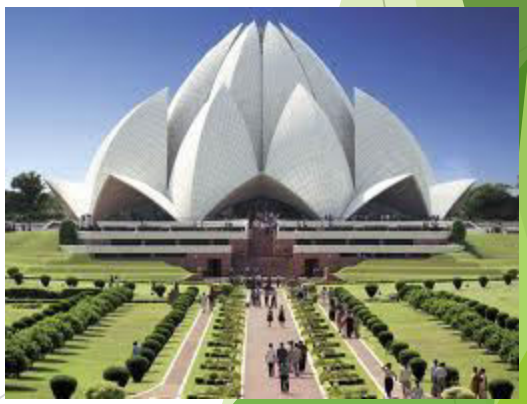
BASIC CIVIL ENGINEERING



BUILDING MATERIALS

- STONES
- BRICKS
- CEMENT
- CONCRETE
- STEEL

STONES

- Stone is a naturally available material of construction and is obtained from rocks.

Classification of Rocks

Rocks are classified in following three ways

1. Geological Classification
2. Physical Classification
3. Chemical Classification

Geological Classification

Based on the mode of formation, the rocks are classified as:

i. Igneous Rocks:

- These rocks are formed by the cooling of molten rocky material called magma which is inside the earth's surface.

eg. Granite.

- If the magma cools at a relatively shallow depth from earth's surface then it is called Hyperbyssal rocks.

eg. Dolerite.

Geological Classification contd…

- If the magma cools at earth's surface
- then it is called volcanic rocks.

eg. Basalt.

ii. Sedimentary Rocks:

- Sedimentary rocks are formed by the deposition of products of weathering on the pre-existing rock.
- All the products of weathering are u1timately carried away from their place of origin by the agents of wind, rain, frost, etc.

eg. Sandstone, Limestone, Gypsum, Gravel etc

Geological Classification contd…

iii. Metamorphic Rocks: When the pre-existing rocks (i.e. Igneous and Sedimentary rocks) are subject to great heat and pressure, they are changed in character and forms metamorphic rocks.

eg. Slate, Marble, Gneisses

Physical Classification

- **Stratified Rocks:** These rocks possess planes of stratification and such rocks can easily be split up along these planes.

  eg. Sedimentary Rocks.

- **Unstratified Rocks:** These rocks do not exhibit any definite layers or strata.

  eg. Igneous rocks.

- **Foliated Rocks:** These rocks have a tendency to be split up in a definite direction only.

  eg. Metamorphic Rocks.

Chemical Classification

- **Silicious Rocks:** In these rocks, Silica is the main constituent.

  eg. Granite, Quartzites etc

- **Argillaceous Rocks:** In these rocks, clay or argil is the main constituent.

  eg. Slates, Laterites etc.

- **iii) Calcareous Rocks:** In these rocks, Calcium Carbonate is the main constituent

  eg. Lime stones, Marbles etc.

Tests for Stones

The following are the tests conducted on stones to decide construction work

1. Impact test
2. Crushing strength test
3. Attrition test
4. Hardness Test
5. Water absorption test
6. Freezing and thawing test
7. Microscopic test
8. Smith's test

Impact test:

In this test, a cylinder of diameter 25 mm and height 25 mm is taken out from the sample of stone.

A steel hammer of wt 2 Kg is allowed to fall axially on the cylinder from 1cm height for first blow, 2 cm height for second blow etc.

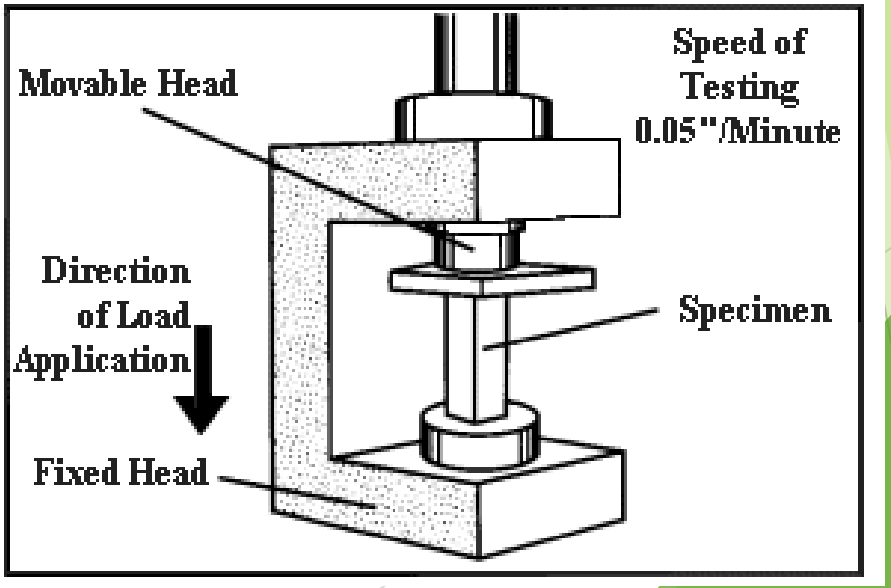
Blow at which the specimen breaks is noted.

If it is n^{th} blow, n represents the toughness index of stone.

Crushing Strength test:

- In this test, a cube of stone is tested in a compression testing machine.
- The rate of loading is 4.0 N / mm^2 per minute.
- The maximum load at which the stone crushes is noted.
- Crushing Strength of the stone =

  Max load / Area of bearing face of the stone



Attrition test:

- In this test, some known weight of stone pieces are taken and put in the Deval's attrition test cylinder.
- The cylinder is rotated about its horizontal axis for 5 hrs at the rate of 30 RPM. Then the contents in the cylinder are sieved by 1.5 mm sieve.

$$\text{Percentage of Wear} = \frac{\text{Initial Weight}}{\text{Loss in Weight}} \times 100$$

Hardness Test:

- In this test, a cylinder of stone diameter 25 mm and height 25 mm is placed in Dorry's testing machine and pressed with a pressure of 12.5 N.
- The annular steel disc of the machine is rotated at a speed of 28 RPM.
- During rotation coarse sand of standard specification is sprinkled on the top of disc.
- After 1000 revolutions, the specimen is taken out and weighed.

$$\text{Coefficient of hardness} = 20 - \frac{\text{Loss in weight in g}}{3}$$

-

Water absorption test:

- In this test, a stone of known weight is immersed in water for 24 hrs.
- Then it is weighed again after 24 hrs and the percentage absorption of water should not exceed 0.6

Freezing and thawing test:

- In this test specimen of stone is placed in freezing mixture at12°c for 24 hours and it is then warmed at atmospheric temperature. The procedure is repeated for several times and the behavior of stone is noted.

Microscopic test:

- In this test, thin sections of stone are taken and they are examined in a microscope to study various properties like grain size, mineral constituents etc.

Smith's test:

- In this test, clear water is taken in a test and pieces of stones are placed in it.
- The tube is vigorously stirred.
- If the water becomes dirty it indicates the stone contains earthy matter.

Qualities of Good Building Stone

A good building stone should have the following qualities:

- The crushing strength of stone should be greater than 100 N/mm^2.
- Stones must be decent in appearance and be of uniform colour.
- Stones must be durable.
- Fracture should be sharp and clear.
- For a good building stone, co-efficient of hardness should not be below 14.

