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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – I– BUILDING MATERIALS SCIA1102

Soil - classification of soil - Stone, Criteria for selection - Tests on stones - Deterioration and Preservation of stone work - Bricks - Classification - Manufacturing of clay bricks - Tests on bricks - Compressive Strength - Water Absorption - Efflorescence - Bricks for special use - Refractory bricks -, Fly Ash Bricks and Concrete blocks - Light weight blocks and panels.

SOIL

Soil is an individual natural body which consists of a wide variety of minerals, organic matter, gases, and liquid that occurs on the top layer of the earth which is responsible to support the rooted plants in a natural environment. To an engineer, soil is the natural aggregate of mineral grains, with or without of organic constituents that can be separated by gentle mechanical means such as agitation in water. It covers huge portion of the earth's crust. It will be called as 'Skin of the Earth' or 'Cover of the Earth'. Soils are formed from the disintegration of rocks by various weathering processes. In general, rocks extend upto a depth of 20km in the earth's surface. The major rock types are igneous, sedimentary, and metamorphic. All soils originate, directly or indirectly from various rock types. According to Terazaghi, soils can be broken down into their constituent particles relatively easily, such as by agitation in water.

SOIL CLASSIFICATION

Soil classification is a dynamic subject, from the structure of the system itself. Soil classification can be approached from the perspective of soil as a material and soil as a resource. Indian Standard Classification and Identification of Soils for General Engineering (IS 1498/2007).

Soil shall be broadly divided into 3 divisions

Coarse-Grained Soils

In these soils, more than half the total material by weight is larger than 75-micron IS Sieve size.

Fine-Grained Soils

In these soil, more than half of the material by weight is smaller than 75-micron Highly organic soil and other miscellaneous soil materials. These soils contain large percentages of fibrous organic matter such as peat and particles of decomposed vegetation. In addition, certain soils containing shells, concretions, cinders and other non-soil materials in sufficient quantities are also grouped in this division. The coarse-grained soils shall be divided into two subdivisions, namely:

Gravels - In these soils, more than half the coarse fraction (+75 micron) is larger than 4·75-mm IS Sieve size. This subdivision includes gravels and gravelly soils.

Sand - In these soils, more than half the coarse fraction (+75 micron) is smaller than 4-75-mm. This subdivision includes sand and sandy soils.

Fine-Grained Soils shall be further divided into 3 subdivisions on the basis of the following arbitrarily selected values of liquid limit:

- Silts and clays of low compressibility - having a liquid limit less than 35 (represented by symbol L),
- Silts and clays of medium compressibility - having a liquid limit greater than 35 and less than 50 (represented by symbol I) and
- Silts and clays of high compressibility - having a liquid limit greater than 50 (represented by symbol H).

Soil classification is a medium of communication among soil engineers for geotechnical practices. This differentiates the coarse grained and fine grained soils. This also provides the basis for detailed geotechnical investigations. As per I.S.1498-1970, the soil is classified as below according to their sizes.

If the soil is coarse grained, it is further identified by estimating and recording the percentage of

- Gravel sized particle, size range from 80 mm to 4-75..mm IS Sieve size (or approximately 5 mm size)
- Sand size particles, size range from 4-75 to 75-micron IS Sieve size and
- Silt and clay size particles, size range smaller than 75-micron IS Sieve.

Classification Based on Grain Size

The range of particle sizes encountered in soils is very large: from boulders with dimension of over 300 mm down to clay particles that are less than 0.002 mm. Some clays contain particles less than 0.001 mm in size which behave as colloids, i.e. do not settle in water**. In the** Indian Standard Soil Classification System (ISSCS), **so**ils are classified into groups according to size, and the groups are further divided into coarse, medium and fine sub-groups. The grain-size range is used as the basis for grouping soil particles into boulder, cobble, gravel, sand, silt or clay.

TABLE 1 CLASSIFICATION BASED ON GRAIN SIZE

Very coarse soils	Boulder size		> 300 mm
	Cobble size		80 - 300 mm
Coarse soils	Gravel size (G)	Coarse	20 - 80 mm
		Fine	4.75 - 20 mm
	Sand size (S)	Coarse	2 - 4.75 mm
		Medium	0.425 - 2 mm
		Fine	0.075 - 0.425 mm

Fine soils	Silt size (M)		0.002 - 0.075 mm
	Clay size (C)		< 0.002 mm

TABLE 2 SIZES OF GRAINS

Boulder	above 300mm
Cobble	300-75mm
Coarse Gravel Fine Gravel	75-20mm 20-4.75mm
Coarse Sand	4.75-2mm
Medium Sand	2.0 -0.425mm
Fine Sand	0.425—0.075mm
Silt	0.075-0.002mm
Clay	below 0.002mm

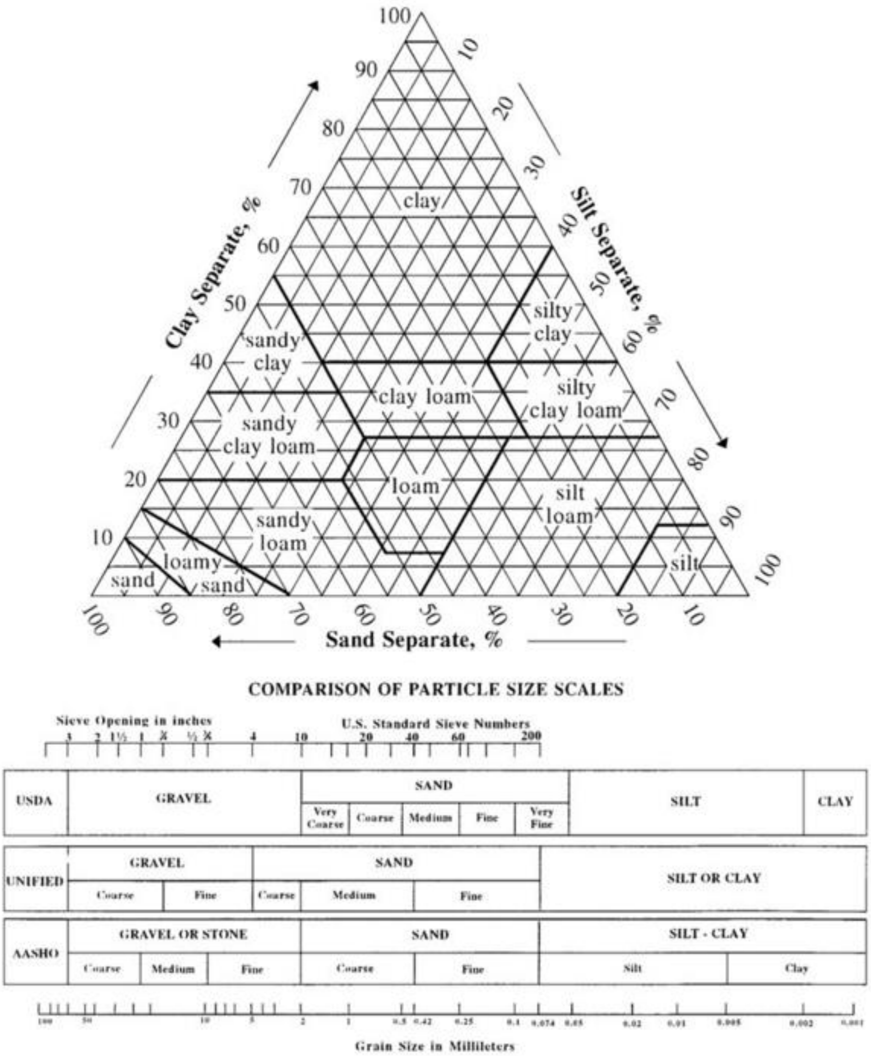


FIG.1 PARTICAL SIZE DISTRIBUTION

STONES

Stones are obtained from the different types of rocks occurring in nature. The properties of a rock are governed by the properties of minerals present in its structure. The common minerals found in igneous rocks are Augite, Chlorite, Felspar, Hornblende, Mica, Olivine, Plagioclase, Quartz, Serpentine. The minerals found in sedimentary rocks are, Calcite, Magnesite, Dolomite, Glauconite, Limonite, Gypsum, Anhydrate. It is estimated that three-fourth of the land area of the globe is underlain by sedimentary rocks and the remaining one-fourth by igneous and metamorphic rocks. The texture or structure of a rock has different types such as, Compact Crystalline, Conglomerate, Foliated, Glassy, Granular crystalline, Pisolitic, Porous granular, porphyritic, vesicular. Stones are used for floors, roofs, foundations, walls, columns, lintels, arches etc. Stones are used for Paving, face-work , as ballast for railways, blocks in the construction of bridges, dams, piers, retaining walls , flux in blast furnaces .

SELECTION OF STONES

4 main performance criteria
Stain resistance
Strength
Resistance to abrasion
Durability

Stones should be selected according to their use. In any case, it should be durable and free from detect.
Stone for pavement. Generally, hard stones of any type can be used for paving walkways and driveway stone for flooring. With the help of machines large size slabs for flooring even from hard rock like Granite can also be produced. Stone for facing work in building. The facing stones should have attractive colours and durable. The imperious varieties are preferred as they do not get change in colour with time, especially in an industrial atmosphere. Stones for concrete
Hard igneous rock-preferred for high strength concrete.
Source: Building Material World

The conditions which govern the selection of stone for structural purposes are cost, fashion, ornamental value and durability, although the latter property is frequently overlooked or disregarded. Cost is largely influenced by

transportation charges, difficulties in quarrying and cutting, the ornamental features, and the durability of stone. The type of dressing of stone may make a difference to the cost, particularly with the stones derived from igneous rocks.
When the cost of quarried stone to cost of finished stone is considered, it will be found that the labour cost is far greater than the price of the stone. Thus, a difference in the price between two alternative stones is unimportant and it would be unwise to reject a more durable stone on the grounds that it was costly.

Another factor which should be considered is the suitability of the stone for the type of design, for example, for a highly carved designs if, by mistake, a harder stone such as granite is selected the cost will be affected. Colour, arrangement and shape of mineral constituents greatly influence fashion and ornamental value. One of the first factors influencing the selection of stone for a particular work will be colour. It is important that the designer is aware about how the colour is likely to change after long exposure and in particular how it may vary in polluted atmospheres. As an example limestone, being slightly soluble in water, will remain clean in portions facing rain but retain a film of soot in sheltered areas. This results in strong colour contrast.

Resistance to fire and weathering factors which are largely influenced by the mineral constitution of the rock are the most important determinators of durability. It is very important to select a stone according to its exposure conditions. Limestones when used in areas not exposed to rain but acted upon by sulphur gases of polluted atmosphere, form a hard and impermeable surface skin which subsequently blisters and flakes off. It must be noted that flaking of this kind occurs mainly on external work only, although the air inside the building is almost equally polluted, probably due to the damper conditions inside. Limestones, sandstones and granites all tend to crack and spall when exposed to fire, and there is really little to choose between them in this respect.

TESTS FOR STONES

The building stones are to be tested for their different properties. Following are such tests for the stones:

- Acid Test
- Attrition Test
- Crushing test
- Crystallization test
- Freezing and thawing test
- Hardness test
- Impact test
- Microscopic test
- Smith's test
- Water absorption test

- **ACID TEST:**

In this test, a sample of stone weighing about 0.0 to 1N is taken. It is placed in a solution of hydrochloric acid having strength of one percent and it is kept there for seven days. The solution is agitated at intervals. A good building stone maintains its sharp edges and keeps its surface free from powder at the end of this period. If edges are broken and powder is formed on the surface, it indicates the presence of calcium carbonate and such as stone will have poor weathering quality. It is natural that this test cannot be applied to the limestones. This test is usually carried out on the sand stones.

- **Attrition Test:**

This test is done to find out the rate of wear of stones which are used in road construction. The results of test indicate the resisting power of stones against the grinding action under traffic. Following procedure is adopted.

- The sample of stone is broken into pieces of about 60mm size.
- Such pieces, weighing 50N, are put in both the cylinders of Devals attrition test machine. The diameter and length of cylinder are respectively 200mm and 340mm.

FIG.2 ATTRITION TEST APPARATUS

- The cylinders are closed. Their axes make an angle of 30^0 with the horizontal.
- The cylinders are rotated about horizontal axis for 5 hours at the rate of 30 R.P.M.

- After this period, the contents are taken out from the cylinders and they are passed through a sieve of 1.50mm mesh.
- The quantity of material which is retained on the sieve is weighed.
- The percentage wear is worked out as follows:

Percent wear = (loss in weight/initial weight) x 100

-

CRUSHING TEST:

The compressive strength of stone is found out with the help of this test.

The sample of stones is cut into cubes of size 40mm x40mmx40mm. The sides of cubes are finely dressed and finished. The minimum number of specimens to be tested is three. Such specimens should be placed in water for about 72 hours prior to test and thereafter tested in saturated condition. The load.bearing surface is then covered with plaster of paris or 5 mm thick plywood. The load is applied axially on the cube in a crushing test machine. The rate of loading is 13.72M/mm2 per minute. The crushing strength of the stone per unit area is the maximum load at which its sample crushes or fails divided by the area of the bearing face of the specimen.

FIG.3 CRUSHING TEST APPARATUS

CRYSTALLIZATION TESTS:

In this test, at least four cubes of stone with side as 40 mm are taken. They are dried for 72 hours and weighted. They are then immersed in 14 percent solution of Na_2So_4 for 2 hours. They are dried at 100°C and weighted. The difference in weight is noted. This procedure of drying, weighing, immersing and reweighing is repeated at least five times. Each time, the change in weight is noted and it is expressed as a percentage of original weight. It is to be noted that the crystallisation of $Caso_4$ in pores of stone causes the decay of stone due to weathering. But, as $CaSo_4$ has low solubility in water, it is not adopted in this test.

FREEZING AND THAWING TEST:

The specimen of stone is kept immersed in water for 2 hours. It is then placed in a freezing mixture at -12OC for 24 hours. It is then thawed or warmed at atmospheric temperature. This should be done in shade to prevent any effect due to wind , sun rays, rain etc. Such a procedure is repeated several times and behaviour of stone is carefully observed.

HARDNESS TEST:

To determine the hardness of a stone, the test is carried out as follows:

- A cylinder of diameter 25 mm and height 25 mm is taken out from the sample of stone.
- It is weighed
- It is placed in Dorrys testing machine and pressed with a pressure of 12.50N
- The annular steel disc of machine is then rotated at a speed of 28 R.P.M
- During the rotation of disc, the coarse sand of standard specification is sprinkled on the disc.
- After 1000 revolutions, the specimen is taken out and weighted.
- The coefficient of hardness is found out from the following equation:
- Coefficient of hardness = 20 –[(loss in weight in gm)/3]


DORRY'S TESTING MACHINE

IMPACT TEST:

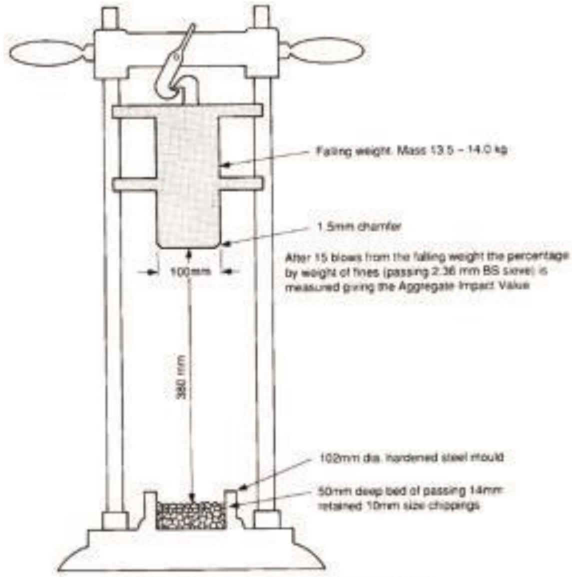


Figure 1. Apparatus for the aggregate impact test (Millard, 1993)

FIG.4 IMPACT TEST APPARATUS

To determine toughness of a stone , the impact test is carried out in page impact machine as follows:

- A cylinder of diameter 25 mm and height 25mm is taken out from the sample of stone.
- It is placed on cast-iron anvil of machine
- A steel hammer of weight 20 N is allowed to fall axially in a vertical direction over the specimen
- The height of first blow is 1 cm, that of second blow is 2 cm, that of third blow is 3 cm, and so on.
- The blow at which specimen breaks is noted. If it is nth blow, n represents the toughness index of stone.

MICROSCOPIC TEST:

FIG.5 MICROSCOPIC TEST APPARATUS

In this test, the sample of stone is subjected to the microscopic examination. The thin sections of stone are taken and placed under the microscopic to study various properties such as:

- Average grain size.
- Existence of pores, fissures, veins and shakes
- Mineral constituents
- Nature of cementing material
- Presence of any harmful substance
- Texture of stone etc.

SMITHS TEST:

This test is performed to find out the presence of soluble matter in a sample of stone. The few chips or pieces of stones are taken and they are placed in a glass tube. This tube is then filled with clear water. After about an hour, the tube is vigorously stirred or shaken. The presence of earthy matter will convert the clear water into dirty water. If water remains clear, the stone will be durable and free from any soluble matter. On the other hand, if the water becomes dirty and free from any soluble matter. On the other hand, if the water becomes dirty, it will indicate that the stone contains too much of soluble earthy and mineral matters.

WATER ABSORPTION TEST:

Following procedure is adopted for this test:

- From the given sample of stone, a cube weighing about 0.50 N is prepared. Its actual weight is recorded. Let it be W1 N.
- The cube is then immersed in distilled water for a period of 24 hours.
- The cube is taken out of water and surface water is wiped off with a damp cloth.
- It is weighted again. Let its weight be W 2 N.
- The cube is suspended freely in water and its weight is recorded. Let it be W 3 N.
- The water is boiled and cube is kept in boiling water for five hours.
- It is then removed and surface water is wiped off with a damp cloth. Its weight is recorded. Let it be W 4 N. From the above data, the values of the following properties of stone are obtained :

  Percentage absorption by weight after 24 hours = [(W2-W1)/W1] x 100 Percentage absorption by volume after 24 hours = [(W2-W1)/ (W2-W3)]x 100 [Volume of displaced water = W2- W3]

  Percentage porosity by volume =[(W4-W1)/(W2-W3)] x 100 Density = [W1/(W2-W3)] N/m^3

Specific Gravity = W1/(W2-W3)

Saturation Coefficient = (Water Absorption / Total Porosity)

= (W2- W1)/(W4-W1)

DETERIORATION OF STONES

The stones with exposed faces are acted upon by various atmospheric and external agencies so as to cause their deterioration. The following are the causes of decay of stones.

- Rain
- Frost
- Temperature Changes
- Wind
- Vegetable Growth
- Living organisms
- Chemical agents
- Alternate wetness and drying
- Nature of mortar
- Impurities in atmosphere

PRESERVATION OF STONES

Preservation of stone is essential to prevent its decay. Different types of stones require different treatments. But in general stones should be made dry with the help of blow lamp and then a coating of paraffin, linseed oil, light paint, etc. is applied over the surface. This makes a protective coating over the stone. However, this treatment is periodic and not permanent. When treatment is done with the linseed oil, it is boiled and applied in three coats over the stone. Thereafter, a coat of dilute ammonia in warm water is applied. The structure to be preserved should be maintained by washing stones frequently with water and steam so that dirt and salts deposited are removed from time to time. However, the best way is to apply preservatives. Stones are washed with thin solution of silicate of soda or potash. Then, on drying a solution of $CaCl_2$ is applied over it. These two solutions called Szerelmy's liquid, combine to form silicate of lime which fills the pores in stones. The common salt formed in this process is washed afterwards. The silicate of lime forms an insoluble film which helps to protect the stones.

An ideal preservative has the following properties:

- It is harmless
- It is easily penetrated in stone surface
- It does not allow moisture to penetrate the stone surface
- It is economical
- Its application on stone surface is easy.
- It does not develop objectionable colour.

The following are the preservatives which are commonly adopted to preserve the stones i.e Coal tar, Paraffin, Solution of Baryta, Paint, Linseed oil, Solution of alum and soap.

BRICKS

One of the oldest building material brick continues to be a most popular and leading construction material because of being cheap, durable and easy to handle and work with. Clay bricks are used for building-up exterior and interior walls, partitions, piers, footings and other load bearing structures. A brick is rectangular in shape and of size that can be conveniently handled with one hand. Brick may be made of burnt clay or mixture of sand and lime or of Portland cement concrete. Clay bricks are commonly used since these are economical and easily available. The length, width and height of a brick are interrelated as below:

Length of brick = 2 × width of brick + thickness

of mortar Height of brick = width of brick

Size of a standard brick (also known as modular brick) should be 19 × 9 × 9 cm and 19 × 9 × 4 cm.

When placed in masonry the 19 × 9 × 9 cm brick with mortar becomes 20 × 10 × 10 cm. However, the bricks available in most part of the country still are 9" × " × 3" and are known as field bricks. Weight of such a brick is 3.0 kg. An indent called frog, 1–2 cm deep, as shown in Fig. 5, is provided for 9 cm high bricks. The size of frog should be 10 × 4 × 1 cm. The purpose of providing frog is to form a key for holding the mortar and therefore, the bricks are laid with frogs on top. Frog is not provided in 4 cm high bricks and extruded bricks.

CLASSIFICATION OF BRICKS

Bricks

Un burnt or Sun dried　　　　Burnt Bricks

The bricks used in construction works are burnt bricks and they are classified into the following four categories:

- First Class Bricks
- Second Class Bricks
- Third Class Bricks
- Fourth Class Bricks

FIRST CLASS BRICKS:

FIG.6 FIRST CLASS BRICKS

These bricks are burnt in kilns and are table molded of standard shape. The surfaces and edges of the bricks are sharp, square, smooth and straight. These bricks are used for superior work of permanent nature. These bricks should have uniform texture and should be free from flaws, cracks and stones. These bricks are thoroughly burnt and are deep red ,or copper colour. No impression should be seen on the brick when a scratch is made by a finger nail. The crushing strength of the brick should not be less than 10 $N/mm^{2.}$ .This limit varies with various government organizations around the country. The water absorption should be 12-15% of its dry weight when immersed in cold water for 24 hours. A ringing or metallic sound should come when two bricks are struck against each other.

Uses: First class bricks are recommended for pointing, exposed face work in masonry structures, flooring and reinforced brick work.

SECOND CLASS BRICKS:

These bricks are ground moulded and they are burnt in kilns. The surface of these bricks is somewhat rough and shape is also slightly irregular. These bricks may have hair cracks and their edges may not be sharp and uniform. These bricks are commonly used at places where brickwork is to be provided with a coat of plaster. This second class bricks are supposed to have the same requirements as the first class ones except that

FIG.7 SECOND CLASS BRICKS

- Small cracks and distortions are permitted.
- A little higher water absorption of about 16–20% of its dry weight is allowed.
- The crushing strength should not be less than 7.0 N/mm^2.

Uses: Second class bricks are recommended for all important or unimportant hidden masonry works and centering of reinforced brick and reinforced cement concrete (RCC) structures.

THIRD CLASS BRICKS:

FIG.8 THIRD CLASS BRICKS

These third class bricks are under burnt, ground moulded and are burnt in clamps. They are soft and light-coloured producing a dull sound when struck against each other. These bricks are not hard and they have rough surfaces with irregular and distorted edges. Water absorption is about 25 per cent of dry weight.

Uses : It is used for building temporary structures and at places where rainfall is not heavy

FOURTH CLASS BRICKS:

These bricks are overburnt with irregular shape and badly distorted in shape and size and are brittle in nature. They are dark in colour.

Uses: The ballast of such bricks is used for foundation and floors in lime concrete and road metal, because of the fact that the overburnt bricks have a compact structure and hence they are sometimes found to be stronger than even the first class bricks

FIG.9 FOURTH CLASS BRICKS

MANUFACTURING OF CLAY BRICKS

The following four distinct operations are involved in the process of manufacturing bricks:

- Preparation of Clay
- Molding
- Drying
- Burning

PREPARATION OF CLAY:

Preparation of clay takes place in the following order.

- Unsoiling
- Digging

- Cleaning
- Weathering
- Blending
- Tempering

UNSOILING:

The soil used for making building bricks should be processed so as to be free of gravel,coarse sand (practical size more than 2 mm), lime and kankar particles, organic matter, etc. About 20 cm of the top layer of the earth, normally containing stones, pebbles, gravel, roots, etc., is removed after clearing the trees and vegetation.

DIGGING:

After removing the top layer of the earth, proportions of additives such as fly ash, sandy loam, rice husk ash, stone dust, etc. should be spread over the plane ground surface on volume basis. The soil mass is then manually excavated, puddled, watered and left over for weathering and subsequent processing. The digging operation should be done before rains.

CLEANING AND WEATHERING:

Stones, gravels, pebbles, roots, etc. are removed from the dug earth and the soil is heaped on level ground in layers of 60–120 cm. The soil is left in heaps and exposed to weather for at least one month in cases where such weathering is considered necessary for the soil. This is done to develop homogeneity in the mass of soil, particularly if they are from different sources, and also to eliminate the impurities which get oxidized. Soluble salts in the clay would also be eroded by rain to some extent, which otherwise could have caused scumming at the time of burning of the bricks in the kiln. The soil should be turned over at least twice and it should be ensured that the entire soil is wet throughout the period of weathering. In order to keep it wet, water may be sprayed as often as necessary. The plasticity and strength of the clay are improved by exposing the clay to weather.

BLENDING:

The earth is then mixed with sandy-earth and calcareous-earth in suitable proportions to modify the composition of soil. Moderate amount of water is mixed so as to obtain the right consistency for moulding. The mass is then mixed uniformly with spades. Addition of water to the soil at the dumps is necessary for the easy mixing and workability, but the addition of water should be controlled in such a way that it may not create a problem in moulding and drying. Excessive moisture content may effect the size and shape of the finished brick.

TEMPERING:

Tempering consists of kneading the earth with feet so as to make the mass stiff and plastics(by plasticity, we mean the property which wet clay has of being permanently deformed without cracking). It should preferably be carried out by storing the soil in a cool place in layers of about 30 cm thickness for not less than 36 hours. This will ensure homogeneity in the mass of clay for subsequent processing. For manufacturing good bricks on a large scale, the tempering is usually done in a pug mill and the operation is called pugging. The process of grinding clay with water and making it plastic is known as the pugging.

A typical pug mill capable of tempering sufficient earth for a daily output of about 15000 to 20000 bricks . A pug mill consists of a conical iron tub with cover at its top. It is fixed on a timber base which is made by fixing two wooden planks at right angles to each other. The bottom of tub is covered except for the hole to take out pugged earth. The diameter of pug mill at bottom is about 800mm and that at top is about one metre.

The provision is made in top cover to place clay inside the pug mill. A vertical shaft with horizontal arms is provided at the centre of iron tub. The small wedge-shaped knives of steel are fixed on horizontal arms. The long arms are fixed at the top of vertical shaft to attach a pair of bullocks. The ramp is provided to collect the pugged clay. The height of pug mill is about 2 m. Its depth below ground is about 600mm to 800mm to lessen the rise of the barrow run and to throw out the tempered clay conveniently. In the beginning , the hole for pugged clay is closed and clay with water is placed in pug mill from the top. When the vertical shaft is rotated or turned by a pair of bullocks, the clay is thoroughly mixed up by the actions of horizontal arms and knives and a homogeneous mass is formed. The rotation of vertical shaft can also be achieved by using steam, diesel or electric power. When clay has been sufficiently pugged, the hole at the bottom of tub, is opened out and the pugged earth is taken out from ramp by barrow i.e., a small cart with two wheels for the next operation of moulding. The pug mill is then kept moving and feeding of clay from top and taking out of pugged clay from bottom are done simultaneously. If tempering is properly carried out, the good brick earth can then be rolled without breaking in small threads of 3mm diameter.

MOULDING:

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

- Hand moulding

- Machine moulding.
- Hand moulding:

In hand moulding, the bricks are moulded by hand i.e ., manually. It is adopted where manpower is cheap and is readily available for the manufacturing process of bricks on a small scale. The moulds are rectangular boxes which are open at top and bottom. They may be of wood or steel. A typical wooden mould should be prepared from well seasoned wood. The longer sides are kept slightly projecting to serve as handles. The strips of brass or steel are sometimes fixed on the edges of wooden moulds to make them more durable. A typical steel mould is prepared from the combination of steel plates and channels. It may even be prepared from steel angles and plates. The thickness of steel mould is generally 6mm. They are used for manufacturing bricks on a large scale. The steel moulds are more durable than wooden moulds and they turn out bricks of uniform size. The bricks shrink during drying and burning.
The bricks prepared by hand moulding are of two types:

- Ground Moulded Bricks
- Table Moulded Bricks
- Ground Moulding:

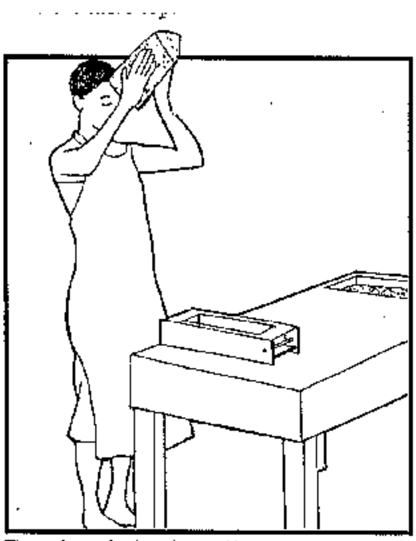
This method is adopted when a large and level land is available. In this process, the ground is levelled and sand is sprinkled on it, to prevent the moulded bricks from sticking to the side of the mould. The moulded bricks are left on the ground for drying. Such bricks do not have frog and the lower brick surface becomes too rough. To overcome these defects, moulding blocks or boards are used at the base of the mould. The process consists of shaping in hands a lump of well pugged earth, slightly more than that of the brick volume. It is then rolled into the sand and with a jerk it is dashed into the mould. The moulder then gives blows with his fists and presses the earth properly in the corners of the mould with his thumb. The surplus clay on the top surface is removed with a sharp edge metal plate called strike or with a thin wire stretched over the mould. After this the mould is given a gentle slope and is lifted leaving the brick on the ground to dry. The bricks prepared by dipping mould in water everytime are known as slop moulded bricks. The fine sand may be sprinkled on the inside surface of mould instead of dipping mould in water. Such bricks are known as the sand – moulded bricks and they have straight and sharp edges. 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.

