CIVIL ENGINEERING

(Diploma Standard)

- ★ Construction Materials and Construction Practice
- ★ Hydraulics
- ★ Transportation Engineering
- ★ Surveying
- ★ Engineering Mechanics
- ★ Construction Management
- ★ Estimating and Costing
- ★ Environmental Engineering and Pollution Control
- ★ Mechanics of Structure
- ★ Structural Engineering

CONSTRUCTION MATERIALS & CONSTRUCTION PRACTICE

CONSTRUCTION MATERIALS

Introduction

The use of the construction materials depends on the nature and purpose of the structure to be built. There are many types of building materials used in construction such as Concrete, Steel, Wood and Masonry. Each material has different properties such as weight, strength, durability and cost which makes it suitable for certain types of applications.

The choice of materials for construction is based on cost and effectiveness to resist the loads and stresses acting on the structure.

Stones

- In many places, stones are more freely available than any building material. They are derived from rocks.
- The stones for construction works are obtained by quarrying rocks. Such stones are very irregular in shape and size. They are therefore dressed for proper bedding, thin joints and speedy construction. When such stones are laid with cement or lime mortar in a systematic manner, they form a structural mass which can resist load without disintegration.

Classification of Rocks

Rocks are classified into three types. They are,

1. Geological classification
2. Physical classification
3. Chemical classification

1. Geological Classification

According to this classification, rocks are of 3 types. They are:

1. Igneous rocks
2. Sedimentary rocks
3. Metamorphic rocks

- **Igneous Rocks :** Stones obtained from these rocks are very strong and durable. It is the result of cooling and consolidation of molten lava released from volcanoes. E.g. Granite, Basalt.
- **Sedimentary Rocks :** They are formed by gradual deposition of broken pieces of rocks which are disintegrated by atmospheric actions. It is transported from one place to another place and deposited at the bottom of rivers or lakes. These deposits harden due to water pressure. E.g. Limestone, Sandstone
- **Metamorphic Rocks :** Metamorphic rocks are a type of rock that have become changed by intense heat or pressure while forming. In the very hot and pressured conditions deep inside the Earth's crust, both sedimentary and igneous rocks can be changed into metamorphic rock. In certain conditions these rocks cool and crystallize into bands of crystals. Later they can become exposed on Earth's surface. The change in colour, structure and texture are due to either pressure or heat or both. Eg. Marbles, Slates.

2. Physical Classification

This classification is based on general structure of rocks. According to this classification, rocks are of three types. They are:

1. Stratified Rocks
2. Unstratified Rocks
3. Foliated Rocks

- **Stratified Rocks :** Sedimentary rocks are distinctly stratified rocks. They are formed by series of parallel layers. E.g. Limestone, Sandstone, Slates.
- **Unstratified Rocks :** Igneous and sedimentary rocks which are affected by movements of earth are of this type of rocks. They cannot be split into thin slabs. E.g. Granite, Marble.
- **Foliated Rocks :** These rocks have a tendency to split up in a definite direction. Such foliated structure is very common in metamorphic rocks. E.g. Gneiss.

3. Chemical Classification

This classification is based on their chief constituents. Chemically, rocks are of three types. They are :

1. Silicious Rocks
2. Calcareous Rocks
3. Argillaceous Rocks

- **Silicious rocks :** These rocks have silica or sand as their main constituent. They are hard and durable. E.g. Sand stone, Granite.
- **Calcareous Rocks :** These rocks have calcium carbonate as their main constituent. E.g. Lime stone, Marble.
- **Argillaceous Rocks :** In these rocks clay predominates. E.g. Slate, Laterite.

Uses of Stones

Stones are widely used in many permanent engineering works on account of their strength and durability. The principal uses of stone in construction are:

- As material for foundation
- As aggregate for concrete making
- As material for road construction
- As thin slabs for Pavings
- In Ornamental Works
- As Wall, Columns, Beams and Lintels in Buildings.
- Limestone for manufacture of cement
- As roofing tiles in the form of slates

Characteristics of Good Building Stones

Following are the characteristics of good building stone:

