MODULE – I

Introduction and Scope of Civil Engineering:

Civil engineering is the art of directing the great sources of power in nature for the use and convenience of man. Basically it is concerned with planning, design and construction for environmental control, development of natural resource, buildings, transportation facilities and other structures required for health, welfare, safety, employment and pleasure of mankind.

The main scope of civil engineering is planning, designing, estimating, supervising, managing and maintenance of structures like building, roads, bridges, dams etc.

Broad disciplines of Civil Engineering:

Civil engineering is a wide field and includes many types of structures such as residential buildings, public buildings, industrial buildings, roads, bridges, tunnels, railways, dams, canals, airports, harbours, waste water treatment plants, water supply networks and drainage networks, drainage networks etc.

According to the type of structures and activities carried out, main branches of civil engineering are classified as follows:

- Structural Engineering
- Geotechnical Engineering
- Transportation Engineering
- Environmental Engineering
- Water resources Engineering
- Surveying and levelling

Building Material and Building Construction:

Brick

- Brick is a small rectangular block obtained by moulding good clay into a block, which is dried and then burnt.
- A brick is one of the oldest building material used to make walls, pavements and other elements in masonry construction.
- The standard size of brick is 190 mm X 90 mm X 90 mm and the nominal size (including mortar thickness) of brick is 200 mm X 100 mm X 100 mm.

Qualities of a good brick

The following are the required properties of good bricks:

(i) *Colour*: Colour should be uniform and bright.

(*ii*) *Shape*: Bricks should have plane faces. They should have sharp and true right angled corners.

(*iii*) *Size*: Bricks should be of standard sizes as prescribed by codes.

(*iv*) *Texture*: They should possess fine, dense and uniform texture. They should not possess fissures, cavities, loose grit and unburnt lime.

(*v*) *Soundness*: When struck with hammer or with another brick, it should produce metallic sound.

(*vi*) *Hardness*: Finger scratching should not produce any impression on the brick.

(*vii*) *Strength*: Crushing strength of brick should not be less than 3.5 N/mm2. A field test for strength is that when dropped from a height of 0.9 m to 1.0 mm on a hard ground, the brick should not break into pieces.

(*viii*) *Water Absorption*: After immersing the brick in water for 24 hours, water absorption should not be more than 20 per cent by weight.

(*ix*) *Efflorescence*: Bricks should not show white patches when soaked in water for 24 hours and then allowed to dry in shade. White patches are due to the presence of sulphate of calcium, magnesium and potassium. They keep the masonry permanently in damp and wet conditions.

(*x*) *Thermal Conductivity*: Bricks should have low thermal conductivity, so that buildings built with them are cool in summer and warm in winter.

(*xi*) *Sound Insulation*: Heavier bricks are poor insulators of sound while light weight and hollow provide good sound insulation.

(*xii*) *Fire Resistance*: Fire resistance of bricks is usually good. In fact bricks are used to encase steel columns to protect them from fire.

Importance of Bricks

Bricks are used in the following civil works:
(*i*) As building blocks.
(*ii*) For lining of ovens, furnaces and chimneys.
(*iii*) For protecting steel columns from fire.
(*iv*) As aggregates in providing water proofing to R.C.C. roofs.
(*v*) For pavers for footpaths and cycle tracks.
(*vi*) For lining sewer lines.

Constituents of good brick earth:

Bricks are the most commonly used construction material. Bricks are prepared by moulding clay in rectangular blocks of uniform size and then drying and burning these blocks. In order to get a good quality brick, the brick earth should contain the following constituents.

- Silica
- Alumina

- Lime
- Iron oxide
- Magnesia

Silica

- Brick earth should contain about 50 to % of silica.
- It is responsible for preventing cracking, shrinking and warping of raw bricks.
- It also affects the durability of bricks.
- If present in excess, then it destroys the cohesion between particles and the brick becomes brittle.

Alumina

- Good brick earth should contain about 20% to 30% of alumina.
- It is responsible for plasticity characteristic of earth, which is important in moulding operation.
- If present in excess, then the raw brick shrink and warp during drying.

Lime

- The percentage of lime should be in the range of 5% to 10% in a good brick earth.
- It prevents shrinkage of bricks on drying.
- It causes silica in clay to melt on burning and thus helps to bind it.
- Excess of lime causes the brick to melt and brick looses its shape.

Iron oxide

- A good brick earth should contain about 5% to 7% of iron oxide.
- It gives red colour to the bricks.
- It improves impermeability and durability.
- It gives strength and hardness.
- If present in excess, then the colour of brick becomes dark blue or blakish.
- If the quantity of iron oxide is comparatively less, the brick becomes yellowish in colour.

Magnesia

- Good brick earth should contain less a small quantity of magnesia about1%)
- Magnesium in brick earth imparts yellow tint to the brick.
- It is responsible for reducing shrinkage
- Excess of magnesia leads to the decay of bricks.

Classification of Bricks as per common practice:

Bricks, which are used in construction works, are burnt bricks. They are classified into four categories on the basis of its manufacturing and preparation, as given below.

1. First class bricks
2. Second class bricks
3. Third class bricks
4. Fourth class bricks

Stones

Stone is a 'naturally available building material' which has been used from the early age of civilization. It is available in the form of rocks, which is cut to required size and shape and used as building block. It has been used to construct small residential buildings to large palaces and temples all over the world.

