Brick

Composition of Good Brick Earth

Following are the constituents of brick earth:

1. Alumina

It is the chief constituent of every kind of clay. A good brick earth should contain about 20 to 30 per cent of alumina. This constituent imparts plasticity to earth so that it can be moulded.

2. Silica

- A good brick earth should contain about 50 to 60 per cent of silica. Presence of this constituent prevents cracking, shrinking and warping of raw bricks. It thus imparts uniform shape to the bricks.
- Excess of silica destroys the cohesion between particles and bricks become brittle.

3. Lime

- It should be present in a finely powdered state and not in lump.
- Lime prevents shrinkage of raw bricks. Sand alone is infusible. But it slightly fuses at kiln temperature in presence of lime.
- Excess of lime causes the brick to melt and hence, its shape is lost. Lumps of lime are converted into quick lime after burning and this quicklime slakes and expands in presence of moisture.

4. Oxide of Iron

- About 5 to 5 per cent is desirable in good brick earth. It helps lime to fuse sand. It also imparts red color to bricks.
- Excess of oxide of iron makes the bricks dark blue or blackish

5. Magnesia

A small quantity of magnesia in brick earth imparts yellow tint color to bricks and decreases shrinkage. But excess of magnesia leads to the decay of bricks.

Harmful Ingredients in Brick Earth

1. Lime

- It causes unsoundness in brick if present in excess amounts.

2. Iron pyrites

- If iron pyrites are present in brick earth, bricks are crystallized and disintegrated during burning.

3. Alkalies

These are mainly in the form of soda and potash

4. Pebbles

The presence of pebbles or grits of any kind is undesirable in brick earth because it will not allow the clay to be mixed uniformly and thoroughly which will result in weak and porous bricks.

5. Organic Matter

Presence of organic matter in brick earth assists in burning. But if such matter is not completely burnt, bricks become porous.

Manufacture of bricks

1. Preparation of clay

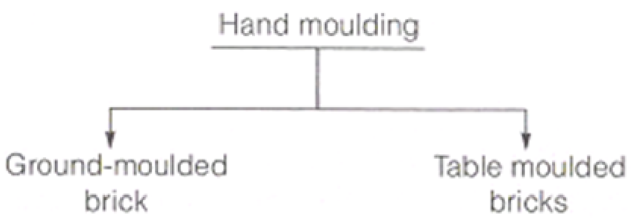
Clay of bricks is prepared in the following order:

i. Unsoiling
ii. Digging
iii. Cleaning
iv. Weathering
v. Blending
vi. Tempering

2. Moulding

Hand Moulding

- Machine Moulding



- Plastic Clay Machine
- Dry Clay Machine

3. Drying

4. Burning: Burning of bricks is done either in clamps or in kilns.

(a) Clamps: Its shape in plan is generally trapezoidal.

(b) Kilns: A kiln is a large over which is used to burn bricks. The kilns which are used in the manufacture of bricks are of the following two types.

(i) Intermittent kilns (ii) Continuous kilns

Tests For Bricks

1. Absorption

- A brick is taken and it is weighted dry. It is then immersed in water for a period of 16 hours.
- Then weight again and the difference in weight should not, in any case, exceed
  (a) 20 per cent of weight of dry brick for first class bricks.
  (b) 22.5 per cent for second class bricks.
  (c) 25 per cent for third class bricks.

2. Crushing strength

- Minimum crushing strength for first class bricks $\not< 10N/mm^2$ and for second class bricks $\not< 7.5N/mm^2$

3. Hardness

In this test, a scratch is made on brick surface with the help of a finger nail. If no impression is left on the surface, brick is treated to be sufficiently hard.

4. Presence of soluble salts

- Soluble salts, if present in bricks, will cause efflorescence on the surface of bricks.
- It is immersed in water for 24 hours. It is then taken out and allowed to dry in shade. Absence of grey or white deposits on its surface indicates absence of soluble salts.
- If the white deposits cover about 10% surface, the efflorescence is said to be slight.
- When white deposits cover about 50% of surface thin it is said to be moderate.
- If grey or white deposits are found on more than 50% of surface, the efflorescence becomes heavy and it is treated as serious.

5. Shape and Size

- Its shape should be truly rectangular with sharp edges.
- Standard size of brick is 19 cm x 9 cm x 9 cm and along with mortar is 20 cm X 20 cm X 20 cm.

6. Soundness

- In this test, two bricks are taken and they are struck with each other.
- Bricks should not break and a clear ringing sound should be produced.

7. Structure

- It should be homogenous compact and free from any defects such as holes, lumps, etc.
- High duty fire-clays can resist temperature range of 1482°C to 1648°C; medium duty fire-clays can resist temperature range of 1315°C to 1482°C and low duty fire-clays can resist temperature up to 870°C only.

Quality of Good Bricks

- The bricks should be table-moulded, well burnt in kilns, copper-coloured free from cracks and with sharp and square edges.
- The bricks should be uniform in shape and should be of standard size.
- The bricks should give a clear metallic ringing sound when struck with each other.
- The bricks when broken or fractured should show a bright homogeneous and uniform compact structure free from voids.
- The brick should be sufficiently hard. No impression should be left on brick surface, when it is scratched with finger hail.
- The bricks should not break into pieces when dropped flat on hard ground from a height of about one meter.
- The bricks, when soaked in water for 24 hour should not show deposits of white salts when allowed to dry in shade.
- No brick should have the crushing strength below 5.50 N/MM^2.

Classification of Bricks

The bricks can broadly be divided into two categories:

1. Unburnt Bricks: The unburnt or sun dried bricks are dried with the help of heat received from the sun after the process of moulding. These bricks can only be used in the construction of temporary and cheap structures. Such bricks should not be used at places exposed to heavy rains.

2. Burnt Bricks: These are classified in four categories:

i. **First Class Bricks**
   - These bricks are table-moulded and of standard shape and they are burnt in kilns.
   - The surfaces and edges of the bricks are sharp square smooth and straight.
   - First class bricks have all qualities of good bricks.
   - These bricks are used for superior work of permanent nature.

ii. **Second Class Bricks**
   - These bricks are ground moulded and they are burnt in kilns.
   - The surface of these bricks is somewhat rough and shape is also slightly irregular.
   - These bricks are commonly used at places where bricks work is to be provided with a coat of plaster.

iii. **Third Class Bricks**
   - These are ground moulded and they are burnt in clamps.
   - These bricks are not hard and they have rough surface with irregular and distorted edges.
   - These bricks gives dull sound when struck together.
   - They are used for unimportant and temporary structures.