- It must have a wear less than 3 percent.
- It must have a SG of greater than 2.7.
- It must have a compact, fine, crystalline structure, strong and durable.
- The toughness index must not be less than 13.
- It must be acid resistant and free form any soluble matter.
- When a stone is immersed in water for 24 hrs, the percentage absorption by weight should not exceed 0.6

Uses of Stones

- Stones are used as basic material for concrete, moorum of roads, calcareous cements etc.
- Stones are adopted to form paving of roads and foot paths.
- Stones are converted to form basic materials for concrete, moorum of roads, artificial stones, hollow blocks, etc.
- Stones are also used as ballast for railway track.
- Stone blocks are used in the construction of bridges, abutments retaining wall, dams etc.

Usuage of stones

Paving road

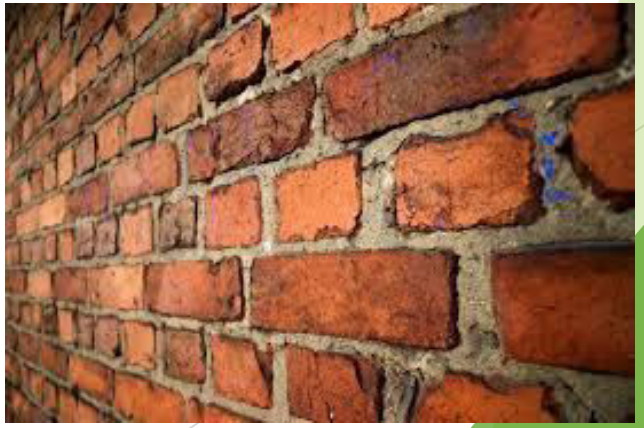
Railway track Ballast

Retaining walls

Dams construction

BRICKS

- Bricks are artificial blocks manufactured from tempered clay into standard sizes.
- Bricks are manufactured from Earth containing
- alumina (20 to 30%)
- Silica (50 to 60%),
- Iron Oxide (5 to 6%) and small quantities of lime and magnesia.



Manufacture of Bricks

Manufacture of bricks involves the following operations

1. Preparation of brick earth
2. Moulding
3. Drying
4. Burnings

Preparation of Brick Earth

This includes the following operations:

- **Removal of loose soil:** The top layer of loose soil should be removed for a depth of 20 cm. It should not be used for preparation of bricks as it contains lot of impurities.

- **Digging, spreading and cleaning:** The earth removed from below 20 cm is spread on a level ground. All undesirable materials like grass, roots, gravel etc are removed.

Preparation of Brick Earth

- **Weathering:** The spread earth is left as such for a few weeks to allow the clay to mellow
- **Blending:** This consists of mixing the clay with suitable ingredients by turning up and down many times
- **Tempering:** This is done to make the whole mass of clay, homogenous and plastic.
- This is done by trampling under feet by men or cattle in a Pug mill when bricks are required on large scale.

Moulding

- The pugged brick earth is then moulded into shape in moulds.
- Moulding can be done on the ground or on top of a table, either by hand or machine.

Drying

- Bricks are dried for a period of 7 to 14 days. During drying this must be protected from wind, rain and direct sun.

Burning

- After drying the bricks area burned in kilns of clamps to make them harder, stronger, denser, less absorbent and more durable

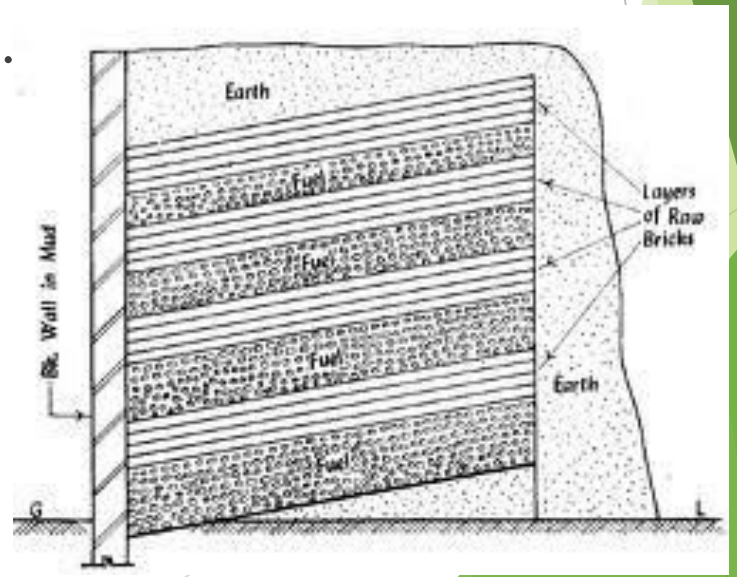
Burning in Clamps:

- A clamp is an arrangement where the bricks and fuel are arranged in alternate layers.
- A floor is prepared and the fuel is first spread at slope of 15°. The fuel consists of wooden piece, cow dung, straw, waste paper etc., On top of this layer the raw bricks are placed.

- Then another layer, of 75cm. thick fuel is spread. Thus alternate layer of brick and fuel are arranged to a height of 3 to 4 cm.

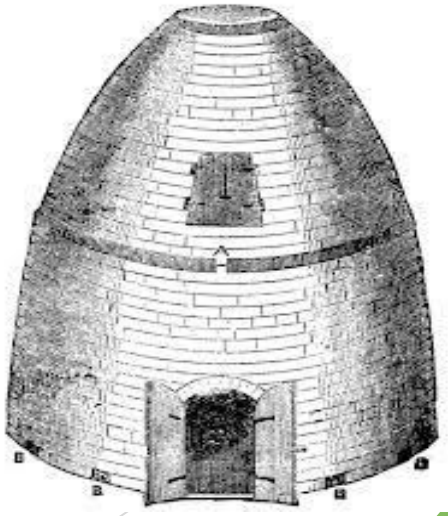
- Then entire clamp is plastered on all the sides and top and filled with earth cover to conserve the heat.

- The bricks are burnt for a period of one or two months and then cooled for the same period.



Burning in Kilns:

- When large number of bricks have to be burnt Kilns are adopted.
- Kilns are of two types
  - Intermittent Kilns and
  - Continuous Kilns
- In intermittent Kilns the loading firing cooling and unloading are done one after the other and not simultaneously
- whereas in continuous these operations are carried out without any interruptions.



Merits and demerits of Clamp and Kiln burning of Bricks

Clamp Burning:

1. It is a temporary structure

2. Initial cost is low

3. Amount of fuel used is low and hence economical

4. Continuous supervision is not necessary

5. Quality of bricks is poor. Only 60% is of First Class variety.

6. Firing cannot be regulated

7. It takes a long time for burning and cooling the bricks (3 to 6 months).

8. There is large amount of wastage of heat from the hot gases.

Kiln Burning:

1. It is a permanent structure
2. Initial cost is higher
3. Fuel cost is higher
4. Constant supervision is necessary

5.Quality of bricks turned out is good. 90% first class bricks

6.Time of firing is only 24 hours and cooling is 12 days.

7.It is yielding about 25,000 bricks per clay

8.Heat of hot gases is utilized in heating bricks to be burnt.

Size and Weight of Bricks

- The Indian Standards Institution, New Delhi has specified, standard bricks of 19cm x 9cm x 9cm with 1cm thick mortar joints.
- This standard brick weight is 3kg.

