MODULE-01

"Building Material And Building Construction"

Syllabus :-

Bricks : Brick as a construction material and its importance, qualities of a good brick;

Stone : Classification, Composition and characteristics

Cement : Classification, tests for cement, uses of cement, types of cement.

Concrete : Quality of mixing water, Workability, Compaction of concrete, Concrete mix design, grade and strength of concrete. Fundamentals of RCC and PSC.

Types of steels used in civil engineering works. Building Components and their basic requirements, mortar, stone and brick masonry, roof, floors.

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14. STONES

DEFINITION- The process of taking out stones from natural rock beds is known as the quarrying. The term quarry is used to indicate the exposed surface of natural rocks. The stones, thus obtained, are used for various engineering purposes. The difference a mine and quarry should be noted. In case of a mine, the operations are carried out under the ground at great depth. In case of quarry, the operations are carried out at ground level in an exposed condition.

SITE FOR QUARRY-The selection of site for a quarry of stones should be done after studying carefully the following aspects:

1. Availability of tools, power, materials and labour for the efficient working of quarry.
2. Easy availability of clean water in sufficient quantity all the year round.
3. Economy in quarrying.
4. Drainage of quarrying pit.
5. Facility of carrying and conveying stones from quarry.
6. Quality of stone available from quarry.

METHODS OF QUARRYING-

Following are the three methods of quarrying:

I. Quarrying with hand tools
II. Quarrying with channeling machine
III. Quarrying with blasting.

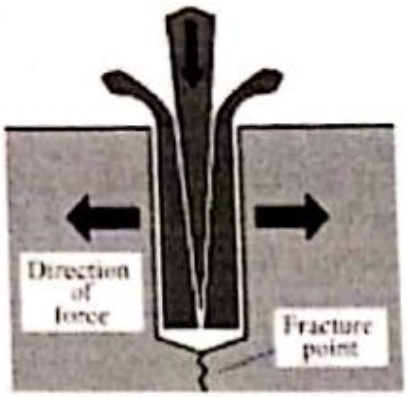
QUARRYING WITH HAND TOOLS-There three methods of doing this type of quarrying:

a) Digging or Excavating
b) Heating
c) Wedging

(a) Digging or Excavating- In this method, the stones are merely excavating with the help of suitable instruments such as pick-axes, hammers, showels, chisels, etc. This method is useful when a soft stone occurs in form of large and small blocks.

(b) Heating- In this method, the top surface of rock is heated. This method is useful when small blocks of more or less regular shape are to be taken out from quarry. It is suitable when the rock formation consists of horizontal layers of shallow depth. It is possible to obtain by these method fairly rectangular blocks required for coursed rubble masonary.

(c) Wedging-In this method, if rock surface contains cracks or fissures,the steel wedges or points, as shown in fig., are driven through such cracks by means of hammers. The blocks of stones are then shifted and they are removed with the help of suitable instruments.



The wedging is adopted for costly stratified rocks which are comparatively soft such as laterite, marble, limestone, sandstone, etc. The wedging is preferred to the blasting, wherever possible.

QUARRYING WITH CHANNELLING MACHINE: In this method, the channeling machine driven by steam, compressed air or electricity are used to make vertical or oblique grooves or channels on the rock mass. These machines make rapidly the grooves having length of about 24m, width of about 50mm to 75mm and depth of about 2.40m to 3.70m. The process consists of the following steps:

(a) The channels are cut around the stone block which is to be removed from the rock mass.
(b) The horizontal holes are drilled beneath the rock.
(c) The wedges are driven into the holes and the block is then broken loose from its bed.

QUARRYING WITH BLASTING:In this method, the explosives are used to convert into small pieces of stones. The main purpose of quarrying stones by is to loosen large masses of rocks and not to violently blow up the whole mass so as to convert it into very small pieces of practically no use.

This method is adopted for quarrying hard stones, having no fissures or cracks. The stones obtained by blasting are usually of small size and they are used as ballast in railways, aggregate for concrete, road metal, etc. The process of blasting is important with respect to the stone quarrying.

Commonly used Stones in India.

Marble:

- Origin and composition: - it is a most common variety of metamorphic rock. It is formed from crystallized limestone by metamorphism\, chemically, it is calcareous and is chiefly composed of calcium carbonate.
- properties :- following are the properties of marble:_
- its crushing strength is from 500 to 600 kg/cm^2

- the usual color of marble is white, but it is also available in different shades of colors such as grey, black, red, brown, yellow and combination of these
- it is compact and crystalline in structure due to which it can take a fine polish
- it is les durable
- Itcan be carved easily and thus is most suited for sculpture work.
- its specific gravity is 2.72 its weight 2720 kg/cum
- its absorption is 1 to 3%
- Chief uses:- used as building stone and in decorative panels

Sandstone:

- Origin and composition:-This stone is a common variety of sedimentary rocks mechanical origin. it is physically, stratified and chemically, siliceous in siliceous in nature, it is chiefly composed of quartz (grains of sand) bound together by a cementing material, but other minerals such as felspar, mica, magnetite etc. are also present.
- Properties:- following are the properties of sand stone:-
- it's crushing strength is 400 to 650 kg/cm^2
- It is white, grey, yellow, light brown, and red in color.
- Its specific gravity is 2.3 to 2.4. Its weight is nearly 2350 kg/cu m.
- Chief uses: - general walls building flagstone.

Slate:

- its crushing strength varies from 700 to 2100 kg/cm^2
- it is hard tough and is least absorptive
- It also offers good abrasive resistance.
- It is a good heat and electrical insulator.
- Its water absorption varies from 0.5 to 1%.
- Following are the uses of slate.
- It is a valuable material for roofing and black boards.
- Thick slabs of harder variety of slates are used for flooring steps shelves mental pieces sills of doors and window etc.
- slate a available at the available at the following localities in India:_
    - simla, kangra, gurgaon, Gurdaspur, Alwar, Rajasthan, (MP) (Haryana) (Gujarat

Basalt:-

- Origin and Composition: these stones are the common varieties of igneous rocks they are formed by solidification of lava on the earth's surface due to volcanic eruption. Some basalts develop step like appearance and are known as traps. They are chiefly composed of silica, alumina and felspar.
- Properties:- Following are the properties of basalt and trap
- Their crushing strength is 700 to 850 kg/sq.cm.
- They are hard and tough

- They are greenish grey to dark grey in color.
- Their specific gravity (2-9 to 2.96) is more than that of granite their weight is nearly 2900kg/cm^3.
- They are available as a vast deposit of basaltic rock, near the western Ghats of India, known as Deccan trap. They are also available at Rajmahal Hills (Bihar) known as Rajmahal Trap. Varieties of basalts jike. Bombay Basalt, Blue basalt, red basalt and yellow basalt are found and used in Maharasatra, Gujarat etc.

Limestone :-

- Color :- White light grey to light buff.
- Texture :- fine to crystalline, may have fossils
- Parting :-parallel to beds: also may have irregular fractures.
- Hardness:- fairly soft steel easily catches
- May show fossils.
- All lime stone are of sedimentary origin and have for their principal ingredient carbonate of lime.
- When clay is present, the stone is called argillaceous limestone; when silica predominates, siliceous limestone; when iron is prevalent, ferruginous limestone; when magnesia is present to the extent of 15 per cent.

Granite:-

- Granite is one of the most valuable stones for construction purposes. Although the quality of granite varies according to the proportions of the constituents and to their method of aggregation, this kind of stone is generally durable,strong, and hard. The hardest and most durable granites contain a greater proportion of quartz anda smaller proportion of feldspar and mica. Feldspar makes granite more susceptible to decomposition by the solution potash contained in it, potash feldspar being less durable than lime or soda feldspar.

  Because of its uniform structure, granite can be quarried in large blocks. The rift, the grain, and the joint planes are advantageous in quarrying, as it is very difficult to cut granite in other places. The uses for which granite is suitable depend on the texture of the stone. Medium-grained stone is best fitted for building construction. Fine-grained stone can be carved and polished.

hist:-

Schist has a more crystalline structure than slate, and the crystals are easily seen. It is composed chiefly of minerals that cleave readily, such as hornblende, mica, etc., mixed with a variable amount of granular quartz and feldspar. The presence of the cleavage minerals produces a fine cleavage or foliation, called schistosity.

- Schist is sometimes used in building construction but it disintegrates very rapidly and is not durable. It should always be set with the planes of schistosity horizontal.

Gneiss -

- Gneiss is a coarse-grainedlaminated rock.
- It is formed by metamorphism of either sedimentary or igneous rock.
- It is oftenused as structural material and as concrete aggregate.

Shale -

- Shale is a typical clay rock that splits readily in lines parallel to the bedding.
- Sand and lime carbonate are always present in this stone and, with increase of either, the rock grades into shaly sandstone or shaly limestone.
- Shale is used for light traffic roads and in the manufacture of brick,tile, and other burned clay products, but it is not suitable for concrete aggregate.

Conglomerate -

- Stratified rock composed of rounded pebbles of any material, such as limestone, quartz, shale, granite grains, feldspar, etc., cemented together is known as conglomerate.
- When the pebbles are quartz with siliceous binding the rock is strong and hard to quarry or dress.
- When the interstices between the pebbles are not filled by the binder, the rock is very porous, and may hold great amounts of ground water.
- This stone is seldom used in building construction.

15. TIMBER

A tree basically consists of three parts namely,trunk,crown and roots.the function of the trunk is to support the crown and to supply water and nutrients from the roots to the leaves through branches and from the leaves back to the roots.the roots are meant to implant the trees in the soil ,to absorb moisture and the mineral substancesit contains and to supply them to the trunk.

Details of structure:

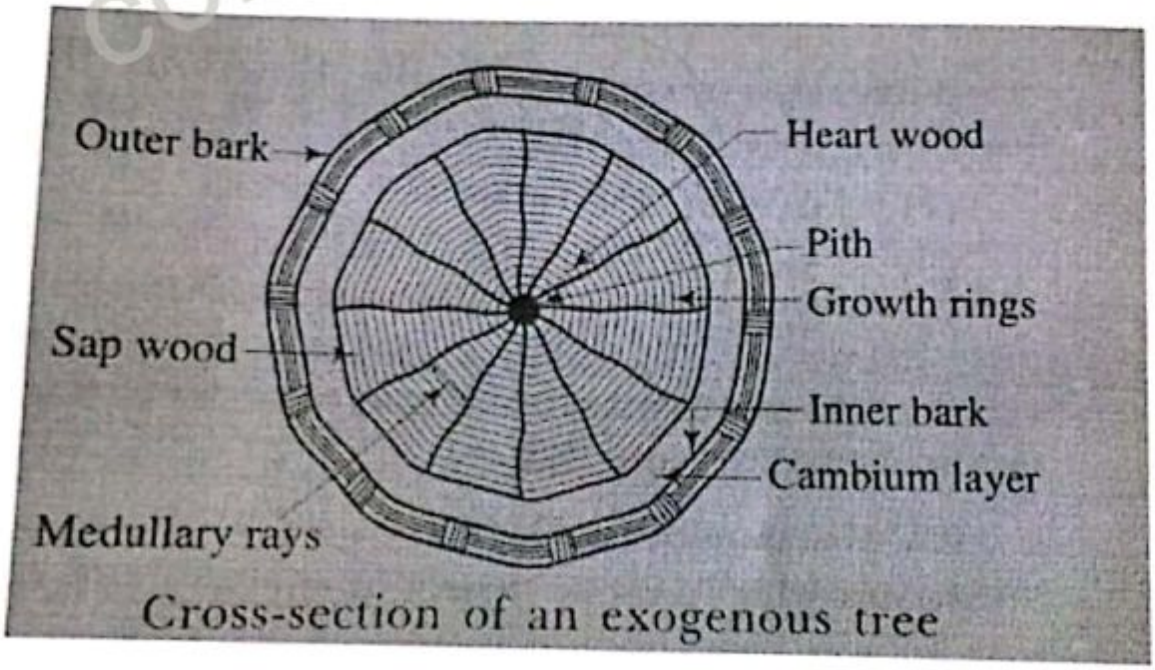
From the visibility aspect,the structure of tree can be divided into two categories :-

(1). Macrostructure

(2). Microstructure

Macrostructure:-

The structure of wood visible to the naked eye or at a small magnification is called the macrostructure.Following are its different components:



Cross-section of an exogenous tree

(1) Pith:

the innermost central portion of the core of the tree is called the pith or medulla. It varies in size and shape and for different types of trees.It consist entirely of cellular tissues and it nourishes its plant at its young age.when the plant becomes old,the pith dies up and decays and the sap is then transmitted by the woody fibres deposited round the pith.the pith of the branches is nothing but merely a prolongation of the stem.