Type of Stones

Stones used for civil engineering works may be classified in the following four ways:

- Geological
- Physical
- Chemical
- Practical

Geological Classification

Based on their origin of formation stones are classified into three main groups—Igneous, sedimentary and metamorphic rocks.

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

(*ii*) *Sedimentary Rocks*: Due to weathering action of water, wind and frost existing rocks disintegrates. The disintegrated material is carried by wind and water; the water being most powerful medium. Flowing water deposits its suspended materials at some points of obstacles to its flow. These deposited layers of materials get consolidated under pressure and by heat. Chemical agents also contribute to the cementing of the deposits. The rocks thus formed are more uniform, fine grained and compact in their nature. They represent a bedded or stratified structure in general. Sand stones, lime stones, mud stones etc. belong to this class of rock.

(*iii*) *Metamorphic Rocks*: Previously formed igneous and sedimentary rocks undergo changes due to metamorphic action of pressure and internal heat. For example due to metamorphic action granite becomes greisses, trap and basalt change to schist and laterite, lime stone changes to marble, sand stone becomes quartzite and mud stone becomes slate.

Physical Classification

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

- Stratified rocks
- Unstratified rocks

(*i*) *Stratified Rocks*: These rocks are having layered structure. They possess planes of stratification or cleavage. They can be easily split along these planes. Sand stones, lime stones, slate etc. are the examples of this class of stones.

(*ii*) *Unstratified Rocks:* These rocks are not stratified. They possess crystalline and compact grains. They cannot be split in to thin slab. Granite, trap, marble etc. are the examples of this type of rocks.

(*iii*) *Foliated Rocks*: These rocks have a tendency to split along a definite direction only. The direction need not be parallel to each other as in case of stratified rocks. This type of structure is very common in case of metamorphic rocks.

Chemical Classification

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

- Silicious rocks
- Argillaceous rocks and
- Calcareous rocks

(*i*) *Silicious rocks*: The main content of these rocks is silica. They are hard and durable. Examples of such rocks are granite, trap, sand stones etc.
(*ii*) *Argillaceous rocks*: The main constituent of these rocks is argil *i.e.*, clay. These stones are hard and durable but they are brittle. They cannot withstand shock. Slates and laterites are examples of this type of rocks.
(*iii*) *Calcareous rocks*: The main constituent of these rocks is calcium carbonate.

Practical Classification

The example of such stones are granite, basalt, laterite, marble, limestone, sandstone and slate.

Requirements of Good Building Stones

The following are the requirements of good building stones:

(i) Strength: The stone should be able to resist the load coming on it. Ordinarily this is not of primary concern since all stones are having good strength. However in case of large structure, it may be necessary to check the strength.

(ii) Durability: Stones selected should be capable of resisting adverse effects of natural forces like wind, rain and heat.

(iii) Hardness: The stone used in floors and pavements should be able to resist abrasive forces caused by movement of men and materials over them.

(iv) Toughness: Building stones should be tough enough to sustain stresses developed due to vibrations. The vibrations may be due to the machinery mounted over them or due to the loads moving over them. The stone aggregates used in the road constructions should be tough.

(v) Specific Gravity: Heavier variety of stones should be used for the construction of dams, retaining walls, docks and harbours. The specific gravity of good building stone is between 2.4 and 2.8.

(vi) Porosity and Absorption: Building stone should not be porous. If it is porous rain water enters into the pour and reacts with stone and crumbles it. In higher altitudes, the freezing of water in pores takes place and it results into the disintegration of the stone.
(vii) Dressing: Giving required shape to the stone is called dressing. It should be easy to dress so that the cost of dressing is reduced. However the care should be taken so that, this is not be at the cost of the required strength and the durability.
(viii) Appearance: In case of the stones to be used for face works, where appearance is a primary requirement, its colour and ability to receive polish is an important factor.
(ix) Seasoning: Good stones should be free from the quarry sap. Laterite stones should not be used for 6 to 12 months after quarrying. They are allowed to get rid of quarry sap by the action of nature. This process of removing quarry sap is called seasoning.
(x) Cost: Cost is an important consideration in selecting a building material. Proximity of the quarry to building site brings down the cost of transportation and hence the cost of stones comes down.

Cement

- Cement is a material with adhesive and cohesive properties which make it capable of bonding minerals fragments into a compact whole. For constructional purposes, the meaning of the term "cement" is restricted to the bonding materials used with stones, sand, bricks, building stones, etc.
- The name "Portland cement" given originally due to the resemblance of the color and quality of the hardened cement to Portland stone – Portland Island in England.