FIG.10 HAND MOULDING OF BRICKS

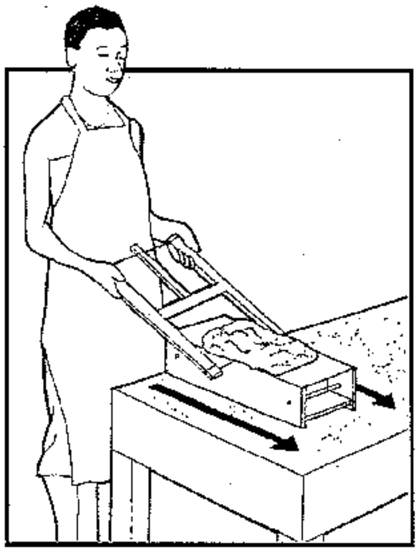
FIG.11 HAND MOULDING OF BRICKS

TABLE MOULDING:

In this method the bricks are moulded on stock boards nailed on the moulding table.Stock boards have the projection for forming the frog. The process of filling clay in the mould is the same as in case of ground moulding.. After this, a thin board called pallet is placed over the mould. The mould containing the brick is then smartly lifted off the stock board and inverted so that the moulded clay along with the mould rests on the pallet. The mould is then removed as explained before and the brick is carried to the drying site.



Throw the wedge into the mould.



Cut off the excess clay.

FIG.12 TABLE MOULDING OF BRICKS

MACHINE MOULDING:

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

- Plastic clay machines
- 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 arrangement 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 the 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 the pressed bricks and they do not practically require drying. They can be sent directly for the process of burning. The wire cut and pressed bricks have regular shape, sharp edges and corners. They have smooth external surfaces. They are heavier and stronger than ordinary hand-moulded bricks. They carry distinct frogs and exhibit uniform dense texture.

FIG.13 PLASTIC CLAY BRICKS

DRYING:

The damp bricks, if burnt, are likely to be cracked and distorted . Hence the moulded bricks are dried before they are taken for the next operation. Of burning. 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 percent or so.
The important facts to be remembered in connection with the drying of bricks are as follows:

Artificial Drying: The bricks are generally dried by natural process. But when bricks are to be rapidly dried on a large scale, the artificial drying may be adopted. In such a case, the moulded bricks are allowed to pass through special layers which are in the form of tunnels or hot channels or floors. Such dryers are heated with the help of special furnaces or by hot flue gases. The tunnel dryers are more economical than hot floor dryers and they may be either periodic or continuous. 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 120ºC and the process of drying of bricks takes place 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 purpose, 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 of 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 the wind or sun for drying. Suitable screens, if necessary, amy be provided to avoid such situations.

FIG.14 DRYING OF BRICKS

BURNING:

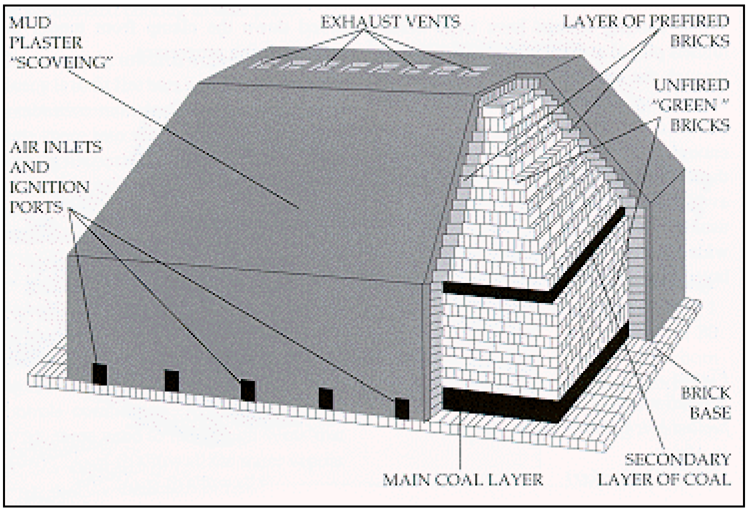
This is a very important operation in the manufacture of bricks. It imparts hardness and strength to the bricks and makes them dense and durable. The bricks should be burnt properly. If bricks are over burnt, they will be brittle and hence break easily. If they are under burnt, they will be soft and hence cannot carry loads. When the temperature of dull red heat, about 650^{o}C, is attained, the organic matter contained in the brick is oxidized and also the water of crystallization is driven away. But heating of bricks is done beyond this limit for the following purposes:

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

- The reactions between the mineral constituents of clay are achieved 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 temperature of about 1100oC is reached, the particles of two important constituents of brick clay, namely alumina and sand, bind themselves together resulting in the increase of strength and density of bricks. Further heating is not desirable and if the temperature is raised beyond 1100^{o}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 structures and they are adopted to manufacture bricks on a large scale.



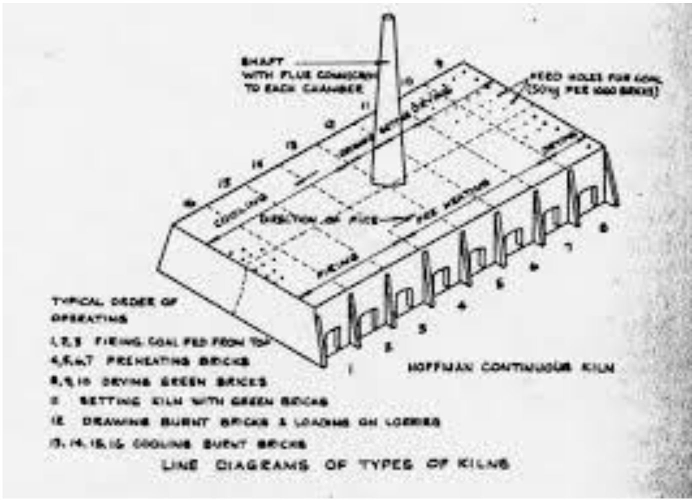


FIG.15 BURNING OF BRICKS

TESTS FOR BRICKS

A brick is generally subjected to the following tests to find out its suitability for the construction work.

- Water absorption
- Shape and size
- Crushing strength

- Hardness
- Presence of soluble salts
- Soundness
- Structure

WATER ABSORPTION:

A brick is taken and it is weighted dry. It is then immersed in water for a period of 16 hours. It is weighted again and the difference in weight indicates the amount of water absorbed by the brick. It should not, in any case exceeds 20 per cent of dry weight of dry brick.

Determination of Water Absorption of Brick ((IS: 3495-PART 2-1992)

Objective: For determination of water absorption of bricks

Reference Standards : IS : 3495 (Part-2)-1992,RA 2011

Equipment & Apparatus: Balance (0-10 kg)

Procedure:

- The specimen is dried in a ventilated oven at a temperature of 105 to 115^{0}C; till it attains substantially constant mass. The specimen is cooled to room temperature and its weight is recorded (M_1)
- The dried specimen is immersed completely in clean water at a room temperature of 27±2^{0}C for 24 hours.
- The specimen is then removed and any traces of water are wiped out with a damp cloth and the specimen is weighed. The weighing is completed 3min after the specimen has removed from water(M_2)

Calculation:

Water absorption, percent by mass after 24 hours immersion in cold water is given by the following formula

$$\text{Water absorption} = \frac{M_2 - M_1}{M_1} \times 100$$

Reports:

The water absorption of brick shall be reported to the nearest one percent.

Safety & Precautions:

- Use hand gloves while removing containers from oven after switching off the oven.
- Thoroughly clean & dry the container before testing.
- Special care should be taken that no outer air enters when using the balance.
- To wear safety shoes & apron at the time of test.

SIZE, SHAPE AND COLOUR TEST:

In this test randomly collected 20 bricks are staked along lengthwise, widthwise and height wise and then those are measured to know the variation of sizes as per standard. Bricks are closely viewed to check if its edges are sharp and straight and uniform in shape. A good quality brick should have bright and uniform color throughout.

Crushing strength/Compression strength:

The crushing strength of a brick is found out by placing it in a compression testing machine. It is pressed till it breaks. As per IS: 1077-1970, the minimum crushing or compressive strength of bricks is 3.50 N/mm^2. The bricks with crushing strength of 7 to 14 N/mm^2 are graded as A and those having above 14 N/mm^2 are graded as AA.

Determination of Compression strength of Brick (IS:3495-PART 1-1992)

Objective: For the determination of compressive strength of bricks

Reference Standard:IS: 3495 – P (1)-1992-Methods of tests of burnt clay building bricks (Determination of compressive strength)

Equipment & Apparatus: a) Compression Testing machine
b)Scale for measuring dimension of brick

Procedure:

- Unevenness observed in the bed faces of bricks is removed to provide two smooth and parallel faces by grinding. It is immersed in water at room temperature for 24 h.
- The specimen is then removed and any surplus moisture is drained out at room temperature. The frog and all voids in the bed face is filled with cement mortar (1 cement, clean coarse sand of grade 3 mm and down). It is stored under the damp jute bags for 24 h followed by immersion in clean water for 3 days.
- The specimen is placed with flat faces horizontal, and mortar filled face facing upwards between two 3 ply plywood sheets each of 3 mm thickness and carefully centered between plates of testing machine.
- Load is applied axially at a uniform rate of 14 N/mm^2 per minute till failure occurs. The maximum load at failure is noted down. The load at failure is

considered the maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine.

FIG.16 COMPRESSION TESTING MACHINE

Calculation:

$$\text{Compressive strength}(N/mm^2) = \frac{\text{Maximum load at failure in N}}{\text{Avg. area of the bed faces in } mm^2}$$

Reports:

Five numbers of bricks should be tested and the average value is reported.

Safety & Precautions:

- Safety shoes should be used at the time of testing.
- Before testing, CTM machine should be properly checked.

HARDNESS TEST:

In this test a scratch is made on brick surface with a hard thing. If that doesn't left any impression on brick then that is good quality brick.

PRESENCE OF SOLUBLE SALTS/ EFFLORESCENCE:

The soluble salts, if present in bricks, will cause efflorescence on the surface of bricks. For finding out the presence of soluble salts in a brick, it is immersed in water for 24 hours. It is then taken out and allowed to dry in shade. The absence of grey or white deposits on its surface indicates absence of soluble salts. If the white deposits cover about 10 per cent surface, the efflorescence is said to be slight and it is considered as moderate, when the white deposits cover about 50 per cent of surface, the efflorescence becomes heavy and it is treated as serious, when such deposits are converted into powdery mass.

FIG.17 EFFLORESCENCE ON PLASTER

Determination of Efflorescence of Bricks(IS: 3495-PART 3-1992)

Objective: For determination of efflorescence of bricks

Reference Standards: IS: 3495 – Part (3)-1992

Equipment & Apparatus: Oven (300^0c)

Procedure:

- A shallow flat bottom dish containing sufficient distilled water to completely saturate the specimens is used for the test. The ends of the bricks are placed in the dish, the depth of immersion in water being 25 mm.
- The whole arrangement is placed in a warm (between 20^0C and 30^0C) well ventilated room until all the water in the dish is absorbed by the specimens and the surplus water evaporates.
- The dish containing the brick is covered with a suitable glass cylinder so that excessive evaporation from the dish may not occur.
- When the water has been absorbed and brick appears to be dry, a similar quantity of water is placed in the dish and it is allowed to evaporate as before. Examine the bricks for efflorescence after the second evaporation and the results are reported.

Reports:

The liability to efflorescence shall be reported as 'Nil', 'Slight', 'Moderate', 'Heavy' or 'Serious' in accordance with the following definitions

<u>Nil</u> : When there is no perceptible deposit of efflorescence

<u>Slight</u> : When not more than 10 percent of the exposed area of brick is covered with a thin deposit of salts

<u>Moderate</u> : When there is a heavier deposit than under 'Slight' and covering up to 50 percent of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.

<u>Heavy</u> : When there is a heavy deposit of salts covering 50 percent or more

of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.

Serious : When there is a heavy deposit of salts accompanied by powdering and / or flaking of the exposed surfaces

Safety & Precautions:

- Use hand gloves while removing containers from oven after switching off the oven.
- Thoroughly clean & dry the container before testing.
- Use apron & safety shoes at the time of testing.

SOUNDNESS TEST:

In this test two bricks are held by both hands and struck with one another. If the bricks give clear metallic ringing sound and don't break then those are good quality bricks.

STRUCTURE TEST:

In this test a brick is broken or a broken brick is collected and closely observed. If there are any flows, cracks or holes present on that broken face then that isn't good quality brick.

Special purpose bricks: Fire-clays:

FIG.17 FIRE CLAY BRICKS

The fire-clay is refractory clay which is capable of resisting a high temperature without being melted or softened. It is used for making refractory materials. A refractory material is able to stand a high temperature without losing its shape. Thus the fire-clay is used in the manufacture of fire-bricks, crucibles, lining materials for furnaces, hollow tiles, etc. The earth that is available from under the coal seams is generally found to be good fire-clay. The constituents of a good fire-clay are two- alumina and silica. The percentages of alumina varies from 25 to 35 and that of silica from 75 to 65. In any case, the impurities such as lime, magnesia, iron oxide and alkalies should not exceed 5 per cent.

Depending upon the fire resisting capacity , the fire-clays are classified into the following three categories:

- High duty fire-clays
- Medium duty fire-clays

- Low duty fire clays.

The high duty fire clays can resist temperature range of 1482’c to 1648’c. The medium duty fire clays can resists temperature range of 1315’c to 1482’c and the low duty fire-clays can resist temperature upto 870’c only.

FIRE-BRICKS:

These bricks are made from fire clay. The process of manufacture is the same as that of ordinary clay bricks. The burning and cooling of fire bricks are done gradually. These bricks are usually white or yellowish white in color. The weight of the fire brick is about 30-35 N. The fire bricks can resist high temperature without softening or melting. Hence they are used for linings of interior surface or furnaces, chimneys, kilns, ovens, fire places etc. The compressive strength of this bricks varies from 200 to 220N/mm2. The percentage of absorption for these bricks varies from 5-10.

Following are the three varieties of fire bricks,

- Acidic bricks
- Basic bricks
- Neutral bricks

Acidic bricks: these bricks are used for acidic lining. Following are the types of acidic bricks.

- Ordinary fire bricks: these bricks are prepared from natural fire clay and they provide a good material for acidic refractory lining.
- Silica bricks: these bricks contain a very high percentage of silica to the extent of about 95-97%. A small quantity of lime about 1-2% is added to

work as binding material.

These bricks are moulded under pressure and burnt at high temperature. The silica bricks can stand a high temperature upto about 2000’c. The compressive strength of such bricks is about 15 $N/mm^{2.}$

Basic bricks: These bricks are used for basic lining and basic refractory materials are used in the manufacture of such bricks. The magnesia bricks are preferred from lime and magnesia rocks. The dolomite may also be adopted for the manufacture of these bricks.

Neutral bricks: these bricks are used for neutral lining. They offer resistance to the corrosive action of slag and acid fumes. As compared to the basic bricks , the neutral bricks are more inert to the slag. Following are the types of neutral bricks.

- Coromite bricks: these bricks are prepared from a mixture of chrome, iron ore, ferrous oxide, bauxite and silica. Such bricks are unaffected by acidic or basic actions.
- High-alumina bricks: these brick contain a high percentage of alumina and they are found to be more inert to the slag.

CONCRETE BLOCKS:

- Raw materials: the materials required for the production of the concrete blocks are aggregates, cement and water. The aggregates of various types have been used with varying degree of success and they include crushed stones, gravel, volcanic cinders, foamed slag, furnace clinkers etc. The aggregates are selected by considering the weight, texture are composition of the unit designed. The strength, texture and economy of the concrete block depend upon the careful grading of the aggregate. If locally available aggregate is suitable it will help in achieving the economy.

FIG.18 CONCRETE BLOCKS WALL

The cement used is ordinary Portland cement. The water required is the normal potable water.

Manufacturing: the fully automatic plants are available for the manufacture of high strength concrete blocks. These automatic machines produce superior quality Concrete blocks. But they involve a large capital investment. The manually operated machine are also available and they can be installed at project site itself which further reduce the transportation cost of the concrete blocks from the place of the production to the place of actual use.

FIG.19 CONCRETE HOLLOWBLOCKS

The process involved in the manufacturing of the concrete blocks is as follows:

- Selection and proportion of ingredients: The main criterion for the selection of the ingredients is the desired strength of the block. The greater the proportion of coarse aggregate, the greater will be the strength of the quantity of cement used.
- Mixing of ingredients: the blending of aggregates, cement, and water should be done very carefully. The mixing should be preferably take place in the mechanical mixer. For hand mixing , the extreme care should be taken to see that the cement

  and aggregates are first mixed thoroughly in dry state and the water is then added gradually.
- Placing and vibration: the mixed concrete is fed into the mould box upto the top level and it is ensured that the box is evenly filled. The vibration of concrete is done till it has uniformly settled in the mould box.
- Curing: the block is watered after about one day of casting and it is

continued for a minimum of 7 days and preferably till 28 days. The longer the curing period, the
better will be the block.

Advantages: the use of concrete blocks are as masonry unit can be observed on many construction sites because of the following advantages;

- It increase the carpet area of the building because of small width of concrete block as compared to the brick masonry wall.
- It provides better thermal insulation, enhanced fire resistance and sound absorption .
- It results in the saving of precious agricultural land which is used for the manufacture of bricks.
- The blocks can be prepared in such a manner that the vertical joints can be staggered automatically and thus the skilled supervision is reduced.
- The construction of concrete block masonry is easier, faster and stronger than the brick masonry.
- The perfect shape and size of the concrete block makes the work of a mason much simpler.
- There is saving in construction of mortar because the numbers of joints are reduced.
- The utility can be further increased by producing the Reinforced Concrete Block (RCB) masonry units. The blocks are provided two holes for placing suitable reinforcing bars and the structures with RCB units could safely resist wind and earthquakes, if so designed. The traditional beams and columns could be completely eliminated and the structure with RCB units can be given a better appearance .

Uses: In view of the advantages mentioned above, the concrete block masonry technique of construction can be adopted on a large scale for mass housing and various civil engineering projects.

QUESTIONS

PART A

1. Classify soil
2. Name the various explosives used in quarry?
3. What is quarrying of stones?
4. List the types of stone finishes
5. What are the characteristics of good building stones?
6. What is the purpose of dressing?
7. Define specific gravity of soil
8. List the methods to find specific gravity
9. Give the classification of rocks
10. Define dressing of stones
11. List the various tests of stones
13. What are the uses of stones?
14. Mention some stone preservatives?
15. State any four advantages of bricks as compared with stones?
16. What are the uses of light weight concrete blocks?
17. Write about water absorption of bricks
18. What is preservation of stone?
19. What is meant by efflorescence?
20. List the criteria for selection of stone
21. What are the characteristics of good building stone?
22. What is the composition of good brick?

23. What is the standard size of brick used in construction?
24. What is meant by hollow blocks? Mention its applications
25. What is meant by Deterioration?
26. What are the harmful ingredients in Brick Earth?
27. Classify soil by its texture?

PART B

1. Explain the tests on stones?
2. Explain the tests on bricks?
3. Explain criteria for selection of stones?
5. Classify bricks
6. Explain water absorption and efflorescence test ?
7. Explain the manufacturing process of bricks?
8. Explain the ingredients of cement blocks?
9. Explain preparation process of light weight concrete blocks?
10. Explain deterioration and preservation of stone work?
11. What are qualities of good bricks? State its different types?
12. What are the factors affecting the quality of bricks?
13. Explain the manufacture of cement with neat sketches?
14. What is the specific gravity of soil and how it can be found?
15. Explain the classification of rocks?
16. Explain with neat sketches the types of stone finishes?
17. Explain the methods of quarrying of stones?

1. Components of road (4)

embankment

subgrade

surface

all the options given

2. material for road (4)

bitumen

cement

soil

all the options given

3. desirable properties of soil as road material (3)

stability

minimum change in volume

all the options given

incompressibility

4. index properties of soil (4)

grain size distribution

consistency limit

classification

all the options given

5. consistency limits of soil are (1)

all the options given

liquid limit

shrinkage limit

plastic limit

6. methods of soil classification involve (4)

US classification

unified classification

textural classification

all the options given

7. as per IS soil classified as (2)

fine

all the options given

silt

clay

8. HRB classifies soil as (1)

A1-A7

clay

silt

all the options given

9. qualities of stone are (2)

Stain resistance

all the options given

Strength

Abrasion Resistance

10. rock can be classified in following ways (3)

geological classification

physical classification

all the options given

chemical classification

11. rock may be classified as (4)

igneous

metamorphic

sedimentary

all the options given

12. rock may be classified as (4)

siliceous

argillaceous

calcareous

all the options given

13. basic tests on stones are (2)

acid test

all the options given

attrition test

crushing test

14. deterioration of stone by (4)

frost

living organisms

rain water

all the options given

15. preservation of stone by (2)

coal tar

all the options given

paint

paraffin

16. uses of bricks are (4)

in buildings

in dams

on roads

all the options given

17. following are classification of bricks (3)

first class

second class

all the options given

third class

18. operations of brick manufacturing are (4)

moulding

drying

burning

all the options given

19. brick moulding methods are (3)

hand moulding

machine moulding

option 1 and 2

none of the options given

20. frog is used in (3)

trade name

key between layers

option 1 and 2

none of the options given

21. burning of bricks involve (4)

clamp

kiln

continuous kiln

all the options given

22. qualities of brick involve (4)

uniform shape

void free

ring sound

all the options given

23. following are the tests on bricks (4)

absorption

crushing

hardness

all the options given

24. special use bricks are (2)

bull nose

all the options given

coping bricks

cw nose bricks

5. special use bricks are (4)

hollow bricks

chequered bricks

perforate bricks

all the options given

26. varieties of fire bricks are (3)

acidic brick

basic brick

all the options given

neutral brick

27. substitute for bricks are (4)

concrete blocks

fly ash bricks

silica bricks

all the options given

28. fly ash bricks are (4)

light in weight

correct in shape

more compressive strength

all the options given

29. demerits of bricks are (4)

more damage

more water absorption

more kiln fuel

all the options given

30.merits of Concrete blocks (4)

more carpet area

thermal insulation

fire resistance

all the options given

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – II– LIME CEMENT AGGREGATE MORTAR STEEL - SCIA1102

Lime - Preparation of lime mortar - Cement - Ingredients - Manufacturing process - Types and Grades Properties of cement and Cement mortar - Hydration - Compressive strength - Tensile strength - Fineness Soundness and consistency - Setting time - Aggregates - Natural stone aggregates - Crushing strength - Impact strength - Flakiness Index - Elongation Index - Abrasion Resistance - Mortar - classifications - properties of good mortar - uses of mortar - Manufacture of steel - properties and uses of different types of steel - mechanical and heat treatment of steel - Anticorrosive measures for steel

LIME

Limestone (calcium carbonate) Burnt in a kiln loses carbon dioxide and becomes quicklime (calcium oxide) Contact with water Producing great heat, to form slaked lime (calcium hydroxide), also called lime putty. This gradually takes up carbon dioxide again from the air and changes back to calcium carbonate. This ‘setting’ is called carbonation. Lime putty mixed with sand makes mortar. This then hardens into an artificial stone made up of grains of sand embedded in a mass of calcium carbonate.

TYPES OF LIME

Lime used shall conform to IS: 712-1984 Building limes are classified as follows:

Class A: Eminently hydraulic lime used for structural purposes.

Class B: Semi hydraulic lime used for masonry mortars.

Class C: Fat Lime used for finishing coat in plastering, white washing etc. and addition of Pozzolanic material for Masonry Mortar.

Class D: Magnesium lime used for finishing coat in plastering, white washing etc.

Class E: Kankar lime used for masonry mortars.

Class F: Siliceous dolomite lime is used generally for under coat and finishing coat of plaster.

Quick Lime: Quick Lime shall be supplied in the form of lumps and not in powder. Soon after delivery, lump lime shall be separated from powder and all under burnt/ over burnt lumps and the powder removed. Quick lime shall not be used directly in the work and shall invariably be slaked and converted to lime putty before use.

Hydrated Lime: Hydrated lime shall be in the form of a fine dry powder. It shall be supplied in suitable containers such as jute bags lined with waterproof.1ngmembrane. The bags shall bear marking indicating the class of lime, net weight, date of manufacture and the brand name. It shall be used within 4 months of its date of manufacture.

PREPARATION OF LIME

Lime Mortar

Lime mortar shall be prepared using lime putty obtained by slaking quick-lime or dry hydrated lime powder and sand with or without the addition of pozzolana ill the specified proportions.

Slaking of Lime

If lime is supplied in the form of quick lime, it shall be slaked and run into putty, if necessary, in accordance with IS: 1635-1975.

Mixing of Lime Mortars

- Putty and sand in the specified proportions shall be mixed with or without addition of water on a dry waterproof platform or in a mixer.
- The mix shall then be fed into a mortar mill with the required addition of

water.

- The mortar shall be raked continuously during grinding, particularly in the angular edges of the mortar mill.
- Water may be added during grinding as required, but care shall be taken not to add more water than to bring the material to the working consistency.
- The mixing shall be done till every particle of the aggregate is coated uniformly with the cementations material.

Dry hydrated lime and sand in specified proportions shall be mixed dry first and shall then be fed into a mortar mill with required additions of water.

Generally, only as much quantity of lime mortar (except made with Class A lime) as would be sufficient for day's work shall be mixed at a time. If eminently hydraulic lime (Class A) is present as an ingredient, the 'mortar shall be used within 4 hours after grinding.

CEMENT

- Most important material in building construction
- Term "cement" means Portland Cement
- "cement" refers to the natural manufactured form limestone and clay and made available in powder form, which when mixed with water can set to a hard durable mass over under water

Ingredients (Main Constituents in cement that gives cementing properties)

	$2CaO$	
(a) Dicalcium silicate	SiO_2	(denoted as C_2S)
	$3CaO$	
(b) Tricalcium silicate	SiO_2	(denoted as C_3S)

(c) Tricalcium Aluminate	3CaOAl2 O3 (denoted as C3A)
(d) Tetracalcium aluminium Ferrite	4CaOAl2 O3Fe2O3 (denoted as C4AF)

Cement Ingredients

Lime (CaO)

Silica (SiO2)

Alumina (Al2O3)

Calcium sulphate (CaSO4)

Iron oxide (Fe2O3)

Magnesia (MgO)

Sulphur (S)

Alkalies

TABLE 1 COMPOSITION OF ORDINARY PORTLAND CEMENT

Ingredient	Percent	Range
Lime (CaO)	62	62-67
Silica (SiO2)	22	17-25
Alumina (Al2O3)	5	3-8
Calcium sulphate (CaSO4)	4	3-4
Iron oxide (Fe2O3)	3	3-4
Magnesia (MgO)	2	1-3

Sulphur (S)	1	1-3
Alkalies	1	0.2-1

MANUFACTURE OF ORDINARY CEMENT

It involves the following steps

- Mixing of raw material
- Burning
- Grinding
- Storage and packaging

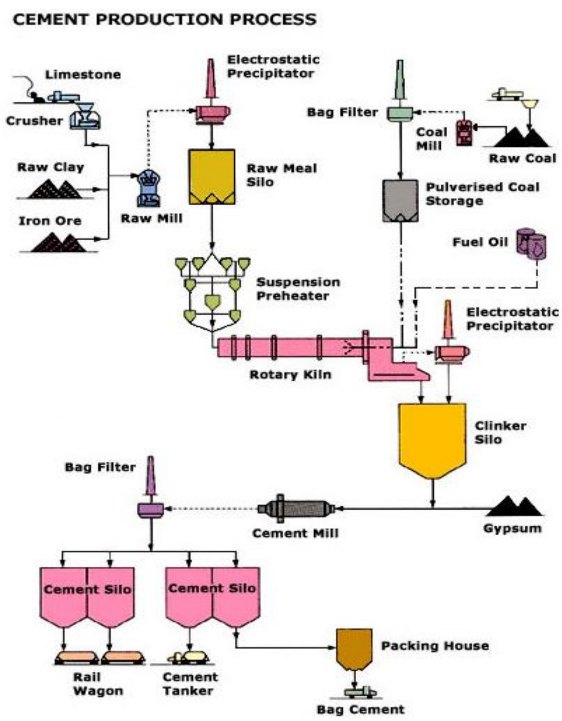

FIG.1 MIXING OF RAW MATERIAL

Dry process **Wet process**

DRY PROCESS

- The raw materials are reduced in size of about 25mm in crushers.

- A current of dry air is then passed over these dried materials
- These dried materials are then pulverized into fine power in ball mills and tube mills.
- All these operations are done separately for each raw material and they are stored in hoppers.
- They are then mixed in correct proportions and made ready for the feed of rotary kiln.
- This finely ground powder of raw materials is known as the raw mix and it is
    - stored in storage tank

Widely used at present because of the following reasons:

Competition Power Quality of cement Technology

PROCEDURE OF MANUFACTURE OF CEMENT BY THE DRY PROCESS

- The boulders upto 1.2 m size are transported in huge dumpers upto 300KN capacity and dumped into the hopper of the crusher
- The crushed limestone now of 75mm size is moved from the crushed by a series of conveyors for stacking.
- The argillaceous or clay materials found in the quarry are also dumped into the crusher and stacked along with the limestone.
- The crushed materials are checked for calcium carbonate, lime alumina, ferrous oxide and silica contents.
- The additive material and crushed limestone are conveyed to the storage hoppers.
- The materials are ground to the desired fineness in the raw mill.

- The material is dropped merely by gravity from the blending to the storage silo thereby conserving power.
- The material from the bottom of the preheater is fed to the rotary kiln.

FLOW DIAGRAM OF DRY PROCESS

Calcareous Materials Lime Stone / Argillaceous Materials Clay

Crushing

Fine Grinding in Ball mills and Tube mills Storage basin Channel Mixing in correct proportions. Preheating @800° by exhaust gases Storage tank for raw mix. Fuel fed from lower end (Coal, oil or natural gas). Fed to rotary Kiln Clinkers are formed. Addition of 2 to 3% of gypsum Clinkers are ground in Ball mill Cement silos Packing plant.

PROCEDURE OF MANUFACTURE OF CEMENT BY THE WET PROCESS

- In this process, the calcareous materials such as limestone are crushed and stored in silos or storage tanks.
- The argillaceous materials such as clay is thoroughly mixed with water in a container known as the wash mill and this washed clay is stored in basins.
- The crushed limestone from silos and wet clay form basins are allowed to fall in a channel in correct proportions.
- This channel leads the materials to grinding mills where they are brought into intimate contact to form what is known as the slurry.
- The grinding is carried out either in ball mill or tube mill or both.
- The slurry is led to correcting basin where it is constantly stirred.
- At this stage the chemical composition is adjusted as necessary.

