UNIT-1

Basics of Civil Engineering

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What is Civil Engineering?

- **Civil ENGINEERING** is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including works like roads, bridges, canals, dams, and buildings.

➢ **Engineering** is concerned mainly with the designing, fabricating, manufacturing, installing, operating, controlling and maintaining engines, machines, instruments and equipment, as well as constructing structures.

➢ **Civil engineering** is that field of engineering concerned with planning, design and construction for environmental control, development of natural resources, building, transportation facilities and other structures required for health, welfare, safe living.

Importance Of Civil Engineering

2. Civil Engineering provides a better standard of living through the creation of basic amenities like sewage treatment facilities, flood protection, well ventilated buildings, e.t.c

Importance Of Civil Engineering

3. Civil Engineering helps protect historical monuments from degradation thus preserving them for future generations.

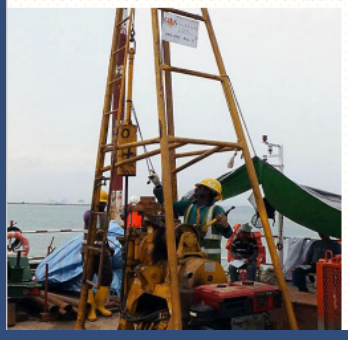
Major Role Of Civil Engineers In Society

- Construction of different infrastructures and buildings that gives services for public use.
- The civil engineer has the responsibility of undertaking preliminary studies of possible plans leading to a recommended scheme.
- Also has the mandate of preparing contract documents for civil engineering projects.
- More than one third of the wealth creation of the globe is from the construction industry.
- The construction industry is the largest employer of manpower.

- Civil engineering is that branch of engineering which aims to provide a comfortable and safe living for the people.
- Shelter, one of the primary needs of mankind, is provided by civil engineers.
- The efficient planning of water supply and irrigation systems increases the food production in a country.
- Shelters, apart from just being shelters, have been constructed by civil engineers to provide a peaceful and comfortable life

Role of Civil Engineer in society

- Main role of Civil engineers is in **surveying, planning, designing, estimation and execution** of structures.
- To solve different engineering problems with the help of **field experience, laboratory techniques, numerica methods, mathematical models, using computer and information technology.**
- To implement management techniques for better **management of man, material, machine and money.**
- To carry out **soil investigation** for design of foundations of structures.
- To invite **tenders** and to select **contractor** for the work.



- To carry out **surveying and levelling** and fixing the alignments (center-line) of roads, railways, canals, tunnels, pipes etc.
- To carry out **planning of buildings** as per its functional needs and also has role in **town and regional planning.**


- To carry out the design of structures as per the principles of structural analysis and design. Civil engineer should ensure that design is **safe, durable and economic**.
- To **supervise** the work during execution and to ensure **progress of work**.
- To carry out **valuation of land or building** for the purpose of finding its sale or purchase price or taxation.

- Civil engineers has to maintain public health by providing pure water for drinking, treating **waste water** before **disposing** in to water course and to **collect the solid waste of town and disposing** it.
- Civil engineer has to provide basic infrastructure of the structures for projects of many other engineering disciplines, like to design machine foundations and to provide steel frame structure and **sheds for industries** for the mechanical engineering project. To construct **tunnels for hydropower station**, to construction cooling tower for thermal power stations and to erect **transmission towers for electrical lines** for electrical engineering.



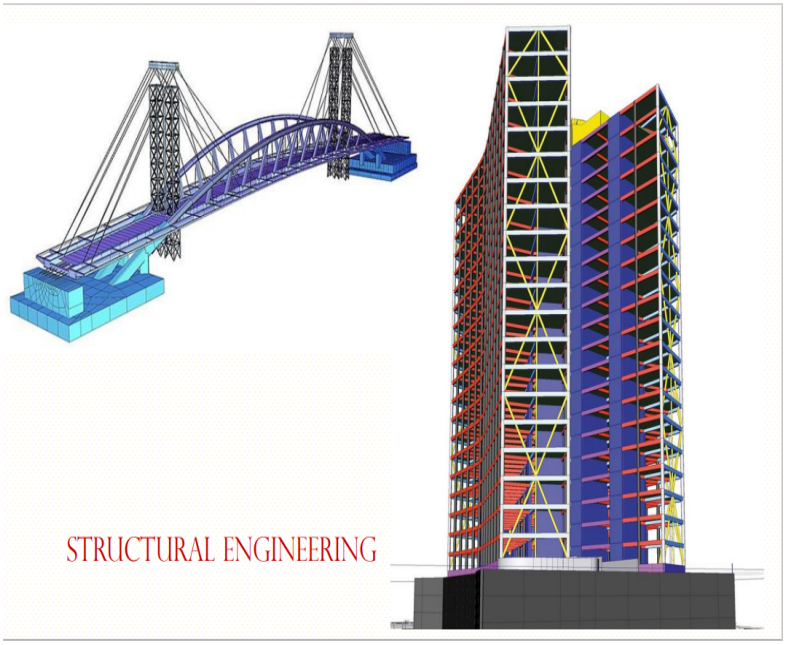

Scope of Civil Engineering

Any discipline of engineering is a vast field with various specializations. The major specializations of civil engineering are listed below:

1. **Structural Engineering**
2. **Geotechnical Engineering**
3. **Fluid mechanics, hydraulics and Hydraulic machines**
4. **Transportation Engineering**
5. **Water supply, Sanitation and Environmental Engineering**
6. **Water resource / Irrigation Engineering**
7. **Surveying, Levelling and Remote sensing**
8. **Building Construction and Planning**

1. Structural Engineering

- It deals with the **analysis** and **design of structures.**
- The construction of a structure needs efficient **planning**, design and method of construction to serve the purpose fully.
- **Loads** acting on various elements of a structure are calculated. On basis of loads and permissible stresses in materials, section of structural elements like beams, columns, slabs, footings are decided



- Generally, there are **five major** steps in any construction project. These include the following:

i. **Positioning** and **arranging** the various parts of the structure into a definite form to achieve best utilization.

ii. Finding out the **magnitude**, **direction** and nature of various **forces** acting on the structure.

iii. Analyzing the structure to know the behavior of the various parts of the structure subjected to the above forces.

iv. Designing the structure such that its stability under the action of various **loads** is ensured.

v. Executing the work with selected **construction materials** and skilled workers.

2. Geotechnical Engineering

- For the efficient functioning of any structure built on earth, the **behavior of soil** must be known.
- **Geotechnical engineering** also deals with the analysis, design and construction of foundation.

- Geotechnical engineering gives the basic idea about the **soil**. This branch also deals with the following aspects:

  The properties and behavior of soil as a material under **"soil mechanics".**

  The various types of foundations for a structure, for a machine, etc. and their suitability.

- Geotechnical engineering is that branch of civil engineering which deals with soil investigation and design of proper foundation of structure.
- All structure must finally transfer the load acting on them to soil safely, so sound knowledge of geology and geotechnical engineering is necessary for construction of earth related structures.
- The **scope** of geotechnical engineering includes, detailed **soil investigation**, soil bearing capacity determination, design and construction of various types of foundation like **simple footing**, **raft foundation**, **pile foundation** etc. and construction of **tunnels**, **retaining walls**, **earthen dams**, earthwork for highways and railways.