(2) Heartwood:

The inner annular rings surrounding the pith constitute the heart wood.It is usually dark in colour .as a matter of fact ,it indicates the dead portion of tree and as such,it does not take active part in the growth of the tree.But it imparts rigidity to the tree hence it provides strong and durable timber for various engineering purposes.

(3) Sapwood:

The outer annular rings between heartwood and cambium layer is known as sapwood.It is usually light in colour in light and weight.It indicates recent growth and it contains sap.The annual rings of sap wood are less sharply defined than those of heartwood.It takes active part in the growth of the tree and the sap moves in upward direction through it. The sapwood is also known as the alburnum.

(4) Cambium layer

The thin layer of sap between sapwood and inner bark is known as the cambium layer.It indicates sap which has not yet been converted into sap wood. If the bark is removed for any reason,the cambium layer gets exposed and the cells cease to be active resulting in the death of the fibre.

(5) Inner bark:

The inner skin or layer covering the cambium layer is known as the inner bark.it gives protection to the cambium layer from any injury.

(6) Outer bark

The outer skin or cover of the tree is known as the outer bark.it is the outermost protective layer and it sometimes contain cracks and fissures.it consists of cells and wood fibre and is also known as the cortex.

(7) Medullary rays

The thin radial fibres extending from pith to cambium layer are known as the medullary rays.the function of these rays is to hold together the annular rings of heartwood and sapwood.these rays are sometimes broken and in some varieties of trees,they are not very prominent.

Microstructure:

The structure of wood apparent only at great magnifications is called the microstructure.

A living cell consists of four parts namely membrane ,protoplasm,sap and core.The cell membrane consists mainly of cellular tissues and cellulose.The protoplasm is a granular,transparent ,viscous vegetable protein composed of carbon,hydrogen,oxygen,nitrogen and sulphur.The core of cell differs from protoplasm merely by the presence of phosphorus and it is generally oval.

The cells ,according to the function they perform,are classified into the following three categories:

- Conductive cells

- Mechanical cells
- Storage cells

(1).conductive cells:

These cells serve mainly to transmit nutrient from root to the branches and leaves.

(2).mechanical cells

These cells are elongated ,thickwalledand have tightly interconnected narrow interior cavities.these cells impart strength to the wood.

(3).storage cells:

These cells serve to store and transmit nutrients to the living cells in the horizontal direction and they are usually located in the medullary rays.

Defects in timber:

Various defects occurring in timber are grouped into following five categories:

(1)defects due to conversion
(2)defects due to fungi
(3)defect due to insects
(4)defects due to natural forces
(5)defects due to seasoning

Defects due to conversion:

During converting timber to commercial form the following defects may occur:

(i) **chip *mark*:** this defect is indicated by marks placed by chips on the finished surface of timber .they may also be formed by parts of a planning machine.

(ii)**Diagonal grain**: this defect is formed due to improper sawing of timber.it is indicated by diagonal mark on straight grained surface of timber.

(iii)**Torn grain**:this defect is caused when a small depression is formed on the finished surface of timber by falling of a tool or so.

(iv)**Wane**:this defects is denoted by the presence of original rounded surface on the manufactured piece of timber.

Defects due to fungi:

Fungi attack timber only when

(1)The moisture content of timber is above 20%.

(2)If there is a presence of air and warmth for the growth of fungi.

Due to attack of fungi following defects occur:

(i)**Bluestain**:the sap of the wood is stained to bluish colour by the action of certain type of fungi.

Scanned with CamScanner

(ii) **Brown rot:**the fungi of certain types remove cellulose compound from wood and hence the wood assumes the brown colour.this is known as the brown rot.

(iii) **Dry rot:**the fungi of certain types feed on wood and during feeding ,they attack on wood and convert it into powder form.This is known as dry rot.

This type of defect occur in place where there is dampness and no free circulation of air.The dry rot may be prevented by using well seasoned timber free from sap.

(iv) **Heart rot:** this is formed when a branch has come out of a tree.It occurs when heart woodis exposed to atmospheric agent.

(v) **Sap stain:**certain types of fungi feed on cell contents of sap wood.In doing so ,the sap wood loses its colour.this is known as sap stain.It generally occurs when moisture content goes beyond 25 % or so.

(vi) **Wet rot:**some varietiesof fungi cause chemical decomposition of wood of timber in doing so timber is converted into a greyish brown powder.This is known as wet rot.

(iv) **White rot:**this defect is opposite of brown rot.In this defect the wood assumes the appearance of a white mass consisting of cellulose compounds.

Defect due to insects:

Defects in timber occur dueto various types of insects.

Such as:

(1) beetles

(2)marine borers

(3)termites

Decay of timber occurs due to the above insects.

Defect due to natural force:

The main natural forces responsible for causing defects in timber two,namely,abnormal growth and rupture of tissues.

(i) Burls:these are also known as the excrescences and they are particularly formed when a tree has received shock or injury in is young age. Due to such injury, the growth of tree is completely upset and irregular projections appear on the body of timber.

(ii) Callus:it indicates soft tissues or skin which covers the wound of a tree.

(iii) Chemical stain: the wood is sometimes discoloured by the chemical action caused with it by some external agency.

(iv) Coarse grain: if a tree grows rapidly, the annual rings are widened. Such timber possesses less strength.

(v) Dead wood: the timber which is obtained from dead standing trees contains dead wood.

(vi)Druxiness: this defect is indicated by white decayed spots which are concealed by healthy wood.

(vii) Foxiness: this defect is indicated by red or yellow tinge in wood or reddish brown stains or spots round the pith of tree discolouring the timber. It is caused due too poor ventilation.

(viii) Knots: these are the bases of branches or limbs which are broken or cut off from the tree. The portion from which the branch is removed receives nourishment from the stem for a pretty long time and it ultimately results in the formation of dark hard rings which are known as the knots.

(ix) Rind galls: the rind means bark and gall indicates abnormal growth. Hence peculiar curved swelling found on the body of a tree known as the rind gall.

(x) Shakes: these are cracks which partly or completely separate the fibres of wood. Following are the different types of shakes: cup shake, heart shake, ring shake, star shake, radial shake.

(xi) Twisted fibres: these are also known as the wandering hearts and they are caused by twisting of young trees by fast blowing wind.

(xii) Upset: these are also known as the ruptures and they indicate the wood fibres which are injured by crushing or compression.

(xiii) water stain: the wood is sometimes discoloured when it comes into contact with water. Thi defect is usually found in converted timber.

(xiv) Wind cracks:if wood is exposed to atmospheric agencies, its exterior surface shrinks. These are known as the wind cracks.

Defects due to seasoning:

Following defects occur in the seasoning process of wood.

(i) Bow: the defect is indicated by the curvature formed in the direction of length of timber.

(ii) case-hardening: the exposed surface of timber dries very rapidly. It therefore shrinks and is under compression. The interior surface which has not completely dried under tension. This defect is known as the case-hardening.

(iii) Check: a check is a crack which separates fibres of wood. It does not extend from one end to the other.

(iv)Collapse: due to uneven shrinkage, the wood sometime flattens during drying. This is known as collapse.

(v) Cup: this defect is indicated by the curvature formed in the transverse direction of timber.

(vi) Honey-combing: due to stresses developed during drying, the various radial and circular cracks in the interior portion of timber. This defect is known as honey-combing.

(vii) Radial shake: these are radial cracks.

(viii) Split: when a check extends from one end to the other, it is known as a split.

(ix) Twist: when a piece of timber has spirally distorted along its length, it is known as a twist.

(x)Warp:when a piece of timber has twisted out of shape, it is said to have warped.

TIMBER

TIMBER is the oldest material used by humans for construction after stone. Despite its complex chemical nature, wood has excellent properties which lend themselves to human use. It is readily and economically available; easily machinable; amenable to fabrication into an infinite variety of sizes and shapes using simple on-site building techniques;

- Exceptionally strong relative to its weight
- A good heat and electrical insulator
- It is a renewable and biodegradable resource.

However, it also has some drawbacks of which the user must be aware. It is a **"natural"** material and is available in limited amount.

Preservation:

Preservation of timber means protecting timber from fungi and insects attack so that its life is increased. Timber is to be seasoned well before application of preservatives. The following are the widely used preservatives:

1.Tar
2.Paints
3.Chemicalsalt
4.Creosote
5. ASCO

1.Tar

Hot coal tar is applied to timber with brush. The coating of tar protects the timber from the attack of fungi and insects. It is a cheapest way of protecting timber. Main disadvantage of this method of preservation is that appearance is not good after tar is applied it is not possible to apply other attractive paints. Hence tarring is made only for the unimportant structures like fence poles.

2.Paints

Two to three coats of oil paints are applied on clean surface of wood. The paint protects the timber from moisture. The paint is to be applied from time to time. Paint improves the appearance of the timber. Solignum paint is a special paint which protects the timber from the attack of termites.

3. Chemical salt

These are the preservatives made by dissolving salts in water. The salts used are copper

sulphate, masonry chloride, zinc chloride and sodium fluoride. After treating the timber with these chemical salt paints and varnishes can be applied to get good appearance.

4. Creosote

Creosote oil is obtained by distillation of coal tar. The seasoned timber is kept in an air tight chamber and air is exhausted. Then creosote oil is pumped into the chamber at a pressure of 0.8 to 1.0 N/mm2 at a temperature of 50°C. After 1 to 2 hours timber is taken out of the chamber.

5.ASCO

This preservative is developed by the Forest Research Institute, Dehradun. It consists of 1 part by weight of hydrated arsenic pentoxide (As_2O_5, 2 H_2O), 3 parts by weight of copper sulphate. ($CuSO_4 \cdot 5\ H_2O$) and 4 parts by weight of potassium dichromate ($K_2Cr_2O_7$) or sodium dichromate ($Na_2Cr_2O_7 \cdot 2\ H_2O$). This preservative is available in powder form. By mixing six parts of this powder with 100 parts of water, the solution is prepared. The solution is then sprayed over the surface of timber. This treatment prevents attack from termites. The surface may be painted to get desired appearance.

Physical Properties:

Specific Gravity (SG):

Generally, specific gravity (SG) and the major strength properties of wood are directly related. SG for the major , usually used structural species ranges from roughly 0.30 to 0.90. Higher allowable design values are assigned to those pieces having narrower growth rings (more rings per inch) or more dense latewood per growth ring and, hence, higher SG.

Thermal Properties/Temperature Effects:

Although wood is an excellent heat insulator, its strength and other properties are affected adversely by exposure for extended periods to temperatures above about 100°F. The combination of high relative humidity or MC and high temperatures, as in unventilated attic areas, can have serious effects on roof sheathing materials and structural elements over and above the potential for attack by decay organisms. Simple remedies and caution usually prevent any problems.

At temperatures above 220°F, wood takes on a thermoplastic behavior. This characteristic, which is rarely encountered in normal construction, is an advantage in the manufacture of some reconstituted board products, where high temperatures and pressures are utilized.

Environmentally friendly

Timber is the most environmentally responsible building material. Timber has low production energy requirements and is a net carbon absorber. Timber is a renewable resource. Well-managed forests produce timber on a sustained continuous basis, with minimal adverse effects on soil and water values.

In plentiful and growing supply

Timber is readily available. Australia has significant forest resources including a plantation estate covering more than 1.6 million hectares, and the area is growing rapidly.

Strong and lightweight

Timber is strong, light and reliable making timber construction simpler and safer than steel or concrete construction. A comparison with steel and concrete shows that radiata pine structural timber, for example, has a strength for weight ratio 20 percent higher than structural steel and four to five times better than unreinforced concrete in compression. The lightweight structures possible in wood confer flow-on advantages in terms of reduced foundation costs, reduced earthquake loading and easier transport. Building components and complete constructions are simple and safe to erect, and cheaper to deconstruct or reuse at the end of a buildingís useful life.

Chemical Properties

Though, would is chemically inert as compared to other materials but is affected by some acids and bases. Some species have proven very useful for food containers (berry boxes and crates) because they are nontoxic and impart no taste to the foods contained therein. Wood structures have also found widespread use as storage facilities for salt and fertilizer chemicals

DRY ROT

The turning of timber tissues to almost dry powder by fungi is called dry rot.The fungus feed upon the wood and eats the wood tissue, thus penetrating the wood fibres from all direction.