Classification of Bricks

1. **First class bricks:** Table moulded edges are clear, square straight. Used for superior works.
2. **Second class bricks:** Ground moulded burnt in kilns surface not smooth and edges not regular used where the bricks work will be plastered.
3. **Third c1ass bricks:** Ground moulded not hard rough surface and edges are also not sharp and regular. Used for unimportant and temporary constructions.
4. **Fourth class bricks**: These are over burnt bricks dark in colour and irregular. Used as aggregates for concrete foundations, floors, roads etc.

Characteristics of Good Bricks

- A good brick should satisfy the following essential qualities
- The bricks should have even surfaces free from flaw or cracks and should have sharp well defined edges.
- These should be so hard that no impression should be left when scratched with finger nails.
- These should produce clear ringing sound when struck against each other.
- No brick should absorb more than 15% of its weight of water.

Characteristics of Good Bricks contd……

- No brick should have a crushing strength less than 3.5 N/mm^2.
- On breaking the surface it should show a bright homogeneous and compact surface free from voids
- A brick soaked in water should not show any deposit of white salts on drying in shade.
- When dropped flat from a height of 1m ,the brick should not break.
- Bricks should not conduct most heat and they should be sound proof.

Testing of Bricks

1. **Crushing strength test**: Minimum crushing strength of bricks is 3.5 $N/mm^2$and for superior bricks; it may vary from 7.0 to 14.0 N/mm^2

2. **Soundness test:** In this test, two bricks are taken and they are struck with each other. Bricks should not break and a clear ringing sound should be produced.

3. **Hardness test:** In this test, a scratch is made on brick surface with the help of a finger nail. If no impression is left on the surface then the brick is treated to be sufficiently hard.

Testing of Bricks contd…..

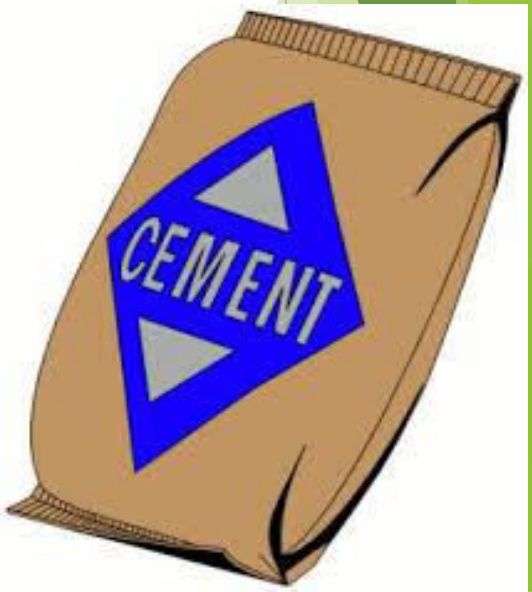
4. Test for presence of soluble salts

- For finding out the presence of soluble salts in a brick, it is immersed in water for 24 hours.
- It is then taken out and allowed to dry in shade.
- Absence of grey or white deposits cover about 10 percent surface, the efflorescence is said to be slight and it is considered as moderate, when the white deposits cover about 50 percent of surface, the efflorescence becomes heavy and it is treated as serious, when such deposits are converted into powdery mass.

5.**Absorption test :** It should not, in any case, exceed 20 percent of weight of dry brick.

CEMENT

- It is the product which is obtained by burning and crushing to powder a well proportioned mixture of calcareous and argillaceous materials.
- It was introduced in 1824 by Joseph Asp Din a brick layer of Leeds, England.
- After hardening it resembles in colour to the stone quarried near Portland in England, so it is named after that as Portland cement.
- It is available in different varieties and the selection of variety depends upon the condition, strength and the type of structure.



Raw materials required for manufacture of cement are

- **Calcareous Materials:** Calcareous materials are those materials which contain calcium or lime as their main constituents such as lime stone, chalk etc.

- **Argillaceous Materials:** Argillaceous materials are those materials which contain alumina as their main constituents such as shale, laterite etc. It provides the required proportion of silica, clay, oxide of iron to the cement.

Proportion of mixing

- The ingredients are generally mixed in the ratio of two parts of Calcareous materials and one part argillaceous material.
- Limestone and shale are first crushed and then they are mixed either in wet state or in dry state by grounding them together.
- The mixture is then burnt in a rotary kiln at a temperature between 1400°C and l500°C.
- Pulverized coal, gas or oil being used as the fuel.
- The clinker so obtained is first cooled and then gypsum (3 to 4%) is added and it is grounded to the required fineness.

Main chemical Ingredients of Cement (Raw Stage)

Sl. No.	Ingredient	Composition	Percentage
1	Lime	CaO	60 to 67
2	Silica	Sio_2	17 to 25
3	Iron Oxide	Fe_2O_3	0.5 to 6
4	Alumina	Al_2O_3	3 to 8
5	Gypsum or Calcium Sulphate	$CaSO_4$	3 to 4
6	Magenisum Oxide	MgO	0.1 to 4
7	Sulphur Trioxide	SO_3	1 to 3
8	Alkalies such as soda	$NaOK_2O$	0.1 to 1

Functions and Effects of Various Ingredients

- **Lime:** It makes the cement sound and provides strength to the cement. Excess of it in original form causes the cement to expand and disintegrate.
- **Silica:** It provides strength to the cement. In excess it slows down the setting of cement.
- **Alumina:** It provides quick setting property to the cement. In excess it weakens the strength of cement.

- **Calcium Sulphate (Gypsum):** It helps in increasing the initial setting time of cement.
- **Iron Oxide:** It provides colour, hardness and strength to the cement.
- **Magnesium Oxide:** It provides colour and hardness to the cement. Excess of it in free state makes the cement unsound.
- **Sulphur Trioxide:** In small quantity it makes the cement sound and in excess it makes the cement unsound.
- **Alkalies:** In excess it causes efflorescence.

Final compounds of Cement

Sl. No.	Compound	Formula	Abbreviation	Range
1	Dicalcium silicate	$2(CaO)SiO_2$	C_2S	21 to 45%
2	Tricalcium silicate	$3(CaO)SiO_2$	C_3S	25 to 50%
3	Tricalcium Aluminate	$3(CaO)Al_2O_3$	C_3A	5 to 11%
4	Tetra Calcium Aluminum Ferrite	$4(CaO)Al_2O_3$ Fe_2O_3	C_4AF	9 to 14%
5	Other Constituents and Gypsum	-	-	8%

Final compounds of Cement contd…….

- **C_2S**
- It hydrates slowly.
- It hardens more slowly
- It provides ultimate strength to the cement.
- It has more resistance to chemica1 attack.
- **C_3S**
- It hydrates more rapidly.
- It develops early strength.
- It generates heat more rapidly and has less resistance to chemical attack.

Final compounds of Cement contd…….

- **C_3A**
- It is fast reacting with large amount of heat generation.
- It causes initial setting of cement.
- It is weak against sulphate attack.
- **C_4AF**
- It is comparatively inactive.
- It has poor cementing value.
- It is slow in reaction with small heat generation.

Properties of Cement

1.Fineness:

- It is the degree of grinding of cement.
- The rate of reaction depends upon the fineness of grinding .
- For accurate measurement it is measured by surface area, air permeability method and the unit is cm^2/gram of cement.