Manufacturing Process of Portland cement

Raw materials

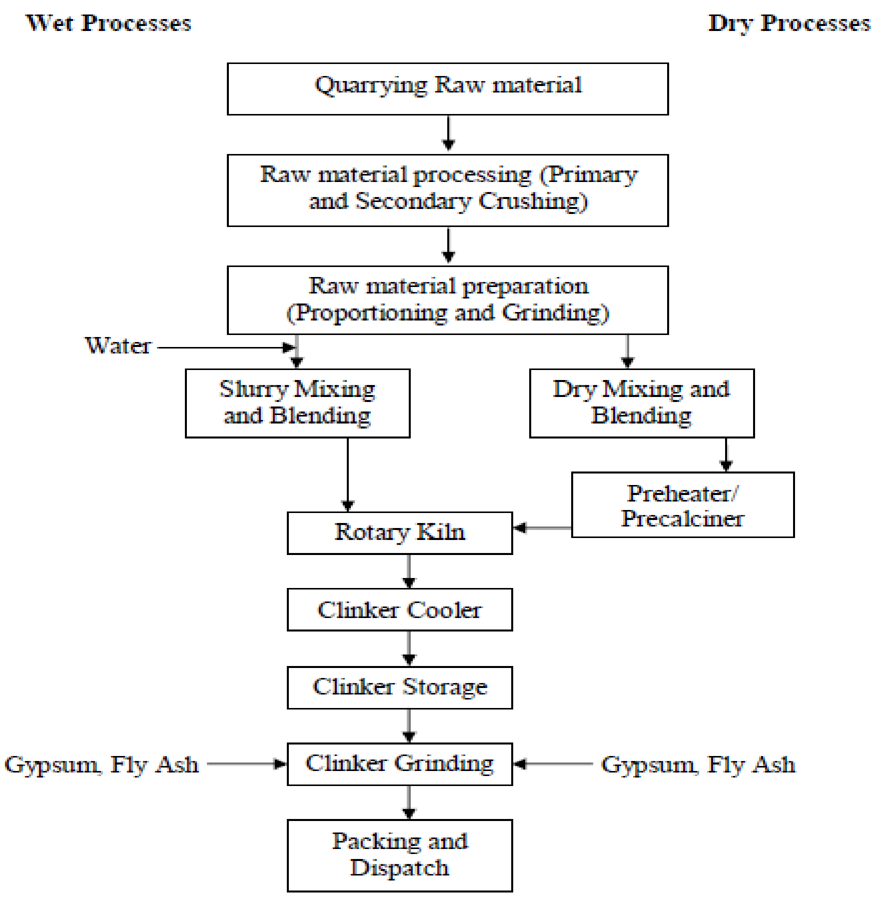
• Calcareous material – such as limestone or chalk, as a source of lime (CaO).
• Clayey material – such as clay or shale (soft clayey stones), as a source of silica and alumina.

Methods of cement manufacturing

1- Wet process - grinding and mixing of the raw materials in the existence of water.
2- Dry process - grinding and mixing of the raw materials in their dry state.

The process to be chosen, depend on the nature of the used raw materials.
Wet process – the percentage of the moisture in the raw materials is high.
Dry process –
• The raw materials is so hard (solid) that they do not disintegrate by water
• Cold countries, because the water might freeze in the mixture
• Shortage of the water needed for mixing process.

Flow Diagram of Cement Manufacturing Process



Wet process

- When chalk is used, it is finely broken up and dispersed in water in a washmill. The clay is also broken up and mixed with water, usually in a similar washmill. The two mixtures are now pumped so as to mix in predetermined proportions and pass through a series of screens. The resulting – cement slurry – flows into storage tanks.
- When limestone is used, it has to be blasted, then crushed, usually in two progressively smaller crushers (initial and secondary crushers), and then fed into a ball mill with the clay dispersed in water. The resultant slurry is pumped into storage tanks. From here onwards, the process is the same regardless of the original nature of the raw materials.
- The slurry is a liquid of creamy consistency, with water content of between 35 and 50%. The slurry mix mechanically in the storage tanks, and the sedimentation of the suspended solids being prevented by bubbling by compressed air pumped from bottom of the tanks. The slurry with the desired lime content passes into the rotary kiln. Its movement down the kiln, encounters a progressively higher temperature. The mass then fuses into balls, 3 to 25 mm in diameter, known as clinker. The clinker drops into coolers.

Dry process

- The raw materials are crushed and fed in the correct proportions into a grinding mill, where they are dried and reduced in size to a fine powder. The dry powder, called raw meal, is then pumped to a blending silo, and final adjustment is now made in the proportions of the materials required for the manufacture of cement. To obtain a uniform mixture, the raw meal is blended in the silo, usually by means of compressed air.
- The blended meal is sieved and fed into a rotating dish called a granulator, water weighing about 12% of the meal being added at the same time. In this manner, hard pellets about 15 mm in diameter are formed.
- The pellets are baked hard in a pre-heating grate by means of hot gases from the kiln. The pellets then enter the kiln, and subsequence operations are the same as in the wet process of manufacture.

Grinding of the clinker

The cooled clinker (produced by wet or dry process), which is characteristically black and hard, is interground with gypsum in order to prevent flash setting of the cement, and to facilitate the grinding process. The grinding is done in a ball mill. The cement discharged by the mill is passed through a separator, fine particles being removed to the storage silo by an air current, while the coarser particles are passed through the mill once again.

Use

• Cement mortar for Masonry work, plaster and pointing etc.
• Concrete for laying floors, roofs and constructing lintels, beams, weather shed, stairs, pillars etc.
• Construction for important engineering structures such, culverts, dams, tunnels, light house, blocks, etc.
• Construction of water wells, tennis courts, septic tanks, lamp posts, telephone cabins etc.
• Making joint for joints, pipes, etc.
• Manufacturing of precast pipes, garden seats, artistically designed wens, flower posts, etc.
• Preparation of foundation, water tight floors, footpaths, etc.

Types of Cements

Many types of cements are available in markets with different compositions and for use in different environmental conditions and specialized applications. A list of some commonly used cement is described in this section:

(i) Ordinary Portland Cement

Ordinary Portland cement is the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay) to 1450°C in a kiln, in a process known as calcination, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which is then blended with the other materials that have been included in the mix. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'Ordinary Portland Cement'(often referred to as OPC).