- **Crushing Strength :** For a good structural stone, the **crushing strength should be greater than 100 N/mm².**
- **Appearance :** The stones which are to be used for face work, should be decent in appearance and they should be capable of preserving their colour uniformly for a long time. The colour of the stones for face work should be chosen by keeping in mind the environmental condition of the surrounding area.
- **Durability :** A good building stone should be durable. The various factors contributing the durability of a stone are its chemical composition, texture, resistance to atmosphere and other influences, location of the structure, etc. The important atmospheric agency which affect the durability of a stone is alternate conditions of heat and cold due to difference in temperature.
- **Dressing of Stones:** Stones should be such that they can be easily carved, moulded out and dressed. Dressing of stones results in economy of construction.
- **Fracture :** For a good building stone, its fracture should be sharp, even, bright and clear with grains, well cemented together. A dull, chalkey and earthly fracture of a stone, reduces the life span of the building.
- **Hardness :** The co-efficient of hardness, as worked out in hardness test should be **greater than 17 for a stone to be used in road work. If it is between 14 and 17, the stone is said to be of medium hardness.**
- **Attrition :** In attrition test, if wear is more than 3%, the stone is not satisfactory. If it is equal to 3%, the stone is just tolerable.
- **Fire Resistance :** The minerals composing stone should be fire resistant in such a way that the shape is preserved when a fire occurs.
- **Seasoning :** The stones should be well seasoned before putting into use. The stones obtained freshly from a quarry, contain some moisture which is known as the quarry sap. The presence of this moisture makes the stone soft.
- **Specific Gravity :** For good building stone, the **specific gravity should be greater than 2.7 or so.**
- **Texture :** A good building stone should have compact, fine, crystalline structure free from cavities, cracks or patches of soft or loose material. These stones with such texture are strong and durable.
- **Water Absorption :** All the stones are more or less porous, but for a good stone, percentage of water absorption by weight s**hould not exceed 0.60 after 24 hours immersion in water.**

Crushing strength of common building stones

Name of Stone	Crushing Strength in N/mm²
Trap	300 to 350
Basalt	153 to 189
Granite	104 to 140
Slate	70 to 210
Marble	72
Sand stone	65
Lime stone	55
Laterite	1.8 to 3.2

Tests on Stones

To acertain the required properties of stones, the following tests can be conducted:

- crushing strength test
- water absorption test
- abrasion test
- impact test
- acid test.

Crushing Strength Test : For conducting this test, specimen of size 40 × 40 × 40 mm are prepared from parent stone. Then the sides are finely dressed and placed in water for 3 days. The saturated specimen is provided with a layer of plaster of paris on its top and bottom surfaces to get even surface so that load applied is distributed uniformly. Uniform load distribution can be obtained satisfactorily by providing a pair of 5 mm thick play wood instead of using plaster of paris layer. The specimen so placed in the compression testing machine is loaded at the rate of 14 N/mm² per minute. The crushing load is noted. Then crushing strength is equal to the crushing load divided by the area over which the load is applied. At least three specimen should be tested and the average should be taken as crushing strength.

Water Absorption Test : For this test cube specimen weighing about 50 grams are prepared and the test is carried out in the steps given below:

- Note the weight of dry specimen as W_1.
- Place the specimen in water for 24 hours.
- Take out the specimen, wipe out the surface with a piece of cloth and weigh the specimen. Let its weight be W_2.
- Suspend the specimen freely in water and weight it. Let its weight be W_3.
- Place the specimen in boiling water for 5 hours. Then take it out, wipe the surface with cloth and weigh it. Let this weight be W_4. Then,

Percentage absorption by weight

$$= \frac{W_2 - W_1}{W_1} \times 100 \qquad \text{..... (1)}$$

Percentage absorption by volume

$$= \frac{W_2 - W_1}{W_2 - W_3} \times 100 \qquad \text{..... (2)}$$

Percentage porosity by volume

$$= \frac{W_4 - W_1}{W_2 - W_3} \times 100 \qquad \text{..... (3)}$$

$$\text{Density} = \frac{W_1}{W_2 - W_1} \quad \ldots\ldots (4)$$

$$\text{Specific gravity} = \frac{W_1}{W_2 - W_3} \quad \ldots\ldots (5)$$

$$\therefore \text{ Saturation coefficient} = \frac{\text{Water absorption}}{\text{Total porosity}}$$

$$= \frac{W_2 - W_1}{W_4 - W_1}$$

Abrasion Test : This test is carried out on stones which are used as aggregates for road construction. The test result indicate the suitability of stones against the grinding action under traffic. Any one of the following test may be conducted to find out the suitability of aggregates:

1. Los Angeles abrasion test
2. Deval abrasion test
3. Dorry's abrasion test.

However Los Angeles abrasion test is preferred since these test results are having good correlation with the performance of the pavements.

