Plane Geometrical construction

Objectives: At the end of this lesson you shall be able to
- **define the terms of most commonly used geometrical shapes.**

Introduction

Geometry is the shape of the object represented as views, how the object will look when it is viewed from various angles, such as front, top, side, etc. Preparation of engineering drawings involves a numbers of geometrical constructions, which are mostly based on plane geometry. Knowledge of various geometrical shapes and their terms are essential, hence, it is necessary to study geometrical constructions.

Important geometrical terms

Triangles

Equilateral, Isosceles and Scalene. (A scalene triangle has three unequal sides).

Quadrilaterals

1 **square-** All sides equal and all angles right angles.

2 **Rectangle or oblong-** Opposite sides equal and all angles right angle.

3 **Rhombus-** All sides equal, but angles are not right angles.

4 **Rhomboid**- Opposite sides equal and parallel, but angles are not right angles.

5 **Trapezoid**- Only two sides parallel.

6 **Trapezium**- No sides parallel, but may have two of its sides equal. When two of the sides are equal, it is called a trapezium or kite.

Polygons:

Regular and irregular; when all sides are equal, it is a regular polygon, otherwise irregular.

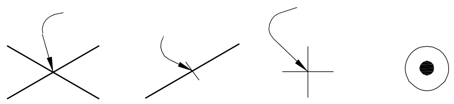
Pentagon- 5 sides; Hexagon- 6 sides; Heptagon- 7 sides; Octagon- 8 sides; Nonagon- 9 sides; Decagon- 10 sides;

Types of Lines and Angles

Objectives: At the end of this lesson you shall be able to
- **define points and lines**
- **state the classification of lines**
- **state the different types of angles**
- **explain the method of measuring angles.**

A point represents a location in space, having no width or height. It is represented by drawing intersection of lines or a dot. (Fig 1)

Fig 1



POINT

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Line is the path of a point when it moves. It has no thickness and are of two types:

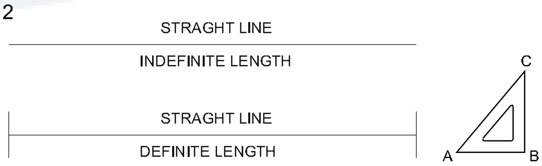
– Straight line

– Curved line

Straight line: It is the path of a point when it is moving in a particular direction. It has only length and no width. (Fig 2) Also a straight line is the shortest distance between two points. Straight line, depending on its orientation are classified as Horizontal, Vertical and Inclined or Oblique line.

Horizontal line (Fig 2)**:** Horizontal lines are those which are parallel to a horizontal plane. Example of horizontal plane is the surface of a still water. (Fig 3)

Fig 2



STRAIGHT LINE

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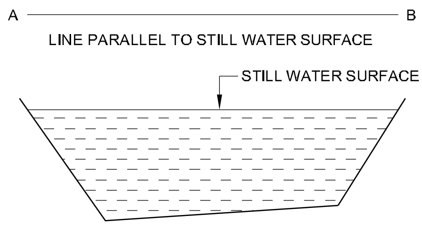
Fig 3



HORIZONTAL LINE

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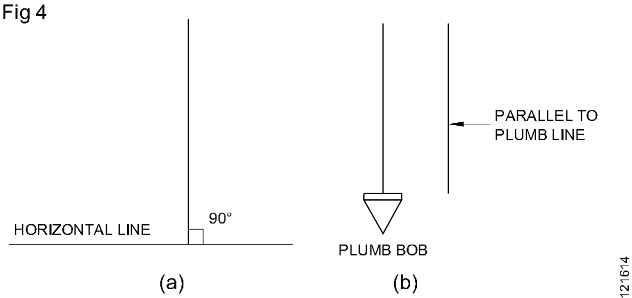
Vertical line (Fig 4a)**:** Lines which are perpendicular to horizontal lines are called vertical lines. It can be treated as a line along the plumb line of the plumb bob or parallel to a plumb line. (Fig 4b)

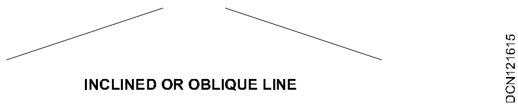
Inclined line or Oblique line: A straight line which is neither horizontal nor vertical is called an inclined line. (Fig 5)

Fig 4



VERTICAL LINE

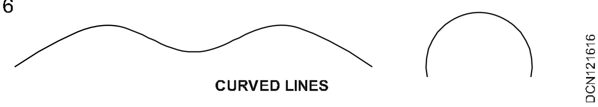
Fig 5



INCLINED OR OBLIQUE LINE

Curved line: It is the path of a point which always changes its direction. Examples of curved lines are shown in Fig 6.

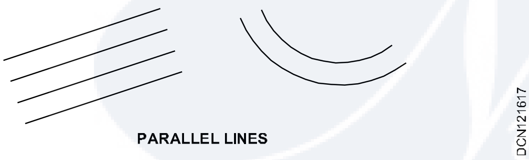
Fig 6



CURVED LINES

Parallel lines: They are the lines with same distance between them. They may be straight lines or curved lines. Parallel lines do not meet when extended. (Fig 7)

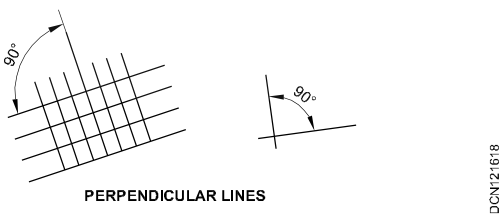
Fig 7



PARALLEL LINES

Perpendicular lines: When two lines meet at 90°, the two lines are said to be perpendicular to each other. One of this line is called as reference line. (Fig 8)

Fig 8



PERPENDICULAR LINES

Angles: Angle is the inclination between two straight lines meeting at a point or meet when extended. AB and BC are two straight lines meeting at B. The inclination between them is called an angle. The angle is expressed in degrees or radians.

Concept of a degree: When the circumference of a circle is divided into 360 equal parts and radial lines are drawn through these points, the inclination between the two adjacent radial lines is defined as one degree. Thus a circle is said to contain 360°. (Fig 9)

Acute angle: If an angle which is less than 90° is called an acute angle. (Fig 10)

Right angle: Angle between a reference line and a perpendicular line is called right angle. (Fig 11)

Fig 9

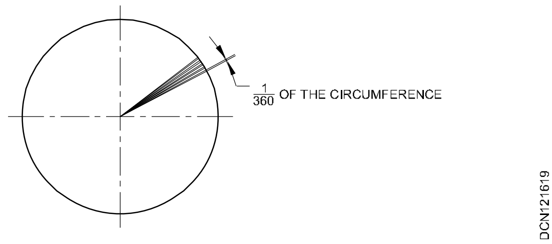
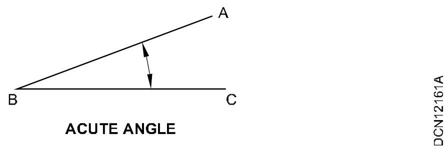
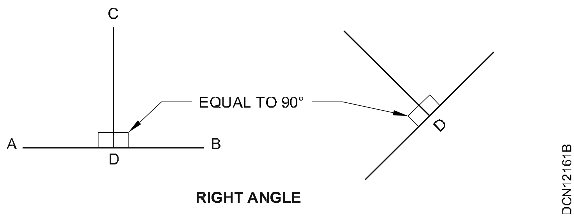


Fig 10



ACUTE ANGLE

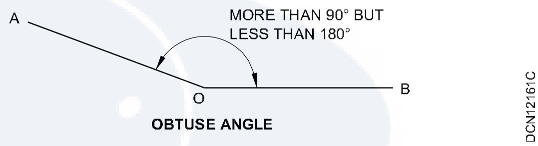
Fig 11



RIGHT ANGLE

Obtuse angle: This refer to an angle between 90° and 180°. (Fig 12)

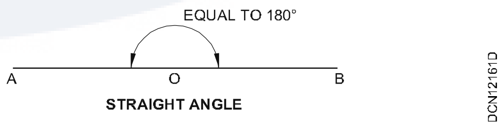
Fig 12



OBTUSE ANGLE

Straight angle: This refers to an angle of 180°. This is also called as the angle of a straight line. (Fig 13)

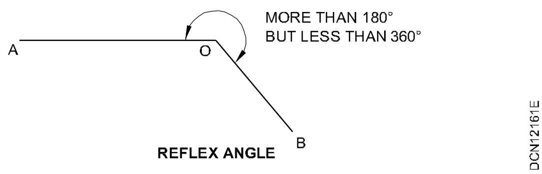
Fig 13



STRAIGHT ANGLE

Reflex angle: It is the angle which is more than 180°. (Fig 14)

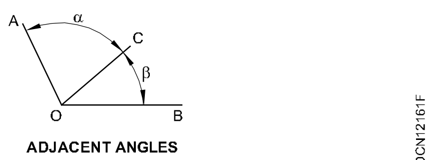
Fig 14



REFLEX ANGLE

Adjacent angles: These are the angles lying on either side of a line. (Fig 15)

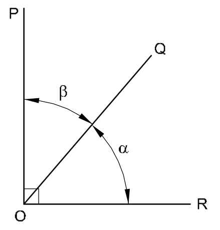
Fig 15



ADJACENT ANGLES

Complementary angles: When the sum of the two angles is equal to 90°, angle POQ + angle QOR = 90° angle POQ and angle QOR are complementary angles to each other. (Fig 16)

Fig 16

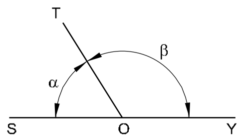


COMPLEMENTARY ANGLES

Supplementary angle: When the sum of the two adjacent angles is equal to 180°, example angle SOT + angle TOY = 180°, angle SOT and angle TOY are supplementary angles to each other. (Fig 17)

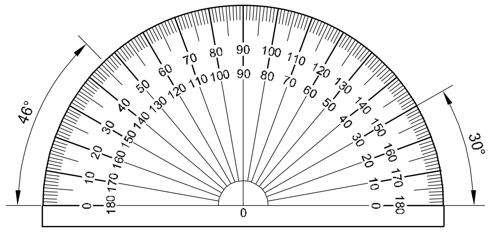
Protractor: Protractor is an instrument for measuring angles. It is semi-circular or circular in shapes and is made of flat celluloid sheet. The details of graduation in a semi-circular protractor is shown in figure 18.

Fig 17



SUPPLEMENTARY ANGLES

Fig 18



The angles can be set or measured from both sides, aligning the reference line and point `0' with the corner point of the angle.

Figure 18 shows how to read or set the angle. Protractor can also be used to divide a circle or drawing sectors.

Triangles and their types

Objectives: At the end of this lesson you shall be able to
- **define triangles**
- **name the different types of triangles and state their properties.**

Triangle is a closed plane figure having three sides and three angles. The sum of the three angles always equals to 180°.

To define a triangle, we need to have a minimum of three measurements as follows:

– 3 sides or

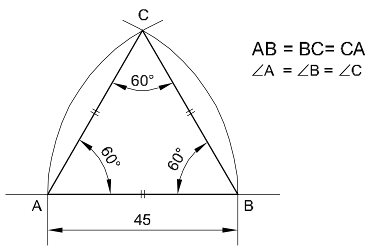
– 2 sides and one angle or

– 2 angles and one side

Types of triangles

– **Equilateral triangle** is a triangle having all the three sides equal. Also all the three angles are equal (60°) (Fig 1)

Fig 1



– **Isosceles triangle** has two of its sides equal. The angles opposite to the two equal sides are also equal. (Fig 2)

– **Scalene triangle** has all the three sides unequal in lengths. All the three angles are also unequal. (Fig 3)

Fig 2

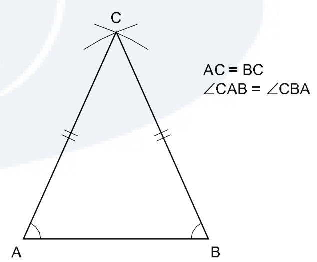
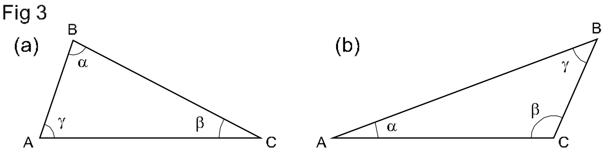
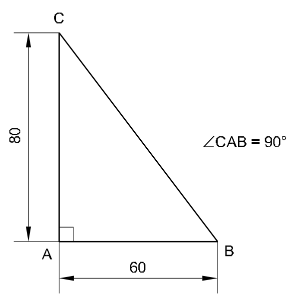


Fig 3



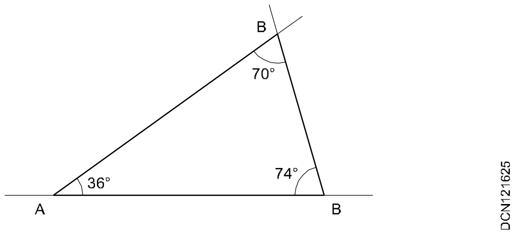
– **Right angled triangle** is one in which one of the angles is equal to 90° (Right angle). The side opposite to right angle is called hypotenuse. (Fig 4)

Fig 4



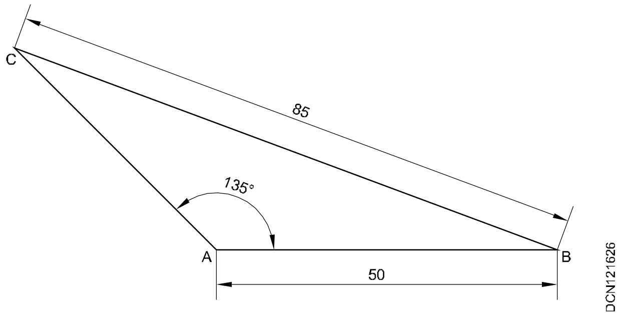
– **Acute angled triangle** is one in which all the three angles are less than 90°. (Fig 5)

Fig 5



– **Obtuse angled triangle** has one of the angles more than 90°. (Fig 6)

Fig 6



The sum of the three angles in any triangle is equal to 180°.

The sum of any two sides is more than the third side.

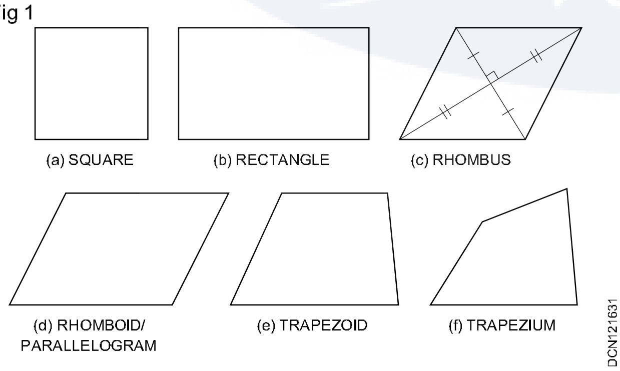
Quadrilaterals and their properties

Objectives: At the end of this lesson you shall be able to
- **define a quadrilateral**
- **name the quadrilaterals**
- **state the properties of quadrilaterals.**

Quadrilateral is a plane figure bounded by four sides and four angles. Sum of the four angles in a quadrilateral is of interior angles is equal to 360°. The side joining opposite corners is called diagonal. To construct a quadrilateral out of four sides, four angles and two diagonals a minimum of five dimensions are required of which two must be sides. Quadrilaterals are also referred as Trapezoid.

Types of quadrilaterals. (Fig 1)

Fig 1



– Square

– Rectangle

– Rhombus

– Rhomboid/Parallelogram

– Trapezoid

– Trapezium

Square : In a square all the four sides are equal and its four angles are right angles. The two diagonals are equal and perpendicular to each other.

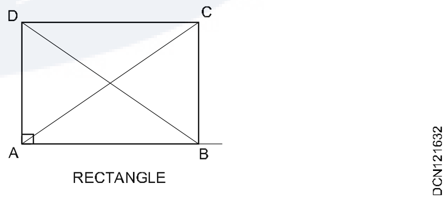
To construct a square we need to know (a) length of the side or (b) length of the diagonal.

Rectangle (Fig 2)**:** In a rectangle, opposite sides are equal and parallel and all four angles are right angles.

To construct a rectangle we need to know the length (a) two adjacent sides or (b) diagonal and one side.

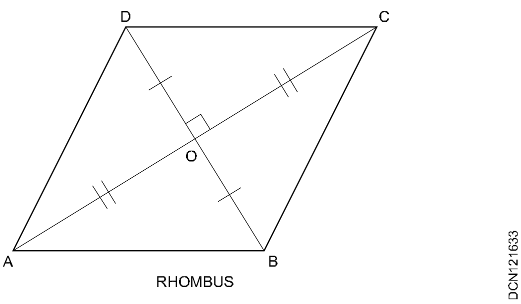
Fig 2 shows a rectangle ABCD. Sides AB = DC and BC = AD. Diagonals AC and BD are equal, bisect but not at right angles.

Fig 2



Rhombus (Fig 3)**:** In rhombus all the four sides are equal, but only the opposite angles are equal. ABCD is the rhombus where AB = BC = CD = AD.

Fig 3



Angle ABC = Angle ADC and Angle BAD = Angle BCD.