This type of cement use in construction when there is no exposure to sulphates in the soil or ground water.

(ii) Rapid hardening Portland cement

- It is firmer than Ordinary Portland Cement
- It contains more C3S are less C2S than the ordinary Portland cement.
- Its 3 days strength is same as 7 days strength of ordinary Portland cement.

*(iii)*Low Heat Portland cement

- Heat generated in ordinary Portland cement at the end of 3days 80 cal/gm. While in low heat cement it is about 50cal/gm of cement.
- It has low percentage of C_3A and relatively more C_2S and less C_3A than O.P. Cement.
- Reduce and delay the heat of hydration.

(iv) Sulphate resisting Portland cement

- Maximum C_3A content by 3.5% and minimum fineness by 2500 cm^2/g.
- Firmer than ordinary pot land cement.
- Sulphate forms the sulpha-aluminates which have expensive properties and so causes disintegration of concrete.

(v) Blast Furnace Slag Cement

- For this cement, the slag as obtained from blast furnace is used
- The clinkers of cement are ground with about 60 to 65 percent of slag.
- Its strength in early days is less and hence it required longer curing period.
- It proves to be economical as slag, which is a Waste product, is used in its manufactures.

(vi) Portland Pozzolana cement

- As per Indian standard, the proportions of Pozzolana may be 10 to 25 % by weight. e.2. Burnt clay, shale, Fly ash.
- This Cement has higher resistance to chemical agencies and to sea water because of absence of lime.
- It evolves less heat and initial strength is less but final strength is 28 days onward equal to ordinary Portland cement.
- It possesses less resistance to the erosion and weathering action.
- It imparts higher degree of water tightness and it is cheap.

(vii) White cement

- Grey colour of O.P. cement is due to presence of Iron Oxide. Hence in White Cement FeO, is limited to 1 %. Sodium Alumina Ferrite (Crinoline) NavAlF6 is added to act as flux in the absence of Iron-Oxide.
- It is quick drying, possesses high strength and has superior aesthetic values and it also cost less than ordinary Cement because of specific requirements imposed upon the raw materials and the manufacturing process.
- White Cement are used in Swimming pools, for painting garden furniture, moulding sculptures and statues etc.

(viii) Coloured cement

- The Cement of desired colour may be obtained by mixing mineral pigments with ordinary Cement.
- The amount of colouring material may vary from 5 to 10 percent. If this percentage exceeds 10percent, the strength of cements is affected.
- The iron Oxide in different proportions gives brown, red or yellow colour. The coloured Cement are widely used for finishing of floors, window sill slabs, stair treads etc.

(ix) Expansive cement

- This type of cement is produced by adding an expanding medium like sulphoaluminate and a stabilising agent to the ordinary cement.
- The expanding cement is used for the construction of water retaining structures and for repairing the damaged concrete surfaces.

(x) High alumina cement

- This cement is produced by grilling clinkers formed by calcining bauxite and lime. It can stand high tempertures.
- If evolves great heat during setting. It is therefore not affected by frost.

Various tests on Cement:

Basically two types of tests are under taken for assessing the quality of cement.

Field test:

There are four types of field tests to access the colour, physical property, and strength of the cement as described below.

Colour

- The colour of cement should be uniform.
- It should be typical cement colour i.e. grey colour with a light greenish shade.

Physical properties

- Cement should feel smooth when touched between fingers.
- If hand is inserted in a bag or heap of cement,it should feel cool.

Presence of lumps

- Cement should be free from lumps.
- For a moisture content of about 5 to 8%,this increase of volume may be much as 20 to 40 %,depending upon the grading of sand.

Strength

- A thick paste of cement with water is made on a piece of thick glass and it is kept under water for 24 hours. It should set and not crack.

Laboratory tests:

Six laboratory tests are conducted mainly for assessing the quality of cement. These are: fineness, compressive strength, consistency, setting time, soundness and tensile strength.

(i) *Fineness*

- This test is carried out to check proper grinding of cement.
- The fineness of cement particles may be determined either by sieve test or permeability apparatus test.

- In sieve test, the cement weighing 100 gram is taken and it is continuously passed for 15 minutes through standard BIS sieve no. 9.The residue is then weighed and this weight should not be more than 10% of original weight.
- In permeability apparatus test, specific area of cement particles is calculated. This test is better than sieve test. The specific surface acts as a measure of the frequency of particles of average size.

(ii) *Compressive strength*

- This test is carried out to determine the compressive strength of cement.
- The mortar of cement and sand is prepared in ratio 1:3.
- Water is added to mortar in water cement ratio 0.4.
- The mortar is placed in moulds. The test specimens are in the form of cubes and the moulds are of metals. For 70.6 mm and 76 mm cubes ,the cement required is 185gm and 235 gm respectively.
- Then the mortar is compacted in vibrating machine for 2 minutes and the moulds are placed in a damp cabin for 24 hours.
- The specimens are removed from the moulds and they are submerged in clean water for curing.
- The cubes are then tested in compression testing machine at the end of 3days and 7 days. Thus compressive strength was found out.

(iii)Consistency

The purpose of this test is to determine the percentage of water required for preparing cement pastes for other tests.

