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Unit 2

ELEMENTS OF A BUILDING

The following are the basic elements of a building:
1. Foundation
2. Plinth
3. Walls and columns
4. Sills, lintels and chajjas
5. Doors and windows
6. Floors
7. Roofs
8. Steps, stairs and lifts
9. Finishing work
10. Building services.

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. If the foundation is on piles, a plinth beam is cast to support wall above floor level. At the top of plinth a damp proof course is provided. It is usually 75 mm thick plain concrete course. The function of the plinth is to keep the ground floor above ground level, free of dampness. Its height is not less than 450 mm. It is required that plinth level is at least 150 mm above the road level, so that connections to underground drainage system can be made.

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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. The projection of chajja varies from 600 mm to 800 mm.

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. Number of doors should be minimum possible. The size of the door should be of such dimension as will facilitate the movement of the largest object likely to use the door. Windows are provided to get light and ventilation in the building. They are located at a height of 0.75 m to 0.9 m from the floor level. In hot and humid regions, the window area should be 15 to 20 per cent of the floor area. Another thumb rule used to determine the size and the number of windows is for every 30 m^3 of inside volume there should be 1 m^2 window opening.

6. Floors: Floors are the important component of a building. They give working/useful area for the occupants. The ground floor is prepared by filling brick bats, waste stones, gravel and well compacted with not less than 100 mm sand layer on its top. A lean concrete of 1 : 4 : 8, 100 mm thick is laid. On this a damp proof course may be provided. Then floor finishing is done as per the requirement of the owner. Cheapest floor finish for a moderate house is with 20 to 25 mm rich mortar course finished with red oxide. The costliest floor finish is mosaic or marble finishing.

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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. In no case the size of two consecutive steps be different. Number of steps required depends upon the difference in the levels of the ground and the floor. Stairs give access from floor to floor. They should consists of steps of uniform sizes. In all public buildings lifts are to be provided for the conveniences of old and disabled persons. In hostels G + 3 floors can be built without lifts, but in residential flats maximum floors permitted without lifts is only G + 2. Lift is to be located near the entrance. Size of the lift is decided by the number of users in peak hours. Lifts are available with capacity 4 to 20 persons.

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.

10. Building Services: Water supply, sanitation and drainage works, electric supply work and construction of cupboards and show cases constitute major building services. For storing water from municipal supply or from tanker a sump is built in the house property near street. From the sump water is pumped to over head tanks placed on or above roof level so as to get water all the 24 hours. Plumbing work is made so as to get water in kitchen, bathrooms, water closets, sinks and garden taps. For draining rain water from roofs, down take pipes of at least 100 mm diameters should be used. Proper slopes should be given to roof towards down take pipe. These pipes should be fixed at 10 to 15 mm below the roof surface so that rain water is directed to the down take pipe easily. The sanitary fittings are to be connected to stone ware pipes with suitable traps and chambers. Stone ware pipes are then connected to underground drainage of municipal lines or to the septic tank. Many carpentry works are required for building service. They are in the form of showcases, cupboards, racks etc. Electric supply is essential part of building services. The building should be provided with sufficient points for supply of lights, fans and other electric gadgets.

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CONCRETE

1. Plain cement concrete

Plain cement concrete is an intimate mixture of binding material, fine aggregate, coarse aggregate and water. This can be easily moulded to desired shape and size before it looses plasticity and hardens.

Major ingredients of concrete are:

1. Binding material (like cement, lime, polymer)
2. Fine aggregate (sand)
3. Coarse aggregates (crushed stone, jelly)
4. Water.

A small quantity of admixtures like air entraining agents, water proofing agents, workability agents etc. may also be added to impart special properties to the plain concrete mixture. Depending upon the **proportion of ingredient,** strength of concrete varies. It is possible to determine the proportion of the ingredients for a particular strength by mix design procedure. In the absence of mix design the ingredients are proportioned as 1:1:2,1;1$\frac{1}{2}$:3 1:2:4, 1:3:6 and 1:4:8, which is the ratio of weights of cement to sand to coarse aggregate. In proportioning of concrete it is kept in mind that voids in coarse aggregates are filled with sand and the voids in sand are filled with cement paste.

Functions of Various Ingredients

Cement is the binding material. After addition of water it hydrates and binds aggregates and the surrounding surfaces like stone and bricks. Generally richer mix (with more cement) gives more strength. Setting time starts after 30 minutes and ends after 6 hours. Hence concrete should be laid in its mould before 30 minutes of mixing of water and should not be subjected to any external forces till final setting takes place.

Coarse aggregate consists of crushed stones. It should be well graded and the stones should be of igneous origin. They should be clean, sharp, angular and hard. They give mass to the concrete and prevent shrinkage of cement.

Fine aggregate consists of river sand. It prevents shrinkage of cement. When surrounded by cement it gains mobility enters the voids in coarse aggregates and binding of ingredients takes place. It adds density to concrete, since it fills the voids. Denser the concrete higher is its strength.