Prevention:

1.well seasoned timber should be used.
2.timber should be used where there is free circulation and access of air.

Remedy:

1. the timber should be painted with a solution of copper sulphate

2.the high temperature of seasoning of kiln helps in killing the Fungi.

WET ROT

The disintegration of tissue of timber due to alternate wetting and drying is called wet rot. The attacks take place through the wounds in bark by the access of water.

Prevention:

All timber for exterior or underground work should
be first properly seasoned and then coated with tar to keep out the dampness.

Remedy:

The best remedy for treating wet rot is by using a suitable preservative

Seasoning of Timber

From day to day, most people have some contactwith "seasoned" timber. From childhood days woodencots and toys, to school desks and, eventually, to wooden furniture and flooring in homes or places of employment - seasoned timber is to be found. Yet how many people really understand what seasoned timber is?

Only when cracks appear in furniture or floor, orwhen a door shows some degree of warping, is anythought given to this concept. It is to be regretted thateven some people associated with the timber tradehave little knowledge of what seasoned timber is andthe best method of obtaining it.

What is "seasoned" timber?

The process of drying out the water from "wet" or"green" timber is termed "seasoning", or more simply"drying". Water is just as essential to the life of atree as it is for all living matter. Together with thevarious minerals, it enters through the roots of the treeand is carried in the sapwood - the outer woody part tothe leaves. The food, that is the sugars and starch,are made in the leaves by photosynthesis and aretransported in solution down the inner bark to thegrowing cells. The whole trunk of the tree is made upof cells, which are like small tubes, having walls ofcellulose and a more or less hollow' cavity filled withwater and other materials known as sap. Consequently,when the tree is felled and the resulting logis sawn into timber, the sawn sections consist ofinnumerable small cells containing water. Drying themoisture out of wood enhances its properties to suchan extent that the resulting timber is given the specialname "seasoned" rather than "dried" although theterms are identical.

Why is timber seasoned?

Seasoning timber causes many changes in its properties, and in practically every case the change is animprovement. There is only one principal disadvantagein drying timber, namely, the loss in volume dueto shrinkage. However, by a correct understandingof the shrinkage of timber this effect can be minimized,and timber can then be confidently usedwithout fear of adverse behaviour subsequently inservice.

Types of Seasoning

(i) Natural Seasoning: It may be air seasoning or water seasoning. Air seasoning is carried out in a shed with a platform. On about 300 mm high platform timber balks are stacked as shown in Fig. 1.8.

(ii)

Care is taken to see that there is proper air circulation around each timber balk. Over a period, in a natural process moisture content reduces. A well-seasoned timber contains only 15% moisture. This is a slow but a good process of seasoning. Water seasoning is carried out on the banks of rivers. The thicker end of the timber is kept pointing upstream side. After a period of 2 to 4 weeks the timber is taken out. During this period sap contained in the timber is washed out to a great extent. Then timber is stalked in a shed with free air circulation.

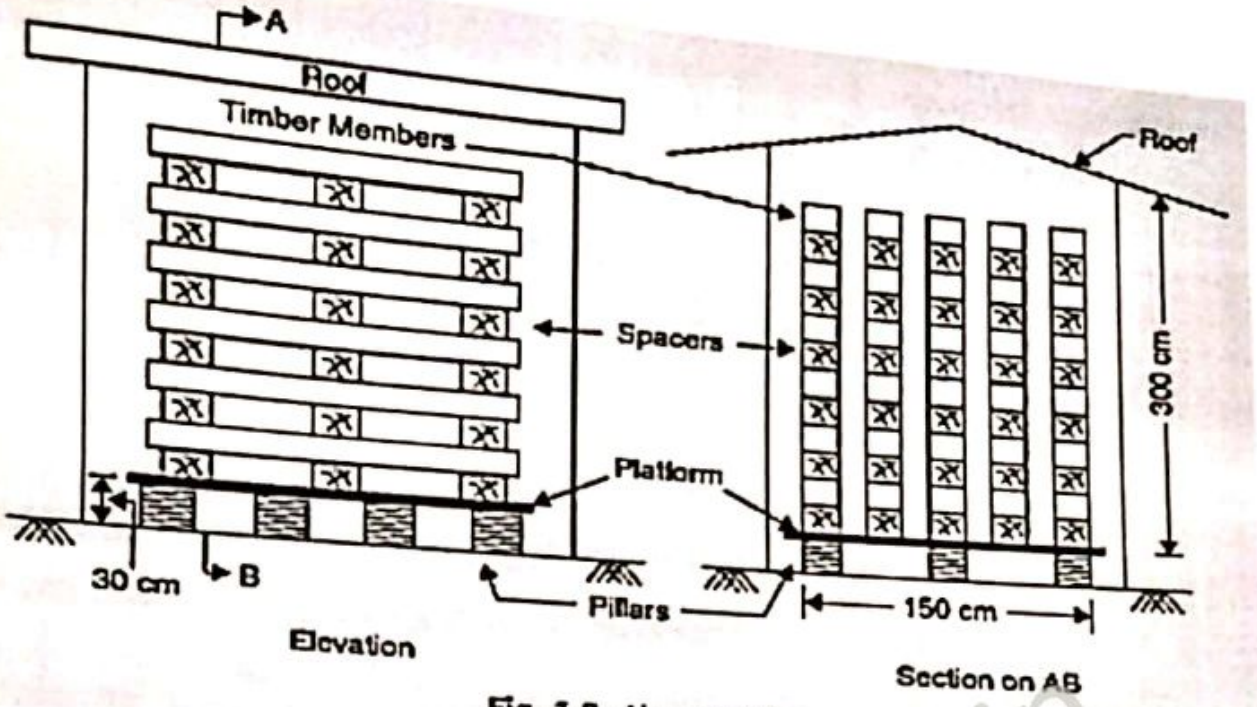


Fig. 1.8. Air seasoning

(iii) **Artificial Seasoning:** In this method timber is seasoned in a chamber with regulated heat,controlled humidity and proper air circulation. Seasoning can be completed in 4 to 5 days only. The different methods of seasoning are:

(a) Boiling
(b) Kiln seasoning
(c) Chemical seasoning
(d) Electrical seasoning.

(a) Boiling: In this method timber is immersed in water and then water is boiled for 3 to 4 hours.Then it is dried slowly. Instead of boiling water hot steam may be circulated on timber.The process ofseasoning is fast, but costly.

(b) Kiln Seasoning: Kiln is an airtight chamber. Timber to be seasoned is placed inside it. Thenfully saturated air with a temperature 35°C to 38°C is forced in the kiln. The heat gradually reachesinside timber. Then relative humidity is gradually reduced and temperature is increased, and maintained till desired degree of moisture content is achieved.

The kiln used may be stationary or progressive. In progressive kiln the carriages carrying timber travel from one end of kiln to other end gradually. The hot air is supplied from the discharging end so that temperature increase is gradual from charging end to discharging end. This method is used for seasoning on a larger scale.

(c) Chemical Seasoning: In this method, the timber is immersed in a solution of suitablesalt.Then the timber is dried in a kiln. The preliminary treatment by chemical seasoning ensures uniform seasoning of outer and inner parts of timber.

(d) Electrical Seasoning: In this method high frequency alternate electric current is passed through timber. Resistance to electric current is low when moisture content in timber is high.

As moisture content reduces the resistance reduces. Measure of resistance can be used to stop seasoning at appropriate level.

However it is costly process. This technique has been tried in some plywood industries but not in seasoning of timber on mass scale.

Different methods of seasoning:

Air Seasoning

The traditional method for drying wood, air seasoning is also the longest, taking six to nine months. To air season wood, stack logs or planks outside on pallets in such a manner that air can circulate vertically and horizontally through the timbers. The raised pallets also keep wood away from vegetation and damp ground. Plank and log ends are often wrapped or sealed to prevent excessive moisture loss through these areas. Protect the drying wood from the elements with an overhead canopy.

Kiln Seasoning

The most common and effective commercial process for drying wood is kiln seasoning, which accelerates the process of removing moisture through the use of external energy. Drying takes two days to one weekend, depending on the type of wood. Two methods, progressive and compartmental, are used for kiln seasoning. In a progressive kiln, timber enters at one end and travels on a trolley through chambers with different air conditions to progressive dry the wood. This method produces a constant flow of seasoned timber. Wood seasoned via the compartmental process remains in a single building where it is subjected to a program of varying conditions until the moisture content is removed. This process is used for hard-to-dry or expensive wood.

Solar Kiln

This method combines the speed of kiln seasoning with the low energy of air drying. Solar kilns have single-thickness windows on the south side of the structure that work as collectors to trap the sun's energy. Heat collectors, made from black metal are attached near the top of the window sashes. Various methods force the heated air to circulate through the kiln to dry the wood. Some solar kilns have insulation to retain heat at night. This process takes approximately twice as long as traditional kiln seasoning. Because of its gentle nature, it is well suited to producing wood for furniture fabrication.

Microwave Seasoning

Microwave seasoning uses pulsed energy directed into timbers to drive out moisture in a manner that will not cause seasoning degrade. This method also provides advantages such as high speed and high quality and is well suited for seasoning lumber, blocks, veneer, chips, paper and wood-based composite materials. Areas in the wood with the most moisture absorb the most energy resulting in even temperature during the drying process and a uniform moisture content. These factors enhance quality and reduce timber checking and warping.

Advantages of seasoning:

Three most important advantages of seasoning have already been made apparent:

1. Seasoned timber lasts much longer than unseasoned. Since the decay of timber is due to the attacks of wood-destroying fungi, and since the most important condition of the growth of these fungi is water, anything which lessens the amount of water in wood aids in its preservation.

2. In the case of treated timber, seasoning before treatment greatly increases the effectiveness of the ordinary methods of treatment, and seasoning after treatment prevents the rapid leaching out of the salts introduced to preserve the timber.

3. The saving in freight where timber is shipped from one place to another. Few persons realize how much water green wood contains, or how much it will lose in a comparatively short time. Experiments along this line with lodge-pole pine, white oak, and chestnut gave results which were a surprise to the companies owning the timber.

Freight charges vary considerably in different parts of the country; but a decrease of 35 to 40 per cent in weight is important enough to deserve everywhere serious consideration from those in charge of timber operations.

When timber is shipped long distances over several roads, as is coming to be more and more the case, the saving in freight will make a material difference in the cost of lumber operations, irrespective of any other advantages of seasoning.

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

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Table 1.1 : Comparison of Stone with Bricks as a Material of Construction

Sl. No.	Stone	Brick
1.	It is a natural material.	It is manufactured from clay.
2.	It is heavier.	It is lighter.
3.	It costs much to dress it to required shape and size.	It can easily be moulded to any shape or size.
4.	It is more costly except in hilly areas.	Except in hilly areas, it can be locally manufactured and is cheaper.
5.	It is less porous and therefore better suited for construction of water retaining structures.	It is more porous and requires costly water proofing treatment when used for constructing water retaining structures.
6.	Because of more strength, it is better suited for constructing structures carrying extra heavy loads or subjected to heavy pressures, e.g. harbour, dock and forts etc.	Reasonably good for normal loads.
7.	It is a better conductor of heat.	It is a poorer conductor of heat.
8.	It withstands attacks of weather better.	It is good for normal conditions but needs protection by way of plastering and pointing.
9.	Superior qualities of stones are used for constructing monuments and for decoration.	Good quality bricks are sometimes left unplastered to achieve some Architectural effect.

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- 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.**
- The bricks available in most part of the country still are 9" × 4½" × 3" and are known as field bricks. Weight of such a brick is 3.0 kg.
- An indent called frog, 1–2 cm deep, is provided for 9 cm high bricks.
- The size of frog should be 10 × 4 × 1 cm.

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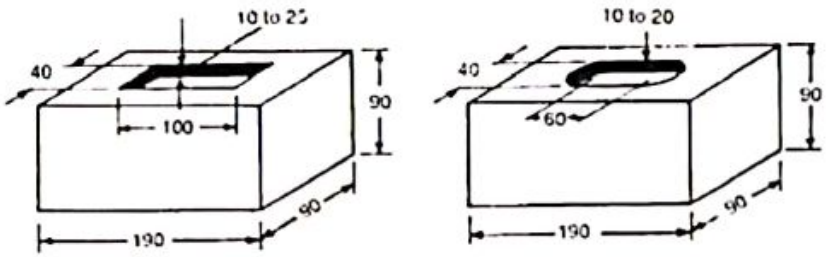
- The purpose of providing frog is to form **a key** for **holding the mortar** and therefore, the bricks are laid with frogs on top.
- Frog is not provided in 4 cm high bricks and extruded bricks.