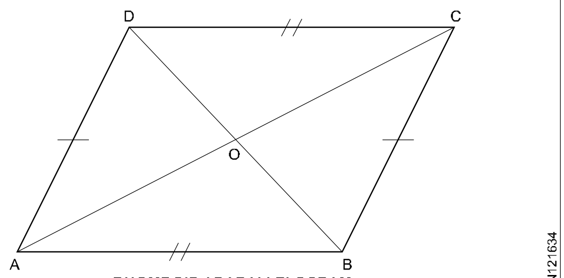
Diagonals AC and BD are not equal but bisecting at right angles.

AO = OC and BO = OD.

To construct a rhombus we need to know (a) two diagonals (b) one diagonal and an opposite angle or (c) one side and its adjacent angle.

Rhomboid/Parallelogram (Fig 4)**:** In a parallelogram opposite sides are equal and parallel. Opposite angles are also equal. Diagonals are not equal but bisect each other.

Fig 4



RHOMBOID / PARALLELOGRAM

Parallelogram is also known as rhomboid. To construct a parallelogram we need (a) two adjacent sides and angle between them or (b) one side, diagonal, and angle between them or (c) two adjacent sides and perpendicular distance between the opposite sides.

In the parallelogram ABCD, AB = DC; AD = BC

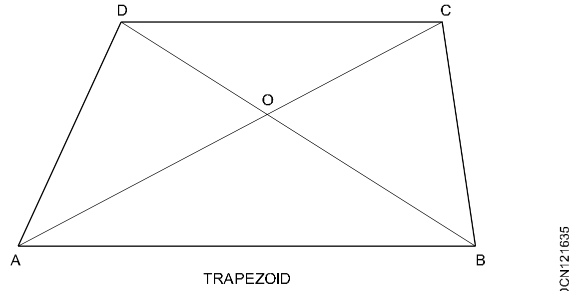
Angle DAB = angle DCB, angle ABC = angle ADC

Sides AB,CD and AD, BC are parallel.

Diagonals AC and BD are not equal but bisect at 0.

Trapezoid (Fig 5)**:** It is a quadrilateral, all the four sides are different and only two sides are parallel, all the four angles are different. The diagonals do not bisect at right angles.

Fig 5



TRAPEZOID

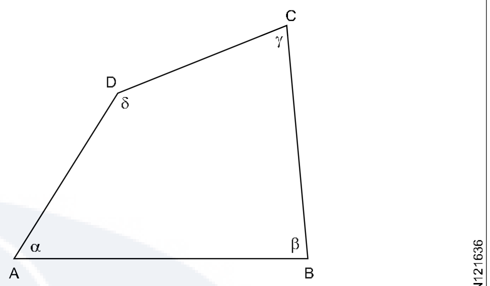
ABCD is a trapezoid, sides AB and DC are parallel but not equal.

Diagonals AC and BD and AO = OC need not be equal.

Sides AD and BC may sometimes equal.

Trapezium (Fig 6)**:** It is a plane figure of 4 sides, and any two sides equals to each other.

Fig 6



TRAPEZIUM

Polygon and their properties

Objectives: At the end of this lesson you shall be able to
- **define a polygon**
- **name the polygon in terms of the number of sides**
- **state the properties of polygon.**

Polygon is a plane figure bounded by many (usually five or more) straight lines. When all the sides and included angles are equal, it is called as a regular polygon.

Names of polygons: Polygons are named in terms of their number of sides as given below: (Fig 2)

Name	No. of sides
Pentagon	Five sides
Hexagon	Six sides
Heptagon	Seven sides
Octagon	Eight sides
Nonagon	Nine sides
Decagon	Ten sides
Undecagon	Eleven sides
Dadecagon	Twelve sides

Fig 1

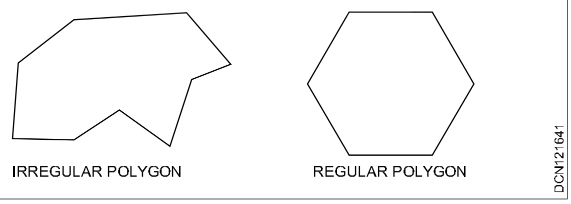
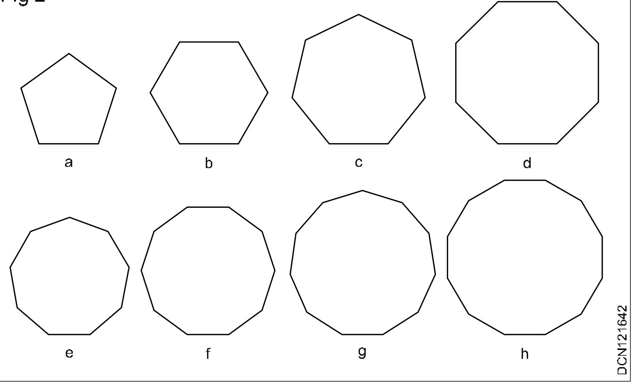


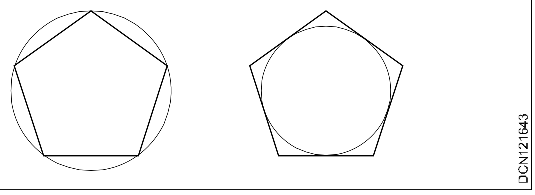
Fig 2



Properties of polygon

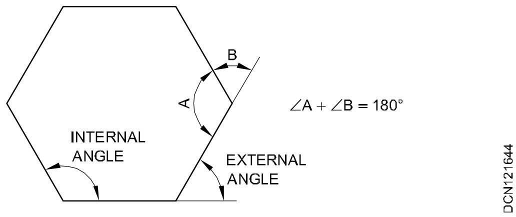
- All corners of a regular polygon lie on the circle. The sides of a regular polygon will be tangential to the circle drawn in side. (Fig 3)

Fig 3



- The sum of the interior angles of a polygon is equal to (2 x n - 4) x rt angle, where n is the number of sides.
- The sum of exterior angles of a polygon is equal to 360°.
- The sum of the interior angle and the corresponding external angle is 180°. (Fig 4)

Fig 4



Circles

Objectives: At the end of this lesson you shall be able to

- **state what is a circle**
- **name its elements**
- **state the function of a compass**
- **explain concentric and eccentric circles.**

Circle: Circle is a plane figure bound by a curve, formed by the locus of a point which moves so that it is always at a fixed distance from a stationery point the "Centre".

Radius: The distance from the centre to any point on the circle is called the "Radius".

Diameter: The length of a straight line between two points on the curve, passing through the centre is called the "Diameter", D: Dia or d. It is twice the radius.

Circumference: It is the linear length of the entire curve, equal to πD

Arc: A part of the circle between any two points on the circumference or periphery is called an 'Arc'.

Chord: A straight line joining the ends of an arc is called the chord. (Longest chord of the circle is the diameter)

Segment: A part of the circle or area bound by the arc and chord is the segment of the circle.

Sector: It is the part of a circle bounded by two radii (plural of radius) meeting at an angle and an arc.

Quadrant: Part of a circle with radii making 90° with each other is a quadrant (one fourth of the circle).

Half of the circle is called as semi-circle.

Tangent of a circle is a straight line just touching the circle at a point. It does not cut or pass through the circle when extended. The point where the tangent touches the circle is called the "point of tangency". The angle between the line joining the centre to the point of tangency and the tangent is always 90°.

Fig 1 shows all the above elements.

Concentric circles: When two or more circles (drawn) having common centre, they are called concentric circles. Ball bearing is the best example of concentric circles. (Fig 2)

Fig 1

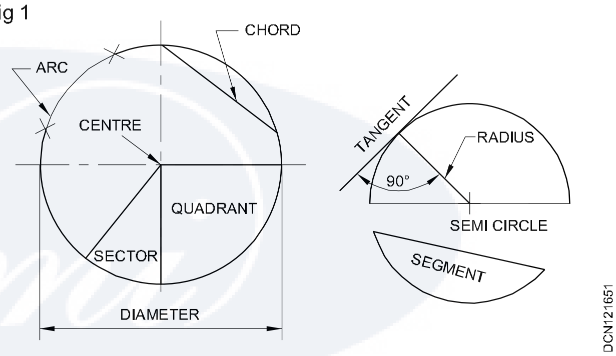
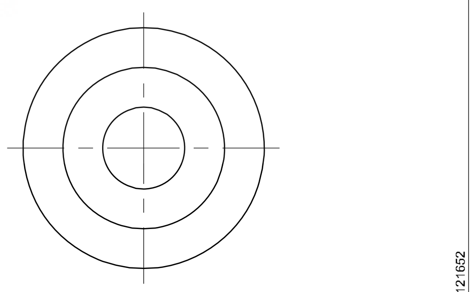


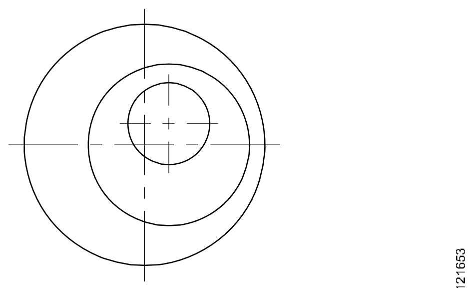
Fig 2



CONCENTRIC CIRCLES

Eccentric circles: Circles within a circle but with different centres are called eccentric circles. (Fig 3)

Fig 3



ECCENTRIC CIRCLES

Types of scales

Objectives: At the end of this lesson you shall be able to
- **state the necessity of scales**
- **explain representative fraction (RF)**
- **list the types of scales**
- **explain plain, comparative scales, scale of chords, diagonal scale and vernier scale.**

Inroduction

Engineering drawings are rarely drawn to the same size of the object. In the preparation of drawings of a building, it is not practically possible to make the drawing to the same size of the building. Here, the drawing is prepared to the reduced size and it is called reduced scale drawing.

Thus, the drawings prepared proportionately to the smaller or larger size than the actual size, are said to be made to a scale. Scale of a drawing may be defined as the ratio of linear dimension of the same object. Scales used in engineering practice are available in sets of 8 or 12 scales. Same times the required scale will not be available. Then, it is necessary to construct a new scale.

Therefore, a convenient scale is always chosen to prepare the drawings of big as well as small object in proportionately smaller or larger sizes. So the scales are used to prepare a drawing at a full size, reduced size or enlarged size.

Representative fraction

Representative fraction may be defined as the ratio of the distance between any two points of the object on a drawing to the actual distance between the same points of the object and it is abbreviated as R.F.

Mathematically,

R.F= distance on drawing/Distance on object

Reducing scale

An actual length of 5m of a room is represented by 25 mm length on drawing. Then,

R.F= distance on drawing/Distance on object

= 25mm/5m

= $25/5 \times 100 \times 10$

= 1/200

Scale of drawing is 1:200

Enlarging scale

An actual length of a typical terminal strip of 10mm is represented by 50mm length on drawing. Then,

R.F. = Distance on drawings / Distance on object

= 50mm/10mm

= 5/1

Scale of drawing is 5:1.

Full scale

An actual length of an electrical switch board of length 30 mm, is represented by a 30mm length on drawing. Then,

R.F.= Distance on drawing/Distance on object

= 30mm/30mm

= 1/1

Scale of drawing is 1:1.

Scales used to scale drawn large parts in engineering drawings and architecture:

1:40 1:100

1:50 1:150

1:65 1:200

1:80

Typical scales for site plan. Units in m.

1:500 1:5000

1:1000 1:10000

1:2000 1:20000

Scales used in surveys. Units in m.

1:50000 1:200000

1:100000 1:50000

Scale used in maps. Units in m.

1:1000000

Recommended scales

Scales recommended for use on engineering drawings are given below-

Full Scale	Reduced scale	Enlarged Scale
1:1	1:2	10:1
	1:2.5	5:1
	1:5	2:1
	1:10	
	1:20	
	1:50	
	1:100	
	1:200	

Civil Engineers and Architects generally use reduced scales while Mechanical and Electrical Engineers use both reduced and enlarged scales according to the need of the problems.

Metric measurements

Table 11.1

10 millimeters (mm)	1 centimeter (cm)
10 centimeters (cm)	1 decimeter (dm)
10 decimeters (dm)	1 meter (m)
10 meters (m)	1 decameter (dam)
10 decameters (dam)	1 hectometer (hm)
10 hectometers (hm)	1 kilometer (km)

Types of scales

- Plain scale
- Diagonal scale
- Vernier scale
- Comparative scale
- Scale of chords (for angles)

To construct a scale the following information is essential

RF of the scale

- Units which it must represent example mm, cm, m, ft inches etc.
- the maximum length it must show
- Minimum length of the scale = RF x the maximum length required to be measured.

Plain scales (Fig 1)**:** Scales are drawn in the form of rectangle, of length 15 cm (can be upto 30 cm) and width 5 mm. It is divided into suitable number of parts. The first part of the line is sub-divided into smaller units as required.

Every scale should have the following salient features:

- The zero of the scale is placed at the end of the first division from left side.
- From zero, mark further divisions are numbered towards right.
- Sub-divisions are marked in the first division from zero to left side.
- Names of units of main divisions and sub divisions should be stated/printed below or at the end of the divisions.
- Indicate the `RF' of the scale.

Example of construction of a plain scale to measure metres and decimetres. RF = $\frac{1}{50}$ and to measure upto 8 metres. Minimum standard length of scale = 15 cm.

The length of the scale = RF x maximum length to be measured = $\frac{1}{50} \times 8 \times 100 \text{ CM} = 16 \text{ CM.}$

Length of 16 cm is divided into 8 equal parts or major divisions each representing one metre. If each major division is divided into 10 sub-divisions each sub-division will represents one decimetre.

A distance of 6.7 m will be shown as in the Fig 1.

Comparative scales (Fig 2)**:** Comparative scale is a graphical device to compare or convert one variable into another. It compares two similar units in different systems. For example meters, yards, kilometers, miles, temperature in degrees, centigrades and Fahrenheit etc.

Fig 2 shows the construction of a comparative scale to convert Fahrenheit (F) into Celsius (Centigrade-C) and Celsius into Fahrenheit.

- The line AB (15 cm) is divided equally into 10 equal parts.
- Division on the top side of the scale is divided into 10

Fig 1

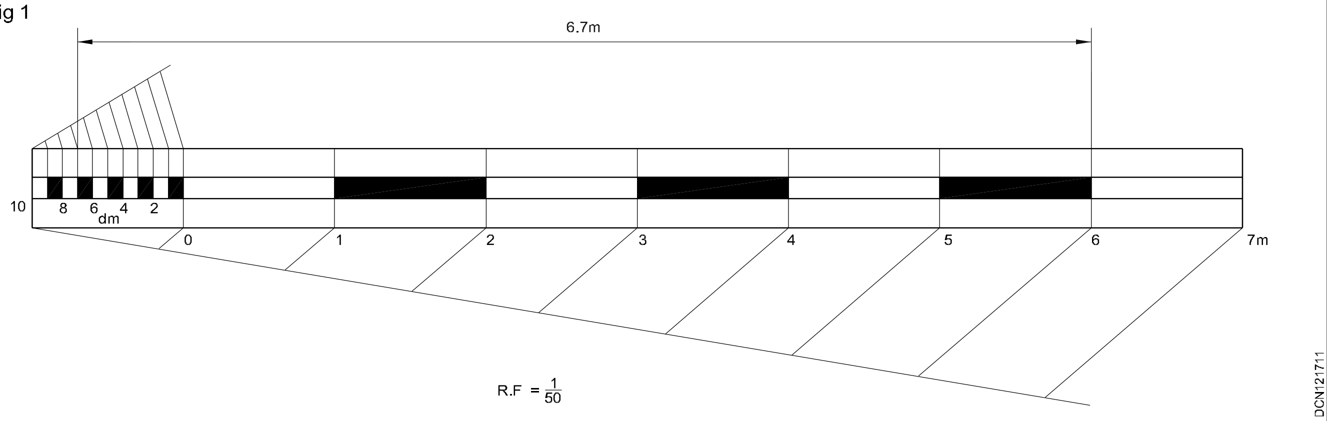
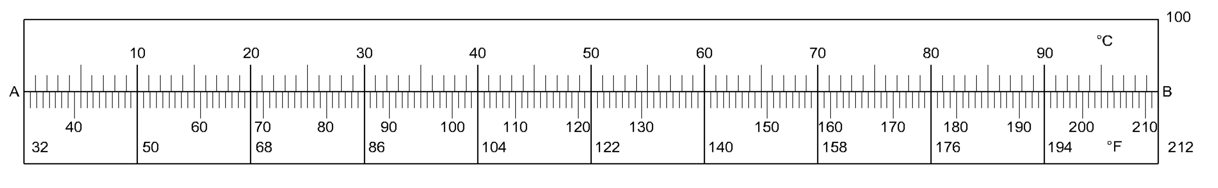


Fig 2



COMPARATIVE SCALE

equal sub-divisions. Each sub-division is representing 1°C.

- Division on the bottom side of the scale is divided into 18 equal sub-divisions. Each sub-division is called 1°F.
- Datum of 'F' side scale is starting with 32°F instead of 0.
- Conversion from °C to F or vice-versa can be found out directly from the scale.

  10°C equivalent reading of F scale = 50°F

  25°C equivalent reading of F scale = 77°F

For the verification of the conversion using the scale use the following formulae.

