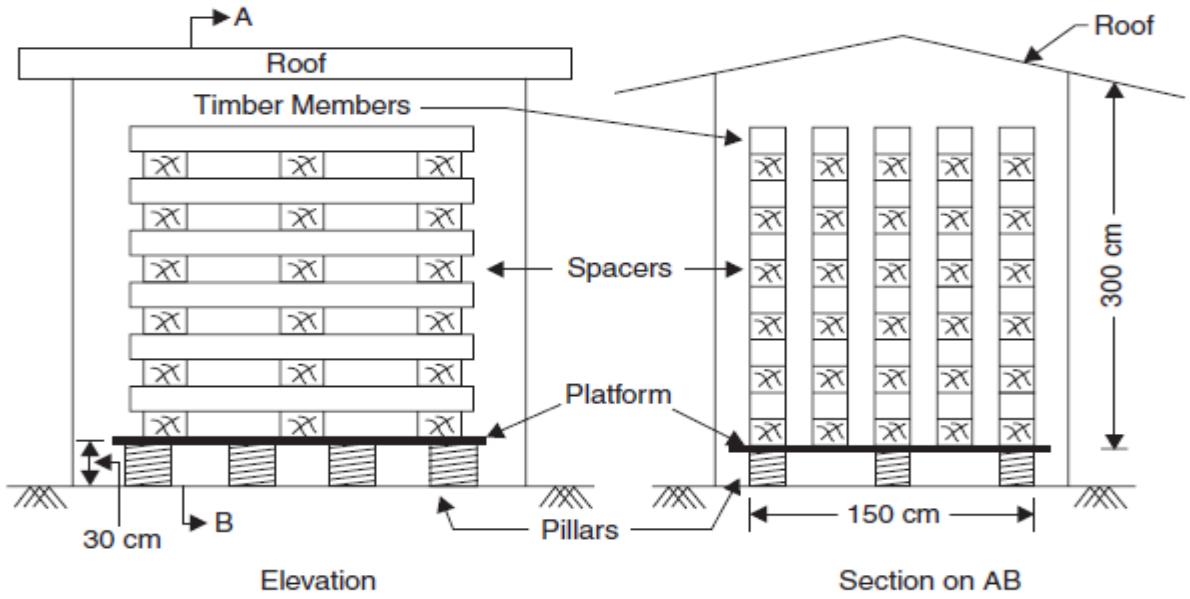
Basic Civil Engineering

(Subject Code: 1150CE101)



Lecture Slides

By

Department of Civil Engineering

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Syllabus

UNIT I: Building Materials

Introduction – Civil Engineering – Materials – Bricks – Composition – Classifications – Properties – Uses – Stone – Classification of Rocks – Quarrying – Dressing – Properties – Uses – Timber – Properties – Uses – Plywood –Cement – Grades – Types – Properties – Uses – Steel – Types – Mild Steel – Medium Steel – Hard Steel –Properties – Uses – Market Forms – Concrete – Grade designation – Properties – Uses – Advancements in Concrete – Pre-stressed Concrete – Pre fabricated concrete.

UNIT II: Building Components

Building – Selection of site – Classification – Components – Foundations – Functions – Classifications – Bearing Capacity – Flooring – Requirements – Selection – Types – Cement concrete marble – Terrazzo floorings – Roof – Types and requirements.

UNIT III: Planning Aspects and Regulations

Building types and design criteria – Space standards for residential, commercial and institutional categories – Building by-laws applicable for approval by the local governing body – Development control rules for Chennai Metropolitan Area. Basic guidelines for earthquake resistant structures.

UNIT IV: Water Supply and Sanitary Systems

Water supply – Objectives – Quantity/Quality of water –Sources – Standards of drinking water – Distribution system –Sewage – Classification – Technical terms – Septic tank – Components and functions – layout of external services –water supply – Sewage disposal – water supply and plumbing layout for a residential building.

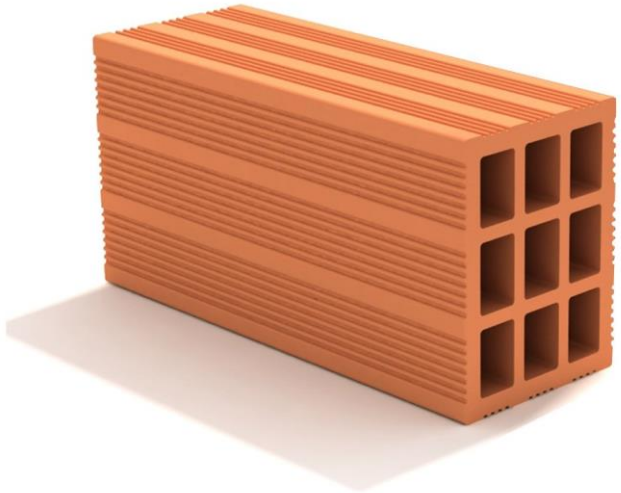
UNIT V: Surveying and Transportation

Surveying – Objectives – Classification – Principles of Survey – Transportation – Classification – Cross section and components of road – Classification of roads – Railway – Cross section and components of permanent way – Functions – Water way – Docks and Harbors – Classification - Components – Bridges – Components of bridges.

