# Chapter 1
# BASICS OF CIVIL ENGINEERING

## 1.1 INTRODUCTION

Engineers have probably contributed more to the shaping of civilisation than any other professional group. In every society, the role of engineers is to develop the technological application to meet practical needs. For example, the application of an electrical system is to provide power to a city, a water wheel is to run a mill, an artificial heart is to prolong life, etc. The systems that supply our food, water, fuel, power, transportation network, communication and other conveniences are the products of engineering skill. Despite the essential part engineers play in the above progress and in the well-being of humanity, their exact role is imperfectly understood. Engineering is the art of converting knowledge into useful practical applications. An engineer is a person, who plays the key role in this process of conversion. Since engineering is the profession which serves people, their environment is an important consideration. Often, there have been difficulties in distinguishing engineers from scientists. It is difficult to determine where the work of the scientist ends and that of the engineer begins. The basic distinction between the linked professions of science and engineering lies in their goals. Scientists aim to invent while engineers strive to use the inventions effectively to cater to the needs of mankind. For example, the German physicist Heinrich Hertz discovered radio waves while Guglielmo Marconi developed wireless telegraphy using radio waves, a feat of engineering. And after the scientific principles of nuclear fission were established, the hard work of creating atomic weapons and useful power plants was accomplished by electrical, chemical and mechanical engineers.

## 1.2 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.

## 1.3 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, numerical methods, mathematical models, using computer and information technology.

- To implement management techniques for better management of man, material, machine and money.
- To carryout soil investigation for design of foundations of structures.
- To invite tenders and to select contractor for the work.
- To carryout surveying and levelling and fixing the alignments (center-line) of roads, railways, canals, tunnels, pipes etc.
- To carryout 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 carryout valuation of land or building for the purpose of finding its sale or purchase price or taxation.
- Civil engineers have to maintain public health by providing pure water for drinking, treating waste water before disposing into 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 hydro power station, to construction cooling tower for thermal power stations and to erect transmission towers for electrical lines for electrical engineering.
- Measure and map the earth's surface.
- Plan new townships and extension of existing towns.
- Build tanks and dams to exploit water resources.
- Build river navigation and flood control projects.
- Build canals and distributaries to take water to agricultural fields.
- Purify and supply water to the needy areas like houses, schools, offices etc.
- Provide and maintain communication systems like roads, railways, harbors and airports.
- Devise systems for control and efficient flow of traffic.

## 1.4 SCOPE OF CIVIL ENGINEERING:

The main scope of civil engineering or the task of civil engineering is planning, designing, estimating, supervising construction, execution, and maintenance of structures like building, roads, bridges, dams, etc.

Population demographics along with increasing urbanization have facilitated the need for sustainable and efficient infrastructure solutions. Development in green buildings, sensor-embedded roads and buildings, geopolymer concrete, and water management will stimulate global civil engineering industry growth.

## VARIOUS DISCIPLINES OF CIVIL ENGINEERING:

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

1. Structural engineering
2. Geotechnical engineering
3. Transportation engineering
4. Hydraulics and Water Resources Engineering.
5. Environmental Engineering

### 1.4.1 STRUCTURAL ENGINEERING

Structural engineering is the most important specialisation in civil engineering. The construction of a structure needs efficient planning, design and method of construction to serve the purpose fully. Generally, there are five major steps in any construction project.

These include the following:

1. Positioning and arranging the various parts of the structure into a definite form to achieve best utilisation.
2. Finding out the magnitude, direction and nature of various forces acting on the structure.
3. Analysing the structure to know the behaviour of the various parts of the structure subjected to the above forces.
4. Designing the structure such that its stability under the action of various loads is ensured.
5. Executing the work with selected construction materials and skilled workers.

### 1.4.2 GEOTECHNICAL ENGINEERING

For the efficient functioning of any structure built on earth, the behaviour of soil must be known. Geotechnical engineering gives the basic idea about the soil. This branch also deals with the following aspects:

1. The properties and behaviour of soil as a material under “soil mechanics”.
2. The various types of foundations for a structure, for a machine, etc. and their suitability.

Geotechnical engineering also deals with the analysis, design and construction of foundation.

### 1.4.3 TRANSPORTATION ENGINEERING

- 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 specialisation 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, harbour engineering deals with the harbours and airport engineering deals with the airports.

### 1.4.4 HYDRAULICS, WATER RESOURCES ENGINEERING

- Water is an important need for all living beings. Study of mechanics of water and its flow characteristics is another important field in civil engineering and it is known as hydraulics.
- Requirement of water in cities for domestic purpose and for industries is continuously increasing. Rural areas need water for agricultural field also. Hence civil engineers have to look for new water resources and for storing them. This branch of civil engineering is known as water resources engineering.
- Water stored in reservoirs by building bunds and dams should be brought to agricultural fields through canals and distributaries. Study connected with this aspect is known as irrigation engineering.

### 1.4.5 ENVIRONMENTAL ENGINEERING

- When water is required for drinking purpose it should be purified and made potable. Purification of water and the technology involved in taking it to the houses is known as water supply engineering.
- Waste water and solid waste should be treated and disposed so that they do not create health hazard. This branch of civil engineering is known as sanitary engineering.
- Apart from tackling solid and waste water disposal civil engineers have to tackle air pollution problem also.
- Due to industrialization air pollution is becoming a major problem.
- It is estimated that for every tonne of cement produced one tonne of $CO_2$ is released to environment. Vehicles also produce lot of $CO_2$.
- During the last one century, the environmental pollution has resulted in global warming by 4°C.
- An environmental disaster will be unavoidable if China, India and other developing countries start consuming as much energy and materials as the West did it in its march to industrialization.
- Hence environmental engineering is emerging as an important field of study in civil engineering.

## 1.5 FUNCTIONS OF A CIVIL ENGINEER

Various functions of a civil engineer are listed below.