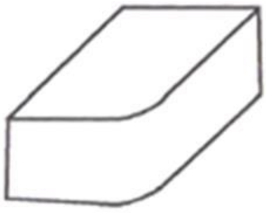
Size and Weight Of Bricks(For India)

- Standard size of bricks is 19 cm × 9 cm × 9 cm
- Normal size (with mortar) is 20 cm × 10 × 10 cm.
- The commonly adopted nominal size of traditional bricks is 23 cm × 11.4 cm × 7.6 cm.
- It is found that the weight of 1 m^3 of bricks earth is about 1800 kg. Hence the average weight of a brick will be about 3 to 3.50 kg.

Shape of Bricks

1. Bullnose Brick

- A brick moulded with a rounded angle is termed as a bullnose. It is used for a rounded quoin.
- A connection which is formed when a wall takes a turn is known as quoin.



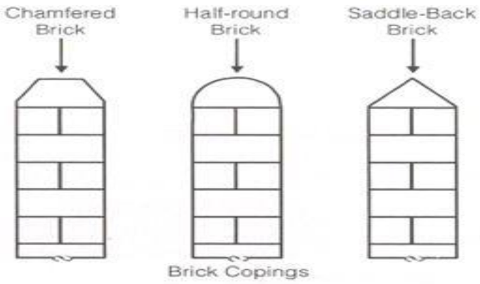
Bullnose Brick

2. Channel Bricks

- These bricks are moulded to the shape of a gutter or a channel and they are very often glazed.
- These bricks are used to function as drain.

3. Coping bricks

- These bricks are made to suit the thickness of walls on which coping is to be provided.



4. Cownose Bricks

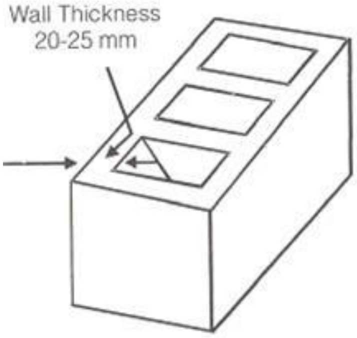
- A brick moulded with a double bulinose on end is known as cownose.

5. Curved Sector Bricks

- These bricks are in the form of curved sector and they are used in the construction of circular brick masonry pillars, brick chimneys.
- The perforation may be circular, square, rectangular or any other regular shape in cross-section.
- The water absorption after immersion for 24 hour in water should not exceed 15% by water.
- Compressive strength of perforated bricks should not be less than 7 N/mm^2 on gross area.

6. Hollow Bricks

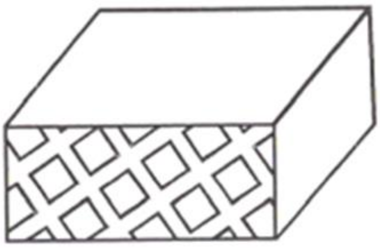
- These are also known as cellular or cavity bricks. Such bricks have wall thickness of about 20 mm to 25 mm. They are prepared from special homogeneous clay. They are light in weight about one third the weight of the ordinary bricks of the same size. The use of such bricks leads to speedy construction. They also reduce the transmission of heat, sound and damp. They are used in the construction of brick partitioning.



Hollow Brick

7. Paving bricks

- These bricks are prepared from clay containing a higher percentage of iron. Excess iron vitrifies the bricks at a low temperature. Such bricks resist better the abrasive action of traffic. Paving bricks may be plain or checkered.



Chequered Brick

8. Perforated Bricks

- Perforated bricks are used in the construction of brick panels for lightweight structures and multi-storeyed framed structures.

CEMENT

Introduction

- Cement is an extreme ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients.

Chemical Composition

- The identification of the major complex compounds is largely based on R.H. Bougue's work and hence these are called Bougue's compounds.

Constituents	Percentage	Average
Lime (CaO)	60 to 67%	63
Silica (SiO_2)	17 to 25%	20
Alumina (Al_2O_3)	3 to 8 %	6
Iron oxide (Fe_2O_3)	0.5 to 6%	3
Magnesia (MgO)	0.1 to 4%	2
Sulphur Trioxide (SO_3)	1 to 3%	1.5
Soda and Potash (Na_2O + K_2O)	0.5 to 1.3%	1

Bogue's Compounds

- **Bogues Compounds when** water is added to cement it react with the ingredients of the cement chemically & results in the formation of complex chemical compounds terms as BOGUES compounds. which are not for simultaneously.

- **Tri-Calcium Aluminate (3CaO.Al2O3 or C3A) -------------------------8-12%**
- **Tetra Calcium Alumino Ferrate (4CaO.Al2O3.Fe2O3 or C4AF)----6-10%**
- **Tri-Calcium Silicate (3CaO.SiO2 or C3S)--------------------------------30-50%**
- **Di-Calcium Silicate (2CaO.SiO2 or C2S)---------------------------------20-45%**

1. Tri-Calcium Aluminate (3CaO.Al2O3 or C3A)

- Formed in 24 hrs of addition of water
- Max. evolution of heat of hydration
- check setting time of cement

2. Tetra Calcium Alumino Ferrate (4CaO.Al2O3.Fe2O3 or C4AF)

- Formed within 24 hrs of addition of water
- High heat of hydration in initial periods

3. Tri-Calcium Silicate (3CaO.SiO2 or C3S)

- Responsible for initial strength of cement
- Contribute about 50-60% of strength

4. Di-Calcium Silicate (2CaO.SiO2 or C2S)

- Last compound formed during hydration of cement
- responsible for progressive later stage strength
- Structure requires later stages strength proportion of this component increase
- e.g. hydraulic structures, bridges.

Type of Cements

i. Ordinary Portland Cement
ii. Rapid Hardening Cement – **IS: 8041-1990**
iii. Extra Rapid Hardening Cement
iv. Low Heat Portland Cement - **IS: 12600-1989**
v. Portland Slag Cement – **IS: 455-1989**
vi. Portland Pozzolana Cement – **IS: 1489-1991 (Part 1 and 2)**
vii. Sulphate Resisting Portland Cement – **IS: 12330-1988**
viii. White Portland Cement – **IS: 8042-1989**
ix. Coloured Portland Cement - **IS: 8042-1989**
x. Hydrophobic Cement - **IS: 8043-1991**
xi. High Alumina Cement - **IS: 6452-1989**
xii. Super Sulphated Cement - **IS: 6909-1990**
xiii. Special Cements
    a. Masonry Cement
    b. Air Entraining Cement
    c. Expansive Cement
    d. Oil Well Cement

Field Tests For Cement

- **Colour:** Grey colour with a light greenish shade.
- **Physical Properties:** Cement should feel smooth when touched between fingers.
- If hand is inserted in a bag or heap of cement, it should feel cool.
- If a small quantity of cement is thrown in a bucket of water, it should sink and should not float on the surface.
- **Presence of lumps:** Cement should be free from lumps.
- **Permissible Limits for Impurities in Water**