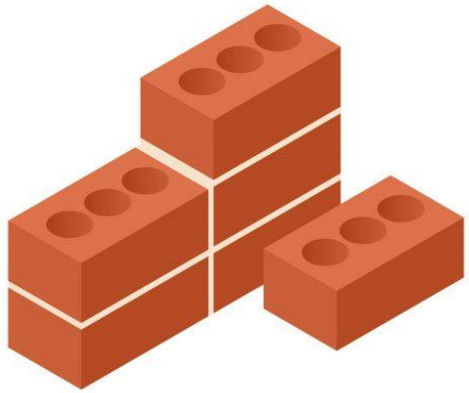
Unit I: Building Materials

Introduction – Civil Engineering – Materials – Bricks – Composition – Classifications – Properties – Uses – Stone – Classification of Rocks – Quarrying – Dressing – Properties – Uses – Timber – Properties – Uses – Plywood –Cement – Grades – Types – Properties – Uses – Steel – Types – Mild Steel – Medium Steel – Hard Steel –Properties – Uses – Market Forms – Concrete – Grade designation – Properties – Uses – Advancements in Concrete – Pre-stressed Concrete – Pre fabricated concrete.

Bricks



“Brick is obtained by moulding good clay into a block, which is dried and then burnt. This is the oldest building block to replace stone. Manufacture of brick started with hand moulding, sun drying and burning in clamps”



Composition of Bricks

- **Alumina:** It is the chief constituent of clay. A good brick should have 20-30 % of alumina. This imparts plasticity to earth.

- **Silica:** It exists in a free or combined form. A good brick earth should contain 50-60% of silica. The presence of silica prevents cracking, shrinkage and warping of raw bricks. It imparts uniform shape to bricks. The durability depends on proper proportion of silica.

- **Lime:** Up to 5% 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 lime content.

- **Iron Oxide:** This gives the red color to bricks. A small quantity of iron oxide up to 5 or 6% is desirable.

- **Magnesia:** This imparts yellow tints to bricks and it reduces shrinkage 2 to 3%.

Classification of Bricks

- ***First Class Bricks:*** These bricks are of standard shape and size. They are burnt in kilns. They fulfil all desirable properties of bricks.

- ***Second Class Bricks:*** These bricks are ground moulded and burnt in kilns. The edges may not be sharp and uniform. The surface may be some what rough. Such bricks are commonly used for the construction of walls which are going to be plastered.

- ***Third Class Bricks:*** These bricks are ground moulded and burnt in clamps. Their edges are somewhat distorted. They produce dull sound when struck together. They are used for temporary and unimportant structures.

- ***Fourth Class Bricks:*** These are the over burnt bricks. They are dark in colour. The shape is irregular. They are used as aggregates for concrete in foundations, floors and roads.

Properties of Good Bricks

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

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

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

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

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

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

(vii) **Strength:** Crushing strength of brick should not be less than 3.5 N/mm^2. A field test for strength is that when dropped from a height of 0.9 m to 1.0 mm on a hard ground, the brick should not break into pieces.

Properties of Good Bricks

(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.

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

Manufacturing of Bricks

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

(a) Preparation of brick earth

(b) Moulding of bricks

(c) Drying of bricks

(d) Burning of bricks

Preparation of Brick Earth:

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

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

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

Manufacturing of Bricks

d) ***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.

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

Moulding of bricks:

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

(a) ***Hand Moulding:*** This is done by a mould which is rectangular box with open at top and bottom. It may be of wood or steel.

(a) Ground Moulding

(b) Table Moulding

(b) ***Machine Moulding:*** When bricks are manufactured in huge quantity at the same spot then moulding is done by machines. These machines contain a rectangular opening of size equal to the length and width of bricks.

Manufacturing of Bricks

Drying of Bricks:

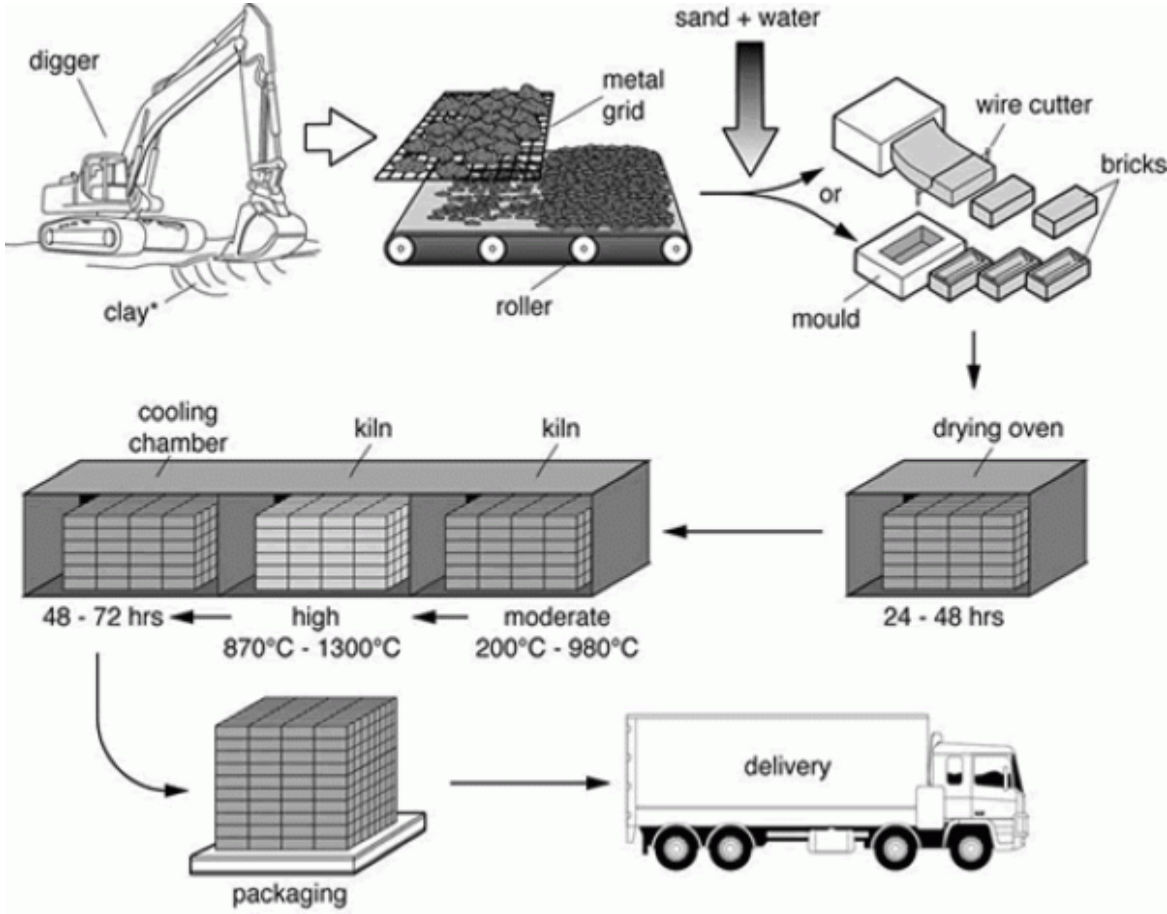
After the bricks are moulded, they are dried. This is done on specially prepared drying yards. Bricks are stacked in the yard with 8 to 10 bricks in each row.

Bricks are dried for a period of 5 to 12 days. During drying it must be protected from wind, rain. After drying, bricks are sent for the next operation of burning.

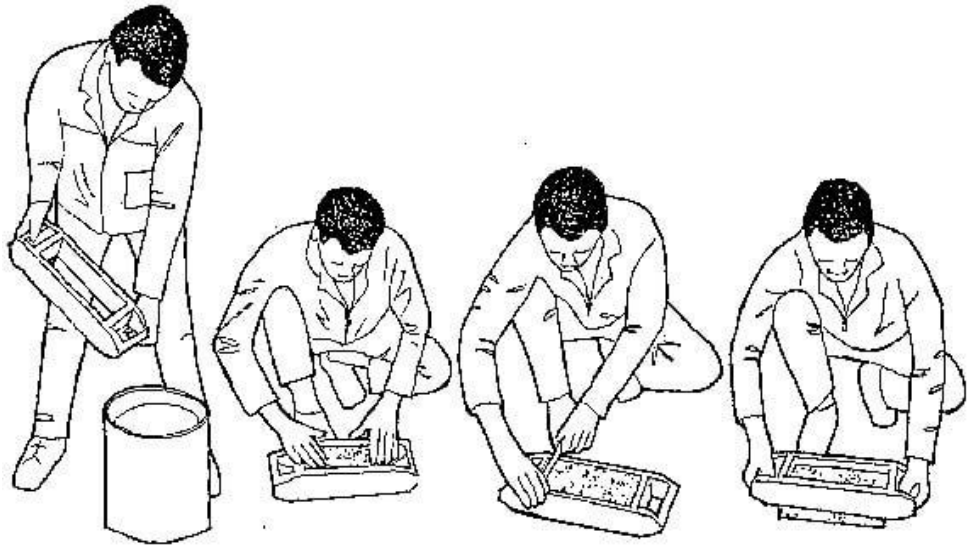
Burning of Bricks:

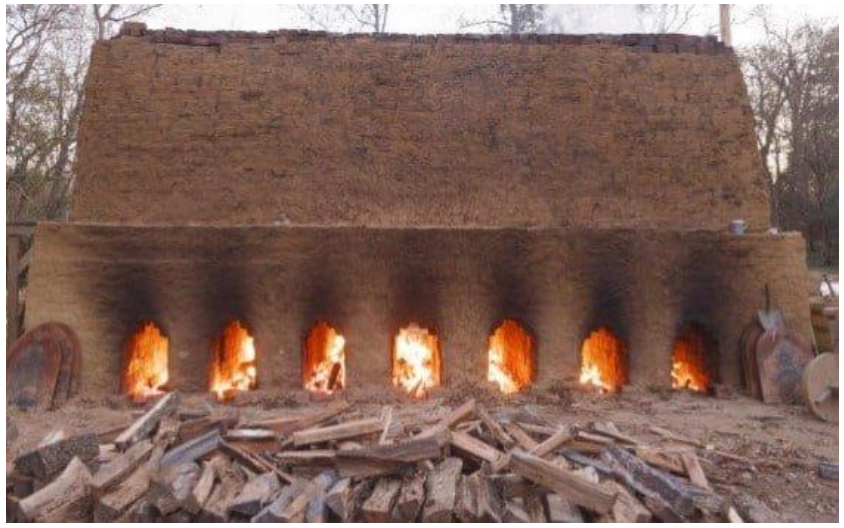
Burning imparts hardness and strength to bricks and makes them dense and durable.

It must be done carefully and properly because un-burnt bricks remain soft and hence cannot carry loads and over burnt bricks becomes brittle and hence break easily. Bricks are burnt either in clamp or kiln.



Manufacturing of Bricks – Process Flow





Uses of Bricks

(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.

Stones

“Stone is a ‘*naturally available building material*’ which has been used from the early age of civilization. It is available in the form of rocks, which is cut to required size and shape and used as building block.

Red Fort, Taj Mahal, Vidhan Sabha at Bangalore and several palaces of medieval age all over India are the famous stone buildings“

Classification of Stones

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

- Geological
- Physical
- Chemical

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

a) ***Igneous Rocks:*** These rocks are formed by cooling and solidifying of the rock masses from their molten magmatic condition of the material of the earth. Generally igneous rocks are strong and durable. *Granite*, *trap* and *basalt* are the rocks belonging to this category.

b) Sedimentory Rocks: Due to weathering action of water, wind and frost existing rocks disintegrates. The disintegrated material is carried by wind and water; the water being most powerful medium. Flowing water deposits its suspended materials at some points of obstacles to its flow. These deposited layers of materials get consolidated under pressure and by heat. *Sand stones, lime stones, mud stones* etc. belong to this class of rock.

Classification of Stones

c) Metamorphic Rocks: Previously formed igneous and sedimentary rocks under go changes due to metamorphic action of pressure and internal heat. For example, due to metamorphic action,

- Granite -> -> Greisses
- Trap -> -> Schist
- Basalt -> -> Laterite
- Lime stone -> -> Marbles
- Sandstone -> -> Quartzite
- Mud stone -> -> Slate

II. Physical Classification:

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

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

Classification of Stones

III. Chemical Classification: On the basis of their chemical composition engineers prefer to classify rocks as:

- Silicious rocks
- Argillaceous rocks and
- Calcareous rocks

(*i*) ***Silicious rocks:*** The main content of these rocks is silica. They are hard and durable. Examples of such rocks are *granite, trap, sand stones* etc.

(*ii*) ***Argillaceous rocks:*** The main constituent of these rocks is argil i.e., clay. These stones are hard and durable but they are brittle. They cannot withstand shock. *Slates* and *laterites* are examples of this type of rocks.

(*iii*) ***Calcareous rocks:*** The main constituent of these rocks is calcium carbonate. *Limestone* is a calcareous rock of sedimentary origin while *marble* is a calcareous rock of metamorphic origin.

Properties of Stones

(*i*) ***Structure:*** The structure of the stone may be stratified (layered) or unstratified. Structured stones should be easily dressed and suitable for super structure. Unstratified stones are hard and difficult to dress. They are preferred for the foundation works.

(*ii*) ***Texture:*** Fine grained stones with homogeneous distribution look attractive and hence they are used for carving. Such stones are usually strong and durable.

(*iii*) ***Density:*** Denser stones are stronger. Light weight stones are weak. Hence stones with specific gravity less than 2.4 are considered unsuitable for buildings.

(*iv*) ***Appearance:*** A stone with uniform and attractive colour is durable, if grains are compact. Marble and granite get very good appearance, when polished. Hence they are used for face works in buildings.

(*v*) ***Strength:*** Strength is an important property to be looked into before selecting stone as building block. Indian standard code recommends, a minimum crushing strength of 3.5 N/mm^2 for any building block.