$C = (F - 32) \times \frac{5}{9}$

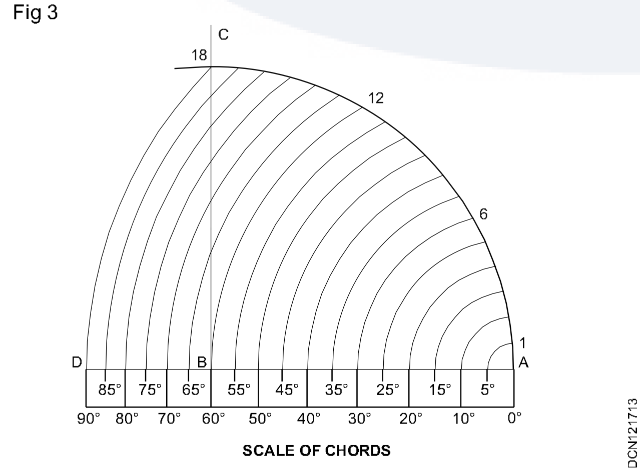
$F = (C \times \frac{9}{5}) + 32$

Scale of chords (Fig 3)**:** It is different from conventional linear scales. It is used to construct angles in the absence of a protractor, so called as a scale to measure or set angles or degrees. There is no rigid length of scale, so any convenient length can be taken to construct it.

Fig 3 shows the method of constructing the scale of chords.

- Draw a quadrant ABC and extend AB.
- A as centre, AC as radius, draw an arc CD.
- AD is the chord of arc AC.
- Divide the arc AC into 18 equal parts and each part is 5°.

Fig 3



– A as centre, draw arcs with radius. A1, A2, A3.....A18 to intersect line DA and mark them 5°, 10°.....90°.

Diagonal scale: Plain scales cannot be used for taking smaller measurement. The distance between the consecutive divisions on a plain scale, at best can only be 0.5 mm. In other words, the smallest measurement that can be taken. Using a plain scale of RF 1:1 is 0.5 mm. If the RF of a plain scale is 1:5, the smallest measurement such a scale can take is 2.5 mm (0.5 mm x 5).

To overcome this limitation two different types of scales are employed. They are

- Diagonal scale
- Vernier scale

Principle of diagonal scale: Diagonal scale relies on a "diagonal" to divide a small distance into further equal parts.

Principle of diagonal scale is based on the principle of similar triangles.

***Example*:** A small distance AB is to be divided into 10 equal parts using diagonal scale.

AB is the line to be divided into 10 equal parts.

Diagonal scale is shown in the Figure 4.

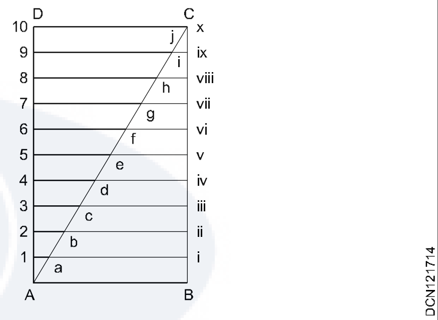
Side AD is the line to be divided into 10 equal parts 1 to 10. Parallel lines are drawn to AB from points 1,2.....10.

Join one of the diagonal AC.

Join parallel line cuts the diagonal at a,b.....j.

Distance 1 - a is $\frac{1^{th}}{10}$ of AB = 0.1 AB

Fig 4



Distance 2 - b is $\frac{2^{th}}{10}$ of AB = 0.2 AB

Distance a - i is $\frac{9^{th}}{10}$ of AB = 0.9 AB

Distance b - ii is $\frac{8^{th}}{10}$ of AB = 0.8 AB

If AB is 1 mm then 1 - a will be 0.1 mm and 2 - b will be 0.2 mm.

Similarly a - i will be 0.9 mm and c - iii will be 0.7 mm.

Parallel lines on both sides of the diagonal can be considered for measurement.

Vernier scale (Fig 5)**:** As stated earlier vernier scales are yet another means of dividing a small dimension into a number of equal parts so as to facilitate taking smaller measurements than is possible by plain scales.

Vernier scale consists of two parts - secondary scale or vernier scale (VS) and primary scale or main scale (MS).

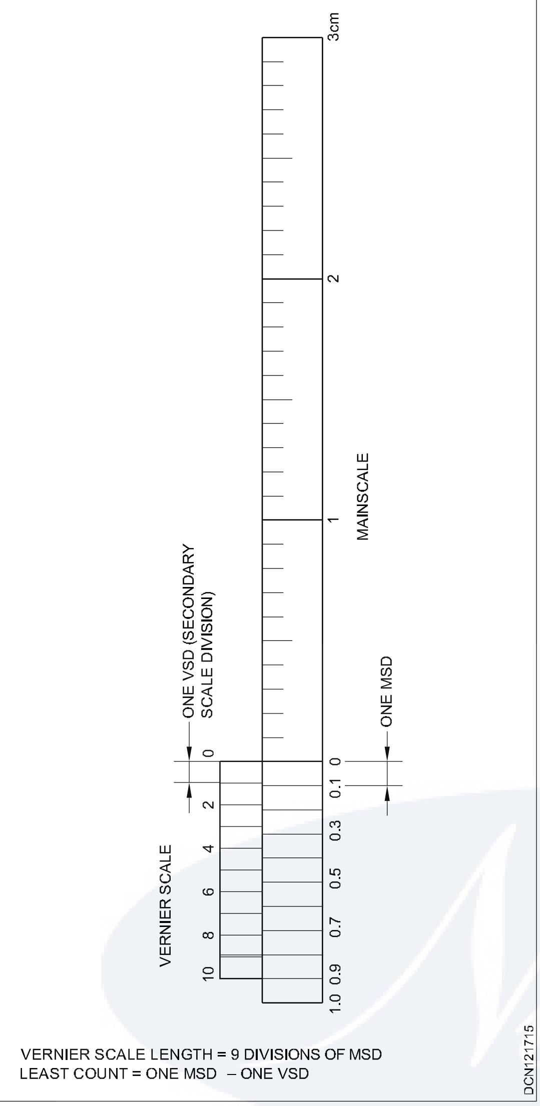
The smallest measurement that can be taken on the main scale is called main scale division (MSD).

Least count of the vernier scale is the fraction of the main scale division upto which the measurement can be taken.

To arrive at the fraction of MSD, imaginarily MSD is divided into a number of equal parts (n)

$$n = \frac{\text{MSD}}{\text{Fractional part of msd}}$$

Fig 5



The length of the secondary scale depend upon the MSD and number of divisions (n) we have decided to make.

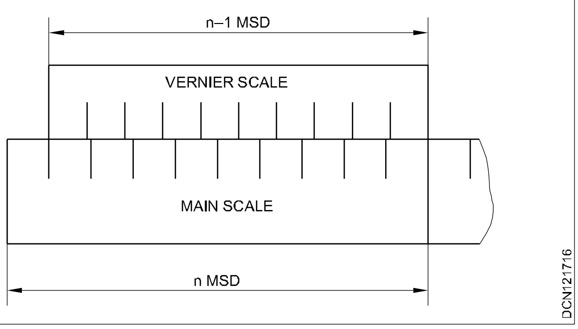
If one MSD is to be divided into 'n' parts, the length of the secondary scale (vernier) will be equal to the length of either (n-1) or (n + 1) parts of MSD.

Length of the secondary scale is divided into 'n' equal parts.

Thereby one secondary scale (vernier) division is equal to $\frac{(n-)MDC}{N}$ OR $\frac{(n+1)MSD}{N}$ as the case may be.

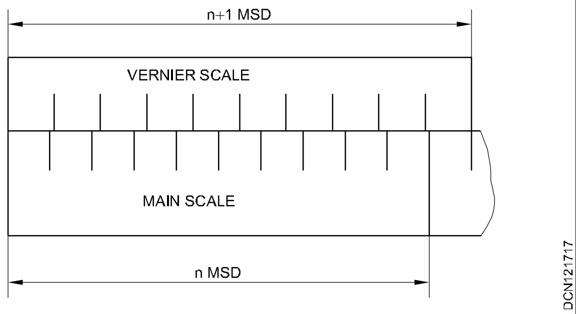
Direct or forward reading: Vernier scale is the scale constructed having n - 1 numbers of MSD as the secondary scale (vernier) length. (Fig 6)

Fig 6



Retrograde or backward reading: Vernier scale is the scale having n + 1 numbers of MSD as the secondary scale (vernier) length. (Fig 7)

Fig 7



According to Direct reading vernier

1 Main scale division - 1Secondary scale division (vernier) $= \frac{1}{n}MSD$

1 cm - $\frac{9}{10}$ $= \frac{1}{10}CM$

According to backward reading vernier

1 Secondary division (vernier) - 1 Main scale division $= \frac{1}{n}MSD$

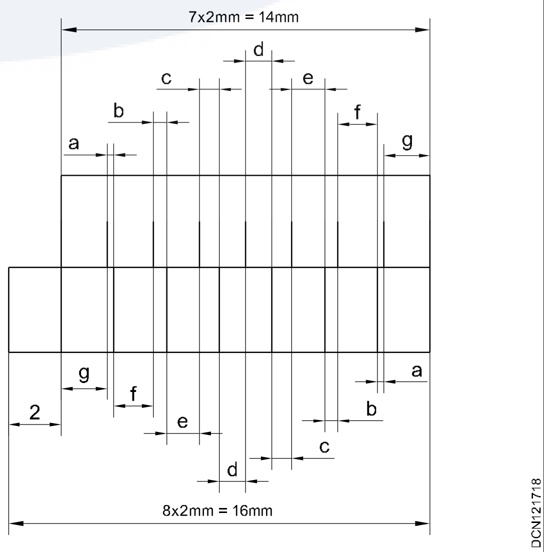
1.1 cm - 1.0 cm $= \frac{1}{10}CM$

MSD is the least count of the vernier scale

Example on direct reading vernier scale (Fig 8)**:** Construct a directing reading scale with one MSD = 2 mm, Least count = 0.25 mm.

First find the number of equal parts MSD (n)

Fig 8



$$n = \frac{MSD}{\text{least cound}} = \frac{2\,mm}{0.25mm} = 8$$

Length of secondary scale (vernier) is equal to 'n - 1' number of MSDs. 7 divisions of MSDs are taken and the length is equally divided into 8 parts on secondary scale (vernier)

1 secondary scale division = $\frac{7 \times 2mm}{8} = 1\frac{3}{4}mm$

The difference of one MSD and one secondary scale The difference of one MSD and one secondary scale division (vernier) will be

$$2mm - 1\frac{3}{4}mm = \frac{1}{4}mm = 0.25mm$$

It means that the scale can measure upto $\frac{1}{4}$ mm (0.25 mm).

In the figure, the fraction of the MSD is shown as the distance between the lines of VSD and MSD and they are marked as a,b,c.....g.

Figure 9 shows a retrograde vernier scale with same least 0.25 mm (1/4 mm) and one MSD = 2 mm.

Length of secondary (vernier) scale is n + 1 number of MSDs.

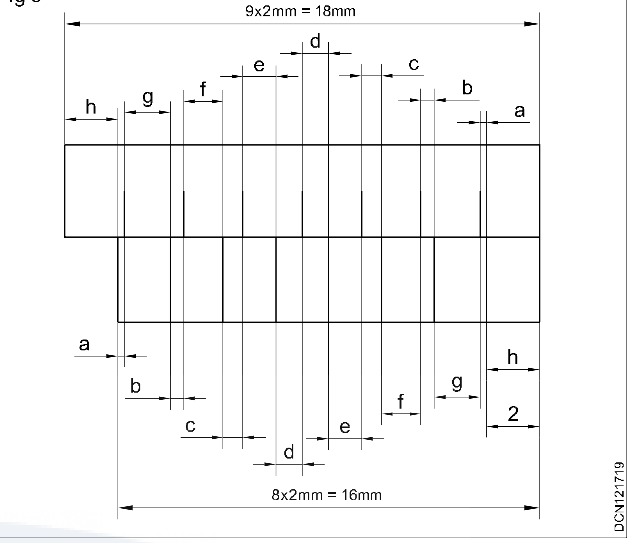
9 MSDs are equally divided into 8 parts on secondary (vernier) scale.

1 secondary (vernier) division = $= \frac{9 \times 2mm}{8} = 2\frac{1}{4}mm$

1 VSD - 1 MSD = least count

Least count = 0.25 mm

Fig 9



Properties of materials

Objectives: At the end of this lesson you shall be able to
- **classify MATERIALS**
- **state the properties of materials**
- **explain the properties of building materials.**

Introduction

The engineering material plays a vital role in our national economy.

This lesson deals with the study of Materials in respect of,

1 sources, composition, properties,

2 manufacturing methods and testing

3 utility in the various fields,

4 modern techniques for handling and using to materialize economical and safer

Classification

Materials may be classified as follows,

A. 1 Civil MATERIALS

building stones, clay products, lime, cement, concrete, mortar, timber, etc.

2 Electrical MATERIALS

copper, aluminum, iron and steel…..conductors,

Silicon, germanium, etc………semiconductors

Asbestos, mica, varnishes, air, etc……insulators Bakelite, Iron, nickel, cobalt, etc……..magnetic materials

3 Mechanical MATERIALS

Cast iron, steel, lubricating materials, etc..

B. Metals

Iron, aluminum, copper, zinc, etc…

And further… ferrous metals (cast iron, wrought iron and steel) and alloy (silicon steel, high speed steel, spring steel, etc.) and non-ferrous metals (copper, aluminum, zinc, etc.) and alloy (brass, bronze, duralumin, etc.)

C 1 Metals and alloy, (steels, copper, aluminum, brass, bronze, invar, super alloys, etc.)

2 Ceramics, (silica, soda lime glass, concrete, cement, ferrites, garnets, etc.)

3 Organic polymers, (plastics, p.v.c, polythene; fibres; terylene, nylon, cotton; natural and synthetic rubbers, leather, etc.)

Properties of materials.

1 Physical properties

2 Mechanical properties

3 Electrical properties

4 Magnetic properties and chemical properties

Properties of building materials

The properties of various building Materials(have to be ascertained for purposes of specifying them for particular use, classifying them and testing them for acceptance) may be classified into following categories:

1 Mechanical properties, (e.g. elasticity, plasticity, hardness, strength, etc.)

2 Chemical properties, (e.g. chemical composition, acidity, alkalinity, corrosion, etc.)

3 Electrical properties, (e.g. resistivity, conductivity, dielectric strength, etc.)

4 Optical properties, (e.g. light transmission, colour, reflectivity, refractive index, etc.)

5 Thermal properties, (e.g. specific heat, thermal conductivity, thermal expansion, etc)

Physical properties

Depending on the type of materials, these include a number of properties like;

1 **Specific gravity:** It is the ratio of the weight of material per unit volume (not including air holes and pores) to the weight of an equal volume of water under its standard conditions. It is used to calculate the density and porosity of materials.

2 **Density:** It is defined as the mass of a material per unit of its volume.

3 **Bulk density or unit weight:** The mass per unit volume of a material in its natural state.

4 **Porosity:** The degree by which the volume of a material is occupied by pores is indicated by the term porosity. The strength, bulk density, durability, thermal conductivity, etc. of a material depend on its porosity.

5 **Water absorption:** The water absorption of a material is its ability to absorb and retain water. This property is important in the case of stones, bricks, etc.

6 **Hygroscopicity:** It is the property of a material to absorb water vapour from air, as in the case of salt, sugar, etc., timber, is a hygroscopicity material.

7 **Permeability:** It is the capacity of a material to permit water to pass through it under pressure. It is important in the case of soils.

8 **Fire resistance:** It is the ability of a material to resist the action of high temperature without losing its load-bearing capacity.

9 **Durability:** Durability is the resistance of a material to destruction by natural agencies.

Building stones

Objectives: At the end of this lesson you shall be able to
- **define rock and building stone**
- **explain the characteristics of good building stones**
- **classify the rocks**
- **identify type of stones available in India**
- **explain testing of stone.**

Introduction

Stones are obtained from rocks, which may be classified according to geological, physical, chemical and practical classifications. A particular building stone may be selected depending on the requirements of the structure to be built.

Definition:

The soldified definite portion of earth's surface has not definite chemical composition and shape is called rock.

The quarried pieces of rock which is using for engineering purpose are called stone.

Characteristics of a good stone

To find the suitability of stones under different conditions, the following characteristics should be considered.

Appearance and colour: Have the ability to receive good polish, a pleasing colour and be free from cracks and spots.

WEIGHT: A heavy stone possesses more compactness and less porosity.

Porosity and absorption: If it present in greater extent it makes the unsuitable for building construction.

Fineness of grain: Fine grained stone are suitable for molding works.

Compactness: Compact stone can with stand the effects of external agencies effectively.Durability of stone is decided by their compactness or density of composition.

Resistance to fire: Should have homogeneous composition and be free from calcium carbonate or oxide of iron.

Electrical resistance: The stone must be non-absorbent like slate.

Hardness and toughness: To resist wear and tear, the stone must be adequately hard and tough. Hardness may be tested by scratching with a pen knife and toughness tested by hammer.

Strength: The crushing strength of stone should be greater them 100N/mm2. All igneous rocks have around 100N/mm2and same of the metamorphic rocks also satisfy this requirement. Sedimentary rock has a low strength.

Specific gravity: For docks, harbors, gravity dams etc stones should have a high specify gravity, not less 2.6.The more specify gravity; more will be the weight of the stone for a given volume.

Durability: A stone is more durable, if it is compact, homogeneous and free from any Materials affected, also have negligible water absorption.

Dressing: Stone should possess uniform texture and softness if it is to hard, finish will be poor and dressing uneconomical

Cost: An important consideration in the selection of building stone.

Seasoning: Stone must be free from quarry sap, after quarrying and dressing, stone should be left for a period of 6-12 months for proper seasoning.