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Chemical Composition of Brick Earth

- Alumina or clay = 20-30 % by weight
- Silica or sand = 35 – 50 % by weight
- Silt = 20-25% by weight

(Total content of clay and silt may preferably be not less than 50% by weight)

- Remaining ingredients, include

i. Iron oxide
ii. Magnesia (MgO)
iii. Lime (CaO)
iv. Sodium potash, etc.,

1-2% by weight

Total lime and magnesia in case of alluvial soil should not more than 1 % and in other cases should not be preferably more than 15%.

The total soluble material should not be more than 1 % by weight

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Functions of constituents of brick earth

- **Alumina:**
  - It is the chief constituent of every clay. A good brick earth should contain about 20% to 30% of alumina.
  - This impart plasticity to the earth so that it can be moulded.
  - If alumina is present in excess, with inadequate quantity of sand, the raw bricks shrink and warp during drying and burning and become too hard when burnt.

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Functions of constituents of brick earth (contd.)

- **Silica**
  - It exists in clay either as free or combined.
  - As free sand, it is mechanically mixed with clay and in combined form, it exists in chemical composition with alumina
  - A good earth brick should contain 35% to 50% of silica.
  - It prevents cracking, shrinkage and warping of raw bricks. It imparts uniform shape to the bricks.
  - The durability of bricks depends on the proportion of silica in brick earth.
  - The excess of silica destroys the cohesion between particles and the bricks become brittle.

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Functions of constituents of brick earth (contd.)

- **Lime**
  - It should be present in a very finely powdered state because even small particles of the size of a pin-head cause flaking of the bricks.
  - It prevents shrinkage of raw bricks.
  - The sand alone is infusible. But it slightly fuses at kiln temperature in presence of lime. Such fused sand works as a hard cementing material for brick particles.
  - The excess of lime causes the brick to melt and hence its shape is lost.
  - The lumps of lime are converted into quick lime after burning and this quick lime slakes and expands in presence of moisture. Such an action results in splitting of bricks into pieces.

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Functions of constituents of brick earth (Contd.)

- **Oxide of iron:**
  - It helps as lime to fuse sand.
  - It also impart red colour to the bricks.
  - The excess of oxide of iron makes brick dark blue or blackish.
  - If the quantity of iron oxide is comparatively less, the bricks will be yellowish in colour.
- **Magnesia**
  - A small quantity of magnesia in brick earth imparts yellow colour to the bricks and decreases shrinkage.
  - But excess of magnesia leads to the decay of bricks

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Testing of Bricks

- Compressive strength Test.
- Specimen brick is immersed in water for 24 hours
- The frog of brick is filled flush with 1:3 mortar and brick is stored under damp jute bags for 24 hours followed by immersion in clean water for three days.
- The specimen is then placed between plates of compression testing machine.
- Load is applied axially at uniform rate till failure. Maximum load at failure divided by average area of bed face gives compressive strength.
- $compressive\ strength = \frac{maximum\ load\ at\ failure}{loaded\ area\ of\ brick}$

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Testing of Bricks

- Absorption Test.
  - 24 hours immersion cold water test.

    Dry bricks are oven dried at 105° ± 5° C
    Room temperature cooled bricks weighed W_1
    Bricks immersed in water at 27° ± 2° C for 24 hrs
    Soaked bricks weighed W_2
    Water absorption in % = $(W_2 - W_1)/W_1 \times 100$
  - Five hours boiling water test

    Oven dried bricks weight : W1
    Bricks immersed in water and boiled for 5 hours and then cooled down at room temperature in 16-19 hours
    Cooled down weight as W2
    Water absorption in % = $(W_2 - W_1)/W_1 \times 100$

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Testing of Bricks

- Efflorescence Test. The soluble salts if present in bricks cause efflorescence on the surface of brick.
- Brick is immersed in water for 24h. 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.
  - Nil — imperceptible efflorescence
  - Slight — deposit covers area < 10% of exposed area
  - Moderate — deposit covers exposed area 10% to 50%
  - Heavy — deposit covers exposed area > 50%
  - Serious — deposits are heavy and powder or flake away the surface

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Testing of Bricks

- Structure Test. A specimen is broken and its structure is examined.
  - It should be homogeneous, compact, and free from defects e.g., lumps and holes, etc.
- Soundness test. This test is performed by striking two specimen bricks with each other. The bricks should not break and a clear ringing sound should be produced.
- Hardness test. This test is performed by making a scratch on brick surface with the help of finger nail. If no impression is left on surface, the brick is considered to be sufficiently hard.

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Testing of Bricks

- **Shape and size test**
  - In this test, a specimen brick should be closely inspected.
  - It should be of standard size and its shape should be truly rectangular with sharp edges.
  - 20 bricks of standard size (190mm x 90mm x90mm) are randomly selected and stacked length-wise, along the width and along the height.
  - For good quality bricks, the results should be within the following permissible limits:
    - **Length : 3680 mm to 3920 mm**
    - **Width : 1740 mm to 1860 mm**
    - **Height: 1740 mm to 1860 mm**

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Special Bricks

- Specially shaped bricks
- Burnt clay facing bricks
- Heavy duty bricks
- Perforated bricks
- Burnt clay hollow bricks
- Sandlime bricks
- Sewer bricks
- Acid resistant bricks

Special shaped bricks

- Bull-nosed bricks
- Cant or plinth bricks
- Circular bricks
- Squint bricks
- Cornice bricks
- Coping bricks
- Paving bricks

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Specially Shaped Bricks

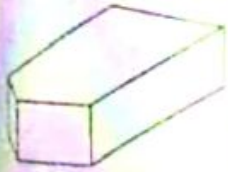
1. Specially shaped bricks:

These are bricks of special shapes to suit different situations in which they are used. Specially

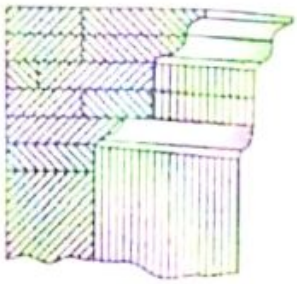
(i) Bull-nosed brick

(ii) Cant or plinth brick

(iii) Circular brick



(iv) Squint brick



(v) Cornice brick

(vi) Coping brick

(vii) Chequered brick

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Defects of Bricks

- Over-burning. Burnt beyond complete vitrification
- Under-burning. Burnt less not to cause complete vitrification
- Bloating. Spongy swollen mass over the surface due to excess carbonaceous matter and sulphur
- Black Core. Due to bituminous matter or carbon

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- Efflorescence. Grey of white crystallization of alkalis on the surface, due to water absorption
- Spots. Dark sulphur spots due to iron sulphides
- Blisters. Broken blisters due to air entrapped during molding
- Laminations. Thin lamina produced due to air entrapped in voids of clay

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Substitutes for Bricks

- **Reason for Alternatives**
  - High wastage during transportation
  - High water absorption of bricks
  - Inconsistency in size of bricks
  - Increasing cost of kiln fuel
  - Unavailability of skilled labour.
- **Substitutes**
  - Concrete blocks
  - Flyash bricks
  - Sand-lime or calcium bricks.

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What are the types of cement?

Followings are the types of cement:

- Ordinary Portland Cement (OPC)
- Portland Pozzolana Cement (PPC)
- Rapid Hardening Cement.
- Quick setting cement.
- Low Heat Cement.
- Sulphates resisting cement.
- High Alumina Cement.
- White Cement.

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Cement is one of the most important materials used in construction. The strength of a structure depends upon several factors, cement quality is one of them. To achieve the desired strength of concrete and to increase the longevity of structure good quality cement should always be used.

So it is important to check the quality of cement before using. In our previous article, we have already discussed the different types of cement and th eir uses in construction. Today we will discuss how to check the quality of cement at site.

To check the quality of cement we need to pass some easy tests which are described below.

1. Date Of Packing:

The strength of cement decreases with time. First of all, check the manufacturing date in the bag before using. Generally, cement should be used before 90 days from the manufacturing date. The percentage of strength loss of cement is given in the below table.

Age of Cement	% Reduction In its Strength
3 Months	20-30
6 Months	30-40
12 Months	40-50

2. Cement Color:

The cement should be uniform in color. Good quality cement should have gray color with greenish shade.

3. Check For Lumps:

No lumps should be present in the cement. Lumps are formed due to absorption of moisture from the climate.

4. Rubbing Test:

Cement should feel smooth while rubbing in between fingers. If it gives a rough feeling that means cement is mixed with sand.

5 Temperature Test:

Simply insert your hand into the cement bag, it should give cool feeling if its quality is good. Otherwise, you may feel warm because of hydration reaction.

6. Float Test:

Take some amount of cement and throw it in water. The cement should float for sometimes before it sinks in the water.

7. Setting Test:

Make a thick cement paste with water and immerse it in water for 24 hours. It should be set and should not develop cracks.

8. Strength Test:

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Cement is made by heating limestone (calcium carbonate) with small quantities of other materia (such as clay) to 1450°C in a kiln. The resulting hard substance, called 'clinker', is then ground wit a small amount of gypsum into a powder to make 'Cement', the most commonly used type of cement. This cement is called Ordinary Portland Cement

Ordinary Portland Cement (OPC) is the most common **cement** used in general concrete construction when there is no exposure to sulphates in the soil or groundwater.

Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-speciality grout. It was developed from other types of hydraulic lime in England in the mid 19th century and usually originates from limestone.

To retard the faster setting time of **cement** resulted from (C3A) compound a percentage of raw **gypsum** (selenite) is **added** during the grinding of the clinker.

OPC is environment friendly as well as economical.
Ordinary Portland Cement (OPC-53, OPC-43, OPC-33).

The 43 grade OPC is the most popular general-purpose cement in India. The OPC can be used for following applications:

- General Civil Engineering construction work
- RCC works(preferably where grade of concrete is up to M-30)
- Pre-cast items such as blocks, tiles, pipes etc
- Asbestos products such as sheets and pipes
- Non-structural works such as plastering, flooring etc.

Portland Pozzolana Cement (PPC)

The Portland Pozzolana Cement is a kind of Blended Cement which is produced by either inter grinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions or grinding the OPC clinker, gypsum and Pozzolanic materials separately and thoroughly blending them in certain proportions.

Portland Pozzolana *Cement* also commonly known as *PPC cement*. These types of *cement* are manufactured by using pozzolanic materials as one of the main ingredient. The percentage of pozzolanic material used in the preparation should be between 10 to 30. If the percentage is exceeded, the strength of *cement*is reduced.

Pozzolana is a natural or artificial material containing silica in a reactive form. It may be further discussed as siliceous or siliceous and aluminous material which in itself possesses little, or no cementitious properties but will in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. It is essential that pozzolana be in a finely divided state as it is only then that silica can combine with calcium hydroxide (liberated by the hydrating Portland Cement) in the presence of water to form stable calcium silicates which have cementitious properties.

The pozzolanic materials commonly used are:

- Volcanic ash
- Calcined clay

The physical tests which are generally performed to determinethe acceptability of cements are –

1. Fineness Test
2. Consistency Test
3. Setting time Test
4. Soundness Test
5. Strength Test
6. Heat of Hydration Test
7. Specific Gravity Test

1. Fineness Test

Fineness is the mean size of cement grain. Fineness test is done to measure the mean size of cement grain.

The finer the cement the surface area for hydration will be large and it increases the strength of cement. But the fineness varies in different types of cement.

Following three methods are applied to test the fineness of cement

Sieve method

Air Permeability method

Sedimentation method

2. Consistency Test

This test is done to estimate the required water quantity to form a normal consistency cement paste. It is defined as the percentage of water required for the cement paste.

3. Setting Time Test

Cement has two types of setting time, one is initial setting time and another is final setting.

Initial setting time is the state of cement mortar or concrete when it starts to become stiffen and unworkable.

Final setting time is the state when cement mortar or concrete has become fully unworkable.

