STRESSES AND STRAINS

1.1 LOAD

Any external force acting on a body is called load. The unit of load are same as that of force. Load is measure in **Newton (N)**

1.2 CLASSIFICATION OF LOAD

1. **According to the effect produced on the body:**

i. **Tensile load:** the load whose effect is to increase the length of the body in the direction of its application is known as tensile load.

ii. **Compressive load:** the load whose effect is to decrease the length of the body in the direction of its application is known as compressive load.

iii. **Shearing load:** the load whose effect is to cause sliding of one face of the body relative to the other is called shearing load.

iv. **Bending load:** the load whose effect is cause a certain degree of curvature or bending in the body is called bending load.

v. **Twisting load:** the effect produced by two couples applied at opposite ends of the body so as to cause one end to rotate about its longitudinal axis relative to the other end are called twisting load.

2. **According to the manner of application of load on the body:**

i. **Dead load:** these load are also known as static load. Magnitude, direction and point of application of these loads are fixed for a given member.

ii. **Live load:** these load are also known as fluctuating load. Magnitude, direction and point of application of these load are not fixed for a given member.

1.3 STRENGTH

The strength of a material may be defined as the maximum resistance which a material can offer to the externally applied load.

1.4 STRESS

Stress may be define as the internal resistance per unit area of cross-section offered by a body against the deformation.

$$\sigma = \frac{F}{A}$$

σ = stress induced in the body

P = load or force acting on a body

A = cross-sectional area of the body

1.5 TYPES OF STRESSES

1. **Direct stress:** when a force is applied perpendicular to the cross-section of the member the stress induced is known as direct stress.

i. **Tensile stress:** when an axial pull is applied on the cross-section area of a body, the stress induced is known as tensile stress.

ii. **Compressive stress:** when an axial push is applied on the cross-sectional area of a body, the stress induced is known as compressive stress.

2. **Shear stress:** when two equal and opposite forces are applied tangentially to the cross section of a body, the stress induced is known as shear stress.

1.6 STRAIN

Strain may be defined as the ratio of change in dimension of the body to the original dimension of the body. Strain is denoted by Epsilon

$$strain = \frac{change\ in\ dimension}{original\ value\ of\ dimension}$$

1.7 types of strains

1. **Tensile strain:** the ratio of increased in length to the original length of the member is termed as tensile strain.
2. **Compressive strain:** the ratio of decrease in length to the original length of the member is termed as compressive strain.
3. **Shear strain:** the ratio of angular deformation to original length along the force is termed as shear strain.
4. **Volumetric strain:** the ratio between the change in volume and the original volume of a member is known as volumetric strain or bulk strain.

1.8 ELASTICITY AND ELASTIC LIMIT

i. **Elasticity:** the deformation produce by external force do not disappear after the removal of external forces, such material are called plastic material

ii. **Elastic limit:** the value of stress corresponding to this limiting force upto which the material is perfectly elastic is known as elastic limit

1.9 HOOKE'S LAW

This law states that when a material is loaded within limit of proportionality, the strain is directly proportional to stress produced by stress

$$\sigma \propto \varepsilon$$

$$\sigma = E\varepsilon$$

$$E = \frac{\sigma}{\varepsilon}$$

1.10 LASTIC CONSTANTS

1. **Modulus of elasticity :** It may defined as the ratio of tensile stress and tensile strain or ratio of compressive stress and compressive strain. It is denoted by E.

$$E = \frac{\sigma}{\epsilon}$$

2. **Modulus of rigidity:** the ratio of shear stress and shear strain is known as modulus of rigidity or shear modulus. This is denoted by G

Modulus of rigidity = shear stress/shear strain

3. **Bulk modulus:** when a body is subjected to three mutually perpendicular normal stresses of equal intensity, the ratio of normal stress to the corresponding volumetric strain is known as bulk modulus. It is denoted by K.

K = Normal stress/volumetric strain

1.11 LONGITUDINAL STRAIN AND LATERAL STRAIN

Longitudinal strain: the strain along the direction of the applied force is known as longitudinal strain.

Lateral strain: The strain at right angles to the direction of applied force is known as lateral strain.

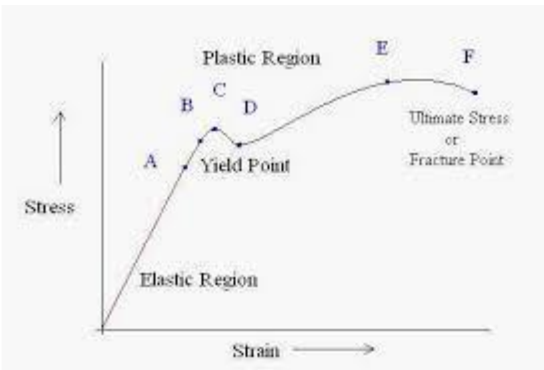
1.12 POISSON'S RATIO

The ratio of lateral strain to the longitudinal strain is known as poisson's ratio. It is denoted by 1/m

Poisson's ratio = lateral strain /longitudinal strain

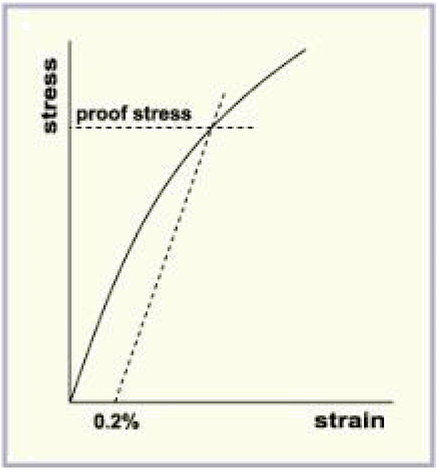
1.13 ENSILE TEST FOR DUCTILE METALS

1. **Limit of proportionality:** limit of proportionality may be defined as that stress at which the stress-strain curve begins to deviate from the straight line.
2. **Elastic limit:** Elastic limit may be defined as the stress developed in the material without any permanent deformation.
3. **Yield point:** the stress corresponding to yield point is known as yield point stress.
4. **Ultimate stress:** the stress attains its maximum value and is known as ultimate stress.
5. **Breaking stress:** the stress corresponding to point F is known as breaking stress.



1.14 PROOF STRESS

Proof stress is the stress necessary to cause a permanent extension equal to a defined percentage of gauge length.



1.15 MAXIMUM OR ULTIMATE TENSILE STRESS

It is defined as the ratio of the maximum load to which a specimen is subjected in a tensile test and the original cross-sectional area of the specimen.

Ultimate stress = maximum load/original cross-sectional area

1.16 WORKING STRESS

The material is not subjected upto ultimate stress, but only upto a fraction of ultimate stress. This stress is known as working stress.

Working stress = ultimate stress/factor of safety

1.17 FACTOR OF SAFETY

The ratio of ultimate stress and working stress is known as factor of safety.

Factor of safety = ultimate stress/working stress

Factor of safety depend upon the following factors:

1. Types of load
2. Frequency of vibration of load
3. Degree of safety required
4. Degree of economy required
5. Dependability of the structure
6. Life span of the structure

1.18 BREAKING STYRESS

It may be defined as the ratio of load at the time of fracture and the original cross-sectional area.

Breaking stress = load at breaking point/original cross sectional

area **1.19 YIELD STRESS**

It is may be define as the lowest stress at which extension of the test specimen takes place without increase in load.

Yield stress = load at yield point/original cross-sectional area

1.20 ECHANICAL PROPERTIES OF MATERIALS

1. **Elasticity/Stiffness**

This is a measure of elastic deformation of a body under stress which is recovered when the stress is released. The ratio of stress to strain in the elastic region is known as stiffness or modulus of elasticity (Young's Modulus). When the stress goes beyond the elastic limit the material will no longer return completely to its original dimension.

2. **Yield (or Proof Strength)**

Stress needed to produce a specified amount of plastic or permanent deformation. (Usually a 0.2 % change in length)

3. **Ultimate Tensile Strength (UTS)**

The maximum stress a material can withstand before fracture.

4. **Ductility**

The amount of plastic deformation that a material can withstand without fracture.

5. **Hardness**

The resistance to abrasion, deformation, scratching or to indentation by another hard body. This property is important for wear resistant applications.

6. **Toughness**

This is commonly associated with impact loading. It is defined as the energy required to fracture a unit volume of material. Generally, the combination of a high UTS and a high ductility results in a higher toughness.

7. **Fatigue Strength and Endurance Limit**

Fatigue failure results from a repeated cyclic application of stress which may be below the yield strength of the material. This is known to be the most common form of mechanical failure of all engineering components. The number of stress cycles needed to cause fatigue failure depends on the magnitude of the stress. Below a certain stress level material does not fail regardless to the number of cycles. This is known as endurance limit and is an important parameter in many design applications.

8. **Creep Resistance**

The plastic deformation of a material which occurs as a function of time when the material is subjected to constant stress below its yield strength. For metals this is associated with high temperature applications but polymers may exhibit creep at low temperatures.

RESILIENCE

2.1 IMPORTANT TERMS

1. **Strain energy:** the work done in straining the body within the elastic limit is known as strain energy

Strain energy = work done

2. **Resilience:** It is a common term used for the total strain energy stored in a body. Sometimes, the resilience may be defined as the capacity of a strained body for doing work on the removal of the straining force.
3. **Proof resilience:** The maximum strain energy which can be stored in a body upto the elastic limit is called proof resilience.
4. **Modulus of resilience:** proof resilience per unit volume the body is known as modulus of resilience.

Modulus of resilience = proof resilience/volume of the body

5. **proof load:** the maximum load which can be applied to a body without its permanent deformation is called proof load.

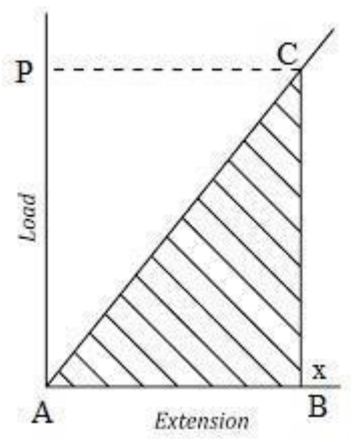
2.2 TYPES OF LOADING

1. Gradually
2. Suddenly
3. With impact

2.3 STRAINED ENERGY STORED IN A BODY DUE TO GRADUALLY APPLIED LOAD

A Gradually applied load is that which is applied gradually on the body i.e. loading begins from zero and increase gradually till the body is fully loaded.

Let us consider a body which is subjected with tensile load which is increasing gradually up to its elastic limit from value 0 to value P and therefore deformation or extension of the body is also increasing from 0 to x and we can see it in following load extension diagram as displayed here.



We have following information from above load extension diagram for body which is subjected with tensile load up to its elastic limit.
σ= Stress developed in the body
E = Young's Modulus of elasticity of the material of the
body A= Cross sectional area of the body
P = Gradually applied load which is increasing gradually up to its elastic limit from value 0 to value P
P=σ.A
x = Deformation or extension of the body which is also increasing from 0 to
x L = Length of the body
V= Volume of the body = L.A
U = Strain energy stored in the body
Let use the value of the extension or deformation "x" in strain energy equation and we will have
U = (1/2) (σ. L/ E).σ. A
U = (1/2) (σ^2/E) L.A
U = (σ^2/2E) V
U = (σ^2/2E) V
Therefore strain energy stored in a body, when load will be applied gradually, will be given by following equation.

$$\frac{\sigma^2}{2E} \times V$$

$$\text{Proof resilience} = \frac{\sigma^2}{2E} \times V$$

Modulus of resilience

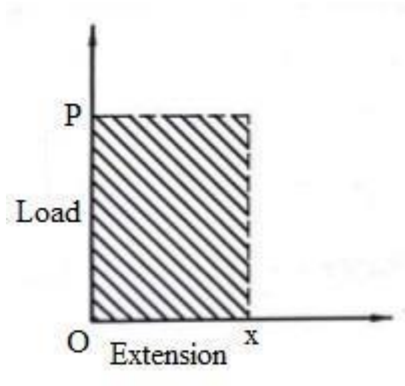
Modulus of resilience = Proof resilience/Volume of the body

$$\text{Modulus of resilience} = \frac{\sigma^2}{2E}$$

2.4 STRAIN ENERGY IN A BODY DUE TO SUDDENLY APPLIED

LOAD A Load applied suddenly on a body is called suddenly applied load.

Let us see the load extension diagram as displayed here for this case where body will be subjected with sudden load and we will find out here the stress induced in the body due to sudden applied load and simultaneously we will also secure the expression for strain energy for this situation.



Let us go ahead step by step for easy understanding, however if there is any issue we can discuss it in comment box which is provided below this post.

We have following information from above load extension diagram for body which is subjected with sudden applied load.

σ = Stress developed in the body due to sudden applied load
E = Young's Modulus of elasticity of the material of the
body A= Cross sectional area of the body
P = Sudden applied load which will be constant throughout the deformation process of the body
x = Deformation or extension of the
body L = Length of the body
V= Volume of the body = L.A
U = Strain energy stored in the body
Strain energy stored in the body = Work done by the load in deforming the
body Strain energy stored in the body = Area of the load extension curve
Strain energy stored in the body = P.
x U = P. x

As we know that maximum strain energy stored in the body U will be provided by the following expression as mentioned here.

$$U = \frac{\sigma^2}{2E} \times V$$

$$U = \frac{\sigma^2}{2E} \times A.\ L$$

$$P.\ x = \frac{\sigma^2}{2E} \times A.\ L$$

Let use the value of the extension or deformation "x" in above equation and we will have

$$P \times \frac{\sigma}{E} \times L = \frac{\sigma^2}{2E} \times A.\ L$$

$$P = \sigma \times A / 2$$

$$\sigma = 2P/A$$

2.5 STRAIN ENERGY STORED IN A BODY DUE TO IMPACT

LOAD A Load applied with some velocity is called impact load.

Let us see the following figure, where we can see one vertical bar which is fixed at the upper end and there is collar at the lower end of the bar. Let us think that one load is being dropped over the collar of the vertical bar from a height of h as displayed in following figure.

$$P\left(h + \frac{\sigma\ L}{E}\right) = \frac{1}{2} \cdot \frac{\sigma^2}{E}(A \times L)$$

$$Ph + \frac{P.\sigma\ L}{E} = \frac{\sigma^2}{2E}(AL)$$

$$\frac{\sigma^2}{2E} - \frac{P.\sigma}{A.E} = \frac{P.h}{A.L}$$

$$\sigma^2 - \frac{2P\sigma}{A} = \frac{2PhE}{A.L}$$

$$\sigma^2 - \frac{2P\sigma}{A} + \frac{P^2}{A^2} = \frac{2PhE}{A.L} + \frac{P^2}{A^2}$$

$$\left(\sigma - \frac{P}{A}\right)^2 = \frac{P^2}{A^2} + \frac{2.P.h.E}{A.L}$$

$$\left(\sigma - \frac{P}{A}\right) = \sqrt{\frac{P^2}{A^2} + \frac{2P.h.E}{A.L}}$$

$$\sigma = \frac{P}{A} + \sqrt{\frac{P^2}{A^2} + \frac{2P.h.E}{A.L}}$$

SHEARING FORCE AND BENDING MOMENT

A beam is a structure which is to carry all types of loading coming over it and is economically designed depending upon the type of loading, magnitude of loading and nature of support over which the beam rests.

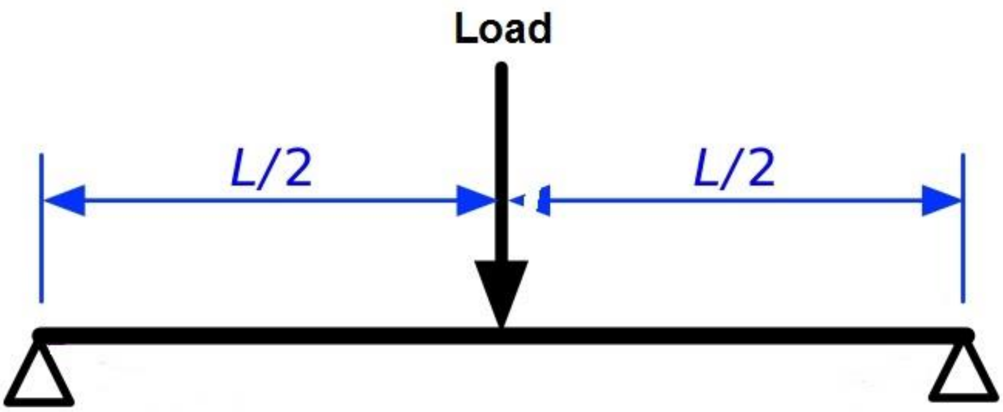
NATURE OF SUPPORT

1. **Hinged Support:** In hinged support position of member is fixed but its direction is not fixed. It can offer resistance to the member horizontally and vertically

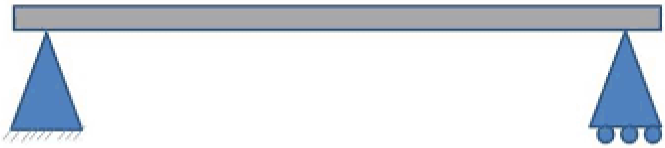
Hinged Support

2 **Fixed Support:** In fixed support, both position and direction of member are fixed. Reaction from the support can be any direction.

3 **Simply Supported:** In this case member rests freely over the support. The reaction will be normal to support. The position and direction are not fixed. Its horizental component is assumed to be zero.

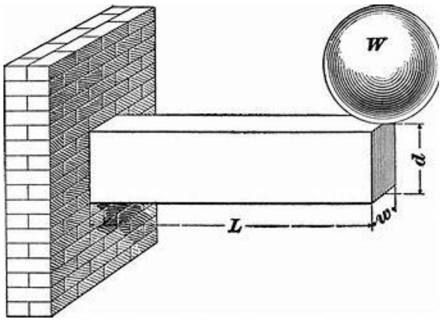


4. **Roller Support:** In this case reaction will always be normal to support and it does not offer any horizental resistance, hence horizental component is always zero.

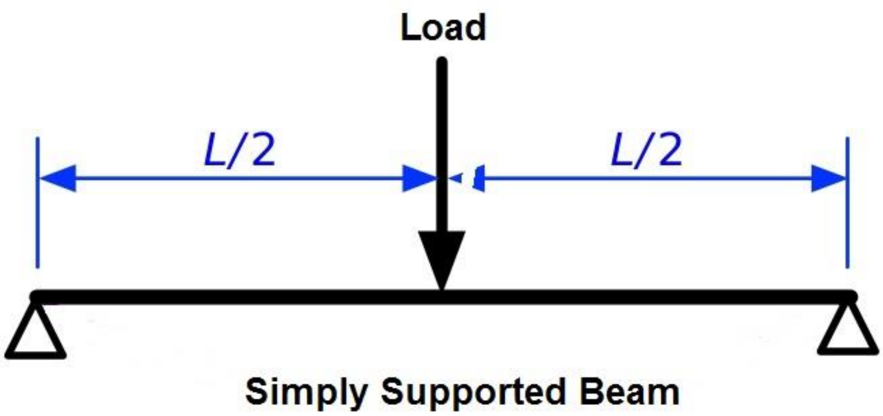


TYPES OF BEAMS

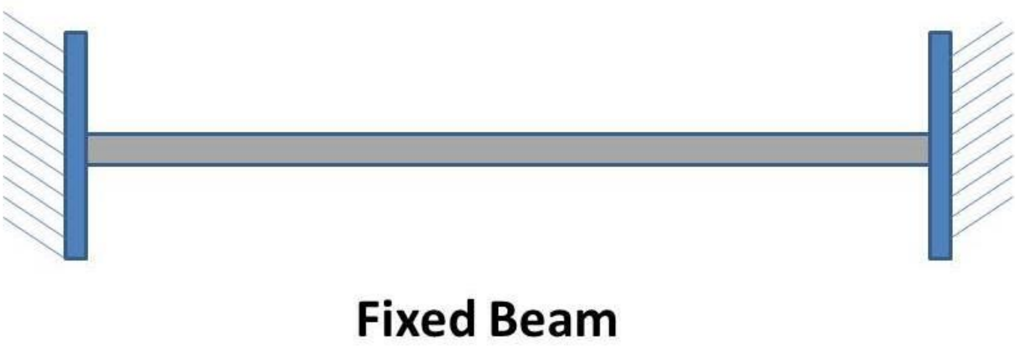
1. **Cantilever:** A beam whose one end is firmly fixed and other end is free, is known as cantilever.



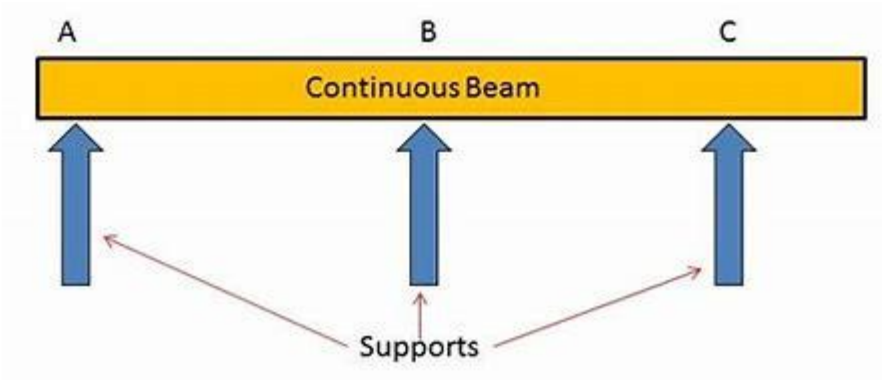
2. **Simply Supported Beam:** A beam whose both ends are simply resting on wall,columns etc. is called simply supported beam.