1. Surveying
2. Planning
3. Structural analysis and design
4. Professional Practice

(a)Estimating (b) Costing and accounts (c) Valuation (d) Contracts

5. Construction management

(a)Planning and scheduling (b) Construction execution and supervision

6. Quality control and research
7. Maintenance of structure

### 1.5.1 Surveying:

- To carryout surveying for setting out of works and for preparing map of land. Leveling is carried out to measure levels and to prepare contour map. Measurements of distances and angles are taken with the help of surveying instruments. Maps are useful for planning of the construction project.

### 1.5.2 Planning:

- To carryout planning of the different units according to their functional needs. Say for example buildings are constructed to create living space and roads are constructed for transportation of vehicles over them. Technical feasibility study, economic viability study, environmental impact analysis, surveying and soil investigations are the different planning activities. On the bases of the data collected and map prepared by surveying, planning of the project is made.

### 1.5.3 Structural Analysis and design:

- To carryout structural design of the structure by selecting the type of material like concrete or steel and fixing the size and shape of various structural components like slab, beam column etc. Structural analysis is required prior to the designing of the structure.

### 1.5.4 Quality control and research:

- To have a quality check by testing of material and checking workmanship. During the actual construction, quality of the materials can be checked by testing the various properties of the materials. Materials should comply the needs of specifications.
- Workmanship like dimensions, lines and levels, finishing etc. is also required to be checked. To carryout research for improvement in the quality, strength, durability and look of the structure through innovative practices.

### 1.5.5 Professional Practice:

a) **Estimating:** To prepare estimate of work. Estimates are prepared from data of drawings, specifications, rates etc. The procedure for preparing estimate is known as estimating.

b) **Costing and accounts:** To carryout costing to know the actual expenditure in the payment of bills to the contractor, and many other expenditure, during construction of the work.

c) **Valuation:** To carryout valuation of the property like land or land with building. Valuation is carried out for the purpose of knowing the fair and just price or market value of the property for the purpose of sales, purchases, insurance, taking loans and other purposes.

d) **Contracts:** To carryout the construction of work through contractor according to the conditions of the contract. On the bases of the contractor's qualification, past performance and rates filled in the tender papers, work is allocated to the contractor.

### 1.5.6 Construction Management:

- **Planning and Scheduling:** To carryout project planning and prepare different schedules. Scheduling is the procedure of fixing the order of execution of different activities during construction. For preparing schedules methods like bar chart and critical path methods are generally used. Economic analysis is also carried out to know the economic viability and to select one alterative among several other options.

- **Construction execution and Supervision:** To carry out the actual execution of the construction of the structure and to supervise the progress of the work as per plan, design and specification and condition of the contract. During the actual construction engineer has to provide technical guidance to the contractor and monitor the progress. Management practices during construction also includes handling of the equipment and storing of material. It also includes observing labor laws and safety precautions.

### 1.5.7 Maintenance of Structure:

To carry out the maintenance of the structure after the construction is over. Structures needs maintenance and proper care. Due to continuous utilization of structure, wear and tear occur hence maintenance of the structure is required. Repair works are required to protect the structures to make them free from the effects of damage or deterioration. Some maintenance works are carried out annually like white washing and painting. Different types of the repair works are current repairs, special repairs and major according to the type of the repair.

## 1.6 BUILDING CONSTRUCTION AND PLANNING

Construction Engineering is a professional discipline that deals with the designing, planning, construction, and management of infrastructures such as roads, tunnels, bridges, airports, railroads, facilities, buildings, dams, utilities and other projects. It is considered a professional sub-practice area of civil engineering or architectural engineering.

The following stages are carried out for any type of project:

1. In the beginning, technical feasibility, environmental impact assessment and economical viability of the project are studied.
2. Soil investigation includes collecting data regarding soil and bearing capacity of soil. Soil investigations are done for the purpose of foundation design.
3. Surveying includes preparing site plan, contour map and measurement of field dimensions and levels.
4. On the basis of the data collected, planning and designing are carried out and drawings are prepared. Buildings are planned according to the fundamental principles of planning and by laws of local municipal bodies. Building planning also requires basic knowledge of principles of architecture.

## CONSTRUCTION MATERIALS:

### 1.6.1 CEMENT

Cement is obtained by burning at a very high temperature a mixture of calcareous (limestone) and argillaceous (clay) materials. The calcined product is known as clinker. A small quantity of gypsum is added to the clinker and is pulverised 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. It was first produced by a mason Joseph Aspdin in England in 1924. He patented it as portland cement.

### 1.6.2 GOOD QUALITIES OF CEMENT [May, June 2010, 2013, 2014]

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/mm$^2$ and tensile strength of 2 N/mm$^2$. Also, at the age of seven days, compressive strength should not be less than 17.5 N/mm$^2$ and tensile strength should not be less than 2.5 N/mm$^2$.
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 loose more than 4 per cent of its weight.
7. The total sulphur content of cement should not be greater than 2.75 per cent.
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 mm$^2$/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.

### 1.6.3 USES OF CEMENT [May, June 2010; nov, dec 2011, 2013, 2014]

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, light houses and docks needs cement.
4. The manufacture of precast piles, pipes, garden seats, artistically designed urns, flower pots, 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.

### 1.6.4 TYPES OF CEMENT [nov, dec 2009; May, June 2010]

**1) Portland Cement:** Cement obtained by burning and crushing of argillaceous and calcareous materials, which on setting if resembles a variety of sandstone found in Portland of England; such cement is known as ordinary Portland cement.