- Take 300 gm of cement and add 30 percent by weight or 90 gm of water to it.
- Mix water and cement thoroughly.
- Fill the mould of Vicat apparatus and the gauging time should be 3.75 to 4.25 minutes.
- Vicat apparatus consists of a needle is attached a movable rod with an indicator attached to it.
- There are three attachments: square needle, plunger and needle with annular collar.
- The plunger is attached to the movable rod. the plunger is gently lowered on the paste in the mould.
- The settlement of plunger is noted. If the penetration is between 5 mm to 7 mm from the bottom of mould, the water added is correct. If not process is repeated with different percentages of water till the desired penetration is obtained.

(iv) Setting time

- This test is used to detect the deterioration of cement due to storage.The test is performed to find out initial setting time and final setting time.
- Cement mixed with water and cement paste is filled in the Vicat mould.
- Square needle is attached to moving rod of Vicat apparatus.
- The needle is quickly released and it is allowed to penetrate the cement paste. In the beginning the needle penetrates completely. The procedure is repeated at regular intervals till the needle does not penetrate completely.(upto 5mm from bottom)
- Initial setting time should not be less than 30min for ordinary Portland cement and 60 min for low heat cement.
- The cement paste is prepared as above and it is filled in the Vicat mould.
- The needle with annular collar is attached to the moving rod of the Vicat apparatus.

- The needle is gently released. The time at which the needle makes an impression on test block and the collar fails to do so is noted.
- Final setting time is the difference between the time at which water was added to cement and time as recorded in previous step, and it should not be more than 10hours.

(v) *Soundness*

- The purpose of this test is to detect the presence of uncombined lime in the cement.
- The cement paste is prepared.
- The mould is placed and it is filled by cement paste.
- It is covered at top by another glass plate. A small weight is placed at top and the whole assembly is submerged in water for 24 hours.
- The distance between the points of indicator is noted. The mould is again placed in water and heat is applied in such a way that boiling point of water is reached in about 30 minutes. The boiling of water is continued for one hour.
- The mould is removed from water and it is allowed to cool down.
- The distance between the points of indicator is again measured. The difference between the two readings indicates the expansion of cement and it should not exceed 10 mm.

(vi) *Tensile strength*

- Test was formerly used to have an indirect indication of compressive strength of cement.
- The mortar of sand and cement is prepared.
- The water is added to the mortar.
- The mortar is placed in briquette moulds. The mould is filled with mortar and then a small heap of mortar is formed at its top.It is beaten down by a standard spatula till water appears on the surface. Same procedure is repeated for the other face of briquette.
- The briquettes are kept in a damp for 24 hours and carefully removed from the moulds.
- The briquettes are tested in a testing machine at the end of 3 and 7 days and average is found out.

Concrete

Concrete is a composite material composed mainly of water, aggregate, and cement. Often, additives and reinforcements are included in the mixture to achieve the desired physical properties of the finished material.

Concrete is a mixture of binding material, fine aggregate, coarse aggregate and water.

Production of concrete

The following steps are involved in the concreting:

1. Batching
2. Mixing
3. Transporting and placing and
4. Compacting.

1. **Batching**: The measurement of materials for making concrete is known as batching. The following two methods of batching is practiced:

(*a*) Volume batching
(*b*) Weight batching.

(*a*) *Volume Batching:* In this method cement, sand and concrete are batched by volume. A gauge box is made with wooden plates, its volume being equal to that of one bag of cement. One bag of cement has volume of 35 litres. The required amount of sand and coarse aggregate is added by measuring on to the gauge box.
Volume batching is not ideal method of batching. Wet sand has higher volume for the same weight of dry sand. It is called bulking of sand. Hence it upsets the calculated volume required.

(*b*) *Weight Batching:* This is the recommended method of batching. A weighing platform is used in the field to pick up correct proportion of sand and coarse aggregates. Large weigh batching plants have automatic weighing equipments.

2. **Mixing**: To produce uniform and good concrete, it is necessary to mix cement, sand and coarse aggregate, first in dry condition and then in wet condition after adding water.
The following methods are practiced:
(*a*) Hand Mixing
(*b*) Machine Mixing.

(*a*) *Hand Mixing*: Required amount of coarse aggregate for a batch is weighed and is spread on an impervious platform. Then the sand required for the batch is spread over coarse aggregate. They are mixed in dry condition by overturning the mix with shovels. Then the cement required for the batch is spread over the dry mix and mixed by shovels. After uniform texture is observed water is added gradually and mixing is continued. Full amount of water is added and mixing is completed when uniform colour and consistency is observed. The process of mixing is completed in 6–8 minutes of adding water. This method of mixing is not very good but for small works it is commonly adopted.

(*b*) *Machine Mixing:* In large and important works machine mixing is preferred. Required quantities of sand and coarse aggregates are placed in the drum of the mixer. 4 to 5 rotations are made for dry mixing and then required quantity of cement is added and dry mixing is made with another 4 to 5 rotations. Water is gradually added and drum is rotated for 2 to 3 minutes during which period it makes about 50 rotations. At this stage uniform and homogeneous mix is obtained.

3. **Transporting and Placing of Concrete.** After mixing concrete should be transported to the final position. In small works it is transported in iron pans from hand to hand of a set of workers. Wheel barrow and hand carts also may be employed. In large scale concreting chutes and belt conveyors or pipes with pumps are employed. In transporting care should be taken to see that segregation of aggregate from matrix of cement do not take place.
Concrete is placed on form works. The form works should be cleaned and properly oiled. If concrete is to be placed for foundation, the soil bed should be compacted well and is made free from loose soil.