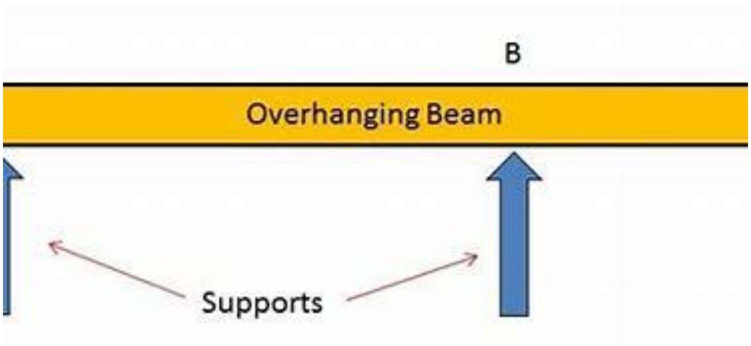
3. **Fixed Beam**: A beam whose both ends are firmly fixed in walls or columns is known as fixed beam.



4 **Continuous Beam:** A beam which has more than two support is known as continuous beam.

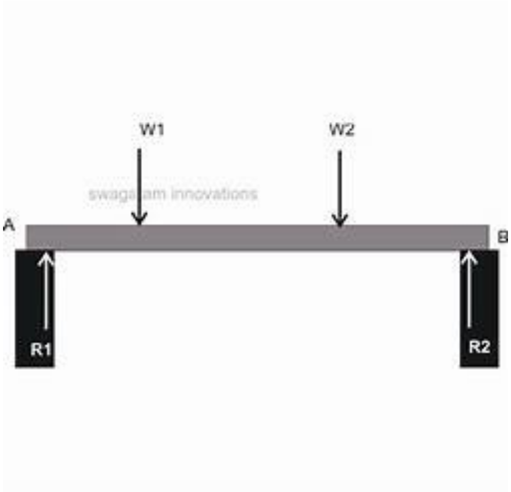


5 **Overhanging Beams:** When the supports are not at the ends of the beam or one or both the ends project beyond the support,then the beam is called overhanging beams.

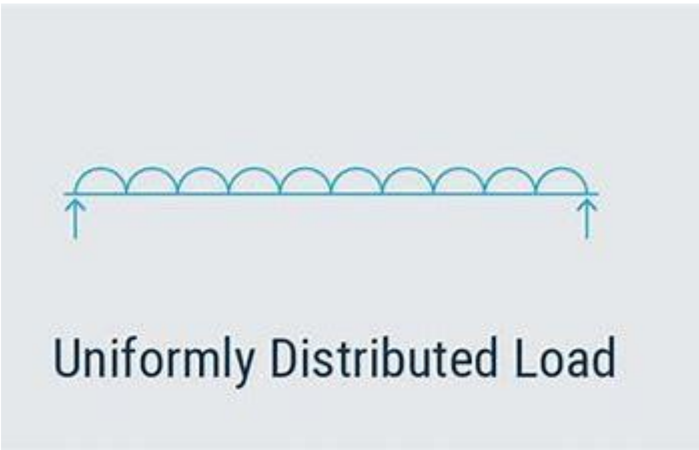


TYPES OF LOADING

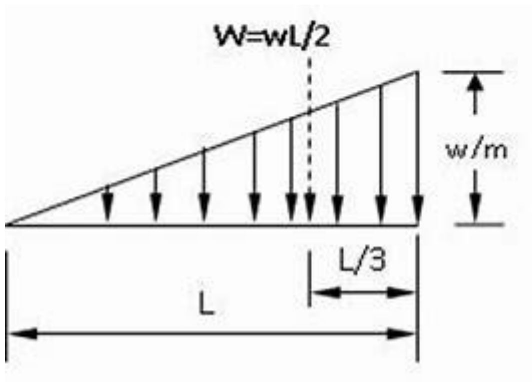
1. **Concentrated or point load**: This type of load act on particular point of beam.



2. **Uniformly Distributed Load (U.D.L.):** This type of load is uniformly distributed over whole span of beam on or part of it. It is given in Newton/meter length.



3. **Varying Load:** If the intensity of load distribution increase from zero/unit length to a particular value (say) w/unit length uniformly. It is called varying load.



MOMENT OF INERTIA

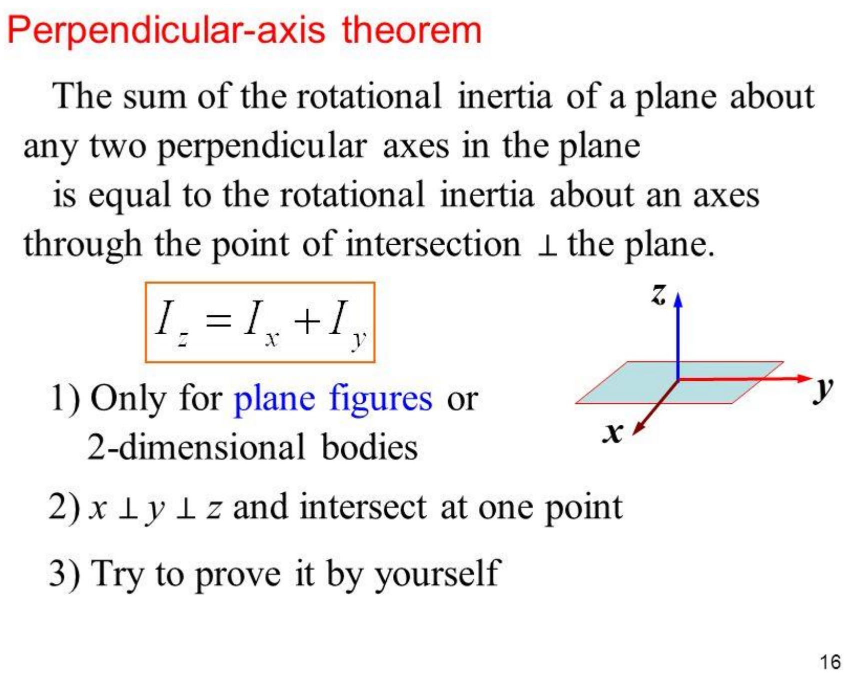
MOMENT OF INERTIA

Moment of inertia (M.I) for a very small area about any axis is given by the product of area and square of distance between centroid of area and the given axis. This is also called second moment of the area.

$$M.I. = Area * (distance)^2$$

THEOREM OF PERPENDICULAR AXIS

The moment of inertia of a plane of lamina about the perpendicular axis to its plane is equal to the sum of moments of inertia of plane of lamina about any two perpendicular axes intersecting each other at the point through which the perpendicular axis passes.

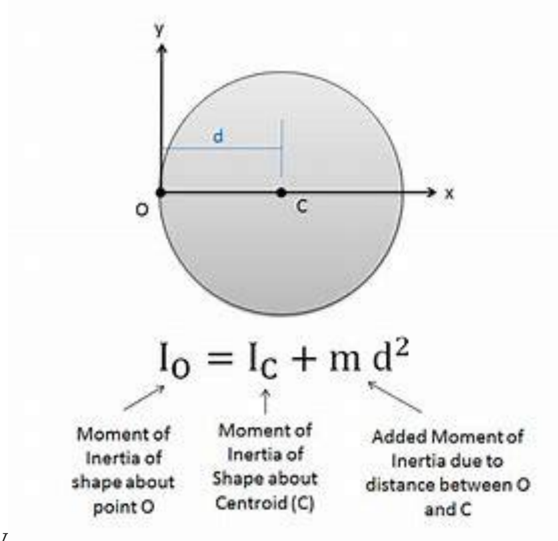


THEOREM OF PARALLEL AXIS

The moment of inertia (M.I.) of a plane of lamina about any axis is equal to its M.I. about a parallel axis passing through its centroid plus the product of the area of lamina and the square of the distance between tow axes.

RADIUS OF GYRATION

The radius of gyration of an area is the distance from the centroid of the area to the



giv en axis. It is denoted by K.

Consider a figure having area (A), moment of inertia (I) and centroid (G)

MOMENT OF INERTIA (M.I.) OF A CIRCULAR DISC

$$Izz = D^4/32.$$

If Ixx = M.I. of disc about X-X axis.

Iyy = M.I. of disc about Y-Y axis.

By the theorem of - axis,

$$Izz = Ixx + Lyy$$

$$Izz = 2Ixx$$

$$Ixx – 1/2Izz = D^4/64$$

$$Iyy = D^4/64$$

MOMENT OF INERTIA (M.I), OF A HOLLOW CIRCULAR DISC

$Izz = /32[D^4-d^4]$

$Ixx = /D^4-d^4]$

Iyy = /64 [D4 -d4]

BENDING STRESSES

BENDING Equation:-

$$M/I=E/R$$

Hence M/I=E/R=f/y……………………………………BENDING EQUATION

Where

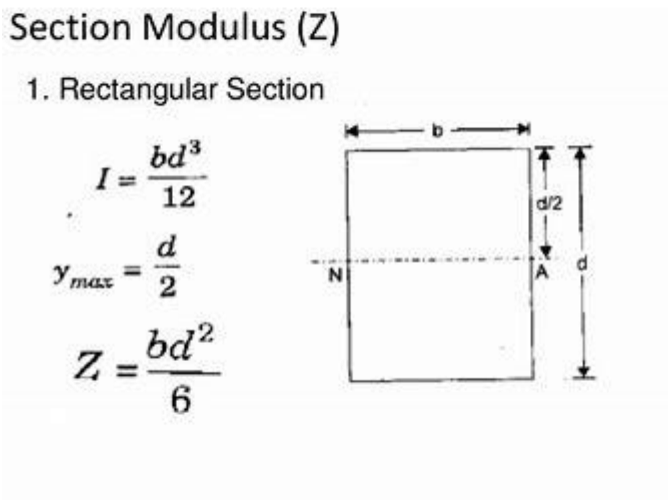
- M= B.M. or Moment of resistance of section
- I= M.I. of the whole section about N.A.
- E=Younge's modulus of elasticity
- R=Radius of curvature of N.A.
- f= Bending stress at a distance y from N.A.
- y=Distance of fibre from N.A.

APPLICATION OF BENDING EQUATION

The bending equation is authentic only for cases where there is pure Bending moment or there is no shearing force. Generally where shearing force is zero, the Bending moment is found to be maximum, in that case Bending equation holds correct results. The Bending Moment at a section accompanied by a shearing force can’t be considered fairly correct for the application of Bending equations.

ASSUMPTIONS IN THE THEORY OF PURE BENDING

1 The material of the beam is homogenous or uniform throughout.
2 The material of the beam is isotropic i.e. having same elastic properties in all the directions.
3 The elastic limit remains within the permissible value.
4 The value of E (Young’s modulus) remains same for tension and compression.
5 The transverse section of the beam remains plane before and after bending.
6 The resultant force on the transverse section of the beam is zero.
7 The beam is assumed to be straight initially.
8 Each layer of beam is free to expand or contract independently of the layers above and below it.
9 The application of load is only in the plane of bending.



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BLENDING STRESSES

INTRODUCTION

When a section of beam is subjected to Bending moment, shear stresses and Bending stresses are set up in the beam. When there is no shearing force it can be considered as pure bending. Theses longitudinal bending stresses can either be compressive or tensile in nature.

BENDING EQUATIONS

M.I. of entire section of beam about N.A.

M/I = E/R.

Hence M/I = E/R = f/y……………………………………

M = B.M. or Moment of resistance of section,
I = M.I of the whole section about N.A.
E = Young's modulus of elasticity,
R = Radius of curvature of N.A,
F = Bending stress at a distance y from N.A.,
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8.Each layer of beam is free to expand or contract independently of the layers above and below it.
9.The application of load is only in the plane of bending.

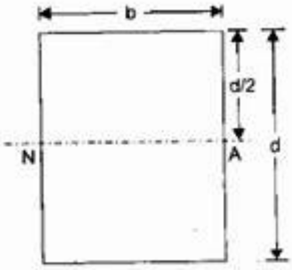
Section Modulus (Z)

1. Rectangular Section

$$I = \frac{bd^3}{12}$$

$$y_{max} = \frac{d}{2}$$

$$Z = \frac{bd^2}{6}$$



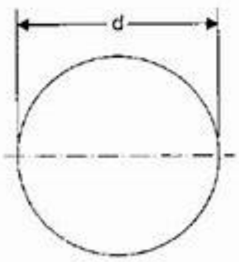
Section Modulus (Z)

3. Circular Section

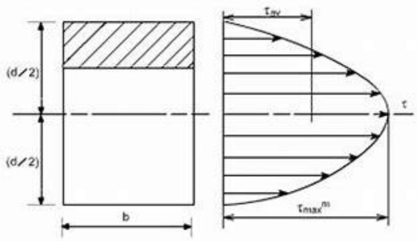
$$I = \frac{\pi}{64} d^4$$

$$y_{max} = \frac{d}{2}$$

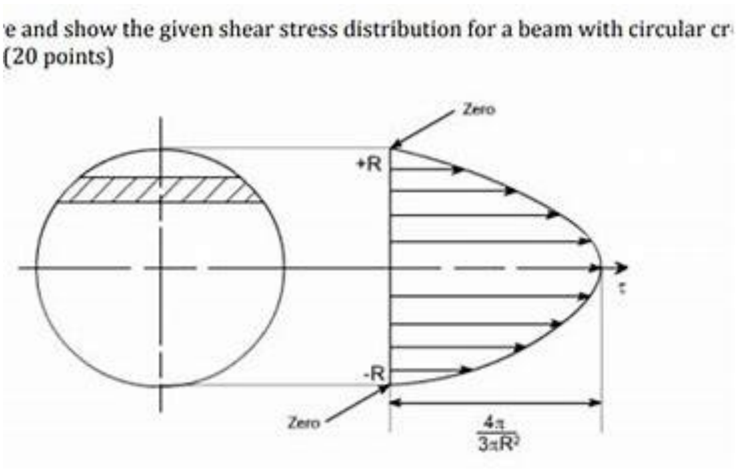
$$Z = \frac{\pi}{32} d^3$$



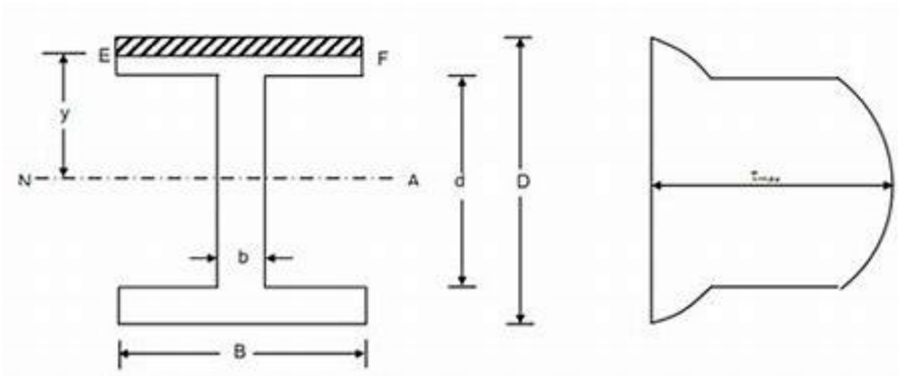
SHEAR STRESSES



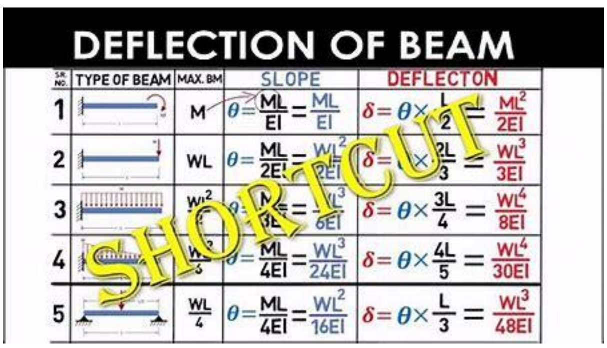
Shear stress is distributed parabolically across the rectangular section
Shear stress will be maximum at y = 0 and will be zero at the extreme ends.



shear stressses of I section.



SLOPE AND DEFLECTION


DEFLECTION OF BEAM

SR. NO.	TYPE OF BEAM	MAX. BM	SLOPE	DEFLECTON
1		M	$\theta = \frac{ML}{EI} = \frac{ML}{EI}$	$\delta = \theta \times \frac{L}{2} = \frac{ML^2}{2EI}$
2		WL	$\theta = \frac{ML}{2EI} = \frac{WL^2}{2EI}$	$\delta = \theta \times \frac{2L}{3} = \frac{WL^3}{3EI}$
3		$\frac{WL^2}{2}$	$\theta = \frac{ML}{3EI} = \frac{WL^3}{6EI}$	$\delta = \theta \times \frac{3L}{4} = \frac{WL^4}{8EI}$
4		$\frac{WL^2}{3}$	$\theta = \frac{ML}{4EI} = \frac{WL^3}{24EI}$	$\delta = \theta \times \frac{4L}{5} = \frac{WL^4}{30EI}$
5		$\frac{WL}{4}$	$\theta = \frac{ML}{4EI} = \frac{WL^2}{16EI}$	$\delta = \theta \times \frac{L}{3} = \frac{WL^3}{48EI}$

SHORTCUT

Surveying- 1

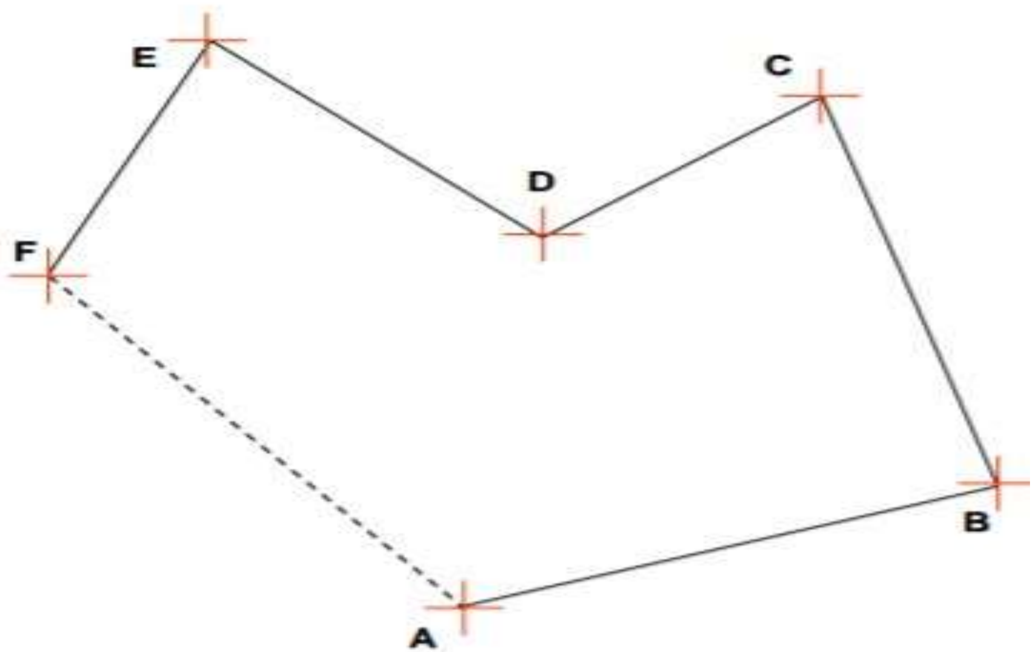
DEFINITION OF SURVEYING

Surveying is the art and science of determining the relative positions of various points or stations on the surface of the earth by measuring the horizontal and vertical distances , Angles and taking the details of these points and by preparing a map or plan to any scale.