Impurity	**Permissible Limits**
Organic	200 mg/L
Inorganic	3000 mg/L
Sulphates (SO_3)	400 mg/L
Chlorides (CI)	2000 mg/L for plain concrete work, 500 mg/L for reinforced concrete work
Suspended matter	2000 mg/L

Laboratory Tests For Cement

1. Chemical Composition Test

- Ratio of percentage of lime to percentage of silica, alumina and iron oxide known as Lime Saturation Factor (LSF), when calculated by the formula shall not be greater than 1.02 and not less than 0.66.

$$\frac{CaO - 07SO_3}{(28SiO_2 + 12Al_2O_3 + 0.65Fe_2O_3)}$$

- Ratio of percentage of alumina (al_2O_3) to that of iron oxide (Fe_2O_3) shall not be less than 0.66
- Weight of insoluble residue shall not be more than 4 per cent.
- Weight of Magnesia Shall not be more than 6 per cent
- Total loss on ignition shall not be more than 5 per cent.
- Total sulphur content calculated as sulphuric anhydride shall not be more than 2.5% when C_3A is 5% or less and shall not be more than 3% when C_3A is more than 5%

2. Normal Consistency Test

- The normal (standard) consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate a depth of 33 to 35 mm from the top (or 5 to 7 mm from the bottom) of the mould.
- **Vicat Apparatus:** Vicat apparatus assembly consists of a plunger 300 gm in weight with a length of 50 mm and diameter of 10 mm and a mould which is 40 mm deep and 80 mm in diameter.

3. Initial Setting Time Test

When water is added to cement, the resulting paste starts to stiffen and gain strength and lose the consistency simultaneously. The term setting implies solidification of the plastic cement paste. Initial and final setting times may be regarded as the two stiffening states of the cement. The beginning of solidification, called the initial set, marks the point in time when the paste has become unworkable

- Initial setting time should not be less than 30 minutes for OPC and 60 minutes for low heat cement.

4. Final Setting Time Test

The final setting time is the time after which the paste becomes so hard that the angular attachment to the needle, under standard weight, fails to leave any mark on the hardened concrete. Initial and final setting times are the rheological properties of cement.

- The final setting time should not be more than 10 hours.

5. Soundness Test

- The soundness of cement is determined either by 'Le Chatelier's method' or by means of a 'Autoclave' test.
- No satisfactory test is available for deduction of soundness due to excess of calcium sulphate. But its content can be easily determined by chemical analysis.
- Le Chatelier's Method
- Autoclave Test

6. Strength Test

(a) Compressive Strength Test

- Three cubes are tested for compressive strength at 1 day, 3 day, 7 days and 28 day where the period of testing being reckoned from the completion of vibration.
- The compressive strength shall be the average of the strengths of the three cubes for each period respectively.
- The compressive strength of 33 grade OPC at 3 day and 28 day is 16 MPa, 22 MPa and 33 MPa respectively.

(b) Tensile Strength Test

- Six briquettes are tested and average tensile strength is calculated.
- A load is applied steadily and uniformly, starting from zero and increasing at the rate of 0.7 N/mm^2 in 12 seconds.
- OPC should have a tensile strength of not less than 2 MPa and 2.5 MPa after 3 and 7 days respectively.
- Generally, tensile strength is 10-15% of compressive strength.

7. Fineness Test: There are three methods for testing fineness viz.

(a) Sieve Method

- 100 gm of cement sample is taken and air set lumps, if any, in the sample are broken with fingers.
- The sample is placed on a 90 micron sieve and continuously sieved for 15 minutes.
- The residue should not exceed the limits specified below:

	Type of cement	% Residue by weight
(i)	Ordinary Portland cement	10
(ii)	Rapid hardening cement	5
(iii)	Portland Pozzolana cement	5

(b) Air Permeability Method

- Fineness of cement is represented by specific surface i.e. total surface area in cm^2 per gram of cement.

(c) Wagner Turbidimeter Test

- The cement is dispersed uniformly in a rectangular glass tank filled with kerosene.
- Parallel light rays are passed through the solution which strike the sensitivity plate of a photoelectric cell.

8. Heat of hydration Test

- The apparatus used to determine the heat of hydration of cement is known as **calorimeter**.
- The heat of hydration for low heat Portland cement should not be more than 66 and 75 cal/gm for 7 and 28 days respectively.

9. Specific Gravity Test

- The specific gravity of cement is obtained by using **Le Chatelier's flask**.

CONCRETE

Water-cement Ratio

Important properties of water to be used for cement concrete are:

- Content of organic solids not more than 0.02%
- Content of inorganic solids not more that 0.30%
- Content of sulphates not less than 0.05%
- Content of sulphate alkali chlorides not more than 10%
- Turbidity not more than 2000 ppm.
- Acid not more than 10,000 ppm.
- pH should be between 4.5 to 8.5.

Abram's water-cement ratio law

- This law states that for any given conditions of test the strength of workable concrete mix is dependent only on the water cement ratio. It means that if the concrete is fully compacted, the strength is not affected by aggregate shape, type or surface texture or the aggregate grading. According to this law, the strength of mix increases with decrease in water content.

Workability of Concrete

- Workability is the amount of work to produce full compaction.
- The important facts in connection with workability are:

(i) If more water is added to attain the required degree of workmanship, it results into concrete of low strength and poor durability.

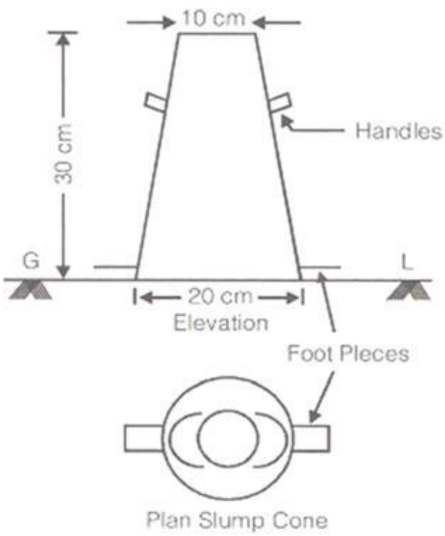
(ii) If the strength of concrete is not to be affected, the degree of workability can be obtained:

- by slightly changing the proportions of fine and coarse aggregates, in case the concrete mixture is too we; and
- by adding a small quantity of water cement paste in the proportion of original mix, in case the concrete mixture is too dry.

(iii) The workability of concrete is also affected by the maximum size of the coarse aggregates to be used in the mixture.