Name of Stone	*Crushing Strength in N/mm^2*
Trap	300 to 350
Basalt	153 to 189
Granite	104 to 140
Slate	70 to 210
Marble	72
Sand stone	65
Lime stone	55
Laterite	1.8 to 3.2

Properties of Stones

(*vi*) ***Hardness:*** It is an important property to be considered when stone is used for flooring and pavement. Coefficient of hardness is to be found by conducting test on standard specimen in **Dory's testing machine**. For road works coefficient of hardness should be at least **17**. For building works stones with coefficient of hardness less than **14** should not be used.

(*vii*) ***Percentage wear:*** It is measured by attrition test. It is an important property to be considered in selecting aggregate for road works and railway ballast. A good stone should not show wear of more than **2%**.

(*viii*) ***Porosity and Absorption:*** All stones have pores and hence absorb water. The reaction of water with material of stone cause disintegration. Absorption test is specified as percentage of water absorbed by the stone when it is immersed under water for 24 hours. For a good stone it should be as small as possible and in no case more than 5.

(*ix*) ***Weathering:*** Rain and wind cause loss of good appearance of stones. Hence stones with good weather resistance should be used for face works.

(*x*) ***Toughness:*** The resistance to impact is called toughness. It is determined by impact test. Stones with toughness index more than **19** are preferred for road works. Toughness index **13 to 19** are considered as medium tough and stones with toughness index **less than 13** are poor stones.

Tests on Stones

To ascertain the required properties of stones, the following tests can be conducted:

(i) Crushing strength test

(ii) Water absorption test

(iii) Abrasion test

(iv) Impact test

(v) Acid test.

(vi) Fire Resistance Test

(vii) Smith's Test

(viii) Crystallization Test

(ix) Microscopic Test

(x) Freezing and Thawing Test

Uses of Stones

Stones are used in the following civil engineering constructions:

(i) Stone masonry is used for the construction of foundations, walls, columns and arches.

(ii) Stones are used for flooring.

(iii) Stone slabs are used as damp proof courses, lintels and even as roofing materials.

(iv) Stones with good appearance are used for the face works of buildings. Polished marbles and granite are commonly used for face works.

(v) Stones are used for paving of roads, footpaths and open spaces round the buildings.

(vi) Stones are also used in the constructions of piers and abutments of bridges, dams and retaining walls.

(vii) Crushed stones with graved are used to provide base course for roads. When mixed with tar they form finishing coat.

(viii) Crushed stones are used in the following works also:

(a) As a basic inert material in concrete

(b) For making artificial stones and building blocks

(c) As railway ballast.

Quarrying of Stones

"Quarrying is the process of taking out the stones from the rock beds" The two types of quarrying are as follows:

I. Quarrying to obtain stone blocks for building construction

II. Quarrying to obtain small sized, irregular shaped aggregates for concrete, roads, etc.

The method of Quarrying may be carried out by following ways:

Excavation: The excavation is done using pickaxes and crowbars to separate the stones.

Wedging: Wedging is the method of making vertical holes closely on the rock and forcing the steel wedges and pins into the rock. Along the line of holes, the cracks are developed in rocks and stones come out.

Blasting: Blasting is the method of boring the holes in the rock and inserting explosives into the holes which will make the rock to break into small pieces of stones.

Heat Application: In this method, the top layers of rocks are heated by burning piles of wood on the surface of the rock. Due to expansion the top layers are separated from the bottom layers. By this method, granite and gneiss are removed from the rocks.

Wedging

Excavation

Heat Application

Dressing of Stones

"Dressing of stones is the process by which the stones are cut to a suitable size and shape"

Dressing of stones is done for following purposes:

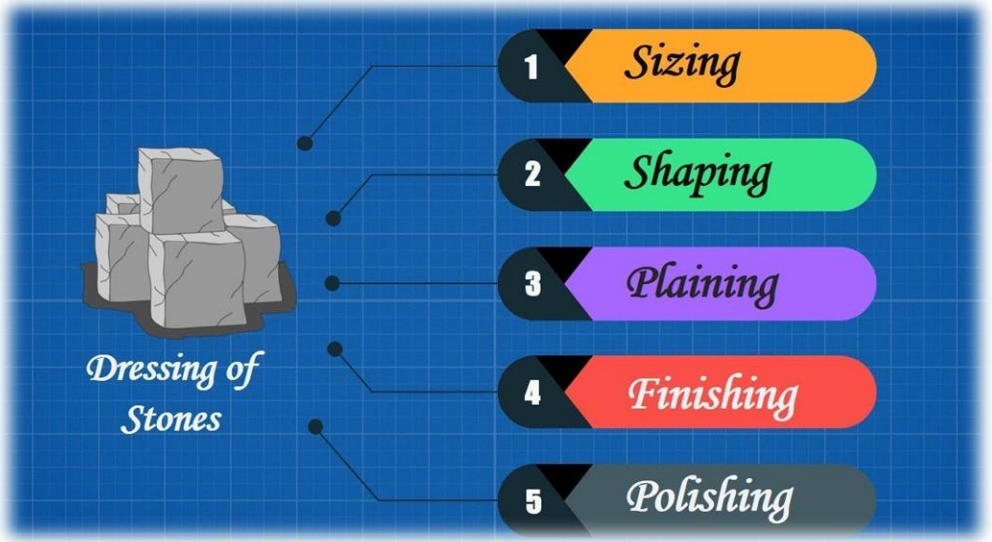
i. To obtain a good appearance in masonry walls