★ Measurements taken in Horizontal and Vertical planes

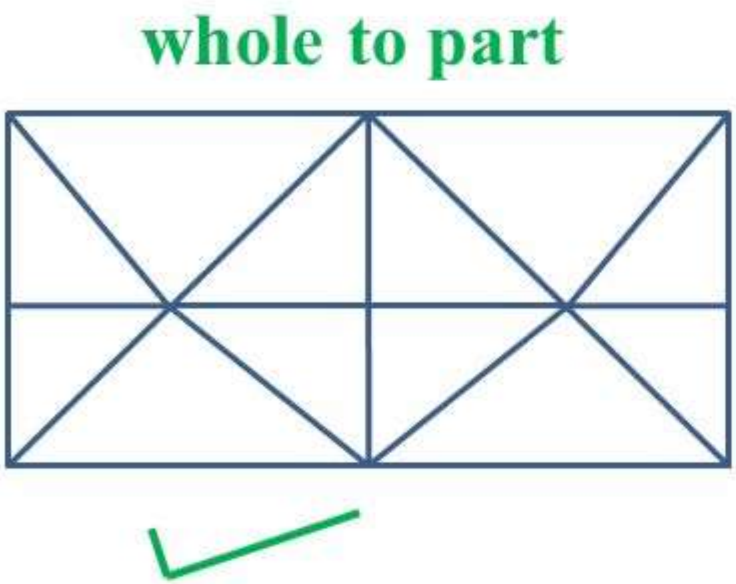
Measurements

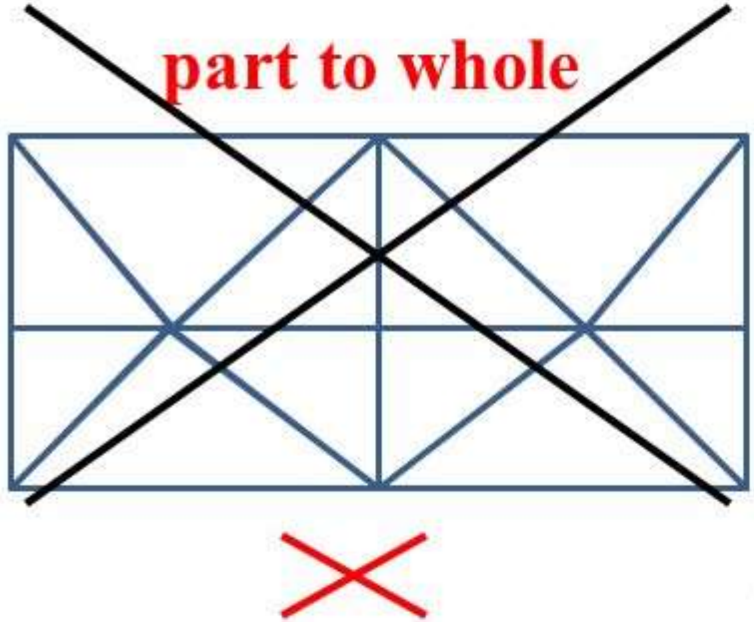
- Linear Measurement
- Angular Measurement



Fundamental principles of surveying

1. To work from **whole to part**
2. To fix or to locate a **new point** or station by **at least two independent measurements** or processes





Chain surveying

OBJECTIVE: Study of various instruments used in chain surveying and their uses

INSTRUMENTS:

1) Chain or tape
2) Arrows
3) Ranging rods
4) Cross staff
5) Offset rods
6) Pegs
7) Plumb bob

Ranging

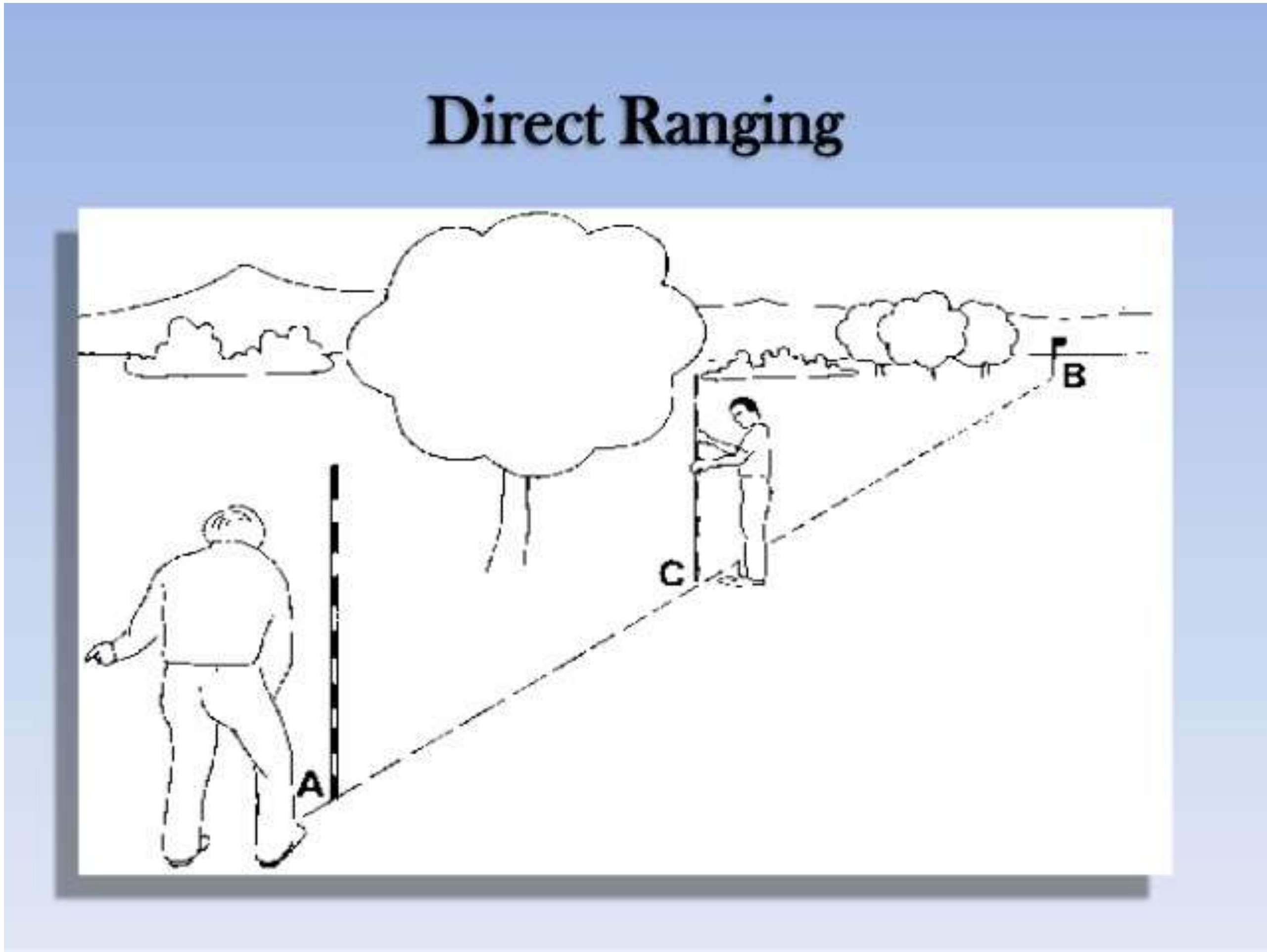
Ranging is essential step in chain surveying to ensure that measurements are made in a straight path along the survey line. If the end stations are inter-visible, direct ranging can be resorted.

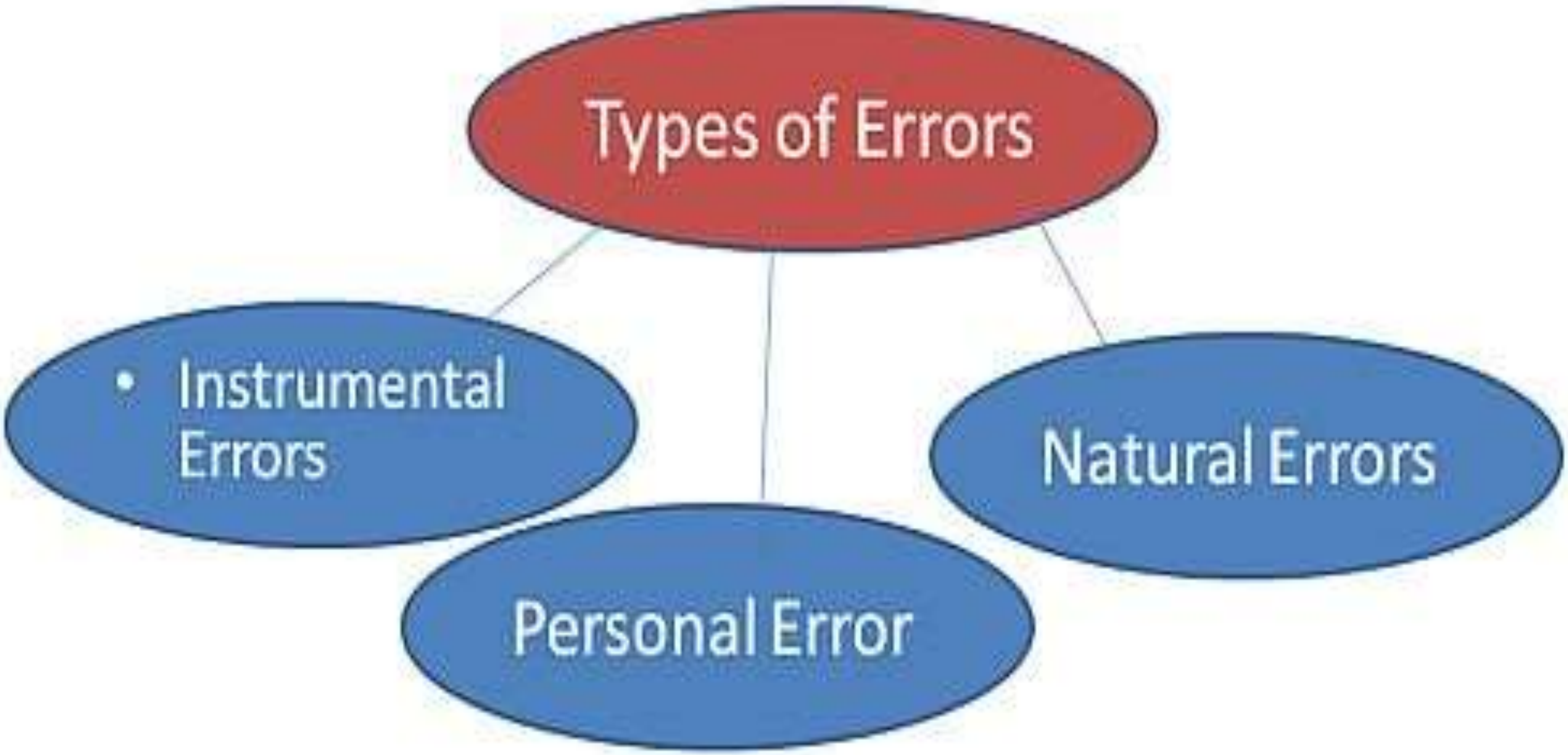
Ranging are of two types:

- Direct Ranging
- Indirect Ranging

Operation in Chain Surveying

- Ranging
- Chaining
- Offsetting




Types of Errors
• Instrumental Errors
Personal Error
Natural Errors

ADVANTAGES OF CHAIN SURVEY

1. Is a simplest and commonest method used in surveying exercises.
2. The equipment used to conduct chain survey are simple to use.
3. The equipment used in chain survey can easily be replaced. For example measuring rods can be replaced with measuring tape.
4. This method does not involve complicated mathematical calculation.
5. Enable us to make quick measurements of small areas of flat or nearly flat & associated objects.
6. Is applicable in adding new information to existing plans or large scale maps. Example: adding the new details of National Stadium to existing map of Dar es Salaam City.
7. Is useful in planning (Eg. arrangement of rooms).
8. It is economical since it needs few people to conduct it (normally chain survey team has three people Booker, leader and follower).

Disadvantages:

- It cannot be used for large areas
- It cannot be used in thick bushy areas with ups and downs.
- Chain surveying is not always accurate.

What Is The Compass

A compass is an instrument designed for the measurement of directions with reference to the magnetic meridian.

The two main types of compass

- Prismatic compass
- Surveyor`s compass

Compass Surveying

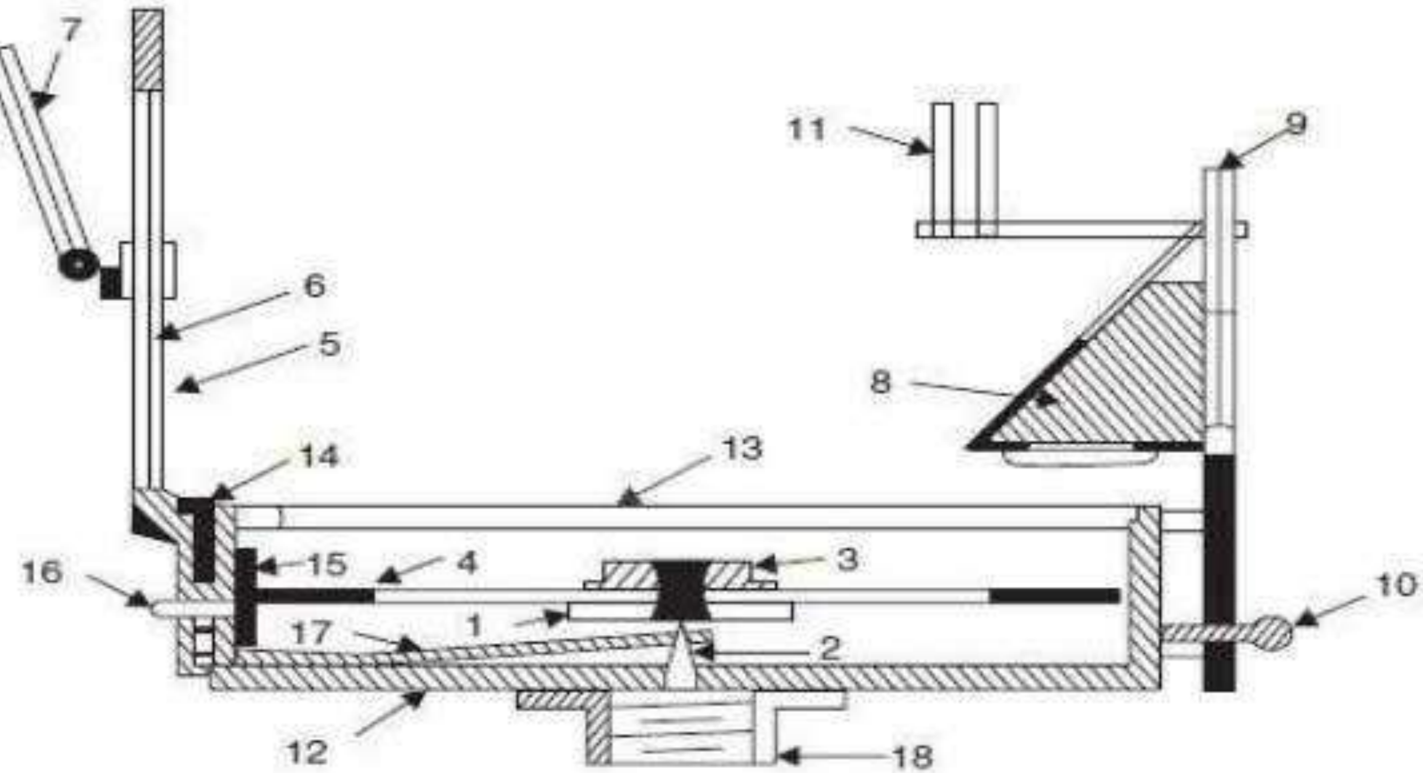
The Prismatic Compass

The prismatic compass is a magnetic compass which consists of the following parts.

Cylindrical Metal Box

Cylindrical metal box is having diameter of 8 to 12 cm. It protects the compass and forms entire casing or body of the compass. It protects compass from dust, rain etc.

Prismatic Compass



1. Needle
2. Pivot
3. Agate cap
4. Graduated disc
5. Slit metal frame
6. Horse hair
7. Mirror
8. Reflecting prism with cap
9. Eye vane
10. Focussing stud
11. Dark sunglasses
12. Box
13. Glass cover
14. Lifting pin
15. Light spring
16. Brake pin or knob
17. Lifting lever
18. Support to fit on tripod

Prismatic compass

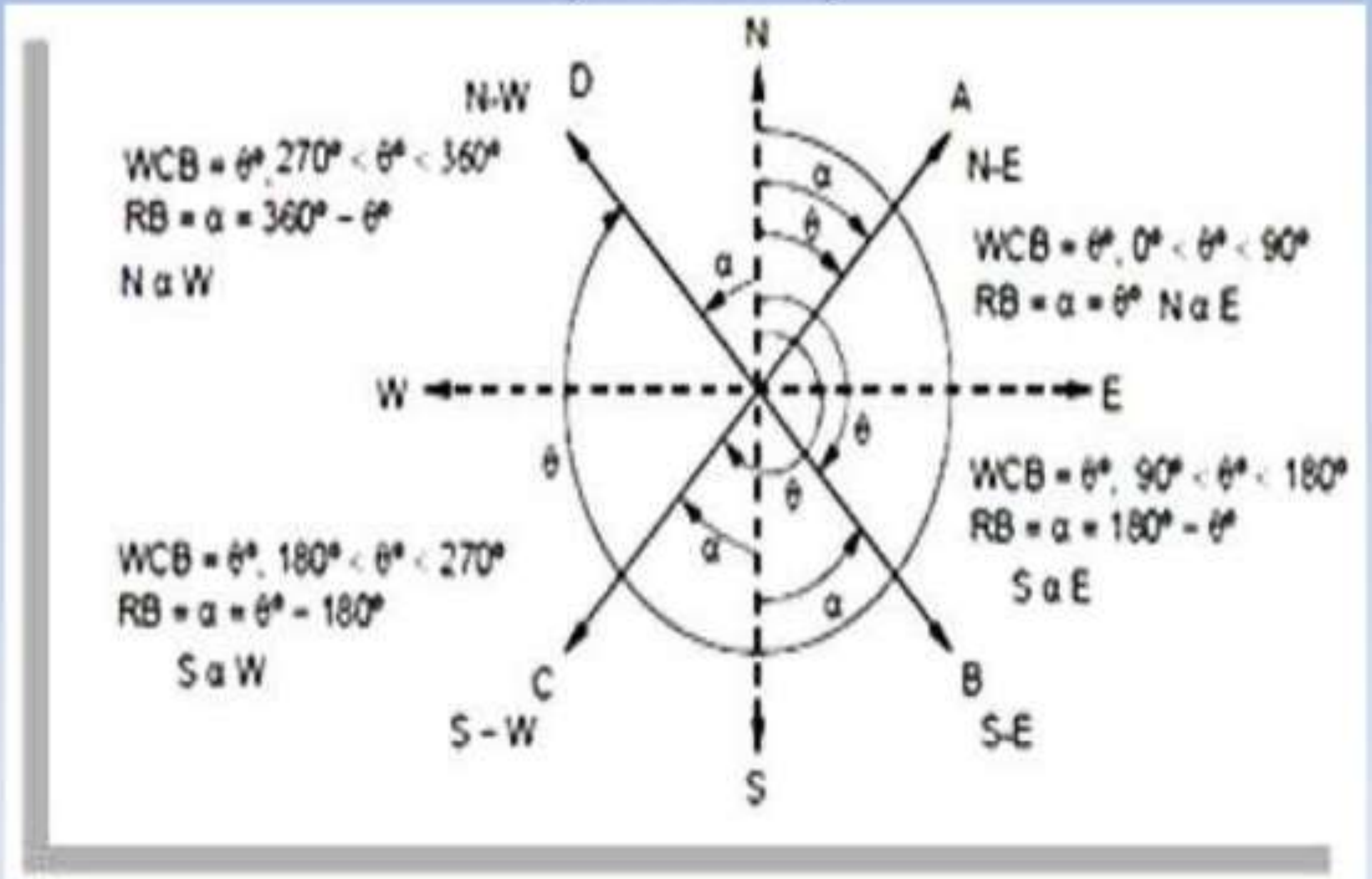
The Surveyor's Compass

Working of Surveyor's Compass:

- **Centering**
- **Levelling**
- **Observing the Bearing of a Line**
- First two operations are similar to that of prismatic compass but the method of taking observation differs from that.
- Observing the bearing of a line. In this type of compass, the reading is taken from the top of glass and under the tip of north end of the magnetic needle directly. No prism is provided here.

Sr. No.	*Prismatic Compass*	*Surveyors Compass*
1.	Graduation circle is fixed to broad type needle. Hence, it will not rotate with the line of sight.	Graduation circle is fixed to the box. Hence, it rotates with the line of sight.
2.	There is a prism at viewing end.	At viewing end there is no prism. There is only a slit.
3.	Sighting and reading can be done simultaneously.	Sighting and viewing cannot be done simultaneously.
4.	The magnetic needle do not act as an index.	Magnetic needle acts as index while reading.
5.	The graduations are in whole circle bearing.	The graduations are in quadrantal system.
6.	Graduations are marked inverted since its reflection is read through prism.	Graduations are marked directly. They are not inverted.
7.	The reading is taken through a prism.	The reading is taken by directly viewing from top glass.
8.	Tripod may or may not be used. It can be held on a stretched hand also.	Tripod is essential for using it.

Whole Circle Bearing System (W.C.B)



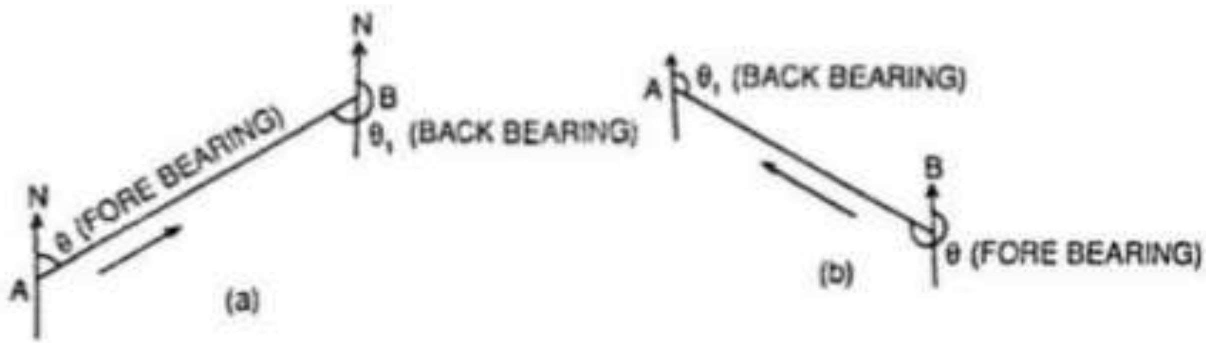
The Following Table Should be Remembered for Conversion of WCB to RB

Case	WCB between	R.B.	QUADRANT
1	0^0 TO90^0	WCB	N-E
2	90^0 TO -180^0	180-WCB	S-E
3	180^0 TO -270^0	WCB-180^0	S-W
4	270^0 TO 360^0	360-WCB	N-W

Fore bearing and Back bearing

The bearing of a line measured in the forward direction of the survey lines is called the 'fore bearing'(F.B.) of that line.

The bearing of a line measured in direction backward to the direction of the progress of survey is called the 'back bearing'(B.B.) of the line.



In WCB the difference between FB and BB should be exactly 180°

BB=FB+/-180°

Use the +ve sign when FB<180°

Use the –ve sign when FB> 180°

Local Attraction

- may be **constant** or **may vary** depending upon the surrounding magnetic influences
- draws the needle **away** from the magnetic meridian

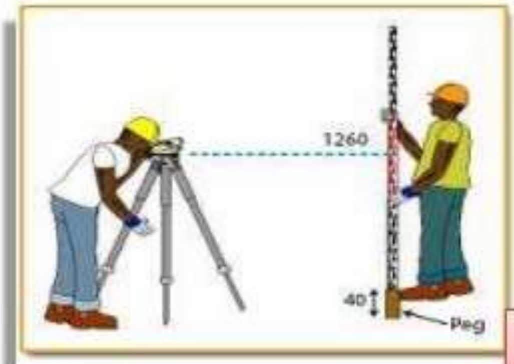
LEVELLING

✓ According to science

- Leveling is a branch of surveying which deals with the measurement of relative heights of different points on, above or below the surface of the earth. Thus in leveling, the measurements (elevations) are taken in the vertical plane.