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Water used for making concrete should be clean. It activates the hydration of cement and forms plastic mass. As it sets completely concrete becomes hard mass. Water gives workability to concrete which means water makes it possible to mix the concrete with ease and place it in final position. More the water better is the workability. However excess water reduces the strength of concrete. To achieve required workability and at the same time good strength a water cement ratio of 0.4 to 0.45 is used, in case of machine mixing and water cement ratio of 0.5 to 0.6 is used for hand mixing.

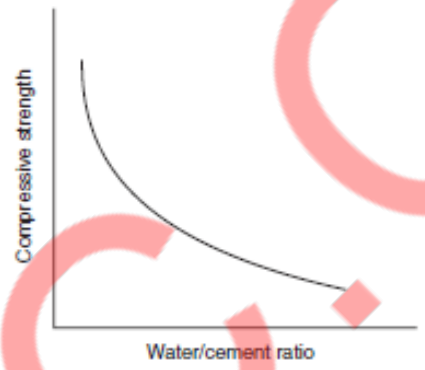

Fig 1: Variation of strength of concrete with w/c ratio

Preparing and Placing 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

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(*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. The quantity of water required for making concrete is found after deciding water cement ratio. For example, if water cement ratio is 0.5, for one bag of cement (50 kg), water required is 0.5 × 50 = 25 kg, which is equal to 25 litres. Suitable measure is used to select required quantity of water. 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.

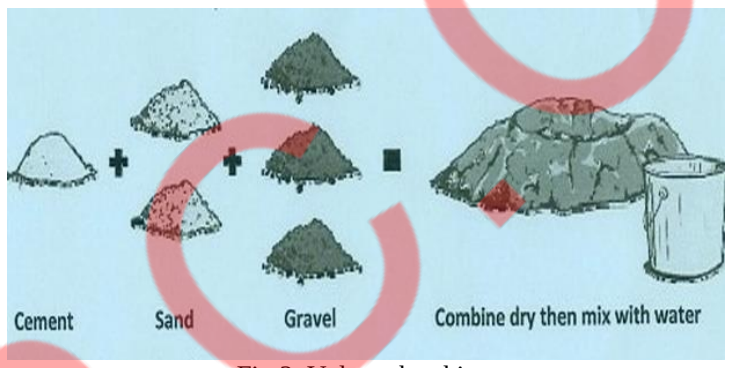

Fig 2: Volume batching

(*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.

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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. Figure 3.2 shows a typical concrete mixer. Required quantities if 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.

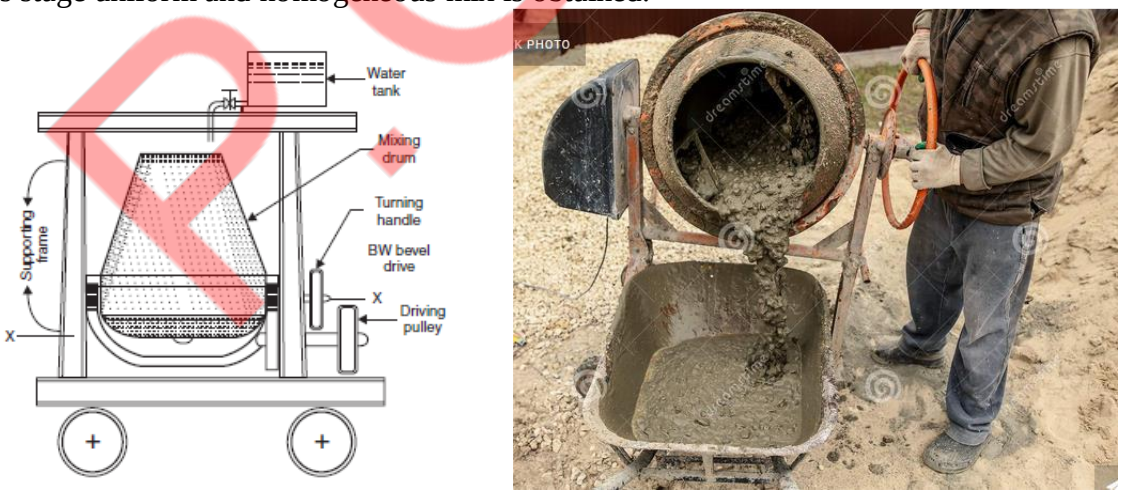

Fig 3: Concrete mixer

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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 aggregates 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. When vibrators are used for compaction, water cement ratio can be less, which also help in improving the strength of concrete. Vibration should be stopped as soon as cement paste is seen on the surface of concrete. Over vibration is not good for the concrete.

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.

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Fig 4: Compaction of concrete

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 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 bunds with mortar.

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(*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

Concrete has completely different properties when it is the plastic stage and when hardened. Concrete in the plastic stage is also known as *green concrete*. The properties of green concrete include:
1. Workability
2. Segregation
3. Bleeding
4. Harshness.