Two methods are used to find the initial and final setting time of cement

Vicat needle method, and

Gillmore needle method

4. Soundness Test

Soundness of cement means it doesn't undergo large volume change after setting. Large changes in volume produce cracks, disintegration and distortion, ultimately leading to failure. So it is very important to test the soundness of cement.

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ment is one of the most used material when it comes to construction. Every single construction project has the need for cement and steel. From foundations to strengthening the walls, cement is a very important building material.

It is generally well known for its impeccable physical properties, which are:

- **Fineness:**
  The uniform size among the particles in the cement is the main reason for their undeterrable strength. The finer the particles the perfect the strength build-up in them. High fineness denotes that there is more area available for water reaction in the cement.
- **Soundness:**
  The ability to not change the properties when water is mixed with it is called as soundness. Material which is sound, don't get cracks or structural weakness easily. This is the sole reason for cement being very useful. Concrete and mortar, which are made from cement. have high soundness.
- **Consistency:**
  The uniformity in the particle nature is what makes the whole material very consistent. Due to regularity, the whole finished product is very consistent in strength.
- **Setting Time:**
  The time at which the cement paste loses its plasticity after the addition of water is known as initial Setting Time. The time consumed by paste to become hard mass is known as final Setting Time. The initial setting time is required for mixing, transporting and placing of the concrete. At the time of initial setting time the temperature rises rapidly and at the final setting time, the temperature reaches the peak value.
- **Heat of Hydration:**
  The chemical reaction between cement and water is known as hydration of cement and heat generated in this is known as heat of hydration.
- **Comprehensive strength:**
  This is the strength of cement which helps it to resist Compressive stress.

'o test the soundness two methods can be applied.

.e-chatelier method

Autoclave method

5. Strength Test

Cement has two types of strength – compressive strength and tensile strength.

To know the compressive strength and tensile strength of cement following tests are performed –

Cement mortar cube test (for compressive strength)

Briqutte test (for tensile strength)

Split tensile test (for tensile strength)

6. Heat of Hydration Test

Cement produce large amount of heat during hydration process. When large amount of concrete volume is poured the inner temperature is greater than outer surface of concrete. Because outer surface is exposed to weather. Thus surface shrinks rapidly than the inner and tends to produce cracks. That is why it is important to test the heat of hydration of cement.

Following test is performed to know the heat of hydration of cement

Calorimeter method

7. Specific Gravity test

Specific gravity of cement is a comparison of weight of a cement volume to the weight of same volume of water.

Le-chaterlier flask is used to test the specific gravity of cement.

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Initial and Final Setting time of Cement

Krishna October 6, 2017 5 Comments

Contents [show]

Setting time of cement:

When cement is mixed with water, it hydrates and makes cement paste. This paste can be moulded into any desired shape due to its plasticity. Within this time cement continues with reacting water and slowly cement starts losing its plasticity and set harden. This complete cycle is called Setting time of cement.

Initial Setting time of Cement:-

The time to which cement can be moulded in any desired shape without losing it strength is called Initial setting time of cement

Or

The time at which cement starts hardens and completely loses its plasticity is called Initial setting time of cement.

Or

The time available for mixing the cement and placing it in position is an Initial setting time of cement. If delayed further, cement loses its strength.

For Ordinary Portland Cement, The initial Setting Time is 30 minutes.

Final setting time of Cement:-

The time at which cement completely loses its plasticity and became hard is a final setting time of cement.

Or

The time taken by cement to gain its entire strength is a Final setting time of cement.

For Ordinary Portland Cement, The Final Setting Time is 600 minutes (10hrs).

Significance of calculating Initial and final setting time of cement:-

Well, After mixing cement with water, it takes time to place the cement paste in position, initial setting time possess a primary role in strength & it is mandated that cement paste or concrete is placed in position before it crosses initial setting time i.e..30mins. And it shouldn't be disturbed until it completes Final setting time i.e.. 600mins for Ordinary Portland Cement.

Also Read:-**How to calculate Normal or standard consistency of cement**

Factors that affect initial and final setting time of cement:-

The fineness of cement, the presence of salts in sand, atmospheric conditions. For example, cement requires a temperature of 27°c to complete Hydration, during winters the climate is low which stops the hydration and takes a longer time to set harden.

Calculation of Initial and Final Setting time of Cement:-

As Per **IS: 4031 (Part 5) – 1988.** Initial and final setting time of cement is calculated using VICAT apparatus conforming to IS:

Types of Cement:

Following are the different types of cement used in construction works.

1. Rapid Hardening Cement:

Rapid hardening cement is very similar to ordinary portland cement (OPC). It contains higher c3s content and finer grinding. Therefore it gives greater strength development at an early stage than OPC. The strength of this cement at the age of 3 days is almost same as the 7 days strength of OPC with the same water-cement ratio.

The main advantage of using rapid hardening cement is that the formwork can be removed earlier and reused in other areas which save the cost of formwork. This cement can be used in prefabricated concrete construction, road works, etc.

2. Low Heat Cement:

Low heat cement is manufactured by increasing the proportion of C_2S and by decreasing the C_3S and C_3A content. This cement is less reactive and its initial setting time is greater than OPC. This cement is mostly used in mass concrete construction.

3. Sulfate Resisting Cement:

Sulfate resisting cement is made by reducing C_3A and C_4AF content. Cement with such composition has excellent resistance to sulfate attack. This type of cement is used in the construction of foundation in soil where subsoil contains very high proportions of sulfate .

4. White Cement:

White cement is a type of ordinary Portland Cement which is pure white in color and has practically the same composition and same strength as OPC. To obtain the white color the iron oxide content is considerably reduced. The raw materials used in this cement are limestone and china clay.

This cement, due to its white color, is mainly used for interior and exterior decorative work like external renderings of buildings, facing slabs, floorings, ornamental concrete products, paths of gardens, swimming pools etc.

5. Portland Pozzolana Cement:

Portland pozzolana cement is produced either by grinding together, portland cement clinkers and pozzolana with the addition of gypsum or calcium sulfate or by intimately and uniformly blending portland cement and fine pozzolana.

It produces lower heat of hydration and has greater resistance to attack of chemical agencies than OPC. Concrete made with PPC is thus considered particularly suitable for construction in sea wate hydraulic works and for mass concrete works.

6. Hydrophobic Cement:

Hydrophobic cement is manufactured by adding water repellant chemicals to ordinary portland cement in the process of grinding. Hence the cement stored does not spoiled even during monsoo This cement is claimed to remain unaffected when transported during rains also. Hydrophobic cement is mainly used for the construction of water structures such dams, water tanks, spillways water retaining structures etc.

7. Colored Cement:

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This Cement is produced by adding 5- 10% mineral pigments with portland cement during the time of grinding. Due to the various color combinations this cement is mainly used for interior and exterior decorative works.

8. Waterproof Portland Cement:

Waterproof cement is prepared by mixing with ordinary or rapid hardening cement, a small percentage of some metal stearates (Ca, Al, etc) at the time of grinding. This cement is used for the construction of water-retaining structure like tanks, reservoirs, retaining walls, swimming pools, dams, bridges, piers etc.

9. Portland Blast Furnace Cement:

In this case, the normal cement clinkers are mixed with up to 65% of the blast furnace slag for the final grinding. This type of cement can be used with advantage in mass concrete work such as dams, foundations, and abutments of bridges, retaining walls , construction in sea water.

10. Air Entraining Cement:

It is produced by air entraining agents such as resins, glues, sodium salts of sulfate with ordinary portland cement.

11. High Alumina Cement:

High alumina cement (HAC) is a special cement, manufactured by mixing of bauxite (aluminum ore) and lime at a certain temperature. This cement is also known as calcium aluminum cement (CAC). The compressive strength of this cement is very high and more workable than ordinary portland cement.

12. Expansive Cement:

The cement which does not shrink during and after the time of hardening but expands slightly with time is called expansive cement. This type of cement is mainly used for grouting anchor bolts and prestressed concrete ducts.

Category : Concrete Technology

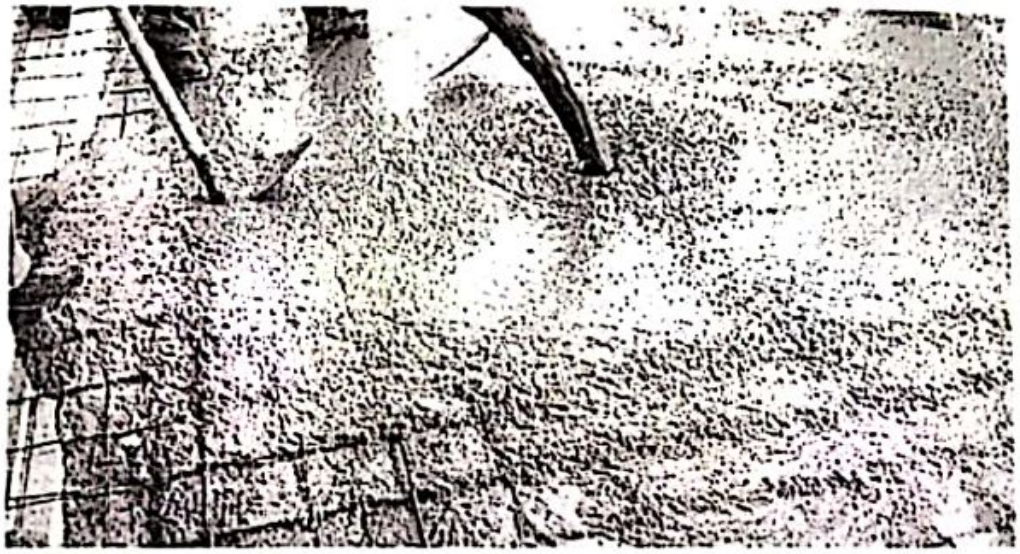
Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Portland cement is the commonly used type of cement for production of concrete. Concrete technology deals with study of properties of concrete and its practical applications.

In a building construction, concrete is used for the construction of foundations, columns, beams, slabs and other load bearing elements.

There are different types of binding material is used other than cement such as lime for lime concrete and bitumen for asphalt concrete which is used for road construction.

Various types of cements are used for concrete works which have different properties and applications. Some of the type of cement are Portland Pozzolana Cement (PPC), rapid hardening cement, Sulphate resistant cement etc.

Materials are mixed in specific proportions to obtain the required strength. Strength of mix is specified as M5, M10, M15, M20, M25, M30 etc, where M signifies Mix and 5, 10, 15 etc. as their strength in kN/m^2. In United States, concrete strength is specified in PSI which is Pounds per Square Inch.



Water cement ratio plays an important role which influences various properties such as workability, strength and durability. Adequate water cement ratio is required for production of workable concrete.

When water is mixed with materials, cement reacts with water and hydration reaction starts. This reaction helps ingredients to form a hard matrix that binds the materials together into a durable stone-like material.

Concrete can be casted in any shape. Since it is a plastic material in fresh state, various shapes and sizes of forms or formworks are used to provide different shapes such as rectangular, circular etc.

Various structural members such as beams, slabs, footings, columns, lintels etc. are constructed with concrete.

ACI 318 Building code requirements for structural concrete and ACI 301 Specifications for Structural Concrete are used in United States as standard code of practice for concrete construction.

There are different types of admixtures which are used to provide certain properties. Admixtures or additives such as pozzolans or superplasticizers are included in the mixture to improve the physical properties of the wet mix or the finished material.

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Various types of concrete are manufactured these days for construction of buildings and structures. These have special properties and features which improve quality of construction as per requirement

Components of Concrete

Components of concrete are cement, sand, aggregates and water. Mixture of Portland cement and water is called as paste. So, concrete can be called as a mixture of paste, sand and aggregates. Sometimes rocks are used instead of aggregates.

The cement paste coats the surface of the fine and coarse aggregates when mixed thoroughly and binds them. Soon after mixing the components, hydration reaction starts which provides strength and a rock solid concrete is obtained.

What is Grade of Concrete?

Grade of concrete denotes its strength required for construction. For example, M30 grade signifies that compressive strength required for construction is 30MPa. The first letter in grade "M" is the mix and 30 is the required strength in MPa.

Based on various lab tests, grade of concrete is presented in Mix Proportions. For example, for M30 grade, the mix proportion can be 1:1:2, where 1 is the ratio of cement, 1 is the ratio of sand and 2 is the ratio of coarse aggregate based on volume or weight of materials.

The strength is measured with concrete cube or cylinders by civil engineers at construction site. Cube or cylinders are made during casting of structural member and after hardening it is cured for 28 days. Then compressive strength test is conducted to find the strength.