Classification of rocks

ROCKS

- **GEOLOGICAL** Depending upon how the rocks was originally formed
  - **Igneous**-Primary eruptive or un-stratified rocks, etc. e.g. Trap or Basalt, Granite, etc. **Sedimentary-**Stratified or aqueous rocks, e. g. Lime stone, Sand stone, etc. **Metamorphic**- e. g. Lime stone changes to Marble, Slate
- **PHYSICAL** Depending upon what its structure
  - **Stratified**-These rocks have many strata or layer. e. g. limestone, Slate and Sandstone. **Un-Stratified**-These rocks do not have strata and have granular structure. E.g. Granite, Trap, Marble etc. **Foliated**-These can be split along definite planes. E.g. Gneiss.
- **CHEMICAL** Depending upon its chemical composition
  - **Silicious-** Silicon is more e.g. Sandstone, Granite. **Calcareous-** Lime is more e.g.Limestone, Marble, etc. **Argillacious-** Clay is more, e.g. Slate, Schist.
- **PRACTICAL** Based on uses
  - Granite, Basalt, Laterite, Limestone, Sandstone, Slate etc

Types of Rocks

Rocks may be classifed in the following three ways:

1.Geological 2.Physical 3.Chemical

GEOLOGICAL CLASSIFICATION

Based on their origin of formation stones are classifed into three main groups- igneous, sedimentary and metamorphoric rocks.

Igneous rocks: These rocks are formed by cooling and solidifying of the rock masses from their molten magmatic condition of the material of the earth. Generally igneous rocks are strong and durable. Granite, trap and basalt are the rocks belonging to this category, Granites are formed by slow cooling of the lava under thick cover on the top. Hence they have crystalline surface. The cooling of lava at the top surface of earth results into non-crystalline and glassy texture. Trap and basalt belong to this category.

Sedimentary rocks : Due to weathering action of water, wind and frost exisitng rocks disintegrates. The disintegrated material is carried by wind and water, the water being most powerful medium. Flowing water deposits its suspended Materials at some points of obstacles to its flow. These depositied layers of Materials get consolidated under pressure and by heat. Chemical agents also contribute to the cementing of the deposits. The rocks thus formed are more uniform, fine grained and compact in their nature.

They represent a bedded or startified structure in general. Sand stones, lime stones, mud stones etc. belongs to this class of rock.

Metamorphic rocks: previously formed igneous and sedimentary rocks under go changes due to metamorphic action of pressure and interanl heat. For example due to metamorphic action grainte becomes gneiss, trap and basalt changes to schist and laterite, lime stone changes to marble, sand stone becomes quartizite and mud stone becomes slate.

Physical Classification

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

1. Stratified rocks 2. Unstratified rocks

Stratified rocks : These rocks are having layered structure. They posses planes of stratification or cleavage. They can be easily split along these planes. Sand stones, slate etc. are the examples of this class of stones.

Unstratified rocks: 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 : These rocks have a tendency to split along a definite direction only. The direction need not be parallel to each other as in case of stratified rocks.

Chemical classification

On the basis of their chemical composition engineers prefer to classify rocks as:

Silicious rocks, Argillaceous rocks and Calcareous rocks

Silicious rocks : The main content of these rocks is silica. They are hard and durable. Examples of such rocks are granite,, traps and quartzines etc.

Argillaceous rocks: The main constituent of these rocks is argil i.e., clay. These stones are hard and durable but they are brittle. They cannot withstand shock. Slates and laterites are examples of this type of rocks.

Calcareous rocks: The main constituent of these rocks is calcium carbonate. Limestone is a calcareous rock of sedimentary origin while marble is a calcareous rock of metamorphic origin.

Testing of stones

To determine the suitability of stone for its use in engineering works the following tests are performed:

1 Hardness test

2 Crushing test

3 Impact test

4 Fire resistance test

5 Attrition test

6 Acid test

7 Water absorption test

8 Smith's test

9 Crystallization test

10 Microscopic test

11 Freezing and thawing test.

1 **Hardness:** To determine the hardness of stone

2 **Crushing test :** To determine the maximum load at which stone crushes or fails while loading.

3 **Impact test:** To determine the toughness of a stone.

4 **Fireresistance test:** Determine the presence of calcium carbonate which will produce fire

5 **Attrition test:** To determine the rate of wear of stones

6 Acid test: To determine the action of acid on the stone

7 **Water absorbption test :** To find out the % of water absorbtion of test stone.

8 **Smith's test :** Indicate the presence of earthly matter

9 **Crystallization test :** To determine the durability or weathering quality

10 **Microscopic test:** To study the mineral constituents, grain size etc.

11 **Freezing and thawing test:** To determine the behavior of stone under freezing

Table

COMMON BUILDING STONES OF INDIA

STONES	ROCKS	CHARACTERISTICS	USES	PLACES
Basalt and Trap	Igneous	Hard and tough; difficult to work Its sp. gravity is 3 and compressive strength varies from 1530 to 1890 kg/cm^2. Its weight varies from 1800 to 2900 kg/m^3	Road metal, for rubble masonry, foundation work, etc.	Maharashtra, Bihar, Gujarat, Bengal. And M.P.
Chalk	Sedimentary	Pure white limestone soft and easy to from powder.	In preparing glazier's putty: as colouring material in manufacture of Portland cement.	Maharashtra, Bihar, Gujarat, Bengal. Punjab, Rajasthan, M.P, Andaman- Island U.P.& H.P.
Gneiss	Metamorphic	Splits into thin slabs easy to work .Its sp. Gravity is 2.69 and compressive strength is 2100kg/cm^2.	Street paving, rough stone masonry work, etc.	Madras, Mysore, Bihar, A.P, Maharashtra, Bengal, Kerala, Gujarat

STONES	ROCKS	CHARACTERISTICS	USES	PLACES
Granite	Igneous	Hard, durable and available in different colours, highly resistant to natural forces, can take nice polish. Its Sp. gravity Varies from 2.6 to 2.7 and compressive strength varies from 770 to 1300 kg/cm^2. Its weight is about 2600 to 2700 kg/m^3.	Steps, sills, facing walls work bridge piers, columns, road metal, ballast, etc. It is unsuitable for carving.	Kashmir, Madras, Punjab, Rajasthan, U.P, M.P, Mysore, Assam, Bengal, Bihar, Orissa, Kerala, & Gujarat.
Kankar	Sedimentary	Impure limestone	Road metal, manufacture of hydraulic lime, etc.	North & central India.
	Metamorphic	Porous and spongy structure, easily quarried in blocks. Contains high percentage of Oxide of iron; available in different colours. Its compressive strength various from 18 to 32 kg/cm^2.	Building stone, road metal, rough stone, masonry work. etc.	Bihar, Orissa, Mysore, M.P., Maharashtra, Kerala, A.P., & Madras.
Lime Stone	Sedimentary	Consist of carbonate of lime easy to work Its Sp. gravity various from 2.00 to 2.75 and compressive strength is 550 kg/cm^2.	Floors steps , walls, road metal, manufacture of lime in blast furnace etc.	Maharashtra, Bihar, Gujarat, Bengal. Punjab, Rajasthan, M.P, Andaman- Island U.P.& H.P.
Marble	Metamorphic	Can take nice polish and available in different coluours. Its Sp. gravity is 2.65 and compressive strength is 720 kg/cm^2. and carved.	Flooring, facing work, Columns, steps, ornamental works etc. It can take nice polise It can easily be shown	Maharashtra, Gujarat, Rajasthan, M.P, Mysore, U.P and A.P.
Moorum	Metamorphic	Decomposed laterite, deep brown or red in colours.	Blindage for metal roads,for fancy paths and garden walls .	Bihar, Orissa, Mysore, M.P, Mah., Kerala, A.P., & Madras
Quartzite	Metamorphic	Hard, brittle, crystalline, and compact, difficult to work and dress.	Retaining wall, road metal, concrete, aggregate, pitching, rubble masonry,facing building etc.	Madras, Punjab, U.P, Mysore, Bengal, Gujarat. Rajasthan, A.P.
Sand stone	Sedimentary	Consists of quartz and other minerals, easy to work &dress and available in different colours. It is Sp.gravity various from 2.65 to 2.95 and compressive strength is 650 kg/cm^2. Its weight is about 2000 to 2200 kg/ cm^3.	Steps, facing work columns, flooring walls, road metal,ornamental work etc .	Maharashtra, Bihar, Gujarat, Bengal, Punjab, Rajasthan, M.P, Andaman Island, U.P, H.P, A.P, Kashmir, Madras .
Slate	Metamorphic	Black colour and splits along natural bedding planes, non-absorbent. Its Sp. gravity is 2.89 and compressive strength varies from 75 to 207 N/mm².	Roofing work, sills, damp proof courses, etc.	U.P., M.P., Bihar, Madras, Mysore and Rajasthan.

Quarrying (building stones)

Objectives: At the end of this lesson you shall be able to
- **define quarrying**
- **state quarry location**
- **explain methods of quarrying**
- **list out the explosives used in blasting.**

Introduction

Good stones are obtained by quarrying from solid rocks formation and not from loose boulders. Boulders are weathered blocks of stones are not fit for important constructions. The term quarry refers to the places exposed to air like a stone outcrop from which we extract the building stone (by digging or blasting). On the other hand, the term mine refer to the places where we extract mineral resources like coal, precious stones, etc.

Definition: The art of extracting stone from the rock beds is called quarrying.

Quarry location

It is required to be carefully paid attention to before starting the quarry

1 examination of rocks surface

2 layout

3 men and machine

4 removed the top surface

5 structural stability

Methods of quarrying

The different types of methods of quarrying are the following.

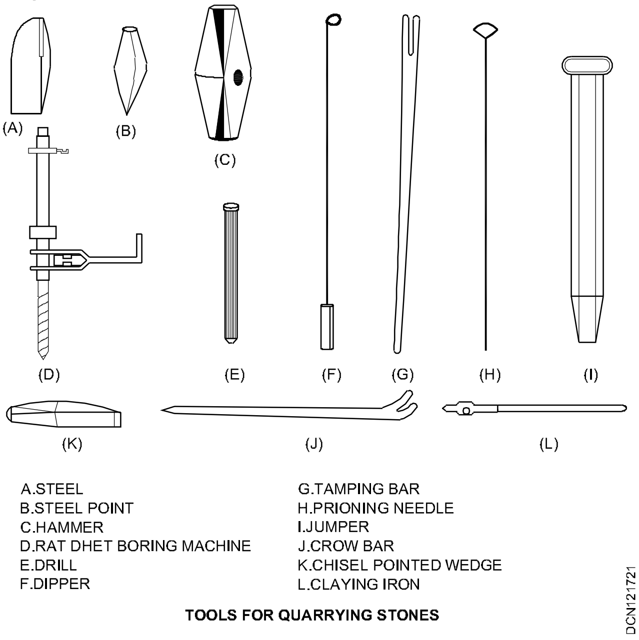
1 Quarrying by hand tools.

2 Quarrying by use of channelling machine.

3 Quarrying by blasting.

1 Quarrying by hand tools:

Fig 1



TOOLS FOR QUARRYING STONES

It is very old method and still used for soft stones occurring in large or small blocks. With the help of suitable instruments such as pickaxes, hammers, shovels, chisels, scraping spoon, priming needle, dipper, and steel, pin.

The following are the methods used:

1 By digging and excavating

2 By Heating

3 By wedging

2. Quarrying by use of a channelling machine:

1 Use a channeling machine, driven by steam, compressed air or electricity.

2 Machine can cut 50 to 75 mm width channels up to 24 m. in length and240 to 370 cm in depth.

3 First, cut channels of sufficient depth.

4 Horizontal holes are then driven beneath the block from the exposed face.

5 Wedges are then driven into the horizontal holes, when the block will break loose.

6 The block is lifted from its bed, to be cut into the slabs of required sizes.

3. Quarrying by blasting with explosives:

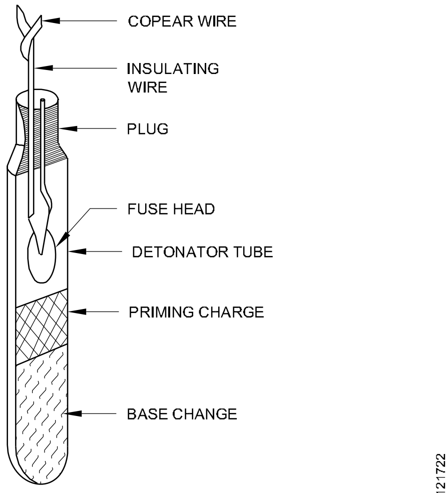
1 The explosives are used to convert rocks in to small pieces of stone.

2 The operation of blasting constitutes the boring or drilling of holes,

3 Charging them with some suitable explosive

4 Then firing the charge.

Fig 2



ELECTRICAL DETONATOR

5 This method is adopted for quarrying hard stones, having no fissures or cracks.

Explosives in blasting:

1 In the process of blasting, following factors are considered to avoid the occurrence of serious accidents:

2 Failure of explosion

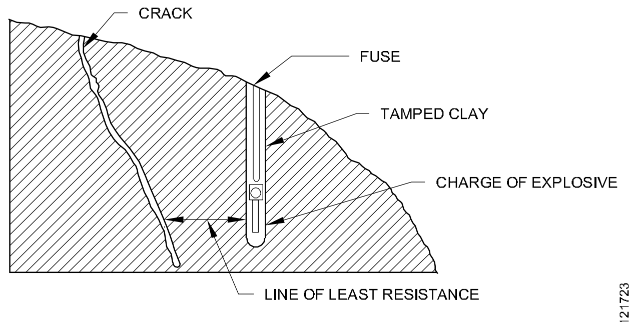
3 Line of least resistance (line along which the explosion of the powder will find least opposition to its vent to the atmosphere)

4 Needle and tamper

5 Notice of blasting

6 Retreat to a distance

Fig 3



TAMPED AND CHARGED BLAST HOLE

7 Seepage of water

8 Skilled supervision

Table 3.1

Sl. No	Name of Explosive	Composition	Remarks
1	Blasting gelatine.	It consists of 93% of nitro-glycerine and cotton 7% of gun cotton.	It has high explosive powder about 50% more than that of dynamite.
2	Codite.	It is prepared from gelatinized combination of nitro-glycerine and nitro-cellulose.	It is powerful explosive and it does not produce smoke. It can be used under water.
3	Gelignite	It consists of 65% blasting gelatine and 35% of absorbing powder.	It is more convenient than dynamite. It is a powerful explosive and can be used under water.
4	Gun-cotton	Clean cotton is saturated in a cool mixture of nitric acid (HNO_3) and sulphuric acid (H_2SO_4). It is pressed in to blocks or sticks while it is wet	It is as strong as dynamite. But its shat tering power is less. If it decomposes with rise of temperature. It is genarly transported and stored in moist condi tions.
5	Liquid oxygen	It is oxygen in liquid state.	It is stored in special containers. It is comparatively cheaper. It is used for blasting on a large scale, mining for operations, for blasting under water etc.
6	Rock-a-rock	It consists of 79% of potassium chlorate ($KClO_3$) and 21% of nitro-benzol .	Its action under water is more effective. It is used in U.S.A.
7	Dynamite	75% nitrogly cerine mixed with 25% sandy earth to form a thick paste.	Quick action, more powerful than blast ing power and six times powerful used under water and damp situation.
8	Blasting power	65% potassiun nitrate 20% sulphur	Slow action, cheaper. 15% charcoal

Precautions to be taken while blasting

1 It should be done at fixed hours made known to the public.

2 Before actual firing, siren should give timely warning to workmen and others to retire to safety.

3 Danger flag (red) should be displayed at a distance about 200 m around the area of explosion. And no person should allow entering in the danger zone other than the firing man.

4 All fuses should cut to proper lengths before inserting them into the holes.

5 For making a hole in cartridges to take detonates, only hard wooden pegs should be used.

6 Cartridges should preferably be handled with rubber or polythene gloves on.

Dressing of stones (building stones)

Objectives: At the end of this lesson you shall be able to
- **define dressing**
- **state purposes of dressing**
- **explain varieties of finishes**
- **list out the artificial stones**
- **explain natural bed of stone.**

Definition

The stone after being quarried are to be cut into suitable size and with suitable surface. This process is known as the dressing of stone and it is carried out for following purpose.

1 To get the desired appearance from stone work to make the transport from quarry easy and economical.

2 To suit to the requirement of stone masonry.

3 To take advantage of local men near who are trained for such type of work.

Following are the varieties of finishes obtained by the dressing of stone:-

1 Axed finished

2 Boosted as droved finish

3 Chisel -draughted margins

4 Circular finish

5 Dragged as combed finish

6 Furrowed finish

7 Moulded finish

8 Hammer-dressed finish

9 Plain finish

10 Polished finished

11 Punched machine

12 Reticulated finish

13 Rubbed finished

14 Tooled finished

15 Shackling finished

16 Self-faced or rock faced or quarry faced finish

17 Sunk finish

Artificial stones

It is also known as cast stones or reconstructed stones. Since it is difficult to obtain durable natural stones at a moderate cost in many localities, many processes have been invented for the manufacture of artificial stone.

Varieties of artificial stones

1 Cement concrete blocks.

2 Ransom's patent stone,

3 Artificial marble,

4 Terrazzo

5 Mosaic tiles,

Fig 1 a.