ii. To obtain proper bedding and bonding in masonry walls

iii. To provide thin mortar joints between stones and thus savings in mortar

iv. To make the easy transport and handling

v. To obtain the required size and shape of the masonry structures



Types of Dressing of Stones

i. ***Quarry Dressing:*** If the dressing of stones is done in the stone quarries to minimize the transportation cost, it is called as quarry dressing.

ii. ***Site Dressing:*** If the stones are dressed at construction site to get a neat size and shape based on the requirement, it is called site dressing. In site dressing, the tools such as punching machine, chisel, hammer, axe, etc. may be used to make the even surface in the stones.

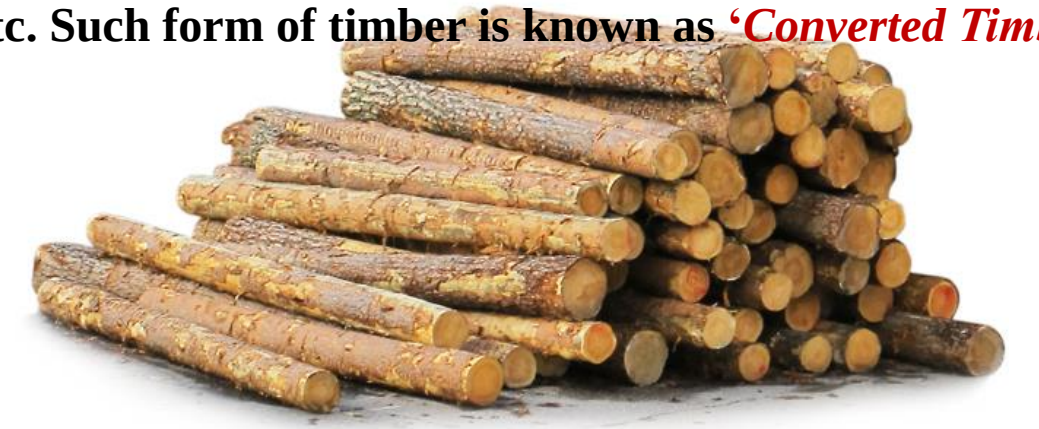
Timber

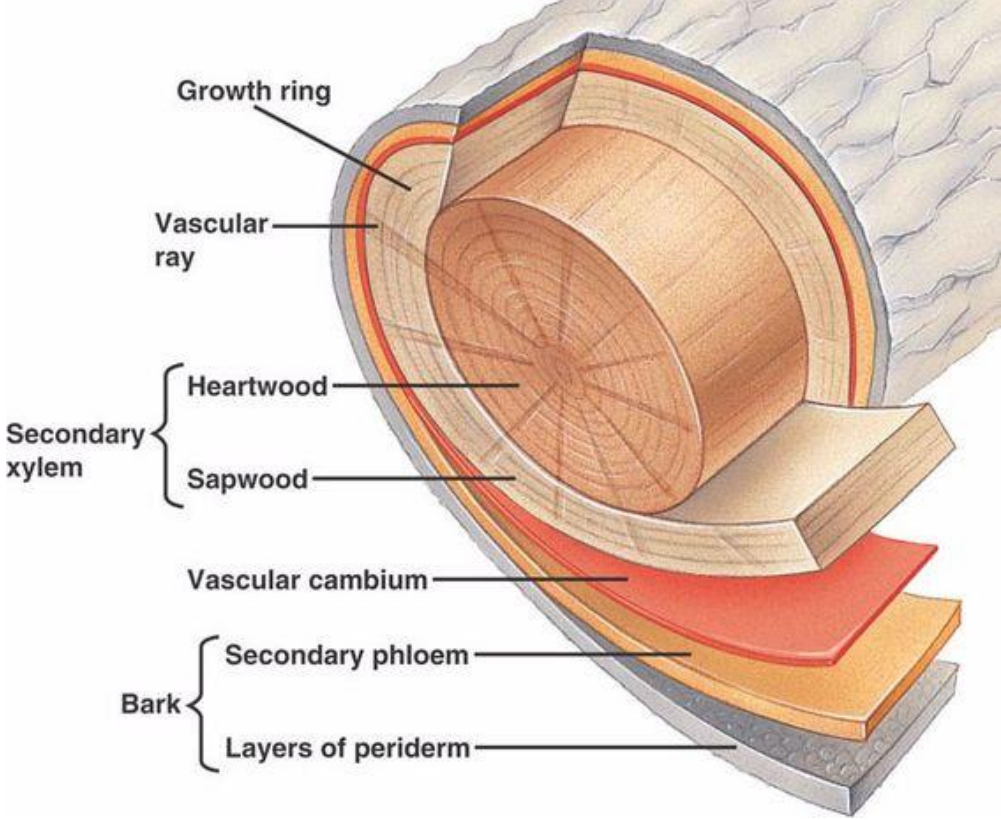
In fact the word *timber* is derived from an old English word 'Timbrian' which means 'to build'.