✓ Simple Definition

- Leveling is the process used to determine a difference in elevation between two points.



Principle of levelling

- *Principle:- The principle of levelling is to obtain horizontal line of sight with respect to which vertical distances of the points above or below this line of sight are found.*

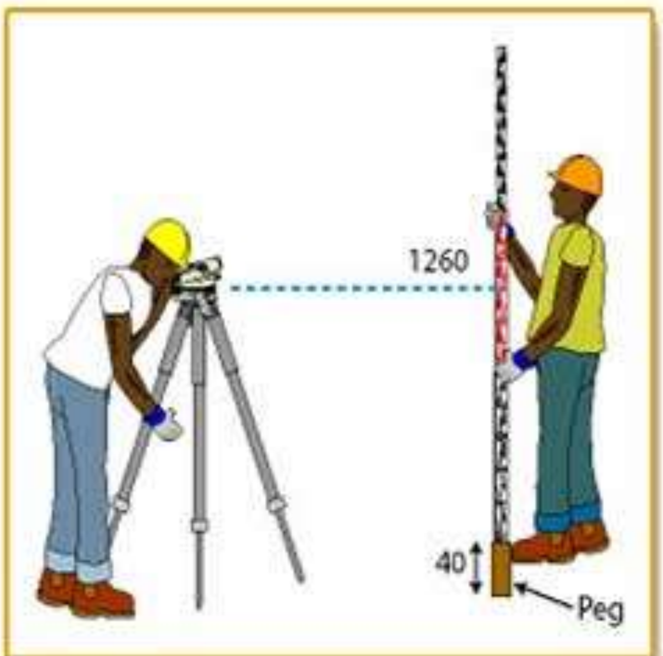
TYPES OF LEVELS:

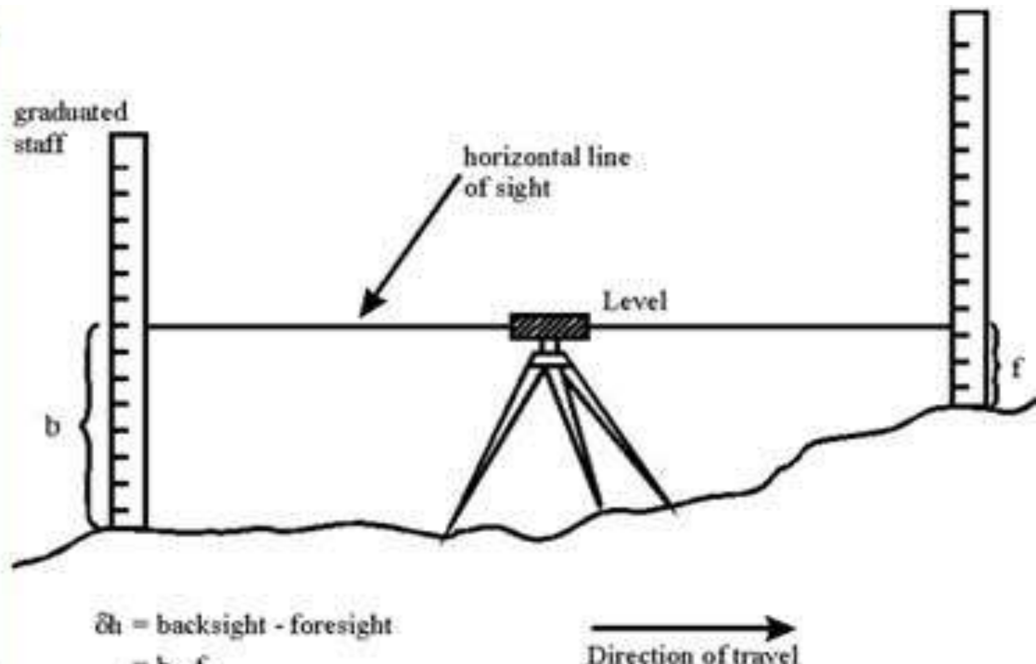
i) Dumpy level

ii) Tilting level

iii) Automatic level

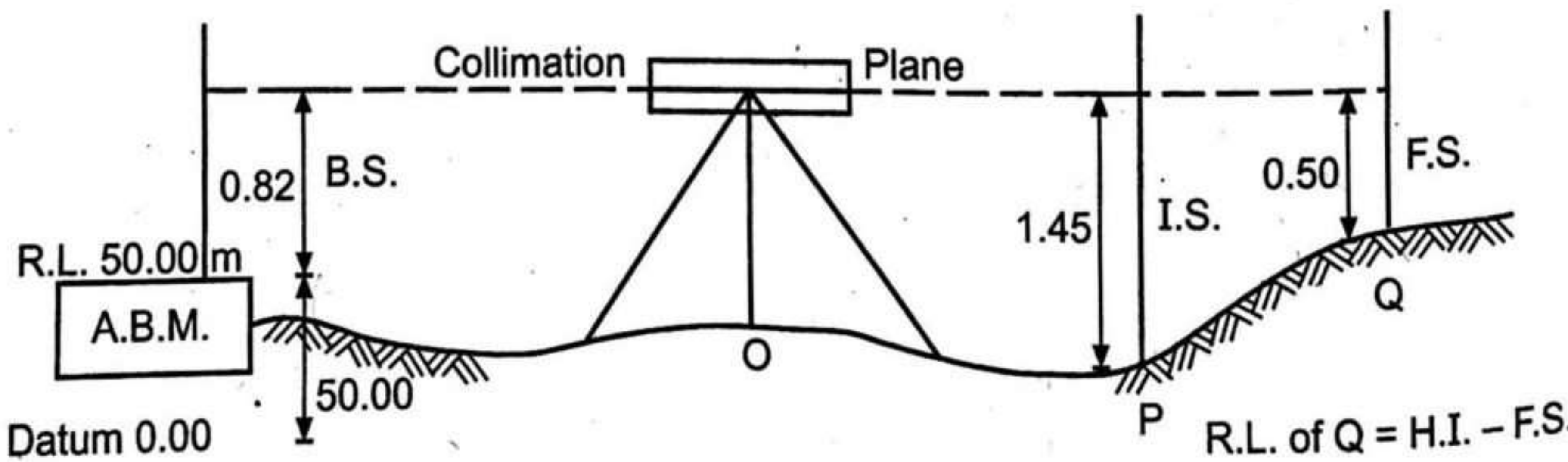
iv) Digital Auto level





Reduction Of Level

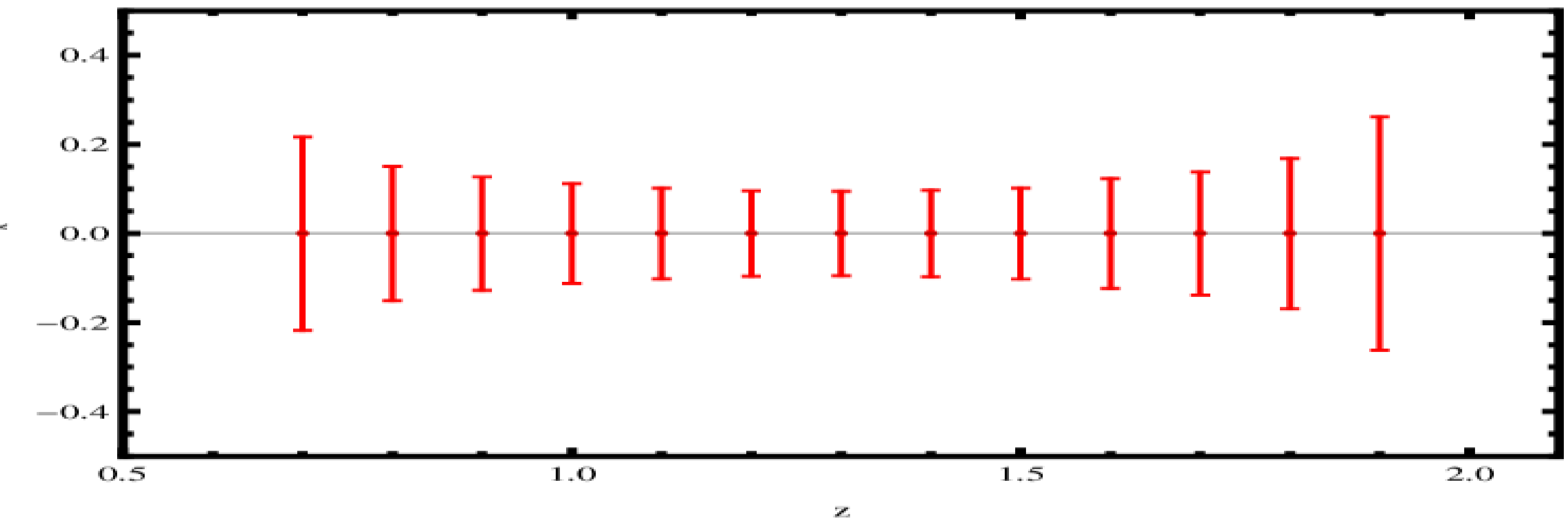
- Height of Instrument Method
- Rise and Fall Method



Sl.No	Height of collimation system	Rise and fall system
1	It is rapid as it involves few calculation	It is laborious involving several calcuation
2	There is no check on the RL of the intermediate sight	There is a check on the RL of the intermediate points
3	Errors in the intermediate RLs cannot be detected.	Errors in the intermediate RLs can be detected as all the points are correlated
4	There are two checks on the accuracy of RL calculation	There are three checks on the accuracy of RL calculation
5	This system is suitable for longitudinal leveling where there are a number of intermediate sights	This system is suitable for fly leveling where there are no intermediate sights

Errors in Levelling

- Instrumental Error
- Personal Error
- Natural Error

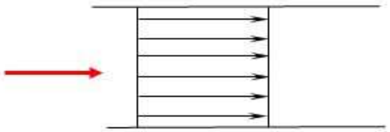


FUNDAMENTALS OF
FLUID MECHANICS

Types of fluid Flow

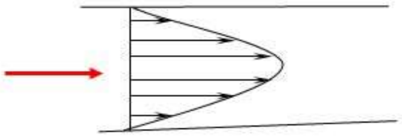
1. Real and Ideal Flow:

If the fluid is considered frictionless with zero viscosity it is called ideal.
In real fluids the viscosity is considered and shear stresses occur causing conversion of mechanical energy into thermal energy



Ideal

Friction = 0
Ideal Flow ($\mu = 0$)
Energy loss =0

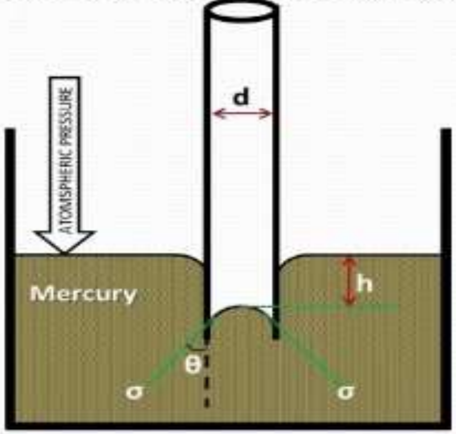


Real

Friction ≠ o
Real Flow ($\mu \neq 0$)
Energy loss ≠ 0

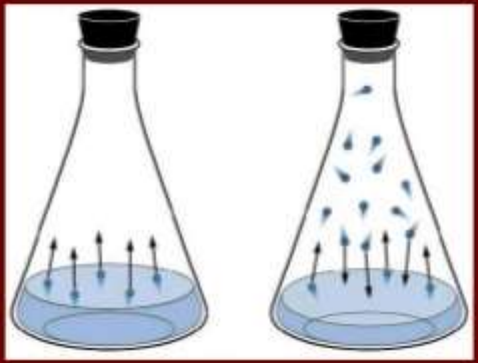
CAPILLARITY FALL

- Tendency of liquids to be depressed in tubes of small diameter in opposition to, external forces like gravity



Vapor Pressure and Boiling

- **Vapor Pressure** – the pressure exerted by a **vapor** in equilibrium with its **liquid** state.
- Liquid molecules at the surface **escape** into the **gas** phase.
- These gas particles create **pressure** above the **liquid** in a closed container.



Pascal's Law

Pascal's law states that a pressure exerted on a confined fluid is exerted equally in all directions throughout the fluid.

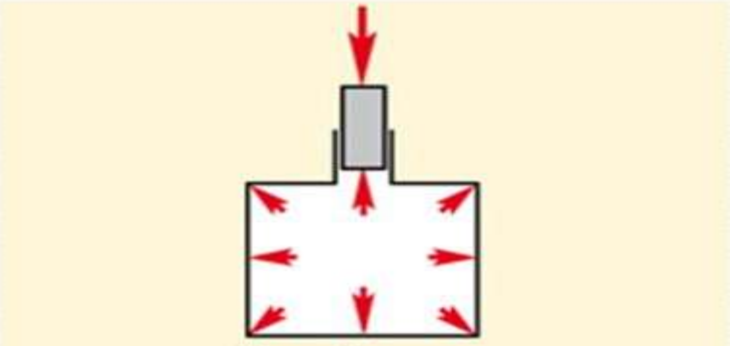
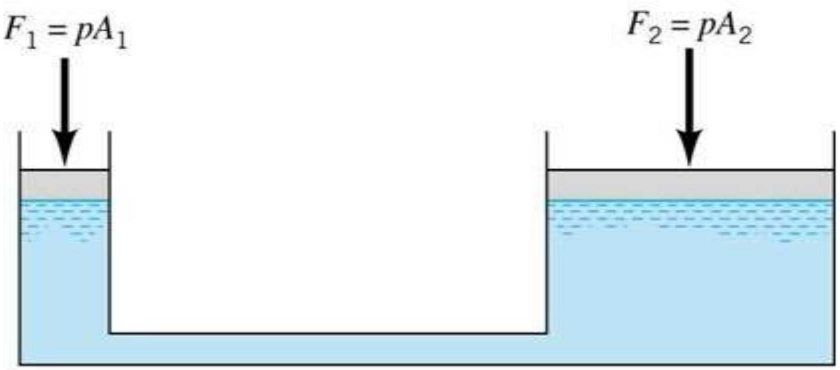


Figure 1

Hydrostatic Application: Transmission of Fluid Pressure



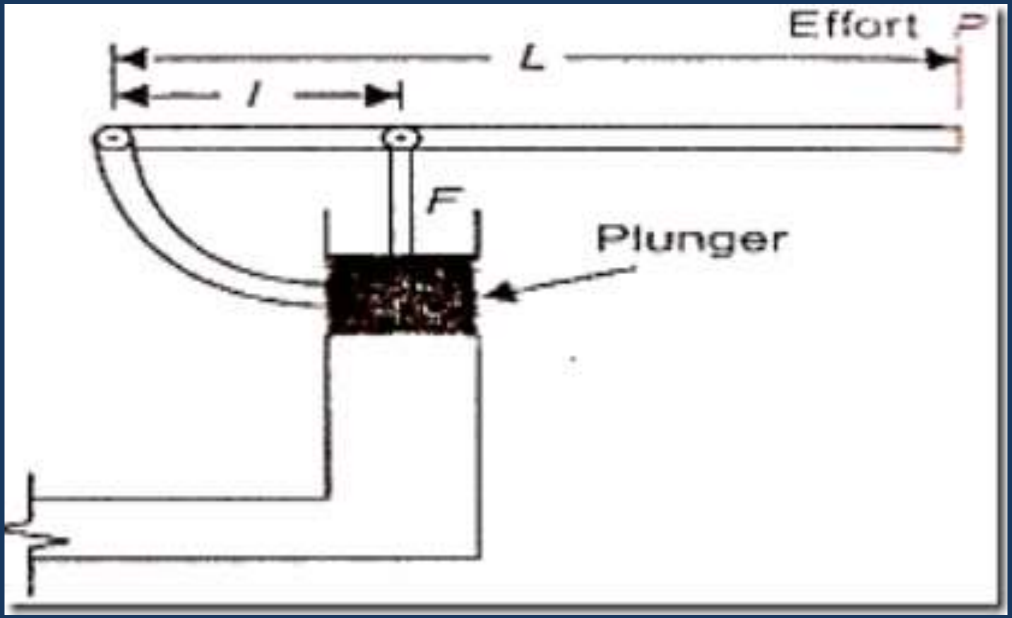
- Mechanical advantage can be gained with equality of pressures
- A small force applied at the small piston is used to develop a large force at the large piston.
- This is the principle between hydraulic jacks, lifts, presses, and hydraulic controls

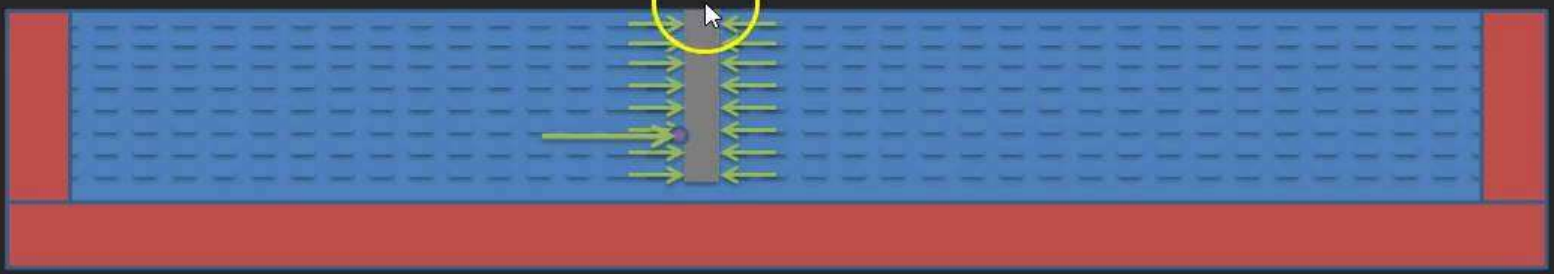
$$F_2 = \frac{A_2}{A_1} F_1$$

$$F_1 = \frac{A_1}{A_2} F_2$$

SECOND APPLICATION OF PASCAL's LAW

LEVRAGE OF HYDRAULIC PRESS





Total Pressure Force

It is the total force exerted by a fluid on a given plate or curved plate, when the fluid comes in contact with the plane.

Centre of Pressure

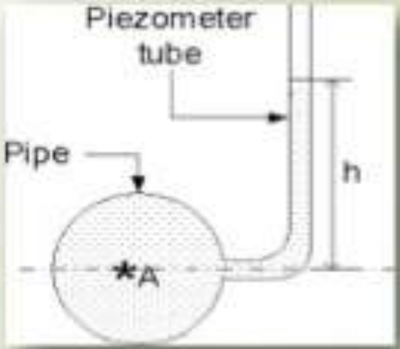
It is a point , where the total pressure force acts on the plate.

Piezometer:

- Simple type manometer, vertical L shape tube, open at top, attached to a container pipe
- P = sp wt * height + p(atm)   Absolute pressure.
- P= sp wt * height   Gauge pressure

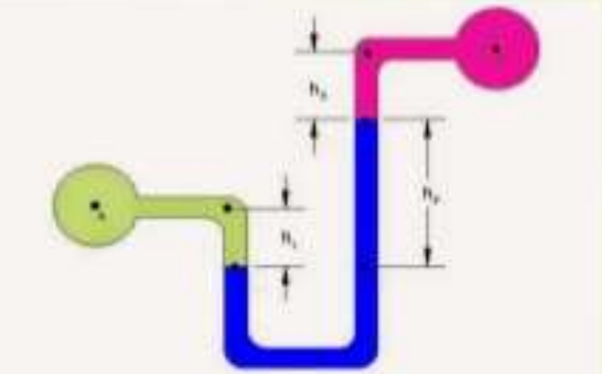
Vertical column for measuring static Pressures of liquids.

- It has a tube in which the Fluid(liquid) can rise freely, the height of the liquid in the tube will give the value of Pressure.
- Its diameter is kept at least 12mm in order to reduce the error.
- ADVANTAGES: easy technique, accurate,economical
- DISADVANTAGES: cannot measure...
  1) negative pressure
  2) pressure of gases
  3) control of column height



Differential Manometer:

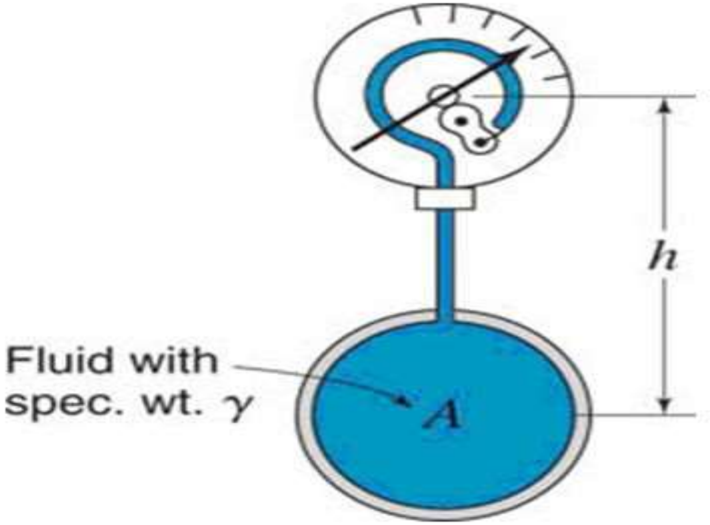
- In many cases we require the difference between two pressures. For such purposes we use a Differential manometer.
- In this arrangement of manometer we connect the two ends with different liquids whose pressure we want to measure.
- It is to be noted that only those liquids should be used who are immiscible with each other. Otherwise liquids will mix and we will not be able to measure the difference of their heights.
- Math equation:



Differential U - Tube Manometer

2. Bourdon Gauge:

- The pressure, above or below the atmospheric pressure, may be easily measured with the help of a bourdon's tube pressure gauge.
- It consists on an elliptical tube: bent into an arc of a circle. This bent up tube is called Bourdon's tube.
- Tube changes its curvature with change in pressure inside the tube. Higher pressure tends to "straighten" it.
- The moving end of tube rotates needle on a dial through a linkage system.