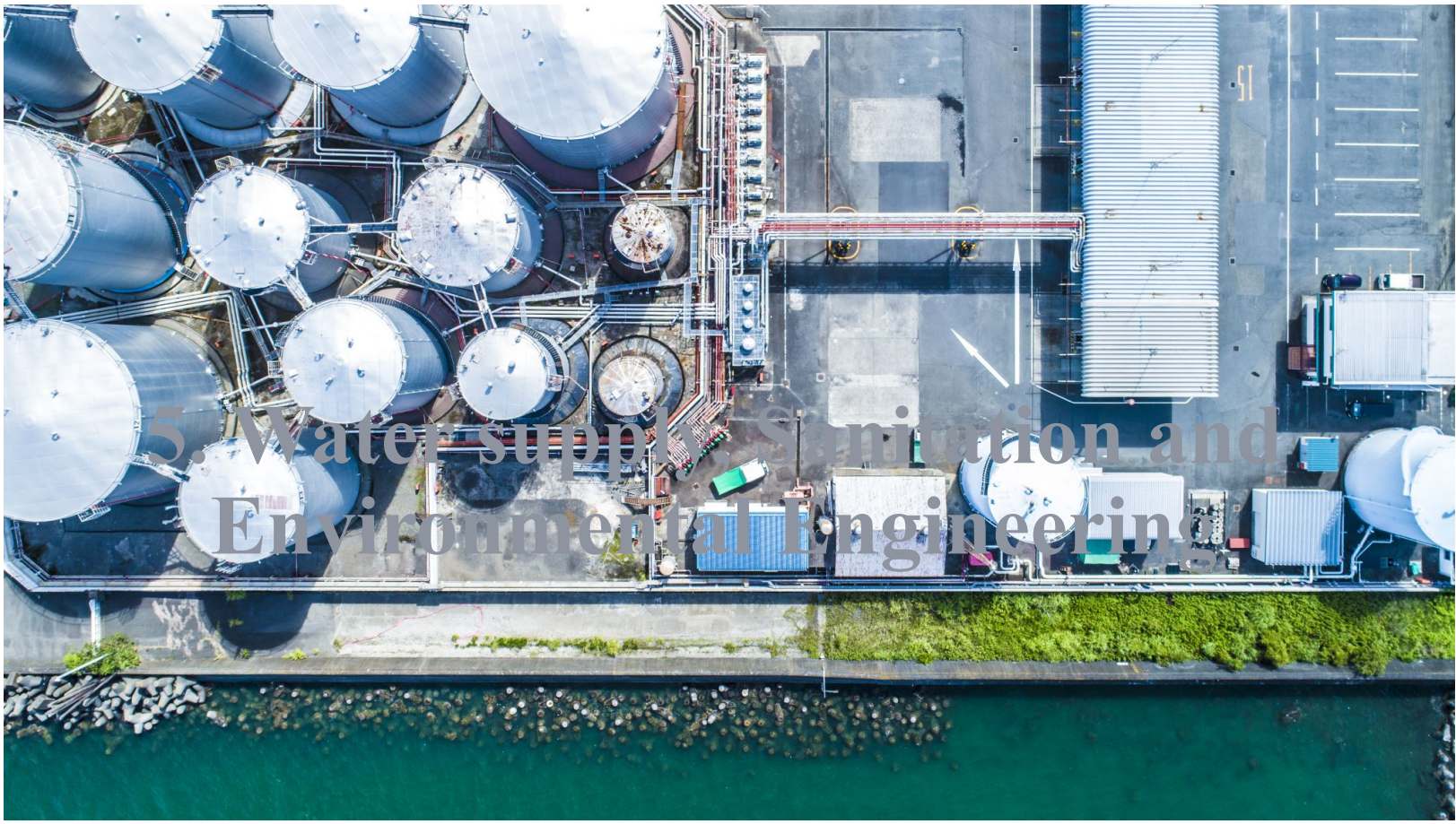
GEOTECHNICAL ENGINEERING

3. Fluid mechanics, hydraulics and Hydraulic machines

- Fluid mechanics deals with the properties and behavior of fluids at rest or in motion. The principles of fluid mechanics can be applied to daily life as in the case of the flight of planes.
- The design of hydraulic structures, such as dams and regulators, require the force exerted by water and the behavior of water under pressure.
- Machines which utilize the hydraulic energy are called hydraulic machines. For example, turbines use potential energy of water to generate power.

4. Transportation Engineering

- **Transportation** is that branch of civil engineering which deals with planning, designing and construction of roads, bridges, railways, tunnels, harbor, ports, docks, runways, and airports.
- The development of a nation mainly depends on the **communication facilities** available. A nation's wealth is measured in terms of the **road and railway** facilities available. There are three modes of transportation, viz. land, water and air. This specialization deals with the **design, construction** and **execution of the communication routes.**
- The different branches of transportation engineering include the following: highway engineering deals with the **planning and designing of roads**, **railway engineering** deals with the railway tracks, **harbor engineering** deals with the harbors and airport engineering deals with the airports.



5. Water supply, Sanitation and Environmental Engineering

- The responsibility of providing potable (drinking) water to the public and disposing the waste water safely is that of a civil engineer.

  The sources of water are precipitation and underground water.

- Water supply engineering deals with the location, collection of water, its treatment methods, tests for standard limits and efficient supply of water.

- Sanitary engineering deals with the collection of used water, their treatment methods and effective disposal which safeguards the whole world.

- The role of an environmental engineer is to build a bridge between biology and technology by applying all the techniques to the job of cleaning the debris.

6. Water Resource / Irrigation Engineering

- Constructing structures relating to water resources engineering like **dams, barrages, canals, canal structures and hydropower station**.
- It also includes irrigation methods, water shed management, rainwater harvesting, soil conservation, open channel hydraulics, flow measurement, hydrology, flood control.
- Irrigation engineering includes the study and design of works related to the control of river water and the drainage of waterlogged areas.
- Thus, irrigation engineering deals with the controlling and harnessing of various resources of water, by constructing dams, reservoirs, canals, head works and distribution channels to the cultivable land.

7. Surveying, Levelling and Remote sensing

- Before starting any important civil engineering project, such as the construction of railways, highways, dams and buildings, it becomes necessary to have a detailed survey map showing accurate boundary of the project area.
- Surveying is defined as an art of collecting data for mapping the relative positions of points on the surface of the earth. Levelling is the process of determining the relative heights of the points on the surface of earth in a vertical plane.
- The main purpose of the survey work is to prepare the plan of the object to be surveyed.
- Various instruments are used to measure and collect the necessary information to draw the plan. Remote sensing uses the technique of obtaining the data about an area by taking aerial photographs. The intelligent interpretation gives a clear picture of the terrain.

8. Building Construction and Planning

- Constructing Residential buildings like apartments, tenements, flats, raw houses, bungalows, villas, quarters etc.
- Constructing Public buildings like schools, colleges, government offices, post offices, hospitals, shopping complexes, hostels etc.
- Constructing Industrial buildings like workshops, warehouses, stores and industrial sheds.

Town Planning:

- Planning of the town by zoning of the land, planning road network, planning other services like water supply and drainage.
- Preparing master plan of town planning schemes and regulating construction by building byelaws.