A tree that yields good wood for construction is called *'Standing Timber.'*

After felling a tree, its branches are cut and its stem is roughly converted into pieces of suitable length, so that it can be transported to timber yard. This form of timber is known as *'Rough Timber'*

**By sawing, rough timber is converted into various commercial sizes like planks, battens, posts,
beams etc. Such form of timber is known as *'Converted Timber'***





Cross Section of Exogenous Trees

1. ***Pith:*** It is the inner most part of the tree and hence the oldest part of exogeneous tree when the plant becomes old, the pith dies and becomes fibrous and dark. It varies in size and shape.

2. ***Heart Wood:*** This is the portion surrounding pith. It is dark in colour and strong. This portion is useful for various engineering purpose. This is the dead part of wood. It consists of several annular rings.

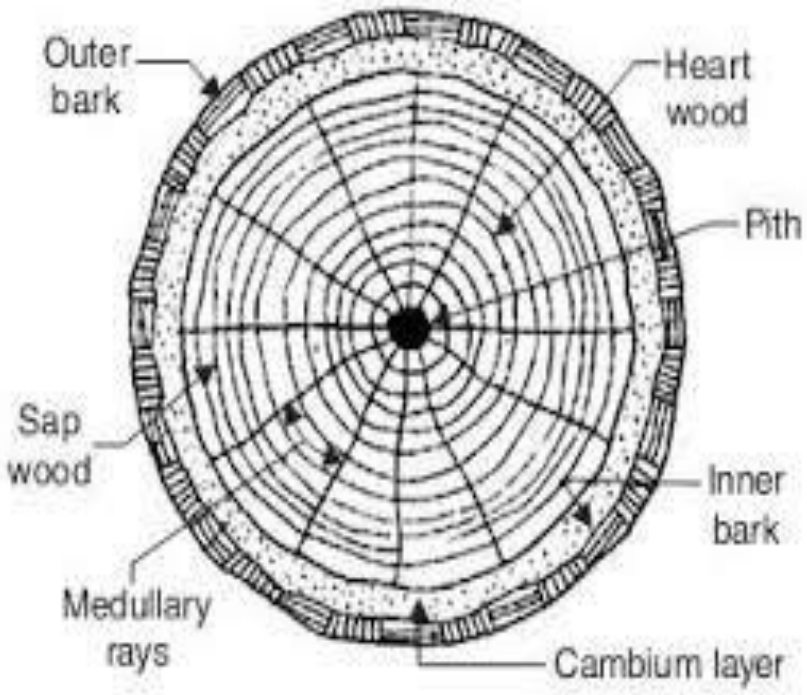
3. ***Sap Wood:*** It is the layer next to heart wood. It denotes recent growth and contains sap. It takes active part in the growth of trees by allowing sap to move in upward direction. The annual rings of sap wood are less sharply divided and are light in colour. The sap wood is also known as alburnum.

4. ***Cambium Layer:*** It is a thin layer of fresh sap lying between sap wood and the inner bark. It contains sap which is not yet converted into sap wood. If the bark is removed and cambium layer is exposed to atmosphere, cells cease to be active and tree dies.

5. ***Inner Bark:*** It is a inner skin of tree protecting the cambium layer. It gives protection to cambium layer.

6. ***Outer Bark:*** It is the outer skin of the tree and consists of wood fibres. Sometimes it contains fissures and cracks.

7. ***Medullary Rags:*** These are thin radial fibres extending from pith to cambium layer. They hold annular rings together. In some of trees they are broken and some other they may not be prominent.



Classification of Timbers

I Classification based on Mode of Growth:

(a) Exogeneous Trees: These trees grow outward by adding distinct consecutive ring every year. These rings are known as annual rings. Hence it is possible to find the age of timber by counting these annual rings. These trees may be further divided into (1) Coniferrous and (2) Deciduous.

(b) Endogenous Trees: These trees grow inwards. Fresh fibrous mass is in the inner most portion. Examples of endogenous trees are bamboo and cane. They are not useful for structural works.