Regular grades of concrete are M15, M20, M25 etc. For plain cement concrete works, generally M15 is used. For reinforced concrete construction minimum M20 grade of concrete are used.

Concrete Grade	Mix Ratio	Compressive Strength MPa (N/mm^2)	Compressive Strength psi
Normal Grade of Concrete			
M5	1 : 5 : 10	5 MPa	725 psi
M7.5	1 : 4 : 8	7.5 MPa	1087 psi
M10	1 : 3 : 6	10 MPa	1450 psi
M15	1 : 2 : 4	15 MPa	2175 psi
M20	1 : 1.5 : 3	20 MPa	2900 psi
Standard Grade of Concrete			
M25	1 : 1 : 2	25 MPa	3625 psi
M30	Design Mix	30 MPa	4350 psi
M35	Design Mix	35 MPa	5075 psi
M40	Design Mix	40 MPa	5800 psi
M45	Design Mix	45 MPa	6525 psi

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High Strength Concrete Grades

M50	Design Mix	50 MPa	7250 psi
M55	Design Mix	55 MPa	7975 psi
M60	Design Mix	60 MPa	8700 psi
M65	Design Mix	65 MPa	9425 psi
M70	Design Mix	70 MPa	10150 psi

How to Make Concrete?

Concrete is manufactured or mixed in proportions w.r.t. cement quantity. There are two types of concrete mixes, i.e. nominal mix and design mix. Nominal mix is used for normal construction works such as small residential buildings. Most popular nominal mix are in the proportion of 1:2:4.

Design mixed concrete are those for which mix proportions are finalized based on various lab tests on cylinder or cube for its compressive strength. This process is also called as mix design. These tests are conducted to find suitable mix based on locally available material to obtain strength required as per structural design. A design mixed offers economy on use of ingredients.

Once suitable mix proportions are known, then its ingredients are mixed in the ratio as selected. Two methods are used for mixing, i.e. Hand Mixing or Machine Mixing.

Based on quantity and quality required, the suitable method of mixing is selected. In the hand mixing, each ingredients are placed on a flat surface and water is added and mixed with hand tools. In machine mixing, different types of machines are used. In this case, the ingredients are added in required quantity to mix and produce fresh concrete.

Once the it is mixed adequately it is transported to casting location and poured in formworks. Various types of formworks are available which as selected based on usage.

Poured concrete is allowed to set in formworks for specified time based on type of structural member to gain sufficient strength.

After removal of formwork, curing is done by various methods to make up the moisture loss due to evaporation. Hydration reaction requires moisture which is responsible for setting and strength gain. So, curing is generally continued for minimum 7 days after removal of formwork.

Types of Concrete Construction

Concrete is generally used in two types of construction, i.e. plain concrete construction and reinforced concrete construction. In PCC, it is poured and casted without use of any reinforcement. This is used when the structural member is subjected only to the compressive forces and not bending.

When a structural member is subjected to bending, reinforcements are required to withstand tension forces structural member as it is very weak in tension compared to compression. Generally, strength of concrete in tension is only 10% of its strength in compression.

It is used as a construction material for almost all types of structures such as residential concrete buildings, industrial structures, dams, roads, tunnels, multi storey buildings, skyscrapers, bridges, sidewalks and superhighways etc.

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Example of famous and large structures made with concrete are Hoover Dam, Panama Canal and Roman Pantheon. It is the largest human made building materials used for construction.

Steps of Concrete Construction

The construction steps are:

1. Selecting quantities of materials for selected mix proportion
2. Mixing
3. Checking of workability
4. Transportation
5. Pouring in formwork for casting
6. Vibrating for proper compaction
7. Removal of formwork after suitable time
8. Curing member with suitable methods and required time.

5.1 Basic ingredients of concrete

Concrete is a mixture of cement, water, fine aggregate (sand) and coarse aggregate (gravel or crushed rocks) in which the cement and water have hardened by a chemical reaction – hydration – to bind the nearly (non - reacting) aggregate.

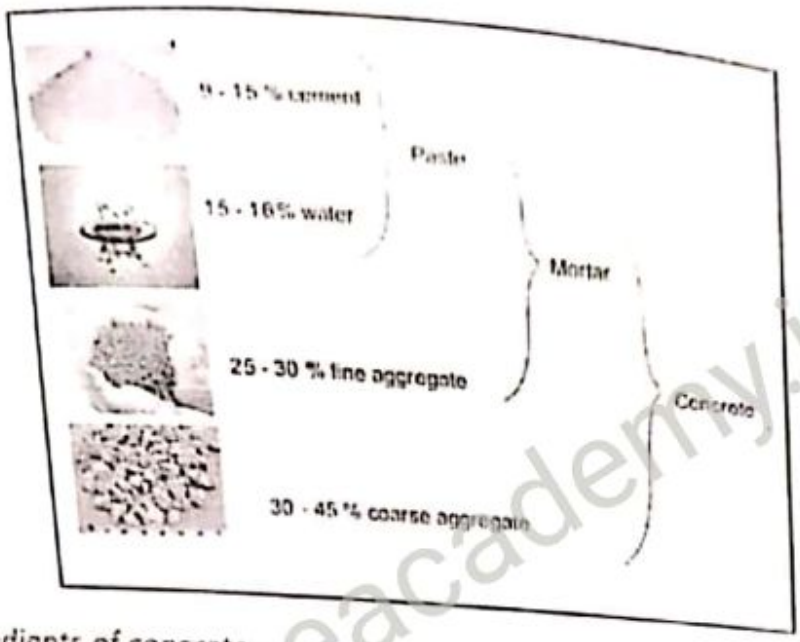

Figure 1.Basic ingredients of concrete

The importance of the ingredients should be known before there are used in cement concrete.

5.1.1 Cement

Cement is binding material in the cement concrete. This concrete is used for different engineering works where strength and durability are of prime importance.

Functions of cement:

- It fills up voids existing in the fine aggregate and makes the concrete impermeable.
- It provides strength to concrete on setting and hardening.
- It binds the aggregate into a solid mass by virtue of its setting and hardening properties when mixed with water.

5.1.2 Aggregate

Aggregates are used in two size groups to provide good quality of concrete:

- Fine aggregate (sand) particle size less than 4.75mm
- Coarse aggregate – Particle size more than 4.75mm

Fine aggregate (sand):

Sand consists of small angular or rounded grains of silica. Sand is commonly used as the fine aggregate in cement concrete. Both natural and artificial sands are used for this purpose.

Functions of sand:

1. It fills the voids existing in the coarse aggregate.
2. It reduces shrinkage and cracking of concrete.
3. By varying the proportion of sand concrete can be prepared economically for any required strength
4. It helps in hardening of cement by allowing the water through its voids.
5. To form hard mass of silicates as it is believed that some chemical reaction takes place between silica of sand and constituents of cement.

Requirements:

1. Fine aggregate should consist of coarse angular sharp and hard grains.
2. It must be free from coatings of clay and silt.
3. It should not contain any organic matter.
4. It should be free from hygroscopic salt.
5. It should be strong and durable and chemical inert.
6. The size of sand grains should pass through 4.75mm sieve and should be entirely retained on 75 micron sieve.

Coarse aggregate:

Functions of coarse aggregates:

1. Coarse aggregate makes solid and hard mass of concrete with cement and sand.
2. It increases the crushing strength of concrete.
3. It reduces the cost of concrete, since it occupies major volume.

Requirements:

1. Coarse aggregate used may be crushed stone, gravel and broken bricks.
2. Crushed stone: It is an excellent coarse aggregate provided. It is obtained by crushing granite, sandstone and close grained limestone.
3. Crushed granite chips are commonly and advantageously used in reinforced cement concrete.
4. Broken bricks well burnt and over burnt bricks are broken into suitable size and used as aggregate. It should be well watered before its use. Broken bricks are used as aggregate for concrete in foundations and under floors.
5. But generally crushed stone is only used as coarse aggregate.

5.1.3 Water

The water is used in concrete plays an important part in the mixing, laying compaction setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water is used in the mix.

Functions of water:

1. Water is only the ingredient that reacts chemically with cement and thus setting and hardening takes place.
2. Water acts as a lubricant for the aggregate and makes the concrete workable.
3. It facilitates the spreading of cement over the fine aggregate.

5.1.4 Concrete admixtures

Concrete admixtures are added to change the properties of concrete to make it function as required. Admixtures are used to modify properties of both fresh and hardened concrete as discussed below:

Functions of admixtures to modify fresh concrete properties:

a) To increase workability without increasing water content or to decrease the water content at the same workability.
b) To retard or accelerate both initial and final setting times.
c) To reduce or prevent settlement.
d) To create slight expansion in concrete and mortar.
e) To modify the rate or capacity for bleeding or both.
f) To reduce segregation of concrete, mortars and grouts.
g) To improve penetration and or pumpability of concrete, mortars and grouts.
h) To reduce rate of slump loss.

Functions of admixtures to modify hardened concrete properties:

a) To retard or reduce heat generation during early hardening.
b) To accelerate the rate of strength development.
c) To increase the strength of concrete or mortar (Compressive, tensile or flexural).
d) To increase the durability or resistance to severe conditions of exposure including the application de-icing salts.
e) To decrease the capillary flow of water.
f) To decrease the permeability to liquids.
g) To control the expansion caused by the reaction of alkalis with certain aggregate constituents
h) To produce cellular concrete.
i) To increase the bond of concrete to steel reinforcement.
j) To increase the bond between old and new concrete.
k) To improve impact resistance and abrasion resistance.

l) To inhibit the corrosion of embedded metal.
m) To produce coloured concrete or mortar.

The classification of concrete admixtures is presented as follow:

1. Set-Retarding:

Set retarding concrete admixtures are used to delay the chemical reaction that takes place when the concrete starts the setting process.

2. Air-Entrainment:

Air entrained concrete can increase the freeze-thaw durability of concrete. Other benefits from this admixture are:

- High resistance to cycles of wetting and drying
- High degree of workability
- High degree of durability

The entrained air bubbles act as a physical buffer against the cracking caused by the stresses due to water volume augmentation in freezing temperatures. Air entrainers are compatible with almost all the concrete admixtures. Typically for every 1% of entrained air, compressive strength will be reduced by about 5%.

3. Water-Reducing:

Water-reducing admixtures are chemical products that when added to concrete can create a desired slump at a lower water cement ration than what is normally designed. Water-reducing admixtures are used to obtain specific concrete strength using lower cement content.

4. Accelerating:

Accelerating concrete admixtures are used to increase the rate of concrete strength development, or to reduce concrete setting time. Calcium chloride could be names as the most common accelerator component; however, it could promote corrosion activity of steel reinforcement. Accelerating admixtures are especially useful for modifying the properties of concrete in cold weather.

5. Shrinkage Reducing:

Shrinkage reducing concrete admixtures are added to concrete during initial mixing. This type of admixture could reduce early and long term drying shrinkage.

6. Super plasticizers:

The main purpose of using super plasticizers is to produce flowing concrete with very high slump in the range of 200 - 250 mm to be used in heavily reinforced structures and in placements where adequate consolidation by vibration cannot be readily achieved. The other major application is the production of high-strength concrete at w/c's ranging from 0.3 to 0.4. High workability concrete

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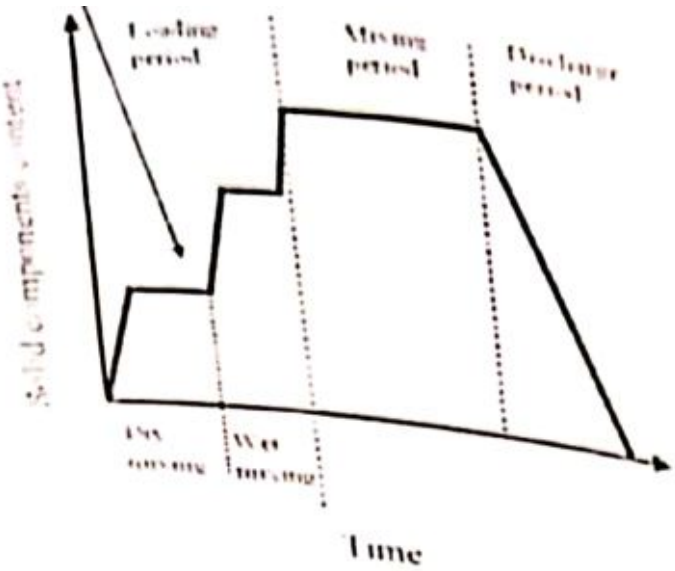


Figure 7. Mixing schedule.