- The corrected slurry is stored in storage tanks and kept ready to serve as feed for rotary kiln.

FLOW DIAGRAM OF WET PROCESS

Calcareous Materials Lime Stone / Argillaceous Materials Clay Crusher/Wash mill. Storage basin(Silos)Channel. Wet grinding mill (Ball mill) to make slurry Blending of slurry to correct composition. Storage of corrected slurry Fuel fed from lower end (Coal, oil or natural gas). Corrected slurry fed to rotary Kiln (from upper end) Slurry converted to Clinkers. Addition of 2 to 3% of gypsum Clinkers are ground in Ball mill Cement silos Packing plant

BURNING

A rotary kiln is formed of steel tubes and the diameter varies from 2.50m to 3.0m Lengths vary for 90m to 120m. Laid at a gradient of about 1 in 25 to 1 in 30. The kiln is supported at intervals by columns of masonry or concrete. The refractory lining is provided on the inside surface of rotary kiln. It is so arranged that the kiln rotates at about one to three revolutions per minute about its longitudinal axis. The corrected slurry is injected at the upper end of kiln. The hot gases or flames are forced through the lower end of kiln.

Dry zone The portion of the kiln near its upper end is known as the dry zone. And in this zone, the water of slurry is evaporated. As the slurry gradually descends there is rise in temperature and in the next section of kiln, the carbon dioxide form slurry is evaporated. The small lumps, known as the nodules are formed at this stage. These nodules then gradually roll down passing through zones of rising temperature and ultimately reach to the burning zone where e temperature is about 1400^{o} C to 1500^{o} CBurning zone Calcined product is formed and nodules are converted into small hard dark greenish blue balls which are known as the clinkers.

GRINDING

The clinkers as obtained 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. Gypsum controls the initial setting time of cement (gypsum acts as a retarder and it delays the setting action of cement). 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 and stored in a dry place.

FLOW DIAGRAM OF BURNING AND GRINDING OPERATION OF CEMENT

From storage tanks

Rotary klin

Coal dust

Formation of clinkers

coolers

Grinding of clinkers in ball mills and tube mills

Gypsum

Storage in silos

Weighing and packing in bags

Distribution

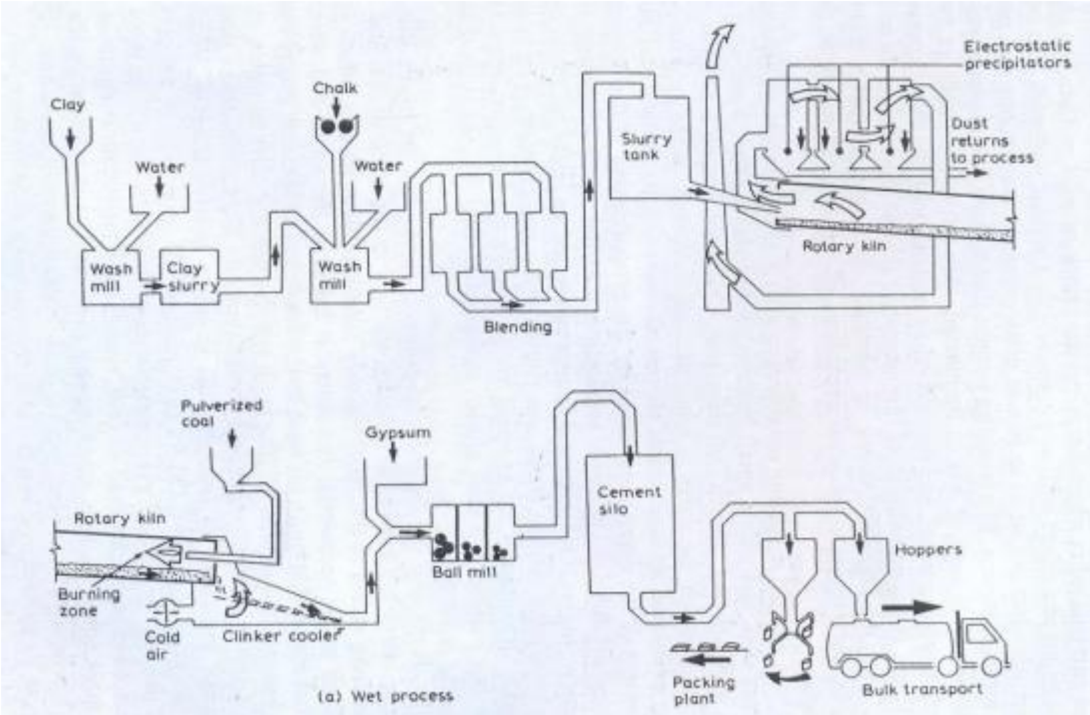

FIG.2 FLOW DIAGRAM OF CEMENT MANUFACTURING

Packing of cement

Plastic and paper bags are more suitable to protect from air moisture. Packed in 50 kgs

TABLE 2 TYPE OF CEMENT AND ITS IS CODES

Sl.No.	Type of Cement	Reference
1	Ordinary Portland Cement 33 Grade	IS: 269
2	Ordinary Portland Cement 43 Grade	IS:8112
3	Ordinary Portland Cement 53 Grade	IS:12269
4	Rapid Hardening Cement	IS:8041
5	Extra Rapid Hardening Cement	
6	Sulphate Resisting Cemnt	IS:12330
7	Portland Slag Cement	IS:455

8	Quick Setting Cement	
9	Super Sulphated Cement	IS:6909
10	Low Heat Cement	IS: 12600
11	Portland Pozzolana Cement (Calcined based)	IS:1489 P-1
12	Portland Pozzolana Cement (Calcined based)	IS:1489 P-2
13	Air Entraining Cement	
14	Coloured Cement: White Cement	IS:8042
15	Hydrophobic Cement	IS:8043
16	Masonry Cement	IS:3466
17	Expansive Cement	
18	Oil Well Cement	IS:8229
19	Rediset Cement	
20	Concrete Sleeper Grade Cement	IRS-R40
21	High Alumina Cement	IS:6452

GRADE OF CEMENT

Grade 33 --as per IS-269 (1989) designated at C-33

Grade 43 --as per IS-8112 (1989) designated at C-43

Grade 53 --as per IS-2269 (1989) designated at C-53

Sleeper cement as per IRS- T40-85 (this will be between C43 and C53) supplied only to railways.

PROPERTIES OF CEMENT

Physical properties Mechanical properties Chemicalproperties

Physical properties of cement

- Depend upon its chemical composition, thoroughness of burning ad fineness of grinding
- Gives strength to the masonry
- An excellent binding material
- Easily workable
- Offers good resistance to the moisture
- Possesses a good plasticity
- Stiffens or hardens early
- A t thin paste of cement with water should feel sticky between the fingers.
- A cement thrown in water should sink and should not float on the surface Mechanical properties of cement
- The compressive strength at the end of 3 days should not be less than 11.5 N/mm^2 and that at the end of 7 day should not be less than $17.5N/mm^2$.
- The tensile strength at the end of 3 days should not be less than 2N/mm2 and that at the end of 7 days should not be less than $2.50N/mm^2$.
- Chemical properties of cement
- The ratio of percentage of alumina to iron oxide should not be less than 0.66
- The ratio of percentage of lime to alumina, iron oxide and silica, known as Lime Saturation Factor (LSF) should not be less than 0.66 and should not be more than 1.02.
- Total loss of ignition should not be more than 4 per cent.
- Total sulphur content should not be more than 4 per cent.
- Weight of insoluble residue should not be more than 1.50 per cent.
- Weight of magnesia should not exceed 5%

MORTAR

Paste prepared by adding required quantity of water to a mixture of binding material like cement or lime and fine aggregate like sand.

Classification of mortars

Based on Bulk density Kind of binding material Nature of application special mortars.

PROPERTIES OF CEMENT MORTARS

- Capable of developing good adhesion with the building units such as bricks, stones
- Capable of developing the designed stresses
- Capable of resisting penetration of rain water
- should be cheap
- Should be durable
- Should be easily workable
- Should not affect the durability of materials with which it comes into contact
- Should set quickly so that speed in construction may be achieved
- Joints formed by mortar should not develop cracks and they should be able to maintain their appearance for a sufficiently long period.

HYDRATION

- The reaction of cement with water is exothermic
- The reaction liberates a considerable quantity of heat.
- This liberation of heat is called Heat of Hydration.
- Study and control of the heat of hydration becomes important in the construction of concrete dams and other mass concrete constructions.

- Different compounds hydrate at different rates and liberate different quantities of heat.

TABLE 3 Heat of Hydration

Heat of Hydration at the given age (cal/g)			
Compound	**3 Days**	**90 Days**	**13 Years**
C3S	58	104	122
C2S	12	42	59
C3A	212	311	324
C4AF	69	98	102

Heat of hydration of cement is an additive property(H)

H= aA + bB+ cC + dD

Where, A, B, C, and D are the percentage contents of C3S, C2S, C3A and C4AF.

And a, b, c and d are coefficients representing the contribution of 1 % of the corresponding compound to the heat of hydration

COMPRESSIVE STRENGTH (CEMENT MORTAR)

- Compressive strength is the basic data required for mix design.
- By this test, the quality and the quantity of concrete can be controlled and the degree of adulteration can be checked.
- The test specimens are 70.6 mm cubes having face area of about 5000 sq. mm.
- Large size specimen cubes cannot be made since cement shrinks and cracks may develop.
- The temperature of water and test room should be 27°± 2°C.

- A mixture of cement and standard sand in the proportion 1:3 by weight is mixed dry with a trowel for one minute and then with water until the mixture is of uniform colour.
- Three specimen cubes are prepared. The material for each cube is mixed separately.
- The quantities of cement, standard sand and water are 185 g, 555 g and (P/4) + 3.5, respectively where P = percentage of water required to produce a paste of standard consistency.
- The mould is filled completely with the cement paste and is placed on the vibration table. Vibrations are imparted for about 2 minutes at a speed of 12000±400 per minute.
- The cubes are then removed from the moulds and submerged in clean fresh water and are taken out just prior to testing in a compression testing machine.
- Compressive strength is taken to be the average of the results of the three cubes.
- The load is applied starting from zero at a rate of 35 N/sq mm/minute.
- The compressive strength is calculated from the crushing load divided by the average area over which the load is applied. The result is expressed in N/mm^2

TABLE 4 COMPRESSIVE STRENGTH

Material	**Compressive strength (N/mm2)**	
	14 Days	**28 Days**
Class A lime	1.75	2.8
Class B lime	1.25	1.75
Cement 33 Grade	22	33

TENSILE STRENGTH

Generally used for the rapid hardening cement

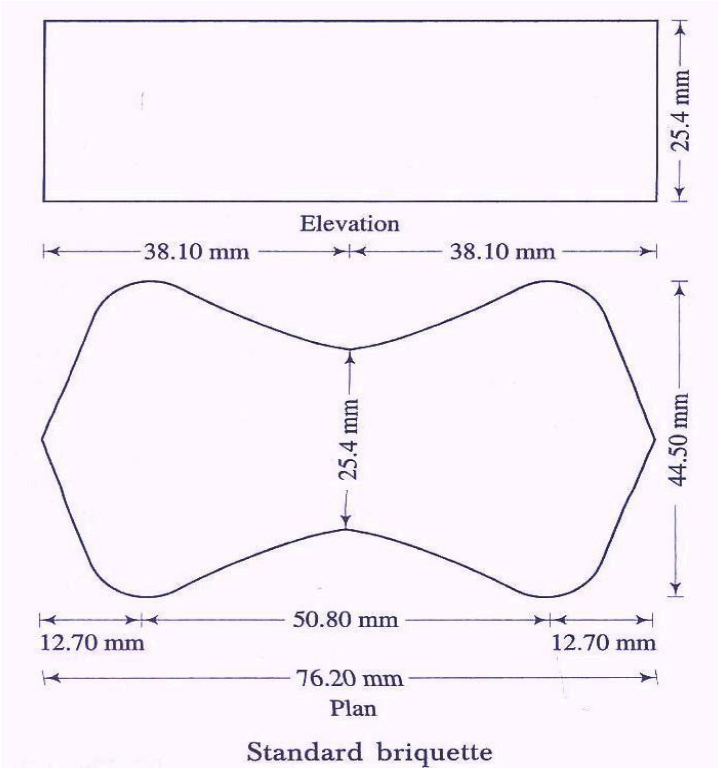

FIG.3 TENSILE STRENGTH OF CEMENT

Following Procedure is adopted :

- Mortar is prepared in 1:3 proportions and the quantity of water is 8% by weight of cement and sand and placed in briquette moulds.
- The mould is filled with mortar and then a small heap of mortar is formed at
- It is beaten down by a standard spatula till water appears on the surface.
- Twelve standard briquettes are prepared by following same procedure and the quantity of cement may be 600 gm for 12 briquettes.
- The briquettes are kept in a damp cabin for 24 hours and after 24 hours the briquettes are carefully remove from the moulds and they are submerged in clean water for curing.

- The briquettes are tested in testing machine at the end of 3 days and 7 days.
- Six briquettes are tested in each test and average is found out.
- During the test the load is to be applied uniformly at the rate of 35Kg/Cm^2 or 3.50N/mm^2.
- The cross-sectional area of briquette at its least section is 6.45cm^2.
- Ultimate tensile stress = Failing load/6.45
- The tensile stress at the end of 3days should not be less than 20Kg/Cm^2 or 2 N/mm^2.
- And that at the end of 7 days should not be less than 25Kg/Cm^2 or 2.50 N/mm^2.

FINENESS

- Test is carried out to check proper grinding of cement.
- The fineness of cement particles may be determined by either by sieve test or by permeability apparatus test.
- In sieve test, the cement weighing 100 gm is taken and it is continuously passed for 15 minutes through standard BIS sieve no.9 and residue is then weighed and this weight should not be more than 10% of original weight.
- In permeability apparatus test. Specific surface area of cement particles is calculated. This test is better than sieve test and it gives an idea of uniformity of fineness. The specific surface acts as a measure of the frequency of particles of average size. The specific surface of cement should not be less than 2250cm^2/gm.

SOUNDNESS

Purpose of the test

To detect the presence of uncombined lime in cement. This test is performed with the help of Le Chatelier apparatus as shown in figure below. It consists of a brass mould of diameter 30mm and height 30mm. There is a split in mould and it does not exceed 0.50mm. On either side of split, there are two indicators with pointed ends. The thickness of mould cylinder is 0.50mm.

Procedure :

- The cement paste is prepared. The percentage of water is taken as determined in the consistency test.
- The mould is placed on a glass plate and it is filled by cement paste.
- A small weight is placed at top and the whole assembly is submerged in water for 24 hours. The temperature of water should be between 24 °C to 35 °C.
- The distance between the points of indicator is noted the mould is again placed in water and heat is applied in such a way that boiling point of water is reached in about 30 minutes. The boiling of water is continued for one hour.
- The mould is removed from water and it is allowed to cool down.
- The distance between the points of indicator is again measured.
- The difference between the two readings indicates the expansion of cement and it should not exceed 10mm.

CONSISTENCY

Purpose – to determine the percentage of water required for preparing e cement pastes for other test.

Procedure :

- Take 300gm of cement and add 30 % by weight or 90 gm of water to it.
- Mix water and cement on a non-porous surface. The mixing should be done thoroughly.
- Fill the mould of Vicat apparatus. The interval between the addition of water

to the commencement of filling the mould is known as the time of gauging and it should be 3 $^{3}/4$to 4 $^{1}/2$ minutes.

- The vicat apparatus is shown in figure above and it consist of a frame to which is attached a movable rod weighing 300 grams and having diameter and length as 10mm and 50 respectively. And indicator is attached to the movable rod. This indicator moves on vertical scale and it gives the penetration. The vicat mould is in the form of a cylinder and it can be split into two halves. The vicat mould placed on no porous plate. There are there attachment- square needle, plunger and needle with angular collar. The square needle is used for initial setting time test, the plunger is used for consistency test and the needle with annular collar is used for final setting time test.
- The plunger is attached to the movable rod of vicat apparatus. The plunger gently lowered on the paste in the mould.
- The settlement of plunger is noted. If the penetration is between 5mm to 7mm from the bottom of the mould, the water added is correct. If the penetration is not proper, the process is repeated with different percentage of water till the desired penetration is obtained.

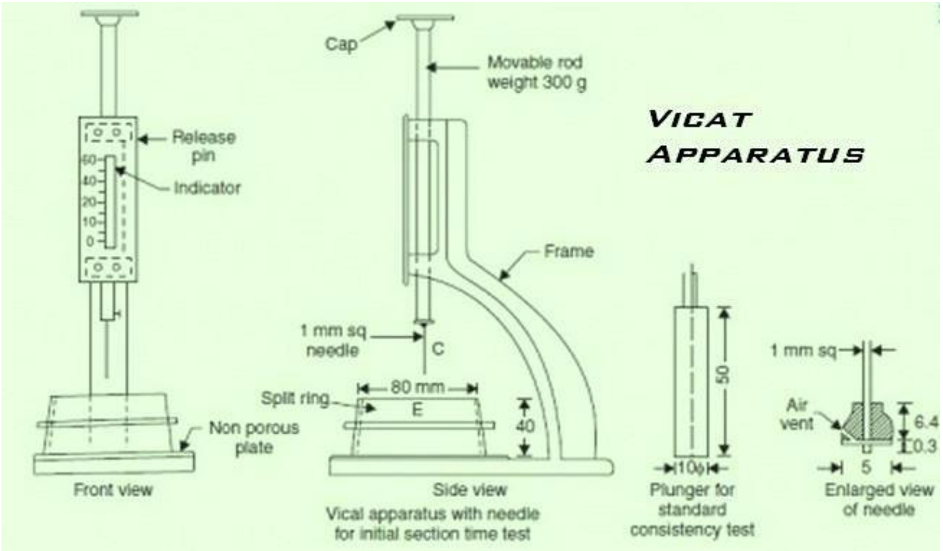

FIG.4 VICAT APPARATUS FOR CEMENT TEST

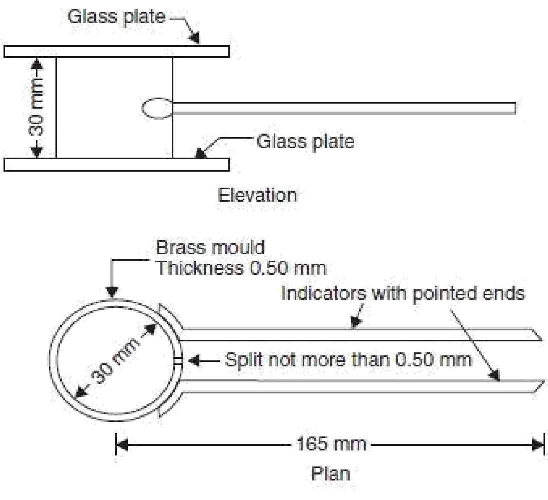

Fig. 1.6. Le Chatelier's apparatus

FIG.5 LE CHATELIER APPARATUS FOR CEMENT TEST

SETTING TIME

This test is used to detect the deterioration of cement due to storage. It may be noted that this is purely a conventional type of test and it has got no relation with the setting or hardening of actual concrete. The test is carried out to find out initial setting time and final setting time.

Initial setting time:

- The cement weighing 300 gms is taken and its mixed with percentage of water as determined in consistency test .
- The cement past is filled in the vicat mould.
- Square needle of cross section 1mm * 1mm is attached to the moving rod of the vicat apparatus.
- The needle is quickly released and it is allowed penetrate the cement past. In the beginning, the needle penetrate completely. It is then taken out and dropped at a fresh place. The procedure is repeated regular intervals till the needle does not penetrate completely. The needle should penetrate upto 5mm measured from the bottom.
- The initial setting time is interval between the addition of the water to the cement and the stage when needle ceased to penetrate completely. This time about 30 minutes of the ordinary cement.

FINAL SETTING TIME:

- The cement paste is prepared as about and it is filled in the vicat mould.
- The needle with annular collar is attached to the moving rod of the vicat apparatus. This needle has a sharp point projecting in the centre with annular collar.
- The needle is gently released. The time at which the needle makes an impression on test block and the collar fails to do so is noted.

- Final setting time is the difference between the time at which water was added to the cement and time as recorded in (c). This time should be about 10 hours for ordinary cement.

AGGREGATES

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Aggregates can be classified as

- Normal weight aggregates
- Light weight aggregates
- Heavy weight aggregates

Normal weight aggregates can be further classified as natural aggregate and artificial aggregates.

Natural	Artificial
Sand, Gravel, Granite	Broken brick, Air-cooled slag
Quartzite, Basalt, Sandstone	

Aggregates can be classified based on the size of aggregate as coarse aggregate and fine aggregate.

NATURAL STONE AGGREGATES

All natural aggregate materials originate from bed rocks. There are three kinds of rock namely igneous, sedimentary and metamorphic. These classifications are based on the mode of formation of rocks. Igneous rocks are formed by the cooling of molten magma at the surface of the crest. The sedimentary rocks are formed originally below the sea-bed and subsequently lifted up. Metamorphic rocks are either igneous or sedimentary rocks which are metamorphic due to extreme heat and pressure.

Most igneous rocks make satisfactory concrete aggregates because they are hard, tough and dense. The sedimentary rocks with the stratified structure are quarried and concrete aggregates are derived from it. Metamorphic rocks show foliated structure. Many metamorphic rocks such as quartzite and gneiss have been used for production of good concrete aggregate.

CRUSHING STRENGTH

The aggregate crushing value gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. The aggregate crushing value should not be more than 45% for aggregate used for concrete other than for wearing surfaces and 30% for concrete used for wearing surfaces such as runways, roads and airfield pavements. The standard aggregate crushing test is made on aggregate passing a 12.5mm sieve I.S Sieve and retained on 10mm I.S Sieve. About 6.5kg of the sample is taken. The aggregate is filled into the cylindrical measure in three layers of equal depth. Each layer is tamped 25 times with the tamping rod and leveled off. the weight of the sample contained in the cylinder is taken.(A). The apparatus with the test sample is placed on the compression testing machine and is loaded uniformly upto a total load of 10 tons. The load is then released and the whole material removed from the cylinder and sieved on a 2.36mm I.S Sieve. The fraction passing the sieve is weighed (B).

Aggregate crushing value = (B / A) * 100

B = weight of fraction passing 2.36mm I.S

sieve A = weight of surface dried sample.

FIG.6 AGGREGATE CRUSHING TEST APPARATUS

IMPACT STRENGTH

The aggregate impact value gives relative measure of the resistance of an aggregate to sudden shock or impact. The aggregate impact value should not be more than 45% by weight for aggregates used for concrete other than wearing surfaces and 30% by weight for concrete to be used as wearing surfaces such as runways, roads and pavements.

The test sample consists of aggregate passing through 12.5mm and retained on 10mm I.S Sieve. The aggregate shall be dried in an oven and cooled. The aggregate is filled about one- third full and tamped with 25 strokes by the tamping rod. A similar quantity is added and tamped in the standard manner. The measure is filled to overflowing and struck off level. The net weight of the aggregate is determined (weight A). The whole sample is filled into a cylindrical steel cup fixed on the base of the machine. A hammer is raised to a height of 380mm above the upper surface of aggregate and allowed to fall freely on the aggregate. The sample is subjected to 15 blows and the crushed aggregate is removed from the cup. It is sieved on 2.36mm sieve and the fraction passing the sieve is weighed. (weight B).

Aggregate impact value = (B/ A) * 100.

B = weight of fraction passing 2.36mm I.S

sieve A = weight of surface dried sample.

FIG.7 AGGREGATE IMPACT TEST APPARATUS

FLAKINESS INDEX

It is the percentage by weight of particles in it whose least dimension is less than $3/5^{th}$ of their mean dimension. The Flakiness index is not applicable to sizes smaller than 6.3 mm. The test is conducted by using a metal thickness guage. A sufficient quantity of aggregate is taken such that a minimum number of 200 pieces of any fraction can be tested. Each fraction is gauged in turn for thickness on the metal guage. The total amount passing in the guage is weighed. The flakiness index is the total weight of the material passing the various thickness gauges expressed as a percentage of the total weight of the sample taken.

ELONGATION INDEX

It is the percentage by weight of particles, whose greatest dimension is greater than 1.8 times their mean dimension. The elongation index is not applicable to sizes smaller than 6.3 mm. The test is conducted by using a metal length guage. A sufficient quantity of aggregate is taken such that a minimum number of 200 pieces of any fraction can be tested. Each fraction is gauged individually for length on the metal guage. The total amount retained by the guage is weighed. The elongation index is the total weight of the material retained on the various length gauges expressed as a percentage of the total weight of the sample gauged

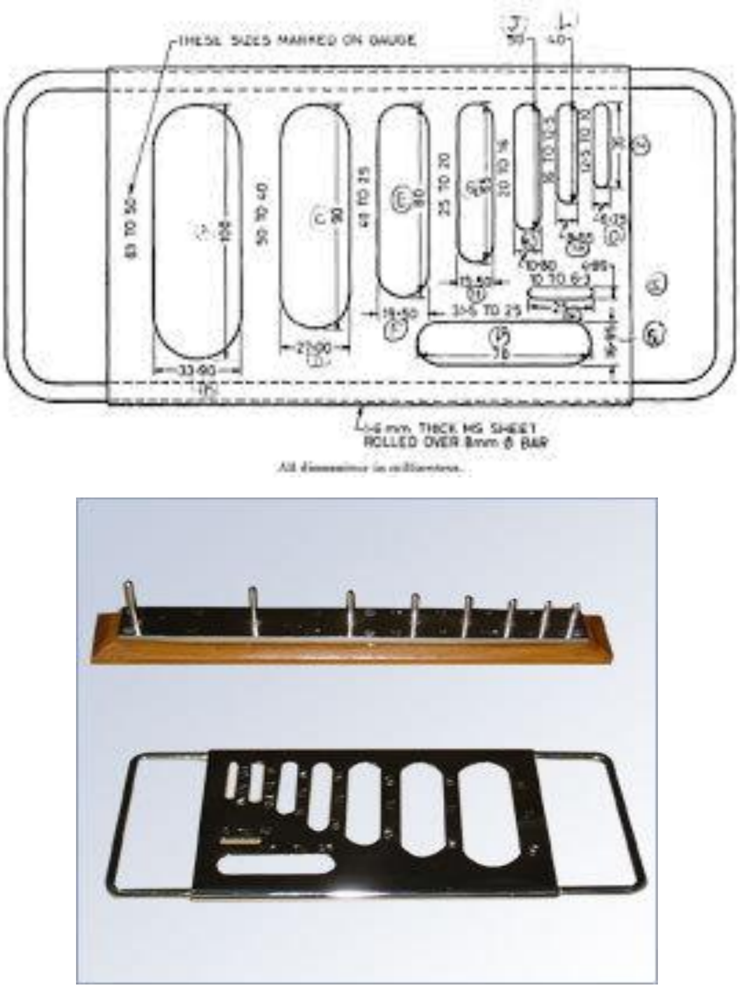

FIG.7 ELANGATION TEST APPARATUS

ABRASION RESISTANCE

Three tests are in common use to test aggregate for its abrasion resistance. They are Dorry Abrasion test, Deval Attrition test, Los Angels test. Aggregates which are used for road constructions and pavement construction are tested with respect to its resistance to wear. In Deval Attrition test, particles are subjected to wear in an iron cylinder. The proportion of material crushed finer than 1.7mm size is expressed as a percentage of the original material taken. this percentage is the attrition value of aggregate.

In Dorry Abrasion test a cylindrical specimen is subjected to abrasion against rotating metal disc sprinkled with quartz sand. The loss in weight of the cylinder after 1000 revolutions of the table is determined.

Los Angels test involves taking specified quantity of material along with specified number of abrasive charge in a standard cylinder and revolving it for specified revolutions. The particles smaller than 1.7mm sizes are separated out. The loss in weight gives the abrasion value of the aggregate.

FIG.8 ELANGATION TEST APPARATUS

FIG.9 LOS ANGELES ABRASION TEST ON AGGREGATE

MORTAR

Mortar is a paste prepared by adding required quantity of water to a mixture of binding material and fine aggregate. The binding material like cement or lime is referred as matrix and the fine aggregate like sand is referred as the adulterant. The matrix binds the particles of the adulterant and the durability, quality and strength of mortar depend on the quantity and quality of matrix.

CLASSIFICATION OF MORTAR

Mortars are classified based on the following:

- Bulk density
- Kind of binding material
- Nature of application
- Special mortars

Based on bulk density, mortar is classified into heavy mortars and light weight mortars. Mortars having a bulk density of 15 KN/m^3 or more are heavy mortars and that having a bulk density less than $15KN/m^3$ are light weight mortars.

Based on the kind of binding material, mortar is classified into lime mortar, surkhi mortar, cement mortar, gauged mortar, gypsum mortar. In lime mortar, lime is used as the binding material. The lime may be fat lime or hydraulic lime. The fat lime shrinks to a great extent and hence it requires about 2 to 3 times its volume of sand. The proportion of lime to sand by volume is about 1:2 for hydraulic lime. It is used for lightly loaded above ground parts of building. Surkhi mortar is prepared by using surkhi instead of sand or by replacing half of sand in case of fat lime mortar. It is used for masonry work of all kinds in foundation and superstructure. In cement mortar, cement is used as the binding material. The proportion of cement to sand by volume varies from 1:2 to 1:6. It is used in underground constructions. Gauged mortar is also known as composite mortar or lime cement mortar. It is formed by the combination of cement and clay. It is used for bedding and for thick brick walls. Gypsum mortars are prepared from gypsum binding materials such as building gypsum and anhydrite binding materials.

Based on nature of application, mortar is classified into brick laying mortar and finishing mortars. Brick laying mortars are used for brick work and walls. Finishing mortars include common plastering work and mortars for developing architectural or ornamental effects. Special mortars include fire resistant mortar, light weight mortar, packing mortar, sound absorbing mortar, X-ray shielding mortar etc. Fire resistant mortar is prepared by adding aluminous cement to the finely crushed powder of fire bricks. Is is used for lining furnaces, fire places, ovens etc. Light weight mortar is prepared by adding, materials like saw dust, wood powder to the lime mortar or cement mortar. It is used in sound proof constructions. To pack oil wells, special mortars are formed, known as packing mortar. To reduce the noise level, the sound absorbing plaster is formed with the help of sound absorbing mortar. X-ray shielding mortar is used for providing plastering coat to walls and ceiling of x-ray cabinets.

-

PROPERTIES OF GOOD MORTAR

- It should be capable of developing good adhesion with the building units.
- It should be capable of developing the designed stresses.
- It should be capable of resisting penetration of rain water.
- It should be cheap.
- It should be durable.
- It should be easily workable
- It should not affect the durability of materials with which it comes into contact.
- It should set quickly so that speed in construction is achieved
- The joints formed by mortar should not develop cracks.