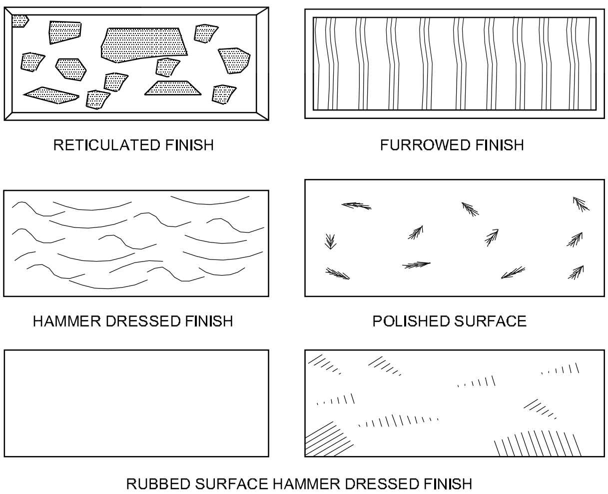


Fig 1 b.

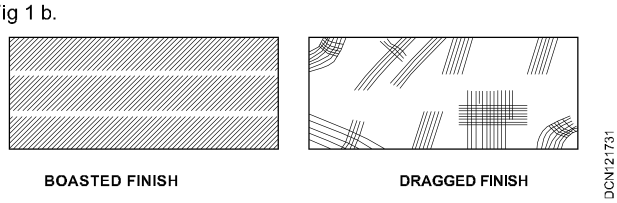
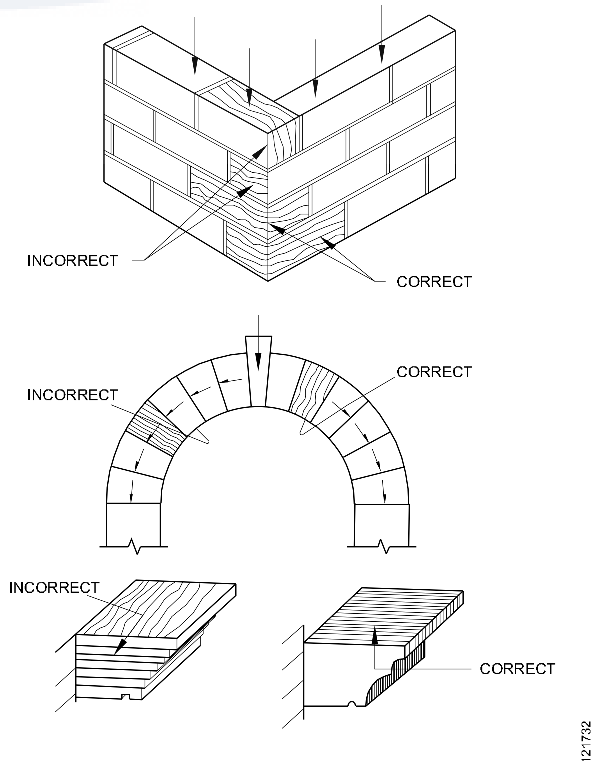


Fig 2



POSITION OF NATURAL BED OF STONES IN STRUCTURES

6 Reconstructed stone,

7 Bituminous stone

Natural bed of stone

1 It is the original position occupied by the sedimentary (stratified) rocks from which the stone is obtained. It is also known as the plane of cleavage.

2 These rocks have a distinct plane of division along which stones can easily be split and it thus indicates the layer is divided into numerous thin layers or laminations, whose planes are parallel to the plane of the main strata.

3 Thus, stone quarried from such rocks should be placed in a stone masonry; in such a manner that the direction of load or pressure is at right angles to its laminations.

4 Such an arrangement gives maximum strength to the stone work.

With respect to natural bed, the stones are placed in different situations as follows:

1 Arches

The bedding plane is kept at right angles to the resultant line of thrust, from consideration of the stability of the arch.

2 Cornices, string courses, etc.

The natural bed should be placed vertically and perpendicular to the face otherwise the layers of overhanging portions being horizontal will drop of.

3 Column or a wall

In this, the load line is vertical; the stones should be placed with the planes of bedding radial, so that, thrust acts normal to the bedding plane.

Clay products (bricks)

Objectives: At the end of this lesson you shall be able to
- **define clay products**
- **compare stone and brick**
- **explain composition of brick earth**
- **describe the method of manufacturing of bricks**
- **explain the qualities of good bricks**
- **classify the bricks**
- **state testing of bricks**
- **list out the special bricks.**

Introduction

The clay occurs plenty in nature, when it is made wet with water possesses a high degree of tenacity and plasticity it can be moulded in designed shape and they dried and burnt.The clay products which are employed in building industry are bricks, ceramic products (tiles, refractory bricks, terra-cotta, porcelain, earthen-wares and stone-wares). Burning of moulded clay products makes them sufficiently strong for use as construction materials.

Bricks: Moulded clay in rectangular block of uniform size, shape as per standard, which is dried and burned for the purposes of masonry work, is called brick.

Comparision of stone and brick

S.No.	Stone	Brick
1	It is heavier than brick	It is lighter than stone.
2	It is obtained from rock	It is made from clay.
3	Free from clay holes and flaws.	Free from lumps, flaws and cracks.
4	Hard and tough	Hard and sound
5	It absorbs heat more than a brick.	It absorbs less heat comparatively.
6	Water absorption <5%	Water absorption <16%
7	It is uniform in colour and can be Shaped to the desired size.	Uniform in colour, shape and size.
8	It has high durability.	It is durability is less than that of stone.
9	Suitable for industrial area as it is acid and smoke proof.	Acid and smoke resistance is good but Less than that of stone.
10	Dressing, transporting costly.	Overall cost of manufacturing is less.
11	Labour cost for laying is more.	Labour cost is less

Brick earth:(IS: 2117-1975)

A good brick earth should be such that it can be easily moulded and dried without cracking and wrapping. In order to determine the suitability of the brick earth, the necessary field tests are carried out, e.g. consistency test, test for moulding properties and test for deformation and shrinkages on burning.

Requirements of good brick earth:-

1 It must have proper proportions of sand, silt and clay.

2 It must be homogeneous.

3 It should have sufficient plasticity.

4 It must be free from lumps of lime or kankar.

5 It must be free from earth containing alkaline salts, kankar.

6 It must be free from pebbles, grits and lumps of earth.

7 It must not contain vegetable and organic matter.

8 It should not mix with salty water.

Composition of brick earth

1 Alumina (or) clay = 20-30% by weight

2 Silica or Sand = 35-50%by weight

3 Silt = 20-25% by weight

4 i. Iron oxide

ii. Magnesia

iii. Lime (CaO)

iv. Sodium potash = 1.2% by weight

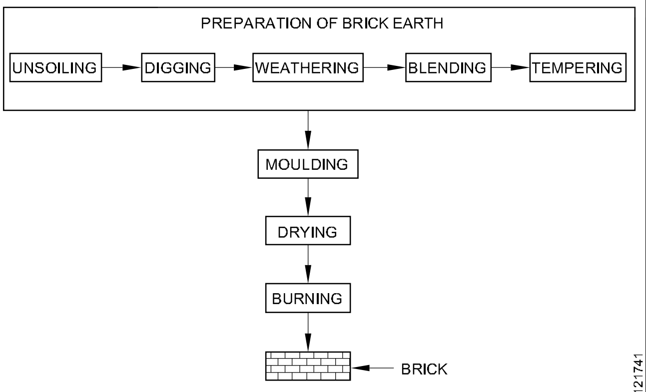
Total water- soluble material not more than 1%.

Lime + magnesia not more than 1% for alluvial soil

Not more than 15 for others.

Manufacturing of clay bricks (IS: 2117-1975)

Fig 1



OPERATIONS INVOLVED IN MANUFACTURING OF CLAY BRICKS

The process of manufacture can be described the following steps:

Selection of site, (selection and un-soiling)

Prepartion of clay, (digging & cleaning, weathering)& blending and tempering

Preparation of clay: The clay for bricks is prepared in the following order

i unsoiling

ii digging

iii cleaning

iv weathering

v blending

vi tempering

Unsoiling: The top layer of soil about 20cm in depth is taken out and thrown away. The clay in top soil is full of impurities and hence, it is to be rejected for the purpose of preparing bricks.

Digging : The clay is then dug out from the ground. It is spread on the levelled ground just a little deeper than the general level of ground. The height of heaps of clay is about 60cm to 120cm

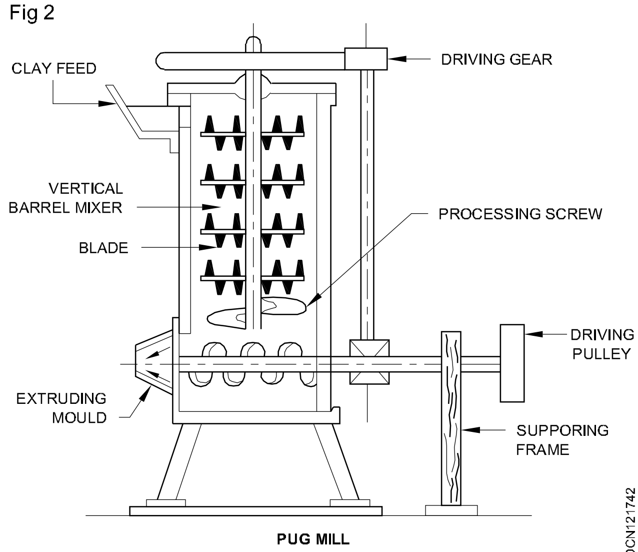
Cleaning: The clay as obtained in the process of digging, should be cleaned of stones, pebbles, vegetables matter, etc. If these particles are in excess the clay is to be washed and screened. Such a process naturally will prove to be troublesome and expensive. The lumps of clay should be converted into powder form in the earth crushing roller.

Weathering: The clay is then exposed to atmosphere for softening or mellowing the period of exposure varies from few weeks to full for a large project the clay is dug out just before the monsoon is allowed to weather throughout the monsoon.

Blending: The clay is made loose and any ingredient to be added to it, is spread out at its top. The blending indicates intimate or hormonious mixing. It is carried out by taking small portion of every time and by turning it up and in vertical direction. Blending makes clay fit for next stage of tempering.

Tempering: In the process of tempering, the clay is brouhght to a proper degree of hardness and it is made fit for the next operation . The water in required quanity is

Fig 2



PUG MILL

mass of clay added to clay and whole mass is kneaded or pressed under the feet of men or the tempering should be done exhaustively to obtain homogeneous uniform character.

Moulding : The clay which is prepared as above is then sent for the next operation of moulding. Following are the two ways of moulding:

Bricks

1 Hand moulding

2 Machine moulding

Hand moulding : In hand moulding the bricks are mould by hand ie manually. It is adoped where man power is cheap and is readilly available for the manufacturing process of brick on a small scale. The moulds are rectangular boxes which a open at top and bottom. They may be of wood or steel.

Ground moulded bricks : The ground is first made level and fine sand is sprinkled over it. The mould is dipped in water and placed over the ground the lump of tempered clay is taken and it is dashed in the mould. the clay is pressed or forced in a mould in such a way that it fills all the corners of mould. The extra or surplus clay is removed either by wooden strike or metal strike or frame with wire . A strike is a piece of wood or metal with sharp edge. It is to be dipped in water every time. The mould is then lifted up and raw brick is left on the ground. The mould is dipped in water and it is placed just near the previous brick to prepare another brick. The process is repated till the ground is covered with raw bricks. A brick moulder can mould about 750 bricks per day with working period of 8 hours. When such bricks become sufficiently dry, they are carried and placed in the drying sheds.

Table moulded bricks: The process of moulding these bricks is just similar as above. But in this case the moulder stands near a table of size about 2m X 1m. The clay mould water pots stock bard strkies and pallet boards are placed for the further process of drying. However the efficiency of moulder decreases gradully because of standing at the same place for long duration. The cost of brick moulding also increases when table moulding is adopted.

Machine moulding : The moulding may also be achieved by machines. It proves to be economical when bricks in large quantity are to be manufactured at the same pot in a short time. It is also helpful for moulding hard and strong clay. These machine are broadly classfied in two categories:

1 Plastic clay machines

2 Dry clay machines

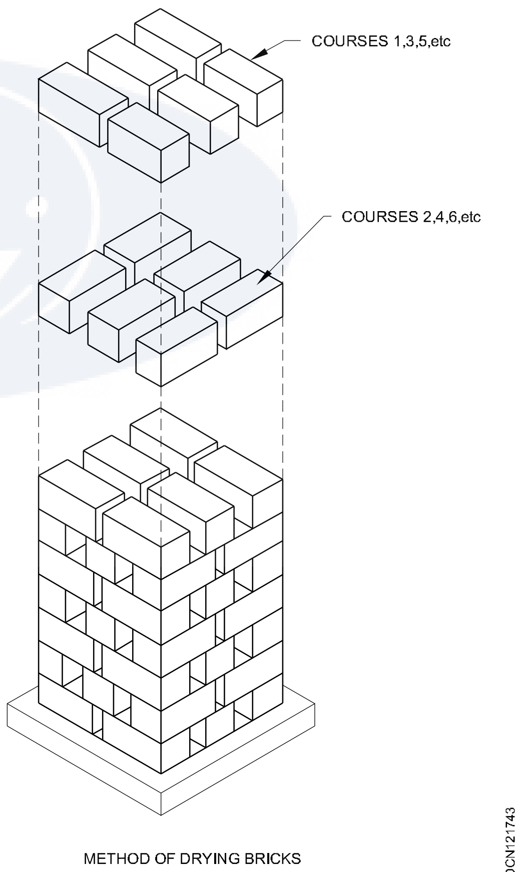
Plastic clay machines: Such machines contain a rectangular opening of size equal to length and width of a brick. The pugged clay is placed in the machine and as it comes out through the opening it is cut into strips by wires fixed in frames. The arrangements is made in such a way that strips of thickness equal to that of the brick are obtained. As the bricks are cut by wire, they are also known as wire cut bricks.

Dry clay machines: In these machines, the strong clay is first converted into powder form. A small quantity of water is then added to form a stiff plastic paste. Such paste is placed in mould and pressed by machine to form hard and well shaped bricks. These bricks are known as pressed bricks and they do not practically require drying. They can be sent directly for the process of buring.

The wire cut and pressed bricks have regular shape, sharp edges and corners. They have smooth external surface.They are heavier and stronger than ordinary hand moulded bricks. They carry distinct frogs and exhibit uniform dense texture.

Drying : The damp bricks, if burns are likely to be cracked and distorted. Hence the moulded bricks are dried before they are taken for the next operation of buring. For drying the bricks are laid longitudinally in stacks of width equal to two bricks. A stack consists of eight or ten tiers. The bricks are laid along and across the stock in alternate layers. All bricks are placed on edge. The bricks should be allowed to dry till they become leather hard or bone-dry with moisture content of about 2 per cent or so (Fig 3).

Fig 3



METHOD OF DRYING BRICKS

The important facts to be remembered in connections with drying of bricks are as follows:

Artificial drying : The bricks are generally dried by natural process. But when bricks are to be rapidly dired on a large scale, the artificial drying may be adopted. In such a case, the moulded bricks are allowed to pass through special dryers which are in the form of tunnels or hot channels or floors. Such dryers are heated with the help of special furnances or by hot flue gases. The tunnel dryers are more economical than hot floor dryers and they may be either periodic or continous.

In the former case, the bricks are filled, dried and emptied in rotation. In the latter case, the loading of bricks is done at one end and they are taken out at the other end. The temperature is usually less than 120^{0}C and the process of drying of brikcs takes about 1 to 3 days depending upon the temperature maintained in the dryer, quality of clay product etc.

Circulation of Air: The bricks in stacks should be arranged in such a way that sufficient air space is left between them for free circulation of air.

Drying yard: For the drying purposes, special drying yards should be prepared. It should be slightly on a higher level and it is desirable to cover it with sand. Such an arrangement would prevent the accumulation of rain water.

Period for drying: The time required by moulded bricks to dry depends on prevailing weather conditions.Usually it takes about 3 to 10 days for bricks to become dry.

Screens: It is to be seen that bricks are not directly exposed to wind or sun for drying. Suitable screens, if necessary may be provided to avoid such situations.

Burning : This is a very important operation in the manufacturing of bricks. It imparts hardness and strength to bricks and makes them dense and durable. The bricks should be burnt properly. If bricks are overburnt, they will be brittle and hence break easily, if they are underburnt, they will be soft and hence, cannot carry loads.

When the temperature of dull red heat, about 650^{0}C is attained, the organic matter contained in the brick is oxidized and also the water of crystallization in driven away. But heating of bricks is done beyond this limit for the following purposes:

(i) If bricks are cooled after attaining the temperature of about 650^{0}C, the bricks formed will absorb moisture from the air and get rehydrated.