2.Setting Time:

- Setting of cement is the phenomenon by virtue of which the green cement changes into hard mass.
- Initial setting is a stage in the process of hardening after which any crack that may appear will not reunite and the completion of this process is, known as final setting time.
- The time between water is added in cement and initial setting takes place is known as Initial Setting Time.

- Cement should not loose its plasticity till the various operations of mixing, transporting and placing are complete. Hence this time is generally kept not less than 30 minutes.

3.Strength:

- The quality of concrete and cement is always judged by strength and that is only by compressive strength because cement is weak in tension and for it steel reinforcement is always provided.
- For this purpose cement and standard sand are mixed in the ratio of 1:3

3.Soundness:

- Free lime and magnesia present in cement makes the cement unsound by increasing the volume after setting.
- It is generally measured by Le-Chatelier method or by Autoclave method.

4.Heat of Hydration:

- Setting of cement is due to chemical reactions between cement and water and this process is known as Hydration.
- As, this reaction is exothermal process, so sufficient heat is generated and this process continues for an indefinite period at a diminishing rate.
- It is always measured in calories/gram unit.

Different Types of Cement

1. Ordinary Portland cement.
2. Rapid Hardening Portland cement
3. Low Heat Portland cement
4. Portland Blast Furnace slag cement
5. Portland Sulphate resistant cement
6. Air entraining portland cement
7. White and coloured cement
8. High Alumina cement
9. Pozzoana cement
10. Oil well cement
11. Quick setting cement
12. Expanding cement

1.Ordinary Portland Cement:

- It is also known as Normal setting cement.
- It is used in Road pavements, buildings, culverts, water pipes etc.
- Out of the total consumption of different types of cement 90% of this type is used.

2. Rapid Hardening Cement:

- It contains less quantity of C_2S and more quantity of C_3S.
- It is generally used where high early strength is required.
- It is used by concrete product manufactures, highway pavements which are to be opened early for road traffic and in cold weather concreting due to its high heat of hydration development.

3. Low Heat Portland Cement:

- This cement is so called because it develops low heat at the time of hydration.
- It contains C_3A and; C_3S in less quantity because they develop early heat.
- It develops strength quite late and It is generally used in massive concrete structures such as dams, bridge, abutments, retaining walls etc.

4. Blast Furnace Slag Cement:

- Percentage of slag varies from 25 to 65%.
- It is cheaper as compared to ordinary cement because waste product is used in it.
- It can also be used in massive concrete such as dams, bridges etc.

5. Sulphate Resistant Portland Cement:

- It contains very low percentage of C_3A and C_4AF.
- It is used in canal lining, construction of pipe lines and culverts etc.

6. Air Entraining Portland Cement:

- It is ordinary Portland cement mixed with small quantities or air entertaining materials during grinding.
- The diameter of air bubbles varies from 0.075 mm and 1.25 mm. On account of air bubbles the strength of cement is reduced.
- Air bubbles are permitted only up to 3 to 4 percentage, as these reduce 10 to 15% strength of cement.
- This cement is more plastic and workable causing less segregation and bleeding in concrete.
- It also reduces the water requirement and has high resistance to weather.

7. White and Coloured Cement:

- In it white chalk and china clay are used instead of lime stone and clay as these are having low percentage of Iron Oxide i.e.1 %.
- Oil is used as fuel to avoid contamination o£ coal ash. It is 3 to 4 times costlier than ordinary cement.
- It is used for decorative floorings.
- For coloured cement suitable pigments varying from 5 to 10% free from soluble salts are added during grinding.

8. High Alumina Cement:

- It contains 35% to 45% of aluminates Bauxite and chalk or lime stone are mixed dry and heated till they melt and on cooling they form clinkers.
- It is dark in colour and initial setting time varies from 3 to 6 hrs and final setting takes place with in 2 hours of the Initial set.
- It gives high heat of hydration and, is also costlier than ordinary Portland cement.
- It is used in structures subjected to the action of sea water, chemical and sulphate bearing water. It

9. Pozzolana Cement:

- Pozzolana is a naturally occurring material such as volcanic ash or Pumice stone or an artificial product such as burnt clay or shale containing siliceous and aluminous mineral substances.
- As per BIS 1489-1967, the proportion of pozzolana material varies from 10 to 25% by weight of cement.
- It increases the workability, reduces heat of hydration, and increases the water tightness.
- It also offers greater resistance against sulphatic action and sea water.

10. Oil Well Cement:

- As the name indicates, it is used for cementing; oil wells.
- It is used at greeter depth under high temperature and pressure.
- Iron Oxide is so adjusted that all the alumina is converted into C_4AF and sc proportion of C_3A is very small, high increases the setting time of cement and also hardens quickly after setting.
- It protects the oil well causing from corrosion and also help in supporting the oil well casing and thus reduce the tension, in steel pipes.

11. Quick Setting Cement:

- It has less proportion of $CaSO_4$ (Gypsum) or a small % of aluminium sulphate is added at the time of grinding.
- Its initial setting time is 5 minutes and final setting time is 30 minutes.

12. Expanding Cement:

- As per the name, its volume increases on hardening.
- It takes about 15 days-for the expansion to occur fully but the time can be controlled by curing.
- The upper limit of expansion is 1%.
- The agent which causes expansion is Calcium Sulpho Aluminate ($3CaOA1_2O_33CaSO_4$) which is formed by the presence of calcium sulphate with Calcium Oxide present in cement in sufficient quantity.

Field Tests on Cement:

- The colour of cement should be uniform gray with light greenish shade.
- Cement should feel smooth when touched.
- If hand is inserted in a bag of cement it should feel cool not warm.
- If a small quantity of cement is thrown in a bucket of water, it should sink and should not float on the surface.
- Cement should be free from any hard lumps.

- A sample meant for testing shall be drawn from at least 12 different bags or barrels or containers or from 12 different positions in a heap if cement is loose. Chemical composition of cement should be checked for B. I. S. specifications.

Laboratory Tests on Cement:

1. Fineness of Cement:

- 100 gm of cement is weighed accurately and placed on IS: sieve No. 9 (90 micron).
- The residue left is weighed. This shall not exceed 10% by weight of the sample.
- This is estimated in terms of the specific surface, i.e., the surface area per unit weight.

2. Consistency:

- This is a test conducted to estimate the quantity of water to be mixed in cement to form a paste of normal consistency for use in other tests.