Building Construction MATERIALS

Cement:

➢ **Cement** is a commonly used **binding material** in the construction

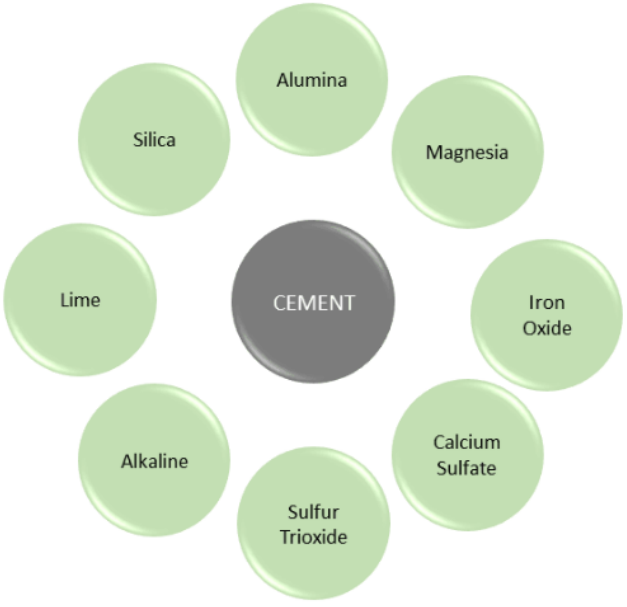
➢ Cement is obtained by burning at a very high temperature a mixture of **calcareous** and **argillaceous** materials. The calcined product is known as **clinker**.

➢ A small quantity of **gypsum** is added to the clinker and is pulverized into very fine powder known as cement.

➢ On setting, cement resembles a variety of sandstone found in Portland in England and is, therefore, called **Portland cement**.

What is cement made of – Composition of Cement

• There are eight major ingredients in cement:



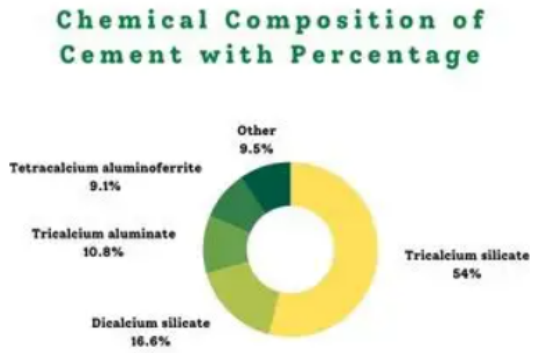
Ingredient	Percentage in cement
Lime	60-65
Silica	17-25
Alumina	3-8
Magnesia	1-3
Iron oxide	0.5-6
Calcium Sulfate	0.1-0.5
Sulfur Trioxide	1-3
Alkaline	0-1

Chemical Formulas of Cement Materials

- Cement is made of different chemical components as discussed above.
- Cement chemical composition is dependent on the chemical composition of these ingredients. These components have their own chemical formula. There is no specific chemical formula for cement itself.

The followings are the chemical formula for major components of cement:

- Lime -$Ca(OH)_2$
- Silica - SiO2
- Alumina - Al2O3
- Magnesia - MgO
- Iron oxide - Fe2O3
- Calcium Sulfate - CaSO4



Chemical Composition of Cement with Percentage

Major Compounds of Cement, Their Common Name, and Approximate Weight Range

Name of Compound	Formula	Abbreviation	Common Name	Usual Range by Weight
Tricalcium silicate	3 $CaO.SiO_2$	C_3S	alite	45-60 %
Dicalcium silicate	2 $CaO.SiO_2$	C_2S	belite	15-30 %
Tricalcium aluminate	3 $Al_2O_3.SiO_2$	C_3A	–	6-12 %
Tetracalcium aluminoferrite	4 $Al_2O_3.Fe_2O_3$	C_4AF	ferrite	6-8 %

Major Compounds of Cement, Their Common Name, and Approximate Weight Range

- By changing the chemical composition and by using different raw materials and additives, many types of cements can be manufactured.
- Different types of cements are classified as Portland and Non-Portland cement.

. **Rapid-hardening Cement:**

This cement is similar to the ordinary **Portland cement**. As the name suggests, it develops **strength rapidly.** The rapid rate of strength development is attributed to the higher fineness of grinding. This cement is used where high strength is required instantly in initial stages. For example, repair works, early removal of formwork, etc.

2. Sulphate-resisting Cement: Ordinary Portland cement has less resistance to the attacks of sulphates. This type of cement with higher silicate content is effective in fighting back the attacks of sulphates. This is used for the construction of sewage treatment works, marine structures and foundations in soils having large sulphate content.

3. Low-heat Cement: This cement hardens slowly but produces less heat than the other cements while reacting with water. This can be used in mass concreting works like construction of dams, etc.

4. Quick-setting Cement: This cement sets very quickly. This is due to the reduction of gypsum content in the normal Portland cement. It is used for underwater construction and also for grouting operation.

5. Portland pozzolana Cement: Pozzolana is a siliceous material. Portland pozzolana cement is produced by grinding Portland cement clinker and pozzolana with gypsum. It produces less heat of hydration and offers greater resistance to the attack of aggressive water.

6. High-alumina Cement: This cement generates high heat while reacting with water and causes high early strength development. So this cement can be used

7. Air-entraining Cement This cement is produced by mixing a small amount of an air-entraining agent with ordinary Portland cement. By adding this, the properties of concrete can be changed, and it also increases the frost resistance of hardened concrete.

8. Masonry Cement This cement has great plasticity, workability and water retentivity as compared with ordinary Portland cement. This is used for masonry constructions in making mortars and plasters.

9. Expansive Cement This cement produces an expansion in concrete during curing. As a result of expansion, cracks due to shrinkage of concrete are avoided. So, this can be used for filling the cracks by grouting and also to overcome cracks formation in reinforced cement concrete structures.

10. Hydrophobic Cement This is a water-repellent cement and is of great utility when the cement has to be stored for longer duration in wet climatic conditions. This cement also improves the workability of concrete

11. Coloured Cement Coloured cement consists of ordinary Portland cement with 5 to 10 per cent of pigment for colouring. This is used for aesthetic purposes.

12. White Cement The colour of this cement is white and it has the same properties of ordinary Portland cement. This can be used for architectural purposes and for manufacturing coloured concrete, flooring tiles, etc.

13. High-strength Cement Certain special works require high strength concrete. To improve the strength a higher content of C3S and higher fineness are incorporated in ordinary Portland cement. This cement can be used for railway sleepers, prestressed concrete, precast concrete and air-field works.

Good Qualities of Cement:

1. The colour should be uniform.

2. Cement should be uniform when touched. Cement should be cool when felt with hand. If a small quantity of cement is thrown into a bucket of water, it should sink.

3. Cement should be free from lumps.

4. Cement mortar at the age of three days should have a compressive strength of 11.5 N/mm2 and tensile strength of 2 N/mm2 . Also, at the age of seven days, compressive strength should not be less than 17.5 N/mm2 and tensile strength should not be less than 2.5 N/mm2 .

5. In cement, the ratio of percentage of alumina to that of iron oxide should not be less than 0.66.

6. When ignited, cement should not lose more than 4 per cent of its weight.

7. The total Sulphur content of cement should not be greater than 2.75 percent.

8. The weight of insoluble residue in cement should not be greater than 1.5 per cent.

9. Weight of magnesia in cement should not exceed 5 per cent.

10. The specific surface of cement as found from the fineness test should not be less than 2250 mm2/gm.

11. The initial setting time of cement should not be less than 30 minutes and the final setting time shall be around 10 hours.