**2) Rapid Hardening Cement:** It is produced by burning the ingredients at high temperature and with high lime content. It attains high strength within few days (same initial and final setting time as that of OPC). It is used for those works which is to be completed speedily and economically.
**3) 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.
**4) 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.
**5) 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.
**6) 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.
**7) High-alumina Cement:** This cement generates high heat while reacting with water and causes high early strength development. So this cement can be used for generating high early strength in cold climates.
**8) 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.
**9) 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.
**10) 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.
**11) 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.
**12) 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.
**13) 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.
**14) High-strength Cement:** Certain special works require high strength concrete. To improve the strength a higher content of $C_3S$ 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.

### 1.6.5 Properties of Ordinary Portland Cement

**(*i*) Chemical properties:** Portland cement consists of the following chemical compounds:

(*a*) Tricalcium silicate - 3 $CaO.SiO_2$ ($C_3S$)

(*b*) Dicalcium silicate - $2CaO.SiO_2$ ($C_2S$)

(*c*) Tricalcium aluminate - $3CaO.Al_2O_3$ ($C_3A$)

(*d*) Tetracalcium alumoferrite - $4CaO.Al_2O_3.Fe_2O_3$

There may be small quantities of impurities present such as calcium oxide (CaO) and Magnesium oxide (MgO).

When water is added to cement, $C_3A$ is the first to react and cause initial set. It generates great amount of heat. $C_3S$ hydrates early and develops strength in the first 28 days. It also generates heat. $C_2S$ is the next to hydrate. It hydrates slowly and is responsible for increase in ultimate strength. $C_4AF$ is comparatively inactive compound.

**(*ii*) Physical properties:** The following physical properties should be checked before selecting a portland cement for the civil engineering works. IS 269–1967 specifies the method of testing and prescribes the limits:

(*a*) Fineness (*b*) Setting time

(*c*) Soundness (*d*) Crushing strength.

**(*a*) *Fineness*:** 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 per cent. In terms of specific surface should not be less than 2250 $cm^2$ /gm.

***b*) *Setting time*:** 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.

**(*c*) *Soundness:*** 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 recommends test with Le Chatelier mould for testing this property. At the end of the test, the indicator of Le Chatelier mould should not expand by more than 10 mm.

***(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.

### 1.6.6 Grades of Cement

**(a) M33 grade Cement** M refers to the mix, 33 refers the compressive strength of 15 × 15 × 15 cm size concrete cube at the age of 28 days—used for plastering work.

**(b) M43 grade Cement** M refers to the mix, 43 refers the compressive strength of 15 × 15 × 15 cm size concrete cube at the age of 28 days—used for bricks or stone masonry walls constructions.

**(c) M53 grade Cement** M refers to the mix, 53 refers the compressive strength of 15 × 15 × 15 cm size concrete cube at the age of 28 days—used for concreting works.

## 1.7 AGGREGATES

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.

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.

**1.7.1 Fine aggregate:** This is the aggregate for which its size is less than 4.75 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.

**Ex:** River sand or machine sand, crushed stone sand, and crushed gravel sand

**1.7.2 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.

**Ex:** crushed gravel or stone, Dolomite aggregates, and the natural disintegration of rock

### 1.7.1 SAND (FINE AGGREGATE) [May, June 2012; nov, dec 2012]

### 1.7.1.1 Classification of sand:

According to the nature of source, sand is classified into two groups:

(a) Natural Sand (b) Artificial Sand

**(a) NATURAL SAND**: It Is the one which is carried by the river water and is quarried from the river bed, when the river becomes dry.

**(b) ARTIFICIAL SAND:** Is the one which is the outcome of crushing and breaking stones into different sizes of stone aggregates in a stone crushing plant (or) crushed gravel sand.

### 1.7.1.2 Qualities of Good Sand [May, June 2012, 2014; nov, dec 2012]

(a) Sand should be clean, hard and durable and preferably dry.

(b) It should be free from mica, chemical salts, organic and inorganic impurities and outer foreign matters.

(c) It should preferably be free from, clay, silt and fine dust. In case if the presence of them is unavoidable, they should not be present by more than 5% by weight (or 7% by volume)

(d) Sand particles should be well graded and shall have sizes ranging from (150 micron) 0.15 m.m to 4.75 m.m.

(e) The fineness modulus of sand shall be from 1.6 to 3.5.

### 1.7.1.3 Uses of Sand [May, June 2012, 2014; nov, dec 2012]

(a) It is used for making mortar and concrete

(b) It is used for filling in the basement of buildings to receive the flooring concrete.

(c) It is used as a binding material on the top of bituminous road.

(d) It imparts mechanical strength to the mortar and prevents shrinkage and cracking of mortar while setting.

(e) It forms major portion of mortar and reduces the cost of mortar.

(f) It is mixed with expensive clay soils to stabilise them and prevent cracking of clay soils due to seasonal moisture changes.

### 1.7.1.4 Tests on Sand

The following tests are conducted to find out the suitability of sand.

(a) Sieve analysis and fineness modulus test

(b) Test for bulkage of sand

**(a) Sieve analysis and fineness modulus test**: The sand is sieved through 1. S. Sieves 4.75 mm, 2.36 mm., 1.18 mm, 600 micron, 300 micron and 150 micron sieves and percentage retained in each sieve is found out.

Fineness modulus of sand = sum of the percentages retained in each sieve / 100.

Requirement A fineness modulus of 1.6 to 2.0 for sand for plastering mortar and a fineness modulus of 2.5 to 3.5 for sand for concrete and a fineness modulus of 2.0 to 3.0 for sand for masonry mortar may be sufficient.

**(b) Test for bulking of sand:** The volume of dry sand will increase due to the presence of water in the sand up to about 25% of water content and therafter it will decrease and become equal to its dry volume, when it is saturated with water. This increase in volume of sand is know as bulking of sand. River sand will generally be wet and its volume will be more than the dry volume.

Hence, it is necessary to known the bulking of sand to allow for its increase in volume in the volume batching of concrete and mortar. The increase is volume of sand is found out from the test for bulkage of sand.