USES OF MORTAR

- To bind the building units into a solid mass.
- To carry out pointing and plastering work on exposed surfaces of masonry.
- To form an even and soft bedding layer for building units.
- To form joints of pipes.
- To improve the general appearance of structure.
- To prepare moulds for coping, corbels, cornice etc.
- To serve as a matrix or cavity to hold coarse aggregates etc.
- To hide the open joints of brickwork and stone work.
- To fill up the cracks detected in the structure during maintenance process.
- To distribute uniformly the super incumbent weight from upper layer to

TABLE 5 SELECTION OF MORTAR

No	Nature of work	Type of mortar
1	Construction work in waterlogged areas and exposed positions	Cement or lime mortar prop. 1:3
2	Damp proof courses and cement concrete roads	Cement mortar prop. 1:2
3	General R.C.C work such as lintels, pillars, slabs, stairs etc	Cement mortar prop. 1:3
4	Internal walls and surfaces.	Lime mortar prop 1:3
5	Mortar for laying fire bricks	Fire resisting mortar
6	Partition walls and parapet walls	Cement mortar prop. 1:3
7	Plaster work	Cement mortar prop. 1:3
8	Pointing work	Cement mortar prop. 1:1 to 1:2
9	Reinforced brickwork	Cement mortar prop. 1:3
10	Stone masonry with best varieties of stone	Lime mortar prop 1:2
11	Stone masonry with ordinary stones	Lime mortar prop 1:2
12	Thin joints in brickwork	Lime mortar prop 1:3

MANUFACTURE OF STEEL

The steel is suitable for all constructional purposes and hence it has practically replaced cast iron and wrought iron in the present day practice of building construction. It is equally good in compression as well as in tension.

The steel is manufactured by the following processes.

- Bessemer process
- Cementation process
- Crucible steel process

- Duplex process
- Electric process
- L.D. process
- Open hearth process

BESSEMER PROCESS:

This process can be acidic or basic based on the nature of lining material of converter. Acidic process is adopted when iron ores contain very small amount of sulphur and phosphorous. Basic process is adopted for pig iron containing impurities of any type. The converter is charged with molten pig iron and is brought in an upright position. A blast of hot air is forced through the tuyeres. Air oxidizes impurities of pig iron and a yellow flame is seen at the nose of the converter. When the blast is shut off, the required amount of ferro manganese is added to get steel of desired quality.

CEMENTATION PROCESS

It consists of converting pig iron into pure wrought iron and then preparing steel by adjusting carbon content. The cementation furnace is heated and the bars of pure wrought iron are subjected to intense heat. The wrought iron combines with carbon and steel of desired quality is obtained.

CRUCIBLE STEEL PROCESS:

The fragments of blister steel are taken and they are mixed with charcoal. They are placed in fire clay crucibles and heated. The molten iron is poured into suitable moulds. The steel produced is known as cast steel. It is used for making surgical instruments.

DUPLEX PROCESS:

It is a combination of two processes. (1) acid Bessemer process (2) basic open hearth process. The molten pig iron is treated in acid lined Bessemer converter. It is then treated in basic lined open hearth. The process is economical and it results in saving of time.

ELECTRIC PROCESS:

An electric furnace is used in this process. It is made from steel plates. Electricity is used for heating and melting the metal. The furnace is provided with electrodes. When electric current is switched on, the electric arcs are formed between the electrodes and the surface of metal and with the intense heat of arcs, the metal is heated and melted.

L.D. PROCESS:

This is a modification of Bessemer process. It is known as Lintz- Donawitz process. In this process pure oxygen is used instead of air. A jet of pure oxygen is blown at extra ordinary speed on molten metal. The high temperature developed in the converter burns away impurities of metal and low carbon steel is prepared.

OPEN HEARTH PROCESS:

The process is carried out in open hearth furnace. The hearth is filled with molten pig iron from cupola furnace. A mixture of pre-heated air and coal gas is allowed to pass over the hearth. This mixture catches fire and produces intense heat. The molten metal is poured into mould for forming ingots. These are treated to form steel of commercial pattern.

USES OF STEEL

Based on carbon content, steel is designated as mild steel, medium carbon steel or high carbon steel. The carbon content of mild steel is about 0.1 to 0.25%. The carbon content of low carbon steel is less than 0.1%. The carbon content of medium carbon steel is about 0.25 to 0.6%. The high carbon steels is also known as hard steel and its carbon content varies from 0.6 to 1.1%.

TABLE 6 USES OF STEEL

Name of Steel	Carbon content	Uses
Mild Steel	Upto 0.1%	Motor body, sheet metal, tin, plate etc
Medium carbon steel	Upto 0.25%	Boiler plates, structural steel etc
	Uto 0.45%	Rails, Tyres etc
	Upto 0.6%	Hammers, Large stamping and pressing dies etc
High carbon steel	Upto 0.75%	Sledge hammers, springs, stamping dies
Hard steel	Upto 0.9%	Minor's drills, smith's tool, stone mason's tools etc
	Upto 1%	Chissels, hammmers, wood working tools
	Upto 1.1%	Axes, cutlery, drills, knives, picks, punches

Operations involved:

- Drawing
- Forging
- Pressing
- Rolling

DRAWING:

This operation is carried out to reduce the cross section and to increase the length proportionately. The metal is drawn through dies. The drawing is continued till wire of required diameter is obtained.

FORGING:

This operation is carried out by repeated blows under a power hammer or a press. The process increases the density and improves grain sizes of metals.It is used for the manufacture of bolt, cramps etc.

PRESSING:

It is carried out in equipment known as press. It does not involve any shock. The metal is pressed between die and punch and article of desired shape is obtained.

ROLLING:

It is carried out in specially prepared rolling mills. The ingots are passed in succession through different rollers until articles of desired shape are obtained. It is used for the manufacture of angles, channels, joists etc.

HEAT TREATMENT PROCESS OF STEEL

- Annealing
- Case hardening
- Cementing
- Cyaniding
- Hardening
- Nitriding
- Normalising
- Tempering

ANNEALING:

The object of the process is to make the steel soft so that it can be easily worked upon with a machine. The steel to be annealed is heated to the desired temperature and allowed to cool slowly in the furnace. The annealing reduces the tensile strength, but it increases ductility and brings back the steel to the best physical state to resist fracture.

CASE HARDENING:

In this treatment, the outside surface becomes hard, the core of the materials retains original properties. The case hardening is important for components like gears, bearing surfaces etc.

CEMENTING:

In this process, the skin of the steel is saturated with carbon. It consists of heating of steel in a carbon rich medium between 880 and 950^{o}C.

CYANIDING:

The process is used to produce hard cases on the surfaces of low or medium carbon steel. It consists of adding carbon and nitrogen to the surface layer of steel so as to increase its hardness, wear resistance and fatigue limit.

HARDENING:

The process is the reverse of annealing process. The steel is made hard by this process whereas it is made soft by the annealing process. In hardening process, cooling is carried out at a controlled rate. Such a control rate of cooling is known as quenching.

NITRIDING:

The process of saturating the surface layer of steel with nitrogen by heating is known as nitriding. Heating is carried out between 480 to 650 degree Celsius in an atmosphere of Ammonia. Treatment makes the steel hard and increases its resistance to corrosion.

NORMALISING:

The object of this process is to restore steel structure to normal condition, when it is disturbed due to mechanical work. The process is done by heating steel 40 to 50 degree Celsius above its upper critical temperature and maintained at that temperature and allowed to cool.

TEMPERING:

The process is applied to steel which are treated with hardening process. The hardened steel is in a stressed condition and very brittle and cannot be used for practical purposes. Hence steels after hardening must be tempered to obtain good mechanical properties and to relieve internal stresses.

PROPERTIES OF MILD STEEL

- It can be magnetized permanently
- It can be readily forged and welded.
- It cannot be easily hardened and tempered.
- It has fibrous structure
- It is malleable and ductile.
- It is not easily attacked by salt water.
- It is tougher and more elastic than wrought iron
- It is used for all type of structural work.
- It rusts easily and rapidly
- Its melting point is about 1400 degree Celsius.

Properties of hard steel

-)

  It can be easily hardened and tempered.
- It can be magnetized permanently
- It cannot be readily forged and welded.
- It has granular structure.
- It is not easily attacked by salt water.
- It is tougher and more elastic than mild steel.
- It is used for finest cutlery, edge tools
- It rusts easily and rapidly
- Its melting point is about 1300 degree Celsius.
- Its specific gravity is 7.90.

ANTICORROSIVE MEASURES FOR STEEL

- Coal tarring

- Electroplating
- Embedding in cement concrete
- Enamelling
- Galvanizing
- Metal spraying
- Painting
- Parkersing
- Sherardising
- Tin plating and terne plating

COAL TARRING:

In this method, iron is dipped in hot coal tar so that a film of coal tar sticks to the surface. The film protects the iron surface from atmospheric actions leading to the corrosion.

ELECTROPLATING:

A thin layer of chromium, cadmium, copper or nickel is laid on the surface of ferrous metal with the help of electric current and by employing the principle of electrolysis.

EMBEDDING IN CEMENT CONCRETE:

If steel is embedded in cement concrete, it is not affected by corrosion. The cement concrete should be properly laid and cured so that it does not contain voids.

ENAMELLING:

The surface of iron is provided with a smooth surface by melting a suitable flux on it. It is used for ornamental iron works.

GALVANIZING:

The surface of the metal is cleaned and treated with dilute solution of HCl and after washing it is then dipped in a bath of molten zinc.

METAL SPRAYING:

The metal is covered with a spray of vaporized aluminium, lead, tin or zinc. The praying gives a thin film of uniform thickness

Painting

The metal surface is covered with a layer of paint. The surface is properly cleaned before the application of paint.

PARKERSING:

The article is immersed in a hot water bath of a chemical known as Parco. The insoluble phosphates are formed on the surface of article due to reactions and these keep away the moisture.

SHERARDISING:

The article is washed with acid solution and with clean water. It is then dried and covered with dust of pure zinc. It is heated to a high temperature. zinc melts and combines with metal and forms a protective layer.

TIN PLATING AND TERNE PLATING:

The metal is cleaned with dilute solution of acid and dipped in a bath of molten tin. The method of terne plating is similar to tin plating except that the lead tin alloy is used for coating instead of pure tin.

QUESTIONS

PART A

1.What are the uses of lime?

2.Define hydraulicity?

3. List the ingredients of cement?

4. What are the uses of cement?

5. What are the properties of cement?

6. Differentiate Fat lime from Hydraulic lime?

7.Define consistency?

8.What is meant by calcination?

9.What is slaked lime?

10What are the constituents of lime stone?

11.List the classification of lime

12.Enumerate the sources of lime?

13What are the precautions to be taken in handling of lime?

15.List the varieties of cement?

16.What is soundness?

17.What are the properties of cement?

18.What is meant by bulking of sand?

20.What is grade of cement?

21.What are the sources of natural stone aggregates?

22.What are the composition of ordinary cement?

23.What is cement Mortar?

24.Write any four uses of mortar?

25.Define abrasion resistance?

26.What is meant by flakiness index?

27.What is fineness of cement?

28.What is setting time of cement?

29.What is by elongation index?

30.What are the market forms of steel?

31.State the four field tests for cement

32.What is lime mortar?

33.State the various uses of steel

PART B

1.Write the characteristics of Portland Pozzolana Cement and White Cement

2.Enumerate the laboratory tests for cement and describe any two of them?

3.Describe the Tests on cement mortar?

4.Explain the manufacturing process of steel?

5.How to determine the compressive Strength and Tensile Strength of Cement?

6.Classify Mortar?

7.Write notes on High alumina Cement and hydrophobic Cement

8.Mention the properties of Good Mortar?

9.What are the purposes of heat treatment processes for steel?

10.Explain about the manufacture of lime ?

11.Briefly explain about the manufacture of cement?

12.Explain about the Anticorrosive measures for steel?

13.Explain about the properties and uses of different types of steel?

14.Discuss about natural stone aggregates ?

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – III - CONCRETE SCIA1102

Constituents of concrete (Cement and aggregate): Proportioning of concrete, water-cement ratio, Fresh concrete, Batching, Mixing, Transportation and placing, Compaction, Curing and finishes - Admixtures (Chemical, mineral) – RMC specifications.

CONSTITUENTS OF CONCRETE (CEMENT AND AGGREGATE)

Concrete is a mixture of

- Cement (11%),
- Fine aggregates (26%),
- Coarse aggregates (41%)
- water (16%)
- air (6%).

Cement --Powder

Cement + Water --Cement Paste

Cement Paste + Fine Aggregate (FA) --Mortar

Mortar + Coarse Aggregate (CA) --Concrete

Portland cement, water, sand, and coarse aggregate are proportioned and mixed to produce concrete suited to the particular job for which it is intended. Concrete a composite man-made material is the most widely used building material in the construction industry. It consists of a rationally chosen mixture of binding material such as lime or cement, well graded fine and coarse aggregates, water and admixtures (to produce concrete with special properties). In a concrete mix, cement and water form a paste or matrix which in addition to filling the voids of the fine aggregate, coats the surface of fine and coarse aggregates and binds them together. The matrix is usually 22-34% of the total volume. Freshly mixed concrete before set is known as wet or green concrete whereas after setting and hardening it is known as set or hardened concrete.

PROPORTIONING OF CONCRETE

Process of selection of relative proportions of cement, sand, coarse aggregate and water, so as to obtain a concrete of desired quality is known as the proportioning concrete. It is observed that if a vessel, as shown in figure below is taken and filled with stones, of equal size, the voids to the extent of about 45 % are formed.

This result is independent of the size of the stones. It is interesting to note that if sand is taken in place of stones, the same result will be obtained. The result can be verified by pouring water in the vessel till it is full. The volume of water added in the vessel represents the amount of voids. The theory of formation of concrete is based on this phenomenon of formation of voids, when coarse aggregate is placed, such as voids are formed. When fine aggregate i.e., sand is added it occupies these voids. Further, when finely powdered cement is added, it occupies the voids of sand particles. Finally, when water is added, it occupies very fine voids between the cement particles.

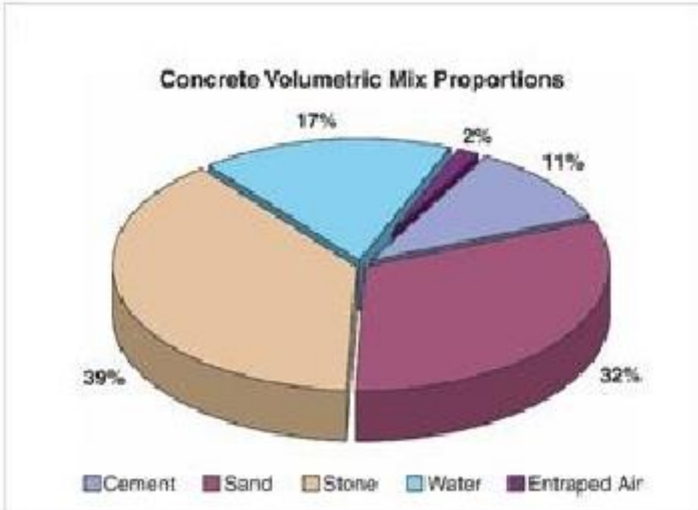

FIG.1 PROPORTIONING OF CONCRETE

In general, the proportions of coarse aggregate, fine aggregate, cement and water should be such that the resulting concrete has the following properties.

- When concrete is fresh, it should have enough workability so that it can be placed in the formwork economically.
- The concrete must possess maximum density or in other words, it should be the strongest and most watertight.

- The cost of materials and labour required to form the concrete should be minimum.

METHODS OF PROPORTIONING CONCRETE

- Arbitrary method
- Fineness modulus method

- Minimum voids method
- Maximum density method
- Water-cement ratio method

PRINCIPLES OF PROPORTIONING:

The fundamental object in proportioning concrete or mortar mixes is the production of a durable material of requisite strength, water tightness, and other essential properties at minimum cost. To achieve these objectives, careful attention must be given to the selection of cement, aggregate, and water to the following considerations: The mix must be workable so that it can be placed and finished without undue labour. Since cement is the most costly ingredient in the mix, the proportion used should be as small as is consistent with the attainment of desired properties. Within wide limits, experiments have shown:

- The strength and degree of water tightness of mixes, having like constituent materials, density, and workability, increase with the cement content.

- With the cement content, materials, and workability all constant, the strength and degree of water tightness increase with the density of the mix.

- For usual methods of placement, the strength and degree of water tightness of well cured concrete and mortar are greatest when the mix is plastic (has a slump of approximately 50 mm). Drier mixes, although frequently as strong, are likely to be porous unless compacted by pneumatic rammers or electrically driven vibrators. Increasing the water content beyond that required for plasticity causes the strength to decrease rapidly.

- Concrete with 4–7 per cent, by volume, entrained air made by using an air entraining cement or by adding air-entraining admixtures is more resistant to freezing and thawing action and also to scaling due to the use of salt for ice removal than concrete made withregular cement and without air-entraining admixtures. In addition to the above, the following statements appear to be justified by the results of experience and tests.

- To proportion concrete for the maximum resistance to fire, a porous noncombustible aggregate of high specific heat together with cement sufficient to provide the requisite strength should be thoroughly mixed and placed with as little ramming as possible to produce a porous concrete.

- In proportioning concrete or mortar which is to be subjected to freezing temperatures shortly after placement, a minimum amount of water and quick setting cement should be used.

- Concrete for road construction should be made from a carefully graded, hard tough aggregate bound together with as small a proportion of rich mortar as is consistent with the required workability, strength, and imperviousness. In locations where resistance to freezing and thawing is required, the concrete should have 3–6 per cent of entrained air. The principal methods used in scientific proportioning of mixes are based upon relationships between properties and ratio of cement to voids in the mix, or on the relationship between properties and the ratio of water to cement in the mix.

WATER-CEMENT RATIO

The water in concrete has to perform the following **two** functions:

- The water enters into chemical action with cement and this action causes the setting and hardening of concrete.
- The water lubricates the aggregates and it facilitates the passage of cement through voids of aggregates. This means that water makes the concrete workable.

The ratio of the amount of water to the amount of cement by weight is termed as the water-cement ratio and the strength and quality of concrete primarily depend upon this ratio. The quantity of water is usually expressed in litres per bag of cement and hence the water-cement ratio reduces to the quantity of water required in litres per kg of cement as one litre of water weighs one kg. For instance, if water required for 1 bag of cement in 30 litres, the water-cement ratio is equal to 30/50 = 0.60.

TABLE 1 PROBABLE CUBE CRUSHING STRENGTH WITH WATER-CEMENT RATIO

Net water – cement ratio by weight	**Probable cube crushing strength in N/mm ^{2}**	
	7 Days	**28 Days**
0.4	35	47
0.5	25	37
0.6	18	28
0.8	10.5	17.5

FRESH CONCRETE

Properties of Fresh Concrete (Properties at Early Ages)

- Workability
- Slump Loss
- Segregation/Bleeding
- Plastic Shrinkage
- Time of Set

Workability:

Definition: Effort required manipulating a concrete mixture with a minimum of segregation. It is not a fundamental property of concrete.

- consistency (slump) -- easy to flow
- Cohesiveness --tendency to bleed and segregate

Slump Test:

Slump test is a test conducting before concrete to be used for casting. The purpose of slump test is to determine the water content in concrete and its workability

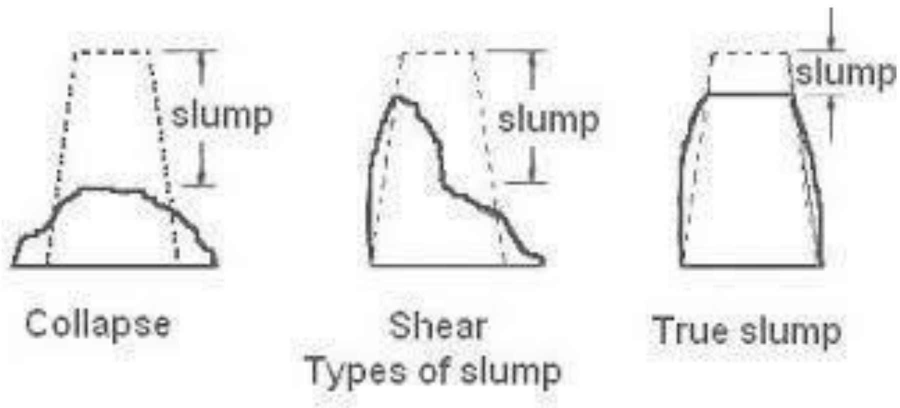

FIG.2 SLUMP TEST

TABLE 2 RECOMMENDED SLUMPS OF CONCRETE

Sl.No.	Type of concrete	Slump
1	Concrete for road construction	20 – 40 mm
2	Concrete for tops of curbs, parapets, piers, Slabs and walls that are horizontal	40 – 50 mm
3	Normal R.C.C Work	80 – 150mm
4	Mass concrete	25 – 50 mm
5	Concrete to be vibrated	10 – 25 mm

TABLE 3 SUITABILITY OF CONCRETE SLUMP

Slump Test

Degree of workability	Slump (mm)	Compacting Factor	Use for which concrete is suitable
Very low	0 - 25	0.78	Very dry mixes; used in road making. Roads vibrated by power operated machines
Low	25 - 50	0.85	Low workability mixes; used for foundations with light reinforcement. Roads vibrated by hand operated Machines
Medium	50 - 100	0.92	Medium workability mixes; manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibrations
High	100 - 175	0.95	High workability concrete; for sections with congested reinforcement. Not normally suitable for vibration

>Table : Workability, Slump and Compacting Factor of concrete with 19 or 38 mm (3/4 or 1 1/2 in) maximum size of aggregate.

Advantages of slump test:

- It grants the facility to easily detect the difference in water content of successive batches of concrete of the same identical mix.
- Apparatus is cheap, portable and convenient to be used at site.

Limitations of slump test:

- No direct relationship between the workability and the value of slump.
- Not suitable for a concrete in which maximum size of the aggregate exceeds 40mm.
- A chance of many shapes of slump to occur and it is difficult to decide which

the correct value.

- Slump occurs only in case of plastic mixes. It does not occur in case of dry mixes.

CONSISTENCY:

Consistency or fluidity of concrete is an important component of workability and refers in a way to the wetness of the concrete. If a mix is too wet, segregation may occur with resulting honeycomb, excessive bleeding, and sand streaking on the formed surfaces. On the other hand, if a mix is too dry it may be difficult to place and compact and segregation may occur because of lack of cohesiveness and plasticity of the paste.

HARDENED CONCRETE

Properties of Hardened Concrete

The principal properties of hardened concrete which are of practical importance can be listed as:

- Strength
- Permeability & durability
- Shrinkage & creep deformations
- Response to temperature variations

Of these compressive strength is the most important property of concrete. Because Of the abovementioned hardened properties compressive strength is one of the most important property that is often required, simply because;

- Concrete is used for compressive loads
- Compressive strength is easily obtained
- It is a good measure of all the other properties.

Compressive Strength is determined by loading properly prepared and cured cubic, cylindrical or prismatic specimens under compression.

• Cubic: 15x15x15 cm

Cubic specimens are crushed after rotating those 90° to decrease the amount of friction caused by the rough finishing.

• Cylinder: h/D=2 with h=15

To decrease the amount of friction, capping of the rough casting surface is performed.

TRANSPORTATION AND PLACING

The concrete, as it comes out of the mixer or as it is ready for use on the platform, is to be transported and placed on the formwork.

The type of equipment to be used for transport of concrete depends on:

- Nature of work
- Height above ground level
- Distance between the points of preparation and placing of concrete.

For Ordinary building works:

Human ladder is formed and concrete is conveyed in pans form hand to hand.

For important works:

Various Mechanical devices such as

- Dumpers
- Truck mixers
- Buckets
- Chutes
- Belt conveyors
- Pumps hoist.etc. may be used

Two important precautions necessary in the transportation of concrete:

- The concrete should be transported in such a way that there is no segregation of the aggregates.

- Under no circumstances, the water should be as added to the concrete during its passage form mixer to the formwork

Precautions to be taken during the placing of concrete:

- The formwork or the surface which is to receive the fresh concrete should be properly cleaned prepared and well-watered.
- The large quantities of concrete should not be deposited at a time.
- It is desirable to deposit concrete as near as practicable to its final position.
- The concrete should be dropped vertically form a reasonable height.
- The concrete should be deposited in horizontal layers of about 150mm height.

- As far as possible, the concrete should be placed in single thickness.
- The concrete should be thoroughly worked around the reinforcement and tapped in such a way that no honeycombed surface appears on removal of the formwork.
- The concrete should be placed on the formwork as soon as possible . But in no case, it should be placed after 30 minutes of its preparation.

Testing of Concrete (Including NDT)

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works.

- Compression Test

- The flexural strength of concrete

- Test cores

Non –Destructive Testing methods

- Have been in use for about four decades
- Powerful method for evaluating existing concrete structures with regard to their strength and durability apart from assessment and control of quality of hardened concrete.
- In certain cases, the investigation of crack depth, micro cracks and progressive deterioration are also studied by this method.
- Though non-destructive testing methods are relatively simple to perform, the analysis and interpretation of test results are not so easy.

- Therefore, special knowledge is required to analyze the hardened properties of concrete.
- In the non-destructive methods of testing, the specimen are non loaded to failure and as such the strength informed or estimated cannot to expected to yield absolute values of strength.
- These methods, therefore, attempt to measure some other properties of concrete form which an estimate of its strength, durability and elastic parameters are obtained.
- Some such properties of concrete are
- Hardness
- Resistance to penetration of projectiles
- Rebound number
- Ability to allow ultrasonic pulse velocity to propagate through it

- The electrical properties of concrete, its ability to absorb scatter and transmit X-rays and Gamma – rays.
- Its response to nuclear activation and its acoustic emission allow us to estimate its
  - Moisture content
  - Density
  - Thickness
  - Cement content

Based Upon the above, Various Non-Destructive methods of testing Concrete have been developed

TABLE 4 NON-DESTRUCTIVE TESTING ON CONCRETE

NDT methods	Equipment used	Used to find
Surface hardness test	Williams testing pistol and impact hammers	Concrete strength
Rebound test	Rebound hammer	Concrete strength and for comparative investigations
Penetration and pull out techniques	Simbi hammer, split pins, the Windsor probe, and the pullout test	Strength estimations and for comparative studies
Dynamic or vibration tests	Resonant frequency and mechanical sonic and ultrasonic pulse velocity methods	Durability ,uniformity of concrete strength and elastic properties
Combined methods	Ultrasonic pulse velocity and rebound hammer	Strength of concrete
Radioactive and nuclear methods	X-rays and Gamma-rays penetration test	Measurement of density, thickness of concrete, neutron scattering and neutron activation
Radioactive and nuclear methods	Neutron scattering and Neutron activation method	Moisture and cement content determination
Magnetic and electrical methods	Magnetic method	Determining cover of reinforcement in concrete

	Electrical methods(microwave absorption techniques)	Measure moisture content and thickness of concrete
Acoustic emission techniques	-	To study the initiation and growth of cracks in concrete
Surfaces hardness methods	William testing pistol, frank spring hammer and Einbeck pendulum hammer	Measuring the surface hardness

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ADMIXTURES (CHEMICAL, MINERAL)

Defined as materials, other than cement, water and aggregates, that is used as ingredient of concrete and is added to the batch immediately before or during mixing. Admixtures can be classified by function as follows:

- Air-entraining admixtures
- Water-reducing admixtures
- Plasticizers
- Accelerating admixtures
- Retarding admixtures
- Hydration-control admixtures
- Corrosion inhibitors
- Shrinkage reducers
- Alkali-silica reactivity inhibitors
- Coloring admixtures

- Miscellaneous admixtures such as workability, bonding, damp proofing, Permeability reducing, grouting, gas-forming, ant washout, foaming, and pumping admixtures

The major reasons for using admixtures are:

- To reduce the cost of concrete construction
- To achieve certain properties in concrete more effectively than by other means
- To maintain the quality of concrete during the stages of mixing, transporting, placing, and curing in adverse weather conditions
- To overcome certain emergencies during concreting operations

Construction chemicals

- Construction curing compounds
- Polymer bonding agents
- Polymer modified mortar for repair and maintenance
- Mould releasing agents
- Protective and decorative coatings
- Installation aids
- Floor hardeners and dust-proofers
- Non-shrink high strength grout
- Surface retarders
- Bond – aid for plastering
- Ready to use plaster
- Grunting aid

- Construction chemicals for water-proofing
  - Integral water-proofing compounds
  - Membrane forming coatings
  - Polymer modified mineral slurry coatings
  - Protective and decorative coatings
  - Chemical DPC
  - Silicon based water-repellent material
  - Waterproofing adhesive for tiles ,marble and granite
  - Injection grout for cracks
  - Joint sealants

Concrete and Environment

There is increasing concern now that the choice of construction materials must also be governed by ecological considerations.

General: Introduction

Choice of construction materials must also be governed by ecological considerations. At the beginning of the 20th Century, the world population was 1.5 billion; by the end of the 20th Century it had risen to 6 billion. Considering that it took 10,000 years - last ice age for the population to rise to the 1.5 billion mark, the rate of growth from 1.5 to 6 billion people is remarkable.

At the beginning of the 20th Century, approximately ten percent of the people lived in cities; in the year 2001 nearly three of the six billion inhabitants live in and around the cities. Unfortunately, our technology choices have turned out to be wasteful because decisions are based on short term and narrow goals of the enterprise rather than a holistic view of the full range of consequences from the use of a technology. Only 6% of the total global flow of materials, some 500 billion tons a year, actually ends up in consumer products whereas much of the virgin materials are being returned to the environment in the form of harmful solid, liquid, and gaseous wastes.

The greatest environmental challenge today is that of the human-made climate change due to global warming caused by steadily rising concentration of green-house gases in the earth's atmosphere during the past 100 years. In a nature-centered capitalism, the environment will no longer be treated as a minor factor of production but rather an envelope containing, provisioning, and sustaining the entire economy Ordinary concrete, typically, contains about 12 percent cement, 8 percent mixing water, and 80 percent aggregate by mass. This means that, in addition to 1.5 billion tonnes of cement, the concrete industry is consuming annually 9 billion tonnes of sand and rock together with one billion tonne of mixing water.