12. The expansion of cement should not be greater than 10 mm when soundness test is conducted.

Uses of Cement:

1. Cement mortar, a mixture of cement and sand, is used for masonry work, plastering, pointing and in joints of pipes, drains, etc.

2. Cement is the binding material in concrete used for laying floors, roofs and constructing lintels, beams, weather sheds, stairs, pillars, etc.

3. Construction of important engineering structures, such as bridges, culverts, dams, tunnels, storage reservoirs, lighthouses and docks needs cement.

4. The manufacture of precast piles, pipes, garden seats, artistically designed urns, flowerpots, dust bins, fencing post, etc., requires cement.

5. For underwater construction, quick setting cement is used. Rapid hardening cement is used for structures requiring early strength.

6. White and coloured cements are used for imparting coloured finishes to the floors, panels and exterior surfaces of buildings.

7. Expansive cements, which expands while setting, can be used in repair works of cracks

Physical Tests on Cement

a. Fineness Test
b. Soundness Test
c. Setting Time
d. Crushing Strength Test

a) **Fineness Test**:

➢ It is measured in terms of percentage of weight retained after sieving the cement through **90-micron sieve** or by surface area of cement in square centimeters per gramme of cement.

➢ According to **IS code** specification weight retained on the sieve should not be more than **10%.**

➢ In terms of **specific surface** should not l

(b) Soundness Test:

➢ Once the concrete has hardened it is necessary to ensure that no volumetric changes takes place. The cement is said to be unsound, if it exhibits volumetric instability after hardening.

➢ IS code recommending test with **Le Chatelier mould** for testing this property.

➢ At the end of the test, th ot expand by more than 10 mm

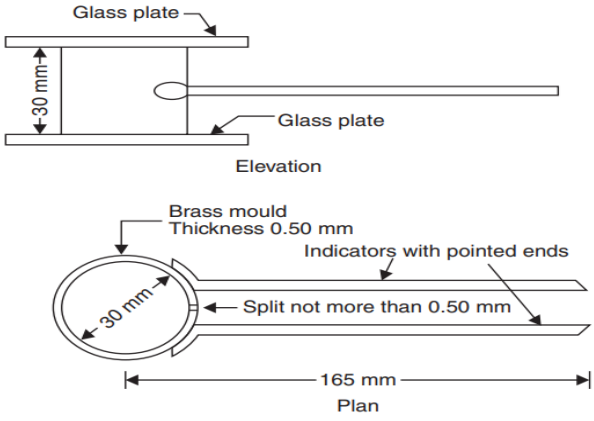


Fig. 1.6. Le Chatelier's apparatus

(c) Setting time Test:

➢ A period of **30 minutes** as minimum setting time for initial setting and a maximum period of **600 minutes** as maximum setting time is specified by IS code, provided the tests are conducted as per the procedure prescribed by ***IS 269-1967***.

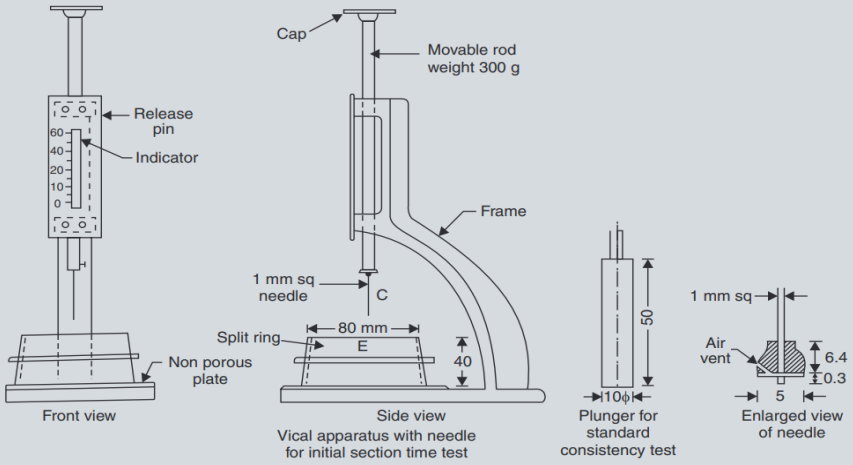
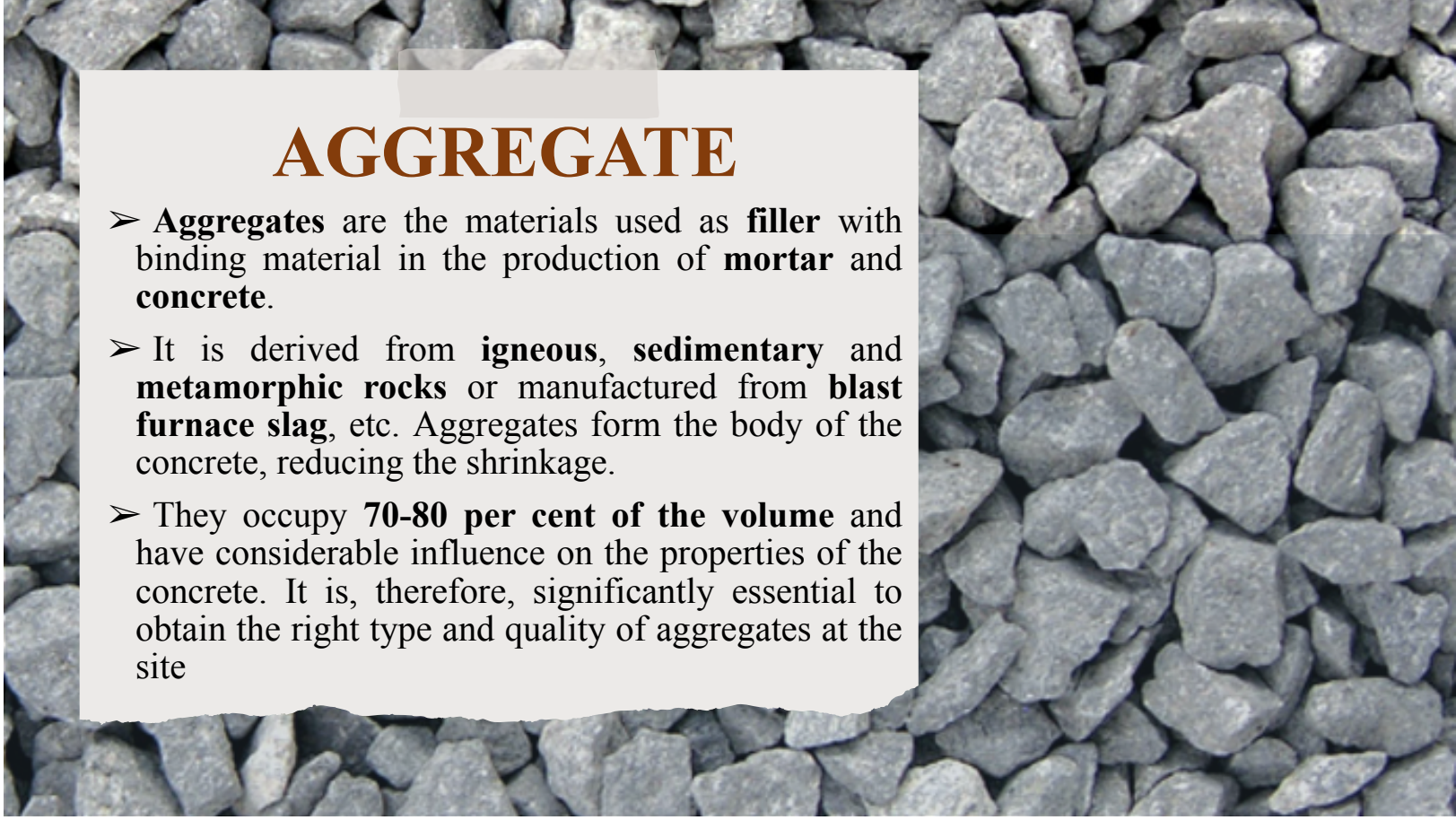