Concrete should be dropped on its final position as closely as possible. If it is dropped from a height, the coarse aggregates fall early and then mortar matrix. This segregation results into weaker concrete.

4. **Compaction of Concrete:** In the process of placing concrete, air is entrapped. The entrapped air reduces the strength of concrete up to 30%. Hence it is necessary to remove this entrapped air. This is achieved by compacting the concrete after placing it in its final position. Compaction can be carried out either by hand or with the help of vibrators.

(*a*) *Hand Compaction:* In this method concrete is compacted by ramming, tamping, spading or by slicing with tools. In intricate portions a pointed steel rod of 16 mm diameter and about a metre long is used for poking the concrete.

(*b*) *Compaction by Vibrators:* Concrete can be compacted by using high frequency vibrators. Vibration reduces the friction between the particles and set the motion of particles. As a result entrapped air is removed and the concrete is compacted. The use of vibrators reduces the compaction time.

The following types of vibrators are commonly used in concreting:
(*a*) Needle or immersion vibrators
(*b*) Surface vibrators
(*c*) Form or shutter vibrators
(*d*) Vibrating tables.

Needle vibrators are used in concreting beams and columns. Surface vibrators and form vibrators are useful in concreting slabs. Vibrating tables are useful in preparing precast concrete elements.

Curing of Concrete

Curing may be defined as the process of maintaining satisfactory moisture and temperature conditions for freshly placed concrete for some specified time for proper hardening of concrete. Curing in the early ages of concrete is more important. Curing for 14 days is very important. Better to continue it for 7 to 14 days more. If curing is not done properly, the strength of concrete reduces. Cracks develop due to shrinkage. The durability of concrete structure reduces.

The following curing methods are employed:
(*a*) Spraying of water
(*b*) Covering the surface with wet gunny bags, straw etc.
(*c*) Ponding
(*d*) Steam curing and
(*e*) Application of curing compounds.

(*a*) Spraying of water: Walls, columns, plastered surfaces are cured by sprinkling water.
(*b*) Wet covering the surface: Columns and other vertical surfaces may be cured by covering the surfaces with wet gunny bags or straw.
(*c*) Ponding: The horizontal surfaces like slab and floors are cured by stagnating the water to a height of 25 to 50 mm by providing temporary small hunds with mortar.
(*d*) Steam curing: In the manufacture of pre-fabricated concrete units steam is passed over the units kept in closed chambers. It accelerates curing process, resulting into the reduction of curing period.
(*e*) Application of curing compounds: Compounds like calcium chloride may be applied on the curing surface. The compound shows affinity to the moisture and retains it on the surface. It keeps the concrete surface wet for a long time.

Properties of Concrete

(i) Workability:

This is defined as the ease with which concrete can be compacted fully without segregating and bleeding. It can also be defined as the amount of internal work required to fully compact the concrete to optimum density. The workability depends upon the quantity of water, grading, shape and the percentage of the aggregates present in the concrete.

The workability is measured by:
(*a*) The slump observed when the frustum of the standard cone filled with concrete is lifted and removed.
(*b*) The compaction factor determined after allowing the concrete to fall through the compaction testing machine.
(*c*) The time taken in seconds for the shape of the concrete to change from cone to cylinder when tested in Vee-Bee consistometer.

(ii) Strength:

The characteristic strength of concrete is defined as the compressive strength of 150 mm size cubes after 28 days of curing below which not more than 5 per cent of the test results are expected to fail. The unit of stress used is N/mm^2.

- Concrete grade is denoted by letter M (mix) and one number which is the characteristic strength at 28 days in N/mm^2

Grade of Concrete	M 5	M 7.5	M 10	M 15	M 20	M 25
Characteristic strength at 28 days in N/mm^2	5	7.5	10	15	20	25
Proportion of mix	1:5:10	1:4:8	1:3:6	1:2:4	1:1.5:3	1:1:2

Uses of concrete

1. As bed concrete below column footings, wall footings, on wall at supports to beams
2. As sill concrete
3. Over the parapet walls as coping concrete
4. For flagging the area around buildings
5. For pavements
6. For making building blocks

Form work

When concrete is placed, it is in plastic state. It requires to be supported by temporary supports and casings of the desired shape till it becomes sufficiently strong to support its own weight. This temporary casing is known as formwork.

REINFORCED CEMENT CONCRETE (R.C.C.)

Concrete is good in resisting compression but is very weak in resisting tension. Hence reinforcement is provided in the concrete wherever tensile stress is expected. The best reinforcement is steel, since tensile strength of steel is quite high and the bond between steel and concrete is good. As the elastic modulus of steel is high, for the same extension the force resisted by steel is high compared to concrete. However in tensile zone, hair cracks in concrete are unavoidable. Reinforcements are usually in the form of mild steel or ribbed ste.

PRESTRESSED CONCRETE (PSC)

Strength of concrete in tension is very low and hence it is ignored in R.C.C. design. Concrete in tension is acting as a cover to steel and helping to keep steel at desired distance. Thus in R.C.C. lot of concrete is not properly utilized. Prestressing the concrete is one of the method of utilizing entire concrete. The principle of prestressed concrete is to introduce calculated compressive stresses in the zones wherever tensile stresses are expected in the concrete structural elements. When such structural element is used stresses developed due to loading has to first nullify these compressive stresses before introducing tensile stress in concrete. Thus in prestressed concrete entire concrete is utilized to resist the load.
Prestressed concrete is basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from external loads are counteracted to a desired degree.