Then Los Angeles value can be calculated as :

$$= \frac{\text{Weight of aggregate passing through sieve}}{\text{Original weight}} \times 100$$

The following values are recommended for road works:

For bituminous mixes – 30%

For base course – 50%

Impact Test : The resistance of stones to impact is found by conducting tests in impacting testing machine. It consists of a frame with guides in which a metal hammer weighing 13.5 to 15 kg can freely fall from a height of 380 mm.

Aggregates of size 10 mm to 12.5 mm are filled in cylinder in 3 equal layers; each layer being tamped 25 times. The same is then transferred to the cup and again tamped 25 times. The hammer is then allowed to fall freely on the specimen 15 times. The specimen is then sieved through 2.36 mm sieve. Then,

$$\text{Impact value} = \frac{W_2}{W_1}$$

where W_2 = weight of fines

W_1 = original weight.

The recommended impact values for various works are:

- for wearing course $\not>$ 30%
- for bituminous mechadam $\not>$ 35%
- for water bound mechadam $\not>$ 40%

Acid Test : This test is normally carried out on sand stones to check the presence of calcium carbonate, which weakens the weather resisting quality. In this test, a sample of stone weighing about 50 to 100 gm is taken and kept in a solution of one per cent hydrochloric acid for seven days. The solution is agitated at intervals. A good building stone maintains its sharp edges and keeps its surface intact. If edges are broken and powder is formed on the surface, it indicates the presence of calcium carbonate. Such stones will have poor weather resistance.

BRICKS

- Clay bricks were used by humans from very early dates. First, it was used without burning as sundried bricks. Burnt brick was a common building material among the Egyptians. Now a days, they are made from specially selected and matured brick earth. It is used to construct the building because of its good bearing capacity, long life and strength. Bricks are made up of blending a good clay, moulded to a rectangular shape of uniform size, dried and burned. As bricks are in uniform size they can be beautifully laid in masonry work.
- Bricks are obtained by moulding clay in rectangular moulds, then by drying and burning them. In places where stones are not easily available, bricks are used in construction. These are preferred because of its durability, strength, reliability, low cost, etc.

- The earliest bricks were sun dried and made from mud.
- It was used in 8000 BC in southern Turkey around the city of Jericho.
- In Mesopotamia (modern Iraq) the first true arch of sun baked brick was made about 4000 BC.
- Ceramic or fried (burned) bricks were used as early as 3000 BC in early Indus valley cities.

Size and Weight of Brick

- The Bricks are prepared in various sizes. The custom in the locality is the governing factor to decide the size of brick. Such bricks which are not standardised are known as traditional bricks.
- BIS has recommended the bricks of uniform size. Such bricks are known as Modular bricks. **The actual size of modular bricks is 190mm × 90mm × 90mm. With mortar thickness (10mm) the nominal size of modular brick is 200mm × 100mm × 100mm.**
- But practically to match with the beam width, a brick or block of width **230mm is used widely in construction industry. 115mm is considered for half brick. The brick of size 230 mm × 110mm × 110 mm or 230mm × 110mm × 76mm is generally used in construction industry.**
- **It is found that the weight of 1m^3 of brick earth is about 1800 kg. Hence the average weight of brick will be about 3.0 to 3.5 kg.**
- The size of Indian brick, we are using is 228mm × 107mm × 69mm.

Brick Earth

Bricks are easily moulded from plastic clays also known as brick clay or brick earth.

Composition of Good Brick Earth

According to IS 2119-1975 the clay or mixture of clay selected should preferably confirm the following composition.

Clay = 20 – 30% by weight

Silt = 20 – 35% by weight

Sand = 35 – 50% by weight

Constituents of Brick Earth

Following are the constituent of good brick earth.

- **Alumina :** It is the chief constituent of clay. A good brick earth should **contain 20 to 30% of alumina.** This constituent imparts plasticity to earth. So that it can be moulded easily. If alumina is present in excess, raw bricks shrink and warp during drying and burning.
- **Silica :** A good brick earth should contain **about 50 to 60% of silica.** Silica exists in clay either as free or in combined form. As free sand, it is mechanically mixed with clay and in combined form, it exists in chemical composition with alumina. Presence of silica prevents cracking, shrinking and warping of raw bricks. It thus imparts uniform shape to the bricks. Durability of bricks depends on the proper proportion of silica in brick earth. Excess of silica destroys the cohesion between particles and brick will become brittle.
- **Lime :** A small quantity of lime is desirable in finely powdered state to prevents shrinkage of raw bricks. Excess of lime causes the brick to melt and hence its shape is lost.
- **Oxide of Iron :** A small quantity of oxide of iron to the extent of **5 to 6%** is desirable to impart red colour to bricks. Excess of iron oxide makes the bricks dark blue or blackish.
- **Magnesia :** A small quantity of magnesia in brick earth imparts yellow tint to bricks, and decrease shrinkage. But excess of magnesia leads to the decay of bricks.