Fig. 1.5. Vicat apparatus

(d) Crushing strength:

➢ For this mortar cubes are made with standard sand and tested in compression testing machine as per the specification of IS code.

➢ The minimum strength specified is 16 N/mm2 after 3 days and 22 N/mm2 after 7 days of curing.



AGGREGATE

➢ **Aggregates** are the materials used as **filler** with binding material in the production of **mortar** and **concrete**.

➢ It is derived from **igneous**, **sedimentary** and **metamorphic rocks** or manufactured from **blast furnace slag**, etc. Aggregates form the body of the concrete, reducing the shrinkage.

➢ They occupy **70-80 per cent of the volume** and have considerable influence on the properties of the concrete. It is, therefore, significantly essential to obtain the right type and quality of aggregates at the site

What is Aggregate?

- **Aggregate** is hard material made up of **rock materials**. It is the disintegration of the hard stratum of the rock.
- It consists of many types, that includes **gravel**, **concrete**, **crushed rock**, etc. It is used in the construction of buildings, construction of pavement surfaces, etc.
- Aggregate can be **fine aggregate** or **coarse aggregate** based on the **size distribution of particles**.
- These aggregates can be used for making concrete with the proper mixing of sand and cement. The properties of the aggregates will be different for different sizes of aggregates.

What are the Properties of Aggregate:

- Different aggregates' properties depend on aggregates' different **characteristics**, which include the **size** of aggregates, the **shape** of aggregate, etc. Here are some properties of aggregates are described below.
- **Strength:** It is the value of the load for which aggregate can remain safe and transfer the loads applied.
- **Toughness:** It is the capacity of load against the impact load acting on the aggregates.
- **Fire resistance** of aggregate, **shape**, **surface texture**, **water absorption capacity**, **hardness**, **porosity** etc., are also the properties of aggregates. These properties will govern the overall strength of the aggregates.

Types of Aggregate:

- Aggregates can be of many types based on the different parameters. These parameters can be shape, size, strength, etc. Based on the size of the aggregates, they can broadly be classified as fine aggregate and coarse aggregate.
- **Fine aggregate:** This is the aggregate for which its **size** ranges between **4.75 mm to 0.075 mm**. These are also called **sand**. These are the natural particles that the mining process can generate. It consists of the particle of the crushed stone or the sandy material.
- **Coarse aggregate:** These aggregates have a **size** of **more than 4.75 mm**. These aggregates are used in the construction of concrete structures. Such aggregates include river gravel and stone particles made from rock stratum.


Fine aggregate


Coarse aggregate

Classification of Aggregate

- Aggregates can be classified into different types based on their **origin, size, shape and other characteristics.**

The classification of aggregates essential for the is mentioned below.

1. **Based on origin:** Natural and artificial
2. **Based on size:** According to size, aggregates are classified as **coarse aggregate, fine aggregate** and all-in aggregate.

The aggregate **retained** on the **4.75 mm sieve** is identified as coarse aggregate.
Aggregate **passing through** a **4.75 mm siev**e is defined as fine aggregate.
Naturally available aggregates of different fractions of fine and coarse sizes are known as all-in-aggregate.

3. **Based on shape:** Aggregates are classified as **rounded, irregular**, **angular**, and **flaky**.
4. **Rounded aggregate:** These are generally obtained from rivers or seashore and produce minimum voids (about 32 per cent) in the concrete.
5. **Irregular aggregate:** They have about **36 per cent voids** and require more cement paste than the rounded aggregate. Because of their irregular shapes, they develop a good bond and are suitable for making ordinary concrete.
6. **Angular aggregate:** They have sharp, angular and rough particles having **maximum voids (about 40 per cent**). Angular aggregate provides a very good bond than the earlier two, are most suitable for high-strength

Uses of Aggregate:

- Aggregates have many uses in the construction of various structures. Its use depends on the aggregates' size, shape and strength parameters. Aggregates are used to construct buildings, railway bridges, dams and other concrete structures. Using aggregates in concrete structures helps to bind the other ingredients in the concrete structures.
- Aggregate enhances the strength of the concrete structures.
- The crushing strength of concrete is enhanced by using aggregate material. It increases the compactness of the aggregate. Its uses in concrete structures reduce the cement quantity in the concrete. Aggregates are used in different sizes in the concrete mix based on the required strength and compactness

Advantages of Aggregate in Concrete structures

- Aggregate in civil engineering is hard structures made from the disintegration of rocks. It can be used in the designing of concrete structures and other structures. It is a durable and high-strength material. It has many advantages in the construction of concrete structures. Here are some advantages based on various **aggregate properties** in concrete structures.
- Aggregates provide more strength to the concrete.
- The use of aggregates in concrete structures increases the compactness of the structures.
- The use of aggregate reduces the quantity of cement in the concrete mix.
- It also reduces the water requirement in the concrete mix.
- It reduces the shrinkage of concrete in the dry mix.
- It reduces the voids in the concrete.

Different Tests on Aggregate:

Different types of tests are carried out on the aggregate to determine its properties like **strength**, **durability**, **corrosion resistance**, **hardness**, etc.

- **Crushing test:** This test is carried out to determine the aggregate's crushing strength according to IS code 2386 (part IV) 1963. The crushing value of an aggregate indicates the resistance against the crushing of the aggregates. If the **crushing value** of the aggregate is on or **above 35**, it will be considered a **weak aggregate**.
- **Abrasion test:** **Los angles abrasion test** is carried out to know the abrasion resistance of the coarse aggregate. It determines the **percentage wear of the aggregate** due to relative rubbing. It also indicates the **hardness property** of the aggregates.
- **Impact test:** Aggregate may be supposed to impact load during its life cycle, so it's important to get the impact strength of the aggregate. It measures the strength of the aggregate against the impact load acting over the aggregate. It

BRICKS

➢ This is the **oldest** building block to replace stone and it is extensively used at present because of its **durability**, **strength**, **reliability**, **low cost**, etc.

➢ **Brick** is obtained by moulding good clay into a block, which is dried and then burnt.

➢ Manufacture of brick started with hand moulding, sun drying and burning in clamps.

Constituents of a Brick:

1. Alumina It is the **chief constituent** of clay. A good brick should have **20–30** per cent of alumina. This imparts **plasticity** to the earth.