Continuity Equation

- For steady flow condition $d(M_{CV})/dt = 0$

$$\rho_1 A_1 V_1 - \rho_2 A_2 V_2 = 0 \Rightarrow \rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

$$M = \rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

- Hence, for stead flow condition, mass flow rate at section 1= mass flow rate at section 2. i.e., mass flow rate is constant.
- Similarly $G = \rho_1 g A_1 V_1 = \rho_2 g A_2 V_2$
- Assuming incompressible fluid, $\rho_1 = \rho_2 = \rho$

$$A_1 V_1 = A_2 V_2 \Longrightarrow Q_1 = Q_2 \Longrightarrow Q_1 = Q_2 = Q_3 = Q_4$$

- Therefore, according to mass conservation for steady flow of incompressible fluids volume flow rate remains same from section to section.

Forms of Energy

- **(1). Kinetic Energy:** Energy due to motion of body. A body of mass, *m*, when moving with velocity, *V*, posses kinetic energy,

$$KE = \frac{1}{2} mV^2$$

m and *V* are mass and velocity of body

- **(2). Potential Energy:** Energy due to elevation of body above an arbitrary datum

$$PE = mgZ$$

Z is elevation of body from arbitrary datum
m is the mass of body

- **(3). Pressure Energy:** Energy due to pressure above datum, most usually its pressure above atmospheric

$$\text{PrE} = \gamma h \qquad !!!$$

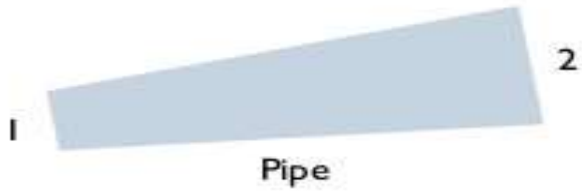
Bernoulli's Equation

- *It states that the sum of kinetic, potential and pressure heads of a fluid particle is constant along a streamline during steady flow when compressibility and frictional effects are negligible.*
- *i.e. , For an ideal fluid, Total head of fluid particle remains constant during a steady-incompressible flow.*
- *Or total head along a streamline is constant during steady flow when compressibility and frictional effects are negligible.*

$$\text{Total Head} = Z + \frac{P}{\gamma} + \frac{V^2}{2g} = constt$$

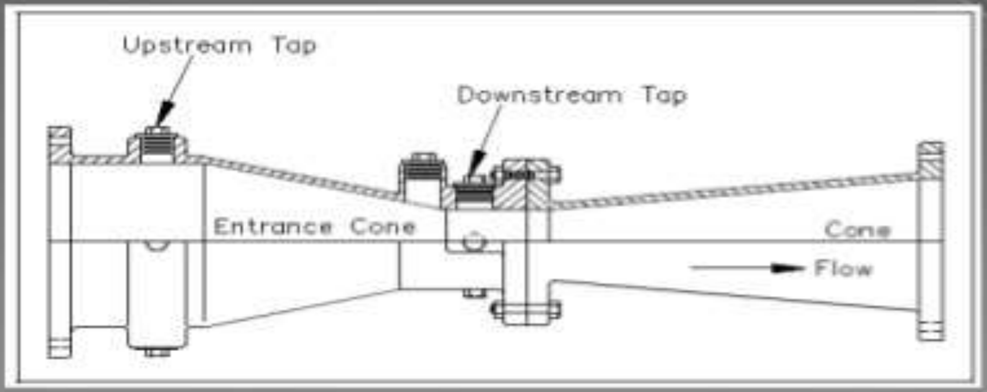
$$Z_1 + \frac{P_1}{\gamma} + \frac{V^2_1}{2g} = Z_2 + \frac{P_2}{\gamma} + \frac{V^2_2}{2g}$$

$$H_1 = H_2$$



VENTURIMETER

- It's a device, used to measure the rate of flow of fluid through a pipe
- It consists of :
1. Inlet section.
2. Convergent section,
3. A cylindrical throat.
4. A gradually divergent cone.



Notches

- A notches is defined as an opening in the side of a vessel or tank in such a manner that the liquid surface in the tank.
- A notch is generally made of metallic plate.
- It is used for measuring the discharge rate of a liquid from a small channel or tank.

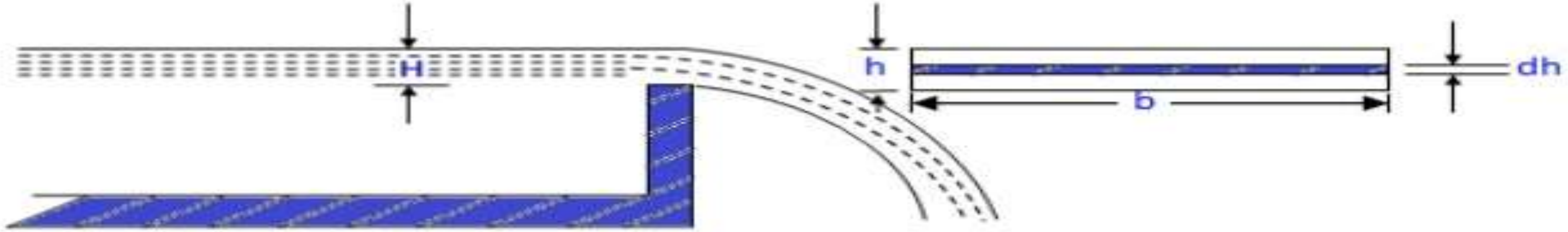


Fig : Rectangular Notch

Weir

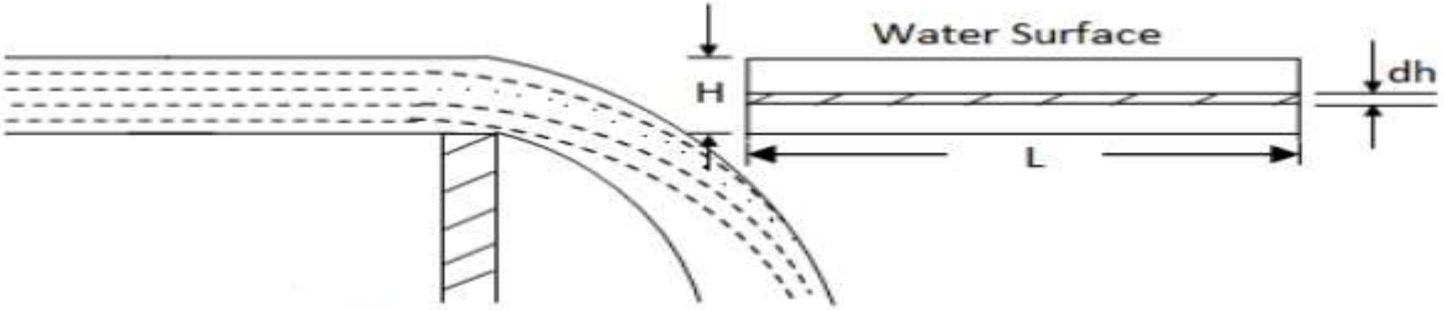


Fig : Rectangular weir

- A weir is basically an obstruction in the flow path in an open channel.
- The weir will cause an increase in the water depth as the water flows over the weir.
- In general, the greater the flow rate, the greater will be the increase in depth of flow, The height of water above the top of the weir is the measurement usually used to correlate with flow rate.

Difference between Notch & Weir

NOTCH

- A notch may be defined as an opening provided in one side of a tank or reservoir, with u/s liquid level below the top edge of the opening.
- The bottom edge of notch over which water flows is known as sill or crest.
- A notch is usually made of a metallic plate.
- A notch is used to measure small discharge of small stream or canal.
- Notches are of small size.

WIER

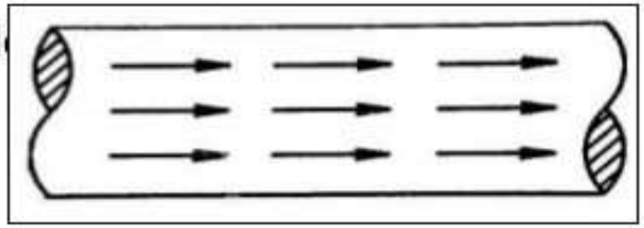
- A weir may be defined as a structure constructed across a river or canal to store water on the upstream side.
- The top of the weir over which water flows is known as crest.
- A weir is made of cement concrete or masonary.
- A weir is used to measure large discharge of rivers and large canals.
- Weirsd are of bigger size.

1. Laminar Flow:-

Laminar flow is defined as that type of flow in which the fluid particles move along well-defined paths or stream lines and all the stream lines are straight and parallel.

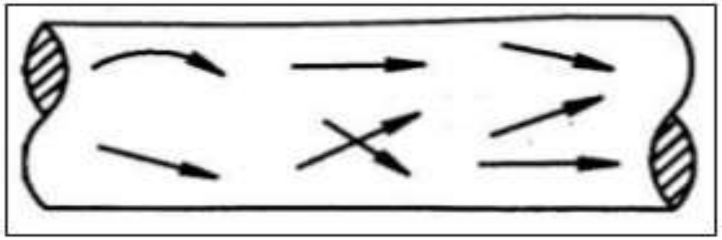
Factors responsible for laminar flow are:-

- High viscosity of fluid.
- Low velocity of fl
- Less flow area.



2. Turbulent Flow:-

Turbulent flow is defined as that type of flow in which the fluid particles move is a zigzag way. The Fluid particles crosses the paths of each other.



For example,

- Flow in river at the time of flood.
- Flow through pipe of different cross- section.

Energy Principles in Open Channel Flow

Rectangular Channel

For rectangular section

At critical Flow

$$F_r = \frac{V}{\sqrt{gD_h}} = \frac{V}{\sqrt{gD}}$$

a) Critical depth, ***yc , is defined as that depth of flow of liquid at which the specific*** energy is minimum, *Emin,*

$$F_r = 1 = \frac{V}{\sqrt{gD_h}}$$

$$y_c = \left(\frac{Q^2}{B^2 g}\right)^{\frac{1}{3}}$$

q=Q/B

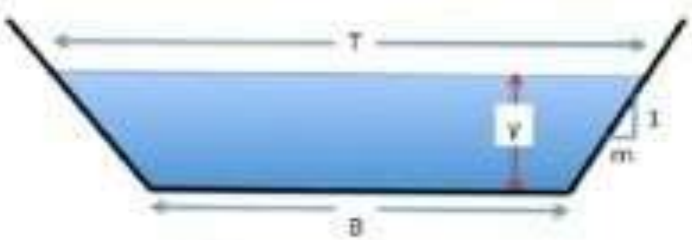
$$y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

b) Critical velocity, Vc , is the velocity of flow at critical depth.

$$V_c = \sqrt{g \times y_c}$$

Trapezoidal Channel

- The trapezoidal conduit is a reasonably common geometry
  - triangular channel and rectangular channel are special cases of the trapezoidal conduit.
- Engineered (improved) natural channels are reasonably well approximated by trapezoidal equations
  - the geometry is important in drainage engineering



B = Bottom width;
T = Top width;
y = Depth;
m = Side slope (H:V), i.e. (m:1).

$$A_{trap}(y) = y(B + my)$$

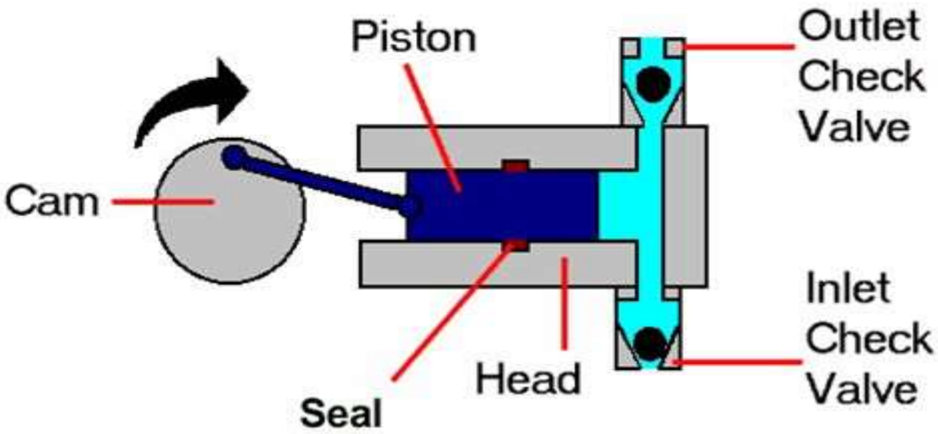
$$T_{trap}(y) = B + 2my$$

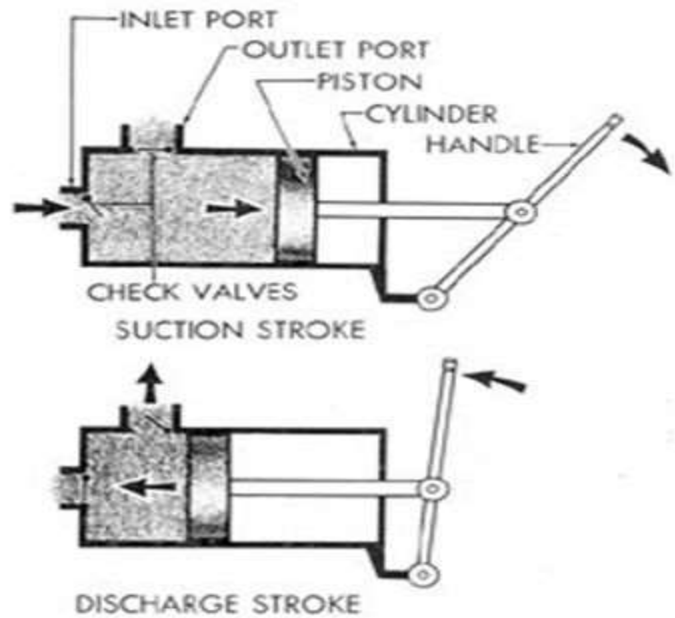
$$P_{w\ trap}(y) = B + 2y\sqrt{1 + m^2}$$

$$R_{h\ trap}(y) = \frac{y(B + my)}{B + 2y\sqrt{1 + m^2}}$$

Reciprocating pumps.

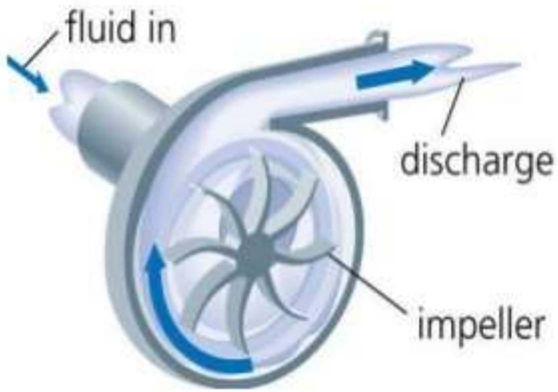
- In the reciprocating pump a piston sucks the fluid into a cylinder then pushes it up causing the water to rise.

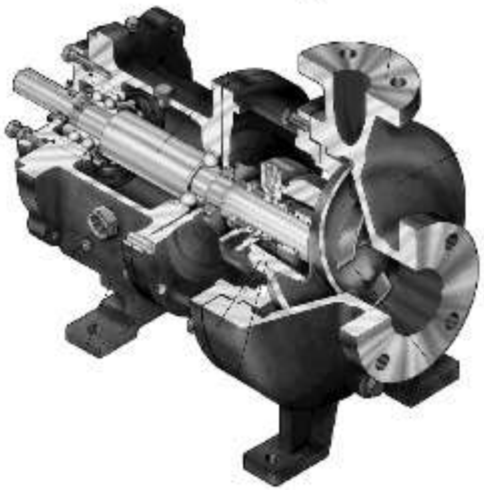




Centrifugal Pump:

- Centrifugal pumps (radial-flow pumps) are the most used pumps for hydraulic purposes. For this reason, their hydraulics will be studied in the following sections.





Construction Material

Contents:

- Classification of stones
- Rocks & it's types
- Bricks & it's classification
- Cement & it's composition
- Paints and it's composition

- *Construction planning* is a fundamental and challenging activity in the management and execution of construction projects.

<u>Classification of stones :</u>

- The term rock is commonly defined as a hard mass of mineral matter having, as a rule, no definite external form.
- The word stone is applied indiscriminately to all classes of hard rocks.

Description of Classes:

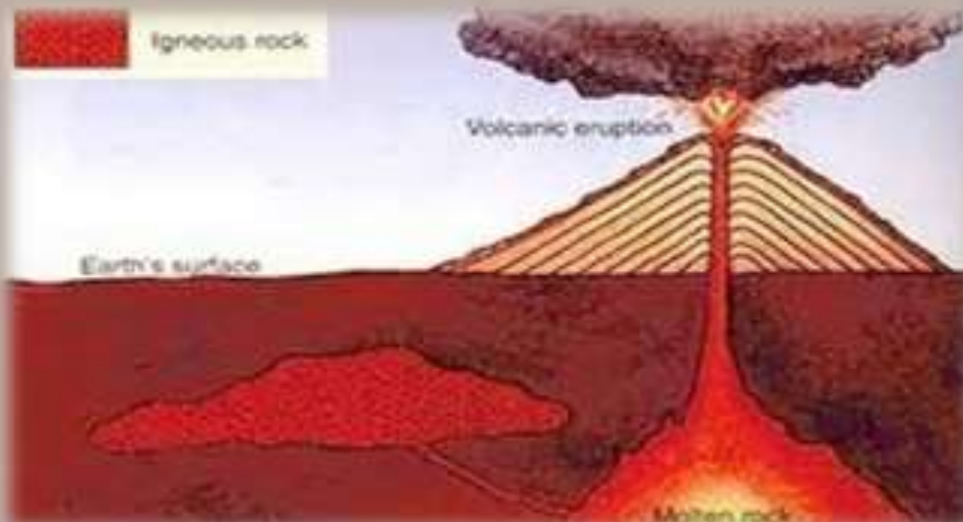
Rocks are classified as follows:

1. According to geological origin-
   Igneous, Sedimentary and Metamorphic
2. According to the physical form-
   Stratified, Unstratified and Foliated.
3. According to their chemical composition–
   Silicious, Argillaceous and Calcerous.

GEOLOGICAL CLASSIFICATION:

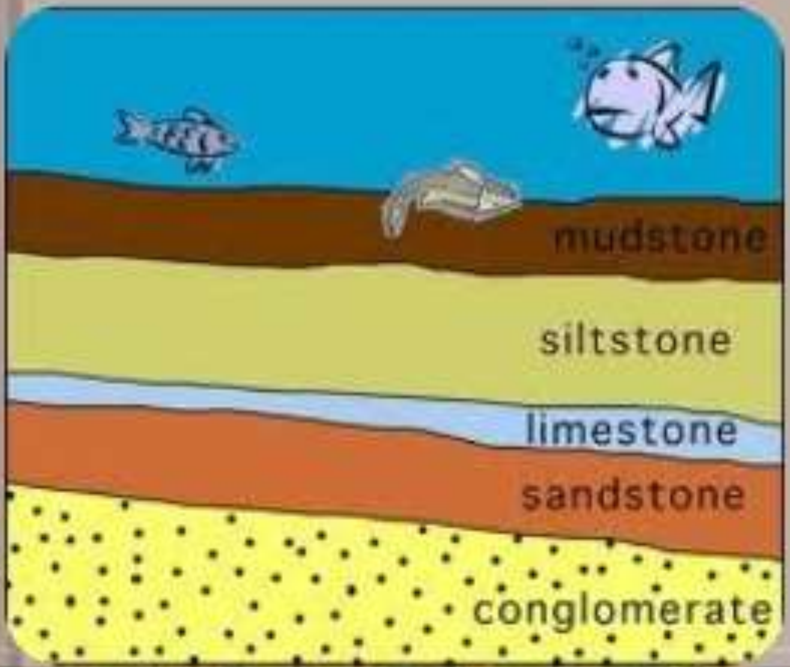
IGNEOUS ROCK:

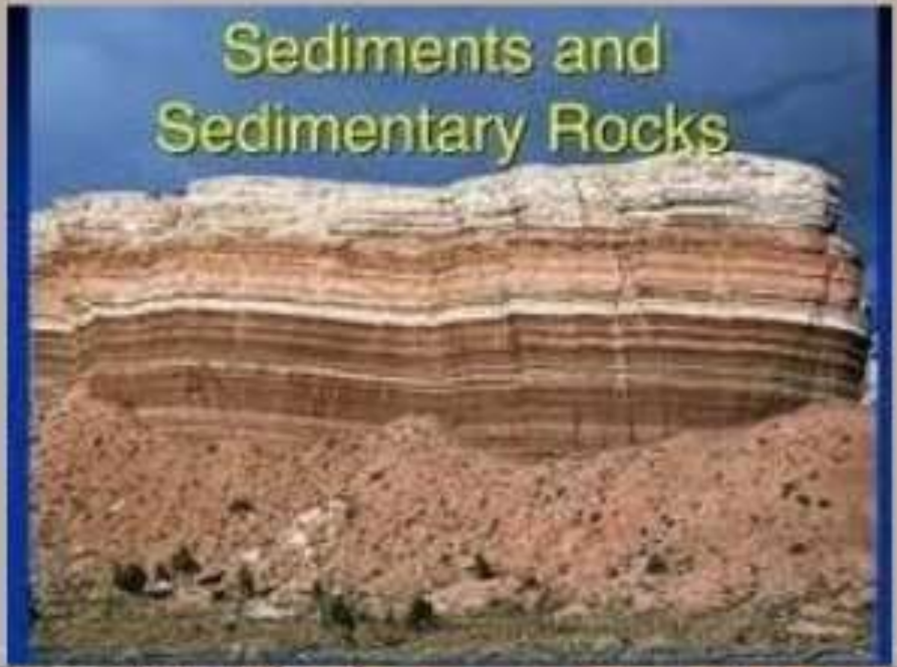
- Igneous Rock, rock formed when molten or partially molten material, called magma, cools and solidifies. The inner layers of the earth are at a very high temperature causing the masses of silicates to melt.



