right)+b^4x^2}$$

$$= \frac{2\mu\alpha ab}{a^2+b^2}\sqrt{a^2-x^2+b^2x^2/a^2}$$

$$= \frac{2\mu\alpha ab}{a^2+b^2}\sqrt{a^2-x^2(1-b^2/a^2)}$$

$$(\tau)_C = \frac{2\mu\alpha ab}{a^2+b^2}\sqrt{a^2-e^2x^2}\ , \qquad \ldots(A23)$$

where

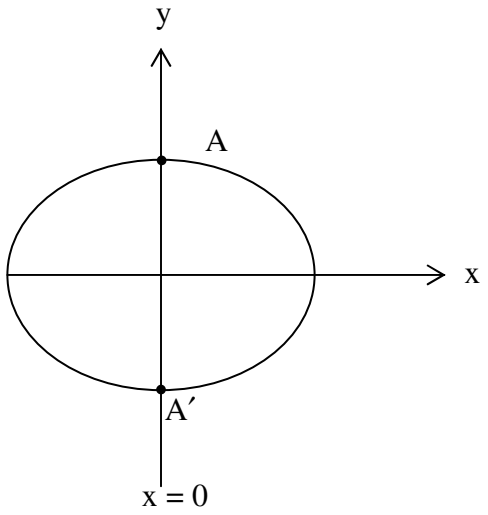
$$e^2 = 1 - b^2/a^2\ , \qquad \ldots(A24)$$

is the eccentricity of the ellipse.

We note that the maximum value of shearing stress (A23) occurs when x = 0. Thus,

$$\tau_{max} = \frac{2\mu\alpha a^2 b}{a^2+b^2} = \frac{2M}{\pi ab^2} \quad \text{at the points } (0, \pm b)\ . \qquad \ldots(A25)$$

Thus, the maximum shear stress occurs at the extremities of the minor axis



of the ellipse and maximum shear stress is given by (A25).

Warping curves: The warping curves are given by the relation

$$w = \text{constt.}$$

or

$$xy = \text{constt.}, \qquad \ldots(A26)$$

using (A21).

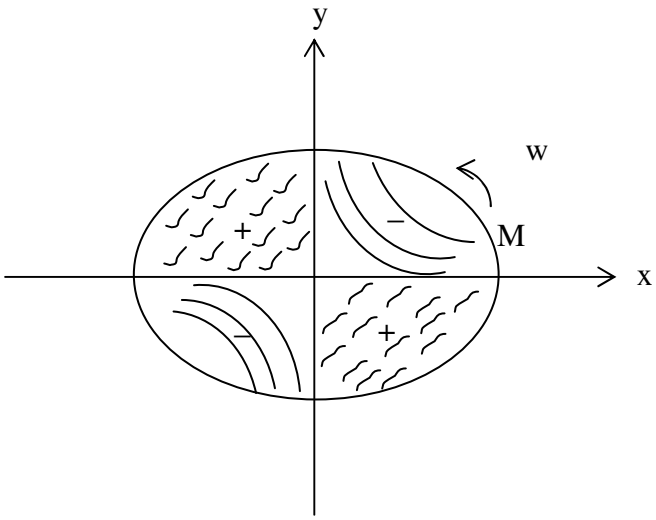
These are rectangular hyperbolas. We know that

$$w = -\frac{a^2 - b^2}{a^2 + b^2} \alpha\, xy\ .$$

In the first quadrant, x and y are both positive so $w < 0$.

In the third quadrant $x < 0$, $y < 0$, so $w < 0$.

Therefore, in I and III quadrants, the curves becomes concave. In figure, −ve sign represents concave curves.



In the II and IV quadrants, the curves become convex which are represented by + sign in the figure.

Remark 1. Let A be the area of the ellipse and I be the moment of inertia about z-axis. Then

$$A = \pi\, ab,$$

$$I = I_x + I_y = \frac{\pi ab}{4}(a^2 + b^2),$$

$$D_e = \frac{\mu A^4}{4\pi^2 I}\ . \qquad \ldots(A27)$$

Remark 2. The results for a circular bar can be derived as a particular case of the above−a bar with elliptic cross section, on taking b = a. We find

$$\phi\,(x, y) = 0\ ,$$

$$w\,(x, y) = 0\ ,$$

$$\Psi\,(x, y) = 0\ .$$

7.7. TORSION OF BEAMS WITH TRIANGULAR CROSS-SECTION

Consider a cylinder of length l whose cross section is a triangular prism. Let z-axis lie along the central line of the of the beam and one end of the beam lying in the plane z = 0 is fixed at the origin and the other end lie in the plane z = l. A couple of moment M is applied at the centriod (0, 0,l) of end.

We shall determine the resulting deformation.

Let

$$\phi + i\psi = i\, c\, (x + iy)^3 + ik, \qquad ..(B1)$$

where c and k are constants. We find

$$\phi = c\,(-3x^2y + y^3), \qquad ..(B2)$$

$$\psi = c\,(x^3 - 3x\,y^2) + k\ . \qquad ..(B3)$$

We shall be solving the Dirichlet problem in ψ:

$$\text{(i)}\quad \nabla^2 \psi = 0 \quad \text{in R}, \qquad ..(B4)$$

$$\text{(ii)}\quad \psi = \tfrac{1}{2}(x^2 + y^2) \quad \text{on C}, \qquad ..(B5)$$

where C is the boundary of a triangular cross section occupying the region R.

We note that ψ, given by (B3), is a harmonic function in the two-dimensional region R.

On the boundary C, we must have

$$c\,(x^3 - 3x\,y^2) + k = \tfrac{1}{2}(x^2 + y^2) \qquad ..(B6)$$

By altering the value of constant c and k, we obtain various cross-sections of the beam. In particularly, if we set

$$C = -\frac{1}{6a} \quad \text{and} \quad k = \frac{2}{3}a^2, \qquad ..(B7)$$

in equation (B6), we have

$$-\frac{1}{6a}(x^3 - 3x\,y^2) + \frac{2}{3}a^2 = \tfrac{1}{2}(x^2 + y^2)$$

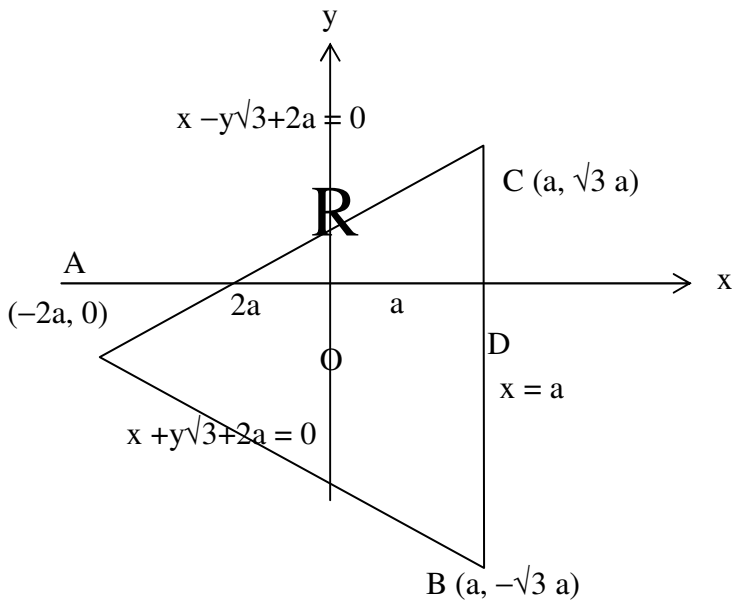
or

$$x^3 - 3x\,y^2 + 3a\,x^2 + 3a\,y^2 - 4\,a^3 = 0$$

or

$$(x - a)\,(x - y\sqrt{3} + 2a)\,(x + y\sqrt{3} + 2a) = 0\ . \qquad ..(B8)$$

This shows that the boundary C consists of an equilateral triangle ABC



formed by the st. lines

$$x = a\ ,$$

$$x + \sqrt{3}y + 2a = 0,$$

$$x - \sqrt{3}\ y + 2a = 0\ . \qquad \text{..(B9)}$$

The altitude of this cross-section is 3a and each length of the triangle is $2\sqrt{3}$ a. The centroid of this cross-section is origin , lying on the central line of the beam.

The unique solution of the Dirichlet problem (B4, 5) is

$$\psi = -\frac{1}{6a}(x^3 - 3x\ y^2) + \frac{2}{3}a^2\ . \qquad \text{…(B10)}$$

The torsion function becomes

$$\phi = -\frac{1}{6a}(y^3 - 3\ x^2 y)\ . \qquad \text{…(B11)}$$

The stress function Ψ is given by

$$\Psi = \psi\ (x, y) - \tfrac{1}{2}\ (x^2 + y^2)$$

$$= -\frac{1}{6a}[x^3 - 3x\ y^2 + 3\ x^2 a + 3y^2 - 4a^3]\ . \qquad \text{..(B12)}$$

The non-zero shear stresses are

$$\tau_{zx} = \mu\alpha \left(\frac{\partial \psi}{\partial y} - y \right)$$

$$= \frac{\mu\alpha}{a} (x - a)\, y \,, \qquad \ldots(B13)$$

$$\tau_{zy} = \mu\alpha \left(-\frac{\partial \psi}{\partial x} + x \right)$$

$$= \frac{\mu\alpha}{2a} (x^2 + 2ax - y^2) \,. \qquad \ldots(B14)$$

The displacement at any points of the triangular beam are given by

$$u = -\alpha\, yz,$$

$$v = \alpha\, xz,$$

$$w = \alpha\phi = \frac{\alpha}{6a} (3\, x^2 y - y^3) \qquad \ldots(B15)$$

where α is the twist per unit length.

We know that the maximum value of the shearing sheers τ occurs at the boundary C.

On the boundary x = a, we find

$$\tau_{zx} = 0, \qquad \tau = \tau_{zy} = \frac{\mu\alpha}{2a} (3\, a^2 - y^2), \qquad \ldots(B16)$$

which is maximum where y = 0. Thus

$$\tau_{max} = \frac{3}{2} \mu\alpha a \,, \qquad \ldots(B17)$$

at the point D(a,0), which is the middle point of BC.

Also, $\tau = 0$ at the points (corner pts B & C) where $y = \pm\sqrt{3}a$.

At the point A($-2a$, 0), τ is zero. Thus, the stress τ is zero at the corner points A, B, C. We note that at the centroid O(0, 0), the shear stress is also zero.

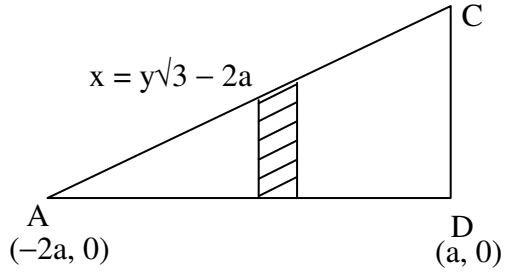
Similarly, we may check that the shearing stress τ is maximum at the middle points of the sides AC and AB, and the corresponding maximum shear stress is each equal to $\frac{3}{2} \mu\alpha a$.

Torsional rigidity: We know that M is the moment of the applied couple along z-axis. Therefore

$$M = \iint_R \left(x\,\tau_{zy} - y\,\tau_{zx}\right) dx\,dy$$

$$= \frac{\mu\alpha}{2a} \iint_R \left(x^3 + 2ax^2 - xy^2 - 2y^2x + 2y^2a\right) dx\,dy$$

$$= 2.\ \frac{\mu\alpha}{2a} \int_{x=-2a}^{a} \int_{y=0}^{y=\frac{x+2a}{\sqrt{3}}} \left(x^3 + 2ax^2 - xy^2 - 2y^2x + 2ay^2\right) dy\,dx \ . \quad \ldots(B18)$$



This gives

$$M = \frac{9\sqrt{3}}{5}\,\mu\,\alpha a^4, \qquad \ldots(B19)$$

Consequently, we obtain

$$D = \frac{9\sqrt{3}}{5}\,\mu\ a^4, \qquad \ldots(B20)$$

$$\alpha = \frac{5M}{9\sqrt{3}\mu a^4}, \qquad \ldots(B21)$$

with $a = \frac{1}{3}$ rd of the altitude of the equilateral triangle, each side being equal to $2\sqrt{3}a$.

Equation (B21) determines the constant α when the moment M and the cross-section are known. Equation (B13), (B14), and (B21) yield

$$\tau_{zx} = \frac{5M}{9\sqrt{3}a^5}\,y(x - a), \qquad \ldots(B22)$$

$$\tau_{zy} = \frac{5M}{18\sqrt{3}a^5}\,(x^2 + 2\,ax - y^2)\ . \qquad \ldots(B23)$$

Equations (B17) and (B21) imply

$$\tau_{max} = \frac{15M}{18\sqrt{3}a^4}, \qquad \ldots(B24)$$

at the point D (a, 0).

Theorem. Show that the points at which the shearing stress is maximum lie on the boundary C of the cross-section of the beam.

Proof. To prove this theorem, we use the following theorem from analysis.

"Let a function f(x, y) be continuous and has continuous partial derivatives of the first and second orders and not identically equal to a constant and satisfy the in equality $\nabla^2 f \geq 0$ in the region R. Then *f* (x, y) attains its maximum value on the boundary C of the region R".

We knows that the shear stress τ is given by

$$\tau^2 = \mu^2 \alpha^2 (\Psi_x^2 + \Psi_y^2) \quad , \qquad \ldots.(1)$$

where Ψ is the stress function. Now

$$\frac{\partial}{\partial x}\tau^2 = \mu^2\alpha^2\left[2\Psi_x\Psi_{xx} + 2\Psi_y\Psi_{yx}\right]$$

$$= 2\,\mu^2\alpha^2[\Psi_x\Psi_{xx+}\Psi_y\Psi_{yy}], \qquad \ldots.(2)$$

and

$$\frac{\partial^2}{\partial x^2}\tau^2 = 2\mu^2\alpha^2\left[\Psi_{zz}^2 + \Psi_x\Psi_{xxx} + \Psi_{yx}^2 + \Psi_y\Psi_{yxx}\right]. \quad ...(3)$$

Similarly

$$\frac{\partial^2}{\partial y^2}\tau^2 = 2\mu^2\alpha^2\left[\Psi_{yy}^2 + \Psi_y\Psi_{yyy} + \Psi_{xy}^2 + \Psi_x\Psi_{xyy}\right]. \quad ...(4)$$

Adding (3) and (4),

$$\nabla^2\tau^2 = 2\mu^2\alpha^2\left[\left(\Psi_{xx}^2 + \Psi_{yy}^2\right) + \Psi_x\frac{\partial}{\partial x}\left(\Psi_{xx} + \Psi_{yy}\right) + \Psi_y\frac{\partial}{\partial y}\left(\Psi_{xx} + \Psi_{yy}\right) + 2\Psi_{xy}^2\right]$$

$$= 2\mu^2\propto^2\left[\Psi_{xx}^2 + \Psi_{yy}^2 + 2\Psi_{xy}^2\right]. \qquad ...(5)$$

$$\geq 0 \qquad \text{in R.}$$

Therefore, by above result, τ^2 (and hence stress τ) attains the maximum value on the boundary C of the region R.

Question. Let D_0 be the torsional rigidity of a circular cylinder, D_e that of an elliptic cylinder, and D_t that of a beam whose cross-section is an equilateral triangle. Show that for cross-section of equal areas

$$D_e = kD_0, \qquad D_t = \frac{2\pi\sqrt{3}}{15} D_0, \text{ where } k = \frac{2ab}{a^2 + b^2} \le 1,$$

and a, b are the semi-axis of the elliptical section.

Solution. We know that for a circular cylinder of radius r,

$$D_0 = \frac{\pi}{2} \mu r^4 . \qquad ...(1)$$

We know that for an elliptic cylinder $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$,

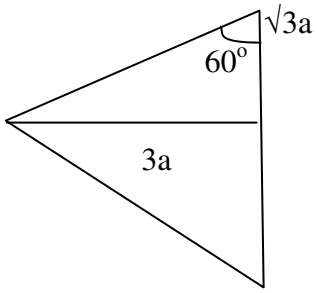
$$D_e = \frac{\pi \mu a^3 b^3}{a^2 + b^2} . \qquad ...(2)$$

We know that for an equilateral triangle (with each side of length $2\sqrt{3}x$)

$$D_t = \frac{9\sqrt{3}}{5} \mu x^4 . \qquad ...(3)$$

Since the areas of all the cross-section are equal, so

$$\pi r^2 = \pi ab = 3\sqrt{3} x^2 . \qquad ...(4)$$



Now

$$\frac{D_e}{D_0} = \frac{\pi \mu a^3 b^3}{a^2 + b^2} \times \frac{2}{\pi \mu r^2}$$

$$= \frac{2a^3 b^3}{r^4 (a^2 + b^2)}$$

$$= \frac{2a^3 b^3}{a^2 b^2 (a^2 + b^2)}$$

$$= \frac{2ab}{a^2 + b^2} \quad ,$$

$$= k \, . \qquad ...(5)$$

Also

$$\frac{D_t}{D_0} = \frac{a\sqrt{3}\mu x^4}{5} \times \frac{2}{\pi \mu r^4}$$

$$= \frac{18\sqrt{3}\, x^4}{5\pi r^4}$$

$$= \frac{18\sqrt{3} x^4}{5\pi (27\, x^4 / \pi)}$$

$$= \frac{18\sqrt{3}\pi}{5 \times 27} = \frac{2\pi\sqrt{3}}{15} \qquad ..(6)$$

Hence, the result.

Chapter-8
Variational Methods

8.1. INTRODUCTION

We shall be using the minimum principles in deriving the equilibrium and compatibility equations of elasticity.

8.2. DEFLECTION OF AN ELASTIC STRING

Let a stretched string, with the end points fixed at (0, 0) and (λ, 0), be deflected by a distributed transverse load $f(x)$ per unit length of the string. We suppose that the transverse deflection y(x) is small and the change in the stretch force T produced by deflection is neglible.

These are the usual assumption used in deriving the equation for y(x) from considerations of static equilibrium.

We shall deduce this equation from the Principle of Minimum Potential Energy.
We know that the potential energy V is defined by the formula

$$V = U - \int_0^{\lambda} f(x)\, y\, dx, \qquad ...(1)$$

where the strain energy U is equal to the product of the tensile force T by the total stretch e of the string. That is

$$U = T\, e, \qquad ...(2)$$

where

$$e = \int_0^{\lambda} (ds - dx)$$

$$= \int_0^{\lambda} \left[\sqrt{1 + (y')^2} - 1\right] dx \text{ `}. \qquad ...(3)$$

Since, we are dealing with the linear theory, so

$$(y')^2 << 1, \qquad ...(4)$$

and equation (3) can be written as

$$e = \frac{1}{2}\int_0^{\lambda} (y')^2 \, dx. \qquad ...(5)$$

From equations (1), (2) and (5), finally we write

$$V = \int_0^{\lambda} \left[\frac{1}{2} T(y')^2 - f(x)\, y \right] dx . \qquad ...(6)$$

The appropriate Euler's equation of the functional (6) is (left as an exercise)

$$T\frac{d^2y}{dx^2} + f(x) = 0 . \qquad ...(7)$$

This equation is the familiar / well known equation for the transverse deflection of the string under the load *f*(x).

8.3. DEFLECTION OF THE CENTRAL LINE OF A BEAM

Let the axis of a beam of constant cross-section coincides with the x-axis. Suppose that the beam is bent by a transverse load

$$p = f(x) , \qquad ...(1)$$

estimated per unit length of the beam.

As per theory of deformation of beams, we suppose that the shearing stresses are negligible in comparison with the tensile stress

$$\tau_{xx} = \frac{My}{I} , \qquad ....(2)$$

where M is the magnitude of the moment about the x-axis and I is the moment of inertia of the cross-section about x-axis.

The strain e_{xx} is then given by

$$e_{xx} = \frac{\tau_{xx}}{E}$$

$$= \frac{My}{IE} , \qquad ...(4)$$

where E is the Young's modulus.

The strain-energy function W is given by

$$W = \frac{1}{2}\tau_{xx}\, e_{xx}$$

$$= \frac{M^2y^2}{2EI^2} . \qquad ...(5)$$

The strain energy per unit length of the beam is found by integrating W over the cross-section of the beam, and we get

$$\int_R W d\sigma = \frac{M^2}{2EI^2} \int_R y^2 d\sigma$$

$$= \frac{M^2}{2EI}. \qquad ...(6)$$

The well known Bernoulli- Euler law is

$$M = -EI\frac{d^2y}{dx^2}. \qquad ....(7)$$

The total strain energy U obtained by integrating the expression (6) over the length of the beam, and using (7), we find

$$U = \frac{1}{2}\int_0^{\lambda} E\, I\left(\frac{d^2y}{dx^2}\right)dx. \qquad ....(8)$$

We suppose that the ends of the beam are clamped, hinged, or free, so that the supporting forces do not work and contribute nothing to potential energy V.

If we neglect the weight of the beam, the only external load is p = *f*(x), then the formula

$$V = U - \int_0^{\lambda} f(x)\, y\, dx, \qquad ...(9)$$

for the potential energy gives

$$V = \int_0^{\lambda}\left[\tfrac{1}{2} E\, I\left(\frac{d^2y}{dx^2}\right) - f(x)\ y\right]dx. \qquad ..(10)$$

The Euler's equation of the above function V is (left as an exercise)

$$\frac{d^2}{dx^2}\left(EI\frac{d^2y}{dx^2}\right) - f(x) = 0. \qquad ...(11)$$

8.4. DEFLECTION OF AN ELASTIC MEMBRANE

Let the membrane, with fixed edges, occupy some region in the xy-plane. We suppose that the membrane is stretched so that the tension T is uniform and that T is so great that it is not appreciably changed when the membrane is deflected by a distributed normal load of intensity *f*(x, y).

We first compute the strain energy U. The total stretch e of the surface

$$z = u(x, y), \qquad \ldots(1)$$

is

$$e = \iint_R (d\sigma - dx\,dy)$$

$$= \iint_R \left[\sqrt{u_x^2 + u_y^2 + 1} - 1\right] dx\ dy, \qquad \ldots.(2)$$

where

$$d\sigma = \left(\sqrt{u_x^2 + u_y^2 + 1}\right) dx\,dy \qquad \ldots.(3)$$

is the element of area of the membrane in the deformed state.

As usual, it is assumed that the displacement u and its first derivatives are small. Then, we can write (2) as

$$e = \frac{1}{2} \iint_R \{u_x^2 + u_y^2\} dx\,dy. \qquad \ldots.(4)$$

Hence, the strain energy U is given by

$$U = T\,e$$

$$= \frac{T}{2} \iint_R \{u_x^2 + u_y^2\} dx\,dy. \qquad \ldots.(5)$$

We know that the potential energy is given by the formula

$$V = U - \iint_R f(x, y)\, u\, dx\,dy\ . \qquad \ldots(6)$$

Equations (5) and (6) give the potential energy as

$$V = \iint_R \left\{\frac{T}{2}\left(u_x^2 + u_y^2\right) - f(x, y)\right\} u\ dx\,dy. \qquad \ldots.(7)$$

The equilibrium state is characterized by the condition

$$\delta V = 0. \qquad \ldots.(8)$$

This gives (left as an exercise)

$$T \nabla^2 u + f(x, y) = 0. \qquad \ldots(9)$$

8.5. TORSION OF CYLINDERS

We consider the Saint –Venant torsion problem for a cylinder of arbitrary cross-section. We shall use the Principle of Minimum Complementary Energy to deduce the appropriate Compatibility equation.

We know that the displacement components in the cross-section are

$$u(x, y, z) = -\alpha zy, \qquad v(x, y, z) = \alpha zx, \qquad \ldots(1)$$

where α is the twist per unit length of the cylinder.

We assume with Saint-Venant principle that nonvanishing stresses are τ_{zx} and τ_{zy}.

The formula for complementary energy is

$$V^* = U - \int_{\sum u} T_i u_i \; d\sigma, \qquad \ldots(2)$$

where the surface integral is evaluated over the ends of the cylinder, and strain energy U is given by

$$U = \int_{\tau} W \; d\tau, \qquad \ldots.(3)$$

where

$$W = \frac{1}{2}\tau_{ij}\, e_{ij}$$

$$= (\tau_{zx}\, e_{zx} + \tau_{zy}\, e_{zy}), \qquad \ldots.(4)$$

From shear strain relations, we have

$$\tau_{zx} = 2\mu\, e_{zx},$$

$$\tau_{zy} = 2\mu\, e_{zy}. \qquad \ldots.(5)$$

From equations (4) and (5), we find

$$W = \frac{1}{2\mu}(\tau^2_{zx} + \tau^2_{zy}), \qquad \ldots.(6)$$

and hence

$$U = \frac{1}{2\mu}\int_{\tau}\left[\tau^2_{zx} + \tau^2_{zy}\right] d\tau. \qquad \ldots(7)$$

Now, we shall compute the surface integral in (2).

i). For the end $z = 0$, we have

$$u + v = 0,$$

so

$$\int_R T_i . u_i \; d\sigma` = 0. \qquad \ldots(8)$$

ii). On the end $z = \lambda$, we have

$$\int_R T_i . u_i \; d\sigma = \alpha \iint_R \left(-\lambda y \tau_{zx} + \lambda x \tau_{zy}\right) dx\, dy . \qquad \ldots.(9)$$

Thus, we find

$$V^* = \frac{\lambda}{2\mu} \iint_R \left(\tau^2_{zx} + \tau^2_{zy}\right) dx\, dy - \alpha\lambda \iint_R \left(x \tau_{zy} - y \tau_{zx}\right) dx\, dy . \quad \ldots(10)$$

In this case, the admissible stresses satisfy the equilibrium equation (left as an exercise)

$$\frac{\partial \tau_{zx}}{\partial x} + \frac{\partial \tau_{zy}}{\partial y} = 0, \qquad \text{in R} \ , \qquad \ldots(11)$$

and the boundary condition

$$\tau_{zx} \cos (x, \nu) + \tau_{zy} \cos (y, \nu) = 0, \qquad \text{on C.} \qquad \ldots(12)$$

Equilibrium equation (11) will clearly be satisfied identically if we introduce the stress function.

$$\Psi = \Psi(x, y)$$

such that

$$\tau_{zx} = \mu\alpha \frac{\partial \Psi}{\partial y} \ ,$$

$$\tau_{zy} = -\mu\alpha \frac{\partial \Psi}{\partial x} . \qquad \ldots(13)$$

The boundary condition (12) then requires that

$$\mu\alpha \left(\frac{\partial \Psi}{\partial y} \frac{dy}{ds} + \frac{\partial \Psi}{\partial x} \frac{dx}{ds} \right) = 0 \ ,$$

or

$$\frac{d\Psi}{ds} = 0 \ ,$$

or

$$\Psi = \text{constant}, \qquad \text{on C.} \qquad \ldots(14)$$

On substituting expressions for stresses from (13) into equation (10), we get

$$V^* = \left(\frac{\mu\alpha^2\lambda}{2}\right)\iint_R \left[(\Psi_x)^2 + (\Psi_y)^2 + 2\left(x\Psi_x + y\Psi_y\right)\right] dx\,dy\,. \qquad ...(15)$$

The corresponding Euler equation (exercise) is

$$\nabla^2\,\Psi = -2\,, \quad \text{in R}, \qquad ...(16)$$

which is precisely the equation for the Prandtl stress function.

Remark: The formula (15) for V^* can be written in a simple form which we shall find useful in subsequent considerations.

We note that

$$\iint_R \left(x\,\Psi_x + y\,\Psi_y\right) dx\,dy = \iint_R \left[\frac{\partial}{\partial x}(x\,\Psi) + \frac{\partial}{\partial y}(y\Psi)\right] dx\,dy - 2\iint_R \Psi\,dx\,dy\,. \quad ..(17)$$

But

$$\iint_R \left[\frac{\partial}{\partial x}\left(x\,\Psi\right) + \frac{\partial}{\partial y}(y\,\Psi)\right] dx\,dy = \int_C \Psi\left[x\cos(x,\nu) + y\cos(y,\nu)\right] ds\,. \qquad ...(18)$$

So that we obtain

$$V^* = \left(\frac{\mu\alpha^2\lambda}{2}\right)\iint \left[(\nabla\Psi)^2 - u\Psi\right] dx\,dy + 2\int_C \Psi\left[x\cos(x,\nu) + y\cos(y,\nu)\right] ds, \quad ..(19)$$

where

$$(\nabla\Psi)^2 = (\Psi_x)^2 + (\Psi_y)^2. \qquad ...(20)$$

If the region R is simply connected, we can take

$$\Psi = 0, \qquad \text{on C}\,, \qquad ...(21)$$

and for the determination of Ψ, we have the functional

$$V^* = \left(\frac{\mu\alpha^2\lambda}{2}\right)\iint_R \left[(\nabla\Psi)^2 - 4\Psi\right] dx\,dy\,, \qquad ...(22)$$

This functional (22) is to be minimized on the set of all functions of class C^2 vanishing on the boundary C of the simply connected region R.

8.6. VARIATIONAL PROBLEM RELATED TO THE BIHARMONIC EQUATION

Consider the variational problem

$$I(u) = \iint_R \left[\left(\nabla^2 u \right)^2 - 2 f u \right] dx\, dy = \min, \qquad \ldots.(1)$$

where the admissible functions u(x, y) satisfy on the boundary C of the region R the conditions

$$u = \phi(s), \qquad \ldots(2)$$

$$\frac{\partial u}{\partial \eta} = h(s), \qquad \ldots(3)$$

Suppose that the set { u(x, y)} of all admissible functions includes the minimizing function u(x, y). We represent an arbitrary function $\bar{u}(x, y)$ of this set in the form

$$\bar{u}(x, y) = u(x, y) + \in \eta(x, y), \qquad \ldots(4)$$

where $\in$ is a small real parameter.

We know that the necessary condition that u minimize the integral (1) is

$$\delta I = \left[\frac{d}{d \in} I(u + \in \eta) \right]_{\in = 0} = 0. \qquad \ldots(5)$$

Using (1), we write

$$I(u + \in \eta) = \iint_R \left[\left\{ \nabla^2 (u + \in \eta) \right\}^2 - 2f (u + \in \eta) \right] dx\, dy. \qquad \ldots(6)$$

Therefore equations (5) and (6) give

$$\iint_R \left[\nabla^2 u \nabla^2 \eta - f \eta \right] dx\, dy = 0. \qquad \ldots(7)$$

We note that

$$\nabla^2 u \nabla^2 \eta, = (\nabla^2 u) \left(\frac{\partial^2 \eta}{\partial x^2} + \frac{\partial^2 \eta}{\partial y^2} \right)$$

$$= \left[\frac{\partial}{\partial x} \left(\nabla^2 u \frac{\partial \eta}{\partial x} \right) + \frac{\partial}{\partial y} \left(\nabla^2 u \frac{\partial \eta}{\partial y} \right) \right] - \left[\frac{\partial}{\partial x} \left(\eta \frac{\partial}{\partial x} \nabla^2 u \right) + \frac{\partial}{\partial y} \left(\eta \frac{\partial}{\partial y} \nabla^2 u \right) \right]$$
$$+ \left[\frac{\partial^2}{\partial x^2} \left(\nabla^2 u \right) + \frac{\partial^2}{\partial y^2} \left(\nabla^2 u \right) \right] \eta .$$

...(8)

Applying Gauss Diwergence & Stoke's theorems we get

$$\iint_R \left[\frac{\partial}{\partial x}\left(\nabla^2 u \frac{\partial \eta}{\partial x} \right) + \frac{\partial}{\partial y}\left(\nabla^2 u \frac{\partial \eta}{\partial y} \right) \right] dx\ dy = \int_C \nabla^2 u \frac{\partial \eta}{\partial \nu} ds, \qquad ...(9)$$

$$\iint_R \left[\frac{\partial}{\partial x}\left(\eta \frac{\partial}{\partial x} \nabla^2 u \right) + \frac{\partial}{\partial y}\left(\eta \frac{\partial}{\partial y} \nabla^2 u \right) \right] dx\ dy = \int_C \eta \frac{\partial}{\partial \nu}\left(\nabla^2 u \right) ds. \quad ...(10)$$

For equations (7) to (10), we obtain

$$\delta I = \iint_R \left(\nabla^2 \nabla^2 u - f \right) \eta\, dx\, dy + \int_C \nabla^2 u \frac{\partial \eta}{\partial \nu} ds - \int_C \eta \frac{\partial}{\partial \nu}\left(\nabla^2 u \right) ds = 0 \quad ...(11)$$

From equations (2) to (4), we have

$$\eta = 0 \text{ and } \frac{\partial \eta}{\partial \nu} = 0 \qquad \text{on C.} \qquad ...(12)$$

Using result (12), equation (11) gives

$$\nabla^4 u = f(x, y) \quad \text{in the region R.} \qquad ...(13)$$

This is the same differential equation which arises in the study of the transverse deflection of thin elastic plates.

We have assumed in the foregoing that the admissible functions in the set {u (x, y)} satisfy the boundary conditions (2) and (3).

If we consider a larger set S of all functions u belonging to class C^4, then (11) must hold for every u in this set. But the set S includes functions that satisfy the boundary conditions (2) and (3), and thus we must have,

$$\iint_R \left(\nabla^4 u - f \right) \eta\, dx\, dy = 0. \qquad ...(14)$$

Since η is arbitrary, it follows that the minimizing function u(x, y) again satisfy (13) and we conclude from (11) that

$$\int_C \nabla^2 u \frac{\partial \eta}{\partial \nu} ds - \int_C \eta \frac{\partial}{\partial \nu}\left(\nabla^2 u \right) ds = 0, \qquad ...(15)$$

for every η of class C^4.

Now if we consider first all η such that

$$\eta = 0 \quad \text{on C and } \frac{\partial \eta}{\partial \nu} \neq o \qquad \text{on C,} \qquad ...(16)$$

it follows from (15) that

$$\nabla^2 u = 0, \qquad \text{on C.} \qquad ...(17)$$

On the other hand, if we consider only those η such that

$$\eta \neq 0, \ \frac{\partial \eta}{\partial \nu} = 0, \qquad \text{on C,} \qquad ...(18)$$

We get the condition

$$\frac{\partial}{\partial \nu}(\nabla^2 u) = o, \qquad \text{on C.} \qquad ...(19)$$

Hence if the functional in (1) is minimized on the set S of all u of class C^4, the minimizing function will be found among those functions of S which satisfy the conditions (17) and (19) on the boundary of the region.

Remark:- For this variational problem (1), we shall obtain the same differential equation (13) when the minimizing function $u = u(x, y)$, instead of the system given in (2) and (3), satisfies the following boundary condition.

$$\nabla^2 u = 0,$$

$$\frac{\partial}{\partial \nu}\left(\nabla^2 u\right) = 0, \quad \text{on C .}$$

8.7. RITZ METHOD :– ONE DIMENSIONAL CASE

Consider the variational problem

$$I(y) = \int_{x_0}^{x_1} F(x, y, y')dx, \qquad \ldots(1)$$

in which all admissible function $y = y(x)$ are such that

$$y(x_0) = y_1, \quad y(x_1) = y_1. \qquad \ldots(2)$$

We know that such a function y is a solution of the Euler's equation

$$F_y - \frac{d}{dx}F_y' = 0. \qquad \ldots.(3)$$

A direct method to obtain the desired function was proposed by W. Ritz in 1911.

In this method, we construct a sequence of functions which converge to desired solution of the Euler's equation (3).

Outlines of the Ritz Method:

Let $y = y^*(x)$ be the exact solution of the given variational problem. Let $I(y^*) = m$ be the minimum value of the functional in (1).

In this method, one tries to find a sequence $\{\bar{y}_n(x)\}$ of admissible functions such that

$$\lim_{n\to\infty} I(\bar{y}_n(x)) = m, \qquad ...(4)$$

so that

$$\lim_{n\to\infty} \bar{y}_n(x) = y^*(x), \qquad ...(5)$$

is the required function.

Ritz proposed to construct a function $\bar{y}(x)$ by choosing a family of functions

$$y(x) = \phi(x, a_1, a_2 \ldots\ldots\ldots\ldots, a_k) \qquad ....(6)$$

depending on k real parameters a_i, where ϕ is such that for all values of the a_i, the end conditions given in (2) are satisfied.

Then, on putting the value of y from (6) in (1), one obtains

$$I(a_1, a_2, a_3, \ldots\ldots\ldots, a_k).$$

This functional can be minimized by determining the values of the parameters a_i from the following system of equations:

$$\frac{\partial I(a_1, a_2, \ldots\ldots\ldots a_k)}{\partial a_r} = 0 \qquad \text{for } r = 1, 2, \ldots\ldots\ldots k. \qquad ...(7)$$

Let this system has solution $\bar{a}_1, \bar{a}_2, \ldots\ldots\ldots, \bar{a}_k$. Then, the minimizing function, say $\bar{y}(x)$, is

$$\bar{y}(x) = \phi(x, \bar{a}_1, \bar{a}_2, \ldots\ldots\ldots, \bar{a}_k). \qquad ...(8)$$

It is expected that $\bar{y}(x)$ will be a fair approximation to the minimizing function $y^*(x)$ when the number of parameters in (3) is made sufficiently large.

Now, we construct a sequence $\{\bar{y}_n(x)\}$ of functions $\bar{y}_n(x)$ such that

$$\lim_{n\to\infty} I(\bar{y}_n) = m. \qquad ...(9)$$

Consider a sequence of families of functions of the type (6), namely,

$$\left.\begin{aligned} y_1(x) &= \phi_1(x, a_1) \\ y_2(x) &= \phi_2(x, a_1, a_2) \\ y_3(x) &= \phi_3(x, a_1, a_2, a_3) \\ &\text{-- ------ -----,} \\ y_n(x) &= \phi_n(x, a_1, a_2, \ldots\ldots\ldots, a_n) \end{aligned}\right\}, \qquad \ldots(10)$$

in which the family $y_k(x) = \phi_k(x, a_1, \ldots\ldots\ldots, a_k)$ includes in it all functions in the families with subscript less than k.

The parameters a_i in each function y_k can be determined so as to minimize the integral $I(y_k)$. We denote the values of the parameters thus obtained by $\bar{a}_i$, so that the minimizing functions are

$$\bar{y}_n(x) = \phi_n(x, \bar{a}_1, \bar{a}_2, \ldots\ldots\ldots, \bar{a}_n), \qquad \ldots(11)$$

for n = 1, 2,…. Since each family $y_k(x)$ includes the families $y_{k-1}(x)$ for special values of parameters a_i, the successive minima $I(\bar{y}_k)$ are non-increasing, therefore,

$$I(\bar{y}_1) \geq I(\bar{y}_2) \geq I(\bar{y}_3) \geq \ldots\ldots\ldots \geq I(\bar{y}_{n-1}) \geq I(\bar{y}_n) \geq \ldots\ldots\ldots \qquad \ldots(12)$$

Since the sequence $\{I(\bar{y}_n)\}$ of real numbers is bounded below by m and is non-increasing (m being the exact minima), therefore, it is a convergent sequence.

In order to ensure the convergence of this sequence to $I(y^*)$, one must impose some conditions on the choice of functions ϕ_i in (10). We take the set of functions in (10) to be relatively complete.

Then for each $\in \to 0$, there exists (by definition of relatively complete) in the family (10), a function

$$y^*_n(x) = y_n(x, a^*_1, a^*_2, \ldots\ldots\ldots a^*_n)$$

such that

$$\left| y^*_n - y^* \right| < \in , \qquad \ldots(13)$$

and

$$\left| y^*_n{}' - y^*{}' \right| < \in , \qquad \ldots(14)$$

for all $x \in (x_0, x_1)$. But, it is known that F (x, y, y′) is a continuous function of its arguments, therefore,

$$\left| F(x, y^*_n, y^{*\prime}_n) - f(x, y^*, y^{*\prime}) \right| < \in, \qquad \ldots(15)$$

for all x in (x_0, x_1). Consequently

$$I(y^*_n) - I(y^*) = \int_{x_0}^{x_1} \left[F(x, y^*_n, y^{*\prime}_n) - F(x, y^*, y^{*\prime}) \right] dx$$

$$= \int_{x_0}^{x_1} \left| F(x, y^*_n, y^{*\prime}_n) - F(x, y^*, y^{*\prime}) \right| dx$$

$$< \in', \text{ say.}$$

This gives

$$I(y^*_n) < I(y^*) + \in'. \qquad \ldots(16)$$

As y^*_n is a function of the set (10) and $I(\bar{y}_n)$ is a minimum of I (y) on the family y_n, therefore,

$$I(y^*_{n)} \geq I(\bar{y}_n). \qquad \ldots(17)$$

As y^* is the exact solution of the problem and $\bar{y}_n$ is an approximation of the same, therefore,

$$I(y^*) \leq (\bar{y}_n). \qquad \ldots(18)$$

Combining the in equalities (16) to (18), we find

$$I(y^*) \leq I(\bar{y}_n) \leq I(\bar{y}_n) < I(y^*) + \in, \qquad \ldots(19)$$

but $\in'$ can be made as small as we wish, therefore, we get

$$\lim_{n \to \infty} I(\bar{y}_n) = \lim_{n \to \infty} I(y^*_n) = I(y^*). \qquad \ldots(20)$$

This completes the proof.

Definition. Let y (x) be an admissible function satisfying the end conditions

$$y(x_0) = y_0, \; y(x_1) = y_1.$$

If , for each $\in > 0$, their exists in the family (6) a function

$$y^*_n(x) = y_n(x, a^*_1, a^*_2, a^*_3, \ldots, a^*_n)$$

such that

$$\left| y^*_n - y^* \right| < \in \qquad \text{and} \qquad \left| y^*_n{}' - y^{*\prime} \right| < \in$$

for all x in (x_0, x_1), then the family of functions in (6) is said to be **relatively complete.**

Remark:– Among useful, relatively complete sets of functions in the interval $(0, \lambda)$ are

(i) trigonometrically polynomials : $\sum_{k=1}^{n} a_k \sin\left(\frac{k\pi x}{\lambda}\right)$,

(ii) algebraic polynomials : $\sum_{k=1}^{n} a_k x^k (\lambda - x)$.

Question:– Show that the system of equations

$$\frac{\partial}{\partial a_j} I(y_n) = 0 \text{ (for } j = 1, 2, 3, \ldots\ldots, n)$$

for the coefficients in the approximate solution

$$y_n(x) = \sum_{k=1}^{n} a_k \phi_k(x)$$

of the variational problem

$$I(y) = \int_0^{\lambda} \left[p y'^2 + q y^2 + 2 f y \right] dx = \min,$$

$$y(0) = y(\lambda) = 0 ,$$

by the Ritz method is

$$\int_0^{\lambda} \left[p y'_n \phi'_j + q\, y_n \phi_j + f \phi_j \right] dx = 0 , \; j = 1, 2, \ldots\ldots, n.$$

Solution:– We have

$$I(y_n) = \int_0^{\lambda} \left[p y_n'^2 + q y_n^2 + 2 f y_n \right] dx . \qquad \ldots(1)$$

Therefore, we find

$$\frac{\partial}{\partial a_j} I(y_n) = \int_0^{\lambda} \left[2p\, y_n' . \frac{\partial}{\partial a_j} . (y_n') + 2\, q\, y_n \frac{\partial}{\partial a_j} . y_n + 2 f \frac{\partial}{\partial a_j} y_n \right] dx$$

$$= 2 \int_0^{\lambda} \left[p y_n' \phi'_j + q y_n \phi_j + f \phi_j \right] dx. \qquad \ldots(2)$$

Hence, the system of equations

$$\frac{\partial}{\partial a_j} I(y_n) = 0 \qquad ...(3)$$

becomes, using (2),

$$\int_0^{\lambda} \left[p\, y_n' \phi_j' + q\, y_n \phi_j + f \phi_j \right] dx = 0 \quad , \qquad \ldots(4)$$

for j = 1, 2, ……..,n.

This completes the solution.

8.8. RITZ METHOD :– TWO-DIMENSIONAL CASE

Consider the functional in the form

$$I(u) = \iint_R F(x, y, u, u_x, u_y)\, dx\, dy . \qquad \ldots(1)$$

We suppose that the admissible functions in the variational problem,

$$I(u) = \text{minimum}, \qquad \ldots(2)$$

satisfy the condition

$$u = \varphi(s)$$

on the boundary C of the region R.

Let $u^*(x, y)$ be an exact solution of the variational problem (obtained by solving the corresponding Euler's equation) and let

$$I(u^*) = m \ , \qquad ...(3)$$

be the minimum value of the functional (1).

We now introduce a sequence $\{u_n(x, y)\}$ of families of admissible functions

$$u_n(x, y) = \phi_n(x, y, a_1, a_2, \ldots\ldots, a_n), \qquad ...(4)$$

with parameters a_i, and suppose that each family $u_i(x, y)$ includes in it families with subscripts less than i.

We further assume that the set (4) is relatively complete.
Then, for each $\in > 0$, there exists a function

$$u^*_n(x, y) = \phi_n(x, y, a^*_1, a^*_2, \ldots\ldots\ldots, a^*_n)$$

belonging to the set (4) such that

$$\left| u^*_n - u^* \right| < \in, \qquad \left| \frac{\partial u^*_n}{\partial x} - \frac{\partial u^*}{\partial x} \right| < \in, \left| \frac{\partial u^*_n}{\partial y} - \frac{\partial u^*}{\partial y} \right| < \in \ , \qquad ...(5)$$

for all (x, y) $\in$ R . With the help of (4), we form I (u_n) and determine the parameters a_i so that I (u_n) is a minimum.

Let $\bar{a}_i$ be the values of the a_i obtained by solving the system of equations (known as Ritz's equations)

$$\frac{\partial I(u_n)}{\partial a_j} = 0, \qquad ...(6)$$

for j =1, 2, …..,n. We write

$$\bar{u}_n (x, y) = \varphi_n (x, y, \bar{a}_1, \bar{a}_2, ...\bar{a}_n) . \qquad \ldots(7)$$

The sequence $\{I (\bar{u}_n)\}$ of real numbers then converges to I (u*) = m, where u^* (x, y) is the function that minimizes (1).

The remaining proof is similar to the proof for one dimensional case.

Illustration. Find an approximate solution to the problem of extremising the functional

$$I (z) = \iint_D \left[z_x^2 + z_y^2 - 2z \right] dx\, dy , \qquad \ldots(1)$$

where the region R is a sequence, $-a \le x \le a$, $-a \le y \le a$ and z = 0 on the boundary of the sequence D.

Solution: We shall seek an approximate solution in the form

$$z_1 = z = \alpha_1 (x^2 - a^2) (y^2 - a^2) , \qquad \ldots(2)$$

in which α_1 is a constant to be determined.

It is clear that this function z_1 satisfies the boundary condition. Putting the value of z from (2) into (1), we find

$$I (z_1) = \iint_D \left[4\alpha_1^2 x^2 \left(y^2 - a^2\right)^2 + 4\alpha_1^2 y^2 \left(x^2 - a^2\right)^2 - 2\alpha_1 \left(x^2 - a^2\right)\left(y^2 - a^2\right) \right] dx\, dy$$

$$= 4\alpha_1^2$$

$$\int_{-a}^{a} x^2 dx \int_{-a}^{a} \left(y^2 - a^2\right)^2 dy + 4\alpha_1^2 \int_{-a}^{a} y^2 dy . \int_{-a}^{a} \left(x^2 - a^2\right)^2 dx - 2\alpha_1 \int_{-a}^{a} \left(x^2 - a^2\right) dx \int_{-a}^{a} \left(y^2 - a^2\right) dy$$

$$= 4\alpha_1^2 \left[\frac{x^3}{3} \right]_{-a}^{a} \left[\frac{y^5}{5} - \frac{2a^3 y^3}{3} + a^4 y \right]_{-a}^{a}$$

$$+ 4\alpha_1^2 \left[\frac{y^3}{3} \right]_{-a}^{a} \left[\frac{x^5}{5} - 2a^2 \frac{x^3}{3} + a^4 x \right]_{-a}^{a}$$

$$- 2\alpha_1 \left[\frac{x^3}{3} - a^2 x \right]_{-a}^{a} \left[\frac{y^3}{3} - a^2 y \right]_{-a}^{a}$$

$$= 8\alpha_1^2 \frac{1}{3} \left(a^3 + a^3\right) \left(\frac{a^5}{5} - \frac{2a^5}{3} + a^5 \right) (2) - 2\alpha_1 \left(\frac{a^3}{3} - a^3 \right) .4$$

$$= \frac{32}{3} \alpha_1^2 a^3 \left(\frac{8a^5}{15} \right) - 8\alpha_1^2 \left(\frac{2a^3}{3} \right)^2 = \frac{32 \times 8}{3 \times 15} \alpha_1^2 a^8 - \frac{32}{9} \alpha_1 a^6 . \quad ...(3)$$

For an extremum value, we have

$$\frac{d I(\alpha_1)}{d\alpha_1} = 0 \quad ...(4)$$

This gives

$$\alpha_1 = \frac{5}{16a^2} . \quad ...(5)$$

Thus, an approximate solution is

$$z = \frac{5}{16a^2} (x^2 - a^2) (y^2 - a^2) . \quad ...(6)$$

Question. Show that the system of equations $\frac{\partial}{\partial a_j} I(u_n) = 0$, (j = 1, 2, ……,n) for the determination of coefficients in the minimizing function

$$u_n = \sum_{i=1}^{n} a_i \phi_i (x, y)$$

for the problem

$$I(u) = \iint_R \left[u_x^2 + u_y^2 + 2fu\right] dx\, dy = \min, \qquad u = 0 \quad \text{on C}$$

is

$$\iint_R \left[\frac{\partial u_n}{\partial x}\frac{\partial \phi_j}{\partial x} + \frac{\partial u_n}{\partial y}\frac{\partial \phi_i}{\partial y} + f\,\phi_j \right] dx\, dy = 0\,, \quad j = 1, 2, 3, \ldots\ldots, n.$$

Solution:– The minimizing function is

$$u_n = \sum a_i\, \phi_i$$

……(1)

We form

$$I(u_n) = \iint_R \left[u_{n,x}^2 + u_{n,y}^2 + 2fu_n\right] dx\, dy\,. \qquad \ldots(2)$$

Therefore, we find

$$\frac{\partial}{\partial a_j} I(u_n) =$$

$$\iint_R \left[2u_{n,x} \frac{\partial}{\partial a_j}\left(u_{n,x}\right) + 2u_{x,y} \frac{\partial}{\partial a_j}\left(u_{n,y}\right) + 2f \frac{\partial}{\partial a_j} u_n \right] dx\, dy \qquad \ldots(3)$$

We have

$$u_{n,x} = \sum_{i=1}^{n} a_i \frac{\partial \phi_i}{\partial x}, \qquad \ldots(4)$$

and

$$\frac{\partial}{\partial a_j}(u_{n,x}) = \frac{\partial \phi_j}{\partial x}\,. \qquad \ldots(5)$$

Similarly,

$$\frac{\partial}{\partial a_j}(u_{n,y}) = \frac{\partial \phi_j}{\partial y}\,, \qquad \ldots(6)$$

$$\frac{\partial}{\partial a_j} u_n = \phi_j \ . \qquad \ldots(7)$$

Using (5) to (7) in relation (3), we write

$$\frac{\partial}{\partial a_j} I(u_n) = 2 \iint_R \left[\frac{\partial u_n}{\partial x} \frac{\partial \phi_j}{\partial x} + \frac{\partial u_n}{\partial y} \frac{\partial \phi_j}{\partial y} + f \phi_j \right] dx\, dy. \qquad \ldots(8)$$

Therefore, the system of equations

$$\frac{\partial}{\partial a_j} I(u_m) = 0 \ , \qquad \ldots(9)$$

becomes

$$\iint_R \left[\frac{\partial u_n}{\partial x} \frac{\partial \phi_j}{\partial x} + \frac{\partial u_n}{\partial y} \frac{\partial \phi_j}{\partial y} + f \phi_j \right] dx\, dy = 0, \qquad ..(10)$$

for j = 1, 2, …..,n.

Question:– Show that the system of equations $\frac{\partial I(u_n)}{\partial a_j} = 0$, (j = 1, 2, …….,n) , for determining the coefficients in the approximate solution

$$u_x = \sum_{i=1}^{n} a_i \phi_i$$

for the problem

$$I(u) = \iint_R \left[\left(\nabla^2 u \right)^2 - fu \right] dx\, dy = \min,$$

$$u = 0, \qquad \frac{\partial u}{\partial \eta} = 0 \qquad \text{on C , (C being the boundary of R) ,}$$

is

$$\iint_R \sum_{i=1}^{\eta} \left[a_i \nabla^2 \phi_i \nabla^2 \phi_j - f \phi_j \right] dx\, dy = 0$$

for j = 1, 2,…..,n.

Solution:– We form $I(u_n)$. We obtain

$$I(u_n) = \iint_R \left[\left(\nabla^2 u_n \right)^2 - 2 f u_n \right] dx\, dy. \qquad \ldots(1)$$

We find

$$\frac{\partial}{\partial a_j} I(u_n) = 2 \iint_R \left[\nabla^2 u_n . \frac{\partial}{\partial a_J} \left(\nabla^2 u_n \right) - f \frac{\partial}{\partial a_J} u_n \right] dx\, dy$$

$$= 2 \iint_R \left[\nabla^2 u_n . \nabla^2 \phi_j - f \phi_j \right] dx\, dy$$

$$= 2 \iint_R \sum_{i=1}^{\eta} \left[\nabla^2 \phi_i \nabla^2 \phi_j - f \phi_j \right] dx\, dy. \qquad ...(2)$$

Therefore, the system of equations

$$\frac{\partial}{\partial a_j} I(u_n) = 0 \ , \qquad ...(3)$$

becomes

$$\iint_R \sum_{i=1}^{\eta} \left[\nabla^2 \phi_i \nabla^2 \phi_j - f \phi_j \right] dx\, dy = 0 \ , \qquad ...(4)$$

for j = 1, 2,……..,n. This completes the solution.

8.9. GALERKIN METHOD

In 1915, Galerkin proposed a method of finding an approximate solution of the boundary value problems in mathematical physics. This method shall have wider scope than the method of Ritz.

Method : Let it be required to solve a linear differential equation

$$L(u) = 0 \qquad \text{in R}, \qquad \ldots(1)$$

subject to some homogeneous boundary conditions, L being a linear differential operator.

It is assumed, for simplicity that the domain R is two-dimensional.

We seek an approximate solution of the problem of the type

$$u_n(x, y) = \sum_{i=1}^{n} a_i \phi_i (x, y) \qquad \ldots(2)$$

where the ϕ_i are suitable coordinate functions and a_i are constant.

We suppose that the functions ϕ_i satisfy the same boundary conditions as the exact solution u(x, y). We further suppose that the set $\{\phi_i\}$ is complete in the

sense that every piecewise continues function *f*(x, y), say, can be approximated in R by the sum $\sum_{i=1}^{n} c_i \phi_i$ in such a way that

$$\delta_N = \iint_R \left(f - \sum_{i=1}^{N} c_i \phi_i \right) dx\, dy \qquad \ldots(3)$$

can be made as small as we wish.

Ordinarily, u_n given in (2) will not satisfy (1). Let

$$L(u_n) = \in_n (x, y), \qquad \text{where } \in_x (x, y) \neq 0, \quad \text{in R}. \quad \ldots(4)$$

If maximum of $\in_n (x, y)$ is small, we can consider $u_n (x, y)$ given is (2) as a satisfactory approximation to the exact solution u(x, y).

Thus, to get a good approximation, we have to choose the constants a_i so as to minimize the error function $\in_n (x, y)$.

A reasonable minimization technique is suggested by the following:

If one represents u(x, y) by the serious $u(x, y) = \sum_{i=1}^{\infty} a_i \phi_i$, with suitable properties and consider $u_n = \sum_{i=1}^{\eta} c_i \phi_i$ as the nth partial sum, then, the orthogality condition,

$$\iint_R L(u_n)\, \phi_i (x, y)\, dx\, dy = 0, \qquad \ldots(5)$$

as $n \to \infty$ is equivalent to the statement

$$L(u) = 0, \qquad \ldots(6)$$

by virtue of (1).

This led Galerkin to impose on the error function $\in_n$ a set of orthogality conditions **(now called Galerkin conditions)**

$$\iint_R L(u_n)\, \phi_i (x, y)\, dx\, dy = 0, \qquad \ldots(7)$$

for i =1, 2, ……,n. This yields the set of equations

$$\iint_R L\left(\sum_{j=1}^{\eta} a_j \phi_j\right)\phi_i \; dxdy = 0, \qquad \ldots(8)$$

for i =1, 2,……,n.

This set of n equations determine the constants a_i in the approximate solution (2).

Remark 1. When the differential equation and the boundary conditions are self-adjoint and the corresponding functional I (u) in the problem

$$I(u) = \min , \qquad \ldots(9)$$

is positive definite, then the system of Galerkin equation in (8) is equivalent to the Ritz system

$$\frac{\partial}{\partial a_j} I(u_n) = 0. \qquad \ldots(10)$$

Remark 2. It is important to the note that in Galerkin's formulation, there is no reference to any connection of equation (1) with a variational problem. Indeeds, the Galerkin method can be applied to a wider class of problems phrased in terms of integrals and other types of functional equations.

Question. Solve the variational problem

$$\int_0^1 \left[y'^2 - y^2 - 2xy \right] dx = \min,$$

$$y(0) = y(1) = 0 \ , \qquad \ldots(1)$$

by the Galerkin method.

Solution:– Here

$$F = y'^2 - y^2 - 2xy \ ,$$

and Euler's equation is

$$y'' + y - x = 0 \ , \qquad \text{in } 0 < x < 1 \ ,$$

$$L[y] = \frac{d^2y}{dx^2} + y - x = 0. \qquad \ldots(2)$$

We consider an approximate solution of the problem of the form

$$y_n = (1 - x)\left[a_1 x + a_2 x^2 + \ldots\ldots\ldots + a_n x^n\right] , \quad \ldots(3)$$

which satisfy the boundary conditions.

The first approximation is

$$y_1 = a_1\, x(1 - x)$$

$$= a_1\,(x - x^2). \qquad \ldots(4)$$

Here,

$$\phi_1 = x - x^2\,. \qquad \ldots(5)$$

We find

$$L[y_1] = a_1\,(-2) + a_1\,(x - x^2) + (-x) = a_1\,(x - x^2 - 2) - x, \quad \ldots(6)$$

and the coefficient a_1 is determined from the Galerkin's equation

$$\int_0^1 L\,(u_1)\,\phi_1\,dx = 0. \qquad \ldots(7)$$

This yields

$$\int_0^1 \left[a_1\left(x - x^2 - 2\right) - x\right].(x - x^2)\,dx = 0$$

$$\int_0^1 \left[a_1\left(x - x^2 - 2\right)\left(x - x^2\right) - \left(x^2 - x^3\right)\right]\,dx = 0$$

$$\int_0^1 \left[a_1\left(-2x + 3x^2 - 2x^3 + x^4\right) - \left(x^2 - x^3\right)\right]\,dx = 0\,.$$

This gives

$$a_1 = \frac{-5}{18}\,. \qquad \ldots.(8)$$

Thus, an approximate solution of the given variational problem, using Galerkin method, is

$$y \equiv y_1\,(x) = \frac{-5}{18}\;\;(x - x^2)\;\;.$$

8.10 APPLICATION OF GALERKIN METHOD TO THE PROBLEM OF TORSION OF BEAMS

Consider a cylindrical bar subjected to no body forces and free external forces on its lateral surface. One end of the bar is fixed in the plane z= 0 while the other end is in the plane $z = \lambda$ (say). The bar is twisted by a couple of magnitude M whose moment is directed along the axis of the bar (i.e., z-axis). Prandtl introduced a function $\Psi\,(x, y)$, **known as Prandtl stress function,** such that

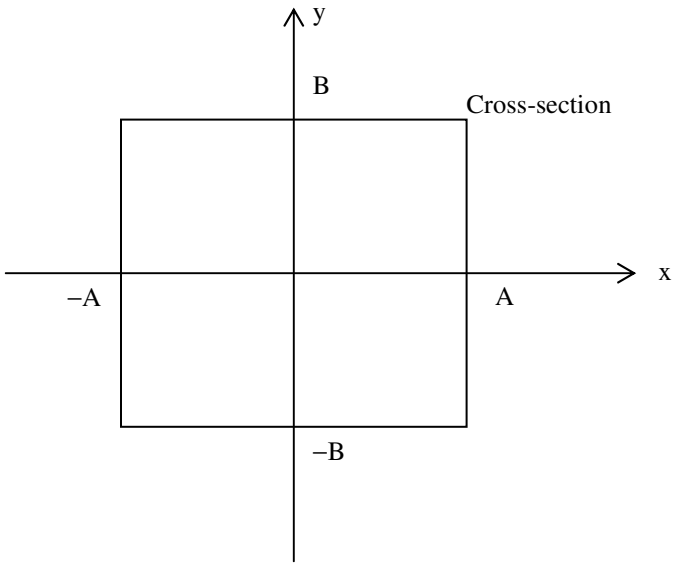
$$\tau_{zx} = \mu\,\alpha\,\frac{\partial \Psi}{\partial y}, \qquad \tau_{zy} = -\mu\,\alpha\frac{\partial \Psi}{\partial x}, \qquad \ldots.(1)$$

and stress function Ψ is determined from the system

$$\nabla^2\,\Psi = -2 \quad \text{in R}, \qquad \ldots.(2)$$

$$\Psi = 0 \quad \text{on C}, \qquad \ldots.(3)$$

where R is the region of the cross-section of the bar and C its boundary.
Let R be the rectangle $|x| \le A$, $|y| \le B$.



Now we have to solve the system consisting of equations (2) and (3) by using the Galerkin method. We write (2) as

$$L(\Psi) = 0, \qquad \ldots.(4)$$

where

$$L \equiv \nabla^2 + 2. \qquad \ldots(5)$$

We take an approximate solution in the form

$$\Psi_n(x, y) = (x^2 - A^2)(y^2 - B^2)(a_1 + a_2 x^2 + a_3 y^2 + \ldots\ldots a_n x^{2k} y^{2k}). \quad \ldots(6)$$

This approximate solution satisfies the boundary conditions in (3). Here a_1, a_2,…..,a_n are constants to be determined by using Galerkin method.

The first approximation is

$$\Psi_1 = a_1\phi_1 = a_1 (x^2 - A^2)(y^2 - B^2), \qquad \ldots(7)$$

with

$$\phi_1 = (x^2 - A^2)(y^2 - B^2). \qquad \ldots(8)$$

The coefficient a_1 is determined from the Galerkin equation

$$\int_{-B}^{B}\int_{-A}^{A} L(\Psi_1)\phi_1 \, dx dy = 0 . \qquad ...(9)$$

This implies

$$\int_{-B}^{B}\int_{-A}^{A} \{\nabla^2 \Psi_1 + 2\}\phi_1 \, dx dy = 0$$

$$\int_{-B}^{B}\int_{-A}^{A} \left[2a_1(y^2 - B^2) + 2a_1(x^2 - A^2) + 2\right](x^2 - A^2)(y^2 - B^2) dx\, dy = 0$$

$$2a_1 \int_{-A}^{A} (x^2 - A^2) dx \int_{-B}^{B} (y^2 - B^2)^2 dy + 2a_1 \int_{-A}^{A} (x^2 - A^2) dx \int_{-B}^{B} (y^2 - B^2)^2 dy$$

$$+ 2\int_{-A}^{A} (x^2 - A^2) dx \int_{-B}^{B} (y^2 - B^2)^2 dy = 0$$

Integration yields

Hence

$$a_1 = \frac{5}{4}\left(\frac{1}{A^2 + B^2}\right). \qquad ..(10)$$

Therefore, an approximate solution, by Galerkin method, to the given boundary value problem is

$$\Psi_1 = \frac{5}{4}\left(\frac{1}{A^2 + B^2}\right)(x^2 - A^2)\,(y^2 - B^2). \qquad ..(11)$$

Note:– Approximate values of the torsinal rigidity D and maximum shear stress τ_{max} can also be computed with the help of (7). We recall that

$$D = 2\mu \iint_R \Psi \, dx\, dy , \qquad ..(12)$$

and the maximum shear stress τ_{max} occurs at the mid points of the longer sides of the bar.

If B > A, then

$$\tau_{max} = \left[\tau_{yz}\right]_{\substack{x=A \\ y=0}}$$

$$= -\mu\,\alpha \left[\frac{\partial \Psi}{\partial x}\right]_{\substack{x=A \\ y=0}} . \qquad ...(13)$$

Inserting the values of $\Psi = \Psi_1$ given in (7) into relations (12) and (13), we find that

$$D_1 = \frac{5}{18}\mu a^2 b\left[\frac{(b/a)^2}{1+(b/a)^2}\right], \qquad ...(14)$$

$$\tau_{max} = \frac{5}{4}\mu\alpha a\left[\frac{(b/a)^2}{1+(b/a)^2}\right], \qquad ...(15)$$

with $a = 2A$, $b = 2B$.

8.11. METHOD OF KANTOROVICH

In 1932, Kantorvich proposed a generalization of the Ritz method. In the present method, the integration of partial differential equation (Euler's equation) reduces to the integration of a system of ordinary differential equations.

In the application of the Ritz method to the problem

$$I(u) = \iint_R F(x, y, u, u_x, u_y)\,dx\,dy = \min , \qquad \ldots(1)$$

we consider approximate solutions in the form

$$u_n = \sum_{k=1}^{\eta} a_k \phi_k(x, y) \quad , \qquad \ldots.(2)$$

where the functions $\varphi_k(x, y)$ satisfy the same boundary conditions as those imposed on the exact solution u (x, y) and a_k are constants. We then determined the coefficients a_k so as to minimize I (u_n).

In the method of Kantorvich, the a_k in (2) are no longer constants but are unknown functions of x such that the product

$$a_k(x)\,\phi_k(x, y)$$

satisfies the same boundary conditions as u(x, y).

This led to minimize

$$I(u_n) = I\left(\sum_{k=1}^{\eta} a_k(x)\phi_k(x,y)\right). \qquad \ldots(3)$$

Since the functions ϕ_k (x, y) are known functions, we can perform integration w. r. t. y in (1) and then obtain a functional of the type

$$I(u_n) = \int_{x_0}^{x_1} f\left[a_k(x), a'_k(x), x\right] dx. \qquad \ldots(4)$$

Kantorvich proposed to determine the function a_k (x) so that they minimize the functional (4). It is clear that a_k (x) can be determined by solving the second order ordinary differential equations (Euler's equations)

$$f_{a_k} - \frac{d}{dx} f_{(a_k)} = 0, \quad \text{for } k = 1,2,\ldots\ldots,n\,. \qquad \ldots(5)$$

Once a_k (x) are determined from (5), an approximate solution is known.

8.12. APPLICATION OF KANTORVICH METHOD TO THE TORSINAL PROBLEM

The torsion boundary value problem is

$$\left.\begin{aligned} \nabla^2\Psi &= -2 \quad \text{in } R \\ \Psi &= 0 \quad \text{on } C, \end{aligned}\right\} \qquad \ldots.(1)$$

C being the boundary of R, where R is the rectangle $|x| \le A$, $|y| \le B$.
The variational problem associated with this boundary value problem is (a well known result)

$$I(\Psi) = \iint_R \left[\Psi_X{}^2 + \Psi_y^2 - 4\Psi\right] dx\, dy = \min. \qquad \ldots(2)$$

An approximate to its solution is

$$\Psi_1 = a_1(x)\,(y^2 - B^2)\,, \qquad \ldots(3)$$

with

$$\phi_1(x, y) = y^2 - B^2. \qquad \ldots(4)$$

Here $\phi_1(x, y)$ vanishes on the part $y = \pm B$ of the boundary C. In order that

$$a_1(x)\,(y^2 - B^2) = 0 \quad \text{on } C, \qquad \ldots(5)$$

we shall determine a_1 (x) such that

$$a_1(A) = a_1(-A) = 0. \qquad \ldots(6)$$

Inserting the value of Ψ from (3) in (2), we get

$$I(a_1) = \iint \left[\{a_1'(x)\}^2 \left(y^2 - B^2\right)^2 + 4y^2 \{a_1(x)\}^2 - 4a_1(x)\left(y^2 - B^2\right) \right] dx\, dy$$

$$= \int_{-A}^{A} \left[\{a_1'(x)\}^2 \int_{-B}^{B} \left(y^4 + B^4 - 2B^2 y^2\right) dy + 4\{a_1(x)\}^2 \right.$$

$$\left. \times \int_{-B}^{B} y^2 dy - 4a_1(x) \int_{-B}^{B} \left(y^2 - B^2\right) dy \right] dx$$

$$= \int_{-A}^{A} \left[\{a_1'(x)\}^2 \left[\frac{y^5}{5} + B^4 y - \frac{2B^2 y^3}{3} \right]_{-B}^{B} \right.$$

$$\left. + 4\{a_1(x)\}^2 \left\{ \frac{y^3}{3} \right\}_{-B}^{B} - 4a_1(x) \left\{ \frac{y^3}{3} - B^2 y \right\}_{-B}^{B} \right] dx$$

$$= \int_{-A}^{A} \left[2(a_1')^2 \left(\frac{B^5}{5} + \frac{B^5}{1} - 2\frac{B^5}{3} \right) + 4a_1^2 \left(2\frac{B^3}{3} \right) - 8a_1 \left(\frac{B^3}{3} - B^3 \right) \right] dx$$

$$= \left(\frac{2B^3}{3} \right) \int_{-A}^{A} \left[\frac{8}{5} B^2 \left(a_1'\right)^2 + 4a_1^2 + 8a_1 \right] dx \ . \qquad \ldots(7)$$

Here

$$f(a_1, a_1', x) = \frac{8}{5} B^2 \left(a_1'\right)^2 + 4a_1^2 + 8a_1 . \qquad \ldots(8)$$

$$f_{a_1} = 8a_1 + 8,$$

$$f_{a_1'} = \frac{16}{5} B^2 a_1' . \qquad \ldots(9)$$

Euler's equation becomes

$$(8a_1 + 8) - \frac{d}{dx} \left(\frac{16}{5} B^2 a_1' \right) = 0$$

$$a_1''(x) \ \frac{5}{2B^2} a_1(x) - \frac{5}{2B^2} = 0 . \qquad \ldots(10)$$

Its solution is

$$a_1(x) = C_1 \cosh. \left(\frac{kx}{B}\right) + C_2 \sinh \left(\frac{kx}{B}\right) - 1, \qquad ...(11)$$

with

$$k = \sqrt{\frac{5}{2}}\,. \qquad ...(12)$$

The function $a_1(x)$ must be an even function, therefore $C_2 = 0$.

Putting $a_1(A) = 0$, we get,

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$$C_1 = \frac{1}{\cosh(kx/B)}\,. \qquad ...(13)$$

Thus, we find

$$\Psi_1 = (y^2 - B^2)\left[\frac{\cosh(kx/B)}{\cosh(kA/B} - 1\right], \qquad ...(14)$$

as an approximate solution obtained by Kantorvich method.

Chapter-9

Waves in Elastic Solids

9.1. WAVES IN AN ISOTROPIC ELASTIC SOLID

In the absence of body force , equations of motion are

$$\tau_{ij,j} = \rho \ddot{u}_i \qquad (1)$$

for i , j = 1 , 2 , 3. Here , dot signifies the differentiation with respect to time t and ρ is the density of the solid. τ_{ij} is the stress tensor , u_i is the displacement vector.

The left of (1) is a force in the x_i-direction due to stresses and the right of (1) is the inertia term – mass × acceleration.

We know that the generalized Hooke's law for an isotropic homogeneous elastic medium is

$$\tau_{ij} = \lambda \delta_{ij} u_{k,k} + \mu (u_{i,j} + u_{j,i}) . \qquad (2)$$

Here , homogeneity implies that ρ , λ and μ are constants throughout the medium , λ and μ being Lame′ constants.

We put

$$\theta = u_{k,k} = \text{div } \bar{u} \ , \qquad (3)$$

$$\bar{\Omega} = \text{curl } \bar{u} . \qquad (4)$$

θ is the cubical dilatation and $\bar{\Omega}$ is the rotation vector.

Putting (2) into (1) and using (3) , we obtain the following Navier's equation of motion (exercise)

$$(\lambda + \mu) \text{ grad}\theta + \mu \nabla^2 \bar{u} = \rho \ddot{\bar{u}} \ , \qquad (5)$$

in which ∇^2 is the Laplacian.

Taking divergence of both sides of (5) and using (3) , we obtain

$$(\lambda + \mu) \text{ div}(\text{grad } \theta) + \mu \nabla^2(\theta) = \rho \ddot{\theta}$$

or

$$(\lambda + \mu) \nabla^2 \theta + \mu \nabla^2 \theta = \rho \ddot{\theta}$$

or $$\nabla^2 \theta = \frac{1}{\alpha^2} \frac{\partial^2 \theta}{\partial t^2} \ . \qquad (6)$$

where

$$\alpha = \sqrt{\frac{\lambda + 2\mu}{\rho}} = \sqrt{\frac{k + \frac{4}{3}\mu}{\rho}} \ . \qquad (7)$$

It shows that the changes in the cubical dilation θ propagates through the elastic isotropic solid with speed α .

Here , k is the modulus of compressibility.

Taking curl of (5) both sides , we write

$$(\lambda + \mu) \ curl \ (grad \ \theta) + \mu \nabla^2 \ (curl \ \bar{u}) = \rho \frac{\partial^2}{\partial t^2} (curl \, \bar{u}) \qquad (8)$$

From , vector calculus , we have the identity

$$\text{curl grad } \phi \equiv 0 \ . \qquad (9)$$

Using (4) and (9) , equation (8) gives

$$\nabla^2 \ \bar{\Omega} = \frac{1}{\beta^2} \frac{\partial^2 \bar{\Omega}}{\partial t^2} \ , \qquad (10)$$

where

$$\beta = \sqrt{\frac{\mu}{\rho}} \ . \qquad (11)$$

Equation (10) shows that changes in rotation $\bar{\Omega}$ propagates with speed β.

Remark 1: The speed of both the waves depend upon the elastic parameters λ , μ and the density ρ of the medium. Since λ > 0 & μ > 0 , it can be seen that

$$\alpha > \beta.$$

That is , the dilatational waves propagate faster than the shear waves.

Therefore , dilatational waves **arrive first while** rotational waves arrive after that **on a seismogram.** For this reason , dilatational waves are also called primary waves and rotational waves are called secondary waves.

Remark 2: For a Poisson's solid ($\lambda = \mu$) , we have

$$\alpha = \sqrt{3}\,\beta.$$

For most solids , particularly rocks in Earth , there is a small difference between λ & μ. So, we may take $\lambda = \mu$ and solid is then called a Poisson's solid.

Remark 3: In seismology , the dilatational waves are called **P-waves** and rotational waves are denoted by **S – waves.**

Remark 4: If $\mu = 0$, then $\beta = 0$. That is , there is no S – wave in a medium with zero rigidity.

That is , **in liquids , S – waves cann't exist**. However , P – waves exists in a liquid medium.

Remark 5: Since

$$\text{div}\ \bar{\Omega} = \text{div}(\text{curl}\ \bar{u}) \equiv 0\ ,$$

it follows that a rotational wave is free of expansion/compression of volume.

For this reason , the rotational wave $\bar{\Omega}$ is also called **equivoluminal/dilatationless.**

Remark 6: The dilatational wave ($\theta \neq 0$) causes a change in volume of the material elements in the body. Rotational wave (when $\bar{\Omega} \neq 0$) produces a change in shape of the material element without changes in the volume of material elements.

Rotational waves are also referred as shear waves or a wave of distortion.

Remark 7: For a typical metal like **copper** , the speeds of primary and secondary and waves are estimated **as**

$$\textbf{α = 4.36km/sec and β = 2.13km/sec}\ ,$$

respectively.

Remark 8: At points far away from initially disturbed region , **the waves are plane waves**.

This suits seismology because the recording station of a disturbance during an earthquake is placed at a great distance in comparison to the dimensions of initial source.

Remark 9: We note that equations (6) and (10) both are forms of wave equations. Equation (6) shows that a disturbance θ , **called dilatation wave/compressive wave** propagates through the elastic medium with velocity α. Similarly , equation (10) shows that a disturbance $\bar{\Omega}$, **called a rotational wave** , propagates through the elastic medium with velocity β.

Thus, we conclude that any disturbance in an infinite homogeneous isotropic elastic medium can be propagated **in the form of two types of** these waves.

The speed α depends upon rigidity μ and modulus of compressibility k. On the other hand , β depends upon rigidity μ only.

Helmholtz's Theorem (P and S wave of Seismology)

Any vector point function $\bar{F}$ which is finite, uniform and continuous and which vanishes at infinity, may be expressed as the sum of a gradient of a scalar function ϕ and curl of a zero divergence vector $\bar{\psi}$.

The function ϕ is called the scalar potential of $\bar{F}$ and $\bar{\psi}$ is called the vector potential of $\bar{F}$.

The equation of motion for an elastic isotropic solid with density ρ (for zero body force) is

$$(\lambda + 2\mu)\, \nabla(\nabla .\ \bar{u}) - \mu\, \nabla \times \nabla \times \bar{u} = \rho\, \frac{\partial^2 \bar{u}}{\partial t^2} \ . \quad (1)$$

We write the decomposition for the displacement vector u in the form

$$\mathbf{u} = \nabla\, \phi + \nabla \times \bar{\psi} \ , \quad (2)$$

with

$$\text{div}\ \bar{\psi} = 0 \quad (3)$$

The scalar point function ϕ and vector point function $\bar{\psi}$ are called Lame′ potentials.

We know the following vector identities.

$$\nabla \times \nabla\, \phi \equiv \bar{0} \quad , \quad (4)$$

$$\nabla\ .\ (\nabla \times \bar{\psi}) \equiv 0\ . \quad (5)$$

Now $\nabla\ .\ \bar{u} = \nabla.(\nabla\, \phi + \nabla \times \bar{\psi})$

$$= \nabla\ .\ \nabla\phi$$

$$= \nabla^2\phi \qquad (6)$$

and

$$\nabla \times \bar{u} = \nabla \times(\nabla \phi + \nabla \times \bar{\psi})$$

$$= \nabla \times \nabla \times \bar{\psi}$$

$$= \text{grad (div } \bar{\psi}) - \nabla^2 \bar{\psi}$$

$$= -\nabla^2 \bar{\psi} . \qquad (7)$$

Using (6) and (7) in (1) , we write

$$(\lambda + 2\mu)\, \nabla\{\nabla^2 \phi\} + \mu\, \boldsymbol{\nabla} \times\{\nabla^2 \bar{\psi}\} = \rho \frac{\partial^2}{\partial t^2}(\nabla \phi) + \rho \frac{\partial^2}{\partial t^2}(\nabla \times \bar{\psi})$$

or

$$(\lambda + 2\mu)\, \nabla \left[\nabla^2\phi - \left(\frac{\rho}{\lambda + 2\mu}\right) \frac{\partial^2 \phi}{\partial t^2}\right] + \mu \boldsymbol{\nabla} \times\{\left[\nabla^2 \bar{\psi} - \left(\frac{\rho}{\mu}\right) \frac{\partial^2 \bar{\psi}}{\partial t^2}\right] = \bar{0}, \qquad (8)$$

which is satisfied if we take ϕ and Ψ to be solutions of wave equations

$$\nabla^2 \phi = \frac{1}{\alpha^2} \frac{\partial^2 \phi}{\partial t^2} , \qquad (9)$$

$$\nabla^2 \bar{\psi} = \frac{1}{\beta^2} \frac{\partial^2 \bar{\psi}}{\partial t^2} , \qquad (10)$$

where

$$\alpha = \sqrt{\frac{\lambda + 2\mu}{\rho}} \quad , \qquad (11)$$

$$\beta = \sqrt{\frac{\mu}{\rho}} . \qquad (12)$$

Wave equation (9) is a **Scalar wave equation** and equation (10) is a **vector wave equation**.

Waves represented by (9) are P-waves while waves represented by (10) are S-waves.

ϕ and $\bar{\psi}$ are now called the **scalar and vector potentials** associated with P- and S-waves , respectively.

Note : We can write the displacement vector $\bar{u}$ as

$$\bar{u} = \bar{u}_P + \bar{u}_S \ , \qquad (1)$$

where

$$\bar{u}_P = \nabla \phi \ , \qquad (2)$$

$$\bar{u}_S = \text{curl} \ \bar{\psi} \ . \qquad (3)$$

Hence $\bar{u}_P$ is the displacement due to P-wave alone and $\bar{u}_S$ is the displacement due to S-wave alone.

One – Dimensional Waves

(a) P-waves : Consider the solution where $\bar{\psi} = 0$. Then the one-dimensional P-wave satisfies the equation

$$\frac{\partial^2 \phi}{\partial x^2} = \frac{1}{\alpha^2} \frac{\partial^2 \phi}{\partial t^2} \qquad , \qquad \alpha = \sqrt{\frac{\lambda + 2\mu}{\rho}} \ , \qquad (1)$$

whose solution is

$$\phi = \phi(x \pm \alpha t) \ , \qquad (2)$$

representing a wave in x –direction. The corresponding displacement vector is

$$\bar{u}_P = \nabla \phi$$

$$= \left(\frac{\partial \phi}{\partial x} \right) \hat{e}_1 \ . \qquad (3)$$

That is , the displacement vector $\bar{u}_P$ is in the direction of propagation of P-wave. Therefore , P-waves are **longitudinal waves**.

Since

$$\text{curl} \ \bar{u}_P = \text{curl}(\text{grad} \ \phi)$$

$$= 0 \ , \qquad (4)$$

So , P-waves are **irrotational/rotationless**. P-waves do not cause any rotation of the material particles of the medium.

Since

$$\text{div} \ \bar{u}_P = \text{div}(\text{grad} \ \phi)$$

$$= \nabla^2 \phi$$

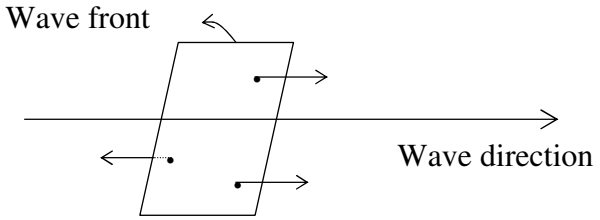
$$\neq 0 \quad , \tag{5}$$

therefore, P-waves are dilatational/compressional.

In this case , wavefronts are planes ,

x = constant .

The particle motion , for P-waves , is perpendicular to the wave fronts(figure).



If we look for a free oscillation of angular velocity ω , then we take

$$\phi(x , t) = e^{i\omega t} \phi(x) , \tag{6}$$

where

$$\frac{d^2\phi}{dx^2} + h^2 \phi = 0. \tag{7}$$

Here , $$h = \frac{\omega}{\alpha} , \tag{8}$$

is the wave number.

(b) S-waves : The one-dimensional wave equation for S-wave is

$$\frac{\partial^2 \overline{\psi}}{\partial x^2} = \frac{1}{\beta^2} \frac{\partial^2 \overline{\psi}}{\partial t^2} \quad , \tag{1}$$

where

$$\beta = \sqrt{\frac{\mu}{\rho}} \ . \tag{2}$$

The corresponding displacement vector is

$$\overline{u}_S = \text{curl} \ \ \overline{\psi} \ . \tag{3}$$

Solution of (1) is of the type

$$\overline{\psi} (x, t) = \psi_1(x - \beta t) \ \hat{e}_1 + \psi_2(x - \beta t) \hat{e}_2 + \psi_3(x - \beta t) \hat{e}_3 \quad . \tag{4}$$

From (3) and (4) , we find

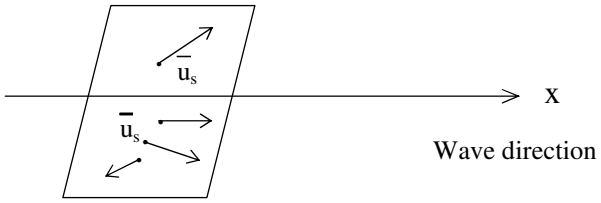
$$\bar{u}_S = -\frac{\partial \psi_3}{\partial x}\,\hat{e}_2 + \frac{\partial \psi_2}{\partial x}\,\hat{e}_3 . \qquad (5)$$

This shows that the displacement vector $\bar{u}_S$ lies in a plane parallel to yz-plane, which is perpendicular to the x-direction , representing the direction of S-wave propagation.

The wavefronts are planes having x-axis their normals.

Thus, particle motion due to a S-wave is parallel to the wavefronts.

So, S-wave are **transverse waves** (figure).



Since

$$\text{div}\ \bar{u}_S = \text{div}(\text{curl}\ \bar{\psi}\,)$$

$$= 0 \quad , \qquad (6)$$

so, S-waves are **dilationless/equivoluminal**.

Since

$$\text{curl}\ \bar{u}_s = \text{curl curl}\ \bar{\psi}_s$$

$$= -\nabla^2\ \bar{\psi}$$

$$\neq 0 \quad , \qquad (7)$$

so , S-waves are not irrotational , they are **rotational**.

As strains are not zero , S-waves are **shear/distortional** waves.

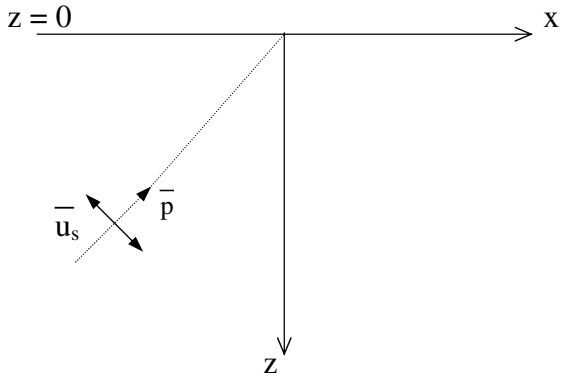
Each component ψ_i satisfy the scalar wave equation for S-waves.

9.2. SV- AND SH-WAVES

We shall now consider the study of waves as related to Earth , for example , waves generated by earthquakes. We consider the surface of the earth (taken as plane , approximately) as horizontal. Let z-axis be taken vertically downwards and xy-plane as horizontal.

To determine x- and y-directions in the horizontal plane, we proceed as below.

Let $\bar{p}$ be the direction of propagation of a S-wave. Let the plane made by the vector $\bar{p}$ and the z-axis be the xz-plane. Then x-axis lies in the horizontal plane (z = 0) bounding the earth and the propagation vector $\bar{p}$ lies in the vertical xz-plane (figure).



(A S-wave)

We choose y-axis as the direction perpendicular to the xz-plane so that x- , y- and z-axis form a right handed system.

The displacement vector $\bar{u}_S$ corresponding to a S-wave propagating in the $\bar{p}$-direction , is perpendicular to $\bar{p}$-direction.

We resolve $\bar{u}_s$ into two components – the first component $\bar{u}_{SV}$ lying in the vertical xz-plane and the second component $\bar{u}_{SH}$ parallel to y-axis(i.e. $\perp$ to xz-plane).

A S-wave representing the motion corresponding to the first component of the displacement vector **is known as a SV-wave**.

For a SV-wave , the particle motion is perpendicular to the direction $\bar{p}$ of propagation of wave and lies in the vertical xz-plane which is normal to the horizontal bounding surface. Let $\bar{u}_{SV}$ denote the corresponding displacement vector. Then , we write

$$\bar{u}_{SV} = (u , 0 , w) ,$$

contains both horizontal component u in the x-direction and vertical component w in the z-direction. A **SV-wave is a vertically polarized shear wave**. SV stands for **vertical shear**.

A S-wave representing the second displacement component , parallel to the y-axis , lying in the horizontal plane , **is known as SH-wave**. Let $\bar{u}_{SH}$ denote the corresponding displacement. Then

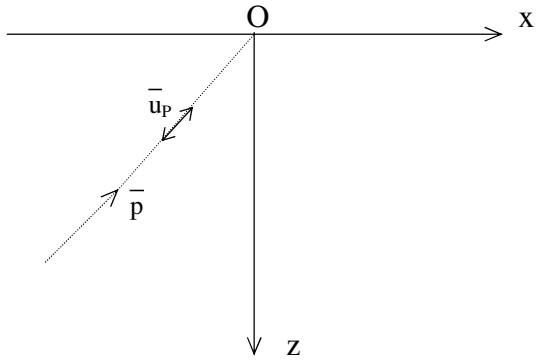
$$\bar{u}_{SH} = (0 , v, 0) ,$$

is parallel to y-axis. The motion due to a SH-wave is perpendicular to $\bar{p}$-direction (i.e., in a transverse direction) and along a horizontal direction. A SH-wave is a horizontally polarized shear wave. SH stands for horizontal shear.

When a P-wave propagates in the $\bar{p}$-direction , then the corresponding displacement , denoted by $\bar{u}_P$, is given by

$$\bar{u}_P = (u , 0 , w) .$$

The displacement $\bar{u}_P$ contains both horizontal component in the x-direction and vertical component in the z-direction(figure)



(A P-wave)

9.3. WAVE PROPAGATION IN TWO – DIMENSIONS

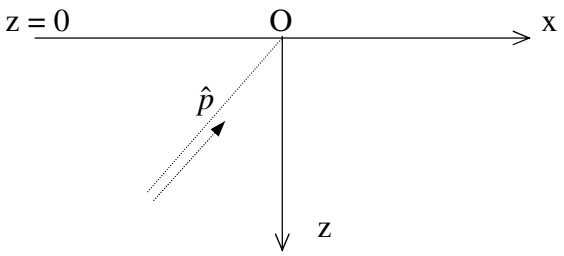
We assume that waves are propagating in planes parallel to the vertical xz-plane containing the wave propagation vector

$$\hat{p} = l\,\hat{e}_1 + n\,\hat{e}_2$$

with

$$l^2 + n^2 = 1.$$

Then the wave motion will be the same in all planes parallel to xz-plane (figure) and independent of y so that $\frac{\partial}{\partial y} \equiv 0$.



Under this assumption , the Navier equation of motion for isotropic elastic materials

$$(\lambda + \mu) \text{ grad div } \bar{u} + \mu \nabla^2 \bar{u} = \rho \ddot{\bar{u}} \qquad (1)$$

gives

$$(\lambda + \mu) \frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x} + \frac{\partial w}{\partial z}\right) + \mu \nabla^2 u = \rho \ddot{u}, \qquad (2)$$

$$(\lambda + \mu) \frac{\partial}{\partial z}\left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial x}\right) + \mu \nabla^2 w = \rho \ddot{w} \qquad (3)$$

$$\mu \nabla^2 v = \rho \ddot{v} \quad , \qquad (4)$$

where the displacement vector $\bar{u} = (u, v, w)$ is independent of y ,

$$\text{cubical dilatation} \equiv \theta = \frac{\partial u}{\partial x} + \frac{\partial w}{\partial z} \ , \qquad (5)$$

and Laplacian is given by

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial z^2} . \qquad (6)$$

Let z = 0 be the boundary surface. The components of the stress acting on the surface z = 0 are given by

$$\tau_{zx} = 2\mu e_{zx} = \mu\left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial x}\right) , \qquad (7)$$

$$\tau_{zz} = \lambda \theta + 2\mu e_{zz} = (\lambda + 2\mu) \frac{\partial w}{\partial z} + \lambda \frac{\partial u}{\partial x} \ , \qquad (8)$$

$$\tau_{zy} = 2\mu e_{zy} = \mu \frac{\partial v}{\partial z} . \qquad (9)$$

From above equations , we conclude that the general two – dimensional problem of propagation of plane elastic waves , parallel to the xz-plane, splits into **two independent problems** stated below –

Problem I – Consisting of equations (4) and (9).

Problem II – Consisting of equations (2) , (3) (7) and (8).

Problem I (SH-problem) : In this problem the displacement components are

$$u = w \equiv 0 , \quad , v = v(x , z , t) \tag{10}$$

and

$$\tau_{zx} = \tau_{zz} = 0 \quad , \tau_{zy} = \tau_{zy}(x , z, t) = \mu \frac{\partial v}{\partial z} . \tag{11}$$

In this problem , the displacement component v(x , z, t) satisfies the scalar wave equation

$$\nabla^2 v = \frac{1}{\beta^2} \frac{\partial^2 v}{\partial t^2} . \tag{12}$$

This differential equation is independent of modulus of compressibility k. So the motion due to such waves is equivoluminal. Since the displacement component v is horizontal and is perpendicular to the direction $\hat{p}$ of propagation ($\hat{p}$ lies in xz-plane) , the waves represented by v are **horizontally polarized waves or SH –waves**.

Problem II (P-SV problem) : In this problem

$$v \equiv 0 , u = u(x, z, t) , w = w(x, z , t) , \tag{13}$$

$$\tau_{zy} \equiv 0 , \tau_{zx} = \mu \left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial x} \right) , \ \tau_{zz} = (\lambda + 2\mu) \frac{\partial w}{\partial z} + \lambda \frac{\partial u}{\partial x} ,$$

$$\tau_{xx} = \lambda \left(\frac{\partial u}{\partial x} + \frac{\partial w}{\partial z} \right) + 2\mu \frac{\partial u}{\partial x} . \tag{14}$$

In this problem , the in-plane displacement components u and w satisfying the two simultaneous partial differential equations (2) and (3) , and the in-plane stress components τ_{xx} , τ_{zx} and τ_{zz} also contain these two displacement components. The displacement component v plays no role in the solution of this problem and hence taken as identically zero.

The displacement components *u* and *w* can be expressed in terms of two scalar potentials

$$\phi = \phi(x , z , t) \text{ and } \psi = \psi(x, z, t)$$

through the relations

$$u = \frac{\partial \phi}{\partial x} + \frac{\partial \psi}{\partial z} , \tag{15}$$

$$w = \frac{\partial \phi}{\partial z} - \frac{\partial \psi}{\partial x} , \tag{16}$$

with help of Helmholtz's theorem (on taking $\overline{\psi} = -\psi\ \hat{e}_2$).

Using (15) and (16) in the equations of motion (2) and (3) , we obtain

$$\frac{\partial}{\partial x}\left[\alpha^2 \nabla^2 \phi - \frac{\partial^2 \phi}{\partial t^2}\right] + \frac{\partial}{\partial z}\left[\beta^2 \nabla^2 \psi - \frac{\partial^2 \psi}{\partial t^2}\right] = 0\,, \qquad (17)$$

$$\frac{\partial}{\partial z}\left[\alpha^2 \nabla^2 \phi - \frac{\partial^2 \phi}{\partial t^2}\right] - \frac{\partial}{\partial x}\left[\beta^2 \nabla^2 \psi - \frac{\partial^2 \psi}{\partial t^2}\right] = 0\,. \qquad (18)$$

These equations are identically satisfied when the scalar potentials ϕ and ψ are solutions of following scalar wave equations

$$\nabla^2 \phi = \frac{1}{\alpha^2}\frac{\partial^2 \phi}{\partial t^2}\,, \qquad (19)$$

$$\nabla^2 \psi = \frac{1}{\beta^2}\frac{\partial^2 \psi}{\partial t^2}\,, \qquad (20)$$

where $$\alpha = \sqrt{\frac{(\lambda + 2\mu)}{\rho}}\,, \quad \beta = \sqrt{\frac{\mu}{\rho}}\,. \qquad (21)$$

The plane wave solutions of (19) represents P-waves and those of (20) represent S-waves.

The potentials ϕ and ψ are **called displacement potentials**.

In the displacements (15) and (16) , the contribution from ϕ is due to P-waves and that from ψ is due S waves.

P-SV wave is a combination of P-wave and the SV-wave. The displacement vector (u , 0, w) lies in a vertical plane and S-waves represented by the potential ψ are also propagated in a vertical plane , so these S-waves are vertically polarized shear waves or simple SV-waves.

The stress τ_{zx} and τ_{zz} in terms of potentials ϕ and ψ are

$$\tau_{zx} = \mu\left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial x}\right)$$

$$= \mu\left(2\frac{\partial^2 \phi}{\partial x \partial z} + \frac{\partial^2 \psi}{\partial z^2} - \frac{\partial^2 \psi}{\partial x^2}\right), \qquad (22)$$

$$\tau_{zz} = \lambda \text{ div } \bar{u} + 2\mu \cdot \frac{\partial w}{\partial z}$$

$$= \lambda \nabla^2 \phi + 2\mu \left(\frac{\partial^2 \phi}{\partial z^2} - \frac{\partial^2 \psi}{\partial x \partial z} \right)$$

$$= \left(\lambda \nabla^2 + 2\mu \frac{\partial^2}{\partial z^2} \right) \phi - 2\mu \frac{\partial^2 \psi}{\partial x \partial z} . \qquad (23)$$

Since ,

$$\frac{\lambda}{\mu} = \frac{\lambda + 2\mu - 2\mu}{\mu} = \frac{\lambda + 2\mu}{\mu} - 2 = \frac{\alpha^2}{\beta^2} - 2 , \quad (24)$$

therefore , we write

$$\tau_{zz} = \mu \left[\left(\frac{\alpha^2}{\beta^2} - 2 \right) \nabla^2 \phi + 2 \frac{\partial^2 \phi}{\partial z^2} - 2 \frac{\partial^2 \psi}{\partial x \partial z} \right] . \qquad (25)$$

Note 1: In the SH-problem , other stresses are

$$\tau_{xx} = \tau_{yy} = 0 , \quad \tau_{xy} = \mu \frac{\partial v}{\partial x} . \qquad (26)$$

Note 2: In the P-SV problem , other stresses are (in terms of ϕ an ψ)

$$\tau_{xx} = \lambda \nabla^2 \phi + 2\mu \, e_{xx}$$

$$= \lambda \nabla^2 \phi + 2\mu \left(\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \psi}{\partial x \partial z} \right), \qquad (27)$$

$$\tau_{yy} = \lambda \nabla^2 \phi + 2\mu \, e_{yy}$$

$$= \lambda \nabla^2 \phi \quad , \qquad (28)$$

$$\tau_{xy} = 2\mu \, e_{xy} = 0 . \qquad (29)$$

Note 3: In the case of two – dimensional wave propagation , the SH motion is decoupled from the P-SV motion. The displacement vector due to P-SV type motion is

$$\bar{u} = \nabla \phi + \nabla \times (\psi \hat{e}_2)$$

$$= (u, o, w) .$$

9.4. PLANE WAVES

A geometric surface of all points in space over which the phase of a wave is constant is called a wavefronts.

Wavefronts can have many shapes. For example , wavefronts can be planes or spheres or cylinders.

A line normal to the wave fronts , indicating the direction of motion of wave, is called a ray.

If the waves are propagated in a single direction , the waves are called **plane waves**, and the wavefronts for plane waves are parallel planes with normal along the direction of propagation of the wave.

Thus, a plane wave is a solution of the wave equation in which the disturbance/displacement varies only in the direction of wave propagation and is constant in all the directions orthogonal to propagation direction.

The rays for plane waves are parallel straight lines.

For spherical waves , the disturbance is propagated out in all directions from a point source of waves. The wavefronts are concentric spheres and the rays are radial lines leaving the point source in all directions.

Since seismic energy is usually radiated from localized sources , seismic wavefronts are always curved to some extent. However , at sufficiently large distances from the source , the wavefronts become flat enough that a plane wave approximation become locally valid.

Illustration (1) : For one –dimensional wave equation

$$\frac{\partial^2 \phi}{\partial x^2} = \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2} \ , \qquad (1)$$

a progressive wave travelling with speed c in the positive x-direction is represented by

$$\phi(x, t) = A\, e^{ik(x-ct)} = A\, e^{i(kx-wt)} \ , \qquad (2)$$

where

k = wave number ,

$\omega = c\, k$ = angular frequency ,

λ = wavelength = $2\pi/k$,

A = amplitude of the wave.

Let

$$\bar{x} = x\ \hat{e}_1 \quad , \quad \bar{k} = k\ \hat{e}_1 \ . \tag{3}$$

Then $\bar{k}$ is called the propagation vector and (2) can be written in the form

$$\phi(x, t) = A\ e^{i(\ \bar{k}.\ \bar{x} - \omega t)} \ . \tag{4}$$

In this type of waves , wavefronts are planes

$$x = \text{constant} \ , \tag{5}$$

which are parallel to yz – plane.

Illustration 2: A two – dimensional wave equation with speed c is

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2} \ . \tag{1}$$

If we take

$$u = l\, x + m\, y - c\, t \ , \tag{2}$$

$$v = l\, x + m\, y + c\, t \ , \tag{3}$$

where l , m are constants , then equation (1) is reduced to (exercise)

$$\frac{\partial^2 \phi}{\partial u\, \partial v} = 0 \quad , \tag{4}$$

provided

$$l^2 + m^2 = 1. \tag{5}$$

Integrating (4) , we get

$$\begin{aligned} \phi &= f(u) + g(v) \\ &= f(lx + my - ct) + g(lx + my + ct) \quad , \end{aligned} \tag{6}$$

where f and g are arbitrary functions.

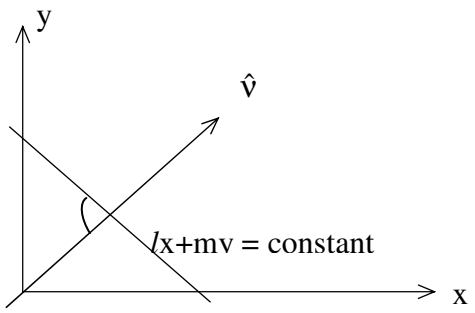
Let

$$\hat{v} = l\, \hat{e}_1 + m\ \hat{e}_2 \quad . \tag{7}$$

Then $\hat{v}$ is a unit vector perpendicular to the system of straight lines

$$lx + my = \text{constant}, \tag{8}$$

in two-dimensional xy-plane.



At any instant , say $t = t_0$, the disturbance ϕ is constant for all points (x, y) lying on the line (8). Therefore , ϕ represents a plane propagating with speed c in the direction $\hat{v}$. The wavefronts are straight lines given by equation (8).

Illustration 3: Three-dimensional wave equation is

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} + \frac{\partial^2 \phi}{\partial z^2} = \frac{1}{c^2} \frac{\partial^2 \phi}{\partial t^2}, \tag{1}$$

which propagates with speed c.

As discussed earlier , solution of (1) is

$$\phi(x, y, z, t) = f(lx + my + nz - ct) + g(lx + my + nz + ct) \tag{2}$$

where the constants l, m , n satisfy the relation

$$l^2 + m^2 + n^2 = 1 . \tag{3}$$

Let

$$\hat{v} = l\hat{e}_1 + m\,\hat{e}_2 + n\,\hat{e}_3 . \tag{4}$$

Then $\hat{v}$ is a unit vector which is normal to the system of parallel planes

$$lx + my + nz = \text{constant}. \tag{5}$$

The wavefronts are parallel planes given by equation (5) , which travel with speed c in the direction $\hat{v}$. So, the wave (2) is a three-dimensional progressive plane wave.

Question : Determine the wavelength and velocity of a system of plane waves given by

$$\phi = a \sin (A\,x + B\,y + C\,z - D\,t) \ ,$$

where a , A, B , C , D are constants.

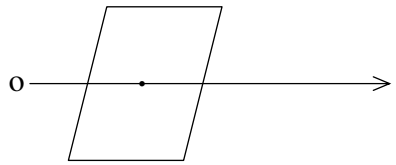
Solution : Let $< l$, m , n> be the direction cosines of the direction of wave propagation with speed c. Then

$$l^2 + m^2 + n^2 = 1 \qquad (1)$$

Equation of a wave front is

$$l\,x + m\,y + n\,z = p \qquad (2)$$

where p is the length of perpendicular from the origin to the wave front.



$< l$, m , n >

The plane wave ϕ, therefore , must be of the type

$$\phi = a \sin k\,(l\,x + m\,y + n\,z - c\,t) \ , \qquad (3)$$

where k = wave number and ,

c = wave velocity.

Comparing (3) with the given form

$$\phi = a \sin (A\,x + B\,y + C\,z - D\,t) \ , \qquad (4)$$

we find

$$l = \frac{A}{\sqrt{A^2 + B^2 + C^2}} \ , \quad m = \frac{B}{\sqrt{A^2 + B^2 + C^2}} \ , \quad n = \frac{C}{\sqrt{A^2 + B^2 + C^2}} \ , \qquad (5)$$

and

$$k = \sqrt{A^2 + B^2 + C^2} \ , \qquad (6)$$

$$c = \frac{D}{\sqrt{A^2 + B^2 + C^2}} \ . \qquad (7)$$

Therefore , wave length $= \frac{2\pi}{k} = \frac{2\pi}{\sqrt{A^2 + B^2 + C^2}}$, (8)

and

$$\text{wave velocity} = \frac{D}{\sqrt{A^2 + B^2 + C^2}} \ . \qquad (9).$$

Chapter-10

Surface Waves

10.1. INTRODUCTION

In an elastic body, it is possible to have another type of waves (other than body waves) which are propagated over the surface and penetrate only a little into the interior of the body.

Such waves are similar to waves produced on a **smooth surface of water when** a stone is thrown into it.

These type of waves are **called SURFACE WAVES.**

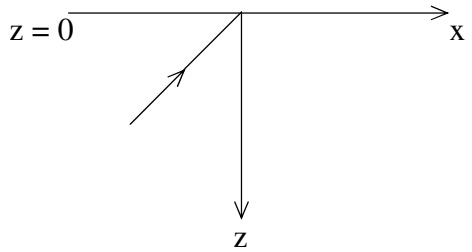
Surface waves are "tied" to the surface and diminish exponentially as they get farther from the surface.

The criterion for surface waves is that the **amplitude** of the displacement in the medium **dies exponentially with the increasing distance from the surface.**

In seismology , the interfaces are , in the ideal case , horizontal and so the plane of incidence is **vertical**. Activity of surface waves is restricted to the neighbourhood of the interface(s) or surface of the medium.

Under certain conditions , such waves can propagated independently along the surface/interface. For surface waves , the disturbance is confined to a depth **equal to a few wavelengths**.

Let us take xz – plane as the plane of incidence with z – axis vertically downwards. Let z = 0 be the surface of a semi-infinite elastic medium (Figure) .



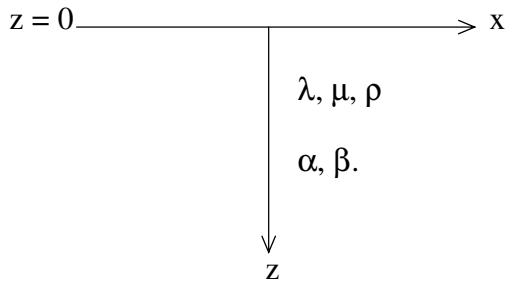
For a surface wave , its amplitude will be a function of z (rather than an exponential function) which tends to zero as $z \to \infty$. For such surface – waves , the motion will be two – dimensional **,** parallel to xz – plane , so that $\frac{\partial}{\partial y} = 0$.

The existence of surface waves raises the question of whether they might (under certain conditions) be able to travel freely along the plane (horizontal) as a guided wave.

10.2. RAYLEIGH WAVES

Rayleigh (1885) discussed the existence of a simplest surface wave propagating on the free – surface of a homogeneous isotropic elastic half – space.

Let the half – space occupies the region $z \geq 0$ with z – axis taken as vertically downwards. Let ρ be the density and λ , μ be the Lame′ elastic moduli and z = 0 be the stress – free boundary of the half – space (figure).



Suppose that a train of plane waves is propagating in the media in the positive x – direction such that

(i) the plane of incidence is the vertical plane (xz – plane) so that the motion , i.e. , disturbance is independent of y and hence $\frac{\partial}{\partial y} \equiv 0$.

(ii) the amplitude of the surface wave decreases exponentially as we move away from the surface in the z – direction.

This problem is a **plane strain problem** and the displacement vector $\overline{u}$ is of the type

$$\overline{u} = (u , 0 , w) , \quad u = u(x , z, t) , \quad w = w(x , z , t) . \quad (1)$$

The displacement components u and w are given in term of potential ϕ and ψ through the relations

$$u = \frac{\partial \phi}{\partial x} + \frac{\partial \psi}{\partial z} , \qquad (2)$$

$$w = \frac{\partial \phi}{\partial z} - \frac{\partial \psi}{\partial x} , \qquad (3)$$

where potentials ϕ and ψ satisfy the scalar wave equations

$$\nabla^2 \phi = \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial z^2} = \frac{1}{\alpha^2} \frac{\partial^2 \phi}{\partial t^2} \ , \qquad (4)$$

$$\nabla^2 \psi = \frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial z^2} = \frac{1}{\beta^2} \frac{\partial^2 \psi}{\partial t^2} \ , \qquad (5)$$

and wave velocities α and β are given by

$$\alpha = \sqrt{(\lambda + 2\mu)/\rho} \ , \qquad (6)$$

$$\beta = \sqrt{\mu/\rho} \ . \qquad (7)$$

This wave motion is of a P-SV type wave travelling along the stress – free surface of the half space and such a motion takes place in the xz – plane.

Now , we seek solutions of wave equations (4) and (5) of the form

$$\phi(x , z , t) = f(z)\, e^{ik(ct-x)} \ , \qquad (8)$$

$$\psi(x , z , t) = g(z)\, e^{ik(ct-x)} \ , \qquad (9)$$

where k is the wave number , c is the speed of surface wave travelling in the +ve x-direction and $\omega = ck$ is the angular frequency.

The substitution of (8) and (9) into wave equations (4) and (5) leads to two ordinary differential equations (exercise)

$$\frac{d^2 f}{dz^2} - k^2 a^2 f = 0 \ , \qquad (10)$$

and

$$\frac{d^2 g}{dz^2} - k^2 b^2 g = 0 \ , \qquad (11)$$

with

$$a = \sqrt{1 - c^2/\alpha^2} > 0 \ , \qquad (12)$$

and

$$b = \sqrt{1 - c^2/\beta^2} > 0 \ . \qquad (13)$$

From equations (8) to (11) ; we find (exercise)

$$\phi\,(x , z , t) = (A\, e^{-akz} + A_1\, e^{akz})\, e^{ik(ct - x)} \ , \qquad (14)$$

$$\psi(x , z , t) = (B\, e^{-bkz} + B_1\, e^{bkz})\, e^{ik(ct - x)} \ , \qquad (15)$$

where A , A_1 B and B_1 are constants.

Since the disturbance due to surface waves must die rapidly as $z \to \infty$, we must have

$$A_1 = B_1 = 0 . \tag{16}$$

Thus , for Rayleigh waves , we get

$$\phi(x , z , t) = A\, e^{-akz}\, e^{i(\omega t - kx)} , \tag{17}$$

and

$$\psi(x , z , t) = B\, e^{-bkz}\, e^{i(\omega t - kx)} , \tag{18}$$

with

$$c < \beta < \alpha . \tag{19}$$

The equation (19) gives the condition for the existence of surface waves on the surface of a semi – infinite isotropic elastic media with velocity c in the positive x – direction.

To find frequency equation for the velocity c and ratio of A and B ; we use the stress – free boundary conditions. This conditions are

$$\tau_{zx} = \tau_{zy} = \tau_{zz} = 0 \qquad \text{at } z = 0. \tag{20}$$

From relation in (2) and (3) , we find

$$\begin{aligned} \text{div } \bar{u} &= \frac{\partial u}{\partial x} + \frac{\partial w}{\partial z} \\ &= \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial z^2} \\ &= \nabla^2 \phi . \end{aligned} \tag{21}$$

The stresses in terms of potentials ϕ and ψ are given by

$$\begin{aligned} \tau_{zx} &= \mu \left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial x} \right) \\ &= \mu \left[2 \frac{\partial^2 \phi}{\partial x\, \partial z} + \frac{\partial \psi}{\partial z^2} - \frac{\partial^2 \psi}{\partial x^2} \right] , \end{aligned} \tag{22}$$

$$\tau_{zz} = \lambda \text{ div } \bar{u} + \mu \frac{\partial w}{\partial z}$$

$$= \mu \left[\left(\frac{\alpha^2}{\beta^2} - 2 \right) \frac{\partial^2 \phi}{\partial x^2} + \; + \frac{\alpha^2}{\beta^2} \frac{\partial^2 \phi}{\partial z^2} - 2 \frac{\partial^2 \psi}{\partial x \, \partial z} \right], \qquad (23)$$

$$\tau_{zy} = \mu \left(\frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} \right)$$

$$= 0 . \qquad (24)$$

The boundary condition $\tau_{zx} = 0$ at z = 0 in (20), gives (exercise)

$$2A(-ik)\,(-ak) - B(-ik)^2 + B(-bk)^2 = 0$$

or $$2\,i\,a\,k^2 A + B(1 + b^2)\,k^2 = 0$$

or $$2\,i\,a\,A = -B(1 + b^2)$$

or $$\frac{A}{B} = \frac{i(1+b^2)}{2a} . \qquad (25)$$

The boundary condition $\tau_{zz} = 0$ at z = 0 , gives (exercise)

$$\left(\frac{\alpha^2}{\beta^2} - 2 \right) . \, A \, . \, (-k^2) + \frac{\alpha^2}{\beta^2} . \, A \, . \, (\alpha^2 k^2) - 2B \, (-ik) \, (-bk) = 0$$

or $$A \left[-\frac{\alpha^2}{\beta^2} + 2 + \frac{\alpha^2 a^2}{\beta^2} \right] k^2 \; - 2 \, i \, b \, B \, k^2 = 0$$

or $$A \left(2 - \frac{\alpha^2}{\beta^2} + \frac{\alpha^2 a^2}{\beta^2} \right) = 2 \, i \, b \, B$$

or $$\frac{A}{B} = \left(\frac{2ib}{2 - \frac{\alpha^2}{\beta^2} + \frac{\alpha^2 a^2}{\beta^2}} \right) . \qquad (26)$$

Eliminating A/B from equations (25) and (26) and substituting the value of a and b from equation (12) and (13) , we obtain

$$(1 + b^2) \left(2 - \frac{\alpha^2}{\beta^2} + \frac{\alpha^2 a^2}{\beta^2} \right) = 4 \, a \, b$$

or $$\left(2-\frac{c^2}{\beta^2}\right)\left[2-\frac{\alpha^2}{\beta^2}+\frac{\alpha^2}{\beta^2}\left(1-\frac{c^2}{\alpha^2}\right)\right]$$

$$=4\sqrt{1-\frac{c^2}{\alpha^2}}\ \sqrt{1-\frac{c^2}{\beta^2}}$$

or $$\left(2-\frac{c^2}{\beta^2}\right)\left[2-\frac{\alpha^2}{\beta^2}+\frac{\alpha^2}{\beta^2}-\frac{c^2}{\beta^2}\right]=4\sqrt{1-\frac{c^2}{\alpha^2}}\ \sqrt{1-\frac{c^2}{\beta^2}}$$

or $$\left(2-\frac{c^2}{\beta^2}\right)^2 - 4\left(1-\frac{c^2}{\alpha^2}\right)^{\frac{1}{2}}\left(1-\frac{c^2}{\beta^2}\right)^{\frac{1}{2}}=0\ . \qquad (27)$$

This equation contains only one unknown c.

This equation determines the speed c for Rayleigh surface waves in an uniform half – space.

Equation (27) is called the **RAYLEIGH EQUATION** for Rayleigh waves. It is also called the **Rayleigh frequency equation**. It is also called the **Rayleigh wave – velocity equation**.

This equation is the **period equation** for Rayleigh waves.

In order to prove that Rayleigh waves really exists , we must show that frequency equation (27) has at least one real root for c. To show this , we proceed as follows :

From equation (27) , we write

$$\left(2-\frac{c^2}{\beta^2}\right)^4 = 16\left(1-\frac{c^2}{\alpha^2}\right)\left(1-\frac{c^2}{\beta^2}\right)$$

or $$16 - 32\ \frac{c^2}{\beta^2} + 24\ \frac{c^4}{\beta^4} - 8\frac{c^6}{\beta^6} + \frac{c^8}{\beta^8}$$

$$=16\left[1-\frac{c^2}{\alpha^2}-\frac{c^2}{\beta^2}+\frac{c^4}{\alpha^2\beta^2}\right]$$

$$=16\left[1-\frac{c^2}{\beta^2}\frac{\beta^2}{\alpha^2}-\frac{c^2}{\beta^2}+\frac{c^4}{\beta^4}\cdot\frac{\beta^2}{\alpha^2}\right]$$

or

$$-32 + 24\,\frac{c^2}{\beta^2} - 8\frac{c^4}{\beta^4} + \frac{c^6}{\beta^6} + 16\,\frac{\beta^2}{\alpha^2} + 16 - 16\,\frac{c^2}{\beta^2}.\frac{\beta^2}{\alpha^2} = 0\,. \qquad (28)$$

Put

$$s = c^2/\beta^2\,, \qquad (29)$$

then equation (28) gives

$$f(s) = s^3 - 8s^2 + \left(24 - 16\frac{\beta^2}{\alpha^2}\right)s - 16\left(1 - \frac{\beta^2}{\alpha^2}\right) = 0\,. \qquad (30)$$

It is polynomial **equation of degree 3 in s** with real coefficients.

Hence the frequency equation (30) has at least one real root since complex roots occur in conjugate pairs.

Moreover

$$f(0) = -16\left(1 - \frac{\beta^2}{\alpha^2}\right) < 0\,, \qquad (31)$$

and

$$f(1) = 1 - 8 + 24 - \frac{16\beta^2}{\alpha^2} + \frac{16\beta^2}{\alpha^2} = 1 > 0\,, \qquad (32)$$

since $\beta < \alpha$.

Hence , by the intermediate theorem of calculus , the frequency equation (30) has at least one root in the range (0 , 1).

That is , there exists $s \in (0\ ,\ 1)$ which is a root of the Rayleigh frequency equation.

Further , $0 < s < 1$ implies

$$0 < \frac{c^2}{\beta^2} < 1$$

or $$\mathbf{0 < c < \beta}\,. \qquad (33)$$

This establishes that Rayleigh surface waves propagating with speed $c = c_R$, where

$$0 < c_R < \beta < \alpha\,,$$

always exists.

This proves the existence of Rayleigh surface waves.

Special Case (Poisson's solid) : When the semi-infinite elastic medium is a Poisson's solid ,

then $\lambda = \mu$ and $\sigma = \frac{1}{4}$ and

$$\frac{\alpha^2}{\beta^2} = \frac{\lambda + 2\mu}{\mu} = 3. \qquad (34)$$

For this type of elastic medium , frequency equation (30) becomes

$$3s^3 - 24\, s^2 + 56\, s - 32 = 0$$

or $$(s - 4)\,(3s^2 - 12\, s + 8) = 0$$

giving

$$s = 4\ ,\ 2 + \frac{2}{\sqrt{3}}\ ,\ 2 - \frac{2}{\sqrt{3}}$$

or $$\frac{c^2}{\beta^2} = 4\ ,\ 2 + \frac{2}{\sqrt{3}}\ ,\ 2 - \frac{2}{\sqrt{3}}\ . \qquad (35)$$

But c must satisfy the inequality $0 < c < \beta$, therefore , the only possible value for $c = c_R$ is

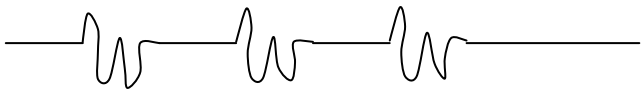
$$\frac{c_R^{\,2}}{\beta^2} = 2 - \frac{2}{\sqrt{3}}\ ,$$

or

$$c_R = \left[\sqrt{2 - \frac{2}{\sqrt{3}}}\right] .\ \beta \cong 0.9195\ \beta\ , \qquad (36)$$

giving the speed of propagation of Rayleigh surface waves along the stress free boundary of the Poissonian half-space in the x-direction.