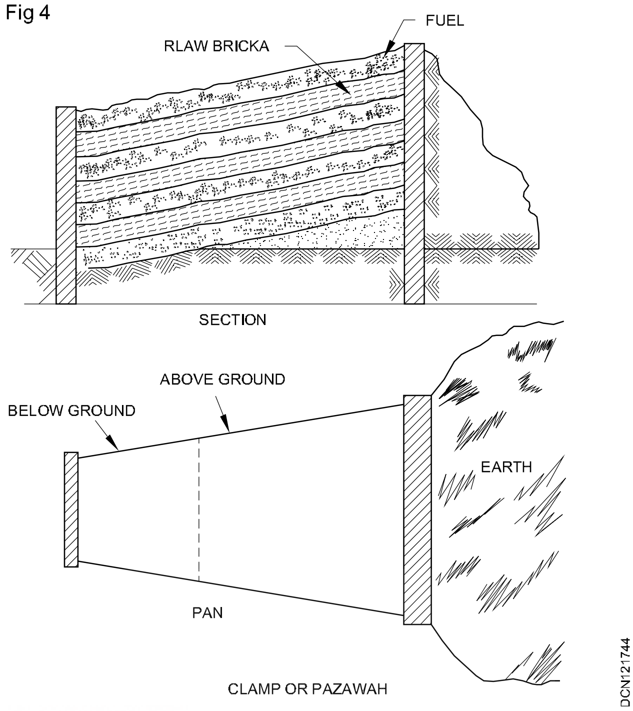
(ii) The reactions between the mineral constituents of clay are achieve at higher temperature and these reactions are necessary to give new properties such as strength hardness, less moisture absorption.etc. to the bricks

When the temperatrue of about 1100^{0}C is reached, the particles of two important constituents of brick clay, namely alumina and sand bind themselves together resulting in the increases of strength and density of bricks. Further heating is not desirable and if the temperatrue is raised beyond 1100^{0}C a great amount of fusible glassy mass is formed and the bricks are said to be vitrified. The bricks begin to loose their shape beyond a certain limit of vitrification.

The burning of bricks, is done either in clamps or in kilns the clamps are temporary structures and they are adopted to manufacture bricks on a small scale to serve a local demand or a specific purpose. The kilns are permanent structure and they are adopted to manufacture bricks on a large scale.

Clamps : A typical clamp is shown in fig 4 following procedure is adopted in its construcion.

Fig 4



CLAMP OR PAZAWAH

A piece of ground is selected its shape in plan is generally trapezoidal. The floor of clamp is prepared in such a way that short end is slightly in the excavation and wider end is raised at an angle of about 15^0 from ground level.

The brick wall in mud is construced on the short end and a layer of fuel is laid on the prepared floor. The fuel may consists of grass, cow dung, litter, husks of rice or ground nuts, etc. The thickness of this layer is about 70 cm to 80cm. The wood or coal dust may also be used as fuel.

A layer consisting of 4 or 5 courses of raw bricks, is then put up. The bricks are laid on edges with small spaces between them for the circulation of air.

A second layer of fuel is then placed and over it another layer of raw bricks is put up. Thus alternate layers of fuel and raw bricks are formed. The thickness of fuel layer gradually decreases as the height of clamp increases.

The total height of a clamp is about 3m to 4m . When nearly one-third height is reached the lower portion of the clamp is ignited. The object for such an action is to burn the bricks in lower part when the constvection of upper part of clamp is in progress.

When clamp is completely constructed it is plastered with mud on sides and top and filled with earth to prevent the escape of heat. If there is any sudden and violent outbursts of fire, it is put down by throwing earth or ashes.

The clamp is allowed to burn for a period of about one to two months.

It is then allowed to cool for more or less the same period as buring

The burnt bricks are then taken out from the clamp.

Advantages of clamp buring

The advantages of clamp burning are as follows:

The burning and cooling of bricks are gradual in clamps. Hence the bricks produced are tough and strong.

The buring of bricks by clamp proves to be cheap and Economical no skilled labour and supervision are required for the construciton and working of clamps.

The clamp is liable to damage/affected from high wind or rain.

There is consisderable saving of fuel.

Disadvantage of clamp burning

Following are the disadvantags of clamp buring

The bricksa are not of regular shape. This may be due to settlements of bricks when fuel near bottom is burnt and turned to ashes

It is very slow process

It is not possible to regulate fire in a clamp once it starts burning and the bricks are liable to uneven buring

The quality of bricks is not uniform. The bricks near the bottom are overburnt and those near sides and top are underburnt

Kilns: A kiln is large oven which is used to burn brick. The kilns which are used in the manufacture of bricks are of the following two types

Intermittent kilns

Continuous kilns

Intermittent kilns : These kilns are intermittent in operation which means that they are loaded, fired, cooled and unloaded. Such kilns may be either rectangular or circular in plan. They may be overgound or underground. They are classified in two ways:

Intermittent up draught kilns

Intermittent down-draught kilns

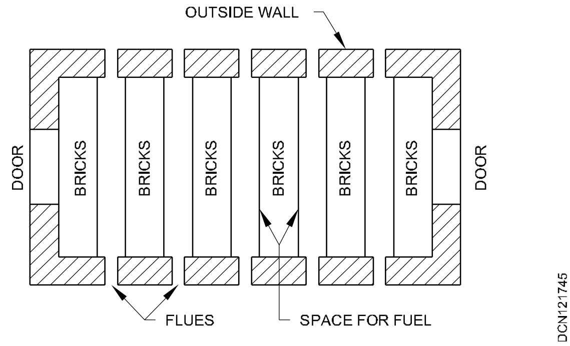
Intermittent up draught kilns : These kilns are in the form of rectangular structures with thick outside walls. The wide doors are provided at each end for loading and unloading of kilns. The flues are channels or passages which are provided to carry flames or hot gases through the body of kiln. A temporary roof may be installed of any light material. Such roof gives protection to raw bricks from rain while they are being placed in position. This roof is to be removed when the kiln is fired. Fig-5 shows the plan of a typical intermittent up-draught kiln. The working of the kiln is as follows:

The raw bricks are laid in rows of thickness equal to 2 to 3 bricks and of height equal to 6 to 8 bricks. A space of about 2 bricks is left between adjacent rows. This space is utilized for placing fuel.

The fuels are filled with brushwood which takes up a fire easily. The interior portion is then filled with fuel of bigger size.

An arch like opening is formed by projecting 4 to 5

Fig 5



rows of bricks. The projection of each row is about 30mm to 40mm.

The loading of kiln with raw bricks is then carried out.The top course is finished with flat bricks . Other courses are formed by placing bricks-on-edge.

The end doors are built up with dry bricks and are covered with mud or clay.

The kiln is then fired. The fire can be regulated by opening or closing the iron sheet doors of the fire holes and by controlling the supply of fuel. The progress of burning at any instant can be seen through these holes. For the first three days, the firing is kept slow by proper manipulation of flues. The strong fire is maintained for a period of 48 to 60 hours. The draught rises in the upwards direction from bottom of kiln and brings about the buring of bricks.

The kiln is allowed to cool down gradually for at least 7days and the brikcs are taken out.

The procedure is then repeated for the next buring of bricks.

The bricks manufactured by the intermittent up-draught kilns are better than those prepared by clamps. But such kilns have the following disadvantags

The quality of burnt bricks is not uniform. The bricks near, bottom are overburnt and those near top are underburnt.

The supply of bricks is not continous

There is wastage of fuel heat as kiln is to be cooled down every time after burning.

Intermittent down-draught kilns: These kilns are rectangular or circular in shape. They are provided with permanent walls and closed light roof. The floor of the kiln through flues. The working of this kiln is more or less similar to the up-draught kiln. But it is so arranged in this kiln that hot gases are carried through vertical flues up to level of roof and they are then released. These hot gases move downward by the chimney draught and in doing so, they burn the bricks.

Following advantages are claimed for intermittent down-draught kilns:

The bricks are evenly burnt

The performances of this kiln is better than that of up-draught kiln.

There is close control of heat and hence, such kilns are useful for burning structural clay tiles, terra-cotta, etc.

Continuous kilns: These kilns are continous in operation. This means that loading, firing, cooling and uploading are carried out simultaneously in these kilns. There are various types of the continuous kilns. Following three varieties of continous kilns will be discussed:

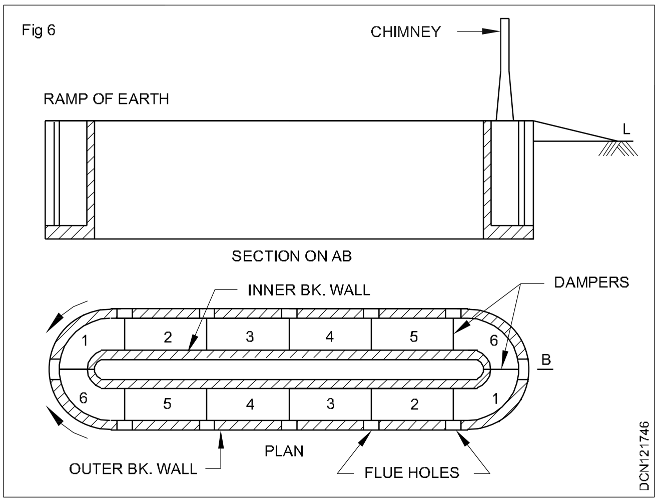
Bull's trench kiln

Hoffman's kiln

Tunnel kiln

Bull's trench kiln: This kiln may be of rectangular circular or oval shape in plan. Fig 6 shows a typical bulls kiln of oval shape in plan. As the name suggest the kiln is constructed in a trench excavated in ground. In latter case, the ramps of earth should be provided on outside walls. The outer and innner walls are to be constructed of bricks. The opening are generally provided in the outer walls to act as flue holes. The dampers are in the form of iron plates and they are used to divide the kilns in suitable sections as shown in fig 6. This is most widely used kiln in India and it gives continuously supply of bricks.

The bricks are arranged in sections. They are arranged in such a way that the flues are formed. The fuel is placed in flues and it is ignited through flue holes after covering top surfaces with earth and ashes to prevent the escape of heat. The flue holes are provided in sufficient number on top to inset fuel holes when buring is in progress. Usually two movable iron chimneys are employed to from draught. These chimneys are placed in advance of section being fired. Hence the hot gases leaving the chimneys warm up the bricks in next section. Each section requires about one day to burn. When a section has been burnt, the flue holes are closed and it is allowed to cool down gradually. The fire is advanced to next section and chimneys are moved forward as shown by arrows in Fig 6.



The Bull's trench kiln is working continuously as all the operations-loading, buring cooling and uploading are carried out simultaneously Fig 6 shows Bull's kiln with two sets of sections. Two pairs of chimneys and two gangs of workers will be required to operated this kiln. A tentative arrangements for different sections may be as follows:

Section 1 - Loading

Section 2 - Empty

Section 3 - Unloading

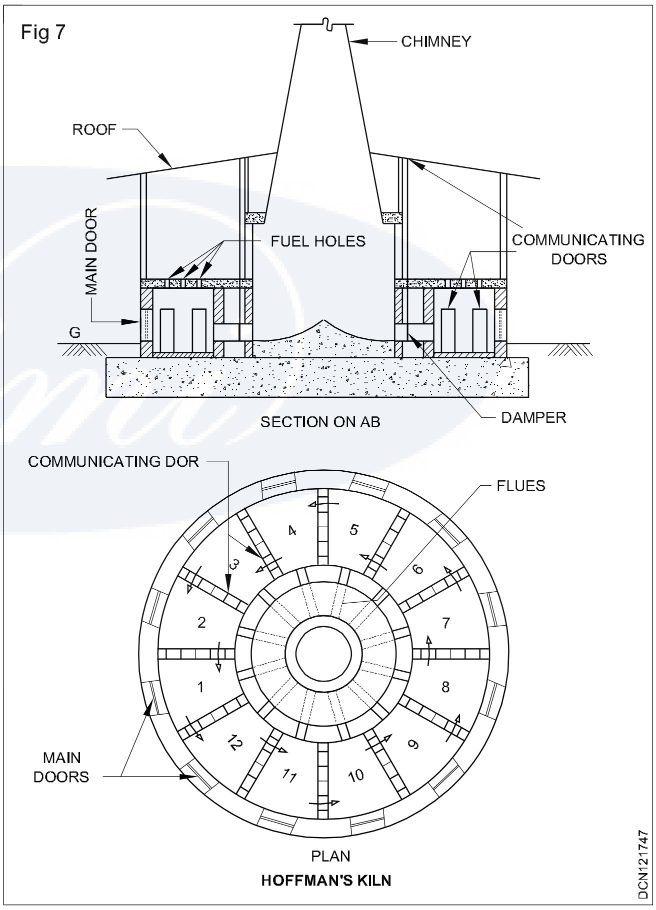
Section 4 - Cooling

Section 5 - Burning

Section 6 - Heating

Hoffman's kiln: This kiln is constructed overground and hence, it is sometimes known as flame kiln. Its shape is circular in plan and it is divided into a number of compartments or chambers. As a permanent roof is provided the kiln can even function during rainy season. Fig 7 shows plan and section of Hoffman's kiln with 12 chambers. Each chamber is provided with following:

- a maindoor for loading and unloading of bricks
- communicating doors which would act as flues in open conditions.



a radial flue connected with a central chimney and fuel holes with covers to drop fuel, which may be in the form of powdered coal, into burning chambers.

The main doors are closed by dry bricks and covered with mud, when required. For communications doors and radial flues, the dampers are provided to shut or open them. In the normal conditions, only one radial flue is connected to chimney to establish a draught.

In this type of kiln each chamber performs various functions in succession, namely loading drying burning cooling and unloading. As an illustration 12 chambers shown in Fig 7 may be functioning as follows:

Chamber 1	-	loading
Chamber 2 to 5	-	drying and pre-heating
Chamber 6 and 7	-	Burning
Chamber 8 and 11	-	Cooling
Chamber 12	-	Unloading

With the above arrangements the circulation of the flue gas will be shown by arrows in fig 7 The cool air enters through chambers 1 and 12 as their main doors are open. After crossing the cooling chambers 8 to 11, it enters the burning section in a heated condition. It then moves to chambers 2 to 5 to dry and pre-heat the raw bricks. The damper of chamber 2 is in open condition and hence, it escapes into atmosphere through chimney.

The initial cost of installing this kiln is high: but it possesses the following advantages:

- The bricks are burnt uniformly equally and evenly. Hence the high percentage of good quality bricks can be produced
- It is possible to regulate heat inside the chambers through fuel holes.
- The supply of bricks is continous and regular because of the fact that the top of kiln is closed and it can be made to work during the entire year.
- There is considerable saving in fuel due to pre-heating of raw bricks by flue gas. Thus the hot gases are fully utilized in drying and pre-heating the raw bricks.
- There is no air pollution in the locality because the exhaust gases to not contain black smoke or coal dust particles.

Qualities of good bricks

The good brick which are to be used for construction of important engineering structure should possess the following qualities

1 Size and shape	6 Porosity
2 Color	7 Strength
3 Structural	8 Resistance of fire
4 Hardness	9 Efflorescence
5 Soundness	10 Durability

Example

1 Colour: - Uniform copper red colour.

2 Shape: - Rectangular 19 x 9 x 9 cm Standard.

3 Sound: - Sound proof, clear ringing sound when struck with each other.

4 Absorption:- It should not<20% for I Class <22% for II Class When socked in cold water for 24hrs

5 Toughness: - Should not be break when dropped from an height of 1 meter.

6 Crushing Strength: - 3-5 N/mm square. Minimum.

7 Specific gravity - 2-2.6

Classification of brick:-

The brick can broadly be dividing into two categories as following:

1 Unburnt bricks: These brick are dried with the help of sun heat only.

2 Burnt bricks: These brick are burnt clamp or kiln. They are classified into the following the four categories:-

1 **1ST Class bricks:** R.B. work, following, as blast R.C. work arches etc.

2 **2nd Class brick:** Un-important situation and for internal walls.

3 **3rd Class brick:** Temporary building

4 **4th Class brick:** Foundation and Floor etc.

Testing of bricks: Indian standards, IS: 3495-1992, 'Method of test for burnt clay bricks, Part 1 to 4' gives details of the tests, as follows:

Class designation IS:3102-1071 according to their compressive strength (N/ mm²)	Sampling size	Lot size	Test to be made
10	20 bricks	50,000 or more	1 com.strength 2 waterabsorption 3 efflorescence 4 dimensional test 5 hardness 6 soundness
7.5 to 3.5	20 bricks	100,00 or more	Test at the discretion of the engineer in charge.

The tests to be made on bricks, as given above, are as follows

1 **Absorption test:** To know about the amount of water absorbed of brick.

2 **Crushing strenght test:** To know about the compressive strength in brick

3 **Effloresence test:** To know about the presence of soluble salt in the brick.

4 **Hardness test:** To know the hardness of brick by figure nail.

5 **Shape and size:** To know the standard size and shape of brick.

6 **Soundness:** To know about the strength of soundness.

7. **Structure:** To know about the any hole, lumps in the brick.

Special bricks: (Fig 8)

These bricks differ from the commonly used building bricks with respect to their shape, specification and special purpose for they are made.