SEDIMENTARY ROCKS:

- Sedimentary rocks are types of rock that are formed by the deposition and subsequent cementation of that material at the Earth's surface and within bodies of water.





METAMORPHIC ROCKS:

- Metamorphic Rock is a type of rock formed when rocky material experiences intense heat and pressure in the crust of the earth. This change from one mineral assemblage to another is called metamorphism.

Physical Classification of Rocks:

Based on the structure, the rocks may be classified as:

1. Stratified rocks
2. Unstratified rocks

Stratified Rocks:

The layering that occurs in most sedimentary rocks and in those igneous rocks formed at the Earth's surface, as from lava flows and volcanic fragmental deposits. The layers range from several millimeters to many meters in thickness and vary greatly in shape

Unstratified:

These rocks are not stratified. They possess crystalline and compact grains. They cannot be split in to thin slab. Granite, trap, marble etc. are the examples of this type of rocks.

Foliated rocks:

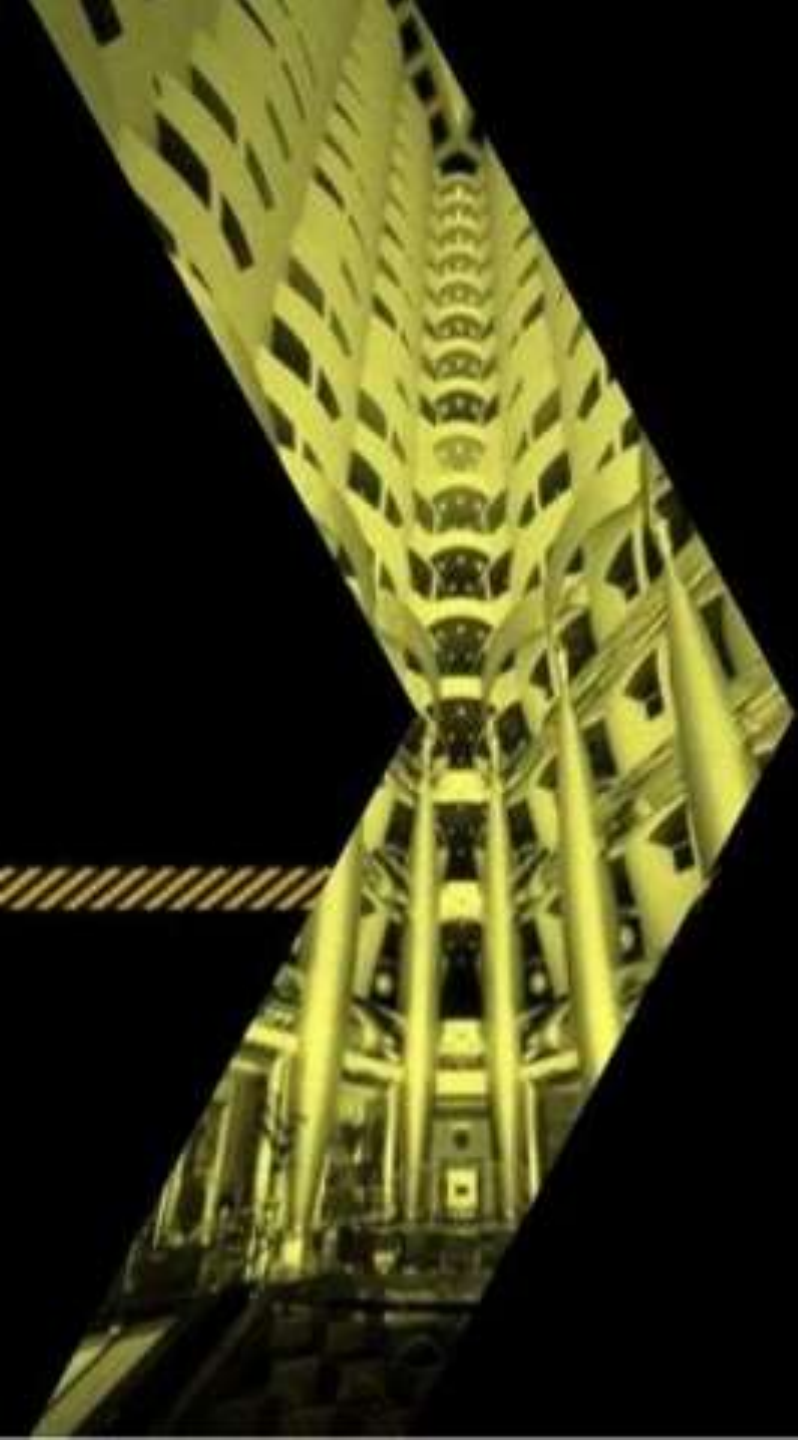
Metamorphic rock is formed when existing rock (whether it is sedimentary, igneous, or another metamorphic rock) is changed by intense pressure and temperature. Typically, this happens deep within the Earth, or near volcanoes.

BRICKS

A small rectangular block typically made of fired or sun dried clay, used in building and other construction.

It Has Two Main Types On The Basis Of Size And Dimensions:-

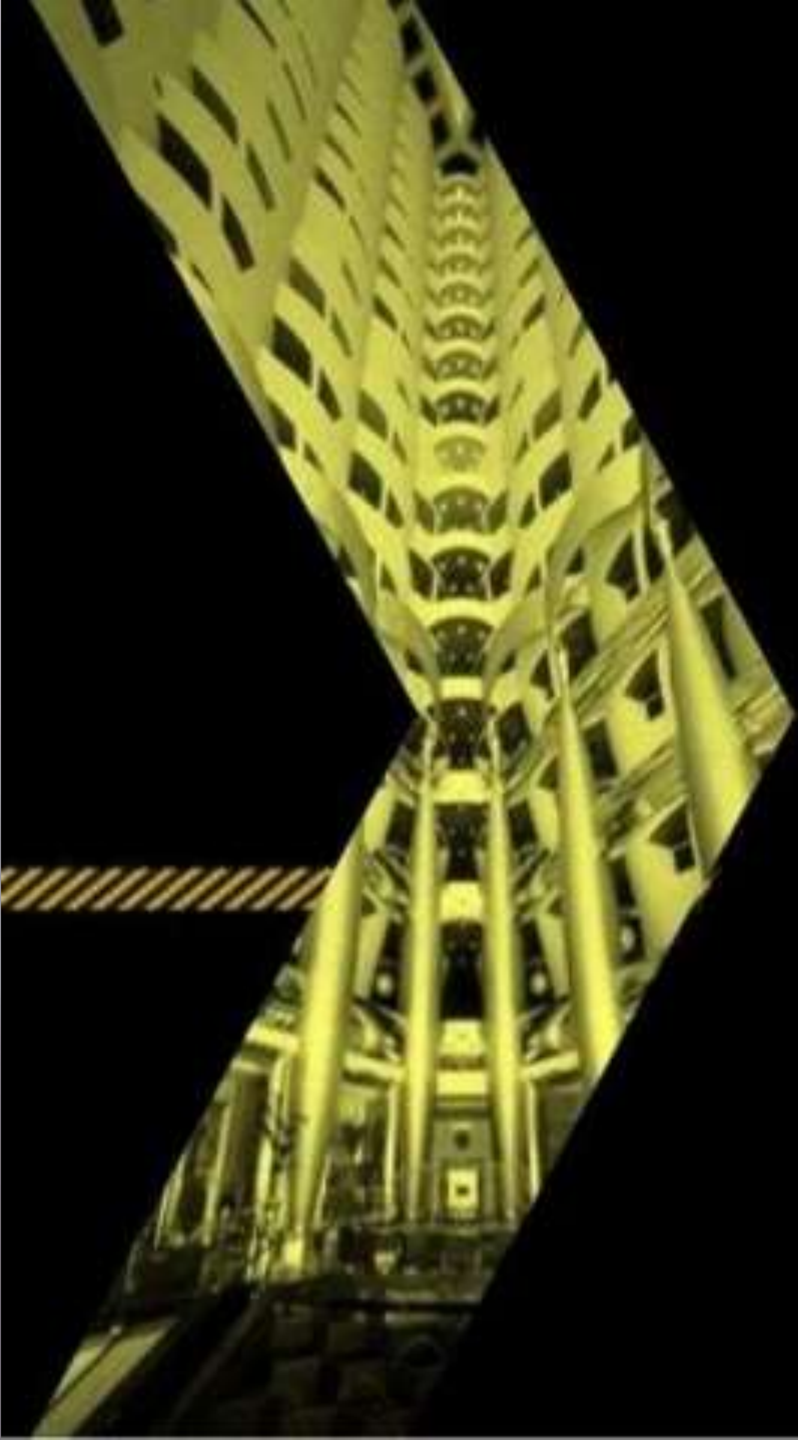
- Modular Bricks
- Traditional Bricks



Traditional Bricks

The Dimension Of Traditional Bricks

Varies From 21 To 25 Cm In Length
&
From 10 To 30 Cm In Width
&
From 7.5 To 1 Cm In Height



Modular Bricks

Indian Standard Institution Has Suggested Uniform Brick Size Is Known As Modular Brick.

The Actual Size Is 19 ¬ 9 ¬ 9 Cm

Classification Of Bricks On The Basis Of Manufacturing Quality

1. First class bricks
2. Second class bricks
3. Third class bricks
4. Fourth class bricks

FIRST CLASS BRICKS

- MADE OF GOOD EARTH WHICH IS FREE FROM SALINE DEPOSITS AND ARE SAND MOLDED.
- BURNT THOROUGHLY WITHOUT BEING VITRIFIED AND HAVE DEEP RED, CHERRY AND COPPER COLOR.

SECOND CLASS BRICKS

- They shall be well burnt or slightly over burnt.
- They must give clear ringing sound when struck.
- The may have slight irregularities in size, shape and color.
- The minimum crushing strength of second class brick should be 70 kg per sq cm

THIRD CLASS BRICKS

- THESE BRICKS ARE SLIGHTLY UNDER BURNT OR OVER BURNT.
- THEY ARE NOT UNIFORM IN SHAPE, SIZE AND EDGES.
- THEY SHALL NOT OBSERVE WATER MORE THAN 25% OF THEIR OWN DRY WEIGHT AFTER 24 HOURS, IMMERSION IN COLD WATER.
- THEY HAVE SOME SIGNS OF EFFLORESCENCE

FOURTH CLASS BRICKS

- These are over burnt bricks which are dark in colour and are irregular in size and shape.
- These are used as aggregate in concrete and for flooring.
- Over burnt bricks are not used for building construction

Cement

- Binding Material
- Provide strength to concrete with a process called Hydration
- The ready mix of cement consist of silicate and aluminate of lime.
- Consist of seven major ingredients:-

A.) Hydrated Lime (60%-67%) CaO:- Provide strength and responsible for hydration

B.) Silica (17%-25%) SiO2:- Provide Strength to cement due to formation of dicalcium Silicate & tricalcium Silicate

C.)Alumina (3%-8%)Al2O3:- Resistance against high temperature/control of temperature.

D.) Magnesia(0.1%-4%)MgO:- Responsible of Hardness

E.) Iron Oxide (0.5%-6%)FE2O3:-Responsible for Strength and Color of Cement

F.) Sulpher Trioxide (1%-2.25%)SO3:- Responsible of Setting time of Cement

G.) Alkalies (Soda and Potash):- 0.1% to 1%

Types of Cement

Type	Clasification	Characteristics	Applications
Type I	OPC BS EN-197-1:2000 ASTM C-150-94	Fairly high C_3S content for good early strength development Not more then 10% by weight particles will retain on BS Sieve No. 170 Chemical composition: C_3S-**tricalcium silicate**=50% (Responsible for Final setting time, produce heat) C_2S-**dicalcium silicate**=25% (Responsible for final setting time) C_3A-**tricalcium aluminate**=12% (Responsible for initial setting time and quick setting time, produce heat) C_4AF-**tetracalcium aluminoferrite**=8% (Responsible for initial setting time and quick setting time)	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance BS EN-197-1:2000 ASTM C-150	Low C_3A content (<8%) Chemical composition C_3S=46% C_2S=29% C_3A=6% C_4AF=12%	Structures exposed to soil or water containing sulfate ions
Type III	Rapid Hardening Cement BS EN -197-1	Grind more finely, provide more heated with high temperature in factory may have slightly more C_3S Not more then 5% by weight particles will retain on BS Sieve No. 170 Chemical composition C_3S=60% C_2S=12% C_3A=12% C_4AF=8%	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting) BS 1370-1979	Low content of C_3S (<50%) and C_3A<5% More amount of C_2S Chemical composition C_3S=30% C_2S=46% C_3A=5% C_4AF=12%	Massive structures such as dams. Now rare.
Type V	High sulfate resistance BS-4027-1996	Very low C_3A content (<5%) Chemical composition C_3S=40% C_2S=36% C_3A=4% C_4AF=12%	Structures exposed to high levels of sulfate ions
White	White color	No C_4AF, low MgO	Decorative (otherwise has properties similar to Type I)

Tests of Cement

A.) Fineness Test:- to check the particles grinding

Equipment used: BS Sieve No.170

B.) Consistency Test: To Check the %age of water required for Cement Paste

Equipment Used: Vicat Apparatus

C.) Setting Time Test: to check Initial and Final setting time of Cement

Equipment Used:- Vicat Apparatus

D.) Soundness Test: to check the changes in volume of cement paste after setting time.

Equipment Used: Le Chateller Apparatus

E.)Compression Test

F.) Tensile Test

Values for Compression strength of Cement

- Ordinary Portland Cement

3 Days= 112.7 kg/m^2

7 Days=176 kg/m^2

- Rapid Hardening Cement

3 Days= 211.3 kg/m^2

7 Days=264.1 kg/m^2

Values for Tensile strength of Cement

- Ordinary Portland Cement

3 Days= 21 kg/m^2

7 Days=26 kg/m^2

- Rapid Hardening Cement

3 Days= 21 kg/m^2

7 Days=32 kg/m^2

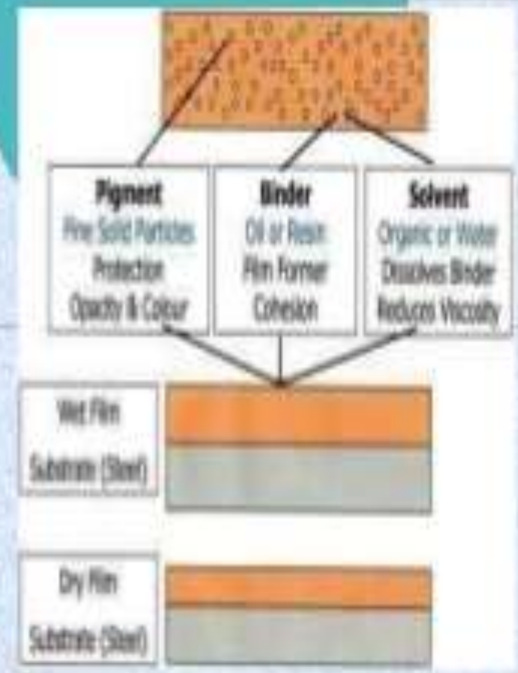
PAINTS

- **WHAT IS PAINT??**
- THE PAINTS ARE COATING OF FLUID MATERIAL AND THEY ARE APPLIED OVER THE SURFACE OF TIMBER AND METALS.
- PAINT IS A LIQUID COMPOSITION AFTER APPLICATION IT IS CONVERT IN TO A SOLID FILM.

COMPOSITION:-

PAINT

- BINDER
- SOLVENT
- PIGMENT
- ADDITIVES



BASE

- ✓Principle constituent
- ✓A metallic oxide
- ✓Makes the paint film opaque.
- ✓Possesses binding properties which helps reduce shrinkage cracks on drying.
- ✓E.g.,:- white lead, red lead, zinc white, aluminium powder, iron oxide etc.,

VEHICLE

- ✓ Also known as binder.
- ✓ Vehicle is an oil to which the base is mixed.
- ✓ Holds all constituents of paint.
- ✓ Helps spread it over the surface to be painted.
- ✓ Imparts durability, toughness & water proofness to paint film & resistance to weathering and gloss.
- ✓ E.g., :- linseed oil, nut oil, poppy oil & tung oil

PIGMENTS

- ✓Used to hide the surface imperfections.
- ✓To impart the desired colour.
- ✓Improves the impermeability & enhances resistance to weathering.
- ✓Finely ground mineral, organic substances or metal powders.
- ✓Affect the flow characteristics making it possible to paint vertical & uneven surfaces smoothly.

SOLVENTS

- ✓ Oils used to tin the paints, increase the spread.
- ✓ Also, known as thinners.
- ✓ They make paints of workable consistency & evaporate during drying of the film.
- ✓ It makes paint thinner and hence increases the coverage. It helps in spreading paint uniformly over the surface Terpentine and neptha are commonly used thinners. After paint applied, thinner evaporates and paint dries.
- ✓ Eg.,:- petroleum, spirit, naptha, turpentine oil.
- ✓ Most commonly used turpentine because of its high solvent power, excellent flattening properties.

DRIERS

- ✓ Also, known as plasticizers.
- ✓ Are chemicals added to paint for specific purposes.
- ✓ These are the compounds of metal like lead, manganese, cobalt.
- ✓ The function of a drier is to absorb oxygen from the air and supply it to the vehicle for hardening. The drier should not be added until the paint is about to be used.
- ✓ E.g., as catalyst for accelerating the drying of vehicle.
- ✓ Quantity of drier is limited to 8%.
- ✓ Excess affects the elasticity of paint leading to flaking failure.
- ✓ Red lead is the best for primary coat over steel &metal work.
- ✓ It produces extremely hard & tough film, almost impervious to air & moisture.
- ✓ The cost of zinc & lead chromates is high.
- ✓ E.g.,:- letharge, lead acetate, red lead, manganese dioxide, cobalt, zinc.

ADULTERANTS

- ✓ These bring down the overall cost, reduce the weight and increase the durability.
- ✓ Adulterants also help to reduce cracking of dry paint and sometimes help to keep the pigment in suspension.
- ✓ Barium sulphate, calcium carbonate, magnesium silicate and silica are but a few examples. The best adulterant is barium sulphate.
- ✓ Silica is used only in the undercoats so as to take the advantage of its roughness in development of bond with the next coat.

PROPERTIES OF AN IDEAL PAINT

- ✓ It should be possible to apply easily and freely.
- ✓ It should dry in reasonable time.
- ✓ It should form hard and durable surface.
- ✓ It should not be harmful to the health of workers.
- ✓ It should not be easily affected by atmosphere.
- ✓ It should possess attractive and pleasing appearance.
- ✓ It should form a thin film of uniform nature i.e., it should not crack.
- ✓ It should possess good spreading power.
- ✓ It should be cheap.

BUILDING CONSTRUCTION

Contents :

- Foundation & it's types
- Stairs & it's classification
- Masonry & it's types
- Building & it's classification
- Doors and windows & it's types

Foundation

A **foundation** is a lower portion of **building** structure that transfers its gravity loads to the earth. **Foundations** are generally broken into two categories: shallow **foundations** and deep **foundations**. A tall **building** must have a strong **foundation** if it is to stand for a long time.

PURPOSE OF FOUNDATION

- The purpose of foundation is to transfer the load of the structure to the underlying soil without causing the danger of failure in shear and excessive settlement.