Slump Test

- Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work.
- It is not a suitable method for very wet or very dry concrete and stiff mix.



Recommended Slumps of Concrete

No.	Type of Concrete	Slump
1.	Concrete for road construction	20 to 40 mm
2.	Beams and slabs	50 to 100 mm
3.	Normal RCC work	80 to 150 mm
4.	Mass concrete	25 to 50 mm
5.	Concrete to be vibrated	10 to 25 mm
6.	Impermeable work	75 to 120 mm

Compaction Factor Test

- In the compaction factor test the degree of workability is measured in terms of internal energy required to compact the concrete thoroughly.
- A compaction factor of 0.95 represents flowing concrete having high workability; 0.92 plastic concrete having medium workability; 0.85 stiff plastic concrete having low workability and a compaction factor of 0.75 represents stiff concrete having very low workability.
- The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field.
- The degree of compaction called the compacting factor is measured by the density ratio i.e., the ratio of the density actually achieved in the test to density of same concrete fully compacted.

Degree of workability	Slump (mm)	Compacting factor		Use for which concrete is suitable
		Small apparatus	Large apparatus	
Very low	–	0.78	0.80	Roads vibrated by power-operated machines. At the more workable end of this group, concrete may be compacted in certain cases with hand-operated machines.
Low	25 – 75	0.85	0.87	Roads vibrated by hand-operated machines. At the more workable end of this group, concrete may be manually compacted in roads using aggregate of rounded or irregular shape. Mass concrete foundations without vibration or lightly reinforced sections with vibration.
Medium	50-100	0.92	0.935	At the less workable end of this group, manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibration.
High	100-150	0.95	0.96	For sections with congested reinforcement. Not normally suitable for vibration, for pumping and tremle placing.
Very high	–	–	–	Flow table test is more suitable.

Vee-Bee Test

- This test is preferred for finding workability of stiff concrete mix having very low workability.
- In this test a Vee-Bee time of 5 to 3 seconds represent stiff plastic concrete having medium workability, 10 to 15 seconds represents stiff concrete of low workability and Vee-Bee time to 18 to 10 seconds represent very stiff concrete having very low workability.

Vee Bee Consistometer

- This test consists of a vibrating table, metal pot, a sheet metal concrete a standard iron rod.
- The time required for the shape of concrete to change from slump concrete shape to cylindrical shape in second is known as Vee Bee Degree.

- This method is very suitable for very dry concrete whose slump value cannot be measured by slump test but the vibration is too vigorous for concrete with a slump greater than about 50 mm.

Flow Test

- This is a laboratory test which gives an indication of the quality of concrete with respect to consistency cohesiveness and the proneness to segregation.
- The spread or the flow of the concrete is measured and this flow is related to workability.

- **Defects in concrete**

Bleeding of Concrete

If excess water in the mix comes up at the surface causing small pores through the mass of concrete, it is called bleeding.

Segregation

It is caused when coarse aggregate is separated out from the finer materials resulting in large voids, less durability and less strength.

Water-proofing Cement Concrete

- Cement concrete to a certain extent may be made impermeable to water by using hydrophobic cement.

Lightweight Concrete

The bulk density of ordinary concrete is about 2300 kg/m^3. Concrete having bulk density between 500 to 1800 kg/m^3 is known as lightweight concrete and it is prepared from the following materials:

1. **Binding material**
2. **Aggregates**
3. **Steel**

IS 456 Guidelines

For **Min. Cement Content**, **Min./Max.** Grade **of Concrete** & **Max. W/C Ratio** for **Plain** and **Reinforced** Cement Concrete **for Different Exposures** with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 and 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in **5.2**. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

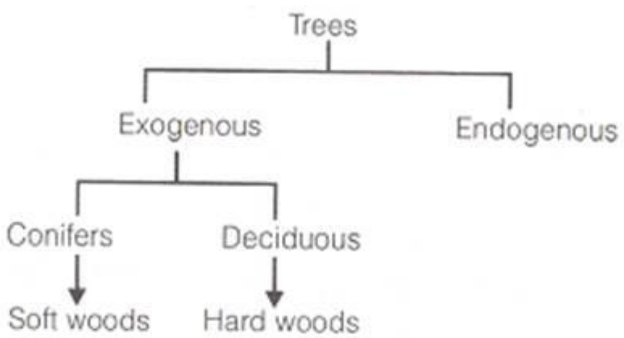
2 Minimum grade for plain concrete under mild exposure condition is not specified.

Timber, Lime and other Materials

Timber

Classification of trees

- Trees are classified according to their mode of growth. Following is the classification of trees:



1. Exogenous Trees

- Conifers are also known as evergreen trees and leaves of these do not fall till new ones are grown. As these bear cone-shaped fruits, they are given the name conifers. These trees yield soft woods.

- Deciduous trees are also known as broadleaf trees and leaves of these trees fall in autumn and new ones appear in spring season. Timber for engineering purposes is mostly derived from deciduous trees. These trees yield hard woods.

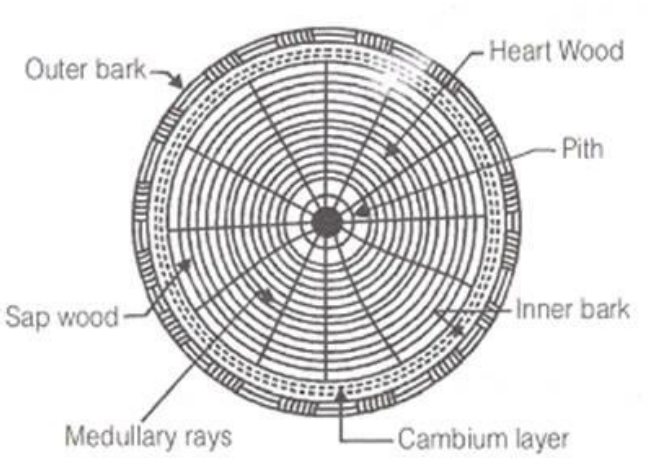
2. Endogenous Trees

These trees grow inwards and fibrous mass is seen in their longitudinal sections. Timber from these trees has very limited engineering applications. Examples of endogenous trees are bamboo, cane, palm, etc.