Challenge I:

Environmental Impact World demand/year

- 11.5 billion ton of concrete
- 1.5 billion ton of cement
- 1 billion ton of water

• 9 billion ton of aggregate

1.5 billion ton of cement - Generates 1.5 billion ton of CO_2 Responsible for 5% - CO_2 production in the world
1 billion ton of water - 110,000 times the amount of water in the SF Bay
9 billion ton/y of aggregate Depletion of natural resources

Challenge II:

Long-term durability Civil Infrastructure quickly deteriorating of the 597,340 bridges in this country, 73,784, or about 12.4 percent, are structurally deficient.
Major deterioration Corrosion of reinforced concrete

- Sulfate attack
- Alkali silica reaction
- Hot weather

Future Demand for Concrete:

The 11.5 billion tonnes-a-year concrete industry is thus the largest user of natural resources in the world. The demand for concrete is expected to grow to approximately 18 billion tons (16 billion tonnes) a year by 2050. The mining, processing, and transport of huge quantities of aggregate, in addition to billions of tons of raw materials needed for the cement manufacture, consume considerable energy and adversely affect the ecology of virgin lands. Both in developed and developing countries, gigantic construction projects are underway in the metropolitan areas not only for new construction but also for rehabilitation or replacement of existing structures. Reducing the Environmental Impact of Concrete Portland cement is a product of an industry that is not only energy-intensive but also responsible for large emissions of CO_2 -- a major green-house gas. The manufacture of one ton of Portland-cement clinker releases a ton of CO_2 into the atmosphere. The world's yearly cement output of 1.5 billion tonnes of mostly Portland cement, accounts for nearly 7 percent of the global CO_2 emissions. Industrial ecology the waste product of one industry is recycled as a substitute for virgin raw material of another industry, thereby reducing the environmental impact of both. Opportunities Over a billion tons of construction and demolition wastes are being disposed of in road-bases and landfills every year, in spite the fact that cost-effective technologies are available to recycle most of it as a partial replacement for coarse aggregate in concrete mixtures.

Most waste-waters and undrinkable natural waters can be substituted for municipal water for mixing concrete unless proven harmful by testing Blended Portland cements containing fly ash from coal-fired power plants and granulated slag from the blast-furnace iron industry provide excellent examples of industrial ecology because they offer a holistic solution to reduce the environmental impact of several industries. Technology for Green Concrete The high-volume fly ash provides a promising of how we can build concrete structures in the future that would be far more durable and resource-efficient than those made of conventional Portland-cement concrete. Whether as a component of blended cements or as a mineral admixture added to concrete during mixing, the fly ash content of HVFA concrete mixtures is typically between 50 to 60 percent by mass of the total cementitious material.

A Better Concrete in the Future Although as a structural material concrete generally has a history of satisfactory performance, it is expected that even a better product will be available in the future owing to overall improvements in elastic modulus, flexural strength, tensile strength, impact strength, and permeability. A reduction of the water content in a concrete mixture decreases the porosity of both the matrix and the interfacial transition zone and thus has a strengthening effect. Again, the presence of a pozzolan in a hydrating cement paste can lead to the processes of pore-size and grain-size refinement. Improved concrete (1) A better control of the bleeding tendency in concrete mixtures will be sought through proper aggregate grading, and the use of water-reducing and mineral admixtures (e.g., fly ash or finely ground natural pozzolans or slags). Improved concrete (2) Fiber reinforcement of concrete that is subject to cyclic or impact loads will be commonly practiced. For developing countries, the use of natural organic fibres (such as sisal fiber and rice straw) presents interesting possibilities. The use of centralized and high-speed concrete mixers instead of truck mixing will help in the production of more homogeneous concrete than is generally available today.

Environmental Benefits

Low CO_2 intensity - the production of concrete, which consists of 10% - 15% cement, results in emissions of about 0.13 tonne of CO_2 per tonne of concrete, equal to 1/9 the emissions of cement. Concrete manufacturing results in less CO_2 per unit than almost all other construction materials, making it the sustainable construction material of choice.

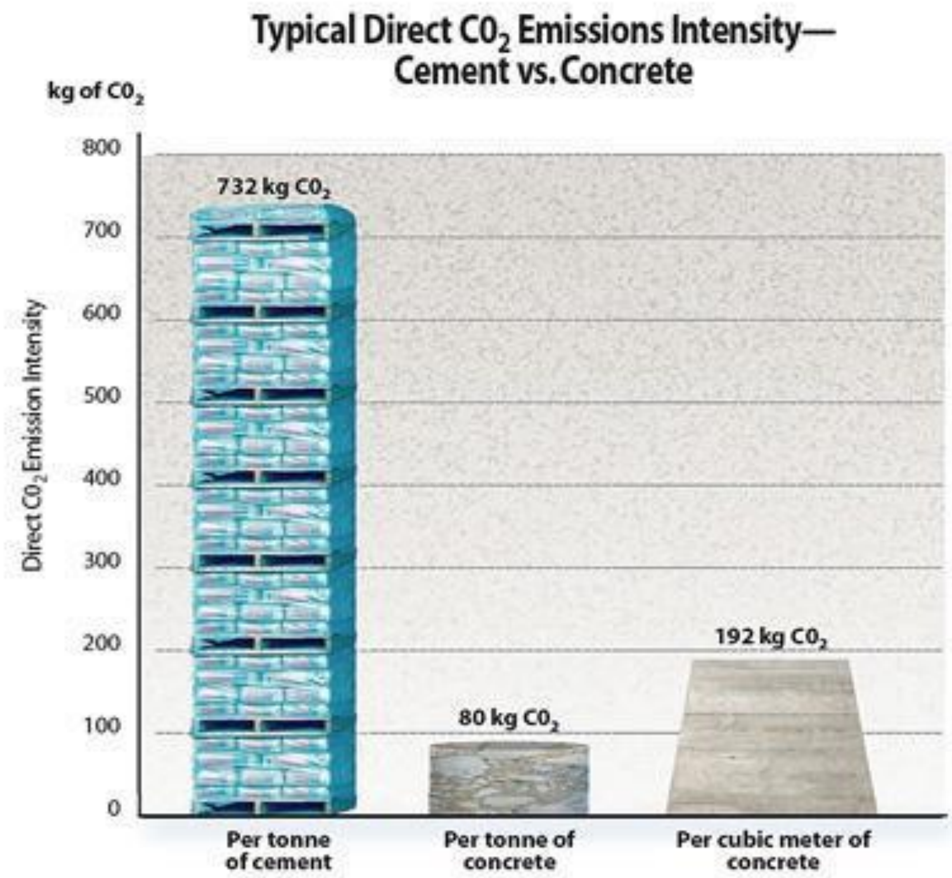

FIG. 3 EMISSION INTERSITY

- Resource efficient - the ingredients for concrete - sand, gravel and limestone - are abundant worldwide. Quarries are readily reclaimed for recreation, residential or commercial development. They can also be restored to their natural state.

- Local resource - because the ingredients of concrete exist almost everywhere, concrete can be manufactured near a job site, requiring minimal energy for transportation. At least 60% of all concrete is made within 160 km of the job site. Wood and steel products, on the other hand, typically travel hundreds or even thousands of kilometers.

- Less construction waste - as concrete is manufactured to specifications, only the product that is required is delivered to the site. This means that less material is sent to landfill upon project completion.

- Reusable - many concrete products can be reused, such as concrete pavers and precast wall panels. Concrete sidewalk slabs are reused to build "dry stone" retaining walls. A well designed concrete building with long floor spans and column-free space is adaptable to a succession of different occupants.

- Recycling medium - Concrete makes waste products useful. Concrete is ideal as a medium for the inclusion of recycling waste or industrial byproducts such as blast-furnace slag (from steel making) and fly ash (from coal-burning electric plants). About a third of the fly ash produced annually in the U.S. is used in concrete. Use of such industrial by-products as Supplementary Cementing Materials (SCMs) to replace some of the cement in concrete mixtures also improves product performance for specific applications.

- New life for old concrete - Used concrete can be 100% recycled as aggregate for use in roadbeds or as a granular material. Concrete yields 45% to 80% coarse aggregate usable for new concrete mixtures. The rest can be crushed and re-used as base material for roadbeds, parking lots or other applications.

- Replenishes aquifers - Pervious concrete pavement and permeable interlocking concrete pavers can be used to reduce storm water runoff and allow water to return to the water table.

QUESTIONS

Part A (2 Marks)

1. List the ingredients of concrete.
2. What are the manufacturing processes?
3. List out the properties of fresh concrete.
4. Define slump.
5. List out properties of hardened concrete.
6. What is the concrete mix proportioning?
7. What is meant by water cement ratio?
8. List the admixtures of concrete.
9. Write the types of admixtures.

Part B (12 Marks)

1. Briefly discuss the properties of fresh concrete
2. Explain the following details. Compressive strength, Tensile strength, Shear strength
3. Briefly explain the testing of concrete.

4. Explain the proportioning of concrete
5. Explain the quality control (sampling and in acceptance etc.,) and elements of plan in detail.
6. What are the measures taken during transportation and placing of concrete.
7. Briefly explain concrete and environment and list the environmental benefits of green concrete.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – IV– TIMBER AND MODERN MATERIALS SCIA1102

Timber - Market forms - Industrial timber - Doors and Windows – specification - Plywood - Veneer - False ceiling materials - Panels of laminates - Steel - Aluminum and Other Metallic Materials - Composition - Aluminium composite panel - Uses - Market forms - Mechanical treatment. Glass - Ceramics - Sealants for joints - Fibre glass reinforced plastic.

TIMBER

TIMBER

(Denotes wood which is suitable for building or carpentry or various other engineering purposes and it is applied to the trees measuring not less than 600mm in girth or circumference of the trunk)

Converted timber	rough timber	standing timber
(Timber which is sawn and cut into Suitable commercial sizes)	(timber which is obtained after felling a tree)	(timber contained in a living tree)

FIG.1 CLASSIFICATION OF TIMBER

The conversion of timber is a phrase usually used in reference to turning a log into a pile of boards/planks. This is done using a saw mill of some kind. There are several things that need to be taken into account when sawing up a log. Standing timber means the current value of trees that have been planted which will yield saleable timber when felled at maturity, usually forestry trees. The Inland Revenue accepts that fruit trees do not generate saleable timber

FIG.2 CONVERTED TIMBER

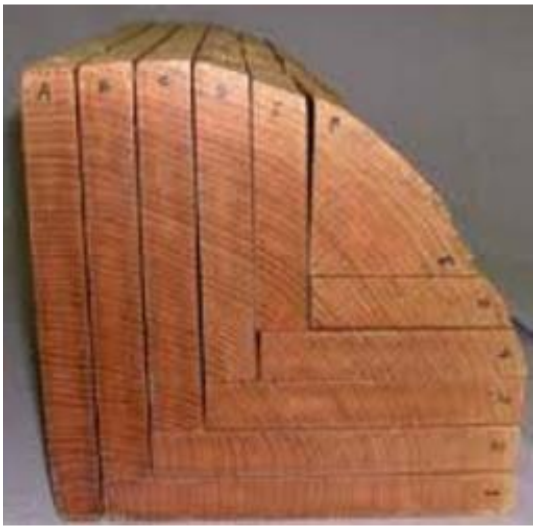

FIG.3 CONVERTED TIMBER (2)

FIG.4 ROUGH TIMBER

FIG.5 STANDING TIMBER

Processing of timber

- Felling of trees
  - Age of trees for felling
  - Method of felling
  - Season for felling
- Seasoning of timber
  - Meaning of seasoning

    (The water is to be removed before the timber can be used for any engineering purpose.)
  - Free moisture and bound moisture

    (Moisture in the timber can be either in the cell cavities or in the cell walls. The former is known as the free moisture or free water and major part of moisture in timber is present as free water. The latter is known as the bound moisture and it is closely associated with the body of timber.)
  - Determination of moisture content

    $P = ((W_1 – W_2) /W_2)) \times 100$ where P – percentage of moisture,

W_1 – original weight of timber, W_2 oven – dry weight of timber.(drived in an oven at a temperature of 103 °C ± 2 °C)

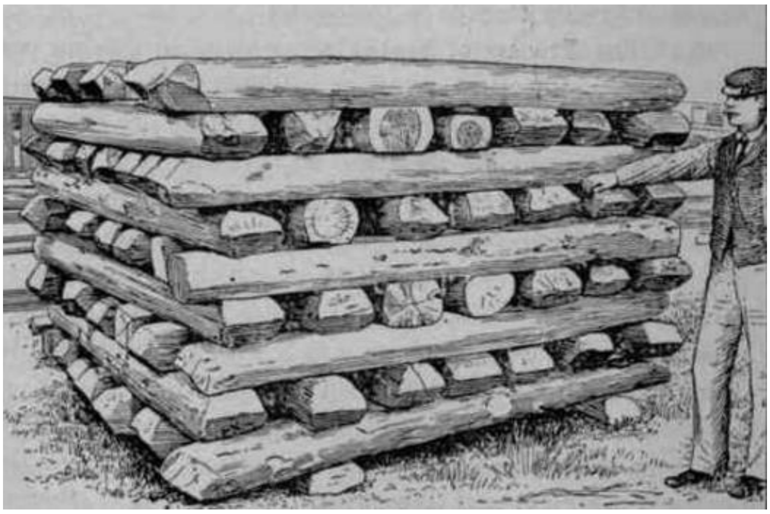

FIG.6 SEASONING OF TIMBER

FIG.7 SEASONING OF TIMBER

- Objects of seasoning

To allow timber to burn readily, if used as fuel

- To impart hardness, stiffness, strength and better electrical resistance to timber.
- To increase resisting power of the timber

- To maintain shape and size of the components of timber To make timber easily workable
- To make fit for receiving treatment of paints, preservatives, varnishes, etc. To make timber safe form of fungi and insects.

- Method of seasoning

Natural seasoning and artificial seasoning(various methods- boiling , chemical seasoning, kiln seasoning, electrical seasoning, and water seasoning.

  - Comparison between natural seasoning and artificial seasoning

- Conversion of timber

  - Process by which timber is cut and sawn into suitable sections is known as the conversion. (power machines may be employed at different stages of process.)

FIG. 8CONVERSION OF TIMBER

- Preservation of timber

  - Object of preservation of timber

To increase the life of timber structures

To make the timber structures durable

To protect the timber structures form the attack of destroying agencies such as fungi, insects , etc.

Requirements of a good preservative

- Should be capable of covering a large area with small quantity
- Should be cheap and easily available
- Should be durable
- Should be non-inflammable
- Should be quite efficient in killing fungi, insects, etc.
- Should be safe and harmless for persons and animals
- Should offer high resistance to the moisture and dampness.

Types of preservatives

- Ascu treatment
- Chemical salts
- Coal tar
- Creosote oil
- Oil paints
- Solignum paints

Methods of preservation of timber

- Brushing
- Charring
- Dipping and steeping
- Hot and cold open tank treatment
- Injecting under pressure
- Spraying

FIG.9 OIL PAINTS, BRUSHING

Qualities of good timber

In general, the quality of timber depends on the following factors:

- Environmental conditions of the locality
- Maturity of the tree
- Method of seasoning
- Nature of the soil
- Process of preservation
- Time of felling.

Following are the characteristics or quality of a good timber

- Appearance:
- Colour
- Defects
- Durability
- Elasticity
- Fibres
- Fire- resistance

- Hardness
- Mechanical wear
- Shape
- Smell
- Sound
- Strength
- Structure
- Toughness
- Water permeability
- Weathering effects
- Weights
- Working conditions

Factors affecting the strength of timber

- Abnormalities of growth
- Faults in seasoning
- Invasion of insects
- Irregularities of grain
- Moisture content
- Presence of knots, shakes, etc.
- Way in which a timber piece is cut from the log, etc.

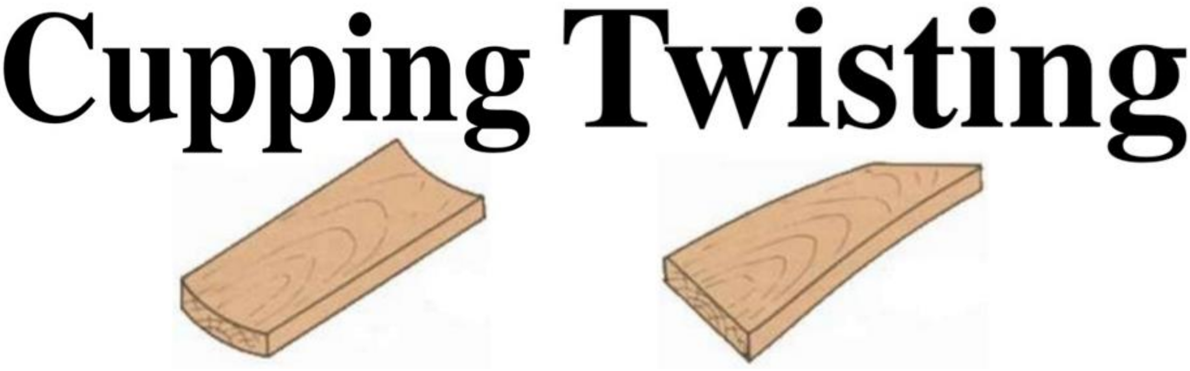

FIG.10 CUPPING AND TWISTING OF WOOD

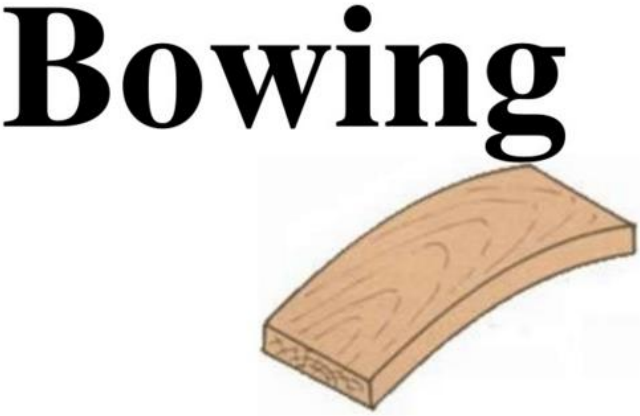

FIG.11 BOWING OF WOOD BY FAULT SEASONING

FIG.12 INVASION OF INSECTS

FIG.13 IRREGULARITIES OF GRAIN ON WOOD SURFACE

FIG.14 PRESENCE OF KNOTS

MARKET FORMS OF WOOD

Various types of market forms of timber

Batten - timber piece whose breadth and thickness do not exceed 50mm

Baulk - roughly squared timber piece and it is obtained by removing bark and sap wood. Cross-sectional dimension exceeds 50mm.

Board - timber piece with parallel sides and thickness is 50mm to 100mm and its width does not exceed 230mm

Deal	-	piece of soft wood with parallel sides and thickness varies from 50mm to 100mm and its width does not exceed 230mm.
End	-	short piece of batten, deal, scantling etc.,
Log	-	trunk of tree obtained after removal of branches
Plank	-	timber piece with parallel sides and thickness is less than 50mm and its width exceeds
Pole	-	it is a sound long log of wood and its diameter does not exceed 200mm and it is also known as a spar
Quartering	-	square piece of timber and the length of side being 50 mm to 150mm.
Scantling	-	timber piece whose breadth and thickness exceed 50mm but are less than 200mm in length (pieces of miscellaneous sizes of timber sawn out of a log.

DOORS AND WINDOWS

General:

- Wood has a proven durability as an appropriate material for windows and doors, particularly in harsh climates
- Wood is 100% renewable
- offers long term value
- Timber has an elegant appearance and feel, with unquestionable thermal performance, required for today‘s tough construction

regulations.

- Timber is the only naturally renewable material for windows
- The total amount of energy used to make a timber windows and doors is 20% of the energy required to make a (PVC) plastic window.
- The timber used in our products is responsible sourced from well managed forests. For every tree felled, two others are planted. This environmentally responsible approach to forestry ensures that timber resources are sustainable.
- Our Timber windows & doors use less energy to manufacture than those made from any other material, therefore reducing carbon emissions to the atmosphere.
- Our double and triple glazed windows and doors provide good energy efficiency, so will continue to save carbon emissions throughout their long life.
- Very few window materials compare to timber in terms of character, style and versatility.
- As a natural product, it brings warmth, good looks and added value to any property. Couple his with high quality glazing and factory applied modern decorating techniques, and your timber windows will provide you with long lasting high performance for years to come.

Timber windows & doors use less energy to manufacture than those made from any other material, therefore reducing carbon emissions to the atmosphere

Timber door and window frames shall be installed either by ‗ built-in method ‘ or ‗prepared opening method ‘

The thickness selected for door shutters shall be not less than 40 mm for permanent installations.

The thickness may be reduced for temporary installations. These, however, would require additional care in maintenance.

For aesthetic and decorative purposes in high class buildings, decorative type of door shutters may be used.

The most commonly used decorative surface timber is teak. These require polishing and waxing as against painting required for commercial door shutters.

Types of doors:

- Timber/wood doors
- Battened and ledged doors
- Framed and paneled doors
- Flush doors
- Glass doors
- Steel doors
- PVC doors
- Fiberglass doors
- Fiber reinforced plastics doors
- Aluminum doors
- Bamboo-jute composite doors

INDUSTRIAL TIMBER

The timber which is prepared scientifically in a factory is termed as the industrial timber and such timber possesses desired shspe, appearance, stength, etc.

Following are the few varieties of industrial timber:

- Veneers
- Plywoods
- Fibreboards

- Impreg timbers
- Compreg timbers
- Block board and lamin board
- Glulam
- Flushdoor shutters
- Particle board (or) chip board
- hardboard

PLYWOOD

Plywood - sheet material manufactured from thin layers or "plies" of wood veneer that are glued together with adjacent layers having their wood grain rotated up to 90 degrees to one another.

It is an engineered wood from the family of manufactured boards which includes medium-density fiberboard (MDF) and particle board (chipboard).

All plywood‘s bind resin and wood fiber sheets (cellulose cells are long, strong and thin) to form a composite material. This alternation of the grain is called cross-graining several important benefits:

- it reduces the tendency of wood to split when nailed at the edges; o it reduces expansion and shrinkage,
- providing improved dimensional stability;
- it makes the strength of the panel consistent across all directions. There are usually an odd number of plies, so that the sheet is balanced—this reduces warping.

Different varieties of plywood exist for different applications:

- Softwood plywood Hardwood plywood
- Tropical plywood
- Aircraft plywood
- Decorative plywood (overlaid plywood)
- Flexible plywood
- Marine plywood
- Other plywood's

Grades

Grading rules differ according to the country of origin. Most popular standard is the British Standard (BS) and American Standard (ASTM). Joyce (1970), however, lists some general indication of grading rules:

Grade Description

A - Face and back veneers practically free from all defects.

A/B - Face veneers practically free from all defects. Reverse veneers with only a few small

knots or discolorations.

A/BB - Face as A but reverse side permitting jointed veneers, large knots, plugs, etc.

B - Both side veneers with only a few small knots or discolorations.

B/BB - Face veneers with only a few small knots or discolorations. Reverse side permitting jointed veneers, large knots, plugs, etc

BB - Both sides permitting jointed veneers, large knots, plugs, etc.

WG - Guaranteed well glued only. All broken knots plugged.

X - Knots, knotholes, cracks, and all other defects permitted.

JPIC Standards

Grade Description

BB/CC -Face as BB, back as CC. BB as very little knots of less than 1/4 inches, slight discoloration, no decay, split and wormholes mended skillfully, matched colors, no blister, no wrinkle. Most popular choice for most applications.

Applications

Plywood is used in many applications that need high-quality, high-strength sheet material. Quality in this context means resistance to cracking, breaking, and shrinkage, twisting and warping.

Exterior glued plywood

It is suitable for outdoor use, but because moisture affects the strength of wood, optimal performance is achieved in end uses where the wood's moisture content remains relatively low. On the other hand, subzero conditions don't affect plywood's dimensional or strength properties, which makes some special applications possible.

Plywood

It is used as an engineering material for stressed-skin applications.

used for marine and aviation applications

used for the hulls in the hard-chine Motor Torpedo Boats (MTB) and Motor Gun Boats (MGB) built by the British Power Boat Company and Vosper's.

currently successfully used in stressed-skin applications

often used to create curved surfaces because it can easily bend with the grain.

Skateboard ramps often utilize plywood as the top smooth surface over bent curves to create transition that can simulate the shapes of ocean waves.

Softwood plywood applications

Typical end uses of spruce plywood are:

- Floors, walls and roofs in home constructions
- Wind bracing panels

- Vehicle internal body work
- Packages and boxes
- Fencing

There are coating solutions available that mask the prominent grain structure of spruce plywood. For this coated plywood there are some end uses where reasonable strength is needed but the lightness of spruce is a benefit e.g.:

- Concrete shuttering panels
- Ready-to-paint surfaces for constructions

Hardwood plywood applications

Phenolic resin film coated (Film Faced) plywood is typically used as a ready-to-install component e.g.:

- Panels in concrete form work systems
- Floors, walls and roofs in transport vehicles
- Container floors
- Floors subjected to heavy wear in various buildings and factories
- Scaffolding materials

Birch plywood is used as a structural material in special applications e.g.:

- ind turbine blades
- Insulation boxes for liquefied natural gas (LNG) carriers

Smooth surface and accurate thickness combined with the durability of the material makes birch plywood a favorable material for many special end uses e.g.:

- High-end loud speakers
- Die-cutting boards

- supporting structure for parquet
- Playground equipment
- Furniture
- Signs and fences for demanding outdoor advertising
- Musical instruments
- Sports equipment

FIG.15 MARINE PLYWOOD

FIG.16 AIRCRAFT PLYWOOD

FIG.17 FLUSH DOORS

FIG.18 GLASS DOORS

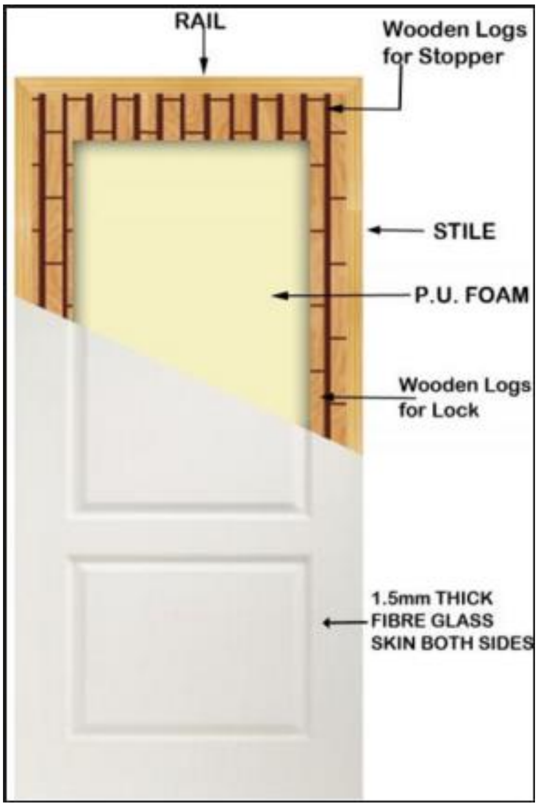

FIG.19 FIBER REINFORCED PLASTICS DOORS

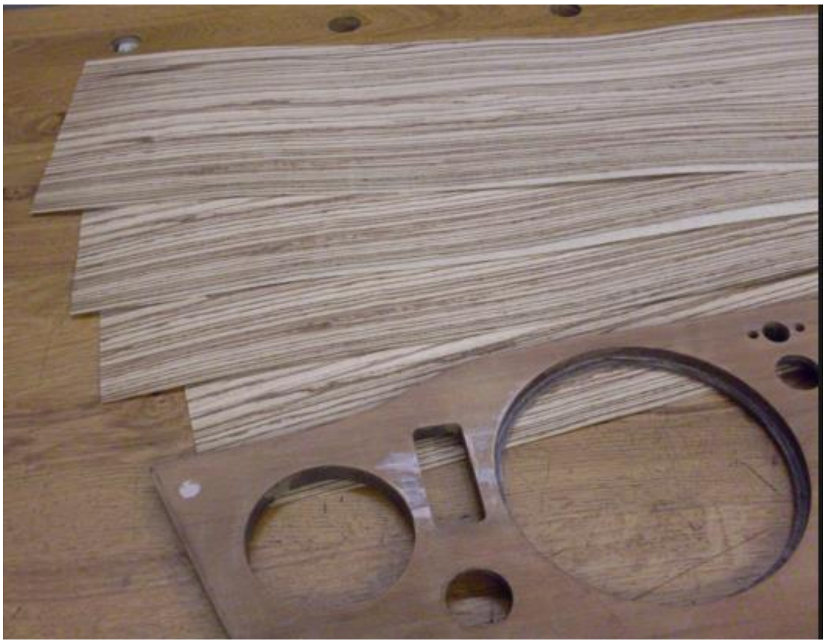

FIG.20 VENEERS

FIG.21 FIBREBOARDS

FIG.22 GLULAM BEAMS

Tropical plywood applications

Tropical plywood is widely available from the South-East Asia region, mainly from Malaysia and Indonesia. Tropical plywood boasts premium quality, and strength. Depending on machinery, tropical plywood can be made with high accuracy in thickness, and is a highly preferable choice in America, Japan, Middle East, Korea, and other regions around the world.

- Common plywood
- Concrete panel
- Floor base
- Structure panel
- Container flooring
- Lamin board
- Laminated veneer lumber (LVL)

VENEER

- In woodworking, veneer refers to thin slices of wood, usually thinner than 3 mm (1/8 inch), that typically are glued onto core panels (typically, wood, particle board or medium-density fiberboard) to produce flat panels such as doors, tops and panels for cabinets, parquet floors and parts of furniture.
- They are also used in marquetry. Plywood consists of three or more layers of veneer, each glued with its grain at right angles to adjacent layers for strength.
- Veneer beading is a thin layer of decorative edging placed around objects, such as jewelry boxes.
- Veneer is also used to replace decorative papers in Wood Veneer HPL. Veneer is also a type of manufactured board.
- Veneer is obtained either by "peeling" the trunk of a tree or by slicing large rectangular blocks of wood known as flitches.
- The appearance of the grain and figure in wood comes from slicing through the growth rings of a tree and depends upon the angle at which the wood is sliced.

Three main types of veneer-making equipment used commercially:

- A rotary lathe in which the wood is turned against a very sharp blade and peeled off in one continuous or semi-continuous roll. Rotary-cut veneer is mainly used for plywood, as the appearance is not desirable because the veneer is cut concentric to the growth rings.
- A slicing machine in which the flitch or piece of log is raised and lowered against the blade and slices of the log are made. This yields veneer that looks like sawn pieces of wood, cut across the growth rings; such veneer is referred to as "crown cut".
- A half-round lathe in which the log or piece of log can be turned and moved in such a way as to expose the most interesting parts of the grain.