Thus , the order of arrival of P, SV-and Rayleigh waves is



P SV Rayleigh

From equations (12) and (13) ; we write

$$a^2 = 1 - \frac{c_R^{\,2}}{\alpha^2}$$

$$= 1 - \frac{c_R^{\,2}}{\beta^2} \cdot \frac{\beta^2}{\alpha^2}$$

$$= \frac{1}{9}(3 + 2\sqrt{3}) ,$$

or

$$a = \frac{1}{3}\sqrt{3 + 2\sqrt{3}} \cong 0.8475 \approx 0.84\ 8 , \qquad (37)$$

and

$$b^2 = 1 - \frac{c_R^{\,2}}{\beta^2}$$

$$= \frac{1}{3}[2\sqrt{3} - 3] ,$$

or $$b \cong 0.3933 \cong 0.393 . \qquad (38)$$

Further , from equations (25) , (37) and (38) , we find

$$\frac{A}{B} = 1.468\ i \quad . \qquad (39)$$

Remark 1: Displacements due to Rayleigh waves (Particle motion)

From equations (2) , (3) , (17) , (18) and (26) ; we find

$$u(x , z , t) = [A(-ik)\, e^{-akz} + B(-bk)\, e^{-bkz}]\, e^{i(\omega t - kx)}$$

$$= k[-i\, A\, e^{-akz} - A\left(\frac{2 - c^2/\beta^2}{2i}\right) e^{-bkz}]\, e^{i(\omega t - kx)}$$

$$= -\, i\, k\, A\, [e^{-akz} - \left(1 - \frac{c^2}{2\beta^2}\right) e^{-bkz}]\, e^{i(\omega t - kx)} . \qquad (40)$$

Similarly , we shall find

$$w(x , z , t) = [(-ak)\, A\, e^{-akz} - (-ik) B\, e^{-bkz}]\, e^{i(\omega t - kx)}$$

$$= k[- a A e^{-akz} + \frac{ie^{bkz}(-2iAa)}{(2 - c^2/\beta^2)}] e^{i(\omega t - kx)}$$

$$= k A [-a e^{-akz} + \left(\frac{a}{1 - c^2/2\beta^2}\right) e^{-bkz}] e^{i(\omega t - kx)} . \quad (41)$$

Let $\theta = \omega t - kx$, (42)

$$U(z) = e^{-akz} - \left(1 - \frac{c^2}{2\beta^2}\right) e^{-bzk} , \quad (43)$$

$$W(z) = -a e^{-akz} + \left(\frac{a}{1 - c^2/2\beta^2}\right) e^{-bkz} . \quad (44)$$

Then , taking the real parts of equations (40) and (41) and using equation (42) to (44) ; we find

$$u(x , z , t) = A k U(z) \sin \theta , \quad (45)$$

$$w(x , z , t) = A k W(z) \cos \theta , \quad (46)$$

we remember that A is the potential amplitude. Eliminating θ from equations (45) and (46) , we obtain

$$\frac{u^2}{[Ak\ U(z)]^2} + \frac{w^2}{[Ak\ W(z)]^2} = 1 , \quad (47)$$

which is an equation of an ellipse in the vertical xz-plane.

Equation (47) shows that particles , during the propagation of Rayleigh Surface Waves, describe ellipses.

Remark 2: Particle Motion at the surface (z = 0)

On the surface z = 0 ,we find, at z = 0 ,

$$U(0) = \frac{c^2}{2\beta^2} , \quad W(0) = a\left(\frac{\frac{c^2}{2\beta^2}}{1 - c^2/2\beta^2}\right) \quad 48)$$

Since $0 < c < \beta$, so

$$U(0) > 0 , \quad W(0) > 0 . \quad (49)$$

Let $a_1 = A\,k\,W(0)$, $b_1 = A\,k\,U(0)$. (50)

Then $a_1 > 0$, $b_1 > 0$, (51)

and equation (47) reduces to

$$\frac{u^2}{b_1^2} + \frac{w^2}{a_1^2} = 1 \, . \tag{52}$$

Remark 3: Particular case (Poisson's Solid) :

In this case , we find, at z = 0 ,

$$\frac{a_1}{b_1} = \frac{W(0)}{U(0)} = \sqrt{3}\,a \cong 1.5 \quad , \tag{53}$$

using (37). So

$$a_1 > b_1 \, . \tag{54}$$

Thus , the surface particle motion (on z = 0) is an ellipse with a vertical major axis.

The horizontal and vertical displacement components are out of phase by $\frac{\pi}{2}$. The resulting surface particle motion is **Retrograde** (opposite to that of wave propagation).

Remark 4: The dependencies of the displacement components u and w on depth(z) are given by equation (43) to (46) .

There is a value of z for which u = 0 (For Poisson's solid , at $z = + 0.19\lambda$, $\lambda = \frac{2\pi}{k}$, u = 0) , whereas w is never zero.

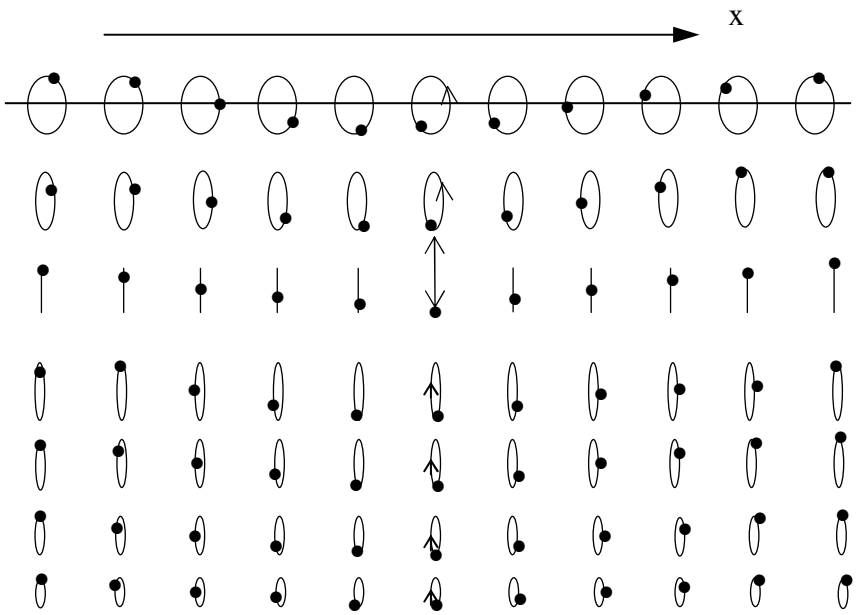
At the depth , where u is zero , its amplitude changes sign.

For greater depths , the particle motion is **Prograde.**

With increasing depth , the amplitudes of u and w decrease exponentially , with w always larger than u.

Thus , the elliptic motion changes from retrograde at the surface to prograde at depth , passing through a node at which there is no horizontal motion.

So , for the propagation of Rayleigh surface waves , a surface particle **describes an ellipse** , about its mean position , in the retrograde sense.



Particle motion for the fundamental Rayleigh mode in a uniform half-space , propagating from left to right. One horizontal wavelength (∧) is shown ; the dots are plotted at a fixed time point. Motion is counter clockwise (retrograde) at the surface , changing to purely vertical motion at a depth of about ∧/5 , and becoming clockwise (prograde) at greater depths. Note that the time behavior at a fixed distance is given by looking from right to left in this plot.

Remark 5: We see that frequency equation (27) for Rayleigh surface waves is independent of ω. Therefore , the velocity c_R of Rayleigh surface waves is constant and fixed.

This phenomenon is called nondispessive.

That is , **Rayleigh waves are undispresed**.

Remark 6: Maximum displacement parallel to the direction of Rayleigh waves

$= (u)_{max.}$

$= b_1$

$= \frac{2}{3} a_1$, for a Poisson solid.

= **two-third of** the maximum displacement in the vertical direction

for a Poisson solid.

Note (1) : Rayleigh waves are important because the largest disturbances caused by an earthquake recorded on a distant seismogram are usually those of Rayleigh waves.

GROUND ROLL is the term commonly used for Rayleigh waves.

Note (2) : Although a "a free surface" means contact with a vacuum , the elastic constants and density of air are so lows in comparison with values for rocks that the surface of the earth is approximately a free surface.

Note (3) : The boundary conditions $\tau_{zx} = \tau_{zz} = 0$ at $z = 0$ require that these two conditions must be satisfied , and so we require two parameters than can be adjusted. Therefore , we assume that both P-and SV-components exist and adjust their amplitude to satisfy the boundary conditions.

Exercise : Show that the displacement components at the surface of an elastic Poisson solid due to Rayleigh waves are

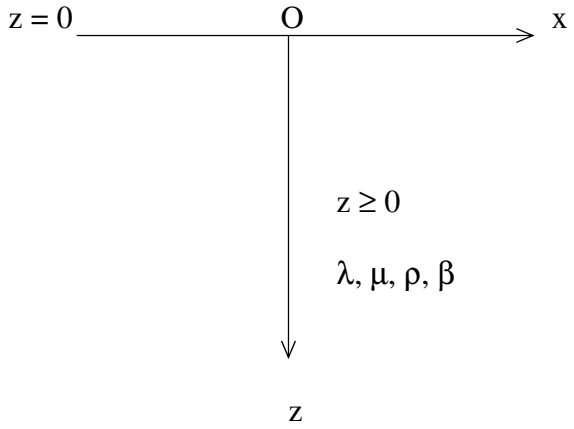
$$u(x, t) = -0.423\ kA \sin k(x - c_R t)$$

$$w(x, t) = 0.620\ kA \cos k(x - c_R t)\ , \qquad v \equiv 0\ ,$$

with usual notation.

10.3. SURFACE WAVES OF SH-TYPE IN A HALF-SPACE

We consider first the possibility of the propagation of SH type surface waves (called Love waves) in a homogeneous semi-infinite isotropic elastic medium occupying the half-space $z \geq 0$. The horizontal boundary $z = 0$ of the medium is assumed to be stress free. Let ρ be the density of the **medium and λ , μ Lame′ constants**(figure) .



(Elastic isotropic half-space)

Let the two – dimensional SH-wave motion takes place in the xz-plane. The basic equations for SH- wave motion are

$$u = w = 0\ , \qquad v = v(x\ , z\ , t)\ , \qquad (1)$$

$$\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial z^2} = \frac{1}{\beta^2}\frac{\partial^2 v}{\partial t^2} \quad , \tag{2}$$

$$\beta^2 = \frac{\mu}{\rho} \ . \tag{3}$$

We try a plane wave solution of wave equation (2) of the form

$$v(x, z, t) = B \ . \ e^{-bkz} \ . \ e^{i(\omega t - kx)} \quad , \tag{4}$$

where ω is the angular frequency of wave , k = wave number and $c = \omega/k$ is the speed with which surface waves are travelling in the x-direction on the surface $z = 0$; $b > 0$ and B is an arbitrary constant.

The amplitude of surface wave is $B\ e^{-bkz}$ which die exponentially as z increases.

Substituting the value of v(x, z, t) from equation (4) into equation (2) , we find

$$b^2 = 1 - \frac{c^2}{\beta^2} \ . \tag{5}$$

Since $b > 0$,so

$$c < \beta \ . \tag{6}$$

Using the stress-displacement relations , we find

$$\tau_{31} = \tau_{33} = 0 \ ,$$

$$\tau_{32} = \mu \frac{\partial v}{\partial z} = -\mu \ b \ k \ . \ B \ . \ e^{i(\omega t - kx)} \ . \ e^{-bkz} \tag{7}$$

Hence , the stress-free condition of the boundary $z = 0$ implies that , using (7) ,

$$\mu \ b \ k \ B \ e^{i(\omega t - kx)} = 0$$

or

$$B = 0 \quad , \tag{8}$$

as $\mu \neq 0$, $b \neq 0$, $k \neq 0$.

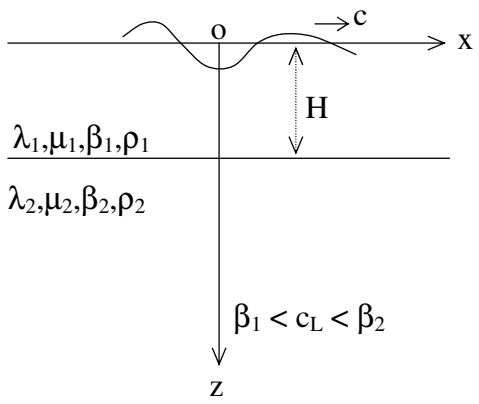
This implies that in the case of a homogeneous isotropic elastic half – space, Love waves do not exist at all.

10.4. PROPAGATION OF LOVE WAVES

Surface waves of the SH-type are observed to occur on the earth's surface. Love (1911) showed that if the earth is modelled as an isotropic elastic layer of finite thickness lying over a homogeneous elastic isotropic half-space (rather than considering earth as a purely uniform half-space) then SH type waves occur in the stress-free surface of a layered half-space.

Now , we consider the possibility of propagation of surface waves of SH-type (Love waves) in a semi-infinite elastic isotropic medium consisting of a horizontal elastic layer of uniform thickness H lying over a half-space.

It is assumed that two elastic isotropic media are welded together and the horizontal boundary z = 0 of the semi-infinite medium is stress – free (see , figure).



Let the layer and the half-space have different densities ρ_1, ρ_2 and different shear moduli μ_1 , μ_2 respectively. Let two-dimensional SH-motion takes place parallel to xz-plane. The basic equation for SH-wave motion are

$$u_1 = w_1 \equiv 0 \ , \ \ v_1 = v_1(x \ , z, t) \ \ , \tag{1}$$

$$\frac{\partial^2 v_1}{\partial x^2} + \frac{\partial^2 v_1}{\partial z^2} = \frac{1}{\beta_1^2} \frac{\partial^2 v_1}{\partial t^2} \ \ , \tag{2}$$

$$\beta_1^2 = \frac{\mu_1}{\rho_1} \ , \tag{3}$$

in the layer $0 \le z \le H$, and

$$u_2 = w_2 = 0 \ , \quad v_2 = v_2(x \ , z \ , t) \ , \tag{4}$$

$$\frac{\partial^2 v_2}{\partial x^2} + \frac{\partial^2 v_2}{\partial z^2} = \frac{1}{\beta_2^2} \frac{\partial^2 v_2}{\partial t^2} \ , \tag{5}$$

$$\beta_2^2 = \frac{\mu_2}{\rho_2} \ , \tag{6}$$

in the half-space ($z \geq H$).

Suitable plane wave solutions of wave equations (2) and (5) are (exercise) , as discussed in detail already ,

$$v_1(x , z , t) = (A_1 \ e^{-b_1 kz} + B_1 \ e^{b_1 kz}) \ e^{i(\omega t - kx)} \ , \tag{7}$$

in the layer $0 \leq z \leq H$, and

$$v_2 (x , z , t) = A_2 \ e^{-b_2 kz} \ e^{i(\omega t - kx)} \ , \tag{8}$$

in the half-space ($z \geq H$). ω is the angular wave frequency and k is the wave number , and $c = \omega/k$ is the speed of propagation of surface wave (if it exists) in the positive x-direction. A_1, B_1 are constants, b_1 and b_2 are real numbers with $b_2 > 0$. However , b_1 is unrestricted because z is finite in the layer.

Substituting for v_2 from (8) into (5) yields the relation

$$b_2^2 = \left(1 - \frac{c^2}{\beta_2^2}\right) , \tag{9}$$

and , therefore ,

$$c < \beta_2 , \tag{10}$$

otherwise

$$v_2 \to \infty \text{ as } z \to \infty.$$

From equations (7) and (2), we find

$$b_1^2 = \left(1 - \frac{c^2}{\beta_1^2}\right) . \tag{11}$$

The stress-displacement relations imply

$$\tau_{31} = \tau_{33} \equiv 0 \ , \tag{12}$$

in the layer as well as in the half space. Also

$$\tau_{32} = \mu_1 \ k(-b_1 \ A_1 \ e^{-b_1 kz} + b_1 \ B_1 \ e^{b_1 kz}) \ e^{i(\omega t - kx)} \ , \tag{13}$$

in the layer $0 \leq z \leq H$, and

$$\tau_{32} = k\,\mu_2\,A_2\,(-b_2)\,e^{-b_2 kz}\,.\,e^{i(\omega t - kx)} \qquad (14)$$

in the half space $z \geq H$.

The stress-free boundary $z = 0$ implies that

$$\tau_{32} = 0 \quad , \qquad (15)$$

at $z = 0$. This gives

$$B_1 = A_1 \,. \qquad (16)$$

Since , there is a welded contact between the layer and the half-space at the interface $z = H$, so the displacement and the tractions must be continuous across the interface $z = H$.

Thus , the boundary conditions at $z = H$ are

$$v_1 = v_2 \,, \qquad (17)$$

$$\tau_{32}\big|_{\text{layer}} = \tau_{32}\big|_{\text{half-space}} \,. \qquad (18)$$

From equations (13) , (14) , (17) and (18) , we find

$$A_1\,e^{-kb_1H} + B_1\,e^{kb_1H} = A_2\,e^{-kb_2H} \quad , \qquad (19)$$

and

$$\mu_1\,k\,b_1[-A_1\,e^{-b_1kH} + B_1\,e^{b_1kH}] = -\,\mu_2\,b_2\,k\,e^{-b_2kH} \,. \qquad (20)$$

Equation (16) , (19) and (20) are three homogeneous in A_2 , A_1 , B_1 and A_2.

We shall now eliminate them. From equations (19) & (20) , we write (after putting $B_1 = A_1$)

$$\frac{A_1[e^{-kb_1H} + e^{kb_1H}]}{A_1.\mu_1 b_1(e^{-b_1kH} - e^{b_1kH})k} = \frac{1}{\mu_2 b_2 k}$$

or

$$\frac{e^{-b_1kH} - e^{b_1kH}}{e^{-kb_1H} + e^{kb_1H}} = \frac{\mu_2 b_2}{\mu_1 b_1}$$

or $$\tan h(b_1 k H) + \frac{\mu_2 b_2}{\mu_1 b_1} = 0. \qquad (21)$$

Equation (21) is known as period equation/frequency equation/Dispersion equation for surface Love waves.

Equation (21) can also be written as

$$\tan h\left[kh . \sqrt{1 - \frac{c^2}{\beta_1^2}} \right] = -\frac{\mu_2}{\mu_1} \cdot \frac{\sqrt{1 - \frac{c^2}{\beta_2^2}}}{\sqrt{1 - \frac{c^2}{\beta_1^2}}} .$$

or $$\tan h\left[\frac{\omega H}{c} \sqrt{1 - \frac{c^2}{\beta_1^2}} \right] = -\frac{\mu_2}{\mu_1} . \frac{\sqrt{1 - \frac{c^2}{\beta_2^2}}}{\sqrt{1 - \frac{c^2}{\beta_1^2}}} . \qquad (22)$$

Equation (22) is a transcendental equation.

For given ω, we can find the speed c for surface Love waves. We note **the value of c depends upon ω .** This means that **waves of different frequencies will**, in **general , propagate with different phase velocity.**

This phenomenon is known as dispersion.

It is caused by the **inhomogeneity of the medium** (layered medium) due to some abrupt discontinuities within the medium (or due to continuous change of the elastic parameters which is not the present case).

Thus, **Love waves are dispressed.**

We consider now the following two possibilities between c and β_1 .

(i) Either $c \le \beta_1$, (ii) or $c > \beta_1$. (23)

When $c \le \beta_1$ **:** In this case b_1 is real (see , equation (11)) and left side of (22) becomes real and positive and right side of (22) is real and negative. Therefore , equation (22) can not possess any real solution for c.

Therefore , in this case , Love waves do not exist.

So , for the existence of surface Love waves , we must have

$$\mathbf{c > \beta_1} \quad . \tag{24}$$

In this case (24), b_1 is purely imaginary and we may write

$$b_1 = = \sqrt{1-\frac{c^2}{\beta_1^{\,2}}} = i\left(\sqrt{\frac{c^2}{\beta_1}-1}\right) . \tag{25}$$

Then equation (22) becomes

$$\tan\left(kH\sqrt{\frac{c^2}{\beta_1^{\,2}}-1}\right) = \frac{\mu_2}{\mu_1}\left(\frac{\sqrt{1-\frac{c^2}{\beta_2^{\,2}}}}{\sqrt{\frac{c^2}{\beta_1^{\,2}}-1}}\right) . \tag{26}$$

From equations (10) and (24) ; we find

$$\beta_1 < c < \beta_2 . \tag{27}$$

Equation (26) is a transcendental equation that yields infinitely many roots for c.

Thus, the possible **speeds of the Love waves are precisely** the roots of equations (26) that lie **in the interval (β_1 , β_2).**

This indicates that the **shear velocity in the layer** must be less than the **shear velocity in the half-space** for the possible existence of Love waves.

This gives **the upper and lower bounds for** the speed of Love waves.

Remark 1: If the layer and the half – space are such that $\beta_1 \leq \beta$, then existence of Love waves are not possible

Remark 2: In the limiting case when the layer is absent , we have

$$\mu = \mu_1 \text{ and } \rho = \rho_1$$

and therefore

$$\beta = \beta_1$$

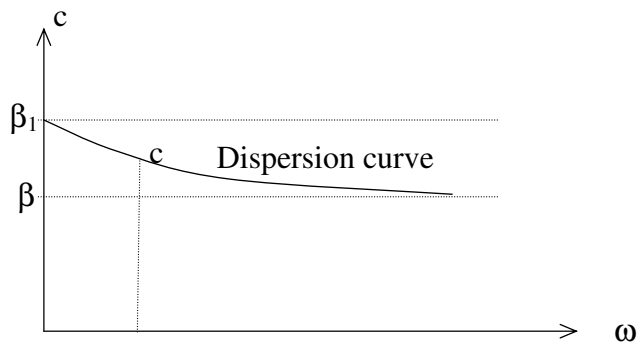
Equation (22) leads to the impossible condition

$$0 = -1 .$$

Hence , in this case , the wave considered can not exist.

Remark 3: When k or $\omega \to 0$, we get $c \to \beta_1$.

The dispersion curve is given in the following figure.



Here , if we assume

$$\mu_1/\mu = 1.8 , \beta = 3.6\text{km/sec} , \beta_1 = 4.6\text{km/sec}$$

then

$$c_L = \text{speed of Love waves} = 4.0\text{km/sec}.$$

10

SURFACE WAVES

10.1. INTRODUCTION

In an elastic body, it is possible to have another type of waves (other than body waves) which are propagated over the surface and penetrate only a little into the interior of the body.

Such waves are similar to waves produced on a **smooth surface of water when** a stone is thrown into it.

These type of waves are **called SURFACE WAVES.**

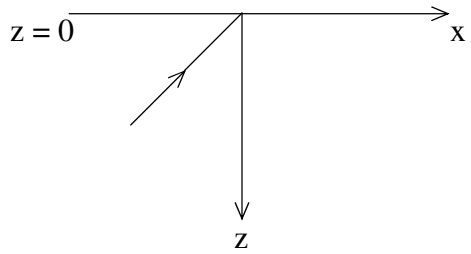
Surface waves are "tied" to the surface and diminish exponentially as they get farther from the surface.

The criterion for surface waves is that the **amplitude** of the displacement in the medium **dies exponentially with the increasing distance from the surface.**

In seismology , the interfaces are , in the ideal case , horizontal and so the plane of incidence is **vertical**. Activity of surface waves is restricted to the neighbourhood of the interface(s) or surface of the medium.

Under certain conditions , such waves can propagated independently along the surface/interface. For surface waves , the disturbance is confined to a depth **equal to a few wavelengths**.

Let us take xz – plane as the plane of incidence with z – axis vertically downwards. Let z = 0 be the surface of a semi-infinite elastic medium (Figure) .



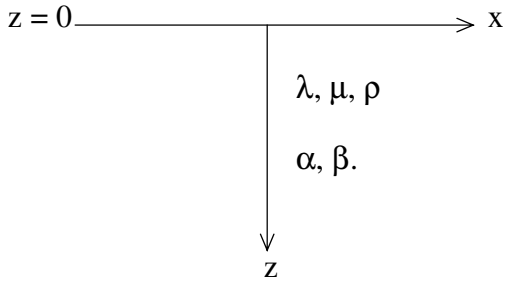
For a surface wave , its amplitude will be a function of z (rather than an exponential function) which tends to zero as $z \to \infty$. For such surface – waves , the motion will be two – dimensional **,** parallel to xz – plane , so that $\frac{\partial}{\partial y} = 0$.

The existence of surface waves raises the question of whether they might (under certain conditions) be able to travel freely along the plane (horizontal) as a guided wave.

10.2. RAYLEIGH WAVES

Rayleigh (1885) discussed the existence of a simplest surface wave propagating on the free – surface of a homogeneous isotropic elastic half – space.

Let the half – space occupies the region $z \geq 0$ with z – axis taken as vertically downwards. Let ρ be the density and λ , μ be the Lame′ elastic moduli and $z = 0$ be the stress – free boundary of the half – space (figure).



Suppose that a train of plane waves is propagating in the media in the positive x – direction such that

(i) the plane of incidence is the vertical plane (xz – plane) so that the motion , i.e. , disturbance is independent of y and hence $\frac{\partial}{\partial y} \equiv 0$.

(ii) the amplitude of the surface wave decreases exponentially as we move away from the surface in the z – direction.

This problem is a **plane strain problem** and the displacement vector $\bar{u}$ is of the type

$$\bar{u} = (u , 0 , w) , \quad u = u(x , z, t) , \quad w = w(x , z , t) . \quad (1)$$

The displacement components u and w are given in term of potential ϕ and ψ through the relations

$$u = \frac{\partial \phi}{\partial x} + \frac{\partial \psi}{\partial z} , \qquad (2)$$

$$w = \frac{\partial \phi}{\partial z} - \frac{\partial \psi}{\partial x} , \qquad (3)$$

where potentials ϕ and ψ satisfy the scalar wave equations

$$\nabla^2 \phi = \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial z^2} = \frac{1}{\alpha^2} \frac{\partial^2 \phi}{\partial t^2} \ , \qquad (4)$$

$$\nabla^2 \psi = \frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial z^2} = \frac{1}{\beta^2} \frac{\partial^2 \psi}{\partial t^2} \ , \qquad (5)$$

and wave velocities α and β are given by

$$\alpha = \sqrt{(\lambda + 2\mu)/\rho} \ , \qquad (6)$$

$$\beta = \sqrt{\mu/\rho} \ . \qquad (7)$$

This wave motion is of a P-SV type wave travelling along the stress – free surface of the half space and such a motion takes place in the xz – plane.

Now , we seek solutions of wave equations (4) and (5) of the form

$$\phi(x , z , t) = f(z)\, e^{ik(ct-x)} \ , \qquad (8)$$

$$\psi(x , z , t) = g(z)\, e^{ik(ct-x)} \ , \qquad (9)$$

where k is the wave number , c is the speed of surface wave travelling in the +ve x-direction and $\omega = ck$ is the angular frequency.

The substitution of (8) and (9) into wave equations (4) and (5) leads to two ordinary differential equations (exercise)

$$\frac{d^2 f}{dz^2} - k^2 a^2 f = 0 \ , \qquad (10)$$

and

$$\frac{d^2 g}{dz^2} - k^2 b^2 g = 0 \ , \qquad (11)$$

with

$$a = \sqrt{1 - c^2/\alpha^2} > 0 \ , \qquad (12)$$

and

$$b = \sqrt{1 - c^2/\beta^2} > 0 \ . \qquad (13)$$

From equations (8) to (11) ; we find (exercise)

$$\phi(x , z , t) = (A\, e^{-akz} + A_1\, e^{akz})\, e^{ik(ct - x)} \ , \qquad (14)$$

$$\psi(x , z , t) = (B\, e^{-bkz} + B_1\, e^{bkz})\, e^{ik(ct - x)} \ , \qquad (15)$$

where A , A_1 B and B_1 are constants.

Since the disturbance due to surface waves must die rapidly as $z \to \infty$, we must have

$$A_1 = B_1 = 0 . \tag{16}$$

Thus , for Rayleigh waves , we get

$$\phi(x , z , t) = A\, e^{-akz}\, e^{i(\omega t - kx)} , \tag{17}$$

and

$$\psi(x , z , t) = B\, e^{-bkz}\, e^{i(\omega t - kx)} , \tag{18}$$

with

$$c < \beta < \alpha . \tag{19}$$

The equation (19) gives the condition for the existence of surface waves on the surface of a semi – infinite isotropic elastic media with velocity c in the positive x – direction.

To find frequency equation for the velocity c and ratio of A and B ; we use the stress – free boundary conditions. This conditions are

$$\tau_{zx} = \tau_{zy} = \tau_{zz} = 0 \qquad \text{at } z = 0. \tag{20}$$

From relation in (2) and (3) , we find

$$\text{div } \bar{u} = \frac{\partial u}{\partial x} + \frac{\partial w}{\partial z}$$

$$= \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial z^2}$$

$$= \nabla^2 \phi . \tag{21}$$

The stresses in terms of potentials ϕ and ψ are given by

$$\tau_{zx} = \mu \left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial x} \right)$$

$$= \mu \left[2 \frac{\partial^2 \phi}{\partial x \, \partial z} + \frac{\partial \psi}{\partial z^2} - \frac{\partial^2 \psi}{\partial x^2} \right] , \tag{22}$$

$$\tau_{zz} = \lambda \text{ div } \bar{u} + \mu \frac{\partial w}{\partial z}$$

$$= \mu \left[\left(\frac{\alpha^2}{\beta^2} - 2 \right) \frac{\partial^2 \phi}{\partial x^2} + \frac{\alpha^2}{\beta^2} \frac{\partial^2 \phi}{\partial z^2} - 2 \frac{\partial^2 \psi}{\partial x \partial z} \right], \quad (23)$$

$$\tau_{zy} = \mu \left(\frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} \right)$$

$$= 0 . \quad (24)$$

The boundary condition $\tau_{zx} = 0$ at z = 0 in (20), gives (exercise)

$$2A(-ik)(-ak) - B(-ik)^2 + B(-bk)^2 = 0$$

or $$2 i a k^2 A + B(1 + b^2) k^2 = 0$$

or $$2 i a A = -B(1 + b^2)$$

or $$\frac{A}{B} = \frac{i(1+b^2)}{2a} . \quad (25)$$

The boundary condition $\tau_{zz} = 0$ at z = 0 , gives (exercise)

$$\left(\frac{\alpha^2}{\beta^2} - 2 \right) . A . (-k^2) + \frac{\alpha^2}{\beta^2} . A . (\alpha^2 k^2) - 2B (-ik) (-bk)$$

$$= 0$$

or $$A \left[-\frac{\alpha^2}{\beta^2} + 2 + \frac{\alpha^2 a^2}{\beta^2} \right] k^2 - 2 i b B k^2 = 0$$

or $$A \left(2 - \frac{\alpha^2}{\beta^2} + \frac{\alpha^2 a^2}{\beta^2} \right) = 2 i b B$$

or $$\frac{A}{B} = \left(\frac{2ib}{2 - \frac{\alpha^2}{\beta^2} + \frac{\alpha^2 a^2}{\beta^2}} \right) . \quad (26)$$

Eliminating A/B from equations (25) and (26) and substituting the value of a and b from equation (12) and (13) , we obtain

$$(1 + b^2) \left(2 - \frac{\alpha^2}{\beta^2} + \frac{\alpha^2 a^2}{\beta^2} \right) = 4 a b$$

or $$\left(2-\frac{c^2}{\beta^2}\right)\left[2-\frac{\alpha^2}{\beta^2}+\frac{\alpha^2}{\beta^2}\left(1-\frac{c^2}{\alpha^2}\right)\right]$$

$$=4\sqrt{1-\frac{c^2}{\alpha^2}}\ \sqrt{1-\frac{c^2}{\beta^2}}$$

or $$\left(2-\frac{c^2}{\beta^2}\right)\left[2-\frac{\alpha^2}{\beta^2}+\frac{\alpha^2}{\beta^2}-\frac{c^2}{\beta^2}\right]=4\sqrt{1-\frac{c^2}{\alpha^2}}\ \sqrt{1-\frac{c^2}{\beta^2}}$$

or $$\left(2-\frac{c^2}{\beta^2}\right)^2 - 4\left(1-\frac{c^2}{\alpha^2}\right)^{\frac{1}{2}}\left(1-\frac{c^2}{\beta^2}\right)^{\frac{1}{2}}=0\ . \qquad (27)$$

This equation contains only one unknown c.

This equation determines the speed c for Rayleigh surface waves in an uniform half – space.

Equation (27) is called the **RAYLEIGH EQUATION** for Rayleigh waves. It is also called the **Rayleigh frequency equation**. It is also called the **Rayleigh wave – velocity equation**.

This equation is the **period equation** for Rayleigh waves.

In order to prove that Rayleigh waves really exists , we must show that frequency equation (27) has at least one real root for c. To show this , we proceed as follows :

From equation (27) , we write

$$\left(2-\frac{c^2}{\beta^2}\right)^4 = 16\left(1-\frac{c^2}{\alpha^2}\right)\left(1-\frac{c^2}{\beta^2}\right)$$

or $$16 - 32\ \frac{c^2}{\beta^2} + 24\ \frac{c^4}{\beta^4} - 8\frac{c^6}{\beta^6} + \frac{c^8}{\beta^8}$$

$$=16\left[1-\frac{c^2}{\alpha^2}-\frac{c^2}{\beta^2}+\frac{c^4}{\alpha^2\beta^2}\right]$$

$$=16\left[1-\frac{c^2}{\beta^2}\frac{\beta^2}{\alpha^2}-\frac{c^2}{\beta^2}+\frac{c^4}{\beta^4}.\frac{\beta^2}{\alpha^2}\right]$$

or

$$-32 + 24\,\frac{c^2}{\beta^2} - 8\frac{c^4}{\beta^4} + \frac{c^6}{\beta^6} + 16\,\frac{\beta^2}{\alpha^2} + 16 - 16\,\frac{c^2}{\beta^2}.\frac{\beta^2}{\alpha^2} = 0\,. \qquad (28)$$

Put

$$s = c^2/\beta^2\,, \qquad (29)$$

then equation (28) gives

$$f(s) = s^3 - 8s^2 + \left(24 - 16\frac{\beta^2}{\alpha^2}\right)s - 16\left(1 - \frac{\beta^2}{\alpha^2}\right) = 0\,. \qquad (30)$$

It is polynomial **equation of degree 3 in s** with real coefficients.

Hence the frequency equation (30) has at least one real root since complex roots occur in conjugate pairs.

Moreover

$$f(0) = -16\left(1 - \frac{\beta^2}{\alpha^2}\right) < 0\,, \qquad (31)$$

and

$$f(1) = 1 - 8 + 24 - \frac{16\beta^2}{\alpha^2} + \frac{16\beta^2}{\alpha^2} = 1 > 0\,, \qquad (32)$$

since $\beta < \alpha$.

Hence , by the intermediate theorem of calculus , the frequency equation (30) has at least one root in the range (0 , 1).

That is , there exists $s \in (0\ ,\ 1)$ which is a root of the Rayleigh frequency equation.

Further , $0 < s < 1$ implies

$$0 < \frac{c^2}{\beta^2} < 1$$

or $$\mathbf{0 < c < \beta}\,. \qquad (33)$$

This establishes that Rayleigh surface waves propagating with speed $c = c_R$, where

$$0 < c_R < \beta < \alpha\,,$$

always exists.

This proves the existence of Rayleigh surface waves.

Special Case (Poisson's solid) : When the semi-infinite elastic medium is a Poisson's solid ,

then $\lambda = \mu$ and $\sigma = \frac{1}{4}$ and

$$\frac{\alpha^2}{\beta^2} = \frac{\lambda + 2\mu}{\mu} = 3. \qquad (34)$$

For this type of elastic medium , frequency equation (30) becomes

$$3s^3 - 24\, s^2 + 56\, s - 32 = 0$$

or $$(s - 4)\,(3s^2 - 12\, s + 8) = 0$$

giving

$$s = 4\ ,\ 2 + \frac{2}{\sqrt{3}}\ ,\ 2 - \frac{2}{\sqrt{3}}$$

or $$\frac{c^2}{\beta^2} = 4\ ,\ 2 + \frac{2}{\sqrt{3}}\ ,\ 2 - \frac{2}{\sqrt{3}}\ . \qquad (35)$$

But c must satisfy the inequality $0 < c < \beta$, therefore , the only possible value for $c = c_R$ is

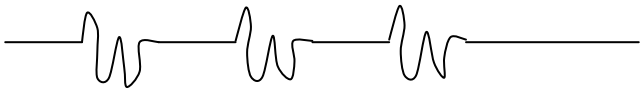
$$\frac{c_R^{\,2}}{\beta^2} = 2 - \frac{2}{\sqrt{3}}\ ,$$

or

$$c_R = \left[\sqrt{2 - \frac{2}{\sqrt{3}}}\right] .\ \beta \cong 0.9195\ \beta\ , \qquad (36)$$

giving the speed of propagation of Rayleigh surface waves along the stress free boundary of the Poissonian half-space in the x-direction.

Thus , the order of arrival of P, SV-and Rayleigh waves is



P SV Rayleigh

From equations (12) and (13) ; we write

$$a^2 = 1 - \frac{c_R^{\,2}}{\alpha^2}$$

$$= 1 - \frac{c_R^{\,2}}{\beta^2} \cdot \frac{\beta^2}{\alpha^2}$$

$$= \frac{1}{9}(3 + 2\sqrt{3}) ,$$

or

$$a = \frac{1}{3}\sqrt{3 + 2\sqrt{3}} \cong 0.8475 \approx 0.84\ 8 , \qquad (37)$$

and

$$b^2 = 1 - \frac{c_R^{\,2}}{\beta^2}$$

$$= \frac{1}{3}[2\sqrt{3} - 3] ,$$

or $$b \cong 0.3933 \cong 0.393 . \qquad (38)$$

Further , from equations (25) , (37) and (38) , we find

$$\frac{A}{B} = 1.468\ i \quad . \qquad (39)$$

Remark 1: Displacements due to Rayleigh waves (Particle motion)

From equations (2) , (3) , (17) , (18) and (26) ; we find

$$u(x , z , t) = [A(-ik)\, e^{-akz} + B(-bk)\, e^{-bkz}]\, e^{i(\omega t - kx)}$$

$$= k[-i\, A\, e^{-akz} - A\left(\frac{2 - c^2/\beta^2}{2i}\right) e^{-bkz}]\, e^{i(\omega t - kx)}$$

$$= -\, i\, k\, A\, [e^{-akz} - \left(1 - \frac{c^2}{2\beta^2}\right) e^{-bkz}]\, e^{i(\omega t - kx)} . \qquad (40)$$

Similarly , we shall find

$$w(x , z , t) = [(-ak)\, A\, e^{-akz} - (-ik) B\, e^{-bkz}]\, e^{i(\omega t - kx)}$$

$$= k[- a A e^{-akz} + \frac{ie^{bkz}(-2iAa)}{(2 - c^2/\beta^2)}] e^{i(\omega t - kx)}$$

$$= k A [-a e^{-akz} + \left(\frac{a}{1 - c^2/2\beta^2}\right) e^{-bkz}] e^{i(\omega t - kx)} . \quad (41)$$

Let $\theta = \omega t - kx$, (42)

$$U(z) = e^{-akz} - \left(1 - \frac{c^2}{2\beta^2}\right) e^{-bzk} , \quad (43)$$

$$W(z) = -a e^{-akz} + \left(\frac{a}{1 - c^2/2\beta^2}\right) e^{-bkz} . \quad (44)$$

Then , taking the real parts of equations (40) and (41) and using equation (42) to (44) ; we find

$$u(x , z , t) = A k U(z) \sin \theta , \quad (45)$$

$$w(x , z , t) = A k W(z) \cos \theta , \quad (46)$$

we remember that A is the potential amplitude. Eliminating θ from equations (45) and (46) , we obtain

$$\frac{u^2}{[Ak\, U(z)]^2} + \frac{w^2}{[Ak\, W(z)]^2} = 1 , \quad (47)$$

which is an equation of an ellipse in the vertical xz-plane.

Equation (47) shows that particles , during the propagation of Rayleigh Surface Waves, describe ellipses.

Remark 2: Particle Motion at the surface (z = 0)

On the surface z = 0 ,we find, at z = 0 ,

$$U(0) = \frac{c^2}{2\beta^2} , \quad W(0) = a\left(\frac{\frac{c^2}{2\beta^2}}{1 - c^2/2\beta^2}\right) \quad 48)$$

Since $0 < c < \beta$, so

$$U(0) > 0 , \quad W(0) > 0 . \quad (49)$$

Let $a_1 = A k W(0)$, $b_1 = A k U(0)$. (50)

Then $a_1 > 0 \quad , b_1 > 0 \quad ,$ (51)

and equation (47) reduces to

$$\frac{u^2}{b_1^2} + \frac{w^2}{a_1^2} = 1 \, . \tag{52}$$

Remark 3: Particular case (Poisson's Solid) :

In this case , we find, at z = 0 ,

$$\frac{a_1}{b_1} = \frac{W(0)}{U(0)} = \sqrt{3}\, a \cong 1.5 \quad , \tag{53}$$

using (37). So

$$a_1 > b_1 \, . \tag{54}$$

Thus , the surface particle motion (on z = 0) is an ellipse with a vertical major axis.

The horizontal and vertical displacement components are out of phase by $\frac{\pi}{2}$.

The resulting surface particle motion is **Retrograde** (opposite to that of wave propagation).

Remark 4: The dependencies of the displacement components u and w on depth(z) are given by equation (43) to (46) .

There is a value of z for which u = 0 (For Poisson's solid , at $z = + 0.19\lambda$, $\lambda = \frac{2\pi}{k}$, u = 0) , whereas w is never zero.

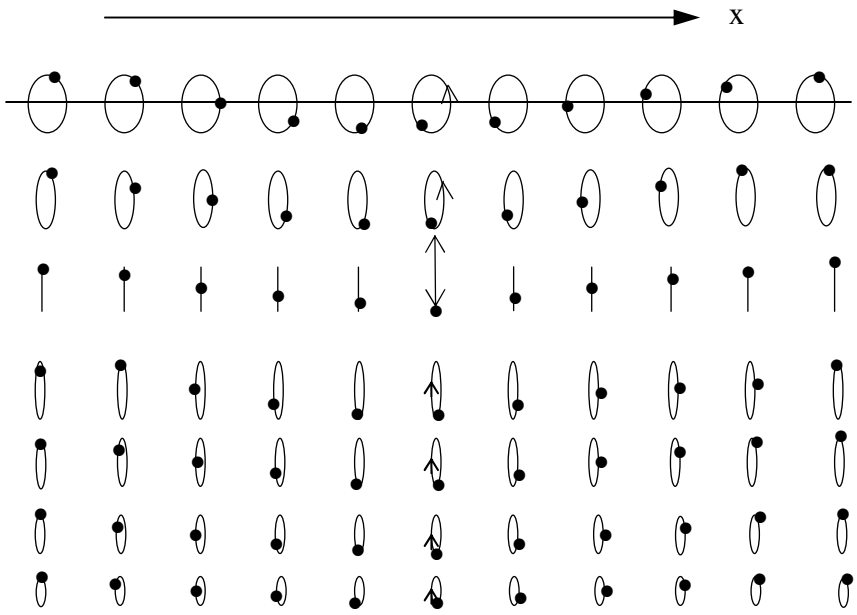
At the depth , where u is zero , its amplitude changes sign.

For greater depths , the particle motion is **Prograde.**

With increasing depth , the amplitudes of u and w decrease exponentially , with w always larger than u.

Thus , the elliptic motion changes from retrograde at the surface to prograde at depth , passing through a node at which there is no horizontal motion.

So , for the propagation of Rayleigh surface waves , a surface particle **describes an ellipse** , about its mean position , in the retrograde sense.



Particle motion for the fundamental Rayleigh mode in a uniform half-space , propagating from left to right. One horizontal wavelength (∧) is shown ; the dots are plotted at a fixed time point. Motion is counter clockwise (retrograde) at the surface , changing to purely vertical motion at a depth of about ∧/5 , and becoming clockwise (prograde) at greater depths. Note that the time behavior at a fixed distance is given by looking from right to left in this plot.

Remark 5: We see that frequency equation (27) for Rayleigh surface waves is independent of ω. Therefore , the velocity c_R of Rayleigh surface waves is constant and fixed.

This phenomenon is called nondispessive.

That is , **Rayleigh waves are undispresed**.

Remark 6: Maximum displacement parallel to the direction of Rayleigh waves

$= (u)_{max.}$

$= b_1$

$= \frac{2}{3}\, a_1$, for a Poisson solid.

= **two-third of** the maximum displacement in the vertical direction

for a Poisson solid.

Note (1) : Rayleigh waves are important because the largest disturbances caused by an earthquake recorded on a distant seismogram are usually those of Rayleigh waves.

GROUND ROLL is the term commonly used for Rayleigh waves.

Note (2) : Although a "a free surface" means contact with a vacuum , the elastic constants and density of air are so lows in comparison with values for rocks that the surface of the earth is approximately a free surface.

Note (3) : The boundary conditions $\tau_{zx} = \tau_{zz} = 0$ at $z = 0$ require that these two conditions must be satisfied , and so we require two parameters than can be adjusted. Therefore , we assume that both P-and SV-components exist and adjust their amplitude to satisfy the boundary conditions.

Exercise : Show that the displacement components at the surface of an elastic Poisson solid due to Rayleigh waves are

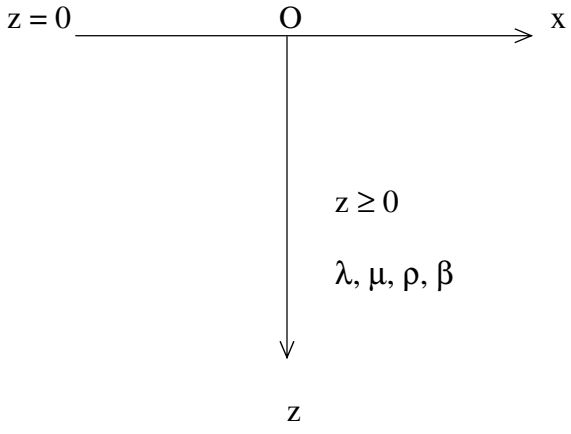
$$u(x, t) = -0.423\ kA \sin k(x - c_R t)$$

$$w(x, t) = 0.620\ kA \cos k(x - c_R t)\ , \qquad v \equiv 0\ ,$$

with usual notation.

10.3. SURFACE WAVES OF SH-TYPE IN A HALF-SPACE

We consider first the possibility of the propagation of SH type surface waves (called Love waves) in a homogeneous semi-infinite isotropic elastic medium occupying the half-space $z \geq 0$. The horizontal boundary $z = 0$ of the medium is assumed to be stress free. Let ρ be the density of the **medium and λ , μ Lame′ constants**(figure) .



(Elastic isotropic half-space)

Let the two – dimensional SH-wave motion takes place in the xz-plane. The basic equations for SH- wave motion are

$$u = w = 0 , \qquad v = v(x , z , t) \ , \tag{1}$$

$$\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial z^2} = \frac{1}{\beta^2}\frac{\partial^2 v}{\partial t^2} \ , \tag{2}$$

$$\beta^2 = \frac{\mu}{\rho} \ . \tag{3}$$

We try a plane wave solution of wave equation (2) of the form

$$v(x, z, t) = B \ . \ e^{-bkz} \ . \ e^{i(\omega t - kx)} \ , \tag{4}$$

where ω is the angular frequency of wave , k = wave number and $c = \omega/k$ is the speed with which surface waves are travelling in the x-direction on the surface z = 0 ; b > 0 and B is an arbitrary constant.

The amplitude of surface wave is $B\ e^{-bkz}$ which die exponentially as z increases.

Substituting the value of v(x, z, t) from equation (4) into equation (2) , we find

$$b^2 = 1 - \frac{c^2}{\beta^2} \ . \tag{5}$$

Since b > 0 ,so

$$c < \beta \ . \tag{6}$$

Using the stress-displacement relations , we find

$$\tau_{31} = \tau_{33} = 0 \ ,$$

$$\tau_{32} = \mu \frac{\partial v}{\partial z} = - \mu \ b \ k \ . \ B \ . \ e^{i(\omega t - kx)} \ . \ e^{-bkz} \tag{7}$$

Hence , the stress-free condition of the boundary z = 0 implies that , using (7) ,

$$\mu \ b \ k \ B \ e^{i(\omega t - kx)} = 0$$

or

$$B = 0 \ , \tag{8}$$

as $\mu \neq 0$, $b \neq 0$, $k \neq 0$.

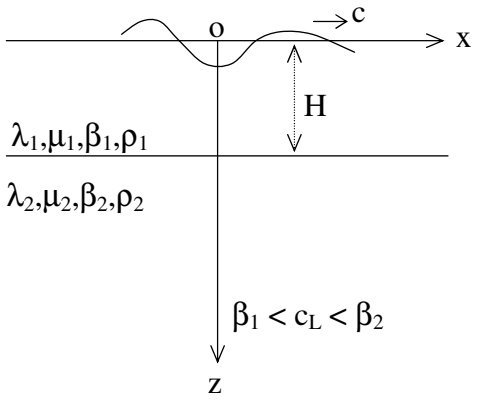
This implies that in the case of a homogeneous isotropic elastic half – space, Love waves do not exist at all.

10.4. PROPAGATION OF LOVE WAVES

Surface waves of the SH-type are observed to occur on the earth's surface. Love (1911) showed that if the earth is modelled as an isotropic elastic layer of finite thickness lying over a homogeneous elastic isotropic half-space (rather than considering earth as a purely uniform half-space) then SH type waves occur in the stress-free surface of a layered half-space.

Now , we consider the possibility of propagation of surface waves of SH-type (Love waves) in a semi-infinite elastic isotropic medium consisting of a horizontal elastic layer of uniform thickness H lying over a half-space.

It is assumed that two elastic isotropic media are welded together and the horizontal boundary z = 0 of the semi-infinite medium is stress – free (see , figure).



Let the layer and the half-space have different densities ρ_1, ρ_2 and different shear moduli μ_1 , μ_2 respectively. Let two-dimensional SH-motion takes place parallel to xz-plane. The basic equation for SH-wave motion are

$$u_1 = w_1 \equiv 0 , \quad v_1 = v_1(x , z, t) \quad , \tag{1}$$

$$\frac{\partial^2 v_1}{\partial x^2} + \frac{\partial^2 v_1}{\partial z^2} = \frac{1}{\beta_1^2} \frac{\partial^2 v_1}{\partial t^2} \quad , \tag{2}$$

$$\beta_1^2 = \frac{\mu_1}{\rho_1} \quad , \tag{3}$$

in the layer $0 \le z \le H$, and

$$u_2 = w_2 = 0 , \quad v_2 = v_2(x , z , t) , \tag{4}$$

$$\frac{\partial^2 v_2}{\partial x^2} + \frac{\partial^2 v_2}{\partial z^2} = \frac{1}{\beta_2^2} \frac{\partial^2 v_2}{\partial t^2} , \qquad (5)$$

$$\beta_2^2 = \frac{\mu_2}{\rho_2} , \qquad (6)$$

in the half-space ($z \geq H$).

Suitable plane wave solutions of wave equations (2) and (5) are (exercise) , as discussed in detail already ,

$$v_1(x , z , t) = (A_1 \ e^{-b_1 kz} + B_1 \ e^{b_1 kz}) \ e^{i(\omega t - kx)} \quad , \qquad (7)$$

in the layer $0 \leq z \leq H$, and

$$v_2 (x , z , t) = A_2 \ e^{-b_2 kz} \ e^{i(\omega t - kx)} \qquad , \qquad (8)$$

in the half-space ($z \geq H$). ω is the angular wave frequency and k is the wave number , and $c = \omega/k$ is the speed of propagation of surface wave (if it exists) in the positive x-direction. A_1, B_1 are constants, b_1 and b_2 are real numbers with $b_2 > 0$. However , b_1 is unrestricted because z is finite in the layer.

Substituting for v_2 from (8) into (5) yields the relation

$$b_2^2 = \left(1 - \frac{c^2}{\beta_2^2}\right) , \qquad (9)$$

and , therefore ,

$$c < \beta_2 , \qquad (10)$$

otherwise

$$v_2 \rightarrow \infty \text{ as } z \rightarrow \infty.$$

From equations (7) and (2), we find

$$b_1^2 = \left(1 - \frac{c^2}{\beta_1^2}\right) . \qquad (11)$$

The stress-displacement relations imply

$$\tau_{31} = \tau_{33} \equiv 0 \quad , \qquad (12)$$

in the layer as well as in the half space. Also

$$\tau_{32} = \mu_1 \ k(-b_1 \ A_1 \ e^{-b_1 kz} + b_1 \ B_1 \ e^{b_1 kz}) \ e^{i(\omega t - kx)} , \qquad (13)$$

in the layer $0 \le z \le H$, and

$$\tau_{32} = k\,\mu_2\,A_2\,(-b_2)\,e^{-b_2 kz}\,.\,e^{i(\omega t - kx)} \qquad (14)$$

in the half space $z \ge H$.

The stress-free boundary $z = 0$ implies that

$$\tau_{32} = 0 \quad , \qquad (15)$$

at $z = 0$. This gives

$$B_1 = A_1 \,. \qquad (16)$$

Since , there is a welded contact between the layer and the half-space at the interface $z = H$, so the displacement and the tractions must be continuous across the interface $z = H$.

Thus , the boundary conditions at $z = H$ are

$$v_1 = v_2 \,, \qquad (17)$$

$$\tau_{32}\big|_{\text{layer}} = \tau_{32}\big|_{\text{half-space}} \,. \qquad (18)$$

From equations (13) , (14) , (17) and (18) , we find

$$A_1\,e^{-kb_1H} + B_1\,e^{kb_1H} = A_2\,e^{-kb_2H} \quad , \qquad (19)$$

and

$$\mu_1\,k\,b_1[-A_1\,e^{-b_1kH} + B_1\,e^{b_1kH}] = -\,\mu_2\,b_2\,k\,e^{-b_2kH} \,. \qquad (20)$$

Equation (16) , (19) and (20) are three homogeneous in A_2 , A_1 , B_1 and A_2.

We shall now eliminate them. From equations (19) & (20) , we write (after putting $B_1 = A_1$)

$$\frac{A_1[e^{-kb_1H} + e^{kb_1H}]}{A_1.\mu_1 b_1(e^{-b_1kH} - e^{b_1kH})k} = \frac{1}{\mu_2 b_2 k}$$

or

$$\frac{e^{-b_1kH} - e^{b_1kH}}{e^{-kb_1H} + e^{kb_1H}} = \frac{\mu_2 b_2}{\mu_1 b_1}$$

or

$$\tan h(b_1\,k\,H) + \frac{\mu_2 b_2}{\mu_1 b_1} = 0. \qquad (21)$$

Equation (21) is known as period equation/frequency equation/Dispersion equation for surface Love waves.

Equation (21) can also be written as

$$\tan h\left[kh.\sqrt{1-\frac{c^2}{\beta_1^2}} \right] = -\frac{\mu_2}{\mu_1} \cdot \frac{\sqrt{1-\frac{c^2}{\beta_2^2}}}{\sqrt{1-\frac{c^2}{\beta_1^2}}}.$$

or

$$\tan h\left[\frac{\omega H}{c} \sqrt{1-\frac{c^2}{\beta_1^2}} \right] = -\frac{\mu_2}{\mu_1} \cdot \frac{\sqrt{1-\frac{c^2}{\beta_2^2}}}{\sqrt{1-\frac{c^2}{\beta_1^2}}}. \quad (22)$$

Equation (22) is a transcendental equation.

For given ω, we can find the speed c for surface Love waves. We note **the value of c depends upon ω .** This means that **waves of different frequencies will**, in **general , propagate with different phase velocity.**

This phenomenon is known as dispersion.

It is caused by the **inhomogeneity of the medium** (layered medium) due to some abrupt discontinuities within the medium (or due to continuous change of the elastic parameters which is not the present case).

Thus, **Love waves are dispressed.**

We consider now the following two possibilities between c and β_1 .

(i) Either $c \le \beta_1$, (ii) or $c > \beta_1$. (23)

When $c \le \beta_1$ **:** In this case b_1 is real (see , equation (11)) and left side of (22) becomes real and positive and right side of (22) is real and negative. Therefore , equation (22) can not possess any real solution for c.

Therefore , in this case , Love waves do not exist.

So , for the existence of surface Love waves , we must have

$$\mathbf{c > \beta_1} \quad . \quad (24)$$

In this case (24), b_1 is purely imaginary and we may write

$$b_1 = = \sqrt{1-\frac{c^2}{\beta_1^{\,2}}} = i\left(\sqrt{\frac{c^2}{\beta_1}-1}\right) . \qquad (25)$$

Then equation (22) becomes

$$\tan\left(kH\sqrt{\frac{c^2}{\beta_1^{\,2}}-1}\right) = \frac{\mu_2}{\mu_1}\left(\frac{\sqrt{1-\frac{c^2}{\beta_2^{\,2}}}}{\sqrt{\frac{c^2}{\beta_1^{\,2}}-1}}\right) . \qquad (26)$$

From equations (10) and (24) ; we find

$$\beta_1 < c < \beta_2 . \qquad (27)$$

Equation (26) is a transcendental equation that yields infinitely many roots for c.

Thus, the possible **speeds of the Love waves are precisely** the roots of equations (26) that lie **in the interval (β_1 , β_2).**

This indicates that the **shear velocity in the layer** must be less than the **shear velocity in the half-space** for the possible existence of Love waves.

This gives **the upper and lower bounds for** the speed of Love waves.

Remark 1: If the layer and the half – space are such that $\beta_1 \le \beta$, then existence of Love waves are not possible

Remark 2: In the limiting case when the layer is absent , we have

$$\mu = \mu_1 \text{ and } \rho = \rho_1$$

and therefore

$$\beta = \beta_1$$

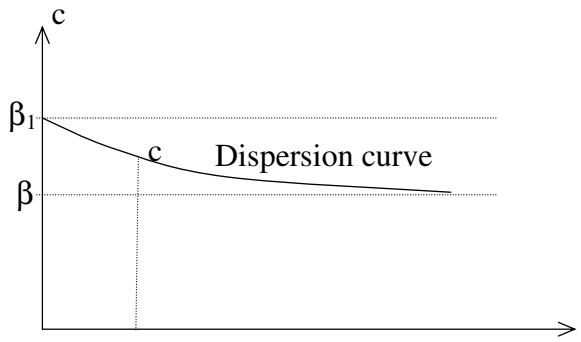
Equation (22) leads to the impossible condition

$$0 = -1 .$$

Hence , in this case , the wave considered can not exist.

Remark 3: When k or $\omega \to 0$, we get $c \to \beta_1$.

The dispersion curve is given in the following figure.



Here , if we assume

$$\mu_1/\mu = 1.8 \text{ , } \beta = 3.6\text{km/sec} \text{ , } \beta_1 = 4.6\text{km/sec}$$

then

$$c_L = \text{speed of Love waves} = 4.0\text{km/sec.}$$

ਪਰਾਵੈਦਾਸ ਪ੍ਰਸ਼ਾਸ਼ਨ ਨੂੰ ਗੜ੍ਹੀ ਵਲ ਸਮੇਤ ਸੀ। ਉਨ੍ਹੇ ਗਾਇਕੀ ਤਾਂ ਸਾਰ ਨੂੰ ਸੀਤ ਲਈ ਭੇਡੀਓ ਟੈਸੀਵਿਜ਼ਨ ਤਾਂ ਸਿਰਾਰਡ ਤੇ ਵੜੀ ਲਾਸਾਰੀ ਨਾਲ ਤੇ ਵਧਾਰ ਹੋਏ ਸਵਦੇ ਹੈ।

ਸੀਤ ਦੇ ਜੁੰਮ ਪਿੱਠ ਸੰਗੀਤ ਸਿੱਖਣ ਪਤਿਸ਼ਾਲੇ ਆਸਾਰ ਤੇ ਸਿਲਾ ਹੈ। ਸੰਗੀਤ ਸਾਸਿਰ ਤੇ 'ਸੰਗੀਤ ਰਸਾ' ਇਸ ਸਿਲੇਲ ਪੰਤਸਰਾਈ ਦੇ ਕਾਸਰ ਲਈ ਪਸ਼ਾ ਦੌਰ ਸਿਖਾਈ ਸੰਗੀਤ ਦੀ ਜਾਦਸਾਰੀ ਸ਼ਾਪਤ ਕਰ ਸਰਦੇ ਹੈ।

ਸੰਗੀਤ ਦਰਸ਼ਾਕ ਵਿੱਚ ਲਾਸਾਸ਼ਦਾਰੀ ਦਾ ਯੋਗਦਾਨ :- ਭੇਡੀਓ ਦੇ ਵਿਕਾਸ ਸਾਰਗ ਖੁੱਲ੍ਹ ਗਿਆ ਹੈ। ਸਾਰਤਰੀ ਸੰਗੀਤ ਲੋਕ ਸੰਗੀਤ ਨੂੰ ਜਨ-ਸਧਾਰਨ ਵਿੱਚ ਤਸਸਰ ਪਿਆਰ ਵਧਾਉਣ ਵਿਚ ਇਸੀ ਭੇਡੀਓ ਨੇ ਸਹੱਤਵਪੂਰਨ ਜਿੰਮੇਵਾਰੀ ਨਿਭਾਈ ਹੈ।

ਸੁਤੰਤਰਤਾ ਦੇ ਬਾਅਦ-ਸੰਗੀਤਕ ਵਸਾਰਣ ਲਾਸਾਸ਼ਦਾਰੀ ਦਾ ਸੁੱਖ ਸਾਰਮਭ ਵਧ ਗਿਆ। ਸੀਤ ਨਿਮਾਣਾ ਸਮੇਂ ਭੇਡੀਓ ਤੇ ਸੰਗੀਤ ਦੇ ਵੱਖ-ਵ ਰਾਜਸ-ਚੂਸ ਪੇਸ਼ ਕੀਤੇ ਜਾਂਦੇ ਹਨ। ਸੀਤ ਰਥੀ ਚੈਸਰ, ਸਪਤਾਹਰ, ਸਾਸਿਰ ਅਤੇ ਦਰੰਸਰ ਸੰਗੀਤਿਕ ਪ੍ਰੋਗਰਾਮ ਸਾਰਸਾਵਾਰੀ ਦੁਸਾਰ ਪ੍ਰਸਾਰਿਤ ਕੀਤੇ ਜਾਂਦੇ ਹਨ। ਜਿਨ੍ਹਾਂ ਦੁਸਾਰ ਸਰਾਰ ਰਸਾਰਾਰ ਦੀ ਰਸਾ ਸੀਤ ਸਾਸਾਰੀਰਾਸ ਸਰ-ਸਧਾਰਨ ਨੂੰ ਉਪਸਧਾ ਹੈ।

1. ਸਾਸ਼ਤਰੀ ਸੰਗੀਤ ਦਾ ਦਰਜਾ :- ਸੰਗੀਤ ਦਾ ਦਰਜਾ ਅਤੇ ਦੁਸਾਰ ਰਾਸਰ ਦੀ ਦਿਸ਼ਾ ਵਿੱਚ ਭੇਡੀਓ ਦਾ ਸੀਤ ਵੀ ਵਿਲੇਸ਼ ਸਰੰਤਪੂਰੰ ਹੈ। ਭੇਡੀਓ ਦੁਸਾਰ ਸੀਤ ਸ਼ਾਸਿੰਧੀ ਰਾਪਤ ਰਸਾਰਾਰ ਦੇ ਗਾਇਨ ਤੇ ਵਾਦਨ ਅਤੇ ਸੁਗਾਰ ਸੰਗੀਤ ਦੇ ਵਿਕਾਸ ਪੇਸ਼ ਕੀਤੇ ਜਾਂਦੇ ਹਨ। ਇਸ ਤਾਸ਼ ਸਤਤਾ ਦੇ ਦਿੰਨ ਵੀ ਸੰਗੀਤ ਪ੍ਰਤੀ ਭਰੀ ਪੰਦ ਵੀਵੀ ਤੋਂ ਅਤੇ ਦੂਸਰੇ ਰਸਾਰਾਰਾਂ ਸਮੇ ਤੇ ਸਥਿਤੀ ਅਨੁਰੂਸ ਆਪਣੇ ਸੰਗੀਤ ਨੂੰ ਢਾਸਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦੇ ਰਹੀਏ ਸਨ।

2. ਸਾਗੀਲੀ ਸੌਂਦਰੀਆਂ ਦਾ ਦੁਸਾਰਣ :- ਭੇਡੀਓ ਦੁਸਾਰ ਸੰਗੀਤ ਦੀਆਂ ~~ਸਾਗੀਲੀ ਸੌਂਦਰੀਆਂ~~ ਜਿਵੇਂ- ਸ਼ੁਰਸ਼ ਸੰਗੀਤ, ਸ਼ਾਸਤਰੀ ਸੰਗੀਤ, ਪੌਪ ਸੰਗੀਤ, ਤਸਤੀ ਸੰਗੀਤ ਤੇ ਫਿਲਮੀ ਸੰਗੀਤ ਆਦਿ ਦਾ ਪ੍ਰਸਾਰਣ

ਸਾਪੇਖਿਕ ਯੁੱਗ ਵਿੱਚ ਸੰਗੀਤ ਦਾ ਰੂਪ :-

ਸਾਪੇਖਿਕ ਯੁੱਗ ਵਿੱਚ ਸੰਗੀਤ ਦੇ ਦੋ-ਦੋ ਰੂਪ ਇਸ ਪ੍ਰਕਾਰ ਹਨ ਕਿ ਸਾਮਤਰੀ ਸੰਗੀਤ ਅਤੇ ਸਾਮਤਰੀ ਸੰਗੀਤ, ਇਲੈਸਟਰੀ ਸੰਗੀਤ, ਕੋਰਲ ਸੰਗੀਤ ਆਦਿ। ਸਾਮਤਰੀ ਸੰਗੀਤ ਅਤੇ ਇਹਨਾਂ ਰੂਪਾਂ ਨਾਲ ਸਤ ਤੋਂ ਉੱਤਮ ਤੱਕ ਪ੍ਰਕਾਰ ਤੇ ਕੋਰ ਵਿਸਤਾਰ ਵਿੱਚ ਪੜ੍ਹੋ।

1. ਸਾਮਤਰੀ ਸੰਗੀਤ :-

ਸਾਮਤਰੀ ਸੰਗੀਤ ਦੇ ਤਿੰਨ ਮੁੱਖ ਅੰਗ ਹਨ ਦਾਰਜ, ਗਾਇਨ ਤੇ ਨ੍ਰਿਤ। ਸਮੀਖੀ ਯੁੱਗ ਦੀ ਆਰੰਭਾਵ ਵੇਲੇ ਸਤ ਜੀਵਨ ਨੂੰ ਉਹਨਾਂ ਕਰਨ ਲਈ ਰੀਤੀ ਤੇ ਧਰਮ ਇਸ ਕਾਰਜ ਲਈ ਕੇਵਲ ਸਮੇਂ ਦੀ ਘਾਟ ਤੇ ਸਾਰੀ ਤੇ। ਤੁਣ ਉਹ ਚੀਟਿਆ ਹੋ ਸਾਮਤਰੀ ਸੰਗੀਤ ਦਾ ਆਰੰਭ ਨਹੀ ਸਾਰ ਸਕਦਾ। ਇਸ ਇਤਹਾਸ ਸਹਿਗਾਇਕਾਂ, ਸੰਗੀਤਕ ਤੇ ਔਰਕਸ ਨੂੰ ਆਰੰਭ ਨਹੀ ਕਰ ਸਕਦਾ। ਆਧੁਨਿਕ ਸਾਮਤਰੀ ਗਾਇਨ ਤੇ ਦਾਰਜ ਲਗ ਭੇਦ ਦੀਆਂ ਸੰਪੂਰਨ ਸਹਿਗਾਇਕਾਂ ਤੋਂ ਹਾਰਿਆ ਨਹੀ। ਸਾਮਤਰੀ ਸੰਗੀਤ ਸਭੀ ਤਮੇਸ਼ਾ ਧਰੋਵੇ ਲਈ ਹੀ ਸੇਵਾ ਰੱਖੀ ਜਾਂਦੀ ਤੇ। ਇਸ ਵਿੱਚ ਕਿ ਹੀ ਵਧੇਰੇ ਲੋੜ ਪੈਂਦੀ ਤੇ ਧਰਮ ਆਸ਼ੇ ਸਤੁੱਖ ਦੇਵ ਸਕੀ ਹੀ ਤੇ। ਕਲਾ ਸਤਤ ਵਿੱਚ ਸਾਮਤਰੀ ਸੰਗੀਤ ਧਾਰੇ ਨਿਆਸਰ ਲੱਗੀਆ।

ਸੰਗੀਤ ਸੰਮੇਲਨਾਂ ਦੇ ਪ੍ਰਭਾਵ ਵਿੱਚ ਪੀਜਾਧ.

ਗਲੋਬਲਨ ਸੰਗੀਤ ਸੰਮੇਲਨਾਂ ਨੂੰ ਇੱਕ ਖਾਸ ਪ੍ਰਕਾਸ਼ ਜਾਲਿਸ ਦੇ ਤਰ ਸਾਰ ਅਤੇ ਉੱਤੇ ਦੇਸ਼ਾਂ ਦੇ ਉਸਤਾਦ ਸੰਗੀਤਕਾਰਾਂ ਨੂੰ ਇਹ ਵਰਦੇ ਸਰੋਤਿਆਂ ਦੇ ਸਤਮੁੱਖ ਉਹਨਾਂ ਦੀ ਕਲਾ ਦਾ ਪ੍ਰਦਰਸ਼ਨ ਕਰਨ ਲਾਂਦਾ ਤੇ। ਇਸ ਨਾਲ ਜਿੱਥੇ ਕੋਰ ਉਸਤਾਦ ਕਲਾਕਾਰਾਂ ਦੀ ਕਲਾ ਦ ਆਦਿਕ ਆਦਰ ਹੁੰਦਾ ਤੇ ਉੱਥੇ ਸੰਗੀਤ ਸਭੀ ਉਹਨਾਂ ਦੀ ਸਗਤ ਵੇਖਦੀ

ਸੰਗੀਤ ਦੇ ਵਿਕਾਸ ਦੇ ਸਾਧਨ :-

ਸਾਰੇ ਯੁੱਗ ਵਾਂਗੀ ਵਾਂਗ ਹੀ ਯੁੱਗ ਨਹੀ ਦ ਯੁੱਗ ਤੇ। ਚੀਜ਼ਾਂ ਦੇ ਵਿਕਾਸ ਦੇ ਨਾਲ-ਨਾਲ ਸੰਗੀਤ ਵਿੱਚ ਵੀ ਦਾ ਵਿਕਾਸ ਹੋਇਆ ਤੇ। ਅੱਜ ਸੰਗੀਤ ਦੇ ਬੇਤਰ ਵਿਕਾਸ ਤੇ ਕਿਸਮਾ, ਸੰਗੀਤ ਸਹਿਯੋਗ, ਸੰਗੀਤ ਸੰਮੇਲਨ, ਸਾਰਸਾਹੀ, ਟੂਰਨਾਮੈਂਟ, ਰਿਕਾਰਡ ਤੇ ਟੇਪ ਰਿਕਾਰਡ ਦੇ ਕਾਰਨ ਘਰ-ਘਰ ਸੰਗੀਤ ਪੇਸ਼ ਕਿਆ ਅੱਜ ਸੰਗੀਤ ਤੇ ਲੱਖਾਂ-ਕਰੋੜਾਂ ਰੁਪਏ ਜਾਂ ਚੁੱਕੀਆਂ ਹਨ ਜਿੱਥੇ ਸਹਿਗਾਇਕੀ ਦੇ ਨਾਲ ਨ੍ਰਿਤ ਵੀ ਅੱਜ ਤੋਂ ਪਹਾ ਕਾਫ਼ੀ ਵਿੱਚ

ਚਾਹਿਆ ਹੈ। ਲਾਪ ਰਚਨਾ ਵਿਚ ਕੰਵਰ ਦੇ ਸਮਾਜ ਦੇ ਸਰਮੁੱਖ ਰੱਖਦਾ ਹੈ। ਸੰਗੀਤ ਸਮੁਸਤੀ ਪਰਿਸ਼ਾ ਗਾਜ਼ ਦਰਬਾਰੀ ਵਿਚ ਮਿਲੀ ਪਰਾਂਹਣ ਜੁੜੇ ਵਿਚ. ਦੀ ਸੰਗੀਤ ਦਾ ਘਟਤ ਵਿਕਾਸ ਹੋਇਆ ਵਿਚਿਤ ਗਜ਼ ਦੀ ਭਾਰਤ ਉੱਪਰ ਘਟਤ ਸਮਾਂ ਜਿਹਾ 15 ਅਗਸਤ 1947 ਨੂੰ ਭਾਰਤ ਸਾਜ਼ਾਦ ਹੋਇਆ ਸਜ਼ਾਦੀ ਪ੍ਰਾਪਤੀ ਤੇ ਪਹਿਲਾ ਸੰਗੀਤਕਾਰ ਨੂੰ ਦਰਬਾਰੀ ਸਮੁਸਤੀ ਮਿਲੀ ਤੇ ਇਸੀ ਸੀ। ਉਨਾਂ ਦਾ ਇਹ ਸਮਾਜ ਜਿਹਾ ਸਜ਼ਾਦੀ ਉਪਰੰਤ ਭਾਰਤੀ ਸੰਗੀਤ ਦੇ ਰਸਾਰ ਅਤੇ ਵਿਕਾਸ ਵਿਚ ਵੀ ਵਾਧਾ ਹੋਇਆ ਅਤੇ ਇਸਦਾ ਵਿਕਾਸ ਕਿਵੇਂ ਹੋਇਆ। ਇਸਦੀ ਜਾਣਕਾਰੀ ਹੇਠ ਲਿਖਿਆ ਲੇਖ ਪੜ੍ਹਾਂਗੇ ਤਾਂ ਕਿ ਜਾਣ ਸਕੀਏ ਕਿ ਭਾਰਤੀ ਸੰਗੀਤ ਦਾ ਵਿਕਾਸ ਕਿੰਨਾ ਹੋਇਆ ਅਤੇ ਕਿਵੇਂ ਹੋਇਆ।

ਸਜ਼ਾਦੀ ਉਪਰੰਤ ਸੰਗੀਤ :

ਸਜ਼ਾਦੀ ਪ੍ਰਾਪਤੀ ਤੋਂ ਫਲਸਰ ਸੀਵਨ ਦੇ ਹਰ ਖੇਤਰ ਵਿਚ ਰਾਜੀਸ਼ਾਹੀ ਪਰਿਵਰਤਨ ਹੋਏ। ਛੋਟੇ-ਛੋਟੇ ਰਾਜਾਂ ਤੋਂ ਫਲਸਰ ਵੀ ਸੁੰਤਭਤਾ ਸਮਾਗਜ਼ ਦੀ ਸਮਾਪਤੀ ਹੋਈ, ਸੁੰਤਭਤਾ ਭਾਰਤ ਵਿਚ ਫੁੱਲੀ ਅਤੇ ਦੇਸ਼ ਦੀ ਸਾਂਝ ਦੇਸ਼ ਸਾਰੀਆਂ ਖੇਤਰਾਂ ਨੂੰ ਤਰੱਕੀ ਉਤਸਾਹ ਮਿਲਿਆ ਅਤੇ ਇਸਦੇ ਰਸਾਰ ਅਤੇ ਰਸਾਰ ਦਾ ਵੀਸ ਉਸੀ ਤਰਾਂ ਲੱਗੇ ਹੋਇਆ। ਸਜ਼ਾਦੀ ਤੋਂ ਫਲਸਰ ਹੀ ਭਾਰਤ ਵਿੱਚ ਦੂਰਦਰਸ਼ਨ, ਜਿਲੇਕਾ ਸੰਗੀਤ ਸੰਮੇਲਨਾਂ ਨੇ ਸਿਖ ਦੇ ਸੰਗੀਤ ਨੂੰ ਪੂਰਾ ਸੀਵਨ ਦੀਤਾ। ਤਰ ਸੰਗੀਤ ਦੇਵਨ ਤੋਂ ਇਸਤਰੀਆਂ ਤੋਂ ਹੀ ਸੀਮਿਤ ਨਹੀਂ ਰਹੇ ਇਸਦਾ ਦਾਇਰਾ ਵਿਸ਼ੇਸ਼ ਵਰਗ ਤੱਕ ਸਿਮਤ ਹੈ। ਆਮ ਜਨਤਾ ਵਿੱਚ ਸੰਗੀਤ ਦਾ ਘਟਤ ਪ੍ਰਚਾਰ ਹੋ ਗਈ ਸੀ। ਦੇਵਨ ਤੋਂ ਸੰਗੀਤ ਤੋਂ ਜਾਣੂ ਸਨ। ਗੁਰੂ ਸਿਖ ਪਰੰਪਰਾ ਦਾ ਸਮਾਪਤੀ ਹੋ ਰਹਾ ਸੀ। ਦੇਸ਼ ਦੀ ਵੰਡ ਤੋਂ ਉਹ ਦੀ ਵਿਲਖਣੀ ਸੰਗੀਤ ਸਿਖ ਸਰਦਾ ਸੀ ਜਿਸ ਉੱਪਰ ਗੁਰੂ ਦੀ ਕਿਰਪਾ ਤੁਹੀ ਸੀ ਪਰ ਸਾਧਾਰਣ ਜਿਹਾ ਇਸ ਤਰਾਂ ਨਹੀਂ ਹੈ। ਲਗ ਹਰ ਇਕ ਵਿਲਖਣੀ ਸੰਗੀਤ ਸਿਖ ਸਕਦਾ ਹੈ, ਸੰਗੀਤ ਨੂੰ ਸਕੂਲਾਂ, ਕਾਲਜਾਂ ਵਿਚ ਵਿਸ਼ਵਵਿਦਿਆਲਿਆ ਵਿਚ ਥੋੜੇ ਜਿਹੇ ਰੂਪ ਵਿਚ ਸਾਮਿਲ ਕਰਕੇ ਇਕ ਨਿਰਧਾਰਿਤ ਪਾਠਕ੍ਰਮ ਸਾਮਿਲ ਕੀਤਾ ਗਿਆ ਹੈ। ਇਸ ਤਰਾਂ ਸੰਗੀਤ ਦੀ ਸਿਖਿਆ ਵਿਚ ਵੀ ਸੰਗੀਤ ਦਾ ਘਟਤ ਹੀ ਵਿਕਾਸ ਹੋਇਆ ਹੈ।

Sec - A, (Part - 2)

Sandeep Singh

Past Independence Era

Lesson - 11

ਭੂਮਿਕਾ :-

ਭਾਰਤੀ ਸੰਗੀਤ ਨੂੰ ਵਿਸ਼ਵ ਸੰਗੀਤ ਵਿੱਚ ਸਭ ਤੋਂ ਮਹਾਨ ਸੰਗੀਤਾ ਗਿਆ ਹੈ। ਸੰਗੀਤ ਪ੍ਰਾਚੀਨ ਕਾਲ ਤੋਂ ਹੀ ਚੱਲਿਆ ਆ ਰਿਹਾ ਹੈ, ਜਿਵੇਂ-ਜਿਵੇਂ ਸਮੇਂ ਦਾ ਵਿਕਾਸ ਹੁੰਦਾ ਗਿਆ ਤਿਵੇਂ-ਤਿਵੇਂ ਹੀ ਸੰਗੀਤ ਦਾ ਵਿਕਾਸ ਹੁੰਦਾ ਗਿਆ। ਸੰਗੀਤ ਇੱਕ ਅਜਿਹੀ ਚੀਜ਼ ਹੈ। ਜੋ ਮਨੁੱਖ ਦੇ ਦਿਲ ਦੀਆਂ ਡੂੰਘਾਈਆਂ ਨੂੰ ਛੂੰਹਦੀ ਹੈ। ਮਨੁੱਖੀ ਮਨ ਨੂੰ ਸਾਰਥਿਤ ਕਰਦੀ ਹੈ। ਇਸ ਲੇਖ ਵਿੱਚ ਅਸੀਂ ਸੰਗੀਤ ਦੇ ਵੱਖ-ਵੱਖ ਪਰਿਪੇਖਾਂ ਦਾ ਜਾਣਕਾਰੀ ਪ੍ਰਾਪਤ ਕਰਦੇ ਹਾਂ ਜਿਵੇਂ ਪ੍ਰਾਚੀਨ ਕਾਲ ਦਾ ਸੰਗੀਤ, ਮੱਧਕਾਲੀ ਉਪਰੰਤ ਸੰਗੀਤ ਅਤੇ ਆਧੁਨਿਕ ਯੁੱਗ ਵਿੱਚ ਸੰਗੀਤ ਰੂਪ ਧਾਰੇ ਉਸਦਾ ਵਰਣਨ ਕਰਾਂਗੇ।

ਆਜ਼ਾਦੀ ਤੋਂ ਪਹਿਲਾਂ ਦਾ ਸੰਗੀਤ :-

ਸੰਗੀਤ ਪ੍ਰਾਚੀਨ ਕਾਲ ਤੋਂ ਚੱਲਿਆ ਆ ਰਿਹਾ ਹੈ। ਸਿੰਧੂ ਘਾਟੀ ਦੀ ਸੱਭਿਅਤਾ ਦੀਆਂ ਖੁਦਾਈਆਂ ਤੋਂ ਮਿਲੇ ਪ੍ਰਮਾਣਾਂ ਤੋਂ ਸਾਨੂੰ ਇਹ ਪਤਾ ਚੱਲਦਾ ਹੈ ਕਿ ਉਸ ਸਮੇ ਵੀ ਸੰਗੀਤ ਪ੍ਰਚਾਰ ਵਿੱਚ ਸੀ। ਵੈਦਿਕ ਕਾਲ ਵਿੱਚ ਸਾਮ ਮੁਖ ਛੰਦ ਵਿੱਚ ਆਏ ਸਨ। ਮੁਸਲਿਮ ਕਾਲ ਤੇ ਸੰਗੀਤ ਦੇ ਕਾਲ ਦਾ ਸੁਨਿਹਰੀ ਯੁੱਗ ਸੀ। ਭਾਰਤ ਉੱਪਰ ਬਹੁਤ ਸਾਰੇ ਹਮਲਾਵਰਾਂ ਨੇ ਹਮਲੇ ਕੀਤੇ। ਵਹੀ ਹਮਲਾਵਰ ਸਾਥ ਕੁਝ ਵਧਿਆ ਚੰਗੇ ਸਾਰੇ ਅਤੇ ਕੁਝ ਲੈਕੇ ਵਿੱਚੇ ਹੀ ਵਾਪਸ ਚਲੇ ਗਏ। ਜਿਨੇ ਵੀ ਹਮਲਾਵਰ ਭਾਰਤ ਵਿੱਚ ਆਏ ਉਹਨਾਂ ਨੇ ਆਪਣੀ ਕੋਈ ਨਾ ਕੋਈ ਛਾਪ ਛੱਡੀ। ਮੁਗਲ ਕਾਲ ਵਿੱਚ ਘਰਾਣੇ ਅਤੇ ਸੰਗੀਤ ਪੈਦਾ ਹੋਏ। ਅਤੇ ਘਰਾਣੇ ਅਤੇ ਗੁਰੂਆਂ ਦੀ ਰਚਨਾ ਕੀਤੀ ਗਈ ਜਿਨ੍ਹਾਂ ਤੋਂ ਸਾਨੂੰ ਘਰਾਣੇ ਅਤੇ ਸਮੱਗਰੀ ਪ੍ਰਾਪਤ ਹੁੰਦੀ ਹੈ। ਸੰਗੀਤ ਦੇ ਸੰਬੰਧੀ ਇਹ ਗੱਲ ਤਾਂ ਸੱਚ ਹੈ ਕਿ ਪ੍ਰਚੀਨ ਕਾਲ ਤੋਂ ਲੈ ਕੇ ਆਧੁਨਿਕ ਕਾਲ ਤੱਕ ਦੀ ਇਕ ਲੰਬੀ ਯਾਤਰਾ ਕਾਲ ਵਿੱਚ ਭਾਰਤੀ ਸੰਗੀਤ ਕਲਾ ਨੇ ਘਰਾਣੇ ਅਤੇ ਸੰਗੀਤਕਾਰ ਪੈਦਾ ਕੀ ਅਤੇ ਘਰਾਣੇ ਅਤੇ ਉਸਤਾਦ ਪੈਦਾ ਕੀਤੇ। ਇਤਿਹਾਸ ਇਸ ਗੱਲ ਦੀ ਗਵਾਹੀ ਭਰਦਾ ਹੈ ਕਿ ਦਰਬਾਰਾਂ ਨੇ ਸੰਗੀਤ ਵਿੱਚ ਜੋ ਕੁਝ

Date: / /

ਵਿਸ਼ੇਸ਼ ਪਤਝ ਕਰਦਾ ਹੈ, ਇਸੇ ਤਰ੍ਹਾਂ ਦੇ ਵੱਖ-ਵੱਖ ਅਗਵਾਈਆਂ ਦੇ ਸਾਂਝੇਯਤ ਨਾਲ ਨੀ ਵਿਭਿੰਨ ਸ਼ੈਲੀਆਂ ਵਿਕਸ ਹੀਆਂ ਮੰਜ਼ਿਲਾਂ ਉੱਚ ਕਰਦੀਆਂ ਹਨ। ਅਤੇਕ ਸ਼ੈਲੀਆਂ ਇਹਨਾਂ ਅਗਵਾਈਆਂ ਦੁਆਰਾ ਆਪਣਾ ਵਿਕਾਸਸ਼ੀਲ ਸਫ਼ਰ ਤੈਅ ਕਰਦੀਆਂ ਆ ਰਹੀਆਂ ਹਨ, ਹਰ ਅਗਵਾਈ ਦੇ ਸੰਗੀਤਕਾਰ ਆਪਣੇ ਅਗਵਾਈ ਵੀਆਂ ਮੌਲਿਕ ਧਾਰਨਾਂ ਦੀ ਕਲਪਨਾ ਤੇ ਵਿਲੱਖਣ ਯੋਗਦਾਨੀ ਕਰਦੇ ਹਨ। ਅਗਵਾਈਆਂ ਦਾ ਮੁੱਖ ਉਦੇਸ਼ ਵੀ ਇਹੀ ਹੈ।

ਅਗਵਾਈ ਪਰੰਪਰਾ ਦੇ ਨਾਂ-ਪੱਖੀ ਪ੍ਰਭਾਵ :→

1. ਅਗਵਾਈ ਪਰੰਪਰਾ ਨੇ ਉੱਚ-ਪੱਧਰੀ ਸੰਗੀਤ ਕਲਾਕਾਰ ਸਥਾਪਿਤ ਕੀਤੇ।
2. ਹਰ ਅਗਵਾਈ ਪਰੰਪਰਾ ਵਿਚ ਹਰ ਅਗਵਾਈ ਨੇ ਇਕ ਵਿਸ਼ੇਸ਼ ਸ਼ੈਲੀ ਵਿਚ ਚੀਜ਼ਾਂ ਤਿਆਰ ਕੀਤੀ।
3. ਅਗਵਾਈਆ ਨੇ ਗੁਰੂ-ਸ਼ਿਸ਼ ਪਰੰਪਰਾ ਨੂੰ ਕਾਇਮ ਰੱਖਿਆ।
4. ਅਗਵਾਈ ਪਰੰਪਰਾ ਨੇ ਸੰਗੀਤ ਦੇ ਸਿਧਾਂਤਕ ਸਰੂਪ ਨੂੰ ਅੱਗੇ ਵਧਾਇਆ।
5. ਅਗਵਾਈ ਪਰੰਪਰਾ ਸਦਕਾ ਪਰੰਪਰਾਗਤ ਸੰਗੀਤ ਲਿਖਣ ਰੂਪ ਵਿਚ ਸਾਂਭਿਆ ਜਾ ਸਕਿਆ।

ਅਗਵਾਈ ਪਰੰਪਰਾ ਦੇ ਨਾਂ-ਪੱਖੀ ਪ੍ਰਭਾਵ :→ 1. ਅਗਵਾਈ ਪਰੰਪਰਾ ਸੰਗੀਤ ਨੂੰ ਤਾਲ ਅਤੇ ਸਿੱਖਿਆ ਨਾਲ ਸੰਬੰਧ ਜੋੜਨ ਤੋਂ ਅਸਫਲ।
ਵੱਵਲ ਤਰਜ਼-ਹਰ-ਤਰਜ਼ ਸੰਗੀਤ ਸਿੱਖਿਆ 'ਚ ਖਤਮ ਹੋ ਗਈ ਸੀ।
2. ਅਗਵਾਈ ਦਾਰੀ ਪਰੰਪਰਾ ਕਾਰਨ ਘਰ-ਘਰਤੀ ਅਗਵਾਈ ਦਾ ਕਲਾਕਾਰ ਸੰਗੀਤ
3. ਦੇ ਸਿਧਾਂਤਿਕ ਪੱਖ ਨੂੰ ਸਮਝਣ ਚ ਅਸਮਰਥ ਹੋਏ ਹਨ।
4. ਉਸਤਾਦਾਂ ਦੇ ਕਰਿ ਸ਼ਾਗਿਰਦਾਂ ਨੇ ਸੰਗੀਤ ਦੇ ਨਾਲ ਉਹਨਾਂ ਦੇ ਅਟੁੱਟ ਰਿਸ਼ਤੇ ਨੂੰ ਵੀ ਧਾਰਣ ਕਰ ਲਿਆ ਜਿਵੇਂ :→ ਸ਼ਰਾਬ, ਭੰਗ, ਤੰਬਾਕੂ, ਅਫੀਮ ਜੁੱਤਾ ਆਦਿ।
5. ਅਨੇਕਾਂ ਹਾਨੀ ਚੀਜ਼ਾਂ ਚ ਸੁੱਧ ਉਚਾਰਨ ਤੇ ਗਲਾਂ ਦੀ ਸੁੱਧਤਾ ਦੀ ਕਾਇਮ ਰਹੀ ਸੀ ਵਿਰੋਧ ਸਾਰੀ ਸਿੱਖਿਆ ਸੁੰਨ-ਸਥਾਨੀ ਸੀ।
6. ਸੀਮਿਤ ਤੇ ਸੰਕੀਰਨ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਦੇ ਕਾਰਨ ਆਪਸ ਚ ਈਰਖਾ ਤੇ ਦੋਸ਼ ਦੀ ਭਾਵਨਾ ਵਧੀ।
7. ਆਪਣੇ ਅਗਵਾਈ ਦੀਆਂ ਸਿਫਤਾਂ ਅਤੇ ਦੂਜੇ ਅਗਵਾਈ ਦੀ ਨਿੰਦਾ ਹੋਈ

मैगीउ चीड़ी-रग-चीड़ी उहरा गैउरा ऽ। मैगीउ चभ्रंख मैगीउ-वाग री गाहिमी है उम रे चीयां-चुंउग अउे ग्मउेउरग है-च-ह आपटे चल्लग्ग चामें अयठ हैरे ग्ठ हिरी चगहे-रागी चर्मेपग ऽ। चगहे रा अग्व वृंक्ष गुलां है चीड़ी-रग-चीड़ी अॅगे उेग्ठ, 'गृह-मिश्र' चर्मेपग ऽ। भॅयवाड़ीठ मभ्मिर चग्मिखिउीयां रे ठभ्मग्य चगहिभां रा नलभ अउे दिवाभ गैहिया। उाभेठ उें चगिछां मैगीउ चेउग हिछ वेटीय-गट्टा चूलुहिउ ठगीं मी। चगहिभां री उिउपउी भ्रभछ भाभ-ग्भ भभें गैरी।

चगहिभां रा ठभवग्ग अउे वाग्भ हिची :- आभी मैगीउ हिछ चगहिभां रे ठां मैचीखिउ गृह भां उिग्भं रे मीग्ग-चैउ भां गभ्रग्धाग रे ठां उुॅचग ग्री भायागिउ ग्ठ विभे ची गृह रे मैगीउ हिछ वृंक्ष भीठागैभां हिभ्भेभउेट गुैरीभां ग्ठ भे रूभगे भरिग ठगीं गुैरीभां वछ रे दखें-दखगे भ्रग्भाउभव उॅं हिखें वृंक्ष खाभ उॅउ हिव गृह री वछ हिखें उिचभिरे ग्ठ अउे वृंक्ष गैग खाभ उॅ रूभे गृह री वछ रा हिभ्भेभ अउे भीभ-भहां भीग वह भांरे ग्ठ। उिग उिभरी वछ है हिछखह मैठी चूरग वग्रे ग्ठ। हिग्ठां हिभ्भेभ उॅं है गुगिह वग्ठ अउे हिभ्भेभ मैठी हिछ लिपैभउ गभिछ वग्ठ ची विभे चगहे रे भिश्र रा भ्रचव उिरेभ गुैरा ऽ। चगहे री भेहिछखहउ अउे हि-भ्भेभउ है वाहिभ वॅखह लटी हिग भ्रची ऽ कि वेटी चीभिश्र उिभरे हिभ्भेभ छॅच्छां रा चाखूची भठ्भवग वगे। भेवग उिग-भिग वग्ठ हिछ भभेठह ऽ उं उिभ चगहे रा चउग भ्रठाहिव ऽ। मैगीउ रे खेउग हिछ भियांउिव अउे विभाउभव रेहां रा हिभ्भेभ भॅउह ऽ। भिचे गृह भिश्र है भियांउिव भिॅचिभा हिरा ऽ, उेंचे ठाल ची भियांउिव गिभाग हिछ ची चूापउ वग्रा ऽ। चगहे रीभां चैरिभां चगहिभां री हिभ्भेभउ है ओ गग वग्रीभां ग्ठ। वची मैगीउवाग उं हिग्ठां चैरिभां है ची गगां री वभेटी मद्दीवग वग्रे ग्ठ। वेटी हिव चगहे विभे हिव मैठी रे हिवाभ ल्ली

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ਸਮੇਂ ਦਰਬਾਰ ਵਿਚ ਉੱਚ-ਦਰਦੀਆਂ ਗਾਇਕ ਵਰਗ ਲਈ ਵਿਚੋਤਰ ਦੀ ਵਰਤ ਲੱਗੀ। ਜਿਸ ਸਦਕਾ ਪ੍ਰਚਲਿਤ ਪਸਤੀ ਰਚੀ ਹੋਰ ਹੋ ਗਈ। ਹਰ ਸੰਗੀਤਕਾਰ ਆਪਣੀ ਸੰਤਾਨ, ਸ਼ਿਸ਼ਤੇਦਾਰ ਅਤੇ ਅਜ਼ੀਜ਼ਾਂ ਨੂੰ ਆਪਣੇ ਦਰਬਾਰ ਵਿਚ ਉੱਚੀਆਂ ਦਰਦੀਆਂ 'ਤੇ ਰੱਖਣ ਦਾ ਯਤਨ ਕਰਦਾ ਸੀ। ਸੰਗੀਤ ਸਿੱਖਿਆ ਦਾ ਵੀ ਸੰਕੀਰਣ ਹੋ ਗਿਆ। ਵੱਖ-ਵੱਖ ਸੰਗੀਤਕਾਰਾਂ ਦੇ ਇਸ ਮੁਕਾਬਲੇ ਪੂਰਨ ਦੇ ਫਲਸਰੂਪ ਤਿੰਨ-ਤਿੰਨ ਦੋ ਸੌ ਪਰੰਪਰਾਵਾਂ ਤੋਂ ਵਿਚ ਆਈਆਂ, ਜਿਸ ਨੂੰ ਘਰਾਣਾ ਕਿਹਾ ਜਾਣ ਲੱਗਾ।

ਘਰਾਣਾ ਕੀ ਹੈ? →

ਭਾਰਤ ਦੀ ਵਿਰਾਸਤੀ ਪਰੰਪਰਾ ਵਿਚ ਗੁਰੂ-ਸ਼ਿਸ਼ ਦਾ ਸਿਖਾਉ ਵਿਸ਼ੇਸ਼ ਮਹੱਤਵ ਦਾ ਹਾਮੀ ਹੈ। ਜਿਸ ਗੁਰੂ ਤੋਂ ਵਿਦਿਆ ਗ੍ਰਹਿਣ ਕਰਨ ਲਈ ਯੋਗ, ਸਰ ਅਤੇ ਯਤ ਗ੍ਰਹਿਣ ਕਰਦੇ ਸਮਾਂ ਕਾਫਲਾ ਨਾਲ ਸੰਬੰਧ ਰਖਦਾ ਹੈ ਅਤੇ ਗੁਰੂ ਆਪਣੇ ਸ਼ਿਸ਼ ਨੂੰ ਯੋਗਤਾ ਅਨੁਸਾਰ ਗਿਆਨ ਪ੍ਰਦਾਨ ਕਰਦਾ ਹੈ। ਸੰਗੀਤ ਵਿਚ ਵੀ ਗੁਰੂ-ਸ਼ਿਸ਼ ਪਰੰਪਰਾ ਦੀ ਮਹੱਤਤਾ ਹੈ। ਹਰ ਕਲਾਕਾਰ ਆਪਣੀ ਕਲਾ ਦਾ ਨਿਰੰਤਰ ਪ੍ਰਚਾਰ ਚਾਹੁੰਦਾ ਹੈ। ਇਸੇ ਲਈ ਉਹ ਆਪਣੇ ਵਰਗ ਜਾਂ ਕਿਸੇ ਹੋਰ ਵਿਅਕਤੀ ਦੀ ਭਾਲ ਕਰਦਾ ਹੈ, ਜੋ ਉਸ ਦੁਆਰਾ ਸਥਾਪਿਤ ਪਰੰਪਰਾ ਨੂੰ ਅੱਗੇ ਤੋਰ ਸਕੇ। ਇਸ ਕਾਰਜ ਲਈ ਗੁਰੂ ਆਪਣੀ ਸੰਤਾਨ ਜਾਂ ਕਿਸੇ ਹੋਰ ਯੋਗ ਵਿਦਿਆਰਥੀ ਸ਼ਿਸ਼ ਨੂੰ ਚੁਣਦਾ ਹੈ। ਸਾਰਿਆਂ ਗੁਰੂ ਦੀ ਤਾਲੀਮ ਵਿਚ ਉਸਦੇ ਸਮਕਾਲੀ ਸੰਗੀਤ ਸਿੱਖਿਆ ਗ੍ਰਹਿਣ ਕਰਦਾ ਹੈ, ਗੁਰੂ-ਸ਼ਿਸ਼ ਦੀ ਇਸ ਪਰੰਪਰਾ ਦਾ ਨਿਰਮਾਣ ਤਿੰਨ ਪੀੜ੍ਹੀਆਂ ਦਾ ਨਿਰੰਤਰ ਸਿਖਲਾਈ ਦੇ ਸਥਾਪਿਤ ਕਰਦਾ ਹੈ।

ਘਰਾਣੇ ਦੀ ਪਰਿਭਾਸ਼ਾ :→

'ਘਰ' ਸ਼ਬਦ ਤੋਂ 'ਘਰਾਣਾ' ਬਣਿਆ ਹੈ। ਜਿਸ ਦੀ ਭਾਰ ਸੰਤਾਨ ਜਾਂ ਦੋ ਤਿੰਨ ਸਥਿਤੀਆਂ ਦੀ ਉਮਾਰੀ ਨੂੰ ਘਰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਇਸੇ ਲਈ ਘਰ-ਘਰਾਣਿਆਂ ਦੀ ਚਰਚਾ ਅਕਸਰ ਸਮਾਜਿਕ ਸਿਖਿਆਂ ਵਿਚ ਮਿਲਦੀ ਹੈ ਪਰ ਵਿਦਿਆ ਘਰਾਣਿਆਂ ਤੋਂ ਹੀ ਸੰਗਰਾਮ, ਪਰਿਵਾਰ ਜਾਂ ਧੰਮਾਵਲੀ ਨਿਸ਼ਚਿਤ ਹੁੰਦੀ ਹੈ। ਜਦੋਂ ਘਰ ਵਿਚ ਵੰਸ਼ ਵੀਰੀ-ਵਿਰਾਸਤ ਜਾਂ ਗੁਰ ਦੀ ਪੀੜ੍ਹੀ ਦਰ ਪੀੜ੍ਹੀ ਨਿਰੰਤਰ ਚਲਦੇ ਰਹਿੰਦੇ ਹਨ, ਉਦੋਂ ਹੀ ਸੰਗੀਤਕਾਰਾਂ ਵਿਚ ਵੀ ਘਰਾਣੇਦਾਰ

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Ques-3. ਪੰਜਾਬੀਆਂ ਦੀ ਉਤਪਤੀ ਅਤੇ ਵਿਕਾਸ ਬਾਰੇ ਚਰਚਾ ਕਰੋ?

Answer- ਪੰਜਾਬੀਆਂ ਦੀ ਉਤਪਤੀ ਅਤੇ ਵਿਕਾਸ :→

ਸਭਿਆਚਾਰ ਜਾਂ ਸੰਸਕ੍ਰਿਤੀ ਦਾ ਦਾਇਰਾ ਉਸਦਾ ਵਿਸ਼ਾ ਮੰਨਿਆ ਜਾਂਦਾ ਹੈ। ਹਰੇਕ ਸਭਿਆਤਾ ਜਾਂ ਸੰਸਕ੍ਰਿਤੀ ਵਿਚ ਲੋਕਾਂ ਆਪਣੀ ਪ੍ਰਗਤੀਸ਼ੀਲਤਾ ਅਤੇ ਕਲਾਤਮਕਤਾ ਵਰਗੇ ਗੁਣਾਂ ਨੂੰ ਇਸ ਕਲਾਵਾਂ ਦੇ ਵਿਕਾਸ ਰਾਹੀਂ ਹੀ ਪ੍ਰਗਟ ਕੀਤਾ ਹੈ ਜੋ ਕਿ ਮਨੁੱਖ ਨੂੰ ਹੋਰ ਜੀਵਾਂ ਨਾਲੋਂ ਵਿਲੱਖਣ ਬਣਾਉਂਦੇ ਹਨ। ਇਹਨਾਂ ਕਲਾਵਾਂ ਵਿਚ ਸੰਗੀਤ ਕਲਾ ਇਕ ਅਤਿਅੰਤ ਸਰਲ ਕਲਾ ਹੈ। ਭਾਰਤੀ ਸੰਗੀਤ ਅਨੇਕ ਸ਼ਾਸਤਰੀਕ, ਧਾਰਮਿਕ ਅਤੇ ਸਮਾਜਿਕ ਪ੍ਰਭਾਵਾਂ ਸਦਕਾ ਪ੍ਰਭਾਵਿਤ ਹੁੰਦਾ ਰਿਹਾ ਹੈ। ਆਦਿ ਕਾਲ ਤੋਂ ਹੀ ਇਸ ਦੇ ਕਈ ਰੂਪ ਅਤੇ ਸ਼ੈਲੀਆਂ ਪ੍ਰਚਲਨ ਵਿਚ ਰਹੀਆਂ ਹਨ ਅਤੇ ਅੱਜ ਵੀ ਕਈ-ਕ ਸ਼ੈਲੀਆਂ ਹਨ ਭਾਰਤੀ ਸੰਗੀਤ ਦੀ ਪਧਤੀਆਂ ਵਿਚ ਵਿਦਮਾਨ ਹੈ।

1. ਹਿੰਦੁਸਤਾਨੀ ਸੰਗੀਤ ਪਧਤੀ

2. ਕਰਨਾਟਕੀ ਸੰਗੀਤ ਪਧਤੀ

ਸਮਾਂ ਪਾ ਕੇ ਇਹ ਦੋਵੇਂ ਸੰਗੀਤ ਪਧਤੀਆਂ ਵਿਚਕਾਰ ਕੇ ਆਪਸੀ ਮੇਲ-ਜੋਲ ਹੋਏ। ਇਕ ਨੂੰ ਹਿੰਦੁਸਤਾਨੀ ਸੰਗੀਤ ਪਧਤੀ ਅਤੇ ਦੂਜੀ ਨੂੰ ਕਰਨਾਟਕੀ ਸੰਗੀਤ ਪਧਤੀ ਦਾ ਨਾਂ ਦਿੱਤਾ ਗਿਆ। ਹਿੰਦੁਸਤਾਨੀ ਸੰਗੀਤ ਪਧਤੀ ਫ਼ਾਰਸੀ ਅਤੇ ਇਸਲਾਮੀ ਸੰਸਕ੍ਰਿਤੀ ਦੇ ਪ੍ਰਭਾਵ ਸਦਕਾ ਹੋਂਦ ਵਿਚ ਆਈ। ਵੱਖ-ਵ ਰਾਜਿਆਂ-ਮਹਾਰਾਜਿਆਂ ਨੇ ਭਾਰਤੀ ਸੰਗੀਤ ਦੇ ਪ੍ਰਚਾਰ ਅਤੇ ਪਸਾਰ ਲਈ ਵਿਸ਼ੇਸ਼ ਯਤਨ ਕੀਤੇ। ਉਨ੍ਹਾਂ ਨੇ ਆਪਣੇ ਦਰਬਾਰਾਂ ਵਿਚ ਸੰਗੀਤਕਾਰਾਂ ਨੂੰ ਉੱਚ-ਪਦਵੀਆਂ ਦੇ ਕੇ, ਸਮੇਂ-ਸਮੇਂ 'ਤੇ ਸੰਗੀਤ ਸਭਿਆਂ ਦਾ ਆਯੋਜਨ ਕਰਕੇ ਅਤੇ ਸੰਗੀਤਕਾਰਾਂ ਨੂੰ ਉਤਸ਼ਾਹਿਤ ਕਰਕੇ ਵਿਦਵਾਨ ਗੁਣੀਜਨਾਂ-ਸ਼ਾਸਤਰਜਿਆਂ ਨੇ ਸੰਗੀਤ ਗਰੰਥਾਂ ਨੂੰ ਤਿਆਰ ਕੀਤਾ। ਸੰਗੀਤਕਾਰਾਂ ਦੇ ਇਸ ਦਰਬਾਰ ਦੇ ਸਿੱਧੇ ਸੰਪਰਕ ਹੋਣ ਕਰਕੇ ਉਨ੍ਹਾਂ ਦੀ ਰੋਜ਼ੀ-ਰੋਟੀ ਦਾ ਸਮੱਸਿਆ ਹਮੇਸ਼ਾ ਲਈ ਖ਼ਤਮ ਹੋ ਗਈ ਅਤੇ ਉਹਨਾਂ ਸਾਹਮਣੇ ਕਿਸੇ ਵੱਡੇ ਦਰਬਾਰ ਵਿਚ ਸਥਾਨ-ਸਥਾਪਿਤ ਹੋਣ ਦਾ ਉਦੇਸ਼ ਹੀ ਹੋਣ ਲੱਗਾ। ਕਈ ਵਾਰ ਵੱਡੇ ਸੰਗੀਤਕਾਰ ਆਪਣੀ ਵੱਖ ਦੇ ਵਿਦਿਆਰਥੀਆਂ ਨੂੰ, ਖਾਸ ਕਰਕੇ ਆਪਣੀ ਔਲਾਦ ਨੂੰ ਸਿਰਫ਼ ਹੀ ਸੰਗੀਤ ਦੀ ਸਿੱਖਿਆ ਪ੍ਰਦਾਨ ਕਰਨੇ ਲੱਗੇ ਇਸ

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ਰਾਗ- ਸੁਯ ਸਾਰੰਗ ਦਿਖ

ਚਖ਼ਾ ਵਿਖਾਲੁ

ਮੁਖਬੀ :→ ਮੰਗਲ ਗਾਉ ਅਯਨੇ ਸਜਨ ਕੇ ਅੰਗਨ।

ਅੰਤਰ :→ ਸਾਜ ਸਜਾਉ ਅਯਨੇ ਸਜਨ ਕੇ,
'ਸਹਾਰੰਗ' ਸਨ ਸੁੱਖ ਪਾਉ।

12. ਰੀਸ ਰੇਸ, ਰੇ ਸੁੰਯ ਸੁਰੇ ਰੀਸ
ਸੈ ऽ ऽ ऽ, ऽ ग ऽ ऽ ऽ ऽ ऽ

ਸਰੇ ਰੀਸ
1. ਰੀ -- ਸਯ 2. ਸ --- 3. ਰੀ - ਸ (ਸ)
ग ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ

4. ਰੇ ਸ ਰੇ - 5. ਰੀ ਸ ਰੇਸ, ਰੇ, ਰੇ ਸੁੰਯ ਯ ਸੁੰਯ, ਸੁੰ
ऽ ऽ ऽ ऽ ऽ ऽ ऽ, ऽ ऽ ऽ ऽ ऽ ऽ, ऽ

6. ਯ -- ਸੁੰਯ 7. ਸੁੰਯ ਰੀ - ਰੀ, ਰੀ ਯ ਸੁੰਯ ਸੁੰ
ਸ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ

8. ਯ --- 9. ਸੁੰਯ ਰੀ ਸੁੰ ਰੇ ਸੁੰ ਰੀ ਸੁੰ, ਰੀ, ਰੀ
रे ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ

10. ਸੁੰ - ਰੀ - ਯ ਯ 11. ਸੁੰਯ - ਸੁਰੇ ਰੀਸ
ग ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ ऽ

दोहरे विभक्ति

परिभाषा :- जब एक ही शब्द में दो विभक्ति के चिह्न हो तो उसे दोहरी विभक्ति कहते हैं।

उदाहरण :- दिव्य ने रूपक से पूछा, "तुम्हारे घर में कौन-कौन है?"