1 Specially shaped bricks

2 Heavy duty bricks

3 Perforated bricks

4 Burnt clay hollow bricks

5 Sand lime bricks

6 Sewer bricks

7 Acid resistant bricks

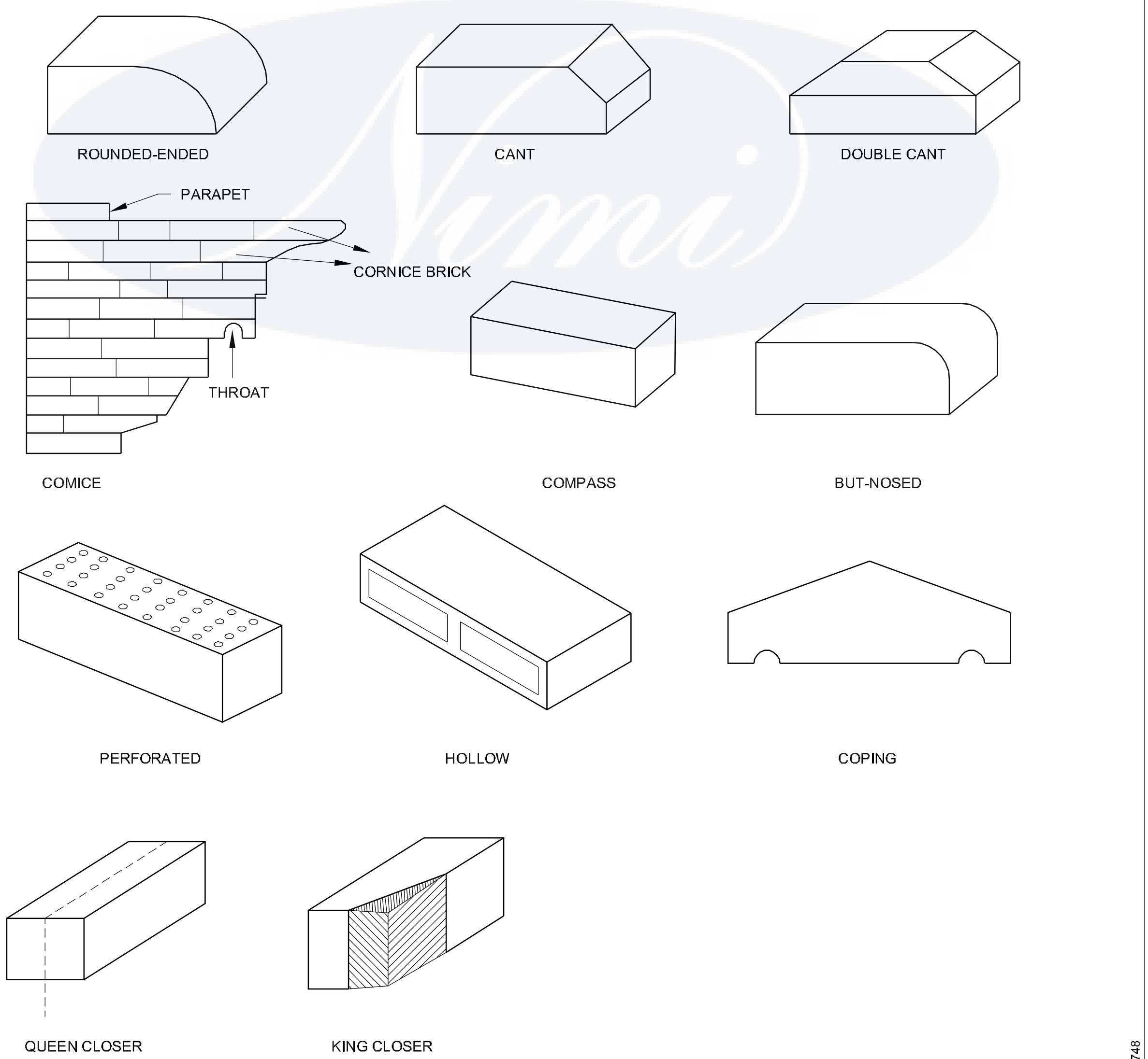
Hollow bricks

Hollow bricks are made from clay and formed with cavities which module their weight.

These bricks are used 20 mm to 25 mm thick wall. They are suitable for partition wall.

The cavity reduces the transmission of sound and hoot. The hollow bricks are machine pressed and formed cavity in the brick (Fig 8)

Fig 8



FORMS OF BRICKS

Lime

Objectives: At the end of this lesson you shall be able to
- **define lime**
- **classify lime**
- **state properties of lime**
- **describe uses of lime**
- **compare fat and hydraulic lime**
- **explain tests for lime**
- **list out the precautions in handling lime.**

Introduction

lime is produced from calcium carbonates in the form of limestone, seashells, coral, kankar, etc. quicklime is not a stable product. If it left exposed to air, it absorbs carbon dioxide from air and revert back to carbonate. Hence, quick lime should be slaked to calcium hydroxide (Hydrated or slaked lime) as early as possible to make the material stable.

Definition

A powder obtained by heating limestone, is called lime.

Classification

IS: 712-1973, classifies lime as follows:

Class a: eminently hydraulic lime, which can be used for structural works, such as arches, domes, etc.

Class b: semi-hydraulic lime which can be used for constructing masonry.

Class c: fat lime that can be used for finishing coat in plastering, white washing, etc. or used for masonry mortar with addition of pozzolanic material.

Class d: magnesium or dolomite lime is used for finishing coat in plastering and whitewashing.

Class e: Kankar lime produced by burning lime nodules (found in soils like black cotton soils contain silica) is hydraulic. It can be used for masonry mortar.

Class f: Siliceous dolomite lime is used generally for undercoat and finishing coat of plaster.

Notes:

1 Carbide lime is a by-product of manufacturing of acetylene. It can be used for mortar for plaster work, but generally it is not recommended for whitewashing un less procured fresh in the form of a paste before it dries up or is treated properly.

2 Lime containing more than30percentage impurities like clay is called poor limes.

Properties of lime

1 Easily workable.

2 Possesses good plasticity.

3 Stiffens early.

4 Provides strength to the masonry.

5 Offers good resistance to moisture.

6 An excellent cement and adheres to the masonry units perfectly

7 Lime masonry proves durable due to low shrinkage in drying.

Uses of lime

1 It is used as a matrix for concrete.

2 It is used as a binding material in mortars for stoneware and also in bedding and joining brickwork of low strength.

3 It is used for plastering walls, ceilings, etc.

4 It is employed for white washing and as a base coat for distempers.

5 It is used for knotting of timber work before painting.

6 It is used for production of artificial stone, lime - sand bricks, foam-silicate products, etc.

7 When mixed with Portland cement, the lime-cement mortar attains such valuable properties, that it replaces the costly cement plaster and serves as a plasticizer.

8 It is used as a flux in the manufacture of steel.

9 Eminently hydraulic lime can be used for masonry work below ground level.

10 It is used in the manufacture of paints.

11 It is used for stabilizing the soils.

12 It is employed for creating good sanitary conditions in foul, damp and filthy places.

Tests for lime: It can be classifies into two types- laboratory test and field test.

Laboratory tests for building lime: Indian standards specify ten laboratory tests for lime in IS: 6932-1973 'Methods of test for building lime'.

Field tests for building lime: IS: 6924-1974, gives a number of field tests for building lime, as follows:

1 Visual examination: class C lime should be pure white in colour.

2 Hydrochloric acid test: The purpose of this test is to assess the classification and calcium-carbonate content of lime.

3 Ball test: the purpose of this test is to assess the classification.

Comparison between fan lime and hydraulic limes:

S.No.	Item	Fat Lime	Hydraulic lime
1	Composition	It is obtained from comparatively pure carbonate of lime containing only 5% of clayey impurities.	It is obtained from lime stones containing to the extent of about 5 to 30 % and some amount of ferrous oxide.
2	Slaking action	It slakes vigorously. Its volume is increased to about 2 to 2 1/2 times the volume of quick lime. The slaking is accompained by sound and heat.	It slakes slowly. Its volume a slightly increased. The slaking is not accompanied by sound or heat.
3	Setting action	It sets slowly in presence of air. It absorbs carbon dioxide from atmosphere and forms atmosphere and forms calcium carbonate.	It sets under water. It combines with water and forms crystals of hydrated tri-calcium silicate.
4	Hydraulicity	It does not possess hydraulic property.	It possesses hydraulic property.
5	Colour	It is perfectly white in colour.	Its colour is not so white as fat lime.
6	Strength	It is not very strong. Hence, it cannot be used where strength is required.	It is strong and can therefore be adopted where strength is required.
7	Uses	It is used for plastering, white washing, etc. and for preparing mortar with sand or surkhi.	It is used for preparing mortar for thick walls, damp places, etc. extreme care is required to prepare mortar of this lime for plaster work.

4 **Impurity test:** the purpose of this test is to assess the quality of lime.

5 **Plasticity test:** the purpose of this test is to assess the plasticity of lime

6 **Workability test:** the purpose of this test is to assess the workability of lime.

Precautions in handling lime:

1 Contact with water: the quick lime should not be allowed to come in contact with water before slaking.

2 Facilities for workers: goggles for eyes and respirators for nose and throat protection, rubber gloves, gum boots, skin protecting cream or oil and there should be provision of adequate quantity of water.

3 Fire hazard: all suitable measures should be taken to avoid chances of any fire hazard.

Cement

Objectives: At the end of this lesson you shall be able to
- **define cement**
- **state the properties of cement**
- **explain uses of cement**
- **compare cement and lime**
- **state manufacturing of cement**
- **explain the flow diagram of the wet process of cement manufacturing**
- **describe types of cement**
- **state cement water proofer**
- **state Admixtures**
- **explain test for cement**

Introduction

cement is the most important material in building construction. This is obtained by heating a mixture of lime and clay. Cement may be prescribed as a material with adhesive and cohesive properties which must be capable of bonding mineral fragments into a compact whole. Cement may be classified as: (i) Natural Cement, (ii) Artificial Cement.

Definition

Material obtained by burning mixture of calcareous and argillaceous Materials with a small quantity of gypsum at a very high temperature and pulverized into very fine powder, known as Cement.

Properties of cement

Good cement possesses the following properties:

1 Provides strength to masonry.

2 Stiffens or hardens early.

3 Possesses good plasticity.

4 An excellent building material.

5 Easily workable.

6 Good moisture-resistant.

Uses of cement:

1 Cement mortar for masonry works, plaster, pointing, etc.

2 Concrete for laying floors, roofs and constructing lintels, beams, weather sheds, stairs, pillars, etc.

3 Construction of important engineering structures such as, bridges, culverts, dams, tunnels, storage reservoirs, light houses, docks, etc.

4 Construction of water tanks, wells, tennis courts, septic tanks, lamp posts, roads, telephone cabins, etc.

5 Making joints for drains, pipes, etc.

6 Manufacture of precast pipes, piles, garden seats, artistically design urns, flower pots, etc., dustbins, fencing posts, etc.

7 Preparation of foundations, watertight floors, footpaths, etc. The comparision between cement and lime is shown in Table - A

Manufacture of portland cement: (Fig 1 and Fig 2)

There are two processes employed,

1 Wet process- this process is generally used if the raw Materials available are soft e.g. chalk and clay.

Burning: The burning is carried out in a rotary kilin as shown in fig 1. A rotary klin is formed of steel tubes. Its diameter varies form 250 cm to 300cm. Its length varies from 90m ti 120m. It is laid at a gradien of about 1 in 25 to 1 in 30. The klin is supported at intervals by columns of massonry or concrete. The refractory lining is provided on the inside surface or rotary klin. It is so arranged that the klin rotates at about one to three revolutions per minute about its longitudinal axis.

The corrected slurry is injected at the upper end of klin. Fig 1 shows the rotary klin for the wet process. The hot gases or flames are forced through the lower end of kiln. The portion of the kiln near its upper end is known as dry zone and in this zone, the water of slurry is evaporated. As the slurry gradually descends, there is rise in temperatrue and in the next sectin of kiln, the carbon dioxide from slurry is evaporated. The small lumps, known as nodules, are formed at this stage . These nodules then gradually roll down passing through zones of risinhg temperatrue and ultimately reach to the burning zone, where temperature is about 1400^{0}C to 1500^{0}C. In burning zone, the calcined product is formed and nodules are converted into small hard dark greenish blue balls which are known as clinkers.

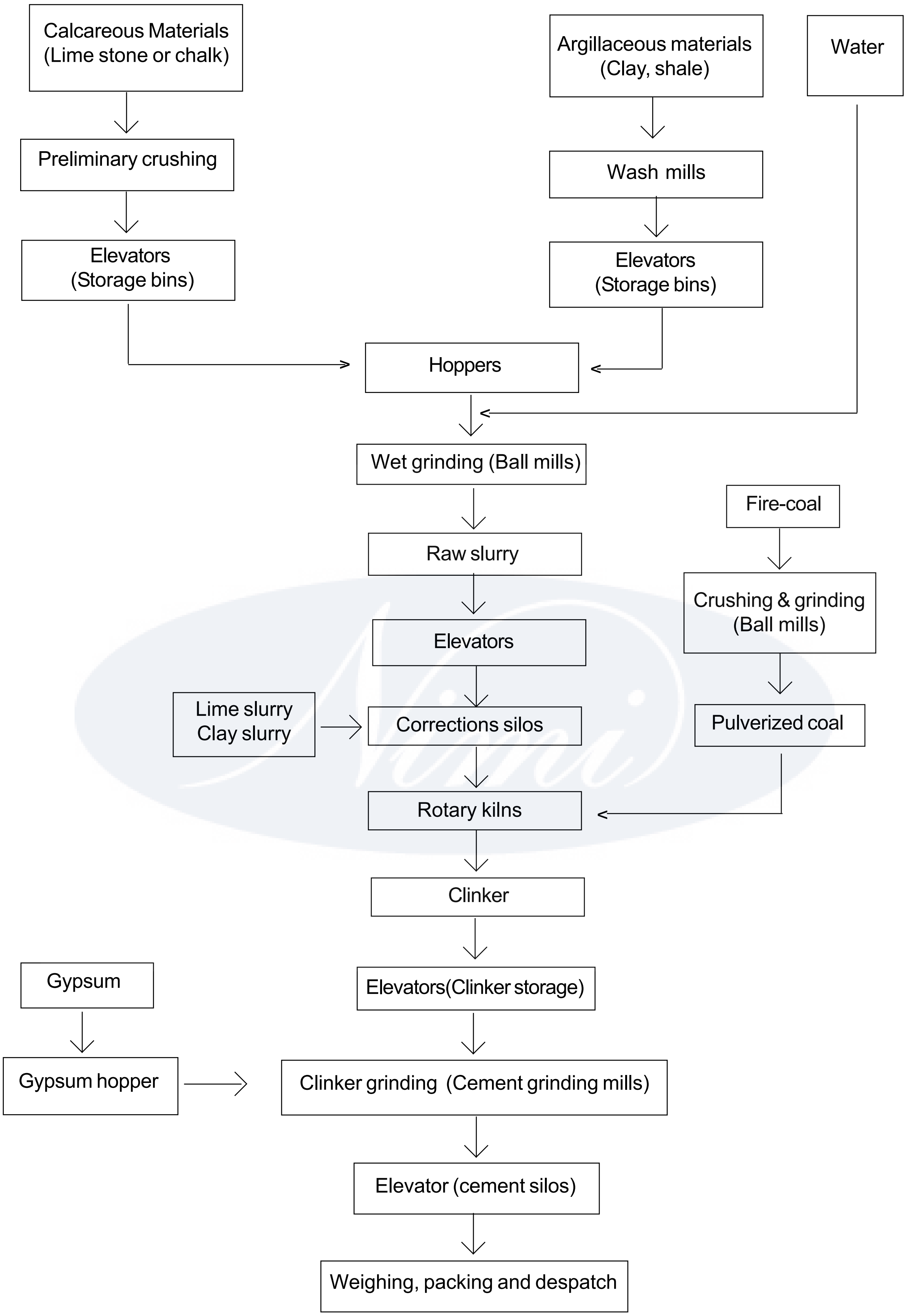
In the modern technology of dry process, the coal brought from the coal fields is pulverised in vertical coal mill and it is stored in silos. It is pumped with required quantity of air through the burners. The preheated raw Materials roll down the kiln and get heated to such an extent that the carbon dioxide is driven off with combusion gases. The material is then heated to temperature of nearly 1400^{0}C to 1500^{0}C when it gets fused together. The fused product is known as clinkers or raw cement.