- Let W_1 = Weight of cement taken for the test.
- W_2 = Weight of water added corresponding to the condition of the stipulated extent of penetration of the plunger.

percentage of water=Pa=(W2/w1)*100

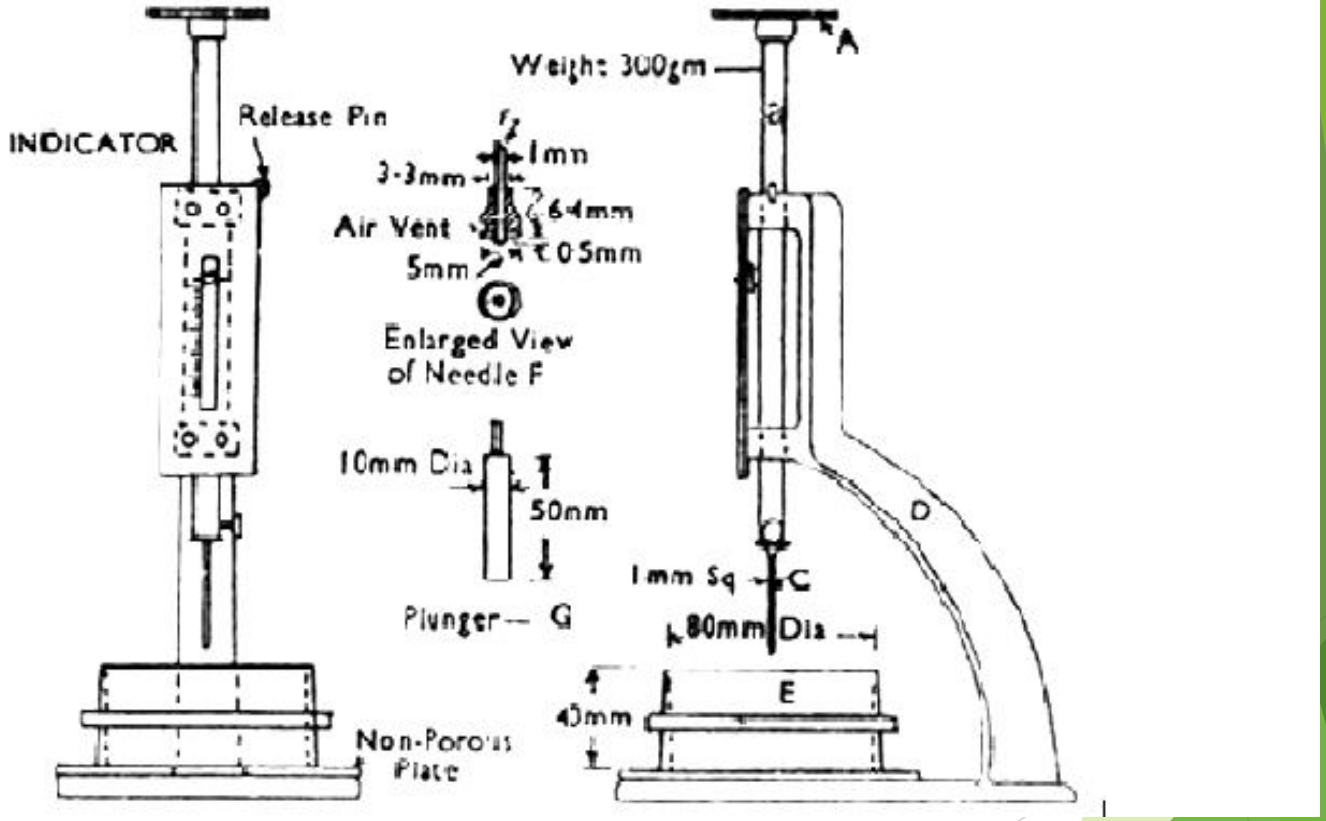
3. Test for Setting Time:

- The object of this test is to make a distinction between normal setting and quick setting types of cement end also to detect deterioration due to storage.

- Weigh 300 gm of cement and add P_a percentage of water (which is the percentage of water required to have normal consistency. See test for consistency.)
- The paste obtained after mixing is filled in the mould.1. In the Vicat apparatus, attach the needle of square section, i.e. 1 mm X 1 mm to the Vicat rod. Lower the system so that the needle just touches the surface of the paste and gently release.
- Find out if the needle pierces into the paste fully. If it does, again release the needle on the paste after a few seconds and again observe whether the needle pierces fully into the paste

- This is repeated till the needle does not pierce into the paste completely. Now the interval of time between this instant and the instant at which water was added to the cement is called the initial setting time.
- Now change the needle to the third one which has a projecting sharp point in the centre with an annular attachment.
- Now release this needle as before on the same paste. The needle as well as the attachment will make their impressions on the paste.
- Repeat this process till only the needle makes the impression but not the attachment.
- The interval of time between this instant and the instant at which the water was added is called the final setting time.

Vicat Apparatus



CONCRETE

- Concrete is the most versatile material for all types of construction works and has been used for innumerable construction works, either as plain concrete or as reinforced cement concrete or as precast concrete, or prestressed concrete or in many other forms.
- The various constituents of concrete are cement, water, fine aggregate, and coarse, aggregates. In Reinforced Cement Concrete Steel is also used.

Cement: Properties and various types of cement have already been discussed previously

Aggregate:

- These are the inert or chemically inactive materials which form the bulk of cement concrete.
- These aggregates are bound together by means of cement. The aggregates are classified into two categories, Fine and coarse.
- The material which is passed through 4.75mm size sieve is termed as fine Aggregate. Usually natural river sand, issued as a fine aggregate.
- The material which is retained on 4.75 mm size B. S. test sieve termed as a coarse aggregate. Broken stone is generally used as a coarse aggregate.

Water:

- Water which is used for making concrete should be clean and free from harmful impurities such as oil, alkali, acid etc.
- In general water which is fit for drinking should be used for making concrete.

Grades of Concrete

- Concrete as per IS 456 2000 is classified into three groups as ordinary concrete, Standard concrete and High strength concrete.
- M10, M15 and M20 are ordinary concrete, M25, M30, M35, M40, M45, M50 and M55 are grouped as Standard concrete and M60, M70, M75 and M80 are grouped under High strength concrete.
- The letter ‘M’ refers to the mix and the number indicates the specified compressive strength of that mix at 28 days expressed in N/mm^2.
- For lean concrete bases and simple foundations for masonry walls M5 and M7.5 grades of concrete may be used. These mixes need not be designed

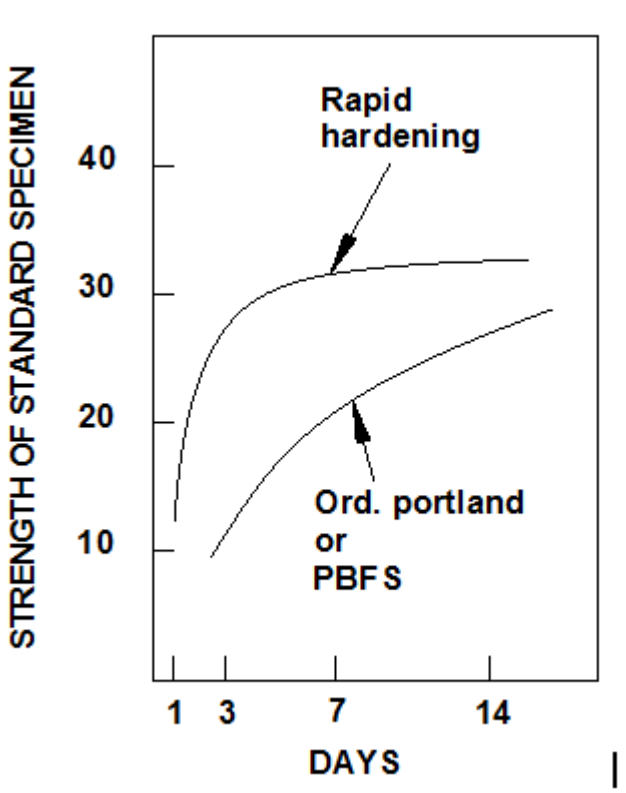
Grades of Concrete contd……

- Grades of concrete lesser than M20 are not to be used in RCC work.
- For general guidance, the nominal mix proportions (volume ratio) correspond approximately to the different grades as follows:

- M 5 - 1:5:10
- M 7.5- 1:4:8
- M 10 - 1:3:6
- M 15 - 1:2:4
- M 20 - 1:1.5:3
- M 25 - 1:1:2

Sl. No.	Concrete Grade	Characteristic Compressive Strength
1.	M10	10
2.	M15	15
3.	M20	20
4.	M25	25
5.	M30	30
6.	M35	35
7.	M40	40

Gain of strength with age



Gain of strength with age contd…….