**Test procedure** A small quantity of wet sand is poured into a glass measuring jar and rammed by a small rod of dia 6 mm. and level of sand is noted (say $h_1$). Now water is poured into the cylinder until the sand is submerged and the glass jar is well shaken and now the level of sand is noted. (say $h_2$). $h_2$ will be less than $h_1$ and sand is saturated when it is submerged.

Percentage bulkage of sand = $\frac{h1-h2}{h1}\ x\ 100$

### 1.7.2 STONES (COARSE AGGREGATES) [May, June 2011]

Building stones are obtained from rocks. It is essential to have some knowledge about rocks in order to study the properties of stones. Rocks are mainly classified into igneous rocks, sedimentary rocks and metamorphic rocks.

Igneous rocks are formed by the cooling of the molten material from beneath the earth's surface. Stones from these rocks are said to be harder. Granite which is widely used in building constructions is a good example.

Sedimentary rocks are formed by the deposition of weathering products on existing rocks. Deposits are in layers and when load is applied along the layers these rocks easily split.

Metamorphic rocks are formed by the change in character of the pre-existing rocks. These will be hard if the basic rock is an igneous rock.

### 1.7.2.1 Qualities of good stone [nov, dec 2009, 2011; May, June 2011, 2013; apr, May 2015]

1. The crushing strength of stone should be greater than 100 N/mm2. All igneous rocks have a strength around 100 N/mm2 and some of the metamorphic rocks also satisfy this requirement. Sedimentary rocks have a lower strength.
2. Stones must be decent in appearance and be of uniform colour. Light coloured stones resist weathering action in a better way and hence preferred.
3. Stones must be durable. For the stones to be durable, their natural bed must be perpendicular to the direction of pressure.
4. Stones should be such that these can be easily carved and dressed. This property is opposed to strength and hardness but this depends upon the situation in which the stone is used.
5. For a good building stone its fracture should be sharp and clear.
6. If the stone is to be used in road work, it should be hard enough to resist wear and tear.
7. A good building stone must have a wear less than 3 per cent. If it is equal to 3 percent, it is just tolerable while if it is more than 3 per cent it is not satisfactory.
8. Stones must be fire resistant, i.e., these must retain their shape when a fire occurs. Limestone resists fire up to about 800°C. Sandstones can resist fire in a better way. Argillaceous stones are poor in strength, but resist fire to some extent.
9. A good stone should not contain quarry sap which is nothing but moisture present in the stones.
10. A good building stone must have a specific gravity greater than 2.7.
11. A good stone must have a compact, fine, crystalline structure, strong and durable.
12. A good stone should not absorb water more than 0.6 per cent by weight. It must be capable of withstanding effects of atmosphere.
13. A good building stone must be acid resistant and free from any soluble matter.

### 1.7.2.2 USES OF STONES [nov, dec 2011]

Stones are used

1. In the construction of buildings from the very ancient times.
2. For foundations, walls, columns, lintels, arches, roofs, floors, damp proof courses, etc.
3. For facing works in brick masonry to give a massive appearance.
4. Since stones are hard, these can be used for pavements.

5. As a basic material for concrete, moorum of roads, calcareous cements, etc.

6. As ballast in railways, flux in blast furnaces, blocks in construction of bridges, piers, abutments, retaining walls, light houses, dams, etc.

### 1.7.2.3 QUARRYING OF STONES

Quarrying is the process of extracting stone blocks from existing rocks. It is done at some depth below the top surface of rock where the effects of weathering are not found. Quarrying of soft and hard rocks is done by the following methods:

1. Digging, heating or wedging: In soft rocks like limestone and marble, stones are obtained by digging, heating or wedging using hand tools, namely, pick-axes, hammers, chisels, etc.

2. Blasting: In hard and dense rocks, stones are obtained by blasting using explosives.

### 1.7.2.4 DRESSING OF STONES

Stones obtained after quarrying have rough surfaces and are irregular in shape and size. Dressing is the process of cutting the stones to a regular shape and size and the required surface finish. The purposes of dressing are:

1. To prepare the stones for a suitable size for any handling and transport.

2. To prepare the stones into a regular shape and pleasing appearance, with neat horizontal and vertical mortar joints between the adjacent stones.

3. To make hammer-dressed surface, tooled surface, polished surface, rubbed surface or cut-stone surface to suit a particular stone masonry.

4. To secure proper bedding in stone masonry.

## 1.8 BRICKS

Brick is one of the oldest building materials made of burnt clay. Bricks are obtained by moulding clay in rectangular blocks of uniform size and then by drying and burning them in kilns.

### 1.8.1 QUALITIES OF GOOD BRICKS [nov 2011, 2014; May, June 2013; apr, May 2015]

1. Bricks should have perfect edges, well-burnt in kilns, copper coloured, free from cracks with proper rectangular shape and of standard size (19 × 9 × 9 cm).

2. Bricks should give a clear ringing sound when struck with each other.

3. Bricks must be homogeneous and free from voids.

4. The percentage absorption of water by weight should not be greater than 20 per cent for first-class bricks and 22 per cent for second-class bricks when soaked in cold water for 24 hours.

5. Bricks should be sufficiently hard, i.e., no nail impression must be present when scratched. The average weight of bricks should be 3–3.5 kg.

6. Bricks should not break when dropped from a height of 1 m.

7. Bricks should have low thermal conductivity and should be soundproof.

8. Bricks should not show deposits of salts when immersed in water and dried.

9. The minimum crushing strength of bricks must be 3.5 N/mm2.

### 1.8.2 CLASSIFICATION OF BRICKS:-

**1.** Unburned bricks: - These bricks are sundried. They have low strength and are used in the temporary and cheap structures.