The properties of hardened concrete are:
1. Strength
2. Resistance to wear
3. Dimensional changes
4. Durability
5. Impermeability.

Properties of Green Concrete

1. 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.
2. Segregation: Separation of coarse particles from the green concrete is called segregation.
3. Bleeding: This refers to the appearance of the water along with cement particles on the surface of the freshly laid concrete.
4. Harshness: Harshness is the resistance offered by concrete to its surface finish.

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Properties of Hardened Concrete

1. 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/mm2.

2. Dimensional Change: Concrete shrinks with age. The total **shrinkage** depends upon the constituents of concrete, size of the member and the environmental conditions. Total shrinkage is approximately 0.0003 of original dimension.

3. Durability: Environmental forces such as weathering, chemical attack, heat, freezing and thawing try to destroy concrete. The period of existence of concrete without getting adversely affected by these forces is known as durability.

4. Impermeability: This is the resistance of concrete to the flow of water through its pores.

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.
7. major use of concrete is as a major ingredient of reinforced and pre stressed concrete.

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 steel bars of 6 mm to 32 mm diameter. A cage of reinforcements is prepared as per the design requirements, kept in a form work and then green concrete is poured. After the concrete hardens, the form work is removed. The composite material of steel and concrete now called R.C.C. acts as a structural member and can resist tensile as well as compressive stresses very well.

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Properties of R.C.C./Requirement of Good R.C.C.

1. It should be capable of resisting expected tensile, compressive, bending and shear forces.
2. It should not show excessive deflection and spoil serviceability requirement.
3. There should be proper cover to the reinforcement, so that the corrosion is prevented.
4. The hair cracks developed should be within the permissible limit.
5. It is a good fire resistant material.
6. When it is fresh, it can be moulded to any desired shape and size.
7. Durability is very good.
8. R.C.C. structure can be designed to take any load.

Uses of R.C.C.

It is a widely used building material. Some of its important uses are listed below:

1. R.C.C. is used as a structural element, the common structural elements in a building where R.C.C. is used are:
(*a*) Footings (*b*) Columns
(*c*) Beams and lintels (*d*) Chajjas, roofs and slabs. (*e*) Stairs.
2. R.C.C. is used for the construction of storage structures like
(*a*) Water tanks (*b*) Dams (*c*) Bins (*d*) Silos and bunkers.
3. It is used for the construction of big structures like
(*a*) Bridges (*b*) Retaining walls
(*c*) Docks and harbours (*d*) Under water structures.
4. It is used for pre-casting
(*a*) Railway sleepers (*b*) Electric poles
5. R.C.C. is used for constructing tall structures like
(*a*) Multi-storey buildings (*b*) Chimneys
(*c*) Towers.
6. It is used for paving (*a*) Roads (*b*) Airports.
7. R.C.C. is used in building atomic plants to prevent danger of radiation. For this purpose R.C.C. walls built are 1.5 m to 2.0 m thick.

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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. Pre stressing the concrete is one of the method of utilizing entire concrete. The principle of pre stressed 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 pre stressed concrete entire concrete is utilized to resist the load.

Another important advantage of PSC is hair cracks are avoided in the concrete and hence durability is high. The fatigue strength of PSC is also more. The deflections of PSC beam is much less and hence can be used for longer spans also. PSC is commonly used in the construction of bridges, large column free slabs and roofs. PSC sleepers and electric poles are commonly used. The material used in PSC is high tensile steel and high strength steel. The tensioning of wires may be by pre tensioning or by post tensioning. Pre tensioning consists in stretching the wires before concreting and then releasing the wires. In case of post tensioning, the ducts are made in concrete elements. After concrete of hardens, pre stressing wires are passed through ducts. After stretching wires, they are anchored to concrete elements by special anchors.

TYPES OF SUPER STRUCTURES BASED ON THE METHOD OF LOAD TRANSFER

On this basis there are two types

1. Load Bearing Structures
2. Framed Structures

1. Load Bearing Structures: In this type of structure the load on the structure is transferred vertically downward through walls. Loads from roof and floors gets transferred to wall and then wall has to transfer these loads as well as self weight. Such constructions are used in residential buildings where dimension of rooms is less. Residential buildings up to ground + 2 floors can be built economically with such structures.

2. Framed Structures: In this type of structures a frame work of columns, beams and floors are built first. Then walls are built to partition the living area. The walls are subjected to self weight only. This type of super structures are required when number of stories in a building is more and also when larger areas are to be covered free from walls.

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Sr. No	Load bearing structure	Framed structure
1	Cost is less	Cost is more
2	Suitable up to 3 storeys	Suitable for any number of storeys
3	Walls are thicker hence floor area is reduced.	Walls are thinner hence more floor area is available for use.
4	Slow construction	Speedy construction
5	Not possible to alter the position of walls after construction	Position of walls maybe changed whenever necessary
6	Resistance to earthquake is poor	Resistance to earthquake is good.