2. Silica It exists in clay in a free or combined form. A good brick earth should contain about **50–60** per cent of silica. The presence of silica prevents cracking, shrinking and warping of raw bricks. It imparts uniform shape to bricks. The **durability** depends on proper proportion of silica.

3. Lime Up to **5** per cent of lime is **desirable in good brick** earth. It **prevents shrinkage** in raw bricks. Sand alone is infusible, but it fuses at kiln temperature due to the presence of lime. Bricks may melt and lose their shape due to excess of lime content.

4. Oxide of iron This gives the **red colour** to bricks. A small quantity of iron oxide up to **5 or 6** per cent is desirable.

5. Magnesia This imparts **yellow** tints to bricks, and it **reduces shrinkage**

Classification of Bricks Based on their Quality

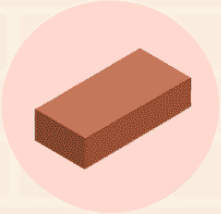
Bricks are classified based on the manufacturing process adopted. The classification is given as follows:

First-class bricks are table-moulded and of standard shape and size . These comply with all good qualities of bricks and are used for superior and permanent works.

2. Second-class bricks are ground-moulded and burnt in kilns. The surfaces of such bricks are rough and are slightly irregular in shape. Such bricks are used with a coat of plaster.

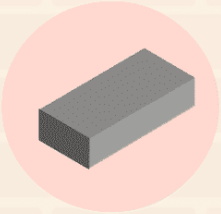
3. Third-class bricks are ground-moulded and are burnt in clamps. These bricks are not hard but rough with irregular and distorted edges. These give a dull sound when struck with each other. They are used for unimportant and

5 Types of Materials Used for Bricks



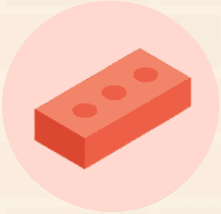
Common Burnt Clay Bricks

Used in general work



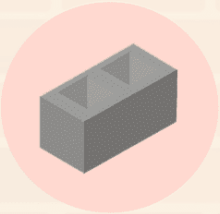
Sand Lime Bricks

Offer excellent strength



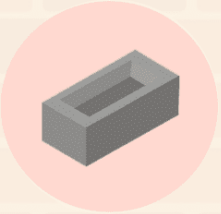
Engineering Bricks

Offer excellent load-bearing capacity



Concrete Bricks

Provide excellent aesthetic presence



Fly Ash Clay Bricks

May expand when in contact with moisture

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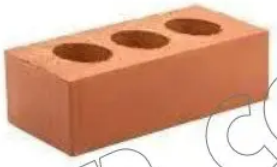
Different Types of Bricks

Burnt Clay Bricks

Sun-Dried Clay Bricks/ Mud Bricks

Concrete Bricks

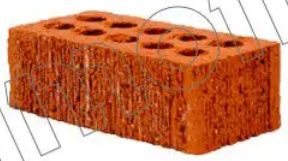


Engineering Bricks

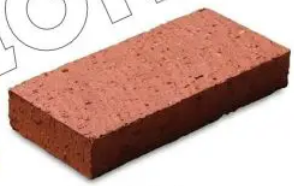
Sand Lime Bricks

Fly Ash Bricks

Refractory Bricks



Common Bricks



Clay Bricks

Perforated Bricks

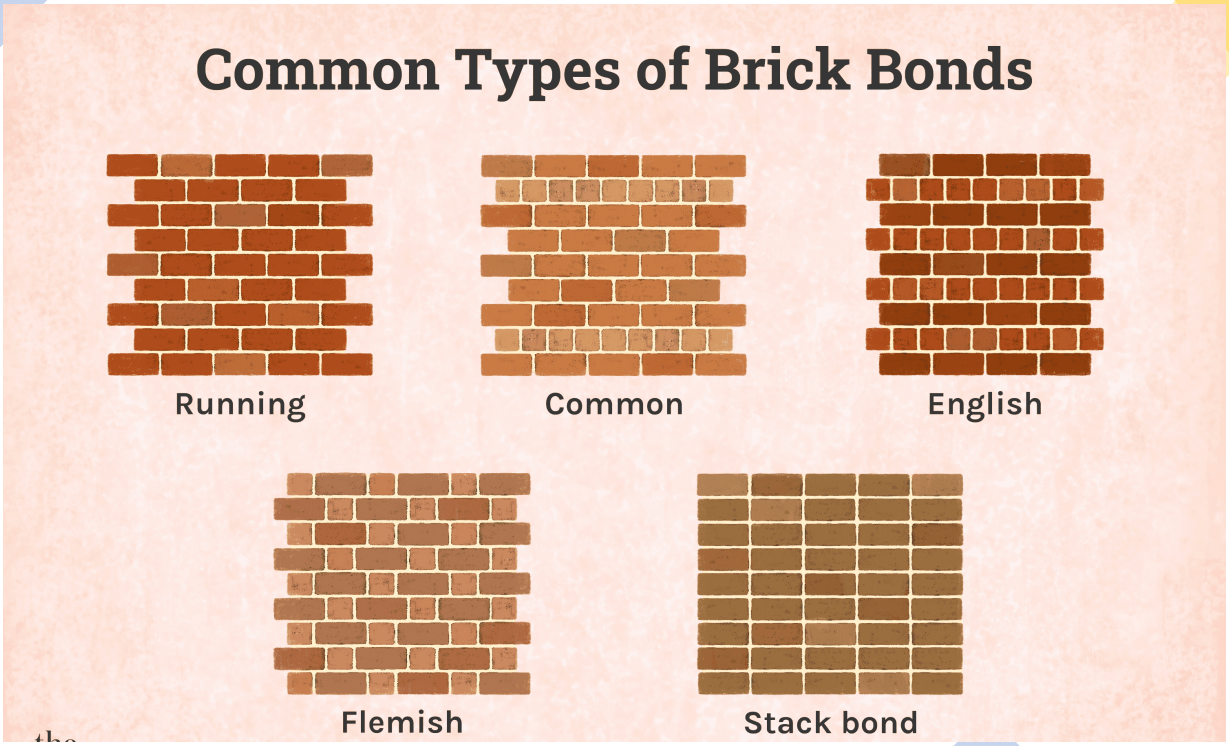
Hollow Clay Bricks

Solid Bricks

Lightweight Bricks

Acid Bricks

Bullnose Bricks



Manufacture of Bricks

The following are the four processes involved in the manufacture of bricks.

1. Preparation of brick earth
2. Moulding of bricks
3. Drying of bricks
4. Burning of bricks

1. Preparation of Brick Earth: Preparation of brick earth involves the following operations.

(i) Removal of loose soil (ii) Digging, Spreading and Cleaning (iii) Weathering (iv) Blending (v) Tempering.

2. Moulding of Bricks: The tempered clay is then sent for the next operation of moulding. There are two methods of moulding.

(i) Hand moulding (ii) Machine moulding

3. Drying of Bricks: After the bricks are moulded, they are dried. This is done on specially prepared drying yards. Bricks are stacked in the yard with 8 to 10 bricks in each row. Bricks are dried for a period of 5 to 12 days.