**2.** Burnt bricks: - these bricks are used in all construction works.

***a) First class bricks:-***

- It should have all the requirements of a good standard brick.
- Made of regular good earth, thoroughly burnt and have regular shape, uniform reddish colour, and sharp edges.
- They should not absorb more than 20% of its dry weight, when immersed in water for 24 hours.
- The thickness of mortar joints does not exceed 10 mm.
- Its compressive strength should be greater than 100 kg/ cm2.
- They are table moulded and burnt in kilns.
- It is used for quality work.

***b) Second class bricks:-***

- These bricks are moulded on ground and are burnt in kilns.
- Surface of brick is rough and shape is irregular.
- Water absorption should not be more than 22% of its weight.
- Thickness of mortar joints is 12 mm.
- Minimum compressive strength 80 kg/ cm2.
- Used at places where the brickwork is to be provided with a coat of plaster and for internal walls.

***c) Third class bricks:-***

- They are not hard.
- Rough surfaces with irregular edges.
- Half burnt bricks of uniform reddish colour.
- Defects in colour, shape and size.
- Water absorption not more than 25%.
- Minimum compressive strength 45 kg/ m2
- These bricks give dull sound when struck together.
- Used for unimportant and temporary structures and at places where the rainfall is not heavy.

d) ***Fourth class bricks:-***

- Over burnt, irregular shape, dark colour.
- Used as aggregate for concrete.

### 1.8.3 USES OF BRICKS [nov, dec 2010; May, June 2013; apr, May 2015]

1. Bricks are mainly used for the construction of walls.

2. Bricks when moulded in the shape of a gutter can be used as drains.

3. Bricks with cavities known as hollow bricks can be used for insulation purposes and because of their light weight they are more useful in speedy constructions.

4. Paving bricks prepared from clay containing higher percentage of iron can be used for pavements, since they resist abrasion in a better way.

5. Bricks with holes are used in multi-storeyed framed structures.

6. Fire bricks made of fire clay can be used as a refractory material.

7. Sand-lime bricks are used for ornamental work.

8. Bricks are used in the construction of compound walls, columns, etc. Broken pieces of bricks are used as aggregates in concrete.

9. Bricks of superior quality can be used in the facing of a wall.

10. Bricks are used in the construction of chimneys and other special works.

### 1.8.4 CONSTITUENTS OF A BRICK [nov, dec 2011, 2014]

**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.

**ADVANTAGES OF USING BRICKS:**

The following are the advantages of bricks over other construction materials, like stone, concrete etc.,

(a) Bricks are cheaper and easy to handle.

(b) They are of standard size and hence easy to have proper bonding.

(c) Consumes less mortar when compared to stone masonry.

(d) Labour required for brick masonry is less.

(e) Brick walls can be raised to a larger height, when compared to stone masonry.

(f) Because of regular size the surface of wall will be plane and given a neat appearance.

(g) Brick masonry consumes, less mortar for plastering.

(h) Easy to drill holes for fixing service connection line.

(i) Bricks have low thermal conductivity and high sound insulation properties.

(j) They possess very high resistance to fire.

(k) They are non–combustible and non–inflammable.

**DISADVANTAGES OF USING BRICKS:**

(a) The compressive strength of brick is less compared to stone and concrete.

(b) Water absorption is more than that of stone or concrete.

(c) Only a selected variety of clay can be used for manufacture of bricks

(d) Kilns are required to be constructed for manufacturing bricks.

(e) It has got a very low tensile strength compared to other building materials.

## 1.8.5 TESTS ON BRICKS:

The following are the field tests by judgment for assessing the quality of bricks.

**Field tests:**

1. The bricks should be truly rectangular in shape with sharp edges and plane faces and of the same size.
2. They should be hard and well burnt and should give a metallic ringing sound when struck with a steel rod.
3. They should be of uniform red colour and of fine texture.
4. When the bricks are dropped on the ground from one metre height, they should not crack or break.
5. They should be free from cracks, fissures, pebbles or nodules of free lime.

**Lab Tests:**

**1. Test for water absorptions:**

(a) 3 samples of clean well dried bricks are taken and their dry weight is found out individually.

(b) The bricks are then immersed in water for 24 hours.

(c) After 24 hours, the bricks are taken out, surface dried and weighed in a balance and wet weight found out.

(d) If the wet weight of each bricks is $W_2$, the percentage water absorption of each brick = $\frac{W2-W1}{W1}\ x\ 100$

(e) The average percentage of water absorption of three samples is the water absorption of the bricks.

**Required standard** - The average absorption should not be greater than 20%. Too much of water absorption indicates under burnt condition and poor strength.

**2. Test for efflorescence (For the presence of salt):**

Salts like sulphates of calcium, magnesium, sodium and potassium present in the brick will cause efflorescence on the brick surface, when they get dissolved in water. Bricks containing too much of salt are less resistant to weathering and will have poor strength.

1. Three samples of bricks are immersed in good water for 24 hours.
2. After 24 hours, the bricks are taken out and examined for white patches of salt on the surfaces.
3. If the white patches of salt present are heavy, the bricks are poor and are to be rejected.
4. If the while patches present are small to medium, the bricks can be accepted.

**3. Test for compressive strength:**

The load carrying capacity of bricks is increased, as the compressive strength increases.

(a) Three samples of bricks are taken and immersed in good water for 24 hours.

(b) After 24 hours of immersion, the bricks are taken out and surface dried.

(c) Each brick is placed on the compression testing machine and the load on the brick is gradually increased until the brick fails. The failure load of each brick is found out.

(d) Average failure load of the 3 bricks is the compressive strength of the bricks.

Requirement standards

1. Country Bricks = 3.5 to 5.0 $N/mm^2$

2. II Class bricks = 5.0 to 7.5 $N/mm^2$

3. I Class bricks = 7.5 to 12.5 $N/mm^2$

## 1.8.6 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

**(i) Removal of loose soil:** The top layer of the loose soil about 20cm depth contains lot of impurities and hence it should be taken out and thrown away.