5.3.4 Ready-Mixed Concrete (RMC)

Ready-mixed concrete is mixed in a central plant, and delivered to the job site in mixing trucks ready for placing (Figure 8).

- Ready Mix Concrete is a technique of production of concrete in massive quantities away from the actual site of placing.
- It is very useful where demand of concrete is very high and construction sites are in blocked areas, where mixing on site is not possible due to lake of storage place.
- RMC is ready to use material. It is widely adopted throughout the world.
- It reduces noise pollution as well as air pollution.
- The supervisory and labour costs associated with the production of RMC is less, and the quality of concrete is high.
- It is suitable for huge industrial and residential projects where time plays a vital role
- . So ultimately it provides economy in the construction and better finish to the structure.

Three mixing methods can be used for ready-mixed concrete:

1. Central-mixed concrete is mixed completely in a stationary mixer and delivered in an agitator truck (2 rpm to 6 rpm).
2. Shrink-mixed concrete is partially mixed in a stationary mixer and completed in a mixer truck (4 rpm to 16 rpm).
3. Truck-mixed concrete is mixed completely in a mixer truck (4 rpm to 16 rpm)

5.4 Properties of fresh concrete

There are two sets of criteria that we must consider when making concrete:

1. Short-term requirements, like workability
2. Long-term requirements of hardened concrete, such as, strength, durability, and volume stability

5.4.1 Workability

ACI (American Concrete Institute) defines the concrete workability as 'that property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished'.

A concrete is said to be workable if:

- It can be handled without segregation
- It can be placed without loss of homogeneity
- It can be compacted with specified effort
- It can be finished easily

Depending upon the water cement ratio in the concrete mix, the workability may be determined by the following three methods: (i) Slump Test, (ii) Compaction Factor Test, (iii) Vee-bee Consistometer test. The workability is a composite property, with at least two main components:

a. **Consistency:** which is described as the "ease of flow" of the concrete, and
b. **Cohesiveness:** which he describes as the "tendency not to bleed or segregate"

This lecture will cover the slump test. For more reading about the other test see for example the following link: http://civilblog.org/2015/10/29/3-methods-of-determining-

5.4.1 *Factor affecting the workability*

The factors which affect workability of concrete are:

- **Cement content of concrete:** More the quantity of cement, the more will be the paste available to coat the surface of aggregates and fill the voids between them → will help to reduce the friction between aggregates and smooth movement of aggregates during mixing, transporting, placing and compacting of concrete
- **Water content of concrete:** Generally, a water cement ratio of 0.45 to 0.6 is used for good workable concrete without the use of any admixture.
- **Mix proportions of concrete:** the low cement - aggregate ratio of concrete will make the less paste available for aggregates and mobility of aggregates is restrained.

- **Size of aggregates:** Lower sizes of aggregates with same water content are less workable than the large size aggregates
- **Shape of aggregates:** rounded aggregates will be easy to mix than elongated, angular and flaky aggregates due to less frictional resistance.
- **Use of admixtures in concrete:** workability enhancer admixtures such as plasticizers and super plasticizers which increases the workability of concrete even with low water/cement ratio

5.4.1.2 Consistency (Slump) test

Workability (Consistency) of concrete mixture is measured by slump test, EN 12350 2 - Testing fresh concrete. Slump test [5]. Slump test, shown in Figure 9, is carried out with a mould called slump cone whose top diameter is 10cm, bottom diameter is 20 cm and height is 30 cm. the test may be performed in the following steps:

1. Place the slump mould on a smooth flat and non-absorbent surface.
2. Place the mixed concrete in the mould to about one-fourth of its height.
3. Compact the concrete 25 times with the help of a tamping rod uniformly all over the area.
4. Place the concrete in the mould about half of its height and compact it again.
5. Place the concrete up to its three fourth height and then up to its top. Compact each layer 25 times with the help of tamping rod uniformly. For the second subsequent layers, the tamping rod should penetrate into underlying layers.
6. Strike off the top surface of mould with a trowel or tamping rod so that the mould is filled to its top.
7. Remove the mould immediately, ensuring its movement in vertical direction.
8. When the settlement of concrete stops, measure the subsidence of the concrete in millimetres which is the required slump of the concrete.

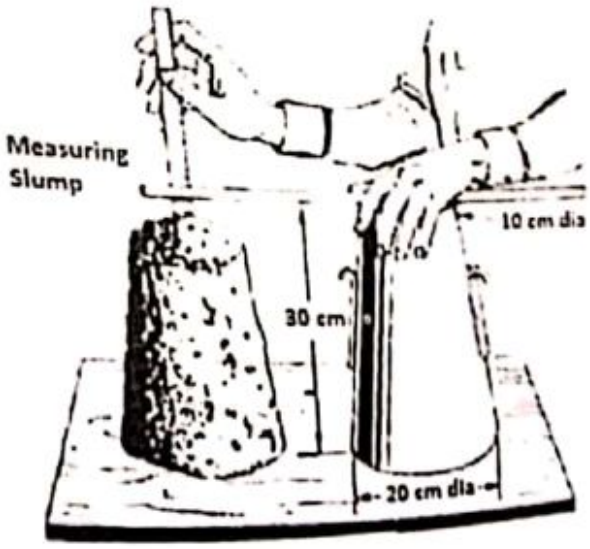


Figure 9. Measurement of the concrete slump (Slump Test)

The standards for slump defines three conditions where the slump test should not be used, see .

1) **Non-plastic concrete (Zero Slump):** When slump is less than 15 mm, concrete may not be adequately plastic for the slump test. The slump test is not effective in distinguishing these concrete mixtures: two concretes with a zero slump can have drastically different workability, especially in their response to vibration.
2) **Non-cohesive concrete (Collapsed slump):** When slump is greater than 230 mm, concrete may not be adequately cohesive for the slump test. Non-cohesive concrete is highly susceptible to segregation and should be redesigned, such as by adding a viscosity modifying admixture or adjusting aggregate grading. Not all concrete with slump greater than 230 mm is non-cohesive. For example, self-consolidating concrete can flow under its own mass with adequate cohesion to resist segregation.
3) **Shear slump concrete:** If during the slump test, a portion of the concrete shears from the rest of the concrete, the slump cannot be evaluated.

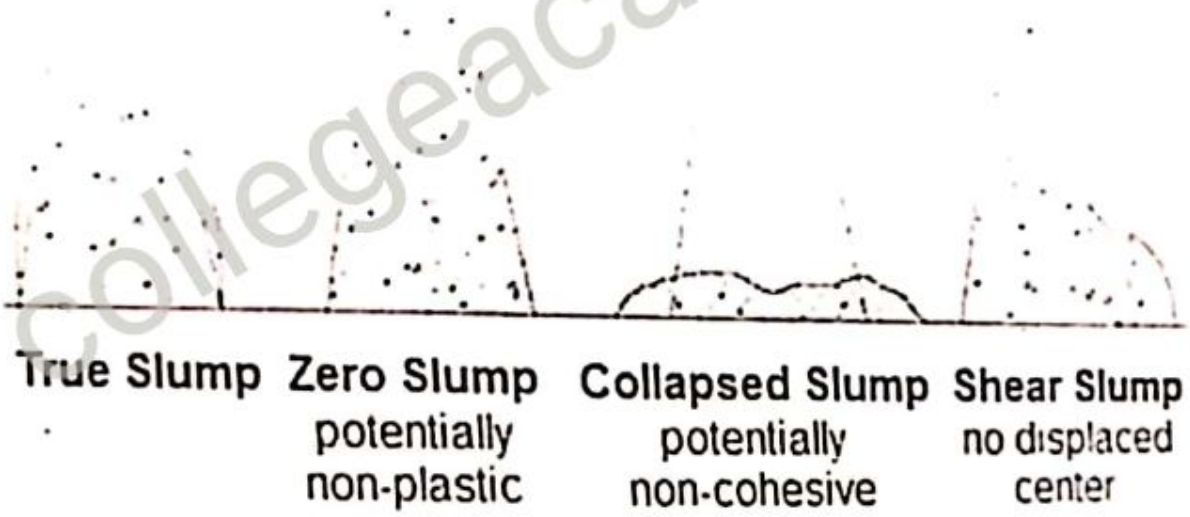


Figure 10. Concrete slump conditions.

Applications of slump test

- The slump test is used to ensure uniformity for different batches of similar concrete under field conditions and to ascertain the effects of plasticizers on their introduction
- This test is very useful on site as a check on the day-to-day or hour- to hour variation in the materials being fed into the mixer. An increase in slump may mean, for instance, that the moisture content of aggregate has unexpectedly increases.
- Other cause would be a change in the grading of the aggregate, such as a deficiency of sand
- . Too high or too low a slump gives immediate warning and enables the mixer operator to remedy the situation.

Table 4 Concrete slump for various uses.

Consistency	Slump [mm]	Use	Method of compaction
High workability	100 - 150	Constructions with narrow passages and/or complex shapes. Heavily reinforced concrete.	Manual
Medium workability	50 - 100	All normal uses. Non-reinforced and normally reinforced concrete.	Manual
Plastic	25 - 50	Open structures with fairly open reinforcement, which are heavily worked manually for compaction like floors and pavings. Mass concrete.	Manual or Mechanical
Stiff	0 - 25	Non-reinforced or sparsely reinforced open structures like floors and pavings which are mechanically vibrated. Factory pre-fabrication of concrete goods. Concrete blocks.	Mechanical
Damp	0	Factory prefabrication of the concrete goods.	Mechanical or Pressure

5.4.1.3 Segregation and Bleeding

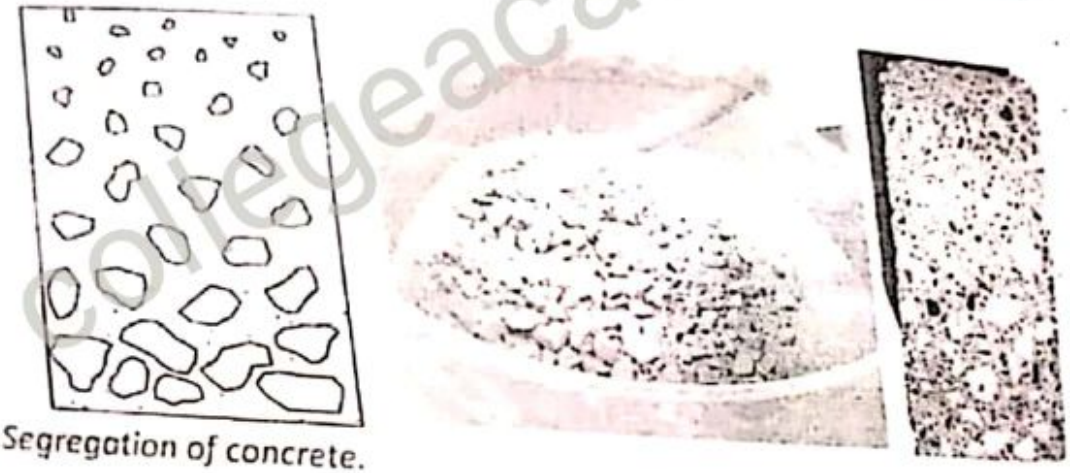


Figure 11. Segregation of concrete.

Segregation refers to a separation of the components of fresh concrete, resulting in a non-uniform mix. This can be seen as a separation of coarse aggregate from the mortar, caused from either the settling of heavy aggregate to the bottom or the separation of the aggregate from the mix due to improper placement.

Some factors that increase segregation are:

- Larger maximum particle size (25mm) and proportion of the larger particles
- High specific gravity of coarse aggregate.
- Decrease in the amount of fine particles.
- Particle shape and texture.
- Water/cement ratio.

Good handling and placement techniques are most important in prevention of segregation.

Figure 12. Bleeding of concrete.

Bleeding is defined as the appearance of water on the surface of concrete after it has consolidated but before it is set. Since mixing water is the lightest component of the concrete, this is a special form of segregation. Bleeding is generally the result of aggregates settling into the mix and releasing their mixing water. Some bleeding is normal for good concrete.

However, if bleeding becomes too localized, channels will form resulting in "craters". The upper layers will become too rich in cement with a high w/c ratio causing a weak, porous structure. Salt may crystalize on the surface which will affect bonding with additional lifts of concrete. This formation should always be removed by brushing and washing the surface. Also, water pockets may form under large aggregates and reinforcing bars reducing the bond.