Types of veneers

Few types of veneers available, each serving a particular purpose.

Raw veneer has no backing on it and can be used with either side facing up. It is important to note that the two sides will appear different when a finish has been applied, due to the cell structure of the wood.

Paper backed veneer is as the name suggests veneers that are backed with paper. The advantage to this is it is available in large sizes, or sheets, as smaller pieces are joined together prior to adding the backing. This is helpful for users that do not wish to join smaller pieces of raw veneers together. This is also helpful when veneering curves and columns as the veneer is less likely to crack.

Phenolic backed veneer is less common and is used for composite, or manmade wood veneers. Due to concern for the natural resource, this is becoming more popular. It too has the advantage of being available in sheets, and is also less likely to crack when being used on curves.

Laid up veneer is raw veneer that has been joined together to make larger pieces. The process is time-consuming and requires great care, but is not difficult and requires no expensive tools or machinery. Veneers can be ordered through some companies already laid up to any size, shape or design.

Reconstituted veneer is made from fast-growing tropical species. Raw veneer is cut from a log, and dyed if necessary. Once dyed, the sheets are laminated together to form a block. The block is then sliced so that the edges of the laminated veneer become the ―grain‖ of the reconstituted veneer.

Wood on Wood Also called 2-ply is a decorative wood veneer face with a utility grade wood backer applied at an opposing direction to the face veneer.

Advantages of using veneers

Furniture made with wood veneer uses less wood than the same piece of furniture made with solid wood.

Some projects built using wood veneer would not be possible to construct using solid lumber, owing to expansion and contraction caused by fluctuation of temperature and humidity.

Thermocol

Thermocol is a light and cellular plastic material used for sound and heat insulation of ceiling, walls, and refrigerators and for air conditioning of the buildings. It is soft, light, strong and durable having compressive strength in the range of 11.7 N/mm2 to 14.4 N/mm2. It has excellent heat, sound and electric insulating properties.

FALSE CEILING MATERIALS

- Plaster of Paris (POP)
- Gypsum oard
- Mineral fibre
- Metal ceiling

Natural panels

Extensively used material in false ceiling

Raw materials – wood fibers and magnesite gives off white color to fibrecrete natural panels.

Standard size – 2m x 1/2m, 1.22m x 0.61m

Thickness in mm – 6,13,15,20,25,40,50,75,100,150.

Density in kg/Cum – 400, 450, 600, 800

Cement finish panels

Extensively been used for roof insulation in all kinds of buildings external cabins such as Time offices, security offices telephone booths

Our cement finish panels are cost effective and highly durable in nature.

PANELS OF LAMINATES

Laminate panel is a type of manufactured timber made from thin sheets of substrates or wood veneer.

It is similar to the more widely used plywood, except that it has a plastic, protective layer on one or both sides.

Laminate panels are used instead of plywood because of their,

- Resistance to impact
- Weather
- Moisture
- Shattering in cold (ductility),
- And chemicals.

Laminate panel layers (called veneers) are glued together with adjacent plies having their grain at right angles to each other for greater strength.

The plastic layer(s) added for protection vary in composition, thickness, color and texture according to the application.

Types

A number of varieties of laminate panel exist for different applications.

- Plywood + ABS laminate panels
- Plywood + FRP laminate panels
- Plywood + aluminum laminated panels
- Lightweight composite panels

Sizes

Most commonly used thickness range from 1/8" to 1/2" and 3/8", in a variety of colours and textures.

Applications

- Weather-proof,
- Impact resistant sheet material.

Typical end uses of spruce plywood are:

- Floors, walls and roofs in clean rooms
- Vehicle internal body work
- Packages and boxes
- Road cases

STEEL

Steel is the most suitable building material among metallic materials.

This is due to a wide range and combination of physical and mechanical properties that steels can have.

FIG.23 FORMS OF STEEL

By suitably controlling the carbon content, alloying elements and heat treatment, a desired combination of hardness, ductility, and strength can be obtained in steel.

On the basis of carbon content steel may be classified as under:

Type of steel	Carbon content (%)	Uses
Mild steel	upto 0.10%	Motor body, sheet metal tin plate, etc.
Medium carbon steel	upto 0.25%	Boiler plates, structural steel, etc.
	upto 0.45%	Rails, tires, etc.
	upto 0.60%	Hammers, large stamping and pressing dies, etc.
High carbon steel	upto 0.75%	Sledge hammers, springs, stampling dies, etc.
or hard steel	upto 0.90%	Miner‘s drills, smith‘s tools, stone manson‘s tools, etc.
	upto 1.00%	Chisels, hammers, saws, wood working tools, etc.

	upto 1.10%	Axes, cutlery, drills, knives, picks, punches, etc.

Properties and Uses

Mild Steel (low carbon or soft steel).

It is ductile, malleable; tougher and more elastic than wrought iron.

Mild steel can be forged and welded, difficult to temper and harden.

It rusts quickly and can be permanently magnetized.

properties are:

Specific gravity	- 7.30,	
Ultimate compressive	- 800–1200	N/mm 2
Tensile strengths	- 600– 800	N/mm 2.

Mild steel is used in the form of rolled sections, reinforcing bars, roof coverings and sheet piles and in railway tracks.

High Carbon Steel: (hard steel)

Carbon content in high carbon steel varies from 0.55 to 1.50%. It is tougher and more elastic than mild steel.

It can be forged and welded with difficulty.

Properties are:

Specific gravity - 7.90.

Ultimate compressive - 1350 N/mm2

Tensile strengths - 1400–2000 N/mm2

High carbon steel is used for reinforcing cement concrete and prestressed concrete members. It can take shocks and vibrations and is used for making tools and machine parts.

High Tensile steel: (high strength steel)

The carbon content in high tensile steel is 0.6–0.8%, manganese 0.6%, silicon 0.2%, sulphur 0.05% and phosphorus 0.05%.

Properties are:

Ultimate tensile strength - 2000

N/mm2 Minimum elongation -

10 percent .High

Tensile steel is used in prestressed concrete construction.

Manufacturing Methods

The prominent steel-making processes are:

- Bessemer process
- Cementation process
- Crucible process
- Open Hearth process
- Electric Smelting process
- Duplex process
- Lintz and Donawitz (L.D.) process

The most prominent present-day steel-making process is the Bessemer process was introduced in 1856. The pig iron is first melted in Cupola furnace and sent to Bessemer converter (Fig.) Blast of hot air is given to oxidize the carbon. Depending upon the requirement, some carbon and manganese is added to the converter and hot air is blasted once again. Then the molten material is poured into moulds to form ingots. L.D. process is Fig. Bessemer converter for the Manufacture of Steel modification of the Bessemer process in which there in no control over temperature. By this method steel can be made in hardly 25 minutes. In Open-hearth process also known as Siemen‘s-Martin process, the steel produced is more homogeneous than by Bessemer‘s. The electric process is costly but no ash or smoke is produced. The Crucible process involves melting of blister steel or bars of wrought iron in fire clay crucibles. Cast steel so obtained is very hard and is used for making surgical equipments. The Duplex process is a combination of Acid Bessemer process and Basic Open Hearth process

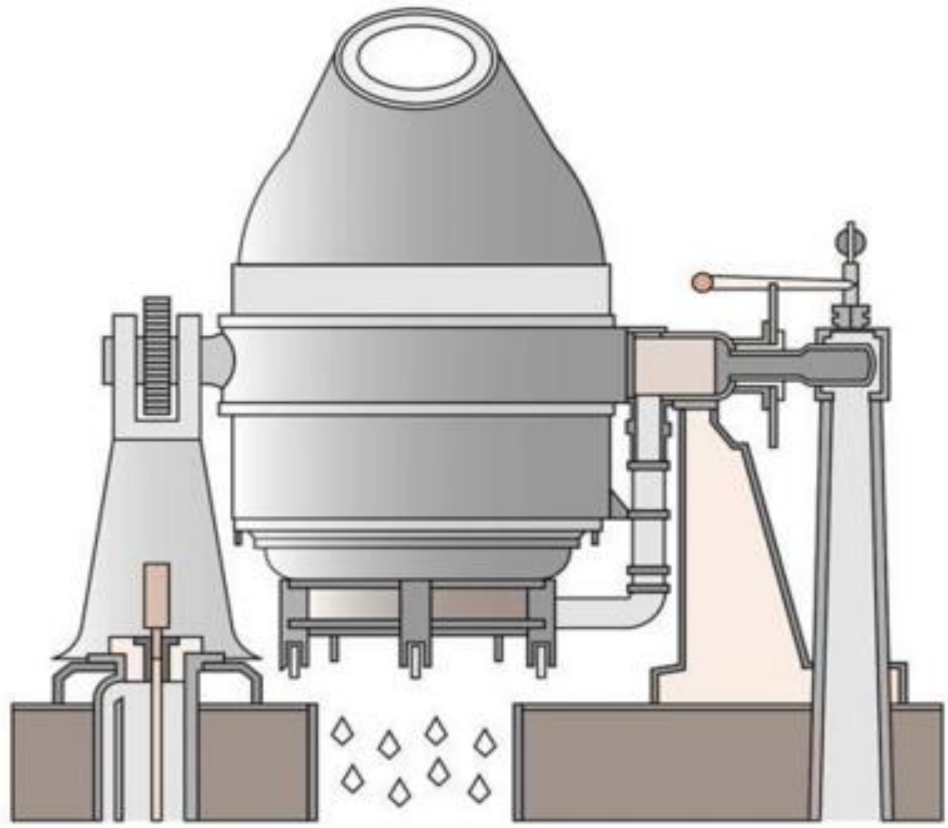

FIG. 24 BESSEMER PROCESS OF STEEL MANUFACTURING

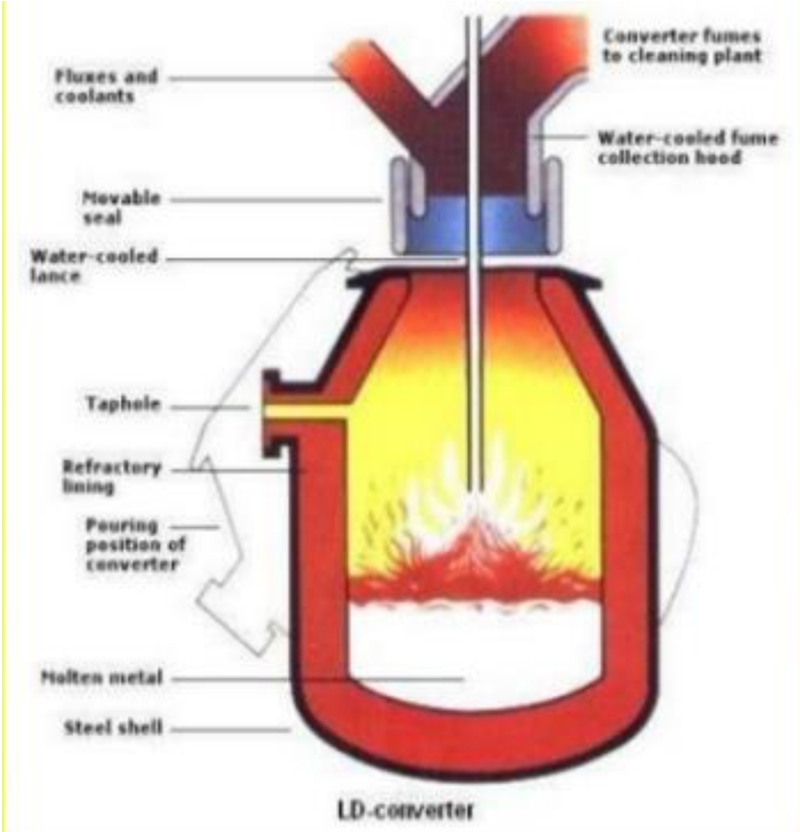

FIG.25 LD CONVERTOR

ALUMINIUM COMPOSITE PANEL

Aluminium composite panel (**ACP**) also **aluminium composite material**, (**ACM**) is a type of flat panel that consists of two thin aluminium sheets bonded to a nonaluminum core.

ACPs are frequently used for external cladding or facades of buildings, insulation.

ACPs are produced in a wide range of metallic and non-metallic colours as well as patterns that imitate other materials, such as wood or marble.

USES

Applications

ACP is mainly used for external and internal architectural cladding or partitions, false ceilings, signage, machine coverings, container construction etc.

Applications of ACP are not limited to external building cladding, but can also be used in any form of cladding such as partitions, false ceilings etc.

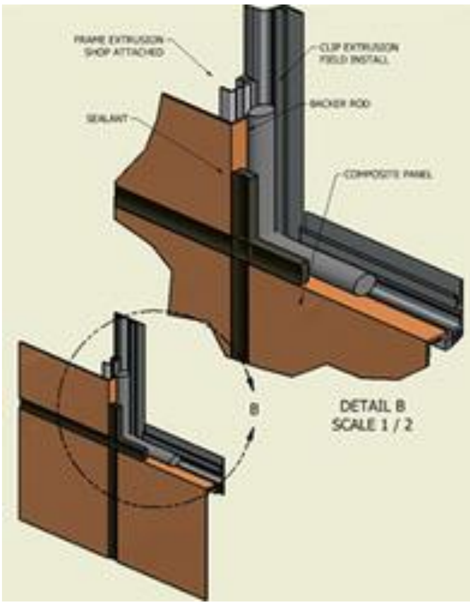

FIG.26 ALUMINIUM COMPOSITE PANEL

ACP is also widely used within the signage industry as an alternative to heavier, more expensive substrates.

Epcot's Spaceship Earth is an example of the use of ACP in architecture.

ACP has been used as a light-weight but very sturdy material in construction, particularly for transient structures like trade show booths and similar temporary elements.

ACP material has been used in famous structures as Spaceship Earth, VanDusen Botanical Garden, and the Leipzig branch of the German National Library.

MECHANICAL TREATMENT

Mechanical treatment of steel

Purpose – to give desired shape to the ingots so as to make steel available in market forms.

Treatment may be hot working (very common) or cold working

Operation involved in the mechanical treatment of steel

- Drawing

- Forging
- Pressing
- Rolling

Drawing:

This operation carried out

- To reduce the cross – section
- To increase the length proportionately.

In this operation the metal is drawn through dies or specially shaped tools. The drawing is continued till wire of required diameter or cross- section is obtained Process is used to prepare wires and rods

Forging:

- Operation carried out by repeated blows under a power hammer or a press.
- The metal is heated above the critical temperature range.
- It is then placed on anvil and subjected to blows of a hammer.
- This process increase the density and improves grain size of metal.
- The riveting belongs to forging the density and improves grain size of metal.
- The riveting belongs to forging operations.

Process is used for the manufacture of bolts, cramps, etc.

Pressing:

This is slow process and it is carried out in equipment known as the press. Main advantage – does not involve any shock.

Useful – when a large number of similar engineering articles are to be produced.

- A press consists mainly of a die and a punch.
- The metal is thus pressed between die and punch and article of desired

shape is obtained.

- For preparing articles with wide changes of shape, the pressing is to be carried out in different stages.

Rolling :

- This operation is carried out in specially prepared rolling mills.
- The ingots, while still red hot, are passed in succession through different rollers until articles of desired shape are obtained.
- The various shapes such as angles, channels, flats, joists, rails, etc. are obtained by the process of rolling.
- It is possible to prepare joint less pipe with the help of this process.
- The solid rod is bored by rollers in stages until the pipe of required diameter and thickness is obtained

GLASS

- Amorphous substance having homogeneous texture.
- Hard, brittle, transparent or translucent material.
- Common material glazed into frames for doors, windows and curtain walls.
- Common types used in building construction are sheet, plate, laminated, insulating, tempered, wired and patterned glass.
- Most ordinary colourless glasses are alkali-lime silicate and alkali-lead silicate with tensile and compressive strengths of about 30–60 N/mm2 and 700–1000N/mm2, respectively and modulus of elasticity in the range 0.45 × 105 to 0.8 × 105 N/mm2.
- The strength is very much afftected by internal defects, cords and foreign intrusions.
- The main shortcoming of glass is its brittleness which depends on a number of factors, the chief one being the ratio of the modulus of

elasticity of the material to its tensile strength.

Constituents

The raw materials used in manufacturing glass are sand, lime (chalks) and soda or potash which is fused over 1000° C. Oxides of iron, lead and borax are added to modify hardness, brilliance and colour.

Functions of the various ingredients are as follows.

Silica is used in the form of pure quartz, crushed sandstone and pulverised flint; should be free from iron contents for best quality glass.

Since it melts at very high temperatures (1710° C) carbonates of sodium or potassium are added to lower down the fusing temperature to about 800° C.

These also make liquid silica more viscous and workable.

Lime is used in the form of limestone, chalk or pure marble and sometimes marl.

The addition of lime makes the glass fluid and suitable for blowing, drawing, rolling, pressing or spinning.

It also imparts durability and toughness to glass.

Excess of lime makes the molten mass too thin for fabrication. Soda acts as an accelerator for the fusion of glass and an excess of it is harmful.

Potash renders glass infusible and makes glass fire resistant.

Lead Oxide imparts colour, brightness and shine.

When 15–30% of it added to substitute lime it lowers the melting point, imparts good workability, while its transparency is lost with the glass becoming brittle and crystalline.

Cullets are broken glasses added to act as a flux to prevent loss of alkali by volatisation during the process of forming glass and also to lower the fusion temperature. However, flux may reduce the resistance of glass to chemical attack, render it water- soluble or make it subject to partial or complete devitrification (crystallisation) on cooling. These crystalline areas are extremely weak and brittle. Stabilizers are added to overcome these defects.

Titanic acid, oxides of Nickel and Cobalt are used for chromatic neutralisation.

Note: Iron is not desirable as a constituent. However, when present it imparts a bottle green colour to the glass. To overcome this manganese dioxide known as glass maker‘s soap is added which washes the liquid glass and removes the colour.

CLASSIFICATION

Depending upon the constituents glasses

- Soda-lime glass,
- Lead glass
- Boro-silicate glass

Commercial Forms

- Sheet Glass
- Plate Glass
- Tempered Glass
- Wired Glass
- Obscured Glass
- Laminated Glass
- Heat absorbing Glass
- Ground Glass
- Block Glass
- Coloured Glass
- Opal Glass
- Optical Glass
- Enamel Glass

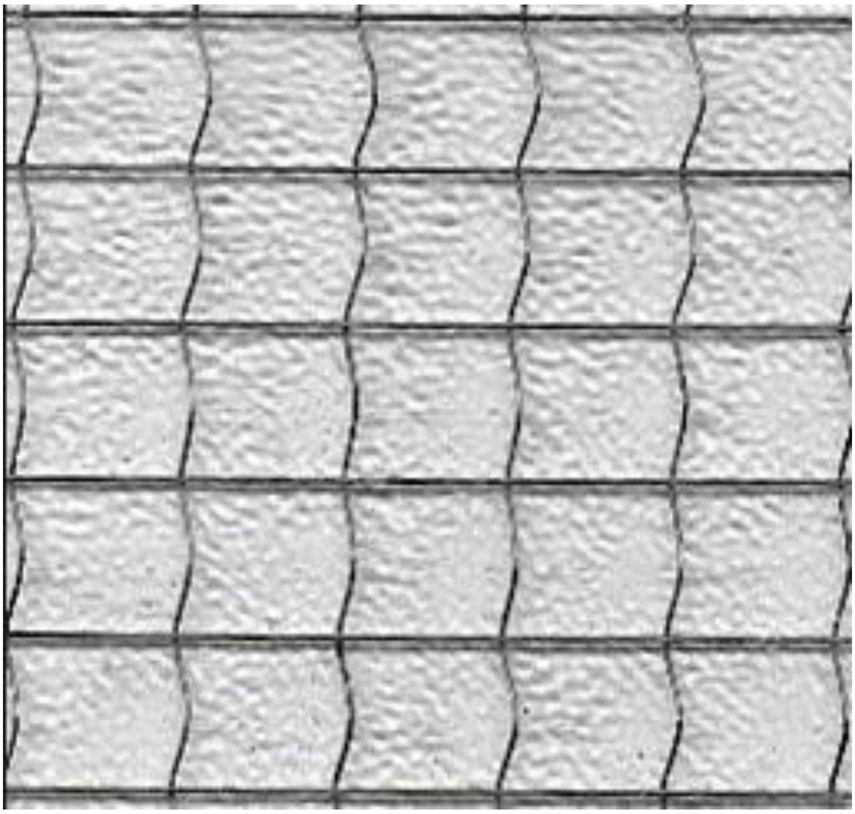

FIG.27 WIRED GLASS

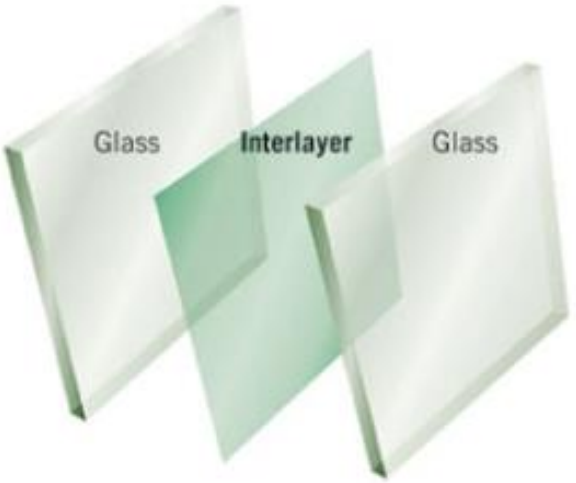

FIG.28 LAMINATED GLASS

FIG.29 ENAMEL GLASS

Depending upon the constituents glasses

Soda-lime Glass (soda-ash glass, soda glass or soft glass)

- Soda-lime glass is obtained by fusing a mixture of silica, lime and soda.
- The quality of this glass can be improved by adding alumina and magnesium oxide and the glass is then called crown glass.
- This is the most common type of glass used in doors, windows and for making glass-wares such as bottles.

Lead Glass (flint glass)

- Obtained by fusing a mixture of silica, lead and potash.
- It is free from iron impurities and is colourless.
- Lead glass has high shining appearance and can take polish.
- It is not affected by temperature.
- Electric bulbs, optical glasses, cut glass, ornamental glass works and radio valves are some of the articles made from it.

Boro-silicate Glass

- Obtained by fusing a mixture of silica, borax, lime and felspar.

- The examples are pyrex glass and heat resisting glass.
- Boro-silicate glass can withstand high temperatures and is most suitable for making laboratory equipments and cooking utensils.

Commercial Forms

Sheet Glass - used for glazing doors, windows and partitions and is obtained by blowing the molten glass into the shape of a cylinder. The ends of the cylinder so produced are cut away and the cylinder is flattened over a plane tray. It is available in thicknesses of 2, 2.5, 3, 4, 5, 5.5 and 6.5 mm and up to 1750 × 1100 mm size and is classified as

Type	Uses
Ordinary glazing quality	General engineering purpose
Selected glazing quality	Class works
Special selected quality	Superior quality works such as show cases and cabinets etc.

Plate Glass - used for all engineering purposes and is superior to sheet glass. A plate glass differs from a sheet glass in that it has a parallel, distortion-free surface obtained by grinding or floating process. It is produced by pouring the molten glass on casting tables and levelling it to an uniform thickness. Both the glass surfaces are then ground, smoothened and polished. Glass so produced is clear and contains unblemished true plane surfaces and is available in thicknesses of 3 to 32 mm and sizes up to 2750 × 900 mm. It is classified as

Type	**Uses**
Ground glass quality	Showcases, cabinets, counters, shop fronts, etc.

Selected glazing quality	Making mirrors
Special selected quality	High class works, wind screen of vehicles

Tempered Glass is made from plate glass by reheating and sudden cooling and is 3 to 5 times stronger than plate glass. Although not unbreakable, it resists bending stress better than plate glass and, when broken, the pieces are relatively small in size. It is used extensively in sports arenas, sliding doors and curtain walls.

Wired Glass is produced by embedding wire nets 0.46 to 0.56 mm into the centre of sheet glass during casting. The minimum thickness of wired glass is 6 mm. When broken it does not fall into pieces. It has higher melting point than ordinary glass. Wired glass is used for fire resisting doors and windows, for sky lights and roofs. A special example of this is wired-refrax glass which transmits 100 per cent more light than the other glasses.

Obscured Glass is made comparatively opaque to sunlight and also known as patterned glass. They are classified as frosted, rolled and ribbed.

Frosted glass is produced by subjecting the polished face of the glass to a sand blast which grinds off the surface. It can also be produced by etching on glass by hydrofluoric acid.

Rolled glass has a series of waves of desired pattern on the surface and is also known as figured rolled glass.

Ribbed glass A series of triangular ribs are produced in the glass during casting.

Laminated Glass is made by sandwiching a layer of polyvinyl butyral between two or more layers of plate or sheet glass. It is also lso known as safety glass. The examples are heat proof glass, sound proof glass and bullet proof glass. Heat and sound proof glasses two or more glass plates are sandwiched by a tinted plastic inner layer. It provides high resistance to heat and glare. By increasing the thickness of plastic layer the glass can be made more sound resistant.

Bullet proof glass is produced by placing vinyl plastic and glass in several alternate layers and pressing them with outer layers of glass. It is used in banks, jewellery stores and display windows. Insulating glass is composed of two glass plates into which a layer of 6–13 mm thick dehydrated air is sealed. The round edges are formed by fusing together the two glass plates. These glasses reduce the heat transmission by 30–60 per cent.

Heat absorbing Glass is bluish green in colour and cuts ultra violet rays of sun. The example is calorex. It is used in railway carriages, factories, hospitals, health clubs and kitchens.

Ground Glass - In this type of glass one face of plate or sheet glass is made rough by grinding. It is used for maintaining privacy by obstructing vision and at the same time allowing light. The ground glass is used for bedrooms, toilets and for making black boards.

Block Glass - is hollow sealed made by fastening together two halves of pressed glass? It is used for making partitions.

Coloured Glass - produced by adding oxides of metals to molten glass:

Opal Glass is also known as milk glass. It is produced by adding bone ash, oxide of tin and white arsenic to vitreosil (99.5% silica glass known as clear silica glass). The composition is 10 parts of sand, 4 parts cryolite and 1 part zinc oxide.

Enamel Glass is produced by adding calcined lead and tin oxide to the ordinary glass. The composition is 10 parts sand, 20 per cent lead and tin oxide and 8 parts potash.

Optical Glass contains phosphorus, lead silicate and a little cerium oxide, the latter capable of absorbing ultraviolet light injurious to eyes. They are used for making lenses.

CERAMICS

A ceramic is an inorganic, nonmetallic solid prepared by the action of heat and subsequent cooling.

Ceramic materials may have a crystalline or partly crystalline structure, or may be amorphous (e.g., a glass).

Because most common ceramics are crystalline, the definition of ceramic is often restricted to inorganic crystalline materials, as opposed to the non crystalline glasses, a distinction followed here.

Earliest ceramics made by humans were pottery objects, including 27,000 year old figurines, made from clay, either by itself or mixed with other materials, hardened in fire.

Later ceramics were glazed and fired to create a colored, smooth surface.

Ceramics now include domestic, industrial and building products and a wide range of ceramic art.

In the 20th century, new ceramic materials were developed for use in advanced ceramic engineering; for example, in semiconductors.

FIG.30 CERAMIC TILES

SEALANTS FOR JOINTS

The development of construction technique has posed the problem of providing durable sealants in the joints between different engineering materials such as aluminium, concrete, glass, marble, masonry wall, steel and stone.

The spacing of joints should be kept in such a way that the stresses developed due to the movement of building materials are properly regulated and maintained within permissible limits.

A sealant material in a joint has to face the following conditions:

- It changes shape with the change in the width of the joint.
- It is always in shear in lap joints
- It is always in tension

Following are the properties of a good sealant so as to fulfill its provision in a joint:

- Should have good bond
- Should not deteriorate either due to weather effects (or) due to stress and stress relief cycles.
- Should remain flexible and soft.

It is found that the sealants possessing above properties are classified as elastometric sealants and these sealants are silicone based, urethane based, acrylic based and polysulphide based sealants.

Out of all these, the polysulphide based sealants have become more popular because of their superior performance.

FIBRE GLASS REINFORCED PLASTIC (FRP)

Description:

FRP is a composite material made of a polymer matrix reinforced with fibers. The polymer is usually an epoxy, vinylester or polyesterthermosetting plastic. FRP is commonly used in the aerospace, automotive, marine, and construction industries.

Application: FRP is manufactured and tested to perform in locations such as: commercial kitchens, public restrooms, hospitals, schools, correctional facilities, restaurants, car washes, meat and dairy facilities, coolers and freezers, supermarkets, clean rooms and laboratories.

FIG.31 FRP PRODUCTS

QUESTIONS FOR PRACTICE

PART A (2 MARKS)

- Define timber.
- What are the market forms of timber?
- List out the industrial timber.
- Write a critical note on veneers.
- What are ply woods?
- What is meant by seasoning of timber?

- Write a critical note on panels of laminates.
- Describe the various processes adopted to manufacture steel.
- State the various uses of steel.
- State the properties of aluminum
- Mention the characteristics of aluminum as important building materials.
- What are the different forms of aluminum?

- **PART B (12 MARKS)**

- Explain the market forms and industrial timber.
- Explain in detail the processing of timber and qualities of good timber.
- Explain in detail about the false ceiling materials and the uses.
- What are panels of laminates? Explain in detail.
- Explain the importance of glass as an construction material illustrate your answer by giving for of the recent developments in the glass industries.
- Write the properties and manufacturing process of steel. And explain Bessemer process process in detail.
- Explain aluminium composite panels and its applications.
- Explain the importance of geo-membrane and geo-textiles for reinforcement.

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SCHOOL OF BUILDING AND ENVIRONMENT

DEPARTMENT OF CIVIL ENGINEERING

UNIT – V– MODERN MATERIALS-PLASTERING-PAINT-VARNISHING-DPC SCIA1102

Clay products - Refractory's - Composite materials - Types - Applications of laminar composites Fibre textiles - Geo-membranes and Geo-textiles for earth reinforcement - white and colour washing - painting, varnishing and distempering - Dampness and fire proofing - anti termite measures.

CLAY PRODUCTS

Clay products are one of the most important classes of structural materials. The raw materials used in their manufacture are:

- clay blended with quartz sand,
- chamatte (refractory clay burned at 1000–1400°C and crushed), slag, sawdust, pulverized coal.

Bulk specific gravity of clay brick ranges from 1.6 to 2.5.

According to the method of manufacture and structure, bricks, tiles, pipes, terracotta, earthenware's, stoneware's, porcelain, and majolica are well recognized and employed in building construction.