Manufacture of Brick

The following are various steps involved in the preparation of bricks :

1. Preparation of clay
2. Moulding
3. Drying
4. Burning

Preparation of Clay

The preparation of clay involves the following operations:

- **Unsoiling :** Top layer of 20 cm depth is removed as it contain impurities.
- **Digging :** Clay dug out from ground is spread on level ground about 60 cm to 120 cm heaps.
- **Cleaning :** Stones, pebbles, vegetable matter, etc., are removed and the lumps are converted in to powder form.
- **Weathering :** Clay is to be exposed to atmosphere from few weeks to full season.
- **Blending :** Clay is made loose and any ingredient to be added to it is spread out at top and it is turned up and down in vertical direction.
- **Tempering :** Clay is brought to a proper degree of hardness. Then water is added to the clay and the whole mass is kneaded or pressed under the feet of men or cattle.

For large scale, tempering is usually done in pug mill.

Process : Clay with water is placed in pug mill from the top. When the vertical shaft is rotated by using electric power, clay is thoroughly mixed up by the actions of horizontal arms and knives. When clay has been sufficiently pugged, hole at the bottom of tub is opened and the pugged earth is taken out from ramp.

Moulding

Clay which is prepared from pug mill is sent to the next operation of moulding. Following are the two ways of moulding :

1. Hand Moulding
2. Machine Moulding.

1) Hand Moulding :

Moulds are rectangular boxes made of wood or steel which are open at top and bottom. Steel moulds are more durable and used for manufacturing bricks on large scale as shown in fig. Bricks prepared by hand moulding are of two types.

a) Ground Moulding

b) Table Moulding

a) Ground Moulding :

Ground is first made level and fine sand is sprinkled over it. Mould is dipped in water and placed over the ground to fill the clay. Extra clay is removed by wooden or metal strike, after the mould is filled. Mould is then lifted up and raw brick is left on the ground. Mould is then dipped in water every time. Lower faces of ground moulded bricks are rough and it is not possible to place frog on such bricks. Ground moulded bricks of better quality and with frogs on their surface are made by using a pair of parallel boards and a wooden block.

b) Table Moulding :

Process of moulding these bricks is just similar to ground moulded bricks. These are moulded on a table of size about 2m × 1m. The clay, mould, water pots, stock board, strikes and pallet boards are placed on the table. The bricks are moulded on the table and sent for the further process of drying.

However the efficiency of moulder decreases gradually because of standing at the same place for long duration. The cost of brick moulding also increases when table moulding is adopted.

2) Machine Moulding :

This method proves to be economical when bricks in huge quantity are to be manufactured at the same

spot. It is also helpful for moulding hard and string clay. These machine are broadly classified into two categories

a) Plastic Clay Machine.

b) Dry Clay Machine.

Plastic Clay Machine :

This machine containing rectangular opening of size equal to thickness and width of a brick. Pugged clay is placed in the machine and as it comes out through the opening, it is cut into strip of standard length by wires. So these bricks are called **"Wire cut bricks"**.

Dry Clay Machines :

In these machines, strong clay is first converted into powder form and then water is 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 heavier than ordinary hand moulded bricks. They carry distinct frog and exhibit uniform texture.

Drying

The damp brick, if burnt, are likely to be cracked and distorted. Hence, moulded bricks are dried before they are taken for the next operation of burning.

Bricks are laid along and across the stock in alternate layers. The drying of brick is done by the following means:

- **Artificial Drying :** Drying by tunnels usually 120°c about 1 to 3 days.
- **Circulation of Air :** Stacks are arranged in such a way that sufficient space is left between them for free circulation of air.
- **Drying Yard :** Special yards should be prepared slightly higher level to prevent the accumulation of rain water.
- **Period of Drying :** Usually three to ten days needed for bricks to dry.