STRUCTURE OF A TREE

From the visibility aspect, the structure of a tree can be divided into two categories:

1. Macrostructure



Cross-section of an exogenous tree

2. Microstructure

- Wood consists of living and dead cells of various sizes and shapes.
- A living cell consists of four parts, namely (i) membrane, (ii) protoplasm (iii) sap (iv) core. Cell membrane consists mainly of cellular tissue and cellulose. Protoplasm is a granular, transparent viscous vegetable protein composed of carbon, hydrogen, oxygen nitrogen and sulphur. Core of cell differs from protoplasm merely by the presence of phosphorus and it is generally oval.
- **Age of trees for felling:** The age of good trees for felling varies from 50 to 100 years.
- **Season for felling:** In autumn and spring, sap is in vigorous motion and hence, felling of trees in these seasons should be avoided. For hilly areas, mid-summer would be the proper season for felling as there is heavy rainfall in winter. For plain areas, mid-winter would be the proper season for felling as in summer, water contained in sap would be easily evaporated and it will lead to the formation of cracks.

DEFECTS IN TIMBER

Defects occurring in timber are grouped into the following five divisions.

1. **Defect Due to Conversion**
    i. Chip mark
    ii. Diagonal grain
    iii. Torn grain
    iv. Wane
2. **Defects Due to Fungi**
    i. Blue Stain
    ii. Brown Rot
    iii. Dry Rot
    iv. Heart rot
    v. Sap Stain
    vi. Wet Rot
    vii. White Rot
3. **Defects Due to Insects**
    i. Beetles
    ii. Marine Borers
    iii. Termites
4. **Defects Due to Natural Forces**
    i. Burls
    ii. Callus
    iii. Chemical stain
    iv. Coarse grain
    v. Dead wood
    vi. Druxiness
    vii. Foxiness
    viii. knots
    ix. Rind galls
    x. Shakes
    xi. Twisted fibres
    xii. Upsets
    xiii. Water stain
    xiv. Wind cracks
5. **Defects Due to Seasoning**

    Follow defects occur in seasoning process of wood.

    i. Bow
    ii. Case-hardening
    iii. Check
    iv. Collapse
    v. Cup
    vi. Honey-combing
    vii. Radial shakes
    viii. Split
    ix. Twist
    x. Warp

PRESERVATION OF TIMBER

Preservation of timber is carried out to achieve the following three objects:

- To increase the life of timber structures
- To make the timber structures durable, and
- To protect the timber structures from the attack of destroying agencies such as fungi, insects, etc.

Requirements of a Good Preservative

- It should allow decorative treatment on timber after being applied over timber surface.
- It should be capable of covering a large area with small quantity.
- It should be cheap and easily available.
- It should be free from unpleasant smell.
- Its penetrating power into wood fibres should be high. It is necessary for the preservative to be effective to penetrate at least for a depth of 6 mm to 25 mm.

Types of Preservatives

1. **Ascu Treatment**
    - Ascu is special preservative which is developed at the Forest Research Institute, Dehradun. Its composition is as follows.
    - X-Part by weight of hydrated arsenic pentoxide, ($As_2O_5.2H_2O$).
    - Y-Part by weight of blue vitriol or copper sulphate, ($CuSO_4.5H_2O$).
    - Z-Part by weight of potassium dichromate ($K_2Cr_2O_7$) or sodium dichromate ($Na_2Cr_2O_7.2H_2O$)
2. **Chemical Salts**
3. **Coal Tar**
4. **Creosote oil**
5. **Oil Paints**
6. **Solignum Paints**

Method for Preservation

There are six Methods Adopted for Preservation of Timber:

1. **Brushing**
2. **Charring**
3. **Dipping and Steeping**
4. **Hot and Cold Open Tank Treatment**
5. **Injecting Under Pressure**
6. **Spraying**

FIRE RESISTANCE OF TIMBER

1. **Application of Special Chemicals**
2. **Sir Abel's Process**

SEASONING OF TIMBER

1. **Object of Seasoning**
    - To allow timber to burn readily, if used as fuel.
    - To decrease the weight of timber and thereby to lower the cost of transport and handling.
    - To make timber safe from the attack of fungi and insects.
    - To reduce the tendency of timber to crack, shrink and warp.
    - To make timber fit for receiving treatment of paints, preservatives, varnishes.
    - To import hardness, stiffness, strength and better electrical resistance to timber.

2. **Methods of Seasoning**

(a) Natural Seasoning

In this method, the seasoning of timber is carried out by natural air and hence it is also sometimes referred to as air seasoning.

Advantage

- It does not require skilled supervision
- This method of seasoning timber is cheap and simple.
- It is uneconomical to provide artificial seasoning to timber sections thicker than 100 mm, as such sections dry very slowly.

Disadvantage

- As the process depends on the natural air, it sometimes becomes difficult to control it
- The drying of different surface may not be even and uniform.
- If ends of thick sections of timber are not projected by suitable moisture proof coating, there are chances for end splitting.

(b) Artificial Seasoning

- Following are the reasons for adopting the artificial seasoning to the natural seasoning.

A. The defects such as shrinkage, cracking and warping are minimized.
B. The drying is controlled and there are practically no chances for the attack of fungi and insects.
C. The drying of different surface is even and uniform.
D. It considerably reduces the period of seasoning.
E. There is better control of circulation of air, humidity and temperature.

i. **Boiling**
   In this method of artificial seasoning, timber is immersed in water and water is then boiled. But it affects the elasticity and strength of wood.
ii. **Chemical seasoning**
   This is also known as salt seasoning. In this method, timber is immersed in a solution of suitable salt. It is then taken out and seasoned in the ordinary way.
iii. **Electrical seasoning**

- In this method, use is made of high frequency alternating currents.
- This is the most rapid method of seasoning.
- Due to high cost this method is unecomonical.

iv. **Klin Seasoning**

- In this method, drying of timber is carried out inside an airtight chamber or oven.

v. **Water Seasoning**

- Timber pieces are immersed wholly in water, preferably in running water of a stream. Care should be taken to see that timber is not partly immersed.
- Timber is taken out after a period of about 2 to 4 weeks. During this period, sap contained in timber is washed away by water.

Lime

Some Basic Definitions

1. **Calcination:** The heating of limestone to redness in contact with air is known as the calcinations.
2. **Hydraulicity:** It is the property of lime by which it sets or hardens in damp places, water or thick masonry walls where there is no free circulation of air.
3. **Quick Lime:** The lime which is obtained by the calcination of comparatively pure limestone is known as the quick lime or caustic lime. It is capable of slaking with water and has no affinity for carbonic acid.
    - Its chemical composition is (CaO) oxide of calcium and it has great affinity for moisture.
    - The quick lime as it comes out from kilns is known as the lump lime.
4. **Setting:** The process of hardening of lime after it has been converted into paste form is known as the setting. It is quite different from mere drying.
5. **Slaked Lime** The product obtained by slaking of quick lime is known as the slaked lime or hydrate of lime. It is in the form of white powder and its chemical composition is $Ca(OH)_2$ or hydrated oxide of calcium.

$$\underset{\text{Quick Lime}}{CaO} + \underset{\text{water}}{H_2O} \rightarrow \underset{\text{(Hydrated Lime)}}{Ca(OH)_2 + \text{Heat}}$$

6. **Slaking:** When water is added to the quick lime in sufficient quantity a chemical reaction takes place.
    - Due to this chemical reaction the quick lime cracks, swell and falls into a powder form which is the calcium hydrate Ca $(OH)_2$ and it is known as the hydrated lime.
    - This process is known as the slaking.