Clay bricks have pleasing appearance, strength and durability whereas clay tiles used for light-weight partition walls and floors possess high strength and resistance to fire.

Clay pipes on account of their durability, strength, lightness and cheapness are successfully used in sewers, drains and conduits

REFRACTORY'S (Fire-Clay Or Refractory Clay)

Fire-clay is a term, loosely applied, to include those sedimentary or residual clays which vitrify at a very high temperature and which, when so burnt, possess great resistance to heat.

These are pure hydrated silicates of alumina and contain a large proportion of silica 55–75%, alumina 20–35%, iron oxide 2–5% with about 1 per cent of lime, magnesia and alkalis. Fire clays are capable of resisting very high temperatures up to 1700°C without melting or softening and resist spalling. The presence of a small percentage of lime and magnesia and alkalis help to melt the clay particles more firmly, whereas a large percentage of lime and magnesia tend to melt the clay at low temperatures.

FIG.1 HIGH DENSE FIRE CLAY BRICKS

Iron oxide or other alkalis reduce refractory qualities of fire clay. The fire clay is used for manufacturing fire bricks used in furnaces linings, hollow tiles, and crucibles.

COMPOSITE MATERIALS

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties.

The individual components remain separate and distinct within the finished structure.

Metal-filled plastics

Metals and alloys
(steels, aluminium,
alloys, copper and
brasses, titanium, etc.

Plastics (resins,
thermoplastics,
rubbers, foams,
textile, fibres, etc.

ceramic matrix composites (including ordinary reinforced concrete and steel-fibre reinforced concrete)

Fiber – reinforced plastics (GRP, FRP, GFRP, CFRP glass coated fabrics, etc.)

Ceramics and glasses (glass, fired ceramics, concrete, etc.

Metal matrix composites,

Evolution of composites form different classes of engineering materials

Typical engineered composite materials include:

- Composite building materials such as cements, concrete
  Reinforced plastics such as fiber-reinforced polymer
- Metal Composites
- Ceramic Composites (composite ceramic and metal matrices) Composite materials are generally used for buildings,
  - bridges
  - Structures such as:
- boat hulls
- swimming pool panels
- race car bodies
- shower stalls
- bathtubs
- storage tanks
- imitation granite
- cultured marble sinks
- counter tops.

The most advanced examples perform routinely on spacecraft in demanding environments.

TYPES of Composites

Composite materials - usually classified by the type of reinforcement they use. This reinforcement is embedded into a matrix that holds it together.

The reinforcement is used to strengthen the composite.

For example, in a mud brick, the matrix is the mud and the reinforcement is the straw. Common composite types include:

- Random-fiber or short-fiber reinforcement,
- Continuous-fiber or long-fiber reinforcement,
- Particulate reinforcement,
- Flake reinforcement,
- Filler reinforcement.

Fiber:

It is defined as one of the delicate, hair portions of the tissues of a plant or animal or other substances that are very small in diameter in relation to there length. A fiber is a material which is several hundred times as long as its thick.

Textile Fiber:

Textile fiber has some characteristics which differ between fiber to Textile fiber. Textile fiber can be spun into a yarn or made into a fabric by various methods including weaving, knitting, braiding, felting, and twisting. The essential requirements for fibers to be spun into yarn include a length of at least 5 millimeters, flexibility, cohesiveness, and sufficient strength. Other important properties include elasticity, fineness, uniformity, durability, and luster. Banana fiber is one kind of fiber but it is not a textile fiber. Because it can not fill up the above properties. So we can say that all fiber are not textile fiber.

Types of Textile Fiber:

Generally two types of fiber.

Natural fiber.

Manmade fiber.

Natural Fiber:

Natural fibers include those produced by plants, animals, and geological processes. They are biodegradable over time. They can be classified according to their origin.

A class name for various genera of fibers (including filaments) of:

- animal (i.e., silk fiber and wool fiber);
- mineral (i.e., asbestos fiber); or
- vegetable origin (i.e., cotton fiber, flax fiber, jute fiber, and ramie fiber).

ManmadeFiber:

It is also known as Manufactured fiber. Synthetic or man-made fibers generally come from synthetic materials such as petrochemicals. But some types of synthetic fibers are manufactured from natural cellulose; including rayon, modal, and the more recently developed Lyocell. A class name for various genera of fibers (including filaments) produced from fiber-forming substances which may be:

- Polymers synthesized from chemical compounds, e.g., acrylic fiber, nylon fiber, polyester fiber, polyethylene fiber, polyurethane fiber, and polyvinyl fibers;
- Modified or transformed natural polymers, e.g., alginic and cellulose-based fibers such as acetates fiber and rayons fiber; and

- Minerals, e.g., glasses. The term manufactured usually refers to all chemically produced fibers to distinguish them from the truly natural fibers such as cotton, wool, silk, flax, etc.e.g: Glass fiber,

GEO-MEMBRANES AND GEO-TEXTILES FOR EARTH REINFORCEMENT.

The Primary purpose of reinforcing a soil mass is to improve its stability, increasing its bearing capacity and reduce Settlements and Lateral deformations. Reinforcing materials: stainless steel, aluminum, and fiberglass to nylon, polyster, polyamides, and other synthetics in the form of strips. Geosynthetics, geotextiles, geogrids and geocomposits.

Geosynthetic reinforced soil (GRS) retaining walls have been used successfully as earth retaining structures for more than four decades (Allen et al., 2002). The main reasons for their popularity are reduced cost, ease of construction and better performance compared to conventional unreinforced soil wall alternatives. Average cost savings of 50% over traditional concrete cantilever walls have been reported in the USA (Koerner et al., 1998) and in the UK (Jones, 1994). A corollary benefit of this technology is a reduction in environmental cost. Jones (1994) estimated that 40% less SO2 is released to the atmosphere during fabrication of the component parts using GRS walls compared to traditional cantilever wall structures. A major cost component for GRS walls is the soil used in the reinforced zone when it must be transported to site (typical case). Most often this material is a select material that must meet speci- fications regarding particle size distribution, strength and permeability. The availability of naturally occurring deposits of acceptable granular soil materials at reasonable distances from a project site can be prohibitive. A strategy to reduce this cost is to employ recycled construction and demolition waste (RCDW) as the backfill material in geosynthetic reinforced soil walls (Santos et al., 2012a,b). Part of the cost benefit is the savings that accrue from avoiding the tipping charges required to dispose of the RCDW in a landfill. As an example, approximately 70% of the waste disposed in landfills in the city of Brasilia, Brazil, comes from construction and demolition works (Santos, 2011). This figure is not much different in several other cities in the country. A description of typical construction demolition waste in Brazil is reported by Santos et al. (2010b).

FIG.2 PLASTER OF PARIS

FIG. 3 GYPSUM BOARD FALSE CEILING

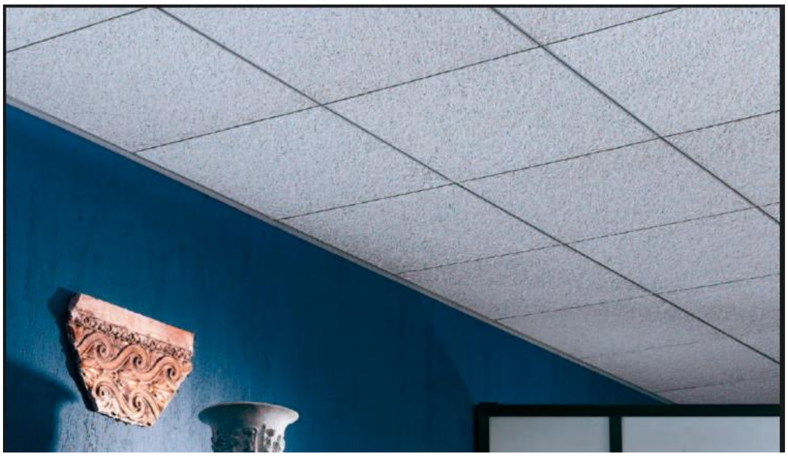


FIG.4 MINERAL FIBER FALSE CEILING

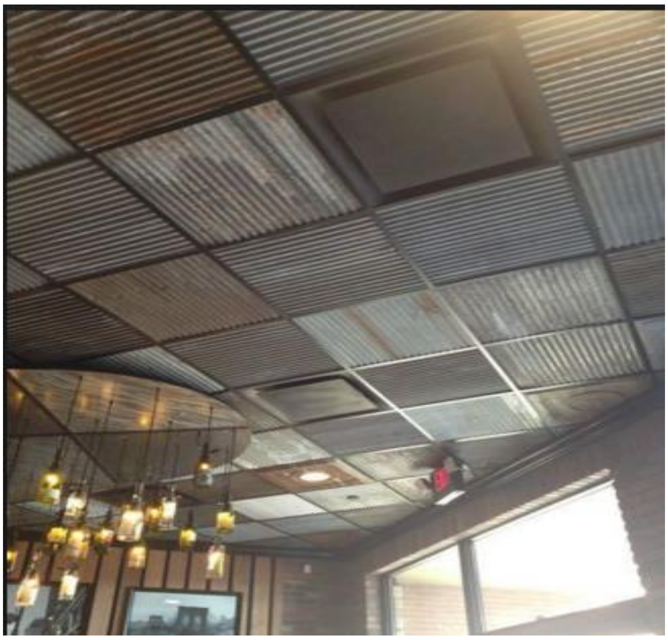


FIG.5 METAL CEILING

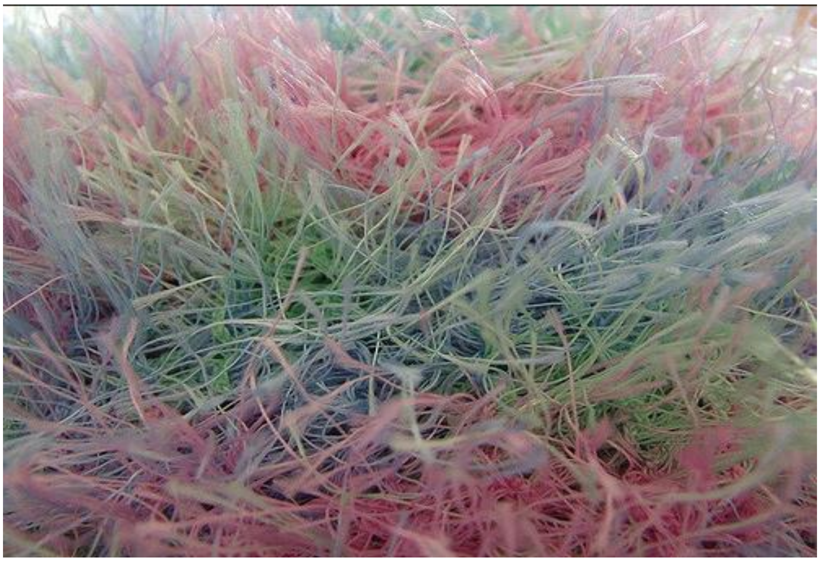


FIG.6 POLYESTER FIBER TEXTILE

Building finishes

- Floor finish
- Wall finish
- Ceiling finish

PLASTERING

Process of covering rough walls and uneven surfaces in the construction of houses and other structures with a plastic material called plaster or mortar.

OBJECTIVE OF PLASTERING

- To provide an even, smooth, regular, clean and durable finished surface
- To improve the appearance
- To protect the surfaces form the effects of atmospheric agencies
- To conceal the defective workmanship
- To cover up the use of inferior quality and porous materials and the joints formed in masonry work
- To provide a satisfactory base for white washing, colour washing, painting or distempering.
- Internal plastering, the object is to protect the surfaces against dust and vermin nuisance.

TYPES OF PLASTERS

- Lime plaster - an intimate mixture of equal proportion of lime and sand ground in a mortar mill to form a paste of required consistency.

- Cement plaster - an intimate mixture of Portland cement with sand with required amount of water to make a plastic mass.

- Mud plaster - prepared with equal volumes of clay or brick earth and of chopped straw, hay, loose soil or cow dung and hemp.

- Waterproof plaster – consists of one part cement, two parts of sand and pulverized alum at the rate of 12 kg/m3 of sand. In order to make this to be waterproof, soap water containing about 75 gm soap/litre of water is added.

Requirements of a Good Plaster

- Should provide a smooth, non-absorbent and washable surface. Should
- not shrink while drying which results in cracking of the surface.

  Should adhere firmly to the surface and resist the effects of atmospheric agencies. Should offer good insulation against sound and high resistance
- against fire.

  Should provide the surface a decorative appearance and should be durable.

METHODS OF PLASTERING

Method of Plastering

- Internal plastering on surfaces of brick and concrete.
- External wall plastering.
- Soffit plastering / Soffit finishing with cement based easy plaster material and wall putty.
- Improving joint of brick walls & structural concrete joints.

Internal Plastering on surfaces of Brick and Concrete

Surface where plastering is to be done will be cleaned. Level pegs on walls will be fixed with reference to the off lines to brick walls set out in floors. (Using centre plumb bob and nylon thread). All the brick walls will be wetted before pasting mortar on walls. First coat mortar filling (1:4 Cement and Sand) up to 15 mm will be applied on surfaces where required mortar thickness exceed 25mm.

Walls and columns will be plastered 1:4 Cement and Sand to achieve semi rough finished surface. Vertical joint of structural columns / walls & brick walls will be treated by fixing 200mm width chicken mesh with wire nails / concrete nails by centering the mesh to the vertical wall joint. All the embedded service lines and provisions (Conduits, Boxes and etc. will be completed on brick walls and check with the drawings.

Joints between walls and beams will be formed up to a maximum of 20mm and will be sealed using 30 minutes fire rated flexible filler. (Material descriptions will be submitted for the approval of the Engineer. Internal plastering on surfaces of concrete columns, beams & walls which are aligned with surfaces of brick walls will be plastered and other concrete surfaces will be finished with cement base easy plaster. (Material descriptions will be submitted for the approval of the Engineer.

External Wall Plastering

Alignment and fixing level pegs on external wall surfaces will be done using the surveying instrument / centre plumb bobs. Projections on the wall surfaces will be chipped off and cleaned after completing the level pegs on walls. First coat mortar filling (1:4 Cement and Sand) up to 15 mm will be applied on surfaces where required mortar thickness exceed 25mm.

Cement paste on concrete surfaces will be applied to improve the bonding of plaster to the concrete surfaces. Maximum width of 20mm horizontal grooves between walls and beams will be formed by cutting using grinders with diamond wheels after plastering the wall surface. This groove will be filled with approved weather sealant.

External wall plaster will be finished with rough surface. 1:10 slope at the external side of the window sill will be formed while plastering the window reveals. Soffit Plastering / Soffit Finishing with Cement Based Easy Plaster.

The slab soffits and beams' sides and soffits which are to be smooth surfaced painted finished will be smoothen with easy plaster (Material literature will be submitted separately) and places where concrete surfaces are uneven, will be roughen & leveled with cement and sand mortar plaster before applying easy plaster to make surface smooth.

Improving Joints of Brick Wall & Structural Concrete

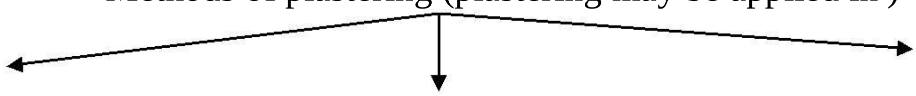
- 200mm wide Chicken Mesh will be fixed at the joint.
- Concrete surfaces will be washed and cleaned.

- Concrete surface which are to be plastered will be roughen or put spot cement slurry.

Quality Controlling & Quality Assurance

- Experienced supervisory staff will be employed for carrying out the work.
- Selected masons will be engaged for plastering work.
- Vertical and alignment of walls will be checked while plastering.
- Mixing of mortar will be done under the supervision of foremen.
- Sieved sand will be used for plaster.

Methods of plastering (plastering may be applied in)



One coat (Cheap constn.) Two coats (Ordinary Works) Three coats (Superior jobs)

Plastering in Two coats

Procedure for carrying out the plastering in cement in two coats is as follows:

- The mortar joints are raked out to a depth of 20mm and the surface is cleaned and well watered.
- If the surface to be plastered is very rough, a preliminary coat is applied.
- The first coat if plaster is now applied with a thickness of 9mm to 10mm for brick masonry.
- To maintain uniform thickness screeds are formed on the wall surface by fixing dots.
- Fixing a dot is just placing small quantity of plaster making a square of 150mm x 150mm.
- Another dot is placed vertically bellow this and a vertical strip of plaster connecting these two dots are provided.
- This screed. Screeds are placed at a distance of 2m and plaster is applied between them.
- The second coat is applied after about 6 hours and the thickness of second coat is about 3mm to 12mm. It is finished as per the requirements.
- The completed work is allowed to set for 24 hours and it is well watered for at least one week.

Plastering in Three coats

Procedure for plastering in three coats is the same as the above except that the number of coats is three. It is done as detailed in table below:

TABLE 1 PLASTERING IN THREE COATS

Coat	Name of coat	thickness	Remarks
First coat	Rendering coat	9mm to 10mm	Left for a period of 3 to 4 days to Harden
Second coat	Floating coat	6mm to 9mm	The purpose is to prepare an even surface
Third coat	Setting or finishing coat	3mm	This is similar to the second coat of two coat plaster

.

SPECIAL EXTERNAL FINISHED FOR PLASTERED SURFACES

Stucco Plastering

- Stucco is the name given to a decorative type of plaster which gives as excellent finish.
- Mixture of lime, white stone, gypsum and oxides for colouring.
- Used for interior as well as exterior surfaces
- Usually lain in three coats making the total thickness of plaster of about 25mm
- First coat is called the scratch coat
- Second a finer coat, also known as brown coat
- Third coat is called the white coat or finishing coat
- Each coat should be permitted to dry thoroughly before the next coat is applied.

Special types of finishing (external plastered surfaces)

- Smooth cast
- Rough cast
- Pebble dash

- Scrapped finish
- Textured finish

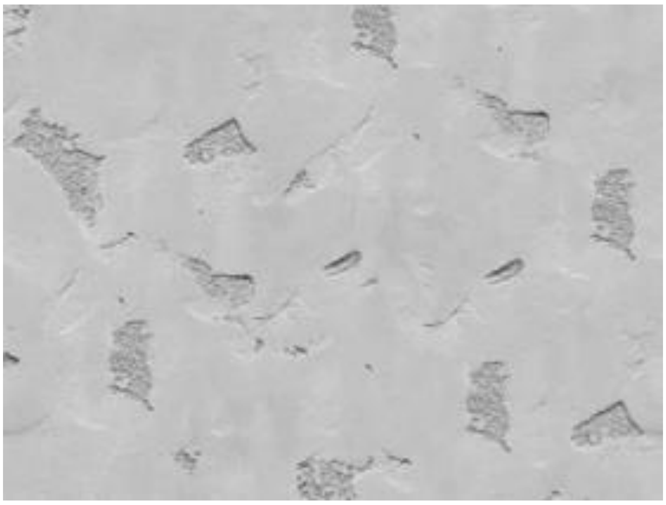


FIG.7 CAT FACE TEXTURE

FIG.8 DASH FINISH

FIG.9 LACE FINISH

FIG.10 SAND OR FLOAT FINISH

FIG.11 SMOOTH FINISH

FIG.12 FINE WORM FINISH

FIG.13 STUCCO TEXTURES

- Small pebbles or crushed stones of suitable size (usually varying from 10 to 20 mm) are thrown on to a freshly applied final coat of mortar and left exposed.
- The mortar of the final neat is usually made by mixing cement and coarse sand in the ratio of 1:3 and is laid in about 1mm thickness
- This finish possesses all the advantages of the rough cast finish and is recommended in similar condition.

Scrapped finish

- In this type of finish the final coat after being leveled and allowed to stiffen for a few hours, is scrapped with a steel straight edge, old saw blade or other such tool to remove the surface skin.
- In this case, the final coat in usually 6 to 12mm thick of which about 3mm is removed in the scrapping process.

- The scrapping is done after the setting has taken place.

- Scrapped finish is less liable to crack than plain finishes.

Textured finish

- In textured finish, ornamental patterns or textured surfaces are produced by working with various tools or the freshly applied final coat.

- This type of finish possesses all the advantages of the rough cast finish

Special Materials used in plastering

- Plaster of Paris –also known as calcium sulphate plaster and is obtained by heating gypsum

- Keene's cement- this is hardest and densest form of gypsum.

- Barium plaster – this is essentially made of barium sulphate

- Acoustical plaster – this is gypsum mixture, which is employed as a final coat to serve the purpose of a sound-repellent finish.

DEFECTS IN PLASTERING

The development of one or more local swellings on the finished plaster surface.

FIG.14 BLISTERING

The development of one or more fissures not assignable to structural cause.

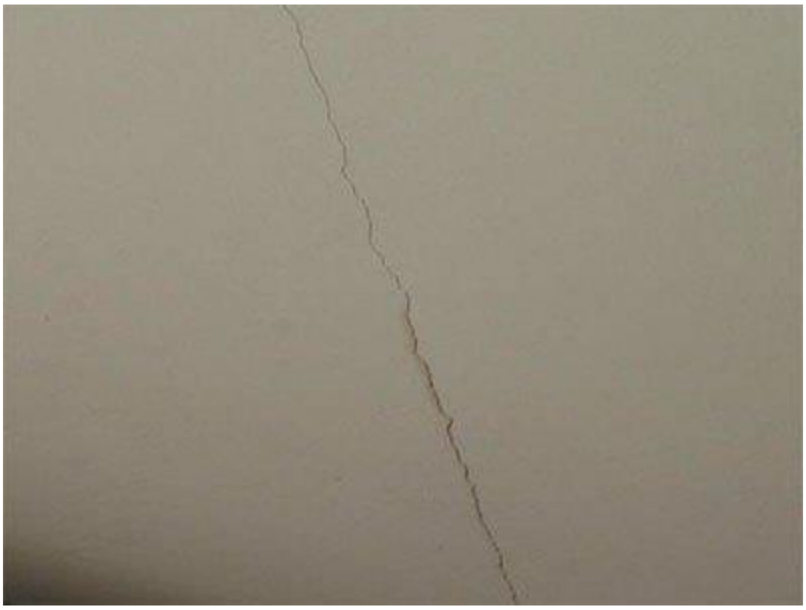


FIG.15 CRACKING

The development of a series of hair cracks on the finished plaster surface. Known as 'map crazing', when it forms a haphazard pattern over the wall surface affected.

FIG.16 CRAZING

A deposit of soluble salts on the surface of the plaster or background.

FIG.17 EFFLORESCENCE

FLADING

The scaling away of patches of plaster surface due to lack or loss of adhesion with the previous coat.
The appearance on the surface of the plaster of the pattern of joints or similar breaks in the continuity of the surface characteristics of the background.

FIG.18 GRINNING

The removal of substantial areas of plaster work from the background.

FIG.19 PEELING

POPPING OR BLOWING

The appearance on the surface of the plaster of conical hollows (pops or blows) in the backing and/or finishing coats.

Blistering of plastered surfaces: Small patched swell out beyond the plane and this is particularly seen inside the building

Crazing: development of fine hair cracks (cracks- formed – visible or invisible)

Efflorescence: Soluble salts are present in plaster materials as well as in building materials. When newly constructed wall dried out, soluble salts appear as a white crystalline substance.

Flaking: Formation of a very small loose mass on the plastered surface. And it is due to the failure of bond between coats of plaster.

Peeling: plaster form some portion of the surface comes off, a patch is formed. And it is due to failure of bond in coats of plaster.

Blow or Pop: A conical hole is formed on the surface (plaster may contain particles which expand on setting)

Rust stain: Seen on the plastered, especially when plaster is applied on metal hath.

Excessive dampness at certain points on the surface makes the portion soft. (The reasons are due to the presence of thinners in the finishing coat, presence of deliquescent salts, excessive suction of the under coat etc.,

Uneven surface is due to poor workmanship.

Remedies for minimizing the defects in plastering work:

- Workmanship – best in brickwork and plastering work.
- Bond of brickwork – should be proper.
- Efflorescence – removed by rubbing brushes on the surface.
- Bricks of superior class should be used.
- Surface to be plastered should be well watered so that it may not absorb water from the plaster.
- Damp proof courses should be provided at convenient places in the building.
- Fresh plastered surfaces should be protected from superfluous quantity of water and excessive heat.

POINTING

Different Styles of Pointing Finish

Fill joints flush with surface, then choose the type of finish of pointing:

"Bucket handle pointing" can be done with metal pointing tool or with a short length of chopped off hosepipe run through the joint. Other types of pointing styles can be seen below.

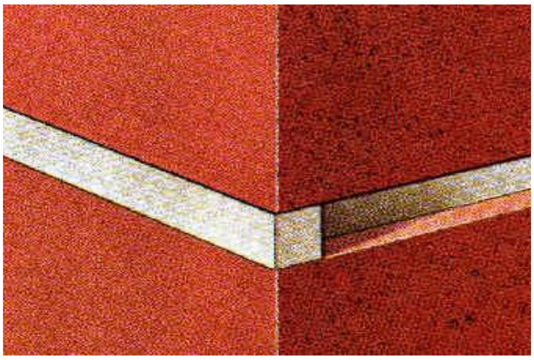


FIG.20 FLUSH POINTING

Flush pointing Done by cutting off surplus and rubbing over with back of trowel

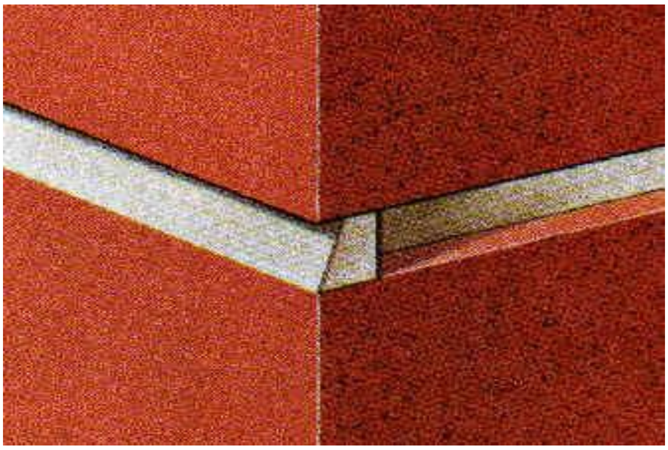


FIG.21 WEATHER STRUCK POINTING

Weather struck pointing Done by using pointing trowel at an angle

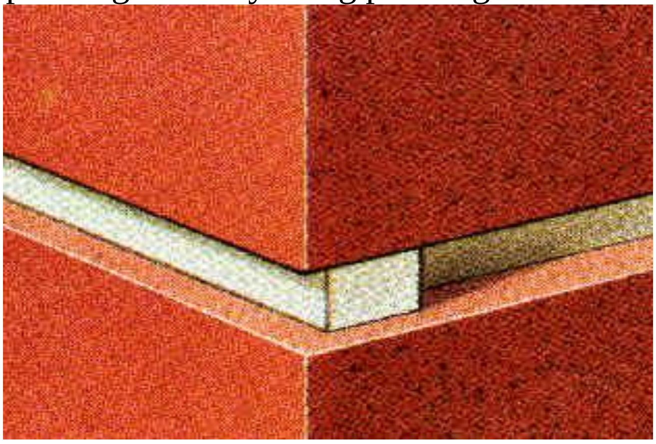


FIG.22 RECESSED POINTING

Recessed pointing Done by raking out mortar with mortar rake

Pointing is the art of finishing the mortar joints of the walls or similar structure with either cement mortar or lime mortar in order to protect the joints from atmospheric agencies and also to improve the appearance of the structure.

Pointing is restored to:

- Where a uniform and smooth surface is not required
- Where the exhibition of the natural beauty of the materials such as stone blocks, bricks, etc.,
- Where the materials used in construction can withstand effects of weather
- Where the workmanship is quite good

Procedure of pointing:

- Prior to pointing, all the mortar joints on the face are raked out by a special pointing tool to a depth of about 1 ¾ cm to provide an adequate key for the fresh mortar used for pointing.

  All the loose mortar and dust are then brushed out of joints and the wall surface is well washed, wetted with clean water and kept wet for a few hours.

  The joints after being prepared are filled with lime or cement mortar with a small trowel.

  The mortar is well pressed into the joints to ensure a solid contact with the internal old mortar joints.

  Excess mortar sticking to the sides is scraped away carefully.

  The finished pointing is kept wet for about 4 days for lime pointing and 10 days for cement pointing.

- Lime pointing: it is done with lime mortar prepared with equal parts of lime and fine white sand, carefully ground in a mortar mill.
- Cement pointing: it is done with cement mortar prepared by mixing equal parts of cement and fine sand using it quickly before it starts

setting.

- Surkhi pointing: in this case the mortar may consist of 1 part of lime and 2 part of surkhi.

Forms of pointing

- Struck joint pointing: the upper portion is inside the face of masonry by 12mm while the bottom portion of the pointing is flush with masonry.

- Tuck pointing: the joint, after having been raked, is filled with cement mortar.a groove 6mm wide and 3mm deep is formed along the centre of the joint while the previously applied cement mortar is soft. The grove is filled with lime putty which projects by 3mm. Lime putty is sometimes replaced by cement. The pointing gives a pleasing appearance.

- Recessed joint pointing: mortar is pressed behind the walls. It is used for high class masonry work.

- Flush pointing: it is suitable for brick as well as stone masonry. The raked portion of the joint is filled with mortar and surface made flush to the masonry for toweling.

- V-groove jointing: it derives its name for its shape. It is suitable for rubble and ashlar masonry work.

- Keyed joint pointing: after filling the joint with mortar a semi-circle is formed inside the pointing by some tool. The pointing gives an elegant appearance.

- Weathered joint pointing: as the name suggest, this type of joint gives adequate protection against weathering. However, it requires comparatively large quantity of water.

WHITE WASHING

- Fresh lime is slaked at site of work and mixed thoroughly with sufficient quantity of water in a tub.

- It is then screened through a clean cloth.

- The clean gum dissolved in hot water is then added at the rate of 20 N per cum. Of lime.

- The surface to be whitewashed should be cleaned before the work is started.
- For whitewashing walls which are whitewashed before, the old loose whitewash is to be first removed and repairing to the plaster is carried out, if necessary.
- The whitewash is applied with jute brush and the brush is so worked that a surface with uniform colour is obtained.
- The three coats are generally applied; each after the previous coat has completely dried.
- The lime is toxic for germs. It reflects light and thus it increases the brightness of the surface.
- The whitewashing therefore is extensively used for interior wall surfaces and ceiling of houses.