विश्लेषण :-

1	तुम्हारे	तुम्हा + रे	रे (संबंध कारक चिह्न)
2	घर में	घर + में	में (अधिकरण कारक चिह्न)
3	कौन-कौन	कौन + कौन	कौन (संज्ञा)
4	है	है (क्रिया)	
5	दिव्य ने	दिव्य + ने	ने (कर्ता कारक चिह्न)
6	रूपक से	रूपक + से	से (अपादान कारक चिह्न)
7	पूछा	पूछ + आ	आ (भूतकालिक क्रिया चिह्न)
8	तुम्हारे घर में कौन-कौन है		
9	वह मुझे अपने साथ ले गया		
10	वह अपने साथ मुझे ले गया		
11	मैं उसके साथ वहाँ गया		
12	मैं वहाँ उसके साथ गया		
13	उसने मुझे वहाँ		
14	उसने वहाँ मुझे		
15	मुझे उसने वहाँ		
16	मैं वहाँ उसके साथ गया		

(3) ਅਵਰੋਹ ਵਿਚ ਰਿਸ਼ਭ ਧਰ ਸੁੱਧ ਮਧਿਅਮ ਦਾ ਕਣ ਲੈ ਕੇ ਮ ਤੇ ਆਂਦੇ ਹਨ।

(4) ਇਹ ਗੰਭੀਰ ਪ੍ਰਕਿਰਤੀ ਦਾ ਰਾਗ ਹੈ। ਇਸ ਦਾ ਚਲਨ ਵਿਸ਼ੇਸ਼ ਕਰਕੇ ਮੰਦਰ ਤੇ ਮਧਿਅਮ ਸਪਤਕਾਂ ਵਿਚ ਹੁੰਦਾ ਹੈ।

(5) ਅਵਰੋਹ ਵਿਚ ਮ ਤੋਂ ਰੇ ਤੇ ਜੰਪ ਲੈ ਕੇ ਆਇਆ ਜਾਂਦਾ ਹੈ ਜਿਵੇਂ :→ ਰੇ ਸ ਧ ਮ ਗ਼ ਰੇ ਨੀ ਸ।

(6) ਪ੍ਰਯੋਗ ਕਾਲ ਵਿਚ ਸਾਰੰਗ ਤੋਂ ਸੁੱਧ ਸਾਰੰਗ ਸਮਝਿਆ ਜਾਂਦਾ ਸੀ ਪਰ ਅੱਜਕਲ ਸਾਰੰਗ ਤੋਂ ਬ੍ਰਿਹਾਦੀ ਸਾਰੰਗ ਸਮਝਿਆ ਜਾਂਦਾ ਹੈ।

(2) ## ਸੁੱਧ ਸਾਰੰਗ ਅਤੇ ਸ਼ਾਮ ਕਲਿਆਣ

(1) ਸੁੱਧ ਸਾਰੰਗ ਇਕ ਸੰਪੂਰਨ ਰਾਗ ਹੈ ਅਤੇ ਸ਼ਾਮ ਕਲਿਆਣ ਅਤੇ ਕਾਮੋਦ ਰਾਗਾਂ ਦਾ ਮਿਸ਼ਰਣ ਹੈ।

(2) ਸੁੱਧ ਸਾਰੰਗ ਇਸ ਵਿਚ ਗਾਇਆ ਜਾਂਦਾ ਹੈ ਅਤੇ ਸ਼ਾਮ ਕਲਿਆਣ ਰਾਤ ਨੂੰ ਗਾਇਆ ਵਜਾਇਆ ਜਾਂਦਾ ਹੈ।

(3) ਸੁੱਧ ਸਾਰੰਗ ਵਿਚ ਰਿਸ਼ਭ ਵਾਦੀ ਅਤੇ ਪੰਚਮ ਸੰਵਾਦੀ ਹੈ ਅਤੇ ਸ਼ਾਮ ਕਲਿਆਣ ਵਿਚ ਧ ਵਾਦੀ ਅਤੇ ਸ ਸੰਵਾਦੀ ਹੈ।

(4) ਸੁੱਧ ਸਾਰੰਗ ਦੀ ਜਾਤੀ ਔਡਵ - ਸਾਡਵ ਅਤੇ ਸ਼ਾਮ ਕਲਿਆਣ ਦਾ ਜਾਤੀ ਔਡਵ - ਸੰਪੂਰਨ ਹੈ।

(5) ਸੁੱਧ ਸਾਰੰਗ ਵਿਚ ਵੈਵਤ ਅਲਪ ਹੈ, ਪਰ ਸ਼ਾਮ ਕਲਿਆਣ ਵਿਚ ਵੈਵਤ ਦਾ ਅਲਪ ਪ੍ਰਯੋਗ ਨਹੀਂ ਹੈ। ਉਤਰੰਗ ਵਿਚ ਵੈਵਤ ਦੋਨਾਂ ਰਾਗਾਂ ਨੂੰ ਇਕ - ਦੂਸਰੇ ਤੋਂ ਅਲੱਗ ਕਰਦਾ ਹੈ।

(6) ਸੁੱਧ ਸਾਰੰਗ ਵਿਚ ਗੰਧਾਰ ਵਰਜਿਤ ਹੈ, ਪਰ ਸ਼ਾਮ ਕਲਿਆਣ ਦੇ ਪ੍ਰਯੋਗ ਵਿਚ ਗੰਧਾਰ ਦਾ ਪ੍ਰਯੋਗ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਅਤੇ ਇਹ ~~ਸ਼ਾਮ~~ ਦੇ ਸਮੇਂ ਗਾਇਆ ਵਜਾਇਆ ਜਾਂਦਾ ਹੈ। ਪੂਰਵਾਂਗ ਵਿਚ ਗੰਧਾਰ ਦੁਆਰਾ ਸੁੱਧ ਸਾਰੰਗ ਅਤੇ ਸ਼ਾਮ ਕਲਿਆਣ ਨੂੰ ਅਲੱਗ ਕੀਤਾ ਜਾਂਦਾ ਹੈ।

1. ਇਹ ਸਵੇਰ ਦੁਪਹਰ ਦਾ ਰਾਗ ਹੈ।
2. ਦੋਨੋਂ ਰਾਗਾਂ ਦੀ ਸਮਾਨ ਮੁਰ ਮੰਗਤੇ (ਮਾਂਡੀ) - ਰੇ ਸੰਧ, ਧਨੀ ਸੰਸ ਰੇ
3. ਸੁੱਧ ਸਾਰੰਗ ਵਿਚ ਧ ਅਲਪ ਹੈ। ਸ਼ਾਮ ਕਲਿਆਣ ਵਿਚ ਨਹੀਂ।

Viva

Date : / /

ਰਾਗ - ਮੁਖ ਮਾਰੰਗ

ਖਾਟ - ਕੱਲ੍ਹਿਆਣ
ਸਵਦ - ਦੋਹੇ ਸ ਧਾਰੀ ਸੁੱਧ
ਵਰਜਿਤ ਸਵਦ - ਗ
ਆਰੋਹ ਦਿਖ - ਧ ਵਰਜਿਤ
ਜਾਤੀ - ਔਡਵ-ਸਾਡਵ
ਵਾਦੀ - ਰੇ
ਸੰਵਾਦੀ - ਧ
ਸਮਾਂ - ਦਿਨ ਦਾ ਦੂਜਾ ਯਹਿਰ
ਪ੍ਰਕਿਰਤੀ - ਗੰਭੀਰ
ਸ਼ੁਰ-ਪ੍ਰਕਿਰਤਿਕ ਰਾਗ - ਸ਼ਾਮ ਕੱਲ੍ਹਿਆਣ
ਤਿਆਗ ਦੇ ਸਵਦ - ਰੇ, ਧ ਅਤੇ ਨੀ
ਸਸਾਡ ਸੁਰ ਸੰਗਤੀਆਂ - ਰੇ ਸ ਧ, ਧ ਨੀ ਸ, ਸ ਰੇ
ਰਾਮੋਦ ਅੰਗ - ਗ ਸ ਰੇ ਸ
ਆਰੋਹ - ਨੀ ਸ ਰੇ, ਸੰ ਧ, ਨੀ ਸੰ
ਅਵਰੋਹ - ਸੰ ਨੀ, ਧ ਪ, ਸੰ ਧ, ਸ ਗੰ ਰੇ ਸ ਨੀ ਸ
ਅਵਰੋਹ ਦੇ ਪ੍ਰਵਾਂਗ ਦਿਖ ਗ ਦਾ ਪ੍ਰਯੋਗ
ਪਕੜ - ਸੰ ਰੇ ਸੰ ਧ, ਸ ਰੇ, ਸ, ਨੀ ਧ ਸ ਨੀ ਰੇ ਸ।
ਰਾਗ ਦੀ ਯਹਿਚਾਣ - ਗ ਸ ਧ, ਗ ਸ ਰੇ

(1) ਸੁੱਧ ਸਾਰੰਗ ਅਧੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ :→ (1) ਇਸ ਦੇ ਨਾਮ ਤੋਂ ਹੀ ਪਤਾ ਚੱਲਦਾ ਹੈ ਕਿ ਇਹ ਸਾਰੰਗ ਦਾ ਹੀ ਇਕ ਪ੍ਰਕਾਰ ਹੈ। ਵਰਤਮਾਨ ਗਾਇਕ ਇਸ ਦੇ ਗਾਉਣ ਤੇ ਅਵਰੋਹ ਵਿਚ ਕੋਮਲ ਨਿ (ਕੋਮਲ) ਨਾਲ ਲਗਾਉਂਦੇ ਤੇ ਵਰਜ ਲਗਾਉਂਦੇ ਹਨ ਪਰ ਪੁਰਾਤਨ ਘੱਟ ਅਵਰੋਹ ਸਿਧ।

(2) ਇਸ ਦੇ ਆਰੋਹ ਵਿਚ ਰੀਖ ਤੇ ਅਵਰੋਹ ਵਿਚ ਸੁੱਧ ਸ ਦਾ ਪ੍ਰਯੋਗ ਵੀਰ ਸਭਾ ਹੈ। ਕਦੇ-ਕਦੇ ਦੋਹੇਂ ਸ ਵਿਚ ਹੀ ਪ੍ਰਯੋਗ ਵੀ ਸਾਰੰਗ ਜਿਵੇਂ :→ ਰੇ ਸੰ ਸ ਰੇ, ਸ ਨੀ।

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ‘ਰੋਹੀ ਬੀਆਬਾਨ’ ਦਾ ਆਲੋਚਨਾਤਮਕ ਅਧਿਐਨ

Karamjeet Singh Kussa de Novel ‘Rohi Biabaan' da Alochnatmak Adhyan

Sarbjeet

M.A. Punjabi Student

Regd.no. 11302238

ਲਵਲੀ ਪ੍ਰੋਫ਼ਸ਼ਨਲ ਯੂਨੀਵਰਸਿਟੀ ਫਗਵਾੜਾ ਦੇ
ਸਕੂਲ ਆਫ਼ ਆਰਟਸ ਐਂਡ ਲੈਂਗੁਏਜਿਜ਼ ਅਧੀਨ
ਐਮ.ਏ. (ਪੰਜਾਬੀ) ਦੀ ਡਿਗਰੀ ਦੇ ਇੱਕ
ਹਿੱਸੇ ਦੀ ਪੂਰਤੀ ਹਿਤ ਪ੍ਰਸਤੁਤ
ਖੋਜ-ਪ੍ਰਬੰਧ

ਫ਼ੈਕਲਟੀ ਆਫ਼ ਬਿਜ਼ਨਸ ਐਂਡ ਆਰਟਸ
ਲਵਲੀ ਪ੍ਰੋਫ਼ੈਸ਼ਨਲ ਯੂਨੀਵਰਸਿਟੀ, ਫਗਵਾੜਾ

2015

ਘੋਸ਼ਣਾ ਪੱਤਰ

ਮੈਂ ਸਰਬਜੀਤ ਇਹ ਬਿਆਨ ਕਰਦੀ ਹਾਂ ਕਿ ''ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਦਾ ਆਲੋਚਨਾਤਮਕ ਅਧਿਐਨ'' ਵਿਸ਼ੇ 'ਤੇ ਲਿਖੇ ਇਸ ਖੋਜ-ਪ੍ਰਬੰਧ ਵਿਚਲਾ ਖੋਜ ਕਾਰਜ ਨਿਰੋਲ ਰੂਪ ਵਿਚ ਮੇਰਾ ਆਪਣਾ ਹੈ ਅਤੇ ਇਸ ਵਿਚ ਕੋਈ ਹੋਰ ਹਿੱਸੇਦਾਰ ਨਹੀਂ ਹੈ। ਇਸ ਖੋਜ-ਪ੍ਰਬੰਧ ਵਿਚ ਕੋਈ ਵੀ ਅਜਿਹਾ ਖੋਜ ਕਾਰਜ ਸ਼ਾਮਲ ਨਹੀਂ ਹੈ, ਜਿਸ ਲਈ ਕਿਸੇ ਹੋਰ ਯੂਨੀਵਰਸਿਟੀ ਜਾਂ ਅਦਾਰੇ ਵੱਲੋਂ ਕੋਈ ਡਿਗਰੀ ਜਾਂ ਡਿਪਲੋਮਾ ਦਿੱਤਾ ਜਾ ਚੁੱਕਾ ਹੋਵੇ।

ਖੋਜਾਰਥੀ

ਸਰਬਜੀਤ

ਰਜਿ.ਨੰ. 11302238

ਪ੍ਰਮਾਣ ਪੱਤਰ

ਪ੍ਰਮਾਣਿਤ ਕੀਤਾ ਜਾਂਦਾ ਹੈ ਕਿ ਖੋਜਾਰਥੀ ਸਰਬਜੀਤ ਨੇ ''ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਦਾ ਆਲੋਚਨਾਤਮਕ ਅਧਿਐਨ'' ਵਿਸ਼ੇ ਉੱਤੇ ਐਮ.ਏ. (ਪੰਜਾਬੀ) ਦੀ ਡਿਗਰੀ ਲਈ ਮੇਰੀ ਨਿਗਰਾਨੀ ਅਧੀਨ ਖੋਜ-ਕਾਰਜ ਕੀਤਾ ਹੈ। ਇਹ ਖੋਜਾਰਥੀ ਦਾ ਮੌਲਿਕ ਕਾਰਜ ਹੈ ਅਤੇ ਉਸਦੀ ਮਿਹਨਤ ਦਾ ਪ੍ਰਤਿਫ਼ਲ ਹੈ। ਮੈਂ ਇਸ ਖੋਜ ਪ੍ਰਬੰਧ ਨੂੰ ਐਮ.ਏ. ਦੀ ਡਿਗਰੀ ਲਈ ਯੋਗ ਸਮਝਦਾ ਹਾਂ ਅਤੇ ਮੁਲਾਂਕਣ ਹਿੱਤ ਪ੍ਰਸਤੁਤ ਕਰਨ ਦੀ ਸ਼ਿਫਾਰਸ਼ ਕਰਦਾ ਹਾਂ। ਇਸ ਤੋਂ ਪਹਿਲਾ ਇਹ ਖੋਜ-ਕਾਰਜ ਕਿਸੇ ਵੀ ਡਿਗਰੀ ਲਈ ਕਿਸੇ ਵੀ ਯੂਨੀਵਰਸਿਟੀ ਜਾਂ ਅਦਾਰੇ ਵਿਚ ਪੇਸ਼ ਨਹੀਂ ਕੀਤਾ ਗਿਆ।

ਮਿਤੀ:

ਨਿਗਰਾਨ

ਡਾ. ਬਲਵਿੰਦਰ ਸਿੰਘ ਥਿੰਦ

ਸਹਾਇਕ ਪ੍ਰੋਫ਼ੈਸਰ,

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ਭੂਮਿਕਾ

ਪੰਜਾਬੀ ਨਾਵਲ ਸਾਹਿਤ ਵਿਚ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦਾ ਨਾਂ ਸਫ਼ਲ ਨਾਵਲਕਾਰਾਂ ਵਿਚ ਸ਼ੁਮਾਰ ਹੈ। ਉਸ ਦੇ ਕਿਸੇ ਇਕ ਨਾਵਲ ਦੇ ਆਧਾਰ 'ਤੇ ਸ਼ਾਇਦ ਇਹ ਟਿੱਪਣੀ ਅਤਿਕਥਨੀ ਜਾਪੇ ਪਰ ਜੇ ਉਸ ਦੀ ਸਮੁੱਚੀ ਨਾਵਲ-ਰਚਨਾ ਨੂੰ ਵੇਖੀਏ ਤਾਂ ਇਹ ਦ੍ਰਿਸ਼ਟੀਗੋਚਰ ਹੋ ਜਾਂਦਾ ਹੈ ਕਿ ਪੰਜਾਬ ਦੇ ਕਿਸਾਨੀ ਸੱਭਿਆਚਾਰ ਦੀ ਦਸ਼ਾ ਤੇ ਦਿਸ਼ਾ ਨੂੰ ਨਿਰਧਾਰਤ ਕਰਨ ਵਾਲੇ ਮੂਲ ਪ੍ਰੇਰਕਾਂ ਦਾ ਆਭਾਸ ਜਿਸ ਸ਼ਿੱਦਤ ਨਾਲ ਕੁੱਸਾ ਕਰਵਾ ਸਕਿਆ ਹੈ, ਉਹ ਕਿਸੇ ਹੋਰ ਨਾਵਲਕਾਰ ਦੇ ਹਿੱਸੇ ਨਹੀਂ ਆਇਆ। ਪੰਜਾਬ ਦੇ ਅਰਥਚਾਰੇ ਵਿਚ ਸਰਮਾਏਦਾਰੀ ਉਤਪਾਦਨ ਪ੍ਰਣਾਲੀ ਦੀ ਪ੍ਰਭੂਤਾ ਉਪਰੰਤ ਇਥੋਂ ਦੇ ਕਿਸਾਨੀ ਸਮਾਜ ਦੇ ਇਕ ਪਾਸੜ ਵਿਕਾਸ ਨਾਲ ਵਿਭਿੰਨ ਤਰ੍ਹਾਂ ਦੇ ਸੰਕਟ ਪੈਦਾ ਹੋਏ। ਭਾਰਤੀ ਜਾਗੀਰਦਾਰੀ ਅਤੇ ਪੰਜਾਬੀ ਕਿਸਾਨੀ ਵਿਚਕਾਰਲਾ ਫ਼ਰਕ ਕੁੱਸਾ ਨੇ ਇਸ ਨਾਵਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਵਿਚ ਸਫ਼ਲਤਾ ਪੇਸ਼ ਕੀਤਾ ਹੈ।

ਇਸ ਖੋਜ-ਪ੍ਰਬੰਧ ਨੂੰ ਚਾਰ ਭਾਗਾਂ ਵਿਚ ਵੰਡਿਆ ਗਿਆ ਹੈ। ਅਧਿਆਇ ਪਹਿਲਾ ''ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਸਿਧਾਂਤਕ ਪਰਿਪੇਖ ਅਤੇ ਇਤਿਹਾਸਕ ਪੜਾਅ'' ਵਿਚ ਸਭ ਤੋਂ ਪਹਿਲਾਂ ਸਾਹਿਤ ਬਾਰੇ ਅਤੇ ਸਾਹਿਤ ਦੇ ਮਹੱਤਵ ਬਾਰੇ ਦੱਸਿਆ ਗਿਆ ਹੈ ਕਿ ਸਾਹਿਤ ਸਮਾਜ ਦਾ ਪ੍ਰਤੀਬਿੰਬ ਹੁੰਦਾ ਹੈ। ਮਨੁੱਖ ਦਾ ਸਾਹਿਤ ਨਾਲ ਰਿਸ਼ਤਾ ਮੁੱਢ ਕਦੀਮ ਤੋਂ ਹੀ ਚਲਦਾ ਆ ਰਿਹਾ ਹੈ। ਸਾਹਿਤ ਨੂੰ ਅਸੀਂ ਆਮ ਤੌਰ 'ਤੇ ਦੋ ਕਿਸਮਾਂ ਵਿੱਚ ਰੱਖ ਕੇ ਦੇਖ ਸਕਦੇ ਹਾਂ, ਜ਼ੁਬਾਨੀ ਸਾਹਿਤ ਜਾਂ ਲੋਕ ਸਾਹਿਤ, ਲਿਖਤੀ ਸਾਹਿਤ। 'ਸਾਹਿਤ' ਸ਼ਬਦ ਅੰਗਰੇਜ਼ੀ ਸ਼ਬਦ 'Literature' ਦਾ ਸਮਾਨਾਰਥੀ ਹੈ। ਇਸ ਤੋਂ ਬਾਅਦ ਗਲਪ ਬਾਰੇ ਜਾਣਕਾਰੀ ਦਿੱਤੀ ਗਈ ਹੈ ਕਿ ਗਲਪ ਮਨ ਦੀ ਘਾੜਤ ਹੈ ਜਾਂ ਇੰਝ ਕਹਿ ਲਉ ਕਿ ਗਲਪ ਕਲਪਨਾ ਦਾ ਦੂਜਾ ਨਾਂ ਹੈ। ਜਦੋਂ ਗੱਪ ਵੀ ਜ਼ਿੰਦਗੀ ਦੀ ਅਸਲੀਅਤ ਵਰਗੀ ਪ੍ਰਤੀਤ ਹੋਵੇ ਤਾਂ ਇਹ ਗਲਪ ਬਣ ਜਾਂਦੀ ਹੈ। ਗਲਪ ਦੇ ਘੇਰੇ ਵਿਚ ਨਾਵਲ, ਕਹਾਣੀ, ਨਾਟਕ, ਆਦਿ ਆਉਂਦੇ ਹਨ। ਸਾਹਿਤ ਦੇ ਖੇਤਰ ਵਿਚ ਗਲਪ ਅੱਜ ਸਭ ਤੋਂ ਵੱਧ ਸਲਾਹਿਆ ਜਾਣ ਵਾਲਾ ਸਾਹਿਤਕ ਰੂਪ ਹੈ। ਇਸ ਤੋਂ ਬਾਅਦ ਨਾਵਲ ਨੂੰ ਸਮਝਣ ਦਾ ਯਤਨ ਕੀਤਾ ਗਿਆ ਹੈ ਨਾਵਲ ਨੂੰ ਆਧੁਨਿਕ ਯੁੱਗ ਦਾ ਬਿਰਤਾਂਤ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਨਾਵਲ ਇਕ ਗਲਪੀ

ਪ੍ਰਵਚਨ ਹੁੰਦਾ ਹੈ। ਇਸ ਵਿਚ ਗਲਪੀ ਰਚਨਾ ਵਿਧੀ ਦੀ ਵਰਤੋਂ ਵਿਚਾਰਾਂ ਦੀ ਪ੍ਰਤੱਖਣ ਪ੍ਰਕਿਰੀਆ ਸਮੇਂ ਵੀ ਹੁੰਦੀ ਹੈ ਅਤੇ ਪ੍ਰਗਟਾਅ ਵੇਲੇ ਵੀ। ਨਾਵਲੀ ਬਿਰਤਾਂਤ ਦੇ ਯਥਾਰਥ ਦੇ ਵਸਤੂ ਵੇਰਵਿਆਂ ਨੂੰ ਨਵੇਂ ਸਿਰੇ ਤੋਂ ਵਿਉਂਤ ਕੇ, ਉਨ੍ਹਾਂ ਦਾ ਨਿਵੇਕਲਾ ਅਰਥ ਪ੍ਰਬੰਧ ਰਚਦਾ ਹੋਇਆ, ਉਸ ਨੂੰ ਨਿਵੇਕਲੇ ਸੰਸਾਰ ਦੀ ਹਸਤੀ ਪ੍ਰਦਾਨ ਕਰਦਾ ਹੈ। ਦਰਅਸਲ ਨਾਵਲ ਸਾਹਿਤ ਨਾਵਲੀ ਜਗਤ ਦੇ ਅੰਤਰ ਪਾਸਾਰਾਂ, ਜਲਿਟ ਸਮੱਸਿਆਵਾਂ, ਅੰਤਰ ਵਿਰੋਧਾਂ, ਮਾਨਵੀ ਗੁੰਝਲਾਂ ਅਤੇ ਮਾਨਵੀ ਚੇਤਨਾ ਦੇ ਅੰਤਰ ਮਨ ਵਿਚਲੇ ਦਵੰਧਾਂ ਦੀ ਬਾਖੂਬੀ ਨਾਲ ਪੇਸ਼ ਕਰਨ ਵਾਲਾ ਸਾਹਿਤ ਰੂਪ ਹੈ। ਇਸ ਤੋਂ ਬਾਅਦ ਵਿਦਵਾਨਾਂ ਦੁਆਰਾ ਨਾਵਲ ਬਾਰੇ ਦਿੱਤੀਆਂ ਗਈਆਂ ਮਹੱਤਵਪੂਰਨ ਪਰਿਭਾਸ਼ਾਵਾਂ ਨੂੰ ਅੰਕਿਤ ਕੀਤਾ ਗਿਆ ਹੈ। ਫਿਰ ਨਾਵਲ ਦੇ ਤੱਤਾਂ ਬਾਰੇ ਭਰਪੂਰ ਚਰਚਾ ਕੀਤੀ ਗਈ ਹੈ। ਫਿਰ ਨਾਵਲੀ ਤੱਤਾਂ ਬਾਰੇ ਜਾਣਕਾਰੀ ਦੇਣ ਉਪਰੰਤ ਨਾਵਲ ਦੇ ਇਤਿਹਾਸਕ ਪੜਾਅ ਉੱਤੇ ਵੀ ਚਾਨਣਾ ਪਾਇਆ ਗਿਆ ਹੈ ।

ਅਧਿਆਈ ਦੂਜਾ ਵਿਚ ‘‘ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦਾ ਜੀਵਨ ਅਤੇ ਰਚਨਾ’’ ਨੂੰ ਦੱਸਿਆ ਗਿਆ ਹੈ। ਜਿਸ ਵਿਚ ਨਾਵਲਕਾਰ ਕੁੱਸਾ ਦੀ ਜੀਵਨ ਦ੍ਰਿਸ਼ਟੀ ਅਤੇ ਗਪਲ ਦ੍ਰਿਸ਼ਟੀ ਦੇ ਅੰਤਰ-ਸੰਬੰਧਾਂ ਨੂੰ ਜਾਨਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕੀਤੀ ਗਈ ਹੈ।ਕੁੱਸਾ ਜਾ ਜਨਮ 1.1.1953 ਨੂੰ ਸਰਦਾਰ ਮੇਹਰ ਸਿੰਘ ਧਾਲੀਵਾਲ ਦੇ ਘਰ ਪਿੰਡ ਕੁੱਸਾ ਜ਼ਿਲ੍ਹਾ ਮੋਗਾ ਵਿਚ ਹੋਇਆ। ਕੁੱਸਾ ਦੇ ਸਵੈ-ਕਥਨ ਦੇ ਰੂਪ ’ਚ ਪੇਸ਼ ਕੀਤਾ ਜਾ ਰਿਹਾ ਲੇਖ ‘ਮੈਂ ਲਿਖਾਰੀ ਕਿਵੇਂ ਬਣਿਆ’ ਨੂੰ ਵੀ ਇਸ ਅਧਿਆਇ ਦਾ ਹਿੱਸਾ ਬਣਾਇਆ ਗਿਆ ਹੈ। ਇਹ ਇਕ ਅਜਿਹੀ ਇਤਿਹਾਸਕ ਲਿਖਤ ਹੈ ਜਿਸ ਰਾਹੀਂ ਕੁੱਸਾ ਨੇ ਆਪਣੀ ਜੀਵਨ-ਦ੍ਰਿਸ਼ਟੀ ਅਤੇ ਪਹਿਲੇ ਪੰਜ ਨਾਵਲਾਂ ਦੀ ਸਿਰਜਣ-ਪ੍ਰਕਿਰਿਆ ਬਾਰੇ ਬੜੀ ਰੌਚਿਕ ਸ਼ੈਲੀ ਰਾਹੀਂ ਪ੍ਰਮਾਣਿਕ ਜਾਣਕਾਰੀ ਦਿੱਤੀ ਹੈ। ਆਪਣੇ ਬਾਰੇ ਲਿਖਿਆ ਇਹ ਉਸ ਦਾ ਇਕੋ-ਇਕ ਲੇਖ ਹੈ।

ਅਧਿਆਈ ਤੀਜਾ ਵਿਚ ‘‘ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਦਾ ਵਿਸ਼ਾ-ਪੱਖ’’ ਨੂੰ ਅੰਕਿਤ ਕੀਤਾ ਗਿਆ ਹੈ। ਜਿਸ ਦੇ ਅੰਤਰਗਤ ਪੰਜਾਬੀ ਪੇਂਡੂ ਸਮਾਜ ਦੀ ਪੇਸ਼ਕਾਰੀ, ਛੋਟੀ ਕਿਸਾਨੀ ਦਾ ਸੰਕਟ, ਔਰਤ ਦੀ ਦੁਰਦਸ਼ਾ ਦੀ ਪੇਸ਼ਕਾਰੀ, ਜੱਟ ਮਾਨਕਿਕਤਾ ਦੀ ਪੇਸ਼ਕਾਰੀ,

ਯਥਾਰਥ ਦੀ ਪੇਸ਼ਕਾਰੀ, ਕਿਸਾਨੀ ਸਭਿਆਚਾਰ ਦੀ ਹੋਂਦ ਤੇ ਹੋਣੀ ਬਾਰੇ ਜਾਣਕਾਰੀ ਦਿੱਤੀ ਗਈ ਹੈ। ਇਸ ਨਾਵਲ ਦੇ ਵਿਸ਼ੇ ਵਿਚੋਂ ਮੁੱਖ ਗੱਲ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਸੰਕਟ, ਉਨ੍ਹਾਂ ਦੀਆਂ ਮੂਲ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਉਜਾਗਰ ਕਰਨਾ ਹੈ।

ਅਧਿਆਇ ਚੌਥਾ ਵਿਚ ‘‘ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ‘ਰੋਹੀ ਬੀਆਬਾਨ ਦਾ ਕਲਾਤਮਕ-ਪੱਖ’’ ਹੈ। ਜਿਸ ਵਿਚ ਇਸ ਨਾਵਲ ਵਿਚ ਪ੍ਰਸਤੁਤ ਪਾਤਰਾਂ ਦੇ ਆਧਾਰ ’ਤੇ ਕੁੱਸਾ ਦੀ ਪਾਤਰ ਕਲਾ ਨੂੰ ਘੋਖਿਆ ਗਿਆ ਹੈ। ਨਾਵਲ ਵਿਚ ਪੇਸ਼ ਕੀਤੇ ਮਨੁੱਖੀ ਚਰਿੱਤਰ ਨਾਵਲਕਾਰ ਦੀ ਗਲਪ ਚੇਤਨਾ ਦਾ ਪ੍ਰਗਟਾਵਾ ਕਰਦੇ ਹਨ। ਪੈਦਾਇਸ਼ੀ ਰਿਸ਼ਤਿਆਂ ਵਿੱਚ ਜਕੜੇ ਪੇਂਡੂ ਪਾਤਰਾਂ ਦੀ ਮਾਨਸਿਕਤਾ ਦਾ ਚਿਤਰਨ ਉਹ ਬੜੇ ਯਥਾਰਥਮਈ ਢੰਗ ਨਾਲ ਕਰਦਾ ਹੈ। ਨਾਵਲਕਾਰ ਨੇ ਵਾਤਾਲਾਪ ਬੜੇ ਢੁਕਵੇਂ ਵਰਤੇ ਹਨ। ਵਾਰਤਾਲਾਪ ਰਾਹੀਂ ਹੀ ਉਹ ਪਾਤਰਾਂ ਬਾਰੇ ਅਹਿਮ ਜਾਣਕਾਰੀ ਦਿੰਦਾ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਵਰਤੀ ਭਾਸ਼ਾ ਸਰਲ ਅਤੇ ਸਪੱਸ਼ਟ ਹੈ। ‘ਰੋਹੀ ਬੀਆਬਾਨ’ ਨਾਵਲ ਪ੍ਰਤੀਕਾਤਮਕ ਸ਼ੈਲੀ ਵਿਚ ਲਿਖਿਆ ਨਾਵਲ ਹੈ। ਖੋਜ-ਪ੍ਰਬੰਧ ਦੇ ਅੰਤ ਵਿਚ ਸਾਰ ਅਤੇ ਪੁਸਤਕ ਸੂਚੀ ਵੀ ਦਿੱਤੀ ਗਈ ਹੈ। ਅੰਤ ਵਿਚ ਮੈਂ ਉਨ੍ਹਾਂ ਵਿਦਵਾਨਾਂ ਦੀ ਧੰਨਵਾਦੀ ਹਾਂ ਜਿਨਾਂ ਦੁਆਰਾ ਲਿਖੀਆਂ ਪੁਸਤਕਾਂ ਮੇਰੇ ਖੋਜ ਕਾਰਜ ਦਾ ਆਧਾਰ ਬਣੀਆਂ ਹਨ।

ਸਾਰ ਤੱਤ

ਰੋਹੀ ਬੀਆਬਾਨ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦਾ ਪ੍ਰਸਿੱਧ ਨਾਵਲ ਹੈ ਜੋ ਕਿ ਛੋਟੀ ਕਿਸਾਨੀ ਨੂੰ ਦਰਪੇਸ਼ ਮੁੱਖ ਰੱਖ ਕੇ ਲਿਖਿਆ ਗਿਆ ਹੈ। ਇਸ ਤੋਂ ਇਲਾਵਾ ਇਸ ਨਾਵਲ ਵਿਚ ਕੁੱਝ ਹੋਰ ਵੀ ਵਿਸ਼ੇ ਦ੍ਰਿਸ਼ਟੀਗੋਚਕ ਹੁੰਦੇ ਹਨ ਜਿਵੇਂ ਜੱਟ ਮਾਨਸਿਕਤਾ ਦਾ ਬਿਆਨ, ਔਰਤ ਦੀ ਦੁਰਦਸ਼ਾ ਦੀ ਪੇਸ਼ਕਾਰੀ, ਪੇਂਡੂ ਸਭਿਆਚਾਰ ਦੀ ਪੇਸ਼ਕਾਰੀ, ਯਥਾਰਥ ਦੀ ਪੇਸ਼ਕਾਰੀ। ਖੋਜ ਅਧੀਨ ਨਾਵਲ ਦਾ ਮੂਲ ਵਿਸ਼ਾ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਸੰਕਟ ਨੂੰ ਪੇਸ਼ ਕਰਨਾ ਹੈ। ਇਸ ਵਿਚ ਪ੍ਰਸਤੁਤ ਸਮੱਸਿਆਵਾਂ ਅੱਜ ਦੇ ਸਮੇਂ ਵਿਚ ਭਖਦੀਆਂ ਸਮੱਸਿਆਵਾਂ ਹਨ। ਨਾਵਲ ਦੀ ਮੂਲ ਕਥਾ ਇਕ ਗ਼ਰੀਬ ਪਰਿਵਾਰ ਦੇ ਦੁਆਲੇ ਘੁੰਮਦੀ ਹੈ। ਸਾਰਾ ਪਰਿਵਾਰ ਮਿੱਟੀ ਨਾਲ ਮਿੱਟੀ ਹੋਇਆ ਰਹਿੰਦਾ ਹੈ ਪਰ ਗੁਜ਼ਾਰਾ ਤਾਂ ਵੀ ਮੁਸ਼ਕਲ ਨਾਲ ਹੁੰਦਾ ਹੈ। ਨਾਵਲ ਦੇ ਅੰਤ ਵਿਚ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਪ੍ਰਤੀਕਵਾਦੀ ਸ਼ੈਲੀ ਵਰਤ ਕੇ ਬਲਬਾਂ ਦੀ ਮੱਧਮ ਲੋਅ ਨੂੰ ਗ਼ਰੀਬ ਕਿਸਾਨਾਂ ਲਈ ਇਕ ਆਸ ਦੀ ਕਿਰਨ ਵਜੋਂ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ਕੁੱਸਾ ਨੇ ਇਸ ਨਾਵਲ ਵਿਚ ਕਿਸਾਨੀ ਸਭਿਆਚਾਰ ਦੇ ਯਥਾਰਥ ਦੀ ਪੇਸ਼ਕਾਰੀ ਕੀਤੀ ਹੈ ਜੋ ਕਿ ਅਜੋਕੇ ਸਮਾਜ ਦੀ ਮੰਗ ਵੀ ਹੈ।

ਖੋਜ ਕਾਰਜ ਦਾ ਖੇਤਰ

ਇਸ ਖੋਜ-ਕਾਰਜ ਵਿਚ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਇਕ ਹੀ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਦਾ ਅਲੋਚਨਾਤਮਕ ਅਧਿਐਨ ਕੀਤਾ ਗਿਆ ਹੈ। ਇਸ ਖੋਜ ਕਾਰਜ ਵਿਚ ਸੀਮਾ ਇਸ ਕਰਕੇ ਨਿਰਧਾਰਤ ਕੀਤੀ ਗਈ ਹੈ ਕਿਉਂਕਿ ਇਹ ਐਮ.ਏ. ਪੰਜਾਬੀ ਦੀ ਡਿਗਰੀ ਦੇ ਹਿੱਤ ਲਈ ਕੀਤਾ ਖੋਜ ਕਾਰਜ ਹੈ ਅਤੇ ਪਾਠਕ੍ਰਮ ਵਿਚੋਂ ਘੱਟ ਸਮਾਂ ਮਿਲਣ ਦੇ ਕਾਰਨ ਸਿਰਫ਼ ਇਕ ਹੀ ਨਾਵਲ ਉੱਪਰ ਧਿਆਨ ਕੇਂਦਰਿਤ ਕੀਤਾ ਜਾਂ ਸਕਦਾ ਸੀ ਇਸ ਕਾਰਨ ਇਸ ਖੋਜ ਪ੍ਰਬੰਧ ਦੀ ਸੀਮਾਂ ਨਿਰਧਾਰਤ ਕੀਤੀ ਗਈ ਹੈ।

ਉਦੇਸ਼

1. ਨਾਵਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਦਾ ਸਿਧਾਂਤਕ ਅਧਿਐਨ ਕਰਨਾ।
2. ਇਸ ਨਾਵਲ ਵਿਚ ਪ੍ਰਸਤੁਤ ਛੋਟੀ ਕਿਰਸਾਣੀ ਦੇ ਦੁਖਾਂਤ ਨੂੰ ਸਮਝਣ ਦਾ ਯਤਨ ਕਰਨਾ।
3. ਪੇਂਡੂ ਸਮਾਜ ਵਿਚ ਜੰਮੇ-ਪਲ਼ੇ ਵਿਅਕਤੀਆਂ ਦੀ ਮਾਨਸਿਕਤਾ ਨੂੰ ਜਾਨਣਾ।
4. ਔਰਤ ਦੀ ਦੁਰਦਸ਼ਾ ਦੇ ਕਾਰਨਾ ਦੀ ਤਲਾਸ਼ ਕਰਨਾ।

ਖੋਜ ਵਿਧੀਆਂ

ਇਸ ਖੋਜ ਪ੍ਰਬੰਧ ਵਿਚ ਹੇਠ ਲਿਖੀਆਂ ਵਿਧੀਆਂ ਦੀ ਵਰਤੋਂ ਹੋਵੇਗੀ

ਤਰਕਵਾਦੀ ਵਿਧੀ

ਇਹ ਵਿਧੀ ਤਰਕ ਉੱਤੇ ਅਧਾਰਿਤ ਹੈ। ਇਸ ਵਿਚ ਸਭ ਕਿਰਿਆਵਾਂ ਤੱਥਾਂ ਦੇ ਵਿਸ਼ਲੇਸ਼ਣ ਅਤੇ ਉਹਨਾਂ ਦੇ ਨਿਸ਼ਕਰਸ਼ ਲਈ ਤਰਕ ਦਾ ਆਸਰਾ ਲੈ ਕੇ ਚੱਲਦੀਆਂ ਹਨ। ਬਹੁਤੇ ਗੈਰ-ਸਾਹਿਤਕ ਵਿਸ਼ਿਆਂ ਦੀ ਖੋਜ ਲਈ ਇਸ ਵਿਧੀ ਦਾ ਇਸਤੇਮਾਲ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਇਹ ਦੋ ਤਰ੍ਹਾਂ ਦੀ ਹੁੰਦੀ ਹੈ:-

ਅਗਨਾਤਮਕ ਵਿਧੀ

ਇਹ ਵਿਸ਼ੇਸ਼ ਤੋਂ ਸਧਾਰਣ ਵੱਲ ਚੱਲਦੀ ਹੈ।

ਨਿਗਨਾਤਮਕ ਵਿਧੀ

ਇਹ ਸਧਾਰਣ ਤੋਂ ਵਿਸ਼ੇਸ਼ ਵੱਲ ਚਲਦੀ ਹੈ।

ਮਨੋਵਿਸ਼ਲੇਸ਼ਣੀ ਵਿਧੀ

ਇਹ ਫਰਾਇਡ ਦੇ ਸਿਧਾਂਤ ਉੱਪਰ ਨਿਰਧਾਰਤ ਹੈ ਜਿਸ ਵਿਚ ਮਨੁੱਖੀ ਮਨ ਦਾ ਵਿਸ਼ਲੇਸ਼ਣ ਕੀਤਾ ਜਾਂਦਾ ਹੈ।

ਪੂਰਵ ਖੋਜ ਕਾਰਜ

1. ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਵਿਚ ਪ੍ਰਤੀਮਾਨ, ਪੰਜਾਬੀ ਯੂਨੀਵਰਸਿਟੀ, ਚੰਡੀਗੜ੍ਹ, 2002
2. ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਕਿਰਸਾਣੀ ਸਮਾਜ (ਗੁਰਦਿਆਲ ਸਿੰਘ ਅਤੇ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਦੇ ਸੰਦਰਭ ਵਿਚ), ਪੰਜਾਬ ਯੂਨੀਵਰਸਿਟੀ ਚੰਡੀਗੜ੍ਹ, 2005
3. ਗੁਰਦਿਆਲ ਸਿੰਘ ਤੇ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਵਿਚ ਪੇਸ਼ ਦਲਿਤ ਚੇਤਨਾ ਦਾ ਅਧਿਐਨ, ਕੁਰੂਕਸ਼ੇਤਰ ਯੂਨੀਵਰਸਿਟੀ, 2005

ਮੈਂ ਆਪਣੇ ਨਿਗਰਾਨ ਡਾ. ਬਲਵਿੰਦਰ ਸਿੰਘ ਥਿੰਦ ਜੀ ਬਹੁਤ ਧੰਨਵਾਦੀ ਹਾਂ, ਜਿਹਨਾਂ ਨੇ ਮੇਰੇ ਇਸ ਖੋਜ ਕਾਰਜ ਵਿਚ ਮੇਰੀ ਸਹਾਇਤਾ ਕੀਤੀ। ਉਹਨਾਂ ਨੇ ਆਪਣੇ ਕੀਮਤੀ ਸਮੇਂ ਵਿਚੋਂ ਮੈਨੂੰ ਸਮਾਂ ਦੇ ਕੇ ਮੇਰੇ ਇਸ ਖੋਜ ਕਾਰਜ ਨੂੰ ਨੇਪਰੇ ਚੜ੍ਹਾਇਆ। ਉਹਨਾਂ ਨੇ ਮੇਰੇ ਕੀਤੇ ਕੰਮ ਨੂੰ ਸਮੇਂ-ਸਮੇਂ 'ਤੇ ਦੇਖਿਆ ਅਤੇ ਕੀਤੇ ਹੋਰੇ ਕੰਮ ਨੂੰ ਸੋਧ ਕਰਕੇ ਅੰਤ ਤੱਕ ਇਸ ਖੋਜ ਕਾਰਜ ਨੂੰ ਪੂਰਾ ਕਰਨ ਲਈ ਮੇਰੀ ਮੱਦਦ ਕੀਤੀ।

ਅਧਿਆਇ ਪਹਿਲਾ

ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਸਿਧਾਂਤਕ ਪਰਿਪੇਖ ਅਤੇ ਇਤਿਹਾਸਕ ਪੜਾਅ

1.1 ਨਾਵਲ ਵਿਧਾ ਦੀ ਗਾਲਪਨਿਕ ਪਛਾਣ

ਸੁੰਦਰ ਸਾਹਿਤ ਕਿਰਤ ਨੂੰ ਰਚਨਾ ਕਲਾ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਕਲਾ ਦੋ ਪ੍ਰਕਾਰ ਦੀ ਹੁੰਦੀ ਹੈ: ਉਪਯੋਗੀ ਅਤੇ ਲਲਿਤ। ਲੁਹਾਰ, ਤਰਖਾਣ ਅਤੇ ਸੁਨਿਆਰੇ ਆਦਿ ਦੀ ਕਲਾ ਉਪਯੋਗੀ ਅਤੇ ਚਿਤਰਕਾਰੀ, ਰਾਗ, ਸੰਗੀਤ, ਮੂਰਤੀਕਲਾ ਅਤੇ ਸਾਹਿਤ ਲਲਿਤ ਕਲਾ ਦੇ ਘੇਰੇ ਵਿੱਚ ਆਉਂਦੇ ਹਨ। ਸਾਹਿਤ ਸਮਾਜ ਦੀ ਉਪਜ ਹੁੰਦਾ ਹੈ ਕਿਉਂਕਿ ਲੇਖਕ ਸਮਾਜ ਦਾ ਅੰਗ ਹੁੰਦਾ ਹੈ ਅਤੇ ਉਸਦੀ ਵਿਚਾਰਧਾਰਾ ਸਮਾਜ ਦੇ ਹਾਲਾਤ ਅਤੇ ਉਸਦੇ ਅਨੁਭਵ ਦਾ ਸੁਮੇਲ ਹੁੰਦੀ ਹੈ। ਇਸੇ ਲਈ ਵਿਦਵਾਨ ਸਾਹਿਤ ਨੂੰ ਸਮਾਜ ਦਾ ਦਰਪਣ ਮੰਨਦੇ ਹਨ ਪਰੰਤੂ ਸਾਹਿਤ ਸਮਾਜ ਦਾ ਦਰਪਣ ਹੁੰਦਿਆਂ ਹੋਇਆਂ ਸਮਾਜ ਨੂੰ ਬਦਲਣ ਜਾਂ ਪ੍ਰਭਾਵਿਤ ਕਰਨ ਦੀ ਸਮਰੱਥਾ ਰੱਖਦਾ ਹੈ ਕਿਉਂਕਿ ਸਾਹਿਤ ਦਾ ਸਬੰਧ ਸਿੱਧਾ ਮਨੁੱਖੀ ਮਾਨਸਿਕਤਾ ਨਾਲ ਹੁੰਦਾ ਹੈ। ਕਿਸੇ ਵਿਅਕਤੀ ਵਿਚ ਪਰਿਵਰਤਨ ਲਿਆਉਣ ਲਈ ਉਸ ਦੇ ਮਨ ਜਾਂ ਵਿਚਾਰਾਂ ਨੂੰ ਬਦਲਣਾ ਜ਼ਰੂਰੀ ਹੁੰਦਾ ਹੈ ਕਿਉਂਕਿ ਕਿਸੇ ਵਿਅਕਤੀ ਦੇ ਵਿਚਾਰਾਂ ਦਾ ਸਮੂਹ ਹੀ ਉਸ ਦਾ ਜੀਵਨ ਫਲਸਫ਼ਾ ਅਖਵਾਉਂਦਾ ਹੈ। ਮਨੁੱਖ ਦਾ ਸਾਹਿਤ ਨਾਲ ਰਿਸ਼ਤਾ ਮੁੱਢ ਕਦੀਮ ਤੋਂ ਹੀ ਚਲਦਾ ਆ ਰਿਹਾ ਹੈ। ਮਨੁੱਖ ਨੇ ਆਪਣੀਆਂ ਭਾਵਨਾਵਾਂ ਨੂੰ ਤ੍ਰਿਪਤ ਕਰਨ ਦੇ ਲਈ ਲਲਿਤ ਕਲਾਵਾਂ/ ਸਾਹਿਤ ਦਾ ਸਹਾਰਾ ਲਿਆ ਹੈ। ''ਸਾਹਿਤ ਦੀ ਰਚਨਾ ਇਕ ਫੁਲਵਾੜੀ ਜਾਂ ਨਿਸ਼ਾਂਤ ਬਾਗ਼ ਵਾਂਗ, ਸ਼ਾਹੀ ਮਹੱਲ ਜਾਂ ਪਹਾੜੀ ਕਿਲੇ ਵਾਂਗ, ਕਾਰਖਾਨੇ ਜਾਂ ਮਾਡਲ ਟਾਊਨ ਵਾਂਗ, ਫ਼ਵਾਰੇ, ਝਰਨੇ ਜਾਂ ਝੀਲ ਵਾਂਗ ਹੋ ਸਕਦੀ ਹੈ।''[1] ਇਸ ਲਈ ਸਾਹਿਤ ਦੀ ਸੁੰਦਰਤਾ ਦੋ ਪ੍ਰਕਾਰ ਦੀ ਹੁੰਦੀ ਹੈ। ਜਿਸ ਤਰ੍ਹਾਂ ਸੁੰਦਰਤਾ ਫੁੱਲ ਵਿਚ ਤੇ ਫੁਲਵਾੜੀ ਵਿਚ ਹੁੰਦੀ ਹੈ, ਪਾਣੀ ਤੇ ਝੀਲ ਵਿਚ, ਕਮਰੇ ਤੇ ਮਹਿਲ ਵਿਚ, ਇਸੇ ਤਰ੍ਹਾਂ ਸਾਹਿਤ ਦੀ ਸੁੰਦਰਤਾ ਰੂਪ ਜਾਂ ਪ੍ਰਗਟਾ ਵਿਚ ਹੁੰਦੀ ਹੈ ਅਤੇ ਨਾਲ ਹੀ ਭਾਵਾਂ ਵਿਚ ਵੀ, ਨਾ ਕੇਵਲ ਰਚਨਾ ਜਾਂ ਬਣਤਰ ਦੀ ਹੁੰਦੀ ਹੈ, ਸਗੋਂ ਭਾਵ ਜਾਂ ਵਿਚਾਰਾਂ ਦੀ ਵੀ। ਸਾਹਿਤ ਨੂੰ ਅਸੀਂ ਆਮ ਤੌਰ 'ਤੇ ਦੋ ਕਿਸਮਾਂ ਵਿੱਚ ਰੱਖ ਕੇ ਦੇਖ ਸਕਦੇ ਹਾਂ :-

1. ਜ਼ੁਬਾਨੀ ਸਾਹਿਤ ਜਾਂ ਲੋਕ ਸਾਹਿਤ

2. ਲਿਖਤੀ ਸਾਹਿਤ

'ਸਾਹਿਤ' ਸ਼ਬਦ ਅੰਗਰੇਜ਼ੀ ਸ਼ਬਦ 'Literature' ਦਾ ਸਮਾਨਾਰਥੀ ਹੈ। ਸਾਹਿਤ ਦੀ ਮਹਾਨਤਾ ਨੂੰ ਜੇਕਰ ਵੇਖਣਾ ਹੋਵੇ ਤਾਂ ਵਿਸ਼ਵ ਦੇ ਮਹਾਨ ਲੇਖਕਾਂ ਦੇ ਵਿਚਾਰਾਂ ਵਿਚੋਂ ਵੇਖਿਆ ਜਾ ਸਕਦਾ ਹੈ। ਮਿਸਾਲ ਵਜੋਂ :

1. ਮੈਥਿਊ ਆਰਨਲਡ ਅਨੁਸਾਰ ''ਸਾਹਿਤ ਸੰਸਾਰ ਦੇ ਗਿਆਨ ਅਤੇ ਵਿਚਾਰਾਂ ਦਾ ਉੱਤਮ ਨਮੂਨਾ ਹੈ।''[2]

2. ਪਲੈਟੋ ਸਾਹਿੱਤ ਨੂੰ ਅਨੁਕਰਣ ਦਾ ਅਨੁਕਰਣ ਮੰਨਦਾ ਹੈ।[3]

ਵਿਦਵਾਨਾਂ ਦੀ ਸਾਂਝੀ ਰਾਇ ਮੁਤਾਬਕ ਸਾਹਿਤ ਨੂੰ ਦੋ ਰੂਪਾਂ ਵਿੱਚ ਵੰਡ ਕੇ ਅਧਿਐਨ ਕੀਤਾ ਗਿਆ ਹੈ:-

1. ਪਦ ਜਾਂ ਕਵਿਤਾ (Poetry)

2. ਗਦ ਜਾਂ ਵਾਰਤਕ (Prose)

ਸਾਹਿਤ ਦੇ ਇਤਿਹਾਸ ਵਿਚ ਸਭ ਤੋਂ ਪਹਿਲਾਂ ਕਵਿਤਾ ਹੋਂਦ ਵਿਚ ਆਈ। ਅੱਜ ਤੱਕ ਇਹ ਇਕ ਸਰਵ-ਪ੍ਰਮਾਣਿਤ ਮੱਤ ਹੈ ਕਿ ਦੁਨੀਆਂ ਦੀ ਹਰ ਭਾਸ਼ਾ ਵਿਚ ਪਹਿਲਾਂ ਕਵਿਤਾ ਦਾ ਜਨਮ ਹੋਇਆ ਅਤੇ ਢੇਰ ਚਿਰ ਬਾਅਦ ਜਾ ਕੇ ਕਿਤੇ ਵਾਰਤਕ ਉਪਜੀ। ਇਸ ਪਹਿਲ-ਕਦਮੀ ਦਾ ਕਾਰਨ ਬੜਾ ਸਪੱਸ਼ਟ ਹੈ ਅਤੇ ਉਹ ਇਹ ਕਿ ਕਵਿਤਾ 'ਦਿਲ ਦੀ ਬੋਲੀ' ਹੈ ਅਤੇ ਵਾਰਤਕ 'ਦਿਮਾਗ ਦੀ ਭਾਸ਼ਾ' ਹੈ।

ਹਥਲੇ ਖੋਜ-ਪ੍ਰਬੰਧ ਦਾ ਸਬੰਧ ਸਾਹਿਤ ਦੀ ਗਲਪ ਵਿਧਾ ਵਿਚਲੇ ਨਾਵਲ ਰੂਪਾਕਾਰ ਨਾਲ ਹੈ ਅਤੇ ਨਾਵਲ, ਗਲਪ ਸਾਹਿਤ ਦੀ ਇਕ ਮਹੱਤਵਪੂਰਨ ਵੰਨਗੀ ਹੈ। ਗਲਪ ਜਿੱਥੇ ਪੂੰਜੀਵਾਦੀ ਦੌਰ ਅੰਦਰ ਮੱਧ ਸ਼੍ਰੇਣੀ ਵਿਚ ਜਿਉਂਦੇ ਮਨੁੱਖ ਦੀ ਅੰਦਰੂਨੀ ਚੇਤਨਾ ਦੀ ਬਾਤ ਪਾਉਂਦਾ ਹੈ ਉਥੇ ਸਮਾਜ ਦੇ ਪ੍ਰਾਣੀਆਂ ਦਾ ਸਾਧਾਰਣੀਕਰਨ ਰੂਪ ਪੇਸ਼ ਕਰਨ ਵਾਲਾ ਸਾਹਿਤ ਰੂਪ ਵੀ ਹੈ। ਗਲਪ ਦਾ ਆਰੰਭ ਮਨੁੱਖੀ ਮਨ ਦੀ ਜਗਿਆਸਾ ਅਤੇ ਮਨੁੱਖੀ ਸਰੀਰ ਦੇ ਪਰਾਕ੍ਰਮਾਂ ਤੋਂ ਹੋਇਆ। ਆਦਿਕਾਲ ਮਨੁੱਖ ਨੂੰ ਆਪਣੀ ਰੋਜ਼ੀ-ਰੋਟੀ ਦੀ ਵਿਵਸਥਾ ਲਈ ਜਿਥੇ ਪ੍ਰਕਿਰਤੀ ਨਾਲ ਸੰਘਰਸ਼ ਕਰਨਾ ਪੈਂਦਾ ਸੀ, ਉੱਥੇ ਪ੍ਰਕਿਰਤੀ ਦੇ ਹੋਰ ਜੀਵ ਜੰਤੂਆਂ ਨਾਲ ਵੀ ਨਜਿੱਠਣਾ ਪੈਂਦਾ ਸੀ। ਸੋ ਆਪਣੀ ਹੋਂਦ ਨੂੰ ਬਰਕਰਾਰ ਰੱਖਣ ਵਾਸਤੇ ਮਨੁੱਖ ਨੇ ਹੋਲੀ-ਹੋਲੀ ਭਾਸ਼ਾ ਸਿੱਖੀ ਅਤੇ ਭਾਸ਼ਾ ਆਖਿਰ ਵਿਚ ਸੰਚਾਰ ਦਾ ਉੱਤਮ ਸਾਧਨ ਬਣੀ। ਭਾਸ਼ਾ ਸਿੱਖਣ ਤੋਂ ਢੇਰ ਚਿਰ ਬਾਅਦ ਮਨੁੱਖ ਨੇ ਲਿਖਣ ਦੀ ਜਾਂਚ ਸਿੱਖੀ। ਫਿਰ ਸਾਹਿਤ ਮੌਖਿਕ ਰੂਪ ਤੋਂ ਲਿਖਤੀ ਰੂਪ ਵੱਲ ਪ੍ਰਵੇਸ਼ ਕਰਨ ਲੱਗਾ। ਇਤਿਹਾਸ ਗਵਾਹ ਹੈ ਕਿ ਕਵਿਤਾ ਦਿਲ ਦੀ ਬੋਲੀ ਹੋਣ ਕਰਕੇ ਸਭ ਤੋਂ ਪਹਿਲਾਂ ਹੋਂਦ ਵਿਚ ਆਈ, ਫਿਰ ਢੇਰ ਚਿਰ ਬਾਅਦ ਵਾਰਤਕ ਹੋਂਦ ਵਿਚ ਆਈ। ''ਪੰਜਾਬੀ ਵਾਰਤਕ ਨੂੰ ਭਾਈ ਵੀਰ ਸਿੰਘ, ਮੋਹਨ ਸਿੰਘ ਵੈਦ, ਪ੍ਰੋ. ਪੂਰਨ ਸਿੰਘ, ਗੁਰਬਖਸ਼ ਸਿੰਘ, ਲਾਲ ਸਿੰਘ ਕਮਲਾ ਅਕਾਲੀ ਨੇ ਇੱਕ ਉੱਨਤ ਪੜਾਉ ਤੱਕ ਅਪੜਾ ਦਿੱਤਾ। ਕਵਿਤਾ ਵਿਚ ਵਧੇਰੇ ਜ਼ੋਰ ਭਾਵਾਂ ਉੱਪਰ ਦਿੱਤਾ ਜਾਂਦਾ ਹੈ, ਪਰ ਵਾਰਤਕ ਵਿਚ ਵਿਵੇਕਸ਼ੀਲ ਕਲਪਨਾ ਉੱਤੇ।''[4] ਆਦਿ ਕਾਲ ਵਿਚ ਕਹਾਣੀ ਜਨਮੀ ਅਤੇ ਆਧੁਨਿਕ ਕਾਲ ਵਿਚ ਨਾਵਲ ਦਾ ਜਨਮ ਹੋਇਆ। ਗਲਪ ਵਿਚ ਇਹ ਦੋਵੇਂ ਰੂਪ ਸ਼ਾਮਿਲ ਹਨ।

ਪ੍ਰੋ. ਗੁਰਦਿਆਲ ਸਿੰਘ ਫੁੱਲ ਮੁਤਾਬਕ; ''ਗਲਪ ਜੀਵਨ ਦਾ ਇਨ-ਬਿਨ ਪ੍ਰਗਟਾਅ ਨਹੀਂ ਹੈ, ਸਗੋਂ ਜੀਵਨ ਦਾ ਸਿਰਜਣਾਤਮਕ ਪ੍ਰਗਟਾਅ ਹੈ।''[5]

ਸੁਰਿੰਦਰ ਕੁਮਾਰ ਦਰਵੇਸ਼ਰ ਅਨੁਸਾਰ, ''ਗਲਪ ਮਨ ਦੀ ਘਾੜਤ ਹੈ।''[6] ਅੱਠ-ਭੁਜੀ ਤੀਵੀਂ ਦੀ ਵਾਸਤਵਿਕ ਹੋਂਦ ਸੰਭਵ ਨਹੀਂ ਪਰ ਇਤਿਹਾਸ ਦੇ ਇਕ ਖਾਸ ਪੜਾ ਉੱਪਰ ਮਨੁੱਖ ਨੇ ਇਸ ਦੀ ਕਲਪਨਾ ਕੀਤੀ ਅਤੇ ਇਸ ਨੂੰ ਦੇਵੀ ਮਾਂ ਦੇ ਰੂਪ ਵਿਚ ਸਿਰਜ ਲਿਆ। ਮਨੁੱਖ ਦੀ ਕਲਪਨਾ ਦਾ ਚਮਤਕਾਰ ਹੀ ਹੈ ਜੋ ਨਾਰੀ-ਸ਼ਕਤੀ ਦੀ ਮਹਿਮਾ ਦਾ ਪ੍ਰਤੀਕ ਹੈ ਅਤੇ ਇਸ ਦੇ ਸੰਚਾਰ ਦਾ ਵਸੀਲਾ ਵੀ। ਮਨੋ-ਕਲਪਿਤ ਹੋਣ ਕਰਕੇ ਇਹ ਗਲਪ ਹੈ। ''ਪੰਜਾਬੀ ਦੀ ਆਧੁਨਿਕ ਗਲਪ ਪੰਜਾਬ ਵਿਚ ਬਰਤਾਨਵੀ ਸਾਮਰਾਜ ਅਧੀਨ ਪੈਦਾ ਹੋਏ ਮੱਧ-ਵਰਗ ਸਮਾਜ ਦੀ ਦੇਣ ਹੈ। ਇਸੇ ਲਈ ਇਹ ਮੱਧ-ਵਰਗੀ ਦ੍ਰਿਸ਼ਟੀ ਦੀ ਵਾਹਕ ਹੈ।''[7] ਦਰਅਸਲ ਜਦੋਂ ਗੱਪ ਵੀ ਜ਼ਿੰਦਗੀ ਦੀ ਅਸਲੀਅਤ ਵਰਗੀ ਪ੍ਰਤੀਤ ਹੋਵੇ ਤਾਂ ਇਹ ਗਲਪ ਬਣ ਜਾਂਦੀ ਹੈ। ਭਾਵ ਕਿ ਗਲਪ ਕਲਪਨਾ ਦਾ ਦੂਜਾ ਰੂਪ ਹੈ। ਗਲਪ ਦਾ ਜਨਮ ਜੀਵਨ ਦੀ ਕਿਸੇ ਵਾਸਤਵਿਕ ਘਟਨਾ ਤੋਂ ਹੁੰਦਾ ਹੈ। ਜਿਹੜੀ ਘਟਨਾ ਹੈਰਾਨੀਜਨਕ ਹੁੰਦੀ ਹੈ, ਉਸ ਨੂੰ ਸਮਾਜ ਦੇ ਲੋਕ ਮੌਖਿਕ ਰੂਪ ਵਿਚ ਬਿਆਨ ਕਰਦੇ ਰਹਿੰਦੇ ਹਨ। ਗਲਪ ਅਸਲੀ ਜੀਵਨ ਨਹੀਂ, ਸਗੋਂ ਜੀਵਨ ਦੀ ਅਸਲੀਅਤ ਬਾਰੇ ਇੱਕ ਵਿਸ਼ੇਸ਼ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਹੈ। ''ਗਲਪਕਾਰ ਦੀ ਅੱਖ ਇਕ ਕਲਾਕਾਰ ਦੀ ਅੱਖ ਹੈ ਜਿਹੜੀ ਵੇਖਣ, ਜਾਚਣ, ਪਰਖਣ ਅਤੇ ਆਲੋਚਨਾ ਕਰਨ ਦੀ ਸਮਰੱਥਾ ਰੱਖਦੀ ਹੈ।''[8] ਸੋ ਗਲਪ ਵਿਚ ਪੰਜ ਸਾਹਿਤਕ ਰੂਪਾਂ ਦੀ ਚਰਚਾ ਹੁੰਦੀ ਹੈ-ਕਹਾਣੀ, ਲੰਮੀ ਤੇ ਨਿੱਕੀ ਕਹਾਣੀ, ਮਿੰਨੀ ਕਹਾਣੀ, ਨਾਵਲਿਟ ਅਤੇ ਨਾਵਲ। ''ਅੰਗਰੇਜ਼ੀ ਵਿਚ ਗਲਪ ਨੂੰ ਫਿਕਸ਼ਨ (Fiction) ਦੇ ਸਮਾਨ-ਅਰਥੀ ਸਮਝਿਆ ਜਾਂਦਾ ਹੈ, ਇਸ ਤਰ੍ਹਾਂ ਦੀ ਰਚਨਾ ਦਾ ਦਿਲ ਪਰਚਾਣ ਲਈ ਬਹੁਤਾ ਕਲਪਤ ਹੋਣਾ ਅਤੇ ਜੀਵਨ ਦੀ ਵਾਸਤਵਿਕਤਾ ਤੋਂ ਕੁਝ ਹਟ ਕੇ ਹੋਣਾ ਜ਼ਰੂਰੀ ਸਮਝਿਆ ਜਾਂਦਾ ਹੈ।''[9] ਭਾਵੇਂ ਹੁਣ ਇਹ ਗੱਲ ਨਹੀਂ ਰਹੀ ਅਤੇ ਅੱਜ ਦਾ ਗਲਪ ਸਾਹਿਤ ਜੀਵਨ ਦੇ ਯਥਾਰਥ ਦੇ ਕਾਫ਼ੀ ਨੇੜੇ ਹੁੰਦਾ ਹੈ। ''ਸਾਹਿਤਕ ਖੇਤਰ ਵਿਚ ਵਾਸਤਵਿਕ ਜੀਵਨ ਦੀ ਉਹ ਕਾਲਪਨਿਕ ਕਥਾ ਜੋ ਰੋਚਿਕ ਤੇ ਉਤੇਜਨਾ ਭਰਪੂਰ ਸ਼ੈਲੀ ਵਿਚ ਬਿਆਨੀ ਗਈ ਹੋਵੇ, ਗਲਪ ਆਖੀ ਜਾਂਦੀ ਹੈ।''[10] ''ਨਾਵਲ ਆਧੁਨਿਕ ਗਲਪ ਦਾ ਅਜਿਹਾ ਰੂਪ ਹੈ ਜਿਹੜਾ ਸਾਡੀਆਂ ਇਤਿਹਾਸਕ ਤੇ ਸਮਾਜਕ ਸਥਿਤੀਆਂ ਦੇ ਅਰਥਾਂ ਅਤੇ ਮੁੱਲਾਂ ਦੇ ਮਸਲਿਆਂ ਨਾਲ ਸਾਡੇ ਨਾਲ ਸਿੱਧੇ ਤੇ ਖੁੱਲ੍ਹੇ ਰੂਪ ਵਿਚ ਬਾਵਾਸਤ ਹੁੰਦਾ ਹੈ।''[11] ਨਾਵਲ ਇਨਸਾਨੀ ਜ਼ਿੰਦਗੀ ਦੀ ਪੇਸ਼ਕਾਰੀ ਜ਼ਿਆਦਾ ਪ੍ਰਭਾਵਸ਼ਾਲੀ ਢੰਗ ਨਾਲ ਕਰਦਾ ਹੈ। ਇਸ ਲਈ ਨਾਵਲ ਪੂੰਜੀਵਾਦੀ ਯੁੱਗ ਵਿੱਚ ਸਭ ਤੋਂ ਵੱਧ ਪੜ੍ਹਿਆ ਅਤੇ ਲਿਖਿਆ ਗਿਆ ਹੈ। ਨਾਵਲ ਆਧੁਨਿਕ ਪੂੰਜੀਵਾਦੀ ਯੁੱਗ ਵਿੱਚ ਸਭ ਤੋਂ ਮਹੱਤਵਪੂਰਨ ਅਤੇ ਪ੍ਰਸੰਗਿਕ ਰੂਪਾਕਾਰ ਹੋ ਨਿਬੜਿਆ ਹੈ। ਕਿਉਂਕਿ ਇਹ ਆਧੁਨਿਕ ਜੀਵਨ ਦੀਆਂ ਗੁੰਝਲਦਾਰ ਸਮੱਸਿਆਵਾਂ ਅਤੇ ਥੁੜਾਂ ਨੂੰ ਪ੍ਰਸਤੁਤ ਕਰਨ ਵਿੱਚ ਸਮਰੱਥ ਹੈ। ਆਕਾਰ ਵਿੱਚ ਵੱਡਾ, ਵਿਧੀ ਵਿੱਚ ਵਸਤੂ ਮੁੱਖ ਅਤੇ ਰੂਪਾਕਾਰ ਹੱਦਾਂ ਤੋਂ ਕਾਫ਼ੀ ਹੱਦ ਤੱਕ ਸੁਤੰਤਰ ਇਸ ਵਿਧਾ ਨੂੰ ਆਧੁਨਿਕ ਲੇਖਕਾਂ ਨੇ ਵੀ ਬਹੁਤ ਪਿਆਰ ਕੀਤਾ ਹੈ।

ਨਾਵਲ ਨੂੰ ਆਧੁਨਿਕ ਯੁੱਗ ਦਾ ਬਿਰਤਾਂਤ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਨਾਵਲ ਇਕ ਗਲਪੀ ਪ੍ਰਵਚਨ ਹੁੰਦਾ ਹੈ। ਇਸ ਵਿਚ ਗਲਪੀ ਰਚਨਾ ਵਿਧੀ ਦੀ ਵਰਤੋਂ ਵਿਚਾਰਾ ਦੀ ਪ੍ਰਤੱਖਣ ਪ੍ਰਕਿਰੀਆ ਸਮੇਂ ਵੀ ਹੁੰਦੀ ਹੈ ਅਤੇ ਪ੍ਰਗਟਾਅ ਵੇਲੇ ਵੀ। ਨਾਵਲੀ ਬਿਰਤਾਂਤ ਦੇ ਯਥਾਰਥ ਦੇ ਵਸਤੂ ਵੇਰਵਿਆਂ ਨੂੰ ਨਵੇਂ ਸਿਰੇ ਤੋਂ ਵਿਉਂਤ ਕੇ, ਉਨ੍ਹਾਂ ਦਾ ਨਿਵੇਕਲਾ ਅਰਥ ਪ੍ਰਬੰਧ ਰਚਦਾ ਹੋਇਆ, ਉਸ ਨੂੰ ਨਵੇਕਲੇ ਸੰਸਾਰ ਦੀ ਹਸਤੀ ਪ੍ਰਦਾਨ ਕਰਦਾ ਹੈ। ਇਸੇ ਕਰਕੇ ਨਾਵਲੀ ਪਾਠ ਵਿਚ ਅਰਥਸ਼ੀਲ ਪ੍ਰਬੰਧ ਆਪਣੇ ਆਪ ਨੂੰ ਸਵੈ-ਸਿੱਧ ਸੰਸਾਰ ਵਿਚ ਬਦਲ ਕੇ ਖ਼ੁਦਮੁਖ਼ਤਾਰ ਵਸਤੂ ਬਣਦਾ ਹੈ। ਜ਼ਾਹਿਰ ਹੈ ਕਿ ਨਾਵਲ ਦਾ ਗਲਪੀ ਪ੍ਰਵਚਨ ਭਾਵੇਂ ਵਸਤੂ ਯਥਾਰਥ ਦਾ ਹੀ ਰੂਪ ਹੁੰਦਾ ਹੈ, ਪਰ ਇਸ ਦੇ ਆਪਣੇ ਨਿਯਮ, ਰਿਵਾਇਤਾਂ ਅਤੇ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ ਹੁੰਦੀਆਂ ਹਨ। ਇਸ ਸਥਿਤੀ ਦੀ ਵਿਆਖਿਆ ਇਸ ਤਰ੍ਹਾਂ ਕੀਤੀ ਜਾ ਸਕਦੀ ਹੈ ਕਿ ਵਸਤੂ-ਯਥਾਰਥ ਵਿਚ ਵਾਪਰਨ ਵਾਲੀਆਂ ਘਟਨਾਵਾਂ, ਨਾਵਲ ਵਿਚ ਕਾਰਜ ਬਣ ਜਾਂਦੀਆਂ ਹਨ ਜਿਉਂਦੇ ਜਾਗਦੇ ਮਨੁੱਖ ਪਾਤਰ ਬਣ ਜਾਂਦੇ ਹਨ, ਜ਼ਿੰਦਗੀ ਵਿਚਲੇ ਇਤਫਾਕ, ਦੁਰਘਟਨਾਵਾਂ, ਸੰਗਤੀਆਂ, ਵਿਸੰਗਤੀਆਂ ਅਤੇ ਰੁਝਾਣ ਵਿਸ਼ੇਸ਼ ਕਿਸਮ ਦੀਆਂ ਪਾਠਕ ਯੁਗਤਾਂ ਬਣ ਜਾਂਦੇ ਹਨ। ''ਇਹ ਪ੍ਰਕਿਰੀਆਂ ਹੀ ਨਾਵਲੀ ਸੰਸਾਰ ਨੂੰ ਵਸਤੂ-ਯਥਾਰਥ ਨਾਲ ਦੋਹਰੇ ਰਿਸ਼ਤੇ ਵਿਚ ਜੋੜਦੀ ਹੈ ਅਤੇ ਉਹ ਪੂਰੀ ਤਰ੍ਹਾਂ ਵਿਲੱਖਣ ਹੁੰਦਾ ਹੈ। ਨਾਵਲ ਨੂੰ ਪੂੰਜੀਵਾਦੀ ਵਿਵਸਥਾ ਦਾ ਪ੍ਰਮੁੱਖ ਸਾਹਿਤ ਰੂਪ ਮੰਨਿਆ ਜਾਂਦਾ ਹੈ।''[12]

ਸੋ ਨਾਵਲ ਦੇ ਰੂਪ ਬਾਰੇ ਵਿਚਾਰ ਚਰਚਾ ਕਰਨ ਵੇਲੇ ਪਹਿਲੀ ਗੱਲ ਇਹ ਹੈ ਕਿ ਇਸ ਦਾ ਸੰਰਚਨਾਤਮਕ ਰੂਪ ਬਿਰਤਾਂਤਕ ਸੁਭਾਅ ਵਾਲਾ ਹੈ ਜੋ ਮਨੁੱਖ ਨੂੰ ਸਮੁੱਚੇ ਰੂਪ ਵਿਚ ਗ੍ਰਹਿਣ ਕਰਨ ਅਤੇ ਪੇਸ਼ ਕਰਨ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ। ਰੈਲਫ ਫਾਕਸ ਅਨੁਸਾਰ ''ਨਾਵਲ ਪੂੰਜੀਵਾਦੀ ਯੁੱਗ ਦਾ ਮਹਾਂਕਾਵਿ ਹੈ।''[13]

ਪੱਛਮ ਵਿੱਚ ਵੀ ਨਾਵਲ ਪਿਛਲੀਆਂ ਕੁਝ ਸਦੀਆਂ ਤੋਂ ਹੀ ਪ੍ਰਚਲਿਤ ਹੋਇਆ ਹੈ। ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਜਨਮ ਪੱਛਮੀ ਪ੍ਰਭਾਵ ਦਾ ਫ਼ਲ ਹੈ। ਇਹ ਪ੍ਰਭਾਵ ਪੰਜਾਬੀ ਨਾਵਲ ਉਤੇ ਸਿੱਧਾ ਨਹੀਂ ਸਗੋਂ ਬੰਗਾਲੀ, ਉਰਦੂ ਅਤੇ ਹਿੰਦੀ ਰਾਹੀਂ ਪਿਆ ਹੈ। ਨਾਵਲ ਰਚਣ ਲਈ ਲੇਖਕ ਨੂੰ ਜੀਵਨ ਦੀ ਵਿਸ਼ਾਲ ਸੂਝ ਹੋਣੀ ਚਾਹੀਦੀ ਹੈ ਹਰ ਸਮਾਜ ਵਿਚ ਨਾਵਲ ਰਚਣਾ ਉਦੋਂ ਹੀ ਆਰੰਭ ਹੁੰਦੀ ਹੈ ਜਦੋਂ ਸਮਾਜ ਵਿੱਚ ਚੇਤੰਨਤਾ ਜਾਵੇ। ਇੱਕ ਚੰਗਾ ਨਾਵਲਕਾਰ ਬਣਨ ਲਈ ਜੀਵਨ ਨੂੰ ਅਤਿ ਡੂੰਘਾਈ ਤੱਕ ਮਾਨਵ ਤੇ ਵੇਖਣਾ ਚਾਹੀਦਾ ਹੈ ਤਾਂ ਹੀ ਉਹ ਨਾਵਲ ਵਿਚ ਜੀਵਨ ਨੂੰ ਅਨੇਕ ਭਾਂਤੀ ਢੰਗ ਨਾਲ ਗੁੰਦ ਸਕੇਗਾ।

1.2 ਨਾਵਲ ਦਾ ਨਾਮਕਰਣ

ਜਿਥੋਂ ਤੱਕ ਨਾਵਲ ਦੀ ਉਤਪਤੀ ਦਾ ਸਵਾਲ ਹੈ ਵਧੇਰੇ ਵਿਦਵਾਨਾਂ ਦਾ ਮੰਨਣਾ ਹੈ ਕਿ ਨਾਵਲ ਯੂਰਪ ਵਿਚ ਉਦਯੋਗਿਕ ਕ੍ਰਾਂਤੀ ਆਉਣ ਤੋਂ ਬਾਅਦ ਮਨੁੱਖ, ਸਮਾਜ ਅਤੇ ਸੱਭਿਆਚਾਰ ਉੱਪਰ ਪਏ ਦਬਾਅ ਅਤੇ ਪ੍ਰਭਾਵਾਂ ਸਦਕਾ ਹੋਂਦ ਵਿਚ ਆਇਆ। ਭਾਵ ਇਹ ਕਿ ਮੱਧ ਯੁੱਗ ਦੇ ਨਿਰੂਪਣ ਲਈ ਜੋ ਸਮਰੱਥਾ ਮਹਾਂ-ਕਾਵਿ ਵਿੱਚ ਸੀ

ਲੱਗਭਗ ਉਹੀ ਸਮਰੱਥਾ ਪੂੰਜੀਵਾਦੀ ਯੁੱਗ ਦੀ ਪੇਸ਼ਕਾਰੀ ਲਈ ਨਾਵਲ ਵਿੱਚ ਮੌਜੂਦ ਹੈ। ''ਨਾਵਲ ਸ਼ਬਦ ਅੰਗਰੇਜ਼ੀ ਭਾਸ਼ਾ ਤੋਂ ਲਿਆ ਗਿਆ ਹੈ। ਅੰਗਰੇਜ਼ੀ ਦੇ Novel ਸ਼ਬਦ ਦੀ ਉਤਪਤੀ ਇਤਾਲਵੀ ਭਾਸ਼ਾ ਦੇ ਸ਼ਬਦ 'Novus' ਅਤੇ 'Novella'ਤੋਂ ਹੋਈ ਹੈ।''[14] ਇਸ ਸ਼ਬਦ ਦਾ ਅਰਥ ਸੀ ਨਵੀਨ ਜਾਂ ਨਵਾਂ ਭਾਵ ਇੱਕ ਨਵਾਂ ਸਾਹਿਤਕ ਰੂਪ ਹੈ ਜਿਸ ਵਿਚ ਜ਼ਿੰਦਗੀ ਦੀ ਇੱਕ ਘਟਨਾ ਅਤੇ ਪਾਤਰਾਂ ਭਰਪੂਰ ਲੰਬੀ ਕਹਾਣੀ ਕਹੀ ਗਈ ਹੈ।

1.3 ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਸਿਧਾਂਤਕ ਪਰਿਪੇਖ

ਨਾਵਲ ਦਾ ਸ਼ਾਬਦਿਕ ਅਰਥ

ਨਾਵਲ ਦੇ ਡਿਕਸ਼ਨਰੀ ਅਰਥ ਸ਼ਬਦ 'Novella' ਦੁਆਰਾ ਪ੍ਰਗਟ ਹੋਏ ਹਨ। ''ਇਸ ਸ਼ਬਦ ਦਾ ਮੂਲ ਇਤਾਲਵੀ ਭਾਸ਼ਾ ਵਿਚ 'ਨਵੇਂ'' ਅਰਥਾਂ ਵਿਚ ਪ੍ਰਪਾਤ ਹੈ। ਰੋਮਨ ਸ਼ਬਦ 'Nouns' ਦਾ ਅਰਥ ਵੀ ਨਵਾਂ ਤੇ ਅਨੋਖਾ ਹੈ ਜਿਸ ਦਾ ਅਧਾਰ ਵੀ Novellaਹੀ ਹੈ।''[15] Novella ਸ਼ਬਦ ਛੋਟੀ ਕਹਾਣੀ' ਲਈ ਵਰਤਿਆ ਜਾਂਦਾ ਸੀ। ਅੰਗਰੇਜ਼ੀ ਵਿਚ ਇਹ 'Novel' ਅਤੇ ਇਸ ਦਾ ਪਰਿਆਏਵਾਚੀ ਹਿੰਦੀ ਸ਼ਬਦ 'ਉਪਨਿਆਸ' ਹੈ। ਪੰਜਾਬੀ ਵਿਚ ਇਸ ਲਈ ਅੰਗਰੇਜ਼ੀ ਵਾਲਾ ਰੂਪ 'ਨਾਵਲ' ਪ੍ਰਸਿੱਧ ਹੈ।

ਇਤਾਲਵੀ ਸ਼ਬਦ 'Novella' ਤੋਂ ਸਪਸ਼ਟ ਹੁੰਦਾ ਹੈ ਕਿ ਨਾਵਲ ਇਕ ਅਜਿਹੀ ਰਚਨਾ ਹੈ, ਜਿਸ ਵਿਚ ਜੀਵਨ ਦੀ ਕਹਾਣੀ ਨੂੰ ਸਮਕਾਲੀ ਸਮਾਜ ਦੇ ਸੰਦਰਭ ਵਿਚ ਨਵੀਨ ਢੰਗ ਨਾਲ ਬਿਆਨ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਇਸ ਦਾ ਭਾਵ ਹੈ ਇਹ ਹੋਇਆ ਕਿ ਨਾਵਲ ਵਿਚ 'ਨਵੀਨਤਾ' ਦਾ ਤੱਤ ਅਤਿਅੰਤ ਜ਼ਰੂਰੀ ਹੈ।

ਭਾਰਤੀ ਵਿਦਵਾਨ ਉਪਨਿਆਸ ਦਾ ਅਰੰਭ ਸੰਸਕ੍ਰਿਤ ਤੋਂ ਹੋਇਆ ਮੰਨਦੇ ਹਨ। ਉਪਨਿਆਸ ਇਕ ਅਜਿਹੀ ਰਚਨਾ ਹੈ ਜਿਸ ਵਿਚ ਸੰਪੂਰਨ ਜ਼ਿੰਦਗੀ ਦੀ ਲੰਬੀ ਕਹਾਣੀ ਨੂੰ ਨਾਵਾਂ, ਥਾਵਾਂ, ਘਟਨਾਵਾਂ ਦੀ ਸਹਾਇਤਾ ਨਾਲ ਯੋਗ ਭਾਸ਼ਾ ਵਿਚ ਬਿਆਨ ਕੀਤਾ ਗਿਆ ਹੋਵੇ। ਨਾਵਲ, ਪਾਤਰ, ਨਾਵਲੀ ਕਾਰਜ ਅਤੇ ਨਾਵਲੀ ਘਟਨਾਵਾਂ ਜੀਵਨ ਦੀ ਅਸਲੀਅਤ ਦਾ ਭੁਲੇਖਾ ਪੈਦਾ ਕਰਨ ਵਾਲੇ ਹੋਣੇ ਚਾਹੀਦੇ ਹਨ।

1.4 ਨਾਵਲ ਦੀ ਪਰਿਭਾਸ਼ਾ

1.4.1 ਵਿਦੇਸ਼ੀ ਚਿੰਤਕਾਂ ਅਨੁਸਾਰ

ਰਾਲਫ਼ ਫ਼ਾਕਸ ਦੇ ਸ਼ਬਦਾਂ ਵਿੱਚ:

''ਨਾਵਲ ਕਹਾਣੀ ਕਰਨ ਦੀ ਇੱਕ ਮਹਾਨ ਲੋਕ ਕਲਾ ਹੈ ਜਿਸ ਦਾ ਵਿਸ਼ਾ ਸੰਪੂਰਨ ਮਨੁੱਸ਼ ਚਰਿੱਤਰ ਹੈ। Novel is a great folk art of story telling which attempstotreat the whole man for its theme." [16]

ਵੈਬਮਟਰ ਅਨੁਸਾਰ:

''ਨਾਵਲ ਇੱਕ ਵਾਰਤਕ ਵਿੱਚ ਲਿਖੀ ਵੱਡੇ ਅਕਾਰ ਦੀ ਕਲਪਨਾ ਭਰਪੂਰ ਕਹਾਣੀ ਹੁੰਦੀ ਹੈ, ਜਿਸ ਵਿੱਚ ਮਨੁੱਖੀ ਜੀਵਨ ਦੀ ਅਸਲੀਅਤ ਨੂੰ ਸਾਕਾਰ ਕਰਨ ਵਾਲੇ ਪਾਤਰਾਂ ਅਤੇ ਉਨ੍ਹਾਂ ਦੇ ਕਾਰਜਾਂ ਦਾ ਵਰਨਣ ਹੁੰਦਾ ਹੈ। ''[17]

ਵੈਬਸਟਰ ਅਨੁਸਾਰ:

''ਉਪਨਿਆਸ ਵਾਰਤਕ ਵਿੱਚ ਲਿਖੀ ਇੱਕ ਵੱਡੇ ਅਕਾਰ ਦੀ ਕਲਪਨਾ ਭਰਪੂਰ ਕਹਾਣੀ ਹੁੰਦੀ ਹੈ ਜਿਸ ਵਿੱਚ ਮਾਨਵ ਜੀਵਨ ਦੇ ਯਥਾਰਥ ਪੱਖ ਨੂੰ ਪ੍ਰਗਟਾਉਣ ਵਾਲੇ ਪਾਤਰਾਂ ਤੇ ਉਨ੍ਹਾਂ ਦੇ ਵਾਰਜਾਂ ਦਾ ਵਰਨਣ ਹੁੰਦਾ ਹੈ। ''[18]

1.4.2 ਪੰਜਾਬੀ ਚਿੰਤਕਾਂ ਮੁਤਾਬਿਕ:

ਡਾ.ਰੌਸ਼ਨ ਲਾਲ ਅਹੂਜਾ ਦੇ ਅਨੁਸਾਰ,

''ਨਾਵਲ ਸਧਾਰਨ ਜੀਵਨ ਦਾ ਇੱਕ ਕਲਪਿਤ ਪਰ ਯਥਾਰਥਕ ਚਰਿੱਤਰ ਹੈ।''

ਡਾ. ਸਵਿੰਦਰ ਸਿੰਘ ਸਿੰਘ ਉੱਪਲ ਅਨੁਸਾਰ,

''ਨਾਵਲ ਵਿਧੀ ਅਨੁਸਾਰ ਪੰਜ ਪ੍ਰਮੁੱਖ ਵਿਸ਼ੇਸ਼ਾਵਾਂ-ਜੀਵਨ, ਫਲਸਫ਼ਾ, ਪਾਤਰ, ਗੋਂਦ, ਵਾਤਾਵਰਨ ਅਤੇ ਵਾਰਤਾਲਾਪ ਦਾ ਨਾਵਲ ਵਿਚ ਹੋਣਾ ਜ਼ਰੂਰੀ ਮੰਨਿਆ ਜਾਂਦਾ ਹੈ। ''[19]

1.4.3 ਹਿੰਦੀ ਚਿੰਤਕਾਂ ਮੁਤਾਬਿਕ

ਟੀ. ਆਰ.ਵਿਨੋਦ ਨਾਵਲ ਨੂੰ ਪੂੰਜੀਵਾਦੀ ਵਿਵਸਥਾ ਦਾ ਚਿਤਰਣ ਕਰਨ ਵਾਲਾ ਸਾਹਿਤ ਰੂਪ ਮੰਨਦੇ ਹੋਏ ਲਿਖਦੇ ਹਨ:

''ਇਸ ਵਿਵਸਥਾ ਵਿਚ ਮਨੁੱਖ ਦੀਆਂ ਸਾਧਾਰਨ, ਨਿੱਤ ਬਦਲਦੀਆਂ, ਵਿਸਤਾਰ ਫੜਦੀਆਂ, ਜਲਿਟ ਹੁੰਦੀਆਂ, ਪਰਸਪਰ ਵਿਰੋਧੀ ਭਾਵਨਾਵਾਂ ਦੇ ਹਾਲਾਤ ਦੇ ਪ੍ਰਸੰਗ ਵਿਚ ਚਿੱਤਰ ਸ਼ਾਇਦ ਸਾਹਿਤ ਦਾ ਹੋਰ ਰੂਪ ਪ੍ਰਸਤੁਤ ਨਹੀਂ ਕਰ ਸਕਦਾ। ਇਸ ਲੋੜ ਦੀ ਪੂਰਤੀ ਨਾਵਲ ਨੇ ਕੀਤੀ। ''[20]

ਉਪਰੋਕਤ ਸਾਰੀਆਂ ਪਰਿਭਾਸ਼ਾਵਾਂ ਆਪਣੇ ਆਪ ਵਿਚ ਸੰਪੂਰਨ ਵੀ ਹਨ ਅਤੇ ਅਪੂਰਨ ਵੀ ਕਿਉਂਕਿ ਨਾਵਲ ਦੀ ਸਹੀ ਅਤੇ ਤੱਥ ਭਰਪੂਰ ਪਰਿਭਾਸ਼ਾ ਅੱਜ ਤੱਕ ਨਹੀਂ ਹੋ ਸਕੀ। ਜੋ ਕੁਝ ਵੀ ਹੋਇਆ ਹੈ, ਉਹ ਇਕ, ਦੋ

ਜਾਂ ਵੱਧ ਵਿਦਵਾਨਾਂ ਦੇ ਵਿਚਾਰਾਂ ਦੀ ਸਾਂਝ ਦੇ ਅਧਾਰ 'ਤੇ ਹੋਇਆ ਹੈ। ਫਿਰ ਅਸੀਂ ਕਹਿ ਸਕਦੇ ਹਾਂ ਕਿ ਨਾਵਲ ਹੀ ਇਕ ਅਜਿਹੀ ਲੰਬੀ ਸਾਹਿਤਕ ਗਲਪਮਈ ਰਚਨਾ ਹੈ, ਜਿਸ ਵਿਚ ਵਿਆਪਕ ਜੀਵਨ ਦਾ ਵਿਸ਼ਲੇਸ਼ਣ ਪਾਤਰਾਂ, ਕਹਾਣੀ, ਘਟਨਾਵਾਂ, ਵਾਰਤਾਲਾਪ ਅਤੇ ਭਾਸ਼ਾ ਦੁਆਰਾ ਕੋਈ ਨਾਵਲਕਾਰ ਇਕ ਵਿਲੱਖਣ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਤੋਂ ਅਜਨਬੀ ਢੰਗ ਨਾਲ ਇਉਂ ਕਰਦਾ ਹੈ ਕਿ ਗਲਪੀ ਸੰਸਾਰ ਸਚੁਮੱਚ ਦਾ ਸੰਸਾਰ ਨਾ ਹੁੰਦਾ ਹੋਇਆ ਵੀ ਸੱਚਾ ਪ੍ਰਤੀਤ ਹੁੰਦਾ ਹੈ।

1.5 ਨਾਵਲ ਦੇ ਤੱਤ

1.5.1 ਕਥਾ/ਕਹਾਣੀ ਅਤੇ ਕਥਾਨਕ/ਪਲਾਟ:

ਨਾਵਲ ਦਾ ਸਭ ਤੋਂ ਮਹੱਤਵਪੂਰਨ ਤੱਤ ਹੈ ਕਥਾ ਜਾਂ ਕਹਾਣੀ । ਜੀਵਨ ਦੀ ਕਹਾਣੀ ਨੂੰ ਇੱਕ ਕਲਾਤਮਿਕ ਢੰਗ ਨਾਲ ਪੇਸ਼ ਕਰਨ ਨੂੰ ਨਾਵਲ ਰਚਨਾ ਕਹਿੰਦੇ ਹਨ। ਈ. ਐੱਮ. ਫਾਰਸਟਰ ਨੇ ਵੀ ਕਹਾਣੀ ਤੱਤ ਨੂੰ ਨਾਵਲ ਦਾ ਸਭ ਤੋਂ ਜ਼ਰੂਰੀ ਅੰਗ ਮੰਨਿਆ ਹੈ।[21] ਨਾਵਲ ਇੱਕ ਅਜਿਹਾ ਰੂਪਾਕਾਰ ਹੈ ਜਿਸ ਦਾ ਮੂਲ ਤੱਤ ਕਹਾਣੀ ਹੈ। ਇਸ ਕਹਾਣੀ ਤੱਤ ਤੋਂ ਬਿਨਾਂ ਨਾਵਲ ਦੀ ਹੋਂਦ ਸੰਭਵ ਹੀ ਨਹੀਂ। ਕਹਾਣੀ ਆਦਿ ਕਾਲ ਤੋਂ ਮਨੁੱਖ ਦੀ ਸਖੀ ਰਹੀ ਹੈ। ਮਨੁੱਖ ਨੇ ਕਹਾਣੀਆਂ ਦਾ ਸਹਾਰਾ ਵੱਖੋ-ਵੱਖ ਕਾਰਜਾਂ ਲਈ ਲਿਆ ਹੈ, ਜਿਸ ਵਿੱਚ ਮੰਨੋਰੰਜਨ ਤੋਂ ਇਲਾਵਾ ਸੱਭਿਆਚਾਰ ਦੇ ਸੰਚਾਰ ਅਤੇ ਜੰਗਲੀ ਜਾਨਵਰਾਂ ਤੋਂ ਬਚਣ ਲਈ ਜਾਗਦੇ ਰਹਿਣ ਲਈ ਵੀ ਕਹਾਣੀਆਂ ਸੁਣਾ ਕਿ ਉਤਸੁਕਤਾ ਬਣਾਈ ਰੱਖਣ ਲਈ ਕੀਤੀ। ਰਹੱਸ ਦਾ ਨਾਵਲ ਦੇ ਪਲਾਟ ਵਿਚ ਵਿਸ਼ੇਸ਼ ਮਹੱਤਵ ਹੈ ਪਰੰਤੂ ਇਸ ਰਹੱਸ ਨੂੰ ਬਾਅਦ ਵਿਚ ਖੋਲ੍ਹਣਾ ਹੁੰਦਾ ਹੈ। ਭਾਵੇਂ ਪਾਠਕ ਇਸ ਤੋਂ ਅਨਜਾਣ ਹੁੰਦਾ ਹੈ ਪਰ ਨਾਵਲਕਾਰ ਇਨ੍ਹਾਂ ਰਹੱਸਾਂ ਨੂੰ ਬੜੇ ਵਿਧੀ ਪੂਰਨ ਢੰਗ ਨਾਲ ਪਹਿਲਾਂ ਹੀ ਵਿਉਂਤ ਕੇ ਚੱਲਦਾ ਹੈ।

ਕਥਾ/ਕਹਾਣੀ ਲੇਖਕ ਦੀ ਮਰਜ਼ੀ ਅਨੁਸਾਰ ਨਹੀਂ ਚਲਦੀ ਪ੍ਰੰਤੂ ਕਥਾਨਕ ਲੇਖਕ ਦੀ ਸਿਰਜਣਾਤਮਕ ਪ੍ਰਤਿਭਾ ਦੇ ਅਨੁਸਾਰ ਚਲਦਾ ਹੈ। ਨਾਵਲ ਦੀ ਕਹਾਣੀ ਨੂੰ ਕਿਥੋਂ ਸ਼ੁਰੂ ਕਰਨਾ ਹੈ, ਵੱਖ-ਵੱਖ ਘਟਨਾਵਾਂ ਨੂੰ ਕਿਸ ਤਰਤੀਬ ਵਿੱਚ ਪੇਸ਼ ਕਰਨਾ ਹੈ, ਕਹਾਣੀ ਦੀ ਸਮਾਪਤੀ ਕਿਸ ਪੜਾਉ ਉੱਪਰ ਕਰਨੀ ਹੈ ਅਜਿਹੇ ਨਿਰਨੇ ਲੇਖਕ ਨੂੰ ਖ਼ੁਦ ਕਰਨੇ ਪੈਂਦੇ ਹਨ। ਉਪਰੋਕਤ ਚਰਚਾ ਤੋਂ ਸਪੱਸ਼ਟ ਹੈ ਕਿ ਨਾਵਲ ਸਿਰਫ ਕਹਾਣੀ ਨਹੀਂ ਹੁੰਦਾ। ਸਗੋਂ ਇਹ ਤਾਂ ਕਥਾ ਵਸਤੂ ਜਾਂ ਕਹਾਣੀ ਨੂੰ ਤਰਤੀਬ ਵਿੱਚ ਬੰਨ੍ਹ ਕੇ ਪੇਸ਼ ਕਰਨਾ ਹੈ। ਅਰਸਤੂ ਅਨੁਸਾਰ ਵਸਤੂ ਦੋ ਪ੍ਰਕਾਰ ਦੀ ਹੋ ਸਕਦੀ ਹੈ।

1.ਸਰਲ: ਜਿਸ ਕਹਾਣੀ ਵਿੱਚ ਕਿਰਿਆ ਇੱਕੋ,ਨਿਰੰਤਰ ਅਤੇ ਸੰਪੂਰਨ ਹੋਵੇ

2.ਗੁੰਝਲਦਾਰ: ਜਦੋਂ ਕਿਸੇ ਨਾਇਕ/ਪਾਤਰ ਬਾਰੇ ਪਾਠਕ ਦੀ ਸੋਚ ਦੇ ਉਲਟ ਘਟਨਾਵਾਂ ਵਾਪਰਦੀਆਂ ਹਨ

ਗੋਂਦ ਇਕਹਰੀ ਵੀ ਹੋ ਸਕਦੀ ਹੈ ਅਤੇ ਗੁੰਝਲਦਾਰ ਵੀ। ਗੁੰਝਲਦਾਰ ਗੋਂਦ ਵਿਚ ਇਕ ਤੋਂ ਵਧੀਕ ਗੋਂਦਾਂ ਵੀ ਹੋ ਸਕਦੀਆਂ ਹਨ। ਗੋਂਦ ਪੰਜਾਬੀ ਵਿਚ ਅੰਗਰੇਜ਼ੀ ਦੇ ਸ਼ਬਦ ਪਲਾਟ ਦਾ ਅਨੁਵਾਦ ਹੈ। ਨਾਵਲ ਵਿਚ ਪਲਾਟ

ਨਾਵਲ ਦੀ ਸਮੁੱਚੀ ਸਕੀਮ ਨਾਲ ਸੰਬੰਧ ਰੱਖਦਾ ਹੈ। ''ਪਲਾਟ ਨਾਵਲ ਨੂੰ ਵਿਸ਼ੇ ਅਨੁਸਾਰ ਚਿੱਤਰਪਟ ਦਿੰਦਾ ਹੈ ਅਤੇ ਉਹ ਚਿੱਤਰਪਟ ਵਿਚ ਕਹਾਣੀ, ਪਾਤਰ ਅਤੇ ਸੂਝ ਆਸਰੇ ਵਿਸ਼ੇ ਦਾ ਯੋਗ ਨਿਭਾਅ ਕਰਦਾ ਹੈ।''[22] ਇਸ ਤਰ੍ਹਾਂ ਗੋਂਦ ਨਾਵਲ ਦੀ ਤਕਨੀਕ ਦੇ ਸਾਰੇ ਅੰਗਾਂ ਵਿਚ ਸੰਤੁਲਨ ਪੈਦਾ ਕਰਦੀ ਹੈ। ਸਾਰ ਰੂਪ ਵਿਚ ਅਸੀਂ ਕਹਿ ਸਕਦੇ ਹਾਂ ਕਿ ਸਫਲ ਪਲਾਟ ਵਿੱਚ ਮੌਲਿਕਤਾ, ਰੌਚਿਕਤਾ ਅਤੇ ਸੁਭਾਵਿਕਤਾ ਦੇ ਗੁਣ ਜ਼ਰੂਰੀ ਹਨ।

1.5.3 ਪਾਤਰ ਤੇ ਪਾਤਰ ਉਸਾਰੀ

ਪਾਤਰ ਨਾਵਲ ਦਾ ਇੱਕ ਮਹੱਤਵਪੂਰਨ ਤੱਤ ਹੈ, ਕਿਉਂਕਿ ਨਾਵਲਕਾਰ ਸਾਰੀ ਕਥਾ ਕਿਸੇ ਪਾਤਰ ਦੇ ਦੁਆਲੇ ਹੀ ਖੜ੍ਹੀ ਕਰਦਾ ਹੈ। ਇਸੇ ਲਈ ਸ਼ਾਇਦ ਪਾਤਰ ਨੂੰ ਨਾਵਲ ਦਾ ਸਭ ਤੋਂ ਜ਼ਰੂਰੀ ਤੱਤ ਮੰਨਿਆ ਜਾਂਦਾ ਹੈ। ਨਾਵਲ ਵਿੱਚ ਇੱਕ ਮੁੱਖ ਪਾਤਰ ਹੁੰਦਾ ਹੈ ਬਾਕੀ ਉਸ ਦੇ ਦੁਆਲੇ ਇਸ ਤਰ੍ਹਾਂ ਘੁੰਮਦੇ ਹਨ ਜਿਵੇਂ ਸੂਰਜ ਦੇ ਦੁਆਲੇ ਗ੍ਰਹਿ। ਨਾਇਕ ਜਾਂ ਮੁੱਖ ਪਾਤਰ ਦਾ ਵਿਰੋਧੀ ਪ੍ਰਤੀਨਾਇਕ ਬਣਦਾ ਹੈ। ਇਹ ਨਾਇਕ ਦੇ ਜੀਵਨ ਨੂੰ ਅਸਫ਼ਲ ਬਣਾ ਦੇਣ ਦੀ ਸ਼ਕਤੀ ਰੱਖਦਾ ਹੈ। ਇਸ ਤਰ੍ਹਾਂ ਪਾਤਰ ਆਮ ਜ਼ਿੰਦਗੀ ਵਿਚ ਵਾਪਰਦੀਆਂ ਘਟਨਾਵਾਂ ਵਰਗੀਆਂ ਘਟਨਾਵਾਂ ਨੂੰ ਜਨਮ ਦਿੰਦੇ ਹਨ ਅਤੇ ਆਪ ਵੀ ਆਮ ਜ਼ਿੰਦਗੀ ਵਿਚ ਆਮ ਮਿਲਦੇ ਇਨਸਾਨਾਂ ਵਰਗੇ ਹੋਣੇ ਚਾਹੀਦੇ ਹਨ। ਉਹਨਾਂ ਦੀ ਸੋਚ ਅਤੇ ਪਹਿਰਾਵਾ ਵੀ ਆਮ ਹੋਣਾ ਚਾਹੀਦਾ ਹੈ ਕਿਉਂਕਿ ਲੇਖਕ ਨੇ ਪਾਤਰਾਂ ਦੇ ਨਿੱਜੀ ਵਿਚਾਰਾਂ ਅਤੇ ਗਤੀਵਿਧੀਆਂ ਦਾ ਸਧਾਰਨੀਕਰਨ ਕਰਨਾ ਹੁੰਦਾ ਹੈ।

ਪਾਤਰ ਉਸਾਰੀ ਲਈ ਦੋ ਵਿਰੋਧੀ ਢੰਗਾਂ ਦੀ ਵਰਤੋਂ ਕੀਤੀ ਜਾਂਦੀ ਹੈ:-

1. ਪ੍ਰਤੱਖ ਪੱਧਰ ਦੀ

2. ਅਪ੍ਰਤੱਖ ਪੱਧਰ ਦੀ

ਪ੍ਰਤੱਖ ਪੱਧਰ 'ਤੇ ਨਾਵਲਕਾਰ ਪਾਤਰਾਂ ਦੇ ਚਿੱਤਰ ਪੇਸ਼ ਕਰਦਾ ਹੈ ਤੇ ਇਹ ਚਿੱਤਰ ਮੋਟੇ ਤੌਰ 'ਤੇ ਪਾਤਰਾਂ ਦੀਆਂ ਭਾਵਨਾਵਾਂ ਅਤੇ ਵਰਤੋਂ ਵਰਤਾਰੇ ਨੂੰ ਪੇਸ਼ ਕਰਦੇ ਹਨ। ਅਪ੍ਰਤੱਖ ਵਿਧੀ ਵਿਚ ਨਾਵਲਕਾਰ ਆਪਣੀਆਂ ਨਾਵਲਕਾਰ ਆਪਣੀਆਂ ਟਿੱਪਣੀਆਂ ਜਾਂ ਦੂਸਰੇ ਪਾਤਰਾਂ ਦੀ ਕਿਸੇ ਇੱਕ ਪਾਤਰ ਬਾਰੇ ਰਾਇ ਤੋਂ ਪਾਤਰ ਉਸਾਰੀ ਕਰਦਾ ਹੈ।

ਪਾਤਰ ਦੋ ਕਿਸਮ ਦੇ ਹੁੰਦੇ ਹਨ

1. ਚਪਟੇ ਪਾਤਰ

2. ਗੋਲ ਜਾਂ ਬਹੁਪੱਖੀ ਪਾਤਰ

ਚਪਟੇ ਪਾਤਰ ਇੱਕੋ ਝਲਕ ਵਿੱਚ ਹੀ ਪ੍ਰਤੱਖ ਜਾ ਸਪੱਸ਼ਟ ਹੋ ਜਾਂਦੇ ਹਨ। ਬੱਚੇ, ਬੁੱਢੇ ਅਤੇ ਮੰਦਬੁੱਧੀ ਪਾਤਰ ਇਸੇ ਸ਼੍ਰੇਣੀ ਵਿੱਚ ਰੱਖ ਕੇ ਘੜੇ ਜਾਂਦੇ ਹਨ। ਇਹਨਾਂ ਪਾਤਰਾਂ 'ਤੇ ਸਥਿਤੀ ਜਾਂ ਵੱਡੇ ਪਾਤਰਾਂ ਦੇ ਬਦਲਣ ਦਾ ਕੋਈ ਅਸਰ ਨਹੀਂ ਹੁੰਦਾ। ਬਹੁਪੱਖੀ ਜਾਂ ਗੋਲ ਪਾਤਰ ਗੋਲ ਜਾਂ ਚੌਰਸ ਵਸਤੂ ਵਾਂਗ ਇਕੋ ਝਲਕ ਵਿੱਚ ਸਾਰੇ ਦਿਖਾਈ ਨਹੀਂ ਦਿੰਦੇ। ਉਹਨਾਂ ਦੇ ਸੁਭਾਅ ਅਤੇ ਲੱਛਣਾਂ ਦੀਆਂ ਪਰਤਾਂ ਅੰਤ ਤੱਕ ਖੁੱਲਦੀਆਂ ਰਹਿੰਦੀਆਂ ਹਨ। ਮੁੱਖ ਪਾਤਰ ਖਾਸ ਕਰ ਨਾਇਕ, ਨਾਇਕਾ, ਪ੍ਰਤੀਨਾਇਕ ਅਤੇ ਪ੍ਰਤੀਨਾਇਕਾ ਇਸ ਸ੍ਰੇਣੀ ਵਿੱਚ ਆਉਂਦੇ ਹਨ। ਜਿਸ ਪਾਤਰ ਦੇ ਨਿਰਮਾਣ ਵਿੱਚ ਜ਼ਿਆਦਾ ਸਮਾਂ ਲੱਗੇ ਉਸ ਦਾ ਵਿਕਾਸ ਹੋਣਾ ਕੁਦਰਤੀ ਹੈ। ਘੱਟ ਬੁੱਧੀ, ਬੱਚੇ ਅਤੇ ਬੁੱਢੇ ਪਾਤਰ ਇਕ ਦੋ ਗੁਣਾਂ ਤੱਕ ਸੀਮਤ ਹੋ ਕੇ ਰਹਿ ਜਾਂਦੇ ਹਨ। ਜਦੋਂ ਕੇ ਵੱਧ ਬੁੱਧੀ ਵਾਲੇ ਪਾਤਰ ਦੇ ਗੁਣ ਸਮੇਂ ਨਾਲ, ਸਥਿਤੀ ਤੇ ਸੰਘਰਸ਼ ਦੇ ਬਦਲਣ ਜਾਂ ਉਲਝਣ ਨਾਲ, ਬਿਮਾਰੀ ਅਤੇ ਸੰਕਟ ਆਦਿ ਨਾਲ ਨਿਖਰਦੇ ਹਨ। ਇਹਨਾਂ ਨੂੰ ਗੋਲ ਪਾਤਰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਚਪਟੇ ਪਾਤਰ ਖੁੱਲ੍ਹਦੇ ਹਨ ਜਦੋਂ ਕੇ ਗੋਲ ਪਾਤਰ ਵਿਕਸਿਤ ਹੁੰਦੇ ਹਨ। ਲੇਖਕ ਨੂੰ ਪਾਤਰ ਉਸਾਰੀ ਸਮੇਂ ਸਾਵਧਾਨੀ ਤੋਂ ਕੰਮ ਲੈਣਾ ਪੈਂਦਾ ਹੈ ਕਿਉਂਕਿ ਪਾਤਰਾਂ ਵਿਚਲੀ ਭਾਵਾਤਮਕ ਸੁਹਿਰਦਤਾ ਹੀ ਨਾਵਲ ਦੀ ਸਫ਼ਲਤਾ ਹੈ।

1.5.4 ਵਾਰਤਾਲਾਪ

ਨਾਵਲ ਵਿਚ ਵਾਰਤਾਲਾਪ ਦਾ ਵਿਸ਼ੇਸ਼ ਮਹੱਤਵ ਹੈ ਭਾਵੇਂ ਨਾਟਕ ਵਾਂਗ ਕੇਂਦਰੀ ਮਹਾਨਤਾ ਪ੍ਰਾਪਤ ਨਹੀਂ ਹੁੰਦੀ, ਫਿਰ ਵੀ ਵਾਰਤਾਲਾਪ ਨਾਵਲੀ ਘਟਨਾਵਾਂ ਨੂੰ ਆਪਸ ਵਿੱਚ ਜੋੜਦੇ ਅਤੇ ਕਹਾਣੀ ਨੂੰ ਰੌਚਿਕਤਾ ਅਤੇ ਗਤੀਸ਼ੀਲਤਾ ਪ੍ਰਦਾਨ ਕਰਦੇ ਹਨ। ਵਾਰਤਾਲਾਪਾਂ ਰਾਹੀਂ ਹੀ ਲੇਖਕ ਪਾਤਰਾਂ ਦੀ ਉਸਾਰੀ ਕਰਦਾ ਹੈ ਅਤੇ ਉਹਨਾਂ ਦੇ ਗੁਣ ਔਗੁਣਾਂ ਬਾਰੇ ਦੱਸਦਾ ਹੈ। ਪਰੰਤੂ ਵਾਰਤਾਲਾਪ ਸਿਰਜਣਾ ਕੋਈ ਖੱਬੇ ਹੱਥ ਦੀ ਖੇਡ ਨਹੀਂ ਕਿਉਂਕਿ ਲੇਖਕ ਨੂੰ ਹਰ ਪਾਤਰ ਦੇ ਮਾਨਸਿਕ ਅਤੇ ਸਮਾਜਕ ਪੱਧਰ ਅਨੁਸਾਰ ਵਾਰਤਾਲਾਪਾਂ ਦੀ ਸਿਰਜਣਾ ਕਰਨੀ ਪੈਂਦੀ ਹੈ। ਮਨੋਵਿਗਿਆਨਿਕ ਪ੍ਰਵਿਰਤੀ ਦੇ ਨਾਵਲਕਾਰ ਨੂੰ ਆਪਣੇ ਪਾਤਰਾਂ ਦੇ ਵਿਚਾਰਾਂ ਅਤੇ ਭਾਵਾਂ ਦੀ ਅੰਦਰੂਨੀ ਕਸ਼ਮਕਸ਼ ਵੱਲ ਵਧੇਰੇ ਧਿਆਨ ਦੇਣਾ ਪੈਂਦਾ ਹੈ। ਵਾਰਤਾਲਾਪ ਸਿਰਜਣਾ ਲਈ ਨਾਵਲਕਾਰ ਨੂੰ ਇੱਕ ਨਾਟਕਕਾਰ ਵਾਂਗ ਯਥਾਰਥ ਅਥੇ ਕਲਪਨਾ ਦਾ ਸਹਾਰਾ ਲੈਣਾ ਪੈਂਦਾ ਹੈ। ਅਲੋਚਕਾਂ ਦੇ ਅਨੁਸਾਰ ਨਾਵਲੀ ਰਚਨਾ ਵਿੱਚ ਸੰਵਾਦ ਬੜਾ ਸੁਭਾਵਿਕ ਹੋਣਾ ਚਾਹੀਦਾ ਹੈ, ਵਾਰਤਾਲਾਪ ਵਾਤਾਵਰਨ ਅਤੇ ਸਥਿਤੀਆਂ ਦੇ ਅਨੁਕੂਲ ਹੋਣੇ ਚਾਹੀਦੇ ਹਨ। ਨਾਵਲ ਅਤੇ ਇਸ ਦੇ ਕਥਾਨਕ ਦੀ ਸਜੀਵਤਾ ਸਮੇਂ, ਸਥਾਨ ਅਤੇ ਸਥਿਤੀਆਂ ਮੁਤਾਬਿਕ ਢੁਕਵੇਂ ਵਾਰਤਾਲਾਪਾਂ ਦੀ ਵਰਤੋਂ 'ਤੇ ਨਿਰਭਰ ਕਰਦੀ ਹੈ। ਅਢੁੱਕਵੇਂ ਵਾਰਤਾਲਾਪ ਨਾਵਲੀ ਪ੍ਰਭਾਵ ਨੂੰ ਖੰਡਿਤ ਕਰ ਦਿੰਦੇ ਹਨ।

ਵਾਰਤਾਲਾਪ ਦੁਆਰਾ ਨਾਵਲਕਾਰ ਨੇ ਸਿਰਫ਼ ਪਾਤਰ ਉਸਾਰੀ ਹੀ ਨਹੀਂ ਕਰਨੀ ਹੁੰਦੀ ਸਗੋਂ ਪਲਾਟ ਅਤੇ ਕਥਾ ਨੂੰ ਵੀ ਅੱਗੇ ਤੋਰ ਕੇ ਗਤੀਸ਼ੀਲ ਕਰਨਾ ਹੁੰਦਾ ਹੈ। ਵਾਰਤਾਲਾਪ ਦਾ ਮਹੱਤਵ ਬਹੁਪੱਖੀ ਹੁੰਦਾ ਹੈ। ਇਸ ਦੀ ਸਹਾਇਤਾ ਨਾਲ ਪਾਤਰਾਂ ਦੇ ਲੁਕਵੇਂ ਗੁਣਾਂ ਦੀ ਜਾਣਕਾਰੀ ਅਤੇ ਛੁਪੇ ਮਨੋਰਥਾਂ ਬਾਰੇ ਵੀ ਪਾਠਕ ਨੂੰ ਪਤਾ ਲੱਗਦਾ ਹੈ। ਵਾਰਤਾਲਾਪ ਕਈ ਵਾਰ ਕਹਾਣੀ ਦੀ ਰਫਤਾਰ ਰੋਕ ਕੇ ਪਾਠਕ ਨੂੰ ਸਾਹ ਵੀ ਦਿਵਾਉਂਦੇ ਹਨ। ਨਾਵਲ ਦੇ ਪ੍ਰਸੰਗ ਵਿਚ ਵਾਰਤਾਲਾਪ ਦੀ ਉਹੀ ਮਹੱਤਤਾ ਹੈ ਜੋ ਭਾਰਤੀ ਫ਼ਿਲਮਾਂ ਵਿੱਚ ਸੰਗੀਤ ਦੀ। ਗੀਤਾਂ ਵਾਂਗ ਹੀ ਵਾਰਤਾਲਾਪ ਕੁਝ ਸਥਿਤੀਆਂ ਨੂੰ ਡੂੰਘਾ, ਭਾਵਪੂਰਤ ਅਤੇ ਕਾਵਿਕ ਬਣਾ ਦਿੰਦੇ ਹਨ। ਵਾਰਤਾਲਾਪ ਦੀ ਭੂਮਿਕਾ ਬਿਰਤਾਂਤ ਦੀ ਨੀਰਸਤਾ ਨੂੰ ਤੋੜ ਕੇ ਨਾਵਲੀ ਬਿਰਤਾਂਤ ਵਿੱਚ ਵਿਵਧਤਾ ਅਤੇ ਵੰਨਸੁਵੰਨਤਾ ਪੈਦਾ ਕਰਨ ਨਾਲ ਜੁੜੀ ਹੋਈ ਹੈ। ਰੂਸੀ ਵਿਦਵਾਨ ਮਿਖਾਇਲ ਬਾਖ਼ਤਿਨ ''ਨਾਵਲੀ ਰਚਨਾ ਪ੍ਰਬੰਧ ਖੁੱਲ੍ਹਾ ਸੁਭਾਅ ਰੱਖਦਾ ਹੈ ਜਿਸ ਦੇ ਕਦੀ ਇਕਹਰਾ ਅਤੇ ਸਥਿਰ ਬਿੰਦੂ ਨਹੀਂ ਹੁੰਦਾ ਸਗੋਂ ਇਹ ਉਸ ਚੁਰਾਹੇ ਵਾਂਗ ਹੁੰਦਾ ਹੈ ਜਿਥੇ ਬਹੁਤ ਸਾਰੇ ਅਰਥਾਂ ਦੇ ਮਾਰਗ ਇੱਕ ਦੂਜੇ ਦੇ ਆਰ-ਪਾਰ ਫੈਲਦੇ ਰਹਿੰਦੇ ਹਨ। ''[23]

1.5.5 ਵਾਤਵਰਨ ਅਤੇ ਸਥਾਨਕ ਰੰਗਣ

ਮਨੁੱਖ ਦੇ ਵਿਕਾਸ ਵਿੱਚ ਭੂਗੋਲਿਕ, ਆਰਥਿਕ, ਸਮਾਜਕ, ਰਾਜਨੀਤਿਕ ਅਤੇ ਧਾਰਮਿਕ ਅਕੀਦੇ ਮਹੱਤਵਪੂਰਨ ਭੂਮਿਕਾ ਨਿਭਾਉਂਦੇ ਹਨ। ਮਨੁੱਖ ਜੋ ਵੀ ਹੈ ਉਹ ਸਿਰਫ਼ ਮਨੁੱਖ ਨਿਰੋਲ ਰੂਪ ਵਿੱਚ ਖ਼ੁਦ ਹੀ ਨਹੀਂ ਹੁੰਦਾ ਸਗੋਂ ਉਹ ਉਪਰੋਕਤ ਸਾਰੇ ਖੇਤਰਾਂ ਦਾ ਪ੍ਰਭਾਵ ਕਬੂਲਦਾ ਹੋਇਆ ਆਪਣੀ ਸ਼ਖ਼ਸੀਅਤ ਘੜਦਾ ਹੈ। ਇਸ ਲਈ ਵਾਤਾਵਰਨ, ਦੇਸ਼ ਕਾਲ ਜਾਂ ਸਥਾਨਕ ਰੰਗਣ ਦਾ ਕਿਸੇ ਵੀ ਸਾਹਿਤਕ ਰਚਨਾ ਵਿੱਚ ਵਿਸ਼ੇਸ਼ ਅਤੇ ਮਹੱਤਵਪੂਰਨ ਸਥਾਨ ਹੁੰਦਾ ਹੈ। ਇੱਕ ਸਫ਼ਲ ਲੇਖਕ ਉਹ ਹੀ ਮੰਨਿਆ ਜਾਂਦਾ ਹੈ ਜੋ ਸਮੇਂ ਸਥਾਨ ਅਤੇ ਸਥਿਤੀਆਂ ਮੁਤਾਬਿਕ ਵਾਤਾਵਰਨ ਅਤੇ ਪਾਤਰਾਂ ਦੀ ਵੇਸ-ਭੂਸ਼ਾ ਘੜ ਸਕੇ ਇਸ ਲਈ ਲੇਖਕ ਨੂੰ ਉਪਰੋਕਤ ਸਾਰੇ ਖੇਤਰਾਂ ਦੀ ਡੂੰਘੀ ਸਮਝ ਹੋਣੀ ਚਾਹੀਦੀ ਹੈ ਜਾਣਕਾਰੀ ਦੀ ਘਾਟ ਕਾਰਨ ਕੀਤੀ ਗਈ ਛੋਟੀ ਜਿਹੀ ਗ਼ਲਤੀ ਵੀ ਪਾਠਕਾਂ ਵਿੱਚ ਮਜ਼ਾਕ ਦਾ ਕਾਰਨ ਬਣ ਸਕਦੀ ਹੈ। ਉਦਾਹਰਨ ਵਜੋਂ ਮੁਗ਼ਲ ਕਾਲ ਨਾਲ ਸਬੰਧਿਤ ਸਾਹਿਤਕ ਰਚਨਾ ਕਰਨ ਲਈ ਰਚਨਹਾਰ ਨੂੰ ਉਸ ਸਮੇਂ ਦੀ ਬੋਲੀ, ਪਹਿਰਾਵਾ ਅਤੇ ਧਾਰਮਿਕ ਰੀਤੀ ਰਿਵਾਜ਼ਾਂ ਦੀ ਸਮਝ ਹੋਣੀ ਚਾਹੀਦੀ ਹੈ। ਉਸ ਸਮੇਂ ਦੇ ਕਿਸੇ ਪਾਤਰ ਨੂੰ ਲੇਖਕ ਜੇ ਕੋਟ-ਪੈਂਟ ਪਵਾ ਕੇ ਟਾਈ ਲਵਾ ਦੇਵੇ ਤਾਂ ਲੇਖਕ ਸਮਾਜ ਵਿੱਚ ਹਾਸੇ-ਮਜ਼ਾਕ ਦਾ ਪਾਤਰ ਬਣ ਕੇ ਰਹਿ ਜਾਵੇਗਾ। ਸਫ਼ਲ ਅਤੇ ਸੁਚੱਜਾ ਵਾਤਾਵਰਨ ਉਸਾਰਨ ਲਈ ਲੇਖਕ ਨੂੰ ਘਟਨਾ ਦੇ ਸਥਾਨ, ਸਮਾਂ ਅਤੇ ਸਮਕਾਲੀ ਪ੍ਰਸਥਿਤੀਆਂ ਦਾ ਸੰਪੂਰਨ ਗਿਆਨ ਹੋਵੇ ਖ਼ਾਸ ਤੌਰ ਤੇ ਇਤਿਹਾਸਕ ਨਾਵਲਾਂ ਦੀ ਸਿਰਜਣਾ ਵਿੱਚ ਤਾਂ ਇਸ ਦਾ ਮਹੱਤਵ ਹੋਰ ਵੀ ਜ਼ਿਆਦਾ ਵਧ ਜਾਂਦਾ ਹੈ। ਨਾਵਲ ਵਿੱਚ ਪ੍ਰਿਸ਼ਟ ਭੂਮੀ ਦਾ ਬਹੁਤ ਮਹੱਤਵ ਹੈ ਪਰੰਤੂ ਨਾਵਲਕਾਰ ਪੂਰਨ ਰੂਪ ਵਿੱਚ ਇਸ ਦੀ ਨਕਲ ਨਹੀਂ ਕਰਦਾ ਸਗੋਂ ਇਸਦੀ ਪੁਨਰ ਸਿਰਜਣਾ ਆਪਣੀਆਂ ਕਲਾਤਮਕ ਛੋਹਾਂ ਨਾਲ ਕਰਦਾ ਹੈ। ਪੰਜਾਬੀ ਨਾਵਲਕਾਰ ਵਾਤਾਵਰਨ ਦੇ ਮਹੱਤਵ ਬਾਰੇ ਕਾਫ਼ੀ ਚੇਤਨ ਹਨ। ਨਾਨਕ ਸਿੰਘ ਦੇ

ਨਾਵਲਾਂ ਵਿਚ ਸਥਾਨਕ ਰੰਗਨ ਦੀ ਪੇਸ਼ਕਾਰੀ ਪੂਰੀ ਨਿਪਨੁੰਤਾ ਨਾਲ ਚਿਤਰੀ ਮਿਲਦੀ ਹੈ। ਪੰਜਾਬੀ ਨਾਵਲਕਾਰਾਂ ਵਿੱਚ ਪ੍ਰਕ੍ਰਿਤੀ ਚਿਤਰਨ ਦੀ ਪ੍ਰਵਿਰਤੀ ਕਾਫ਼ੀ ਪ੍ਰਚਲਿਤ ਰਹੀ ਹੈ।

1.5.5 ਉਦੇਸ਼

ਨਾਵਲ ਦੇ ਸਰੂਪ ਦਾ ਸੰਕਲਪ ਸਿੱਧੇ ਰੂਪ ਵਿੱਚ ਉਦੇਸ਼ ਨਾਲ ਜੁੜਿਆ ਹੁੰਦਾ ਹੈ, ਕਿਉਂਕਿ ਬਿਨਾਂ ਉਦੇਸ਼ ਤੋਂ ਕੋਈ ਵੀ ਰਚਨਾ ਸੰਪੂਰਨ ਨਹੀਂ ਹੁੰਦੀ। ਹਰ ਰਚਨਾ ਪਿੱਛੇ ਰਚਨਹਾਰ ਦਾ ਕੋਈ ਨਾ ਕੋਈ ਮਨੋਰਥ ਜਾਂ ਉਦੇਸ਼ ਜ਼ਰੂਰ ਹੁੰਦਾ ਹੈ। ਕਈ ਲੇਖਕ ਇਸ ਕਾਰਨ ਲਿਖਦੇ ਹਨ ਕਿ ਉਹ ਤਜ਼ਰਬਿਆਂ ਨੂੰ ਵਿਲੱਖਣ ਰੂਪ ਪ੍ਰਦਾਨ ਕਰਕੇ ਪਾਠਕ ਨੂੰ ਗਦਗਦ ਕਰ ਸਕਣ। ਨਾਵਲਕਾਰ ਦਾ ਉਦੇਸ਼ ਉਦੋਂ ਪੂਰਾ ਹੁੰਦਾ ਹੈ ਜਦੋਂ ਉਹ ਪਾਠਕਾਂ ਨੂੰ ਆਪਣੇ ਪਾਤਰਾਂ ਦੀ ਸਚਾਈ ਬਾਰੇ ਜਾਣਕਾਰੀ ਦਿੰਦਾ ਹੈ, ਕਿਉਂਕਿ ਹਰ ਲੇਖਕ ਕੋਈ ਨਾ ਕੋਈ ਅਦਭੁੱਤ ਸੱਚ ਹੁੰਦਾ ਹੈ। ਜਿਸ ਨੂੰ ਉਹ ਆਪਣੇ ਪਾਠਕਾਂ ਨਾਲ ਸਾਂਝਾ ਕਰਦਾ ਹੈ। ਨਾਵਲਕਾਰ ਨੇ ਬੀਤੇ ਸਮੇਂ ਦੀਆਂ ਘਟਨਾਵਾਂ ਨੂੰ ਨਾਟਕੀ ਢੰਗ ਨਾਲ ਪੇਸ਼ ਕਰਕੇ ਅਦਭੁਤ ਅਤੇ ਪਰਾਸਰੀਰਕ ਵੇਰਵਿਆਂ ਦਾ ਪ੍ਰਯੋਗ ਕਰਕੇ ਪਾਠਕ ਨੂੰ ਅਚੰਭਿਤ ਕਰਨ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਨੀ ਹੁੰਦੀ ਹੈ। ਪ੍ਰੰਤੂ ਨਾਵਲਕਾਰ ਦੀ ਇੱਕ ਵੱਡੀ ਸਮੱਸਿਆ ਹੁੰਦੀ ਹੈ ਕਿ ਉਹ ਇਹਨਾਂ ਵੇਰਵਿਆਂ ਨੂੰ ਇਸੇ ਤਰ੍ਹਾਂ ਹੀ ਪੇਸ਼ ਨਹੀਂ ਕਰਦਾ ਸਗੋਂ ਉਹਨਾਂ ਨੂੰ ਜੀਵਨ ਦੇ ਯਥਾਰਥ ਦੀ ਪੇਸ਼ਕਾਰੀ ਦਾ ਭਰਮ ਵੀ ਪੈਦਾ ਕਰਨਾ ਪੈਂਦਾ ਹੈ, ਇਸ ਲਈ ਉਹ ਆਪਣੇ ਪਾਤਰਾਂ ਅਤੇ ਘਟਨਾਵਾਂ ਨੂੰ ਸੰਭਵ ਬਣਾ ਕਿ ਪੇਸ਼ ਕਰਦਾ ਹੈ।