Classification of Limes

1. **Fat Lime:** This lime is also known as the high calcium lime. Pure Lime, rich lime or white lime. It is popularly known as the fat lime as it slakes vigorously and its volume is increased to about 2-2-5 times the volume that of quick lime. The percentage of impurities in such limestone is less than 5%.

2. **Hydraulic Lime:** This lime is also known as the water lime as it sets under water. It contains clay and some amount of ferrous oxide. Depending upon the percentage of clay present the hydraulic lime is divided into following three types.
    1. Feebly hydraulic lime
    2. Moderately hydraulic lime
    3. Eminently hydraulic lime

The hydraulic lime can set under water and in thick walls where there is no free circulation of air.

3. **Poor Lime:** This lime is also known as the impure or lean lime. It contains more than 30% of clay. It slakes very slowly.

Impurities in Limestones

1. **Magnesium carbonate**
    - The magnesium limestones are hard, heavy and compact in texture.
    - The magnesium limestones display irregular properties of calcination, slaking and hardening.
    - Upto 5% of magnesium oxide imparts excellent hydraulic properties to the lime.
2. **Clay**
    - It is mainly responsible for the hydraulic properties of lime.
    - The percentage of clay to produce hydraulicity in time stone usually varies from 10 to 30.
    - Limes containing 3-5 per cent of clay do not display any hydraulic property and do not set and harden under water.
3. **Silica:** In its free form it has a detrimental effect of the properties of lime.
4. **Iron Compounds**
    - Iron occurs in small proportions as oxides, carbonates and sulphides.
    - Pyrite or iron sulphide is regarded to be highly undesirable.
    - For hydraulic limes 2-5 per cent of iron oxide is necessary.
5. **Sulphates:** Sulphates if present slow down the slaking action and increase the setting rate of limes.
6. **Alkalis:** When pure lime is required the alkalis are undesirable. However, up to 5 per cent of alkalis in hydraulic lime do not have any ill effect.

Mortar

Some Basic Definition

- Building mortar is defined as a mixture of cement, sand and water.
- Mortar is similar to concrete but it does not contain coarse aggregate.
- Mortar are used for filling joints as a binder in stone and brick masonry.

Bulking of Sand

- In the case of aggregates there is another effect of the presence of moisture viz. bulking which is an increase in the volume of a given mass of sand (fine aggregate) caused by the films of water pushing the sand particle apart. For a moisture content of about 5-8% this increase of volume may be as much as 20-40% depending upon grading of sand.
- Finer the materials more will be the increase in volume for a given moisture content.

Classification of Mortars

- Mortars are classified on the basis of the following:
- Bulk density
- Kind of binding materials
- Nature of application
- Special mortars

Properties of Good Mortar Mix and Mortar

The important properties of a good mortar mix are mobility, place ability and water retention.

- **Mobility**
- It is used to indicate the consistency of mortar mix which may range from stiff to fluid.
- The mobility of mortar mix depends on the compositions of mortar and the mortar mixes to be used for masonry work are made sufficiently mobile.
- **Placeability**
- The placeability of mortar mix should be such that a strong bond is developed with the surface of the bed.

Properties of a Good Mortar

- It should be capable of developing good adhesion with the building units such as bricks, stones etc.
- It should be capable of developing the designed stresses.
- It should be cheap
- It should be durable.
- It should be easily workable.
- It should set quickly so that speed in construction may be achieved.

Uses of Mortar

- To bind the building units such as bricks, stones.
- To carry out pointing and plaster work on exposed surfaces of masonry.
- To form an even and soft bedding layer for building units.
- To form joints of pipes.
- To hide the open joints of brickwork and stonework.
- To improve the general appearance of structure.

Functions of Sand in Mortar

1. Bulk
2. Setting
3. Shrinkage
4. Strength

Tests for Mortars

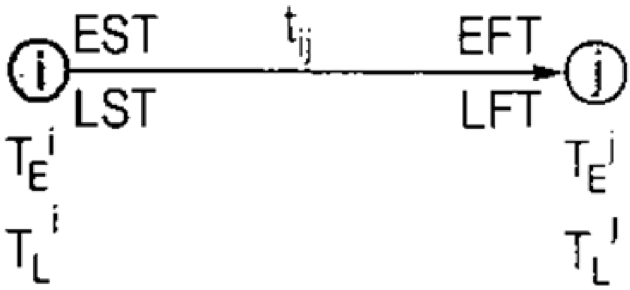
1. **Adhesiveness to Building Units:** Mortar is placed to join them so as to from a horizontal joint. If size of bricks is 19 cm x 9 cm x 9, a horizontal join of 9 cm x 9 cm = 81 cm^2 will be formed. Ultimate adhesive strength of mortar per cm^2 area is obtained by dividing maximum load with = 81 cm^2 area.
2. **Crushing Strength:** Brick masonry or stone masonry laid in mortar to be tested are crushed in compression machine. The load at which the masonry crushes gives the crushing strength
3. **Tensile Strength:** The briquettes are tested in a tension testing machine. Cross-sectional area of central portion is 38 mm x 38 mm or 1444 mm^2 or 14.44 cm^2.

Network Analysis - CPM

Critical Path Method(CPM)

1. A network diagram in CPM is activity oriented.
2. Cost is the most important criteria. Minimum is found corresponding to optimum time.
3. There is only single time estimate for each activity.
4. The probability of completion of activity in this estimated duration is 100%.
5. It is based on deterministic approach.
6. Suitable for repetitive type of work.
7. Normal distribution is followed.

Activity times



(i) Earliest start time $EST = T_E^i$

(ii) Earliest start time

EFT = EST + Activity time

$$EST = T_E^i + t_{ij}$$

(iii) Latest finish time

LFT = T_L of head event

$$LFT = T_L^j$$

(iv) Latest finish time

LST = LFT - t_{ij}

$$LST = T_L^j - t_{ij}$$

Float

Float denotes the range within which activity time or its finish time may fluctuate without effecting the completion of the project.