Table - A

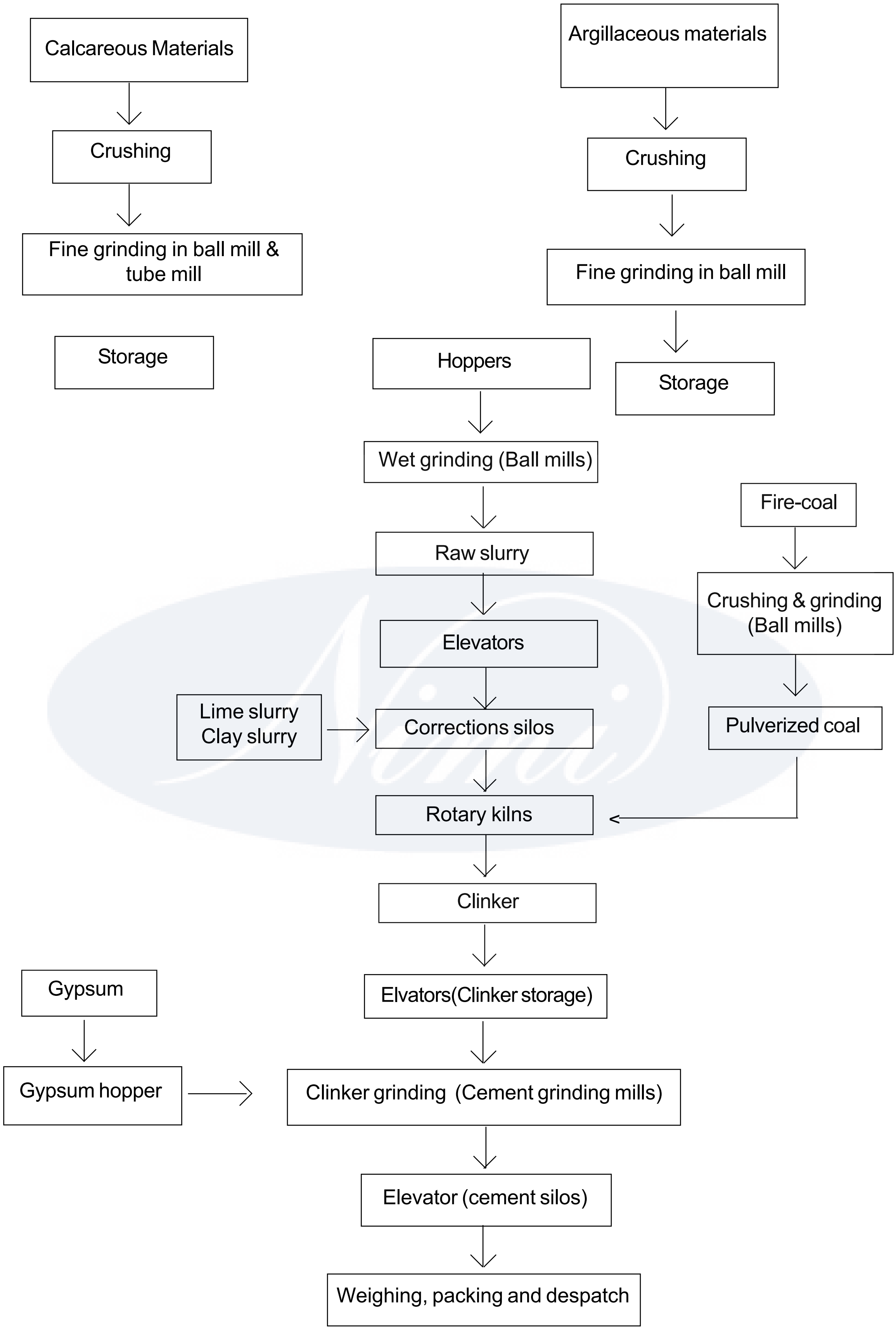
Comparison between cement and lime

S.No.	Aspects	Cement	Lime
1	Colour	Greenish grey.	White or grayish.
2	Slaking	Does not slake when wetted with water	Slakes when wetted with water
3	Setting	Sets rapidly when mixed with water	Sets slowly when mixed with water
4	Strength	Artificial cement possesses more strength	Possesses less strength.
5	Suitability	Can be used for important and heavy engineering structures	Cannot be used for important and heavy engineering structures.

FLOW DIAGRAM FOR WET PROCESS



FLOW DIAGRAM OF DRY PROCESS

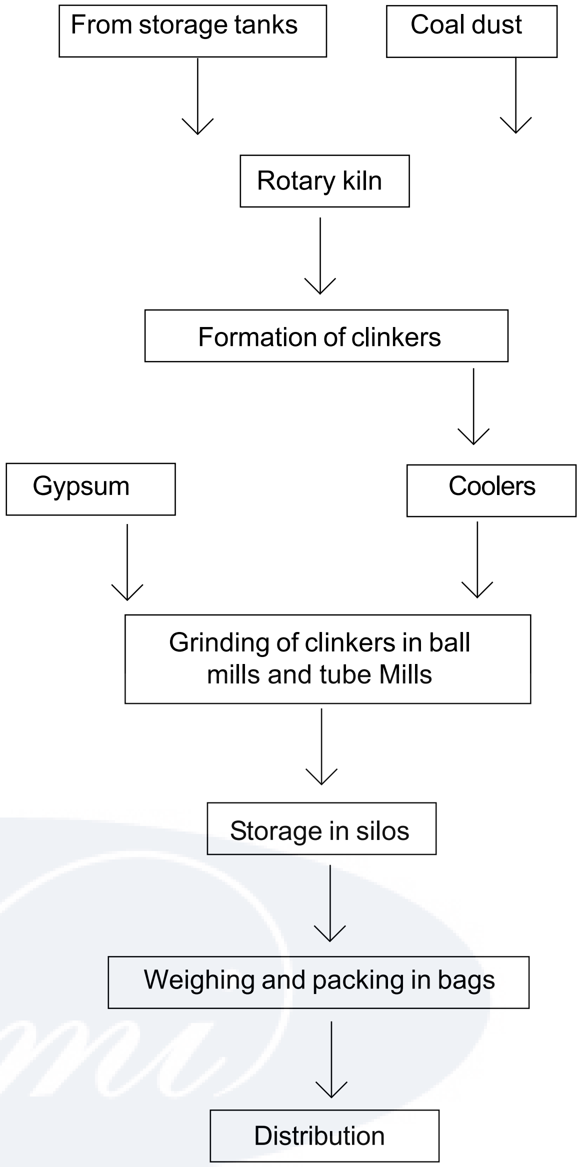


The size of clinkers varies from 3mm to 20mm and they are very hot when they come out of buring zone of kiln. The clinker temperature at the outlet of kilnis nearly 1000^0C to 1500^0C when it gets fused together. The fused product is known as clinkers or raw cement.

The size of clinkers varies from 3mm to 20mm adn they are very hot when they come out of buring zone of kiln. The clinker temperature at the outlet of kin is nearly 1000^0C. A rotary kiln of small size is provided to cool down the hot clinkers. It is laid in opposite direction as shown in Fig 1 and the cooled clinkers having temperature of about 95^0C are collected in containers of suitable sizes.

Grinding : The clinkers as obtianed from the rotary kiln are finely ground in ball mills and tube mills. During grinding a small quantity about 3 to 4 percent of gypsum is added. The gypsum controls the initial setting time of cement. If gypsum is not added,the cement would set as soon as water is added. The gypsum acts as a retarder and it delays the setting action of cement. It thus permits cement to be mixed with the aggregate and tobe placed in position.

The grinding of clinkers in modern plants is carried out in the cement mill which contains chromium steel balls of various sizes. These balls roll within the mill and grind the mixture which is collected in a hopper and taken in the bucket elevator for storage in silos. The cement from silos is fed to the packer machines. Most of the modern plants have electric packing plant having provision plan to account for the weights of empty bags of different types and to ensure a 50kg net weight of cement bag within $\pm 200g^3$ limit . Each bag of cement contains 50kg or about $0.035m^3$ of cement. These bags are automatically discharged from the packer to the conveyoyur belts to different loading area. They are carefully stored in a dry place Fig 1 shows the flow diagram of buring and grinding operations.



Flow diagram of burning and grinding operations of cement

Packing of cement : The packing of cement is mostly done in our country in conventional jute or gunny bags. These bags have proved to be satifactory containers as their shape and size make them convenient to handle. If the properly handled, they may make three to five trips form the factory to the cement users. However the main drawbacks of such type of packing are as follows:

At every point of handling some portion of cement contained in jute bag is wasted.

Even after emptying the cement bag, small quantity of cement remains in the bag and it is thus not possible to take advantage of the full contents of the bag.

Such type of packing leads to the air pollution.

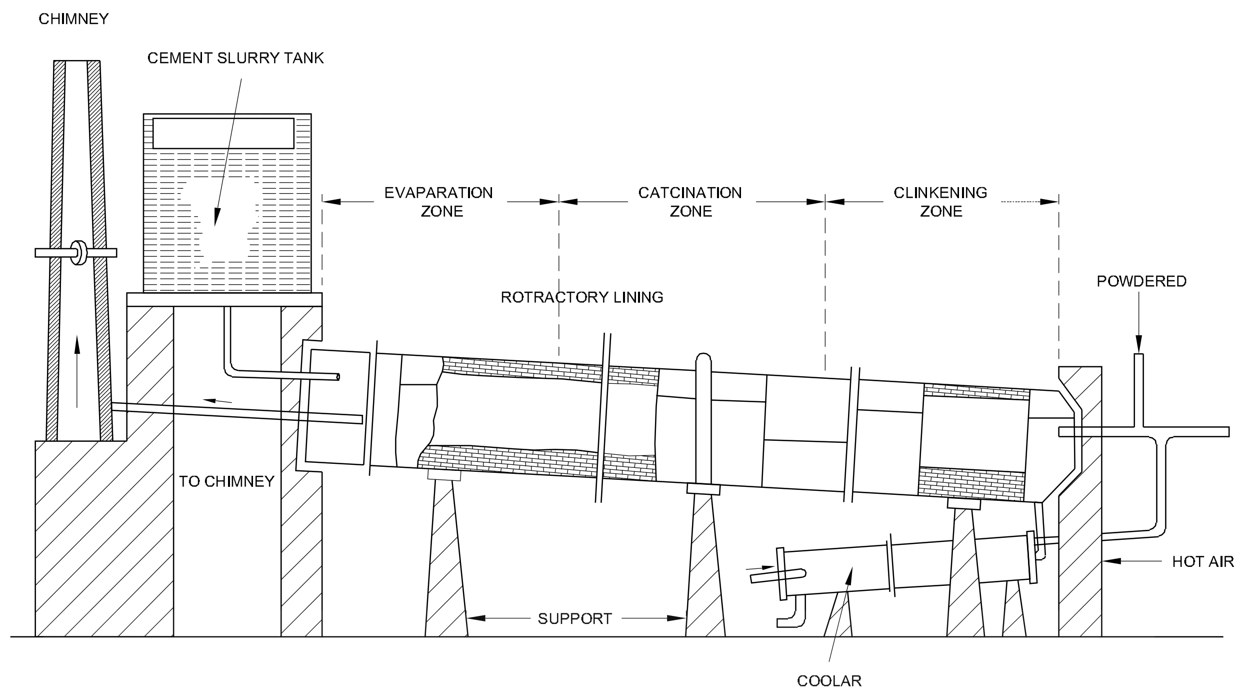
The handling of jute bags proves harmful to the healthy of labourer also as he inhales a considerable amount of cement particles during the transport of such bags.

The quality of cement is affected due to entry of moisture from the atmosphere.

Dry process : this is usually employed where the raw materials are hard such as cement rock or blast furnace slag. adopted in most of the cement industries, due to-

- For dry process the heat required per kg of clinker produced is less.
- The blending of dry powders has now perfected and the wet process which requires much higher consumption of power can be replaced with confidence.
- The application of modern technology has made the production of cement by dry process more economical and of superior quality.
- Both the processes involve the following steps:
- Collection of raw materials.
- Crushing, grinding and mixing of raw materials.
- Burning.
- Grinding of clinker.(Fig 2)

Fig 1



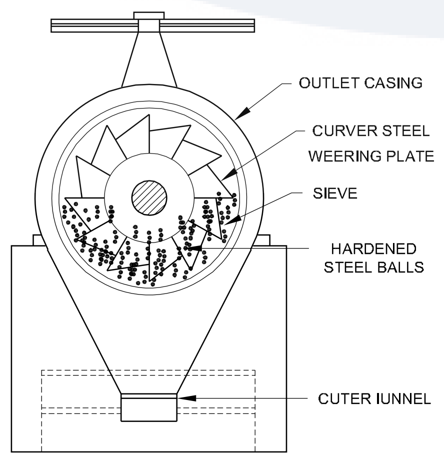
ROTART KILN

Ball mill (Fig 2)

TYPES OF CEMENT

Cement is specified by its grade (compressive strength of 1:3 cement mortars as cubes of 50 cm² areas (7.06 cm) in 28 days for defining strength) thus, Grade-33 cement (C-33) means cement with standard mortar cube strength of 33 N/ mm² in 28 days. Only the grade of the cement is marked on the bags of 50 kg.,

Fig 2



BALL MILL

The following are the IS specifications:

1. Ordinary Portland cement (OPC) in 3 grades,

a) Grade 33 - IS: 269-1989 designated as C-33,

b) Grade 43 - IS: 269-1989 designated as C-43,

c) Grade 53 - IS: 269-1989 designated as C-53

2. Portland pozzolana cement (PPC) (a mixture of OPC and Pozzolana)

a) IS: 1489 (Part-I)-1991 (fly ash -based)

b) IS: 1489 (Part-II)-1991 (calcined clay-based)

3 Sulphate-resisting cement-IS: 12330-1988

4 Portland slag cement-IS:455-1989 (PSC)

5 Low- heat cement-IS: 12600-1989

6 Rapid-hardening cement-IS:8041-1990

7 Concrete sleeper-grade cement-IS: T40-1985

8 Coloured cement-white cement-IS: 8042-1989

9 Oil well cement-IS: 8229-1986

10 Hydrophobic cement-IS: 8043-1991

11 Masonry cement-IS: 3466-1988

12 High-alumina cement-IS: 6452-1989

13 Super-sulphated cement-IS: 6909-1990

14 Expansive cement

15 Quick setting cement

CEMENT WATER PROOFERS

The water proofers are required for all water retaining structures especially for:

i) Swimming pools

ii) Basements

iii) Hospitals

iv) Refrigeration rooms

v) Cold storages

vi) Water supply and sewage works

vii) Exterior plaster

viii) Bath rooms and kitchens

ix) Reservoir

These water proofers render mortar or concrete water tight either by filling the pores physically or reacting chemically. The water proofer may be in powder, paste or liquid form. The amount to be added must be in accordance with the instructions of the manufactures; generally the following proportions are used:

" 2 to 5 %.......when in powder form

" 1part paste and 10 parts water…when in paste form

" 1 litre liquid and 15 litres water….when in liquid form

ADD MIXTURES

These are the Materials which are added in cement mortar or concrete to improve upon their quality. The admixtures serve the following purposes:

1 Improve the workability

2 Retard setting action of the mortar and concrete.

3 Increase the bond strength between reinforcement and concrete.

4 Improve the water proofing properties of the cement mortar or concrete.

5 Reduce shrinkage during setting of mortar or concrete.

6 Reduce bleeding and segregating effect of concrete.

TESTS FOR CEMENT

The properties of concrete or mortar largely depend upon the quality of cement used. The quality of cement can be tested in the laboratory by the following tests based on Indian Standard Specification (IS: 269-1958):

1 Fineness-To know the fineness of grinding.

2 Compressive strength-Cement cubes are prepared and tested after 3,7 and 28 days of curing.

3 Consistency-to know the quantity of water to be added for testing the cement for setting time, soundness and compressive strength. Vicat apparatus is used for this test.

4 Setting times-To know the initial and final setting times. Vicat apparatus is used for this purpose.

5 Soundness -To find out the presence of free lime. Le chatelier apparatus is used for this purpose.

Field tests may be carried out to ascertain roughly the quality of cement:

1 Colour-Greenish grey

2 Presence of lumps, -Pressed between the thumb and fore finger it should be powdered.

3 Rubbing-When rubbed between the fingers it should feel smooth.

4 When a hand full of cement thrown into a bucket of water it floats.

5 One should feel cold when a hand is insert in to a bag of cement.

Grades of cement

The bureau of Indian Standards has classified in three different grades

i 33 grads

ii 43 grade

iii 53 grade

The grade number indicates the compressive strength of cement sand mortar in N/mm^2 at 28 days

Properties of cement

- Provides strength to masonry
- Stiffens or hardens early
- Possesses good plasticity
- An excellent building material
- Easily workable
- Good moisture resistant

S.No.	Types	Features	Uses
1	Ordinary portland cement	General concrete structures	Medium rate of strength developed less resistance to chemcial attack
2	Acid resistant cement	Acid resistant heat resistant coating of installation of chemical industry	It cannot resist the action of water well
3	Rapid hardening portland cement	Rapid strength is developed	Curing period short, burnt at high temperature
4	Blast furnance cement	Mass concrete structure	Initial setting time not less than 30 minutes, final setting time 10 Hrs
5	Expading cement	Construction of water retaining structures repairing the damaged concrete structures	

S.No.	Types	Features	Uses
6	Coloured cement	Finishing of floors, external surface artificial marble, stair tread	By adding 5 to 15% of suitable colouring pigment before the cement is finally ground.
7	High alumina cement	For works in chemical plant and furnaces	It is completely resistant to the action of surface
8	Hydrophobic cement	Frost resistant and water resistant	Initial stage the gain in strength is less
9	Modified portland cement	Heavy construction of heavy abutment, large piers, retaining wall etc	Less heat of hydration
10	Extra rapid hardening cement	Suitable for cold weathering concrete	Qty of calcium chloride should not exceed 3 percentage
11	Sulphate resisting portland cement	Used at places where sulphate action is severe.	

Port land - pozzolana cement (IS:1489)

- This cement is made either by intergrading port land cement clinker and pozzolana or by uniformly blending port land cement and fine prozzolana.
- The pozzolana cement contain varies from 10 to 25% by weight of cement.
- Pozzolana does not possess cementing value themselves but any how the property of combining with the lime which possess cementing property.
- It free lime is removed, the pozzolana concrete have a greatly resistance to chemical agencies and also resist the sea work better than ordinary cement.
- Pozzolana cement is popularly used in the construction of dam.
- Pozzolana cement manufactured in burnt clay or shade or fly ash.

The following table shows the compressive strengths reduces by ordinary portioned cement and port land pozzolana cement.

Table

Compressive strength of port land pozzolana cement and ordinary port land cement

Age in days	Compressive strength	
	Ordinary port land cement	**Port land Pozzolana cement**
1	77 Kg/cm^2 - 8 N/mm^2	77 Kg/Cm^2 - 8 N/mm^2
3	192 Kg/cm^2 - 19 N/mm^2	165 Kg/cm^2 - 16 N/mm^2
7	256 Kg/cm^2 - 26 N/mm^2	247 Kg/cm2 - 25 N/mm^2
14	310 Kg/cm^2 - 31 N /mm^2	301 Kg/cm^2 - 30 N /mm^2
15	375 Kg/cm^2 - 38 N /mm^2	375 Kg/cm^2 - 38 N /mm^2