4. Burning of Bricks: Burning imparts hardness and strength to bricks and makes them dense and durable. It must be done carefully and properly

Properties of Bricks

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. Brick sizes based on **IS 1077** specification (Common burnt clay building bricks), the standard **modular size** of common building brick is **190 x 90 x 90 mm** or **190 x 90 x 40 mm** (length x depth x height).

(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.

(viii) Water Absorption: After immersing the brick in water for **24 hours**, water absorption should not be more than **20 per cent by weight**. For class-I works this limit is 15 per cent.

(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 bricks provide good sound insulation.

Uses 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.

Tests on Bricks

The following laboratory tests may be conducted on the bricks to find their suitability:

(i) Crushing strength
(ii) Absorption
(iii) Shape and size and
(iv) Efflorescence

) **Crushing Strength:** The brick specimen are immersed in water for 24 hours. The frog of the brick is filled flush with 1:3 cement mortar and the specimen is stored in damp jute bag for 24 hours and then immersed in clean water for 24 hours.

i) **Absorption Test:** Brick specimen are weighed dry. Then they are immersed in water for a period of 24 hours. The specimen are taken out and wiped with cloth. The weight of each specimen in wet condition is determined. The difference in weight indicate the water absorbed. Then the percentage absorption is the ratio of water absorbed to dry weight multiplied by 100. The average of five specimen is taken. This value should not exceed 20 per cent.

ii) **Shape and Size:** Bricks should be of standard size and edges should be truely rectangular with sharp edges. To check it, 20 bricks are selected at random and they are stacked along the length, along the width and then along the height. For the standard bricks of size 190 mm × 90 mm × 90 mm. IS code permits the following limits:

Lengthwise: 3680 to 3920 mm

Widthwise: 1740 to 1860 mm

Height wise: 1740 to 1860 mm

(iv) Efflorescence: The presence of alkalis in brick is not desirable because they form patches of gray powder by absorbing moisture. Hence to determine the presence of alkalis this test is performed

Concrete

- **Concrete** is a mixture of **cement, sand, crushed rock and water** which when placed in the skeleton of forms and allowed to cure, becomes hard such as stone.

- **Concrete** has attained the status of a major building material in all branches of modern construction and hence it is necessary to know the properties and uses of concrete.

Properties of Concrete

1. It has a **high compressive strength,** and its strength depends on the **proportion** in which cement, sand, stones and water are mixed.

2. It is free from **corrosion** and there is no appreciable effect of atmospheric agents on it.

3. It hardens with age and the process of hardening continues for a long time after the concrete has attained sufficient strength.

4. As it is weak in tension, steel reinforcement is placed in it to take up the tensile stresses. This is termed as '**Reinforced Cement Concrete**'.

5. It shrinks in the initial stage due to loss of water through forms. The shrinkage of cement concrete occurs as it hardens.

6. It has a tendency to be porous. This is due to the presence of voids which are formed during and after its placing.

7. It forms a hard surface, capable of resisting abrasion

Major ingredients of concrete are

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.

- In the absence of mix design the ingredients are proportioned as **1:1:2, 1:2:4,**

- **Cement** is the **binding material**. After addition of water, it hydrates and binds aggregates and the surrounding surfaces like stone and bricks. Setting time starts after **30 minutes** and ends after **6 hours**.
- 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.**
- Water used for making concrete should be clean. It activates the **hydration of cement and forms plastic 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

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

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.

3. **Transporting and Placing of Concrete:** After mixing concrete should be transported to the final position.

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

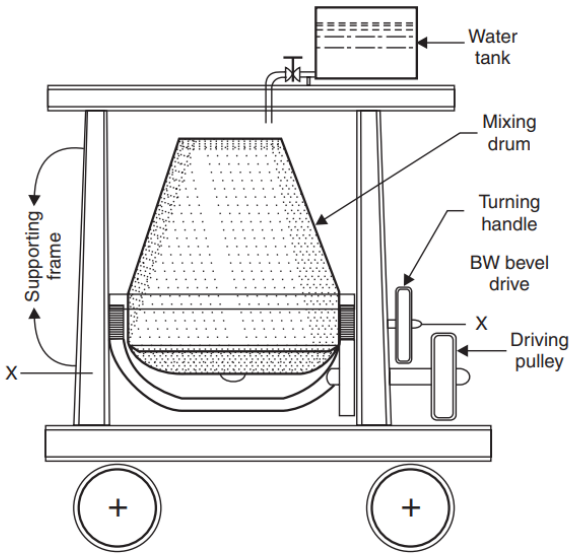


Fig. 3.2. Concrete mixer

- **Compaction by Vibrators**: Concrete can be compacted by using high frequency vibrators.
- 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.
- 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.

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.

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

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.

Segregation: Separation of coarse particles from the green concrete is called segregation. This may happen due to lack of sufficient quantity of finer particles in concrete or due to throwing of the concrete from greater heights at the time of placing the concrete.

Bleeding: This refers to the appearance of the water along with cement particles on the surface of the freshly laid concrete. This happens when there is excessive quantity of water in the mix ordue to excessive compaction.

4. Harshness: Harshness is the resistance offered by concrete to its surface finish. Harshness is due to presence of lesser quantity of fine aggregates, lesser cement mortar and due to use of poorly graded aggregates.

Properties of Hardened Concrete:

. **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.

. **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.

. **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

4. **Impermeability:** This is the resistance of concrete to the flow of water through its pores. Excess water during concreting leaves a large number of continuous pores leading to the permeability

Tests on Concrete:

The following are some of the important tests conducted on **Fresh concrete**:

1. Slump Test: This test is conducted to determine the workability of concrete. It needs a slump cone for test. The decrease in the height of the concrete is called slump. Higher the slump, more workable is the concrete.

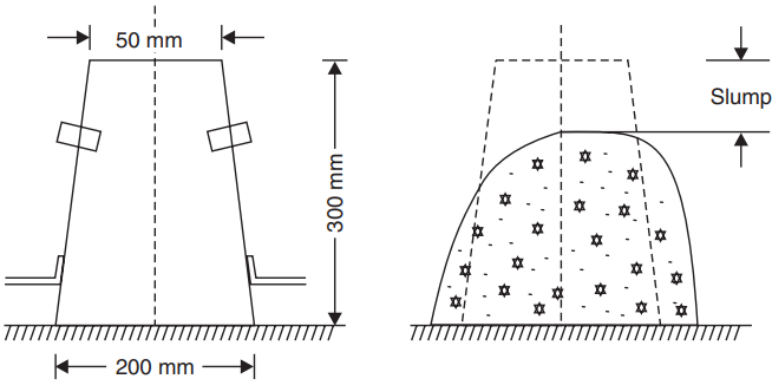


Fig. 3.3. Slump test

2. Compaction factor test:

This is another test to identify the workability of concrete. This test is conducted in the laboratory. The test equipment consists of two hoppers and a cylinder fixed to stand, the dimensions and the distances between the three vessels being standardized.