(i) Total Float (F_T):

F_T = LST – EST or F_T = LFT – EFT

$$F_T = T_L^j - T_E^i - t_e^{ij}$$

(ii) Free Total (F_F):

$$F_T = T_E^i - T_E^i - t_e^{ij} \text{ Or } F_F = F_T - S_j$$

Where S_j = Head event slack

(iii) Independent Float (F_{ID}):

$$F_{ID} = T_E^j - T_L^i - t_e^{ij}$$

$$F_{ID} = F_F - S_i$$

$$F_{ID} = F_T - S_i - S_i$$

Where S_i = Tail event slack

$F_T = 0$ – for critical path $F_T > 0$ –for subcritical path

$F_T < 0$ – for Supercritical path

(iv) Interfering float (F_{IN})

It is the another name of head event slack.

$$F_{IN} = S_j = F_T - F_F$$

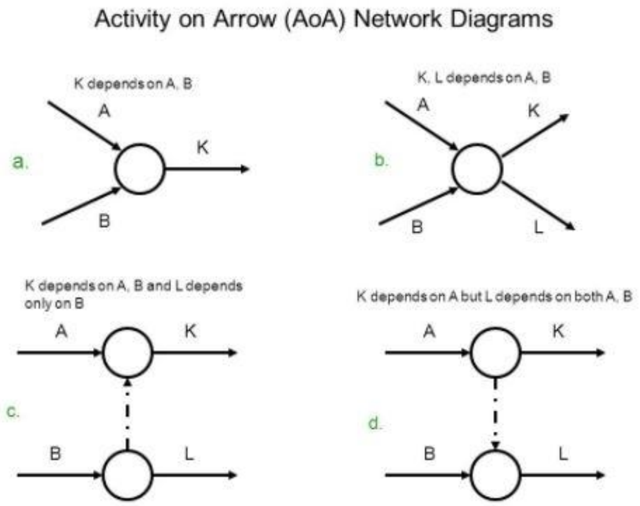
CPM Systems

Mainly two systems are used in CPM analysis:

1. **A-O-A System** (Activity on arrow system)

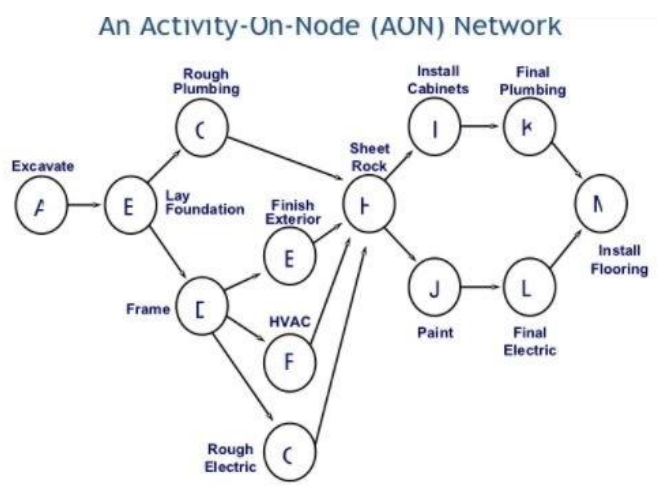
An activity is graphically represented by an arrow.

The tail end and head end of arrow represent start and finish of an activity respectively.



2. **A-O-N System** (Activity on node system or precedence diagram). Activity is represented by circle or node. Events have no places. Arrows are used only to show the dependency relationship between activity nodes.

When two or more activities start parallel then an activity called DEBUT (D_0) is provided at the beginning. Likewise, a finish activity (F_0) is provided at the end when more than one activities finish parallel. Activity D & F have zero duration.



Network Analysis - PERT

Programme Evaluation Review Technique(PERT)

INTRODUCTION

- For PERT. Employs **Beta-distribution** for the **time** – expectation for **activity**.

- The limits with which the duration will lie, is estimated.
- Pert follows the probabilistic approach and absorbs the uncertainties into the time estimates for activity and project durations.
- Therefore PERT is well suited for those projects where there is insufficient or no background information for estimation of time duration
- PERT is used in R&D type projects such as space industry, defence industry etc. As such projects are of non repetitive type or once-through type for which correct time estimates cannot be made.
- Further a PERT analysis is event oriented i e in this analysis interest is more focussed on the PERT (start or completion of activity) rather than the activities

TIME ESTIMATES:

In order to take into account, the uncertainties involved in the activity times three kinds of time estimates are made for each activity in PERT.

(i) **Optimistic time (t_o)**: If everything in the project goes well.

It is the minimum time required for an activity if everything goes perfectly well without any problems or adverse conditions developed during the execution of the activity
In this time estimate, no provisions are made for delays or setbacks and better than normal conditions are assumed to prevail during the execution of the activity

(ii) **Most Likely Time (t_m)**: It is the time for completing an activity that is best.

It is the maximum time required for an activity if everything goes wrong and abnormal situations prevail This time estimate does not include the possible effects of major catastrophes such as flood earthquakes, fire, labour strikes etc.

(iii) **Pessimistic Time (t_p)**: If everything in the project goes wrong.

It is the time required to complete the activity if normal conditions prevail
This time estimate lies between pessimistic and optimistic time estimates

- In PERT activity time is probabilistic but in **CPM** activity time is **deterministic**.
- The other difference: PERT is Event – Oriented. While the CPM is Activity – Oriented (in CPM we actually know the Activity time)

(i) Expected completion time of an Activity: (t_E)

$$t_E = \frac{t_0 + 4t_m + t_p}{6}$$

Where, t_0 = Optimistic time

t_p = Pessimistic time

t_m = Most likely time

(ii) Standard deviation of an Activity (σ)

$$\sigma = \frac{t_p - t_0}{6}$$

(iii) Variance of an activity: (σ^2)

$$\sigma^2 = \left(\frac{t_p - t_0}{6}\right)^2$$

(iv) Central limit theorem:

(a) The mean time of the project as a whole is $t_E = t_{E1} + t_{E2} + \ldots\ldots$ along the critical path.

Probability of completion of project in time t_E is 50%.

(b) The standard deviation of the project as a whole is $\sigma = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \ldots\ldots}$ along the critical path.

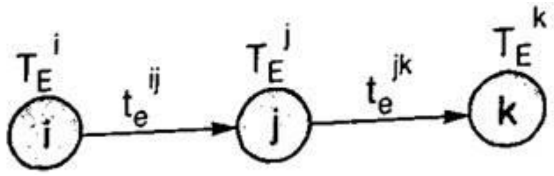
Critical Path: The time wise longest path is called critical path. In this path any type of delay in any event will cause delay to the project. These are shown by double line or dark lines in a network.

An event is critical if its slack is zero.

Event Time

(i) Earliest expected event occurring time (T_E)

$T_E^j = T_E^i + t_e^{ij}$ When there is only one path.



Where, t_e^{ij} = Expected completion time of an activity I – j

$T_E^j = (T_E^i + t_e^{ij})_{max}$ …. when there are more than one path.