- The concrete develops strength with continued hydration.
- The rate of gain of strength is faster to start with and the rate gets reduced with age.
- It is customary to assume the 28 days strength as the full strength of concrete. Actually concrete develops strength beyond 28 days also. The variation of strength with age is shown

Minimum Age of member with full design stress is expected (months)	age factor
1	1.00
3	1.10
6	1.15
12	1.20

Strength of Concrete

- Strength of concrete is its resistance to rupture.
- It may be measured in number of ways, such as strength in compression, in tension, in shear or in flexure.
- The compressive strength of concrete is generally determined by testing cubes or cylinders made in laboratory or field. The size of the mould should be 150mm x150mm x 150mm.

Strength of Concrete contd…..

The strength of the concrete is mainly depend on the following factors:

- Quality of materials and grading of the aggregates
- Water
- Water cement ratio
- Cement content
- Age of concrete; and
- Methods of mixing, placing, compacting and curing.

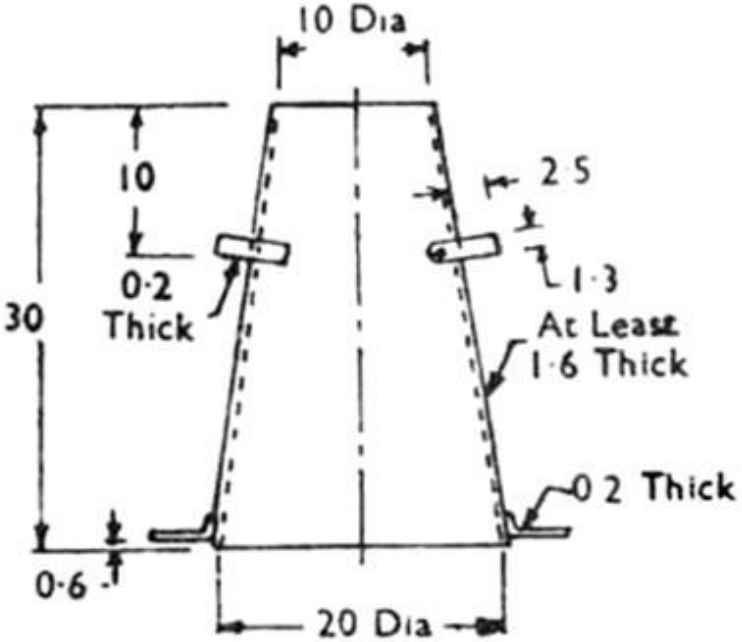
Workability of concrete

- The workability of concrete indicates the ease with which it can be mixed, placed and compacted.

Slump Test

- Slump test is the most commonly used method of measuring workability of concrete which can be employed either in the laboratory or at site of work.

Slump Test contd……



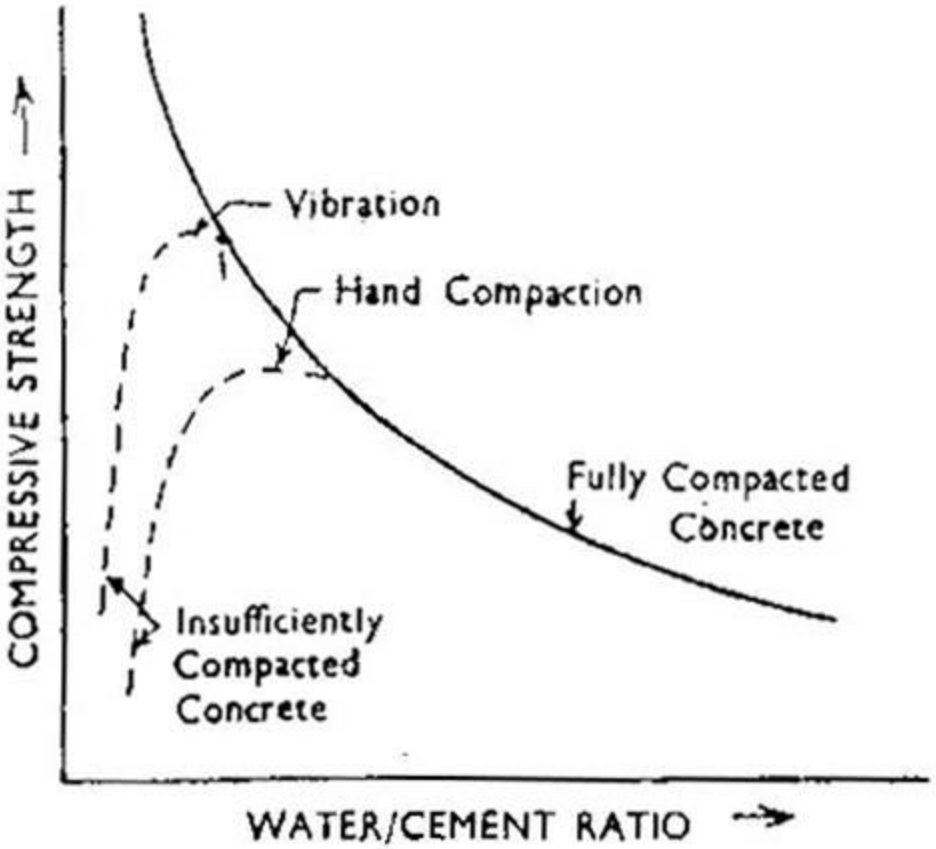
All dimensions in Centimeters

Durability of Concrete

- The concrete possesses a high durability value, it is not much affected by atmospheric actions.
- On the contrary, with the age, the concrete goes on hardening, there by increasing in strength.

Water Cement Ratio

- The strength of concrete depends upon the quantity and quality of its ingredients i.e. cement, aggregate and water.
- General assumption is that strength of concrete directly depends up on the quantity of cement.
- If cement is more, strength will be more but this assumption is not correct because strength of concrete also depends upon water cement ration.



The relatio io of concrete

Operations in Concreting

The following processes are involved in making concrete to achieve desired strength and durability.

1. Storing of material (Cement, aggregate)
2. Batching of material (By volume, by weight)
3. Mixing of concrete (By hand, by machine)
4. Transportation of concrete.
5. Placing of concrete.
6. Curing of concrete

Operations in Concreting contd……

1. Storing of Material

Cement:

- It is a fine powder and also hygroscopic in nature i.e. it absorbs moisture from air or free water and starts setting.
- Hence the water houses constructed for its storage must fulfill the basic requirements.
- Cement stored for long time should be checked before its use.

Aggregates:

- It is essential that aggregate should be free from deleterious materials, organic matters such as tree leaves, vegetable wastes, animal refuse etc.
- It should have uniform moisture content and proper grading of aggregates.

Operations in Concreting contd……

2. Batching of Materials

- Batching means measurement of ingredients of concrete for proper mixing.
- Normally such a quantity is mixed in one batch, which can be transported, placed and compacted with in time i.e. before initial set takes place.