Steel:

It is extensively used building material. The following three varieties of steel are extensively used:
(*a*) Mild steel
(*b*) High carbon steel and
(*c*) High tensile steel.

<u>Mortar</u>:

Mortar is an intimate mixture of binding material, fine aggregate and water. When water is added to the dry mixture of binding material and the inert material, binding material develops the property that binds not only the inert material but also the surrounding stones and bricks. If the cement is the binding material, then the mortar is known as cement mortar. Other mortars commonly used are lime mortar and mud mortar. The inert material used is sand.

<u>ELEMENTS OF A BUILDING</u>

A structure consists of two parts. Namely,

a. Superstructure – Above the plinth level. Superstructure mainly consists of walls, doors windows and lintels. The purpose of superstructure is to provide the necessary utility of the building, structural safety, fire safety, sanitation and ventilation.
b. Sub Structure - Below the plinth level. It is also known as foundation.

The following are the basic elements of a building:

1. Foundation
2. Plinth
3. Walls and columns
4. Sills, lintels and chejjas
5. Doors and windows
6. Floors
7. Roofs
8. Steps, stairs and lifts
9. Finishing work
10. Building services.

The functions of these elements and the main requirement of them is presented in this article.

1. Foundation: Foundation is the most important part of the building. Building activity starts with digging the ground for foundation and then building it. It is the lower most part of the building. It transfers the load of the building to the ground. Its main functions and requirements are:

(*a*) Distribute the load from the structure to soil evenly and safely.
(*b*) To anchor the building to the ground so that under lateral loads building will not move.

(*c*) It prevents the building from overturning due to lateral forces.

(*d*) It gives level surface for the construction of super structure.

2. Plinth: The portion of the wall between the ground level and the ground floor level is called plinth. It is usually of stone masonry.

3. Walls and Columns: The function of walls and columns is to transfer the load of the structure vertically downwards to transfer it to foundation. Apart from this wall performs the following functions also:

(*a*) It encloses building area into different compartments and provides privacy.

(*b*) It provides safety from burglary and insects.
(*c*) It keeps the building warm in winter and cool in summer.

4. Sills, Lintels and Chajjas: A window frame should not be directly placed over masonry. It is placed over 50 mm to 75 mm thick plain concrete course provided over the masonry. This course is called as sill.
Lintels are the R.C.C. or stone beams provided over the door and window openings to transfer the load transversely so as to see that door or window frame is not stressed unduly.
Chajja is the projection given outside the wall to protect doors and windows from the rain. They are usually made with R.C.C.

5. Doors and Windows: The function of a door is to give access to different rooms in the building and to deny the access whenever necessary.

6.Floors: Floors are the important component of a building. They give useful area for the occupants.

7. Roof: Roof is the top most portion of the building which provide top cover to the building. It should be leak proof.

Sloping roof like tiled and A.C. sheet give leak proof cover easily. But they do not give provision for the construction of additional floor.

Tiled roof give good thermal protection. Flat roofs give provision for additional floors. Terrace adds to the comfort of occupants. Water tanks can be easily placed over the flat roofs.

8. Step, Stairs and Lifts: Steps give convenient access from ground level to ground floor level. They are required at doors in the outer wall. 250 to 300 mm wide and 150 mm rise is ideal size for steps.

9. Finishing: Bottom portion of slab (ceiling), walls and top of floor need smooth finishing with plaster. Then they are provided with white wash, distemper or paints or tiles. The function of finishing work is:
(*a*) Give protective cover
(*b*) Improve aesthetic view
(*c*) Rectify defective workmanship
(*d*) Finishing work for plinth consists in pointing while for floor it consists in polishing.

MASONRY

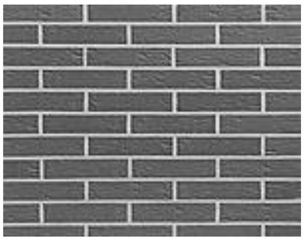
Types of masonries:

a. Brick Masonry
b. Stone Masonry

Brick Masonry (Bonds in Brick work):

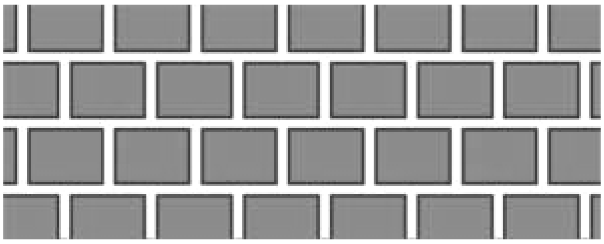
Stretcher Bond:

- All the bricks are arranged in stretcher courses.
- The stretcher bond is useful for one brick partition as there are no headers.
- As the internal bond is not proper this is not used for walls of thickness greater than one brick.