Where T_E^i = Earliest expected time of event i.

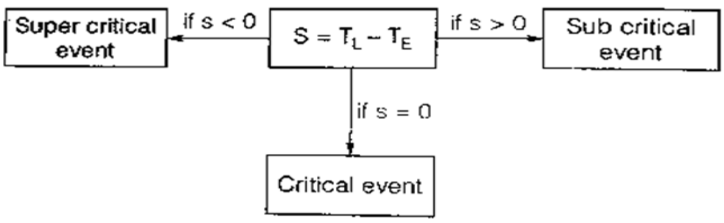
T_E^j = Earliest expected time of event j.

(ii) Latest allowable occurrence time (T_L):

$T_L^i = T_L^i - T_e^{ij}$ When there is only one path.

$T_L^i = (T_L^i - T_e^{ij})_{min}$ When there are more than one path.

(iii) Slack (s): This is the time by which an event may be delayed without affecting the completion time of the project.



- **Probability Factor (z)**

$$z = \frac{T_S - T_E}{\sigma}$$

Where, T_S = Given scheduled completion time of the project

T_E = Expected completion time of the project.

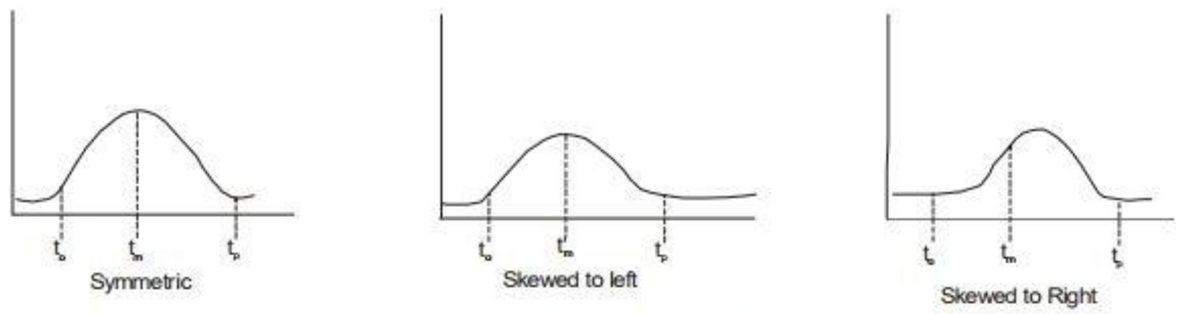
σ = Standard deviation

z	P
0	50%
+1	84.13%
+2	97.72%
+3	99.87%

z	P
0	50%
-1	15.87%
-2	2.28%
-3	0.13%

Frequency Distribution Curve for PERT

It is assumed to be a β - distribution curve with a unimodal point occurring at tm and its end points occurring at t_o and t_p. The most likely time need not be the midpoint of t_o and t_p and hence the frequency distribution curve may be skewed to the left, skewed to the right or symmetric.



β - Distribution curve

ESTIMATING COSTING AND VALUATION

1. **Unit of MEASUREMENT**

S No.	Particulars of Item	Unit of measurement
1.	**Earthwork** (i) Earthwork in excavation (ii) earthwork in filling in foundation trenches (iii) Earthwork in filling in plinth	 Cum Cum cum

2.	**Concrete** (i) concrete in foundation (ii) Cement concrete in beam, slab (iii) Lime concrete in roof terracing (Thickness specified) (iv) Cement concrete in Lintels	Cum Cum Sqm cum
3.	Damp proof course (Thickness specified)	sqm
4.	**Brick work** (i) Brickwork in foundation (ii) Brickwork in superstructure (iii) Thin partition walls (iv) reinforced brick work (v) One brick thick wall (Thickness specified)	Cum Cum Cum Cum sqm
5.	Stone work	cum
6.	**Wood work** (i) doors and windows frames and chowkhats (ii) Shutters of doors and windows (thickness specified) (iii) doors and windows fitting (Hinges, handels etc.)	Cum Sqm Number
7.	**Steel work** (i) Steel reinforcement bars (ii) rivet, bolt and nuts (iii) Binding of steel reinforcement (iv) Iron hold fast (v) Iron railing (vi) iron grills, iron gate and shutters	Quintal Quintal Quintal Quintal Quintal sqm
8.	**Roofing** (i) RCC slab roof (ii) LC roofs over bricks or stone slab (Thickness specified) (iii) Centering and shuttering form work (iv) AC sheet roofing	Cum Sqm Sqm sqm
9.	**Plastering, pointing and finishing** (i) Plastering, cement or lime mortar (Thickness specified) (ii) Pointing	Sqm Sqm

	(iii) White washing, colour washing (Number of coats specified) (iv) Distempering, painting and varnishing (Number of coats specified)	Sqm sqm
10.	**Flooring** (i) 25 mm or 40 mm CC floor (ii) Doors and window sills (iii) 25 mm CC over 75 mm LC floor	 Sqm Sqm Sqm
11.	Steel wooden trusses	No
12.	Glass panels	sqm
13.	Fixing of Glass panels	No.

2. Sinking Fund: A fund which is kept aside annually to reconstruct the property after the expiry of the period of utility is known as sinking Fund.

The sinking fund is calculated using the following formula:

$$I = \frac{Si}{(1+i)^n - 1}$$

Where,

I = Amount of Sinking fund

N = Life of the property

I = Rate of interest expressed in decimal

S = Money required to buy the property

3. Depreciation: The loss in the value of a property due to constant wear and tear is termed as depreciation.

The depreciation can be calculated using the following methods:

(a) Straight Line Method: In this method, it is assumed that the property losses its value by the same amount every year. A fixed amount of the original cost is deducted every year, so that at the end of the utility period, only the scrap value is left.

$$Annual\ Depreciation = \frac{C - S}{n}$$

(b) Constant Percentage Method: In this method, it is assumed that the property will lose its value by a constant percentage of its value at the beginning of every year.

$$Annual\ Depreciation\ = 1 - \left(\frac{S}{C}\right)^{1/n}$$

Where,

S = Scrap value

C = Original cost

n = life of property in years

The value of the property at the end of first year = C – DC.

(c) Sinking Fund Method: In this method the depreciation of a property is assumed to be equal to annual sinking fund plus interest on the fund for that year.

If A is the annual sinking fund and b, c, d etc. represent interest on the sinking fund for subsequent years, then the depreciation at the end of various years can be calculated as:

year	Depreciation	Total Depreciation	Book Value
1st year	A	A	C - A
2nd year	A + b	2A + b	C – (2A + b)
3rd year	A + c	3A + b + c	C – (3A + b + c)