❖ Batching is of two types.

- Volume Batching.
- Weight Batching.

2. Batching of Materials contd…….

Measurement of Cement:

- Cement is always measured by weight.
- A batch of concrete should always consume full number of bags. For this purpose weight, of cement bag is taken as 50 kg.

Measurement of Water:

- Water is generally measured by volume because its weight can not be easily calculated.

Measurement of Aggregate by Volume:

- For these purpose generally wooden boxes of capacity equivalent or part of one cement bag i.e. 35 liters are used. These boxes are known as Petties or Farmas or Gauge Box.

2. Batching of Materials contd…….

Weigh Batching:

- As per the name, ingredients of concrete are measured by weight.
- This is more accurate and is generally used where high quality concrete is required.
- As described earlier generally one cement bag or its multiple is the basic unit.
- In this system allowance for water present in aggregate is made, but bulking has no effect.

Operations in Concreting contd……

3. Mixing of Concrete:

i) Hand Mixing

ii) Machine Mixing.

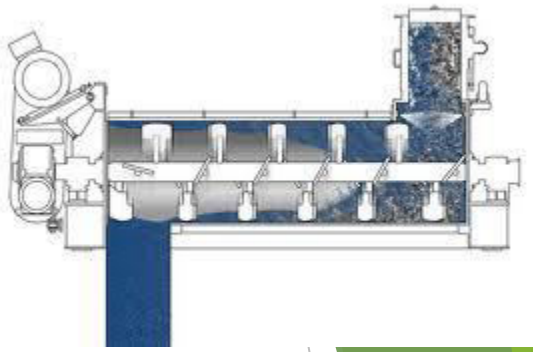
i) Hand Mixing: It is adopted for small works where quantity of concrete required is small. In it various ingredients of concrete are mixed by hand.

ii) Machine Mixing: For producing large quantity of concrete at a faster rate and at lesser cost, machine mixing is adopted.

A. Continuous mixer

B. Batch type mixer.

3. Mixing of Concrete



A. Continuous mixer:

- It mixes and delivers concrete just as a steady stream of concrete, till it is in operation.
- This type of mixers is not so common in use in India.

B.Batch type mixer:

- Mixes and discharge each loads of material separately. These are of two types.

a. Tilting mixers.

b. Non-Tilting or Rotary Mixers.

3. Mixing of Concrete contd……

a. Tilting Mixer:

- It has a conical drum which revolves about an inclined axis of 50^{o} with horizontal.
- The drum can be brought into different positions for charging, mixing and discharging.
- In small mixers the materials are charged directly and in mixers of large capacities loading skips are used.
- The mixed concrete is generally discharged on iron sheets. Blades are fixed, in the internal surface of the rotating drum.

3. Mixing of Concrete contd…….

b. Non-Tilting Type:

- It is also known as rotary type mixer.
- It has a drum revolving about horizontal axis and cylindrical in shape.
- It has an opening on both sides one for charging and other for discharging.
- For charging loading skip is used which is fed with the help of wire ropes and for discharging chutes are used.

Operations in Concreting contd……

4. Transportation of concrete:

- As the initial setting time of cement is generally 30 minutes, hence mixing, transportation, placing and compaction should be completed with in this time.
- In no case this time should not exceed one hour after initial setting time.

5. Placing of Concrete:

- As for as possible concrete should be placed in single thickness.
- In case of deep sections, concrete should be placed in successive horizontal layers and proper care should be taken to develop enough bond between successive layers.

Operations in Concreting contd……

6. Curing of Concrete:

- Concrete surfaces are kept wet for a certain period after placing the concrete.
- The period of curing depends on the type of cement and nature of work.
- For ordinary Portland cement, the curing period is 7 to 14 days. If rapid hardening cement is used, curing period can be considerably reduced.
- It can be done by spraying and ponding of water or covering the concrete with moist earth, sand, or wet gunny bags.

Types of Concrete

The following are the various types of concrete in use.

1. Plain Cement Concrete
2. Reinforced Cement Concrete
3. Pre Stressed Concrete
4. Light Weight Concrete
5. No-Fines Concrete
6. Pre-Cast Concrete
7. Fiber Reinforced Concrete

1. Plain Cement Concrete

- It is a mixture of cement, sand pebbles or crushed rock and water. It possesses the following important properties.
- It is free from corrosion
- It has a high compressive strength
- It blinds rapidly with steel
- It has a tendency to be porous.

2. Reinforced Cement Concrete

- Plain cement concrete is strong in compression but weak in tension.
- To make this efficiency better steel bars known as reinforcement are embedded in concrete.

3. Pre-stressed Concrete

- In this type of concrete, high tensile steel wires are used as reinforcement instead of mild steel bars.
- There are two types of prestressing namely

i) Pre-tensioning and

ii) Post tensioning.

i) Pre-tensioning:

- In pre-tensioning method, the wires are initially stressed and the concrete is cast in the moulds built around the wires.
- The wires released after the concrete attain its strength.

3. Pre-stressed Concrete contd…….

- The tendency of the wires to return to their original length sets up a compression in concrete, which helps the concrete to resists more tensile stress.

ii) Post-tensioning:

- In post tensioning the wires are placed inside the concrete and then stressed.
- The use of prestressed concrete results in saving of concrete and steel to the extent of 50% and 80% respectively compared to RCC.

4. Light Weight Concrete

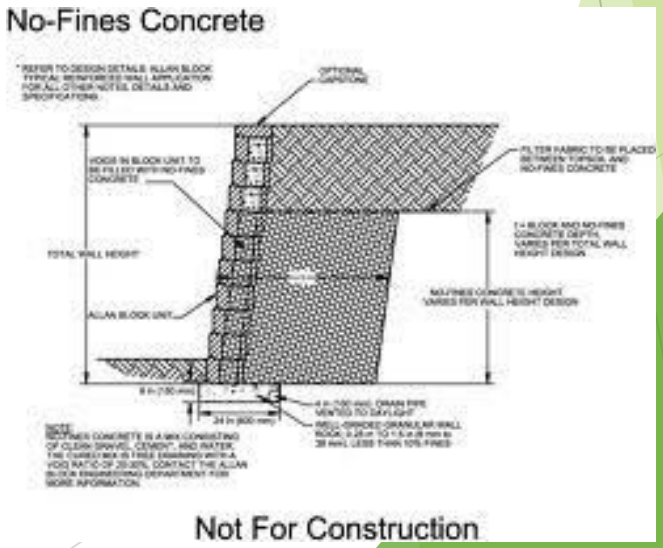
- They are produced from a wide variety of both natural earth substance and fly ash.
- It mainly consists of cement, aggregates of loose porosity, steel and water.
- The bulk density of this concrete varies from 500 to 1800 kg/m^3 whereas the bulk density of ordinary concrete is about 2300 kg/m^3.
- Advantages:
- Its weight is less
- It has better insulating and fire resisting properties
- It saves the cost of material handling because of its lightness.
- Local industrial waste can be economically utilized to prepare this type of concrete.

5. No-fines Concrete

- It consists of cement, coarse aggregate and water. Thus fine aggregate or sand is eliminated.
- This concrete has been adopted for cast-in-situ external load bearing walls of single and multi storey houses, small retaining walls etc.,
- The advantages are It possesses better insulating properties
- The unit weight of no-fines concrete is

about 2/3 of the unit weight of conventional concrete.