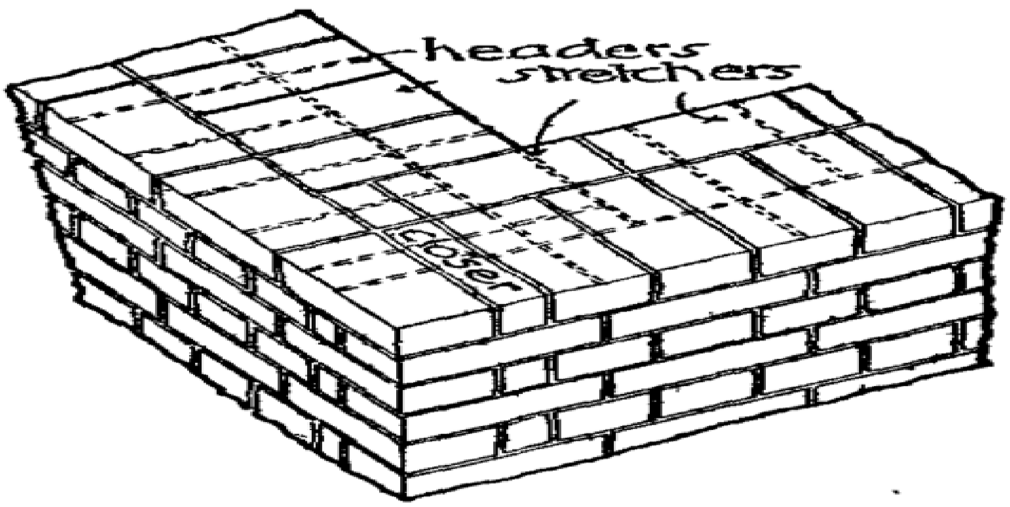
Header Bond

All bricks are arranged in header courses. It is used for curved surfaces since the length will be less.



English Bond:

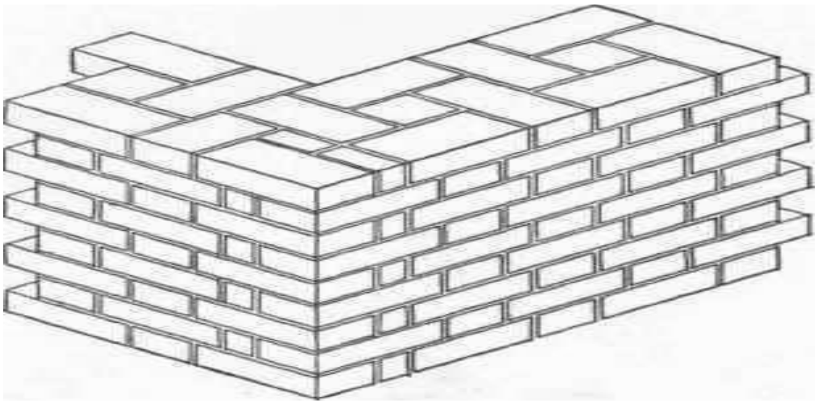
- It is most commonly used type of bond.
- It is the strongest type of bond.
- It is used for all wall thicknesses.
- English bond consists of headers and stretchers in alternative courses of elevation. A queen closer is placed next to the quoin header in each header course to the full thickness of wall. Each alternative header lies centrally over a stretcher of the stretcher course.



Flemish Bond:

The peculiarities of a Flemish bond are as follows.

- In every course headers and stretchers are placed alternatively.
- The queen closer is put next to the queen header in alternate course to develop the lap.
- Every header is centrally supported over a stretcher below it.
- The Flemish bond may be either a double Flemish or Single Flemish bond



Racking Bond:

It is used for thick walls.

It is subdivided into

1. *Diagonal bond*

2. Herringbone bond.

Stone Masonry

- It is a natural choice for masonry.
- Stone masonry is the construction carried out using stones with mortar. Because of high cost of transportation, painful and costly work of dressing and need for experienced labour, stone masonry is presently not popular.
- Further stone masonry walls occupy more space compared brick work.

Uses of stone masonry:

- Foundation, floor, walls, lintels, column, roofs, etc.
- Walls, roofs, lintels for temples, monuments etc.,
- Facing works in brick masonry to give massive appearance.

Classification of stone masonry

Rubble Masonry

Random rubble masonry

Uncoursed and coursed

- Squared rubble masonry
- Polygonal rubble masonry

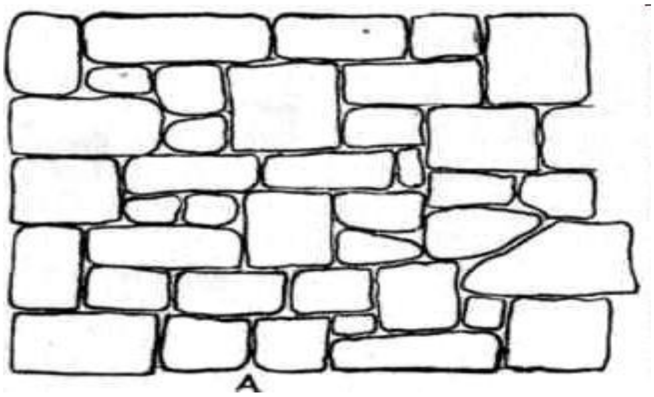
Ashlar Masonry

Ashlar fine masonry

- Ashlar rough tooled masonry
- Ashlar rock or quarry faced masonry
- Ashlar chamfered masonry
- Ashlar facing masonry

Random Rubble masonry:

- Random rubble masonry, uses stones of Irregular shapes.
- The stones are arranged in a random fashion.
- The joints are points to achieve a good appearance.
- The efficiency of this type depends upon the workmanship.



Square rubble masonry

- In square rubble masonry, the stones are roughly squared with straight edges and sides with hammer blows.

Ashlar Masonry:

- In Ashlar masonry, no irregular stones are used.
- The entire construction is done using square or rectangular dressed stones.
- The sides and faces of the stones are dressed finely with chisel.