Burning

- This is very important operation in the manufacture of bricks. It imparts hardness and strength to brick and makes them dense and durable. The bricks should be burnt properly.
- If bricks are over burnt, they will be brittle and hence break easily. If they are under burnt, they will be soft and cannot carry loads.
- During burning, when the temperature of about 650°c is attained, the organic matter contained in the brick is oxidized and also the water of crystallization is driven away.
- When the temperature of about 1100°c is reached, the particles of the earth bind themselves together resulting in the increase of strength and density to bricks. Further heating is not desirable and if the temperature is raised beyond 1100°c great amount of fusible glassy mass is formed and the bricks will lost its shape. Bricks are burnt in clamps or kilns.

Classification of Brick

According to use, bricks are classified into five categories. They are,

- Ordinary Bricks
- Engineering Bricks (special bricks for carrying heavy loads)
- Facing Bricks
- Fire Bricks
- Special bricks (special shapes)

According to general physical requirements bricks are classified into three categories. They are,

1) Class I
2) Class II
3) Class III

The bricks belongs to these three classification, differ in their general requirements and water absorption property.

As per IS classification, bricks are classified according to their compressive strength. They are 10, 7.5, 5.0 and 3.5 having compressive strength of 10 N/mm^2, 7.5 N/mm^2, 5 N/mm^2 and 3.5 N/mm^2 respectively.

Properties of Good Bricks

- Good bricks should be of compact structure, free from cracks and flaws such as air bubbles, lumps and stones.
- They should be regular in shape and of uniform size with plane faces and sharp edges.
- Length should be equal to twice the width plus the thickness of mortar joints. (Length = (2 × Width) + thickness of mortar joints).
- The colour should be uniform and of deep red or copper colour.
- When soaked in water for 24 hours, a good brick should not absorb water more than 20% of its own weight.
- A well burnt brick should be hard and when scratched with the finger nail, no impression should be formed.
- On striking it with each other, it should give a clear ringing or metallic sound.
- When struck against one another or thrown on end on a hard ground from a **height of 1m,** the bricks should not break.
- **The crushing strength should not be less than 55 kg/cm^2.**

Hollow Blocks

- Concrete blocks are now-a-days used for masonry construction. These blocks are available in three types namely solid blocks, hollow blocks and cellular blocks.
- The normal concrete blocks are called as solid blocks.
- If the percentage of voids is more **than 25%** then it is called as hollow blocks, if the percentage of voids is **less than 25% it is called as perforated blocks.**
- Cellular blocks are generally referred as light weight aerated concrete blocks.

Concrete blocks are usually made large in size. So that the block work is faster and consume less cement in joints than the brick work. Specially made hollow

blocks are also used to construct load bearing walls. Such works are useful in reducing the dead load of masonry in buildings.

Manufacturing of Hollow Blocks

The concrete mix for concrete blocks shall not be richer than one part of cement to six parts of volume of combined aggregate. Lean mixes upto 1 : 8 are also commonly used. The choice of aggregates for manufacturing these block is of utmost importance as cost of aggregates account for a large part of the total cost. Hence "Baby jelly" aggregates that are not generally used for conventional concrete work are found of much use in making these concrete blocks.

Classification of Hollow Blocks

Hollow concrete blocks are classified by IS into the following three grades.

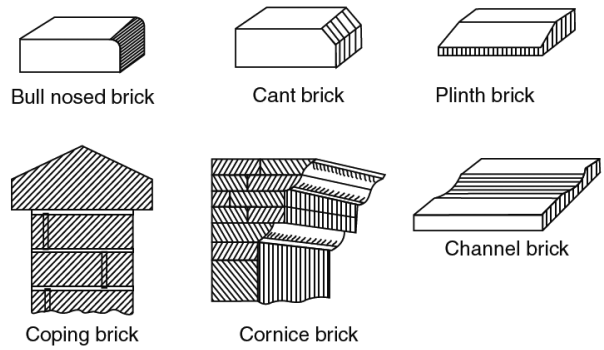
- **Grade A :** These blocks are used for load bearing walls. They should have a minimum density of 1500 kg/m^3. They should be manufactured for minimum specified compressive strength of 3.5, 4.5, 5.5 and 7.0 N/mm^2 in 28 days.
- **Grade B :** These are also used for load bearing walls. They may have a density below 1500 kg / m^3 but, not less than 1000 kg/m^3. They are made for specified compressive strength of 2.0, 3.0 and 5.0 N/mm^2 in 28 days.
- **Grade C :** These are used for non-load bearing walls, and its density is not less than 1000 kg/m^3. They are made for specified strength of 1.5 N/mm^2 in 28 days.

Special Bricks

These bricks are different from the commonly used building bricks with respect to their shape and the purpose for which they are made. Some of such bricks are listed below:

(a) Specially shaped bricks
(b) Facing bricks
(c) Perforated building bricks
(d) Burnt clay hollow bricks
(e) Sewer bricks
(f) Acid resistant bricks.