**(ii) Digging, spreading and cleaning:** The earth is then dug out from the ground. This earth is spread into heaps about 60 cm to 120 cm height. All the undesirable matters like stones, vegetable matter etc. are removed. Lumps of clay should be converted into powder form.

**(iii) Weathering:** The earth is then exposed to atmosphere for softening. The period of exposure varies from weeks to full season.

**(iv) Blending:** The clay is then mixed with suitable ingredients. It is carried out by taking a small portion of clay every time and by turning it up and down in vertical direction.

**(v) Tempering:** This is done to make the whole mass of clay homogenous and plastic. Required water is added to clay and the whole mass is kneaded under the feet of men or cattle.

**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

**1. Hand Moulding:** This is done by a mould which is a rectangular box with open at top and bottom. It may be of wood or steel. Following are the ways of hand moulding:

(a) Ground moulding (b) Table moulding

**2. Machine moulding:** When bricks are manufactured in huge quantity at the same spot then moulding is done by machines.

**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.

During drying it must be protected from wind, rain and direct sun. Sometimes, bricks, are dried artificially by hot gases from kiln. But there is change of warping of bricks in case of artificial drying. After drying, the bricks are sent for the next operation of burning.

**4. Burning of Bricks:**

Burning imparts hardness and strength to bricks and makes them dense and durable. It must be done carefully and properly because under burnt bricks remain soft and hence cannot carry loads and overburnt bricks become brittle and hence, break easily. Burning of bricks is done either in clamp or in kilns.

## 1.9 CEMENT CONCRETE:

Concrete is one of the most commonly used building materials. Concrete is a composite material made from several readily available constituents (aggregates, sand, cement, water). Concrete is a versatile material that can easily be mixed to meet a variety of special needs and formed to virtually any shape.

**CONSTITUENT MATERIALS:**

- Cement
- Water
- Fine Aggregate
- Coarse Aggregate
- Admixtures

**Portland Cement -** The cement and water form a paste that coats the aggregate and sand in the mix. The paste hardens and binds the aggregates and sand together.

**Water**- Water is needed to chemically react with the cement (hydration) and too provide workability with the concrete.

**Aggregates**- Sand is the fine aggregate. Gravel or crushed stone is the coarse aggregate in most mixes.

**Admixtures:** These are additions to the mix used to achieve certain goals. Some of the admixtures are:

- **Accelerating admixture-**accelerators are added to concrete to reduce setting time of the concrete and to accelerate early strength.
- **Retarding admixtures-**Are often used in hot weather conditions to delay setting time.

### 1.9.1 Properties of Concrete [May, June 2009, 2014]

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.

### 1.9.2 Uses of Concrete [May, June 2009, 2014]

1. Concrete can be made impermeable by using hydrophobic cement. This is used for the construction of RCC flat-roof slabs.

2. Coloured concrete is used for ornamental finishes in buildings, park lanes, separating lines of road surfaces, underground pedestrian crossings, etc.

3. Light weight concrete is used in multi-storeyed constructions.

4. No-fines concrete is one in which sand is eliminated. This can be used for cast-insitu external load bearing walls of single and multi-storey houses, retaining walls, damp-proofing material, etc.

5. Concrete is mainly used in floors, roof slabs, columns, beams, lintels, foundations and in precast constructions.

6. It is used in massive structures, such as dams and bridges.

7. Concrete is used in the construction of roads, runways, playgrounds, water tanks and chimneys.

8. It is used in the construction of sleepers in railways.

9. Prestressed concrete is a relatively new type of concrete which is used in many constructions particularly in the construction of bridges.

10. Concrete trusses are also used in factory constructions.

11. Concrete is used in the construction of bunkers, silos, etc.

12. It finds a place in the construction of nuclear reactors because of its high shielding capacity for the radioactivity.

13. Thin economical shell construction are possible with the use of concrete.

### 1.9.3 TYPES OF CONCRETE:

**1. REINFORCED CONCRETE**: Plain concrete is very weak in tension and cannot be used in the construction of lintels, roof slabs, beams, etc. in which the bottom fibres of them are subjected to tensile stresses. As concrete withstands compression but not tension, steel rods are embedded in the bottom portion to withstand the tension. A combination of concrete and steel is known as reinforced cement concrete and is widely used in various situations. Reinforcing bars are available from 6–32 mm diameter and of 22 feet length. They may be of mild steel or Tor steel and may be plain or twisted.

**ADVANTAGES OF REINFORCED CONCRETE** **[May, June 2012]**

1. Reinforced concrete is a versatile building material and can be used for casting members of any shape.
2. It has good resistance to fire, temperature and weathering actions.
3. RCC construction is easy and fast.
4. The component materials used for preparing RCC are easily available
5. Monolithic construction is possible with the use of RCC. This increases the stability and rigidity of the structure.
6. RCC is tough and durable.
7. Maintenance of RCC construction is very cheap.
8. With proper cover, RCC can be made free from rusting and corrosion.

**2. 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. This heavy self-weight causes heavy load and increases the haulage and handling costs. In order to make an economical concrete, attempts were made in the past to reduce the self-weight of concrete. As a result the light weight concrete was developed whose density varies from 300–1850 kg/m3.

**Advantages of light-weight concrete:**

(a) It has low density.

(b) It has low thermal conductivity.

(c) It lowers haulage and handling costs.

**Types of light-weight concrete**

(a) Light-weight aggregate concrete

(b) Aerated concrete

(c) No-fine concrete

**(a) Light-weight aggregate concrete:** By replacing the usual mineral aggregate by cellular porous or light weight aggregate, light-weight aggregate concrete can be produced. Lightweight aggregate can be classified into two categories namely natural and artificial lightweight aggregate.