- The drying shrinkage is low



6. Precast Concrete

- Precast concrete is manufactured in a factory and the transmitted to the site.
- The advantages are:
- The pre-cast articles may be given the desired shape and finish with accuracy.
- The labour required in the manufacturing process of pre-cast units can be easily trained.
- Concrete of superior quality is produced
- The pre-cast structures can be dismantled when required and they can then be suitably used elsewhere.
- The work can be completed in short time.

7. Fiber Reinforced Concrete (FRC)

- It mainly consists of cement, fiber, sand and water. Asbestos, glass, nylon or coconut fibers have been tried as alternative to steel.
- The advantages are:
  - It has thin sections
  - Production rate is less
  - More durable
  - Less maintenance cost

STEEL

- Steel is probably the most versatile commonly used structural material.
- Steel is used to a large extent in modern multi-storied buildings.
- Steel is used as reinforcing bars/wires for concrete since concrete is weak in tension.
- Structural steel is available in various forms and shapes and it is being used for various structural components.

Physical Properties of Mild Steel

- Mass density = 7850 Kg/m^3
- Young's Modulus = 2.04×10^5 N/mm^2
- Modulus of Rigidity = 0.785×10^5 N/mm^2
- Poisson's Ratio = 0.25 – 0.3
- Coefficient of thermal expansion = 12×10^{-6} per ° c

Reinforcement Steel

- Steel reinforcement is of following types

  - Mild Steel bars (MS)
  - High strength deformed bars / rolled twisted bars (HSD / RTS)
  - High tensile bars

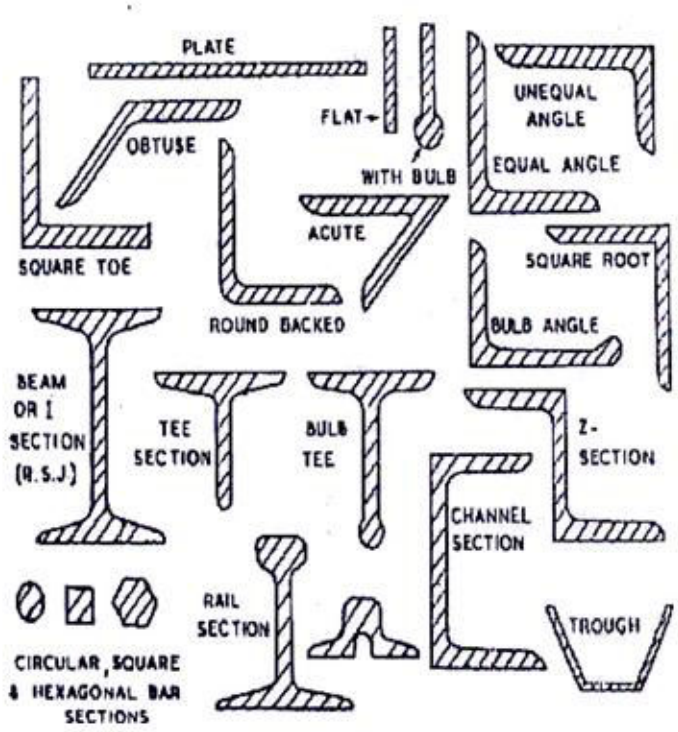
- Normally in all types of structural elements High Strength Deformed bars are used as main reinforcement.
- For distribution bars mild steel is being used.

Reinforcement Steel contd….

- Reinforcement bars are available in various nominal sizes. Mild steel (Grade I) and (Grade II) are available in the following nominal sizes 5,6,8,10,12,16,20 mm diameter which has the yield stress of 250 N/mm^2 and minimum ultimate tensile stress as 410 N/mm^2.
- Diameters 22, 25,28,32,36,40,45,50 are also available which has yield stress as 240 N/mm^2.
- High strength deformed bars / wires are available in the following nominal sizes: 6,8,10,12,16,18,20,22,25,28,32,36,40,45,&50 with the characteristic strength 415 N/mm^2 and 500 N/mm^2.

Structural Steel

Various shapes and sections are used for building works are:



Plates:

- Plates may be of any size or thickness.
- Common uses of plates in building construction are as webs and flanges of deep beams, column flanges, column base, etc.

Flats:

- These are rolled as in the case of plate but are much longer in lengths and have shorter widths.
- The widths vary form 18mm to 50 mm. The minimum and maximum thickness vary from 3mm to 80 mm.
- Flat section may have one rounded side with greater thickness than the remaining section and this is called bulb ball. T

Angles:

- Angle sections are widely used in steel trusses. Most common types are angles with equal legs and with unequal legs and are designated by ISA width and height of legs of angles.
- The equal angles vary form 20 mm x 20mm to 200mm x 200mm in size and 3mm to 5mm in thickness.
- The term 20mm x 20mm denotes that the width of legs is 20mm overall. Unequal angles vary in size from 20mm x 30mm to 220mm x 100mm and thickness from 4mm to 20mm.
- Special angles with a square toe, round backed, acute, square root and bulb types are also available.

T-Sections:

- These are used for roof trusses and for certain built up columns.
- They are designated by the width of the stem, width of the table and by the thickness.
- The standard sizes vary form 40mm x 40mm to 150mm x 150mm with thickness from 6mm to 8mm.
- Special T-Sections with bulbs etc. are also used to some extent.

Channels:

- Channels are mainly used for beams, columns and top and bottom chord members of truss.
- They are designated by the depth, flange width and weight per unit length.

Channels contd…..

- The size varies form 50mm x 75mm x 3kg to 420mm x 100mm x 30kg.
- Whenever stronger channels of lesser depth are required, these are specially cast with greater thickness than given by the standards.

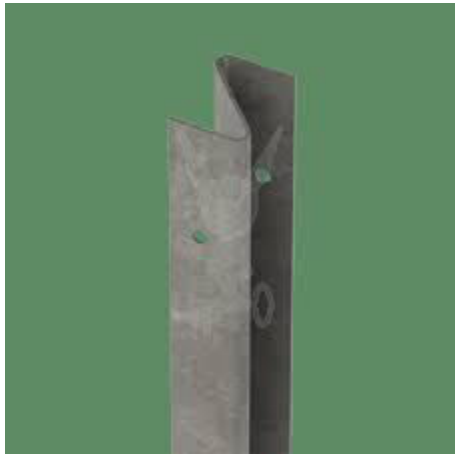
- Indian Standard Junior Channels (ISJC)
- Indian Standard Light Channels (ISLC)
- Indian Standard Medium Weight Channels (ISMC)
- Indian Standard Special Channels (ISSC)

Joists:

- Rolled Steel Joists or I-Sections are most commonly used for beams and columns.
- The British Standard Joists Section varies in size form 7 cm x 4cm to 60 cm x 17 cm. In U.S.A. I-sections have vary wide flanges are used.
- ISI handbook gives the following five series of Beam Sections.
- Indian Standard Junior Beams (ISJB)
- Indian Standard Light Beams (ISLB)
- Indian Standard Medium Weight Beams (ISMB)
- Indian Standard Wide Flange Beams (ISWB)
- Indian Standard H Beams (ISHB)

Miscellaneous Sections:

- Z-Sections, rail-sections, troughs, bars etc. are used to a limited extent in steel work for a building.



THANK YOU