Bleeding may be reduced by:

- Increasing cement fineness.
- Increasing the rate of hydration.
- Using air-entraining admixtures.
- Reducing the water content.

5.4.2 Setting time of concrete

Setting is defined as the onset of rigidity in fresh concrete. Hardening is the development of useable and measurable strength; setting precedes hardening. Both are gradual changes controlled by hydration. Fresh concrete will lose measurable slump before initial set and measurable strength will be achieved after final set.

Setting is controlled by the hydration of C_3S. The period of good workability is during the dormant period, (stage 2). Initial set corresponds to the beginning of stage 3, a period of rapid hydration. Final set is the midpoint of this acceleration phase. A rapid increase in temperature is associated with stage 3 hydration, with a maximum rate at final set.

Order of Operations for Concrete

I. mix design (proportioning)
II. final mixes & testing
III. batching

start the clock

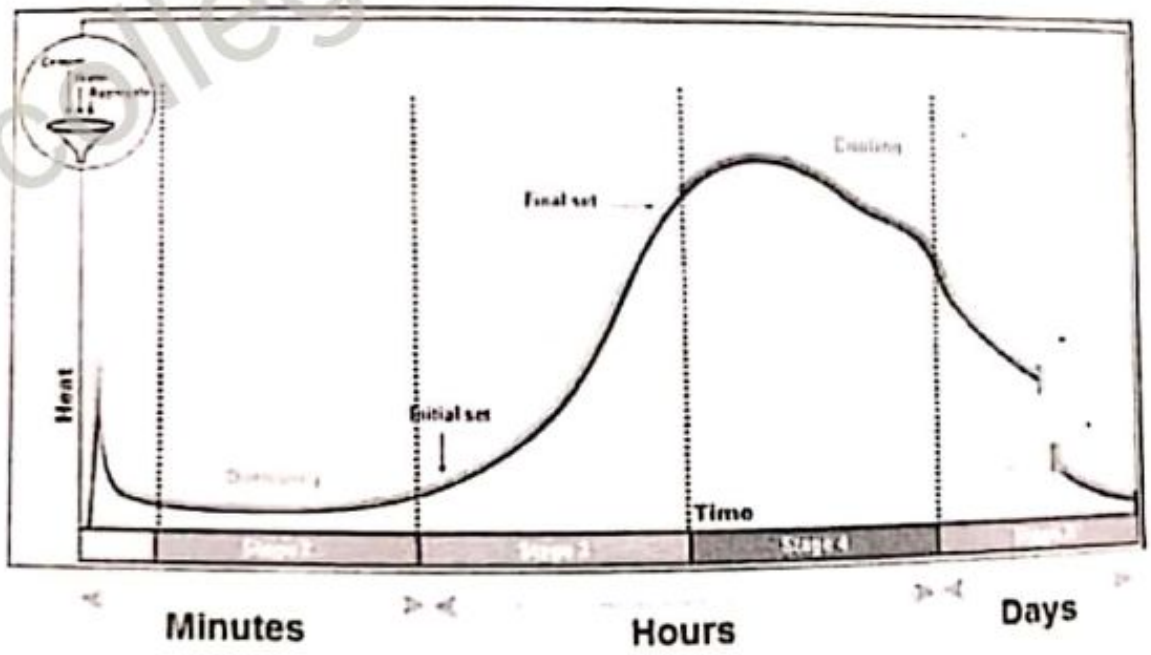
IV. mixing
V. transporting
VI. pouring (placing)
VII. vibrating (consolidating)

VIII. finishing

final set here

IX. curing
X. maintenance

If large amounts of ettringite rapidly form from C_3A hydration, the setting times will be reduced. Cements with high percentages of C_3A, such as expansive or set-regulated cements, are entirely controlled by ettringite formation.



ure 13. Stages in the hydration of cement.

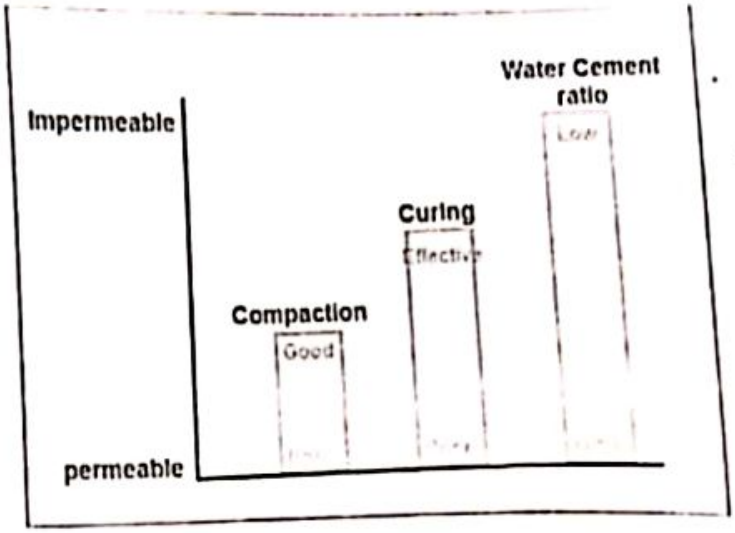


Figure 17. Factors controlling impermeability of concrete.

5.6 Advantages and disadvantages of reinforced concrete

Reinforced concrete is a combination of traditional cement concrete with reinforcements (steel bar). This combination is made to utilize the compressive strength of concrete and tensile strength of steel simultancely. In reinforced concrete, the components works together to resist many types of loading. Concrete resists compression and steel reinforcement resists tension forces. Reinforced concrete, as an economic building material, is very popular now-a-days. It is widely used in many types building around the world. Along with many advantages reinforced concrete also poses some disadvantages also.

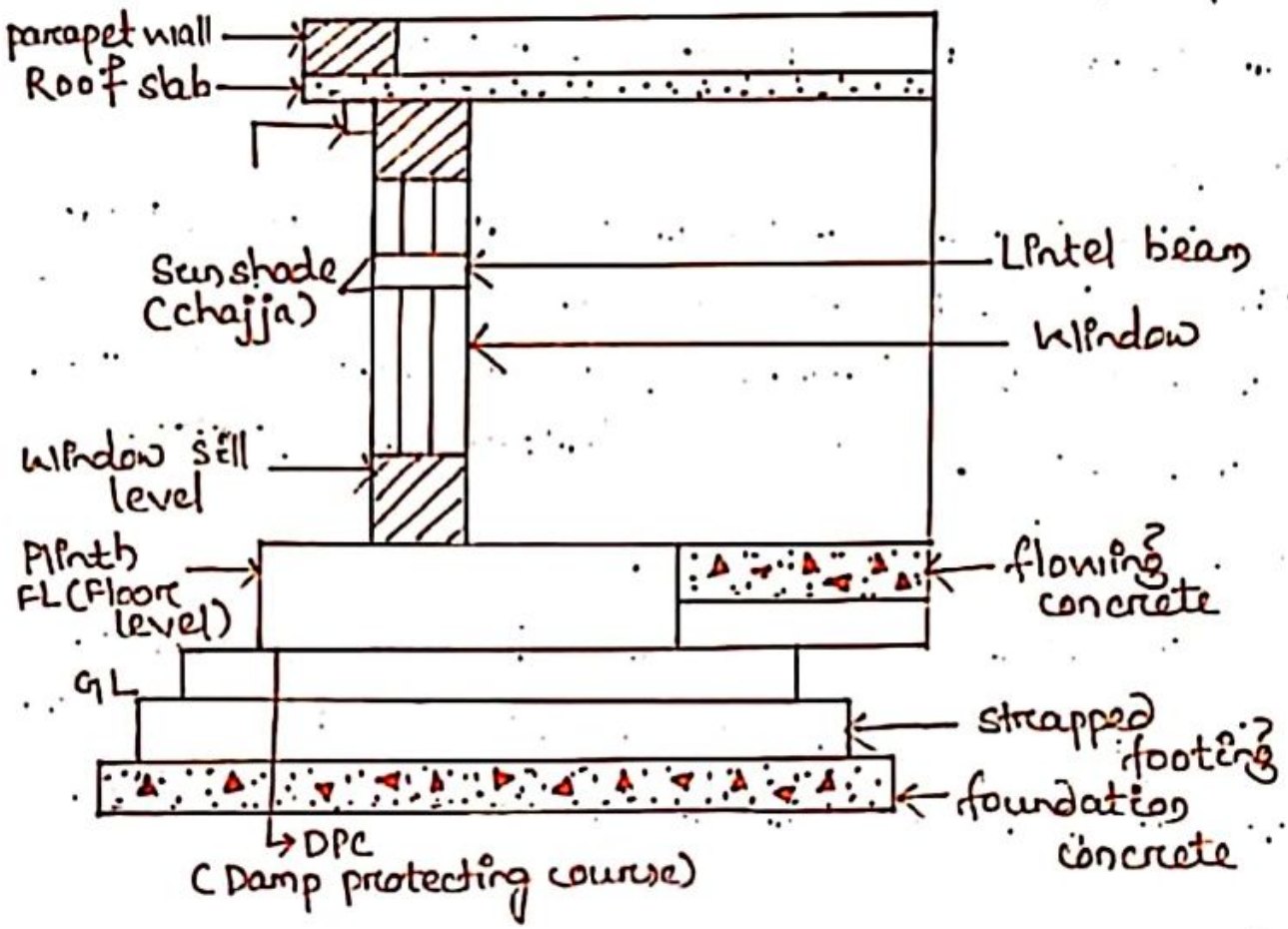
Advantages of Reinforced Concrete

- Reinforced concrete has a high compressive strength compared to other building materials.
- Due to the provided reinforcement, reinforced concrete can also withstand a good amount tensile stress.
- Fire and weather resistance of reinforced concrete is fair.
- The reinforced concrete building system is more durable than any other building system.
- Reinforced concrete, as a fluid material in the beginning, can be economically moulded into a nearly limitless range of shapes.
- The maintenance cost of reinforced concrete is very low.
- . In structure like footings, dams, piers etc. reinforced concrete is the most economical construction material.
- It acts like a rigid member with minimum deflection.
- As reinforced concrete can be moulded to any shape required, it is widely used in precast structural components. It yields rigid members with minimum apparent deflection.
- Compared to the use of steel in structure, reinforced concrete requires less skilled labour for the erection of structure.

Disadvantages of Reinforced Concrete

- The tensile strength of reinforced concrete is about one-tenth of its compressive strength.
- The main steps of using reinforced concrete are mixing, casting, and curing. All of this affect the final strength.
- The cost of the forms used for casting reinforced concrete is relatively higher.
- For multi-storied building the reinforced concrete column section for is larger than steel section as the compressive strength is lower in the case of reinforced concrete.
- Shrinkage causes crack development and strength loss.

"Building Components"



Basic components of building

→ The building broadly cons
  (i) Super structure
  (ii) Sub structure

→ The term superstructure is of structure which is above

→ A part of superstructure loc the surrounding ground and known as "Plinth".

→ The lowest artificially prepared parts of the structure

which are in direct contact with the ground and which transmits the load of the structure to the ground are known as Foundation or Substructure.

Wall :-

The primary function of the wall is to enclosed or divide space. A wall should be strong enough to take the load safely, provide adequate resistance to the rain, sun, wind, sound insulation, privacy and security.

Floor :-

The floor provide support for occupants, furniture and equipments of a building and to devide the building into different level for creating more accomodation.

Plinth :-

The minimum height of the plinth is usually kept not less than 45 cm. It is used to protect the building from dampness or moisture and to enhance the architectural appearance of the building.

Door & window :-

They serve as a connecting link between internal part of building and to allow free movement to the outside of the building. It is also provided for ventilation and lighting.

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Lintel & Sill :-

Window sills are provided between the bottom of the window frame and the wall below to protect the wall from wear and tear. The openings are provided in the walls of the building to accomodate the door and window.

A structural element is introduced between the top of the window frame and the wall coming over it to support the weight of the wall above the openings is called as Lintel.

Roof :-

A roof is the uppermost part of a building whose main function is to enclose the space and to protect the same from the effect of weather elements.

Step :-

A step usually consists of a tread and riser supported by strings. The main function is to provide a means of communication below the various floor.

Parapet wall :-

It is provided over the roof slab so as to give a boundary for safety.

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