- **Specially Shaped Bricks :** Bricks of special shapes are manufactured to meet the requirements of different situations.
- **Facing Bricks:** These bricks are used in the outer face of masonry. Once these bricks are provided, plastering is not required. The standard size of these bricks are 190 × 90 × 90 mm or 190 × 90 × 40 mm.
- **Perforated Building Bricks:** These bricks are manufactured with area of perforation of 30 to 45 per cent. The area of each perforation should not exceed 500 mm^2. The perforation should be uniformly distributed over the surface. They are manufactured in the size 190×190×90 mm and 290×90× 90 mm.
- **Burnt Clay Hollow Bricks:** They are light in weight. They are used for the construction of partition walls. They provide good thermal insulation to buildings. They are manufactured in the sizes 190 × 190 × 90 mm, 290 × 90 × 90 mm and 290 × 140 × 90 mm. The thickness of any shell should not be less than 11 mm and that of any web not less than 8 mm.
- **Sewer Bricks:** These bricks are used for the construction of sewage lines. They are manufactured from surface clay, fire clay shale or with the combination of these. They are manufactured in the sizes 190 × 90 × 90 mm and 190 × 90 × 40 mm. The average strength of these bricks should be a minimum of 17.5 N/mm^2 . The water absorption should not be more than 10 per cent.
- **Acid Resistant Bricks:** These bricks are used for floorings likely to be subjected to acid attacks, lining of chambers in chemical plants, lining of sewers carrying industrial wastes etc. These bricks are made of clay or shale of suitable composition with low lime and iron content, flint or sand and vitrified at high temperature in a ceramic kiln.



Special shaped bricks

Tests on Bricks

The following laboratory tests may be conducted on the bricks to find their suitability:

(i) Crushing strength
(ii) Absorption
(iii) Shape and size and
(iv) Efflorescence.

- **Crushing Strength:** The brick specimen are immersed in water for 24 hours. The frog of the brick is filled flush with 1:3 cement mortar and the specimen is stored in damp jute bag for 24 hours and then immersed in clean water for 24 hours. The specimen is placed in compression testing machine with 6 mm plywood on top and bottom of it to get uniform load on the specimen. Then load is applied axially at a uniform rate of 14 N/mm^2. The crushing load is noted. Then the crushing strength is the ratio of crushing load to the area of brick loaded. Average of five specimen is taken as the crushing strength.
- **Absorption Test :** Brick specimen are weighed dry. Then they are immersed in water for a period of 24 hours. The specimen are taken out and wiped with cloth. The weight of each specimen in wet condition

is determined. The difference in weight indicate the water absorbed. Then the percentage absorption is the ratio of water absorbed to dry weight multiplied by 100. The average of five specimen is taken. This value should not exceed 20 per cent.

- **Shape and Size :** Bricks should be of standard size and edges should be truely rectangular with sharp edges. To check it, 20 bricks are selected at random and they are stacked along the length, along the width and then along the height. For the standard bricks of size 190 mm × 90 mm × 90 mm. IS code permits the following limits:
- Lengthwise : 3680 to 3920 mm
- Widthwise : 1740 to 1860 mm
- Heightwise : 1740 to 1860 mm.

The following field tests help in acertaining the good quality bricks:

(i) uniformity in size
(ii) uniformity in colour
(iii) structure
(iv) hardness test
(v) sound test
(vi) strength test.

- **Uniformity in Size :** A good brick should have rectangular plane surface and uniform in size. This check is made in the field by observation.
- **Uniformity in Colour :** A good brick will be having uniform colour throughout. This observation may be made before purchasing the brick.
- **Structure :** A few bricks may be broken in the field and their cross-section observed. The section should be homogeneous, compact and free from defects such as holes and lumps.
- **Sound Test :** If two bricks are struck with each other they should produce clear ringing sound. The sound should not be dull.
- **Hardness Test :** For this a simple field test is scratch the brick with nail. If no impression is marked on the surface, the brick is sufficiently hard
- **Efflorescense :** The presence of alkalies in brick is not desirable because they form patches of gray powder by absorbing moisture. Hence to determine the presence of alkalies this test is performed as explained below:

Place the brick specimen in a glass dish containing water to a depth of 25 mm in a well ventilated room. After all the water is absorbed or evaporated again add water for a depth of 25 mm. After second evaporation observe the bricks for white/grey patches. The observation is reported as 'nil', 'slight', 'moderate', 'heavy' or serious to mean

- **Nil :** No patches
- **Slight :** 10% of area covered with deposits
- **Moderate :** 10 to 50% area covered with deposit but unaccompanied by flaking of the surface.
- **Heavy :** More than 50 per cent area covered with deposits but unaccompanied by flaking of the surface.
- **Serious :** Heavy deposits of salt accompanied by flaking of the surface.