ਇਸ ਪ੍ਰਕਾਰ ਨਾਵਲਕਾਰ ਆਪਣੇ ਨਾਵਲ ਦੇ ਸਥਾਨ ਨੂੰ ਬੜੀ ਸਾਵਧਾਨੀ ਨਾਲ ਬਿਆਨਦਾ ਹੈ ਹਰ ਚੀਜ਼ ਵੱਲ ਪੂਰਾ ਧਿਆਨ ਕੇਂਦਰਿਤ ਕਰਦਾ ਹੈ ਅਤੇ ਨਾਵਲ ਦੀਆ ਘਟਨਾਵਾਂ ਨੂੰ ਬਿਆਨਦੇ ਸਮੇਂ ਉਹ ਇਤਿਹਾਸ ਦੇ ਇਕ ਵਿਸ਼ੇਸ਼ ਕਾਲ ਦੀ ਚੋਣ ਕਰਦਾ ਹੈ। ਸੋ ਉਦੇਸ਼ ਨਾਵਲ ਦਾ ਅਜਿਹਾ ਤੱਤ ਹੈ ਜਿਹੜਾ ਜੀਵਨ-ਦਰਸ਼ਨ, ਜੀਵਨ ਆਲੋਚਨਾ ਤੇ ਜੀਵਨ ਵਿਆਖਿਆ ਕਰਨ ਦਾ ਮਾਧਿਅਮ ਬਣਦਾ ਹੈ। ਇਸ ਤੱਤ ਦੀ ਨਾਵਲੀ ਰਚਨਾ ਵਿਚ ਵਿਸ਼ੇਸ਼ ਤੇ ਵਿਲੱਖਣ ਹੋਂਦ ਹੈ।

ਡਾ: ਸਵਿੰਦਰ ਸਿੰਘ ਉੱਪਲ ਇਸ ਤੱਤ ਬਾਰੇ ਵਿਚਾਰ ਕਰਦੇ ਹੋਏ ਇਕ ਥਾਂ ਲਿਖਦੇ ਹਨ:

''ਕੁੱਝ ਨਾਵਲਕਾਰ ਆਪਣੀ ਜੀਵਨ ਦਿੱਬ-ਦ੍ਰਿਸ਼ਟੀ ਕਿਸੇ ਸਿਧਾਂਤ ਨਾਲ ਬੱਝ ਕੇ ਲੱਭਦੇ ਹਨ। ਇੰਝ ਕਰਨ ਨਾਲ ਉਹਨਾਂ ਦੀ ਸ਼ਖ਼ਸੀਅਤ ਅਤੇ ਸੁਤੰਤਰ ਚਿੰਤਨ ਵਿਕਾਸ ਨਹੀਂ ਕਰ ਸਕਦੇ।''[24]

1.5.ਭਾਸ਼ਾ ਅਤੇ ਸ਼ੈਲੀ

ਸ਼ੈਲੀ ਹੀ ਮਨੁੱਖ ਹੈ। ਸ਼ੈਲੀ ਹਰ ਲੇਖਕ ਦੀ ਵੱਖਰੀ ਅਤੇ ਮੌਲਿਕ ਹੁੰਦੀ ਹੈ ਸਾਹਿਤਕ ਰਚਨਾ ਦਾ ਹਰ ਤੱਤ ਸ਼ੈਲੀ ਦੁਆਰਾ ਹੀ ਪ੍ਰਦਸ਼ਿਤ ਹੁੰਦਾ ਹੈ। ਲੇਖਕ ਦੀ ਸਫ਼ਲਤਾ ਜਾਂ ਅਸਫ਼ਤਾ ਉਸਦੀ ਸ਼ੈਲੀ ਅਤੇ ਸ਼ਬਦਾਵਲੀ ਤੇ ਨਿਰਭਰ ਕਰਦੀ ਹੈ। ਮੱਧਕਾਲ ਵਿੱਚ ਹੀਰ ਦਾ ਕਿੱਸਾ ਕਈ ਲੇਖਕਾਂ ਨੇ ਲਿਖਿਆ ਪਰੰਤੂ ਵਾਰਸ ਦੀ ਵਿਲੱਖਣ ਸ਼ੈਲੀ ਸਦਕਾ ਹੀ ਜਨ ਪ੍ਰਵਾਨ ਹੋਇਆ । ਸ਼ੈਲੀ ਸਾਰੇ ਤੱਤਾਂ ਨੂੰ ਸੁਭਾਵਿਕ ਰੂਪ ਵਿੱਚ ਜੋੜ ਕੇ ਨਵਾਂ ਰਸ ਪੈਦਾ ਕਰਨ ਦਾ ਹੀ ਨਾਂ ਹੈ। ਨਾਵਲ ਕਈ ਸ਼ੈਲੀਆਂ ਵਿੱਚ ਲਿਖਿਆ ਜਾਂਦਾ ਹੈ ਜਿਵੇਂ ਆਤਮ ਕਥਾ ਸ਼ੈਲੀ, ਡਾਇਰੀ ਸ਼ੈਲੀ, ਕਥਾ ਸ਼ੈਲੀ ਅਤੇ ਪੱਤਰ ਸ਼ੈਲੀ ਆਦਿ। ਨਾਵਲਕਾਰ ਵੱਖਰੀਆਂ-ਵੱਖਰੀਆਂ ਜੁਗਤਾਂ ਦੀ ਵਰਤੋਂ ਕਰਦੇ ਹੋਏ ਕਹਾਣੀ ਨੂੰ ਆਦਿ, ਮੱਧ ਜਾਂ ਅੰਤ ਤੋਂ ਸ਼ੁਰੂ ਕਰਦੇ ਹਨ। ਸ਼ੈਲੀ ਤੋਂ ਨਾਵਲਕਾਰ ਦੀ ਸ਼ਖ਼ਸੀਅਤ ਵੀ ਪਛਾਣੀ ਜਾਂਦੀ ਹੈ। ਪਰੰਤੂ ਚੰਗਾ ਲੇਖਕ ਨਾਵਲੀ ਕਥਾ ਵਿੱਚੋਂ ਨਾ ਤਾਂ ਸਪੱਸ਼ਟ ਰੂਪ ਵਿੱਚ ਪਾਠਕ ਦੇ ਸਾਹਮਣੇ ਆਉਂਦਾ ਹੈ ਅਤੇ ਨਾ ਹੀ ਅਲੋਪ ਹੁੰਦਾ ਹੈ। ਉੱਪਰ ਦੱਸੇ ਅਨੁਸਾਰ ਨਾਵਲੀ ਸ਼ੈਲੀਆਂ ਕਈ ਪ੍ਰਕਾਰ ਦੀਆਂ ਪ੍ਰਚਲਿਤ ਹਨ ਹਰ ਲੇਖਕ ਨੇ ਆਪਣੀ ਸੋਂਖ ਅਤੇ ਪਹੁੰਚ ਅਨੁਸਾਰ ਸ਼ੈਲੀ ਦੀ ਵਰਤੋਂ ਕਰਨੀ ਹੁੰਦੀ ਹੈ। ਡਾ. ਪ੍ਰਤਾਪ ਨਰਾਇਣ ਟੰਡਨ ਨੇ ਨਾਵਲੀ ਸ਼ੈਲੀਆਂ ਦਾ ਵਰਗੀਕਰਨ ਹੇਠ ਲਿਖੇ ਅਨੁਸਾਰ ਕੀਤਾ ਹੈ;

ਵਰਣਾਤਮਿਕ ਸ਼ੈਲ, ਆਤਮ-ਕਥਾਤਮਕ ਸ਼ੈਲੀ, ਪੱਤਰ ਸ਼ੈਲੀ, ਡਾਇਰੀ ਸ਼ੈਲੀ, ਸੰਵਾਦ ਸ਼ੈਲੀ, ਨਾਟਕੀ ਸ਼ੈਲੀ, ਕਾਵਿਕ ਸ਼ੈਲੀ, ਲੋਕ ਕਥਾਤਮਕ ਸ਼ੈਲੀ, ਆਂਚਲਿਕ ਸ਼ੈਲੀ, ਮਨੋਵਿਸ਼ਲੇਸ਼ਣਾਤਮਕ ਸ਼ੈਲੀ

ਸ਼ੈਲੀ ਵਿੱਚ ਲੇਖਕ ਦਾ ਨਿੱਜ ਤੱਤ ਹੋਣਾ ਵੀ ਜ਼ਰੂਰੀ ਹੈ ਕਿਉਂਕਿ ਇਸ ਤੋਂ ਹੀ ਲੇਖਕ ਪਛਾਣਿਆ ਜਾਂਦਾ ਹੈ। ਨਾਵਲਕਾਰ ਆਪਣੇ ਸਹਿਜ ਗਿਆਨ ਦੁਆਰਾ ਰਚਨਾ ਨੂੰ ਸੁਭਾਵਿਕਤਾ ਦਾ ਅੰਸ਼ ਪ੍ਰਦਾਨ ਕਰਦਾ ਹੋਇਆ ਨਿੱਜੀ ਸ਼ੈਲੀ ਦਾ ਰੰਗ ਵੀ ਦਿਖਾ ਜਾਂਦਾ ਹੈ। ਟਾਲਸਟਾਇ, ਗੋਰਕੀ ਅਤੇ ਡਿਕਨਜ਼ ਵਰਗੇ ਨਾਵਲਕਾਰਾਂ ਦੀ ਸ਼ੈਲੀ ਵਿਲੱਖਣ ਹੀ ਨਹੀਂ ਸਗੋਂ ਉਹਨਾਂ ਦੀਆਂ ਸ਼ਖ਼ਸੀਅਤਾਂ ਦਾ ਅਟੁੱਟ ਅੰਗ ਵੀ ਹਨ।

ਇੱਕ ਨਿਪੁੰਨ ਸ਼ੈਲੀਕਾਰ ਹੀ ਸਫ਼ਲ ਨਾਵਲ ਦੀ ਰਚਨਾ ਕਰ ਸਕਦਾ ਹੈ। ਉਂਝ ਤਾਂ ਹਰ ਲੇਖਕ ਦੀ ਸ਼ੈਲੀ ਅਤੇ ਸ਼ਬਦਾਵਲੀ ਅੰਤਰ ਸਬੰਧਿਤ ਹੁੰਦੀਆਂ ਹਨ ਪਰੰਤੂ ਫਿਰ ਵੀ ਇੱਕ ਸਫਲ ਲੇਖਕ ਨੂੰ ਢੁੱਕਵੀਂ ਅਤੇ ਸਰਲ ਭਾਸ਼ਾ ਦੇ ਪ੍ਰਯੋਗ ਲਈ ਸੁਚੇਤ ਯਤਨ ਕਰਨੇ ਪੈਂਦੇ ਹਨ। ਇੱਕ ਸਫ਼ਲ ਨਾਵਲਕਾਰ ਉਹੀ ਹੈ ਜੋ ਵਿਸ਼ੇ ਦੀ ਮੰਗ ਅਤੇ ਪਾਤਰਾਂ ਦੀ ਮਰਜ਼ੀ ਦੀ ਭਾਸ਼ਾ ਉਹਨਾਂ ਦੇ ਮੂੰਹ ਵਿੱਚ ਪਾ ਸਕੇ।

1.5 ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਇਤਿਹਾਸਿਕ ਪੜਾਅ

ਪੰਜਾਬੀ ਨਾਵਲ, ਅੰਗਰੇਜ਼ੀ ਨਾਵਲ ਦੇ ਪ੍ਰਭਾਵ ਅਧੀਨ ਉਨ੍ਹੀਵੀਂ ਸਦੀਂ ਦੇ ਆਖੀਰ ਦਹਾਕਿਆਂ ਵਿਚ ਪੈਦਾ ਹੋਇਆ। ''ਪੰਜਾਬੀ ਨਾਵਲ ਦੀ ਆਧਾਰ-ਸੰਰਚਨਾ ਵਿਚ ਬਹੁਤ ਸਾਰਿਆਂ ਸਾਹਿਤਕ-ਰੂੜੀਆਂ ਪੰਜਾਬੀ ਸਭਿਆਚਾਰ

ਵਿਚੋਂ ਆਈਆਂ ਹਨ, ਇਸ ਕਾਰਨ ਇਹ ਸਾਹਿਤ ਰੂਪ ਪੰਜਾਬੀ ਪਾਠਕਾਂ ਨੂੰ ਕਦੇ ਵੀ ਓਪਰਾ ਮਹਿਸੂਸ ਨਹੀਂ ਹੋਇਆ।''[25] ਪੰਜਾਬੀ ਨਾਵਲ ਦੇ ਆਰੰਭ ਬਾਰੇ ਕਿ ਪਹਿਲਾ ਨਾਵਲਕਾਰ ਕੌਣ ਹੈ? ਅਤੇ ਪੰਜਾਬੀ ਨਾਵਲ ਕਦੋਂ ਆਰੰਭ ਹੋਇਆ? ਬਾਰੇ ਵਿਦਵਾਨਾਂ ਵਿਚ ਮਤਭੇਦ ਹਨ। ਪ੍ਰੋ. ਕਿਰਪਾਲ ਸਿੰਘ ਕਸੇਲ, ਡਾ. ਚਰਨ ਸਿੰਘ ਨੂੰ ਪੰਜਾਬੀ ਦਾ ਪਹਿਲਾ ਨਾਵਲਕਾਰ ਮੰਨਦੇ ਹਨ। ਉਨ੍ਹਾਂ ਦਾ ਮਤ ਹੈ ਕਿ ਡਾ. ਚਰਨ ਸਿੰਘ ਦੇ ਨਾਵਲ 'ਜਗ ਮੜੌਲੀ' ਦਾ ਸਥਾਨ ਪੰਜਾਬੀ ਗਲਪਕਾਰੀ ਵਿਚ ਉਹੀ ਹੈ ਜੋ 'ਜਾਨ ਬਨੀਅਨ' ਦੇ ਨਾਵਲ 'ਪਿਲਗ੍ਰਿਮਜ਼ ਪ੍ਰਾਗਰੈਸ' ਦਾ ਹੈ ਪ੍ਰੰਤੂ ਈਸ਼ਰ ਸਿੰਘ ਤਾਂਘ ਭਾਈ ਵੀਰ ਸਿੰਘ ਨੂੰ ਹੀ ਪੰਜਾਬੀ ਦਾ ਪਹਿਲਾ ਨਾਵਲਕਾਰ ਮੰਨਦੇ ਹਨ ਪਰ ਇਸ ਅਨੁਵਾਦਤ ਨਾਵਲ ਨੂੰ ਪਹਿਲਾ ਨਾਵਲ ਹੋਣ ਦਾ ਮਾਣ ਬਖਸ਼ਣਾ ਉਚਿਤ ਨਹੀਂ। ਪ੍ਰੋ. ਨਰਿੰਜਨ ਤਸਨੀਮ 'ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਆਲੋਚਨਾਤਮਕ ਅਧਿਐਨ' ਵਿਚ ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਆਰੰਭ ਨਾਨਕ ਸਿੰਘ ਤੋਂ ਹੋਇਆ ਮੰਨਦੇ ਹਨ। ਉਨ੍ਹਾਂ ਦਾ ਮੱਤ ਹੈ ਕਿ ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਇਤਿਹਾਸ ਬੇਸ਼ਕ ਭਾਈ ਵੀਰ ਸਿੰਘ ਤੋਂ ਆਰੰਭ ਹੁੰਦਾ ਹੈ ਪਰ ਉਸ ਨੂੰ ਪੰਜਾਬੀ ਦਾ ਪਿਤਾਮਾ ਨਹੀਂ ਕਿਹਾ ਜਾ ਸਕਦਾ ਹੈ ਕਿਉਂਕਿ ਉਸਨੇ ਵੀ ਬਨਿਅਨ ਵਾਂਗ ਧਰਮ ਪ੍ਰਚਾਰ ਲਈ ਨਾਵਲ ਲਿਖੇ।

ਮੌਲਿਕ ਪੰਜਾਬੀ ਨਾਵਲ ਭਾਈ ਵੀਰ ਸਿੰਘ ਦੇ ਸਿੱਖ ਧਰਮ ਕੇਂਦਰਿਤ ਨਾਵਲ 'ਸੁੰਦਰੀ' ਦੇ ਪ੍ਰਕਾਸ਼ਤ ਹੋਣ ਨਾਲ ਆਰੰਭ ਹੁੰਦਾ ਹੈ। ਭਾਈ ਵੀਰ ਸਿੰਘ ਨੇ ਨਾਵਲ ਧਾਰਮਕ ਪ੍ਰਚਾਰ ਲਈ ਲਿਖੇ। 18ਵੀਂ ਸਦੀ ਦੇ ਇਤਿਹਾਸ ਨੂੰ ਵਿਸ਼ਾ-ਵਸਤੂ ਬਣਾ ਕੇ ਭਾਈ ਵੀਰ ਸਿੰਘ ਨੇ ਪੰਜਾਬੀ ਦੇ ਪਹਿਲੇ 'ਨਾਵਲ ਸੁੰਦਰੀ', 'ਸਤਵੰਤ ਕੌਰ' ਤੇ 'ਬਿਜੈ ਸਿੰਘ' ਲਿਖੇ। ਉਨ੍ਹਾਂ ਦਾ ਇਹ ਨਾਵਲ ਲਿਖਣ ਦਾ ਮਕਸਦ ਸਿੱਖ ਧਰਮ ਵਿਚ ਆ ਰਹੇ ਪਤਨ ਨੂੰ ਰੋਕਣਾ ਸੀ। 'ਬਾਬਾ ਨੌਧ ਸਿੰਘ' ਨਾਵਲ ਦਾ ਵਿਸ਼ਾ ਸਿੱਖੀ ਪ੍ਰਚਾਰ ਦੇ ਨਾਲ ਸਮਕਾਲੀ ਪੇਂਡੂ ਸਿੱਖ ਜੀਵਨ ਦੀ ਪੇਸ਼ਕਾਰੀ ਹੈ। ''ਭਾਈ ਵੀਰ ਸਿੰਘ ਵਰਗੇ ਨਾਵਲਕਾਰਾਂ ਦੀ ਵਡਿੱਤਣ ਦਾ ਤਅੱਲੁਕ ਉਸ ਇਤਿਹਾਸਕ ਹਰਕਤ ਨਾਲ ਹੈ ਜਿਸ ਵਿਚੋਂ ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਉਦੈ ਹੋਇਆ।''[26]

ਮੋਹਨ ਸਿੰਘ ਵੈਦ, ਭਾਈ ਵੀਰ ਸਿੰਘ ਦਾ ਸਮਕਾਲੀ ਨਾਵਲਕਾਰ ਹੈ। ਉਸਦੀ ਨਾਵਲ ਕਲਾ ਭਾਈ ਵੀਰ ਸਿੰਘ ਤੋਂ ਪ੍ਰਭਾਵਿਤ ਹੈ ਪਰ ਉਹ ਲੌਕਿਕ ਜੀਵਨ ਦੇ ਵਧੇਰੇ ਨੇੜੇ ਹੈ ਅਤੇ ਉਸਨੇ ਪੰਜਾਬੀ ਸਾਹਿਤ ਨੂੰ ਮੌਲਿਕ, ਅਨੁਵਾਦਤ ਅਤੇ ਬਹੁਗਿਣਤੀ ਨਾਵਲ ਦਿੱਤੇ ਹਨ। ਉਸਨੇ 'ਸੁਖਦੇਵ ਕੌਰ' ਅਤੇ 'ਸੁਘੜ ਨੂੰਹ' ਤੇ 'ਲੜਾਕੀ ਸੱਸ', 'ਇਕ ਸਿੱਖ ਘਰਾਣਾ', 'ਕਪਟੀ ਮਿੱਤਰ', 'ਸੁਸ਼ੀਲ-ਵਿਧਵਾ', 'ਦੰਪਤੀ ਪਿਆਰ', 'ਸਰੇਸ਼ਟ ਕੁਲ', ਵਕੀਲ ਦੀ ਕਿਸਮਤ'ਆਦਿ ਲਿਖੇ। ਉਸਨੇ ਪੰਜਾਬੀ ਨਾਵਲ ਨੂੰ ਇਤਿਹਾਸਕ ਘੇਰੇ ਵਿਚੋਂ ਕੱਢ ਕੇ ਕੁਝ ਯਥਾਰਥ ਛੋਹ ਲਵਾਈ ਜੋ ਉਸਦੀ ਇਸ ਪੱਖੋਂ ਵਰਣਨ ਯੋਗ ਦੇਣ ਹੈ।

ਮੋਹਨ ਸਿੰਘ ਵੈਦ ਤੋਂ ਪਿਛੋਂ ਚਰਨ ਸਿੰਘ ਸ਼ਹੀਦ ਨੇ ਭਾਈ ਵੀਰ ਸਿੰਘ ਦੇ ਪ੍ਰਭਾਵ ਅਧੀਨ ਤਿੰਨ ਇਤਿਹਾਸਕ ਨਾਵਲ 'ਦਲੇਰ ਕੌਰ','ਰਣਜੀਤ ਕੌਰ' ਅਤੇ 'ਚੰਚਲ ਮੂਰਤੀ' ਲਿਖ ਕੇ ਪ੍ਰਕਾਸ਼ਤ ਕਰਾਏ। ਚਰਨ

ਸਿੰਘ ਸ਼ਹੀਦ ਦੇ ਨਾਵਲਾਂ ਵਿਚ ਭਾਈ ਵੀਰ ਸਿੰਘ ਨਾਲੋਂ ਵਖਰੇਵਾਂ ਇਸ ਗੱਲ ਵਿਚ ਹੈ ਕਿ ਸ਼ਹੀਦ ਨੇ ਮਾਨਵਵਾਦੀ ਅਪੀਲ ਰਾਹੀਂ ਸਿੱਖ ਧਰਮ ਵੱਲ ਪਾਠਕਾਂ ਨੂੰ ਪ੍ਰੇਰਿਆ ਹੈ। ਚਰਨ ਸਿੰਘ ਸ਼ਹੀਦ ਆਪਣੇ ਇਤਿਹਾਸਕ ਨਾਵਲਾਂ ਵਿਚ ਭਾਈ ਵੀਰ ਸਿੰਘ ਨਾਲੋਂ ਵਧੇਰੇ ਯਥਾਰਥਵਾਦੀ ਜਾਪਦਾ ਹੈ।

ਮਾਸਟਰ ਤਾਰਾ ਸਿੰਘ ਦੇ ਲਿਖੇ ਨਾਵਲ 'ਪ੍ਰੇਮ ਲਗਨ' ਤੇ 'ਬਾਬਾ ਤੇਗਾ ਸਿੰਘ'ਵਰਣਨਯੋਗ ਹਨ। 'ਬਾਬਾ ਤੇਗਾ ਸਿੰਘ' ਇਕ ਇਤਿਹਾਸਕ ਨਾਵਲ ਹੈ। 'ਪ੍ਰੇਮ ਲਗਨ' ਨਾਵਲ ਅਕਾਲੀ ਲਹਿਰ ਦੇ ਪਿਛੋਕੜ ਵਿਚ ਪੇਂਡੂ ਸਿੱਖ ਜੀਵਨ ਦਾ ਚਿੱਤਰ ਪੇਸ਼ ਕਰਦਾ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਮਾਸਟਰ ਤਾਰਾ ਸਿੰਘ ਨੇ ਭਾਈ ਵੀਰ ਸਿੰਘ ਵਾਂਗ ਪੰਜਾਬੀ ਸਿੱਖ ਭਾਈਚਾਰੇ ਦੇ ਗੁਣਾਂ ਨੂੰ ਵਡਿਆਇਆ ਹੀ ਨਹੀਂ ਸਗੋਂ ਇਸ ਦੇ ਗੁਣਾਂ ਔਗੁਣਾਂ ਦੀ ਸਹੀ ਤਸਵੀਰ ਪੇਸ਼ ਕੀਤੀ ਹੈ।

ਪੰਜਾਬੀ ਨਾਵਲ ਦੇ ਖੇਤਰ ਵਿਚ ਨਾਨਕ ਸਿੰਘ ਦੇ ਆਗਮਨ ਨਾਲ ਇਕ ਨਵਾਂ ਮੋੜ ਆਇਆ ਹੈ। ਪੰਜਾਬੀ ਵਿਚ ਸਭ ਤੋਂ ਵੱਧ ਨਾਵਲ ਨਾਨਕ ਸਿੰਘ ਨੇ ਲਿਖੇ ਹਨ। ਨਾਨਕ ਸਿੰਘ ਪੰਜਾਬੀ ਨਾਵਲ ਦਾ ਸਭ ਤੋਂ ਵੱਡਾ ਸੁਧਾਰਵਾਦੀ ਨਾਵਲਕਾਰ ਹੈ। ਉਸਦੇ ਮੁੱਢਲੇ ਨਾਵਲਾਂ ਵਿਚ ਸਮਾਜਕ ਕੁਰੀਤੀਆਂ, ਵਿਧਵਾ ਵਿਆਹ, ਛੂਤ-ਛਾਤ, ਬਾਲ ਵਿਆਹ, ਭ੍ਰਿਸ਼ਟਾਚਾਰ, ਸਮਾਜਕ ਵਿਸ਼ੇ ਸਮਕਾਲੀ ਸਮਾਜਕ ਜੀਵਨ ਵਿਚੋਂ ਲਏ ਹਨ। ਉਨ੍ਹਾਂ ਦੇ ਨਾਵਲ 'ਖ਼ੂਨ ਦੇ ਸੋਹਲੇ', 'ਅੱਗ ਦੀ ਖੇਡ', 'ਟੁੱਟੀ ਵੀਣਾ', 'ਗੰਗਾ ਜਲੀ ਵਿਚ ਸ਼ਰਾਬ', 'ਪਵਿੱਤਰ ਪਾਪੀ', 'ਨਾਸੂਰ', 'ਮਤਰੇਈ ਮਾਂ', 'ਭੂਆ', 'ਤਾਸ਼ ਦੀ ਆਦਤ' ਆਦਿ ਹਨ। ''ਨਾਨਕ ਸਿੰਘ ਦੀ ਮੱਧ-ਵਰਗੀ ਆਦਰਸ਼ਵਾਦੀ ਤੇ ਸੁਧਾਰਵਾਦੀ ਰਚਨਾ-ਦ੍ਰਿਸ਼ਟੀ ਦੀ ਇਕ ਇਹ ਵੀ ਕਮਜ਼ੋਰੀ ਪ੍ਰਗਟ ਹੁੰਦੀ ਹੈ ਕਿ ਇਹ ਵਸਤੂ-ਯਥਾਰਥ ਦੇ ਇਤਿਹਾਸਕ-ਦਾਰਸ਼ਨਿਕ ਵਿਵੇਕ ਨੂੰ ਪਕੜਣ ਤੋਂ ਅਸਮਰੱਥ ਹੀ ਨਹੀਂ ਰਹੀ, ਸਗੋਂ ਵਿਵਸਥਾ ਵਿਚਲੀ ਕਾਣ ਨੂੰ ਵਿਅਕਤੀ ਵਿਚਲੀ ਕਾਣ ਦੇ ਸੰਦਰਭ ਵਿਚ ਵੇਖਦੀ ਹੋਈ ਵਿਆਪਕ ਵਿਵਸਥਾ ਦੇ ਸੁਧਾਰ ਲਈ ਵਿਅਕਤੀ-ਸੁਧਾਰ ਦੀ ਗਪਲੀ-ਭ੍ਰਾਂਤੀ ਸਿਰਜਦੀ ਹੈ।''[27] ਸੁਰਿੰਦਰ ਸਿੰਘ ਨਰੂਲਾ ਦੀ ਨਾਵਲ ਕਲਾ ਦਾ ਆਰੰਭ ਉਸ ਦੇ ਨਾਵਲ 'ਪਿਉ ਪੁੱਤਰ' ਨਾਲ ਹੁੰਦਾ ਹੈ। 'ਪਿਉ ਪੁੱਤਰ' ਨਾਵਲ ਦੀ ਸਾਹਿਤਕ ਮਹਾਨਤਾ ਦੇ ਨਾਲ-ਨਾਲ ਇਤਿਹਾਸਕ ਮਹਾਨਤਾ ਵੀ ਬਹੁਤ ਹੈ। ਇਸ ਤੋਂ ਪਿਛੋਂ ਨਰੂਲਾ ਨੇ 'ਰੰਗ ਮਹੱਲ', 'ਦੀਨ ਤੇ ਦੁਨੀਆਂ', 'ਜਗਰਾਤਾ', 'ਲੋਕ ਦੁਸ਼ਮਣ', 'ਨੀਲੀ ਬਾਰ', 'ਦਿਲ ਦਰਿਆ', 'ਸਿੱਲ ਅਲੂਣੀ',ਤੇ 'ਆਪਣੇ ਪਰਾਏ' ਆਦਿ ਨਾਵਲ ਦਿੱਤੇ। ਜਸਵੰਤ ਸਿੰਘ ਕੰਵਲ ਮਾਰਕਸਵਾਦੀ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਵਾਲਾ ਨਾਵਲਕਾਰ ਹੈ। ਉਸ ਨੂੰ ਕਈ ਆਲੋਚਕ ਨਾਨਕ ਸਿੰਘ ਦਾ ਉਤਰਾਧਿਕਾਰੀ ਮੰਨਦੇ ਹਨ। ਜਸਵੰਤ ਸਿੰਘ ਕੰਵਲ ਦੀ ਪੰਜਾਬੀ ਨਾਵਲ ਨੂੰ ਸਭ ਤੋਂ ਵੱਡੀ ਦੇਣ ਇਹ ਹੈ ਕਿ ਉਸ ਨੇ ਮਾਲਵੇ ਦੇ ਪੇਂਡੂ ਜੀਵਨ ਨੂੰ ਨਾਵਲਾਂ ਦਾ ਵਿਸ਼ਾ ਬਣਾਇਆ ਹੈ। ਪਿੰਡਾਂ ਵਿਚ ਰਹਿਣ ਕਰਕੇ ਪਿੰਡਾਂ ਦੇ ਜੀਵਨ ਸੰਬੰਧੀ ਉਸ ਦੀ ਜਾਣਕਾਰੀ ਡੂੰਘੀ ਤੇ ਵਿਸ਼ਾਲ ਹੈ। 'ਹਾਣੀ' ਅਤੇ 'ਪੂਰਨਮਾਸ਼ੀ'ਨਾਵਲਾਂ ਵਿਚ ਉਸ ਨੇ ਪੇਂਡੂ ਜੀਵਨ ਨਾਲ ਸੰਬੰਧਤ ਆਰਥਿਕ, ਸਮਾਜਕ, ਸਦਾਚਾਰਕ ਤੇ ਧਾਰਮਕ ਸਾਰੇ ਪਹਿਲੂ ਲਏ ਹਨ।

ਨਰਿੰਦਰ ਸਿੰਘ ਦੀ ਨਾਵਲ ਰਚਨਾ ਦਾ ਆਕਾਰ ਵੀ ਚੋਖਾ ਹੈ। ਉਸ ਦਾ ਸਭ ਤੋਂ ਪਹਿਲਾ ਨਾਵਲ 'ਮਲਾਹ' ਛਪਿਆ। ਇਸ ਤੋਂ ਪਿਛੋਂ ਉਸਨੇ 'ਖੰਨਿਓਂ ਤਿੱਖੀ ਵਾਲੋਂ ਨਿੱਕੀ', 'ਏਤਿ ਮਾਰਗ ਜਾਣਾ', 'ਸ਼ਕਤੀ', 'ਤ੍ਰੀਆ ਜਾਲ', 'ਇਕ ਰਾਹ ਇਕ ਪੜਾ', 'ਅਮਨ ਦੇ ਰਾਹ', 'ਪੁੰਨਿਆ ਕਿ ਮੱਸਿਆ', 'ਟਾਪੂ', 'ਸੈਨਾਪਤੀ', 'ਉਨਤਾਲੀ ਵਰ੍ਹੇ', 'ਵਿਕੇਂਦ੍ਰਿਤ', 'ਚਾਨਣ ਖੜਾ ਕਿਨਾਰੇ'ਅਤੇ 'ਬਾ ਮੁਲਾਹਣਾ ਹੋਸ਼ਿਆਰ' ਨਾਵਲ ਸਾਹਿਤ ਨੂੰ ਦਿੱਤੇ। 'ਬਾਮੁਲਾਹਣਾ ਹੋਸ਼ਿਆਰ' ਨੂੰ ਸਾਹਿਤ ਅਕਾਦਮੀ ਵਲੋਂ ਇਨਾਮ ਮਿਲ ਚੁੱਕਿਆ ਹੈ।

ਪੰਜਾਬੀ ਨਾਵਲ ਦੇ ਖੇਤਰ ਵਿਚ ਅੰਮ੍ਰਿਤਾ ਪ੍ਰੀਤਮ ਇਕ ਵਰਨਣਯੋਗ ਨਾਵਲਕਾਰ ਹੈ। ਉਸ ਨੇ ਨਾਵਲਾਂ ਵਿਚ ਵਧੇਰੇ ਇਸਤਰੀਆਂ ਦੀ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ਅੰਮ੍ਰਿਤਾ ਪ੍ਰੀਤਮ ਇਸਤਰੀ ਦੇ ਹਿਰਦੇ ਦੇ ਦਰਦ ਨੂੰ ਚੰਗੀ ਤਰ੍ਹਾਂ ਪੇਸ਼ ਕਰ ਸਕੀ ਹੈ। 'ਜੈ ਸ਼ਿਰੀ' ਅੰਮ੍ਰਿਤਾ ਦਾ ਪਹਿਲਾ ਨਾਵਲ ਹੈ। ਫਿਰ ਉਸ ਨੇ 'ਡਾਕਟਰ ਦੇਵ', 'ਪਿੰਜਰ' ਅਤੇ 'ਆਲ੍ਹਣਾ' ਲਿਖੇ। 'ਪਿੰਜਰ' ਵੰਡ ਨਾਲ ਸੰਬੰਧਤ ਨਾਵਲ ਹੈ। 'ਚੱਕ ਨੰਬਰ ਛੱਤੀ', 'ਇਕ ਸੀ ਅਨੀਤਾ' ਅਤੇ 'ਦਿੱਲੀ ਦੀਆਂ ਗਲੀਆਂ' ਕੁਝ ਉਸ ਦੇ ਵਿਸ਼ੇਸ਼ ਨਾਵਲ ਹਨ। ਵਿਸ਼ੇ ਅਤੇ ਸ਼ੈਲੀ ਦੇ ਪੱਖੋਂ ਅੰਮ੍ਰਿਤਾ ਪ੍ਰੀਤਮ ਦੀ ਪੰਜਾਬੀ ਨਾਵਲ ਨੂੰ ਦੇਣ ਅੱਖੋਂ ਉਹਲੇ ਨਹੀਂ ਕੀਤੀ ਜਾ ਸਕਦੀ।

ਸੁਰਜੀਤ ਸਿੰਘ ਸੇਠੀ ਨੇ ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਕਈ ਨਵੀਆਂ ਤਕਨੀਕਾਂ ਦੀ ਵਰਤੋਂ ਕੀਤੀ। ਉਹ ਨਗਰ-ਸਾਂਸਕ੍ਰਿਤੀ ਦਾ ਨਾਵਲਕਾਰ ਹੈ। "ਉਸਨੇ ਪੱਛਮ ਦੀਆਂ ਮਨੋਵਿਸ਼ਲੇਸ਼ਣ ਦੀਆਂ ਸਾਹਿਤਕ/ਨਾਵਲੀ ਵਿਧੀਆਂ ਅਤੇ ਜੁਗਤਾਂ ਨੂੰ ਆਧਾਰ ਬਣਾ ਕੇ ਪੰਜਾਬੀ ਨਾਵਲ ਦੇ ਇਤਿਹਾਸ ਵਿਚ ਮਨੋਚਿਤਰਣ ਕਰਨ ਵਾਲੇ ਨਾਵਲ ਲਿਖਣ ਵਿਚ ਮੋਹਰੀਆਂ ਵਾਲਾ ਫ਼ਰਜ ਨਿਭਾਇਆ ਹੈ, ਵਿਸ਼ੇਸ਼ ਤੌਰ ਤੇ ਨਾਵਲ ਵਿਚ ਸਫ਼ਲ ਪ੍ਰਯੋਗ ਕੀਤੇ ਹਨ।"[28] ਉਸ ਨੇ 'ਰੇਤ ਦਾ ਪਹਾੜ', 'ਇਕ ਸ਼ਹਿਰ ਦੀ ਗੱਲ', 'ਕੰਧੀ ਉੱਤੇ ਰੁਖੜਾ', 'ਅੱਲ ਪੱਥਰ', 'ਇੱਕ ਖਾਲੀ ਪਿਆਲਾ', 'ਆਬਰਾ ਕਦਾਬਰਾ', 'ਕੱਲ੍ਹ ਵੀ ਸੂਰਜ ਨਹੀਂ ਚੜੇਗਾ' ਆਦਿ ਨਾਵਲ ਲਿਖੇ ਹਨ। 'ਰੇਤ ਦਾ ਪਹਾੜ' ਵਿਚ ਪੂੰਜੀਵਾਦੀ ਸਮਾਜ ਨੂੰ ਰੇਤ ਦਾ ਪਹਾੜ ਮੰਨਿਆ ਹੈ ਅਤੇ ਉਸ ਦੇ ਖੋਖਲੇਪਨ ਤੋਂ ਪਰਦਾ ਲਾਹਿਆ ਹੈ। 'ਕੰਧੀ ਉਤੇ ਰੁਖੜਾ' ਨਾਵਲ ਵਿਚ ਚਾਰ ਪੀੜ੍ਹੀਆਂ ਦਾ ਜੀਵਨ ਪੇਸ਼ ਕੀਤਾ ਗਿਆ ਹੈ। ਸੁਰਜੀਤ ਸਿੰਘ ਸੇਠੀ ਦੇ ਪਿਛਲੇ ਦੋ ਨਾਵਲ 'ਇਕ ਖਾਲੀ ਪਿਆਲਾ'ਅਤੇ ਕੱਲ੍ਹ ਵੀ ਸੂਰਜ ਨਹੀਂ ਚੜ੍ਹੇਗਾ', ਮਨੋਵਿਗਿਆਨਕ ਯਥਾਰਥਵਾਦ ਨੂੰ ਪੇਸ਼ ਕਰ ਰਹੇ ਹਨ। ਸੇਠੀ ਨੇ ਆਪਣੇ ਨਾਵਲ 'ਇਕ ਖਾਲੀ ਪਿਆਲਾ' ਵਿਚ ਚੇਤਨਾ ਪ੍ਰਵਾਹ ਸ਼ੈਲੀ ਦਾ ਬੜੀ ਸਫ਼ਲਤਾ ਨਾਲ ਨਵਾਂ ਤਜਰਬਾ ਕੀਤਾ ਹੈ। 'ਬਦਨਾਮ ਸੜਕਾਂ' ਸੇਠੀ ਦਾ ਇਕ ਹੋਰ ਨਵਾਂ ਨਾਵਲ ਹੈ। ਇਹ ਨਾਵਲ ਉੱਚ ਮੱਧ ਵਰਗ ਦੇ ਲੋਕਾਂ ਦੀ ਮਾਨਸਿਕ ਜਟਿਲਤਾ ਨੂੰ ਚਿਤਰਦਾ ਹੈ।

ਸੋਹਣ ਸਿੰਘ ਸੀਤਲ ਇਕ ਢਾਡੀ ਅਤੇ ਇਤਿਹਾਸਕਾਰ ਦੇ ਵਾਰਤਕਕਾਰ ਦੇ ਤੌਰ ਤੇ ਵਧੇਰੇ ਪ੍ਰਸਿੱਧ ਹੈ। ਸੁਤੰਤਰਤਾ ਤੋਂ ਪਿਛੋਂ ਉਸ ਦਾ ਝੁਕਾਅ ਨਾਵਲਕਾਰੀ ਵੱਲ ਹੋਇਆ। ਉਸ ਨੇ 'ਮੁੱਲ ਦਾ ਮਾਸ', 'ਅੰਨ੍ਹੀ ਸੁੰਦਰਤਾ',

'ਵਿਜੋਗਣ', 'ਪਤਵੰਤੇ-ਕਾਤਿਲ', 'ਦੀਵੇ ਦੀ ਲੋ', 'ਜੰਗ ਤੇ ਅਮਨ', 'ਤੂਤਾਂ ਵਾਲਾ ਖੂਹ', 'ਜੁਗ ਬਦਲ ਗਿਆ' ਆਦਿ ਨਾਵਲ ਲਿਖੇ। ਜਿਥੇ ਨਾਨਕ ਸਿੰਘ ਸ਼ਹਿਰੀ ਮੱਧ-ਵਰਗੀ ਜੀਵਨ ਨੂੰ ਆਪਣੀ ਰਚਨਾ ਦਾ ਖੇਤਰ ਬਣਾਉਂਦਾ ਹੈ। ਸੀਤਲ ਦੀ ਨਾਵਲ ਕਲਾ ਵਿਚ ਨਾ ਸਿਰਫ਼ ਪੇਂਡੂ ਕਿਰਸਾਣੀ ਜੀਵਨ ਦੀਆਂ ਬਹੁ-ਪੱਖੀ ਸਮੱਸਿਆਵਾਂ ਦਾ ਵਿਸ਼ਲੇਸ਼ਣ ਹੈ, ਸਗੋਂ ਇਸ ਦੇ ਨਾਲ ਸਮੁੱਚੀ ਮਨੁੱਖਤਾ ਦੀਆਂ ਮਨੋ-ਬਿਰਤੀਆਂ ਬੱਝੀਆਂ ਹਨ। ਮਨੁੱਖੀ ਰਿਸ਼ਤਿਆਂ, ਇਸਤਰੀ ਮਰਦ ਦੇ ਸੰਬੰਧਾਂ, ਵੱਖ-ਵੱਖ ਜਾਤੀਆਂ ਦੇ ਕਿਰਦਾਰਾਂ ਨੂੰ ਯਥਾਰਥ ਸੂਝ ਨਾਲ ਸੀਤਲ ਨੇ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ਸੀਤਲ ਨੇ 'ਤੂਤਾਂ ਵਾਲਾ ਖੂਹ' ਤੇ 'ਜੰਗ ਜਾਂ ਅਮਨ' ਵਰਗੇ ਨਾਵਲ ਲਿਖ ਕੇ ਪੰਜਾਬੀ ਵਿਚ ਆਪਣੀ ਖਾਸ ਥਾਂ ਬਣਾ ਲਈ ਹੈ।

ਕਰਤਾਰ ਸਿੰਘ ਦੁੱਗਲ ਨੇ ਪੰਜਾਬੀ ਸਾਹਿਤ ਵਿਚ ਕਹਾਣੀਕਾਰ ਦੇ ਤੌਰ ਤੇ ਪ੍ਰਵੇਸ਼ ਕੀਤਾ। ਦੁੱਗਲ ਨੂੰ ਨਾਵਲਕਾਰ ਦੇ ਤੌਰ ਤੇ ਨਾਵਲ ਖੇਤਰ ਵਿਚ ਉਹ ਸਥਾਨ ਪ੍ਰਾਪਤ ਨਹੀਂ ਹੋ ਸਕਿਆ ਜੋ ਉਸ ਨੂੰ ਨਿੱਕੀ ਕਹਾਣੀ ਦੇ ਖੇਤਰ ਵਿਚ ਪ੍ਰਾਪਤ ਹੈ।ਦੁੱਗਲ ਨੇ ਹੁਣ ਤੱਕ 'ਆਂਦਰਾਂ', 'ਨਹੁੰ ਤੇ ਮਾਸ', 'ਇਕ ਦਿਲ ਵਿਕਾਊ', 'ਦਿਲ ਦਰਿਆ', 'ਮੇਰਾ ਦਿਲ ਮੋੜ ਦੇ', 'ਤ੍ਰੈ ਲੜੀ', 'ਹਾਲ ਮੁਰੀਦਾ ਦਾ', 'ਮਨ ਪਰਦੇਸੀ', 'ਮਾਂ ਪਿਉ ਦੇ ਜਾਏ', 'ਅੰਮੀ ਨੂੰ ਕੀ ਹੋ ਗਿਆ', 'ਫੁੱਲਾਂ ਦਾ ਸਾਥ', 'ਪੈਣਗੇ ਵੈਣ ਡੂੰਘੇ' ਆਦਿ ਨਾਵਲ ਲਿਖੇ ਹਨ। 'ਆਂਦਰਾਂ' ਨਾਵਲ ਵਿਚ ਦੁੱਗਲ ਨੇ ਜਾਗੀਰਦਾਰ ਤੇ ਮੁਜਾਰਿਆਂ ਦੇ ਆਪਸੀ ਸੰਘਰਸ਼ ਨੂੰ ਬਿਆਨ ਕਰਦੇ ਹੋਏ ਜਾਗੀਰਦਾਰੀ ਸਮਾਜ ਦੀਆਂ ਛੁਪੀਆਂ ਬੁਰਾਈਆਂ ਤੇ ਭ੍ਰਿਸ਼ਟਾਚਾਰ ਨੂੰ ਨੰਗਿਆਂ ਕੀਤਾ ਹੈ। 'ਇਕ ਦਿਲ ਵਿਕਾਊ ਹੈ' ਉਸ ਦਾ ਭਾਵਾਤਮਕ ਤੇ ਰੁਮਾਂਟਿਕ ਪ੍ਰਕਾਰ ਦਾ ਨਾਵਲ ਹੈ। 'ਨਹੁੰ ਤੇ ਮਾਸ', 'ਮਨ ਪਰਦੇਸੀ' ਤੇ 'ਮਾਂ ਪਿਉ ਦੇ ਜਾਏ' ਵੰਡ ਨਾਲ ਸੰਬੰਧਤ ਨਾਵਲ ਹਨ। 'ਦਿਲ ਦਰਿਆ', 'ਮੇਰਾ ਦਿਲ ਮੋੜ ਦੇ', 'ਹਾਲ ਮੁਰੀਦਾਂ ਦਾ' ਵਿਚ ਰੁਮਾਂਸ ਦੀ ਪ੍ਰਧਾਨਤਾ ਹੈ, ਵਿਸ਼ੇ ਤੇ ਪੱਖ ਤੋਂ ਕੋਈ ਬਹੁਤਾ ਮਹੱਤਵ ਨਹੀਂ, ਮਨੋਵਿਗਿਆਨਕ ਭਾਂਤ ਦੀ ਪਾਤਰ ਉਸਾਰੀ ਜ਼ਰੂਰ ਹੈ। ਦੁੱਗਲ ਦਾ ਨਵਾਂ ਨਾਵਲ 'ਫੁੱਲਾਂ ਦਾ ਸਾਥ' ਹਿੰਦੂ, ਮੁਸਲਮ ਅਤੇ ਸਿੱਖ ਸੰਪਰਦਾਇਕਤਾ ਉਤੇ ਆਧਾਰਤ ਹੈ।

ਨਵੀਂ ਪੀੜ੍ਹੀ ਦੇ ਨਾਵਲਕਾਰਾਂ ਵਿਚ ਮੋਹਨ ਕਾਹਲੋ ਦਾ ਨਾਂ ਵਰਣਨਯੋਗ ਹੈ। ਇਸ ਦੇ ਨਾਵਲ 'ਬੇੜੀ ਤੇ ਬਰੇਤਾ' ਤੇ 'ਮਛਲੀ ਇਕ ਦਰਿਆ ਦੀ' ਵਿਚ ਜੱਟਾਂ ਅਤੇ ਗੁੱਜਰਾਂ ਦਾ ਚਿੱਤਰ ਪੇਸ਼ ਕਰਕੇ ਜ਼ਿੰਦਗੀ ਦੇ ਯਥਾਰਥ ਨੂੰ ਪੇਸ਼ ਕਰਨ ਦਾ ਯਤਨ ਕੀਤਾ ਹੈ।'ਪ੍ਰਦੇਸੀ ਰੁੱਖ' ਉਸ ਦਾ ਵੰਡ ਨਾਲ ਸੰਬੰਧਤ ਨਾਵਲ ਹੈ।'ਗੋਰੀ ਨਦੀ ਦਾ ਗੀਤ' ਤੇ 'ਬਰਾਦਰੀ ਦੀ ਰਾਣੀ' ਅਤੇ 'ਕਾਲੀ ਮਿੱਟੀ'ਨਾਵਲ ਪਿਛੋਂ ਛਪੇ ਹਨ। ਉਸ ਦੇ ਕਈ ਨਾਵਲ ਬੜੀ ਚਰਚਾ ਦੇ ਕੇਂਦਰ ਬਣੇ ਹਨ।

ਪੰਜਾਬੀ ਨਾਵਲ ਦੇ ਖੇਤਰ ਵਿਚ ਗੁਰਦਿਆਲ ਸਿੰਘ ਦੀ ਆਪਣੀ ਮੌਲਿਕ ਤੇ ਵਿਸ਼ੇਸ਼ ਥਾਂ ਹੈ। ਉਸ ਨੇ ਪੰਜਾਬੀ ਨਾਵਲ ਦੇ ਖੇਤਰ ਵਿਚ ਆਪਣੇ ਨਾਵਲ 'ਮੜ੍ਹੀ ਦਾ ਦੀਵਾ' ਨਾਲ ਆਪਣੀ ਥਾਂ ਬਣਾ ਲਈ। ਇਸ ਪਿਛੋਂ

'ਅਣਹੋਏ', 'ਕੁਵੇਲਾ', 'ਰੇਤ ਦੀ ਇਕ ਮੁੱਠੀ', 'ਅੱਧ ਚਾਨਣੀ ਰਾਤ', 'ਆਥਣ ਉਗਣ', 'ਅੰਨ੍ਹੇ ਘੋੜੇ ਦਾ ਦਾਨ' ਅਤੇ 'ਪਰਸਾ' ਨਾਵਲ ਲਿਖੇ। ਗੁਰਦਿਆਲ ਸਿੰਘ ਨੇ ਆਪਣੇ ਨਾਵਲਾਂ ਵਿਚ ਪੰਜਾਬ ਅਤੇ ਖਾਸ ਕਰਕੇ ਮਾਲਵੇ ਦੇ ਕਿਰਤੀ ਤੇ ਕਿਸਾਨ ਵਰਗ ਦੇ ਜੀਵਨ ਨੂੰ ਚਿਤਰਿਆ ਹੈ। ਉਹ ਪਾਤਰਾਂ ਦੇ ਮਨੋਭਾਵਾਂ ਦਾ ਵਿਸ਼ਲੇਸ਼ਣ ਬੜੀ ਸੋਹਣੀ ਤਰ੍ਹਾਂ ਕਰਦਾ ਹੈ। ਉਸ ਦੇ ਨਾਵਲਾਂ ਦੇ ਪਾਤਰ ਸਾਡੇ ਸਮਾਜ ਦੇ ਜੀਉਂਦੇ ਜਾਗਦੇ ਮਨੁੱਖ ਹਨ। ਉਸਨੇ 'ਤ੍ਰੇੜਾਂ ਤੇ ਰੂਪ' 'ਕਸਕ', 'ਪਰਛਾਵੇਂ', 'ਰੇਤ ਛੱਲ', 'ਅਜਨਵੀ ਲੋਕ', 'ਸਵੇਰ ਹੋਣ ਤੱਕ' ਅਤੇ 'ਗੁਆਚੇ ਅਰਥ' ਨਾਵਲ ਲਈ ਨਰਿੰਜਨ ਤਸਨੀਮ ਨੂੰ ਸਾਹਿਤ ਅਕਾਦਮੀ ਅਵਾਰਡ ਵੀ ਮਿਲਿਆ। ਤਸਨੀਮ ਨੇ ਆਪਣੇ ਨਾਵਲਾਂ ਵਿੱਚ ਵਧੇਰੇ ਕਰਕੇ ਪਾਤਰਾਂ ਦਾ ਮਨੋਵਿਗਿਆਨਿਕ ਵਿਸ਼ਲੇਸ਼ਣ ਕੀਤਾ ਹੈ।

ਦਲੀਪ ਕੌਰ ਟਿਵਾਣਾ ਦੇ ਪ੍ਰਸਿੱਧ ਨਾਵਲ 'ਇਹ ਹਮਾਰਾ ਜੀਵਣਾ' 'ਅਗਨੀ ਪਰੀਖਿਆ' ਅਤੇ 'ਤੀਲ੍ਹੀ ਦਾ ਨਿਸ਼ਾਨ' ਹਨ।'ਇਹ ਹਮਾਰਾ ਜੀਵਣਾ' ਯਥਾਰਥਵਾਦੀ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਤੋਂ ਇੱਕ ਸਫ਼ਲ ਨਾਵਲ ਹੈ। ਉਸਦੇ ਨਵੇਂ ਨਾਵਲ 'ਹਸਤਾਖਰ' 'ਪੈੜ-ਚਾਲ', 'ਰਿਣ ਪਿੱਤਰਾਂ ਦਾ', 'ਲੰਘ ਗਏ ਦਰਿਆ', 'ਜ਼ਿਮੀ ਪੁਛੈ ਅਸਮਾਨ'ਅਤੇ 'ਕਥਾ ਕਹੋ ਉਰਵਸ਼ੀ' ਦਲੀਪ ਕੌਰ ਟਿਵਾਣਾ ਨੂੰ ਉਸਦੀ ਵੱਡ ਆਕਾਰੀ ਗੱਦ ਰਚਨਾ 'ਕਥਾ ਕਹੋ ਊਰਵਸ਼ੀ' ਉੱਤੇ ਬਿਰਲਾ ਫਾਊਂਡੇਸ਼ਨ ਦੇ ਸਰਸਵਤੀ ਸਨਮਾਨ ਨਾਲ ਪੁਰਸਕਾਰਿਆ ਹੈ। ਪੰਜਾਬੀ ਗਲਪ ਦੇ ਖੇਤਰ ਵਿੱਚ ਇਹ ਉਸਦੀ ਮਾਣਯੋਗ ਪ੍ਰਾਪਤੀ ਹੈ।'ਪੋਸਟ ਮਾਰਟਮ' ਅਤੇ 'ਧੁੱਪ ਵਾਲਾ ਸ਼ਹਿਰ' ਆਦਿ ਦੇ ਨਾਮ ਪੰਜਾਬੀ ਖੇਤਰ ਵਿੱਚ ਲਏ ਜਾ ਸਕਦੇ ਹਨ ਇਹਨਾਂ ਵਿੱਚ ਉਸਨੇ ਨਵੀਆਂ ਕੀਮਤਾਂ ਨੂੰ ਪਰਿਵਰਤਨਸ਼ੀਲ ਮਨੁੱਖੀ ਸੁਭਾਅ ਦੇ ਪ੍ਰਸੰਗ ਵਿੱਚ ਦੇਖਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕੀਤੀ ਹੈ।

ਸੁਰਿੰਦਰ ਜੌਹਰ ਦੇ ਨਾਵਲ 'ਰਾਹਾਂ ਦੀ ਧੂੜ' 'ਟੁੱਟੀਆਂ ਤੰਦਾਂ', 'ਮੋਈ ਰੁੱਤ' ਪੰਜਾਬੀ ਨਾਵਲ ਨੂੰ ਦੇ ਚੁੱਕਾ ਹੈ। ਉਸਨੇ ਉਪਰਲੀ ਮੱਧ ਸ਼੍ਰੇਣੀ ਦੇ ਜੀਵਨ ਨੂੰ ਚਿਤਰਿਆ ਹੈ। ਇਸਦੇ ਪਹਿਲੇ ਨਾਵਲਾਂ ਵਿੱਚ ਕਹਾਣੀ ਪ੍ਰਧਾਨ ਹੈ ਉਸਦੇ ਨਵੇਂ ਨਾਵਲ 'ਮੋਈ ਰੁੱਤ' ਵਿੱਚ ਵਸਤੂ ਦੇ ਨਾਲ-ਨਾਲ ਆਕਾਰ ਵੀ ਬਦਲਿਆ ਹੈ।

ਮਨਜੀਤ ਰਾਣਾ ਦੇ ਨਾਵਲ 'ਧਰਤੀ ਦੇ ਵਾਰਸ', 'ਅੰਗਰੇਜ਼ ਕੁੜੀਆਂ' ਅਤੇ 'ਦਿਲ ਤੇ ਦੁਨੀਆਂ' ਮਨਜੀਤ ਰਾਣਾ ਦੀ ਵਿਸ਼ੇਸ਼ਤਾ ਇਸ ਗੱਲ ਤੇ ਹੈ ਕਿ ਉਸਨੇ ਆਪਣੇ ਨਾਵਲਾਂ ਵਿੱਚ ਮਨੁੱਖੀ ਜੀਵਨ ਦੇ ਹਨੇਰੇ ਪੱਖਾਂ ਉੱਤੇ ਰੋਸ਼ਨੀ ਪਾਈ ਹੈ।

ਸੁਰਜੀਤ ਹਾਂਸ ਦੇ ਨਾਵਲ 'ਮਿੱਟੀ ਦੀ ਢੇਰੀ' ਅਤੇ 'ਪੁਸ਼ਤਾ' ਪੰਜਾਬੀ ਨਾਵਲ ਵਿੱਚ ਵੱਖਰੀ ਸ਼ੈਲੀ ਨੂੰ ਪੇਸ਼ ਕਰਨ ਵਾਲੇ ਨਾਵਲ ਹਨ। ਜਗਜੀਤ ਬਰਾੜ ਦੇ ਨਾਵਲ, 'ਧੁੱਪ ਦਰਿਆ ਦੀ ਦੋਸਤੀ' ਨਿੱਕੇ ਆਕਾਰ ਦਾ ਨਾਵਲ ਆਧੁਨਿਕ ਚੇਤਨਤਾ ਦਾ ਪ੍ਰਤੀਕ ਹੈ। ਮਹਿੰਦਰ ਸਿੰਘ ਸਰਨਾ, ਭਾਵੇਂ ਕਹਾਣੀਕਾਰ ਪਹਿਲਾਂ ਹੈ ਤੇ ਨਾਵਲਕਾਰ ਪਿਛੋਂ

ਪਰ ਉਸਦੇ ਨਾਵਲ 'ਪੀੜਾਂ ਮੱਲੇ ਰਾਹ' ਅਤੇ 'ਕਾਂਗਾਂ ਦੇ ਕੰਡੇ' ਲਿਖੇ ਹਨ। ਇਨ੍ਹਾਂ ਤੋਂ ਇਲਾਵਾ ਓਮ ਪ੍ਰਕਾਸ਼ ਗਾਸੋ, ਰਾਮ ਸਰੂਪ ਅਣਖੀ, ਮੋਹਨ ਸਿੰਘ ਕਾਹਲੋ, ਆਦਿ ਵੀ ਪ੍ਰਸਿੱਧ ਨਾਵਲਕਾਰ ਹਨ।

1.6 ਪੰਜਾਬੀ ਨਾਵਲ ਦੀਆਂ ਪ੍ਰਵਿਰਤੀਆਂ

ਹਰ ਭਾਸ਼ਾ ਦੇ ਗਲਪ ਸਾਹਿਤ ਵਿਚ ਜਿਹੜੀਆਂ ਪ੍ਰਮੁੱਖ ਪ੍ਰਵਿਰਤੀਆਂ ਨਜ਼ਰ ਆਉਂਦੀਆਂ ਹਨ, ਉਨ੍ਹਾਂ ਦਾ ਆਧਾਰ, ਉਸ ਭਾਸ਼ਾ ਦੇ ਲੋਕਾ ਦਾ ਸਭਿਆਚਾਰਕ ਵਿਰਸਾ ਅਤੇ ਨਵੀਨ ਚੇਤਨਾ ਅਧੀਨ ਆਈਆਂ ਪਦਾਰਥਕ ਅਤੇ ਬੌਧਿਕ ਤਬਦੀਲੀਆਂ ਹੁੰਦੀਆਂ ਹਨ। ਇਨ੍ਹਾਂ ਤਬਦੀਲੀਆਂ ਅਧੀਨ ਹੀ ਸਾਹਿਤ ਵਿਚ ਨਵੀਨ ਪ੍ਰਵਿਰਤੀਆਂ ਪੈਦਾ ਹੁੰਦੀਆਂ ਹਨ। ਵਿਸ਼ਵ ਭਰ ਦੇ ਗਲਪ ਸਾਹਿਤ ਦਾ ਅਧਿਐਨ ਇਸ ਗੱਲ ਨੂੰ ਦ੍ਰਿੜ ਕਰਵਾਉਂਦਾ ਹੈ ਜਦੋਂ ਕਿ ਕਿਸੇ ਭਾਸ਼ਾ ਦਾ ਸਮਾਜ ਨਵੀਨ ਕਦਰਾਂ-ਕੀਮਤਾਂ ਦਾ ਧਾਰਨੀ ਹੁੰਦਾ ਹੈ ਤਾਂ ਉਸ ਦੇ ਅਰੰਭ ਵਿਚ ਉਸ ਦੇ ਸਾਹਿਤਕਾਰ ਨਵੀਨ ਪ੍ਰਪਾਤ ਦ੍ਰਿਸ਼ਟੀ ਅਧੀਨ ਪਹਿਲਾਂ ਆਪਣੇ ਵਿਰਸੇ ਦਾ ਪੁਨਰ-ਮੁਲਾਂਕਣ ਕਰਨ ਵੱਲ ਰੁਚਿਤ ਹੁੰਦੇ ਹਨ। ਆਧੁਨਿਕ ਕਾਲ ਦੇ ਨਾਵਲ ਵਿਚ ਵੀ ਧਾਰਮਕ ਤੇ ਸਭਿਆਚਾਰਕ ਵਿਰਸੇ ਦੇ ਪੁਨਰ-ਮੁਲਾਂਕਣ ਦੀ ਪ੍ਰਵਿਰਤੀ ਪਹਿਲੀ ਤੇ ਪ੍ਰਮੁੱਖ ਪ੍ਰਵਿਰਤੀ ਹੈ। ਇਸੇ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਹੀ ਪੰਜਾਬੀ ਦੇ ਮੁਢਲੇ ਨਾਵਲਕਾਰ ਭਾਈ ਵੀਰ ਸਿੰਘ ਨੇ ਰਚਨਾ ਕੀਤੀ ਹੈ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਉਸ ਦੇ ਸਮਕਾਲੀਆਂ, ਚਰਨ ਸਿੰਘ ਸ਼ਹੀਦ ਅਤੇ ਭਾਈ ਮੋਹਨ ਸਿੰਘ ਵੈਦ ਨੇ ਨਾਵਲੀ ਰਚਨਾ ਕੀਤੀ।

1.6.1 ਇਤਿਹਾਸਿਕ ਅਤੇ ਧਾਰਮਿਕ ਪ੍ਰਵਿਰਤੀ

ਭਾਈ ਵੀਰ ਸਿੰਘ ਨੇ ਸਿੰਘ ਸਭਾ ਲਹਿਰ ਦੇ ਪ੍ਰਭਾਵ ਅਧੀਨ ਸਾਹਿਤ ਰਚਨਾ ਦਾ ਕਾਰਜ ਅਰੰਭਿਆ। ਉਸ ਸਮੇਂ ਇਕ ਪਾਸੇ ਤਾਂ ਈਸਾਈ ਪਾਦਰੀ ਧਾਰਮਕ ਮਿੱਠੇ ਵਿਵਹਾਰ ਅਤੇ ਆਰਥਿਕ ਸਹੂਲਤਾਂ ਨਾਲ ਲੋਕਾਂ ਨੂੰ ਪ੍ਰਭਾਵਿਤ ਕਰ ਰਹੇ ਸਨ ਅਤੇ ਦੂਜੇ ਪਾਸੇ ਆਰੀਆ ਸਮਾਜ ਫ਼ਿਰਕੂ ਵਾਤਾਵਰਨ ਪੈਦਾ ਕਰ ਰਹੇ ਸਨ। ਭਾਈ ਵੀਰ ਸਿੰਘ ਦੀ ਨਾਵਲੀ ਰਚਨਾ ਦਾ ਮੁੱਖ ਉਦੇਸ਼ ਸਿੱਖਾਂ ਨੂੰ ਇਨ੍ਹਾਂ ਚਾਲਾਂ ਤੋਂ ਸੁਚੇਤ ਕਰਵਾਉਣਾ ਸੀ। ਇਸ ਮੰਤਵ ਅਥਵਾ ਉਦੇਸ਼ ਨੂੰ ਆਧਾਰ ਮੰਨ ਕੇ ਆਪ ਨੇ ਸਿੱਖ ਧਰਮ ਵਿਚਲੀ ਗੌਰਵਤਾ ਅਤੇ ਅਠਾਰ੍ਹਵੀਂ ਸਦੀ ਦੇ ਸੰਘਰਸ਼ ਇਤਿਹਾਸ ਪ੍ਰਤੀ ਦ੍ਰਿਸ਼ਟੀ ਮਨੋਰਥਵਾਦੀ ਹੈ ਜਿਸ ਦਾ ਸੰਕੇਤ ਨਾਵਲ 'ਵਿਜੈ ਸਿੰਘ' ਦੀ ਲਿਖੀ ਭੂਮਿਕਾ ਵਿਚੋਂ ਮਿਲਦਾ ਹੈ।

ਭਾਈ ਵੀਰ ਸਿੰਘ ਤੋਂ ਬਾਅਦ ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਚਰਨ ਸਿੰਘ ਸ਼ਹੀਦ ਅਤੇ ਭਾਈ ਮੋਹਨ ਸਿੰਘ ਦਾ ਸਥਾਨ ਆਉਦਾ ਹੈ। ਇਨ੍ਹਾਂ ਦੋਵਾਂ ਨਾਵਲਕਾਰਾਂ ਦੀਆਂ ਰਚਨਾਵਾਂ ਵਿਚ ਵੀ ਧਰਮ ਪ੍ਰਚਾਰ ਦੇ ਨਾਲ ਨਾਲ ਸਮਾਜ ਸੁਧਾਰ ਦੀਆਂ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਬਿਆਨ ਕੀਤਾ ਗਿਆ ਹੈ। ਭਾਈ ਵੀਰ ਸਿੰਘ, ਚਰਨ ਸਿੰਘ ਸ਼ਹੀਦ, ਮੋਹਨ ਸਿੰਘ ਵੈਦ ਨੇ ਸਿੰਘ ਸਭਾ ਲਹਿਰ ਦੇ ਅਧੀਨ ਨਾਵਲ ਲਿਖੇ।

1.6.2 ਮਾਨਵਵਾਦੀ ਪ੍ਰਵਿਰਤੀ ਤੇ ਸੁਧਾਰਵਾਦੀ ਪ੍ਰਵਿਰਤੀ

ਦੇਸ਼ ਦੀ ਵੰਡ ਦਾ ਸਭ ਤੋਂ ਵੱਧ ਪ੍ਰਭਾਵ ਪੰਜਾਬ ਅਤੇ ਬੰਗਾਲ ਉੱਪਰ ਪਿਆ। ਇਨ੍ਹਾਂ ਥਾਵਾਂ 'ਤੇ ਫ਼ਿਰਕੂ ਫ਼ਸਾਦ ਹੋਏ। ਦੇਸ਼ ਦੀ ਵੰਡ ਅਤੇ ਫ਼ਿਰਕੂ ਫ਼ਸਾਦਾਂ ਤੋਂ ਬਹੁਤ ਸਾਰੇ ਸਾਹਿਤ ਰਚਿਆ ਗਿਆ। ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਇਸ ਪ੍ਰਵਿਰਤੀ ਦਾ ਅਰੰਭ ਹੋਇਆ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਨਾਨਕ ਸਿੰਘ ਨੇ 'ਅੱਗ ਦੀ ਖੇਡ', 'ਖ਼ੂਨ ਦੇ ਸੋਹਲੇ, ਦੇਸ਼ ਦੀ ਵੰਡ ਦੇ ਦੁਖਾਂਤ ਨੂੰ ਸਕਾਰ ਕਰਨ ਲਈ ਰਚੇ। ਇਸ ਤੋਂ ਬਿਨਾਂ 'ਆਦਮ ਖ਼ੋਰ', 'ਗ਼ਰੀਬ ਦੀ ਦੁਨਿਆ', 'ਮੰਝਦਾਰ' ਅਤੇ 'ਚਿਤਰਕਾਰ' ਵਿਚ ਵੀ ਦੇਸ਼ ਦੀ ਵੰਡ ਦਾ ਪ੍ਰਭਾਵ ਵੇਖਿਆ ਜਾ ਸਕਦਾ ਹੈ। ਸੁਰਿੰਦਰ ਸਿੰਘ ਨਰੂਲਾ ਨੇ ਇਸੇ ਪੱਖ ਨੂੰ ਆਪਣੇ ਨਾਵਲਾਂ 'ਦੀਨ ਤੇ ਦੁਨਿਆ' ਅਤੇ 'ਦਿਲ ਦਰਿਆ' ਵਿਚ ਪੇਸ਼ ਕੀਤਾ। ਕਰਤਾਰ ਸਿੰਘ ਦਾ ਨਾਵਲ 'ਆਂਦਰਾਂ' ਅਤੇ 'ਨਹੁੰ ਤੇ ਮਾਸ' ਇਸ ਪ੍ਰਵਿਰਤੀ ਦੇ ਲਖਾਇਕ ਨਾਵਲ ਹਨ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਨਰਿੰਦਰਪਾਲ ਸਿੰਘ ਨੇ (ਤ੍ਰਿਆ ਜਾਲ, ਅਮਨ ਦੇ ਰਾਹ ਤੇ ਇਕ ਪੜਾਅ), ਸੋਹਣ ਸਿੰਘ ਸ਼ੀਤਲ ਨੇ (ਤੂਤਾਂ ਵਾਲਾ ਖੂਹ ਅਤੇ ਈਚੋਗਿਲ ਨਹਿਰ ਤੱਕ) ਨਾਵਲ ਰਚੇ। ਇਨ੍ਹਾਂ ਸਾਰੇ ਨਾਵਲਾਂ ਦਾ ਮੰਤਵ ਵੰਡ ਕਾਰਨ ਉਪਜੇ ਦੁਖਾਂਤ ਦੀ ਰੋਸ਼ਨੀ ਵਿਚ ਮਾਨਵਵਾਦੀ ਵਿਚਾਰਧਾਰਾ ਦਾ ਪ੍ਰਚਾਰ ਕਰਨਾ ਸੀ। ਇਸ ਕਾਲ ਵਿਚ ਅਤੇ ਇਸ ਤੋਂ ਬਾਅਦ ਵੀ ਸੁਧਰਵਾਦੀ ਅਧੀਨ ਬਹੁਤ ਸਾਰੇ ਨਾਵਲ ਲਿਖੇ ਜਾਂਦੇ ਰਹੇ ਹਨ।

1.6.3 ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਯਥਾਰਥਵਾਦ ਦੀ ਪ੍ਰਵਿਰਤੀ

ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਯਥਾਰਥਵਾਦ ਦੀ ਪਰੰਪਰਾ ਬੜੀ ਲੰਮੀ ਤੇ ਗੌਰਵਮਈ ਹੈ। ਨਾਨਕ ਸਿੰਘ ਦੇ ਨਾਵਲਾਂ ਵਿਚ ਪ੍ਰਸਤੁਤ ਸਮਾਜਕ ਯਥਾਰਥ ਤੋਂ ਬਾਅਦ ਇਸ ਪ੍ਰਵਿਰਤੀ ਨੂੰ ਸੁਰਿੰਦਰ ਸਿੰਘ ਨਰੂਲਾ ਦੀ ਯਥਾਰਥਵਾਦੀ ਪਰੰਪਰਾ ਨਾਲ ਜੋੜਿਆ ਜਾ ਸਕਦਾ ਹੈ। ਉਸ ਦਾ ਨਾਵਲ 'ਪਿਉ ਪੁੱਤਰ' ਪੰਜਾਬੀ ਦਾ ਪ੍ਰਥਮ ਯਥਾਰਥਵਾਦੀ ਨਾਵਲ ਮੰਨਿਆ ਜਾਂਦਾ ਹੈ। ਅਜਿਹੇ ਨਾਵਲ ਵਿਚ ਜੀਵਨ ਦਾ ਅਨੁਕਰਨ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਪੱਛਮ ਵਿਚ ਬਾਲਜ਼ਾਕ, ਜ਼ੋਲਾ ਅਤੇ ਫਲਾਬੇਅਰ ਨੇ ਇਸ ਵੰਨਗੀ ਦੇ ਨਾਵਲ ਲਿਖੇ ਸਨ। ਇਸ ਵੰਨਗੀ ਦੇ ਨਾਵਲਾਂ ਨੂੰ ਪ੍ਰਾਕਿਰਤਵਾਦੀ ਰਚਨਾਵਾਂ ਵੀ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਸਮਕਾਲੀ ਜੀਵਨ ਨੂੰ ਯਥਾਰਥਕ ਰੂਪ ਵਿਚ ਪੇਸ਼ ਕੀਤਾ ਗਿਆ ਹੈ।

ਯਥਾਰਥਵਾਦੀ ਨਾਵਲ ਦੇ ਖੇਤਰ ਵਿਚ ਸੰਤ ਸਿੰਘ ਸੇਖੋਂ ਦਾ ਵੀ ਵਿਸ਼ੇਸ਼ ਯੋਗਦਾਨ ਹੈ। ਯਥਾਰਥਵਾਦੀ ਨਜ਼ਰੀਏ ਤੋਂ ਸੇਖੋਂ ਦਾ ਲਹੂ ਮਿੱਟੀ ਬਾਰ ਵਿਚ ਗਏ ਮੁਜ਼ਾਰੇ ਦੇ ਆਰਥਿਕ ਪਰਿਵਾਰਕ ਜੀਵਨ ਦੀ ਬੜੀ ਜੀਵੰਤ ਤਸਵੀਰ ਪੇਸ਼ ਕਰਦਾ ਹੈ। ਗੁਰਦਿਆਲ ਸਿੰਘ ਦੇ ਨਾਵਲ ਵਿਚ ਯਥਾਰਥਵਾਦੀ ਪ੍ਰਵਿਰਤੀ ਦਾ ਨਿਰੂਪਣ ਭਰਪੂਰ ਰੂਪ ਵਿਚ ਹੋਇਆ ਹੈ। ਉਸ ਦੇ ਨਾਵਲ 'ਅਣਹੋਏ', 'ਅੱਧ ਚਾਨਣੀ ਰਾਤ' ਅਤੇ 'ਮੜੀ ਦਾ ਦੀਵਾ' ਆਦਿ ਵਿਚ ਪੰਜਾਬ ਦੇ ਪਿੰਡਾਂ ਅਤੇ ਛੋਟਿਆਂ ਮੰਡੀਆਂ ਦਾ ਯਥਾਰਥਕ ਜੀਵਨ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਜਸਵੰਤ

ਸਿੰਘ ਕੰਵਲ, ਸੁਰਜੀਤ ਸਿੰਘ ਸੇਠੀ, ਦਲੀਪ ਕੌਰ ਟਿਵਾਣਾ, ਸੁਰਜੀਤ ਹਾਂਸ, ਨਰਿੰਜਨ ਤਸਨੀਮ, ਸੁਖਬੀਰ ਆਦਿ ਨਾਵਲਕਾਰਾਂ ਨੇ ਵੀ ਨਾਵਲ ਲਿਖੇ ਹਨ।

1.6.4 ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਪ੍ਰਗਤੀਵਾਦੀ ਪ੍ਰਵਿਰਤੀ

ਪੰਜਾਬੀ ਵਿਚ ਅਜਿਹੇ ਨਾਵਲਾਂ ਦੀ ਗਿਣਤੀ ਕਾਫ਼ੀ ਹੈ ਜਿਨ੍ਹਾਂ ਦੀ ਰਚਨਾ ਪ੍ਰਗਤੀਵਾਦੀ ਲਹਿਰ ਅਧੀਨ ਹੋਈ ਹੈ। ਇਸ ਲਹਿਰ ਦਾ ਪ੍ਰੇਰਨਾ-ਸਰੋਤ ਮਾਰਕਸ ਦਾ ਆਰਥਿਕ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਸੀ। ਵੀਹਵੀਂ ਸਦੀ ਦੇ ਪਹਿਲੇ ਅੱਧ ਤੋਂ ਹੀ ਪੰਜਾਬੀ ਲੇਖਕਾਂ 'ਤੇ ਪਗ੍ਰਤੀਵਾਦੀ ਲਹਿਰ ਦਾ ਅਸਰ ਪੈਣਾ ਅਰੰਭ ਹੋ ਗਿਆ ਸੀ। ਇਸ ਲਹਿਰ ਅਧੀਨ ਪੰਜਾਬੀ ਲੇਖਕਾਂ ਨੇ ਜਾਗੀਰਦਾਰੀ ਸਮਾਜ ਵਿਰੁੱਧ ਅਤੇ ਸਾਮਰਾਜ ਦੇ ਵਿਰੁੱਧ ਰਚਨਾਵਾਂ ਸ਼ੁਰੂ ਕਰ ਦਿੱਤੀਆਂ। ਇਸ ਸਮੇਂ ਲੇਖਕ ਕਿਰਤੀਆਂ, ਕਿਸਾਨਾਂ ਤੇ ਮਜ਼ਦੂਰਾਂ ਦੁਆਰਾ ਕੀਤੇ ਜਾ ਰਹੇ ਸੰਘਰਸ਼ ਦਾ ਸਮਰਥਨ ਕਰਨ ਲੱਗੇ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਸੰਤ ਸਿੰਘ ਸੇਖੋਂ ਦਾ ਨਾਵਲ 'ਲਹੂ ਮਿੱਟੀ' ਅਤੇ ਸੁਰਿੰਦਰ ਸਿੰਘ ਨਰੂਲਾ ਦੇ ਸਾਰੇ ਹੀ ਨਾਵਲ ਲਿਖੇ ਗਏ ਹਨ। ਪ੍ਰਗਤੀਵਾਦੀ ਸਿਧਾਂਤ ਦੀ ਸਭ ਤੋਂ ਵਧੇਰੇ ਸਫ਼ਲ ਪੇਸ਼ਕਾਰੀ ਇਸੇ ਨਾਵਲਕਾਰ ਦੇ ਨਾਵਲਾਂ ਵਿਚ ਹੋਈ ਹੈ। ਨਰੂਲਾ ਦੇ ਦੋ ਨਾਵਲ 'ਲੋਕ ਦੁਸ਼ਮਣ' (1951) ਅਤੇ 'ਨੀਲੀ ਬਾਰ' (1952) ਇਸ ਪ੍ਰਵਿਰਤੀ ਦੇ ਨਾਵਲ ਹਨ।

ਜਸਵੰਤ ਸਿੰਘ ਕੰਵਲ ਦੀਆਂ ਨਾਵਲੀ ਰਚਨਾਵਾਂ ਵਿਚੋਂ 'ਰਾਤ ਬਾਕੀ ਹੈ', 'ਭਵਾਨੀ' ਅਤੇ 'ਲਹੂ ਦੀ ਲੋਅ' ਵਿਸ਼ੇਸ਼ ਤੌਰ 'ਤੇ ਮਹੱਤਵਪੂਰਨ ਪ੍ਰਗਤੀਵਾਦੀ ਰਚਨਾਵਾਂ ਹਨ। ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ, ਜਸਬੀਰ ਭੁੱਲਰ, ਪ੍ਰਗਟ ਸਿੰਘ ਸੰਧੂ, ਬਲਜੀਤ ਕੌਰ ਬੱਲੀ, ਸੁਖਵੰਤ ਕੌਰ ਮਾਨ, ਇੰਦਰ ਸਿੰਘ ਖ਼ਾਮੋਸ਼, ਮਹਿੰਦਰ ਸਿੰਘ ਚੱਕਰ ਆਦਿ ਕੁਝ ਹੋਰ ਵੀ ਪ੍ਰਗਤੀਵਾਦੀ ਨਾਵਲ ਹਨ।

ਅਰੰਭਲੇ ਦੌਰ ਵਿਚੋਂ ਨਾਨਕ ਸਿੰਘ ਦੇ ਨਾਵਲ 'ਨਾਸੂਰ' ਅਤੇ 'ਆਦਮਖੋਰ' ਅਤੇ 'ਪਵਿੱਤਰ ਪਾਪੀ' ਵਿਚ ਵੀ ਇਸ ਪ੍ਰਵਿਰਤੀ ਦਾ ਭਲੀ-ਭਾਂਤ ਨਿਰੂਪਣ ਹੋਇਆ ਵੇਖਿਆ ਜਾਂ ਸਕਦਾ ਹੈ। ਇਸ ਪੱਖ ਤੋਂ ਨਾਨਕ ਸਿੰਘ ਦਾ ਨਾਵਲ 'ਗ਼ਰੀਬ ਦੀ ਦੁਨਿਆ' ਅਤੇ 'ਪਿਆਰ ਦੀ ਦੁਨੀਆ' ਨੂੰ ਵੀ ਰੱਖਿਆ ਜਾ ਸਕਦਾ ਹੈ।

ਡਾ. ਗੁਰਚਰਨ ਸਿੰਘ ਅਰਸ਼ੀ ਦਾ ਨਾਵਲ 'ਬੀਮਾਰ ਸੜਕਾਂ', ਗੁਰਮੁਖ ਸਿੰਘ ਦਾ ਨਾਵਲ 'ਮ੍ਰਿਗ ਤ੍ਰਿਸ਼ਨਾ' ਅਤੇ ਡਾ ਸਵਿੰਦਰ ਸਿੰਘ ਉੱਪਲ ਦਾ ਨਾਵਲ 'ਲਛਮਣ ਰੇਖਾ' ਵੀ ਪ੍ਰਗਤੀਵਾਦੀ ਨਾਵਲ ਹਨ।

1.6.5 ਆਲੋਚਨਾਤਮਕ ਯਥਰਥਵਾਦ ਦੀ ਪ੍ਰਵਿਰਤੀ

ਸਿਧਾਂਤਕ ਰੂਪ ਯਥਰਾਥਵਾਦ ਦੇ ਅੰਤਰਗਤ ਕਈ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਮਿਲਦੇ ਹਨ। ਇਨ੍ਹਾਂ ਵਿਚੋਂ ਇਕ ਆਲੋਚਨਾਤਮਕ ਯਥਾਰਥਵਾਦ ਦਾ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਵੀ ਮਹੱਤਵਪੂਨ ਹੈ। ਇਸ ਪ੍ਰਕਾਰ ਦੇ ਨਾਵਲਾਂ ਵਿਚ ਮਨੁੱਖੀ ਜੀਵਨ

ਨੂੰ ਸਮਾਜਿਕ ਸੰਦਰਭ ਤੋਂ ਵੱਖ ਕਰਕੇ ਨਹੀਂ ਸਗੋਂ ਉਸ ਨਾਲ ਜੋੜ ਕੇ ਵੇਖਿਆ ਜਾਂਦਾ ਹੈ। ਆਲੋਚਨਾਤਮਕ ਯਥਾਰਥਵਾਦ ਦੇ ਖੇਤਰ ਵਿਚ ਗੁਰਦਿਆਲ ਸਿੰਘ ਦੇ ਨਾਵਲਾਂ ਦਾ ਵਿਲੱਖਣ ਤੇ ਮਹੱਤਵਪੂਰਨ ਸਥਾਨ ਹੈ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਉਸ ਦੇ ਨਾਵਲਾਂ ਦੇ ਪਾਤਰ ਸਹਿਜ ਭਾਅ ਸੁਭਾਵਿਕ ਰੂਪ ਵਿਚ ਵਿਕਾਸ ਕਰਦੇ ਅਤੇ ਹੱਕਾਂ ਲਈ ਸੰਘਰਸ਼ ਕਰਦੇ ਹਨ। ਦਲੀਪ ਕੌਰ ਟਿਵਾਣਾ ਦਾ ਨਾਵਲ 'ਏਹੁ ਹਮਾਰਾ ਜੀਵਣਾ' ਵੀ ਇਸ ਪ੍ਰਵਿਰਤੀ ਦਾ ਪ੍ਰਤੀਨਿਧ ਨਾਵਲ ਮੰਨਿਆ ਜਾ ਸਕਦਾ ਹੈ। ਰਾਮ ਸਰੂਪ ਅਣਖੀ ਦੇ ਨਾਵਲ 'ਅੱਧਾ ਆਦਮੀ' ਤੇ 'ਕੱਖਾਂ ਕਾਨਿਆਂ ਦੇ ਪੁਲ' ਇਸੇ ਸ਼੍ਰੇਣੀ ਦੇ ਨਾਵਲ ਹਨ। ਰਾਮ ਸਰੂਪ ਅਣਖੀ ਨੇ ਆਪਣੇ ਨਾਵਲ 'ਜਿਨ ਸਿਰ ਸੋਹਣ ਪਟੀਆਂ' ਵਿਚ ਵੀ ਇਸੇ ਪ੍ਰਵਿਰਤੀ ਨੂੰ ਅਪਣਾਇਆ ਹੈ।

1.6.6 ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਮਨੋਵਿਗਿਆਨਿਕ ਪ੍ਰਵਿਰਤੀ

ਪੰਜਾਬੀ ਵਿਚ ਪੱਛਮੀ ਮਨੋਵਿਗਿਆਨਕ ਨਾਵਲ ਅਤੇ ਫ਼ਰਾਇਡ ਦੇ ਮਨੋਵਿਗਿਆਨਕ ਦੇ ਸਿਧਾਂਤ ਦੇ ਅਧੀਨ ਵੀ ਬਹੁਤ ਸਾਰੇ ਨਾਵਲ ਲਿਖੇ ਗਏ। ਫ਼ਰਾਇਡ ਨੇ ਮਾਨਵ-ਜਾਤੀ ਦੇ ਸਾਰੇ ਸੋਚਣ ਢੰਗ ਨੂੰ ਬਦਲ ਕੇ ਰੱਖ ਦਿੱਤਾ। ਉਸ ਅਨੁਸਾਰ ਮਨੁੱਖ ਦਾ ਬਾਹਰੀ ਵਿਵਹਾਰ ਉਸ ਦੇ ਅੰਦਰਲੇ ਜਗਤ ਦੇ ਵਿਵਹਾਰ ਦੇ ਅਨੁਕੂਲ ਹੁੰਦਾ ਹੈ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਆਧੁਨਿਕ ਨਾਵਲਕਾਰ ਕਹਾਣੀ ਦੇ ਬਿਆਨ 'ਤੇ ਇਨਾ ਜ਼ੋਰ ਨਹੀਂ ਦਿੰਦਾ ਜਿੰਨਾ ਪਾਤਰਾਂ ਦੇ ਮਨੋਵਿਸ਼ਲੇਸ਼ਣ ਨੂੰ ਪੇਸ਼ ਕਰਨ 'ਤੇ ਦਿੰਦਾ ਹੈ। ਪੰਜਾਬੀ ਨਾਵਲ ਦੀ ਇਹ ਪ੍ਰਵਿਰਤੀ ਪੂਰਵ-ਸਤੁੰਤਰਤਾ ਕਾਲ ਵਿਚ ਵੀ ਵੇਖੀ ਜਾ ਸਕਦੀ ਹੈ। ਸਭ ਤੋਂ ਪਹਿਲਾਂ ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਜੋਸ਼ੂਆ ਫ਼ਜਲਦੀਨ ਨੇ 'ਪ੍ਰਭਾ' ਨਾਵਲ ਲਿਖਿਆ।

ਗੁਰਬਖ਼ਸ਼ ਸਿੰਘ ਪ੍ਰੀਤਲੜੀ ਦੇ ਨਾਵਲ 'ਅਣਵਿਆਹੀ ਮਾਂ' ਅਤੇ ਨਾਨਕ ਸਿੰਘ ਨੇ 'ਪਵਿੱਤਰ ਪਾਪੀ' ਨੂੰ ਵੀ ਇਸ ਸ਼੍ਰੇਣੀ ਵਿਚ ਰੱਖਿਆ ਜਾ ਸਕਦਾ ਹੈ। ਦਲੀਪ ਕੌਰ ਟੀਵਾਣਾ ਨੇ 'ਅਗਨੀ ਪ੍ਰਖਿਆ' ਅਤੇ 'ਤੀਲੀ ਦਾ ਨਿਸ਼ਾਨ' ਵਿਚ ਔਰਤ ਦੀ ਮਨੋਅਵਸਥਾ ਨੂੰ ਵੱਖ-ਵੱਖ ਪ੍ਰਸੰਗ ਵਿਚ ਚਿਤਰੀਆ ਹੈ। ਸੁਖਬੀਰ ਦੇ ਤਿੰਨ ਨਾਵਲ 'ਰਾਤ ਦਾ ਚਿਹਰਾ', 'ਪਾਣੀ ਦੇ ਪੁਲ' ਅਤੇ 'ਸੜਕਾ ਦੇ ਕਿਨਾਰੇ, ਮਨੋਵਿਸ਼ਲੇਸ਼ਣਾਤਮਕ ਵਿਧੀ ਦੁਆਰਾ ਸ਼ਹਿਰੀ ਤੇ ਪੇਂਡੂ ਜੀਵਨ ਦੇ ਯਥਾਰਥਕ ਚਿੱਤਰ ਪੇਸ਼ ਕਰਦੇ ਹਨ। ਸੁਰਜੀਤ ਸਿੰਘ ਸੇਠੀ ਦਾ 'ਇੱਕ ਖ਼ਾਲੀ ਪਿਆਲਾ', ਹਰਨਾਮ ਸਿੰਘ ਸਹਿਰਾਈ ਦਾ ਨਾਵਲ 'ਸਫ਼ੈਦ ਪੋਸ਼' ਅਤੇ 'ਪਥਿਕ' ਅਤੇ ਰਜਿੰਦਰ ਸਿੰਘ ਬੇਦੀ ਦਾ ਨਾਵਲ 'ਇਕ ਚਾਦਰ ਅੱਧੋਰਾਣੀ' ਅਤੇ ਅੰਮ੍ਰਿਤਾ ਪ੍ਰੀਤਮ ਦੇ ਨਾਵਲ 'ਬੰਦ ਦਰਵਾਜਾ', 'ਸਾਗਰ ਤੇ ਸਿੱਪੀਆਂ' ਅਤੇ 'ਦਿੱਲੀ ਦੀਆਂ ਗਲੀਆਂ' ਇਸੇ ਦ੍ਰਿਸ਼ਟੀ ਦੇ ਨਾਵਲ ਹਨ। ਕਰਤਾਰ ਸਿੰਘ ਦੁੱਗਲ ਤਾਂ ਬੁਨਿਆਦੀ ਰੂਪ ਵਿਚ ਮਨੋਵਿਗਿਆਨ ਦਾ ਚਿਤੇਰਾ ਸਾਹਿਤਕਾਰ ਹੈ। ਦੁੱਗਲ ਦਾ ਨਾਵਲ 'ਇਕ ਦਿਲ ਵਿਕਾਊ ਹੈ' ਇਕ ਸਫ਼ਲ ਮਨੋਵਿਗਿਆਨਕ ਨਾਵਲ

ਹੈ।ਸੁਰਜੀਤ ਹਾਂਸ ਦਾ ਨਾਵਲ 'ਮਿੱਟੀ ਦੀ ਢੇਰੀ' ਵੀ ਇਸੇ ਵੰਨਗੀ ਦਾ ਨਾਵਲ ਹੈ। ਸੁਰਿੰਦਰ ਜੌਹਰ ਦਾ ਨਾਵਲ 'ਮੋਈ ਰੁੱਤ', ਨਰਿੰਜਨ ਤਸਨੀਮ ਦਾ ਨਾਲ 'ਤ੍ਰੇੜਾਂ' ਵੀ ਇਸੇ ਪ੍ਰਵਿਰਤੀ ਦੇ ਨਾਵਲ ਹਨ।

1.6.7 ਪੰਜਾਬੀ ਨਾਵਲ ਦੀ ਪ੍ਰਯੋਗਵਾਦੀ ਪ੍ਰਵਿਰਤੀ

ਸਮੁੱਚੇ ਪੰਜਾਬੀ ਸਾਹਿਤ ਵਿਚ ਭਾਵੇਂ ਉਹ ਨਾਵਲ ਹੈ, ਨਾਟਕ ਹੈ ਜਾਂ ਕੋਈ ਹੋਰ ਸਾਹਿਤ ਰੂਪ ਹੈ, 1960 ਤੋਂ ਬਾਅਦ ਪ੍ਰਯੋਗਵਾਦੀ ਰੁਚੀ ਸਪਸ਼ਟ ਰੂਪ ਵਿਚ ਜ਼ੋਰ ਫੜਦੀ ਪ੍ਰਤੀਤ ਹੁੰਦੀ ਹੈ। ਇਹ ਪ੍ਰਵਿਰਤੀ ਕੁਝ ਸਾਲਾਂ ਵਿਚ ਮੱਠੀ ਵੀ ਪੈ ਜਾਂਦੀ ਹੈ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਦਵਿੰਦਰ ਸਤਿਆਰਥੀ ਦਾ ਲਿਖਿਆ ਗਿਆ ਨਾਵਲ 'ਘੋੜਾ ਬਾਰਸ਼ਾਹ' ਇਕ ਮਹੱਤਵਪੂਰਨ ਨਾਵਲ ਹੈ।

1.6.8 ਚੇਤਨਾ ਪ੍ਰਵਾਹ ਦੀ ਪ੍ਰਵਿਰਤੀ

ਮਨੋਵਿਗਿਆਨ ਅਤੇ ਪ੍ਰਯੋਗਵਾਦੀ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਵਰਜੀਨੀਆ ਵੂਲਫ਼ ਦੇ ਪ੍ਰਭਾਵ ਸਦਕਾ ਪੰਜਾਬੀ ਵਿਚ ਵੀ ਚੇਤਨਾ-ਪ੍ਰਵਾਹ ਸ਼ੈਲੀ ਵਾਲੇ ਨਾਵਲਾਂ ਦੇ ਕੁਝ ਪ੍ਰਯੋਗ ਹੋਂਦ ਵਿਚ ਆਏ। ਅਸਲ ਵਿਚ ਇਹ ਨਾਵਲ ਭਾਵੇਂ ਮਨੋਵਿਗਿਆਨਕ ਨਾਵਲ ਦਾ ਹੀ ਭਾਗ ਹਨ ਪਰ ਰਚਨਾ ਪੱਖ ਤੋਂ ਵੀ ਕਈ ਨਵੇਂ ਪ੍ਰਯੋਗ ਹਨ। ਸੁਰਜੀਤ ਸਿੰਘ ਸੇਠੀ ਦੇ ਨਾਵਲ 'ਇਕ ਖ਼ਾਲੀ ਪਿਆਲਾ', 'ਅੱਲ੍ਹ ਪੱਥਰ' ਅਤੇ 'ਆਬਰਾ ਕਦਾਬਰਾ' ਨਵੇਂ ਪ੍ਰਯੋਗ ਦੇ ਨਾਵਲ ਹਨ। 'ਕੱਲ ਵੀ ਸੂਰਜ ਨਹੀਂ ਚੜ੍ਹੇਗਾ' ਜਲ੍ਹਿਆਂ ਵਾਲੇ ਬਾਗ ਦੇ ਖ਼ੂਨੀ ਸਾਕੇ ਨਾਲ ਸਬੰਧਤ ਨਾਵਲ ਹੈ। ਮਨਜੀਤ ਰਾਣਾ ਦਾ ਨਾਵਲ 'ਦਿਲ ਤੇ ਦੁਨਿਆ' ਅਤੇ ਜਗਜੀਤ ਬਰਾੜ ਦਾ ਨਾਵਲ 'ਧੁੱਪ ਦਰਿਆ ਦੀ ਦੋਸਤੀ' ਵੀ ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਤਕਨੀਕ ਪੱਖੋਂ ਨਵੇਂ ਪ੍ਰਯੋਗ ਹਨ। ਇਸ ਸ਼ੈਲੀ ਵਿਚ ਰਚਿਆ ਨਰਿੰਜਨ ਤਸਨੀਮ ਦਾ ਨਾਵਲ 'ਰੇਤ ਛੱਲ' ਵੀ ਇਕ ਵਰਨਯੋਗ ਰਚਨਾ ਹੈ। 'ਇਕ ਹੋਰ ਨਵਾਂ ਸਾਲ' ਨਾਵਲ ਵਿਚ ਮਨੋਵਚਨੀ ਦੀ ਵਿਧੀ ਨਾਲ ਇੱਕ ਰਿਕਸ਼ਾ ਚਾਲਕ ਦੀ ਇਕ ਦਿਨ ਦੀ ਜ਼ਿੰਦਗੀ ਆਪ-ਬੀਤੀ ਦੇ ਰੂਪ ਵਿਚ ਪੇਸ਼ ਕੀਤੀ ਹੈ।

1.6.9 ਪੰਜਾਬੀ ਨਾਵਲ ਦੀ ਸੁਹਜਾਤਮਕ ਪ੍ਰਵਿਰਤੀ

ਇਸ ਪ੍ਰਵਿਰਤੀ ਦਾ ਸੰਚਾਲਕ ਵੀ ਕਰਤਾਰ ਸਿੰਘ ਦੁੱਗਲ ਹੈ। ਉਸ ਦੇ ਨਾਵਲ 'ਦਿਲ ਦਰਿਆ', 'ਇਕ ਦਿਲ ਵਿਕਾਊ ਹੈ', 'ਮੇਰਾ ਦਿਲ ਮੋੜ ਦੇ' ਅਤੇ 'ਮਾਂ ਪਿਉ ਜਾਏ' ਇਸੇ ਪ੍ਰਵਿਰਤੀ ਦੇ ਅੰਤਰਗਤ ਲਿਖੇ ਗਏ ਨਾਵਲ ਹਨ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਅਧੀਨ ਕਾਮ ਵਾਸ਼ਨਾਵਾਂ ਦਾ ਪ੍ਰਗਟਾਵਾ ਵੀ ਹੋਇਆ ਹੈ। ਮੋਹਨ ਸਿੰਘ ਕਾਹਲੋਂ ਨੇ ਇਸ ਨੰਗੇਜਵਾਦੀ ਸ਼ੈਲੀ ਵਿਚ ਕੁੱਝ ਨਾਵਲ ਲਿਖੇ ਹਨ।

1.6.10 ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਆਂਚਲਿਕਤਾ ਦੀ ਪ੍ਰਵਿਰਤੀ

ਪੰਜਾਬੀ ਨਾਵਲ ਵਿਚ ਪਹਿਲਾਂ ਤਾਂ ਨੀਮ ਸੁਰ ਵਿਚ ਅੱਜ-ਕੱਲ੍ਹ ਪ੍ਰਮੁੱਖ ਸੁਰ ਵਿਚ ਆਂਚਲਿਕ ਨਾਵਲ ਲਿਖਣ ਦੀ ਪ੍ਰਵਿਰਤੀ ਨਜ਼ਰ ਆ ਰਹੀ ਹੈ। ਇਸ ਪ੍ਰਵਿਰਤੀ ਦਾ ਅਰੰਭ ਤਾਂ ਸੋਹਣ ਸਿੰਘ ਸੀਤਲ, ਹਰੀ ਸਿੰਘ ਦਿਲਬਰ ਅਤੇ ਜਸਵੰਤ ਸਿੰਘ ਕੰਵਲ ਦੇ ਨਾਵਲਾਂ ਨਾਲ ਹੀ ਹੋ ਗਿਆ ਸੀ ਪਰ ਇਸ ਨੂੰ ਇਕ ਵਿਸ਼ੇਸ਼ ਪ੍ਰਵਿਰਤੀ ਦੇ ਰੂਪ ਵਿਚ ਸਵੀਕ੍ਰਿਤੀ ਗੁਰਦਿਆਲ ਸਿੰਘ (ਮੜ੍ਹੀ ਦਾ ਦੀਵਾ) ਨਾਲ ਹੀ ਮਿਲੀ ਹੈ। ਮੋਹਨ ਸਿੰਘ ਕਾਹਲੋਂ ਦਾ ਨਾਵਲ 'ਬੇੜੀ ਤੇ ਬਰੇਤਾ' ਵੀ ਇਸ ਪ੍ਰਵਿਰਤੀ ਦੀ ਪ੍ਰਮੁੱਖ ਉਦਾਰਹਨ ਹੈ। ਸੀਤਲ ਅਤੇ ਦਿਲਬਰ ਦੇ ਸਾਰੇ ਨਾਵਲਾਂ ਵਿਚ ਕ੍ਰਮਵਾਰ ਮਾਝੇ ਅਤੇ ਮਾਲਵੇ ਦੇ ਇਲਾਕੇ ਦੀ ਆਂਚਲਿਕਤਾ ਦਾ ਭਰਪੂਰ ਵਰਣਨ ਮਿਲਦਾ ਹੈ।

ਉਪਰੋਕਤ ਨਾਵਲਾਂ ਵਿਚ ਤਤਕਾਲੀਨ ਪ੍ਰਸਥਿਤੀਆਂ ਨੂੰ ਇਤਿਹਾਸਕ ਸੰਦਰਭ ਵਿਚ ਰੱਖ ਕੇ ਵਿਚਾਰਿਆ ਗਿਆ ਹੈ। ਪ੍ਰਵਿਰਤੀਆਂ ਦੀ ਦ੍ਰਿਸ਼ਟੀ ਤੋਂ ਇਸ ਨੇ ਸਮਕਾਲੀ ਵਿਸ਼ਵ ਦੇ ਨਾਵਲ ਨਾਲ ਤੁਰਨ ਦਾ ਜਤਨ ਕੀਤਾ ਹੈ। ਕਲਾ ਦੀ ਦ੍ਰਿਸ਼ਟੀ ਤੋਂ ਵਿਸ਼ਵ ਭਰ ਦੇ ਨਾਵਲੀ-ਮਾਡਲਾਂ ਤੇ ਕਲਮ ਅਜ਼ਮਾਈ ਕੀਤੀ ਹੈ। ਪੰਜਾਬੀ ਨਾਵਲਕਾਰਾਂ ਪਾਸੋਂ ਭਵਿਖ ਵਿਚ ਹੋਰ ਸੰਭਵਨਾਵਾਂ ਸਿਰਜਣ ਦੀ ਆਸ ਹੈ।

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8. ਗੁਰਚਰਨ ਸਿੰਘ, ਪੰਜਾਬੀ ਗਲਪ ਦਾ ਇਤਿਹਾਸ, ਪੰਨਾ 124
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ਅਧਿਆਇ ਦੂਜਾ

ਕਰਮਜੀਤ ਸਿੰਘ ਦਾ ਜੀਵਨ ਅਤੇ ਰਚਨਾ

2.1 ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦਾ ਜੀਵਨ

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਪੰਜਾਬੀ ਸਾਹਿਤ ਦਾ ਇਕ ਉੱਤਮ ਨਾਵਲਕਾਰ ਹੈ। ਪੰਜਾਬੀ ਨਾਵਲ ਨੂੰ ਉਸ ਨੇ ਆਪਣੀ ਆਮਦ ਨਾਲ ਹੋਰ ਵੀ ਅਮੀਰ ਬਣਾ ਦਿੱਤਾ। ਕੁੱਸਾ ਇਕ ਸਧਾਰਨ ਅਤੇ ਨਿਮਨ ਪਰਿਵਾਰ ਨਾਲ ਸੰਬੰਧ ਰੱਖਦਾ ਸੀ। ਕੁੱਸਾ ਜਾ ਜਨਮ 1.1.1953 ਨੂੰ ਸਰਦਾਰ ਮੇਹਰ ਸਿੰਘ ਧਾਲੀਵਾਲ ਦੇ ਘਰ ਪਿੰਡ ਕੁੱਸਾ ਜ਼ਿਲ੍ਹਾ ਮੋਗਾ ਵਿਚ ਹੋਇਆ। ਉਨ੍ਹਾਂ ਨੇ ਐਮ.ਏ. ਪੰਜਾਬੀ ਅਤੇ ਬੀ.ਐੱਡ. ਦੀ ਪੜ੍ਹਾਈ ਕੀਤੀ। ਕਾਫੀ ਸਮੇਂ ਤੱਕ ਇਨ੍ਹਾਂ ਨੇ ਜਗਰਾਵਾਂ ਨੇੜੇ ਸਰਕਾਰੀ ਸਕੂਲ, ਮੱਲ੍ਹੇ ਵਿਖੇ ਪੜ੍ਹਾਇਆ। ਇਨ੍ਹਾਂ ਦਾ ਪਹਿਲਾ ਵਿਆਹ ਕਿਰਨਜੀਤ ਕੌਰ ਨਾਲ ਹੋਇਆ ਸੀ ਪਰ ਪਹਿਲੀ ਹੀ ਬੱਚੀ ਦੇ ਜਨਮ ਵੇਲੇ ਕਿਰਨਜੀਤ ਦੀ ਮੌਤ ਹੋ ਗਈ। ਬੱਚੀ ਬਚ ਗਈ। ਉਸ ਦਾ ਨਾਂ ਕਮਲ ਹੈ। ਕੁੱਸਾ ਦਾ ਦੂਜਾ ਵਿਆਹ ਸਤਵਿੰਦਰ ਨਾਲ 1990 ਵਿਚ ਹੋਇਆ। ਕੁੱਸਾ ਨੂੰ ਸ਼ਰਾਬ ਪੀਣ ਦੀ ਮਾੜੀ ਲੱਤ ਸੀ। ਡਾ. ਬਲਜਿੰਦਰ ਸਿੰਘ ਨਸਰਾਲੀ ਨੇ ਕੁੱਸਾ ਨਾਲ ਕੀਤੀ ਮੁਲਾਕਾਤ (ਬੱਦਲਾਂ 'ਚ ਗੁੰਮਿਆਂ ਤਾਰਾ-ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ) ਵਿਚ ਲਿਖਿਆ ਹੈ ਕਿ, ''ਬਹੁਤ ਸਾਰੇ ਪਾਠਕਾਂ ਨੂੰ ਤਾ ਕੁੱਸਾ ਬਾਰੇ ਥਹੁ-ਪਤਾ ਹੀ ਨਹੀਂ ਲੱਗਦਾ, ਜੇ ਲੱਗਦਾ ਵੀ ਹੈ ਤਾਂ ਇਹ ਉਹ ਤਾਂ ਜੀ ਸ਼ਰਾਬੀ-ਕਬਾਬੀ ਬੰਦਾ ਹੈ, ਆਪਣੇ ਆਪ ਵਿਚ ਰਹਿੰਦਾ ਹੈ, ਇੰਨੇ ਸੋਹਣੇ ਨਾਵਲ ਪਤਾ ਨਹੀਂ ਕਿਵੇ ਲਿਖ ਲੈਂਦਾ ਹੈ।''[1]

ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਨੂੰ ਜਿੱਥੇ ਪੰਜਾਬੀ ਸਾਹਿਤ ਵਿਚ ਜਾਣੀਆਂ-ਪਛਾਣੀਆਂ ਹਸਤੀਆਂ ਜੋਗਿੰਦਰ ਸਿੰਘ ਰਾਹੀ, ਟੀ. ਆਰ. ਵਿਨੋਦ ਆਦਿ ਨੇ ਸਲਾਹਿਆ ਹੈ, ਉਥੇ ਆਮ ਲੋਕਾਂ ਨੇ ਵੀ ਆਪ ਦੇ ਨਾਵਲਾਂ ਨੂੰ ਚਾਅ ਨਾਲ ਪੜ੍ਹਿਆ ਹੈ। ਕੁੱਝ ਲੋਕ ਇਹ ਵੀ ਮੰਨਦੇ ਹਨ ਕਿ ਕੁੱਸਾ ਆਪਣੇ ਨਾਵਲਾਂ ਵਿਚ ਮਾਲਵੇ ਦੇ ਲੋਕ-ਜੀਵਨ ਦੀ ਫ਼ੋਟੋਗਰਾਫੀ ਹੀ ਕਰਦਾ ਹੈ, ਜ਼ਿੰਦਗੀ ਪ੍ਰਤੀ ਕੋਈ ਵਿਸ਼ੇਸ਼ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਪੇਸ਼ ਨਹੀਂ ਕਰਦਾ। ਪੰਜਾਬੀ ਦੇ ਇਸ ਮਹਾਨ ਸਾਹਿਤਕਾਰ ਦੀ ਮੌਤ 20.3.1998 ਨੂੰ ਹੋ ਗਈ।

2.2 ਕਰਮਜੀਤ ਕੁੱਸਾ ਜੀ ਦੀ ਰਚਨਾ

ਕਰਮਜੀਤ ਕੁੱਸਾ ਪੰਜਾਬੀ ਦਾ ਨੌਜਵਾਨ ਨਾਵਲਕਾਰ ਹੈ। ''ਜਿਸ ਨੇ ਆਪਣੇ ਨਾਵਲਾਂ ਵਿਚ ਮਾਲਵੇ ਦੇ ਪੇਂਡੂ ਕਿਰਸਾਨੀ ਜੀਵਨ ਨੂੰ ਕਲਾਤਮਕ ਢੰਗ ਨਾਲ ਚਿਤਰਿਆ ਹੈ।''[2]ਉਸ ਦੇ ਨਾਵਲ, 'ਬੁਰਕੇ ਵਾਲੇ ਲੁਟੇਰੇ' (1977),

'ਰਾਤ ਦੇ ਰਾਹੀ' (1979), 'ਰੋਹੀ ਬੀਆਬਾਨ' (1982), 'ਅੱਗ ਦਾ ਗੀਤ' (1985), 'ਜ਼ਖ਼ਮੀ ਦਰਿਆ' (1991)। 'ਬੁਰਕੇ ਵਾਲੇ ਲੁਟੇਰੇ' ਪ੍ਰਗਤੀਵਾਦੀ ਵਿਚਾਰਧਾਰਾ ਦਾ ਸਮਰਥਨ ਕਰਨ ਵਾਲਾ ਨਾਵਲ ਹੈ। 'ਰਾਤ ਦੇ ਰਾਹੀ' ਵਿਚ ਪੇਂਡੂ ਸਭਿਅਤਾ ਦਾ ਚਿਤਰ ਹੈ ਜੋ ਆਪਣੇ ਅੰਦਾਜ਼ ਵਿਚ ਹੈ। ਉਹ ਛੋਟੇ ਕਿਸਾਨ ਤੇ ਨਿੱਜੀ ਮਾਲਿਕ ਦਾ ਸੰਬੰਧ ਦਰਸਾਉਣਾ ਚਾਹੁੰਦਾ ਹੈ। ਨਾਵਲਕਾਰ ਨੇ ਸਾਬਿਤ ਕੀਤਾ ਹੈ ਕਿ ਛੋਟੀ ਕਿਸਾਨੀ ਦੀ ਸਥਿਤੀ ਪਹਿਲਾਂ ਨਾਲੋਂ ਵੀ ਮਾੜ੍ਹੀ ਹੋ ਰਹੀ ਹੈ। ਇਹ ਲੋਕ ਕੁਰਬਾਨੀਆਂ ਦੇ ਕੇ ਵੀ ਆਪਣੀ ਹੱਕੀ ਜਗ੍ਹਾ ਨਹੀਂ ਲੈ ਸਕੇ।

'ਅੱਗ ਦਾ ਗੀਤ' ਨਾਵਲ ਵਿਚ ਬਸੰਤ ਕੌਰ ਵਰਗੀ ਅਡੋਲ ਔਰਤ ਹਰੇਕ ਪ੍ਰਸਥਿਤੀ ਵਿਚ ਮੁਸੀਬਤ ਅੱਗੇ ਚਟਾਨ ਬਣ ਕੇ ਖੜ੍ਹ ਜਾਂਦੀ ਹੈ। ਆਪਣੇ ਪਤੀ ਦੇ ਸੱਤੋ ਨਾਲ ਉਧਲਣ ਉਪਰੰਤ ਉਹ ਹਰੇਕ ਮੁਸਿਬਤ ਦਾ ਡਟ ਕੇ ਸਾਹਮਣਾ ਕਰਦੀ ਹੈ।

ਕੁੱਸਾ ਇੱਕ ਉੱਤਮ ਨਾਵਲਕਾਰ ਹੈ। "ਕੁੱਸਾ ਆਪਣੇ ਤੀਸਰੇ ਨਾਵਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਵਿਚ ਵੀ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਸੰਤਾਪ ਦੀ ਗੱਲ ਕਰਦਾ ਹੈ।"[3] ਇਸ ਨਾਵਲ ਦਾ ਮੁੱਖ ਪਾਤਰ ਗੋਰਾ ਹੈ ਜੋ ਆਪਣੇ ਪਿਤਾ-ਪੁਰਖੀ ਕਿੱਤੇ ਖੇਤੀ ਤੋਂ ਪਰ੍ਹੇ ਕਿਸੇ ਵੀ ਦਿਸ਼ਾ ਵੱਲ ਤੁਰਨ ਦੇ ਸਮਰੱਥ ਨਹੀਂ ਹੈ। ਉਸ ਦਾ ਸੁਭਾਅ ਉਸ ਨੂੰ ਕਿਸੇ ਪ੍ਰਤੀਕੂਲ ਸਥਿਤੀ ਨਾਲ ਸਮਝੌਤਾ ਨਹੀਂ ਕਰਨ ਦਿੰਦਾ ਤੇ ਸਭ ਪਾਸਿਓਂ (ਪੜ੍ਹਾਈ, ਫੈਕਟਰੀ, ਟਰੱਕ ਡਰਾਇਵਰੀ, ਵਿਦੇਸ਼ਾਂ 'ਚ ਰੁਜ਼ਗਾਰ) ਨਿਰਵਾਸਤ ਹੋ ਕੇ ਵਾਪਸ ਫੇਰ ਖੇਤੀ ਵੱਲ ਪਰਤਣਾ ਲੋਚਦਾ ਹੈ ਪਰ ਉਸ ਸਮੇਂ ਤੱਕ ਇਹ ਸੰਭਵ ਨਹੀਂ ਰਹਿੰਦਾ। ਅਖੀਰ ਸ਼ਰੀਕਾਂ ਨਾਲ ਸੀਰੀ ਰਲਣ ਦੀ ਮਜ਼ਬੂਰੀ ਤੋਂ ਛੁਟਕਾਰਾ ਪਾਉਣ ਲਈ ਗੋਰਾ ਪਿੰਡੋਂ ਭੱਜ ਤੁਰਦਾ ਹੈ;

> "ਓਦੋਂ ਈ ਪਿੰਡ ਦੀ ਤੇ ਬਾਹਰਲੀ ਬਿਜਲੀ ਇਕ ਦਮ ਬੁਝ ਗਈ।ਚਾਰ ਚੁਫੇਰੇ ਹਨੇਰ-ਗੁਬਾਰ ਪਸਰ ਗਿਆ। ਹੱਥ ਨੂੰ ਹੱਥ ਮਾਰਿਆਂ ਨਹੀਂਦਿਸਦਾ ਸੀ। ਉਸ ਨੇ ਭਉਂ ਕੇ ਵੇਖਿਆ, ਉਸਨੂੰ ਮਹਿਸੂਸ ਹੋਇਆਜਿਵੇਂ ਪਿੰਡ ਦੀ ਮੌਤ ਹੋ ਗਈ ਹੋਵੇ।"[4]

'ਰਾਤ ਦੇ ਰਾਹੀ' ਪੰਜਾਬ ਦੇ ਨਿਮਨ ਅਤੇ ਮੱਧਲੇ ਕਿਸਾਨੀ ਉਪਵਰਗਾਂ ਦੇ ਆਰਥਿਕ ਅਤੇ ਸਾਂਸਕ੍ਰਿਤ ਦੋਹਰੇ ਸੰਕਟ ਦਾ ਗਲਪ-ਬਿੰਬ ਰਾਹੀਂ ਕੀਤਾ ਗਿਆ ਪ੍ਰਗਟਾਅ ਹੈ।"[5] ਨਾਵਲ ਦੇ ਕੇਂਦਰੀ ਪਾਤਰ ਕੇਵਲ ਨੂੰ ਜਿਹੜੀ ਆਰਥਿਕ ਅਤੇ ਸਾਂਸਕ੍ਰਿਤਕ ਸਮੱਸਿਆ ਦਰਪੇਸ਼ ਹੈ ਉਹੀ ਸਮੱਸਿਆ ਕਿਸੇ ਨਾ ਕਿਸੇ ਬਦਲਵੇਂ ਰੂਪ ਵਿਚ ਉਸ ਵਰਗੇ ਦੂਜੇ ਪਾਤਰਾਂ ਦੇ ਸਾਹਮਣੇ ਹੈ। ਨਾਵਲ ਦੀ ਨਾਇਕਾ ਦੀਪੋ ਇਕ ਹੁੰਦੜ-ਹੇਲ ਜਨਾਨੀ ਹੈ ਅਤੇ ਇਕ ਨਿਆਣੀ ਉਮਰ ਦੇ ਮੁੰਡੇ ਕੈਲੂ ਨਾਲ ਵਿਆਹੀ ਹੈ। ਭਾਵ ਘਰ ਵਿਚ ਕੋਈ ਖਾਸ ਆਰਥਿਕ ਤੰਗੀ ਨਹੀਂ ਪਰ ਅਣਜੋੜ ਸੰਬੰਧਾਂ ਕਾਰਨ ਉਹ ਆਪਣੇ ਵਿਆਹੁਤਾ ਜੀਵਨ ਨੂੰ ਬੰਧਨ ਸਮਝਦੀ ਹੈ। ਦੀਪੋ ਦੀ ਆਂਤਰਿਕ ਇੱਛਾ ਪੂਰਤੀ ਦਾ ਭਾਵੁਕ ਵੇਗ ਉਸ ਨੂੰ ਸਭ ਤਰ੍ਹਾਂ ਦੇ ਸਮਾਜਕ ਬੰਧਨ ਤੋੜ ਦੇਣ ਲਈ ਉਕਸਾਉਂਦਾ ਹੈ।

'ਅਕਾਲ ਪੁਰਖੀ' ਨਾਵਲ ਵੀ ਕੁੱਸਾ ਨੇ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਹਿੱਤ ਵਿਚ ਲਿਖਿਆ ਹੈ। ''ਅਕਾਲ ਪੁਰਖੀ ਨਾਵਲ ਦੋ ਭਾਗਾਂ ਵਿਚ ਵੰਡਿਆ ਹੋਇਆ ਹੈ। ਇਕ ਭਾਗ ਕੇਂਦਰੀ ਪਾਤਰ ਪ੍ਰਤਾਪ ਸਿੰਘ ਦਾ ਆਪਣੇ ਦੋਵੇਂ ਵੱਡੇ ਭਰਾਵਾਂ ਨਾਲ ਜੁੜਿਆ ਹੋਇਆ ਹੈ। ਦੂਸਰਾ ਭਾਗ ਉਸਦਾ ਇਕੱਲੇ ਦਾ ਆਪਣਾ ਸੰਘਰਸ਼ ਹੈ।''[6]

ਪ੍ਰਤਾਪ ਛੋਟੀ ਕਿਸਾਨੀ ਨਾਲ ਸੰਬੰਧਿਤ ਹੈ। ਪ੍ਰਤਾਪ ਆਪਣੇ ਭਰਾਵਾਂ ਕੋਲੋਂ ਨਫ਼ਰਤ ਕਰਦਾ ਹੈ ਕਿਉਂਕਿ ਉਹ ਅੰਗਰੇਜ਼ਾਂ ਦੀ ਦਲਾਲੀ ਕਰਦੇ ਹਨ। ਪ੍ਰਤਾਪ ਅਤੇ ਉਸ ਦੀ ਤੀਵੀਂ ਸਖ਼ਤ ਮਿਹਨਤ ਕਰਨ ਦੇ ਬਾਵਜੂਦ ਆਰਥਿਕ ਤੰਗੀ ਦੇ ਸ਼ਿਕਾਰ ਹਨ। ਸੋ ਕੁੱਸਾ ਦੇ ਜੇਕਰ ਸਮੁੱਚੇ ਨਾਵਲਾਂ ਨੂੰ ਧਿਆਨ ਨਾਲ ਵਾਚੀਏ ਤਾਂ ਅਹਿਸਾਸ ਹੁੰਦਾ ਹੈ ਕਿ ਕੁੱਸਾ ਛੋਟੀ ਕਿਸਾਨੀ ਦਾ ਨਾਵਲਕਾਰ ਹੈ। ਜਿਸ ਨੇ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਸੰਤਾਪ ਨੂੰ ਯਥਾਰਥਕ ਤਰੀਕੇ ਨਾਲ ਬਿਆਨ ਕੀਤਾ ਹੈ।

2.3 ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦਾ ਸਾਹਿਤਕ ਪਿਛੋਕੜ

ਕੁੱਸਾ ਦਾ ਵਧੇਰੇ ਰੁਝਾਨ ਨਾਵਲ ਪ੍ਰਤੀ ਸੀ। 'ਬੁਰਕੇ ਵਾਲੇ ਲੁਟੇਰੇ' (1977), 'ਰਾਤ ਦੇ ਰਾਹੀ' (1979), 'ਰੋਹੀ ਬੀਆਬਾਨ' (1982), 'ਅੱਗ ਦਾ ਗੀਤ' (1985), 'ਜ਼ਖ਼ਮੀ ਦਰਿਆ' (1991) ਉਸਦੇ ਪ੍ਰਸਿੱਧ ਨਾਵਲ ਹਨ। 'ਬੁਰਕੇ ਵਾਲੇ ਲੁਟੇਰੇ' ਉਸ ਦੀ ਅਭਿਆਸੀ ਦੌਰ ਦੀ ਰਚਨਾ ਸੀ ਇਸ ਕਾਰਨ ਇਸ ਵਿਚ ਰੋਮਾਨੀਅਤ ਦਾ ਰੰਗ ਵਧੇਰੇ ਪ੍ਰਬਲ ਹੈ ਪ੍ਰੰਤੂ ਪਿਛਲੇ ਨਾਵਲਾਂ ਵਿਚ ਉਸਨੇ ਨਿਮਨ-ਕਿਰਸਾਣੀ ਸਮਾਜ ਦੇ ਉਲਾਰਾਂ-ਵਿਕਾਰਾਂ ਦੀ ਬੜੀ ਵਿਸ਼ਵਾਸ਼ ਯੋਗ ਤਸਵੀਰ ਪੇਸ਼ ਕੀਤੀ ਹੈ। ਕੁੱਸਾ ਦੇ ਅਗਲੇ ਨਾਵਲ 'ਰਾਤ ਦੇ ਰਾਹੀ' ਵਿਚ ਪਰੰਪਰਾਗਤ ਸੰਸਕ੍ਰਿਤੀ ਦੀ ਖੜੋਤ ਤੋਂ ਉਤਪੰਨ ਛੋਟੀ ਕਿਰਸਾਣੀ ਦੇ ਔਰਤ ਮਰਦ ਦੇ ਜਿਨਸੀ ਸੰਬੰਧਾਂ ਦੇ ਵਿਭਿੰਨ ਰੂਪਾਂ ਵਿਚਲੇ ਵਿਵੇਕ ਨੂੰ ਸਿਰਜਿਆ ਗਿਆ ਹੈ। ਇਹ ਨਾਵਲ ਸਾਂਸਕ੍ਰਿਤਿਕ ਅਤੇ ਆਰਥਿਕ ਮੁੱਲਾਂ ਦੇ ਸੰਵਾਦ ਨੂੰ ਸੰਜੀਵ ਰੂਪ ਵਿੱਚ ਪੇਸ਼ ਕਰਦਾ ਹੈ। 'ਰੋਹੀ ਬੀਆਬਾਨ' ਵਿਚ ਹਰੀ ਕ੍ਰਾਂਤੀ ਉਪਰੰਤ ਪੰਜਾਬ ਦੀ ਛੋਟੀ ਕਿਰਸਾਣੀ ਦੇ ਸੰਕਟ ਨੂੰ ਰੂਪਮਾਨ ਕੀਤਾ ਗਿਆ ਹੈ। ਇਸ ਨਾਵਲ ਨੂੰ ਕਿਸਾਨੀ ਸੱਭਿਆਚਾਰ ਦਾ ਦਸਤਾਵੇਜ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਯਥਾਰਥਵਾਦੀ ਨਾਵਲ ਦੀਆਂ ਬਿਰਤਾਂਤਕ ਜੁਗਤਾਂ ਦਾ ਕਲਾਤਮਕ ਪ੍ਰਯੋਗ ਕੀਤਾ ਗਿਆ ਹੈ।

ਉਸਦੇ ਆਪਣੇ ਕਥਨ ਅਨੁਸਾਰ ਉਸ ਨੇ ਸੱਤ ਨਾਵਲ ਲਿਖੇ ਹਨ, ''ਹੁਣ ਤੱਕ ਮੇਰੇ ਛਪੇ ਅਣਛਪੇ ਸੱਤ ਨਾਵਲ ਹਨ, ਪਹਿਲੇ ਤਿੰਨ ਨਾਵਲ ਮੈਂ ਛਾਪੇ ਨੇ, ਸ਼ਾਇਦ ਉਦੋਂ ਛਪਣਾਉਣ ਦੀ ਲੋਚਾ ਵੀ ਨਹੀਂ ਸੀ। ਅਸਲ ਵਿਚ ਬੁਰਕੇ ਵਾਲੇ ਲੁਟੇਰੇ ਰਾਹੀ ਮੇਰਾ ਸਾਹਿਤਿਕ ਸਫਰ ਪਾਠਕਾਂ ਸਾਹਮਣੇ ਪੇਸ਼ ਹੁੰਦਾ ਹੈ।''[7]

2.4 ਕਰਮਜੀਤ ਕੁੱਸਾ ਜੀ ਦੀ ਸਵੈ-ਲਿਖਤ, ਮੈਂ ਲਿਖਾਰੀ ਕਿਵੇਂ ਬਣਿਆ?