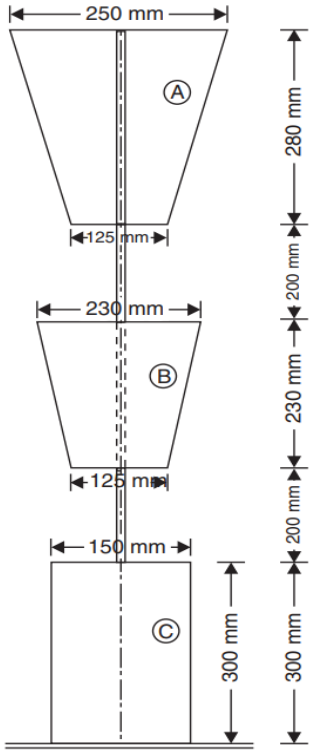


Fig. 3.4. Compaction factor test

3. Crushing strength test:

Metallic moulds of size 150 mm × 150 mm × 150 mm are used for casting concrete cubes. Before filling mould, it is properly oiled on its inner surfaces, so that cubes can be easily separated.

Fresh cube is filled with concrete to be tested in 3 layers and kept in the room. After 24 hours, cube is removed from the mould and kept under water for curing. After 28 days of curing cubes are tested in the compression testing machine

Testing of Hardened Concrete:

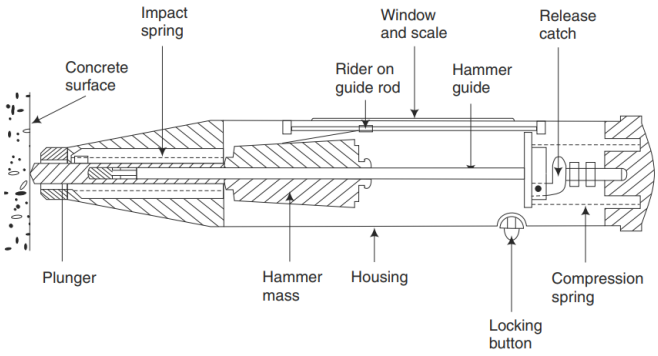
1. Compressive Strength It may be defined as the maximum compressive load that can be taken by concrete per unit area. It has been shown that with special care and control, concrete can be made to bear loads as high as 80 N/mm2 or even more.
2. Tensile strength Plain concrete (without steel reinforcement) is quite weak in tensile strength which may vary from 1/8 to 1/20 of the ultimate compressive strength. It is primarily for this reason that steel bars (reinforcement) are introduced into the concrete at the laying stage so as to get a concrete which is very strong in compression as well as in tension. In plain concrete, tensile strength depends to a great extent on the same factors as the compressive strength does

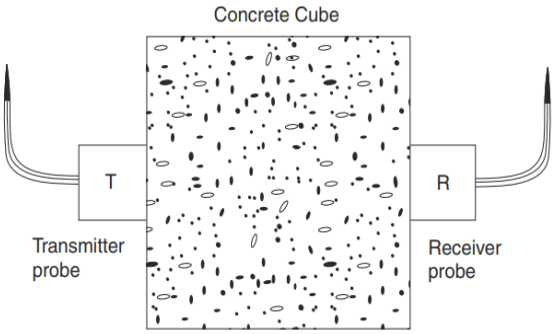
3. Non-destructive tests for concrete

Estimation of concrete or member strength is the most common requirement of in-situ investigations but unfortunately, none of the available methods can be used to provide a reliable value in every situation. Non-destructive tests with all their limitations play a vital role in strength determination.

Two such test methods normally available are the following:

(a) Rebound test method (b) Ultrasonic method





Desirable Properties of Concrete

Appropriate quality and quantity of cement, fine aggregate, coarse aggregate and water should be used so that the **green concrete** has the following properties:

(a) Desired workability

(b) No segregation in transporting and placing

(c) No bleeding and

(d) No harshness.

Hardened concrete should have

(a) required characteristic strength

(b) minimum dimensional changes

(c) good durability

(d) impermeable

Types of Concrete

1. Light-weight concrete One of the disadvantages of normal concrete is the high self weight which has a density of 2200 to 2600 kg/m3.

2. High-density concrete The concrete whose unit weight ranges from about 3360–3840 kg/m3 and which is about 50 per cent higher than the unit weight of normal concrete is known as high-density concrete.

3. Polymer Concrete Air voids and water voids are present in the conventional concrete due to improper compaction, high water-cement ratio and some other causes.

4. Fibre-reinforced concrete: To improve the tensile strength of concrete one of the method used is that of the conventional reinforced steel bars and the other way is by introducing fibres in the concrete and thereby increasing the inherent tensile strength of concrete.

In order to reduce the microcracks, addition of small, closely spaced and uniformly dispersed fibres are used. These fibres act as crack arrester and

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.

However major use of concrete is as a major ingredient of reinforced and prestressed concrete. Many structural elements like footings, columns, beams, chejjas, lintels, roofs are made with R.C.C. Cement concrete is used for making storage structures like water tanks, bins, silos, bunkers etc. Bridges, dams, retaining walls are R.C.C. structures in which concrete is the major ingradient.

STEEL

- Steel is very ductile and has elastic properties. Mild steel having a carbon content of 0.1 – 0.25 per cent is used for structural work. To be used in construction works steel must be available in a certain forms. These are called market forms and are discussed below.

Steel as a Reinforcing Material

1. Reasons for steel to be considered as a good reinforcing material

(i) It develops a good bond with concrete and hence the stresses are transferred from one material to another.

(ii) It has high tensile strength.

(iii) It has high modulus of elasticity.

(iv) Its temperature coefficient of expansion and contraction is same as that of concrete and so thermal stresses do not develop.

(v) It is cheap and readily available.

2. Choice of reinforcing steel

(a) Reinforcing steel should be chosen such that it can be incorporated in the concrete to form a monolithic structure.

(b) The reinforcing steel should be of the smaller section to avoid stress concentration.

3. Forms of reinforcing steel

(b) Round bars It is a commonly adopted form of reinforcing steel.

(c) Flat bars It is more useful in tanks and pipes as they increase effective thickness.

(d) Square bars

(e) Reinforcement in the form of fabric It is used in roads, walls and floor slabs where tensile stresses develop more than in one direction. It is more convenient than placing individual bars at right angles to each other. It claims more tensile strength, better bond with concrete, checking of shrinkage and temperature cracks

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.

(a) **Mild Steel:** It contains a maximum of 0.25% carbon, 0.055% of sulphur and 0.55% of phosphorus.

Properties of Mild Steel:

(ii) It is malleable and ductile

(iii) It is more elastic

(iv) It can be magnetized permanently.

(v) Its specific gravity is 7.8.

(vi) Its Young's modulus is 2.1 × 105 N/mm2.

(vii) It can be welded easily.

(viii) It is equally strong in tension and in compression.

Uses of Mild Steel:

(ix) Round bars are extensively used as reinforcement in R.C.C. works.

(x) Rolled sections like I, T, L, C, plates etc. are used to build steel columns, beams, trusses etc.

(xi) Tubular sections are used as poles and members of trusses.

(**b) High Carbon Steel:** The carbon contains in this steel is 0.7% to 1.5%.

Properties of Carbon Steel:

i) It is more tough and elastic compared to mild steel.

ii) Welding is difficult.

iii) It can be magnetized permanently.

iv) It is stronger in compression than in tension.

v) It withstands shocks and vibrations better.

Uses of High Carbon Steel:

vi) It is used for making tools such as drills, files, chisels.

vii) Many machine parts are made with high carbon steel since it is capable of withstanding shocks and vibrations.

(c) High Tensile Steel: It contains 0.8% carbon and 0.6% manganese.

The strength of this steel is quite high.