LIME

Introduction

Lime is an important binding material in building construction. Several buildings in India were constructed using lime.

Types of Lime

Generally, lime is classified into two types. They are:

1. Fat lime
2. Hydraulic lime

Fat Lime

Due to high calcium content, it is called high calcium lime and it is also called as **white lime and pure lime.** If we get pure lime in nature it is called as quick lime. When fat lime is boiled in water the cubic content increases upto 2.5 times. This lime contains 95% calcium oxide.

Lime was used as a construction material in Egypt for plastering the pyramids approximately in 4000 BC.

Properties of Fat Lime

- It hardens slowly.
- Its plasticity is high.
- It is soluble in water easily and quickly.
- It is in pure white in colour.

Uses of Fat Lime

- Useful for white washing on the plastered walls.
- When added with sand, that lime mortar is used for brick work and stone masonry work.
- When mixed with surkhi, that mortar is used in the constructions of big compound walls, basements, etc.

Hydraulic Lime

It sets under water. There is small quantity of clay content and iron oxide. According to the quantity of clay content, it is classified in to three types. They are:

1. Feebly hydraulic lime
2. Moderately hydraulic lime
3. High quality hydraulic lime

- **Feebly hydraulic lime** is having 5% to 10% clay. This content is easily soluble in water. It takes 21 days to set.
- **Moderately Hydraulic Lime** is having 11% to 21% clay. This content takes two hours for dissolving. It takes one or two weeks to set.
- **High quality hydraulic lime** is having 21% to 30% clay. This soil will not easily soluble. But set in one (or) two days.

I.S Classification of Lime

Indian Standard Institution classified lime into 5 classes.

Class A, Class B, Class C, Class D and Class E.

Class A

It is an eminently hydraulic lime normally used for structural purposes. It is normally supplied as hydrated lime. This contains about 25% of clay. It is especially suitable for under water works.

Class B

Semi hydraulic lime is the name contains both hydraulic lime and fat lime. It contains about 15% of clay. It is supplied both as hydrated or quick lime. It is used for mortar and concrete.

Class C

It is predominantly fat lime used for finishing coat in plastering, white washing, etc., and with suitable admixtures such as surkhi (or) any other pozzolanic material to produce artificial hydraulic lime. It is supplied both quick lime and hydrated lime. This can set under water.

Class D

It is the lime containing substantial proportions of magnesium oxide and is similar to fat lime. It is used for finishing coat in plastering, white washing, etc.

Class E

It is kankar lime generally used for masonry mortars and is supplied as hydrated lime.

Uses of Lime

The following are uses of lime in construction.

- For white washing.
- To prepare Mortar for Masonry and plastering work.
- To prepare lime-sand brick.
- To stabilize earth.
- As inner lining in open hearth furnace.
- In manufacturing of cement.

Difference Between Fat Lime and Hydraulic Lime

Property	Fat Lime	Hydraulic Lime
Main ingredient	95% calcium oxide. 5% clay soil.	5% to 30% clay soil and small quantity of ferrous oxide.
Slacking action	Quickly slacks. At that time volume is increased upto two times. Heat and sound occurs.	Slow slaking property. No sound and heat releases when slakes.
Setting action	Slow setting property. Absorbs carbon-di-oxide from the atmosphere and converts as calcium carbonate.	Sets under water. It changes as tricalcium aluminate and di calcium silicate when combines with water.
Hydraulic property	No hydraulic property.	Possess hydraulic property.
Colour	White.	Moderate white
Strength	Not so hard.	Highly hard.
Uses	Useful for white washing.	To prepare mortar used for the masonry work in water logged areas.