ਬਚਪਨ ਵਿਚ ਹੀ ਮੇਰਾ ਸੁਭਾਅ ਕੁਝ ਅਜਿਹਾ ਸੀ ਕਿ ਮੈਂ ਆਪਣੇ ਬਾਕੀ ਭੈਣ-ਭਰਾਵਾਂ ਦੀ ਨਿਸਬਤ ਜਟਕੇ-ਤਕਾਜ਼ੇ ਵਿਚ ਢਿੱਲਾ ਸਮਝਿਆ ਜਾਂਦਾ ਸੀ। ਕਿਉਂਕੀ ਇਸ ਕਿੱਤੇ ਵਿਚ ਜੇ ਮੁੰਡਾ ਛੈਣੀ ਵਰਗਾ ਨਾ ਹੋਵੇ, ਲੋਕ ਆਖਦੇ ਹਨ ਕਿ ਗੁੜ ਵੰਡਿਆ ਐਵੇਂ ਹੀ ਗਿਆ। ਦਰਅਸਲ ਮੇਰੇ ਚੁੱਪ ਰਹਿਣ ਦਾ ਕਾਰਨ ਇਹ ਸੀ ਕਿ ਮੈਂ ਸੁਰਤ ਸੰਭਾਲਦਿਆਂ ਹੀ ਇਹ ਖ਼ਿਆਲ ਮਨ ਵਿਚ ਰੱਖਦਾਂ ਸਾਂ ਕਿ ਮੈਂ ਕੋਈ ਅਜਿਹਾ ਕੰਮ ਕਰਾਂ, ਜਿਸ ਨਾਲ ਮੇਰੀ ਦਿੱਖ ਕੁਝ ਦੂਸਰਿਆਂ ਨਾਲੋਂ ਵੱਖਰੀ ਹੋਵੇ। ਹੁਣ ਕਈ ਵਾਰ ਇਹ ਸੋਚ ਕੇ ਹੈਰਾਨੀ ਕਿ ਇੱਕ ਦਫ਼ਾ ਮੈਂ ਸੰਤ ਬਣਨ ਬਾਰੇ ਵੀ ਸੋਚਿਆ। ਇਧਰੋਂ-ਉਧਰੋਂ ਸੰਤਾਂ ਦੇ ਵਿਸ਼ੇਸ਼ ਲੱਛਣ ਵੀ ਮੈਂ ਇਕੱਠੇ ਕਰ ਲਏ, ਪਰ ਗੱਲ ਪਤਾ ਨਹੀਂ ਕਿਵੇਂ ਚਿੱਤ ਵਿਚੋਂ ਨਿਕਲ ਗਈ। ਕੁਝ ਕਰਨ ਦੀ ਲਾਲਸਾ ਹੇਠ ਮੈਂ ਆਮ ਦੁਨਿਆਵੀ ਕੰਮਾਂ ਵਿਚ ਵੀ ਵਧੇਰੇ ਦਿਲਚਸਪੀ ਲੈਂਦਾ ਸਾਂ, ਪਰ ਇਸ ਨਾਲ ਮੇਰੀ ਤ੍ਰਿਪਤੀ ਨਹੀਂ ਹੁੰਦੀ ਸੀ। ਦੂਸਰਾ ਇਸ ਦੇ ਨਾਲ ਛੋਟੀ ਕਿਸਾਨੀ ਦਾ ਜੰਮ-ਪਲ ਹੋਣ ਕਰਕੇ ਜ਼ਮੀਨ ਵਾਲਿਆਂ ਨੂੰ ਗੱਲੀਂ-ਬਾਤੀਂ ਛੋਟਾ ਦਿਖਾ ਕੇ ਛਟਿਆਉਂਦੇ ਸਨ। ਭਾਵੇਂ ਸਮਾਜਕ ਦਰਜੇ ਵਿਚ ਉਨ੍ਹਾਂ ਦੀ ਮਾੜੀ-ਮੋਟੀ ਹੋਂਦ ਨਾ ਦੇ ਬਰਾਬਰ ਸੀ। ਪਰ ਜ਼ਮੀਨ ਨਾਲ ਏਨੇ ਜੁੜੇ ਹੋਏ ਸਨ, ਥੋੜ੍ਹੀ ਜ਼ਮੀਨ ਜਾਂ ਬਿਨ ਜ਼ਮੀਨ ਵਾਲੇ ਉਨ੍ਹਾਂ ਦੀਆਂ ਨਜ਼ਰਾਂ ਵਿਚ, ਉਨ੍ਹਾਂ ਦੇ ਪੈਮਾਨੇ ਮੁਤਾਬਕ ਬੰਦੇ ਹੀ ਨਹੀਂ ਹੁੰਦੇ ਸਨ। ਇਸ ਤਰ੍ਹਾਂ ਦਾ ਅਨੁਭਵ ਸ਼ਾਇਦ ਬਹੁਤਿਆਂ ਨੂੰ ਹੁੰਦਾ ਹੋਵੇ, ਪਰ ਮੈਂ ਇਸ ਪੀੜ ਨੂੰ ਜਰਨ ਦਾ ਬਲ ਨਹੀਂ ਰੱਖਦਾ ਸਾਂ। ਇਸ ਦੇ ਉਲਟ ਮੈਂ ਵਿਦਿਆ ਨੂੰ ਆਪਣਾ ਲਖ਼ਸ਼ ਬਣਾ ਲਿਆ ਕਿ ਪੜ੍ਹ ਲਿਖ ਕੇ, ਕੋਈ ਵੱਡਾ ਅਫ਼ਸਰ ਬਣਾਂ ਅਤੇ ਇਹਨਾਂ ਦਲਿੱਦਰ ਨਾਲ ਭਰੇ, ਨਾ ਸ਼ੁਕਰੇ ਅਤੇ ਸੜੇ-ਬੁਸੇ ਜੱਟਾਂ ਤੋਂ ਬਦਲਾ ਲੈਣ ਬਾਰੇ ਕਿਆਸ ਕਰ ਕੇ ਅੰਦਰੇ ਅੰਦਰ ਖੁਸ਼ੀ ਦੇ ਲੱਡੂ ਭੋਰਦਾ ਰਹਿੰਦਾ।

ਪਰ ਇਹ ਸਥਿਤੀ ਬਹੁਤਾ ਸਮਾਂ ਨਾ ਰਹੀ, ਕਾਲਜ ਵਿਚ ਜਾਂਦਿਆਂ ਹੀ ਜਦੋਂ ਸਾਹਿਤ ਨਾਲ ਵਾਹ ਪਿਆ ਤਾਂ, ਮੈਨੂੰ ਜ਼ਿੰਦਗੀ ਦੇ ਅਸਲ ਅਰਥਾਂ ਦੀ ਸਮਝ ਪੈਣ ਲੱਗੀ। ਏਹੀ ਲੋਕ ਜਿਨ੍ਹਾਂ ਨਾਲ ਮੈਨੂੰ ਹੀਣੇਂ, ਬੇਵੱਸ, ਜ਼ਿੰਦਗੀ ਤੋਂ ਦੂਰ ਨਰਕਾਂ ਦੇ ਜੀਵ-ਜੰਤੂ ਪ੍ਰਤੀਤ ਹੋਣ ਲੱਗ ਪਏ। ਇਹੀ ਉਹ ਸਮਾਂ ਸੀ, ਜਦੋਂ ਨਕਸਲੀਏ ਬਾਹਰ ਆ ਕੇ ਐਕਸ਼ਨ ਵਾਲੀ ਲਾਈਨ ਤਿਆਗ ਲੋਕ ਸ਼ਕਤੀ ਨੂੰ ਜਥੇਬੰਦ ਕਰਨ ਦੀ ਹੋੜ ਵਿਚ ਸਨ। ਚੜ੍ਹਦੀ ਉਮਰ ਦੇ ਜੋਸ਼ ਵਿਚ ਇਨ੍ਹਾਂ ਦੇ ਸੰਪਰਕ 'ਚ ਆਉਣ ਸਦਕਾ ਮੈਨੂੰ ਇੱਕ ਹੋਰ ਪਾਸਿਓ ਚਾਨਣ ਹੋਇਆ, ਜਿਸ ਨਾਲ ਮੈਨੂੰ ਸਾਹਿਤ ਨਿੱਜ ਨਾਲੋਂ ਸਮੂਹ ਲਈ ਪ੍ਰੇਰਨਾ ਦਾ ਸੋਮਾ ਮਹਿਸੂਸ ਹੋਇਆ। ਉਂਝ ਮੈਂ ਇਹ ਗੱਲ ਹੁਣ ਵੀ ਮੰਨਦਾ ਹਾਂ ਕਿ ਸਾਹਿਤ ਲੇਖਕ ਦੇ ਨਿੱਜ 'ਚੋਂ ਜਨਮ ਲੈਂਦਾ ਹੈ, ਪਰ ਜਿਹੜਾ ਲੇਖਕ ਇਸ ਨੂੰ ਸਮੂਹ ਦੀ ਪੀੜ ਨਾਲ ਜੋੜ ਲੈਂਦਾ ਹੈ, ਉਸ ਦੀ ਰਚਨਾ ਉਸ ਤੋਂ ਪਰ੍ਹਾਂ ਹੋ ਕੇ ਸਮੁੱਚੇ ਸੰਸਾਰ ਲਈ ਸੰਜੀਵਨੀ ਬਣ ਜਾਂਦੀ ਹੈ। ਇਥੋਂ ਹੀ ਮੈਂ ਸਾਹਿਤ ਨੂੰ ਮਨੁੱਖੀ ਲੋੜ ਸਮਝਿਆ। ਹੌਲੀ-ਹੌਲੀ ਮੈਂ ਆਪਣੇ ਆਲੇ-ਦੁਆਲੇ ਦੀ ਜ਼ਿੰਦਗੀ ਨੂੰ ਵਿਗਿਆਨਿਕ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਰਾਹੀਂ ਸਮਝਣਾ ਸ਼ੁਰੂ ਕਰ ਦਿੱਤਾ। ਸਮਾਂ ਪੈ ਕੇ ਏਹੀ ਲੋਕ, ਮੇਰੇ ਨਾਵਲਾਂ ਵਿਚ ਪਾਤਰ ਬਣ ਉਭਰੇ।

ਹੁਣ ਤੱਕ ਮੇਰੇ ਛਪੇ-ਅਣਛਪੇ ਸੱਤ ਨਾਵਲ ਹਨ। ਪਹਿਲੇ ਤਿੰਨ ਨਾਵਲ ਮੈਂ ਛਾਪੇ ਨਹੀਂ, ਸ਼ਾਇਦ ਉਦੋਂ ਛਪਾਉਣ ਦੀ ਲੋਚਾ ਵੀ ਨਹੀਂ ਸੀ। ਅਸਲ ਵਿਚ 'ਬੁਰਕੇ ਵਾਲੇ ਲੁਟੇਰੇ' ਰਾਹੀਂ ਮੇਰਾ ਸਾਹਿਤਕ ਸਫ਼ਰ ਸ਼ੁਰੂ ਹੁੰਦਾ ਹੈ। ਇਹ ਨਾਵਲ ਨਕਸਲੀ ਲਹਿਰ ਦੀ ਨਵੀਨੀਕਰਨ ਪਾਲਿਸੀ ਤੋਂ ਬਾਅਦ ਲਿਖਿਆ ਸੀ। ਹਰੇ ਇਨਕਲਾਬ ਦੀ ਸ਼ੁਰੂਆਤ ਦੇ ਨਾਲ ਹੀ ਇਸ ਵਿਚ ਵਿਗਾੜ ਪੈਦਾ ਹੋ ਗਏ ਸਨ। ਨਾਵਲ ਲਿਖਣ ਸਮੇਂ ਮੇਰੇ ਮਨ ਵਿਚ ਵਿਚਾਰ ਕੰਮ ਕਰ ਰਿਹਾ ਸੀ ਕਿ ਛੋਟੀ ਕਿਸਾਨੀ ਵੱਡੀ ਕਿਸਾਨੀ ਦੀ ਰੀਸੇ ਕਰਜ਼ੇ-ਤਕਾਵੀਆਂ ਲੈ ਕੇ ਨਾਲ ਰਲਣ ਦੀ ਦੌੜ ਵਿਚ ਲੱਗੀ ਹੋਈ ਸੀ, ਉਹ ਆਪਣੇ ਹਿਤਾਂ ਦਾ ਬਹੁਤਾ, ਲੋਕਾਂ ਦਾ ਘੱਟ ਧਿਆਨ ਰੱਖਦੀ ਹੈ। ਨਾਵਲ ਦਾ ਖਰੜਾ ਲੈ ਕੇ ਮੈਂ ਸ. ਜਸਵੰਤ ਸਿੰਘ ਕੰਵਲ ਕੋਲ ਚਲਾ ਗਿਆ। ਉਹ ਸੁਣ ਕੇ ਏਨੇ ਖੁਸ਼ ਹੋਏ ਤੇ ਉੱਠ ਕੇ ਖੜੇ ਹੋ ਗਏ। ਉਨ੍ਹਾਂ ਹੀ ਇਹ ਨਾਵਲ ਅੰਮ੍ਰਿਤਸਰ ਦੇ ਇਕ ਪਬਲਿਸ਼ਰ ਨੂੰ ਛਾਪਣ ਲਈ ਦੇ ਦਿੱਤਾ। ਪਬਲਿਸ਼ਰ ਨੇ ਆਪਣੀ ਤਰਜ਼ ਨੂੰ ਕਾਇਮ ਰੱਖਦਿਆਂ ਨਾਂਹ ਤਾਂ ਕੀਤੀ ਨਾ, ਪਰ ਦੇਰ ਕਰ ਦਿੱਤੀ। ਕੰਵਲ ਜੀ ਨੇ ਇੱਕ ਵਾਰ ਉਨ੍ਹਾਂ ਨੂੰ ਆਖਿਆ:

"ਕੀ ਗੱਲ ਬਈ, ਤੁਸੀਂ ਮੁੰਡੇ ਦਾ ਨਾਵਲ ਕਿਉਂ ਨਹੀਂ ਛਾਪਦੇ?"

ਪਬਲਿਸ਼ਰ ਹੱਸ ਕੇ ਬੋਲਿਆ, "ਛਾਪਾਂਗੇ ਜੀ, ਤੁਸੀਂ ਬੇਫਿਕਰ ਹੋ ਜਾਵੋ।"

"ਦੇਖ ਲਉ, ਅੱਜ ਤੁਸੀਂ ਇਹਦਾ ਨਾਵਲ ਛਾਪਣ ਲਈ ਬਹਾਨੇਬਾਜ਼ੀ ਕਰਦੇ ਓ ਇਹਦੀ ਗੁੱਡੀ ਚੜ੍ਹ ਜਾਣੀ ਐ। ਤੁਸੀਂ ਫੇਰ ਇਹਦੇ ਮਗਰ ਫਿਰਨਾ ਏ, ਇਹਨੇ ਤੁਹਾਨੂੰ ਨਾਵਲ ਨਹੀਂ ਦਿਆ ਕਰਨਾ।"

'ਰਾਤ ਦੇ ਰਾਹੀਂ' ਲਿਖਣ ਤੋਂ ਪਹਿਲਾਂ ਮੈਂ ਕਾਫੀ ਬਾਹਰਲਾ ਸਾਹਿਤ ਪੜ੍ਹ ਲਿਆ ਸੀ, ਮੈਨੂੰ ਜ਼ਿੰਦਗੀ ਅਤੇ ਸਾਹਿਤ ਵਿਚਕਾਰ ਅਟੁੱਟਵੇਂ ਸੰਬੰਧ ਦੀ ਨਿਗਰ ਜਾਣਕਾਰੀ ਪ੍ਰਾਪਤ ਹੋ ਗਈ ਸੀ। ਬੀ.ਏ. ਕਰ ਕੇ ਮੈਂ ਘਰ ਬੈਠ ਕੇ ਐਮ.ਏ. ਪੰਜਾਬੀ ਦੀ ਤਿਆਰੀ ਕਰਦਾ, ਨਾਲ ਦੀ ਨਾਲ ਨਾਵਲ ਲਿਖਦਾ। ਸਰਦੀਆਂ ਵਿਚ ਜਦੋਂ ਸਾਰਾ ਟੱਬਰ ਆਪੋ-ਆਪਣੇ ਕੰਮ-ਧੰਦੇ ਵਿਚ ਉਲਝ ਜਾਂਦਾ ਤਾਂ ਮੈਂ ਧੁੱਪੇ ਬੈਠ ਕੇ ਪਾਤਰਾਂ ਨਾਲ ਦੋ-ਚਾਰ ਹੁੰਦਾ ਰਹਿੰਦਾ, ਇਹ ਨਾਵਲ ਲਿਖਦਿਆਂ, ਮੇਰੇ ਮਨ ਵਿਚ ਹੋਰ ਗੱਲਾਂ ਨਾਲੋਂ ਬਹੁਤਾ ਇਸ ਗੱਲ ਦਾ ਧਿਆਨ ਸੀ ਕਿ ਮੈਂ ਨਾਵਲ ਨਹੀਂ ਸਗੋਂ ਉਸ ਸਮੇਂ ਦੀ ਜ਼ਿੰਦਗੀ ਨੂੰ ਸ਼ਬਦਾਂ ਵਿਚ ਉਤਰਨਾ ਹੈ। ਜਦੋਂ ਅਸਲੀ ਜੀਵਨ ਵਿਚ ਇਨ੍ਹਾਂ ਪਾਤਰਾਂ ਦੇ ਮੈਨੂੰ ਨੇੜੇ ਹੋ ਕੇ ਵਿਚਰਨ ਦਾ ਮੌਕਾ ਮਿਲਿਆ, ਤਾਂ ਮੈਨੂੰ ਅਜੀਬੋ-ਗ਼ਰੀਬ ਤਜ਼ਰਬਾ ਹੋਇਆ। ਦੂਰੋਂ ਇਨ੍ਹਾਂ ਦੀ ਜ਼ਿੰਦਗੀ ਬੇਰਸ, ਔਖੀ, ਮੁਸ਼ਕਲਾਂ ਨਾਲ ਗ੍ਰਸੀ ਹੋਈ ਜਾਪਦੀ ਸੀ, ਪਰ ਨਜ਼ਦੀਕ ਜਾ ਕੇ ਮੈਂ ਵੇਖਿਆ, ਉਨ੍ਹਾਂ ਦੀ ਜ਼ਿੰਦਗੀ ਵਿਚ ਅਨੰਦ ਸੀ। ਸਭ ਕੁਝ ਤੋਂ ਅਣਜਾਣ ਉਹ ਇਹਨੂੰ ਲੁਤਫ਼ ਬਣਾ ਕੇ ਜਿਉ ਰਹੇ ਸਨ। ਇਥੋਂ ਹੀ ਮੈਨੂੰ ਇਲਮ ਹੋਇਆ ਕਿ ਜੀਵਨ 'ਚ ਗਤੀ ਹੈ। ਇਸ ਵਿਚ ਨਾ ਮਰਨ ਵਰਗੀ ਕੋਈ ਸ਼ੈਅ ਹੈ, ਜਿਹੜੀ ਬੰਦਿਆਂ ਨੂੰ ਆਪਣੇ ਵਿਚ ਉਲਝਾਈ ਰੱਖਦੀ ਸੀ। ਨਾਵਲ ਪੂਰਾ ਕਰ ਕੇ ਮੈਂ ਪੰਜਾਬੀ ਦੇ ਦੋ ਨਾਵਲਕਾਰਾਂ ਅਤੇ ਇਕ ਆਲੋਚਕ ਵਿਦਵਾਨ ਡਾ. ਟੀ.ਆਰ. ਵਿਨੋਦ ਹੋਰਾਂ ਨੂੰ ਪੜ੍ਹਾਇਆ। ਵਿਨੋਦ ਜੀ ਨੇ ਮੈਨੂੰ ਵਧਾਈ ਦਿਤੀ, "ਇਹ ਪੰਜਾਬੀ ਦਾ ਬੇਹਤਰੀਨ ਨਾਵਲ ਹੈ।"

ਇਸ ਤੋਂ ਬਾਅਦ ਮੈਂ ਆਪਣੇ ਅੰਦਰ ਬੈਠੀ ਮਾੜੀ-ਮੋਟੀ ਝਿਜਕ ਦੂਰ ਕਰ ਦਿੱਤੀ ਤੇ ਮੈਨੂੰ ਵਿਸ਼ਵਾਸ਼ ਹੋ ਗਿਆ, ਜਿਹੜਾ ਪਹਿਲਾਂ ਭੁਲਾਂਦਰਾ ਸੀ ਕੀ ਮੈਂ ਕੁਝ ਕਰ ਸਕਦਾ ਹਾਂ, ਤੇ ਫਿਰ ਮੈਂ ਆਪਣੇ ਰਾਹ 'ਤੇ ਨਿਰਸੰਕੋਚ ਹੋ ਕੇ ਤੁਰ ਪਿਆ। ਨਾਵਲ ਛਪਣ 'ਤੇ ਡਾ. ਵਿਨੋਦ ਦਾ ਕਥਨ ਸੱਚ ਹੋ ਨਿਬੜਿਆ; ਨਾਵਲ ਨੂੰ ਪੰਜਾਬੀ ਦੇ ਨਾਵਲ ਇਤਿਹਾਸ ਵਿਚ ਮਾਣਯੋਗ ਸਥਾਨ ਪ੍ਰਾਪਤ ਹੋ ਗਿਆ।

'ਰੋਹੀ ਬੀਆਬਾਨ' ਇੱਕ ਵੱਖਰੇ ਹੀ ਢੰਗ ਨਾਲ ਮੇਰੇ ਜ਼ਿਹਨ 'ਚ ਉਤਾਰਿਆ। ਐਮ.ਏ. ਕਰ ਕੇ ਘਰ ਵਿਹਲਾ ਸਾਂ। ਸਰਵਿਸ ਕੋਈ ਨਹੀਂ ਮਿਲੀ ਸੀ। ਪਟਿਆਲੇ ਜ਼ਿਲ੍ਹੇ ਦੇ ਇੱਕ ਅਕਾਲੀ ਲੀਡਰ ਦੇ ਲਾਰੇ ਪਿੱਛੇ ਮੈਂ ਦਾਹੜੀ ਵਧਾ ਕੇ ਪੰਜਾਬ-ਸਿੰਧ ਬੈਂਕ ਵਿਚ ਭਰਤੀ ਹੋਣ ਦਾ ਸੁਫ਼ਨਾ ਪਾਲ ਰਿਹਾ ਸਾਂ। ਲੋਕ ਮੇਰੀ ਵਿਚਾਰਧਾਰਾ 'ਤੇ ਸ਼ੱਕ ਕਰਨ ਲੱਗ ਲਏ। ਵਿਹਲੇ ਸਮੇਂ ਵਿਚ ਮੈਂ ਬਹੁਤ ਸਾਰਾ ਰੂਸੀ ਸਾਹਿਤ ਜਿਹੜਾ ਦੂਸਰੀ ਸੰਸਾਰ ਜੰਗ ਬਾਰੇ ਸੀ, ਪੜ੍ਹਿਆ। ਜਿਸ ਵਿਚੋਂ ਉਸ ਦੌਰ ਦੇ ਬੱਚਿਆਂ ਦੀ ਮਾਨਸਿਕ ਅਵਸਥਾ 'ਤੇ ਪਏ ਮਾਰੂ ਅਸਰ ਦਾ ਬੜਾ ਗਹਿਰਾ ਚਿਤਰ ਸੀ। ਇਹ ਖਿਆਲ ਏਨਾ ਘਰ ਕਰ ਗਿਆ ਕਿ ਮੈਨੂੰ ਕਿਸਾਨੀ ਵਿਚ ਉਸ ਦੇ ਬਚਪਨ ਦੀ ਹੋ ਰਹੀ ਧੁਹ-ਘੜੀਸ ਨੇ ਜਕੜ ਲਿਆ। ਹੌਲੀ-ਹੌਲੀ ਨਾਵਲ ਹੋਂਦ ਵਿਚ ਆਉਣ ਲੱਗਾ, ਅਜੇ ਚਾਰ-ਪੰਜ ਹੀ ਚੈਪਟਰ ਲਿਖੇ ਸਨ, ਮੇਰਾ ਇਕ ਪਾਠਕ ਵਜੋਂ ਜਾਣੇ ਜਾਂਦੇ ਬੈਂਕ ਮੈਨੇਜਰ ਨੇ ਮੈਨੂੰ ਛੋਟਾ ਜਿਹਾ ਪੋਲਟਰੀ ਫਾਰਮ ਚਲਾਉਣ ਲਈ ਕਰਜ਼ਾ ਦੇ ਦਿੱਤਾ। ਨਾਵਲ ਮੇਰੇ ਮਨੋਂ ਉਤਰ ਗਿਆ। ਮੈਂ ਦਿਨ ਰਾਤ ਮੁਰਗੀਆਂ ਦੀ ਕੈਂ-ਕੈਂ ਵਿਚ ਗੁਜ਼ਾਰਨ ਲੱਗਾ। ਨਾਵਲ ਬਾਰੇ ਤਾਂ ਕੀ ਸੋਚਣਾ ਸੀ, ਮੈਨੂੰ ਆਪਣੀ ਸੁੱਧ-ਬੁੱਧ ਭੁੱਲ ਗਈ। ਇੱਕ ਦਿਨ ਮੋਗੇ ਦੇ ਚੌੜੇ ਬਜ਼ਾਰ ਵਿਚ, ਬੋਰੀਆਂ ਦਾ ਗੱਠਾ ਲਈ ਮੁਰਗੀਆਂ ਦੀ ਖ਼ੁਰਾਕ ਲੈਣ ਜਾ ਰਿਹਾ ਸਾਂ, ਕਿ ਕੰਵਲ ਸਾਹਬ ਮਿਲ ਪਏ। ਹੋਟਲ 'ਚ ਚਾਹ ਪੀਂਦਿਆਂ ਗੱਲਾਂ ਕਰਦਿਆਂ, ਜਦੋਂ ਉਨ੍ਹਾਂ ਨੂੰ ਏਸ ਨਵੇਂ ਧੰਦੇ ਬਾਰੇ ਪਤਾ ਲੱਗਿਆ, ਗੰਭੀਰ ਹੋ ਕੇ ਆਖਣ ਲੱਗੇ,

"ਮੈਨੂੰ ਲੱਗਦਾ ਏ, ਤੂੰ ਸਾਰੀ ਸਾਹਿਤਕਾਰੀ ਵਿੱਠਾਂ ਵਿਚ ਮਿੱਧ ਦੇਣੀ ਐ।"

ਘਰ ਆ ਕੇ ਜਦੋਂ ਬਹਿ ਕੇ ਸੋਚਿਆ, ਮੈਨੂੰ ਗੱਲ ਸੱਚ ਹੁੰਦੀ ਮਹਿਸੂਸ ਹੋਈ। ਵਕਤ ਵਿਚਾਰ ਕੇ, ਖਰੜਾ ਮੁੜ ਅਮਲਾਰੀ ਵਿਚੋਂ ਕੱਢ ਲਿਆ। ਕੁੱਝ ਦਿਨ ਮਨ ਸਾਂਵਾਂ ਸ਼ੁਰੂ ਕਰ ਦਿੱਤਾ। ਨਾਵਲ ਅੱਧਾ ਕੁ ਹੀ ਲਿਖਿਆ ਸੀ ਕਿ ਮੈਨੂੰ ਅਧਿਆਪਕ-ਕੋਰਸ ਵਿਚ ਦਾਖਲਾ ਮਿਲ ਗਿਆ। ਮੈਂ ਖਰੜਾ ਮੁੜ ਅਲਮਾਰੀ ਵਿਚ ਸਾਂਭਿਆ, ਟਰੇਨਿੰਗ ਕਰਨ ਚਲਾ ਗਿਆ। ਕੋਰਸ ਤੋਂ ਬਾਅਦ ਨਾਵਲ ਪੂਰਾ ਕੀਤਾ, ਪਰ ਇਹ ਛਪਿਆ ਫੇਰ ਅਟਕ ਕੇ ਕਿਉਂਕੀ ਜਿਵੇਂ ਮੇਰੀ ਲਿਖਣ ਦੀ ਚਾਲ ਹੈ, ਏਹੀ ਰਵੱਇਆ ਛਪਵਾਈ ਬਾਰੇ ਵੀ ਹੈ।

ਨਾਵਲ ਪ੍ਰੈਸ ਨੂੰ ਦੇ ਕੇ ਮੈਂ ਕਾਫੀ ਸਮਾਂ ਚੁੱਪ ਵੱਟ ਲੈਂਦਾ ਹਾਂ। ਕੁਝ ਲਿਖਣ ਨੂੰ ਜੀਅ ਨਹੀਂ ਕਰਦਾ। ਸਾਹਿਤਕਾਰਾ ਨਾਲ ਜਾਂ ਸਾਹਿਤਕ ਸਮਾਗਮਾਂ ਦੀ ਥਾਂ ਮੈਂ ਆਮ ਲੋਕਾਂ ਨਾਲ ਜ਼ਿਆਦਾ ਘੁੰਮਦਾ ਫਿਰਦਾ ਸਾਂ। ਸਾਹਿਤਕ ਸਮਾਗਮਾਂ ਤੋਂ ਚੁਗਲੀਆਂ ਤੋਂ ਬਿਨਾਂ ਹੋਰ ਚੀਜ਼ ਘਰ ਲੈ ਕੇ ਨਹੀਂ ਪਰਤਦਾ। ਇਸ ਲਈ ਇਥੋਂ ਕੰਨੀ ਕਤਰਾਉਣ ਦਾ

ਹੀ ਯਤਨ ਕਰਦਾ ਹਾਂ। ਮੈਂ ਉਥੇ ਹੀ ਜਾਂਦਾ, ਜਿਥੋਂ ਮੈਨੂੰ ਖੁਸ਼ੀ ਮਿਲਦੀ ਹੈ। ਇਹ ਆਮ ਜੀਵਨ ਵਿਚ ਥਾਂ ਪਰ ਥਾਂ ਪਈ ਹੈ। ਅਜੇਹੇ ਥਾਵਾਂ ਤੋਂ ਜਦੋਂ ਮੈਂ ਮੁੜਦਾ ਹਾਂ, ਤਾਂ ਮੈਂ ਜ਼ਿੰਦਗੀ ਨਾਲ ਭਰਿਆ ਹੁੰਦਾ ਹਾਂ। ਇਸ ਦੇ ਉਲਟ ਜਦੋਂ ਕਿਸੇ ਸਾਹਿਤਕ ਸਮਾਗਮ ਤੋਂ ਮੁੜਾਂ ਤਾਂ ਮੇਰਾ ਸਰੀਰ ਥੱਕਿਆ ਤੇ ਬੇਸੁਰਾ ਹੁੰਦਾ ਹੈ, ਸਿਰ ਪੀੜ ਨਾਲ ਬੋਝਲ, ਹੋਇਆ ਹੁੰਦਾ ਹੈ। ਆ ਕੇ ਕੰਨ ਮਰੋੜਦਾ ਹਾਂ, ਹੁਣ ਨਹੀਂ ਜਾਣਾ। ਪਰ ਫੇਰ ਕਦੇ-ਕਦੇ ਚਲਾ ਜਾਂਦਾ ਹਾਂ।

'ਅੱਗ ਦਾ ਗੀਤ' ਉਨ੍ਹਾਂ ਦਿਨਾਂ ਵਿਚ ਮੇਰੇ ਦਿਮਾਗ਼ ਵਿਚ ਆਇਆ, ਜਦੋਂ ਮੈਂ ਖੰਨਾ ਲਾਗੇ ਇੱਕ ਸਰਕਾਰੀ ਹਾਈ ਸਕੂਲ ਵਿਚ ਪੜ੍ਹਾ ਰਿਹਾ ਸੀ। ਆਮ ਹੀ ਅਖ਼ਬਾਰਾਂ ਵਿਚ ਇੱਕ ਖ਼ਬਰ ਬਾਰ-ਬਾਰ ਛਪਦੀ ਕਿ ਫ਼ਲਾ ਔਰਤ ਏਨੇ ਬੱਚਿਆਂ ਦੇ ਹੁੰਦੇ ਹੋਇਆਂ, ਆਪਣਾ ਘਰ ਛੱਡ ਕੇ ਚਲੀ ਗਈ। ਵਿਚਾਰ ਚਰਚਾ ਸਮੇਂ ਪੜ੍ਹੇ ਲਿਖੇ ਵੀ ਹਾਲਾਤ ਨੂੰ ਨਾ ਸਮਝ ਸਕਿਆ, ਮੌਜੂਦਾ ਪ੍ਰਧਾਨ ਸਦਾਚਾਰ ਦੀ ਓਪਰੀ ਦੱਖ ਵਿਚ ਉਲਝ ਜਾਂਦੇ, ਹਮੇਸ਼ਾ ਹੀ ਲੋਕ ਕਾਰਨਾਂ ਨੂੰ ਅਣਗੌਲਿਆਂ (ਜਾਂ ਬੇਸਮਝੀ ਕਾਰਨ) ਮਾੜੀ ਧਿਰ ਦਾ ਪੱਖ ਲੈਣ ਦੀ ਬਜਾਇ ਕੁਦਰਤੀ ਹੀ ਤਕੜੀ ਧਿਰ ਦੇ ਹਾਮੀ ਬਣ ਬੈਠਦੇ। ਕਈ ਸਾਲ ਪਹਿਲਾਂ ਇੱਕ ਅਜਿਹੀ ਘਟਨਾ ਸਾਡੇ ਪਿੰਡ ਵਾਪਰ ਗਈ ਸੀ। ਇਸ ਵਿਚਾਰ ਨੇ ਹੌਲੀ-ਹੌਲੀ ਪਲਰਦਿਆਂ ਮੇਰੇ ਅੰਦਰ ਪਲਟਾ ਖਾਧਾ ਤੇ ਮੈਂ ਸਿਰਫ਼ ਭੋਂ ਹੀਣ ਪਰਿਵਾਰ ਦੀ ਔਰਤ ਦੇ ਦੁਖਾਂਤ ਨੂੰ ਹੀ ਦਰਸਾਉਣਾ ਚਾਹੁੰਦਾ ਸਾਂ। ਪਰ ਜਦੋਂ ਸਮੁੱਚੇ ਪੇਂਡੂ ਪ੍ਰਬੰਧ ਵਿਚ ਵਿਚਰ ਰਹੀ ਔਰਤ ਦੀ ਸਥਿਤੀ ਨੂੰ ਹੀ ਮੈਂ ਆਪਣੇ ਨਾਵਲ ਦਾ ਵਿਸ਼ਾ ਬਣਾ ਲਿਆ। ਇਸ ਤਰ੍ਹਾਂ 'ਅੱਗ ਦਾ ਗੀਤ' ਵੱਖ-ਵੱਖ ਪਰਤਾਂ ਵਿਚ ਨਾਵਲੀ ਰੂਪ ਲੈ ਕੇ ਪ੍ਰਗਟ ਹੋਇਆ। ਬਾਕੀ ਆਪਣੇ ਆਪ ਸ਼ਾਮਿਲ ਹੋ ਗਿਆ।

'ਅੱਗ ਦਾ ਗੀਤ' ਦੇ ਛਪਣ ਤੱਕ ਪੰਜਾਬ ਦੇ ਉਪਰੋਂ ਰਾਜਸੀ ਦਿਸਦੀ ਹਾਲਤ ਕਈ ਕਰਵਟਾਂ ਲੈ ਚੁੱਕੀ ਸੀ। ਬਲਿਊ ਸਟਾਰ ਓਪਰੇਸ਼ਨ ਹੋ ਚੁੱਕਾ ਸੀ 'ਤੇ ਲੋਕ ਭਾਵੁਕਤਾ ਵੱਸ ਆਪੋ ਆਪਣੇ ਮੋਰਚਿਆਂ ਵਿਚੋਂ ਬੋਲ ਰਹੇ ਸਨ। ਦੂਸਰਾ ਮੈਂ ਇਸ ਨੂੰ ਧਰਮ ਨਾਲ ਸਬੰਧਤ ਲੋਕਾਂ ਅਤੇ ਹਾਕਮ ਜਮਾਤਾਂ ਦਾ ਰਾਜਸੀ ਮਦਾਰੀਪੁਣਾ ਹੀ ਸਮਝਦਾ ਸਾਂ। ਬਹੁਤ ਸਾਰੇ ਯਾਰ-ਮਿੱਤਰ ਕਹਿੰਦੇ, ਇਹਦੇ ਬਾਰੇ ਕੁਸ਼ ਲਿਖ। ਮੈਂ ਹੱਸ ਛੱਡਦਾ, ਮੈਨੂੰ ਇਹ ਕੋਈ ਗੱਲ ਨਹੀਂ ਲੱਗਦੀ ਸੀ, ਸਿਰਫ਼ ਵਕਤੀ ਉਬਾਲ ਹੈ, ਜਿਹੜਾ ਕੁਝ ਸਮੇਂ ਬਾਅਦ ਧੂੜ ਵਾਂਗ ਦਬ ਜਾਏਗਾ। ਜਸਵੰਤ ਸਿੰਘ ਕੰਵਲ ਨੇ ਇੱਕ ਦਿਨ ਆਪਣੇ ਘਰ ਬੈਠਿਆਂ ਮੈਨੂੰ ਕੁਝ ਕਰਨ ਲਈ ਕਿਹਾ, ਮੈਂ ਉਹ ਹੀ ਜਵਾਬ ਦੇ ਦਿੱਤਾ ਕਿ ਇਹ ਕੋਈ ਗੱਲ ਨਹੀਂ। ਇਸ ਬਾਰੇ ਕੀ ਲਿਖਿਆ ਜਾ ਸਕਦਾ ਹੈ। ਉਹ ਮੈਨੂੰ ਚੋਬ੍ਹਾਂ ਜਿਹੀਆਂ ਲਾਉਂਦੇ ਰਹੇ, ਕਿ ਜਿਹੜੇ ਆਪਣੇ ਲੋਕਾਂ ਲਈ ਕੁਝ ਨਹੀਂ ਕਰ ਸਕਦੇ, ਉਹ ਲੋਕਾਂ ਦੇ ਦੇਣਦਾਰ ਹੁੰਦੇ ਐ। ਤੂੰ ਚੁੱਪ ਬੈਠਾ ਏਂ, ਏਸ ਤਰ੍ਹਾਂ ਤੂੰ ਲੋਕਾਂ ਦਾ ਹੱਕ ਮਾਰ ਰਿਹਾ ਆਂ।

ਮੈਂ ਉਨ੍ਹਾਂ ਨੂੰ ਕੀ ਆਖਣਾ ਸੀ। ਚੁੱਪ ਕਰ ਰਿਹਾ। ਇਨ੍ਹਾਂ ਦਿਨ੍ਹਾਂ ਵਿਚ ਲੁਧਿਆਣੇ ਐਕਸਟੈਨਸ਼ਨ ਲਾਇਬਰੇਰੀ 'ਚ ਜਾਂਦਾ ਹੁੰਦਾ ਸਾਂ। ਉਥੋਂ ਮੈਨੂੰ ਯੂਰਪ ਦੇ ਮੱਧ ਯੁੱਗ ਬਾਰੇ ਕੁਝ ਕਿਤਾਬਾਂ ਮਿਲੀਆਂ, ਜਿਨ੍ਹਾਂ ਵਿਚ

ਉਸ ਸਮੇਂ ਦੀ ਚੱਲੀ ਧਾਰਮਕ ਲਹਿਰ ਬਾਰੇ ਜ਼ਿਕਰ ਸੀ ਜੋ ਅਸਲ ਵਿਚ ਕਿਸਾਨੀ ਨੇ ਆਪਣੇ ਹੱਕਾਂ ਬਾਰੇ ਲੜੀ ਸੀ। ਅਚਾਨਕ ਮੈਂ ਮੌਜੂਦਾ ਲਹਿਰ ਨੂੰ ਓਸ ਲਹਿਰ ਨਾਲ ਜੋੜ ਕੇ ਜਦੋਂ ਵੇਖਿਆ ਤਾਂ ਮਨੂੰ ਇਹ ਲਹਿਰ ਨਿਰੀ-ਪੁਰੀ ਧਾਰਮਕ ਲਹਿਰ ਨਾ ਦਿਸੀ, ਇਹਦੇ ਹੇਠ ਬਹੁਤ ਕੁਝ ਸੁਲਗਦਾ ਲੱਗਿਆ। ਉਸ ਦਿਨ ਤੋਂ ਮੈਂ ਇਸ ਲਹਿਰ ਨੂੰ ਇਸਦੇ ਅਸਲੀ ਰੂਪ ਵਿਚ ਸਮਝਣ ਦਾ ਯਤਨ ਕੀਤਾ। ਕੁੱਝ ਕੁ ਸਮਾਂ ਲੰਘਿਆ, ਮੇਰੇ ਅੰਦਰ ਇੱਕ ਹੋਰ ਨਾਵਲ ਨੇ ਅੰਗੜਾਈ ਲਈ। ਪਾਤਰ ਉਠੇ ਤੇ ਆਪਣੇ ਚਿਹਰੇ ਮੁਹਰੇ ਦਿਖਾਉਣ ਲੱਗੇ।

ਬਸ, ਇਸ ਤਰ੍ਹਾਂ ਮੇਰਾ ਲਿਖਣ ਕਾਰਜ ਰੋਕ-ਬੇਰੋਕ ਚੱਲ ਰਿਹਾ ਹੈ। ਕਦੇ-ਕਦੇ ਮਨ ਅੱਕ ਵੀ ਜਾਂਦਾ ਹੈ, ਕੀ ਲੈਣਾ ਹੈ, ਇਸ ਕੰਮ ਤੋਂ ? ਕੀ ਮਿਲਦਾ ਹੈ ? ਪਰ ਜਦੋਂ ਜੀਵਨ ਨਾਲ ਜੁੜਦਾ ਹਾਂ ਤਾਂ ਉਸ ਵਿਚਲੀ ਅਨੰਦਮਈ ਸਰੋਦੀ ਧੁਨ ਫਿਰ ਹੱਲਾਸ਼ੇਰੀ ਦਿੰਦੀ ਹੈ। ਇਉਂ ਮਹਿਸੂਸ ਹੋਣ ਲੱਗ ਪੈਂਦਾ ਹੈ ਕਿ ਜੀਵਨ ਤਾਂ ਅਮਰ ਹੈ ਜੋ ਮਨੁੱਖ ਨੂੰ ਇਸ ਦਾ ਕਿਆਸ ਹੋ ਜਾਵੇ, ਇਸ ਦੀ ਰੰਗੀਲੀ ਹੋਰ ਸੁਹਾਵਣੀ ਹੋ ਜਾਵੇਗੀ। ਬਸ, ਇਸ ਕਿਆਸ ਦੇ ਅਹਿਸਾਸ ਨੂੰ ਦੂਸਰਿਆਂ ਨਾਲ ਸਾਂਝਾ ਕਰਨਾ ਚਾਹੁੰਦਾ ਹਾਂ। ਹੁਣ ਤਾਂ ਇਹ ਹੀ ਅਹਿਸਾਸ ਲਿਖਣ ਲਈ ਅਗਵਾਈ ਕਰਦਾ ਹੈ।[8]

2.5 ਕਰਮਜੀਤ ਕੁੱਸਾ ਨੂੰ ਪ੍ਰਾਪਤ ਸਨਮਾਨ

ਰਾਤ ਦੇ ਰਾਹੀ - ਸਾਹਿਤ ਸਮੀਖਿਆ ਬੋਰਡ ਦਾ ਇਨਾਮ, 1983.

ਰੋਹੀ ਬੀਆਬਾਨ- ਭਾਈ ਵੀਰ ਸਿੰਘ ਗਲਪ ਪੁਰਸਕਾਰ, ਗੁਰੂ ਨਾਨਕ ਦੇਵ ਯੂਨੀਵਰਸਿਟੀ, ਅੰਮ੍ਰਿਤਸਰ, 1983.

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੂੰ ਪ੍ਰਾਪਤ ਇਹ ਸਨਮਾਨ ਇਸ ਗੱਲ਼ ਦਾ ਪ੍ਰਮਾਣ ਹਨ ਕਿ ਕੁੱਸਾ ਪੰਜਾਬੀ ਸਾਹਿਤ ਵਿਚ ਦਾ ਵਿਲੱਖਣ ਨਾਵਲਕਾਰ ਹੈ ਜਿਸ ਨੇ ਅਪਣੀਆਂ ਕਿਰਤਾਂ ਰਾਹੀਂ ਪੰਜਾਬੀ ਸਾਹਿਤ ਵਿਚ ਆਪਣਾ ਸਨਮਾਨਯੋਗ ਸਥਾਨ ਬਣਾ ਲਿਆ ਹੈ।

ਹਵਾਲੇ ਅਤੇ ਟਿੱਪਣੀਆਂ:-

1. ਬਲਦੇਵ ਸਿੰਘ ਧਾਲੀਵਾਲ, ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ਬਿਰਤਾਂਤ ਚੇਤਨਾ ਦੇ ਪਾਸਾਰ, ਪੰਨਾ 173.
2. ਡਾ. ਧਰਮਪਾਲ ਸਿੰਗਲ, ਪੰਜਾਬੀ ਸਾਹਿਤ ਦਾ ਇਤਿਹਾਸ, ਪੰਨਾ 550.
3. ਬਲਦੇਵ ਸਿੰਘ ਧਾਲੀਵਾਲ, ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਦਾ ਰਚਨਾ-ਪ੍ਰਬੰਧ, ਪੰਨਾ 3.
4. ਕੁੱਸਾ ਕਰਮਜੀਤ ਸਿੰਘ, ਰੋਹੀ-ਬੀਆਬਾਨ, ਲੋਕਗੀਤ ਪ੍ਰਕਾਸ਼ਨ, ਲੁਧਿਆਣਾ, ਪੰਨਾਂ 134, 2011.
5. ਬਲਦੇਵ ਸਿੰਘ ਧਾਲੀਵਾਲ, ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਦਾ ਰਚਨਾ-ਪ੍ਰਬੰਧ, ਪੰਨਾ 99.
6. ਉਹੀ, ਪੰਨਾ 160.
7. ਉਹੀ, ਪੰਨਾ 169
8. ਉਹੀ, ਪੰਨਾ 112.

ਅਧਿਆਇ ਤੀਜਾ

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਦਾ ਵਿਸ਼ਾ ਪੱਖ

ਕਿਸੇ ਵੀ ਸਾਹਿਤਕ ਕਿਰਤ ਦੇ ਦੋ ਪੱਖ ਹੁੰਦੇ ਹਨ ਇਕ ਵਿਸ਼ਾ ਪੱਖ ਅਤੇ ਦੂਸਰਾ ਰੂਪਕ ਪੱਖ। ਹਰੇਕ ਸਾਹਿਤਕਾਰ ਆਪਣੀ ਰਚਨਾ ਕਿਸੇ ਨਾ ਕਿਸੇ ਵਿਸ਼ੇ ਦੇ ਆਧਾਰ 'ਤੇ ਕਰਦਾ ਹੈ। ਇਕ ਨਾਵਲ ਵਿਚ ਇਕ ਹੀ ਵਿਸ਼ੇ ਨੂੰ ਵੀ ਪੇਸ਼ ਕੀਤਾ ਜਾ ਸਕਦਾ ਹੈ ਅਤੇ ਇਕ ਤੋਂ ਵੱਧ ਵਿਸ਼ੇ ਲੈ ਕੇ ਵੀ ਨਾਵਲ ਦੀ ਰਚਨਾ ਕੀਤੀ ਜਾ ਸਕਦੀ ਹੈ। ਵਿਸ਼ਾ ਇਕ ਮਹੱਤਵ ਪੂਰਨ ਤੱਤ ਹੈ ਕਿਉਂਕਿ ਵਿਸ਼ੇ ਨੂੰ ਲੈ ਕੇ ਹੀ ਨਾਵਲ ਦੀ ਰਚਨਾ ਹੁੰਦੀ ਹੈ ਅਤੇ ਵਿਸ਼ਾ ਜਿੰਨਾਂ ਸਾਰਥਕ ਹੋਵੇਗਾ ਨਾਵਲ ਓਨਾਂ ਹੀ ਵੱਧ ਪ੍ਰਭਾਵਸ਼ਾਲੀ ਹੋਵੇਗਾ। ਵਿਸ਼ਾ ਹਮੇਸ਼ਾ ਯਥਾਰਥਕ ਹੋਣਾ ਚਾਹੀਦਾ ਹੈ ਅਤੇ ਕੋਈ ਸੇਧ ਦੇਣ ਵਾਲਾ ਹੋਣਾ ਚਾਹੀਦਾ ਹੈ।ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਵਿਚੋਂ ਹੇਠ ਲਿਖੇ ਵਿਸ਼ੇ ਦ੍ਰਿਸ਼ਟੀਗੋਚਕ ਹੁੰਦੇ ਹਨ;

3.1 ਪੰਜਾਬੀ ਪੇਂਡੂ ਸਮਾਜ ਦੀ ਪੇਸ਼ਕਾਰੀ:-

ਪੰਜਾਬ ਮੁੱਢ ਕਦੀਮ ਤੋਂ ਹੀ ਪਿੰਡਾਂ ਦਾ ਦੇਸ਼ ਰਿਹਾ ਹੈ। ਆਰੀਆ ਦੇ ਆਉਣ ਤੋਂ ਪਹਿਲਾਂ ਤੋਂ ਲੈ ਕੇ ਹੁਣ ਤੱਕ ਪੰਜਾਬੀ ਆਪੋ-ਆਪਣੇ ਕਬੀਲੇ ਦੇ ਪਿੰਡ ਬੰਨ੍ਹ ਕੇ ਰਹਿੰਦੇ ਸਨ। ਰਣਜੀਤ ਸਿੰਘ ਅਨੁਸਾਰ ''ਇਹਦਾ ਸਬੂਤ ਹੁਣ ਵੀ ਪਿੰਡਾਂ ਵਿਚ ਮਿਲਦਾ ਹੈ ਕਿਉਂਕਿ ਹਰ ਪਿੰਡ ਵਿਚ ਇਕ ਜਾਂ ਦੋ ਗੋਤਾਂ ਦੇ ਲੋਕ ਹੀ ਰਹਿੰਦੇ ਸਨ, ਜਿਨ੍ਹਾਂ ਦਾ ਮੁੱਢ ਇਕ ਟੱਬਰ ਨਾਲ ਜਾ ਜੁੜਦਾ ਹੈ।''[1] ਪੁਰਾਤਨ ਪਿੰਡਾਂ ਦਾ ਵਾਤਾਵਰਣ ਸਾਦ ਮੁਰਾਦਾ ਅਤੇ ਸਿੱਧੇ ਸਾਦੇ ਮਾਹੌਲ ਵਿਚ ਗੁਜ਼ਰਦਾ ਸੀ। ਇਸ ਵਿਚ ਕੋਈ ਸ਼ੱਕ ਨਹੀਂ ਕਿ ਆਧੁਨਿਕਤਾ ਦੀ ਹਵਾ ਪਿੰਡਾਂ ਵਿਚ ਪੁੱਜ ਰਹੀ ਹੈ ਅਤੇ ਪਿਛਲੇ 20-25 ਸਾਲਾਂ ਵਿਚ ਚੋਖੀਆਂ ਤਬਦੀਲੀਆਂ ਆਈਆਂ ਹਨ, ਪਰ ਫਿਰ ਵੀ ਪੇਂਡੂ ਮਾਹੌਲ ਸ਼ਹਿਰੀ ਮਾਹੌਲ ਨਾਲੋਂ ਅੱਡਰਾ ਹੈ। ਪੰਜਾਬੀ ਗਲਪ ਵਿਚ ਬਹੁਤ ਸਾਰੇ ਗਲਪਕਾਰਾਂ ਨੇ ਪੰਜਾਬੀ ਸਭਿਆਚਾਰ ਅਤੇ ਪੇਂਡੂ ਸਮਾਜ ਦੀ ਪੇਸ਼ਕਾਰੀ ਕੀਤੀ ਹੈ। ਜਿਨ੍ਹਾਂ ਵਿਚੋਂ ਰਾਮ ਸਰੂਪ ਅਣਖੀ, ਗੁਰਦਿਆਲ ਸਿੰਘ, ਸੁਰਿੰਦਰ ਸਿੰਘ ਨਰੂਲਾ ਅਤੇ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਵਿਸ਼ੇਸ਼ ਉਲੇਖ ਯੋਗ ਹਨ। ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨਵਿਚ ਪੇਂਡੂ ਜੀਵਨ ਦਾ ਚਿਤਰਨ ਬਾਖੂਬੀ ਕੀਤਾ ਹੈ। ਜਿਵੇਂ ਕਿ ਨਾਵਲ ਦੇ ਅਰੰਭ ਵਿਚ ਹੀ ਵੇਖਿਆ ਜਾ ਸਕਦਾ ਹੈ:

'' ..... ਚੌਤੇਂ ਵਿਚ ਬੈਠਿਆਂ ਹੀ ਉਹਨੇ ਆਲੇ ਦੁਆਲੇ 'ਖਿੱਲਰੇ-ਖੱਪਰੇ' ਭਾਂਡਿਆਂ ਨੂੰ ਪੋਲੇ ਜਿਹੇ ਹੱਥ ਨਾਲ ਆਪਣੇ ਨੇੜੇ ਖਿੱਚਣ ਦਾ ਯਤਨ ਕੀਤਾ।''[2]

ਇਸ ਤੋਂ ਇਲਾਵਾ ਵਾਰ-ਵਾਰ ਪੇਂਡੂ ਕੰਮ ਧੰਦਿਆਂ ਬਾਰੇ ਵੀ ਗੱਲ ਹੋਈ ਹੈ ਜਿਵੇਂ:

"ਗੋਹਾ-ਕੂੜਾ ਅਜੇ ਅੱਧਾ ਹੀ ਰੂੜੀ ਉੱਤੇ ਸੁੱਟਿਆ ਹੁੰਦਾ, ਉਦੋਂ ਨੂੰ ਹਾਜ਼ਰੀ ਲਿਜਾਣ ਦਾ ਮੌਕਾ ਹੋ ਜਾਂਦਾ। ਦਬਾ-ਦੱਬ ਵਿੰਗੀਆਂ-ਬਾਉਲ੍ਹੀਆਂ ਥੱਪ ਕੇ, ਚਾਹ ਦੀ ਗੜਵੀ ਜਾਂ ਡੋਲਣੇਂ ਚ ਲੱਸੀ ਪਾ ਕੇ ਖੇਤ ਨੂੰ ਵਾਹੋ-ਦਾਹੀ ਹੋ ਲੈਂਦੀ।"[3]

ਖ਼ੁਦ ਪੇਂਡੂ ਸਮਾਜ ਨਾਲ ਜੁੜੇ ਹੋਣ ਕਰਕੇ ਕੁੱਸਾ ਨੂੰ ਪੇਂਡੂ ਸਮਾਜ ਬਾਰੇ ਡੂੰਘੀ ਜਾਣਕਾਰੀ ਹੈ। ਉਸ ਨੇ ਆਪਣੇ ਇਸ ਨਾਵਲ ਰਾਹੀਂ ਪੂਰੇ ਦਾ ਪੂਰਾ ਪੇਂਡੂ ਸਮਾਜ ਚਿਤਰ ਕੇ ਮੋਹਰੇ ਰੱਖ ਦਿੱਤਾ ਹੈ। ਪੇਂਡੂ ਸਮਾਜ ਵਿਚ ਇਕ ਗਲੀ-ਮਹੁੱਲੇ ਦਾ ਦ੍ਰਿਸ਼ ਵੀ ਬੜੇ ਯਥਾਰਥਕ ਢੰਗ ਨਾਲ ਪੇਸ਼ ਕੀਤਾ ਹੈ ਸ਼ਾਰਜੈਂਟ ਅਤੇ ਗੋਰੇ ਦੀ ਲੜਾਈ ਦਰਮਿਆਨ ਅਤੇ ਮਹਿੰਦਰੋ ਅਤੇ ਸਾਧੂ ਦੀ ਤੀਵੀਂ ਦੀ ਵਾਰਤਾਲਾਪ ਰਾਹੀਂ ਪੂਰੇ ਦੇ ਪੂਰੇ ਪੇਂਡੂ ਪਿੰਡ ਦਾ ਦ੍ਰਿਸ਼ ਸਕਾਰ ਹੋ ਜਾਂਦਾ ਹੈ।ਜਿਵੇਂ:

> "ਸ਼ਾਰਜੈਂਟ ਨੇ ਪਰ੍ਹੇ ਖਲੋਤੇ ਗੋਰੇ ਵਲ ਵੇਖਿਆ: ਜਿਹੜਾ ਲੱਤਾਂ-ਬਾਹਾਂ ਛੰਡ ਰਿਹਾ ਸੀ; ਜਿਵੇਂ ਮੱਖ ਲੜਦੀ ਹੋਵੇ। ਉਹ ਫੇਰ ਤੁੜਕਿਆ, "ਉਈ, ਸੱਚੀਂ ਸੂਣ ਆਲੀ ਮਹਿੰ ਆਂਗੂੰ ਤੁਰਦੀ ਐ।"
>
> " ਵੱਡਾ ਸਾਰਾ ਤਾਂ ਢਿੱਡ ਐ.... ਢਿੱਡਲ੍ਹ ਜਿਹੀ ਤਾਂ ਹੈਗੀ ਐ।" ਮਲਾਗਰ ਦੇ ਭਤੀਜੇ ਮੈਂਟੂ ਨੇ ਬੁੱਲ੍ਹਾਂ ਨੂੰ ਬਣਾ ਸੰਵਾਰ ਕੇ ਮੀਚਦੀਆਂ ਕਿਹਾ ਤੇ ਫਿਰ ਥੁੱਕਿਆ, "ਕੀ ਐ ਬਈ ਸੂਣ ਆਲੀਓ ਈ ਹੋਵੇ।"[4]

ਇਸ ਤੋਂ ਬਿਨਾਂ ਪੇਂਡੂ ਸਮਾਜ ਵਿਚ ਜਨਾਨੀਆਂ ਦੀ ਲੜਾਈ ਸਮੇਂ ਵਰਤੀ ਜਾਂਦੀ ਭਾਸ਼ਾ ਅਤੇ ਵਾਤਾਲਾਪ ਮਹਿੰਦਰੋ ਅਤੇ ਸਾਧੂ ਦੀ ਤੀਂਵੀਂ ਦੀ ਲੜਾਈ ਰਾਹੀਂ ਪੇਸ਼ ਹੁੰਦੀ ਹੈ ਜਿਵੇਂ ਕਿ ਸਾਧੂ ਦੀ ਤੀਵੀਂ ਦੇ ਬੋਲ ਹਨ:

> " ਪਤੰਦਰ ਹੋਊ ਤੇਰਾ ਨਾਲੇ ਤੇਰੀ ਮਾਂ ਦਾ.... ਗਿੱਠ ਗਿੱਠ ਦੀ ਜ਼ਬਾਨ ਲੱਗੀ ਐ। ਉਰੇ ਹੋ, ਮਾਰ ਮਾਰ ਚਪੇੜਾਂ ਭੰਨਾਂ ਤੇਰਾ ਮੂੰਹ। ਜਿਹੜਾ ਬੁਰਾਛਾਂ ਤਾਈਂ ਪਾਟਿਐ।"
>
> ਤੇ ਇਹ ਗੱਲਾਂ ਸੁਣ ਕੇ ਮਹਿੰਦਰੋ ਜਦੋਂ ਆਖਦੀ ਹੈ ਕਿ ਉਸ ਨੇ ਪੁੱਤ ਸੁੱਟੇ ਨਹੀਂ ਹੋਏ, "ਕੀ ਹੋ ਗਿਐ, ਬੱਚੇ ਖੇਡਦੇ ਲੜ ਪਏ ਤਾਂ.....।"

ਸਾਧੂ ਦੀ ਤੀਵੀਂ ਵੀ ਅੱਗੇ ਇਹ ਜਵਾਬ ਦਿੰਦੀ ਹੈ:

> "ਤੇਰੇ ਭਾਅ ਦੀ ਨੀ ਕੁਸ਼ ਹੋਣੈਂ.....ਨੀ ਉਦੋਂ ਤਾਂ ਮੈਂ ਛੁਡਾਇਆਂ ਮੁੰਡਾ ਆਕੇ, ਜੇ ਮੁੰਡਾ ਮਰ ਜਾਂਦੈ।"[5]

ਜਿਵੇਂ ਸਾਡੇ ਸਮਾਜ ਵਿਚ ਕਈ ਵਾਰ ਘੱਟ ਜਮੀਨ ਹੋਣ ਕਰਕੇ ਘਰ ਦੇ ਕਿਸੇ ਨਾ ਕਿਸੇ ਵਿਅਕਤੀ ਦਾ ਵਿਆਹ ਨਾ ਹੋਣ ਦੀਆਂ ਕਈ ਉਦਾਰਹਨਾਂ ਮਿਲਦੀਆਂ ਹਨ ਅਤੇ ਫਿਰ ਉਹ ਵਿਅਕਤੀ ਆਪਣੀ ਕਾਮ ਪੂਰਤੀ ਲਈ

ਆਪਣੀਆਂ ਭਰਜਾਈਆਂ ਉੱਪਰ ਮਾੜ੍ਹੀ ਨਜ਼ਰ ਰੱਖਦੇ ਹਨ 'ਤੇ ਇਸ ਪ੍ਰਕਾਰੇ ਹੀ ਇਸ ਨਾਵਲ ਵਿਚ ਹੁੰਦਾ ਹੈ। ਘੋਅਟੀ ਦਾ ਘੱਟ ਜਮੀਨ ਹੋਣ ਕਰਕੇ ਵਿਆਹ ਨਹੀਂ ਹੁੰਦਾ ਅਤੇ ਉਹ ਗੋਰੇ ਦੀ ਮਾਂ ਮਹਿੰਦਰੋ ਉੱਪਰ ਭੈੜੀ ਨਜ਼ਰ ਰੱਖਦਾ ਹੈ। ਜਦੋਂ ਗਿੰਦਰ ਹੁਣੀ ਘੋਅਟੀ ਨਾਲ ਰਲ ਜਾਂਦੇ ਹਨ ਤਾਂ ਇੱਕ ਦਿਨ ਜਦੋਂ ਮਹਿੰਦਰੋ ਸੰਦੂਖ ਦੇ ਮੂਹਰੇ ਸ਼ੀਸ਼ੇ 'ਚ ਆਪਣਾ ਚਿਹਰਾ ਨਿਹਾਰ ਰਹੀ ਸੀ ਤਾਂ ਘੋਅਟੀ ਆਉਂਦਾ ਹੈ ਅਤੇ ਉਸ ਨਾਲ ਬੁਰਾ ਵਿਵਹਾਰ ਕਰਦਾ ਹੈ। ਇਸ ਤੋਂ ਇਲਾਵਾ ਸਮੁੱਚੇ ਨਾਵਲ ਵਿਚ ਪੇਂਡੂ ਸਮਾਜ ਨੂੰ ਅਤੇ ਪੇਂਡੂ ਸਮਾਜ ਦੀਆਂ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਪੇਸ਼ ਕੀਤਾ ਗਿਆ ਹੈ। ਪੇਂਡੂ ਸਮਾਜ ਦੇ ਹਰੇਕ ਪੱਖ ਨੂੰ ਨਾਵਲ ਦਾ ਹਿੱਸਾ ਬਣਾਇਆ ਗਿਆ ਹੈ। ਇਸ ਤੋਂ ਇਲਾਵਾ ਹਰੇਕ ਮੌਸਮ ਵਿਚ ਕਿਸਾਨੀ ਜਗਤ ਵਿਚ ਕੀਤੇ ਜਾਂਦੇ ਕੰਮਾਂ ਦਾ ਵਰਣਨ ਵੀ ਇਸ ਨਵਲ ਵਿਚ ਮਿਲਦਾ ਹੈ। ਕੁੱਲ ਮਿਲਾ ਕੇ ਅਸੀਂ ਕਹਿ ਸਕਦੇ ਹਾਂ ਕਿ ਇਹ ਨਾਵਲ ਪੇਂਡੂ ਸਮਾਜ ਦਾ ਇਕ ਇਤਿਹਾਸਿਕ ਦਸਤਾਵੇਜ ਹੈ।

3.2 ਛੋਟੀ ਕਿਰਸਾਣੀ ਦਾ ਸੰਕਟ:-

ਪੰਜਾਬ ਖੇਤੀ ਪ੍ਰਧਾਨ ਦੇਸ਼ ਹੈ ਅਤੇ ਇੱਥੇ ਸਭ ਤੋਂ ਪਹਿਲਾਂ ਸੱਭਿਅਤਾ ਵਿਕਸਿਤ ਹੋਈ। ਇਸ ਸੰਬੰਧੀ ਰਣਜੀਤ ਸਿੰਘ ਦਾ ਕਹਿਣਾ ਹੈ, "ਪੰਜਾਬ ਨੂੰ ਇਸ ਗੱਲ ਦਾ ਮਾਣ ਹੈ ਕਿ ਇਸ ਦੀ ਸੱਭਿਅਤਾ ਸਭ ਤੋਂ ਪੁਰਾਣੀ ਮੰਨੀ ਜਾਂਦੀ ਹੈ।"[6]ਪੰਜਾਬੀ ਮੁੱਢ ਤੋਂ ਹੀ ਮਿਹਨਤੀ ਰਹੇ ਹਨ। ਪਹਿਲੇ ਸੰਸਾਰ ਯੁੱਗ ਦੇ ਸ਼ੁਰੂ ਹੋਣ ਤੀਕ ਕਿਸਾਨਾਂ ਦੀ ਹਾਲਤ ਬਹੁਤੀ ਭੈੜੀ ਹੋ ਚੁੱਕੀ ਸੀ। ਰਣਜੀਤ ਸਿੰਘ ਅਨੁਸਾਰ "ਮੌਕਾ ਮਿਲਦੀਆਂ ਹੀ ਸਾਰੇ ਪੰਜਾਬੀ ਕਿਸਾਨ ਵਿਦੇਸ਼ਾਂ ਵਿਚ ਮਜ਼ਦੂਰੀ ਕਰਨ ਚਲੇ ਗਏ, ਜਿਨ੍ਹਾਂ ਕੋਲ ਕੁਝ ਗੁੰਜਾਇਸ਼ ਸੀ ਉਨ੍ਹਾਂ ਪੱਛਮੀ ਪੰਜਾਬ ਦੀਆਂ ਨਵੀਆਂ ਅਬਾਦੀਆਂ ਵਿਚ ਜ਼ਮੀਨਾਂ ਖਰੀਦ ਲਈਆਂ।"[7]

ਇਸ ਪ੍ਰਕਾਰ ਉਸ ਸਮੇਂ ਤੋਂ ਹੀ ਕਿਸਾਨ ਦੋ ਸ਼੍ਰੇਣੀਆਂ ਉੱਚ ਕਿਸਾਨੀ ਅਤੇ ਛੋਟੀ ਕਿਸਾਨੀ ਵਿਚ ਵੰਡੇ ਗਏ। ਛੋਟੀ ਕਿਸਾਨੀ ਦੀ ਹਾਲਤ ਇਤਨੀ ਭੈੜੀ ਹੋ ਚੁੱਕੀ ਸੀ ਕਿ ਕਿਸਾਨ ਆਗੂਆਂ ਨੇ ਜਨਮ ਲਿਆ, ਜਿਨ੍ਹਾਂ ਨੇ ਕਿਸਾਨਾਂ ਨਾਲ ਹੋ ਰਹੇ ਧੱਕੇ ਪ੍ਰਤੀ ਸਰਕਾਰ ਨੂੰ ਸੁਚੇਤ ਕੀਤਾ। ਸੋ ਇਸ ਲਹਿਰ ਦਾ ਅਸਰ ਸਾਹਿਤ ਵਿਚ ਵੀ ਮਿਲਦਾ ਹੈ। ਗੁਰਦਿਆਲ ਸਿੰਘ, ਬਲਦੇਵ ਸਿੰਘ ਆਦਿ ਵਰਗੇ ਨਾਵਲਕਾਰਾਂ ਨੇ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਸੰਤਾਪ ਨੂੰ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ਇਸੇ ਲਹਿਰ ਨੂੰ ਅੱਗੇ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਜਾਰੀ ਰੱਖਿਆਂ ਹੈ।

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਕਿਸੇ ਵਕਤੀ ਰਾਜਸੀ ਲਹਿਰ ਦੀ ਉਪਜ ਨਹੀਂ ਸੀ, ਬਲਕਿ ਪੰਜਾਬ ਦੀ ਕਿਰਸਾਨੀ ਦੀਆਂ ਜਲਿਟ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਪੇਸ਼ ਕਰਨ ਲਈ ਉਸ ਨੇ ਖ਼ੁਦ ਦੀ ਚੋਣ ਕੀਤੀ।ਕੁੱਸਾ ਦਾ ਪਿਛਲੇ ਦਹਾਕੇ ਵਿਚ ਉਭਰੇ ਉਤਮ ਕੋਟੀ ਦੇ ਨਾਵਲਕਾਰਾਂ ਵਿਚੋਂ ਸਭ ਤੋਂ ਵੱਧ ਚਰਚਿਤ ਨਾਂ ਹੈ। ਪੰਜਾਬ ਦੀ ਗ਼ਰੀਬ ਕਿਸਾਨੀ ਨਾਲ ਜਨਮ-ਜਾਤ ਦਾ ਸੰਬੰਧ ਹੋਣ ਕਾਰਨ, ਉਸਨੂੰ ਛੋਟੀ ਕਿਸਾਨੀ ਤੇ ਖੇਤ-ਮਜ਼ਦੂਰ ਵਰਗਾਂ ਦੇ ਆਰਥਿਕ-ਸਭਿਆਚਾਰਕ ਸੰਕਟਾਂ ਦਾ ਅਨੁਭਵ ਹੈ।

''ਆਪਣੇ ਨਾਵਲਾਂ ਵਿਚ ਪੰਜਾਬ ਦੀ ਨਿਮਨ ਕਿਸਾਨੀ ਦੇ ਆਰਥਿਕ-ਸਭਿਆਚਾਰਕ ਜੀਵਨ ਦੀ ਜਿਸ ਕਲਾਤਮਕ ਵਿਧੀ ਦੁਆਰਾ ਕੁੱਸੇ ਨੇ ਪੁਨਰ ਸਿਰਜਣਾ ਕੀਤੀ ਹੈ ਉਸ ਪ੍ਰਕਾਰ ਕਿਸੇ ਵੀ ਹੋਰ ਨਾਵਲਕਾਰ ਨੇ ਨਹੀਂ ਕੀਤੀ।''[8] ਗ਼ਰੀਬ ਕਿਸਾਨੀ ਦੇ ਜੀਵਨ-ਯਥਾਰਥ ਦੀਆਂ ਮੂਲ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਪੇਸ਼ ਕਰਨ ਵਾਲਾ ਸਭ ਤੋਂ ਪ੍ਰਭਾਵਕਾਰੀ ਗਲਪੀ ਰੂਪ ਉਸ ਦਾ ਨਾਵਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਹੈ।

'ਰੋਹੀ ਬੀਆਬਾਨ' ਦੀ ਮੂਲ ਕਥਾ ਗ਼ਰੀਬ ਕਿਸਾਨੀ ਦੇ ਇਕਹਰੇ ਤੇ ਛੋਟੇ ਪਰਿਵਾਰ ਦੀ ਕਥਾ ਹੈ। ਇਸ ਪਰਿਵਾਰ ਦੇ ਪੰਜ ਜੀਅ ਹਨ: ਜੋਗਿੰਦਰ-ਮਹਿੰਦਰੋ (ਪਤੀ-ਪਤਨੀ), ਗੋਰਾ ਤੇ ਕੱਦੂ (ਦੋ ਮੁੰਡੇ) ਤੇ ਇਕ ਨਿੱਕੀ ਕੁੜੀ। ਜੱਦੀ ਜ਼ਮੀਨ ਵਿਚੋਂ ਇਸ ਪਰਿਵਾਰ ਦੇ ਹਿੱਸੇ ਕੁੱਲ ਪੌਣਾ ਕਿੱਲਾ ਆਇਆ ਹੈ। ਸਾਰਾ ਪਰਿਵਾਰ ਮਿੱਟੀ ਨਾਲ ਮਿੱਟੀ ਹੋਇਆ ਰਹਿੰਦਾ ਹੈ, ਪਰ ਗੁਜ਼ਾਰਾ ਤਾਂ ਵੀ ਮੁਸ਼ਕਲ ਨਾਲ ਹੁੰਦਾ ਹੈ। ਸਕੂਲ ਤੇ ਘਰ ਵਿਚ ਪੜ੍ਹਾਈ ਦਾ ਢੁਕਵਾਂ ਮਾਹੌਲ ਨਾ ਹੋਣ ਕਾਰਨ 'ਗੋਰਾ' ਤੀਜੀ ਜਮਾਤ ਵਿਚੋਂ ਦੂਜੀ ਵਾਰ ਫੇਲ੍ਹ ਹੋ ਕੇ ਪੜ੍ਹਨੋਂ ਹਟ ਜਾਂਦਾ ਹੈ। ਗਿੰਦਰ ਨੂੰ ਆਪਣੇ ਇਕ ਭਰਾ ਦੀ ਮੌਤ ਪਿਛੋਂ ਇਕ ਵਾਰ ਮੁੜ ਵੱਡੇ ਭਰਾਵਾਂ ਨਾਲ ਰਲਣਾ ਪੈ ਜਾਂਦਾ ਹੈ, ਪਰ ਉਨ੍ਹਾਂ ਦੇ ਦੁਰਵਿਹਾਰ ਤੋਂ ਤੰਗ ਆ ਕਰ ਉਹ ਸਾਲ ਬਾਅਦ ਹੀ ਦੁਆਰਾ ਅੱਡ ਹੋ ਜਾਂਦਾ ਹੈ। ਇਸ ਨਾਵਲ ਦਾ ਮੁੱਖ ਪਾਤਰ ਗੋਰਾ ਹੈ। ਉਹ ਹੌਲੀ-ਹੌਲੀ ਇਲਤੀ ਹੋ ਜਾਂਦਾ ਹੈ। ਉਹ ਚੋਰੀ ਵੀ ਕਰਦਾ ਹੈ, ਬੀੜੀਆਂ ਪੀਣੀਆਂ ਵੀ ਸ਼ੁਰੂ ਕਰ ਦਿੰਦਾ ਹੈ ਅਤੇ ਪਿਉ ਨਾਲ ਰਲ ਕੇ ਸ਼ਰਾਬ ਕੱਢਣੀ ਤੇ ਵੇਚਣੀ ਸ਼ੁਰੂ ਕਰ ਦਿੰਦਾ ਹੈ। ਉਸ ਨੂੰ ਸੁਧਾਰਨ ਵਾਸਤੇ ਸ਼ਹਿਰ ਵਿਚ ਮਾਮੇ ਕੋਲ ਭੇਜਿਆ ਜਾਂਦਾ ਹੈ ਉਸ ਦਾ ਮਾਮਾ ਉਸ ਨੂੰ ਲੁਧਿਆਣੇ ਕਿਸੇ ਬਿਸਕੁਟ ਬੇਕਰੀ ਵਿਚ ਨੌਕਰ ਵੀ ਰਖਾ ਦਿੰਦਾ ਹੈ। ਪਰ ਸ਼ਹਿਰ ਵਿਚ ਉਸ ਦਾ ਜੀਅ ਨਹੀਂ ਲਗਦਾ ਤੇ ਬੇਕਰੀ ਦਾ ਮਾਲਕ, ਬੇਕਰੀ ਦੇ ਕੰਮ ਤੋਂ ਇਲਾਵਾ, ਜਦੋਂ ਉਸ ਨੂੰ ਗੋਹਾ ਸੁੱਟਣ ਨੂੰ ਕਹਿੰਦਾ ਹੈ ਤਾਂ ਉਹ ਹੀਣਤਾ ਅਨੁਭਵ ਕਰਕੇ ਉਥੋਂ ਦੌੜ ਕੇ ਆਪਣੇ ਪਿੰਡ ਪਹੁੰਚ ਜਾਂਦਾ ਹੈ। ਘਰ ਆ ਕੇ ਪਹਿਲਾਂ ਕੁਕੜੀਆਂ ਰੱਖਦਾ ਹੈ, ਫਿਰ ਪਿਉ ਨਾਲ ਰਲ ਕੇ ਸ਼ਰਾਬ ਕੱਢਦਾ ਤੇ ਵੇਚਦਾ ਹੈ। ਮਹਿੰਦਰੋ ਇਸ ਨੂੰ ਪਸੰਦ ਨਹੀਂ ਕਰਦੀ। ਕੁੱਝ ਚਿਰ ਮਗਰੋਂ ਸ਼ਰੀਕੇ ਵਿਚੋਂ ਲਗਦੇ ਇਕ ਚਾਚਾ (ਤੇਲੂ) ਨਾਲ ਕਲਕੱਤੇ ਟਰੱਕ ਡਰਾਇਵਰੀ ਸਿੱਖਣ ਚਲਾ ਜਾਂਦਾ ਹੈ। ਪਰ ਉਥੇ ਵੀ ਉਹ ਦੂਜੇ ਡਰਾਈਵਰਾਂ ਦੀ ਬਦਫੈਲੀ ਤੋਂ ਤੰਗ ਆ ਜਾਂਦਾ ਹੈ ਤੇ ਇਕ ਦਿਨ ਰੋਹ ਵਿਚ ਆ ਕੇ ਉਨ੍ਹਾਂ ਵਿਚੋਂ ਇਕ (ਗੰਤੇ) ਨੂੰ ਕੁੱਟ ਦਿੰਦਾ ਹੈ। ਭਾਵੇਂ ਗੋਰਾ ਸਰੀਰਿਕ ਪੱਖੋਂ ਤਕੜਾ ਹੈ, ਪਰ ਤੇਲੂ ਉਸ ਨੂੰ ਕਾਬੂ ਕਰ ਕੇ ਕੁੱਟਦਾ ਹੈ ਤਾਂ ਉਹ ਉਨ੍ਹਾਂ ਨੂੰ ਛੱਡ ਕੇ ਹੋਰ ਟਰੱਕ ਮਾਲਕ ਕੋਲ ਕੰਮ ਓਂਤੇ ਲੱਗ ਜਾਂਦਾ ਹੈ। ਉਥੇ ਵੀ ਉਸ ਦਾ ਝਗੜਾ ਹੋ ਜਾਂਦਾ ਹੈ ਤੇ ਇਕ ਦਿਨ ਇਕ ਟਰੱਕ ਡਰਾਇਵਰ ਉਸਨੂੰ ਪਾਣੀ ਦੇ ਬਹਾਨੇ ਬਿਹਾਰ ਦੇ ਜੰਗਲਾਂ ਵਿਚ ਉਤਾਰ ਕੇ ਟਰੱਕ ਭਜਾ ਲੈ ਜਾਂਦਾ ਹੈ। ਉਹ ਰੁਲਦਾ-ਖੁਲਦਾ ਤੇ ਧੱਕੇ ਖਾਂਦਾ ਮੁੜ ਆਪਣੇ ਪਿੰਡ ਆ ਜਾਂਦਾ ਹੈ। ਪਿੰਡ ਆ ਕੇ ਜ਼ਮੀਨ ਠੇਕੇ ਵਟਾਈ 'ਤੇ ਲੈ ਕੇ ਵਹਾਈ ਦਾ ਕੰਮ ਸ਼ੁਰੂ ਕਰ ਦਿੰਦਾ ਹੈ। ਸਾਧੂ ਨਾਂ ਦੇ ਗਭਲੇ ਮੇਲ ਦੇ ਕਿਸਾਨ ਨਾਲ ਰਲ਼ ਕੇ ਖੇਤੀ ਕਰਦਾ ਹੈ, ਪਰ ਸਾਧੂ ਉਸਨੂੰ ਆਪਣਾ ਸੀਰੀ ਹੀ ਸਮਝਦਾ ਹੈ। ਉਸ ਨਾਲ ਨਿਭਦੀ ਨਹੀਂ। ਖੇਤੀ ਲਈ ਤੇਲ ਆਦਿ ਵੀ ਸੌਖਾ ਕੰਮ ਨਹੀਂ ਮਿਲਦਾ। ਉਹ ਮੁੜ

ਸ਼ਰਾਬ ਕੱਢਣੀ ਤੇ ਵੇਚਣੀ ਸ਼ੁਰੂ ਕਰ ਦਿੰਦਾ ਹੈ। ਇਕ ਦਿਨ ਪੁਲਿਸ ਦਾ ਛਾਪਾ ਪੈ ਜਾਂਦਾ ਹੈ। ਗੋਰਾ ਬਚ ਤਾਂ ਜਾਂਦਾ ਹੈ, ਪਰ ਘਰ ਦੇ ਹੁਣ ਉਸ ਵਲੋਂ ਫਿਕਰਮੰਦ ਹੋ ਜਾਂਦੇ ਹਨ ਤੇ ਕਿਸੇ ਤੋਂ ਪੈਸੇ ਉਧਾਰੇ ਫੜ ਕੇ, ਇਕ ਏਜੰਟ ਰਾਹੀਂ ਉਸਨੂੰ ਵਿਦੇਸ਼ ਭੇਜ ਦਿੰਦੇ ਹਨ, ਪਰ ਗੈਰਕਾਨੂੰਨੀ ਤੌਰ 'ਤੇ ਭੇਜੇ ਹੋਣ ਕਰਕੇ ਗੋਰਾ ਤੇ ਉਸ ਨਾਲ ਦੇ ਹੋਰ ਬੰਦੇ ਫੜੇ ਜਾਂਦੇ ਹਨ। ਏਜੰਟ ਖਿਸਕ ਜਾਂਦਾ ਹੈ ਤੇ ਗੋਰਾ ਪਿੰਡ ਮੁੜ ਆਉਂਦਾ ਹੈ। ਪਿੰਡ ਦੇ ਜਿਸ ਧਨੀ ਕਿਸਾਨ ਤੋਂ ਕਰਜ਼ਾ ਲਿਆ ਸੀ ਉਹ ਪੈਸੇ ਵਾਪਸ ਮੰਗਦਾ ਹੈ ਤੇ ਨਾ ਦੇਣ ਦੀ ਸੂਰਤ ਵਿਚ ਗੋਰੇ ਨੂੰ ਆਪਣੇ ਨਾਲ ਸੀਰੀ ਰਲਾਉਣ ਦੀ ਪੇਸ਼ਕਸ਼ ਕਰਦਾ ਹੈ। ਘਰ ਦੇ ਮੰਨ ਜਾਂਦੇ ਹਨ, ਪਰ ਗੋਰਾ ਸੀਰੀ ਰਲਣ ਲਈ ਤਿਆਰ ਨਹੀਂ। ਘਰ ਝਗੜਾ ਹੁੰਦਾ ਹੈ, ਗਿੰਦਰ ਉਸਨੂੰ ਕੁੱਟਦਾ ਹੈ ਤੇ ਗੋਰਾ ਗੁੱਸੇ ਵਿਚ ਘਰੋਂ ਨਿਕਲ ਜਾਂਦਾ ਹੈ। ਇਹ ਅਤਿ ਦੀ ਨਿਰਾਸ਼ਾ ਦੀ ਨਿਰਾਸ਼ਾ ਹੈ। ਇਸ ਅਵਸਥਾ ਵਿਚ ਪਿੰਡ ਦੀ ਸੁੰਨ- ਮਸਾਣ ਫਿਰਨੀ 'ਤੇ ਖੜੋਤਿਆ ਉਸ ਨੂੰ ਲਗਦਾ ਹੈ ਜਿਵੇਂ ''ਪਿੰਡ ਦੀ ਮੌਤ ਹੋ ਗਈ ਹੋਵੇ।''

ਉਪਰੋਕਤ ਕਥਾ ਤੋਂ ਹੀ ਇਹ ਤੱਥ ਸਪੱਸ਼ਟ ਹੋ ਜਾਂਦਾ ਹੈ ਕਿ ਪੰਜਾਬ ਦੇ ਖੇਤੀ ਪ੍ਰਧਾਨ ਅਰਥਚਾਰੇ ਵਿਚ ਵੀ ਪੂੰਜੀਵਾਦੀ ਅਰਥ-ਵਿਵਸਥਾ ਇੰਨੀ ਭਾਰੂ ਹੋ ਗਈ ਹੈ ਕਿ ਕਿਸਾਨੀ ਸਾਫ਼ ਤੌਰ 'ਤੇ ਤਿੰਨ ਵਰਗਾਂ ਵਿਚ ਵੰਡੀ ਗਈ ਹੈ। ਹੇਠਲਾ ਮੇਲ (ਗਿੰਦਰ), ਗਭਲਾ ਮੇਲ (ਸਾਧੂ), ਤੇ ਉਪਰਲਾ ਮੇਲ (ਕਰਜ਼ਾ ਦੇਣ ਵਾਲਾ ਧਨੀ ਕਿਸਾਨ)। 'ਰੋਹੀ ਬੀਆਬਾਨ' ਵਿਚ ਇਸ ਤਿੰਨ ਮੇਲ ਦੀ ਕਿਸਾਨੀ ਦੀ ਪਛਾਣ 'ਕੈਨਾਂ ਵਾਲੇ', 'ਟ੍ਰੈਕਟਰਾਂ ਵਾਲੇ', ਤੇ 'ਜੀਪਾਂ ਵਾਲੇ' ਦੇ ਰੂਪਾਂ ਵਿਚ ਹੁੰਦੀ ਹੈ। 'ਜੀਪਾਂ ਵਾਲੇ' ਉਹ ਜ਼ਿਮੀਦਾਰ ਹਨ ਜਿਨ੍ਹਾਂ ਦਾ ਕਿਰਦਾਰ ਬੁਰਜੂਆ ਵਰਗ ਵਾਲਾ ਲੋਟੂ ਹੈ, ਅਣਕਮਾਇਆ ਧਨ, ਮੁੱਲ ਖ਼ਰੀਦੇ ਗੁੰਡੇ, ਸਰਕਾਰੇ-ਦਰਬਾਰੇ ਪੁੱਛ ਪ੍ਰਤੀਕ ਤੇ ਧੱਕੇ ਸ਼ਾਹੀ ਇਸ ਮੇਲ ਦੀ ਮੁੱਖ ਪਛਾਣ ਹੈ। 'ਟ੍ਰਕੈਟਰਾਂ ਵਾਲੇ' ਉਹ ਜੱਟ ਹਨ ਜਿਨ੍ਹਾਂ ਕੋਲ ਗੁਜ਼ਾਰੇ ਜੋਗੀ ਜ਼ਮੀਨ ਹੈ ਤੇ ਜੋ ਕਰਜ਼ੇ-ਤਕਾਵੀਆਂ ਲੈ ਕੇ ਨਵੀਂ ਮਸ਼ਨੀ ਖੇਤੀ ਕਰਨ ਦੀ ਸਮਰੱਥਾ ਰੱਖਦੇ ਹਨ, ਇਕ-ਅੱਧ ਬੱਚੇ ਨੂੰ ਪੜ੍ਹਾਉਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਵੀ ਕਰਦੇ ਹਨ, ਪਰ ਅੰਦਰੋ-ਅੰਦਰੀਂ ਕਿਸਾਨੀ ਦਾ ਇਹ ਉਪਵਰਗ ਵੀ ਹੇਠਾਂ ਵੱਲ ਜਾ ਰਿਹਾ ਹੈ ਕਿਉਂਕਿ ਕਰਜ਼ਿਆਂ 'ਤੇ ਲਈ ਮਸ਼ੀਨਰੀ ਦਿਨੋ-ਦਿਨ ਘਸ ਰਹੀ ਹੈ ਤੇ ਕਰਜ਼ਾ ਸਿਰ ਦਾ ਸਿਰ ਰਹਿੰਦਾ ਹੈ, ਜ਼ਮੀਨ ਅੱਡ ਬਿਲੇ ਲੱਗ ਰਹੀ ਹੈ। ਇਸ ਮੇਲ ਦੀ ਕਿਸਾਨੀ ਦਾ ਸ਼੍ਰੇਣਿਕ ਚਰਿਤਰ ਸ਼ਹਿਰੀ ਮੱਧਵਰਗ ਵਾਲਾ ਹੀ ਹੈ। ਇਹ ਧਨੀ ਕਿਸਾਨੀ ਵਾਂਗ ਹੀ ਆਪਣਿਆਂ ਰੀਝਾਂ ਦੀ ਪੂਰਤੀ ਕਰਨਾ ਚਾਹੁੰਦੀ ਹੈ, ਪਰ ਉਸ ਵਾਲੇ ਵਸੀਲੇ ਇਸਨੂੰ ਪ੍ਰਪਾਤ ਨਹੀਂ।'ਨਿਆਣਿਆਂ ਨੂੰ ਲੱਸੀ ਨਾਲੋਂ ਭੈੜਾ ਦੁੱਧ' ਪਿਲਾ ਕੇ ਤੇ ਫੋਕੇ ਪਾਣੀ ਵਰਗੀ', 'ਮੂੰਗੀ ਦੀ ਦਾਲ' ਖਾ ਕੇ ਮਸਾਂ 'ਪੰਜ ਪਾਂਜੇ' ਪੂਰੇ ਕਰਦੀ ਹੈ। ਕੰਮ ਦੇ ਜ਼ੋਰ ਸਮੇਂ ਇਹ ਗ਼ਰੀਬ ਕਿਸਾਨੀ ਨਾਲ ਵੀ ਭਿਆਲੀ ਪਾ ਲੈਂਦੀ ਹੈ (ਸਾਧੂ ਤੇ ਗੋਰੇ ਦੀ ਵਿੜ੍ਹੀ ਵਾਂਗ) ਅਤੇ ਮਜ਼ੂਬੀਆਂ-ਚਮਾਰਾਂ ਦੀ ਖੁਸ਼ਾਮਦ ਵੀ ਕਰ ਲੈਂਦੀ ਹੈ। ਤੀਜਾ ਮੇਲ ਗ਼ਰੀਬ ਕਿਸਾਨੀ ਦਾ ਹੈ। ਇਸ ਮੇਲ ਦੀ ਗਿਣਤੀ ਓਭ ਤੋਂ ਵੱਧ ਹੈ ਤੇ ਇਸ ਦੀ ਆਰਥਿਕ ਦਸ਼ਾ ਭੋਂਗਣੀ ਵਰਗਾਂ ਦੇ ਬਰਾਬਰ ਪਹੁੰਚ ਗਈ ਹੈ। ਭੋਏਂ ਦੀਆਂ

ਨਿੱਕੀਆਂ-ਨਿੱਕੀਆਂ ਵੰਡੀਆਂ ਕਾਰਨ, ਇਹ ਇੰਨੀ ਘਟ ਗਈ ਹੈ ਕਿ ਛੋਟੇ ਟੱਬਰ ਦੀ ਰੋਟੀ ਵੀ ਮਸਾਂ ਚਲਦੀ ਹੈ। ਜਾਇਦਾਦ ਦੀ ਕਮੀ ਕਾਰਨ ਪਰਿਵਾਰ ਵਿਚ ਕਲੇਸ਼ ਹੁੰਦੇ ਹਨ।

ਇਸ ਨਾਵਲ ਵਿਚ ਸਾਡੇ ਸਮਾਜ ਦਾ ਇਕ ਹੋਰ ਵਰਤਾਰਾ ਵਿਦਮਾਨ ਹੈ। ਇਸ ਦਵੰਦ ਵਿਚ ਇਕ ਪਾਸੇ ਸਦਾਚਾਰਕ ਕੀਮਤਾਂ ਅਤੇ ਦੂਜੇ ਪਾਸੇ ਪੂਰਨ ਹਕੀਕਤਾਂ ਹਨ। ਗਿੰਦਰ ਤੇ ਵਿਸ਼ੇਸ਼ ਕਰਕੇ ਮਹਿੰਦਰੋ ਗੋਰੇ ਨੂੰ ਮਾੜੇ ਕੰਮਾਂ (ਸ਼ਰਾਬ ਕੱਢਣ 'ਤੇ ਵੇਚਣ) ਤੋਂ ਰੋਕਦੇ ਹਨ ਪਰ ਘਰ ਦੀ ਮਾੜੀ ਮਾਲੀ ਹਾਲਤ ਕਾਰਨ ਪੈਸੇ ਆਉਣ 'ਤੇ ਵਿਰੋਧ ਵੀ ਨਹੀਂ ਕਰਦੇ। ਇਸ ਕਾਰਨ ਹੀ ਗਿੰਦਰ ਸ਼ਰਾਬ ਵੇਚਣ 'ਤੇ ਬੁਰਾ ਨਹੀ ਮਨਾਉਂਦਾ, ਪਰ ਪੀਣ ਤੋਂ ਨੱਕ ਵੱਟਦਾ ਹੈ। ਪੈਸੇ ਬਣਦੇ ਵੇਖ ਕੇ ਮਹਿੰਦਰੋ ਵੀ ਦੜ ਵੱਟ ਲੈਂਦੀ ਹੈ। ਪਰ ਹਨੇਰਾ ਹੋਣ ਦੇ ਨਾਲ ਹੀ ਲੋਕ ਵਹੀਰਾਂ ਬੰਨ੍ਹੀ ਉਨ੍ਹਾਂ ਦੇ ਘਰ ਵਲ ਤੁਰੇ ਆਉਂਦੇ ਹਨ। ਮਹਿੰਦਰੋ ਸ਼ਰਮ ਮੰਨਦੀ ਹੈ। ਨਿੱਜੀ ਹਉਮੈ ਨਾਲ ਸੰਬੰਧਿਤ ਇਕ ਹੋਰ ਵਰਤਾਰਾ ਇਸ ਨਾਵਲ ਵਿਚ ਚਿਤਰੀਆ ਮਿਲਦਾ ਹੈ। ਇਕ ਪਾਸੇ ਤਾਂ ਗਿੰਦਰ ਤੇ ਮਹਿੰਦਰੋ ਆਪਣੇ ਮੁੰਡੇ ਗੋਰੇ ਨੂੰ ਸੁਧਾਰਨਾ, ਪੜ੍ਹਾਉਣਾ ਚਾਹੁੰਦੇ ਹਨ ਪਰ ਜਦ ਅਜਿਹਾ ਹੀ ਗੋਰੇ ਦੇ ਜਮਾਤੀ, ਅਧਿਆਪਕ ਜਾਂ ਗਵਾਂਢੀ ਕਰਦੇ ਹਨ ਤਾਂ ਉਹ ਬਰਦਾਸ਼ਤ ਨਹੀਂ ਕਰਦੇ ਅਤੇ ਸਪੱਸ਼ਟ ਜਾਂ ਲੁਕਵਾਂ ਵਿਰੋਧ ਕਰਦੇ ਹਨ।

ਗਿੰਦਰ ਦੀ ਘਰਵਾਲੀ ਮਹਿੰਦਰੋ ਨੂੰ ਇਹ ਭੁਲੇਖਾ ਸਾਰੀ ਉਮਰ ਬਣਿਆ ਰਹਿੰਦਾ ਹੈ ਕਿ ਜੇ ਕਿਤੇ ਉਨ੍ਹਾਂ ਦੀ ਚਾਰ ਪੰਜ ਏਕੜ ਹੀ ਜ਼ਮੀਨ ਹੁੰਦੀ ਤਾਂ ਉਹਨਾਂ ਦਾ ਗੁਜ਼ਾਰਾ ਵਧੀਆ ਚਲ ਜਾਣਾ ਸੀ। ਪਰ ਇਹ ਉਸ ਦਾ ਭੁਲੇਖਾ ਹੀ ਸੀ। ਇਸ ਨਾਵਲ ਵਿਚ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਬੜੇ ਉੱਤਮ ਢੰਗ ਨਾਲ ਬਿਆਨ ਕੀਤਾ ਹੈ ਕਿ ਦਰਮਿਆਨਾਂ ਕਿਸਾਨ ਗ਼ਰੀਬ ਕਿਸਾਨ ਵਿਚ ਬਦਲ ਰਿਹਾ ਹੈ ਅਤੇ ਗ਼ਰੀਬ ਕਿਸਾਨ ਦਿਹਾੜੀ ਮਜ਼ਦੂਰ ਵਿਚ। ਪਰ ਜਾਗੀਰੂ ਸੱਭਿਆਚਾਰ ਦੇ ਪ੍ਰਭਾਵ ਅਧੀਨ ਕਿਸਾਨੀ ਦਾ ਇਸ ਵਰਤਾਰੇ ਨੂੰ ਮਾਨਸਿਕ ਪੱਧਰ 'ਤੇ ਸਵਿਕਾਰ ਕਰਨਾ ਕਠਿਨ ਹੈ। ਆਪਣੀ ਗ਼ਰੀਬੀ ਕਾਰਨਾਂ ਬਾਰੇ ਉਹ ਚੇਤੰਨ ਨਹੀਂ ਇਸ ਲਈ ਉਨ੍ਹਾਂ ਨੂੰ ਦੂਰ ਕਰਨ ਦਾ ਸਵਾਲ ਹੀ ਪੈਦਾ ਨਹੀਂ ਹੁੰਦਾ।

ਅਤਿ ਨਿਮਨ ਕਿਸਾਨੀ ਦੇ ਰੂਬਰੂ ਕਠੋਰ ਸਮੱਸਿਆਵਾਂ 'ਚੋਂ ਨਿਕਲਣ ਲਈ ਗੋਰੇ ਦਾ ਪਿਓ ਗਿੰਦਰ ਉਮਰ ਹੱਡ ਭੱਨਵੀਂ ਮਿਹਨਤ ਕਰਦਾ ਪਰ ਸਫ਼ਲ ਨਹੀਂ ਹੁੰਦਾ। ਅੱਗੋਂ ਗੋਰੇ ਨੂੰ ਵੀ ਉਹ ਉਸ ਦਿਸ਼ਾ ਵੱਲ ਤੋਰਦਾ ਹੈ ਜਿਧਰ ਕਿਸੇ ਤਰ੍ਹਾਂ ਦੀ ਆਸ ਦੀ ਸੰਭਾਵਨਾ ਹੋ ਸਕਦੀ ਹੈ। ਪਰ ਉਹ ਵੀ ਅਸਫ਼ਲ ਰਹਿੰਦਾ ਹੈ। ਉਸ ਵਿਚ ਆਈ ਹੀਣ ਭਾਵਨਾ ਉਸ ਨੂੰ ਬਾਹਰੀ ਅਤੇ ਅੰਦਰੂਨੀ ਟੁੱਟਣ ਦੀ ਪ੍ਰਕਿਰਿਆ ਵਿਚ ਪਾ ਦਿੰਦੇ ਹਨ। ਪ੍ਰਤੀਕੂਲ ਸਥਿਤੀਆਂ ਉਸ ਨੂੰ ਇਸ ਕਦਰ ਸਹਿੰਦੜ ਬਣਾ ਦਿੰਦੀਆਂ ਹਨ ਕਿ ਉਹ ਹਰ ਤਰ੍ਹਾਂ ਦੀ ਪੀੜ ਝੋਲੀ ਵਿਚ ਪਾ ਕੇ ਵੀ ਆਪਣੀ ਮਰਜ਼ੀ ਅਨੁਸਾਰ ਜਿਊਣ ਲਈ ਬਜ਼ਿੱਦ ਰਹਿੰਦਾ ਹੈ।

ਸਮੁੱਚੇ ਰੂਪ ਵਿਚ ਕੁੱਸਾ ਦਾ ਇਹ ਨਾਵਲ ਨਿਮਨ ਕਿਸਾਨੀ ਦਾ ਅਮੀਰ ਹੋਣ ਅਤੇ ਆਪਣੀਆਂ ਆਰਥਿਕ ਤੰਗੀਆਂ ਤੋਂ ਛੁਟਕਾਰਾ ਪਾਉਣ ਲਈ ਕੀਤੇ ਗਏ ਅਨੇਕਾਂ ਯਤਨਾਂ ਨੂੰ ਪ੍ਰਸਤੁਤ ਕਰਦਾ ਹੈ। ਉਹ ਨਾਵਲ ਵਿਚ ਵਿਭਿੰਨ-ਵਿਭਿੰਨ ਵੇਰਵਿਆਂ ਰਾਹੀਂ ਇਸ ਗ਼ਰੀਬੀ ਤੋਂ ਛੁਟਕਾਰਾ ਪਾਉਣ ਲਈ ਕੀਤੇ ਗਏ ਯਤਨਾਂ ਤੇ ਰੌਸ਼ਨੀ ਦਾ ਸੰਕੇਤ ਦਿੰਦਾ ਹੈ ਕਿ ਕਿਸ ਪ੍ਰਕਾਰ ਨਾਵਲ ਦਾ ਮੁੱਖ ਪਾਤਰ ਆਰਥਿਕ ਤੰਗੀ ਤੋਂ ਛੁਟਕਾਰਾ ਪਾਉਣ ਵਾਸਤੇ ਹਰ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ। ਵਿਦੇਸ਼ ਜਾਣ ਦੇ ਚੱਕਰ 'ਚ ਜਦ ਗੋਰੇ ਨਾਲ ਠੱਗੀ ਵੱਜ ਜਾਂਦੀ ਹੈ ਤਾਂ ਸਾਰੀ ਪੂੰਜੀ ਲਟਾਉਣ ਪਿੱਛੋਂ ਲਹਿਣੇਦਾਰਾਂ ਦੀਆਂ ਆਰਾਂ ਦਾ ਸਤਾਇਆ ਗਿੰਦਰ ਘਰ ਮਹਿੰਦਰੋ ਦੇ ਗਲ਼ ਪੈਂਦਾ ਹੈ ਪਰ ਉਹ ਅੱਗੋਂ ਬੜੇ ਤਕੜੇ ਜੇਰੇ ਨਾਲ ਆਖਦੀ ਹੈ:

> ''ਤਾਂ ਕੀ ਐ।'' ਮਹਿੰਦਰੋ ਨੇ ਗੱਲ ਠੰਡੀ ਕਰਨੀ ਚਾਹੀ।
>
> ''ਲੋਕ ਕਿਤੇ ਕਰਦੇ ਨ੍ਹੀ ਕੁਸ਼, ਤੂੰ ਤਾਂ ਐਮੇਂ ਔਖਾ ਹੋਈ ਜਾਨੈਂ,ਕਬੀਲਦਾਰੀਆਂ 'ਚ ਇਹੋ ਹਿਆ ਹੀ ਹੁੰਦੈ।''[9]

ਭਾਵੇਂ ਅੰਤ 'ਤੇ ਇਹ ਸਾਰੇ ਪਾਤਰ ਉਸ ਸਥਿਤੀ 'ਚ ਫਸੇ ਪ੍ਰਤੀਤ ਹੁੰਦੇ ਹਨ ਜਿਥੇ 'ਘੁੱਪ ਹਨੇਰਾ' ਹੈ ਪਰ ਪਾਠਕ ਅਚੇਤ ਹੀ ਇਨ੍ਹਾਂ ਲਈ ਚਾਨਣ ਦੀ ਲੀਕ ਬਣਨਾ ਜ਼ਰੂਰ ਚਿਤਵਦਾ ਹੈ।

3.3 ਔਰਤ ਦੀ ਦੁਰਦਸ਼ਾ ਦੀ ਪੇਸ਼ਕਾਰੀ:-

ਮਨੁੱਖ ਇਕ ਸਮਾਜਿਕ ਜੀਵ ਹੋਣ ਕਰਕੇ ਇਸ ਦਾ ਸਮਾਜ ਤੋਂ ਬਿਨਾਂ ਜਿਉਂਦੇ ਰਹਿਣਾ ਅਸੰਭਵ ਹੈ। ਸਾਡਾ ਜ਼ਿਆਦਾਤ ਸਮਾਜਕ ਜੀਵਨ ਨਾਰੀ ਨਾਲ ਸੰਬੰਧਤ ਹੈ। ਸਮਾਜ ਵਿਚ ਨਾਰੀ ਨੂੰ ਕਈ ਨਾਵਾਂ ਨਾਲ ਸੰਬੋਧਿਤ ਕੀਤਾ ਜਾਂਦਾ ਹੈ ਜਿਵੇਂ ਔਰਤ, ਇਸਤਰੀ ਅਤੇ ਮਰਦ ਅਰਧਾਗਣੀ ਆਦਿ। ਡਾ. ਗੁਰਪ੍ਰੀਤ ਅਨੁਸਾਰ ''ਸਾਡਾ ਜ਼ਿਆਦਾਤਰ ਸਮਾਜਕ ਜੀਵਨ ਔਰਤ ਨਾਲ ਸੰਬੰਧਿਤ ਹੈ ਜਿਸ ਤੋਂ ਬਿਨ੍ਹਾਂ ਸਾਡਾ ਸਮਾਜਕ ਜੀਵਨ ਸੰਭਵ ਨਹੀਂ, ਸਾਡਾ ਸਮਾਜ ਆਰੰਭ ਤੋਂ ਹੀ ਮਰਦ ਪ੍ਰਧਾਨ ਰਿਹਾ ਹੈ। ਇਸ ਮਰਦ ਪ੍ਰਧਾਨ ਸਮਾਜ ਵਿਚ ਔਰਤ ਦੀ ਸਥਿਤੀ ਸ਼ੁਰੂ ਤੋਂ ਹੀ ਮਰਦ ਤੋਂ ਹੇਠਲੇ ਦਰਜੇ ਦੀ ਰਹੀ ਹੈ।''[10] ਔਰਤ ਮਰਦਾਂ ਦੀ ਇਸ ਦੁਨੀਅ ਵਿਚ ਮਾਸ ਦੀਆਂ ਲੋਥਾਂ ਦੀ ਤਰ੍ਹਾਂ ਖਿਲਰੀ ਪਈ ਹੈ।ਮਰਦ ਸ਼ੁਰੂ ਤੋਂ ਹੀ ਔਰਤ ਨੂੰ ਕਾਮ ਪੂਰਤੀ ਦਾ ਸਾਧਨ ਮੰਨਦਾ ਰਿਹਾ ਹੈ ਜੋ ਕਿ ਸਾਡੇ ਸਮਾਜ ਦੀ ਤ੍ਰਾਸਦੀ ਹੈ।

ਇਸ ਗੱਲ ਨੂੰ ਕੁੱਸਾ ਨੇ ਇਸ ਨਾਵਲ ਵਿਚ ਬੜੇ ਵਧੀਆ ਢੰਗ ਨਾਲ ਬਿਆਨ ਕਰਨ ਦਾ ਯਤਨ ਕੀਤਾ ਹੈ। ਜਾਗੀਰਦਾਰੀ ਪ੍ਰਥਾ ਵਿਚ ਜ਼ਮੀਨ ਦੇ ਲਾਲਚ ਕਾਰਨ ਬਹੁ-ਪਤੀ ਵਿਆਹ ਆਮ ਪ੍ਰਚੱਲਿਤ ਸੀ। ਨਾਵਲ ਵਿਚ ਮਹਿੰਦਰੋ ਸਾਰਾ ਦਿਨ ਘਰ ਦਾ ਕੰਮ ਕਰਦੀ ਹੈ, ਬੱਚਿਆਂ ਨੂੰ ਸਾਂਭਦੀ ਹੈ। ਪ੍ਰੰਤੂ ਫਿਰ ਵੀ ਉਸ ਦੇ ਕੰਮ ਦੀ ਕਦਰ

ਘੱਟ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਕੁੱਸਾ ਨੇ ਔਰਤ ਨਾਲ ਸਰੀਰਿਕ ਸ਼ੋਸ਼ਣ ਦਾ ਬਿਆਨ ਵੀ ਯਥਾਰਥਕ ਤਰੀਕੇ ਨਾਲ ਕੀਤਾ ਹੈ। ਮਹਿੰਦਰੋ ਜਦੋਂ ਆਪਣੇ ਦਿਉਰ ਅਤੇ ਸੱਸ ਨਾਲ ਰਲ ਜਾਂਦੀ ਹੈ ਤਾਂ ਉਸ ਦਾ ਦਿਉਰ ਘੋਅਟੀ ਉਸ ਉੱਤੇ ਮਾੜੀ ਨਜ਼ਰ ਰੱਖਦਾ ਹੈ। ਇੱਕ ਦਿਨ ਜਦੋਂ ਮਹਿੰਦਰੋ ਸੰਦੂਖ ਦੇ ਮੂਹਰੇ ਸ਼ੀਸ਼ੇ 'ਚ ਆਪਣਾ ਚਿਹਰਾ ਨਿਹਾਰ ਰਹੀ ਸੀ ਤਾਂ ਘੋਅਟੀ ਆਉਂਦਾ ਹੈ ਅਤੇ ਆਖਦਾ ਹੈ:

"ਹੈਥੇ ਰੱਖ, ਨਹੀਂ ਰੀਸਾਂ ਬਈ ਜੱਟੀ ਦੀਆਂ। ਸ਼ੀਸ਼ਾ ਸੁਰਮਾ ਪੈ ਰਿਹੈ।"

ਮਹਿੰਦਰੋ ਛੇਤੀ ਦੇ ਕੇ ਮਗਰ ਝਾਕੀ; ਸਬਾਤ ਦੇ ਬਾਰ ਵਿਚ ਘੋਅਟੀ ਖੜੋਤਾ ਸੀ। ਉਹ ਖੇਤੋਂ ਪਟੇ ਵਾਲੀ ਚਾਬੀ ਲੈਣ ਆਇਆ ਸੀ; ਜਿਹੜਾ ਸੀ; ਜਿਹੜੀ ਜਾਣ ਲੱਗਿਆਂ ਭੁੱਲ ਗਿਆ ਸੀ।

"ਊ-ਅੰ।" ਮਹਿੰਦਰੋ ਨੇ ਸੰਗ ਜਿਹੀ ਮੰਨਦਿਆਂ, ਪਾਸਾ ਵੱਟਦਿਆਂ ਆਖਿਆ।

"ਕਿਉਂ? ਮੈਂ ਨ੍ਹੀਂ ਸ਼ੀਸ਼ਾ-ਸੁਰਮਾ ਪਾ ਸਕਦੀ। ਮੇਰੇ ਕੀ ਕੋਹੜ ਚੱਲਿ-ਆ?"