**(b) Aerated concrete:** By introducing gas or air bubbles in mortar, aerated concrete can be produced. This concrete is a mixture of water, cement and finely crushed sand with air or gas introducing agents. There are several ways in which aerated concrete can be manufactured. One important way is by the formation of gas or air bubbles using finely powdered metal (usually aluminium powder). Chemical reaction takes place in the concrete and finally large quantity of hydrogen gas is liberated which gives the cellular structure.

**(c) No-fine concrete:** By omitting sand fraction from the aggregate, no-fine concrete can be produced. This concrete is made up of only single-sized aggregate of size passing of 20 mm and retained on 10 mm coarse aggregate, cement and water. The single sized aggregate makes a good no-fine concrete, which in addition gives large voids and hence is light in weight. It also offers an architecturally attractive look. Out of the three main groups of light-weight concrete, the light-weight aggregate concrete and aerated concrete are more often used than the no-fine concrete.

**3. 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. The high-density concrete is mainly used in the construction of radioactive shields. High-density concrete is made by using such a heavy-weight aggregate whose specific gravity is more than 3.5. The aggregates used in this type of concrete should be clean, strong, inert and relatively free from deleterious material. Normally barite, magnetite, lemonite are used to make high-density concrete. To produce high density and high strength concrete, it is necessary to control the water – cement ratio, correct admixture and vibrators for good compaction.

**4. 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. Due to compaction, these voids are founded and the strength of the concrete is naturally reduced. There are number of methods available to reduce the air voids but none of these methods could really help to reduce the water voids. The impregnation of monomer and subsequent polymerisation is the latest technique adopted to reduce the inherent porosity of the concrete, to improve the strength and other properties of concrete. This type of concrete is known as polymer concrete.

**Applications of polymer impregnated concrete:**

1. Prefabricated structural elements
2. Prestressed concrete
3. Marine works
4. Desalination plants
5. Nuclear power plants
6. Sewage works—pipes and disposal works
7. For water proofing of structures
8. Industrial applications

**5. FIBRE-REINFORCED CONCRETE:** Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Due to its poor tensile strength, internal microcracks are present in concrete which leads to brittle fracture. 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 substantially improve its static and dynamic properties. This type of concrete is known as Fibre Reinforced Concrete (FRC). Some of the fibres used are steel fibres. polypropylene, nylons, asbestos, coir, glass and carbon. The property of concrete may vary depending upon the type, diameter, length and volume of fibres. Steel fibre is one of the most commonly used fibre. Most of the times round fibres are used. The diameter of such fibres may vary from 0.25–0.75 mm. The use of steel fibres may improve the flexural, impact and fatigue strength of concrete.

**Applications of fibre-reinforced concrete** - Normally, FRC are used in air field, road pavements, industrial floorings, bridge decks, canal lining, explosive resistant structures, refractory linings, etc. It can also be used in pre-cast products like pipes, boats, beams, staircase steps, wall panels, roof panels, manhole covers, etc.

## 1.10 STEEL

Steel is a common building material used in the construction works. It forms a skeleton and holds the structures together. It is 100% recyclable. Steel is an alloy of iron and carbon with traces of other elements. Total carbon content in steel varies from 0.25-1.5%.

### 1.10.1 TYPES OF STEEL

Depending on the carbon content in it:

1) Carbon upto 0.25% - mild steel or soft steel. Used for making motor body, sheet metal, plates etc.

2) Carbon upto 0.25-0.75% - medium carbon steel. Used for making rails, tyres, hammers, springs, die etc.

3) Carbon 0.75-1.25% - high carbon steel. Used for making chisels, hammer, saw, axes etc.

4) Carbon >1.25% - extra hard steel/stainless steel. Used for making architectural panels, curtain walls etc.

### 1.10.2 USES OF STEEL IN BUILDING CONSTRUCTIONS:

Mainly two types of steels are used in building constructions:

(a) Mild steel

(b) HYSD bars.

**(a) Mild steel (MS) bars:**

MS bars are strong in compression and tension. They are plain in surface and are round sections of diameter 6-50mm. These rods are manufactured in long lengths and can be cut quickly and also be bent easily without any damage.

**Uses:**

- Used as rolled steel sections like I-section, T-section, channel section, angle section etc.
- Used as reinforcement bars in RCC
- Plain and corrugated sheets of mild steel are used as roof coverings
- Construction of buildings, ships, railways, automobiles and electrical industries.

**(b) High yield strength deformed bars (HYSD bars):**

They are deformed bars of high strength. They are rods of steel produced with ribs or deformations on the surface of the bar. They have more tensile stresses and bond strengths.

**Uses**

- Used as reinforcement bars in construction of buildings, bridges, pile foundation etc

- Used in the manufacture of smaller member cross sections.

### 1.10.3 TYPES AND MARKET FORMS OF STEEL:

The various forms in which rolled steel sections are available are as follows:

**(1) Angle sections**

This section has two legs. If the two legs are equal, they are called equal angle section. If the two legs are unequal, they are called unequal angle sections. Angle sections are used in the construction of steel roof trusses, steel columns, beams etc.

**(2) Channel sections**

This section consists of a web and two flanges. These are used as structural members of steel framed structures. These are used in the construction of built in columns, beams and steel bridges.

**(3) T- section**

These are used as members of steel roof trusses, built up sections, chimneys, steel bridges etc.

**(4) I- section**

Also known as rolled steel joists. These are suitable for beams, columns, lintels. Unequal I- sections with heavy weights are used as rails.

**(5) Flat bars**

Available in widths varying from 3-40mm. Used in the construction of steel grill works, windows and gates.

**(6) Square bars**

They are bars with square cross section. Size varies from 5mm to 25mm. weight ranges from 2 N/m – 49 N/m. These are used in the construction of steel grill works, windows and gates etc.

**(7) Round bars**

These are bars with circular cross section. Diameter varies from 5-25mm and weight varies from 1.5-38N. These are used as reinforcement in concrete structures, construction of steel grill works etc.