Factors Affecting Foundation Selection

- Subsurface condition
- Type and magnitude of loading
- Type of structure
- Constraint – vibration, noise
- Cost
- Time
- Logistic

Types Of Foundation

1.Shallow Foundation

It is further classified into:

- ❖Wall footing
- ❖Isolated footing
- ❖Combined footing
- ❖Raft footing
- ❖Inverted arch footing
- ❖ Grillage footing

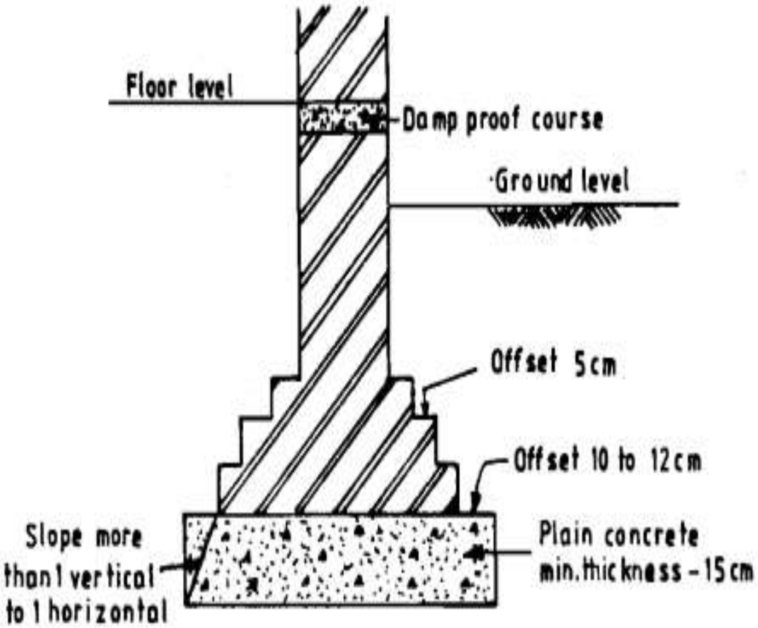
2.**Deep Foundation**

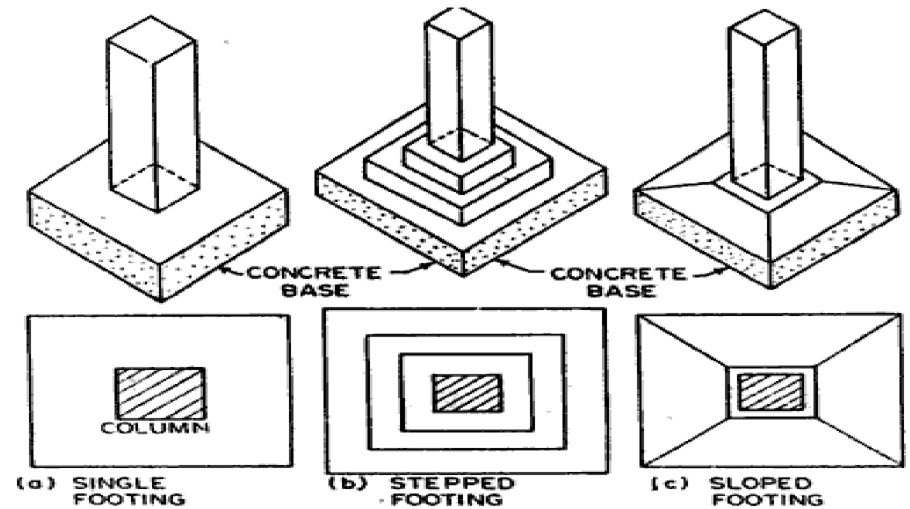
It is further classified into:

- Pile Foundation
- Well Foundation

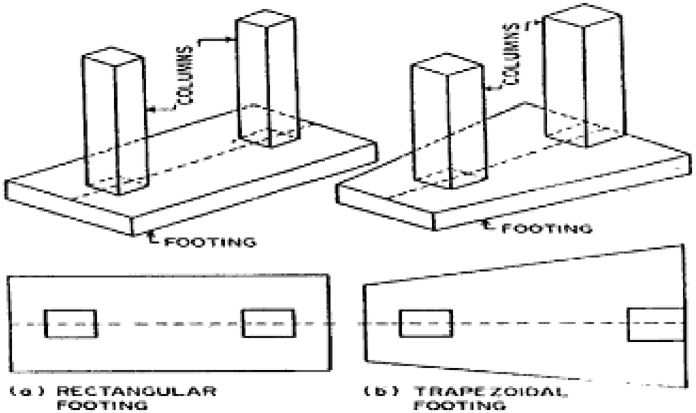
Wall footing

Isolated footing





Combined footing



Raft footing

Inverted arch footing

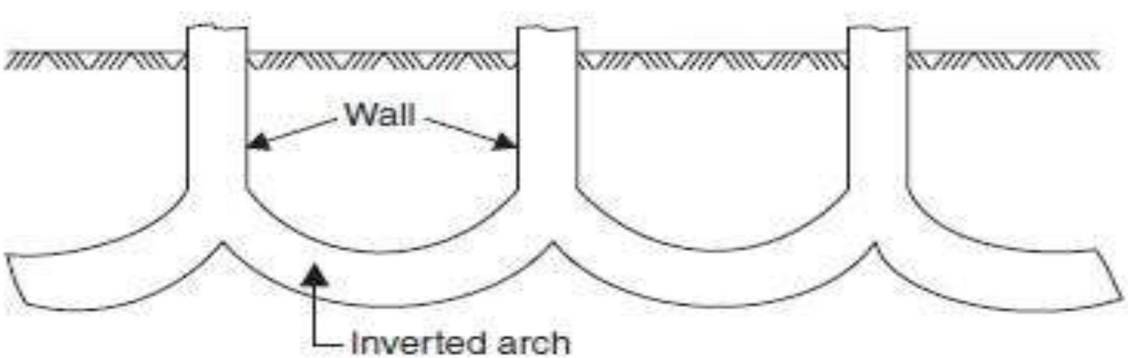


Fig. 7.8. Inverted arch footing

Grillage footing

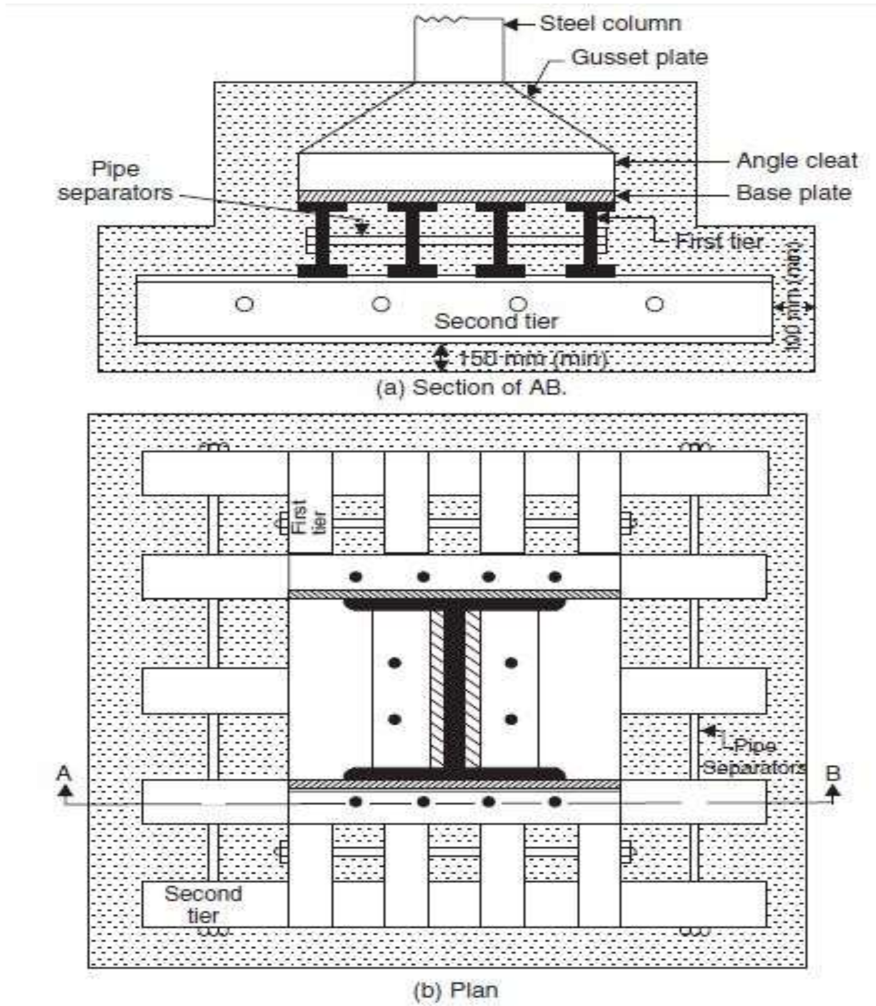
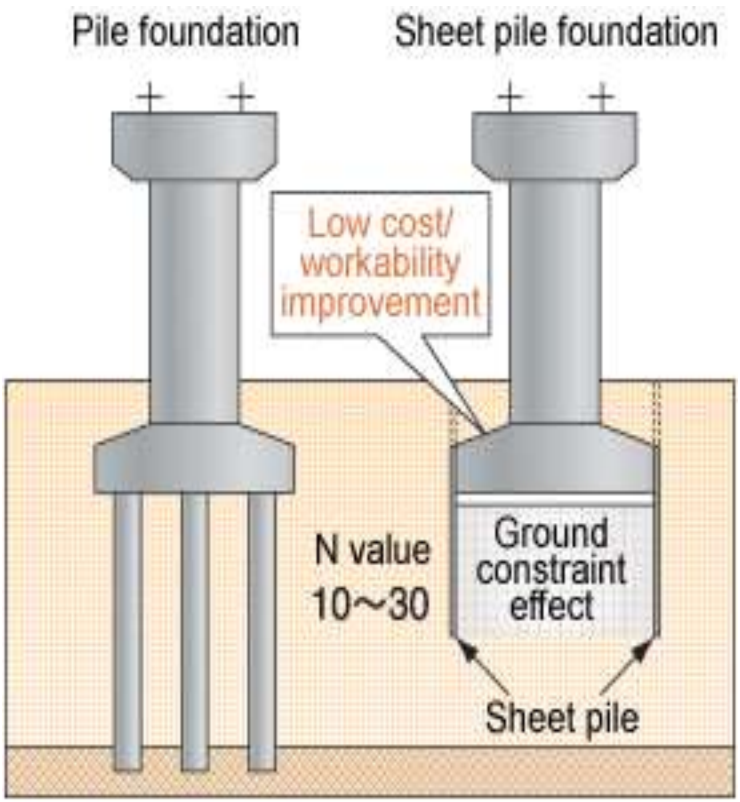


Fig. 7.7. Grillage foundation

Types of Deep Foundation

Pile Foundation



Well Foundation

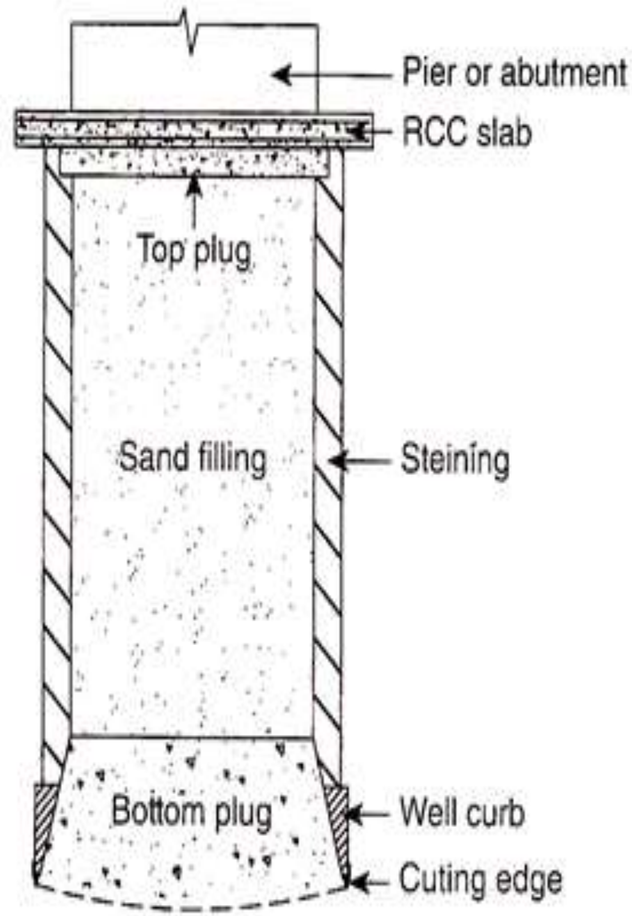
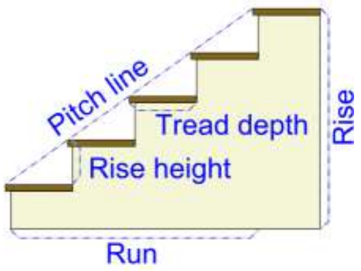


Figure 21.5 Components of a well foundation.

Stairs

A **stairway**, **staircase**, **stairwell**, **flight of stairs**, or simply **stairs** is a construction designed to bridge a large vertical distance by dividing it into smaller vertical distances, called **steps**. Stairs may be straight, round, or may consist of two or more straight pieces connected at angles.

Various Components or Parts of Staircase and their Details



Following are the various components of staircase:

Step

The step is composed of the tread and riser.

Tread The tread "depth" is measured from the outer edge of the step to the vertical "riser" between steps. The "width" is measured from one side to the other.

Riser

The vertical portion between each tread on the stair. This may be missing for an "open" stair effect.

Landing – A landing is the area of a floor near the top or bottom step of a stair. An intermediate landing is a small platform that is built as part of the stair between main floor levels and is typically used to allow stairs to hange directions, or to allow the user a rest.

Staircase – the entire structure relating to a stair, comprising steps, treads, risers, strings, balustrading, landings etc

FLIGHT

It is a series of steps without any platform or landing or break in their direction.

GOING

It is the horizontal distance between two successive riser faces.

NOSING

This is the outer projecting edge of a tread. This is generally made rounded to give more pleasing appearance and makes the staircase easy to navigate

WINDERS

They are tapering steps used for changing the direction of a stair.

SCOTIA

It is a moulding provided under the nosing to improve the elevation of the step, and to provide strength to nosing.

PITCH OR SLOPE

It is angle which the line of nosing of the stair makes with the horizontal.

STRINGS OR STRINGERS

These are the sloping members which support the steps in a stair. They run along the slope of the stair.

BALUSTER

It is a vertical member of wood or metal, supporting the hand rails.

HAND RAIL

It is a rounded or moulded member of wood or metal following generally the contour of the nosing line, and fixed on the top of balusters.

RUN

It is the total length of stair in a horizontal plane, including landings.

HEADER

It is the horizontal structural member supporting stair stringers or landings.

Requirement Of a Good Stair

1. LOCATION

It should preferably be located centrally, ensuring sufficient light and ventilation.

2. WIDTH OF STAIR

The width of stairs for public buildings should be 1.8 m and for residential buildings 0.9 m.

3. LENGTH

The flight of the stairs should be restricted to a maximum of 12 and minimum of 3 steps.

4. PITCH OF STAIR

The pitch of long stairs should be made flatter by introducing landing. The slope should not exceed 400 and should not be less than 250.

5. HEAD ROOM

The distance between the tread and soffit of the flight immediately above it, should not be less than 2.1 to 2.3 m. This much of height is maintained so that a tall person can use the stairs with some luggage on its head.

6. MATERIALS

Stairs should be constructed using fire resisting materials. Materials also should have sufficient strength to resist any impact.

7. BALUSTRADE

All open well stairs should be provided with balustrades, to avoid accidents. In case of wide stairs it should be provided with hand rails on both sides.

8. LANDING

The width of the landing should not be less than the width of the stair.

9. WINDERS

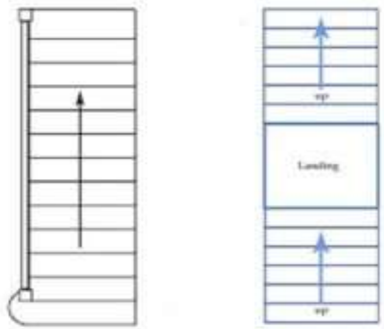
These should be avoided and if found necessary, may be provided at lower end of the flight.

10. STEP PROPORTIONS

The ratio of the going and the rise of a step should be well proportioned to ensure a comfortable access to the stair way.

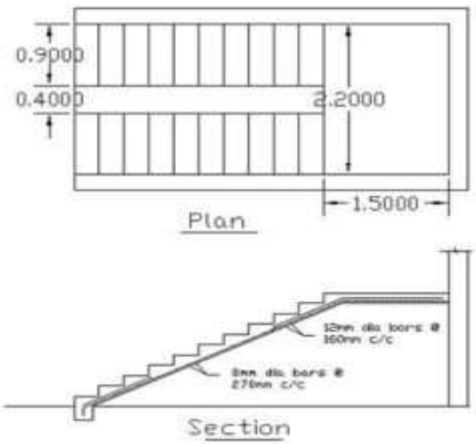
CLASSIFICATION OF STAIRS

1. STRAIGHT STAIR:



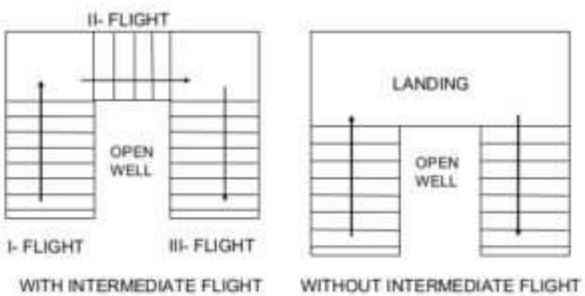
Straight Stair

2. DOGGED-LEGGED STAIR:



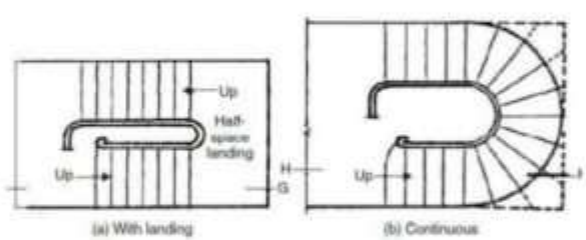
Dog-legged Stair

3. OPEN NEWEL STAIR:



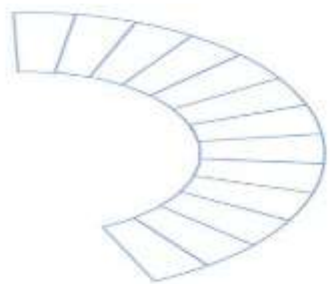
Open Newel Stairs

4. GEOMETRICAL STAIR:

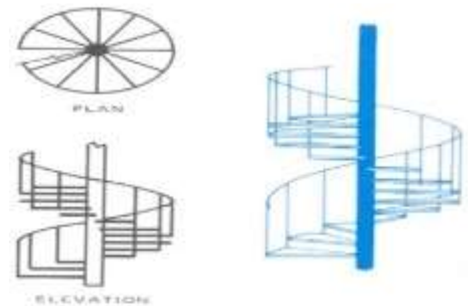


Geometrical Stair

5. CIRCULAR STAIR:

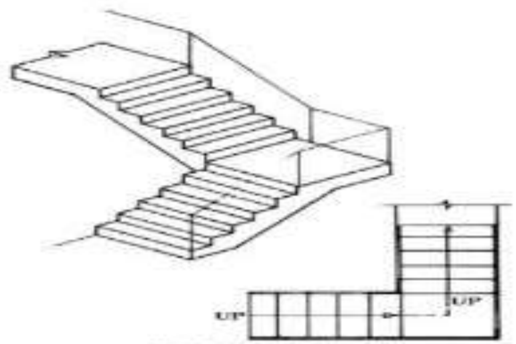


6. SPIRAL STAIR:



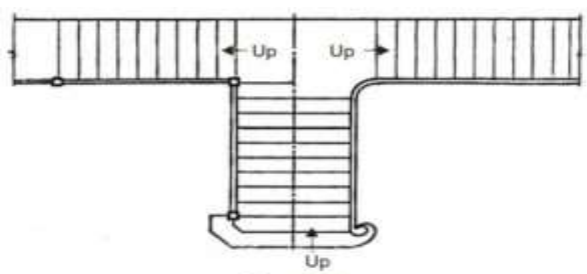
Spiral Stair

7. QUARTER-TURN STAIR:



Quarter-turn Stair

8. BIFURCATED STAIR:



Bifurcated Stair

Masonry

Masonry consists of building structures by laying individual **masonry** units (brick, concrete block, stone, etc). Normally the **masonry** units are laid with cement mortar, which binds them together to create a structure. **Masonry** construction can provide beautiful walls and floors at economical prices.

Brick masonry

Brick masonry is used for construction of buildings and other structures by using brick stone, stone blocks, brick blocks with different types of masonry.

Application of the Brick Masonry

Brick masonry has a number of practical application and can be used very conveniently at places like construction of ordinary as well as important building ,foundation,walls,columns,ornamental works ,circular brick work buttresses, retaining structures, window sills, jambs, corbels, coping, fire places, flumes, tall chimney,cavity walls,floors,arches,culverts,steps,etc.

Advantages of Brick masonry

- Since shape and size of bricks are uniform, it do not need skilled labour for the construction.
- Bricks are light in weight and hence handling them is easy.
- Bricks are easily available around cities and their transportation cost is less because their weight is less.
- It is possible to use all types of mortar in brick masonry.
- Thinner walls can be constructed with bricks but it is not so with stones.
- It is easy to form openings for doors and windows.
- Dead load of brick masonry is less.
- Brick masonry has better fire and weather resistance compared to stone masonry.

TECHNICAL TERMS USED IN MASONRY WORKS

1. HEADER:
It is a full brick or stone which is laid with its length perpendicular to the face of the wall.
2. STRETCHER:
It is a full brick or stone in which is laid its length parallel to the face of the wall.
3. BOND:
It is a term applied to the overlapping of bricks or stones in a wall in alternate courses, to bind the whole wall together.
4. COURSE:
A horizontal layer of bricks or stones is termed as course.
5. HEADER COURSE:
It is a course of brickwork entirely composed of headers.
6. STRETCHER COURSE:
It is a course of brickwork in which all the bricks are laid as stretchers.
7. BED:
It is a term used to indicate the lower surface of bricks or stones in each course. It may also be termed as surface of the bricks on which it rests.
8. FACE:
The surface of a wall exposed to weather is termed as face.
9. FACING:
The material used in the face of the wall is known as facing.
10. BACK:
The inner surface of the wall which is not exposed to the weather is termed as back.
11. BACKING:
The material used in forming the back of the wall is known as backing.
12. HEARTING:
The portion of a wall between facing and backing is termed as hearting.

13. JOINT:
The junction of two or more bricks or stones is called joint.

14. RACKING BACK:
The process of stopping the unfinished end of a wall in stepped fashion.

15. BAT:
It is a portion of a brick cut across the width or a brick cut by some fraction of its length.

16. CLOSER:
It is a portion of a brick cut in such a manner that its one long face remains uncut.

17. KING CLOSER:
It is a brick which is cut in such a way that the width of one of its end is half that of a full brick.

18. QUEEN CLOSER:
It is a term applied to a brick which is half as wide as full brick. Queen closer is made by cutting a brick lengthwise into two portions.

19. BEVELLED CLOSER:
It is similar to king closer with the only difference that the whole length of the brick is bevelled for maintaining half width at one end and full width at the other.

20. MITRED CLOSER:
It is a brick whose one end is cut splayed or mitred for the full width.

21. PERPEND:
It is a vertical joint on the face of a wall directly over vertical joints in an alternate course.

22. FROG:
It is a depression on the top face of a brick. Frog provides a recess for the mortar which on setting forms a key and prevents the displacement of the brick above.

23. PLINTH:
The horizontal projecting or flush course of stone or brick provided at the base of the wall above ground level is known as plinth.