"ਪਾ ਕਿਉਂ ਨ੍ਹੀ ਸਕਦੀ? ਸਰਦਾਰਨੀਏ, ਮੈਂ ਤਾਂ ਆਹਨਾਂ ਪੋਡਰ, ਸੁਰਖੀ ਬਿੰਦੀ ਲਾਅ।"[11]

ਘੋਅਟੀ ਬੂਹੇ 'ਚੋਂ ਖਿਸਕ ਕੇ ਮਹਿੰਦਰੋ ਦੇ ਨੇੜੇ ਆ ਗਿਆ, ਉਹਦੇ ਅੰਦਰ ਧੰਦਕਿਆ ਉਹਨੇ ਪਹਿਲਾਂ ਵੀ ਘੋਅਟੀ ਦੀਆਂ ਅੱਖਾਂ 'ਚ ਓਪਰੀ ਵਾ ਤੱਕੀ ਸੀ।

ਇਸ ਤੋਂ ਇਲਾਵਾ ਵੀ ਘੋਅਟੀ ਹਰ ਸਮੇਂ ਮਹਿੰਦਰੋ ਨਾਲ ਸਰੀਰਿਕ ਸੰਬੰਧ ਬਣਾਉਣ ਦੀ ਤਾਂਘ ਵਿਚ ਰਹਿੰਦਾ ਹੈ। ਇਕ ਦਿਨ ਜਦੋਂ ਗਿੰਦਰ ਆਪਣੀ ਭੂਆ ਕੋਲ ਗਿਆ ਸੀ ਤਾਂ ਘੋਅਟੀ ਨੇ ਉਸ ਨਾਲ ਜ਼ਬਰਦਸਤੀ ਸੰਬੰਧ ਬਣਾ ਲਏ। ਧੱਕਾ ਤਾਂ ਉਹ ਜਰ ਗਈ, ਪਰ ਪੰਜਾਲੀ ਹੇਠ ਧੌਣ ਦੇ ਕੇ ਵੀ ਬਲਦ ਵਾਂਗ ਉਹਨੂੰ ਤੁਰਨਾ ਨਹੀਂ ਆਉਂਦਾ ਸੀ।

ਘੋਅਟੀ ਜਿਉਂ ਖੇਤੋਂ ਆਇਆ ਸੀ, ਤੱਤੇ ਪਾਣੀ ਵਾਂਗ ਰਿੱਝ ਰਿਹਾ ਸੀ। ਰੁੱਗ ਲਾਉਂਦਿਆਂ ਉਹਨੇ ਗੋਰੇ ਨੂੰ ਬੇਸ਼ੁਮਾਰ ਗਾਲ੍ਹਾਂ ਦਿੱਤੀਆਂ। ਮਹਿੰਦਰੋ ਕੰਨ ਘੁੱਟ ਕੇ ਸੁਣਦੀ ਰਹੀ। ਬਾਲਟੀ 'ਚ ਤੱਤਾ ਪਾਣੀ ਉਲਟਾਉਣ ਵੇਲੇ ਉਹਨੂੰ ਘੋਅਟੀ ਦੇ ਲਾਲ ਆਨਿਆਂ ਦਾ ਸੇਕ ਸਹਿਣਾ ਪਿਆ ਤੇ ਚੁੱਪ ਚਾਪ ਬਾਲਟੀ ਚੁੱਕ ਕੇ ਨਲਕੇ ਕੋਲ ਰੱਖ ਆਈ। ਇਸ ਪ੍ਰਕਾਰ ਮਹਿੰਦਰੋ ਇਹ ਸਭ ਵਧਕੀਆਂ ਇਸ ਕਰਕੇ ਸਹਿੰਦੀ ਰਹੀ ਕਿਉਂਕਿ ਉਹ ਚਾਹੁੰਦੀ ਸੀ ਕਿ ਉਨ੍ਹਾਂ ਦਾ ਕਰਜ਼ਾ ਉੱਤਰ ਜਾਵੇ। ਪਰ ਅੰਤ ਮਹਿੰਦਰੋ ਸਾਰੀ ਦੀ ਥਾਂ ਅੱਧੀ ਖਾਣ ਨੂੰ ਤਿਆਰ ਸੀ। ਇਹ ਕੰਜਰ-ਖ਼ਾਨਾ ਉਹ ਕਰ ਨਹੀਂ ਸਕਦੀ ਸੀ। ਗਿੰਦਰ ਤਾਂ ਵਾਹ ਲਾਉਂਦਾ ਕਿ ਮੁੱਠੀ ਬੰਦ ਹੀ ਰਹੇ। ਗਿੰਦਰ ਦੇ ਅੜਬ ਸੁਭਾਅ ਤੋਂ ਡਰਦੀ ਮਹਿੰਦਰੋ ਵੀ ਦੜ੍ਹ ਵੱਟੀ ਰੱਖਦੀ।

3.4 ਜੱਟ ਮਾਨਸਿਕਤਾ ਦੀ ਪੇਸ਼ਕਾਰੀ:-

ਇਸ ਪੂਰੀ ਗੱਲ ਨੂੰ ਸਮਝਣ ਤੋਂ ਪਹਿਲਾਂ ਸਾਡੇ ਵਾਸਤੇ ਮਨੋਵਿਗਿਆਨ ਨੂੰ ਸਮਝ ਲੈਣਾ ਜ਼ਰੂਰੀ ਹੈ। ਮਨੋਵਿਗਿਆਨ ਉਹ ਵਿਗਿਆਨ ਹੈ ਜੋ ਮਨੁੱਖੀ ਮਨ ਦਾ ਅਧਿਐਨ ਕਰਦਾ ਹੈ। ਮਨੁੱਖੀ ਮਨ ਦੀ ਹੋਂਦ ਸਰੀਰ ਵਿਚ ਸੰਭਵ ਹੈ। ਇਸ ਲਈ ਇਸ ਦਾ ਅਧਿਐਨ ਖੇਤਰ ਮਨੁੱਖੀ ਸਰੀਰ ਅਤੇ ਮਨ ਹੈ। ਪਰ ਮਨੁੱਖੀ ਸਰੀਰ ਵਿਚ ਮਨ ਨਾਮ ਦਾ ਕੋਈ ਅੰਗ ਨਹੀਂ ਹੈ। ਮਨ ਤੋਂ ਇੱਥੇ ਭਾਵ ਮਾਨਸਿਕਤਾ ਹੈ। "ਮਨੁੱਖੀ ਦਿਮਾਗ ਦਾ ਕੋਈ ਹਿੱਸਾ ਸੁਚੇਤ, ਅਰਧ-ਸੁਚੇਤ ਜਾਂ ਅਵਚੇਤਨ ਜਦੋਂ ਕਿਸੇ ਵਿਸ਼ੇਸ਼ ਦਿਸ਼ਾ ਵੱਲ ਯਾਤਰਾ ਕਰਦਾ ਹੈ ਤਾਂ ਉਸ ਵਿਚੋਂ ਉਪਜੀਆਂ ਬਿਰਤੀਆਂ ਨੂੰ ਮਾਨਸਿਕਤਾ ਕਿਹਾ ਜਾਂਦਾ ਹੈ।"[12]ਮਨੋਵਿਗਿਆਨ ਦਾ ਮੋਢੀ ਸਿੰਗਮੰਡ ਫਰਾਇਡ ਹੈ। ਇਸ ਪਿੱਛੋਂ ਯੁੰਗ ਅਤੇ ਐਡਲਰ ਆਦਿ ਮਨੋਵਿਗਿਆਨੀਆਂ ਨੇ ਇਸ ਦੇ ਵਿਕਾਸ ਵਿਚ ਮਹੱਤਵਪੂਰਨ ਯੋਗਦਾਨ ਪਾਇਆ ਹੈ। ਫਰਾਇਡ ਨੇ ਮਨੋਵਿਸ਼ਲੇਸ਼ਣ ਸੰਕਲਪ ਨੂੰ ਤਿੰਨ ਅਰਥਾਂ ਵਿਚ ਵਰਤਿਆ ਹੈ। ਮਨੋਵਿਸ਼ਲੇਸ਼ਣ, ਮਾਨਸਿਕ ਰੋਗਾਂ ਦੇ ਇਲਾਜ ਦੀ ਇਕ ਵਿਧੀ ਹੈ। "ਮਨੋਵਿਸ਼ਲੇਸ਼ਣ, ਮਨੁੱਖੀ ਵਿਵਹਾਰ ਦਾ ਵਿਗਿਆਨ ਹੈ। ਇਸ ਪ੍ਰਕਾਰ ਮਨੋਵਿਸ਼ਲੇਸ਼ਣ ਵਿਧੀ ਵਿਵਹਾਰ ਵਿਚ ਸਵੈ ਵਿਰੋਧੀ ਇੱਛਾਵਾਂ ਦੀ ਆਪਸੀ ਟੱਕਰ ਨੂੰ ਖ਼ਤਮ ਕਰ ਕੇ ਮਨੁੱਖੀ ਵਿਅਕਤੀ ਵਿਚ ਸੰਤੁਲਨ ਲਿਆਉਣ ਵਾਲੀ ਵਿਧੀ ਹੈ।"[13]

ਸੋ ਇਸ ਨਾਵਲ ਵਿਚ ਕੁੱਸਾ ਨੇ ਜੱਟ ਮਾਨਸਿਕਤਾ ਦਾ ਜ਼ਿਕਰ ਵੀ ਕੁਦਰਤੀ ਢੰਗ ਨਾਲ ਕੀਤਾ ਹੈ। ਨਾਵਲ ਦਾ ਮੁੱਖ ਨਾਇਕ ਗੋਰਾ ਪੜ੍ਹਾਈ ਅਤੇ ਖੇਤੀ ਦੋਹਾਂ ਵਿਚ ਅਸਫ਼ਲ ਰਹਿੰਦਾ ਹੈ। ਉਸ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਉਸ ਨੂੰ ਕਿਸੇ ਪਾਸੇ ਟਿਕਣ ਨਹੀਂ ਦਿੰਦੀ। ਗੋਰਾ ਪਿੰਡ ਦੇ ਸਕੂਲ ਵਿਚ ਪੜ੍ਹਦਾ ਹੈ ਪ੍ਰੰਤੂ ਉਸ ਦਾ ਮਨ ਪੜ੍ਹਾਈ ਵਿਚ ਨਹੀਂ ਲੱਗਦਾ ਪੜ੍ਹਾਈ ਵਿਚੋਂ ਅਸਫ਼ਲ ਹੋ ਕੇ ਗੋਰਾ ਸਕੂਲ ਜਾਣਾ ਛੱਡ ਦਿੰਦਾ ਹੈ। ਗੋਰੇ ਦਾ ਮਾਮਾ ਉਸ ਨੂੰ ਲਾਲਚ ਦੇ ਕੇ ਸ਼ਹਿਰ ਬੇਕਰੀ ਵਿਚ ਕੰਮ ਕਰਨ ਵਾਸਤੇ ਲੈ ਜਾਂਦਾ ਹੈ। ਪ੍ਰੰਤੂ ਗੋਰੇ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਨੂੰ ਉਸ ਸਮੇਂ ਧੱਕਾ ਲੱਗਦਾ ਹੈ ਜਦੋਂ ਬੇਕਰੀ ਦਾ ਮਾਲਿਕ ਉਸ ਨੂੰ ਗੋਹਾ ਸੁੱਟਣ ਵਾਸਤੇ ਕਹਿੰਦਾ ਹੈ ਅਤੇ ਗੋਰਾ ਉਸ ਨੂੰ ਇਨਕਾਰ ਕਰਦਾ ਹੋਇਆ ਕਹਿੰਦਾ ਹੈ:

"ਗੋਹਾ ਨ੍ਹੀਂ ਮੈ ਸਿੱਟਣਾਂ।"

ਅੱਗੋਂ ਮਾਲਿਕ ਉਸ ਕੋਲੋਂ ਪੁੱਛਦਾ ਹੈ:

"ਕਿਉਂ ਸਿੱਟਣੈਂ ਕਾਹਤੋਂ ਨ੍ਹੀ?

ਗੋਰਾ"ਮੈਂ ਨ੍ਹੀ ਸੁੱਟਣਾ ਗੋਹਾ ਗੂਹਾ।"

ਮਾਲਿਕ"ਹੋਰ ਕੀ ਕਰੇਂਗਾ?"

ਗੋਰਾ "ਹੋਰ, ਹੋਰ ਜੋ ਮਰਜ਼ੀ ਐ, ਕਰਾ ਲੋ।"

"ਗੋਹਾ ਸਿੱਟਣਾਂ ਸੀ ਤਾਂ ਪਿੰਡ ਵਿਚ ਥੋੜ੍ਹਾ ਸੀ ਐਥੇ ਕੀ ਮੈਂ ਕਰਨ ਔਣਾ ਸੀ।"[14]

ਸੋ ਗੋਰਾ ਇਹ ਕੰਮ ਕਰਨ ਤੋਂ ਇਨਕਾਰ ਕਰ ਦਿੰਦਾ ਹੈ ਕਿਉਂਕਿ ਉਸ ਦੀ ਮਾਨਸਿਕਤਾ ਅਨੁਸਾਰ ਇਨ੍ਹਾਂ ਕੰਮਾਂ ਨੂੰ ਘਟੀਆ ਸਮਝਿਆ ਜਾਂਦਾ ਹੈ। ਇਸ ਕਰਕੇ ਗੋਰਾ ਇਹ ਕੰਮ ਛੱਡ ਕੇ ਪਿੰਡ ਭੱਜ ਜਾਂਦਾ ਹੈ। "ਪਾਠਕ ਦੇ ਮਨ ਵਿਚ ਇਹ ਸਵਾਲ ਉਪਜਦਾ ਹੈ ਕਿ ਗੋਰਾ ਆਖਿਰ ਏਨਾ ਵਿਗੜਿਆ ਹੋਇਆ ਕਿਉਂ ਹੈ? ਪਹਿਲੇ ਪ੍ਰਭਾਵਾਂ ਤੋਂ ਕੁਚੱਜੀ ਮਾਂ ਤੇ ਮੂਰਖ ਪਿਉ ਦੇ ਵਿਹਾਰ ਦਾ ਸਿੱਟਾ ਪ੍ਰਤੀਤ ਹੈ।ਦੂਸਰਾ ਉਸ ਦੇ ਜੀਵਨ ਦੀਆਂ ਪ੍ਰਸਥਿਤੀਆਂ ਉਸ ਨੂੰ ਅਜਿਹਾ ਬਣਾ ਦਿੰਦੀਆਂ ਹਨ।"[15]ਗੋਰੇ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਨੂੰ ਉਸ ਸਮੇਂ ਵੀ ਗਹਿਰਾ ਧੱਕਾ ਲੱਗਦਾ ਹੈ ਜਦੋਂ ਉਹ ਆਪਣੇ ਚਾਚੇ ਤੇਲੂ ਨਾਲ ਟਰੱਕ ਡਰਾਇਵਰੀ ਸਿੱਖਣ ਵਾਸਤੇ ਜਾਂਦਾ ਹੈ ਅਤੇ ਟਰੱਕ ਡਰਾਇਵਰ ਉਸ ਨਾਲ ਦੁਰਵਿਵਹਾਰ ਕਰਦੇ ਹਨ। ਉਸ ਨਾਲ ਬਦਫੈਲੀ ਕਰਨ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦੇ ਹਨ ਅਤੇ ਉਸ ਕੋਲੋਂਕੱਪੜੇ ਵੀ ਧਵਾਉਂਦੇ ਹਨ। ਜਦੋਂ ਇਕ ਦਿਨ ਤੇਲੂ ਗੋਰੇ ਨੂੰ ਗੱਡੀ ਧੋਣ ਵਾਸਤੇ ਕਹਿੰਦੇ ਹਨ। ਪਹਿਲਾਂ ਤਾਂ ਤੇਲੂ ਉਹਨੂੰ ਮਿੰਨਤ ਨਾਲ ਮਨਾਉਂਣ ਦਾ ਯਤਨ ਕਰਦਾ ਹੈ ਪਰ ਗੋਰਾ ਪੈਰਾਂ 'ਤੇ ਪਾਣੀ ਨਹੀਂ ਪੈਣ ਦਿੰਦਾ, ਫੇਰ ਤੇਲੂ ਨੇ ਝੜਕਦਿਆਂ ਆਖਿਆਂ:

"ਤੂੰ ਕਰਦਾ ਕਿਵੇਂ ਨ੍ਹੀ ਉਇ? ਤੇਰੇ ਵੱਡੇ ਵੀ ਕਰਨਗੇ.....!"

ਗੋਰੇ"ਵੱਡੇ ਤਾਂ ਮੇਰੇ ਧਾਰ ਵੀ ਨ੍ਹੀ ਮਾਰਦੇ ਐਹੋ-ਜ੍ਹੇ ਕੰਮ ਤੇ।"[16]

ਇਸ ਤੋਂ ਇਲਾਵਾ ਗੋਰੇ ਨੂੰ ਇਹ ਗੱਲ ਵੀ ਨਾ ਚੰਗੀ ਨਾ ਲੱਗੀ ਜਦੋਂ ਟਰੱਕ ਡਰਾਇਵਰ ਉਸ ਨਾਲ ਰੋਟੀ ਖਾਣ ਵੇਲੇ ਵੀ ਫਰਕ ਕਰਦੇ ਹਨ। ਗੋਰੇ ਦੀ ਮਾਨਸਿਕਤਾ ਵਿਚ ਇਹ ਗੱਲਾ ਇਸ ਪ੍ਰਕਾਰ ਧੱਸ ਜਾਂਦੀਆਂ ਹਨ ਕਿ ਉਹ ਡਰਾਇਵਰੀ ਛੱਡ ਕੇ ਪਿੰਡ ਆ ਜਾਂਦਾ ਹੈ।

ਗੋਰਾ ਆਪਣੀ ਆਰਥਿਕ ਮੰਦਹਾਲੀ ਵਿਚੋਂ ਨਿਕਲਣ ਵਾਸਤੇ ਵਿਦੇਸ਼ ਵਿਚ ਜਾਣ ਦਾ ਪ੍ਰੋਗਰਾਮ ਬਣਾਉਂਦਾ ਹੈ ਅਤੇ ਇਸ ਲਈ ਕਰਜ਼ਾ ਲੈਂਦਾ ਹੈ ਪ੍ਰੰਤੂ ਏਜੰਟ ਤੋਂ ਧੋਖਾ ਮਿਲਣ ਉਪਰੰਤ ਗੋਰੇ ਦੇ ਸਿਰ ਕਰਜ਼ੇ ਦਾ ਪਹਾੜ ਆ ਡਿੱਗਦਾ ਹੈ। ਇਸ ਲਈ ਗੋਰਾ ਆਪਣੇ ਸ਼ਰੀਕ ਨਾਲ ਵਿੜੀ ਪਾ ਲੈਂਦਾ ਹੈ। ਪ੍ਰੰਤੂ ਗੋਰੇ ਦੇ ਲਈ ਹੋਣੀ ਉਸ ਸਮੇਂ ਬਣਦੀ ਹੈ ਜਦੋਂ ਉਸ ਨੂੰ ਸਿਰੀ ਰਲਣ ਵਾਸਤੇ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਗਿੰਦਰ ਨਾਲ ਉਹ ਇਸ ਗੱਲ 'ਤੇ ਬਹਿਸ ਕਰਦਾ ਹੈ ਅਤੇ ਕਹਿੰਦਾ ਹੈ:

"ਹੋਰ ਸਾਲਿਆ ਤੂੰ ਥਾਣੇਦਾਰ ਲੱਗੇਂਗਾ"

ਗਿੰਦਰ ਫੇਰ ਉਹਦੇ ਵੱਲ ਨੱਠ ਆਇਆ.....।

ਗੋਰਾ''ਥਾਣੇਦਾਰ ਲੱਗਾਂ ਜਾਂ ਨਾ ਲੱਗਾ। ਪਰ ਮੈਂ ਸੀਰੀ ਨ੍ਹੀ ਰਲਣਾ''

ਗੋਰੇ ਦਾ ਬੋਲ ਫੇਰ ਭੜਕਵਾਂ ਹੋ ਗਿਆ; ਉਸ ਅੱਖਾਂ 'ਚ ਤਾਅ ਭਰਦਿਆਂ ਆਖਿਆ,

''ਥੋਨੂੰ ਇਕ ਵਾਰੀ ਕਹਿ-ਤਾ, ਮੈਨੂੰ ਨਾ ਆਖਿਓ।.....ਸੀਰੀ ਨੀ

ਰਲਣਾ.....ਫੇਰ ਮੈਨੂੰ ਆਖਿਆ, ਮੈਂ ਮਰਜੂੰ ਚਾਹੇ ਮਾਰਦੂੰ।''[17]

ਇਹ ਗੱਲਾਂ ਸੁਣ ਕੇ ਗੋਰਾ ਆਪਣਾ ਛੱਡ ਕੇ ਬਾਹਰ ਚਲਾ ਜਾਂਦਾ ਹੈ। ਅਤੇ ਜਦੋਂ ਉਹ ਪਿੰਡੋਂ ਬਾਹਰ ਆ ਕੇ ਰਤਾ ਕੁ ਹੌਲੀ ਹੋਇਆ, ਹੰਝੂ ਭਰੀਆਂ ਅੱਖਾਂ ਪਾੜ ਕੇ ਖੇਤਾਂ ਵਿਚ ਗੋਲ ਦਾਇਰੇ 'ਚ ਜਗਦੇ ਬਿਜਲੀ ਦੇ ਬਲਬਾਂ ਵੱਲ ਵੇਖਿਆ। ਉਦੋਂ ਈ ਪਿੰਡ ਦੀ ਤੇ ਬਾਹਰਲੀ ਬਿਜਲੀ ਇਕ ਦਮ ਬੁੱਝ ਗਈ। ਚੁਫੇਰੇ ਹਨੇਰ-ਗੁਬਾਰ ਪਸਰ ਗਿਆ। ਹੱਥ ਨੂੰ ਹੱਥ ਮਾਰਿਆ ਨਹੀਂ ਹੱਥ ਨੂੰ ਹੱਥ ਮਾਰਿਆ ਨਹੀਂ ਦਿਸਦਾ ਸੀ। ਉਹਨੇ ਮਗਰ ਭਉਂਕੇ ਦੇਖਿਆ, ਉਹਨੂੰ ਮਹਿਸੂਸ ਹੋਇਆ, ਜਿਵੇਂ ਪਿੰਡ ਦੀ ਮੌਤ ਹੋ ਗਈ ਹੋਵੇ। ਰੌਲਾ ਰੱਪਾ ਵੀ ਨਹੀਂ ਸੁਣਦਾ ਸੀ। ਅਚਾਨਕ ਹੀ ਉਸਦੇ ਮੂਹਰੇ ਬਾਹਰਲੀਆਂ ਮੋਟਰਾਂ ਦੇ ਬਲਬ ਜਗ ਪਏ ਪਰ ਬਿਜਲੀ ਡਿੰਮ ਸੀ। ਜਦੋਂ ਉਸ ਫੇਰ ਪਿੰਡ ਵੱਲ ਭਉਂਕੇ ਦੇਖਿਆ, ਪਿੰਡ 'ਤੇ ਉਸੇ ਤਰ੍ਹਾਂ ਸੁੰਨ ਮਸਾਨ ਵਰਤੀ ਹੋਈ ਸੀ। ਓਹਨੂੰ ਇਕ ਵਾਰ ਫਿਰ ਖਿਆਲ ਆਇਆ, ਪਿੰਡ ਸੱਚੀਂ ਮਰ ਗਿਆ ਸੀ। ਪਰ ਘਰ ਵਿਚ ਘਟੀ ਘਟਨਾ ਯਾਦ ਕਰਕੇ ਉਹਦਾ ਰੋਣ ਨਿਕਲ ਗਿਆ ਤੇ ਉਸ ਦੀ ਏਨੀ ਭੁੱਬ ਨਿਕਲੀ ਕਿ ਚੁਪਾਸੇ ਪਸਰੀ ਵੱਢ-ਖਾਣੀ ਚੁੱਪ ਵਿਚ ਭੁੱਬ ਦੀ ਆਵਾਜ਼ ਹੋਰ ਡਰਾਉਣੀ ਹੋ ਗਈ ਸੀ।

ਇਸ ਪ੍ਰਕਾਰ ਕੁੱਸਾ ਨੇ ਜੱਟ ਮਾਨਸਿਕਤਾ ਦਾ ਵਰਣਨ ਬੜੇ ਹੀ ਯਥਾਰਥਕ ਤਰੀਕੇ ਨਾਲ ਕੀਤਾ ਹੈ। ਗੋਰੇ ਦੇ ਦਰਮਿਆਨ ਕਈ ਘਟਨਾਵਾਂ ਵਾਪਰਦਿਆਂ ਹਨ, ਜਿਨ੍ਹਾਂ ਦੇ ਆਧਾਰ 'ਤੇ ਕੁੱਸਾ ਨੇ ਗੋਰੇ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਦਾ ਵਰਣਨ ਕੀਤਾ ਹੈ।

3.5 ਯਥਾਰਥ ਦੀ ਪੇਸ਼ਕਾਰੀ:-

ਯਥਾਰਥਵਾਦ, ਸਾਹਿਤ ਵਿਚਲੀ ਅਜਿਹੀ ਵਿਚਾਰਧਾਰਾ ਹੈ ਜੋ ਸਨਾਤਨਵਾਦ ਅਤੇ ਰੋਮਾਂਸਵਾਦ ਦੇ ਪ੍ਰਤੀਕਰਮ ਵਜੋਂ ਉਪਜੀ ਹੈ। ਯਥਾਰਥ ਤੋਂ ਭਾਵ ਅਸਲੀਅਤ ਹੈ। ਯਥਾਰਥਵਾਦ ਵਿਚ ਜੀਵਨ ਦੇ ਸਰਵ-ਸਾਧਾਰਨ ਪੱਖਾਂ ਨੂੰ ਉਵੇਂ ਦਾ ਉਵੇਂ ਪੇਸ਼ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਰਸੂਲ ਹਮਜ਼ਾਤੋਵ ਆਪਣੀ ਪੁਸਤਕ 'ਮੇਰੀ ਦਾਗ਼ਿਸਤਾਨ' ਵਿਚ ਲਿਖਦਾ ਹੈ ਕਿ ''ਕੁੱਕੜ ਨੂੰ ਕੁੱਕੜ ਕਹਿਣਾ ਯਥਾਰਥਵਾਦ ਹੈ, ਕੁੱਕੜ ਨੂੰ ਬਾਜ਼ ਕਹਿਣਾ ਰੁਮਾਂਸਵਾਦ ਹੈ।''[18]

ਅਜੋਕੀ ਸਥਿਤੀ ਵਿਚ ਸੰਘਰਸ਼ ਦੂਹਰਾ ਨਾ ਰਹਿ ਕੇ ਤੀਹਰਾ ਹੋ ਗਿਆ ਹੈ। ਜਿਥੇ ਪਹਿਲੀਆਂ ਦੋ ਪ੍ਰਥਾਵਾਂ ਜਾਗੀਰਦਾਰੀ ਤੇ ਸਰਮਾਏਦਾਰੀ ਹੋਂਦ ਵਿਚ ਹਨ, ਉਥੇ ਤੀਜੀ ਪ੍ਰਥਾ ਸਮਾਜਵਾਦੀ ਵੀ ਸੰਸਾਰ ਪੱਧਰ ’ਤੇ ਕਾਇਮ ਹੈ ਜਿਹੜੀ ਆਪਣੀਆਂ ਪਦਾਰਥਕ ਪ੍ਰਪਾਤੀਆਂ ਰਾਹੀਂ ਵਿਚਾਰਧਾਰਾ ਨੂੰ ਵੀ ਪ੍ਰਭਾਵਿਤ ਕਰ ਰਹੀ ਹੈ। ਇਸ ਲਈ ਜਿਥੇ ਪਹਿਲੀਆਂ ਦੋ ਜਮਾਤਾਂ ਵਿਚਲੇ ਸੰਘਰਸ਼ ਸਮੇਂ ਜਾਗੀਰਦਾਰੀ ਵਿਰੁੱਧ, ਸਰਮਾਏਦਾਰੀ ਪ੍ਰਥਾ ਦੇ ਹੱਕ ਵਿਚ ਖੜੋਣਾ ਵਿਗਿਆਨਿਕ ਤੌਰ ’ਤੇ ਦਰੁਸਤ ਹੈ, ਉਥੇ ਸਰਮਾਏਦਾਰੀ ਪ੍ਰਥਾ ਨੂੰ ਸਮਾਜਵਾਦੀ ਪ੍ਰਥਾ ਦੇ ਹੱਕ ਵਿਚ ਰੱਦ ਕਰ ਦੇਣਾ ਚਾਹੀਦਾ ਹੈ। ਇਸ ਲਈ ਜਿਹੜਾ ਸਾਹਿਤ ਅੱਜ ਸਮਾਜਵਾਦੀ ਸਮਾਜ ਦੀ ਸਥਾਪਨਾ ਦੀ ਗੱਲ ਕਰਦਾ ਹੈ, ਉਹ ਸਭ ਤੋਂ ਉੱਤਮ ਹੈ। ਪਰੰਤੂ ਸਾਹਿਤ ਵਿਚ ਸਮਾਜਵਾਦੀ ਯਥਾਰਥ ਦੀ ਪੇਸ਼ਕਾਰੀ ਰਾਜਨੀਤਿਕ ਸ਼ਾਸਤਰ ਵਾਂਗ ਹੈ, ਸਿੱਧੀ ਤੇ ਸਰਲ ਨਹੀਂ ਹੁੰਦੀ। ਇਹ ਕੁਝ ਸਮਾਜ ਵਿਚ ਵਿਆਪਕ ਯਥਾਰਥ ਨੂੰ ਚੇਤਨ ਤੇ ਕਲਾਮਈ ਢੰਗ ਨਾਲ ਪੇਸ਼ ਕਰਕੇ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਇਹ ਯਥਾਰਥ ਤਲਖ਼ ਹਕੀਕਤਾਂ ਨੂੰ ਸਾਹਮਣੇ ਲਿਆ ਕੇ ਪ੍ਰਥਾ ਤੋਂ ਸਮਾਂ ਵਿਹਾ ਚੁੱਕੇ ਤੇ ਅਮਾਨਵੀ ਪੱਖਾਂ ਨੂੰ ਪੇਸ਼ ਕਰਦਾ ਹੈ ਅਤੇ ਸੁਚੇਤ ਤੌਰ ’ਤੇ ਮਰ ਰਹੀਆਂ ਕੀਮਤਾਂ ਨੂੰ ਪੇਸ਼ ਕਰਕੇ ਉਨ੍ਹਾਂ ਵਿਰੁੱਧ ਨਫ਼ਰਤ ਤਿੱਖੀ ਕਰਦਾ ਹੈ।

ਪੰਜਾਬੀ ਸਾਹਿਤ ਅੰਦਰ ਇਹ ਕੁਝ ਕਰਮਜੀਤ ਕੁੱਸਾ ਨੇ ਆਪਣੇ ਨਾਵਲ ਵਿਚ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ‘ਰੋਹੀ ਬੀਆਬਾਨ’ ਵਿਚ ਉਸ ਨੇ ਨਿਰੋਲ ਕਿਸਾਨੀ ਦੇ ਜ਼ਮੀਨ ਤੋਂ ਟੁੱਟਣ ਤੇ ਕੰਗਾਲ ਹੋਣ ਦਾ ਵਰਣਨ ਕੀਤਾ ਹੈ। ਗਿੰਦਰ ਇਕ ਥੋੜ੍ਹੀ ਜ਼ਮੀਨ ਵਾਲਾ ਕਿਸਾਨ ਹੈ, ਉਸ ਦੀ ਘਰਵਾਲੀ ਮਹਿੰਦਰੋ ਤੇ ਉਸ ਦਾ ਮੁੰਡਾ ਗੋਰਾ ਤਿੰਨੋ ਨਾਵਲ ਦੇ ਮੁੱਖ ਪਾਤਰ ਹਨ। ਅਸਲ ਵਿਚ ਗੋਰਾ ਨਾਵਲ ਦਾ ਨਾਇਕ ਹੈ ਜਿਸ ਦੇ ਦੁਆਲੇ ਸਾਰੀ ਕਹਾਣੀ ਘੁੰਮਦੀ ਹੈ। ਥੋੜ੍ਹੀ ਜ਼ਮੀਨ ਹੋਣ ਕਾਰਨ ਪਰਿਵਾਰ ਆਰਥਿਕ ਤੰਗੀਆਂ ਦਾ ਸ਼ਿਕਾਰ ਹੈ। ਜ਼ਮੀਨ ਦੀ ਥੁੜ ਹੋਣ ਕਾਰਨ ਪਰਿਵਾਰ ਆਰਥਿਕ ਤੰਗੀਆਂ ਭੋਗਦਾ ਹੈ ਅਤੇ ਸਾਰਾ ਪਰਿਵਾਰ ਵੱਧ ਤੋਂ ਵੱਧ ਸਰੀਰਿਕ ਮਿਹਨਤ ਕਰਦਾ ਹੈ। ਗਿੰਦਰ ਜਿਥੇ ਸਾਰਾ ਦਿਨ ਖੇਤਾਂ ਵਿਚ ਕੰਮ ਕਰਦਾ ਹੈ ਉਥੇ ਘਰ ਆ ਕੇ ਵੀ ਪਸ਼ੂਆਂ ਨੂੰ ਸਾਂਭਦਾ ਹੈ। ਮਹਿੰਦਰੋ ਖੇਤ ਰੋਟੀ ਦੇ ਕੇ ਆਉਂਦੀ ਹੈ। ਘਰ ਆ ਕੇ ਬੱਚਿਆਂ ਨੂੰ ਸੰਭਾਲਦੀ ਤੇ ਗਿੰਦਰ ਦੀ ਗ਼ੈਰ ਹਾਜ਼ਰੀ ਵਿਚ ਪਸ਼ੂਆਂ ਦੀ ਸੰਭਾਲ ਵੀ ਕਰਦੀ ਹੈ। ਉਹ ਬੱਚਿਆਂ ਨੂੰ ਘਰ ਦੇ ਕੰਮ ਵਿਚ ਲਗਾ ਕੇ ਰੱਖਦੀ ਹੈ। ਗੋਰੇ ਨੂੰ ਪੱਠੇ ਕੁਤਰਨ ਲਾਉਂਦੀ ਹੈ ਤੇ ਛੋਟੀ ਨੂੰ ਕੁੜੀ ਖਿਡਾਉਣ ਬਾਰੇ ਕਹਿੰਦੀ ਹੈ।

ਇਸ ਪਰਿਵਾਰ ਦੀ ਇੱਛਾ ਹੈ ਕਿ ਘਰ ਦਾ ਵੱਡਾ ਮੁੰਡਾ ਗੋਰਾ ਪੜ੍ਹ ਜਾਵੇ ਅਤੇ ਕਿਤੇ ਨੌਕਰੀ ਕਰਕੇ ਆਪਣਾ ਜੀਵਨ ਤੇ ਪਰਿਵਾਰ ਦਾ ਜੀਵਨ ਸੁਧਾਰੇ। ਪਰੰਤੂ ਜਿਸ ਮਾਹੌਲ ਵਿਚ ਇਹ ਪਰਿਵਾਰ ਰਹਿ ਰਿਹਾ ਹੈ ਤੇ ਗੋਰਾ ਵਿਚਰਦਾ ਹੈ ਉਥੇ ਗ਼ਰੀਬ ਕਿਸਾਨ ਦੇ ਪੁੱਤ ਦਾ ਪੜ੍ਹ ਜਾਣਾ ਹਾਦਸੇ ਵਾਂਗ ਹੈ, ਜਿਹੜਾ ਕਦੇ ਕਦਾਈ ਵਾਪਰਦਾ ਹੈ। ਪਰੰਤੂ ਇਸ ਪਰਿਵਾਰ ਦੇ ਸੰਦਰਭ ਵਿਚ ਇਹ ਹਾਦਸਾ ਨਹੀਂ ਵਾਪਰਦਾ। ਗੋਰਾ ਪੜ੍ਹ ਨਹੀਂ ਸਕਦਾ। ਫਿਰ ਉਸ ਨੂੰ ਘਰ ਦੇ ਕੰਮ ਵਿਚ ਲਾਉਣ ਦੇ ਯਤਨ ਕੀਤੇ ਜਾਂਦੇ ਹਨ ਪ੍ਰੰਤੂ ਇਹ ਯਤਨ ਵੀ ਸਫ਼ਲ ਨਹੀਂ ਹੁੰਦੇ। ਜਾਗੀਰਦਾਰੀ

ਪ੍ਰਥਾ ਵਿਚ ਸਰੀਰਕ ਮਿਹਨਤ ਸਭ ਤੋਂ ਨਖਿੱਧ ਕੰਮ ਸਮਝਿਆ ਜਾਂਦਾ ਹੈ। ਹਰ ਇਕ ਵਿਅਕਤੀ ਇਸ ਤੋਂ ਬਚਣ ਦਾ ਰਾਹ ਲੱਭਦਾ ਹੈ। ਜਾਗੀਰਦਾਰੀ ਪ੍ਰਥਾ ਦਾ ਆਦਰਸ਼ ''ਵਿਹਲੇ ਰਹਿਣਾ ਤੇ ਐਸ਼ ਕਰਨੀ'' ਹੁੰਦਾ ਹੈ। ਗੋਰਾ ਖੇਤੀ ਦੇ ਕੰਮ ਤੋਂ ਬਚਣ ਦਾ ਰਾਹ ਲੱਭਦਾ ਹੈ। ਉਹਦਾ ਇੱਕ ਅਮਲੀ ਮਾਮਾ ਉਸ ਨੂੰ ਬੇਕਰੀ ਦਾ ਕੰਮ ਸਿਖਾਉਣ ਦਾ ਝਾਂਸਾ ਦੇ ਕੇ ਸ਼ਹਿਰ ਲੈ ਜਾਂਦਾ ਹੈ ਜਿਥੇ ਬੇਕਰੀ ਦਾ ਮਾਲਿਕ ਉਸ ਤੋਂ ਗੋਹਾ ਕੂੜਾ ਕਾਵਾਉਂਦਾ ਹੈ। ਗੋਰਾ ਇਹ ਕੰਮ ਕਰਨੋਂ ਇਨਕਾਰ ਕਰ ਦਿੰਦਾ ਹੈ ਕਿਉਂਕੀ ਉਸਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਇਸ ਕੰਮ ਨੂੰ ਘਟੀਆ ਸਮਝਦੀ ਹੈ।

ਉਹ ਤਾਂ ਜੱਟਾਂ ਦਾ ਪੁੱਤ ਹੈ ਬੇਸ਼ੱਕ ਥੋੜ੍ਹੀ ਜ਼ਮੀਨ ਹੀ ਹੈ। ਇਹੋ ਜੱਟ ਮਾਨਸਿਕਤਾ ਉਸ ਨੂੰ ਕਿਤੇ ਟਿਕਣ ਨਹੀਂ ਦਿੰਦੀ। ਉਹ ਇੱਕ ਵਾਰ ਫੇਰ ਟਰੱਕ ਡਰਾਇਵਰ ਬਣਨ ਦਾ ਯਤਨ ਕਰਦਾ ਹੈ। ਪ੍ਰੰਤੂ ਇਥੇ ਵੀ ਸਫ਼ਲ ਨਹੀਂ ਹੁੰਦਾ। ਉਸ ਦੇ ਪਿਓ ਦਾ ਮਿੱਤਰ ਤੇਲੂ ਉਸ ਨੂੰ ਸਖ਼ਤੀ ਕਰਦਾ ਹੈ। ਇਕ ਹੋਰ ਡਰਾਇਵਰ ਉਸ ਨਾਲ ਰੋਟੀ ਵਿਚ ਵਿਤਕਰਾ ਕਰਦਾ ਹੈ। ਆਪ ਚੰਗੀ ਖਾਂਦਾ ਹੈ, ਗੋਰੇ ਨੂੰ ਘਟੀਆ ਖੁਆਉਂਦਾ ਹੈ। ਗੋਰਾ ਇਹ ਗੱਲ ਬਰਦਾਸ਼ਤ ਨਹੀਂ ਕਰਦਾ ਅਤੇ ਲੜ-ਝਗੜ ਕੇ ਪਿੰਡ ਵਾਪਿਸ ਚਲਾ ਜਾਂਦਾ ਹੈ। ਇਥੇ ਆ ਕੇ ਖੇਤੀ ਕਰਨ ਦਾ ਯਤਨ ਕਰਦਾ ਹੈ, ਪਰ ਜ਼ਮੀਨ ਘੱਟ ਹੋਣ ਕਰਕੇ ਹੋਰ ਜ਼ਮੀਨ ਹਿੱਸੇ ਠੇਕੇ 'ਤੇ ਲੈਂਦਾ ਹੈ। ਇਕ ਧਨੀ ਕਿਸਾਨ ਨਾਲ ਵਿੜੀ ਕਰਦਾ ਹੈ ਪਰ ਜਮਾਤੀ ਪ੍ਰਥਾ ਤਕੜੇ ਮਾੜੇ ਦੀ ਜੰਗ ਹੁੰਦੀ ਹੈ। ਇੱਥੇ ਹਰ ਤਕੜਾ ਆਪ ਤੋਂ ਛੋਟੇ ਨੂੰ ਦਬਾਉਂਦਾ ਹੈ। ਇਹੋ ਕੁਝ ਗੋਰੇ ਦੇ ਪਰਿਵਾਰ ਨਾਲ ਹੁੰਦਾ ਹੈ। ਗੋਰੇ ਦਾ ਪਿਓ ਗਿੰਦਰ ਸਰੀਰਕ ਮਿਹਨਤ ਕਰਦਾ ਹੈ ਅਤੇ ਨਸ਼ੇ ਦਾ ਆਦਿ ਹੋ ਜਾਂਦਾ ਹੈ। ਉਹ ਅਫ਼ੀਮ ਵੀ ਖਾਂਦਾ ਹੈ ਤੇ ਸ਼ਰਾਬ ਪੀਂਦਾ, ਕੱਢਦਾ ਤੇ ਵੇਚਦਾ ਹੈ। ਇਹੋ ਕੰਮ ਗੋਰਾ ਸ਼ੁਰੂ ਕਰ ਦਿੰਦਾ ਹੈ। ਇਸ ਵਿਚ ਵੀ ਸਫ਼ਲ ਨਹੀਂ ਹੁੰਦਾ। ਫਿਰ ਵਿਦੇਸ਼ ਜਾ ਕੇ ਕਮਾਈ ਦਾ ਯਤਨ ਕਰਦਾ ਹੈ। ਇਸ ਵਿਚ ਸਫ਼ਲ ਹੋਣ ਦੀ ਥਾਂ ਉਲਟਾ ਕਰਜ਼ਾਈ ਹੋ ਜਾਂਦਾ ਹੈ। ਅੰਤ ਵਿਚ ਉਸ ਅੱਗੇ ਬੇਜ਼ਮੀਨੇ ਕਿਸਾਨ ਦੀ ਅੰਤਿਮ ਹੋਣੀ, ਆਪਣੀ ਕਿਰਤ ਵੇਚਣ ਲਈ ਮਜਬੂਰ ਹੋ ਜਾਂਦਾ ਹੈ ਅਤੇ ਸੀਰੀ ਬਣ ਜਾਂਦਾ ਹੈ। ਪਰੰਤੂ ਕਿਸਾਨੀ ਮਾਨਸਿਕਤਾ ਸੀਰੀ ਰਲਣ ਨਾਲੋਂ ਮਰਨਾ ਚੰਗਾ ਸਮਝਦੀ ਹੈ। ਗੋਰੇ ਸਾਹਮਣੇ ਜੀਵਨ ਰੋਹੀ ਬੀਆਬਾਨ ਬਣ ਜਾਂਦਾ ਹੈ।

ਜਗੀਰੂ ਪ੍ਰਥਾ ਵਿਚ ਰਿਸ਼ਤੇ ਵੀ ਲੁੱਟ ਅਤੇ ਨਿੱਜੀ ਹਿੱਤਾਂ ਉਤੇ ਹੋਏ ਹੁੰਦੇ ਹਨ। ਬੇਸ਼ੱਕ ਜਗੀਰੂ ਪ੍ਰਥਾ ਇਸ ਲੁੱਟ ਨੂੰ ਖ਼ੂਨ ਦੇ ਰਿਸ਼ਤੇ ਦੇ ਨਾਂ ਹੇਠ ਲੁਕਾਉਣ ਦਾ ਯਤਨ ਕਰਦੀ ਹੈ। ਗਿੰਦਰ ਦੇ ਆਪਣੇ ਭਰਾ ਹਨ, ਮਾਂ ਹੈ, ਪਰੰਤੂ ਇਹ ਸਾਰੇ ਗਿੰਦਰ ਦੀ ਕਿਰਤ ਲੁੱਟਣ ਤੇ ਵਿਸ਼ੇਸ਼ ਕਰਕੇ ਆਰਥਿਕ ਲੋਭ ਦੇ ਕੇ ਉਸਦੀ ਪਤਨੀ ਮਹਿੰਦਰੋ ਦੀ ਪਤ ਲੁੱਟਣ ਦੇ ਇੱਛਕ ਹਨ। ਜਦੋਂ ਉਹ ਇਸ ਲਈ ਰਾਜ਼ੀ ਨਹੀਂ ਹੁੰਦੀ ਤਾਂ ਉਹ ਉਨ੍ਹਾਂ ਨੂੰ ਅੱਡ ਕਰ ਦਿੰਦੇ ਹਨ। ਇਸ ਕਾਰਨ ਜ਼ਮੀਨ ਹੋਰ ਥੋੜ੍ਹੀ ਰਹਿ ਜਾਂਦੀ ਹੈ ਅਤੇ ਗਿੰਦਰ ਦਾ ਭਰਾ ਮਰ ਜਾਂਦਾ ਹੈ। ਗਿੰਦਰ ਸੋਚਦਾ ਹੈ ਕਿ ਸਾਂਝੇ ਪਰਿਵਾਰ ਵਿਚ ਉਸਦਾ ਕਰਜ਼ਾ ਲਹਿ ਜਾਵੇ ਅਤੇ ਭਰਾ ਸੋਚਦੇ ਹਨ, ਮਹਿੰਦਰੋ ਜਿਥੇ ਘਰ ਦਾ ਕੰਮ ਕਰੇਗੀ ਉਥੇ ਉਨ੍ਹਾਂ ਦੀ ਕਾਮ ਪੂਰਤੀ ਵੀ ਕਰੇਗੀ। ਪਰ ਮਹਿੰਦਰੋ ਵਲੋਂ ਜਿਸਮਾਨੀ ਸੰਬੰਧਾਂ ਦੇ ਇਨਕਾਰ ਕਰਨ 'ਤੇ ਇੱਕਠ ਟੁੱਟ ਜਾਂਦਾ ਹੈ। ਪਰੰਤੂ ਗਿੰਦਰ ਨੂੰ ਇਸ ਇਕੱਠ ਦਾ ਲਾਭ ਜ਼ਰੂਰ ਹੁੰਦਾ ਹੈ। ਉਸਦਾ ਕਰਜ਼ਾ ਲਹਿ ਜਾਂਦਾ ਹੈ।

ਇਥੇ ਮਹਿੰਦਰੋ ਆਪ ਤੋਂ ਪਹਿਲੀ ਪੀੜ੍ਹੀ ਨਾਲੋਂ ਵੱਖਰਾ ਵਿਹਾਰ ਕਰਦੀ ਹੈ। ਉਹ ਕਿਸਾਨੀ ਵਿਚ ਪ੍ਰਚਲਿਤ ਬਹੁ-ਪਤਨੀ ਪ੍ਰਥਾ ਕਬੂਲ ਨਹੀਂ ਕਰਦੀ। ਕਿਸਾਨੀ ਵਿਚ ਜ਼ਮੀਨ ਵੰਡੇ ਜਾਣ ਦੇ ਡਰ ਕਾਰਨ, ਦਿਉਰਾਂ, ਜੇਠਾਂ ਨਾਲ ਇਸਤਰੀ ਦੇ ਸਬੰਧ ਚੁੱਪ ਕਰਕੇ ਕਬੂਲ ਕੀਤੇ ਜਾਂਦੇ ਸਨ। ਜਾਗੀਰਦਾਰੀ ਪ੍ਰਥਾ ਵਿਚ ਇਸਤਰੀ ਦੀ ਆਪਣੀ ਆਜ਼ਾਦ ਹੋਂਦ ਨਹੀਂ ਹੁੰਦੀ। ਉਹ ਪਿਉ, ਭਰਾ, ਪਤੀ ਅਤੇ ਪੁੱਤਰ ਅਧੀਨ ਹੁੰਦੀ ਹੈ। ਜ਼ਮੀਨ ਦੀ ਮਾਲਕੀ ਵਿਚ ਉਸਦਾ ਕੋਈ ਹਿੱਸਾ ਨਹੀਂ ਸੀ ਹੁੰਦਾ। ਇਸ ਲਈ ਆਰਥਿਕ ਪੱਖੋਂ ਨਿਰਭਰ ਹੋਣ ਕਾਰਨ ਉਸ ਲਈ ਆਪਣੀ ਮਰਜ਼ੀ ਕਰਨੀ ਸੰਭਵ ਨਹੀਂ ਹੁੰਦੀ। ਜਗੀਰੂ ਪ੍ਰਥਾ ਦਾ ਧਰਮ, ਸਦਾਚਾਰ ਤੇ ਕਾਨੂੰਨ ਕੇਵਲ ਜ਼ਮੀਨ ਦੇ ਮਾਲਕ ਦੇ ਪੱਖ ਵਿਚ ਹੁੰਦੇ ਹਨ। ਇਸ ਲਈ ਇਸਤਰੀ ਦੇ ਵਿਰੁੱਧ ਹੁੰਦੇ ਹਨ। ਇਸਤਰੀ ਸਰੀਰਿਕ ਤੌਰ 'ਤੇ ਗੁਲਾਮ ਰੱਖਣ ਲਈ ਪਹਿਲਾਂ ਉਸ ਨੂੰ ਮਾਨਸਿਕ ਗੁਲਾਮ ਬਣਾਇਆ ਜਾਂਦਾ ਹੈ। ਉਸ ਦੇ ਮਾਨਸਿਕ ਵਿਕਾਸ ਦੇ ਰਾਹ ਸਾਰੇ ਰੋਕ ਲਏ ਜਾਂਦੇ ਹਨ। ਉਸ ਨੂੰ ਖੁਲ੍ਹਾ ਵਿਚਰਨ ਤੇ ਆਲੇ ਦੁਆਲੇ ਤੋਂ ਚੇਤਨਾ ਗ੍ਰਹਿਣ ਕਰਨ ਤੋਂ ਰੋਕਿਆ ਜਾਂਦਾ ਹੈ। ਉਸ ਨੂੰ ਮੁੱਢ ਤੋਂ ਹੀ ਅਧੀਨਗੀ ਸਿਖਾਈ ਜਾਂਦੀ ਹੈ। ਇਸ ਤਰ੍ਹਾਂ ਉਸ ਨੂੰ ਸਰੀਰਕ ਤੇ ਮਾਨਸਿਕ ਲੁੱਟ ਲਈ ਤਿਆਰ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਉਸ ਨੂੰ ਸਿਖਾਇਆ ਜਾਂਦਾ ਹੈ ਕਿ ਉਹ ਆਪਣੇ ਪਤੀ ਦੀ ਜਾਇਦਾਦ ਬਣ ਕੇ ਰਹੇ।

ਜ਼ਮੀਨੋਂ ਟੁੱਟ ਕੇ ਕਿਸਾਨ ਲਈ ਕੋਈ ਧਰਮ ਜਾਂ ਈਮਾਨ ਜਾਂ ਸਦਾਚਾਰ ਨਹੀਂ ਰਹਿ ਜਾਂਦਾ। ਉਹ ਆਪਣੀ ਹੋਂਦ ਕਾਇਮ ਰੱਖਣ ਲਈ ਕੁਕਰਮ ਕਰਦਾ ਹੈ ਅਤੇ ਉਸ ਨੂੰ ਜਾਇਜ਼ ਸਮਝਦਾ ਹੈ। ਗਿੰਦਰ ਸ਼ਰਾਬ ਕੱਢਦਾ ਹੈ ਤੇ ਵੇਚਦਾ ਹੈ। ਚੋਰੀ ਕਰਦਾ ਹੈ। ਇਕ ਵਾਰ ਇੰਜਨ ਦਾ ਪਟਾ ਟੁੱਟ ਜਾਂਦਾ ਹੈ ਅਤੇ ਉਹ ਖਰੀਦਣ ਦੀ ਥਾਂ ਚੋਰੀ ਕਰਦਾ ਹੈ। ਪਰੰਤੂ ਫੜੇ ਜਾਣ ਦੇ ਡਰੋਂ ਉਸ ਨੂੰ ਮੁੜ ਸੁੱਟ ਦਿੰਦਾ ਹੈ। ਗੋਰੇ ਪੱਲੇ ਮਰਦਾਊਣਾ ਵੀ ਨਹੀਂ ਰਹਿੰਦਾ। ਜਾਗੀਰੂ ਪ੍ਰਥਾ ਵਿਚ ਜਾਗੀਰਦਾਰ ਦਾ ਇਕ ਜੀਵਨ ਆਦਰਸ਼ ਹੁੰਦਾ ਹੈ। ਪਰ ਇਕ ਵਿਅਕਤੀ ਉਸ ਦੀ ਨਕਲ ਕਰਦਾ ਹੈ ਤੇ ਇਸ ਦਾ ਪ੍ਰਗਟਾਵਾ ਦੂਜੇ ਨੂੰ ਨੀਵਾਂ ਕਰਕੇ ਕਰਦਾ ਹੈ। ਗੋਰਾ ਇਕ ਵੇਰ ਫੇਰ ਤੇਲ ਦੀ ਡਰੰਮੀ ਲੈਣ ਸ਼ਹਿਰ ਜਾਂਦਾ ਹੈ ਉਸ ਦਾ ਸਾਇਕਲ ਖਰਾਬ ਹੋ ਜਾਂਦਾ ਹੈ। ਉਹ ਡਰੰਮੀ ਕਿਸੇ ਦੇ ਟਰੈਕਟਰ 'ਤੇ ਰੱਖਣ ਦਾ ਯਤਨ ਕਰਦਾ ਹੈ। ਪਰੰਤੂ ਟਰੈਕਟਰ ਦੇ ਮਾਲਕ ਕਿਸਾਨ ਦਾ ਨੌਕਰ ਹਰੀਜਨ ਹੀ ਉਸ ਨੂੰ ਰੱਖਣ ਨਹੀਂ ਦਿੰਦਾ। ਇਸ ਕਿਸਾਨੀ ਵਿਚ ਜਮਾਤੀ ਚੇਤਨਾ ਤੇ ਜਮਾਤੀ ਇਕਮੁੱਠਤਾ ਕਾਇਮ ਨਹੀਂ ਹੁੰਦੀ। ਇਸ ਤਰ੍ਹਾਂ ਕਿਸਾਨੀ ਦੀਆਂ ਹੇਠਲੀਆਂ ਤੈਹਾਂ ਜਾਗੀਰਦਾਰ ਦੇ ਪਿੱਛੇ ਜਾਗੀਰੂ ਪ੍ਰਥਾ ਦੇ ਹੱਕ ਵਿਚ ਲਾਮ ਬੰਦ ਹੁੰਦੀਆਂ ਤੇ ਖੜਦੀਆਂ ਹਨ। ਇਸ ਤਰ੍ਹਾਂ ਜਾਗੀਰਦਾਰ ਇਕ ਪਾਸੇ ਕਿਸਾਨੀ ਦੀਆਂ ਹੋਰਨਾ ਤੈਹਾਂ ਦੀ ਲੁੱਟ ਵੀ ਕਰਦਾ ਹੈ, ਦੂਜੇ ਪਾਸੇ ਉਨ੍ਹਾਂ ਨੂੰ ਆਪਣੇ ਹਿਤ ਵਿਚ ਵਰਤਦਾ ਹੈ। ਸਰਮਾਏਦਾਰ ਤੇ ਸਮਾਜਵਾਦੀ ਪ੍ਰਬੰਧ ਵਿਰੁੱਧ ਸੰਘਰਸ਼ ਵਿਸ ਉਨ੍ਹਾਂ ਤੋਂ ਹਮਾਇਤ ਪ੍ਰਾਪਤ ਕਰਦਾ ਹੈ।

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਇਸ ਤਰ੍ਹਾਂ ਜਾਗੀਰੂ ਪ੍ਰਥਾ ਦੀ ਅੰਤਿਮ ਅਵਸਥਾ, ਕਿਸਾਨੀ ਦੇ ਕੰਗਾਲੀ-ਕਰਨ ਨੂੰ ਸਾਰੇ ਪੱਖਾਂ ਤੋਂ ਪੜਚੋਲਵੇਂ ਢੰਗ ਨਾਲ ਘੋਖਿਆ ਤੇ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ਇਹ ਪੇਸ਼ਕਾਰੀ ਸੁਭਾਵਕ ਤੇ ਕਲਾਮਈ ਹੈ।

ਇਸ ਨਾਵਲ ਵਿਚ ਕਿਤੇ ਵੀ ਇਹ ਪਤਾ ਨਹੀਂ ਲਗਦਾ ਕਿ ਲੇਖਕ ਕਿਸੇ ਵਿਸ਼ੇਸ਼ ਪ੍ਰਥਾ ਦੇ ਨਖਿੱਧ ਪੱਖ ਨੂੰ ਚੇਤੰਨ ਤੌਰ 'ਤੇ ਪੇਸ਼ ਕਰ ਰਿਹਾ ਹੈ। ਪੇਂਡੂ ਜੀਵਨ ਦੇ ਇਕ ਗ਼ਰੀਬ ਪਰਿਵਾਰ ਦੇ ਨਿਤਪ੍ਰਤੀ ਜੀਵਨ ਨੂੰ ਪੇਸ਼ ਕਰਦਾ ਹੈ। ਉਸਦੇ ਜੀਵਨ ਦੀਆਂ ਆਰਥਿਕ ਤੰਗੀਆਂ, ਸਮਾਜਕ ਉਲਝਣਾਂ ਸੁਤੇ ਸਿਧ ਸਾਮਹਣੇ ਆਈ ਜਾਂਦੀਆਂ ਹਨ। ਉਹਨੇ ਜੀਵਨ ਦੇ ਸਾਰੇ ਪੱਖਾਂ ਨੂੰ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ਗਿੰਦਰ ਤੇ ਮਹਿੰਦਰੋ ਦੀ ਕਾਮ-ਕਰੀੜਾ ਵੀ ਉਚੇਚੇ ਤੌਰ 'ਤੇ ਨਹੀਂ , ਨਿਤ ਪ੍ਰਤੀ ਜੀਵਨ ਦੇ ਅੰਗ ਵਜੋਂ ਪੇਸ਼ ਕੀਤੀ ਹੈ। ਬਹੁਤੇ ਪੰਜਾਬੀ ਲੇਖਕ ਪੇਂਡੂ ਜੀਵਨ ਨੂੰ ਆਦਰਸ਼ ਜੀਵਨ ਵਜੋਂ ਪੇਸ਼ ਕਰਦੇ ਹਨ ਅਤੇ ਇਸਦੇ ਖ਼ਤਮ ਹੋਣ ਦਾ ਪ੍ਰਗਟਾਵਾ ਕਰਦੇ ਹਨ। ਪਰੰਤੂ ਕੁੱਸਾ ਅਜਿਹਾ ਨਹੀਂ ਕਰਦਾ। ਉਸਨੂੰ ਪਤਾ ਹੈ ਕਿ ਕਿਸਾਨੀ ਦੀ ਹੋਣੀ ਸੀਰੀ ਬਣਨਾ ਹੈ। ਉਸਨੂੰ ਕਿਸਾਨੀ ਦੇ ਸਾਰੇ ਪੱਖਾਂ ਨੂੰ ਸੰਕਟ ਗ੍ਰਸਤ ਹੋਣ 'ਤੇ ਇਸ ਦੇ ਸਮਾਂ ਵਿਹਾ ਚੁੱਕੀ ਹੋਣ ਦਾ ਅਹਿਸਾਸ ਹੈ। ਇਸ ਲਈ ਉਸਦਾ ਮੋਹ ਭੰਗ ਹੋ ਚੁੱਕਿਆ ਹੈ। ਇਸੇ ਮੋਹ ਭੰਗ ਨੂੰ ਆਪਣੇ ਨਾਵਲ ਵਿਚ ਪੇਸ਼ ਕਰਦਾ ਹੈ। ਸਮਕਾਲੀ ਯਥਾਰਥ ਨੂੰ ਚੇਤੰਨ ਯਥਾਰਥ ਵਜੋਂ ਪੇਸ਼ ਕਰਨਾ ਕੁੱਸਾ ਦੀ ਸਭ ਤੋਂ ਵੱਡੀ ਪ੍ਰਾਪਤੀ ਹੈ। ਜੋ ਕੁੱਝ ਅੱਜ ਤੱਕ ਉਸਦਾ ਕੋਈ ਸਮਕਾਲੀ ਪੰਜਾਬੀ ਲੇਖਕ ਨਹੀਂ ਸਕਿਆ।

3.6 ਕਿਸਾਨੀ ਸੱਭਿਆਚਾਰ ਦੀ ਹੋਂਦ ਤੇ ਹੋਣੀ ਦਾ ਸੰਕਟ:-

ਪੰਜਾਬ ਖੇਤੀ ਪ੍ਰਧਾਨ ਸਮਾਜ ਹੈ। ਇੱਥੋਂ ਦੀ ਸਾਰੀ ਆਰਥਿਕਤਾ ਖੇਤੀ ਦੇ ਸਹਾਰੇ ਖੜ੍ਹੀ ਹੈ। ਪੰਜਾਬ ਨੂੰ ਕਿਸਾਨੀ ਸੱਭਿਆਚਾਰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਪ੍ਰੰਤੂ ਕਿਸਾਨ ਸਖ਼ਤ ਮਿਹਨਤ ਕਰਨ ਦੇ ਬਾਵਜੂਦ ਨਿਰੰਤਰ ਪਤਨ ਵੱਲ ਜਾ ਰਿਹਾ ਹੈ ਜਿਸ ਕਾਰਨ ਉਸ ਦੀ ਹੋਂਦ ਨਾ ਦੇ ਬਰਾਬਰ ਹੋ ਰਹੀ ਹੈ। ਨਿਮਨ ਵਰਗ ਦਾ ਕਿਸਾਨ ਆਰਥਿਕ ਅਤੇ ਮਾਨਸਿਕ ਪੱਖੋਂ ਕਮਜੋਰ ਹੋ ਰਿਹਾ ਹੈ। ਜੇਕਰ ਨਾਵਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਨੂੰ ਸਮੁੱਚ ਵਿਚ ਸਮਝੀਏ ਤਾਂ ਇਹ ਗੱਲ ਸਾਹਮਣੇ ਆਉਂਦੀ ਹੈ ਕਿ ਕਿਸਾਨੀ ਸਮਾਜ ਵਿਚ ਸਰਮਾਏਦਾਰੀ ਪ੍ਰਣਾਲੀ ਵਿਚ ਨਿਮਨ ਵਰਗ ਅਤੇ ਅਤਿ ਨਿਕਟੀ ਮਜ਼ਦੂਰ ਵਰਗ ਆਰਥਿਕ ਅਤੇ ਸੱਭਿਆਚਾਰਕ ਪੱਧਰ 'ਤੇ ਨਵੇਂ ਸੰਕਟ ਦੇ ਸ਼ਿਕਾਰ ਹੋ ਗਏ ਹਨ। ਇਸ ਸੰਕਟ ਨਾਲ ਪੈਦਾ ਹੋਈਆਂ ਕਠੋਰ ਪ੍ਰਸਥਿਤੀਆਂ ਨੇ ਜਿੱਥੇ ਨਿਮਨ ਵਰਗਾਂ ਦਾ ਸ਼ੋਸ਼ਣ ਕਰਨਾ ਸ਼ੁਰੂ ਕਰ ਦਿੱਤਾ ਹੈ।

ਇਸ ਨਾਵਲ ਦੀ ਸਮੱਸਿਆ ਦਾ ਅਧਾਰ-ਬਿੰਦੂ ਵੀ ਉਕਤ ਸੰਕਟ ਹੀ ਹੈ। ਨਾਵਲ ਦੇ ਮੁੱਖ ਪਾਤਰ ਗੋਰੇ ਨੂੰ ਵਿਰਸੇ ਵਿਚ ਜੋ ਵਿਚ ਜੋ ਵਾਤਾਵਰਨ ਪ੍ਰਾਪਤ ਹੈ ਉਸ ਵਿਚ ਆਰਥਿਕ ਤੰਗੀ ਅਤੇ ਨਿਰਲੱਜ ਰਿਸ਼ਤਿਆਂ ਦੀ ਗੱਲ ਇਸ ਪ੍ਰਕਾਰ ਵਿਦਮਾਨ ਹੈ ਕਿ ਉਸ ਵਿਚ ਵਿਚਰਨਾ ਮੁਸ਼ਕਿਲ ਹੈ ਅਤੇ ਉਸ ਤੋਂ ਵੀ ਵੱਧ ਮੁਸ਼ਕਿਲ ਉਸ ਮਾਹੌਲ ਵਿਚੋਂ ਬਾਹਰ ਨਿਕਲਣ ਦਾ ਸੁਪਨਾ ਲੈਣਾ ਹੈ।

ਅਤਿ ਨਿਮਨ ਕਿਸਾਨੀ ਅਤੇ ਆਰਥਿਕ ਤੰਗੀ ਦੇ ਦਲਦਲ ਵਿਚੋਂ ਨਿਕਲਣ ਲਈ ਗੋਰੇ ਦਾ ਪਿਉ ਗਿੰਦਰ ਵੀ ਉਮਰ ਭਰ ਹੱਡ-ਭੰਨਵੀਂ ਮਿਹਨਤ ਦੇ ਨਾਲ-ਨਾਲ ਕਈ ਪ੍ਰਕਾਰ ਦੇ ਗਲਤ ਕੰਮਾਂ ਦਾ ਸਹਾਰਾ ਵੀ ਲੈਂਦਾ ਹੈ। ਅੱਗੋਂ ਗੋਰੇ ਨੂੰ ਵੀ ਉਹ ਹਰ ਉਸ ਦਿਸ਼ਾ ਵੱਲ ਤੋਰਦਾ ਹੈ ਜਿਧਰ ਕਿਸੇ ਤਰ੍ਹਾਂ ਦੀ ਆਸ ਵਾਲੀ ਕਿਰਨ ਦੀ ਸੰਭਾਵਨਾ ਹੋ

ਸਕਦੀ ਹੈ। ਪ੍ਰੰਤੂ ਗੋਰੇ ਨੂੰ ਹਰ ਪਾਸੇ ਮਿਲੀਆਂ ਤ੍ਰਿਸਕਾਰ ਉਸ ਨੂੰ ਕਿਸੇ ਵੀ ਪਾਸੇ ਦਲੇਰ ਮਨੁੱਖ ਵਾਂਗ ਖਲੋਣ ਨਹੀਂ ਦਿੰਦਾ। ਵਾਰ-ਵਾਰ ਮਿਲੀਆਂ ਹਾਰਾਂ ਦੇ ਕਾਰਨ ਗੋਰਾ ਪੂਰੇ ਨਾਵਲ ਵਿਚ ਬਾਹਰੀ ਅਤੇ ਅੰਦਰੂਨੀ ਪੱਧਰ 'ਤੇ ਟੁੱਟਣ-ਜੁੜਨ ਦੀ ਪ੍ਰਕਿਰਿਆ ਵਿਚ ਪਿਆ ਰਹਿੰਦਾ ਹੈ। ਉਸ ਦੇ ਜੀਵਨ ਵਿਚ ਵਾਪਰੀਆਂ ਘਟਨਾਵਾਂ ਉਸ ਨੂੰ ਆਪਣੀ ਹਿੰਡ ਅਨੁਸਾਰ ਜੀਉਣ ਵਾਲਾ ਮਨੁੱਖ ਬਣਾ ਦਿੰਦੀਆਂ ਹਨ। ਥਾਣੇਦਾਰੀ ਰਵੱਈਏ ਵਾਲੇ ਸਕੂਲ ਅਧਿਆਪਕ ਦੇ ਸਾਹਮਣੇ ਗੋਰੇ ਦਾ ਪ੍ਰਤੀਕ੍ਰਮ ਉਪਰੋਕਤ ਪ੍ਰਸੰਗ ਕਥਨ ਯੋਗ ਹੈ:

> ..... ਜਦੋਂ ਉਸ ਧੌਣ ਭੁਆ ਕੇ ਗੋਰੇ ਵਲ ਤੱਕਿਆ ਤਾਂ ਉਹ ਕਿਸੇ ਸਰਦਾਰ ਵਾਂਗ ਆਕੜਿਆ ਕੁਰੱਖਤ ਜਿਹਾ ਝਾਕ ਰਿਹਾ ਸੀ।
>
> ''ਮਾਸਟਰ ਨੂੰ ਆਪਣੇ ਆਪ ਉਤੇ ਹੀਣਤਾ ਮਹਿਸੂਸ ਹੋਈ''
>
> ''ਇਹ ਕੱਲ੍ਹ ਦਾ ਛੋਹਰ ਉਸ ਦੇ ਮੂਹਰੇ ਆਕੜਿਆ ਖੜੈ''
>
> ਪਲਝੱਟ ਅਧਿਆਪਕ ਢਾਕਾਂ ਹੱਥ ਰੱਖੀ ਵਿੰਹਦਾ ਰਿਹਾ। ਗੋਰਾ ਬਿਨਾਂ ਕਿਸੇ ਡਰ ਡੁੱਕਰ ਤੋਂ ਸੱਜੇ ਪੈਰ ਦੇ ਅੰਗੂਠੇ ਨਾਲ ਗੋਲ ਘੇਰੇ ਵਾਹ ਰਿਹਾ ਸੀ।[19]

ਗੱਲ ਕੀ ਗੋਰੇ ਦਾ ਇਹ ਵਰਤਾਓ ਆਪਣੇ ਹਾਣੀਆਂ, ਅਧਿਆਪਕਾਂ, ਮਾਪਿਆਂ, ਟਰੱਕ ਡਰਾਈਵਰਾਂ, ਬਿਸਕੁਟ ਦੀ ਬੇਕਰੀ ਵਾਲੇ ਸਰਦਾਰ, ਚਾਚਿਆਂ, ਦਾਦੀ ਤੇ ਗਵਾਂਢਿਆਂ ਨਾਲ ਤੂੰ-ਤੂੰ, ਮੈਂ-ਮੈਂ ਜਿਉਂ ਦਾ ਤਿਉਂ ਰਹਿੰਦਾ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਇਸ ਗੱਲ ਦਾ ਬਿਆਨ ਢੁਕਵੇਂ ਢੰਗ ਨਾਲ ਕੀਤਾ ਹੈ ਕਿ ਕਿਸ ਪ੍ਰਕਾਰ ਦਿਨ ਰਾਤ ਮਿਹਨਤ ਕਰਨ ਦੇ ਬਾਵਜੂਦ ਛੋਟੀ ਕਿਸਾਨੀ ਆਪਣੀਆਂ ਆਰਥਿਕ ਸਮੱਸਿਆਵਾਂ ਵਿਚੋਂ ਬਾਹਰ ਨਹੀਂ ਨਿਕਲ ਪਾਉਂਦਾ। ਗੋਰੇ ਦਾ ਪਿਓ ਦਿਨ ਰਾਤ ਮਿਹਨਤ ਕਰਦਾ ਹੈ ਅਤੇ ਗੋਰਾ ਵੀ ਕਈ ਪ੍ਰਕਾਰ ਦੇ ਕੰਮ ਕਰਨ ਵਿਚ ਅਸਫ਼ਲ ਰਹਿੰਦਾ ਹੈ ਤੇ ਗੋਰੇ ਨੂੰ ਉਸ ਦਾ ਮਾਮਾ ਸ਼ਹਿਰ ਵਿਚ ਕੰਮ ਕਰਨ ਲਈ ਲੈ ਜਾਂਦਾ ਹੈ, ਪਰ ਉਥੇ ਉਸ ਦਾ ਮਾਮਾ ਗੋਰੇ ਕੋਲੋਂ ਫੈਕਟਰੀ ਦੇ ਕੰਮ ਤੋਂ ਇਲਾਵਾ ਮੱਝਾਂ ਦਾ ਗੋਹਾ ਸੁੱਟਣ ਲਈ ਮਜ਼ਬੂਰ ਕਰਦਾ ਹੈ ਤਾਂ ਗੋਰੇ ਲਈ ਇਹ ਸਮਾਂ ਮੌਤ ਦੇ ਬਰਾਬਰ ਸੀ ਉਸ ਦੇ ਜੱਟ ਪੁਣੇ ਨੂੰ ਠੇਸ ਪਹੁੰਚਦੀ ਹੈ ਅਤੇ ਉਸ ਨੂੰ ਆਪਣੀ ਹੋਂਦ ਨਕਾਰਾ ਜਾਪਣ ਲੱਗੀ ਤੇ ਉਸ ਨੂੰ ਇਹ ਸਭ ਬਹੁਤ ਬੁਰਾ ਲੱਗਾ ਅਤੇ ਉਸ ਨੇ ਝੱਟ ਦੇਣੀ ਜਵਾਬ ਦਿੱਤਾ:

> ''ਇਹ ਕੰਮ ਮੈਂ ਨ੍ਹੀ ਕਰਨਾ।''
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> ਸਰਦਾਰ ''ਹੋਰ ਕੀ ਕਰੇਂਗਾ?'' ਸਰਦਾਰ ਨੂੰ ਮਾੜੀ ਜਿਹੀ ਤਲਖ਼ੀ ਆਈ।
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> ਗੋਰਾ ''ਹੋਰ; ਹੋਰ ਜੋ ਮਰਜੀ ਕਰਾ ਲੋ।'' ਉਹਦੇ ਚਿੱਤ 'ਚ ਆਈ ਉਹ ਆਖ ਦੇਵੇ

"ਗੋਹਾ ਸਿੱਟਣਾ ਸੀ ਤਾਂ ਪਿੰਡ ਥੋੜਾ ਸੀ ਐਥੇ ਕੀ ਕਰਨ ਔਣਾ ਸੀ।"[20]

ਘਰ ਆਉਣ 'ਤੇ ਵੀ ਜਦ ਮਹਿੰਦਰੋ ਕੰਮ ਛੱਡ ਆਉਣ ਦਾ ਕਾਰਨ ਪੁੱਛਦੀ ਐ ਤਾਂ ਉਹ ਅੱਗੋਂ ਇਨਾਂ ਹੀ ਆਖਦਾ ਹੈ:

"ਮੈਂ ਨ੍ਹੀ ਜਾਣਾ-ਜੁਣਾ, ਸਾਲੇ ਫ਼ੈਕਟਰੀਆਂ ਦੇ ਹੋਏ ਐ।"[21]

ਬੇਸ਼ੱਕ ਪੂਰੇ ਦਾ ਪੂਰਾ ਨਾਵਲ ਗੋਰੇ ਦੇ ਦੁਆਲੇ ਘੁੰਮਦਾ ਹੈ ਪ੍ਰੰਤੂ ਫਿਰ ਵੀ ਕੁੱਸਾ ਨੇ ਕਿਸਾਨੀ ਦੇ ਤਿੰਨ ਵਰਗਾਂ ਦਾ ਜ਼ਿਕਰ ਕੀਤਾ ਹੈ ਅਤੇ ਉਹ ਇਹਨਾਂ ਵਰਗਾਂ (ਜੀਪਾਂ ਵਾਲੇ, ਟਰੈਕਟਰਾਂ ਵਾਲੇ, ਕੈਨਾਂ ਵਾਲੇ) ਦਾ ਵਖਰੇਵਾਂ ਵੀ ਕਰਦਾ ਹੈ। ਇਨ੍ਹਾਂ ਦੇ ਵਿਰੋਧਤਮਕ-ਸੰਬੰਧਾਂ ਨੂੰ ਇਕ ਕੈਨ ਵਾਲੇ ਅੱਧਖੜ ਬੰਦੇ ਦੇ ਇਹ ਸ਼ਬਦ ਪੂਰੀ ਤਰ੍ਹਾਂ ਸਪਸ਼ਟ ਕਰਦੇ ਹਨ:

" ਕੋਈ ਹੱਜ ਐ, ਹੋਈ ਪਈ ਹੈ ਨਾ ਓਹੀ ਗੱਲ ਅਖੇ ਡਾਢੇ ਦਾ ਸੱਤੀਂ

ਵੀਹੀਂ ਸੌ। ਆਪੇ ਈ ਸੌ ਐ ਭਾਈ ।..... ਪਹਿਲਾਂ ਤਾਂ ਓਹਨੇ ਭੈਣ ਦੇ..... ਵੱਡੇ ਲੀਡਰਨੇ ਅੱਧਾ ਦਿਨ ਖਰਾਬ ਕਰਤਾ। ਉਹ ਮਸਾਂ ਗੱਲੋਂ ਲਾਇਆ ਤਾਂ ਏਹ ਟਰੈਕਟਰਾਂ ਆਲੇ ਚੌਧਰੀ ਬਣ ਕੇ ਬਹਿ-ਗੇ। ਅਨਸਾਫ ਦੱਸ, ਕੀ ਕਰੂ.....?"[22]

ਨਿਮਨ ਕਿਸਾਨੀ ਮੁਕਾਬਲੇ ਦੀ ਮੰਡੀ ਵਿਚ ਕਿਤੇ ਵੀ ਧਨੀ ਕਿਸਾਨੀ ਦੇ ਬਰਾਬਰ ਪੂਰੀ ਨਹੀਂ ਆ ਸਕਦੀ। ਇਸ ਲਈ ਉਹਦਾ ਹਰ ਥਾਂ ਪਛੜਨਾ ਸੁਭਾਵਿਕ ਹੈ। ਇਸੇ ਪ੍ਰਕਾਰ ਗ਼ਰੀਬ ਕਿਸਾਨ ਦੀ ਤ੍ਰਾਸਦੀ ਦੀ ਇੱਕ ਗੱਲ ਹੋਰ ਨਿਕਲ ਕੇ ਸਾਹਮਣੇ ਆਉਂਦੀ ਹੈ ਜਦੋਂ ਗੋਰਾ, ਸਾਧੂ ਨਾਲ ਵਿੜੀ ਕਰ ਲੈਂਦਾ ਹੈ। ਜਿਸ ਦਾ ਜ਼ਿਕਰ ਨਾਵਲ ਵਿਚ ਇਉਂ ਆਉਂਦਾ ਹੈ:

"ਝੋਨਾ ਝਾੜਨ ਤੋਂ ਪਿੱਛੋਂ ਗੋਰੇ ਨੇ ਟਾਹਲੀ ਵਾਲੇ ਸਾਧੂ ਨਾਲ ਵਿੜ੍ਹੀ ਕਰ ਲਈ।

ਸਾਧੂ ਆਪ ਜਾ ਕੇ ਉਸ ਪੈਲੀ ਦੂਹਰ ਆਇਆ ਤੇ ਗੋਰਾ ਉਨ੍ਹਾਂ ਨਾਲ ਵਿੱਘ 'ਚ

ਕੰਮ ਕਰਾਉਣ ਲੱਗਾ।"[23]

ਗੋਰੇ ਹੋਰਾਂ ਦਾ ਇਹ ਭਰਮ ਟੁਟਣ ਵੇਲੇ ਉਨ੍ਹਾਂ ਦੀ ਛਟਪਟਾਹਟ ਵੇਖਣ ਯੋਗ ਹੈ:

"ਦੇਖੋ ਤਾਂ ਸਹੀ।" ਮਹਿੰਦਰੋ ਨੇ ਵਾਬੜ ਕੇ ਆਪਣੇ ਬਾਰ 'ਚ

ਖਲੋਤੀ ਮਲਾਗਰ ਦੀ ਘਰਵਾਲੀ ਵੱਲ ਹੱਥ ਕਰ ਕੇ ਆਖਿਆ,

''ਹੈ ਲੋਹੜਾ। ਕਿਮੇਂ ਖੱਜਲ ਕਰਨ ਲੱਗਿਐ। ਐਂ ਤਾਂ ਕੋਈ

ਚੂਹੜਿਆਂ-ਚੱਪੜਿਆਂ ਨਾਲ ਵੀ ਨ੍ਹੀਂ ਕਰਦਾ; ਸ਼ਰੀਕ ਕਦੀ ਐ

ਕਰਦੇ ਹੁੰਦੇ ਐ। ''[24]

ਉਪਰਲੇ ਕਿਸਾਨੀ ਵਰਗ ਸ਼ੋਸ਼ਣ ਕਰਨ ਦੇ ਬਾਵਜੂਦ ਨਿਮਨ ਕਿਸਾਨੀ ਦੇ ਅੰਦਰ ਏਨੀਆਂ ਗਲਤਫ਼ਹਿਮੀਆਂ ਸਿਰਜੀ ਰੱਖਦੇ ਹਨ ਸ਼ੋਸ਼ਕ ਹੋਣ ਦੇ ਬਾਵਜੂਦ ਉਨ੍ਹਾਂ ਦੀ ਦਿੱਖ ਹਲੀਮੀ ਵਾਲੀ ਰਹਿੰਦੀ ਹੈ। ਤੇਲ ਲੈਣ ਗਏ ਗੋਰੇ ਨੂੰ ਜਦ ਆੜ੍ਹਤਿਆ ਪੈਸਿਆਂ ਤੋਂ ਕੋਰਾ ਜਵਾਬ ਦਿੰਦਾ ਹੈ ਤੇ ਬੇਇਜ਼ਤੀ ਵੀ ਕਰਦਾ ਹੈ ਤਾਂ ਇਕ ਰੱਜੇ ਪੁੱਜੇ ਜ਼ਿੰਮੀਦਾਰ ਬਖਤੌਰ ਸਿਉਂ ਦਾ ਮੁੰਡਾ ਗੁਰਦਰਸ਼ਨ ਗੋਰੇ ਲਈ ਸੇਠ ਨਾਲ ਨਾਟਕੀ ਆਢਾ ਲੈ ਕੇ ਆਪਣੇ ਕਿਸਾਨੀ-ਭਾਈਚਾਰੇ ਦਾ ਪ੍ਰਭਾਵ ਪਾਉਣ ਵਿਚ ਸਫਲ ਰਹਿੰਦਾ ਹੈ ਜਿਵੇਂ ਇਹ ਵਾਰਤਾਲਾਪ ਹਨ:

''ਤੂੰ ਐਡੇ ਕੂਲੇ ਨੇ ਓਹ ਸੌ ਰੁਪਈਆ ਕਈ ਆਰੀ ਕੱਢਿਆਹੋਊ, ਇਹਨਾਂ ਤੋਂ, ਨਾਲੇ ਅਹਿਸਾਨ ਓਡੇ ਦਾ ਓਡਾ''

ਗੁਰਦਰਸ਼ਨ ਨੇ ਅੱਖਾਂ ਝਪਕਾਉਦਿਆਂ ਕਿਹਾ,

''ਰੁਪਈਏ ਦੇ ਦੇ, ਮੁੰਡੇ ਦਾ ਕੰਮ ਸਾਰ, ਉਤੋਂ ਮਹੀਨਾ ਕਿਹੜਾ ਐ। ਕਿਤੇ ਜੱਟ ਬਾਣੀਆਂਨੂੰ ਨਾ ਆ ਪੈਣ। ''[25]

ਇਸ ਨਾਵਲ ਵਿਚ ਨਿਮਨ ਕਿਸਾਨੀ ਦਾ ਇੱਕ ਹੋਰ ਦੁਖਾਤ ਪੇਸ਼ ਕੀਤਾ ਹੈ ਕਿਸ ਪ੍ਰਕਾਰ ਜਦੋਂ ਨਿਮਨ ਵਰਗ ਦਾ ਕਿਸਾਨ ਹਰ ਤਰ੍ਹਾਂ ਦਾ ਯਤਨ ਕਰਨ ਦੇ ਬਾਵਜੂਦ ਅਸਫ਼ਲ ਰਹਿਣ 'ਤੇ ਆਪਣੇ ਪੁੱਤ ਨੂੰ ਸੀਰੀ ਰਲਾਉਣ ਵਾਸਤੇ ਵੀ ਤਿਆਰ ਹੋ ਜਾਂਦਾ ਹੈ ਜੋ ਕਿ ਗਿੰਦਰ ਇਸ ਨਾਵਲ ਵਿਚ ਕਰਦਾ ਹੈ ਜਦ ਗਿੰਦਰ ਗੋਰੇ ਨੂੰ ਕਰਜ਼ਾ ਲਾਉਣ ਖਾਤਰ ਸ਼ਰੀਕਾਂ ਦੇ ਸੀਰੀ ਰਲਣ ਲਈ ਆਖਦਾ ਹੈ ਤਾਂ ਗੋਰਾ ਇਸ ਭਲੇ ਵਾਲੀ ਗੱਲ ਦਾ ਡਟਵਾਂ ਵਿਰੋਧ ਕਰਦਾ ਹੈ ਅਤੇ ਦੋਵਾਂ ਪਿਉ ਪੁੱਤ ਵਿਚਕਾਰ ਇਹ ਬਹਿਸ ਹੁੰਦੀ ਹੈ:

''ਹੋਰ ਸਾਲਿਆ ਤੂੰ ਥਾਣੇਦਾਰ ਲੱਗੇਂਗਾ'', ਗਿੰਦਰ ਫੇਰ ਉਹਦੇ ਵੱਲ ਨੱਠ ਆਇਆ.....।

''ਥਾਣੇਦਾਰ ਲੱਗਾਂ ਜਾਂ ਨਾ ਲੱਗਾ। ਪਰ ਮੈਂ ਸੀਰੀ ਨ੍ਹੀ ਰਲਣਾ''

ਗੋਰੇ ਦਾ ਬੋਲ ਫੇਰ ਭੜਕਵਾਂ ਹੋ ਗਿਆ, ਉਸ ਅੱਖਾਂ 'ਚ ਤਾਅ ਭਰਦਿਆਂ ਆਖਿਆ,

"ਥੋਨੂੰ ਇਕ ਵਾਰੀ ਕਹਿ-ਤਾ, ਮੈਨੂੰ ਨਾ ਆਖਿਓ।.....ਸੀਰੀ ਨੀ ਰਲਣਾ.....ਫੇਰ ਮੈਨੂੰ ਆਖਿਆ, ਮੈ ਮਰਜੂੰ ਚਾਹੇ ਮਾਰਦੂੰ।"[26]

ਇਸ ਪ੍ਰਕਾਰ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਇਸ ਨਾਵਲ ਵਿਚ ਇੱਕ ਕਿਸਾਨ ਦੀ ਹੋਣੀ ਦੀ ਬਿਆਨ ਕੀਤਾ ਹੈ ਜੋ ਕਿ ਸੀਰੀ ਰਲਣਾ ਹੈ। ਸਾਰੀ ਉਮਰ ਹੱਡ ਭੰਨਵੀਂ ਮਿਹਨਤ ਕਰਨ ਦੇ ਬਾਵਜੂਦ ਗਿੰਦਰ ਆਰਥਿਕ ਤੰਗੀ ਵਿਚੋਂ ਬਾਹਰ ਨਹੀਂ ਆ ਸਕਦਾ ਉਸ ਦਾ ਪੁੱਤਰ ਗੋਰਾ ਵੀ ਨਿੱਕੀ ਉਮਰੇ ਮਿਹਨਤ ਕਰਨੀ ਸ਼ੁਰੂ ਕਰ ਦਿੰਦਾ ਹੈ ਅਤੇ ਇਸ ਤੰਗੀ ਵਿਚੋਂ ਨਿਕਲਣ ਲਈ ਕਈ ਪ੍ਰਕਾਰ ਦੇ ਗਲਤ ਕੰਮ ਵੀ ਕਰਦਾ ਹੈ ਜਿਵੇਂ ਕਿ ਚੋਰੀ ਕਰਨਾ ਜਾਂ ਸ਼ਰਾਬ ਆਦਿ ਵੇਚਣਾ ਪ੍ਰੰਤੂ ਫਿਰ ਵੀ ਗੋਰਾ ਆਰਥਿਕ ਮੰਦਹਾਲੀ ਦਾ ਸ਼ਿਕਾਰ ਰਹਿੰਦਾ ਹੈ ਅਤੇ ਕਰਜ਼ੇ ਨੂੰ ਉਤਰਨ ਵਾਸਤੇ ਉਸ ਨੂੰ ਸੀਰੀ ਰਲਣ ਵਾਸਤੇ ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਜੋ ਕਿ ਗੋਰੇ ਦੀ ਹੋਣੀ ਦੇ ਸਮਾਨ ਹੈ।

ਸੋ ਕੁੱਲ ਮਿਲਾ ਕੇ ਅਸੀਂ ਕਹਿ ਸਕਦੇ ਹਾਂ ਕਿ ਕੁੱਸਾ ਪੰਜਾਬੀ ਸਾਹਿਤ ਦਾ ਇਕ ਵਿਲੱਖਣ ਅਤੇ ਵਿਸ਼ਸ਼ਟ ਨਾਵਲਕਾਰ ਹੈ ਜਿਸ ਨੇ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨਵਿਚ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਸੰਤਾਪ ਨੂੰ ਪੇਸ਼ ਕਰਨ ਦਾ ਸਫ਼ਲ ਯਤਨ ਕੀਤਾ ਹੈ। ਉਸ ਨੇ ਆਪਣੇ ਇਸ ਨਾਵਲ ਵਿਚ ਬੜੇ ਹੀ ਸੁਭਾਵਿਕ ਢੰਗ ਨਾਲ ਪੇਂਡੂ ਕਿਸਾਨੀ ਸਮਾਜ ਦੀਆਂ ਸਮੱਸਿਆਵਾਂ ਪ੍ਰਤੀ ਸਾਨੂੰ ਜਾਣੂ ਕਰਵਾਇਆ ਹੈ। ਉਸ ਦੇ ਇਸ ਨਾਵਲ (ਰੋਹੀ ਬੀਆਬਾਨ) ਨੂੰ ਬਹੁਤ ਮਾਨਤਾ ਪ੍ਰਾਪਤ ਹੋਈ ਹੈ ਕਿਉਂਕਿ ਇਸ ਦੇ ਪਾਤਰ ਅਤੇ ਘਟਨਾਵਾਂ ਸਾਨੂੰ ਆਪਣੇ ਆਲੇ-ਦੁਆਲੇ ਵਿਚ ਆਮ ਵਿਚਰਦੀਆਂ ਮਿਲਦੀਆਂ ਹਨ ਜਿਸ ਕਰਦੇ ਇਹ ਨਾਵਲ ਯਥਾਰਥ ਦੀ ਪੇਸ਼ਕਾਰੀ ਕਰਦਾ ਪ੍ਰਤੀਤ ਹੁੰਦਾ ਹੈ।

ਹਵਾਲੇ ਅਤੇ ਟਿੱਪਣੀਆਂ:-

1. ਰਣਜੀਤ ਸਿੰਘ, ਪੰਜਾਬੀ ਕਿਸਾਨ ਜੀਵਨ ਅਤੇ ਸੱਭਿਆਚਾਰ, ਪੰਨਾ 41
2. ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ, ਰੋਹੀ ਬੀਆਬਾਨ, ਪੰਨਾ 1
3. ਉਹੀ, ਪੰਨਾ 3
4. ਉਹੀ, ਪੰਨਾ 5
5. ਉਹੀ, ਪੰਨਾ 53
6. ਰਣਜੀਤ ਸਿੰਘ, ਪੰਜਾਬੀ ਕਿਸਾਨ ਜੀਵਨ ਅਤੇ ਸੱਭਿਆਚਾਰ, ਪੰਨਾ 1
7. ਉਹੀ, ਪੰਨਾ 15
8. ਬਲਦੇਵ ਸਿੰਘ ਧਾਲੀਵਾਲ, ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ਬਿਰਤਾਂਤ ਚੇਤਨਾ ਦੇ ਪਾਸਾਰ, ਪੰਨਾ 75
9. ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ, ਰੋਹੀ-ਬੀਆਬਾਨ, ਪੰਨਾ 128
10. ਡਾ. ਗੁਰਪ੍ਰੀਤ ਕੌਰ, ਔਰਤ ਦਾ ਹਮਦਰਦ ਗਿੱਲ ਮੋਰਾਂਵਾਲੀ, ਮੌਸਮ ਦਾ ਸੰਤਾਪ ਦੇ ਪ੍ਰਸੰਗ ਵਿਚ, ਪੰਨਾ 23
11. ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ, ਰੋਹੀ-ਬੀਆਬਾਨ, ਪੰਨਾ 53
12. ਰਾਜਿੰਦਰ ਸਿੰਘ ਸੇਖੋਂ, ਆਲੋਚਨਾ ਅਤੇ ਪੰਜਾਬੀ ਆਲੋਚਨਾ, ਪੰਨਾ 139
13. ਉਹੀ, ਪੰਨਾ 140
14. ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ, ਰੋਹੀ-ਬੀਆਬਾਨ, ਪੰਨਾ 80
15. ਬਲਦੇਵ ਸਿੰਘ ਧਾਲੀਵਾਲ, ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ਬਿਰਤਾਂਤ ਚੇਤਨਾ ਦੇ ਪਾਸਾਰ, ਪੰਨਾ 70
16. ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ, ਰੋਹੀ-ਬੀਆਬਾਨ, ਪੰਨਾ 95
17. ਉਹੀ, ਪੰਨਾ 134
18. ਰਾਜਿੰਦਰ ਸਿੰਘ ਸੇਖੋਂ, ਆਲੋਚਨਾ ਅਤੇ ਪੰਜਾਬੀ ਆਲੋਚਨਾ, ਪੰਨਾ 108
19. ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ, ਰੋਹੀ-ਬੀਆਬਾਨ, ਪੰਨਾ 28
20. ਉਹੀ, ਪੰਨਾ 80
21. ਉਹੀ, ਪੰਨਾ 85
22. ਉਹੀ, ਪੰਨਾ 108
23. ਉਹੀ, ਪੰਨਾ 120
24. ਉਹੀ, ਪੰਨਾ 122

25. ਉਹੀ, ਪੰਨਾ 116

26. ਪੰਨਾ 135

ਅਧਿਆਇ ਚੌਥਾ

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦੇ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਦਾ ਕਲਾਤਮਕ ਪੱਖ

ਕਿਸੇ ਵੀ ਸਾਹਿਤਕ ਵਿਧਾ ਦੀ ਪਰਖ ਉਸ ਦੇ ਕਲਾਤਮਕ ਪੱਖਾਂ ਦੇ ਆਧਾਰ 'ਤੇ ਕੀਤੀ ਜਾਂਦੀ ਹੈ। ਨਾਵਲ ਕਲਾ ਪੱਖੋਂ ਵਧੇਰੇ ਪਰਪੱਕ ਹੋਣਾ ਚਾਹੀਦਾ ਹੈ ਤਦ ਹੀ ਉਸ ਦਾ ਸਾਹਿਤਕ ਮੁੱਲ ਪੈਂਦਾ ਹੈ। ਬੇਸ਼ੱਕ ਨਾਵਲ ਵਿਚ ਵਿਸ਼ਾ ਵਧੇਰੇ ਮਹੱਤਵ ਪੂਰਨ ਹੁੰਦਾ ਹੈ ਪ੍ਰੰਤੂ ਵਿਸ਼ਾ ਵੀ ਉਨ੍ਹਾਂ ਸਮਾਂ ਪ੍ਰਭਾਵਸ਼ਾਲੀ ਨਹੀਂ ਹੋ ਸਕਦਾ ਜਿੰਨਾਂ ਸਮਾਂ ਉਸ ਨੂੰ ਨਾਵਲੀ ਯੁਗਤਾਂ ਨਾਲ ਨਾ ਪੇਸ਼ ਕੀਤਾ ਗਿਆ ਹੋਵੇ। ਰੋਹੀ ਬੀਆਬਾਨਦੇ ਆਧਾਰ 'ਤੇ ਕੁੱਸਾ ਦੀ ਨਾਵਲੀ ਕਲਾ ਨੂੰ ਹੇਠ ਲਿਖੇ ਅਨੁਸਾਰ ਪਰਖਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕੀਤੀ ਗਈ ਹੈ:

4.1 ਪਾਤਰ ਚਿਤਰਣ:-

ਪਾਤਰ ਚਿਤਰਨ ਨਾਵਲਦਾ ਇਕ ਮਹੱਤਵਪੂਰਨ ਤੱਤ ਹੈ। ਨਾਵਲ ਵਿਚ ਪਾਤਰ ਹੀ ਘਟਨਾਵਾਂ ਸਿਰਜਦੇ ਜਾਂ ਭੋਗਦੇ ਹਨ। ਪ੍ਰਸਿੱਧ ਵਿਦਵਾਨ 'ਹਡਸਨ' ਦਾ ਵਿਚਾਰ ਹੈ ਕਿ ''ਪਾਤਰ ਉਸਾਰੀ ਮਨੋਵਿਗਿਆਨਿਕ ਪੱਖ ਤੋਂ ਹੋਣੀ ਚਾਹੀਦੀ ਹੈ।''[1] ਪਾਤਰਾਂ ਦਾ ਸੁਭਾਅ ਸੁਭਾਵਿਕ ਅਤੇ ਕੁਦਰਤੀ ਹੋਣਾ ਚਾਹੀਦਾ ਹੈ। ਆਧੁਨਿਕ ਕਾਲ ਦੇ ਨਾਵਲਾਂ ਵਿਚ ਪਾਤਰ ਆਮ ਤੌਰ 'ਤੇ ਬੌਧਿਕ ਕਿਸਮ ਦੇ ਪਸੰਦ ਕੀਤੇ ਜਾਂਦੇ ਹਨ।

ਨਾਵਲਕਾਰ ਕਹਾਣੀ ਬਿਰਤਾਂਤ ਸਿਰਜਣ ਲਈ ਪਾਤਰਾਂ ਦੇ ਆਰਥਿਕ, ਸੰਸਕ੍ਰਿਤਿਕ, ਸੰਦਰਭਾਂ ਦਾ ਚਿਤਰਨ ਇੰਨੀ ਭਰਪੂਰਤਾ ਨਾਲ ਕਰਦਾ ਹੈ ਕਿ ਪਾਤਰਾਂ ਦੀਆਂਪ੍ਰਸਥਿਤੀਆਂ ਦੀ ਜਾਣਕਾਰੀ ਸੁੱਤੇ ਸਿੱਧ ਹੋ ਜਾਦੀ ਹੈ। ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਨਾਵਲ ਦੇ ਮੁੱਖ ਪਾਤਰ ਦੇ ਜੀਵਨ ਦੇ ਵਸਤੂ ਵੇਰਵਿਆਂ ਨੂੰ ਇੰਨੇ ਵਿਸ਼ਾਲ ਤੇ ਸਪਸ਼ਟ ਢੰਗ ਨਾਲ ਚਿਤਰਿਆ ਹੈ ਕਿ ਉਹਨਾਂ ਵਿੱਚੋਂ ਨਾਵਲ ਦੀ ਮੁੱਖ ਸਮੱਸਿਆਆਰਥਿਕ ਥੁੜਾਂ ਕਾਰਨ ਪੈਦਾ ਹੋਏ ਸਭਿਆਚਾਰਕ ਸੰਕਟਾਂ ਦਾ ਵੇਰਵਾ ਆਪਣੇ ਆਪ ਮਿਲ ਜਾਂਦਾ ਹੈ।ਕੁੱਸਾਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨਦੇ ਪਾਤਰ ਗੋਰੇ ਦੇ ਸੰਕਟ ਦਾ ਕਾਰਨ ਉਸਦੀ ਆਰਥਿਕ ਮੰਦਹਾਲੀ ਮੰਨਦਾ ਹੈ। ਉਸਦੇ ਹਰ ਕੰਮ ਵਿਚ ਅਸਫ਼ਲ ਹੋਣ ਦਾ ਕਾਰਨ ਉਸਦੀ ਸਭਿਆਚਾਰਕ ਪਿਛੋਕੜ ਵਿਚ ਪਈ ਜਾਤੀਗਤ ਹਉਂ ਵਿਚੋਂ ਸਿਰਜਦਾ ਹੈ। ਗੋਰਾ ਕਿਸੇ ਵੀ ਪ੍ਰਸਥਿਤੀ ਨਾਲ ਸਮਝੌਤਾ ਨਹੀਂ ਕਰਦਾ। ਬੇਕਰੀ ਦਾ ਕੰਮ ਛੱਡ ਦਿੰਦਾ ਹੈ ਕਿਉਂਕਿ ਬੇਕਰੀ ਦੇ ਮਾਲਕ ਦੇ ਡੰਗਰਾਂ ਦਾ ਗੋਹਾ ਸੁੱਟਣ ਉਸਨੂੰ ਆਪਣੇ ਪੱਧਰ ਤੋਂ ਨੀਵਾਂ ਜਾਪਦਾ ਹੈ। ਟਰੱਕ ਡਰਾਈਵਰਾਂ ਨੂੰ ਮਾਰਦਾ ਕੁੱਟਦਾ ਹੈ ਕਿਉਂਕਿ ਉਹਨਾਂ ਵੱਲੋਂ ਆਪਣੇ ਨਾਲ ਹੋਈ ਜ਼ਬਰਦਸਤੀ ਤੇ ਅਣਮਨੁੱਖੀ ਵਰਤਾਉ ਨੂੰ ਉਹ ਹੀਣਤਾ ਦੀ ਨਜ਼ਰ ਨਾਲ ਦੇਖਦਾ

ਹੈ। ਜਿਸ ਮਾਨਵੀ ਪੱਧਰ ਦੀ ਉਸਨੂੰ ਪ੍ਰਾਪਤੀ ਹੋ ਚੁੱਕੀ ਹੈ ਉਸਤੋਂ ਡਿੱਗਣ ਲਈ ਉਹ ਤਿਆਰ ਨਹੀਂ ਹੁੰਦਾ ਪਰ ਦੂਸਰੇ ਪਾਸੇ ਉਹੀ ਗੋਰਾ ਸ਼ਰਾਬ ਪੀਂਦਾ, ਚੋਰੀ ਕਰਦਾ, ਨਜ਼ਾਇਜ ਤੌਰ ਤੇ ਸਰਾਬ ਕੱਢਦਾ 'ਤੇ ਉਸ ਵਿਚ ਮਿਲਾਵਟ ਵੀ ਕਰਦਾ ਹੈ ਉਸੇ ਤਰ੍ਹਾਂ ਗਿੰਦਰ ਤੇ ਉਸਦੀ ਘਰਵਾਲੀ ਇੱਕ ਪਾਸੇ ਬੇਹਤਰ ਜੀਵਨ ਜਿਉਣ ਲਈ ਸੰਘਰਸ਼ ਕਰਦੇ ਹਨ। ਗੋਰੇ ਨੂੰ ਪੜ੍ਹਾ ਕੇ ਉਸਦੇ ਜੀਵਨ ਨੂੰ ਸੁਧਾਰਨਾ ਚਾਹੁੰਦੇ ਹਨ ਪਰ ਦੂਸਰੇ ਪਾਸੇ ਆਪ ਮਾਨਵੀ ਮੁੱਲਾਂ ਨੂੰ ਤਿਆਗ ਕੇ ਸਮਾਜਕ ਨਿਘਰ ਦਾ ਸ਼ਿਕਾਰ ਹੋ ਜਾਦੇ ਹਨ।

ਨਾਵਲ ਵਿਚ ਪੇਸ਼ ਕੀਤੇ ਮਨੁੱਖੀ ਚਰਿਤਰ ਨਾਵਲਕਾਰ ਦੀ ਗਲਪ ਚੇਤਨਾ ਦਾ ਪ੍ਰਗਟਾਵਾ ਕਰਦੇ ਹਨ।ਪੈਦਾਵਾਰੀ ਰਿਸ਼ਤਿਆਂ ਵਿੱਚ ਜ਼ਕੜੇ ਪੇਂਡੂ ਪਾਤਰਾਂ ਦੀ ਮਾਨਸਿਕਤਾ ਦਾ ਚਿਤਰਨ ਉਹ ਬੜੇ ਯਥਾਰਥਮਈ ਢੰਗ ਨਾਲ ਕਰਦਾ ਹੈ। ਆਪਣੇ ਪਾਤਰਾਂ ਬਾਰੇ ਅਲੋਚਕਾਂ ਵੱਲੋਂ ਕੀਤੀ ਆਲੋਚਨਾ ਬਾਰੇ ਕੁੱਸਾ ਲਿਖਦਾ ਹੈ, ''ਮੇਰੇ ਨਾਵਲਾਂ ਚੋ ਕਈ ਤੱਤ ਪਾਰਖੂ ਹਮੇਸ਼ਾ ਹੀ ਨਚੋੜ ਕੱਢਦੇ ਹਨ ਕਿ ਤੇਰੇ ਪਾਤਰ ਇਨਕਲਾਬ ਦਾ ਝੰਡਾ ਕਾਹਤੋਂ ਨੀ ਚੁੱਕਦੇ? ਉਹਨਾਂ ਨੂੰ ਇਨਕਲਾਬ ਦੇ ਰਾਹ ਨਾ ਤੋਰਨਾ, ਤੇਰੀ ਪੰਜਾਬੀ ਸਾਹਿਤ, ਜ਼ੁਬਾਨ ਕਲਚਰ ਅਤੇ ਕੌਮ ਨਾਲ ਗਦਾਰੀ ਹੈ।''[2]

ਕਰਮਜੀਤ ਕੁੱਸਾ ਦੀ ਪਾਤਰ ਚਿਤਰਣ ਵਿਧੀ ਵੀ ਉਸ ਦੀ ਗਲਪ ਦ੍ਰਿਸ਼ਟੀ ਵਾਂਗ ਯਥਾਰਥਕ ਹੈ। ਯਥਾਰਥਵਾਦੀ ਲੇਖਕ ਦੀ ਆਮ ਤੌਰ 'ਤੇ ਇਹੀ ਕੋਸ਼ਿਸ਼ ਹੁੰਦੀ ਹੈ ਕਿ ਉਹ ਜਿਉਂਦੇ ਜਾਗਦੇ ਪਾਤਰਾਂ ਨੂੰ ਆਪਣੀ ਰਚਨਾ ਦਾ ਧੁਰਾ ਬਣਾਵੇ। ਯਥਾਰਥ ਦ੍ਰਿਸ਼ਟੀਵਾਲਾ ਨਾਵਲਕਾਰ ਪਾਤਰ ਨੂੰ ਵੱਧ ਤੋਂ ਵੱਧ ਅਸਲੀਅਤ ਦੇ ਨੇੜੇ ਰੱਖਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ। ਉਨ੍ਹਾਂ ਦੇ ਸੁਭਾਅ ਤੇ ਚਿੱਤਰ ਨੂੰ ਸਮਾਜਕ ਸੰਦਰਭ ਵਿੱਚ ਰੱਖ ਕੇ ਸਮਝਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ ਅਤੇ ਉਨ੍ਹਾਂ ਦੀ ਅਸਲੀਅਤ ਦੇ ਵਿਗਾੜ ਦੇ ਕਾਰਨ ਉਨ੍ਹਾਂ ਦੇ ਚੌਗਿਰਦੇ ਵਿਚ ਜਾਂ ਉਨ੍ਹਾਂ ਦੀ ਮਨੋਵਿਗਿਆਨਿਕ ਬਣਤਰ ਵਿਚ ਲੱਭਦਾ ਹੈ। ਕੁੱਸਾ ਵੀ ਇਸੇ ਦ੍ਰਿਸ਼ਟੀ ਅਧੀਨ ਨਾਵਲ ਦੇ ਹਰ ਛੋਟੇ ਵੱਡੇ ਪਾਤਰ ਨੂੰ ਵੱਧ ਤੋਂ ਵੱਧ ਯਥਾਰਥ ਦੇ ਨੇੜੇ ਰੱਖ ਕੇ ਚਿਤਰਦਾ ਹੈ। ਪਾਤਰ ਚਿਤਰਣ ਦੇ ਯਥਾਰਥ ਦੀ ਵਿਧੀ ਨੂੰ ਪਾਤਰਾਂ ਦੀ ਬਾਹਰਲੀ ਦਿਖ ਉਨ੍ਹਾਂ ਦੀ ਪੋਸ਼ਾਕ ਤੇ ਖਾਣ ਪੀਣ ਦੇ ਢੰਗ ਤੋਂ ਲੈਕੇ ਉਨ੍ਹਾਂ ਦੀ ਮਾਨਸਿਕਤਾ ਦੇ ਸੂਖਮ ਵੇਰਵਿਆਂ ਵਾਰੇ ਲੇਖਕ ਨੂੰ ਬਹੁਤ ਚੇਤੰਨ ਰਹਿਣਾ ਪੈਂਦਾ ਹੈ ਉਹ ਆਦਰਸ਼ਵਾਦੀ ਲੇਖਕ ਵਾਂਗ ਪਾਤਰ ਨੂੰ ਆਪਣੀ ਮਰਜ਼ੀ ਅਨੁਸਾਰ ਨਹੀਂ ਚਿਤਰ ਸਕਦਾ।ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਆਪਣੇ ਨਾਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਵਿੱਚ ਇਸੇ ਵਿਧੀ ਅਧੀਨ ਇੱਕ ਪਾਸੇ ਪਾਤਰਾਂ ਦਾ ਤੇ ਦੂਜੇ ਪਾਸੇ ਉਨ੍ਹਾਂ ਦੇ ਸਮਾਜਕਆਰਥਿਕ ਮਾਹੌਲ ਦਾ ਚਿਤਰਣ ਕੀਤਾ ਹੈ ਉਹ ਆਪਣੇ ਪਾਤਰਾਂ ਨੂੰ ਉਨ੍ਹਾਂ ਦੇ ਕਾਰਜ ਰਾਹੀਂ ਚਿਤਰਣ ਤੇ ਵਧੇਰੇ ਜੋਰ ਦਿੰਦਾ ਹੈ। ਆਮ ਤੌਰ ਤੇ ਪਾਤਰਾਂ ਵਾਰੇ ਜਾਣਕਾਰੀ ਤਿੰਨ ਢੰਗਾਂ ਨਾਲ ਦਿੱਤੀ ਜਾਂਦੀ ਹੈ। ਲੇਖਕ ਕਦੇ ਆਪਣੀ ਟਿੱਪਣੀ ਦੁਆਰਾ, ਕਦੇ ਦੂਜੇ ਪਾਤਰਾਂ ਦੀ ਗੱਲਬਾਤ ਰਾਹੀਂ ਤੇ ਜਾਂ ਪਾਤਰਾਂ ਦੇ ਵਿਸ਼ੇਸ਼ ਕਾਰਜਰਾਹੀਂ। 'ਕੁੱਸਾ' ਆਪਣੀ ਟਿੱਪਣੀ ਤੇ ਦੂਜੇ ਪਾਤਰਾਂ ਦੀ ਗੱਲਬਾਤ ਦੇ ਅਧਾਰ ਤੇ ਕਿਸੇ ਪਾਤਰ ਦੀ ਬਾਹਰਲੀ ਦਿੱਖ ਜਾਨਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ। ਜਿਵੇਂ ਮਹਿੰਦਰੋ ਦੇ ਮੋਟੇ ਤੇ ਥਲਥਲ ਕਰਦੇ ਸਰੀਰ ਦਾ

ਨਕਸ਼ਾ ਖਿੱਚਣ ਲਈ ਗੋਰੇ ਦੇ ਹਾਣੀ ਉਸਨੂੰ ਮੈਸ ਕਹਿਕੇ ਪੁਕਾਰਦੇ ਹਨ। ਇਸੇ ਤਰ੍ਹਾਂ ਗੋਰੇ ਤੇ ਕੱਦੂ ਦੀ ਬਾਹਰਲੀ ਸ਼ਖ਼ਸੀਅਤ ਜਾਂ ਪੋਸ਼ਾਕ ਸੰਬੰਧੀ ਦੂਸਰੇ ਪਾਤਰਾਂ ਦੀ ਗੱਲਬਾਤ ਤੋਂ ਪਤਾ ਲਗਦਾ ਹੈ ਜਿਵੇਂ:

> ''ਤੇਰਾ ਰੋਜ ਦਾ ਈ ਇਹ ਕੰਮ ਐ? ਆਉਂਦਾ ਜਾਂਦਾ ਤੈਨੂੰ ਕੱਖ ਨ੍ਹੀ, ਇੱਲਤਾਂ ਕਰਨ ਨੂੰ ਸਾਰਿਆਂ ਤੋਂ ਮੂਹਰੇ।''
>
> ''ਐਤਵਾਰ ਵਾਲੇ ਦਿਨ ਨ੍ਹਾਤਾ ਸੀ- ਕੱਪੜੇ ਧੋਤੇ ਸੀ? ..... ਕੱਪੜੇ ਦੇਖ ਆਪ ਦੇ! ਮੁਸ਼ਕ ਔਂਦਾ ਵਿੱਚੋਂ।''
>
> ''ਨਹੁੰ ਦੇਖ ਕਿਵੇਂ ਕੁਹਾੜਿਆਂ ਆਂਗੂ ਵਧੇ ਐ।''
>
> ''ਝੱਗਾ ਪਜਾਮਾ ਤੇਰਾ ਜੁੱਲ ਵਰਗਾ ਹੋਇਆ ਪਿਐ।- ਮੂੰਹ ਤੂੰ ਨੀ ਧੋਤਾ!- ਧੋਤਾ ਐ ਕਦੇ?'' [3]
>
> ''ਥੋਨੂੰ ਲੱਗ ਜੇ, ਅੱਗ ਐਹੋ ਜਿਆਂ ਨੂੰ।''[4]
>
> ''ਵੇ ਖਾਣ ਗਧਿਓ! ਟੁੱਟੇ ਹੱਥਾਂ ਆਲਿਓ! ਮੂੰਹ ਮੱਥਾ ਤਾਂ ਝੁਲਸ ਲਿਆ ਕਰੋ! ਕਿਉਂ ਤੁਸੀਂ ਸੂਰਾਂ ਦੇ ਹਾਲੀ ਸਕੂਲ ਨੂੰ ਭੱਜ ਲੈਨੇ ਓ?''[5]

ਬੇਕਰੀ ਤੇ ਕੰਮ ਕਰਨ ਵਾਲੇ ਨੌਕਰ ਦੀ ਹਾਲਤ ਦੱਸਣ ਲਈ ਉਸਦਾ ਜ਼ਿਕਰ ਇਉਂ ਕੀਤਾ ਹੈ,

> ''ਥੋੜੇ ਚਿਰ ਬਾਅਦ ਇੱਕ ਮੁੰਡਾ ਆਇਆ, ਜਿਸਦੇ ਤੇੜ ਮੈਲੀ ਵੱਡੀ ਸਾਰੀ ਨੀਕਰ ਤੇ ਜੁੱਲ ਵਰਗਾ ਕੁੱਢਣਾ ਜਿਹਾ ਝੱਗਾ ਪਾਇਆ ਹੋਇਆ ਸੀ। ਜਿਹੜਾ ਥਾਂ-ਥਾਂ ਤੋਂ ਥੰਦਾ ਹੋਇਆ ਪਿਆ ਸੀ।''[6]
>
> ''ਬੰਦੇ ਦੀ ਸ਼ਕਲ ਵੀ ਗੋਰੇ ਨੂੰ ਡਰਾਉਣੀ ਜਾਪੀ, ਜਿਵੇਂ ਕੋਈ ਸੱਚੀ ਮੁੱਚੀ ਦਾ ਭੂਤ ਹੋਵੇ। ਉਹਦਾ ਚਿਹਰਾ ਅਖਰੋਟ ਵਰਗਾ ਸਖਤ ਸੀ ਤੇ ਰੰਗ ਕਾਲੇ ਤਵੇ ਵਰਗਾ, ਚਿਹਰੇ 'ਤੇ ਬੈਠਵਾਂ ਚੌੜਾ ਜਿਹਾ, ਪੋਰ ਵਰਗਾ ਨੱਕ ਤੇ ਨੱਕ ਹੇਠਾਂ ਮੋਟੀਆਂ-ਮੋਟੀਆਂ ਅੱਧ ਕਾਲੀਆਂ ਭਾਰੀਆਂ ਮੁੱਛਾਂ, ਜਿਨ੍ਹਾਂ ਨੂੰ ਬਿੰਦੇ ਝੱਟੇ ਉਹ ਵੱਟ ਚਾੜ੍ਹਨ ਲੱਗ ਪੈਂਦਾ ਤੇੜ ਉਹਦੇ ਮੈਲ ਅੱਟਿਆ ਪਰਨਾ ਸੀ ਤੇ ਗਲ਼ ਸਦੀਆਂ ਤੋਂ ਅਣ ਧੋਤੀ ਬੁਨੈਣ।''[7]

ਕੁੱਸਾ ਜਦੋਂ ਪਾਤਰਾਂ ਦੀ ਅੰਦਰੂਨੀ ਕਿਸਮ ਜਾਂ ਉਹਨਾਂ ਦੇ ਗੁਣਾਂ-ਔਗੁਣਾਂ ਦੀ ਗੱਲ ਕਰਦਾ ਹੈ ਤਾਂ ਉਹ ਉਨ੍ਹਾਂ ਨੂੰ ਕਿਸੇ ਵਿਸ਼ੇਸ਼ ਪ੍ਰਸਥਿਤੀਆਂ ਵਿੱਚ ਵਿਚਰਦਿਆਂ ਵਿਖਾ ਕੇ ਉਨ੍ਹਾਂ ਦੇ ਸਹੀ ਆਪੇ ਦੀ ਪਹਿਚਾਣ ਕਰਵਾਉਂਦਾ ਹੈ।