**(8) Expanded metals**

These are formed by cutting and expanding either plain sheets or ribbed sheets. It has an appearance of diamond mesh. Mesh size varies from 30mm – 150mm across shorter length. These are available in the length of 1 – 3m and width 5m. Used as reinforcing foundations, road floors, bridges etc and also used as lathing materials.

**(9) Plates**

These are available with varying thickness from 5-500 mm weight ranges from 392 N/mm2 - 3925 N/mm2. These are used to connect steel beams for extension of length and for carrying tensional forces in roof trusses.

**(10) Corrugated sheets**

These sheets are formed by passing steel sheet through groves, the groves bend and sheets are pressed and thus corrugations are formed. These are used as roof covering materials.

**(11)Pipes, tubes and steel sheets**

Pipes are used for light columns and other structural purposes and as liquid conduits. Tubes are used for framing roof truss and for light structural works, scaffolding etc….

**(12) Tor steel**

These are most commonly used steel bar for concrete reinforcement. These are used for general concrete reinforcement in buildings, roads, bridges, walls, dams etc…

## 1.11 Introduction to Prefabricated Construction Techniques:

The Prefabrication which means the production or manufacture of elements which away from the construction site, the elements are called as prefabrication. Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. Prefabricated construction, often known as modular construction.

### 1.11.1 Need for Prefabrication:

- Prefabricated structures are used for sites which are not suitable for normal construction methods such as hilly regions, city and also when normal construction materials are not easily available.
- Speedy construction- No curing period.
- Effect Economy.
- Improve Quality.
- Durable structures with less maintenance.
- Attractive finishes.
- Further expenses easy.

### 1.11.2 Benefits of Prefabricated Construction:

The prefabricated building has various benefits over traditional techniques of construction. Among the many advantages are:

- Construction time is greatly decreased when building components are manufactured off-site. Prefabricated modules can be constructed concurrently with site preparation, resulting in quicker project completion.
- Cost Savings: Because of economies of scale, lower labor costs, and reduced material waste, prefabrication allows for cost savings. Weather-related delays and expenses are reduced in factory-controlled settings.
- Prefabrication improves quality control since components are fabricated under rigorous factory conditions. Higher-quality constructions are ensured by consistent standards, exact measurements, and stringent quality inspections.
- The prefabricated building encourages environmentally friendly techniques. Controlled industrial conditions save energy, and careful material planning reduces waste. Modules can also be constructed to be energy efficient and include renewable technology.

- Flexibility and adaptability: Prefabrication enables design modification and flexibility. Modular components are useful for projects that require future growth or relocation since they can be readily dismantled, moved, or modified.

### 1.11.3 Disadvantages of Prefabrication:

- Careful handling of prefabricated components such as concrete panels, steel and glass panels is required.
- Attention has to be paid to the strength and corrosion-resistance of the joining of prefabricated sections to avoid failure of joints.
- Similarly, leaks can form at joints in prefabricated components.
- Transportation cost may be higher for voluminous prefabricated sections than for the materials of which they are made, which can often be packed more compactly.
- Height restrictions under bridges.
- Road transport maximum widths.
- Additional cost of temporary bracing for transportation and lifting or permanent framing to support prefabricated assemblies.
- Large prefabricated sections require heavy-duty cranes and precision measurement and handling to place in position.
- Greater erection equipment's are needed.

### 1.11.4 Prefabricated Building Applications:

Prefabricated construction methods have grown in popularity across a wide range of industries and project types:

- Prefabricated construction is commonly used in residential projects such as single-family homes, townhouses, and apartment complexes. Prefabrication is an excellent solution for meeting the need for affordable homes because of its speed and efficiency.
- Commercial Buildings: Prefabricated construction provides an adaptable option for a wide range of commercial projects, from offices and retail spaces to hotels and restaurants. The flexibility to personalize and change the design enables the creation of distinctive architectural characteristics and branding.
- Prefabricated building techniques are well-suited for educational facilities such as schools, colleges, and universities. The expedited building schedule guarantees that instructional activities are not disrupted.
- Healthcare Facilities: Because of their economy and adaptability, prefabricated construction techniques are increasingly being used in the healthcare industry.

Modular hospitals, clinics, and medical centers may be built fast and tailored to individual healthcare needs.

### 1.11.5 The Future of Prefabricated Building Techniques:

Prefabricated building techniques have a bright future, with additional developments and innovations on the horizon. Among the significant trends influencing the market are:

- Technological Integration: The use of digital technology such as Building Information Modelling (BIM), robots, and automation will improve prefabricated construction efficiency, precision, and quality. Prefabricated constructions will be tracked and maintained in real-time thanks to smart sensors and monitoring systems.
- Prefabricated buildings will prioritize sustainability in the future, combining energy-efficient designs, renewable materials, and green technology. Net-zero energy buildings will become increasingly common, as will the use of recycled or recyclable materials.
- Customization and Design Flexibility: Prefabrication processes will allow architects and designers to construct more distinctive and inventive structures. Customizable modules and components will allow for personalized solutions to specific project needs.
- Collaboration and Integration: Efforts by architects, engineers, manufacturers, and construction teams to collaborate will promote the smooth integration of prefabricated components into the whole construction process. Streamlined communication and collaboration will increase efficiency and assure project success.

### 1.11.6 Uses of Prefabrication:

- Prefabricated components speed up construction time, resulting in lower labour cost.
- Prefabricated allows for year-round construction.
- Work is not affected by weather delays (related to excessive cold, heat, rain, snow etc.)
- The mechanization used in prefabricated construction ensures precise conformity to building code standards and greater quality assurance.
- There are less wasted materials than in site-built construction.
- There is less theft of material/ equipment (and less property damage due to vandalism.)
- Materials are protected from exposure to the elements during construction.
- Worker safety and comfort level are higher than in site-built construction.
- Quality control and factory sealing and design can ensure high energy.