24. SILL:
It is a horizontal member of brick, stone, concrete or wood provided to give support for the vertical members of a window.

25. JAMBS:
The vertical sides of a finished opening for door, window or fire place etc. are termed as jambs.

26. REVEALS:
Reveals are the exposed vertical surfaces left on the sides of an opening after the door or window frame has been fitted in position.

27. LINTEL:
A horizontal member of stone, brick, steel or RCC, used to support the masonry or load above an opening.

28. ARCH:
A mechanical arrangement of wedge-shaped blocks of stone or brick arranged in the form of a curve supporting the masonry or load above an opening.

29. CORNICE:
It is a horizontal moulded projection provided near the top of a building or at the junction of a wall and ceiling.

30. PARAPET:
It is a term applied to a low wall built around a flat roof to act as a protective solid balustrade for the users of the terrace.

31. WEATHERING:
Weathering is the term applied to the bevelled top surface of a stone.

32. GABLE:
It is a triangular shaped portion of masonry at the end of a sloped roof.

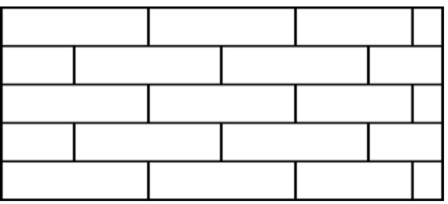
33. SPALLS:
Chips or small pieces of stone broken off a large block are termed as spalls.

34. COLUMNS:
It is an isolated vertical load bearing member whose width does not exceed four times its thickness.
35. PIER:
It is a vertical member of stone or brick masonry constructed to support an arch, beam or lintel etc.
36. BUTTRESS:
It is similar to pier built on the exterior of a wall properly bonded to it.
37. CORBEL:
It is the extension of one or more course of brick or stone from the face of a wall.
38. THRESHOLDS:
The arrangement of steps provided from ground level to reach plinth level on external doors and verandah is termed as thresholds.

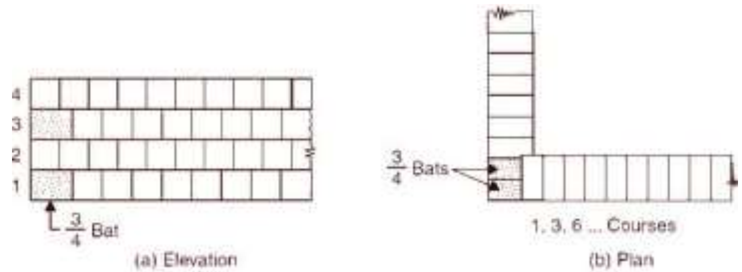
Types of Bonds in Brick Masonry Wall Construction :
The most commonly used types of bonds in brick masonry are:

1. Stretcher bond
2. Header bond
3. English bond
4. Flemish bond
5. Dutch bond
6. English cross bond
7. Brick on edge bond
8. Raking bond
9. Facing bond
10. Garden wall bond

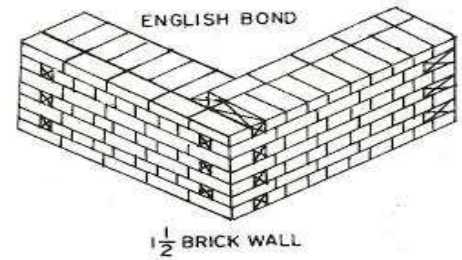
1.Stretcher bond



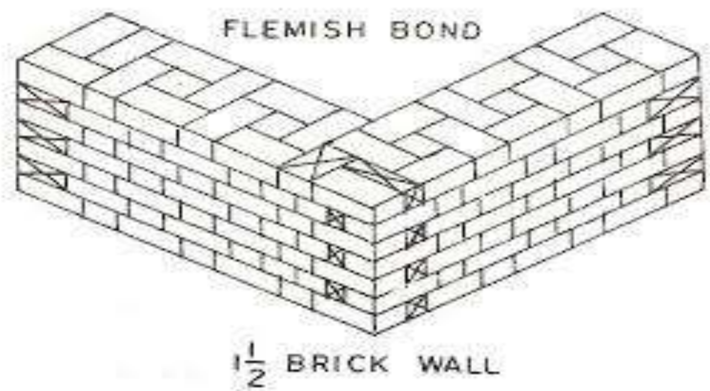
2. Header bond



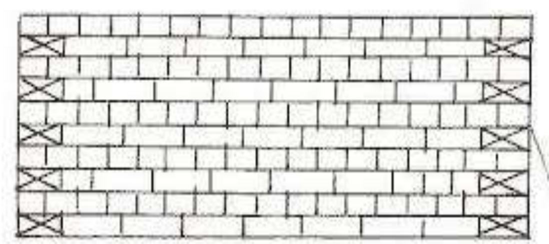
3. English bond



4. Flemish bond

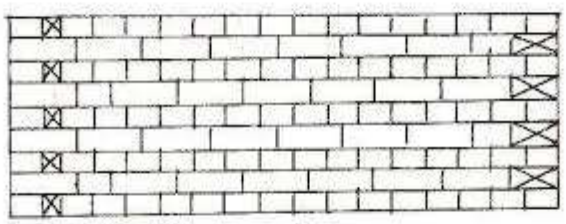


5.Dutch bond



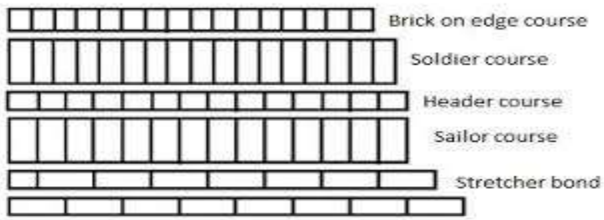
Elevation of a wall in Dutch bond

6.English cross bond

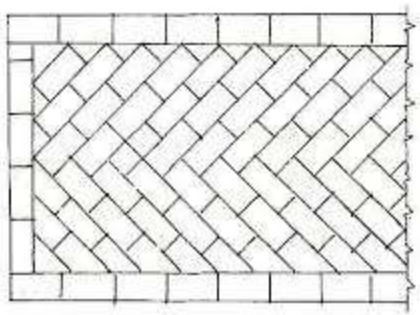


Elevation of wall in English cross-bond.

7.Brick on edge bond



8.Raking bond



Plan showing arrangement of bricks in Herring-bone bond.

10.Garden wall bond

Elevation of wall in Flemish garden wall bond

Stone masonry

The art of building the structures using stone blocks and mortar is termed as stone masonry is preferred where building stones are abundantly available in nature .These stones when cut and dressed to proper shape and size provide an economical material for the construction of various parts of the building in hilly terrains.

Glossary of terms

1. **Natural Bed**: The setting of the stone on the same plane as it was formed in the ground. This generally applies to all stratified materials.
2. **Bed**: The top or bottom of a joint; natural bed-surface of stone parallel to its stratification.
3. **Bedding plane.** The plane along which a stone can be separated, easily, is called bedding plane. Stones are laid in a structure so that load acts perpendicular to their bedding plane.
4. **Cornice.** The course of a masonry provided at ceiling level of the roof projecting outside the surface of the wall of a building, is called cornice.
5. **Throating.** A small groove cut on the underside of a projecting chuajja, cornice, coping, to discharge rain water without trickling to walls, is called throating.
6. **Coping**: A flat stone used as a cap on walls or around the perimeter of patios and pool decks.
7. **Template**: A detailed pattern or drawing showing exact dimensions to be fabricated.
8. **Bond stones**: Bond stones are generally cut to twice the bed thickness of the material being used.
9. **Reveals.** The exposed vertical surfaces perpendicular to window or door frame, are called reveals.
10. **Drip stone.** A projecting dressed stone having its undersurface throated, is called drip stone.

Classification of Buildings

Contents:

* Building structure.
* Non building structure.
* classification of buildings;
  - -> Based on occupancy.
  - -> Based on type of construction.

Building structure:

- A **building** structure is a man-made structure with a roof and walls standing more or less permanently in one place, such as a house or factory.

- Buildings are classified into two categories.

1) Based on the occupancy.
2) Based on the type of construction.

❖Buildings classified, ***based on the occupancy***:

Every building or portion of land shall be classified according to its use or the character of its occupancy as a building of Occupancy. They are categorized into the following types.

1) Agricultural buildings
2) Commercial buildings
3) Residential buildings
4) Educational buildings
5) Government buildings
6) Industrial buildings
7) Military buildings
8) Religious buildings
9) Transport buildings
10) Power plants

Educational buildings:

- This occupancy type shall include any building or portion thereof in which education, training and care are provided to children or adults. This occupancy shall be subdivided as follows :

Museum

School

Archive

library

Government buildings:

- It is a building that houses a branch of government.

Capitol

Embassy

Prison

Fire station

Post office

Agricultural buildings:

✓ They are the structures designed for farmers and for agricultural practices, for growing and harvesting crops, and to raise live stock.

barn

Chicken coop

Farm house

Residential buildings:

- ✓A **Residential** building is that, in which housing predominates, as opposed to industrial and commercial areas. building may vary significantly between, single-family building, multi-family **building**, or mobile homes.

Apartment

Villa

Bungalow

Nursing home

Commercial buildings:

- They are the buildings, which are used exclusively for commercial use.

Ware house

Bank

Convention centers

Gas stations

Automobile companies

Transport buildings:

- This is a structural building which consists of the means of equipment necessary for the movement of passengers or goods on land, water, and air ways.

Air port

Railway station

Parking garage

Light house

Bus station

Power stations/power plants:

- These buildings serve as the industrial facility to generate electric power.

Geo thermal power plant

Fossil fuel power plant

Nuclear power plant

Renewable energy power station

DOORS & WINDOWS

DOOR

A **door** is a moveable barrier secured in a wall opening.

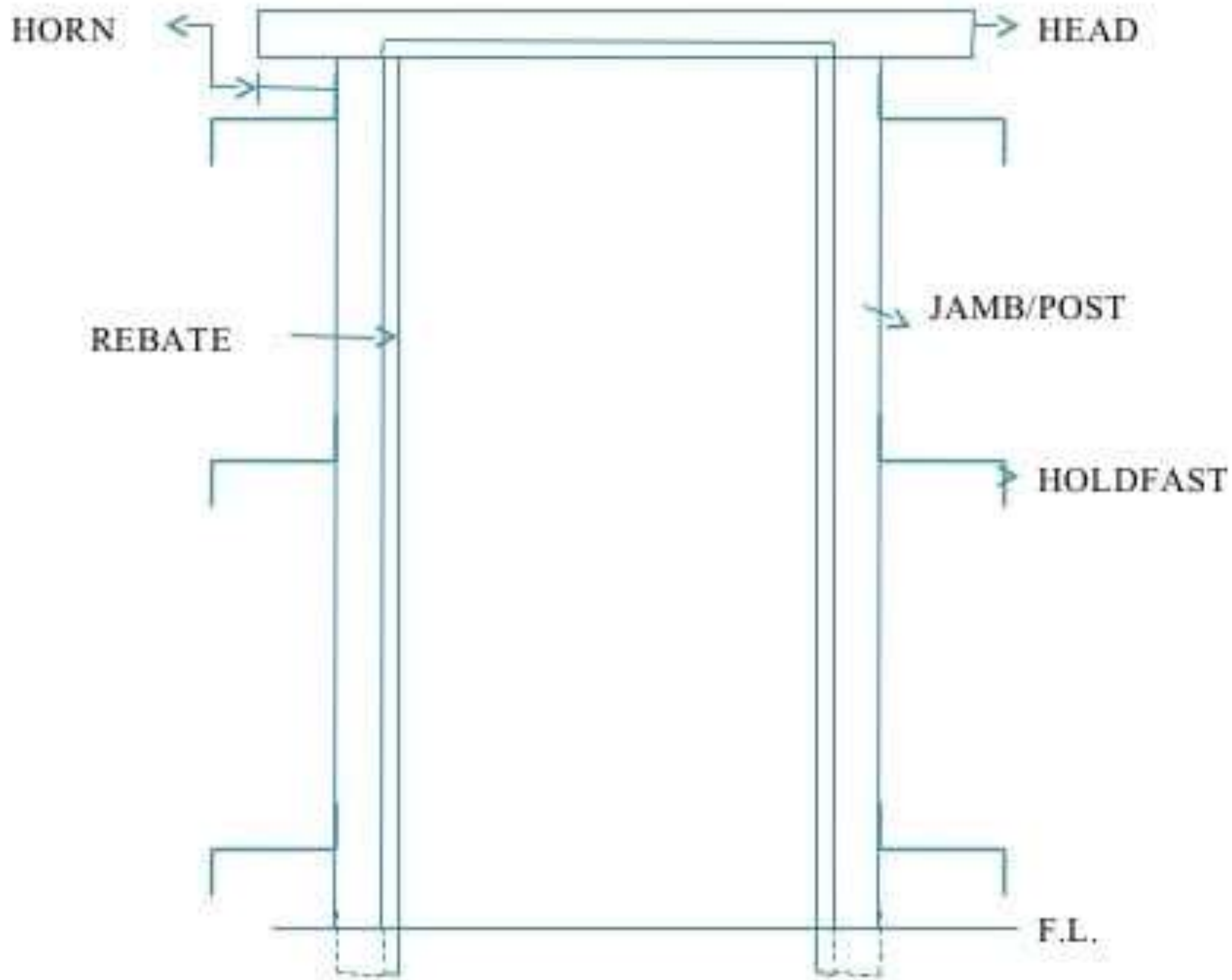
Functions:

1. They admit ventilation and light.
2. Controls the physical atmosphere within a space by enclosing it, excluding air drafts, so that interiors may be more effectively heated or cooled.
3. They act as a barrier to noise.
4. Used to screen areas of a building for aesthetic purposes, keeping formal and utility areas separate.

Components of a door:

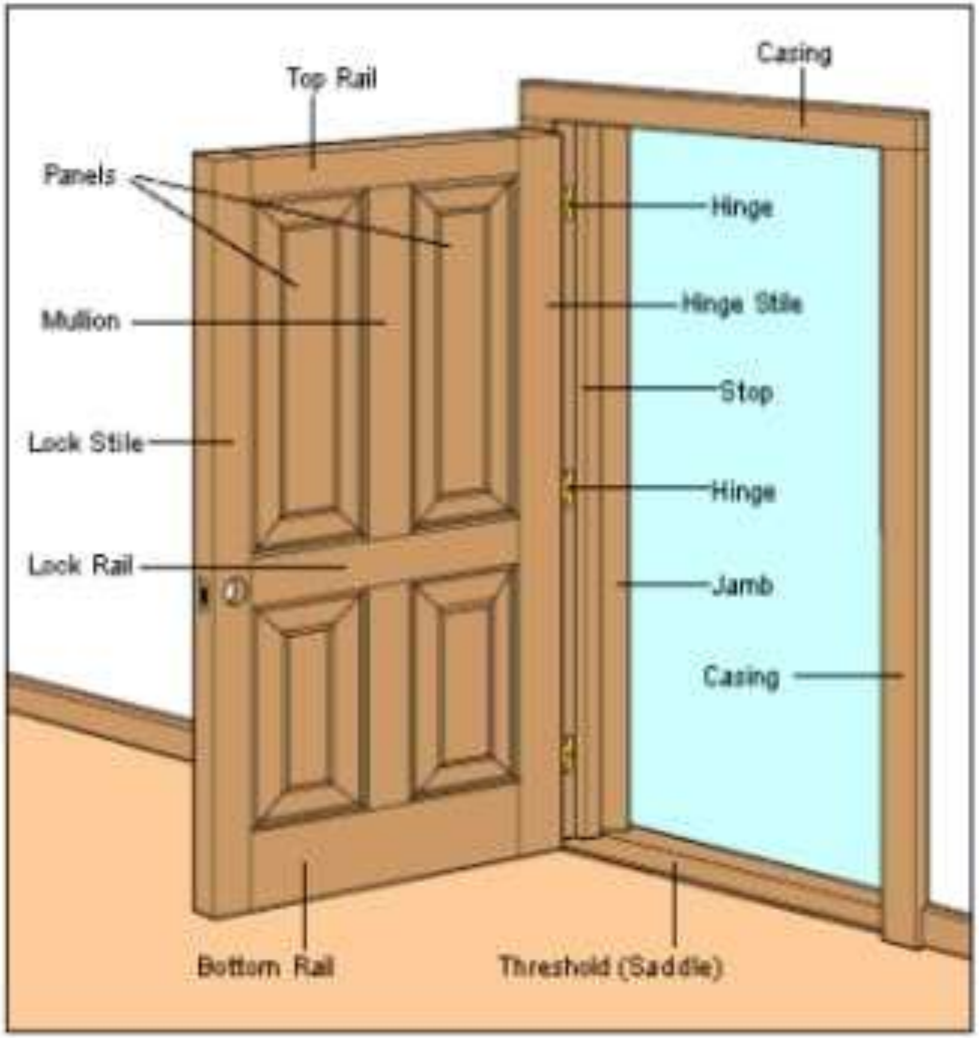
a) Door frame b) Door shutter

Door frame



Location of door in a building

- The number should be kept as minimum.
- It should meet the functional requirement.
- It should preferably be located at the corner of the room, nearly 20 cm from corner.
- If in a room, more than 2 doors are there, they shall be located facing each other.



Casing
Top Rail
Panels
Hinge
Hinge Stile
Mullion
Stop
Lock Stile
Hinge
Lock Rail
Jamb
Casing
Bottom Rail
Threshold (Saddle)

Sliding Window or Slider:

- Has two or more sashes that overlap slightly but slide horizontally within the frame.
- Suitable openings or grooves are left in the frame or wall to accommodate the shutters when are shutters are opened.

Types of Doors

On the basis of working operations

- Hinged doors
  - Battened type
  - Framed and paneled
  - Glazed/Sash
  - Flushed
  - Louvered
  - Wire-guage
- Revolving doors
- Sliding doors
- Swing doors
- Collapsible doors
- Rolling shutter

DOOR FRAMES

Materials used for door frames

- Timber
- Steel
- Aluminium
- Concrete
- Stone

SIZES OF DOORS

The common width-height relations used:

- Width = 0.4 – 0.6 Height
- Height = (width +1.2)m

General sizes used:

a) Residential

External door – 1.0 x 2.0 to 1.1 x 2.0 m

Internal door - 0.9 x 2.0 to 1.0 x 2.0 m

Bath & WC – 0.7 X 2.0 to 0.8 x 2.0 m

Garages for cars – 2.25 x 2.25 m to 2.40 x 2.25 m

b) Public

1.2 x 2.0 m **or** 1.2 x 2.1 m **or** 1.2 x 2.25 m

WINDOWS

Window details

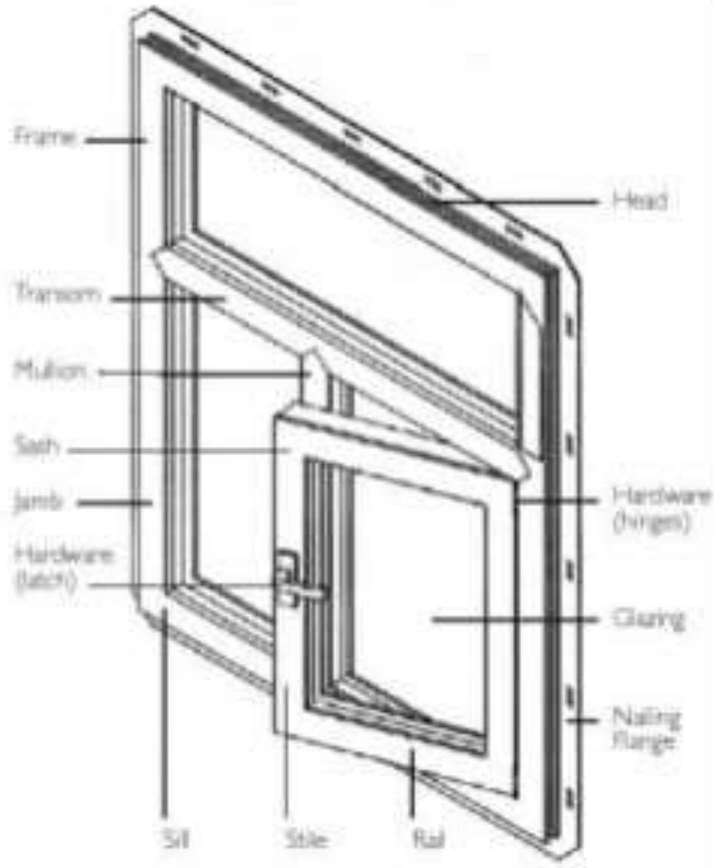


Figure 1 - Components of a window

TYPES OF WINDOWS

Fixed windows

- In this type, the glass pane is permanently fixed in the opening of the wall.
- The shutter can't be opened or closed.
- The function is limited to allowing light and or permit vision in the room.
- No rebates are provided to the frame.
- The shutters are fully glazed.
- In homes they are generally decorative windows near doors, stairwells and high-places or are used in combination with other styles.

- Glazed window

This is a type of casement window where panels are fully glazed.

The frame has styles, top rail and a bottom rail.

The space between top and bottom rail is divided into number of panels with small timber members called, sash bars or glazing bars.

The glass panels are cut 1.5-3.0 mm smaller in size than the panel size to permit movement of sash bars.

Glass panes are fixed to sash bars by putty or by timber beads.

Double-hung windows

- It has two panes, top and bottom that slide up and down in tracks called stiles.
- The most common used windows today. When open, these windows allow air flow through half of its size.
- The two parts are not necessarily the same size.
- Traditionally, each shutter is provided with a pair of counterweights connected by cord or chain over pulleys.
- When the weights are pulled, the shutters open to required level.
- It is possible to have controlled ventilation.
- Sash windows may be fitted with simplex hinges which allow the window to be locked into hinges on one side, while the rope on the other side is detached, allowing the window to be opened for escape or cleaning.
- Nowadays, most new double-hung sash windows use spring balances to support the sashes.