ਨਾਵਲ ਦਾ ਕੇਂਦਰੀ ਪਾਤਰ ਮੁੱਖ ਤੌਰ 'ਤੇ ਵਿਗੜਿਆ ਹੋਇਆ ਜਾਪਦਾ ਹੈ। ਮਾਤਾ-ਪਿਤਾ ਤੇ ਆਂਢ-ਗੁਆਂਢ ਉਸਨੂੰ ਅੜ੍ਹਬ ਅੱਖੜ ਤੇ ਨਿਕੰਮਾ ਸਮਝਦੇ ਹਨ। ਪਰ ਲੇਖਕ ਉਸਦੀ ਸ਼ਖ਼ਸੀਅਤ ਦੇ ਇਨ੍ਹਾਂ ਵਿਗਾੜਾਂ ਦਾ ਕਾਰਨ ਉਸਦੇ ਆਲੇ-ਦੁਆਲੇ ਉਸਦੀ ਸਮਾਜਕ ਸਥਿਤੀ ਵਿੱਚੋਂ ਲੱਭਦਾ ਹੈ। ਘਰ ਦੀ ਆਰਥਿਕ ਤੌਰ 'ਤੇ ਮੰਦੀ ਹਾਲਤ, ਮਾਸਟਰਾਂ ਦੀ ਮਾਰ ਕੁੱਟ, ਹਾਣੀ ਮੁੰਡਿਆਂ ਦੀਆਂ ਟਿੱਚਰਾਂ, ਕੰਮ ਦੀ ਬਹੁਤਾਤ ਕੁੱਝ ਅਜਿਹੇ ਕਾਰਨ ਹਨ ਜੋ ਉਸਦੀ ਪੁੰਗਰਦੀ ਸ਼ਖ਼ਸੀਅਤ ਨੂੰ ਵਿਗਾੜ ਦੇ ਰਾਹ ਤੋਰਨ ਦੇ ਜ਼ਿੰਮੇਵਾਰ ਹਨ। ਪਰ ਇਹੀ ਗੋਰਾ ਜਦੋਂ ਕੰਮ ਵਿਚ ਪੈਂਦਾ ਹੈ ਤਾਂ ਉਹ ਬੜਾ ਸਿਆਣਾ ਤੇ ਜ਼ਿੰਮੇਵਾਰ ਵਿਅਕਤੀ ਲਗਦਾ ਹੈ। ਗੋਰੇ ਦੀ ਅੰਦਰਲੀ ਸ਼ਖ਼ਸੀਅਤ ਅਸਲ ਵਿੱਚ ਉਸਦੇ ਕਾਰਜ ਵਿਚੋਂ ਉਭਰਦੀ ਹੈ। ਉਸਦੀ ਅਫ਼ਸਰੀ ਤੇ ਧੱਕੇ ਸ਼ਾਹੀ ਅੱਗੇ ਡੱਟਕੇ ਖਲੋਣ ਦੀ ਦਲੇਰੀ ਜਾਂ ਨਖਿੱਧ ਕੰਮ ਛੱਡ ਕੇ ਦੌੜ ਜਾਣ ਦਾ ਫੈਸਲਾ ਉਸਦੇ ਅਜਿਹੇ ਅੰਦਰੂਨੀ ਗੁਣ ਹਨ ਜਿਹੜੇ ਉਸਦੇ ਸਾਰੇ ਭੈੜਾਂ ਤੇ ਖੋਜਾਂ ਦੇ ਬਾਵਜੂਦ ਪਾਠਕ ਦੀ ਉਸ ਨਾਲ ਹਮਦਰਦੀ ਬਣਾਈ ਰੱਖਦੇ ਹਨ। ਲੇਖਕ ਨੇ ਇਸੇ ਵਿਧੀ ਦੁਆਰਾ ਹੀ ਦੂਸਰੇ ਪਾਤਰਾਂ ਦਾ ਜਿਕਰ ਵੀ ਉਘਾੜਿਆ ਹੈ।

ਮਹਿੰਦਰੋ ਤੇ ਗਿੰਦਰ ਉਸਨੂੰ ਗਾਲ੍ਹਾਂ ਕੱਢਦੇ, ਕੁੱਟਦੇ, ਮਾਰਦੇ ਹਨ ਪਰ ਦੂਸਰੇ ਪਾਸੇ ਪਿਆਰ ਵੀ ਕਰਦੇ ਹਨ ਕੁੱਟ ਕੇ ਪਛਤਾਉਂਦੇ ਵੀ ਹਨ, ਮਨੁੱਖੀ ਮਨ ਤੇ ਮਨੁੱਖੀ ਸ਼ਖ਼ਸੀਅਤ ਦੀ ਇਹੀ ਖ਼ਾਸੀਅਤ ਹੈ। ਜਿਸਨੂੰ ਯਥਾਰਥਵਾਦੀ ਗਲਪ ਦ੍ਰਿਸ਼ਟੀ ਰੱਖਣ ਵਾਲਾ ਲੇਖਕ ਹੀ ਪਹਿਚਾਣ ਸਕਦਾ ਹੈ। ਇਹੀ ਕਾਰਨ ਹੈ ਕਿ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਨਾਵਲ ਦੇ ਸਾਰੇ ਪਾਤਰ ਨਾ ਤਾਂ ਸੋਲਾਂ ਕਲਾ ਸੰਪੂਰਨ ਹਨ ਜਿਹਨਾਂ ਨੂੰ ਕਿਸੇ ਆਦਰਸ਼ ਮਾਡਲ ਦਾ ਦਰਜਾ ਦਿੱਤਾ ਨਾ ਜਾ ਸਕੇ ਅਤੇ ਨਾ ਹੀ ਅਜਿਹੇ ਨਖਿੱਧ ਚਰਿਤਰ ਵਾਲੇ ਹਨ ਜਿਹਨਾਂ ਨੂੰ ਮਨੁੱਖ ਕਹਿਣ ਉੱਤੇ ਵੀ ਝਿਜਕ ਮਹਿਸੂਸ ਹੋਵੇ। ਉਹ ਇਕੋ ਸਮੇਂ ਪਾਠਕਾਂ ਦੀ ਨਫਰਤ ਤੇ ਹਮਦਰਦੀ ਦੋਹਾਂ ਦੇ ਪਾਤਰ ਬਣਦੇ ਹਨ ਅਤੇ ਉਹਨਾਂ ਦੀ ਸ਼ਖ਼ਸੀਅਤ ਅਤੇ ਅੰਦਰ ਝੁਕੀਆਂ ਸੰਭਾਵਨਾਵਾਂ ਪਾਠਕ ਦੇ ਮਨ ਵਿਚ ਆਸ ਵੀ ਜਗਾਉਂਦੀਆਂ ਹਨ ਤੇ ਰੋਸ ਵੀ ਇਸ ਨਾਵਲ ਦੇ ਪ੍ਰਮੁੱਖ ਤਿੰਨ ਪਾਤਰ ਹਨ- ਗੋਰਾ, ਗਿੰਦਰ ਤੇ ਮਹਿੰਦਰੋ।

ਗੋਰਾ ਨਾਵਲ ਦਾ ਕੇਂਦਰੀ ਪਾਤਰ ਹੈ। ਨਾਵਲ ਦੀ ਕਹਾਣੀ ਦੇ ਆਰੰਭ ਹੋਣ ਸਮੇਂ ਉਸਦੀ ਉਮਰ 8-9 ਸਾਲ ਦੀ ਹੈ ਤੇ ਕਹਾਣੀ ਦੇ ਅੰਤ ਤੱਕ ਉਹ ਕਿਸ਼ੋਰ ਅਵਸਥਾ ਤੱਕ ਪਹੁੰਚ ਜਾਦਾ ਹੈ। 8-9 ਸਾਲ ਦੇ ਸਮੇਂ ਵਿੱਚ ਲੇਖਕ ਨੇ ਉਸਦੀ ਸ਼ਖ਼ਸੀਅਤ ਦੇ ਉਸਾਰੂ ਅਤੇ ਨਿਘਾਰ ਦੋਹਾਂ ਪੱਖਾਂ ਨੂੰ ਚਿਤਰਿਆ ਹੈ। ਨਾਵਲ ਦੇ ਆਰੰਭ ਵਿੱਚ ਉਹ ਪੁੱਜ ਕੇ ਢੀਠ ਤੇ ਅਲੱਥ ਬੱਚੇ ਦੇ ਰੂਪ ਵਿੱਚ ਸਾਹਮਣੇ ਆਉਂਦਾ ਹੈ ਜੋ ਨਾ ਸਕੂਲ ਜਾਣਾ ਚਾਹੁੰਦਾ ਹੈ ਤਾਂ ਨਾ ਕੰਮ ਕਰਨਾ ਉਸ ਨੂੰ ਚੰਗਾ ਲਗਦਾ ਹੈ। ਨਾਵਲਕਾਰ ਨੇ ਉਸਦੀ ਵਿਗੜੀ ਹੋਈ ਸ਼ਖ਼ਸੀਅਤ ਦੇ ਕਾਰਨ ਉਸਦੀ ਘਰੇਲੂ ਅਵਸਥਾ ਤੇ ਆਲੇ ਦੁਆਲੇ ਵਿੱਚੋਂ ਲੱਭੇ ਹਨ ਅਤੇ ਇਹ ਦੱਸਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕੀਤੀ ਹੈ ਕਿ ਪ੍ਰਾਪਤ ਪ੍ਰਸਥਿਤੀਆਂ ਵਿਚ ਗੋਰਾ ਇਹੋ ਜਿਹਾ ਹੀ ਹੋ ਸਕਦਾ ਸੀ। ਗੋਰਾ ਆਪਣੀ ਆਪਣੇ ਨਾ ਪੜ੍ਹ ਸਕਣ ਦਾ ਕਾਰਨ ਘਰ ਦਾ ਲੋੜ ਤੋਂ ਵੱਧ ਕੰਮ ਸਮਝਦਾ ਹੈ ਅਤੇ ਆਪਣੀ ਮਾਂ ਨਾਲ ਲੜ ਕੇ ਉਸਨੂੰ ਕਹਿੰਦਾ ਹੈ:-

"ਮੂੰਹ ਟੱਡ ਕੇ ਕਹਿ ਦੂ, ਪੜ੍ਹ ਲਿਆ ਕਰ, ਪੜ੍ਹ ਕਿਹੜੇ ਵੇਲੇ ਲਿਆ ਕਰਾਂ। ਸਕੂਲੋਂ ਔਣ ਨੀ ਦਿੰਦੀ, ਪਹਿਲਾਂ ਮਸ਼ੀਨ ਮੂਹਰੇ ਜੋੜ ਲੈਨੀ ਐਂ, ਖੇਤੇ ਪੱਠੇ ਚੁਕਾ ਲਿਆ, ਕੁੜੀ ਚੁੱਕ ਲੈ, ਪਸ਼ੂਆਂ ਨੂੰ ਪਾਣੀ ਪਿਆ-ਅਹੁ ਕਰ ਦੇ, ਆਹ ਕਰਦੇ-ਸਤਾਰਾਂ ਸੌ ਕੰਮ ਗਿਣਾ ਦਿੰਨੀ ਐਂ।"[8]

ਪੂਰੇ ਨਵਾਲ ਵਿਚ ਗੋਰੇ ਦਾ ਪਾਤਰ ਚਿਤਰਨ ਇਸੇ ਵਿਧੀ ਦੁਆਰਾ ਹੋਇਆ ਹੈ। ਲੇਖਕ ਨੇ ਉਸਦੇ ਚਰਿੱਤਰ ਦਾ ਇੱਕ ਖਾਸ ਦਿਖਾ ਕੇ ਨਾਲ ਹੀ ਪ੍ਰਤੀਕੂਲ ਸਥਿਤੀਆਂ ਦਾ ਵਰਨਣ ਕੀਤਾ ਹੈ। ਜਿਹੜੀਆਂ ਗੋਰੇ ਦੀ ਸ਼ਖ਼ਸੀਅਤ ਵਿਚ ਵਿਗਾੜ ਪੈਦਾ ਕਰਦੀਆਂ ਹਨ। ਇਹੀ ਪ੍ਰਤੀਕੂਲ ਸਥਿਤੀਆਂ ਗੋਰੇ ਨੂੰ ਅੱਖੜ, ਬੇਲਿਹਾਜ ਤੇ ਕੋੜੈ ਸੁਭਾਅ ਵਾਲੇ ਵਿਅਕਤੀ ਦੇ ਰੂਪ ਵਿੱਚ ਪਾਠਕਾਂ ਦੇ ਸਨਮੁੱਖ ਲਿਆਉਂਦੀਆਂ ਹਨ। 'ਰੋਹੀ ਬੀਆਬਾਨ' ਨੂੰ ਨਾਇਕਤਵ ਨਾਵਲ ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਕਿਉਂਕਿ ਉਸਦੇ ਮੁੱਖ ਪਾਤਰ ਹਲਾਤ ਦੇ ਅੱਗੇ ਬੇਵਸ ਤੇ ਮਜ਼ਬੂਰ ਹਨ ਤੇ ਸਾਰੇ ਸੰਘਰਸ਼ ਦੇ ਬਾਵਜੂਦ ਉਹਨਾਂ ਨੂੰ ਹਾਰ ਦਾ ਮੂੰਹ ਦੇਖਣਾ ਪੈਂਦਾ ਹੈ। ਪਰ ਇਸਦਾ ਇਹ ਮਤਲਬ ਨਹੀਂ ਕਿ ਉਹ ਅਨਾਇਕ ਹਨ। ਗੋਰੇ ਦੇ ਕਿਰਦਾਰ ਵਿੱਚ ਨਾਇਕ ਦੇ ਗੁਣ ਭਰੇ ਹੋਏ ਹਨ ਅਤੇ ਉਸਦੀ ਅਣਖ ਉਸਨੂੰ ਗਲਤ ਕੰਮ ਪ੍ਰਤੀ ਡਟ ਕੇ ਖੜਨ ਤੇ ਪ੍ਰਤੀਕੂਲ ਸਥਿਤੀਆਂ ਨਾਲ ਸਮਝੌਤਾ ਨਾ ਕਰਨ ਦੀ ਦਲੇਰੀ ਕੁਝ ਅਜਿਹੇ ਗੁਣ ਹਨ, ਜਿਹੜੇ ਉਸਨੂੰ ਅਣਖੀ ਮਨੁੱਖ ਦੇ ਰੂਪ ਵਿਚ ਪੇਸ਼ ਕਰਦੇ ਹਨ ਉਹ ਥਾਂ-ਥਾਂ 'ਤੇ ਸਮਾਜ ਦੀਆਂ ਗਲਤ ਕੀਮਤਾਂ ਬਾਰੇ ਆਪਣਾ ਪ੍ਰਤੀਕਰਮ ਜ਼ਾਹਿਰ ਕਰਦਾ ਹੈ। ਇਹੀ ਉਸਦਾ ਅੰਦਰਲਾ ਨਾਇਕਤਵ ਹੈ।

ਗਿੰਦਰ'ਰੋਹੀ ਬੀਆਬਾਨ' ਨਾਵਲ ਵਿਚ ਨਿਮਨ ਕਿਰਸਾਣੀ ਦੇ ਪ੍ਰਤੀਨਿਧ ਪਾਤਰ ਦੇ ਰੂਪ ਵਿਚ ਉਘੜਿਆ ਹੈ। ਗਿੰਦਰ ਗੋਰੇ ਦਾ ਪਿਤਾ ਹੈ। ਇਸ ਕੋਲ ਪਿਤਾ ਪੁਰਖੀ ਜਾਇਦਾਦ ਵਿੱਚੋਂ ਸਿਰਫ ਪੌਣਾ ਕਿਲਾ ਜ਼ਮੀਨ ਹੈ ਜੋਹੱਡ ਭੰਨਵੀਂ ਮਿਹਨਤ ਕਰਨ ਦੇ ਉਪਰੰਤ ਵੀ ਘਰ ਦਾ ਗੁਜ਼ਾਰਾ ਕਰਨ ਦੇ ਸਮਰੱਥ ਨਹੀਂ ਹੁੰਦਾ ਤੇ ਉਹ ਕਰਜ਼ੇ ਦੇ ਭਾਰ ਹੇਠ ਦਬ ਜਾਂਦਾ ਹੈ। ਉਸ ਅੰਦਰ ਮੋਹ ਭਿੱਜਿਆ ਪਿਤਾ ਦਾ ਦਿਲ ਵੀ ਹੈ। ਉਹ ਗੋਰੇ ਨੂੰ ਕੁੱਟਣ ਮਗਰੋਂ ਪਛਤਾਉਂਦਾ ਵੀ ਹੈ ਤੇ ਪੁਚਕਾਰਦਾ ਵੀ ਹੈ।ਉਹ ਅੱਤ ਦੀਆਂ ਆਰਥਿਕ ਤੰਗੀਆਂ ਵਿਚੋਂ ਵਿਚਰਦਾ ਹੋਇਆ ਵੀ ਇਹੀ ਚਾਹੁੰਦਾ ਹੈ ਕਿ ਉਸਦੇ ਮੁੰਡੇ ਪੜ੍ਹ ਲਿਖ ਜਾਣ ਤੇ ਉਸ ਵਰਗੇ ਨਰਕੀ ਜੀਵਨ ਤੋਂ ਛੁਟਕਾਰਾ ਪਾ ਸਕਣ। ਪਰ ਉਸਦੀਆਂ ਪ੍ਰਸਥਿਤੀਆਂ ਨੇ ਉਸਨੂੰ ਸਾਹ ਸੱਤਹੀਣ ਕਰ ਦਿੱਤਾ ਹੈ। ਇਸ ਲਈ ਉਹ ਗੋਰੇ ਦੇ ਉਲਟ ਜਿਉਂਦੇ ਰਹਿਣ ਲਈ ਹਰ ਨੀਵੇਂ ਤੋਂ ਨੀਵਾਂ ਕੰਮ ਕਰਨ ਲਈ ਤਿਆਰ ਹੋ ਜਾਦਾ ਹੈ। ਇਥੋ ਤੱਕ ਕਿ ਕਰਜਾ ਲਾਹੁਣ ਲਈ ਉਸਨੂੰ ਗੋਰੇ ਦਾ ਸੀਰੀ ਰਲਣਾ ਵੀ ਮਾੜਾ ਨਹੀਂ ਲਗਦਾ ਸਥਿਤੀ ਅੱਗੇ ਪੂਰੀ ਤਰ੍ਹਾਂ ਆਤਮ ਸਮਰਪਣ ਕਰ ਦਿੰਦਾ ਹੈ।ਗਿੰਦਰ ਦਾ ਸੁਭਾਅ ਲਚਕੀਲਾ ਹੈ ਅਤੇ ਸਥਿਤੀ ਅਨੁਸਾਰ ਬਦਲਦਾ ਰਹਿੰਦਾ ਹੈ। ਨਿੱਜੀ ਸਵਾਰਥ ਨੂੰ ਵੀ ਕਈ ਵਾਰ ਮੁੱਖ ਰੱਖਦਾ ਹੈ ਜਿਵੇਂ ਭਰਾ ਨਾਲ ਦੁਆਰਾ ਰਲ ਜਾਂਦਾ ਹੈ ਕਿਉਂਕਿ ਇਸ ਪਿੱਛੇ ਉਸਦਾ ਨਿੱਜੀ ਸਵਾਰਥ ਹੈ ਕਿ ਸਾਂਝੇ ਪਰਿਵਾਰ ਵਿਚ ਉਸਦਾ ਕਰਜ਼ਾ ਉੱਤਰ ਜਾਏਗਾ। ਗਿੰਦਰ ਦਾ ਸੁਭਾਅ ਉਸਦੀਆਂ ਪ੍ਰਸਥਿਤੀਆਂ ਦੀ ਦੇਣ ਹੈ ਉਹ ਇੱਕ ਯਥਾਰਥਕ ਪਾਤਰ ਦੇ ਰੂਪ ਵਿੱਚ ਨਾਵਲ ਵਿੱਚ ਉਘੜਦਾ ਹੈ।

ਮਹਿੰਦਰੋ ਗਿੰਦਰ ਦੀ ਪਤਨੀ ਤੇ ਗੋਰੇ ਦੀ ਮਾਂ ਹੈ। ਦੁਰਗਤ ਦੀ ਮਾਰੀ ਅੱਤ ਦੀ ਮਿਹਨਤ ਕਰਦੀ ਹੋਈ ਸਾਰਾ ਦਿਨ ਖਿੱਝਦੀ 'ਤੇ ਖਪਦੀ ਰਹਿੰਦੀ ਹੈ। ਘਰ ਅਤੇ ਬਾਹਰਲੇ ਕੰਮ ਦਾ ਸਾਰਾ ਬੋਝ ਉਸ 'ਤੇ ਹੈ। ਘਰ ਦੇ ਗੋਹੇ ਕੂੜੇ ਤੋਂ ਲੈ ਕੇ ਰੋਟੀ ਪਕਾਉਣ ਤੱਕ ਦਾ ਸਾਰਾ ਕੰਮ ਉਸਦੇ ਸਿਰ ਹੈ। ਹਰ ਵੇਲੇ ਕੰਮ ਕਰਨ ਨਾਲ ਉਹ ਅੱਕੀ ਥੱਕੀ ਰਹਿੰਦੀ ਹੈ ਤੇ ਬੱਚਿਆਂ ਨੂੰ ਗਾਲ਼ਾਂ ਕੱਢਦੀ ਰਹਿੰਦੀ ਹੈ। ਮਹਿੰਦਰੋ ਬੇਸੱਕ ਬੜੇ ਕੌੜੇ ਤੇ ਕ੍ਰੋਧੀ ਸੁਭਾਅ ਦੀ ਜਾਪਦੀ ਹੈ ਪਰ ਇਸ ਸਭ ਦੇ ਬਾਵਜੂਦ ਉਸ ਅੰਦਰ ਮਾਂ ਦਾ ਦਿਲ ਹੈ। ਉਸਨੂੰ ਆਪਣੇ ਬੱਚਿਆਂ ਨਾਲ ਪਿਆਰ ਹੈ ਜਦੋਂ ਗੋਰੇ ਦੀਆਂ ਆਦਤਾਂ ਤੋਂ ਤੰਗ ਹੁੰਦੀ ਹੈ, ਇਕੋ ਸਾਰੇ ਉਸਨੂੰ ਗਾਲ਼ਾਂ ਕੱਢਦੀ ਹੈ, ਗਿੰਦਰ ਕੋਲ ਉਸਦੀਆਂ ਸ਼ਕਾਇਤਾਂ ਵੀ ਕਰਦੀ ਹੈ ਪਰ ਗਿੰਦਰ ਜਦੋਂ ਉਸਨੂੰ ਕੁੱਟਦਾ ਹੈ ਤਾਂ ਉਹ ਲੜ ਪੈਂਦੀ ਹੈ। ਉਹ ਆਪਣੇ ਪੁੱਤਰਾਂ ਨੂੰ ਇੱਜ਼ਤਦਾਰ ਜ਼ਿੰਦਗੀ ਜਿਉਂਦੇ ਵੇਖਣਾ ਚਾਹੁੰਦੀ ਹੈ। ਇਸੇ ਲਈ ਜਦੋਂ ਉਸਨੂੰ ਪਤਾ ਲਗਦਾ ਹੈ ਕਿ ਬੇਕਰੀ ਦਾ ਮਾਲਕ ਗੋਰੇ ਤੋਂ ਗੋਹਾ ਕੂੜਾ ਚੁਕਾਉਣਾ ਚਾਹੁੰਦਾ ਹੈ ਤਾਂ ਉਹ ਮਾਲਕ ਤੇ ਆਪਣੇ ਭਰਾ ਨੂੰ ਗਾਲ਼ਾਂ ਕੱਢਦੀ ਹੈ।

"ਔਣ ਦੇ ਉਹਨੂੰ ਐਥੇ, ਪੁੱਛੂੰ ਉਹਦਾ ਗੋਤ! ਯੱਦਾ ਹੋਇਐ, ਕੰਮ ਲੱਭ ਕੇ ਦੇਣ ਦਾ ਨਾ, ਗੋਹਾ ਸਿੱਟਣੇ ਤਾਂ ਘਰੇ ਥੋੜੈ? ਅਪਾਦਾ ਈ ਸਿੱਟੀ ਜਾਮਾਂਗੇ!ਤੂੰ ਉਸੇ ਸਰਦਾਰ ਦੇ ਮੂੰਹ 'ਤੇ ਮਾਰਨਾ ਸੀ, ਗੋਹੇ ਦਾ ਭਰਿਆ ਬੱਠਲ਼!..... ਮੈਂ ਤਾਂ ਕਦੇ ਗੋਹਾ ਹਟਾਉਣ ਨੀ ਲਾਏ ਤੂੰ ਮੇਰੇ ਮੁੰਡੇ ਨੂੰ ਗੋਹਾਂ ਸਿੱਟਣ ਲਾਵੇ! ਕੋਈ ਨਾ ਆਵੇ ਸੀ, ਐਤਕੀਂ ਪਾੜੇ ਊਹਦਾ ਬੱਬਰ ਕੀੜੇ ਪੈਣਿਐ ਤੂੰ ਭਰਾ ਬਣ ਕੇ ਮੇਰੇ ਪੱਤ ਨਾਲ ਐਂ ਕੀਤੀ!" ਗੋਹਾ ਤਾਂ ਦੁਸ਼ਮਣ ਵੀ ਨਹੀਂ, ਸੁਟਾਉਂਦੇਂ।"[9]

ਸਾਰੇ ਨਾਵਲ ਵਿੱਚ ਉਹ ਇੱਕ ਅਜਿਹੀ ਔਰਤ ਦੇ ਰੂਪ ਵਿੱਚ ਸਾਹਮਣੇ ਆਉਂਦੀ ਹੈ ਜੋ ਇੱਜਤ ਅਣਖ ਵਾਲਾ ਜੀਵਨ ਬਤੀਤ ਕਰਨਾ ਚਾਹੁੰਦੀ ਹੈ। ਪਰ ਹਾਲਾਤ ਅਨੁਕੂਲ ਨਾ ਹੋਣ ਕਾਰਨ ਉਹ ਸਥਿਤੀ ਨਾਲ ਸਮਝੌਤਾ ਕਰ ਲੈਦੀ ਹੈ।

ਸੰਖੇਪ ਰੂਪ ਵਿੱਚ ਕਰਮਜੀਤ ਸਿੰਘਕੁੱਸਾ ਦੀ ਪਾਤਰ ਚਿਤਰਣ ਵਿਧੀ ਸੰਬੰਧੀ ਅਸੀਂ ਕਹਿ ਸਕਦੇ ਹਾਂ ਕਿ ਉਸਨੇ ਆਪਣੇ ਪਾਤਰਾਂ ਨੂੰ ਸਮਾਜਕ, ਸੰਸਕ੍ਰਿਤਿਕ ਤੇ ਮਨੋਵਿਗਿਆਨਿਕ ਮਾਹੌਲ ਵਿੱਚ ਪੇਸ਼ ਕਰਕੇ ਪਾਤਰ ਚਿਤਰਣ ਦੀ ਯਥਾਰਥਵਾਦੀ ਵਿਧੀ ਅਪਣਾਈ ਹੈ, ਉਸਨੇ ਸਾਰੇ ਨਾਵਲ ਵਿੱਚ ਆਪਣੇ ਪਾਤਰਾਂ ਨੂੰ ਉਨ੍ਹਾਂ ਦੇ ਕਾਰਜ ਰਾਹੀਂ ਚਿਤਰਣ 'ਤੇ ਵਧੇਰੇ ਜ਼ੋਰ ਦਿੱਤਾ ਹੈ। ਸੋ ਉਸਦੇ ਪਾਤਰ ਜਿਉਂਦੇ ਜਾਗਦੇ ਵਾਸਤਵਿਕ ਮਨੁੱਖ ਦੇ ਰੂਪ ਵਿੱਚ ਉਘੜੇ ਹਨ।

4.2 ਵਾਰਤਾਲਾਪ 'ਤੇ ਭਾਸ਼ਾ:-

ਵਾਰਤਾਲਾਪ ਨਾਵਲ ਦਾ ਇਕ ਅਹਿਮ ਤੱਤ ਹੈ। ''ਨਾਵਲ ਵਿਚ ਵਾਰਤਾਲਾਪ ਭਾਵੇਂ ਨਾਟਕ ਵਾਂਗ ਕੇਂਦਰੀ ਮਹਾਨਤਾ ਤਾਂ ਨਹੀ ਰੱਖਦੇ ਅਥਵਾ ਏਨੀ ਜ਼ਿਆਦਾ ਗਿਣਤੀ ਵਿਚ ਨਹੀਂ ਹੁੰਦੇ, ਫਿਰ ਵੀ ਨਾਟਕੀ ਬਣਤਰ ਵਿਚ ਇਨ੍ਹਾਂ ਦੀ ਆਪਣੀ ਵਿਸ਼ੇਸ਼ ਤੇ ਵਿਲੱਖਣ ਥਾਂ ਹੁੰਦੀ ਹੈ। ਵਾਰਤਾਲਾਪ ਜਾਂ ਸੰਵਾਦ ਨਾਵਲੀ ਘਟਨਾਵਾਂ ਨੂੰ ਸੁਭਾਵਿਕ ਰੂਪ ਵਿਚ ਆਪਸ ਵਿਚ ਜੋੜਦੇ ਹਨ।''[10] ਸੋ ਵਾਰਤਾਲਾਪ ਨਾਵਲ ਦਾ ਇਕ ਜ਼ਰੂਰੀ ਤੱਤ ਹੈ। ਨਾਵਲਕਾਰ ਨੇ ਵਾਤਾਲਾਪ ਬੜੇ ਢੁਕਵੇਂ ਵਰਤੇ ਹਨ । ਵਾਰਤਾਲਾਪ ਰਾਹੀਂ ਹੀ ਉਹ ਪਾਤਰਾਂ ਬਾਰੇ ਅਹਿਮ ਜਾਣਕਾਰੀ ਦਿੰਦਾ ਹੈ ਜਿਵੇਂ ਇਸ ਨਾਵਲ ਦੇ ਮੁੱਖ ਪਾਤਰ ਦਾ ਚਰਿਤਰ ਦੱਸਣ ਵਾਸਤੇ ਉਹ ਵਾਰਤਾਲਾਪ ਦਾ ਸਹਾਰਾ ਲੈਂਦਾ ਹੈ ਜਿਵੇਂ ਗੋਰੇ ਦੇ ਹਰ ਰੋਜ਼ ਦੇਰ ਨਾਲ ਸਕੂਲ ਜਾਣ ਬਾਰੇ ਦੱਸਣ ਲਈ ਕੁੱਸਾ ਗੋਰੇ ਅਤੇ ਮਾਸਟਰ ਦੇ ਵਾਰਤਾਲਾਪ ਦਾ ਸਹਾਰਾ ਲੈਂਦਾ ਹੈ ਜਿਵੇਂ:

''ਤੂੰ ਐਨਾ ਚਿਰ ਘਰੇ ਆਂਡਿਆਂ 'ਤੇ ਬੈਠਾ ਹੁੰਦੈਂ ਉਇ?''''ਜੀ, ਮੇਰੀ ਜੀ, ਬੀਬੀ ਖੇਤ ਨੂੰ ਗਈ ਸੀ।''

''ਤੇ ਤੂੰ ਬੰਟਿਆਂ ਨਾਲ ਖੇਡਦਾ ਰਿਹੈ?''[11]

''ਨਈਂ ਜੀ, ਸਾਡੇ ਘਰੇ ਨ੍ਹੀ ਸੀ ਜੀ, ਕੋਈ....ਜੀ।''

ਇਸ ਤੋਂ ਇਲਾਵਾ ਲੇਖਕ ਨੇ ਖੁਦ ਵੀ ਪਾਤਰਾਂ ਨਾਲ ਵਾਰਤਾਲਾਪ ਰਚਾ ਕੇ ਵੀ ਗੋਰੇ ਦੇ ਚਰਿੱਤਰ ਨੂੰ ਉਜਾਗਰ ਕੀਤਾ ਹੈ:

''.....ਜਦੋਂ ਉਸ ਧੌਣ ਭੁਆ ਕੇ ਗੋਰੇ ਵਲ ਵੇਖਿਆ ਤਾਂ ਉਹ ਕਿਸੇ

ਸਰਦਾਰ ਵਾਂਗ ਆਕੜਿਆ ਕਰੁੱਖਤ ਜਿਹਾ ਝਾਕ ਰਿਹਾ ਸੀ।

''ਮਾਸਟਰ ਨੂੰ ਆਪਣੇ ਆਪ ਉਤੇ ਹੀਣਤਾ ਮਹਿਸੂਸ ਹੋਈ''

''ਇਹ ਕੱਲ੍ਹ ਦਾ ਛੋਹਰ ਉਸ ਦੇ ਮੂਹਰੇ ਆਕੜਿਆ ਖੜੈ''

ਪਲ ਝਟ ਅਧਿਆਪਕ ਢਾਕਾਂ 'ਤੇ ਹੱਥ ਰੱਖੀ ਵਿੰਹਦਾ ਰਿਹਾ।''[12]

ਇਨ੍ਹਾਂ ਵਾਰਤਾਲਾਪਾਂ ਰਾਹੀਂ ਕੁੱਸਾ ਨੇ ਨਿਮਨ ਕਿਸਾਨੀ ਬਾਰੇ ਇਹ ਗੱਲ ਸਪੱਸ਼ਟ ਕੀਤਾ ਹੈ ਕਿ ਉਹ ਆਰਥਿਕ ਪੱਧਰ 'ਤੇ ਕਮਜ਼ੋਰ ਹੋਣ ਦੇ ਬਾਵਜੂਦ ਮਾਨਸਿਕ ਤੌਰ ਤੇ ਆਪਣੇ ਆਪ ਨੂੰ ਸਰਦਾਰ ਮੰਨਦੇ ਹਨ।ਕੁੱਸਾ ਦੀ ਪ੍ਰਭਾਵਸ਼ਾਲੀ ਭਾਸ਼ਾ ਦੀ ਸਫ਼ਲ ਵਰਤੋਂ ਦੀ ਪ੍ਰਮਾਣਤਾ ਇਸ ਗੱਲ ਵਿਚ ਵੀ ਮਿਲਦੀ ਹੈ ਜਦੋਂ ਉਸ ਨੇ ਪੇਂਡੂ ਲੋਕਾਂ

ਦੀ ਆਮ ਬੋਲ-ਚਾਲ ਦੀ ਭਾਸ਼ਾ ਵਿਚ ਵਰਤੀਆਂ ਜਾਂਦੀਆ ਗਾਲ੍ਹਾਂ ਦੀ ਵਰਤੋਂ ਉਸ ਨੇ ਸਮੁੱਚੇ ਨਾਵਲ ਵਿਚ ਕੀਤੀ ਹੈ। ਜਿਵੇਂ ਕਿ,

> ''ਘੋਅਟੀ: ਉਹ (ਮਹਿੰਦਰੋ) ਕੁੜੀ ਯਾਵ੍ਹੇ ਦੀ ਮੈਸ-ਜੀ ਖਾ ਲੈਂਦੀ ਐ,ਪੀ ਲੈਂਦੀ ਐ, ਸੂਰੀ ਆਂਗੂ ਸ਼ੂਕਦੀ ਰਹਿੰਦੀ ਐ। ''[13]
>
> ਜਾਂ-ਘੋਅਟੀ ਦੇ ਗਿੰਦਰ ਨੂੰ ਆਖੇ ਇਹ ਬੋਲ,
>
> ''ਮੈਨੂੰ ਤਾਂ ਕੁੱਤਾ ਤੇਰੇ ਪੁੱਤਾਂ ਨਾਲੋਂ ਵੱਧ ਪਿਆਰਾ ਐ। ''[14]

ਇਹਨਾਂ ਪਾਤਰਾਂ ਦੀ ਭਾਸ਼ਾ ਵਿਚ ਨੈਤਿਕ ਸ਼ਿਸ਼ਟਾਚਾਰ ਦੇ ਆਸ਼ੇ ਮੂਲੋਂ ਹੀ ਗਾਇਬ ਹਨ। ਨਿਸ਼ੰਗ ਸ਼ਬਦ ਸਭ ਨੂੰ ਇਕ ਦੂਸਰੇ ਸਾਹਮਣੇ ਨਿਰਲੱਜ ਕਰ ਕੇ ਖੜਾ ਕਰਦੇ ਜਾਂਦੇ ਹਨ।ਮਹਿੰਦਰੋ ਦੀ ਸਰੀਰਿਕ ਬਣਤਰ ਵੀ ਕੁੱਸਾ ਨੇ ਵਾਰਤਾਲਾਪ ਹੀ ਵਰਤੋਂ ਕੀਤੀ ਹੈ

> ''ਉਇ ਗੋਰੇ ਦੀ ਬੀਬੀ ਮੈਸ ਆਂਗੂੰ ਤੁਰਦੀ ਐ। ''''ਵੱਡਾ ਸਾਰਾ ਢਿੱਡ ਐ.....ਢਿੱਡਲ੍ਹ ਜੀ ਤਾਂ ਹੈਗੀਐ। ''[15]
>
> ''**ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਹੋਰਨਾਂ ਮਲਵਈ ਲੇਖਕਾਂ ਵਾਂਗ ਬੋਲਚਾਲ ਦੇ ਵਿਚ ਮਲਵਈ ਉਪ-ਭਾਸ਼ਾ ਵਰਤੀ ਹੈ।** ਪਰੰਤੂ ਉਸ ਨੂੰ ਗੱਲ ਕਰਨ ਸਮੇਂ ਹਾਵ-ਭਾਵ ਦੀ ਤਸਵੀਰ-ਤਰਾਸ਼ੀ ਕਰਨ ਦੀ ਕਲਾ ਦੀ ਬਹੁਤ ਮੁਹਾਰਤ ਹੈ, ਜਿੰਨੇ ਚੰਗੇ ਢੰਗ ਨਾਲ ਉਸ ਨੇ ਆਪਣੇ ਨਾਵਲਾਂ ਤੇ ਖਾਸ ਕਰਕੇ ਹਥਲੇ ਨਾਵਲ ਵਿਚ ਕੀਤਾ ਹੈ, ਹੋਰ ਕੋਈ ਲੇਖਕ ਅਜਿਹਾ ਨਹੀਂ ਕਰ ਸਕਿਆ। ਉਹਨੇ ਪੇਂਡੂ ਪਾਤਰਾਂ, ਬੱਚਿਆਂ, ਮਾਲ ਚਾਰਨ ਵਾਲਿਆਂ, ਡਰਾਈਵਰਾਂ, ਮਿਸਤਰੀਆਂ ਦੀ ਮਾਨਸਿਕਤਾ ਨੂੰ ਬਹੁਤ ਡੂੰਘਾਈ ਨਾਲ ਘੋਖਿਆ ਤੇ ਪੇਸ਼ ਕੀਤਾ ਹੈ। ''[16]

4.3 ਪਲਾਟ:-

ਨਾਵਲੀ-ਰਚਨਾ ਵਿਚ ਪ੍ਰਮੁੱਖ ਵਸਤੂ ਨਾਵਲ ਦਾ ਕਥਾ-ਜਗਤ ਅਥਵਾ ਕਹਾਣੀ ਹੁੰਦਾ ਹੈ। ''ਇਹ ਕਹਾਣੀ ਅਥਵਾ ਕਥਾ-ਵਸਤੂ ਨੂੰ ਤਰਤੀਬ ਵਿਚ ਬੰਨ੍ਹ ਕੇ ਪਲਾਟ ਹੀ ਪੇਸ਼ ਕਰਦਾ ਹੈ। ਪਲਾਟ ਨਾਵਲੀ ਥੀਮ ਨੂੰ ਸੰਗਠਨ ਕਰਨ ਦਾ ਨਾਮ ਵੀ ਹੈ। ''[17] ਭਾਵ ਕਿ ਘਟਨਾਵਾਂ ਨੂੰ ਕ੍ਰਮਵਾਰ ਪੇਸ਼ ਕਰਨ ਦੇ ਢੰਗ ਤਰੀਕੇ ਨੂੰ ਪਲਾਟ ਕਿਹਾ ਜਾਂਦਾ ਹੈ।

ਇਸ ਨਾਵਲ ਦਾ ਪਲਾਟ ਇਕਹਿਰਾ ਹੈ ਜੋ ਇਕ ਹੀ ਪਰਿਵਾਰ ਦੇ ਦੁਆਲੇ ਘੁੰਮਦਾ ਹੈ। ਨਾਵਲ ਵਿਚ ਅਨੇਕਾ ਗਲਪੀ ਜੁਗਤਾਂ ਰਾਹੀਂ ਘਟਨਾਵਾਂ ਨੂੰ ਤਰਤੀਬ ਦਿੱਤੀ ਗਈ ਹੈ। ਜਿਵੇਂ ਕਿ ਅਰੰਭਿਕ ਦੌਰ ਵਿਚ ਗੋਰੇ ਦਾ ਪੜ੍ਹਾਈ ਪ੍ਰਤੀ ਰੁਚਿਤ ਨਾ ਹੋਣਾ, ਵਾਰ-ਵਾਰ ਫੇਲ੍ਹ ਹੋਣਾ। ਗੋਰਾ ਜਦੋਂ ਫੇਲ੍ਹ ਹੁੰਦਾ ਹੈ ਤਾਂ ਗੋਰੇ ਨੂੰ ਦੁੱਖ ਤਾਂ ਲੱਗਦਾ ਹੈ ਪਰ ਉਹ ਲਕਾਉਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ।

> ਸ਼ਾਰਜੈਂਟ " ਉਇ ਗੋਰਿਆ, ਤੂੰ ਫੇਲ੍ਹ ਹੋ ਗਿਆ।" "ਤਾਂ ਕੀ ਹੋ ਗਿਆ?" ਗੋਰੇ ਨੇ ਗੜਕੇ ਨਾਲ ਉਤਰ ਦੇਣ ਦਾ ਯਤਨ ਕੀਤਾ"[18]

ਇਸ ਵਾਰ ਫੇਲ੍ਹ ਹੋਣ ਤੇ ਗੋਰਾ ਪੜ੍ਹਨ ਤੋਂ ਹੱਟ ਜਾਂਦਾ ਹੈ, ਅਤੇ ਉਹ ਘਰ ਦੇ ਕੰਮਾਂ ਵਿਚ ਦਿਲਚਸਪੀ ਲੈਣ ਲੱਗ ਜਾਂਦਾ ਹੈ। ਨਾਵਲੀ ਬਿਰਤਾਂਤ ਨੂੰ ਅੱਗੇ ਤੋਰਨ ਵਾਸਤੇ ਕੁੱਸਾ ਇਸ ਵਿਚ ਇਕ ਹੋਰ ਘਟਨਾਂ ਜੋੜਦਾ ਹੈ। ਗੋਰੇ ਨੂੰ ਉਸ ਦੇ ਮਾਮੇ ਦੇ ਨਾਲ ਸ਼ਹਿਰ ਭੇਜ ਦਿੱਤਾ ਜਾਂਦਾ ਹੈ ਇਕ ਬੇਕਰੀ ਵਿਚ ਕੰਮ ਕਰਨ ਵਾਸਤੇ। ਪ੍ਰੰਤੂ ਗੋਰੇ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਨੂੰ ਉਸ ਸਮੇਂ ਠੇਸ ਪਹੁੰਚਦੀ ਹੈ ਜਦੋਂ ਬੇਕਰੀ ਮਾਲਿਕ ਉਸ ਨੂੰ ਗੋਹਾ ਸੁੱਟਣ ਵਾਸਤੇ ਕਹਿੰਦਾ ਹੈ, ਤਾਂ ਗੋਰਾ ਅੱਗੋ ਜੁਵਾਬ ਦਿੰਦਾ ਹੈ:

> "ਇਹ ਕੰਮ ਮੈਂ ਨ੍ਹੀ ਕਰਨਾ।"
>
> ਸਰਦਾਰ ਨੂੰ ਮਾੜੀ ਜਿਹੀ ਤਲਖ਼ੀ ਨਾਲ ਪੁੱਛਿਆ
>
> "ਹੋਰ ਕੀ ਕਰੇਂਗਾ?"
>
> ਗੋਰਾ ਫ਼ਿਰ ਜਵਾਬ ਦਿੰਦਾ ਹੈ:
>
> "ਹੋਰ; ਹੋਰ ਜੋ ਮਰਜ਼ੀ ਕਰਾ ਲੋ।" ਉਹਦੇ ਚਿੱਤ 'ਚ ਆਈ ਉਹ ਆਖ ਦੇਵੇ
>
> "ਗੋਹਾ ਸਿੱਟਣਾ ਸੀ ਤਾਂ ਪਿੰਡ ਥੋੜਾ ਸੀ।"[19]

ਇਹ ਵਾਰਤਾਲਾਪ ਸਿਰਜ ਕੇ ਕੁੱਸਾ ਆਪਣੇ ਨਾਵਲ ਨੂੰ ਹੋਰ ਵੀ ਯਥਾਰਥਮਈ ਬਣਾ ਦਿੰਦਾ ਹੈ ਕਿਉਂਕਿ ਜੱਟ ਮਾਨਕਿਸਤਾ ਦੇ ਅੰਦਰ ਇਹ ਸੱਭ ਕੰਮ ਛੋਟੇ ਸਮਝੇ ਜਾਂਦੇ ਹਨ।

ਨਾਵਲੀ ਪਲਾਟ ਵਿਚ ਇਕ ਹੋਰ ਤੱਥ ਸਾਮਹਣੇ ਆਉਂਦਾ ਹੈ ਕਿ ਗੋਰਾ ਸ਼ਰਾਬ ਵੇਚਦਾ, ਪੀਂਦਾ ਅਤੇ ਬੀੜੀਆਂ ਵੀ ਪੀਂਦਾ ਹੈ ਜੋ ਕਿ ਉਸ ਪਰਿਵਾਰ ਵਿਚ ਸੁਭਾਵਿਕ ਗੱਲ ਲੱਗਦੀ ਹੈ ਜਿਸ ਵਿਚ ਗੋਰਾ ਜੰਮਿਆ-ਪਲਿਆ ਹੈ। ਨਾਵਲੀ ਘਟਨਾ ਉਸ ਸਮੇਂ ਹੋਰ ਨਵਾਂ ਮੋੜ ਲੈਦੀ ਹੈ ਜਦੋਂ ਗੋਰਾ ਟਰੱਕ ਸਿੱਖਣ ਵਾਸਤੇ ਜਾਂਦਾ ਹੈ।

ਪਰ ਉਥੇ ਵੀ ਗੋਰੇ ਦੀ ਕਿਸਮਤ ਉਸ ਦਾ ਸਾਥ ਨਹੀਂ ਦਿੰਦੀ। ਤੇਲੂ ਉਸ ਨਾਲ ਬੁਰਾ ਸਲੂਕ ਕਰਦਾ ਹੈ। ਖ਼ੁਦ ਮੀਟ ਨਾਲ ਰੋਟੀ ਖਾਂਦਾ ਹੈ ਅਤੇ ਗੋਰੇ ਨੂੰ ਸਾਦੀ ਰੋਟੀ ਮਿਲਦੀ ਹੈ। ਗੋਰੇ ਨੂੰ ਕੱਪੜੇ ਧੋਣ ਵਾਸਤੇ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਗੋਰਾ ਅੱਗੋਂ ਜਵਾਬ ਦਿੰਦਾ ਹੈ:

"ਮੈਂ ਚਾਚਾ ਕਦੇ ਧੋਤੇ ਨ੍ਹੀ, ਵਾਸਤਾ ਨ੍ਹੀ।"

ਤੇਲੂ"ਧੋਤੇ ਨ੍ਹੀ ਇਹਨੇ ਵੱਡੇ ਲੌਢ-ਘਰੀਏ ਨੇ! ਘਰੇ ਬੇਬੇ ਦੇ ਆਂਡਿਆਂ 'ਤੇ ਬੈਠਾ ਹੁੰਦਾ ਸੀ, ਇਹੇ।"[20]

ਗੋਰਾ ਸਭ ਕੁੱਝ ਛੱਡ ਕੇ ਪਿੰਡ ਆ ਜਾਂਦਾ ਹੈ। ਨਾਵਲੀ ਪਲਾਟ ਵਿਚ ਇਕ ਹੋਰ ਗਾਲਪਨਿਕ ਘਟਨਾਉਸ ਸਮੇਂ ਆਉਂਦੀ ਹੈ ਜਦੋਂ ਗੋਰਾ ਵਿਦੇਸ਼ ਜਾਣ ਵਾਸਤੇ ਆਪਣੇ ਸ਼ਰੀਕ ਤੋਂ ਪੈਸੇ ਲੈਦਾ ਹੈ ਅਤੇ ਵਿਦੇਸ਼ ਜਾਣ ਤੋਂ ਅਸਫ਼ਲ ਰਹਿਣ 'ਤੇ ਕਰਜ਼ੇ ਹੇਠ ਆ ਜਾਂਦਾ ਹੈ, ਜਿਸ ਨੂੰ ਉਤਾਰਨ ਲਈ ਉਸ ਨੂੰ ਸੀਰੀ ਰਲਣ ਵਾਸਤੇ ਕਿਹਾ ਜਾਂਦਾ ਹੈ।ਜ਼ਮੀਨੋਂ ਟੁੱਟ ਕੇ ਕਿਸਾਨ ਲਈ ਕੋਈ ਧਰਮ ਜਾਂ ਈਮਾਨ ਨਹੀਂ ਰਹਿ ਜਾਂਦਾ। ਉਹ ਆਪਣੀ ਹੋਂਦ ਕਾਇਮ ਰੱਖਣ ਲਈ ਹਰ ਕੁਕਰਮ ਕਰਦਾ ਅਤੇ ਉਸ ਨੂੰ ਜ਼ਾਇਜ਼ ਸਮਝਦਾ ਹੈ ਅਤੇ ਇਸ ਦੇ ਖ਼ਤਮ ਹੋਣ 'ਤੇ ਦਰੇਗ਼ ਕਰਦਾ ਹੈ। ਪ੍ਰੰਤੂ ਨਾਵਲਕਾਰ ਕਰਮਜੀਤ ਸਿਘ ਕੁੱਸਾ ਅਜਿਹਾ ਨਹੀਂ ਕਰਦਾ। ਉਸ ਨੂੰ ਪਤਾ ਹੈ ਕਿ ਕਿਸਾਨੀ ਦੀ ਹੋਣੀ ਸੀਰੀ ਬਣਨਾ ਹੈ। ਉਸ ਨੂੰ ਕਿਸਾਨੀ ਦੇ ਸਾਰੇ ਪੱਖਾਂ ਨੂੰ ਸੰਕਟ-ਗ੍ਰਸਤ ਗੋਣ 'ਤੇ ਇਸ ਦੇ ਸਮਾਂ ਵਿਹਾ ਚੁੱਕੀ ਹੋਣ ਦਾ ਅਹਿਸਾਸ ਹੈ ਇਸ ਲਈ ਉਹਦਾ ਮੋਹ-ਭੰਗ ਹੋ ਚੁੱਕਿਆ ਹੈ। "ਇਸੇ ਮੋਹ ਭੰਗ ਨੂੰ ਉਹ ਆਪਣੇ ਨਾਵਲ ਵਿਚ ਪੇਸ਼ ਕਰਦਾ ਹੈ।"[21] ਗੋਰੇ ਲਈ ਸੀਰੀ ਰਲਣਾ ਹੋਣੀ ਦੇ ਬਰਾਬਰ ਹੁੰਦਾ ਹੈ ਅਤੇ ਉਹ ਇਹ ਗੱਲ ਸੁਣ ਕੇ ਆਖਦਾ ਹੈ:

ਗੋਰਾ"ਭਲੇ ਆਲ੍ਹੀ ਇਹਨਾਂ ਦੀ ਗੱਲ ਨੂੰ ਮੈਂ ਭੁੱਲਿਆ। ਇਹ ਤਾਂ ਕਹਿੰਦੇ ਐ, ਸੀਰੀ ਰਲ੍ਹੇ।"

ਗਿੰਦਰ"ਹੋਰ ਕੀ ਸਾਲਿਆ। ਤੂੰ ਠਾਣੇਦਾਰ ਲੱਗੇਂਗਾ।"

ਗੋਰਾ"ਠਾਣੇਦਾਰ ਲੱਗਾਂ ਚਾਹੇ ਨਾ ਲੱਗਾਂ। ਪਰ ਮੈਂ ਸੀਰੀ ਨ੍ਹੀ ਰਲਣਾ।"

"ਪੰਜ ਹਜ਼ਾਰ ਰੋਜ਼ ਸੁਣਾ ਦਿੰਦੇ ਐ। ਮੈਂ ਥੋਡੇ ਪੈਰੀਂ ਪੱਗ ਧਰੀ ਸੀ।"

ਗਿੰਦਰ "ਤੂੰ ਤਾਂ ਫੇਰ ਕੁੱਤੀ ਦਿਆ ਪੁੱਤਾ ਪੈਂਰੀ ਪੱਗ ਧਰੀ ਨ੍ਹੀ ਸੀ। ਹੁਣ ਐਥੇ ਫੇਰੇ ਦੇਣੇ ਆਉਨੈ। ਜੇ ਬੰਦੇ ਦਾ ਪੁੱਤ ਐਂ ਤਾਂ ਦਰੋਂ ਬਾਹਰ ਹੋ ਜ੍ਹਾ।"

ਗੋਰਾ "ਕਿਉਂ ਦਰੋਂ ਬਾਹਰ ਹੋ ਜਾਂ? ਕਿਹੜਾ ਕੰਜਰ ਮੈਨੂੰ ਘਰੋਂ ਕੱਢਣ ਆਲਾ।"[22]

''**ਪ੍ਰਤੀਕਵਾਦੀ** ਬਿਰਤਾਂਤ ਸ਼ੈਲੀ ਵਿਚ ਲਿਖੇ ਗਏ ਨਾਵਲ ਦਾ ਇਹ ਅੰਤ ਪ੍ਰਤੀਕਾਤਮਕ ਹੈ ਜਿਸ ਦਾ ਮਨੋਰਥ ਹਰੀ ਕ੍ਰਾਂਤੀ ਅਤੇ ਖੇਤੀ ਦੇ ਮਸ਼ਨੀਕਰਣ ਦੇ ਨਾਅਰੇ ਅਧੀਨ ਅਣਗੌਲੀ ਪਈ ਛੋਟੀ ਕਿਰਸਾਣੀ ਦੇ ਆਰਥਿਕ ਸਮਾਜਕ ਦੁਖਾਂਤ ਨੂੰ ਉਜਾਗਰ ਕਰਨਾ ਹੈ। ''[23]

ਸੋ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਇਕ ਸਫ਼ਲ ਨਾਵਲਕਾਰ ਹੈ ਜਿਸ ਨੇ ਆਪਣੇ ਇਸ ਨਾਵਲ ਰਾਹੀਂ ਪੰਜਾਬੀ ਨਾਵਲ ਜਗਤ ਵਿਚ ਆਪਣਾ ਵਿਲੱਖਣ ਸਥਾਨ ਬਣਾ ਲਿਆ ਹੈ। ਉਹ ਆਪਣੇ ਸਮੇਂ ਦਾ ਸਭ ਤੋਂ ਵੱਧ ਚਰਚਿਤ ਨਾਵਲਕਾਰ ਹੈ। ਉਸ ਦੇ ਨਾਵਲਾਂ ਨੂੰ ਅੱਜ ਵੀ ਬੜ੍ਹੇ ਉਤਸ਼ਾਹ ਨਾਲ ਪੜ੍ਹਿਆ ਜਾਂਦਾ ਹੈ।

4.4 ਸਿਰਲੇਖ:-

ਸਿਰਲੇਖ ਨਾਵਲ ਦਾ ਇਕ ਮਹੱਤਵ ਪੂਰਨ ਤੱਤ ਹੈ। ਜਿੰਨਾਂ ਨਾਵਲ ਦਾ ਸਿਰਲੇਖ ਢੁਕਵਾਂ ਹੋਵੇਗਾ ਉਨਾਂ ਹੀ ਪਾਠਕ ਉਸ ਵੱਲ ਰੁਚਿਤ ਹੋਵੇਗਾ। ਨਾਵਲ ਦਾ ਸਿਰਲੇਖ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਪੜ ਹੀ ਪਾਠਕ ਦੇ ਮਨ ਵਿਚ ਨਾਵਲ ਨੂੰ ਪੜ੍ਹਨ ਦੀ ਖਿੱਚ ਪੈਂਦੀ ਹੈ। ਨਾਵਲ ਦਾ ਸਿਰਲੇਖ ਰੋਹੀ ਬੀਆਬਾਨ **ਪ੍ਰਤੀਕਾਤਮਕ** ਹੈ। ਇਹ ਇੱਕ ਪਾਸੇ ਪੰਜਾਬ ਦੇ ਖੇਤੀ ਪ੍ਰਧਾਨ ਸਮਾਜ ਦੀ ਉਸ ਨਿੱਘਰੀ ਹੋਈ ਅਵਸਥਾ ਵੱਲ ਇਸ਼ਾਰਾ ਕਰਦਾ ਹੈ ਜਿਸ ਨੇ ਇਸ ਨੂੰ ਸੁੰਨਸਾਨ ਜੰਗਲ ਵਿਚ ਤਬਦੀਲ ਕਰ ਦਿੱਤਾ ਹੈ ਉਸ ਦੇ ਸਾਹਮਣੇ ਘੁੱਪ ਹਨ੍ਹੇਰਾ ਹੈ। ਜਿਸ ਵਿਚੋਂ ਨਿਕਲਣ ਲਈ ਉਸ ਕੋਲ ਚੇਤਨਾ ਦੀ ਰੌਸ਼ਨੀ ਨਹੀਂ ਹੈ ਦੂਜੇ ਪਾਸੇ ਪੂੰਜੀਵਾਦੀ ਦੌਰ ਵਿਚ ਦਿਨੋ ਦਿਨ ਖਤਮ ਹੁੰਦੀਆਂ ਮਨੁੱਖੀ ਕੀਮਤਾਂ ਵੱਲ ਇਸ਼ਾਰਾ ਹੈ ਜਿਨ੍ਹਾਂ ਦੀ ਅਣਹੋਂਦ ਵਿੱਚ ਮਨੁੱਖ ਮੁੜ ਜੰਗਲੀ ਸਭਿਅਤਾ ਵੱਲ ਜਾ ਰਿਹਾ ਹੈ। ਇਕੱਲਤਾ ਦਾ ਸੰਤਾਪ ਹੁੰਦਾ ਰਿਹਾ ਹੈ ਕਿਉਂਕਿ ਮਨੁੱਖੀ ਸਾਂਝ ਦਾ ਪ੍ਰਤੀਕ ਪਿੰਡ ਤਾਂ ਸੁੱਚੀਂ-ਮੁੱਚੀਂ ਮਰ ਗਿਆ ਹੈ। ਸਮਕਾਲੀ ਪੰਜਾਬ ਦੇ ਪਿੰਡਾਂ ਦੇ ਸੰਕਟ ਗ੍ਰਸਤ ਦ੍ਰਿਸ਼ ਨੂੰ ਨਾਵਲਕਾਰ ਨੇ ਰੂਪਕ ਦੇ ਪੱਧਰ ਉੱਤੇ ਰੋਹੀ ਬੀਆਬਾਨ ਆਖਿਆ ਹੈ। ਇਸ ਮੋਏ ਪਿੰਡ ਦੇ ਵਾਸੀ ਆਪਣੀਆਂ ਲੋੜਾਂ ਥੋੜਾਂ ਵਿੱਚ (ਫਸੇ) ਗ੍ਰਸੇ ਤੇ ਆਪਣੇ ਨਿੱਜੀ ਦੁੱਖਾਂ ਹੇਠ ਤ੍ਰਿਹਾਏ ਹਨ। ਲੇਖਕ ਨੇ ਆਪਣੇ ਇਸ ਨਾਵਲ ਦੁਆਰਾ ਹਰੀਕ੍ਰਾਂਤੀ ਅਤੇ ਖੇਤੀ ਦੇ ਮਸ਼ੀਨੀਕਰਨ ਦੇ ਨਾਅਰੇ ਅਧੀਨ ਅਣਗੌਲ਼ੀ ਪਈ ਛੋਟੀ ਕਿਰਸਾਣੀ ਦੇ ਆਰਥਿਕ ਸਮਾਜਕ ਦੁਖਾਂਤ ਨੂੰ ਬੜੇ ਯਥਾਰਥਕ ਢੰਗ ਨਾਲ ਉਜਾਗਰ ਕੀਤਾ ਹੈ।

ਨਾਵਲ ਦਾ ਮੁੱਖ ਪਾਤਰ ਗੋਰਾ ਹੈ ਜਿਸ ਦੀ ਜ਼ਿੰਦਗੀ ਵਿਚਲੀਆਂ ਘਟਨਾਵਾਂ ਨੂੰ ਆਧਾਰ ਬਣਾ ਕੇ ਕੁੱਸਾ ਨੇ ਇਹ ਨਾਵਲ ਲਿਖਿਆ ਹੈ ਅਤੇ ਗੋਰੇ ਨੂੰ ਹਰ ਪਾਸੇ ਮਿਲੀ ਨਿਰਾਸ਼ਤਾ ਕਾਰਨ ਉਸ ਦਾ ਜੀਵਨ ਇੱਕ ਬੀਆਬਾਨ ਦੀ ਤਰ੍ਹਾਂ ਬਣ ਜਾਂਦਾ ਹੈ ਜਿਸ ਨੂੰ ਆਧਾਰ ਬਣਾ ਕੇ ਕੁੱਸਾ ਨੇ ਇਹ ਪ੍ਰਤੀਕਾਤਮਕ ਸਿਰਲੇਖ 'ਰੋਹੀ ਬੀਆਬਾਨ ਰੱਖਿਆ ਹੈ।

ਨਾਵਲ ਦੇ ਸ਼ੁਰੂਆਤੀ ਦੌਰ ਵਿਚ ਹੀ ਨਾਵਲ ਦਾ ਨਾਇਕ ਹਰ ਪਾਸਿਓਂ ਦੁਰਕਾਰਿਆ ਜਾਂਦਾ ਹੈ ਅਤੇ ਘਰ ਦਾ ਮਾਹੌਲ ਵੀ ਉਸ ਨੂੰ ਜ਼ਿੱਦੀ ਬਣਾ ਦਿੰਦਾ ਹੈ। ਗੋਰੇ ਦੀ ਮਾਂ ਗੋਰੇ ਨੂੰ ਬਚਪਨ ਤੋਂ ਹੀ ਖੇਡਣ ਦੇ ਸਮੇਂ ਤੋਂ ਹੀ ਘਰ ਕੇ ਕੰਮਾਂ ਵਿਚ ਜਾਂ ਛੋਟੀ ਕੁੜੀ ਨੂੰ ਖਿਡਾਉਣ ਲਈ ਆਖਦੀ ਹੈ ਜਿਸ ਤੋਂ ਗੋਰੇ ਨੂੰ ਗੁੱਸਾ ਆਉਦਾ ਹੈ।

ਮਹਿੰਦਰੋ ਗੋਰੇ ਨੂੰ ਖੇਡਦੇ ਸਮੇਂ ਵੀ ਘਰ ਦੇ ਕੰਮ ਵਾਸਤੇ ਬਲਾਉਂਦੀ ਹੈ ਅਤੇ ਆਖਦੀ ਹੈ:

> "ਵੇ, ਗੋਰਿਆ ਵੇ।" ਜਦੋਂ ਉਸ ਉੱਚਾ ਬੋਲ ਕੱਢ ਕੇ ਚਿਲਕਵੀਂ 'ਵਾਜ ਮਾਰੀ; ?ਖੇਡਦੇ ਨਿਆਣਿਆਂ ਨੇ ਕੰਨ ਚੁੱਕ ਲਏ, "ਆ ਐਧਰ.....।"[24]

ਗੋਰੇ ਨੇ ਅੱਗੋਂ ਮੋਢੇ ਉਤਾਂਹ ਚੜ੍ਹਾਏ, ਅੱਖਾਂ ਨੂੰ ਹੋਰ ਈ ਤਰ੍ਹਾਂ ਨਚਾਇਆ ਤੇ ਮੂੰਹ ਵਿਚੋਂ 'ਚਿੱਟ' ਦੀ ਆਵਾਜ਼ ਕੱਢੀ।

ਉਹ ਫਿਰ ਆਖਦੀ ਹੈ:

> "ਮੈਂ ਕਹਿੰਦੀ ਆਂ, ਭਲੀ-ਭੱਤ ਨਾਲ ਐਧਰ ਆਕੇ ਕੁੜੀ ਚੱਕ ਲੈ, ਨਹੀਂ ਤਾਂ ਤੇਰੇ ਨਾਲ ਅੱਜ ਉਹ ਹੋਊ, ਜਿਹੜੀ ਨਾ ਹੋਣੀ।"[25]

ਮਹਿੰਦਰੋ ਗੋਰੇ ਨੂੰ ਹਰ ਸਮੇਂ ਛੋਟੀ ਕੁੜੀ ਨੂੰ ਖਿਡਾਉਣ ਵਾਸਤੇ ਜਾਂ ਫਿਰ ਘਰ ਦੇ ਕੰਮ ਵਾਸਤੇ ਕਹਿੰਦੀ ਰਹਿੰਦੀ। ਇਨ੍ਹਾਂ ਗੱਲਾਂ ਤੋਂ ਗੋਰਾ ਹਰ ਸਮੇਂ ਸਤਾਇਆ ਰਹਿੰਦਾ। ਇਸ ਤੋਂ ਬਿਨਾਂ ਸਕੂਲ ਵਿਚ ਵੀ ਅਧਿਆਪਕ ਗੋਰੇ ਨਾਲ ਬੁਰਾ ਸਲੂਕ ਕਰਦੇ ਗੋਰੇ ਦੇ ਸਕੂਲ ਦੇਰ ਨਾਲ ਪਹੁੰਚਣ 'ਤੇ ਸਕੂਲ ਦਾ ਅਧਿਆਪਕ ਉਸ ਨਾਲ ਬੁਰਾ ਸਲੂਕ ਕਰਦਾ ਹੈ ਅਤੇ ਆਖਦਾ ਹੈ:

> "ਤੂੰਇਹਦਾ ਝੱਗਾ ਕਿਉਂ ਪਾੜਿਆ ਉਇ?"
>
> ਗੋਰੇ ਨੇ ਇਕਦਮ ਅਧਿਆਪਕ ਵੱਲ ਦੇਖਿਆ।
>
> "ਵੇਖਦਾ ਕਿਵੇਂ ਐਂ? ਸਾਡੇ 'ਤੇ ਡੀ.ਓ. ਲੱਗਾ ਏਂ?"[26]

ਮਾਸਟਰ ਨੇ, ਗੋਰੇ ਨੂੰ ਦੋਹਾਂ ਮੋਢਿਆਂ ਤੋਂ ਫੜ੍ਹ ਲਿਆ ਤੇ ਫਿਰ ਖੱਬੇ ਹੱਥ ਦੀਆਂ ਚਾਰੇ ਉਂਗਲਾਂ ਨਾਲ, ਉਸ ਗੋਰੇ ਦੇ ਨੀਵੇਂ ਸਿਰ ਨੂੰ ਠੋਡੀ ਤੋਂ ਉਤਾਂਹ ਕੀਤਾ। ਜਦੋਂ ਗੋਰੇ ਨੇ ਬੱਗੀਆਂ ਜਿਹੀਆਂ ਅੱਖਾਂ ਨਾਲ ਅਧਿਆਪਕ ਵੱਲ ਦੇਖਿਆ। ਉਦੋਂ ਈ ਉਸਦੀ ਸੱਜੀ ਗੱਲ 'ਤੇ ਮਾਸਟਰ ਦਾ ਜਮਦੂਤ ਵਰਗਾ ਹੱਥ ਚਪੇੜ ਬਣ ਪਿਆ। ਇਸ ਪ੍ਰਕਾਰ

ਗੋਰੇ ਨੂੰ ਗੁੱਸਾ ਆਉਂਦਾ ਹੈ ਅਤੇ ਉਹ ਹੀਣ ਭਾਵ ਅਨੁਭਵ ਕਰਦਾ ਹੈ। ਨਾਵਲਕਾਰ ਨੇ ਗੋਰੇ ਨੂੰ ਮੁੱਢ ਤੋਂ ਹੀ ਸਮੱਸਿਆਵਾਂ ਵਿਚ ਗ੍ਰਸਤ ਦਰਸਾਇਆ ਹੈ ਅਤੇ ਉਸ ਨੂੰ ਆਪਣਾ ਜੀਵਨ ਉਜਾੜ ਪ੍ਰਤੀਤ ਹੁੰਦਾ ਹੈ।

ਗੋਰਾ ਮੁੱਢ ਤੋਂ ਹੀ ਆਰਥਿਕ ਮੰਦਹਾਲੀ ਦਾ ਸ਼ਿਕਾਰ ਹੈ ਅਤੇ ਉਹ ਇਸ ਆਰਥਿਕ ਤੰਗੀ ਤੋਂ ਛੁਟਕਾਰਾ ਪਾਉਣ ਵਾਸਤੇ ਕਈ ਪ੍ਰਕਾਰ ਦੇ ਉਪਰਾਲੇ ਵੀ ਕਰਦਾ ਹੈ ਉਹ ਅਤੇ ਦਾ ਪਿਓ (ਗਿੰਦਰ) ਸਖ਼ਤ ਸਰੀਰਿਕ ਮਿਹਨਤ ਕਰਦੇ ਹਨ ਗੋਰਾ ਕਈ ਪ੍ਰਕਾਰ ਦੇ ਨਾਜ਼ਾਇਜ ਕੰਮ ਵੀ ਕਰਦਾ ਹੈ ਉਹ ਸ਼ਰਾਬ ਵੇਚਦਾ ਹੈ ਅਤੇ ਚੋਰੀ ਵੀ ਕਰਦਾ ਹੈ ਪਰ ਉਸ ਦੀ ਆਰਥਿਕਸਮੱਸਿਆ ਜਿਉਂ ਦੀ ਤਿਉਂ ਹੀ ਰਹਿੰਦੀ ਹੈ। ਗੋਰੇ ਦਾ ਮਾਮਾ ਉਸ ਨੂੰ ਧੋਖੇ ਦੇ ਨਾਲ ਸ਼ਹਿਰ ਬੇਕਰੀ ਵਿਚ ਲੈ ਜਾਂਦਾ ਹੈ ਉਥੇ ਬੇਕਰੀ ਦਾ ਮਾਲਕ ਉਸ ਨੂੰ ਗੋਹਾ ਕੂੜਾ ਸੁੱਟਣ ਵਾਸਤੇ ਕਹਿੰਦਾ ਹੈ ਜਿਸ ਨਾਲ ਗੋਰੇ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਨੂੰ ਗਹਿਰਾ ਧੱਕਾ ਵੱਜਦਾ ਹੈ ਅਤੇ ਉਸ ਨੂੰ ਆਪਣੀ ਹੋਂਦ ਬੇਕਾਰ ਲੱਗਦੀ ਹੈ ਇਕ ਵਾਰ ਫੇਰ ਉਸ ਨੂੰ ਆਪਣਾ ਜੀਵਨ ਉਜਾੜ-ਬੀਆਬਾਨ ਜਾਪਦਾ ਹੈ। ਉਸ ਦੇ ਦਿਲ ਵਿਚ ਹੀਣ ਭਾਵਨਾ ਆ ਜਾਂਦੀ ਹੈ ਅਤੇ ਉਹ ਕੰਮ ਛੱਡ ਕੇ ਭੱਜ ਕੇ ਪਿੰਡ ਆ ਜਾਂਦਾ ਹੈ।

ਗੋਰੇ ਸਾਹਮਣੇ ਇਕ ਹੋਰ ਸਮੱਸਿਆ ਉਸ ਸਮੇਂ ਆਉਂਦੀ ਹੈ ਜਦੋਂ ਗੋਰਾ ਆਪਣੀ ਆਰਥਿਕਸਮੱਸਿਆ ਤੋ ਛੁਟਕਾਰਾ ਪਾਉਣ ਵਾਸਤੇ ਬਾਹਰ ਜਾਣ ਦਾ ਕੰਮ ਬਣਾਉਂਦਾ ਹੈ ਅਤੇ ਉਸ ਵਾਸਤੇ ਕਰਜ਼ਾ ਲੈਂਦਾ ਹੈ ਪ੍ਰੰਤੂ ਉਥੋਂ ਵੀ ਅਸਫ਼ਲ ਹੋਣ 'ਤੇ ਗੋਰੇ ਦੇ ਸਿਰ ਕਰਜ਼ਾ ਹੋ ਜਾਂਦਾ ਹੈ ਅਤੇ ਗੋਰੇ ਉਸ ਦੇ ਘਰ ਦੇ ਸੀਰੀ ਰਲਣ ਵਾਸਤੇ ਕਹਿੰਦੇ ਹਨ ਜੋ ਕਿ ਗੋਰੇ ਲਈ ਅਜਿਹਾ ਧੱਕਾ ਸੀ ਜੋ ਉਸ ਲਈ ਹੋਣੀ ਬਰਾਬਰ ਸੀ।

ਇਸ ਪ੍ਰਕਾਰ ਕੁੱਸਾ ਨੇ ਸਮੁੱਚੇ ਨਾਵਲ ਵਿਚ ਗੋਰੇ ਦੇ ਜੀਵਨ ਵਿਚ ਅਨੇਕਾਂ ਸਮੱਸਿਆਵਾਂ ਦਾ ਵਰਣਨ ਕੀਤਾ ਹੈ ਜਿਹਨਾਂ ਵਿਚੋਂ ਗੋਰਾ ਜਿੰਨਾਂ ਨਿਕਲਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ ਉਨ੍ਹਾਂ ਹੀ ਉਸ ਵਿਚ ਧੱਸਦਾ ਰਹਿੰਦਾ ਹੈ ਨਾਵਲ ਦੇ ਅੰਤ ਵਿਚ ਜਦੋਂ ਗੋਰਾ ਘਰੋਂ ਨਿਕਲ ਜਾਂਦਾ ਹੈ ਤਾਂ ਉਸ ਸਮੇਂ ਗੋਰੇ ਨੂੰ ਆਪਣਾ ਪਿੰਡ ਰੋਹੀ ਬੀਆਬਾਨ ਜਾਪਦਾ ਹੈ। ਸੋ ਸਮੁੱਚੇ ਰੂਪ ਵਿਚ ਅਸੀਂ ਕਹਿ ਸਕਦੇ ਹਾਂ ਕਿ ਨਾਵਲ ਦਾ ਸਿਰਲੇਖ ਰੋਹੀ ਬੀਆਬਾਨ ਬਿਲਕੁਲ ਢੁਕਵਾਂ ਹੈ ਜੋ ਕਿ ਨਾਵਲ ਕੀ ਕਲਾ ਨੂੰ ਹੋਰ ਸੁੰਦਰ ਬਣਾਉਂਦਾ ਹੈ।

4.5 ਸ਼ੈਲੀ:-

ਵਿਚਾਰਾਂ ਨੂੰ ਸੁੰਦਰ ਸ਼ਬਦਾਂ ਵਿਚ ਪਰੋਣ ਦੀ ਕਲਾ ਨੂੰ ਸ਼ੈਲੀ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਸ਼ੈਲੀ ਹਰ ਲੇਖਕ ਦੀ ਵੱਖਰੀ ਹੁੰਦੀ ਹੈ। ਕੁੱਸਾ ਬੜੇ ਕਲਾਤਮਕ ਢੰਗ ਨਾਲ ਬੜੀ ਸੁਚੱਜੀ ਸ਼ੈਲੀ ਦੀ ਵਰਤੋਂ ਇਸ ਨਾਵਲ ਨੂੰ ਲਿਖਣ ਵਾਸਤੇ ਕੀਤੀ ਹੈ। ਉਸ ਦੀ ਸ਼ੈਲੀ ਕਰਕੇ ਹੀ ਉਹ ਨਾਵਲਕਾਰਾਂ ਵਿਚੋਂ ਵਿਸ਼ੇਸ਼ ਸਥਾਨ ਰੱਖਦਾ ਹੈ। ਉਸ ਦਾ ਇਹ ਨਾਵਲ

ਪ੍ਰਤੀਕਾਤਮਕ ਸ਼ੈਲੀ ਵਿਚ ਲਿਖਿਆ ਨਾਵਲ ਹੈ। ਗ਼ਰੀਬ ਕਿਸਾਨੀ ਦੇ ਜੀਵਨ-ਯਥਾਰਥ ਦੀਆਂ ਮੂਲ ਇਕਾਈਆਂ ਵਿਚ ਗ੍ਰਸਤ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਹੈ।

'ਰੋਹੀ ਬੀਆਬਾਨ' ਦੀ ਮੂਲ ਕਥਾ ਗ਼ਰੀਬ ਕਿਸਾਨ ਦੇ ਦੁਆਲੇ ਘੁੰਮਦੀ ਹੈ। ਗੋਰੇ ਦੇ ਜੀਵਨ ਵਿਚ ਅਨੇਕਾਂ ਮੁਸ਼ਕਲਾਂ ਆਉਂਦੀਆਂ ਹਨ, ਜਿਨ੍ਹਾਂ ਤੋਂ ਗੋਰਾ ਜਿੰਨਾਂ ਬਚਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ ਓਨਾ ਹੀ ਫਸਦਾ ਜਾਂਦਾ ਹੈ। ''ਇਕ ਚੰਗਾ ਸ਼ੈਲੀਕਾਰ, ਨਾਵਲ ਲਿਖਾਰੀ ਨਾ ਤਾਂ ਨਾਵਲੀ ਕਥਾ ਵਿਚੋਂ ਸਪਸ਼ਟ ਰੂਪ ਵਿਚ ਪਾਠਕ ਦੇ ਸਾਮਹਣੇ ਆਉਂਦਾ ਹੈ ਅਤੇ ਨਾ ਹੀ ਆਪਣੀ ਰਚਨਾ ਵਿਚੋਂ ਅਲੋਪ ਰਹਿੰਦਾ ਹੈ। ਸਮੁੱਚਾ ਸ਼ੈਲੀਕਾਰ, ਬ੍ਰਹਿਮੰਡ ਵਿਚ ਵਿਆਪਕ ਪ੍ਰਭੂ ਵਾਂਗ ਹੁੰਦਾ ਹੈ ਜਿਹੜਾ ਹਰ ਸਮੇਂ, ਹਰ ਥਾਂ ਆਪਣੀ ਰਚਨਾ ਵਿਚ ਮੌਜੂਦ ਹੁੰਦਾ ਹੈ ਪਰ ਨਜ਼ਰ ਨਹੀਂ ਆਉਂਦਾ''।[27]

ਸੋ ਕੁੱਸਾ ਨੇ ਇਸ ਨਾਵਲ ਵਿਚ ਸਮੁੱਚੇ ਨਾਵਲ ਨੂੰ ਬੜ੍ਹੀ ਹੀ ਜੁਗਤ ਦੇ ਨਾਲ ਬਿਆਨ ਕਰਦਾ ਹੈ। ਇੰਝ ਪ੍ਰਤੀਤ ਹੁੰਦਾ ਹੈ ਕਿ ਕੁੱਸਾ ਨੇ ਇਸ ਸਭ ਕੁੱਝ ਆਪਣੇ ਹੰਡੀਂ ਹੰਢਾਇਆ ਹੋਵੇ ਅਤੇ ਉਸ ਨੂੰ ਉਸੇ ਤਰ੍ਹਾਂ ਹੀ ਬਿਆਨ ਕਰ ਦਿੱਤਾ ਹੋਵੇ। ਨਾਵਲ ਦਾ ਨਾਇਕ ਗੋਰਾ ਇਕ ਗ਼ਰੀਬ ਕਿਸਾਨ ਪਰਿਵਾਰ ਨਾਲ ਸੰਬੰਧ ਰੱਖਦਾ ਹੈ ਅਤੇ ਉਸ ਦੇ ਪਰਿਵਾਰ ਦੀ ਹਸਰਤ ਹੈ ਕਿ ਗੋਰਾ ਪੜ੍ਹ ਲਿਖ ਕੇ ਇਕ ਅਫ਼ਸਰ ਬਣ ਜਾਵੇਂ ਪ੍ਰੰਤੂ ਉਸ ਗ਼ਰੀਬ ਪਰਿਵਾਰ ਵਿਚ ਇਹ ਗੱਲ ਅਸੰਭਵ ਹੈ। ਨਾਵਲਕਾਰ ਨਾਵਲ ਵਿਚ ਖ਼ੁਦ ਸ਼ਾਮਲ ਹੋ ਕੇ ਨਾਵਲੀ ਸਥਿਤੀ ਨੂੰ ਬਿਆਨ ਕਰਦਾ ਹੈ। ਜਗ੍ਹਾਂ-ਜਗ੍ਹਾਂ ਤੇ ਨਾਵਲਕਾਰ ਗੋਰੇ ਨਾਲ, ਉਸ ਦੇ ਪਰਿਵਾਰ ਨਾਲ ਅਤੇ ਉਨ੍ਹਾਂ ਦੀ ਆਰਥਿਕ ਮੰਦਹਾਲੀ ਨਾਲ ਜਾਣੂ ਕਰਵਾਉਂਦਾ ਹੈ:

> ''ਅਜੇ ਉਹ ਚਾਹ ਹੀ ਬਣਾ ਕੇ ਹਟੀ ਹੁੰਦੀ ਹੈ, ਕਿ ਗੋਰੇ ਹੋਰੀਂ ਉੱਠ ਖਲੋਂਦੇ। ਜੋਗਿੰਦਰ ਨੇ ਹਲ਼ ਜੋੜਨਾ ਹੁੰਦਾ, ਉਹ ਸਾਝਰੇ ਖੇਤ ਨੂੰ ਤੁਰ ਜਾਂਦਾ ਹੈ। ਜੇ ਕੋਈ ਹੋਰ ਕੰਮ ਨਾ ਹੁੰਦਾ, ਤਦ ਪਸ਼ੂਆਂ ਨੂੰ ਪੱਠੇ ਉਹ ਪਾ ਦਿੰਦਾ।''[28]

''ਨਾਵਲ ਦੀ ਸ਼ੈਲੀ ਅਨੁਸਾਰ ਕਈ ਵਾਰ ਨਾਵਲ ਦਾ ਅਰੰਭ ਮੱਧ ਵਿਚੋਂ ਅਤੇ ਕਈ ਵਾਰ ਅੰਤ ਤੋਂ ਵੀ ਕਰ ਲਿਆ ਜਾਂਦਾ ਹੈ। ਇਕ ਨਿਪੁੰਨ ਸ਼ੈਲੀਕਾਰ ਹੀ ਸਫ਼ਲ ਨਾਵਲ ਦੀ ਰਚਨਾ ਕਰਦਾ ਹੈ।''[29] ਇਸ ਨਾਵਲ ਦਾ ਅਰੰਭ ਗੋਰੇ ਦੇ ਬਚਪਨ ਤੋਂ ਉਸ ਦੇ ਗੱਭਰੂ ਹੋਣ ਤੱਕ ਜਾਂਦਾ ਹੈ। ਨਾਵਲ ਦੇ ਅਨੇਕਾਂ ਵੇਰਵੇਂ ਗੋਰੇ ਦੀਆਂ ਜੀਵਨ ਪ੍ਰਸਥਿਤੀਆਂ ਨਾਲ ਜੁੜੇ ਹਨ। ਜਿਵੇਂ ਬਚਪਨ ਵਿਚ ਸਕੂਲ ਦੀਆਂ ਅਨੇਕਾਂ ਘਟਨਾਵਾਂ ਦਾ ਵਰਣਨ ਹੈ ਜਿਵੇਂ

> ਮਾਸਟਰ '' ਤੂੰ ਇਹਦਾ ਝੱਗਾ ਕਿਉਂ ਪਾੜਿਆ ਉਇ?''
> ਗੋਰਾ '' ਇਹ ਮੈਨੂੰ ਗਾਲ਼ਾਂ ਕੱਢਦਾ ਸੀ ਜੀ, ਨਾਲੇ ਸਾਂਗਾਂ ਲਾਉਂਦਾ ਸੀ।''[30]

ਇਸ ਤੋਂ ਇਲਾਵਾ ਨਾਵਲ ਵਿਚ ਗੋਰੇ ਦੇ ਆਰਥਿਕ ਤੰਗੀ ਤੋਂ ਬਾਹਰ ਨਿਕਲਣ ਲਈ ਕੀਤੇ ਅਨੇਕਾਂ ਯਤਨਾਂ ਦਾ ਵੇਰਵਾ ਵੀ ਇਸ ਨਾਵਲ ਵਿਚ ਮਿਲਦਾ ਹੈ। ਗੋਰੇ ਦੇ ਮਾਮੇ ਦੁਆਰਾ ਉਸ ਨੂੰ ਸ਼ਹਿਰ ਵਿਚ ਕੰਮ ਕਰਨ ਲੈ ਕੇ ਜਾਣਾ ਤੇ ਉਥੋਂ ਭੱਜ ਕੇ ਕੇ ਆ ਕੇ ਤੇਲੂ ਨਾਲ ਟਰੱਕ 'ਤੇ ਜਾਣਾ ਉਥੋਂ ਵੀ ਅਸਫ਼ਲ ਹੋ ਕੇ ਵਿਦੇਸ਼ ਜਾਣ ਦੇ ਚੱਕਰ ਵਿਚਧੋਖਾ ਖਾਣਾ ਅਨੇਕਾਂ ਗਲਪੀ ਯੁਗਤਾਂ ਇਸ ਨਾਵਲ ਵਿਚ ਮਿਲਦੀਆਂ ਹਨ। ਨਾਵਲ ਦਾ ਅੰਤ ਪਿੰਡ ਲਈ ਵਰਤੇ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਸ਼ਬਦ ਨਾਲ ਪ੍ਰਤੀਕਾਤਮਕ ਢੰਗ ਨਾਲ ਹੁੰਦਾ ਹੈ;

''ਹੋਰ ਸਾਲਿਆ ਤੂੰ ਥਾਣੇਦਾਰ ਲੱਗੇਂਗਾ'', ਗਿੰਦਰ ਫੇਰ ਉਹਦੇ ਵੱਲ

ਨੱਠ ਆਇਆ.....।

''ਥਾਣੇਦਾਰ ਲੱਗਾਂ ਜਾਂ ਨਾ ਲੱਗਾ। ਪਰ ਮੈਂ ਸੀਰੀ ਨ੍ਹੀ ਰਲਣਾ''

ਗੋਰੇ ਦਾ ਬੋਲ ਫੇਰ ਭੜਕਵਾਂ ਹੋ ਗਿਆ, ਉਸ ਅੱਖਾਂ 'ਚ ਤਾਅਭਰਦਿਆਂ ਆਖਿਆ,

''ਥੋਨੂੰ ਇਕ ਵਾਰੀ ਕਹਿ-ਤਾ, ਮੈਨੂੰ ਨਾ ਆਖਿਓ।.....ਸੀਰੀ ਨੀ

ਰਲਣਾ.....ਫੇਰ ਮੈਨੂੰ ਆਖਿਆ, ਮੈ ਮਰਜੂੰ ਚਾਹੇ ਮਾਰਦੂੰ।''[31]

ਇਹ ਗੱਲਾਂ ਸੁਣ ਕੇ ਗੋਰਾ ਆਪਣਾ ਛੱਡ ਕੇ ਬਾਹਰ ਚਲਾ ਜਾਂਦਾ ਹੈ ਅਤੇ ਜਦੋਂ ਉਹ ਪਿੰਡੋਂ ਬਾਹਰ ਆ ਕੇ ਰਤਾ ਕੁ ਹੌਲੀ ਹੋਇਆ, ਹੰਝੂ ਭਰੀਆਂ ਅੱਖਾਂ ਪਾੜ ਕੇ ਖੇਤਾਂ ਵਿਚ ਗੋਲ ਦਾਇਰੇ 'ਚ ਜਗਦੇ ਬਿਜਲੀ ਦੇ ਬਲਬਾਂ ਵੱਲ ਵੇਖਿਆ। ਉਦੋਂ ਈ ਪਿੰਡ ਦੀ ਤੇ ਬਾਹਰਲੀ ਬਿਜਲੀ ਇਕ ਦਮ ਬੁੱਝ ਗਈ। ਚੁਫੇਰੇ ਹਨੇਰ-ਗੁਬਾਰ ਪਸਰ ਗਿਆ। ਹੱਥ ਨੂੰ ਹੱਥ ਮਾਰਿਆ ਨਹੀਂ ਹੱਥ ਨੂੰ ਹੱਥ ਮਾਰਿਆ ਨਹੀਂ ਦਿਸਦਾ ਸੀ। ਉਹਨੇ ਮਗਰ ਭਉਂਕੇ ਦੇਖਿਆ, ਉਹਨੂੰ ਮਹਿਸੂਸ ਹੋਇਆ, ਜਿਵੇਂ ਪਿੰਡ ਦੀ ਮੌਤ ਹੋ ਗਈ ਹੋਵੇ। ਰੌਲਾ ਰੱਪਾ ਵੀ ਨਹੀਂ ਸੁਣਦਾ ਸੀ। ਅਚਾਨਕ ਹੀ ਉਸਦੇ ਮੂਹਰੇ ਬਾਹਰਲੀਆਂ ਮੋਟਰਾਂ ਦੇ ਬਲਬ ਜਗ ਪਏ ਪਰ ਬਿਜਲੀ ਡਿੰਮ ਸੀ। ਜਦੋਂ ਉਸ ਫੇਰ ਪਿੰਡ ਵੱਲ ਭਉਂਕੇ ਦੇਖਿਆ, ਪਿੰਡ 'ਤੇ ਉਸੇ ਤਰ੍ਹਾਂ ਸੁੰਨ ਮਸਾਨ ਵਰਤੀ ਹੋਈ ਸੀ। ਓਹਨੂੰ ਇਕ ਵਾਰ ਫਿਰ ਖਿਆਲ ਆਇਆ, ਪਿੰਡ ਸੱਚੀਂ ਮਰ ਗਿਆ ਸੀ। ਪਰ ਘਰ ਵਿਚ ਘਟੀ ਘਟਨਾ ਯਾਦ ਕਰਕੇ ਉਹਦਾ ਰੋਣ ਨਿਕਲ ਗਿਆ ਤੇ ਉਸ ਦੀ ਏਨੀ ਭੁੱਬ ਨਿਕਲੀ ਕਿ ਚੁਪਾਸੇ ਪਸਰੀ ਵੱਢ-ਖਾਣੀ ਚੁੱਪ ਵਿਚ ਭੁੱਬ ਦੀ ਅਵਾਜ਼ ਹੋਰ ਡਰਾਉਣੀ ਹੋ ਗਈ ਸੀ।

ਇਥੇ ਪਿੰਡ ਦੀ ਮੌਤ ਨੂੰ ਇਕ ਪ੍ਰਤੀਕ ਵਜੋਂ ਲਿਆ ਹੈ। ਗੋਰਾ ਆਪਣੇ ਜੀਵਨ ਤੋਂ ਨਿਰਾਸ਼ ਹੋ ਜਾਂਦਾ ਹੈ ਉਸ ਨੂੰ ਆਪਣਾ ਪਿੰਡ ਮੋਇਆ ਦੇ ਬਰਾਬਰ ਲੱਗਦਾ ਹੈ। ਸਿਰੀ ਰਲਣ ਦੀ ਗੱਲ ਉਸ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਉੱਪਰ ਬਹੁਤ ਬੁਰਾ ਪ੍ਰਭਾਵ ਪਾਉਂਦੀ ਹੈ

ਇਸ ਤੋਂ ਇਲਾਵਾ ਇਸ ਨਾਵਲ ਵਿਚ ਮਨੋਵਿਸ਼ਲੇਸ਼ਣੀ ਸ਼ੈਲੀ ਦਾ ਵੀ ਪ੍ਰਯੋਗ ਹੋਇਆ ਹੈ। ਮਨੋਵਿਗਿਆਨ ਉਹ ਵਿਗਿਆਨ ਹੈ ਜੋ ਮਨੁੱਖੀ ਮਨ ਦਾ ਅਧਿਐਨ ਕਰਦਾ ਹੈ। ਮਨੁੱਖੀ ਮਨ ਦੀ ਹੋਂਦ ਸਰੀਰ ਵਿਚ ਸੰਭਵ ਹੈ। ਇਸ ਲਈ ਇਸ ਦਾ ਅਧਿਐਨ ਖੇਤਰ ਮਨੁੱਖੀ ਸਰੀਰ ਅਤੇ ਮਨ ਹੈ। ਪਰ ਮਨੁੱਖੀ ਸਰੀਰ ਵਿਚ ਮਨ ਨਾਮ ਦਾ ਕੋਈ ਅੰਗ ਨਹੀਂ ਹੈ। ਮਨ ਤੋਂ ਇੱਥੋਂ ਭਾਵ ਮਾਨਸਿਕਤਾ ਹੈ। ਮਨੁੱਖੀ ਦਿਮਾਗ ਦਾ ਕੋਈ ਹਿੱਸਾ ਸੁਚੇਤ, ਅਰਧ-ਸੁਚੇਤ ਜਾਂ ਅਵਚੇਤਨ ਜਦੋਂ ਕਿਸੇ ਵਿਸ਼ੇਸ਼ ਦਿਸ਼ਾ ਵੱਲ ਯਾਤਰਾ ਕਰਦਾ ਹੈ ਤਾਂ ਉਸ ਵਿਚੋਂ ਉਪਜੀਆਂ ਬਿਰਤੀਆਂ ਨੂੰ ਮਾਨਸਿਕਤਾ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। "ਮਨੋਵਿਗਿਆਨ ਦਾ ਮੋਢੀ ਸਿੰਗਮੰਡ ਫਰਾਇਡ ਹੈ। "[32]

ਗੋਰਾ ਜਦੋਂ ਸ਼ਹਿਰ ਵਿਚ ਗੋਹਾ-ਕੂੜਾ ਸੁੱਟਣ ਤੋਂ ਇਨਕਾਰ ਕਰਦਾ ਹੈ ਜਾਂ ਟਰੱਕ ਡਰਾਇਵਰਾਂ ਦੇ ਛੋਟੇ ਮੋਟੇ ਕੰਮ ਨੂੰ ਕਰਨ ਤੋਂ ਇਨਕਾਰ ਕਰਦਾ ਹੈ ਤਾ ਉਸ ਸਮੇਂ ਕੁੱਸਾ ਗੋਰੇ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਦਾ ਬਿਆਨ ਕਰਦਾ ਹੈ ਕਿ ਕਿਸ ਪ੍ਰਕਾਰ ਉਸ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਵਿਚ ਇਹ ਸਭ ਕੰਮ ਛੋਟੇ ਸਮਝੇ ਜਾਂਦੇ ਹਨ। ਸੋ ਕੁੱਲ ਮਿਲਾ ਕੇ ਕਿਹਾ ਜਾ ਸਕਦਾ ਹੈ ਕੁੱਸਾ ਇਕ ਸਫ਼ਲ ਸ਼ੈਲੀਕਾਰ ਹੈ ਜਿਸ ਦਾ ਪ੍ਰਮਾਣ ਉਸ ਨੇ ਆਪਣੇ ਇਸ ਨਾਵਲ ਦੀ ਨਿਪੁੰਨਤਾ ਵਿਚ ਦਿੱਤਾ ਹੈ। ਜਿਵੇਂ ਕਿ ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਕਿ ਨਾਵਲੀ ਸ਼ੈਲੀ ਵਿਚੋਂ ਉਸ ਨਾਵਲਕਾਰ ਦੀ ਸ਼ਖ਼ਸੀਅਤ ਨੂੰ ਪਹਿਚਾਣਿਆ ਜਾਂਦਾ ਹੈ। "ਅਸਲੀ ਨਾਵਲ-ਕਥਾ ਦੇ ਹੇਠਾ ਨਾਵਲਕਾਰੀ ਦੀ ਆਪਣੀ ਸ਼ਖ਼ਸੀਅਤ ਵੀ ਵਿਚਰਦੀ ਹੈ। "[33]

ਇਸ ਨਾਵਲ ਵਿਚੋਂ ਕੁੱਸਾ ਸੀ ਸ਼ਖ਼ਸੀਅਤ ਸਾਹਮਣੇ ਆਉਂਦੀ ਹੈ ਕਿ ਉਹ ਗ਼ਰੀਬ ਕਿਸਾਨ ਦੀ ਤ੍ਰਾਸਦੀ ਤੋਂ ਭਲੀ-ਭਾਂਤੀ ਜਾਣੂ ਹੈ ਅਤੇ ਉਹ ਇਨ੍ਹਾਂ ਕਿਸਾਨਾਂ ਦੇ ਹੱਕ ਵਿਚ ਹੈ। ਨਾਵਲਕਾਰ ਨੇ ਪਾਤਰਾਂ ਨੂੰ ਇੰਝ ਉਸਾਰਿਆ ਹੈ ਕਿ ਉਹ ਯਥਾਰਥਕ ਪਾਤਰ ਪ੍ਰਤੀਤ ਹੁੰਦੇ ਹਨ ਕੁੱਸਾ ਨੇ ਪਾਤਰਾਂ ਦੀ ਸਿਰਫ਼ ਬਾਹਰੀ ਦਿੱਖ ਨੂੰ ਹੀ ਨਹੀਂ ਪੇਸ਼ ਕੀਤਾ ਸਗੋਂ ਪਾਤਰਾਂ ਦੀ ਮਾਨਸਿਕਤਾ ਦਾ ਬਿਆਨ ਵੀ ਸੁਚੱਜੇ ਨਾਵਲਕਾਰ ਵਾਂਗ ਕੀਤਾ ਹੈ। ਨਾਵਲਕਾਰ ਦੀ ਸਭ ਤੋਂ ਵੱਡੀ ਪ੍ਰਾਪਤੀ ਇਹ ਹੈ ਕਿ ਉਸ ਨੇ ਭਾਸ਼ਾ ਨਿਰੋਲ ਪੇਂਡੂ ਵਰਤੀ ਹੈ ਜੋ ਕਿ ਨਾਵਲ ਅਨੁਸਾਰ ਢੁਕਵੀ ਹੈ। ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਵਾਰਤਾਲਾਪ ਬੜੇ ਹੀ ਰੌਚਕ ਵਰਤੇ ਹਨ। ਕੁੱਸਾ ਨੇ ਇਸ ਨਾਵਲ ਦਾ ਸਿਰਲੇਖ ਸਿਰਜ ਜੇ ਹੀ ਪਾਠਕਾਂ ਲਈ ਇਹ ਨਾਵਲ ਖਿੱਚ ਦਾ ਕੇਂਦਰ ਬਣਾ ਦਿੱਤਾ। ਕੁੱਸਾ ਨੇ ਪ੍ਰਤੀਕਾਤਮਕ ਸ਼ੈਲੀ ਵਿਚ ਇਹ ਨਾਵਲ ਲਿਖ ਕੇ ਇਸ ਨਾਵਲ ਨੂੰ ਹੋਰ ਦਿਲਚਸਪ ਬਣਾ ਦਿੱਤਾ।ਇਹ ਇੱਕ ਪਾਸੇ ਪੰਜਾਬ ਦੇ ਖੇਤੀ ਪ੍ਰਧਾਨ ਸਮਾਜ ਦੀ ਉਸ ਨਿੱਘਰੀ ਹੋਈ ਅਵਸਥਾ ਵੱਲ ਇਸ਼ਾਰਾ ਕਰਦਾ ਹੈ ਜਿਸ ਨੇ ਇਸ ਨੂੰ ਸੁੰਨਸਾਨ ਜੰਗਲ ਵਿਚ ਤਬਦੀਲ ਕਰ ਦਿੱਤਾ ਹੈ ਉਸ ਦੇ ਸਾਹਮਣੇ ਘੁੱਪ ਹਨ੍ਹੇਰਾ ਹੈ। ਜਿਸ ਵਿਚੋਂ ਨਿਕਲਣ ਲਈ ਉਸ ਕੋਲ ਚੇਤਨਾ ਦੀ ਰੌਸ਼ਨੀ ਨਹੀਂ ਹੈ ਦੂਜੇ ਪਾਸੇ ਪੂੰਜੀਵਾਦੀ ਦੌਰ ਵਿਚ ਦਿਨੋ ਦਿਨ ਖਤਮ ਹੁੰਦੀਆਂ ਮਨੁੱਖੀ ਕੀਮਤਾਂ ਵੱਲ ਇਸ਼ਾਰਾ ਹੈ ਜਿਨ੍ਹਾਂ ਦੀ ਅਣਹੋਂਦ ਵਿੱਚ ਮਨੁੱਖ ਮੁੜ ਜੰਗਲੀ ਸਭਿਅਤਾ ਵੱਲ ਜਾ ਰਿਹਾ ਹੈ। ਇਸ ਪ੍ਰਕਾਰ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਕਲਾਤਮਕ ਪੱਖ ਤੋਂ ਬਹੁਤ ਜ਼ਿਆਦਾ ਵਧੀਆ ਢੰਗ ਨਾਲ ਪੇਸ਼ ਕੀਤਾ ਹੈ ਜਿਸ ਕਾਰਨ ਕੁੱਸਾ ਦਾ ਨਾਂ ਪੰਜਾਬੀ ਦੇ ਉੱਤਮ ਨਾਵਲਕਾਰਾਂ ਵਿਚ ਲਿਆ ਜਾਂਦਾ ਹੈ।

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ਸਾਰ

ਸਾਹਿਤ ਸਾਡੇ ਸਮਾਜ ਦਾ ਮਹੱਤਵਪੂਰਨ ਅੰਗ ਹੈ। ਸਾਹਿਤ ਕਿਸੇ ਵੀ ਸਮਾਜ ਦੇ ਸੱਭਿਆਚਾਰ, ਲੋਕਧਾਰਾ, ਕਦਰਾਂ-ਕੀਮਤਾਂ, ਆਚਾਰ-ਵਿਹਾਰ, ਵਿਰਸੇ ਅਤੇ ਲੋਕਾਂ ਦੀਆਂ ਭਾਵਨਾਵਾਂ ਨੂੰ ਆਪਣੀ ਬੁੱਕਲ ਵਿਚ ਸਮੋਈ ਬੈਠਾ ਹੈ। ਸਾਹਿਤ ਸਮਾਜ ਦਾ ਇਕ ਅਨਿਖੜਵਾਂ ਅੰਗ ਹੈ। ਇਸੇ ਕਰਕੇ ਸਾਹਿਤ ਨੂੰ ਸਮਾਜ ਦਾ ਦਰਪਣ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਸਾਹਿਤ ਅਤੇ ਸਮਾਜ ਨੂੰ ਆਪਸ ਵਿਚ ਇਕ ਕੜੀ ਦੇ ਵਾਂਗ ਜੁੜੇ ਹੁੰਦੇ ਹਨ ਜੇਕਰ ਕਿਸੇ ਇਕ ਵਿਚ ਵੀ ਪਰਿਵਰਤਨ ਆਉਂਦਾ ਹੈ ਤਾਂ ਉਸ ਦਾ ਅਸਰ ਦੂਸਰੇ 'ਤੇ ਪੈਂਦਾ ਹੈ। ਗੱਲ ਕੀ ਦੋਵਾਂ ਨੂੰ ਆਪਸ ਵਿਚੋਂ ਨਿਖੇੜਨਾ ਮੁਸ਼ਕਲ ਹੈ। ਹਥਲੇ ਖੋਜ-ਪ੍ਰਬੰਧ ਵਿਚ ਗਾਲਪਨਿਕ ਵਿਧਾ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਨੂੰ ਲਿਆ ਗਿਆ ਹੈ। ਨਾਵਲ ਗਲਪ ਸਾਹਿਤ ਦਾ ਇਕ ਮਹੱਤਵਪੂਰਨ ਅੰਗ ਹੈ। ਨਾਵਲ ਇਕ ਲੰਬੀ ਬਿਰਤਾਂਤਕ ਰਚਨਾ ਹੈ। ਨਾਵਲ ਗਲਪ ਦਾ ਹਿੱਸਾ ਹੈ ਜਿਵੇਂ ਕਿ ਗਲਪ ਤੋਂ ਭਾਵ ਲਿਆ ਜਾਂਦਾ ਹੈ ਕਿ ਜਦੋਂ ਗੱਪ ਵੀ ਅਸਲੀਅਤ ਵਰਗੀ ਪ੍ਰਤੀਤ ਹੋਵੇ ਤਾਂ ਉਸ ਨੂੰ ਗਲਪ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਸੋ ਇਸ ਆਧਾਰ 'ਤੇ ਨਾਵਲ ਇਕ ਗਾਲਪਨਿਕ ਰਚਨਾ ਹੋਣ ਕਰਕੇ ਇਸ ਵਿਚ ਕਲਪਨਾ ਦਾ ਅੰਸ਼ ਭਾਰੂ ਹੁੰਦਾ ਹੈ। ਨਾਵਲ ਵਿਚ ਕਿਸੇ ਘਟਨਾ ਜਾਂ ਸਮੱਸਿਆ ਨੂੰ ਲੈ ਕੇ ਉਸ ਵਿਚ ਕਲਪਨਾ ਦੇ ਅੰਸ਼ ਮਿਲਾ ਕੇ ਉਸ ਨੂੰ ਇਸ ਢੰਗ ਨਾਲ ਲਿਖਿਆ ਜਾਂਦਾ ਹੈ ਕਿ ਉਹ ਘਟਨਾ ਜਾਂ ਸਮੱਸਿਆ ਸਾਨੂੰ ਇਉਂ ਪ੍ਰਤੀਤ ਹੁੰਦੀ ਹੈ ਜਿਵੇਂ ਇਹ ਸਾਡੀ ਹੀ ਗੱਲ ਕੀਤੀ ਗਈ ਹੋਵੇ। ਨਾਵਲ ਆਧੁਨਿਕ ਯੁੱਗ ਵਿਚ ਸਭ ਤੋਂ ਵੱਧ ਪੜ੍ਹਿਆ ਜਾਣ ਵਾਲਾ ਗਾਲਪਨਿਕ ਰੂਪ ਹੈ। ਨਾਵਲ ਪੂੰਜੀਵਾਦੀ ਸਮਾਜ ਦੀ ਦੇਣ ਹੈ ਜੋ ਕਿ ਭਾਰਤ ਵਿਚ ਪੱਛਮ ਦੇ ਪ੍ਰਭਾਵ ਅਧੀਨ ਭਾਰਤ ਵਿਚ ਆਇਆ। ਪੰਜਾਬੀ ਦੇ ਪਹਿਲੇ ਮੌਲਿਕ ਨਾਵਲ ਬਾਰੇ ਵੱਖ-ਵੱਖ ਵਿਦਵਾਨਾਂ ਦੇ ਵੱਖੋਂ-ਵੱਖ ਮੱਤ ਹਨ ਪ੍ਰੰਤੂ ਪੰਜਾਬੀ ਦਾ ਪਹਿਲਾ ਮੌਲਿਕ ਨਾਵਲ ਭਾਈ ਵੀਰ ਸਿੰਘ ਜੀ ਦੇ ਨਾਵਲ 'ਸੁੰਦਰੀ' ਨੂੰ ਮੰਨਿਆ ਜਾ ਸਕਦਾ ਹੈ ਕਿਉਂਕਿ ਇਸ ਤੱਥ ਨਾਲ ਵਧੇਰੇ ਵਿਦਵਾਨ ਸਹਿਮਤ ਹਨ।

ਨਾਵਲ ਇਕ ਲੰਬੀ ਸਾਹਿਤਕ ਗਲਪਮਈ ਰਚਨਾ ਹੈ ਜਿਸ ਵਿਚ ਵਿਆਪਕ ਜੀਵਨ ਦਾ ਵਿਸ਼ਲੇਸ਼ਣ, ਪਾਤਰਾਂ, ਕਹਾਣੀ, ਘਟਨਾਵਾਂ, ਵਾਰਤਾਲਾਪ ਅਤੇ ਭਾਸ਼ਾ ਦੁਆਰਾ ਕੋਈ ਨਾਵਲਕਾਰ ਇਕ ਵਿਲੱਖਣ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਤੋਂ ਅਜਨਬੀ ਢੰਗ ਨਾਲ ਇਉਂ ਕਰਦਾ ਹੈ ਕਿ ਗਲਪੀ ਸੰਸਾਰ ਸੱਚਮੁੱਚ ਦਾ ਸੰਸਾਰ ਨਾ ਹੁੰਦਿਆ ਹੋਇਆ ਵੀ ਸੱਚ ਵਰਗਾਂ ਪ੍ਰਤੀਤ ਹੁੰਦਾ ਹੈ। ਪੰਜਾਬੀ ਨਾਵਲ, ਅੰਗਰੇਜ਼ੀ ਨਾਵਲ ਦੇ ਪ੍ਰਭਾਵ ਅਧੀਨ ਉਨ੍ਹੀਵੀਂ ਸਦੀਂ ਦੇ ਆਖੀਰਲੇ ਦਹਾਕਿਆਂ ਵਿਚ ਪੈਦਾ ਹੋਇਆ।

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਪੰਜਾਬੀ ਸਾਹਿਤ ਦਾ ਇਕ ਉੱਤਮ ਨਾਵਲਕਾਰ ਹੈ। ਪੰਜਾਬੀ ਨਾਵਲ ਨੂੰ ਉਸ ਨੇ ਆਪਣੀ ਆਮਦ ਨਾਲ ਹੋਰ ਵੀ ਅਮੀਰ ਬਣਾ ਦਿੱਤਾ। ਕੁੱਸਾ ਇਕ ਸਧਾਰਨ ਅਤੇ ਨਿਮਨ ਪਰਿਵਾਰ ਨਾਲ ਸੰਬੰਧ ਰੱਖਦਾ ਸੀ। ਉਸਦੇ ਆਪਣੇ ਕਥਨ ਅਨੁਸਾਰ ਉਸ ਨੇ ਸੱਤ ਨਾਵਲ ਲਿਖੇ ਹਨ, ''ਹੁਣ ਤੱਕ ਮੇਰੇ ਛਪੇ ਅਣਛਪੇ

ਸੱਤ ਨਾਵਲ ਹਨ, ਪਹਿਲੇ ਤਿੰਨ ਨਾਵਲ ਮੈਂ ਛਾਪੇ ਨੇ, ਸ਼ਾਇਦ ਉਦੋਂ ਛਪਣਾਉਣ ਦੀ ਲੋਚਾ ਵੀ ਨਹੀਂ ਸੀ। ਅਸਲ ਵਿਚ 'ਬੁਰਕੇ ਵਾਲੇ ਲੁਟੇਰੇ' ਰਾਹੀਂ ਮੇਰਾ ਸਾਹਿਤਿਕ ਸਫ਼ਰ ਪਾਠਕਾਂ ਸਾਹਮਣੇ ਪੇਸ਼ ਹੁੰਦਾ ਹੈ।" ਕੁੱਸਾ ਦੇ ਛੇ ਨਾਵਲ ਪ੍ਰਕਾਸ਼ਿਤ ਹੋਏ ਹਨ, 'ਬੁਰਕੇ ਵਾਲੇ ਲੁਟੇਰੇ', 'ਰਾਤ ਦੇ ਰਾਤ ਦੇ ਰਾਹੀ, 'ਰੋਹੀ ਬੀਆਬਾਨ', 'ਅੱਗ ਦਾ ਗੀਤ', 'ਜ਼ਖ਼ਮੀ ਦਰਿਆ'। ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੂੰ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਦੀ ਕਲਾਤਮਕ ਵਿਸ਼ੇਸ਼ਤਾ ਕਰਕੇ, ਭਾਈ ਵੀਰ ਸਿੰਘ ਗਲਪ ਪੁਰਸਕਾਰ, ਗੁਰੂ ਨਾਨਕ ਦੇਵ ਯੂਨੀਵਰਸਿਟੀ, ਅੰਮ੍ਰਿਤਸਰ ਵਲੋਂ ਪ੍ਰਦਾਨ ਕੀਤਾ ਗਿਆ, ਜਿਸ ਨੇ ਕੁੱਸਾ ਨੂੰ ਪੰਜਾਬੀ ਨਾਵਲਕਾਰਾਂ ਦੀ ਮੋਹਰਲੀ ਕਤਾਰ ਵਿਚ ਖੜਾ ਕਰ ਦਿੱਤਾ। ਰੋਹੀ ਬੀਆਬਾਨ ਨਾਵਲ ਵਿਚ ਪ੍ਰਸਤੁਤ ਮਸਲੇ ਅਜੋਕੇ ਦੌਰ ਵਿਚ ਭਖਦੇ ਮਸਲੇ ਹਨ, ਜਿਹਨਾਂ ਨਾਲ ਸਾਡਾ ਸਮਾਜ ਜੂਝ ਰਿਹਾ ਹੈ। ਇਸ ਨਾਵਲ ਦਾ ਪ੍ਰਭਾਵ ਤੀਖਣ ਹੈ ਜੋ ਕਿ ਸਾਡੇ ਸਮਾਜ ਵਿਚ ਪ੍ਰਚਲਿਤ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਉਜਾਗਰ ਕਰਦਾ ਹੈ ਜੋ ਕਿ ਸਮੇਂ ਦੀ ਮੰਗ ਹੈ। ਸੋ ਇਸ ਆਧਾਰ 'ਤੇ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਇਕ ਉਤਕ੍ਰਿਸ਼ਟ ਰਚਨਾ ਮੰਨਿਆ ਜਾਂ ਸਕਦਾ ਹੈ ਅਤੇ ਨਾਵਲਕਾਰ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੂੰ ਇਕ ਉੱਤਮ ਨਾਵਲਕਾਰ ਕਿਹਾ ਜਾ ਸਕਦਾ ਹੈ।

ਕੁੱਸਾ ਨੇ ਬਹੁਤ ਗ਼ਰੀਬੀ ਵਿਚ ਆਪਣੀ ਜ਼ਿੰਦਗੀ ਬਤੀਤ ਕੀਤੀ ਜਿਸ ਕਾਰਨ ਉਸ ਨਾਲ ਧੱਕਾ ਵੀ ਹੁੰਦਾ ਰਿਹਾ ਹੈ ਅਤੇ ਉਹ ਖ਼ੁਦ ਇਹ ਗੱਲ਼ ਦੱਸਦਾ ਹੈ ਕਿ ਛੋਟੀ ਕਿਸਾਨੀ ਨਾਲ ਸੰਬੰਧਿਤ ਹੋਣ ਕਰਕੇ ਉਸ ਦੀ ਸਮਾਜ ਵਿਚ ਕੋਈ ਹੋਂਦ ਹੀ ਨਹੀਂ ਸਮਝੀ ਜਾਂਦੀ ਸੀ ਅਤੇ ਕੁੱਝ ਕਰਨ ਦੀ ਤਮੰਨਾ ਨੇ ਉਸ ਨੂੰ ਨਾਵਲਕਾਰ ਬਣਾ ਦਿੱਤਾ।

ਕੁੱਸਾ ਆਪਣੇ ਤੀਸਰੇ ਨਾਵਲ 'ਰੋਹੀ ਬੀਆਬਾਨ' ਵਿਚ ਵੀ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਸੰਤਾਪ ਦੀ ਗੱਲ ਕਰਦਾ ਹੈ।ਨਾਵਲ ਦਾ ਕੇਂਦਰੀ ਪਾਤਰ ਮੁੱਖ ਤੌਰ 'ਤੇ ਵਿਗੜਿਆ ਹੋਇਆ ਜਾਪਦਾ ਹੈ। ਮਾਤਾ-ਪਿਤਾ 'ਤੇ ਆਂਢ ਗੁਆਂਢ ਉਸਨੂੰ ਅੜ੍ਹਬ ਅੱਖੜ ਤੇ ਨਿਕੰਮਾ ਸਮਝਦੇ ਹਨ। ਪਰ ਲੇਖਕ ਉਸਦੀ ਸ਼ਖ਼ਸੀਅਤ ਦੇ ਇਨ੍ਹਾਂ ਵਿਗਾੜਾਂ ਦਾ ਕਾਰਨ ਉਸਦੇ ਆਲੇ ਦੁਆਲੇ ਉਸਦੀ ਸਮਾਜਕ ਸਥਿਤੀ ਵਿੱਚੋਂ ਲੱਭਦਾ ਹੈ। ਘਰ ਦੀ ਆਰਥਿਕ ਤੌਰ 'ਤੇ ਮੰਦੀ ਹਾਲਤ, ਮਾਸਟਰਾਂ ਦੀ ਮਾਰ ਕੁੱਟ, ਹਾਣੀ ਮੁੰਡਿਆਂ ਦੀਆਂ ਟਿੱਚਰਾਂ, ਕੰਮ ਦੀ ਬਹੁਤਾਤ ਆਦਿ ਕੁੱਝ ਅਜਿਹੇ ਕਾਰਨ ਹਨ ਜੋ ਉਸਦੀ ਪੁੰਗਰਦੀ ਸ਼ਖ਼ਸੀਅਤ ਨੂੰ ਵਿਗਾੜ ਦੇ ਰਾਹ 'ਤੇ ਤੋਰਨ ਦੇ ਜ਼ਿੰਮੇਵਾਰ ਹਨ। ਪਰ ਇਹੀ ਗੋਰਾ ਜਦੋਂ ਕੰਮ ਵਿਚ ਪੈਂਦਾ ਹੈ ਤਾਂ ਉਹ ਬੜਾ ਸਿਆਣਾ ਤੇ ਜ਼ਿੰਮੇਵਾਰ ਵਿਅਕਤੀ ਲਗਦਾ ਹੈ। ਗੋਰੇ ਦੀ ਅੰਦਰਲੀ ਸ਼ਖ਼ਸੀਅਤ ਅਸਲ ਵਿਚ ਉਸਦੇ ਕਾਰਜ ਵਿੱਚੋਂ ਉਭਰਦੀ ਹੈ। ਉਸਦੀ ਅਫ਼ਸਰੀ ਤੇ ਧੱਕੇ ਸ਼ਾਹੀ ਅੱਗੇ ਡੱਟ ਕੇ ਖਲੌਣ ਦੀ ਦਲੇਰੀ ਜਾਂ ਨਖਿੱਧ ਕੰਮ ਛੱਡ ਕੇ ਦੌੜ ਜਾਣ ਦਾ ਫੈਸਲਾ ਉਸਦੇ ਅਜਿਹੇ ਅੰਦਰੂਨੀ ਗੁਣ ਹਨ ਜਿਹੜੇ ਉਸਦੇ ਸਾਰੇ ਭੈੜਾ ਤੇ ਖੋਜਾਂ ਦੇ ਬਾਵਜੂਦ ਪਾਠਕ ਦੀ ਉਸ ਨਾਲ ਹਮਦਰਦੀ ਬਣਾਈ ਰੱਖਦੇ ਹਨ। ਲੇਖਕ ਨੇ ਇਸੇ ਵਿਧੀ ਦੁਆਰਾ ਹੀ ਦੂਸਰੇ ਪਾਤਰਾਂ ਦਾ ਜ਼ਿਕਰ ਵੀ ਉਘਾੜਿਆ ਹੈ। ਇਸ ਨਾਵਲ ਦਾ ਮੁੱਖ ਵਿਸ਼ਾ ਛੋਟੀ ਕਿਸਾਨੀ ਦੇ ਸੰਤਾਪ ਨੂੰ ਪੇਸ਼ ਕਰਨਾ ਹੈ। 'ਰੋਹੀ ਬੀਆਬਾਨ' ਦੀ ਮੂਲ ਕਥਾ ਗ਼ਰੀਬ ਕਿਸਾਨੀ ਦੇ ਇਕਹਿਰੇ ਤੇ ਛੋਟੇ ਪਰਿਵਾਰ ਦੀ ਕਥਾ ਹੈ। ਇਸ ਪਰਿਵਾਰ ਦੇ ਪੰਜ ਜੀਅ ਹਨ: ਜੋਗਿੰਦਰ-ਮਹਿੰਦਰੋ (ਪਤੀ-ਪਤਨੀ), ਗੋਰਾ ਤੇ ਕੱਦੂ (ਦੋ ਮੁੰਡੇ) ਤੇ ਇਕ ਨਿੱਕੀ ਕੁੜੀ। ਜੱਦੀ ਜ਼ਮੀਨ