COLORWASHING

- This is prepared by adding the colouring pigment to the screened whitewash.
- It should be seen that the colouring pigment is not affected by the presence of lime.
- Ordinarily, the yellow earth is popular for colourwashing.
- Generally, the walls are colourwashed and ceilings are whitewashed.
- The mixture is to be kept constantly stirred during use.
- The colourwash is applied in the same fashion as the whitewash.
- A satisfactory work does not give out powder when the finished surface is rubbed with the fingers.
- The process of colourwashing imparts cleanliness and pleasant appearance of the surfaces which are treated.

PAINTING, VARNISHING AND DISTEMPERING

- Final finishing of all surfaces such as walls, ceilings, woodwork, metalwork, etc,
- According to the nature of the surface and the finishing required, the surface should be coated with paint or varnish or distemper etc.

PAINTING

The paints are coatings of fluid materials and they are applied over the surfaces of timber and metals.

Objects of painting a surface:

- It protects the surface firm weathering effects of the atmosphere and actions by other liquids, fumes and gases.
- It prevents decay of wood and corrosion in metal.
- It is used to give good appearance to the surface
- The decorative effects may created by painting and the surface becomes hygienically good, clean, colourful, and attractive.

Characteristics of an ideal paint:

- Possess a good spreading power i.e. maximum area of the surface should be covered by minimum quantity of the paint.
- Fairly cheap and economical.
- Easily and freely applied on the surface.
- Dries in reasonable time and not too rapidly. Colour is maintained for a long time. Should form a hard and durable surface.
- Should not affect health of workers during its application. Should not be affected by weathering actions of the atmosphere. Possess attractive and pleasing appearance.
- Should not show cracks when the paint dries.

- When applied on the surface, the paint should form a thin film of uniform nature.

Types of paints:

- Aluminium paints
- Anticorrosive paint
- Asbestos paint
- Bituminous paint
- Cellulose paint
- Cement paint
- Colloidal paint
- Emulsion paint
- Enamel paint
- Graphite paint
- Oil paint
- Plastic paint
- Silicate paints
- Synthetic rubber paint

ALUNINIUM PAINTS

The very finely ground aluminium is suspended in either quick-drying spirit varnish or

sow-drying oil varnish as per requirement.

The spirit or oil evaporates and a thin metallic film of aluminium is formed on the surface.

Widely used for painting gas tanks, hot water pipes, marine piers, oil storage tanks etc.,

Advantages:

- Visible in darkness.

- Resists heat to a certain degree.

- Surfaces of iron and steel are better protected from corrosion by this paint than any other paint.

- Possesses a high covering capacity. A litre of paint can cover an area of about 200 m^2

- Gives good appearance to the surface.

- Impervious to the moisture.

- Possesses high electrical resistance.

ANTICORROSIVE PAINT

Anti-corrosion refers to the protection of metal surfaces from corroding in high-risk (corrosive) environments.

When metallic materials are put into corrosive environments, they tend to have chemical reactions with the air and/or water. The effects of corrosion become evident on the surfaces of these materials. For example, after putting the iron into a corrosive atmosphere for an extended period, the iron starts rusting due to oxygen interaction with water on the iron's surface.

Metal equipment lacking any preventive (anti-corrosive) measures, may become rusted both inside and out, depending upon atmospheric conditions and how much of that equipment is exposed to the air. There are a number of methods for preventing corrosion, especially in marine applications. Anti-corrosion measures are of particular importance in environments where high humidity, mist, and salt are factors.

Essentially consists of oil and a strong drier. A pigment such as chromium oxide or lead or red lead or zinc chrome is taken and after mixing it with some quantity of very fine sand, it is added to the paint.

Advantage:

- Cheap

- Lasts for a long duration

- Appearance of the paint is black.

ASBESTOS PAINT

Peculiar type of paint and it is applied on the surfaces which are exposed to the acidic gases and steam.

BITUMINOUS PAINT

Prepared by dissolving asphalt or mineral pitched or vegetable bitumen in any type of oil or petroleum

Variety of bituminous paints is available.

Paint presents a black appearance and it is used for painting ironwork under water.

VARNISHING

Varnish is a transparent, hard, protective finish or film that is primarily used in wood finishing but also for other materials. Varnish is traditionally a combination of a drying oil, a resin, and a thinner or solvent.

- Varnishes are transparent or nearly transparent solutions of resinous materials and they are applied over the painted surfaces.
- Varnish is used to indicate the solution of resins or resinous substances prepared either in alcohol, oil or turpentine.

Main objects of applying varnish on a wooden surface

- Brightens the appearance of the grain in wood
- Renders brilliancy to the painted surface
- Protects the painted surface from atmospheric actions.
- Protects the unpainted wooden surfaces of doors, windows, roof trusses, floors, etc.. , from the actions of atmospheric agencies.

Characteristics of an ideal varnish

- Should render the surface glossy.

  Should dry rapidly and present a finished surface which is uniform in nature and pleasing in appearance.

Colour of varnish should not fade away when the surface is exposed to the atmospheric actions.

- Protecting film developed by varnish should be tough, hard and durable. Should not shrink or show cracks after drying.

Types of varnishes

- Oil varnishes
- Spirit varnishes
- Turpentine varnishes
- Water varnishes

FIG.23 VARNISH ON WOOD

OIL VARNISHES

Linseed oil is used as solvent in this type of varnish.

Hard resins such as amber and copal are dissolved in linseed oil and if the varnish is not workable, a small quantity of turpentine is added.

Oil varnishes dry slowly, but they form hard and durable surface. In fact, these are the hardest and the most suitable varnishes.

Specially adopted for exposed works which required frequent cleaning

Used on caches and fittings in houses.

Methylated spirits of wine are used as solvent in this type of varnish.

The resins are of soft variety such as lac or shellac.

The spirit varnishes dry quickly.

But they are not durable and are easily affected by weathering actions.

They are generally used for furniture.

The French polish is a variety of this class of varnish and the desired colouring tinge can be obtained by addition of suitable colouring pigment.

The French polish is one of the finest finishes for ornamental furniture prepared from superior quality of wood.

TURPENTINE VARNISHES

Used as solvent in this type of varnish.

The reins adopted are of soft variety such as gum dammar, mastic and rosin.

These varnished dry quickly and possess light colour.

Not durable and tough as oil varnishes.

WATER VARNISHES

Shellac is dissolved in hot water and enough quantity of either ammonia or borax or potash or soda is added such that shellac is dissolved.

Theses varnishes are used for varnishing g maps, pictures etc.

They are also used for delicate internal work and as covering for wall paper.

DISTEMPERING

Distemper is a term with a variety of meanings for paints used in decorating and as a historical medium for painting pictures, and contrasted with tempera. The binder may be glues of vegetable or animal origin (excluding egg). Soft distemper is not abrasion resistant and may include binders such as chalk, ground pigments, and animal glue. Hard distemper is stronger and wear-resistant and can includecasein or linseed oil as binders

- Applied over the plastered surfaces.
- Object of applying distemper to the plastered surfaces
    - to create a smooth surface
- Available in market under different trade names.
- Cheaper than paints and varnishes.
- They present a neat appearance.
- Available in a variety of colours.

Properties of distempers

- On drying, the film of distemper shrinks, hence it leads to cracking and flaking if the surface to receive distemper is weak.
- Coatings of distemper are usually thick and they are more brittle than other types of water paints.
- The film developed by distemper is porous in character and it allows water vapour to pass through it. Hence it permits new walls to dry out without damaging the distemper film.
- They generally light in colour and they provide a good reflective coating.
- They are less durable than oil paints.
- They are treated as water paints and they are easy to apply.

- They can be applied on brickwork, cement plastered surface, lime plastered surface, insulating boards, etc.

- Exhibit poor workability

- They prove to be unsatisfactory in damp locations such as kitchen, bathroom, etc.

PROOFING OF DAMPNESS

Damp proofing is defined by the American Society for Testing and Materials (ASTM) as a material that resists the passage of water with no hydro-static pressure and *waterproof* as a treatment that resists the passage of water under pressure.[1] Generally damp proofing keeps moisture out of a building where vapor barriers keep interior moisture from getting into walls. Moisture resistance is not necessarily absolute: it is usually defined by a specific test method, limits, and engineering tolerances.

Damp proofing is accomplished several ways including:

- A damp-proof course (DPC) is a barrier through the structure by capillary action such as through a phenomenon known as rising damp. Rising damp is the effect of water rising from the ground into your property.[2] The damp proof course may be horizontal or vertical.[3] A DPC layer is usually laid below all masonry walls, regardless if the wall is a load bearing wall or a partition wall.
- A damp-proof membrane (DPM) is a membrane material applied to prevent moisture transmission. A common example is polyethylene sheeting laid under a concrete slab to prevent the concrete from gaining moisture through capillary action.[4] A DPM may be used for the DPC.
- Integral damp proofing in concrete involves adding materials to the concrete mix to make the concrete itself impermeable.[3]
- Surface coating with thin water proof materials for resistance to non-pressurized moisture such as rain water or a coating of cement sprayed on such as shotcrete which can resist water under pressure.[3]
- Cavity wall construction, such as rainscreen construction, is where the interior walls are separated from the exterior walls by a cavity.[3]

Damp proofing is the method adopted to prevent the entry of dampness into a building, so as to keep them dry, habitable and safe.

Provision of damp proofing courses prevents the entry of moisture form walls, floors and basement of a building.

Causes of dampness

- Entry of moisture from the ground
- Entry of rain water
- Exposed tops of walls
- Deposition of atmospheric moisture on walls, floors, and ceilings
- Location
- Orientation
- Workmanship

Effects of dampness

- Creates unhealthy conditions for those who occupy it. Corrosion of the metals used in building construction is evident.

- Formation of unsightly patches on the wall surfaces and ceilings. Formation of dry-rot leading to the decay of timber in a damp atmosphere. Deterioration of electrical fittings.

- Floor covering materials are seriously damaged. Acceleration of the growth of termites. Softening and crumbling of the plaster.

Requirement of an ideal material for damp-proofing

- Damp-proof course should remain effective during the life of the building. Hence the material should be durable.

- Should remain steady and should not allow any movement in itself.
- Should be impervious
- Material should safely resist the load coming on it.
- Should be strong enough to undergo some structural movement without fracture.

Materials used for damp-proofing

Hot bitumen- it is flexible and should be applied with a minimum thickness of 3mm

Mastic asphalt – it is a semi-rigid material and it forms an excellent impervious layer. It is very durable but can withstand only slight distortion.

Bituminous felts – it is also flexible and it is available in rolls of normal width. This can accommodate slight movements. It is liable to squeeze out under pressure.
Metal sheets of lead, copper, and aluminium.

Metal sheets can also be used as damp proofing material.

These metal sheets are flexible and do not squeeze out under pressure.

The surface of lead coming in contact with lime and cement will be corroded and hence it should be protected with bitumen.

Aluminium sheets should also be protected with bitumen but copper does not required any protective coatings.

Methods of Damp Proofing

- If the level of the ground floor is in level with the ground surface or just above it, the damp proofing course is provided as shown in Figure

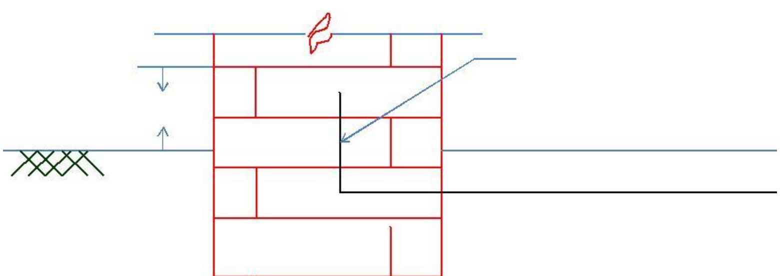


FIG:24 DAMP PROOFING FOR GROUND FLOOR IN LEVEL WITH GROUND SURFACE

If two ground floors are at different levels, D.P.C. is provided as shown in Figure .

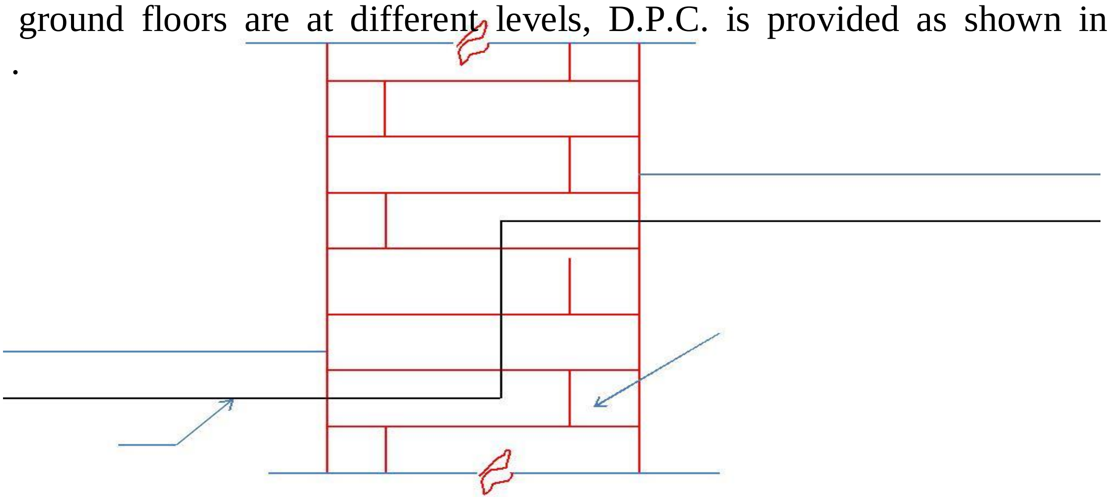


FIG.25 DAMP PROOFING FOR FLOORS AT DIFFERENT LEVELS

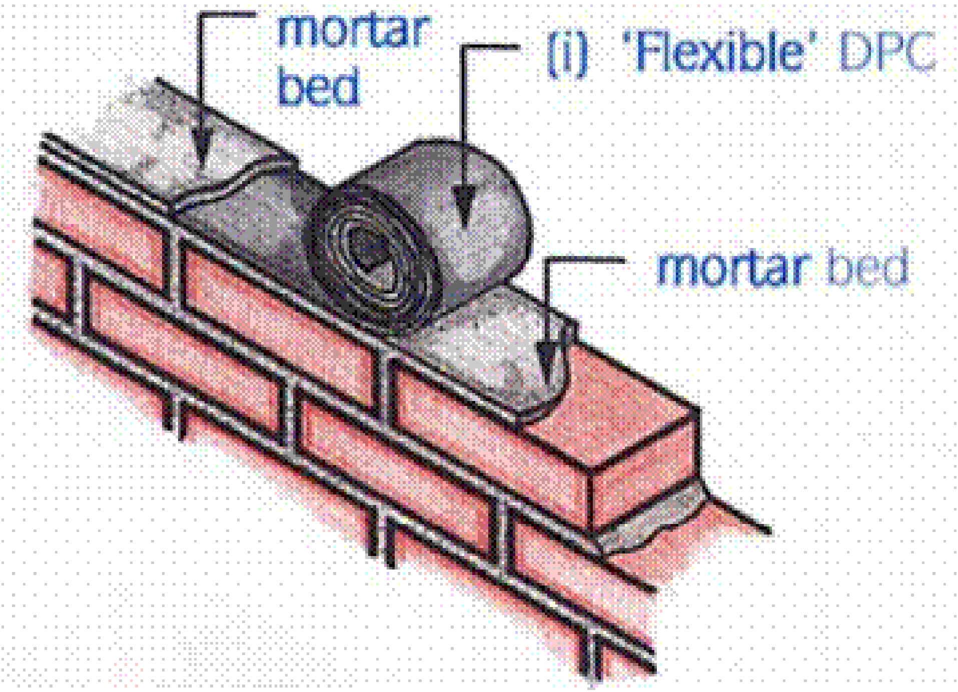


FIG.26 FLEXIBLE DAMP PROOFING

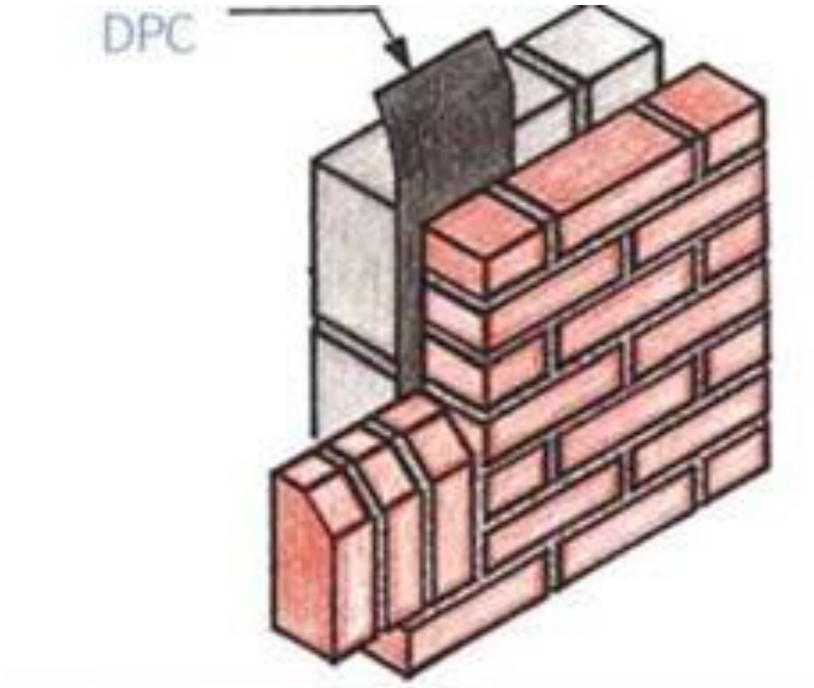


FIG.27 DPC IN WALLS

For sunk slabs and terrace floor to make surface water proof use Bostik Boscocrete and Brushbond
For leak arrest use Renderoc plug
In water tank, septic tank and roof concrete use Conplast WP 90
Fro rebonding of concrete with old concrete work use Nitobond EP

To fix new lintel rod on old wall or concrete use Lokfix
For crake on wall surface use Renderoc CS and Dachflex

PROOFING FOR FIRE

Introduction

- Buildings are made up of different components.

- Some of them are designed to resist fire so as to prevent spread of fire and protect people and their properties from the effect of fire.

- Unauthorized alterations to these building components may reduce their fire resisting property and thus the fire safety of the building.

- This leaflet introduces the common types and functions of fire resisting construction in a building which should not be altered without proper professional advice and the approval of the Building Authority.

Fireproofing is rendering something (structures, materials, etc.) proof against fire, or incombustible; or material for use in making anything fire-proof.[1] It is a passive fire protection measure. "Fireproof" or "fireproofing" can be used as a noun, verb or adjective; it may be hyphenated ("fire-proof")

Preventive maintenance

- Building owners should keep the fire resisting components under proper maintenance.

- If unauthorized alteration or defective fire resisting construction is found, the owner, the occupant, the owner's corporation or the management company should enlist the service of an Authorized Person to advise on the conditions, propose remedial work, and apply for permission from the Building Authority as necessary.

- A list of Authorized Persons can be viewed at the Buildings Department and any District Offices. Authorized Persons include architects, engineers and surveyors registered under the Buildings Ordinance.

Among the conventional materials, purpose-designed spray fireproofing plasters have become abundantly available the world over. The inorganic methods include:

- Gypsum plasters
- Cementitious plasters
- Fibrous plasters

Common Fire Resisting Construction and Deficiencies

Removal of fireman's lift lobby:

Fireman's Lift Lobby- It protects the firemen using the lift. No alteration should be made in the lobby wall and door

Services within staircase enclosure without proper protection

Cable and Duct Protection - Other than firefighting equipment and installations, staircases should not accommodate electrical cables, air ducts or similar services.

Unprotected electric meter room

Special Hazard Rooms - Fire resisting enclosure protects fire spread from such rooms. No unprotected opening should be made in the enclosure.

Damaged / missing fire doors

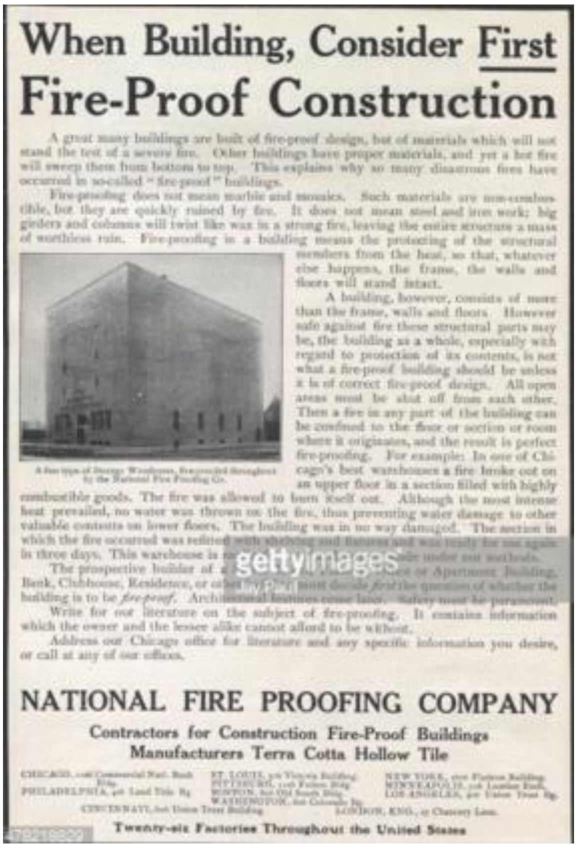


FIG.28 IMPORTANCE OF FIREPOOFING

Fire doors- they protected the staircase from fire and smoke, and should have adequate fire resisting property and self-closing device to keep them in a closed position.

Unauthorized opening in fire resisting wall and the installation of exhaust fan

Staircases, Walls and Floors - They prevent the spread of fire and smoke from one part of a building to another. No opening should be made in these walls and floors. No opening or alteration should also be made in the fire resisting walls and doors for protected lobby.

Door of inadequate fire resistance opens onto common corridors

Common Corridors - Walls and doors enclosing internal corridors are required to have a specified fire resisting property and no holes are allowed, otherwise, fire and smoke may pass through these holes blocking the access to the exits staircase.

Fire resisting building materials

- Brick
- Gypsum
- Stucco
- Concrete
- Fire resisting glass for windows

Bricks:

As bricks are made in a fire kiln, they're already highly resistant to fire. However, it's true that individual bricks are much more fire-resistant than a brick wall. Brick is commonly cited as among the best building materials for fire protection. Depending on the construction and thickness of the wall, a brick wall can achieve a 1-hour to 4-hour fire-resistance rating.

So, although some materials are more fire-resistant than others, several factors might influence a builder's decision, including cost effectiveness, ease of installation and climate.

Gypsum:

Gypsum board is the most commonly used fire-resistant interior finish. Gypsum board, also known as dry wall consists of a layer of gypsum sandwiched between two sheets of paper. Type X gypsum board is specially treated with additives to further improve its fire-resistive qualities.

The paper on the exterior of the type X gypsum board burns slowly and doesn't contribute to fire spread. In addition, gypsum board has a noncombustible core that contains chemically combined water (in calcium sulfate). When affected by fire, the first thing that happens is that this water comes out as steam. This effectively impedes the transfer of heat through the gypsum board. And even after the water is gone, the gypsum core continues to resist fire penetration for a time. Builders often use multiple layers of gypsum board to increase the fire-resistance rating.

Stucco:

Stucco is a plaster that has been used for centuries for both artistic and structural purposes. Modern stucco is made of Portland cement, sand and lime, and it serves as an excellent and durable fire-resistant finish material for buildings. It can cover any structural material, such as brick or wood. It usually consists of two or three coats over metal reinforcing mesh. A one-inch (2.54-centimeter) layer of stucco can easily lend a 1-hour fire rating to a wall.

Roof eaves (overhangs) are a fire hazard, but they can be protected with an encasement of fire-resistant material. Stucco is often recommended as one of the best materials for boxing in hazardous eaves.

Concrete:

Concrete, one of the most common building materials, is also an excellent fire resistant material. It is noncombustible and has low thermal conductivity, meaning that it takes a long time for fire to affect its structural, load-bearing ability, and it protects from the spread of fire. It's actually significantly more fire-resistant than steel, and often used to reinforce and protect steel from fire.

Aggregate can make up 60 to 80 percent of the concrete's volume. The exact fire-resistance properties change depending on the type and amount of aggregate used. Natural aggregates tend not to perform as well. Moisture in the aggregate can expand when heated, causing concrete to sinter after long exposure.

Fire resisting glass for windows:

Windows, important for visibility and light, can nonetheless be a fire hazard. Even before a window is in direct contact with flames, the intense heat of a nearby fire can cause the glass to break. And a broken window allows flames to enter a building easily. In addition, the heat from a fire outside might be enough to simply ignite flammable items inside a home without direct contact.

To protect your house, consider installing fire-resistant windows. One example is dual-paned glass windows. which, in addition to providing energy efficiency, also double the time it would take for fire to break the windows. The outer layer will break first before the inner layer. Tempered glass, which is heat-treated to make it about four times stronger than regular glass, is also effective.
Though they don't provide visibility, glass blocks are extremely fire-resistant while still providing light. Perhaps the best is wired glass, which is tempered glass with metal wire reinforcement. Doors that require fire resistance but also visibility often incorporate wired glass windows.

It's also wise to note the importance of window framing. Steel framing offers the best fire protection, followed by wood and aluminum. Vinyl is the least effective.

ANTI TERMITE PROTECTION

Termite resistant materials

- Steel, aluminium or other metals
- Concrete
- Masonry
- Fibre-reinforced cement
- Naturally termite resistant timbers
- Treated termite resistant timbers.

The use of termite resistant materials must be backed up by regular inspections and a maintenance program.

Therefore provision must be made during construction to allow space for inspection under the floor of the house.

This will include the use of ant caps which aid in the detection of termites.

Concrete slabs - A termite barrier

Concrete slabs form part of the termite barrier. However, termites may be able to access timber framing at the edges of the slab, around service pipes and box-outs for plumbing fixtures or through naturally occurring cracks in the concrete.

The majority of termite infestations occur at the perimeter of the building. Leaving an exposed edge to the perimeter of a concrete slab allows easy detection of the presence of termites.

Concrete slabs - Preventing termite entry with graded stone

Graded stone may be used to prevent termite entry. The stone is finely crushed granite of a size difficult for termites to tunnel through. The graded stone is placed at likely entry points for termites, such as service penetrations and the perimeter

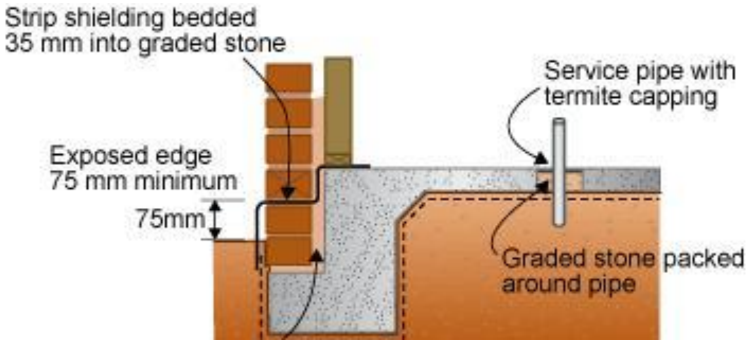


FIG.29 SUSPENDED TIMBER FLOORS - PROTECTION FROM TERMITES

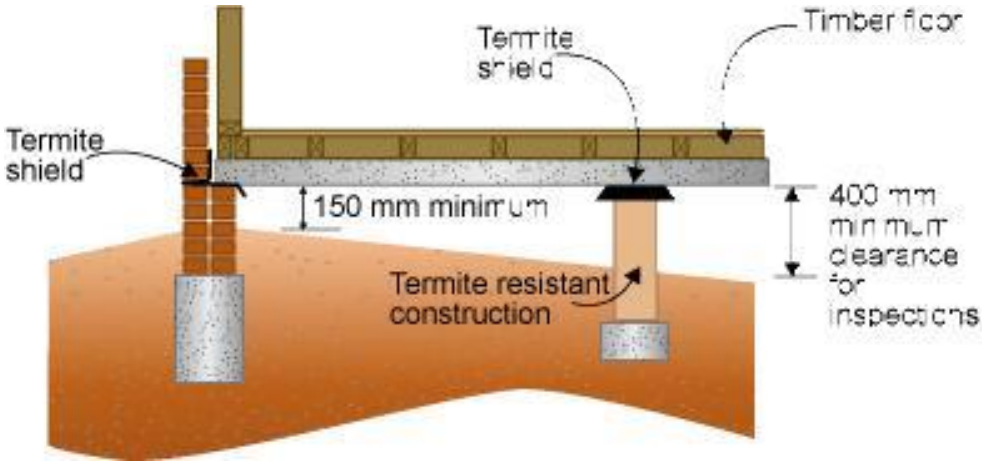


FIG.30 TERMITE RESISTANT CONSTRUCTION

Timber floors can be protected from termites by providing metal shields that force the termites out into the open for easy detection. Adequate space must be provided under the floor to allow for inspection.

FIG.31 WALL CEMENT MORTAR PLASTERING

FIG.32 MUD PLASTERED SURFACE

FIG.33 WATER PROOFING PLASTERING

FIG.34 DISTEMPER COLOUR SHADES

QUESTIONS FOR PRACTICE

PART A (2 MARKS)

1. Give any two objectives of plastering.
2. Write the defects in plastering
3. Define pointing.
4. Write the objectives of painting.
5. List the types of paints.
6. What are the main objectives of applying varnish on a wooden surface?
7. Give few causes of dampness.
8. Give some damp-proofing materials.
9. List the fire resisting building materials.
10. List the termite resistant materials.

PART B (16 MARKS)

1. Define plastering and explain the types of plasters and requirements of good plasters.
2. Explain the methods of plastering.
3. List the special external finished for plastered surfaces and explain any four in detail.
4. Explain defects in plastering and remedies for minimizing the defects in plastering work.
5. Explain procedure of pointing and form of pointing.
6. Explain (a)whitewashing and colourwasing
   (b) Properties of distempers.
7. Give the characteristic of an ideal paint and briefly explain any four type of paints and its advantages.
8. Explain oil varnish, spirit varnish, turpentine varnish and water varnish.
9. Explain causes of dampness, effect of dampness and requirement of ideal materials for damp-proofing.
10. Write the materials used for damp-proofing and explain the methods of damp-proofing with neat sketch.
11. Explain any four fire resisting building materials in detail.
12. Give five termite resistant materials and explain anti termite protection with neat sketch.