Tests on Limestones

The following practical tests are made on limestones to determine their suitability:

1. Physical tests
2. Heat test
3. Chemical test
4. Ball test.

- **Physical Test :** Pure limestone is white in colour. Hydraulic limestones are bluish grey, brown or are having dark colours. The hydraulic lime gives out earthy smell. They are having clayey taste. The presence of lumps give indication of quick lime and unburnt lime stones.
- **Heat Test :** A piece of dry stone weighing W_1 is heated in an open fire for few hours. If weight of sample after cooling is W_2, the loss of weight is $W_2 - W_1$. The loss of weight indicates the amount of carbon dioxide. From this the amount of calcium carbonate in limestone can be worked out.
- **Chemical Test :** A teaspoon full of lime is placed in a test tube and dilute hydrochloric acid is poured in it. The content is stirred and the test tube is kept in the stand for 24 hours. Vigourous effervescence and less residue indicates pure limestone. If effervescence is less and residue is more it indicates impure limestone.

If thick gel is formed and after test tube is held upside down it is possible to identify class of lime as indicated below:

- Class A lime, if gel do not flow.
- Class B lime, if gel tends to flow down.
- Class C lime, if there is no gel formation.
- **Ball Test :** This test is conducted to identify whether the lime belongs to class C or to class B. By adding sufficient water about 40 mm size lime balls are made and they are left undisturbed for six hours. Then the balls are placed in a basin of water. If within minutes slow expansion and slow disintegration starts it indicates class C lime. If there is little or no expansion, but only cracks appear it belongs to class B lime.

SAND

Sand is a building material used in construction for preparing mortar, concrete and also for filling under floor, basements. It is technically named as fine aggregate. It is used in concrete to fill up the voids left by coarse aggregates. Now-a-days, it is difficult to get river sand in large quantities. Hence, M sand (manufactured sand) is introduced in this field to overcome this deficiency.

Sand is a natural product which is obtained as river sand, nalla sand and pit sand. However sea sand should not be used for the following reasons:

- It contains salt and hence structure will remain damp. The mortar is affected by efflorescence and blisters appear.
- It contains shells and other organic matter, which decompose after some time, reducing the life of the mortar.

Sand may be obtained artificially by crushing hard stones. Usually artificial sand is obtained as a by-product while crushing stones to get jelly (coarse aggregate). Sand is used in mortar and concrete for the following purpose:

- It sub-divides the paste of binding material into thin films and allows it to adhere and spread.
- It fills up the gap between the building blocks and spreads the binding material.
- It adds to the density of the mortar.
- It prevents the shrinkage of the cementing material.
- It allows carbon dioxide from the atmosphere to reach some depth and thereby improve setting power.
- The cost of cementing material per unit volume is reduced as this low cost material increases the volume of mortar.
- Silica of sand contributes to formation of silicates resulting into the hardened mass.

The properties of good sand are:

- It should be chemically inert.
- It should be free from organic or vegetable matter.
- It should be free from salt.
- It should contain sharp, angular and coarse grains.
- It should be well graded.
- It should be hard.

River Sand

Sand is generally composed of rounded particles and may or may not contain clay or other impurities. It is obtained from the banks and beds of rivers.

Manufactured Sand (M Sand)

M Sand is defined as a crushed fine aggregate produced from broken granite blocks. Production of M sand generally involves crushing, screening and washing.

Test For Sand

The following are some of the tests conducted to know the quality of sand.

1) Sieve analysis
2) Bulking of sand
3) Voids Ratio
4) Porosity
5) Bulk density

Comparison of River Sand & M Sand

Parameters	River Sand	M-Sand
Process	Naturally available on river banks.	Manufactured in factory
Shape	Smoother texture with better shape. Demands less water.	Angular and has rougher texture. Angular aggregates demands more water. Water demands can be compensated with cement content.
Moisture content	Moisture is trapped in between the particles which is good for concrete purpose.	Moisture is available only in water washed M sand.
Concrete Strength	Lesser concrete strength compared to M – sand.	Higher concrete strength compared to river sand.
Silt Content	Minimum permissible silt content is 3%.Anything more than 3% is harmful to the concrete's durability. We can expect 5 – 20% silt content in medium quality river sand.	Zero silt. Hence good for construction works.
Over sized materials	1 – 6 % of over sized materials can be expected, like pebble, stones, etc.	Since it is artificially manufactured, there is no over sized materials.
Marine Products	1 – 2% like sea shells, etc.	0%
Eco friendly	Harmful to environment. Eco imbalances, reduce ground water level and river water gets dried up.	Though M sand uses natural coarse aggregates to form, it causes less damage to environment as compared to river sand.
Applications	Recommended for RCC plastering and brick/ block work.	Highly recommended for RCC purposes and brick / block works.
Quality	No control over quality since it is naturally occurring. Same river bed sand can have differences in silt content.	Better quality control since manufactured in a controlled environment.