ਵਿਚੋਂ ਇਸ ਪਰਿਵਾਰ ਦੇ ਹਿੱਸੇ ਕੁੱਲ ਪੌਣਾ ਕਿੱਲਾ ਆਇਆ ਹੈ। ਸਾਰਾ ਪਰਿਵਾਰ ਮਿੱਟੀ ਨਾਲ ਮਿੱਟੀ ਹੋਇਆ ਰਹਿੰਦਾ ਹੈ, ਪਰ ਗੁਜ਼ਾਰਾ ਤਾਂ ਵੀ ਮੁਸ਼ਕਲ ਨਾਲ ਹੁੰਦਾ ਹੈ। ਸਕੂਲ ਤੇ ਘਰ ਵਿਚ ਪੜ੍ਹਾਈ ਦਾ ਢੁਕਵਾਂ ਮਾਹੌਲ ਨਾ ਹੋਣ ਕਾਰਨ 'ਗੋਰਾ' ਤੀਜੀ ਜਮਾਤ ਵਿਚੋਂ ਦੂਜੀ ਵਾਰ ਫੇਲ੍ਹ ਹੋ ਕੇ ਪੜ੍ਹਨੋਂ ਹਟ ਜਾਂਦਾ ਹੈ। ਗਿੰਦਰ ਨੂੰ ਆਪਣੇ ਇਕ ਭਰਾ ਦੀ ਮੌਤ ਪਿਛੋਂ ਇਕ ਵਾਰ ਮੁੜ ਵੱਡੇ ਭਰਾਵਾਂ ਨਾਲ ਰਲਣਾ ਪੈ ਜਾਂਦਾ ਹੈ, ਪਰ ਉਨ੍ਹਾਂ ਦੇ ਦੁਰਵਿਹਾਰ ਤੋਂ ਤੰਗ ਆ ਕਰ ਉਹ ਸਾਲ ਬਾਅਦ ਹੀ ਦੁਆਰਾ ਅੱਡ ਹੋ ਜਾਂਦਾ ਹੈ। ਗੋਰਾ ਹੈ ਹੌਲੀ-ਹੌਲੀ ਇਲਤੀ ਹੋ ਜਾਂਦਾ ਹੈ। ਉਹ ਚੋਰੀ ਵੀ ਕਰਦਾ ਹੈ, ਬੀੜੀਆਂ ਪੀਣੀਆਂ ਵੀ ਸ਼ੁਰੂ ਕਰ ਦਿੰਦਾ ਹੈ ਅਤੇ ਪਿਉ ਨਾਲ ਰਲ ਕੇ ਸ਼ਰਾਬ ਕੱਢਣੀ ਤੇ ਵੇਚਣੀ ਸ਼ੁਰੂ ਕਰ ਦਿੰਦਾ ਹੈ। ਗੋਰਾ ਆਰਥਕ ਤੰਗੀ ਵਿਚੋਂ ਨਿਕਲਣ ਲਈ ਕਈ ਯਤਨ ਕਰਦਾ ਹੈ ਪ੍ਰੰਤੂ ਉਹ ਹਰ ਕੰਮ ਵਿਚੋਂ ਅਸਫ਼ਲ ਰਹਿੰਦਾ ਹੈ ਅਤੇ ਅੰਤ ਉਸ ਦੇ ਸੀਰੀ ਰਲਣ ਦੀ ਨੌਬਤ ਆ ਜਾਂਦੀ ਹੈ ਜੋ ਉਸ ਲਈ ਉਸ ਦੀ ਹੋਣੀ ਸੀ। ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਯਥਾਰਥ ਦੀ ਪੇਸ਼ਕਾਰੀ ਕਰਨ ਵਾਲਾ ਨਾਵਲ ਹੈ। ਇਸ ਵਿਚ ਨਾਵਲਕਾਰ ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਨਿਰੋਲ ਕਿਸਾਨੀ ਦੇ ਜ਼ਮੀਨ ਤੋਂ ਟੁੱਟਣ ਤੇ ਕੰਗਾਲ ਹੋਣ ਦਾ ਵਰਣਨ ਬਾਖੂਬੀ ਨਾਲ ਕੀਤਾ ਹੈ। ਨਾਵਲ ਦਾ ਮੁੱਖ ਪਾਤਰ ਗੋਰਾ ਗ਼ਰੀਬ ਪਰਿਵਾਰ ਨਾਲ ਸੰਬੰਧਿਤ ਹੈ ਇਸ ਪਰਿਵਾਰ ਦੀ ਇੱਛਾ ਹੈ ਕਿ ਘਰ ਦਾ ਵੱਡਾ ਮੁੰਡਾ ਗੋਰਾ ਪੜ੍ਹ ਜਾਵੇ ਅਤੇ ਕਿਤੇ ਨੌਕਰੀ ਕਰਕੇ ਆਪਣਾ ਜੀਵਨ ਤੇ ਪਰਿਵਾਰ ਦਾ ਜੀਵਨ ਸੁਧਾਰੇ। ਪਰੰਤੂ ਜਿਸ ਮਾਹੌਲ ਵਿਚ ਇਹ ਪਰਿਵਾਰ ਰਹਿ ਰਿਹਾ ਹੈ ਤੇ ਗੋਰਾ ਵਿਚਰਦਾ ਹੈ ਉਥੇ ਗ਼ਰੀਬ ਕਿਸਾਨ ਦੇ ਪੁੱਤ ਦਾ ਪੜ੍ਹ ਜਾਣਾ ਹਾਦਸੇ ਵਾਂਗ ਹੈ, ਜਿਹੜਾ ਕਦੇ ਕਦਾਈਂ ਵਾਪਰਦਾ ਹੈ। ਪਰੰਤੂ ਇਸ ਪਰਿਵਾਰ ਦੇ ਸੰਦਰਭ ਵਿਚ ਇਹ ਹਾਦਸਾ ਨਹੀਂ ਵਾਪਰਦਾ। ਗੋਰਾ ਪੜ੍ਹ ਨਹੀਂ ਸਕਦਾ। ਫਿਰ ਉਸ ਨੂੰ ਘਰ ਦੇ ਕੰਮ ਵਿਚ ਲਾਉਣ ਦੇ ਯਤਨ ਕੀਤੇ ਜਾਂਦੇ ਹਨ ਪ੍ਰੰਤੂ ਇਹ ਯਤਨ ਵੀ ਸਫ਼ਲ ਨਹੀਂ ਹੁੰਦੇ। ਅੰਤ ਉਸ ਦੇ ਸੀਰੀ ਰਲਣ ਤੱਕ ਦੀ ਨੌਬਤ ਆ ਜਾਂਦੀ ਹੈ।

ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਇਕ ਸਫ਼ਲ ਨਾਵਲ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਉਹ ਸਾਰੀਆਂ ਹੀ ਗਾਲਪਨਿਕ ਜੁਗਤਾਂ ਮੌਜੂਦ ਹਨ ਜੋ ਕਿ ਇਕ ਸਰਵੋਤਮ ਨਾਵਲ ਵਿਚ ਹੋਣੀਆਂ ਜ਼ਰੂਰੀ ਜਾਂਦੀਆ ਮੰਨੀਆਂ ਹਨ। ਇਸ ਨਾਵਲ ਦੀ ਪ੍ਰਾਪਤੀ ਇਸ ਗੱਲ ਵਿਚ ਹੈ ਕਿ ਇਹ ਨਾਵਲ ਇੰਨਾ ਸਮਾਂ ਬੀਤਣ ਦੇ ਬਾਵਜੂਦ ਅੱਜ ਵੀ ਪੰਜਾਬੀ ਨਾਵਲ ਜਗਤ ਵਿਚ ਬੜੀ ਹੀ ਸ਼ਿੱਦਤ ਦੇ ਨਾਲ ਪੜ੍ਹਿਆ ਜਾਂਦਾ ਹੈ। ਕੁੱਸਾ ਮੁੱਖ ਰੂਪ ਵਿਚ ਜ਼ਮੀਨ ਦੀਆਂ ਛੋਟੀਆਂ ਹੁੰਦੀਆਂ ਜਾ ਰਹੀਆਂ ਹਿੱਸੇਦਾਰੀਆਂ ਕਾਰਨ ਬੜੀ ਤੇਜ਼ੀ ਨਾਲ ਬੇਜ਼ਮੀਨ ਹੋ ਰਹੀ ਛੋਟੀ ਕਿਸਾਨੀ ਦੀਆਂ ਇਤਿਹਾਸਕ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਚਿਤਰਣ ਵਾਲਾ ਨਾਵਲਕਾਰ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਕੁੱਸਾ ਕਿਸਾਨੀ ਦੇ ਜਿਨਸੀ ਸੰਬੰਧਾਂ ਦੇ ਸੰਕਟ ਤੋਂ ਹਟ ਕੇ ਉਸ ਦੀ ਦਿਸ਼ਾਹੀਣਤਾ ਦੀ ਸਮੱਸਿਆ ਨੂੰ ਪੇਸ਼ ਕਰਦਾ ਹੈ। ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਪੰਜਾਬੀ ਸਾਹਿਤ ਦਾ ਇਕ ਉੱਤਮ ਨਾਵਲਕਾਰ ਹੈ। ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਨੂੰ ਜਿੱਥੇ ਪੰਜਾਬੀ ਸਾਹਿਤ ਵਿਚ ਨਾਵਲੀ ਜਗਤ ਨਾਲ ਜੁੜੀਆਂ ਜਾਣੀਆਂ-ਪਛਾਣੀਆਂ ਹਸਤੀਆਂ ਜੋਗਿੰਦਰ ਸਿੰਘ ਰਾਹੀ, ਟੀ. ਆਰ.ਵਿਨੋਦ ਆਦਿ ਨੇ ਸਲਾਹਿਆ ਹੈ, ਉਥੇ ਆਮ ਲੋਕਾਂ ਨੇ ਵੀ ਆਪ ਦੇ ਨਾਵਲਾਂ ਨੂੰ ਚਾਅ ਨਾਲ ਪੜ੍ਹਿਆ ਹੈ। 'ਰੋਹੀ ਬੀਆਬਾਨ' ਵਿਚ ਹਰੀ ਕ੍ਰਾਂਤੀ ਉਪਰੰਤ ਪੰਜਾਬ

ਦੀ ਛੋਟੀ ਕਿਰਸਾਣੀ ਦੇ ਸੰਕਟ ਨੂੰ ਰੂਪਮਾਨ ਕੀਤਾ ਗਿਆ ਹੈ। ਇਸ ਨਾਵਲ ਨੂੰ ਕਿਸਾਨੀ ਸੱਭਿਆਚਾਰ ਦਾ ਦਸਤਾਵੇਜ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਯਥਾਰਥਵਾਦੀ ਨਾਵਲ ਦੀਆਂ ਬਿਰਤਾਂਤਕ ਜੁਗਤਾਂ ਦਾ ਕਲਾਤਮਕ ਪ੍ਰਯੋਗ ਕੀਤਾ ਗਿਆ ਹੈ।

ਨਾਵਲ ਕਲਾਤਮਕ ਪੱਖ ਤੋਂ ਵੀ ਉੱਤਮ ਹੈ। ਨਾਵਲ ਦੇ ਸਾਰੇ ਪਾਤਰ ਯਥਾਰਥਕ ਪ੍ਰਤੀਤ ਹੁੰਦੇ ਹਨ। ਨਾਵਲਕਾਰ ਨੇ ਨਾ ਸਿਰਫ਼ ਪਾਤਰਾਂ ਦੀ ਬਾਹਰੀ ਦਿੱਖ ਨੂੰ ਬਿਆਨ ਕੀਤਾ ਹੈ ਸਗੋਂ ਉਨ੍ਹਾਂ ਦਾ ਮਨੋਵਿਸ਼ਲੇਸ਼ਣ ਵੀ ਕੀਤਾ ਹੈ ਉਸ ਦੇ ਪਾਤਰ ਸੁਭਾਵਿਕ ਲੱਗਦੇ ਹਨ।ਕਰਮਜੀਤ ਕੁੱਸਾ ਦੀ ਪਾਤਰ ਚਿਤਰਣ ਵਿਧੀ ਵੀ ਉਸ ਦੀ ਗਲਪ ਦ੍ਰਿਸ਼ਟੀ ਵਾਂਗ ਯਥਾਰਥਕ ਹੈ। ਕੁੱਸਾ ਜਦੋਂ ਪਾਤਰਾਂ ਦੀ ਅੰਦਰੂਨੀ ਕਿਸਮ ਜਾਂ ਉਹਨਾਂ ਦੇ ਗੁਣਾਂ ਔਗੁਣਾ ਦੀ ਗੱਲ ਕਰਦਾ ਹੈ ਤਾਂ ਉਹ ਉਨ੍ਹਾਂ ਨੂੰ ਕਿਸੇ ਵਿਸ਼ੇਸ਼ ਪ੍ਰਸਥਿਤੀਆਂ ਵਿੱਚ ਵਿਚਰਦਿਆਂ ਵਿਖਾ ਕੇ ਉਨ੍ਹਾਂ ਦੇ ਸਹੀ ਆਪੇ ਦੀ ਪਹਿਚਾਣ ਕਰਵਾਉਂਦਾ ਹੈ। ਨਾਵਲ ਦਾ ਕੇਂਦਰੀ ਪਾਤਰ ਮੁੱਖ ਤੌਰ ਤੇ ਵਿਗੜਿਆ ਹੋਇਆ ਜਾਪਦਾ ਹੈ। ਮਾਤਾ-ਪਿਤਾ ਤੇ ਆਂਢ ਗੁਆਂਢ ਉਸਨੂੰ ਅੜ੍ਹਬ ਅੱਖੜ ਤੇ ਨਿਕੰਮਾ ਸਮਝਦੇ ਹਨ। ਪਰ ਲੇਖਕ ਉਸਦੀ ਸ਼ਖ਼ਸੀਅਤ ਦੇ ਇਨ੍ਹਾਂ ਵਿਗਾੜਾਂ ਦਾ ਕਾਰਨ ਉਸਦੇ ਆਲੇ ਦੁਆਲੇ ਉਸਦੀ ਸਮਾਜਕ ਸਥਿਤੀ ਵਿਚੋਂ ਲੱਭਦਾ ਹੈ। ਘਰ ਦੀ ਆਰਥਿਕ ਤੌਰ ’ਤੇ ਮੰਦੀ ਹਾਲਤ, ਮਾਸਟਰਾਂ ਦੀ ਮਾਰ ਕੁੱਟ, ਹਾਣੀ ਮੁੰਡਿਆਂ ਦੀਆਂ ਟਿੱਚਰਾਂ, ਕੰਮ ਦੀ ਬਹੁਤਾਤ ਕੁੱਝ ਅਜਿਹੇ ਕਾਰਨ ਹਨ ਜੋ ਉਸਦੀ ਪੁੰਗਰਦੀ ਸ਼ਖ਼ਸੀਅਤ ਨੂੰ ਵਿਗਾੜ ਦੇ ਰਾਹ ਤੋਰਨ ਦੇ ਜ਼ਿੰਮੇਵਾਰ ਹਨ। ਪਰ ਇਹੀ ਗੋਰਾ ਜਦੋਂ ਕੰਮ ਵਿੱਚ ਪੈਂਦਾ ਹੈ ਤਾਂ ਉਹ ਬੜਾ ਸਿਆਣਾ ਤੇ ਜ਼ਿੰਮੇਵਾਰ ਵਿਅਕਤੀ ਲਗਦਾ ਹੈ। ਗੋਰੇ ਦੀ ਅੰਦਰਲੀ ਸ਼ਖ਼ਸੀਅਤ ਅਸਲ ਵਿੱਚ ਉਸਦੇ ਕਾਰਜ ਵਿੱਚੋ ਉਭਰਦੀ ਹੈ। ਉਸਦੀ ਅਫ਼ਸਰੀ ਤੇ ਧੱਕੇ ਸ਼ਾਹੀ ਅੱਗੇ ਡੱਟਕੇ ਖਲੋਣ ਦੀ ਦਲੇਰੀ ਜਾਂ ਨਿਖੱਧ ਕੰਮ ਛੱਡ ਕੇ ਦੌੜ ਜਾਣ ਦਾ ਫੈਸਲਾ ਉਸਦੇ ਅਜਿਹੇ ਅੰਦਰੂਨੀ ਗੁਣ ਹਨ ਜਿਹੜੇ ਉਸਦੇ ਸਾਰੇ ਭੈੜਾ ’ਤੇ ਖੋਜਾਂ ਦੇ ਬਾਵਜੂਦ ਪਾਠਕ ਦੀ ਉਸ ਨਾਲ ਹਮਦਰਦੀ ਬਣਾਈ ਰੱਖਦੇ ਹਨ। ਲੇਖਕ ਨੇ ਇਸੇ ਵਿਧੀ ਦੁਆਰਾ ਹੀ ਦੂਸਰੇ ਪਾਤਰਾਂ ਦਾ ਜ਼ਿਕਰ ਵੀ ਉਘਾੜਿਆ ਹੈ।

ਇਸ ਨਾਵਲ ਦਾ ਪਲਾਟ ਇਕਹਿਰਾ ਹੈ ਜੋ ਇਕ ਹੀ ਪਰਿਵਾਰ ਦੇ ਦੁਆਲੇ ਘਮੁੰਦਾ ਹੈ। ਨਾਵਲ ਵਿਚ ਅਨੇਕਾ ਗਲਪੀ ਜੁਗਤਾਂ ਰਾਹੀਂ ਘਟਨਾਵਾਂ ਨੂੰ ਤਰਤੀਬ ਦਿੱਤੀ ਗਈ ਹੈ। ਜਿਵੇਂ ਕਿ ਅਰੰਭਿਕ ਦੌਰ ਵਿਚ ਗੋਰੇ ਦਾ ਪੜ੍ਹਾਈ ਪ੍ਰਤੀ ਰੁਚਿਤ ਨਾ ਹੋਣਾ, ਵਾਰ ਵਾਰ ਫੇਲ੍ਹ ਹੋਣਾ। ਇਸ ਵਾਰ ਫੇਲ੍ਹ ਹੋਣ ਤੇ ਗੋਰਾ ਪੜਨ ਤੋਂ ਹੱਟ ਜਾਂਦਾ ਹੈ, ਅਤੇ ਉਹ ਘਰ ਦੇ ਕੰਮਾਂ ਵਿਚ ਦਿਲਚਸਪੀ ਲੈਣ ਲੱਗ ਜਾਂਦਾ ਹੈ। ਨਾਵਲੀ ਬਿਰਤਾਂਤ ਨੂੰ ਅੱਗੇ ਤੋਰਨ ਵਾਸਤੇ ਕੁੱਸਾ ਇਸ ਵਿਚ ਇਕ ਹੋਰ ਘਟਨਾਂ ਜੋੜਦਾ ਹੈ। ਗੋਰੇ ਨੂੰ ਉਸ ਦੇ ਮਾਮੇ ਦੇ ਨਾਲ ਸ਼ਹਿਰ ਭੇਜ ਦਿੱਤਾ ਜਾਂਦਾ ਹੈ ਇਕ ਬੇਕਰੀ ਵਿਚ ਕੰਮ ਕਰਨ ਵਾਸਤੇ। ਪ੍ਰੰਤੂ ਗੋਰੇ ਦੀ ਜੱਟ ਮਾਨਸਿਕਤਾ ਨੂੰ ਉਸ ਸਮੇਂ ਠੇਸ ਪਹੁੰਚਦੀ ਹੈ ਜਦੋਂ ਬੇਕਰੀ ਮਾਲਿਕ ਉਸ ਨੂੰ ਗੋਹਾ ਸੁੱਟਣ ਵਾਸਤੇ ਕਹਿੰਦਾ ਹੈ ਅਤੇ ਗੋਰਾ ਕੰਮ ਛੱਡ ਕੇ ਪਿੰਡ ਵਾਪਿਸ ਆ ਜਾਂਦਾ ਹੈ ਅਤੇ ਇਸ

ਨਾਵਲ ਦੇ ਅੰਤ ਤੱਕ ਕੁੱਸਾ ਇਸ ਨਾਵਲ ਵਿਚ ਤ੍ਰਾਸਦੀ ਉਸ ਸਮੇਂ ਸਿਖ਼ਰ 'ਤੇ ਪਹੁੰਚ ਜਾਂਦੀ ਹੈ ਜਦੋਂ ਗੋਰੇ ਦੇ ਸੀਰੀ ਰਲਣ ਦੀ ਨੌਬਤ ਆ ਜਾਂਦੀ ਹੈ।

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਮਲਵਈ ਭਾਸ਼ਾ ਵਰਤੀ ਹੈ। ਉਸ ਦੀ ਭਾਸ਼ਾ ਸਰਲ ਅਤੇ ਰੌਚਕ ਹੈ ਜੋ ਕਿ ਉਸ ਦੇ ਪਾਤਰਾਂ ਦੇ ਅਨੁਕੂਲ ਹਨ। ਨਾਵਲ ਦੇ ਵਾਰਤਾਲਾਪ ਬੜੇ ਹੀ ਪ੍ਰਭਾਵਸ਼ਾਲੀ ਹਨ ਵਾਰਤਾਲਾਪ ਤੀਖਣ ਹਨ ਜੋ ਪਾਠਕ ਨੂੰ ਪ੍ਰਭਾਵਿਤ ਕਰਦੇ ਹਨ। ਸੱਭ ਤੋਂ ਵੱਡੀ ਪ੍ਰਾਪਤੀ ਇਸ ਗੱਲ਼ ਵਿਚ ਹ ਕਿ ਕੁੱਸਾ ਦੁਅਰਾ ਵਰਤੇ ਵਾਰਤਾਲਾਪ ਸਥਿਤੀ ਦੇ ਅਨੁਕੂਲ ਹਨ।

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਇਸ ਨਾਵਲ (ਰੋਹੀ ਬੀਆਬਾਨ) ਵਿਚ ਘਟਨਾਵਾਂ ਨੂੰ ਬੜੀ ਹੀ ਸੂਝ ਦੇ ਨਾਲ ਇਸ ਪ੍ਰਕਾਰ ਜੋੜਿਆ ਹੈ ਕਿ ਇਹ ਘਟਨਾਵਾਂ ਯਥਾਰਥਕ ਅਤੇ ਸੁਭਾਵਿਕ ਪ੍ਰਤੀਤ ਹੁੰਦੀਆ ਹਨ। ਕੁੱਸੇ ਦੀ ਇਸੇ ਵਿਸ਼ੇਸ਼ਤਾ ਕਰਕੇ ਇਹ ਨਾਵਲ ਸਭ ਤੋਂ ਵੱਧ ਪੜ੍ਹੇ ਜਾਣ ਵਾਲੇ ਨਾਵਲਾਂ ਵਿਚੋਂ ਇਕ ਹੈ।

ਇਹ ਨਾਵਲ ਪ੍ਰਤੀਕਾਤਮਕ ਸ਼ੈਲੀ ਵਿਚ ਲਿਖਿਆ ਨਾਵਲ ਹੈ। ਗਰੀਬ ਕਿਸਾਨੀ ਦੇ ਜੀਵਨ-ਯਥਾਰਥ ਦੀਆਂ ਮੂਲ ਇਕਾਈਆਂ ਵਿਚ ਗ੍ਰਸਤ ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨ ਹੈ। ਰੋਹੀ ਬੀਆਬਾਨ ਦੀ ਮੂਲ ਕਥਾ ਗਰੀਬ ਕਿਸਾਨ ਦੇ ਦੁਆਲੇ ਘੁੰਮਦੀ ਹੈ। ਗੋਰੇ ਦੇ ਜੀਵਨ ਵਿਚ ਅਨੇਕਾਂ ਮੁਸ਼ਕਲਾਂ ਆਉਂਦੀਆਂ ਹਨ, ਜਿਨ੍ਹਾਂ ਤੋਂ ਗੋਰਾ ਜਿੰਨਾਂ ਬਚਣ ਦੀ ਕੋਸ਼ਿਸ਼ ਕਰਦਾ ਹੈ ਓਨਾ ਹੀ ਫਸਦਾ ਜਾਂਦਾ ਹੈ। ਇਸ ਨਾਵਲ ਦਾ ਅਰੰਭ ਗੋਰੇ ਦੇ ਬਚਪਨ ਤੋਂ ਉਸ ਦੇ ਗੱਭਰੂ ਹੋਣ ਤੱਕ ਜਾਂਦਾ ਹੈ। ਨਾਵਲ ਦੇ ਅਨੇਕਾਂ ਵੇਰਵੇਂ ਗੋਰੇ ਦੀਆਂ ਜੀਵਨ ਪ੍ਰਸਥਿਤੀਆਂ ਨਾਲ ਜੁੜੇ ਹਨ।

ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਨੇ ਬੜੇ ਹੀ ਕਲਾਤਮਕ ਤਰੀਕੇ ਦੇ ਨਾਲ ਇਸ ਨਾਵਲ ਨੂੰ ਲਿਖਿਆ ਹੈ। ਨਾਵਲ ਦੀਆਂ ਸਮੁੱਚੀਆਂ ਜੁਗਤਾਂ ਨੂੰ ਬੜ੍ਹੀ ਹੀ ਸੂਝ ਨਾਲ ਵਰਤਿਆ ਗਿਆ ਹੈ। ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਦਾ ਇਹ ਨਾਵਲ ਹਰੇਕ ਪੱਖ ਤੋਂ ਸੰਪੂਰਨ ਕਿਹਾ ਜਾ ਸਕਦਾ ਹੈ। ਇਸ ਗੱਲ ਦੀ ਪ੍ਰਮਾਣਿਕਤਾ ਇਸ ਨੂੰ ਪੰਜਾਬੀ ਨਾਵਲ ਜਗਤ ਵਿਚ ਪ੍ਰਾਪਤ ਵਿਲੱਖਣ ਸਥਾਨ ਤੋਂ ਹੈ।

ਨਾਵਲ ਰੋਹੀ ਬੀਆਬਾਨਇਕ ਸਫ਼ਲ ਨਾਵਲ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਉਹ ਸਾਰੀਆਂ ਹੀ ਗਾਲਪਨਿਕ ਯੁਗਤਾਂ ਮੌਜੂਦ ਹਨ ਜੋ ਕਿ ਇਕ ਸਰਵੋਤਮ ਨਾਵਲ ਵਿਚ ਹੋਣੀਆਂ ਜ਼ਰੂਰੀ ਮੰਨੀਆਂ ਜਾਂਦੀਆ ਹਨ। ਇਸ ਨਾਵਲ ਦੀ ਪ੍ਰਾਪਤੀ ਇਸ ਗੱਲ ਵਿਚ ਹੈ ਕਿ ਇਹ ਨਾਵਲ ਇੰਨਾ ਸਮਾਂ ਬੀਤਣ ਦੇ ਬਾਵਜੂਦ ਅੱਜ ਵੀ ਪੰਜਾਬੀ ਨਾਵਲ ਜਗਤ ਵਿਚ ਬੜੀ ਹੀ ਸ਼ਿੱਦਤ ਦੇ ਨਾਲ ਪੜ੍ਹਿਆ ਜਾਂਦਾ ਹੈ। ਕੁੱਸਾ ਮੁੱਖ ਰੂਪ ਵਿਚ ਜ਼ਮੀਨ ਦੀਆਂ ਛੋਟੀਆਂ ਹੁੰਦੀਆਂ ਜਾ ਰਹੀਆਂ ਹਿੱਸੇਦਾਰੀਆਂ ਕਾਰਨ ਬੜੀ ਤੇਜ਼ੀ ਨਾਲ ਬੇਜ਼ਮੀਨ ਹੋ ਰਹੀ ਛੋਟੀ ਕਿਸਾਨੀ ਦੀਆਂ ਇਤਹਾਸਕ ਸਮੱਸਿਆਵਾਂ ਨੂੰ ਚਿਤਰਣ ਵਾਲਾ ਨਾਵਲਕਾਰ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਕੁੱਸਾ ਕਿਸਾਨੀ ਦੇ ਜਿਨਸੀ ਸੰਬੰਧਾਂ ਦੇ ਸੰਕਟ ਤੋਂ ਹਟ ਕੇ

ਉਸ ਦੀ ਦਿਸ਼ਾਹੀਣਤਾ ਦੀ ਸਮੱਸਿਆ ਨੂੰ ਪੇਸ਼ ਕਰਦਾ ਹੈ। ਕਰਮਜੀਤ ਸਿੰਘ ਕੁੱਸਾ ਪੰਜਾਬੀ ਸਾਹਿਤ ਦਾ ਇਕ ਉੱਤਮ ਨਾਵਲਕਾਰ ਹੈ। ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਨੂੰ ਜਿੱਥੇ ਪੰਜਾਬੀ ਸਾਹਿਤ ਵਿਚ ਜਾਣੀਆਂ-ਪਛਾਣੀਆਂ ਹਸਤੀਆਂ ਜੋਗਿੰਦਰ ਸਿੰਘ ਰਾਹੀ, ਟੀ. ਆਰ.ਵਿਨੋਦ ਆਦਿ ਨੇ ਸਲਾਹਿਆ ਹੈ, ਉਥੇ ਆਮ ਲੋਕਾਂ ਨੇ ਵੀ ਕੁੱਸਾ ਦੇ ਨਾਵਲਾਂ ਨੂੰ ਚਾਅ ਨਾਲ ਪੜ੍ਹਿਆ ਹੈ। 'ਰੋਹੀ ਬੀਆਬਾਨ' ਵਿਚ ਹਰੀ ਕ੍ਰਾਂਤੀ ਉਪਰੰਤ ਪੰਜਾਬ ਦੀ ਛੋਟੀ ਕਿਰਸਾਣੀ ਦੇ ਸੰਕਟ ਨੂੰ ਰੂਪਮਾਨ ਕੀਤਾ ਗਿਆ ਹੈ। ਇਸ ਨਾਵਲ ਨੂੰ ਕਿਸਾਨੀ ਸੱਭਿਆਚਾਰ ਦਾ ਦਸਤਾਵੇਜ ਕਿਹਾ ਜਾ ਸਕਦਾ ਹੈ। ਇਸ ਨਾਵਲ ਵਿਚ ਯਥਾਰਥਵਾਦੀ ਨਾਵਲ ਦੀਆਂ ਬਿਰਤਾਂਤਕ ਜੁਗਤਾਂ ਦਾ ਕਲਾਤਮਕ ਪ੍ਰਯੋਗ ਕੀਤਾ ਗਿਆ ਹੈ।

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B.A II ਸ਼ਬਦਾਵਲੀ - ਪ੍ਰੀਖਿਆ

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ਧੁਨੀ:

ਹਰ ਮਨੁੱਖ ਆਪਣੇ ਉਚਾਰਨ/ਬੋਲ ਅੰਗਾਂ ਰਾਹੀਂ ਅਸੀਮਤ ਧੁਨੀਆਂ ਉਤਪੰਨ ਕਰਨ ਦੀ ਸਮਰੱਥਾ ਰੱਖਦਾ ਹੈ। ਹਰ ਭਾਸ਼ਾ ਕਈ ਦਰਜਨ ਵਿਲੱਖਣ ਧੁਨੀਆਂ ਦੀ ਹੀ ਵਰਤੋਂ ਕਰਦੀ ਹੈ।

ਭਾਸ਼ਾ ਦੀ ਛੋਟੀ ਤੋਂ ਛੋਟੀ ਇਕਾਈ ਧੁਨੀ ਹੈ। ਹਰ ਵਿਅਕਤੀ ਦੀਆਂ ਆਵਾਜ਼ਾਂ ਨੂੰ ਧੁਨੀ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਧੁਨੀ ਨੂੰ ਅੰਗਰੇਜ਼ੀ ਵਿੱਚ Sound ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਧੁਨੀ ਉਸ ਆਵਾਜ਼ ਨੂੰ ਕਹਿੰਦੇ ਹਨ, ਜੋ ਦੋ ਚੀਜ਼ਾਂ ਦੇ ਆਪਸ ਵਿੱਚ ਟਕਰਾਉਣ ਪਿੱਛੋਂ ਪੈਦਾ ਹੁੰਦੀ ਹੈ। ਮਨੁੱਖੀ ਬੋਲ ਵੀ ਦੋ ਉਚਾਰਨ ਅੰਗਾਂ ਦੇ ਆਪਸ ਵਿੱਚ ਟਕਰਾਉਣ ਤੋਂ ਪਿਛੋਂ ਪੈਦਾ ਹੁੰਦੇ ਹਨ। ਭਾਸ਼ਾ ਨਾਲ ਸੰਬੰਧਿਤ ਸਭਿਅ ਧੁਨੀਆਂ ਨੂੰ ਉਚਾਰਨ ਵਾਲੇ ਸੰਚਾਰ ਪ੍ਰਕਿਰਿਆ ਵਾਲਾ ਮੂੰਹ ਹੀ ਉਹ ਧੁਨੀਆਂ ਕੱਚਾ/ਕਹਾ ਗਰੀ ਸਰੋਤ ਦੇ ਕੰਨਾਂ ਤੱਕ ਪਹੁੰਚਦੀਆਂ ਹਨ।

ਮੂੰਹ → ਹਵਾ → ਕੰਨ

ਧੁਨੀ ਵਿਉਂਤ → ਪੰਜਾਬੀ ਧੁਨੀ ਵਿਉਂਤ ਤੋਂ ਭਾਵ ਉਸ ਵਿਉਂਤ ਤੋਂ ਹੈ ਜਿਸਦੇ ਅੰਤਰਗਤ ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਦੀਆਂ ਧੁਨੀਆਂ ਦਾ ਵਰਗੀਕਰਨ ਤੇ ਵਰਤੋਂ - ਵਿਹਾਰ ਦਾ ਅਧਿਐਨ ਕੀਤਾ ਜਾਂਦਾ ਹੈ ਭਾਵ ਇਸ ਵਿਚ ਇਹ ਦੇਖਿਆ ਜਾਂਦਾ ਹੈ ਕਿ ਪੰਜਾਬੀ ਧੁਨੀਆਂ ਨੂੰ ਕਿਹੜੇ - ਕਿਹੜੇ ਵਰਗਾਂ ਵਿੱਚ ਵੰਡਿਆ ਜਾਂਦਾ ਹੈ ਅਤੇ ਇਹ ਧੁਨੀਆਂ ਸ਼ਬਦਾਂ ਜਾਂ ਵਾਕਾਂ ਵਿੱਚ ਕਿਸ ਤਰ੍ਹਾਂ ਵਰਤੀਆਂ ਜਾਂਦੀਆਂ ਹਨ।

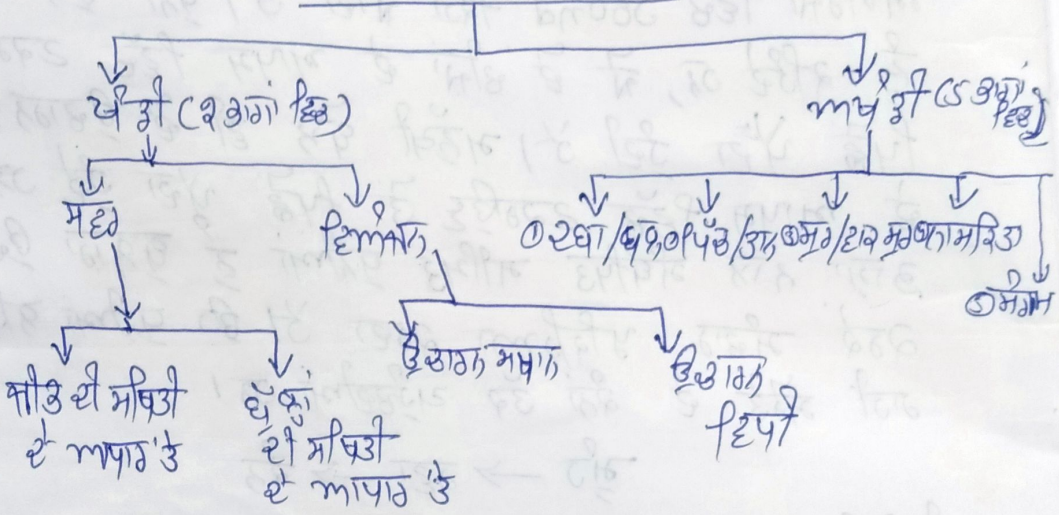
ਧੁਨੀਆਂ ਮਨੁੱਖੀ ਮੂੰਹ ਦੇ ਦੋ-ਦੋ ਉਚਾਰਨ ਅੰਗਾਂ ਰਾਹੀਂ ਉਚਾਰੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਅਤੇ ਇਹਨਾਂ ਉਚਾਰਨ ਧੁਨੀਆਂ ਦੀਆਂ ਕਿਸਮਾਂ ਮੂੰਹ ਦੇ ਕਿਹੜੇ ਉੱਪਰ ਪ੍ਰਭਾਵੀ ਹੁੰਦੀਆਂ ਹਨ। ਸਰੋਤਾ ਉਹਨਾਂ ਧੁਨੀਆਂ ਨੂੰ ਸੁਣਦਾ ਹੈ, ਇਸ ਤਰ੍ਹਾਂ ਧੁਨੀਆਂ ਦੀਆਂ ਤਿੰਨ ਮੁਹਾਂਦਰੇ ਉਭਰਦੀਆਂ ਹਨ।-

(ਓ) ਪ੍ਰਤੀਮਾਂ ਦਾ ਉਦਭਵ
(ਅ) ਪ੍ਰਤੀਮਾਂ ਦਾ ਸੰਕਲਪ
(ਏ) ਪ੍ਰਤੀਮਾਂ ਦੀ ਸੂਚਨਾ ਵਿਧਿਆ

ਇਹਨਾਂ ਤਿੰਨਾਂ ਦੇ ਆਧਾਰ ਤੇ ਹੀ ਆਮ ਪ੍ਰਤੀਮਾਂ ਦੀ ਪਛਾਣ, ਸਥਾਪਨਾ ਅਤੇ ਵਰਗੀਕਰਨ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਆਮਤੌਰ ਪ੍ਰਤੀਮਾਂ ਨੂੰ ਦੋ ਭਾਗਾਂ ਵਿਚ ਵੰਡਿਆ ਜਾਂਦਾ ਹੈ।

① ਬੰਦੀ
② ਸਥੰਭੀ

ਪ੍ਰਤੀਮਾਂ ਦਾ ਵਰਗੀਕਰਨ



I. ਬੰਦੀ ਪ੍ਰਤੀਮਾਂ →

ਬੰਦੀ ਪ੍ਰਤੀਮਾਂ ਉਹ ਆਮ ਪ੍ਰਤੀਮਾਂ ਨੂੰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ, ਜਿਹਨਾਂ ਸਥਾਨ ਵਿਚ ਸੁਰੱਖਿਅਤ ਉੱਚ ਤੇ ਵਿਅਕਤੀ ਦੇ ਸਮੱਗਰ ਰੂਪਾਂ ਜਾਂ ਕਿਸੇ ਦਾ ਸਾਪਣ ਵੱਲੋਂ ਸਰੂਪ ਹੁੰਦਾ ਹੈ। ਇਹਨਾਂ ਪ੍ਰਤੀਮਾਂ ਨੂੰ ਖੰਭਾਂ ਜਾਂ ਦਿਵਾਰਾਂ ਦੇ ਉੱਤੇ ਤੇ ਉਭਾਰ ਦਿੱਤੇ ਸਥੱਲ ਵਰ ਦੇ ਪ੍ਰਕਾਰਿਆ ਜਾ ਸਕਦਾ ਹੈ। ਜਿਵੇਂ :-

ਕਾਸ = ਕ + ਸਾ + ਸ

ਕਾਸ ਸਬਦ ਵਿਚ ਤਿੰਨ ਪ੍ਰਤੀਮਾਂ ਜਾ। ਇਹ ਸਾਰੀਆਂ ਹੀ ਬੰਦੀ ਪ੍ਰਤੀਮਾਂ ਜਾ। ਬੰਦੀ ਪ੍ਰਤੀਮਾਂ ਵਿਚ ਸਦਰ, ਵਿਸਥਾਰ ਅਤੇ ਸਮਯ ਸਦਰ ਨੂੰ ਸੰਕਲਪਾ ਜਾਂਦਾ ਹੈ

ਸਵਰ → ਸਵਰ ਧੁਨੀਆਂ ਉਹਨਾਂ ਮੌਖਿਕ ਧੁਨੀਆਂ ਨੂੰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ, ਜਿਨ੍ਹਾਂ ਦਾ ਉਚਾਰਨ ਕਰਨ ਸਮੇਂ ਸਾਹ ਵੀ ਰੁਕਾਵਟ ਰਹਿਤ ਬਾਹਰ ਨਿਕਲਦੀ ਹੈ ਅਤੇ ਜੀਭ ਦੇ ਉਚਾਰਨ ਅੰਗਾਂ ਵਿਚ ਵੀ ਕੋਈ ਰੁਕਾਵਟ ਪੈਦਾ ਨਹੀਂ ਹੁੰਦੀ। ਜੀਭ ਦੇ ਕਿਸੇ ਵੀ ਅੰਗ ਨੂੰ ਤਾਲੂ ਨਾਲ ਨਹੀਂ ਲਾਉਣਾ ਪੈਂਦਾ। ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਸਾਹ ਹੀ ਮੁੱਖ ਰੂਪ ਵਿਚ ਕਾਰਜਸ਼ੀਲ ਹੁੰਦਾ ਹੈ। ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦੇ ਕਿਸੇ ਵੀ ਹਿੱਸੇ ਨੂੰ ਤਾਲੂ ਨਾਲ ਨਹੀਂ ਲਾਉਣਾ ਪੈਂਦਾ। ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦੇ ਕਿਸੇ ਵੀ ਹਿੱਸੇ ਨੂੰ ਤਾਲੂ ਨਾਲ ਨਹੀਂ ਲਾਉਣਾ ਪੈਂਦਾ। ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦੇ ਕਿਸੇ ਵੀ ਹਿੱਸੇ ਨੂੰ ਤਾਲੂ ਨਾਲ ਨਹੀਂ ਲਾਉਣਾ ਪੈਂਦਾ। ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦੇ ਕਿਸੇ ਵੀ ਹਿੱਸੇ ਨੂੰ ਤਾਲੂ ਨਾਲ ਨਹੀਂ ਲਾਉਣਾ ਪੈਂਦਾ।

ਉਦਾ :- ਅ, ਆ, ਇ, ਈ, ਉ, ਊ, ਏ, ਐ, ਓ, ਔ

(ਓ) ਜੀਭ ਦੀ ਸਥਿਤੀ ਦੇ ਆਧਾਰ ਤੇ- ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦੀਆਂ ਤਿੰਨ ਅਵਸਥਾਵਾਂ ਬਣਦੀਆਂ ਹਨ। ਇਹ ਤਿੰਨ ਅਵਸਥਾਵਾਂ ਜੀਭ ਦੇ ਉੱਪਰ ਉੱਠਣ ਦੀ ਹੈ। ਇਹ ਹੇਠਾਂ ਆਉਂਦੀ ਹੈ। ਇਹ ਵਿਚਕਾਰ ਹੈ

- ਅਗਲੇ ਸਵਰ → ਜਿਨ੍ਹਾਂ ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦਾ ਅਗਲਾ ਹਿੱਸਾ ਵਾਲਜ਼ਲੀਨ ਉੱਚਾ ਹੈ। ਈ, ਏ, ਐ

- ਪਿਛਲੇ ਸਵਰ → ਜਿਨ੍ਹਾਂ ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦਾ ਪਿਛਲਾ ਹਿੱਸਾ ਵਾਲਜ਼ਲੀਨ ਉੱਚਾ ਹੈ। ਉ, ਓ, ਔ

⇒

- ਵਿਚਕਾਰਲੇ ਸਵਰ → ਜਿਨ੍ਹਾਂ ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦੇ ਵਿਚਕਾਰਲੇ ਭਾਗ ਦੀ ਸਥਿਤੀ ਕਰੀ ਨਾਂਹ ਦੀ ਹੈ। ਇ, ਉ, ਅ, ਆ

- ਉੱਚ ਸਵਰ → ਜਿਨ੍ਹਾਂ ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਵੇਲੇ ਜੀਭ ਉੱਪਰ ਉੱਠ ਕੇ ਤਾਲੂ ਦੇ ਬਿਲਕੁਲ ਨੇੜੇ ਚਲੀ ਜਾਂਦੀ ਹੈ, ਉ

- ਨੀਵਾਂ ਸਵਰ - ਜਿਨ੍ਹਾਂ ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਵੇਲੇ ਜੀਭ ਸਭ ਤੋਂ ਹੇਠਾਂ ਰਹਿੰਦੀ ਹੈ। ਆ, ਅੇ, ਅੈ

- ਅਰਧ ਨੀਵਾਂ → ਜਿਨ੍ਹਾਂ ਸਵਰਾਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਦੀ ਸਭ ਤੋਂ ਉੱਚੀ ਥਾਂ ਨਾਲੋਂ ਥੋੜ੍ਹਾ ਨੀਵੀਂ ਰਹਿੰਦੀ ਹੈ, ਅ, ਓ

- ਅਰਧ ਉੱਚ → ਜਿਨ੍ਹਾਂ ਸਵਰ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਵੇਲੇ ਜੀਭ ਥੋੜ੍ਹੀ ਉੱਚੀ ਰਹਿੰਦੀ ਹੈ। ਇ, ਉ

	ਅਗਲੇ ਸਵਰ	ਵਿਚਕਾਰਲੇ ਸਵਰ	ਪਿਛਲੇ ਸਵਰ
ਉੱਚ ਸਵਰ	ਈ		ਊ
ਅਰਧ ਉੱਚ		ਇ	ਉ
ਅਰਧ ਨੀਵਾਂ	ਏ	ਅ	ਓ
ਨੀਵਾਂ ਸਵਰ	ਅੈ	ਆ	ਅੌ

ਗੋਲਾਈ ਰਹਿਤ ਸਵਰ

ਗੋਲਾਈ ਸਹਿਤ ਸਵਰ

(iii) ਬੁੱਲ੍ਹਾਂ ਦੀ ਸਥਿਤੀ ਦੇ ਆਧਾਰ ਤੇ → ਬੁੱਲ੍ਹਾਂ ਦੀ ਸਥਿਤੀ ਦੇ ਆਧਾਰ ਤੇ ਧੁਨੀਆਂ ਦੇ ਦੋ ਵਰਗ ਬਣਦੇ ਹਨ :- (i) ਗੋਲਾਈ ਰਹਿਤ (ii) ਗੋਲਾਈ ਸਹਿਤ

(i) ਮੌਖਾਧੀਰਥ → ਜਿਹੜੇ ਸਵਰ ਉਚਾਰਨ ਵੇਲੇ ਘੱਟੋ ਘੱਟ ਮੌਖ ਖੁੱਲ੍ਹਦੇ ਹਨ, ਉਨ੍ਹਾਂ ਨੂੰ ਮੌਖਾਧੀਰਥ ਸਵਰ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ- ਉ, ਊ, ਓ, ਔ। ਇਹਨਾਂ ਨੂੰ ਮੌਖ ਸਵਰ ਵੀ ਕਹਿੰਦੇ ਹਨ।

(ii) ਮੌਖਾਧੀ ਗਹਿਤ → ਜਿਹਨਾਂ ਨੂੰ ਉਚਾਰਨ ਵੇਲੇ ਘੱਟੋ ਮੌਖ ਅਧਿਕੀ ਵਿਚ ਨਹੀਂ ਖੁੱਲ੍ਹਦੇ, ਉਨ੍ਹਾਂ ਨੂੰ ਮੌਖਾਧੀ ਗਹਿਤ ਜਾਂ ਅਮੌਖ ਸਵਰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਜਿਵੇਂ - ਇ, ਏ, ਐ, ਅ, ਆ, ਏ।

ਸਵਰਾਂ ਦੀ ਪਹਿਚਾਣ ਕਰਨ ਲਈ ਦੋ ਤਰੀਕੇ ਵਰਤੇ ਜਾਂਦੇ ਹਨ। ਤੀਸਰਾ ਕੋਈ ਤਰੀਕਾ ਨਹੀਂ ਹੈ। ਪਹਿਲੇ ਥਿਰ ਦੋਰ ਮਾਤਰਿਕ ਦੋਰ ਹੈ। ਮਾਤਰਿਕ ਦੋਰ ਵਿਚ ਸਵਰਾਂ ਦੀ ਦੋਰ ਉਹਨਾਂ ਦੀ ਮਾਤਰਾ ਦੇ ਅਧਾਰ ਤੇ ਵੰਡੀ ਜਾਂਦੀ ਹੈ। ਮਾਤਰਾ ਦੇ ਅਧਾਰ ਤੇ ਸ੍ਵਰਾਂ ਨੂੰ ਦੋ ਭਾਗਾਂ ਵਿਚ ਵੰਡਿਆ ਜਾਂਦਾ ਹੈ।

(1) ਹ੍ਰਸਵ
(2) ਦੀਰਘ

- ਹ੍ਰਸਵ (ਛੋਟੇ ਸ੍ਵਰ) - ਹ੍ਰਸਵ ਉਹ ਸ਼ਬਦ ਹੈ ਜੋ ਛੋਟਾ, ਲਘੂ। ਜਿਹੜਾ ਸਵਰਾਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਥਿਰ ਮਾਤਰਾ ਜਿੰਨਾ ਸਮਾਂ ਲੱਗੇ, ਉਨ੍ਹਾਂ ਨੂੰ ਹ੍ਰਸਵ ਸਵਰ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ - ਇ, ਉ, ਅ

- ਦੀਰਘ (ਗੁਰੂ ਸ੍ਵਰ) → ਜਿਹੜਾ ਸਵਰਾਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਦੋ ਮਾਤਰਾਂ ਜਿੰਨਾ ਜਾਂ ਹ੍ਰਸਵ ਸਵਰਾਂ ਨਾਲੋਂ ਦੁਗਣਾ ਸਮਾਂ ਲੱਗੇ, ਉਨ੍ਹਾਂ ਨੂੰ ਦੀਰਘ ਸਵਰ ਕਹਿੰਦੇ ਹਨ, ਜਿਵੇਂ - ਊ, ਓ, ਔ, ਈ, ਏ, ਐ, ਆ।

- ਦੋ ਸੰਪੀ ਸਵਰ - ਜਦੋਂ ਦੋ ਸਵਰਾਂ ਦਾ ਉਚਾਰਨ ਆਪਸ ਵਿੱਚ ਇਕ ਖ਼ਾਸ ਤਰੀਕਾ ਹੋਵੇ ਕਿ ਉਹ ਵਿੱਚ ਹੀ ਸਾਧਣ ਤੇ ਸਵਰਾਂ ਦੇ ਅਲੱਗ ਸੰਯੋਗ ਨੂੰ ਦੋ ਸੰਪੀ ਸਵਰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਜਿਵੇਂ - ਪਉ, ਗਉ, ਧੀਆਂ ਵਿੱਚ ਦੋ ਸੰਪੀ ਸਵਰਾਂ ਦੀ ਵਰਤੋਂ ਹੋਈ ਹੈ।

ਪਉ - ਪ + ਅ + ਉ (ਅਖੁ + ਅਖੁ)

ਧੀਆਂ - ਧ + ਈ + ਆਂ (ਚਲਿਖ + ਚੀਸ਼ਖ)

- ਅਸਪ ਸਵਰ → ਧੰਜਾਬੀ ਵਿੱਚ ਜ ਅਤੇ ਵ ਦੇ ਅਸਪ ਸਵਰ ਨਾਲ ਅਤੇ ਇਹਨਾਂ ਦਾ ਉਚਾਰਨ ਸਥਾਨ ਤੇ, ਕਿਤੇ ਇਹ ਪੂਰੇ ਵਿਅੰਜਨ ਵਿੱਚ ਬਦਲ ਜਾਂਦੇ ਨਾ ਅਤੇ ਕਿਤੇ ਸੁੱਧ ਸਵਰ ਤੇ ਜਾਂਦੇ ਨਾ। ਇਹਨਾਂ ਦੇ ਉਚਾਰਨ ਵੇਲੇ ਜੋ ਅੰਗਾਂ ਵਿਚਲੀ ਵਿੱਥ ਕੁਝ ਵਰਤੋਂ ਤੇ ਜਾਵੇ ਤਾਂ ਅਸਪ ਸਵਰਾਂ ਦਾ ਉਚਾਰਨ ਹੋ ਜਾਂਦਾ ਹੈ। ਪਰ ਜੇ ਉਚਾਰਨ ਵੇਲੇ ਅੰਗ ਆਪਸ ਵਿਚ ਛੂਹ ਜਾਣ ਤਾਂ ਪੂਰਾ ਵਿਅੰਜਨ ਉਚਾਰਿਆ ਜਾਂਦਾ ਹੈ।

2. ਵਿਅੰਜਨ →

ਵਿਅੰਜਨ ਧੁਨੀਆਂ ਸੁੰਭੀ ਧੁਨੀਆਂ ਦੇ ਵਰਗ ਵਿਚ ਆਉਂਦੀਆਂ ਨਾ। ਵਿਅੰਜਨ ਉਨ੍ਹਾਂ ਸੁੰਭੀ ਧੁਨੀਆਂ ਨੂੰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਜਿਨ੍ਹਾਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਸਾਡੇ ਫੇਫੜਿਆਂ ਚੋਂ ਵਗਦੀ ਆਉਂਦੀ ਸਾਹ ਦੀ ਹਵਾ ਨੂੰ ਮੂੰਹ ਦੇ ਕਿਸੇ ਨਾ ਕਿਸੇ ਅੰਸ਼ਕ ਰੂਪ ਵਿੱਚ ਰੋਕ ਕੇ ਛੱਡਿਆ ਜਾਂਦਾ ਹੈ। ਵਿਅੰਜਨ ਧੁਨੀਆਂ ਦੇ ਵਰਗੀਕਰਨ ਦੀ ਦੋ ਆਧਾਰ ਹਨ :-

ਵਿਅੰਜਨ

ਉਚਾਰਨ ਸਥਾਨ ਉਚਾਰਨ ਰੀਤ

i. ਉਚਾਰਨ ਸਥਾਨ

ਜੋ ਕਿ ਵਿਦਵਾਨ ਮੁਤਾਬਿਕ ਸਾਡੇ ਮੂੰਹ ਅੰਦਰ ਉਹ ਥਾਂ, ਜਹਾਂ ਸਵਰ ਵਾਲੇ ਵਿਅੰਜਨਾਂ ਦਾ ਵੀ ਵਿਚਾਰ ਕੀਤਾ ਜਾਂਦਾ ਹੈ, ਉਹ ਥਾਂ ਜਾਂ ਸਥਾਨ ਨਾ

ਉਚਾਰਨ ਸਥਾਨ	
ਕਾਕਲੀ ਅਸਪ ਧੁਨੀ	
ਕਾਕਲੀ ਸੁੱਧ ਧੁਨੀ	
ਤਾਲੂ ਅਸਪ ਧੁਨੀ	
ਦਾਂਤੀ ਸੁੱਧ ਧੁਨੀ	
ਲਾਸਯੀ	
ਯਾਸੇਹਾ	
ਵੈਦਹਾਂ	
ਦੰਤ ਸਵਰ	
ਓਸ਼ਠ ਅਸਪ ਧੁਨੀ	
ਸਤਵ	

ਹਿੱਸਿਆਂ ਦਾ ਵਰਗੀਕਰਨ

1. ਉਚਾਰਨ ਸਥਾਨ ਅਨੁਸਾਰ

ਉਚਾਰਨ ਸਥਾਨ ਤੋਂ ਭਾਵ ਉਹ ਥਾਂ ਜਿੱਥੇ ਮੂੰਹ ਦੇ ਕਿਸੇ ਦੋ ਅੰਗਾਂ ਦੇ ਮਿਲਣ ਜਾਂ ਵਿਚਕਾਰ ਤੋਂ ਕਿਸੇ ਧੁਨੀ ਦਾ ਉਚਾਰਨ ਹੁੰਦਾ ਹੈ। ਜਿਵੇਂ ਕਿ ਕਿਸੇ ਧੁਨੀ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਮੂੰਹ ਦੇ ਕਿਹੜੇ ਅੰਗ ਇੱਕ ਦੂਜੇ ਨੂੰ ਛੂੰਹਦੇ ਹਨ, ਜਾਂ ਕਿਹੜੇ ਅੰਗ ਇੱਕ ਦੂਜੇ ਦੇ ਨੇੜੇ ਆਉਂਦੇ ਹਨ, ਜਾਂ ਕਿਹੜੇ ਅੰਗਾਂ ਵਿਚਕਾਰ ਰਗੜ ਪੈਦਾ ਹੁੰਦੀ ਹੈ ਉਸ ਅਨੁਸਾਰ ਹੀ ਉਸ ਧੁਨੀ ਦਾ ਉਚਾਰਨ ਸਥਾਨ ਨਿਰਧਾਰਿਤ ਕੀਤਾ ਜਾਂਦਾ ਹੈ। ਜਿਵੇਂ ਕਿ ਦੋ ਹੋਠਾਂ ਦੇ ਮਿਲਣ ਨਾਲ ਉਚਾਰੀ ਜਾਣ ਵਾਲੀ ਧੁਨੀ ਦੋ ਹੋਠੀ, ਦੰਦ ਅਤੇ ਜੀਭ ਦੇ ਮਿਲਣ ਨਾਲ ਉਚਾਰੀ ਜਾਣ ਵਾਲੀ ਧੁਨੀ ਦੰਦੀ, ਜੀਭ ਦੇ ਅਗਲੇ ਹਿੱਸੇ ਨੂੰ ਤਾਲੂ ਦੇ ਅਗਲੇ ਹਿੱਸੇ ਨਾਲ ਛੂੰਹਦੇ ਹੋਏ ਉਚਾਰੀ ਜਾਣ ਵਾਲੀ ਧੁਨੀ ਤਾਲਵੀ, ਜੀਭ ਦੇ ਪਿਛਲੇ ਹਿੱਸੇ ਨੂੰ ਕੋਮਲ ਤਾਲੂ ਨਾਲ ਛੂੰਹਦੇ ਹੋਏ ਉਚਾਰੀ ਜਾਣ ਵਾਲੀ ਧੁਨੀ ਕੋਮਲ ਤਾਲਵੀ, ਜੀਭ ਦੇ ਪਿਛਲੇ ਹਿੱਸੇ ਨੂੰ ਕਾਕਲ ਨਾਲ ਛੂੰਹਦੇ ਹੋਏ ਉਚਾਰੀ ਜਾਣ ਵਾਲੀ ਧੁਨੀ ਕਾਕਲੀ, ਜੀਭ ਦੇ ਅਗਲੇ ਹਿੱਸੇ ਨੂੰ ਦੰਦਾਂ ਦੇ ਮਸੂੜੇ ਨਾਲ ਛੂੰਹਦੇ ਹੋਏ ਉਚਾਰੀ ਜਾਣ ਵਾਲੀ ਧੁਨੀ ਦੰਦਾਂ ਦੇ ਮਸੂੜੇ ਦ

= ਵੰਨੀ ਦਿਅੰਸ਼ਨ → ਇਹਨਾਂ ਪ੍ਰਤੀਆਂ ਦੇ ਉਦਾਹਰਨ ਦੇਣ ਲਈ ਕੋਣ ਦਾ ਪਿਛਲਾ ਹਿੱਸਾ ਤੇ (ਕੋਸ਼ਕ ਹਾਸ਼ੀ) ਵੰਨ ਆਪਸ ਵਿਚ ਸੰਪਾਤ ਦਰਸਾਉਂਦੇ ਹਨ ਅਤੇ ਸਾਰੇ ਹੀ ਰੇਖਾ ਹਨ ਤੇ ਸਾਰੇ ਕੋਣ ਆਪਣੀ ਥਾਂ ਤੇ ਦਾਖਲ ਆ ਜਾਂਦੇ ਹਨ ਤਾਂ ਵੰਨੀ ਪ੍ਰਤੀਆਂ ਦਾ ਉਦਾਹਰਨ ਪੂਰਾ ਹੁੰਦਾ ਹੈ। ਜਿਵੇਂ :- ਵ, ਖ, ਸ, ਘ, ਫ । ਇਸਨੂੰ ਵਰਗਾਕਾਰ ਹੀ ਦੇਖਦੇ ਹਨ।

= ਆਇਤੀ → ਜਦੋਂ ਕੋਣ ਦਾ ਅਗਲਾ ਹਿੱਸਾ ਸਮਤਲ ਹਾਸ਼ੀ ਨੂੰ ਟੱਚ ਕਰਦਾ ਹੈ ਤਾਂ ਆਇਤੀ ਪ੍ਰਤੀਆਂ ਉਤਪੰਨ ਹੁੰਦੀਆਂ ਹਨ। ਚ, ਛ, ਜ, ਝ, ਞ, ਟ ਆਇਤੀ ਪ੍ਰਤੀਆਂ ਹਨ। ਇਹਨਾਂ ਨੂੰ ਵ ਵਰਗ ਹੀ ਦੇਖਦੇ ਹਨ।

= ਤਿਰਛੇ ਕੋਣੀ → ਇਹਨਾਂ ਪ੍ਰਤੀਆਂ ਦੇ ਉਦਾਹਰਨ ਦੇਣ ਲਈ ਜਦੋਂ ਕੋਣ ਦੀ ਨੋਕ ਉਪਲਬਧ ਦੋਵਾਂ ਤੇ ਸਮਤਲ ਹਾਸ਼ੀ ਦੇ ਲੰਬਵਤ ਆਉਂਦੇ ਹੋਏ ਸਾਰੇ ਹੀ ਰੇਖਾ ਹਨ ਤਾਂ ਤਿਰਛੇ ਕੋਣੀ ਪ੍ਰਤੀਆਂ ਪੰਜ ਹੁੰਦੀਆਂ ਹਨ। ਟ, ਠ, ਡ, ਢ, ਣ, ਨ ਤਿਰਛੇ ਕੋਣੀ ਹਨ। ਇਹਨਾਂ ਨੂੰ ਟ ਵਰਗ ਹੀ ਦੇਖਦੇ ਹਨ।

= ਦੰਤੀ → ਇਹਨਾਂ ਪ੍ਰਤੀਆਂ ਦੇ ਉਦਾਹਰਨ ਦੇਣ ਲਈ ਜਦੋਂ ਕੋਣ ਦੀ ਨੋਕ ਉਪਲਬਧ ਦੋਵਾਂ ਨਾਲ ਟੱਚ ਕਰਦੀ ਹੈ ਤਾਂ ਇਸ ਸਮੇਂ ਉਤਪੰਨ ਹੋਈਆਂ ਪ੍ਰਤੀਆਂ ਨੂੰ ਦੰਤੀ ਪ੍ਰਤੀਆਂ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਤ, ਥ, ਦ, ਧ, ਨ, ਪ, ਫ, ਮ ਦੰਤੀ ਵਿਅੰਜਨ ਹਨ। ਇਹ ਨੂੰ ਤ ਵਰਗ ਦੇਖਦੇ ਹਨ।

= ਓਸ਼ਠੀ → ਸਿਰਫ਼ ਦੋ ਪ੍ਰਤੀਆਂ ਹੋਠਾਂ ਦੀ ਮਦਦ ਨਾਲ ਉਚਾਰੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਉਹਨਾਂ ਨੂੰ ਹੀ ਓਸ਼ਠੀ ਪ੍ਰਤੀਆਂ ਵਰਗ ਕਹਿਆ ਜਾਂਦਾ ਹੈ ਜਿਵੇਂ ਪ, ਫ, ਬ, ਭ, ਮ, ਵ । ਇਹਨੂੰ

ਯ ਵਰਗ ਵੀ ਪੜ੍ਹਦੇ ਹਨ।

= ਸ਼ਰਖੰਡਗੇ / ਖੰਡੇ / ਗਣਿਕ →

ਹ ਵਿਸ਼ਲੇਸ਼ਣ ਪ੍ਰਤੀ ਦਾ ਉਚਾਰਨ ਸਥਾਨ ਵੀ ਹੈ, ਵਿਸ਼ ਪ੍ਰਤੀ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਸਾਹ ਦੀ ਹਵਾ ਨੂੰ ਨਕੋਂ ਸਗੋਂ ਸਾਹ ਦੀ ਚਾਂ ਤੇ ਤੰਗ ਹੋ ਕੇ ਬਾਹਰ ਨਿਕਲਦੀ ਹੈ, ਜੀਭ ਦੰਦਾਂ ਪਿਛੇ ਉਪਰ ਵੱਲ ਨੂੰ ਉਠਦੀ ਹੈ। ਇਸ ਕਰਕੇ ਵਿਸ਼ਲੇਸ਼ਣ ਵਿਚ ਸਾਂਝ ਮਿਲਦੇ ਸਮੇਂ ਵਿਸ਼ ਦੇ ਪ੍ਰਨਾਲਾਂ ਨੂੰ ਗਣਿਕ ਕਹਿੰਦੇ ਹਨ।

ii ਉਚਾਰਨ ਗੰਤ / ਢੰਗ / ਵਿਧੀ →

ਵਿਸ਼ ਵਿਚ ਇਹ ਇਕ ਐਸਾ ਸਾਂਝ ਹੈ ਕਿ ਪ੍ਰਤੀ ਉਚਾਰਨ ਵੇਲੇ ਸਾਹ ਦੀ ਹਵਾ ਕਿਵੇਂ ਬਾਹਰ ਨਿਕਲਦੀ ਹੈ। ਦੰਦਾਂ ਪਿਛੇ ਆਉਂਦੀ ਹਵਾ ਨੂੰ ਵਿਸ਼ ਉਚਾਰਨ ਸਥਾਨ ਉੱਤੇ ਰੋਕ ਕੇ ਵਿਸ਼ ਵਿਚ ਦੂਸਰਾ ਕੰਮ ਸਾਂਝ ਹੈ ਤਾਂ ਉਸਨੂੰ ਉਚਾਰਨ ਵਿਧੀ ਜਾਂ ਗੰਤ ਕਹਿੰਦੇ ਹਨ। ਇਸਨੂੰ ਤਿੰਨ ਵਿਚ ਵੰਡਿਆ ਜਾ ਸਕਦਾ ਹੈ:-

= ਤੱਵਦੇ ਵਿਸ਼ਲੇਸ਼ਣ (15) →

ਤੱਵਦੇ ਵਿਸ਼ਲੇਸ਼ਣਾਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਦੰਦਾਂ ਪਿਛੇ ਆ ਰਹੀ ਹਵਾ ਪੂਰੀ ਤਰ੍ਹਾਂ ਰੋਕ ਕੇ ਵਿਚ ਧਾਰਾ ਕੰਮ ਸਾਂਝ ਹੈ, ਪੰਜਾਬੀ ਵਿਚ ਹਰੇਕ ਵਰਗ ਦੇ ਪਹਿਲੇ ਤਿੰਨ ਅੱਖਰ ਵ, ਪ, ਗ / ਚ, ਛ, ਜ / ਟ, ਠ, ਡ / ਤ, ਥ, ਦ / ਪ, ਫ, ਬ / ਤੱਵਦੇ ਵਿਸ਼ਲੇਸ਼ਣ ਹਨ। ਇਨ੍ਹਾਂ ਨੂੰ ਅੱਗੇ ਵੀ ਹਰ ਥਾਂ ਵਿਚ ਦੱਸਿਆ ਸਾਂਝ ਹੈ, ਜਿਨ੍ਹਾਂ ਦਾ ਵੇਰਵਾ ਹੇਠ ਲਿਖੇ ਅਨੁਸਾਰ ਹੈ:-

ⓐ ਸੰਪੋਸ਼ ਤੇ ਅਘੋਸ਼ / ਨਾਦੀ ਤੇ ਅਨਾਦੀ →

ਸਾਹ ਨਲੀ ਦੇ ਉਪਰਲੇ ਪਿੱਛੇ ਵਿਚ ਧੁੰਨੀਆਂ ਦੀ ਸਖਤ ਵਰਗੇ ਦੇ ਅੰਗ ਹੁੰਦੇ ਹਨ, ਜਿਨ੍ਹਾਂ ਨੂੰ ਸਾਹ ਧੁੰਨੀਆਂ ਜਾਂ ਸਾਹ ਤੰਤੂਆਂ ਵਰਗ ਸਾਂਝ ਹੈ। ਜਦੋਂ ਇਹ ਧੁੰਨੀਆਂ / ਤੰਤੂਆਂ ਆਪਸ ਵਿਚ ਨਸੀਆਂ ਹੋਈਆਂ ਹਨ ਤਾਂ ਹੇਠਲੀਆਂ ਵਿਚੋਂ ਦੀ ਹਵਾ ਵਗਣ ਕਰਕੇ ਵਗਦੀ ਹੈ, ਜਿਸ ਨਾਲ

ਸੰਪਾਦਨ / ਸਧਾਈ ਪ੍ਰਕਿਰਿਆ ਪੈਂਦਾ ਤੇਈਆਂ ਤਰ੍ਹਾਂ ਦਿਹਨਾਂ ਵਿਚ ਸਾਫ਼ਾਂ ਵਿਸ਼ਾਲ ਤੇਈਆਂ ਤਰ੍ਹਾਂ ਦਿਸ ਵਿਚ ਗ, ਸ, ਤ, ਦ, ਧ ਆਦ ਤੁ ਵਰਗ ਦਾ ਤੀਜਾ ਅੱਖਰ ਆਉਂਦਾ ਹੈ।

ਸਪੰਮ / ਸਧਾਈ → ਇਹਨਾਂ ਪ੍ਰਕਿਰਿਆ ਦੇ ਉਦਾਹਰਨ ਦੇਣੇ ਹਾਏ ਧੁੱਨੀਆਂ / ਤੇਈਆਂ ਸਾਪਸ ਵਿਚ ਸੁਰੰਮਿਸ਼ ਸ਼ਬਦੀਆਂ ਦਰਜ ਤੇਈਆਂ, ਦਿਹਨਾਂ ਵਿਚ ਚੌਥੀ ਦਿੱਖ ਹੁੰਦੀ ਹੈ, ਕਿਸ ਵਰਗ ਦਿਹਨਾਂ ਪ੍ਰਕਿਰਿਆ ਨੂੰ ਉਦਾਹਰਨ ਵਿਚ ਵਿਸ਼ਾਲ ਸਾਫ਼ਾਂ ਦਰਜ ਤੇਈਆਂ, ਇਸ ਵਿਚ ਤੁ ਵਰਗ ਦੇ ਪਹਿਲੇ ਦੋ ਅੱਖਰ ਆਉਂਦੇ ਹਨ, ਜਿਵੇਂ + ਕ, ਖ/ਛ, ਛ/ ਟ, ਠ/ਤ, ਥ/ਪ, ਫ।

(ਸ) ਅਲਪਪ੍ਰਾਣ ਅਤੇ ਮਹਾਪ੍ਰਾਣ →

ਅਲਪਪ੍ਰਾਣ → ਅਲਪ ਦਾ ਭਾਵ ਹੈ ਛੋਟਾ / ਸਾਵੇਂ ਹਵਾ ਨੂੰ ਘੱਟ ਵੇਗ ਨਾਲ ਬਾਹਰ ਕੱਢਿਆ ਜਾਂਦਾ ਹੈ। ਇਸ ਵਿਚ ਤੁ ਵਰਗ ਦੇ ਪਹਿਲੇ ਤੇ ਤੀਜਾ ਅੱਖਰ ਆਉਂਦਾ ਹੈ ਜਿਵੇਂ - ਕ, ਗ/ਚ, ਜ/ਤ, ਦ/ਪ, ਬ

ਮਹਾਪ੍ਰਾਣ → ਸਾਵੇਂ ਹਵਾ ਨੂੰ ਵੱਧ ਵੇਗ ਨਾਲ ਬਾਹਰ ਕੱਢਿਆ ਜਾਂਦਾ ਹੈ। ਇਸ ਵਿਚ ਤ ਵਰਗ ਦਾ ਦੂਜਾ ਅੱਖਰ ਆਉਂਦਾ ਹੈ। ਜਿਵੇਂ - ਖ, ਛ, ਠ, ਥ, ਫ

= ਅੱਡਰੇ ਦਿਸ਼ਾਸ਼ਕ → ਅੱਡਰੇ ਦਿਸ਼ਾਸ਼ਕਾਂ ਦੇ ਉਦਾਹਰਨ ਸਮੇਂ ਹੇਠਲਿਆਂ ਵਿਚੋਂ ਆਉਂਦੀ ਹਵਾ ਨੂੰ ਪੂਰੀ ਤਰ੍ਹਾਂ ਰੋਕ ਕੇ ਨਾਲੋਂ ਛੱਡਿਆ ਜਾਂਦਾ। ਜਿਵੇਂ - ਚ, ਟ/ਕ, ਦ/ਫ, ਧ/ਪ, ਨ/ਤ, ਮ। ਇਹਨਾਂ ਦੀ ਸਿਫ਼ਤੀ ਦਸ ਪੰ ਇਹਨਾਂ ਨੂੰ ਅੱਗੇ ਦੋ ਭਾਗਾਂ ਵਿਚ ਵੰਡਿਆ ਜਾਂਦਾ ਹੈ :-

(ੳ) ਨਾਸਕੀ → ਜਿਹਨਾਂ ਦਿਸ਼ਾਸ਼ਕ ਪ੍ਰਕਿਰਿਆ ਦੇ ਉਦਾਹਰਨ ਸਮੇਂ ਹਵਾ ਨੱਕ ਨਾਲੋਂ ਨਿਕਲੇ, ਉਹਨਾਂ ਨੂੰ ਨਾਸਕੀ ਦਿਸ਼ਾਸ਼ਕ ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਜਿਵੇਂ- ਙ, ਞ, ਣ, ਨ, ਮ।

(ਲ) ਝੰਡਾ (Jhanda) ਵਿਅੰਜਨ → ਇਸ ਧੁਨੀ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਪਿਛਲ ਰਾਂਘਾ ਵਿਚ ਪੈਂਦਾ ਹੈਦਾ ਹੈ, ਜਿਵੇਂ - ਗ

(ਫ਼) ਫਟਕੜਾ (Flap) ਵਿਅੰਜਨ → ਇਸ ਨੂੰ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਸਖਤ ਤਾਲੂ ਨੂੰ ਟੱਚ ਕਰਦੇ ਇਕ ਦਮ ਫਟਕੇ ਨਾਲ ਹੇਠਾਂ ਵੱਲ ਆਉਂਦੀ ਹੈ। ਜਿਵੇਂ - ੜ

(ਸ) ਘਾਮੇਘਰ / ਘਾਮਹਿਰ ਵਿਅੰਜਨ → ਇਹਨਾਂ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਮੋਕ ਹੈ ਕੇ ਏਦੇ ਪਰਲ ਦੇ ਨਾਲ ਲੱਗ ਜਾਂਦੀ ਹੈ ਅਤੇ ਹਵਾ ਏਦੇ ਪਾਸਿਆਂ ਹੈ ਬਾਹਰ ਨਿਕਲ ਜਾਂਦੀ ਹੈ ਜਿਵੇਂ - ਲ, ਲ

(ਹ) ਅਰਧ ਸ੍ਵਰ / ਅਰਧ ਵਿਅੰਜਨ → (ਅਸਲੇ ਵਿਅੰਜਨ) 'ਹ' ਅਤੇ 'ਵ' ਏਹਨਾਂ ਧੁਨੀਆਂ ਨੂੰ ਅਰਧ ਸ੍ਵਰ ਅਤੇ ਅਰਧ ਵਿਅੰਜਨ ਵਿਚ ਜਾਣਿਆ ਹੈ। ਇਹਨਾਂ ਦਾ ਉਚਾਰਨ ਸਮਦਾ ਹੈ ਕਿਤੇ ਇਹ ਵਿਅੰਜਨਾਂ ਵਿੱਚ ਵਰਤੇ ਜਾਂਦੇ ਹਨ ਤੇ ਕਿਤੇ ਸ੍ਵਰਾਂ ਵਿੱਚ। ਇਸ ਕਰਕੇ ਇਹਨਾਂ ਨੂੰ ਅਸਲੇ ਵਿਅੰਜਨ ਵੀ ਕਿਹਾ ਜਾਂਦਾ ਹੈ

(ਰ) ਮੱਧਅਮੀ ਜਾਂ ਖਰਿਟੇ ਵਿਅੰਜਨ → ਇਹਨਾਂ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਜੀਭ ਥਿੜਕਦੀ ਹੈ ਜਾਂ ਖਰਿਟੇ ਜਾਂਦੀ ਹੈ, ਉਸ ਨੂੰ ਮੱਧਅਮੀ ਜਾਂ ਖਰਿਟੇ ਵਿਅੰਜਨ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ - ਰ/ੜ।

ਉਪਰੋਕਤ ਵਿਆਕਰਣਕਾਰਾਂ ਨੇ ਸਪਸ਼ਟ ਕੀਤਾ ਹੈ ਕਿ ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਵਿੱਚ ਕੁਲ 38 ਵਿਅੰਜਨ ਹਨ ਜਿਹਨਾਂ ਵਿੱਚੋਂ ਕ ਤੋਂ ਲੈ ਕੇ ਣ ਅਤੇ ਵਿਅੰਜਨਾਂ ਦੇ ਪਾਸੀ ਹਨ। ਫ, ਜ਼ ਦੀ ਵਰਤੋਂ ਅਰਬੀ ਫ਼ਾਰਸੀ ਸ਼ਬਦਾਂ ਵਿੱਚ ਹੀ ਹੁੰਦੀ ਹੈ ਪਰ ਪੰਜਾਬੀ ਉਚਾਰਨ ਵਿੱਚ ਇਹ ਕ, ਚ ਦਾ ਉਚਾਰਨ ਬਣ ਕੇ ਰਹਿ ਜਾਂਦੇ ਹਨ, ਇਹਨਾਂ ਦੀ ਆਪਣੀ ਕੋਈ ਵੱਖਰੀ ਪਹਿਚਾਣ ਨਹੀਂ ਹੈ

II. ਅਖੰਡੀ ਪ੍ਰਤੀਆਂ →

ਅਖੰਡੀ ਪ੍ਰਤੀਆਂ ਤੋਂ ਭਾਵ ਅਜਿਹੀਆਂ ਪ੍ਰਤੀਆਂ ਤੋਂ ਹੈ ਜਿਨ੍ਹਾਂ ਵਿਚ ਮੂਲ ਰੂਪ ਤੋਂ ਲਏ ਗਏ ਵਿਸ਼ੇ ਸਮੱਗਰੀ ਦੇ ਵੱਖ ਵੱਖ ਭੰਡੀ ਪ੍ਰਤੀਆਂ ਨਾਲ ਮਿਲਦੇ ਜੁਲਦੇ ਵਿਸ਼ੇ ਸਮੱਗਰੀ ਜਾਂ ਚਿਤ੍ਰ ਵਿਚ ਪਿਛ, ਧਰ, ਸ੍ਰਮ/ਵਾਰ ਸ੍ਰਮ, ਸੰਗਮ, ਸਾਮਿਗ੍ਰੀ ਨੂੰ ਕਿਸ ਕਿਸਮ ਤੇ ਕਿਹੜੇ ਢੰਗ ਨਾਲ ਵਰਤਿਆ ਗਿਆ ਹੈ ਇਹਨਾਂ ਦਾ ਵੇਰਵਾ ਹੇਠ ਲਿਖੇ ਅਨੁਸਾਰ ਹੈ:-

i. ਧਰ ਜਾਂ ਦਯਾਸ →

ਸਾਧਨਾਂ ਨੂੰ ਘੋਖਣ ਸਮੇਂ ਅਸੀਂ ਸਭਨੀਂ ਪ੍ਰਤੀਆਂ ਜਾਂ ਉਚਾਰ ਖੰਡਾਂ ਉੱਤੇ ਇਕੋ ਕਿਸਮ ਦਾ ਧਰ ਜਾਂ ਦਯਾਸ ਨਹੀਂ ਦੇਖਦੇ ਜਿਸ ਪ੍ਰਤੀ ਉੱਪਰ ਘੱਟ ਧਰ ਦਿੱਤੇ ਜਾਂ ਉੱਥੇ ਕਿਸੇ ਪ੍ਰਤੀ ਉੱਪਰ ਵਿਸ਼ਾਲ ਧਰ ਦਿੱਤੇ ਜਾਂ। ਸਗੋਂ ਕਈ ਥਾਂ ਇਹ ਧਰ ਸਹਿਤ ਤੇ ਕਿਤੇ ਧਰ ਰਹਿਤ ਵਾਲ ਨਿਰਮਾਣ ਹੋਇਆ ਹੈ ਜਿਸ ਤਰ੍ਹਾਂ ਪ੍ਰਤੀ ਜਾਂ ਉਚਾਰਖੰਡ ਤੇ ਜੋ ਦਯਾ ਦਿੱਤਾ ਜਾਂਦਾ ਹੈ, ਉਸਨੂੰ ਧਰ/ਦਯਾਸ ਵਿਗ ਜਾਂਦਾ ਹੈ। ਧਰ ਉਚਾਰ ਪ੍ਰਕਿਰਿਆ ਦੀ ਦੱਸ ਮਾਤ੍ਰਾ ਦਾ ਨਾਂ ਹੈ ਜਿਵੇਂ

ਤਕਾ - ਮੋਟੀ ਦਾ ਤਕਾ (ਜਿਸ ਉੱਪਰ 'ਤ' ਉਕਾਰ ਹੈ)

ਤਕਾ - ਪਾਦੀ ਦਾ ਤਕਾ (ਜਿਸ ਵਿਚ 'ਕ' ਤੇ ਸੌਰ ਹੈ)

ਪੰਜਾਬੀ ਵਿਚ ਧਰ/ਦਯਾਸ ਅੱਧਰ ਨਾਲ ਹੀ ਪਾਇਆ ਜਾਂਦਾ ਹੈ ਜਿਵੇਂ -

ਪਤਾ - ਪੱਤਾ

ਤਤਾ - ਤੱਤਾ

ਇਹ ਦੋ ਸ਼ਬਦ ਜੋ ਕਿਵੇਂ ਪਰਿਵਰਤਿਤ ਵਿਚ ਪਰਿਵਰਤਿਤ 'ਪਤਾ' ਭਾਵ ਸੰਤੁਲਨ ਤੇ ਹੈ, ਦੂਜੇ 'ਪੱਤਾ' ਤੇ ਭਾਵ ਵਿਸ਼ੇ ਦਾਖਲ ਦੇ ਪੱਤੇ ਤੋਂ ਹੈ।

ii. ਪਿੱਛ / ਤਾਸ → ਭਾਸ਼ਾ ਪ੍ਰਤੀਆਂ ਦੇ ਉਚਾਰਨ ਦੌਰਾਨ ਮਾਤ੍ਰਾ ਗਤੀ ਵਿਚ ਸ੍ਰਮ ਕਈ ਵੰਚਤੀਆਂ ਤਾਂ ਸ੍ਰਮ ਤੋਂ ਹੀ ਵੰਚਾਣ

ਜੋ ਵੰਚਣ ਗਤੀ ਹੈ ਵੰਚਣ ਦੀ ਮਹਤਾ ਪਿੱਛ ਜਾਂ ਜਥੇ ਤੋਂ ਹੈ ਤਾਂ ਉਸ ਮਾਤ੍ਰਾ' ਤੇ ਘੋਸ਼ਣ ਦੀ ਸਪਾਸ ਹੈ। ਜਾਂ ਪੰਜਾਬੀ (ਪੜ੍ਹਨ) ਵਿਚ ਪ੍ਰ ਸ਼ਬਦਾਂ ਵਿਚ ਪਿੱਛ ਨਾਲ ਪ

iii. ਸ੍ਰਮ / ਵਾਰ ਸ੍ਰਮ →

ਜਦੋਂ ਪੰਜਾਬੀ ਦੀ ਮਾਤ੍ਰਾ ਤੋਂ ਹੈ ਤਾਂ ਵਰ੍ਹੇ ਤਕਾ ਸ੍ਰਮ ਤੋਂ ਵਰ੍ਹੀ ਹੈ, ਜਿਵੇਂ ਉਚਾਰਨ - ਤਕਾਰ ਉਚਾਰਨ - ਤਕਾਰ ਹੈ ਜਾਂ ਦੂਜੀ ਪੰਜਾਬੀ ਵਿੱਚ ਪ

ਤੀਜਾ ਸ੍ਰਮ ਕ/ਤਕਾ/ ਜਦੋਂ ਜਿਸ ਪਿੱਛ ਤੇ ਮਾਤ੍ਰਾ ਹੈ ਵਾਰ ਸ੍ਰਮ ਘਟਦਾ ਸ਼ਬਦਾਂ ਤੋਂ ਤਕਾਰ ਦੇ ਸ਼ਬਦ ਧਰਦਾ

ਕੀ ਵੇਖਣ ਗਈ ਹੈ ਪਿੱਛੋ ਰਿਹਾ ਬਾਂਦਰ। ਤੀਜੇ ਕਦਮ ਤੇ ਉਹਨੇ ਵੇਖਣ ਦੀ ਮਹੱਤਤਾ ਸਿਮਾਪਤ ਹੋਈ ਹੈ ਤਾਂ ਉਸਨੂੰ ਉਹਦੀ ਪਿੱਛੋ ਆਉਣ ਵਾਲੇ ਸਮ ਤੇ ਉਹਨੇ ਵੇਖਣ ਦੀ ਮਹੱਤਤਾ ਘੱਟ ਹੋਈ ਹੈ ਤਾਂ ਉਸਨੂੰ ਤੀਜੇ ਪਿੱਛੋ ਰਿਹਾ ਬਾਂਦਰ ਸਮਝਦਾ ਹੈ ਕਿਉਂਕਿ ਸਮ ਤੇ ਉਹਨੇ ਹੀ ਵੇਖਣ ਗਈ ਹੈ ਸਮਾਪਤ ਹੋਈ ਹੈ, ਉਸਨੂੰ ਅੱਧਦਮੀ ਪਿੱਛੋ ਰਿਹਾ ਬਾਂਦਰ ਜਾ ਪੈਮਾਇਸ਼ ਦੇ ਦੋ ਸਥਰ ਪਾਸਾ (ਦਿੱਖ) ਤੇ ਪਾਰੂ (ਪੜਾਰੂ) ਵੀਆਂ ਪੂਰੀਆਂ ਮਿਟਦੀ ਤੇ ਤਕੀਬ ਸਮਾਨ ਹੈ। ਪਰ ਸਮਝਾਂ ਵਿੱਚ ਫਰਕ ਹੈ ਸਮਝਾਂ ਦਾ ਇਹ ਫਰਕ ਪਿੱਛੋ ਵਾਲਾ ਪਿਆ ਹੈ।

(iii) ਸਮ / ਹਾਰ ਸਮ ⇒

ਇਹ ਇਮਤੇਸ਼ ਅਖੰਡੀ ਪੂਰੀ ਹੈ ਤੇ ਸਮਾਹਰ ਨਾਲੋਂ ਪੈਮਾਇਸ਼ੀ ਹੀ ਅਖਿਰੀ ਭਾਸ਼ਾ ਹੈ ਕਿਸ ਦਿੱਤ ਸਮ ਦੀ ਸਾਰਥਕ ਹੋਂਦ ਹੈ ਪੂਰੀ ਉਚਾਰਨ ਵੇਲੇ ਵੇਹਲੀਆਂ ਦਿੱਤੇ ਜਾ ਰਹੀ ਹੈ ਸਮ ਉਹਦਾ ਦਿੱਤੇ ਕੰਪਦੀ ਹੋਈ ਵੇਖਣ ਪੈਂਦ ਰਹੀ ਹੈ, ਇਹ ਵੇਖਣ ਦੱਸਦੀ ਘੱਟਦੀ ਮਿਲਦੇ ਹੈ, ਇਸ ਉਚਾਰਨ-ਵਚਾਰ ਤੋਂ ਪਿੱਛੋ ਰਿਹਾ ਬਾਂਦਰ ਜਾ ਨਵੇਂ ਇਸ ਪਿੱਛੋ ਦੇ ਉਚਾਰਨ-ਵਚਾਰ ਦੀ ਵਰੋਂ ਸਥਰ ਵੇ ਪੱਧ ਤੇ ਸਾਰਥਿਕ ਹੋਈ ਹੈ ਜਾਂ ਵਰੀ ਜਾਂਦੀ ਹੈ ਤਾਂ ਇਸਨੂੰ ਸਮ ਰਿਹਾ ਬਾਂਦਰ ਜਾ ਪੈਮਾਇਸ਼ੀ ਦਿੱਤ ਪਿੱਛੋ ਸਮ ਦੀ ਹੋਂਦ ਸਾਰਥਕ ਹੋਈ ਜਾ

ਤੀਜੇ ਸਮ	ਪੰਜਵੇ ਸਮ	ਉਹਦੀ ਸਮ
ਕ/ਅਮਾ/	ਜ/ਅਮਾ/	ਅਹ/ਅਮਾ/

ਨਵੇਂ ਇਸ ਪਿੱਛੋ ਦੇ ਉਚਾਰਨ-ਵਚਾਰ ਦੀ ਵਰੋਂ ਹਾਰ ਪੱਧ ਤੇ ਸਾਰਥਿਕ ਹੋਈ ਹੈ ਤਾਂ ਉਸਨੂੰ ਹਾਰ - ਸਮ ਰਿਹਾ ਬਾਂਦਰ ਜਾ ਹਾਰ ਸਮ ਦਰਅਸਲ ਤਾਂ ਹਾਰ ਦਿੱਤਕੇ ਸਮਝਾਂ ਦੇ ਇਮਤੇਸ਼ਕ ਸਮਝਾਂ ਤੇ ਤਕੀਬ ਹੋਈ ਵਰ ਰਹੀ ਪੈਂਦਾ ਸਾਰੇ ਪੂਰੇ ਹਾਰ ਦੇ ਸਮਝ ਦਰਅਸਲ ਕਾਰੇ ਜਾ ਸਿਵੇਂ :-

ਉਹ ਜਾ ਸਿਮਾ।
ਉਹ ਜਾ ਸਿਮਾ?
ਉਹ ਜਾ ਸਿਮਾ!

ਪੰਜਾਬੀ ਵਿਚ ਸਪਾਸ਼ ਧੁਨੀਆਂ ਵਿਚ ਤੋਂ ਅੱਖਰਾਂ ਦੀ ਪ੍ਰਮੁੱਖ ਥਾਂ ਹੈ ਇਸ ਸ੍ਰੇਣੀ ਵਿਚ ਸ੍ਰੋਤ ਧੁਨੀਆਂ ਹਨ ਜਿਨ੍ਹਾਂ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਮੂੰਹ ਵਿਚ ਕਿਸੇ ਥਾਂ ਤੇ ਪੂਰਨ ਰੂਪ ਵਿਚ ਰੁਕਾਵਟ ਨਹੀਂ ਹੁੰਦੀ ਸਗੋਂ ਹਵਾ ਮੂੰਹ ਵਿਚ ਕਿਸੇ ਥਾਂ ਤੇ ਰੁਕ ਕੇ ਫਿਰ ਰਗੜ ਖਾ ਕੇ ਬਾਹਰ ਨਿਕਲਦੀ ਹੈ ਉਹਨਾਂ ਨੂੰ ਸਪਾਸ਼ ਧੁਨੀਆਂ ਕਹਿੰਦੇ ਹਨ।

(iv) ਨਾਸਿਕਤਾ → ਉਸ ਧੁਨੀ ਨੂੰ ਜਿਸ ਦੇ ਉਚਾਰਨ ਵਿਚ ਹਵਾ ਮੂੰਹ ਅਤੇ ਨਾਸਿਕ ਦੋਵਾਂ ਵਿਚੋਂ ਲੰਘੇ ਉਸ ਨੂੰ ਨਾਸਿਕ ਧੁਨੀ ਕਹਿੰਦੇ ਹਨ। ਨਾਸਿਕ ਧੁਨੀਆਂ ਦੇ ਉਚਾਰਨ ਵੇਲੇ ਜਦ ਹਵਾ ਮੂੰਹ ਵਿਚ ਕਿਸੇ ਥਾਂ ਤੇ ਰੁਕਦੀ ਹੈ ਤਾਂ ਉਸੇ ਸਮੇਂ ਹਵਾ ਨਾਸਿਕ ਵਿਚ ਵੀ ਰੁਕਦੀ ਹੈ ਅਤੇ ਨਾਸਿਕ ਵਿਚੋਂ ਹਵਾ ਨਿਕਲਦੀ ਹੈ ਜਦੋਂ ਕਿ ਮੂੰਹ ਵਿਚ ਰੁਕਾਵਟ ਬਣੀ ਰਹਿੰਦੀ ਹੈ। ਨਾਸਿਕ ਧੁਨੀਆਂ ਵਿਚ ਕੋਈ ਵੀ ਨਾਸਿਕ ਧੁਨੀ ਉਚਾਰਨ ਦੀ ਦ੍ਰਿਸ਼ਟੀ ਤੋਂ ਸੁਤੰਤਰ ਨਹੀਂ ਹੁੰਦੀ ਸਗੋਂ ਸਵਰ ਧੁਨੀਆਂ ਤੋਂ ਬਾਅਦ ਹੀ ਆਉਂਦੀ ਹੈ। ਜਿਵੇਂ- ਮਾਂ, ਨਾਂ, ਹਾਂ, ਆਂ, ਜਾਂ, ਖਾਂ, ਮੀਂਹ, ਤੀਂ, ਨੀਂ, ਹੀਂ, ਮੂੰਹ, ਤੂੰ, ਨੂੰ, ਹੂੰ, ਮੈਂ, ਨੈਂ, ਹੈਂ, ਮੋਂ, ਨੌਂ, ਹੌਂ ਆਦਿ।

(v) ਸੰਘਰਸ਼ → ਸੰਘਰਸ਼ ਉਹ ਵਿਅੰਜਨ ਧੁਨੀ ਹੈ ਜਿਸ ਸਮੇਂ ਫੇਫੜਿਆਂ ਵਿਚੋਂ ਹਵਾ ਦੀ ਨਿਕਾਸੀ ਦਾ ਸਮੇਂ ਮੂੰਹ ਵਿਚ ਕਿਸੇ ਥਾਂ ਤੇ ਰੁਕਾਵਟ ਪੈਦਾ ਹੋਵੇ ਅਤੇ ਹਵਾ ਰਗੜ ਖਾ ਕੇ ਬਾਹਰ ਨਿਕਲੇ ਉਸ ਧੁਨੀ ਨੂੰ ਸੰਘਰਸ਼ ਧੁਨੀ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ- ਸ, ਹ, ਸ਼, ਖ਼, ਗ਼, ਜ਼, ਫ਼, ਸ਼ ਆਦਿ।

= ਉਚਾਰਨ ਸਥਾਨ →

ਉਚਾਰਨ ਦ੍ਰਿਸ਼ਟੀ ਤੋਂ ਪੰਜਾਬੀ ਧੁਨੀਆਂ ਨੂੰ ਹੇਠ ਲਿਖੇ ਅਨੁਸਾਰ ਵੰਡਿਆ ਜਾ ਸਕਦਾ ਹੈ:-

1. ਦੰਤਮੂਲੀ/ਵਰਤਸੀ
2. ਤਾਲਵੀ
3. ਮੂਰਧਨੀ
4. ਦੰਤੀ
5. ਕੋਮਲ ਤਾਲਵੀ
6. ਓਸ਼ਠੀ

- ਦੰਤਮੂਲੀ/ਵਰਤਸੀ → ਜਿਹੜੀਆਂ ਧੁਨੀਆਂ ਦੰਦਾਂ ਦੇ ਮੂਲ ਨੂੰ ਛੂਹ ਕੇ ਉਚਾਰੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਉਹਨਾਂ ਨੂੰ ਦੰਤਮੂਲੀ ਧੁਨੀਆਂ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ- ਸ, ਜ਼, ਨ, ਰ, ਲ, ਲ਼, ਤ, ਥ, ਦ, ਧ ਆਦਿ।

- ਤਾਲਵੀ → ਜਿਹੜੀਆਂ ਧੁਨੀਆਂ ਤਾਲੂ ਨੂੰ ਛੂਹ ਕੇ ਉਚਾਰੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਉਹਨਾਂ ਨੂੰ ਤਾਲਵੀ ਧੁਨੀਆਂ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ- ਚ, ਛ, ਜ, ਝ, ਸ਼, ਯ ਆਦਿ।

- ਮੂਰਧਨੀ → ਜਿਹੜੀਆਂ ਧੁਨੀਆਂ ਮੂਰਧਾ ਨੂੰ ਛੂਹ ਕੇ ਉਚਾਰੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਉਹਨਾਂ ਨੂੰ ਮੂਰਧਨੀ ਧੁਨੀਆਂ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ- ੜ, ਣ, ਟ, ਠ, ਡ, ਢ ਆਦਿ।

- ਦੰਤੀ → ਜਿਹੜੀਆਂ ਧੁਨੀਆਂ ਦੰਦਾਂ ਨੂੰ ਛੂਹ ਕੇ ਉਚਾਰੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਉਹਨਾਂ ਨੂੰ ਦੰਤੀ ਧੁਨੀਆਂ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ- ਤ, ਥ, ਦ, ਧ, ਨ, ਸ, ਲ, ਰ ਆਦਿ।

- ਕੋਮਲ ਤਾਲਵੀ → ਜਿਹੜੀਆਂ ਧੁਨੀਆਂ ਕੋਮਲ ਤਾਲੂ ਨੂੰ ਛੂਹ ਕੇ ਉਚਾਰੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਉਹਨਾਂ ਨੂੰ ਕੋਮਲ ਤਾਲਵੀ ਧੁਨੀਆਂ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ- ਕ, ਖ, ਗ, ਘ, ਹ, ਖ਼, ਗ਼ ਆਦਿ।

- ਓਸ਼ਠੀ → ਜਿਹੜੀਆਂ ਧੁਨੀਆਂ ਓਸ਼ਠ ਨੂੰ ਛੂਹ ਕੇ ਉਚਾਰੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਉਹਨਾਂ ਨੂੰ ਓਸ਼ਠੀ ਧੁਨੀਆਂ ਕਹਿੰਦੇ ਹਨ। ਜਿਵੇਂ- ਪ, ਫ, ਬ, ਭ, ਮ, ਵ ਆਦਿ।

ਇਸ ਨਾਲ ਪੰਜਾਬੀ ਭਾਸ਼ਾ ਵਿਚਲੇ ਦਰਤਾਰੇ ਨੂੰ ਸਮਝਿਆ ਜਾਂਦਾ ਹੈ ਜੋ ਅਜਿਹੇ ਪ੍ਰਸੰਗਾਤਮਕ ਦਰਤਾਰੇ ਨੂੰ ਸੰਗਾਰ ਵਿਚ ਲਿਆਉਂਦਾ ਹੈ।

= ਉਚਾਰਨ ਅੰਗ →

ਮਨੁੱਖੀ ਸਰੀਰ ਦੇ ਜਿਹੜੇ ਅੰਗ ਭਾਸ਼ਾ ਨੂੰ ਉਚਾਰਨ ਵਿਚ ਸਹਾਇਕ ਹੋਏ ਜਾਂ ਉਹਨਾਂ ਨੂੰ ਉਚਾਰਨ ਅੰਗ ਜਾਂ ਪ੍ਰਤੀ ਉਚਾਰਣ ਅੰਗ ਵਿਚ ਲਿਆ ਜਾਂਦਾ ਹੈ ਜਾਂ ਇਹ ਦੋ ਤਰ੍ਹਾਂ ਦੇ ਹੋਏ ਹਨ।

1. ਚਲਣ (ਗਤੀਸ਼ੀਲ) (active)
2. ਅਚਲ (ਸਥਿਰ / nonactive)

① ਚਲਣ / ਗਤੀਸ਼ੀਲ → ਇਹ ਉਹ ਅੰਗ ਹੋਏ ਜਿਨ੍ਹਾਂ ਵਿਚ ਚਲਣ ਸ਼ਕਤੀ ਸਮਝੇ ਜਾ ਸਕਦੇ ਹਨ। ਜਿਵੇਂ - ਜੀਭ, ਹੇਠਲਾ ਬੁੱਲ੍ਹ, ਹੇਠਲੇ ਦੰਦ

② ਅਚਲ / ਸਥਿਰ → ਇਹ ਉਹ ਅੰਗ ਹੋਏ ਜਿਨ੍ਹਾਂ ਵਿਚ ਚਲਣ ਸ਼ਕਤੀ ਨਹੀਂ ਸਮਝੇ ਜਾ ਸਕਦੇ। ਜਿਵੇਂ - ਉਪਰਲੇ ਬੁੱਲ੍ਹ, ਉਪਰਲੇ ਦੰਦ।

ਉਚਾਰਨ ਅੰਗਾਂ ਦਾ ਵੇਰਵਾ ਹੇਠ ਲਿਖ ਅਨੁਸਾਰ ਹੈ:-

- ਦੰਦ → ਹੇਠਲੇ ਦੰਦਾਂ ਦਾ ਵੀ ਭਾਸ਼ਾ ਨੂੰ ਬੋਲਣ ਸਮੇਂ ਉਚਾਰਨ ਵਿਚ ਉਪਰਲੇ ਦੰਦਾਂ ਨਾਲ ਨਾਲ-ਨਾਲ ਪ੍ਰਤੀਮਾਂ ਉਚਾਰਨ ਵਿਚ ਹੀ ਸਹਾਇਕ ਹੋਏ ਹਨ। ਜਦੋਂ ਜੀਭ ਦੀ ਨੋਕ ਦੰਦਾਂ ਨਾਲ ਟੱਚ / ਛੋਹਦੀ ਹੈ ਤਾਂ ਦੰਦੀ ਪ੍ਰਤੀਮਾਂ ਦਾ ਉਚਾਰਨ ਹੁੰਦਾ ਹੈ ਜਿਵੇਂ - ਤ, ਥ, ਦ, ਧ, ਨ।

- ਬੁੱਲ੍ਹ → ਹੇਠਲੇ ਬੁੱਲ੍ਹ ਵਿਚ ਉਚਾਰਨ ਵੇਲੇ ਬੁੱਲ੍ਹਾਂ ਦੁਆਰਾ ਹੋਰ ਪ੍ਰਤੀਮਾਂ ਦਾ ਉਚਾਰਨ ਕੀਤਾ ਜਾਂਦਾ ਹੈ ਜਿਸ ਨਾਲ ਬਿਲਬੀਮਾਂ ਪ੍ਰਤੀਮਾਂ ਉਚਾਰਨੀਮਾਂ ਕਹੀਆਂ ਜਾਂਦੀਆਂ ਹਨ ਜੋ ਹੇਠ ਲਿਖੀ ਹਨ ਜੋ ਹੇਠਾਂ

ਪ੍ਰਤੀਮਾਂ ਵਰਿਛੇ ਯਾ ਸਿਛੇ - ਪ, ਫ, ਧ, ਭ, ਸ

= ਵਾਂ ਸਾਂ ਵਾਰਯ →

ਵਾਂ ਸਾਂ ਵਾਰਯ ਮਾਸ ਦਾ ਕਟਵਦਾ ਉਵਿਸਾਂ ਥਿਕ ਛੋਟਾ ਸਿਰ ਟੁਰਸ਼ਾ ਹੈ, ਸਵੇਂ ਥਿਕ ਮਾਸ ਦਾ ਟੁਰਸ਼ਾ ਮੁੰਹ ਪੋਸ਼ ਦਾ ਸਮਤਾ ਧੋਣ ਵਰ ਥਿਰਾ ਹੈ ਤੇ ਸਾਮਥੀ ਪ੍ਰਤੀਮਾਂ ਦਾ ਉਛਾਸ ਹੈਦਾ ਹੈ ਸਿਛੇ- ਫ, ਫ਼ ਫ, ਨ, ਮ ਅਤੇ ਸਵੇਂ ਥਿਕ ਨੋਵ ਪੋਸ਼ ਦਾ ਸਮਤਾ ਧੋਣ ਵਰ ਥਿਰਾ ਹੈ ਤੇ ਮੌਖਿਕ ਪ੍ਰਤੀਮਾਂ ਦਾ ਉਛਾਸ ਹੈਦਾ ਹੈ, ਥਿਨਾਂ ਨੂੰ ਰਥੀ ਹਾਰ ਵਾਰਯ ਪ੍ਰਤੀਮਾਂ ਦੀ ਵਿਰ ਜਾਂਦਾ ਹੈ।

= ਸੀਰ →

ਸੀਰ ਥਿਕ ਸਮਸਿਰ ਉਛਾਸ ਸਮੂਹ ਹੈ ਜਿਸ ਦਾ ਪ੍ਰਤੀਮਾਂ ਦੇ ਉਛਾਸ ਥਿਕ ਖਾਸ ਸਮਾਨ ਹੈ, ਸੀਰ ਦੀ ਦੋ ਸ਼ਾਖਾ - ਦੋ ਸ਼ਾਖਾਮਾਂ ਮਥਿਕੀ ਦੋ ਹੈ - ਦੋ ਸ਼ਾਖਾਮਾਂ ਪ੍ਰਤੀਮਾਂ ਉਛਾਸ ਥਿਕ ਸਗਥਿਕ ਹੈਦੀ ਹੈ। ਸਵੇਂ ਸੀਰ ਦੀ ਨੋਵ ਦੋਸ਼ਾਂ ਦੇ ਪਿਛਲੇ ਪਾਸੇ ਰੋਮਾਵਲੀ ਹੈ ਤੇ ਦੋਸ਼ੀ ਪ੍ਰਤੀਮਾਂ ਪੋਸ਼ ਹੈਦੀਮਾਂ ਯ, ਸਿਛੇ - ਤ, ਫ, ਫ, ਪ, ਨ ਅਤੇ ਸਵੇਂ ਸੀਰ ਦੀ ਨੋਵ ਦਾ ਪਿਛਲਾ ਪਾਸਾ ਸਮਤ ਹਾਰ ਤੇ ਟੁੱਥ ਰਸ਼ਾ ਹੈ ਤੇ ਉਲਟ ਸੀਰੀ ਪ੍ਰਤੀਮਾਂ ਦਾ ਉਛਾਸ ਹੈਦਾ ਹੈ ਸਿਛੇ - ਟ, ਠ, ਤ, ਫ, ਫ। ਸਵੇਂ ਸੀਰ ਦਾ ਥਿਛਰਯਕਾ ਪਿੰਜਾ ਸਮਤ ਹਾਰ ਤੇ ਟੁੱਥ ਰਸ਼ਾ ਹੈ ਤੇ ਹਾਰਦੀ ਪ੍ਰਤੀਮਾਂ ਦਾ ਉਛਾਸ ਹੈਦਾ ਹੈ, ਸਿਛੇ - ਙ, ਛ, ਞ, ਝ, ਫ। ਸਵੇਂ ਸੀਰ ਦਾ ਪਿਛਲਾ ਪਿੰਜਾ ਕੋਸਕ ਹਾਰ ਤੇ ਟੁੱਥ ਰਸ਼ਾ ਹੈ ਤੇ ਰੋਦੀ ਪ੍ਰਤੀਮਾਂ ਪੋਸ਼ ਹੈਦੀਮਾਂ ਯਾ ਸਿਛੇ - ਰ, ਖ, ਸ, ਘ, ਝ

=> ਦੋਸ਼ ਪਠਾਰ → (ਦੋਸ਼ਾਂ ਦਾ ਪਿਛਲਾ ਪਾਸਾ)

ਦੋਸ਼ਾਂ ਦੇ ਪਿਛਲੇ ਪਾਸੇ ਨੂੰ ਦੋਸ਼ ਪਠਾਰ ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਸਵੇਂ ਸੀਰ ਦੀ ਨੋਵ ਦੋਸ਼ਾਂ ਦੇ ਪਿਛਲੇ ਪਾਸੇ ਨੂੰ ਟੁੱਥ ਰਸ਼ਦੀ ਹੈ ਤੇ 'ਛ' ਅਤੇ 'ਸ' ਪ੍ਰਤੀਮਾਂ ਦਾ ਉਛਾਸ ਹੈਦਾ ਹੈ।

- ਹੇਠਲੇ →

ਹੇਠਲੇ ਮਹੋ
ਥਿਛੇ ਗਤਿਛੇ ਹੈ
ਸਵੇਂ ਮਤੋਸ਼ ਦੀ
ਉਛਾਸ ਥਿਕ
ਹਾ ਹੀ ਛਤੀ
ਥਿਰ ਦਾ ਹੈ
ਹੈਦੀ ਹੈ ਹੇਠ
ਹੈ ਤੇ ਥਿ
ਵਿਰ ਜਾਂਦਾ

= ਸਯਤ ਤਾਲੂ →

ਹੈ
ਤਾਲੂ ਵਿਰ ਜਾ
ਤਾਲੂ ਨੂੰ ਟੁੱ
ਯਾ ਸਿਛੇ

= ਕੋਸਕ ਤਾਲੂ -

ਨੂੰ ਕੋਸਕ ਤ
ਪਿੰਜਾ ਕੋਸਕ
ਉਛਾਸ ਹੈ

= ਨਾਵ ਉਤਗੀਸ

ਧੋਣ ਦੀ ਸ
ਨਾਵ ਧੋਣੀਸ
ਤਤੀਮਾਂ
ਸਗਥਿਕ ਹੈ
ਸਾਧਸ ਪ
ਸਵੇਂ ਥਿ

- ਫੇਫੜੇ →

ਫੇਫੜੇ ਸਰੀਰਾਂ ਸਰੀਰ ਦੇ ਅਜਿਹੇ ਅੰਗ ਹਨ ਜੋ ਸਾਡੇ ਸਰੀਰ ਵਿਚ ਮੌਜੂਦ ਹਨ, ਜੋ ਹਿਲਜੁਲ ਦੀ ਸਹਾਇਤਾ ਕਰਦੇ ਹਨ ਜਾਂ ਸਾਹ ਲੈਣ ਵਿਚ ਸਹਾਇਤਾ ਕਰਦੇ ਹਨ। ਪਰ ਇਹ ਫੇਫੜੇ ਪ੍ਰਤੀਸ਼ਤ ਉਚਾਈ ਵਿਚ ਹੀ ਸਥਾਪਿਤ ਹੁੰਦੇ ਹਨ। ਫੇਫੜਿਆਂ ਵਿਚੋਂ ਸਾਹ ਨਲੀ ਹੇਠਾਂ ਪੱਠਿਆਂ ਵਿਚ ਸਮਾਪਤ ਹੋਣ ਵਾਲੇ ਦੋ ਵੱਖ-ਵੱਖ ਪ੍ਰਤੀਸ਼ਤ ਉਚਾਈ ਵਿਚ ਸਥਾਪਿਤ ਹੁੰਦੇ ਹਨ। ਫੇਫੜਿਆਂ ਵਿਚੋਂ ਹਵਾ ਬਾਹਰ ਕੱਢਣ ਲਈ ਜੋ ਸਿਸਟਮ ਵਿਚ ਕੰਮ ਕਰਦੀ ਹੈ ਉਸ ਨੂੰ Expressive air stream mechanism ਕਿਹਾ ਜਾਂਦਾ ਹੈ।

= ਸਖਤ ਤਾਲੂ →

ਮੂੰਹ ਪਠਾਰ ਦੇ ਬਿਲਕੁਲ ਪਿਛਲੇ ਪਾਸੇ ਨੂੰ ਸਖਤ ਤਾਲੂ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਜਦੋਂ ਕੋਈ ਵੀ ਵਿਅਕਤੀ ਜਿਹਾ ਸਖਤ ਤਾਲੂ ਨੂੰ ਛੂੰਹਦਾ ਹੈ ਤਾਂ ਤਾਲਵੀ ਪ੍ਰਤੀਸ਼ਤ ਪੈਦਾ ਹੁੰਦੀਆਂ ਹਨ। ਜਿਵੇਂ - ਚ, ਛ, ਜ, ਝ, ਞ

= ਕੋਮਲ ਤਾਲੂ →

ਸਖਤ ਤਾਲੂ ਤੋਂ ਥੋੜਾ ਜਿਹਾ ਵਿਚਕਾਰਲੇ ਹਿੱਸੇ ਨੂੰ ਕੋਮਲ ਤਾਲੂ ਕਿਹਾ ਜਾਂਦਾ ਹੈ। ਜਦੋਂ ਕੋਈ ਵੀ ਵਿਅਕਤੀ ਜਿਹਾ ਕੋਮਲ ਤਾਲੂ ਨੂੰ ਛੂੰਹਦਾ ਹੈ ਤਾਂ ਕੰਠੀ ਪ੍ਰਤੀਸ਼ਤ ਪੈਦਾ ਹੁੰਦੀਆਂ ਹਨ। ਜਿਵੇਂ - ਕ, ਖ, ਗ, ਘ, ਙ।

= ਸਾਹ ਉੱਤੇਜੀਆਂ ਜਾਂ ਸਾਹ ਧੁੱਕੂਆਂ →

ਸਾਹ ਨਲੀ ਦੇ ਉਪਰਲੇ ਪਾਸੇ ਧੁੱਕੂਆਂ ਦੀ ਸਹਾਇਤਾ ਦੇ ਕੰਮ/ਅੰਗ ਵਜੋਂ ਜੋ ਹਨ, ਜਿਨ੍ਹਾਂ ਨੂੰ ਸਾਹ ਧੁੱਕੂਆਂ/ਸਾਹ ਉੱਤੇਜੀਆਂ ਕਿਹਾ ਜਾਂਦਾ ਹੈ ਕਿ ਸਾਹ ਉੱਤੇਜੀਆਂ ਸੰਪਰਕ ਤੇ ਅਪਰਸ਼ ਪ੍ਰਤੀਸ਼ਤ ਉਚਾਰਨ ਵਿਚ ਸਹਾਇਕ ਹੁੰਦੀਆਂ ਹਨ। ਜਦੋਂ ਕਿ ਸਾਹ ਉੱਤੇਜੀਆਂ/ਧੁੱਕੂਆਂ ਸਾਧਾਰਨ ਵਿਚ ਵੀ ਵਰਤੀ ਜਾਂਦੀ ਹੈ ਤੇ ਹੁੰਦੀਆਂ ਹਨ ਜੋ ਕਿ ਸੰਪਰਕ ਅਤੇ ਅਪਰਸ਼ ਦੋਵੇਂ ਵਿਚ ਵਰਤੀ ਜਾਂਦੀ ਹੈ ਤੇ ਹੁੰਦੀਆਂ ਹਨ ਜੋ ਕਿ ਅਪਰਸ਼

ਪ੍ਰਤੀਸ਼ਤ ਦਾ ਉਚਾਰਨ ਤੇਹ ਹੈ। ਪਰ ਸਦ ਇਹ ਆਪਸ ਵਿਚ ਸੁਰੰਮਸ਼ ਸ਼ਬਦਾਂ ਤੇਹਾਂ ਹਨ ਤਾਂ ਸਾਕੇਟਕ ਪ੍ਰਤੀਸ਼ਤ ਦਾ ਉਚਾਰਨ ਤੇਹਾ ਹੈ।

ਪ੍ਰਤੀਸ਼ਤ ਦੇ ਉਚਾਰਨ ਅਧਿਆਇ ਤੋਂ ਪਤਾ ਲੱਗਦਾ ਹੈ ਕਿ ਹਰ ਪ੍ਰਤੀ ਉਚਾਰਨ ਸਮੇਂ ਦੀ ਸਰ ਵਿਚ ਸਾਂਝੀ ਹੈ, ਇਸ ਵਾਸਤੇ ਹਰ ਪ੍ਰਤੀ ਦੀ ਸਾਪਣੀ ਮਹੱਤਤਾ ਹੈ। ਪ੍ਰਤੀਸ਼ਤ ਦੇ ਉਚਾਰਨ ਦੇਖੇ ਇਹ ਪਿਆਰ ਵਿਚ ਆਇਆ ਹੈ ਕਿ ਵਿਚਲੀ ਪ੍ਰਤੀ ਵਿਚਲੇ ਉਚਾਰ ਸਮੇਂ ਦੁਆਰਾ ਉਚਾਰੀ ਜਾਂਦੀ ਹੈ।

ਅਭਿਆਸ ਪ੍ਰਸ਼ਨ

(1) ਪੈਰਾਗ੍ਰਾਫ ਦੇ ਉਚਾਰਨ ਸਮੇਂ ਤੁਹਾਨੂੰ ਕੀ ਨੋਟ ਕਿਵੇਂ ਕਰਨਾ ਚਾਹੀਦਾ ਹੈ? (2) ਪ੍ਰਤੀ ਉਪਯੋਗ ਸਮੇਂ ਦੀ ਸੂਚੀ ਬਣਾਓ? (3) ਪ੍ਰਤੀ ਉਚਾਰਨ / ਉਚਾਰਨ ਵਿਚ ਸਬੰਧ ਦੇ ਵਿਚਾਲੇ -2 ਸਮੇਂ ਲਗਾਉਂਦੇ ਹਨ ਤੁਹਾਨੂੰ ਇਹਨਾਂ ਦਾ ਵਰਤਾ ਵਿਧੀ।

(2) ਪ੍ਰਤੀ ਵਿਦਿਆਰਥੀ ਘਰੇ ਕੰਮ ਦੇ ਉਦੇ ਪੈਰਾਗ੍ਰਾਫ ਸਹਾਇਕ ਦਾ ਵਰਤਾਰਾ ਕਰੇ?
(3) ਪੈਰਾਗ੍ਰਾਫ ਦੀਆਂ ਕੰਮੀ ਪ੍ਰਤੀਸ਼ਤ ਘਰੇ ਸਾਂਝਦਾਰੀ ਵਿਧੀ?
(4) ਪੈਰਾਗ੍ਰਾਫ ਦੇ ਵਿਸ਼ਾਸਤਾਂ ਦਾ ਵਰਤਾਰਾ ਕਰੇ?
(5) ਪੈਰਾਗ੍ਰਾਫ ਦੀਆਂ ਸਬੰਧੀ ਪ੍ਰਤੀਸ਼ਤ ਨੂੰ ਵੀ ਵਿਸ਼ਵਾਸ ਸਾਹਿਤ ਵਰਤਾ ਕਰੇ?
(6) ਪ੍ਰਤੀ ਤੋਂ ਕੀ ਭਾਵ ਹੈ? ਉਚਾਰਨ ਸਥਾਨ ਤੇ ਉਚਾਰਨ ਵਿਚ ਦੇ ਸਥਾਨ ਤੇ ਪ੍ਰਤੀਸ਼ਤ ਦਾ ਵਰਗੀਕਰਨ ਕਰੋ?
(7) ਸਧਰ ਸ਼ੁੱਧੀਆਂ ਘਰੇ ਸਾਂਝਦਾਰੀ ਵਿਚੋਂ ਉਦੇ ਦੁਆਰਕ ਘਰੇ ਕੀ ਕਿਵੇਂ?
(8) ਸਧਰ ਸ਼ੁੱਧੀਆਂ ਤੋਂ ਕੀ ਭਾਵ ਹੈ? ਪੈਰਾਗ੍ਰਾਫ ਸਮੇਂ ਸਧਰ ਸ਼ੁੱਧੀਆਂ ਘਰੇ ਵਿਸ਼ਵਾਸ ਰਾਖ ਕਰਕੇ ਕਰੇ?