II Classification based on Modulus of Elasticity:

Young's modulus is determined by conducting bending test. On this basis timber is classified as:

Group A: E = 12.5 kN/mm^2

Group B: E = 9.8 kN/mm^2 to 12.5 kN/mm^2

Group C: E = 5.6 kN/mm^2 to 9.8 kN/mm^2

Classification of Timbers

III Classification based on Durability:

Durability tests are conducted by the forest research establishment. They bury test specimen of size 600 × 50 × 50 mm in the ground to half their length and observe their conditions regularly over several years. Then timbers are classified as:

(a) High durability: If average life is more than 10 years.

(b) Moderate durability: Average life between 5 to 10 years.

(c) Low durability: Average life less than 5 years.

IV Classification based on Grading:

IS 883-1970 classifies the structural timber into three grades-select grade, grade I and grade II. The classification is based on permissible stresses, defects etc.

V Classification based on Availability:

Forest departments classify timbers based on the availability as

X—Most common. 1415 m^3 or more per year

Y—Common. 355 m^3 to 1415 m^3 per year

Z—Less common. Less than 355 m^3 per year.

Properties of Timber

Properties of good timbers are:

Colour: It should be uniform.

Odour: It should be pleasant when cut freshly.

Soundness: A clear ringing sound when struck indicates the timber is good.

Texture: Texture of good timber is fine and even.

Grains: In good timber grains are close.

Density: Higher the density stronger is the timber.

Hardness: Harder timbers are strong and durable.

Warping: Good timber do not warp under changing environmental conditions.

Properties of Timber

Toughness: Timber should be capable of resisting shock loads.

Abrasion: Good timber do not deteriorate due to wear. This property should be looked into, if timber is to be used for flooring.

Strength: Timber should have high strength in bending, shear and direct compression.

Modulus of Elasticity: Timber with higher modulus of elasticity are preferred in construction.

Fire resistance: A good timber should have high resistance to fire.

Permeability: Good timber has low water permeability.

Workability: Timber should be easily workable. It should not clog the saw.

Durability: Good timber is one which is capable of resisting the action of fungi and insects attack

Defects: Good timber is free from defects like dead knots, shakes and cracks.

Seasoning of Timber

This is a process by which moisture content in a freshly cut tree is reduced to a suitable level. By doing so the durability of timber is increased. The various methods of seasoning used may be classified into:

(*i) Natural seasoning*

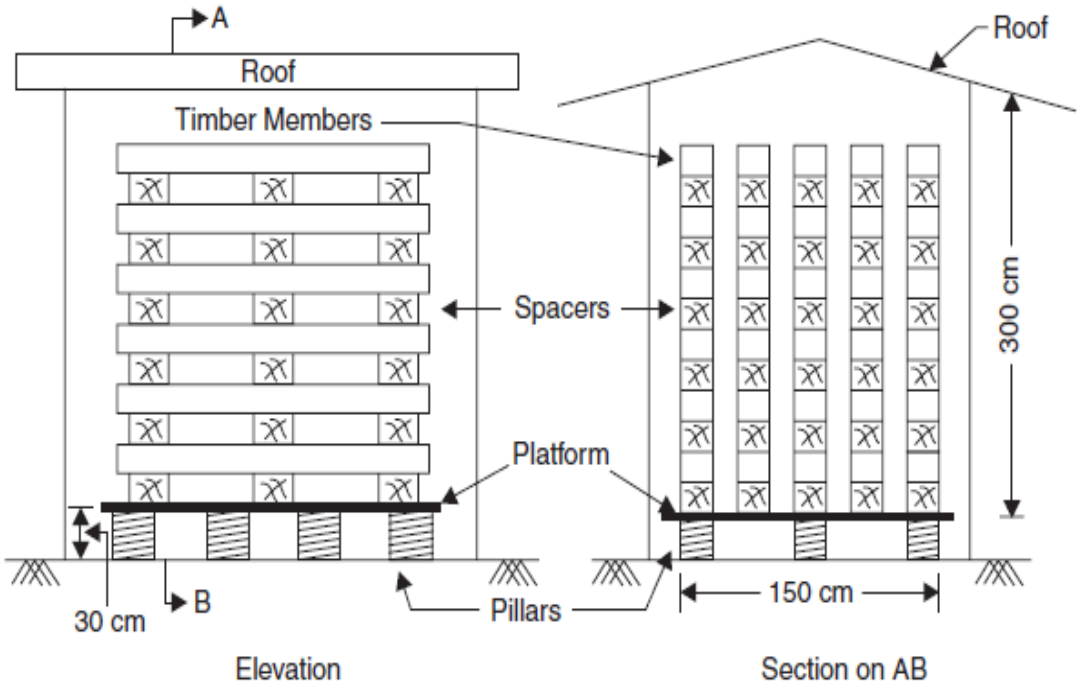
(*ii) Artificial seasoning*

Natural Seasoning :

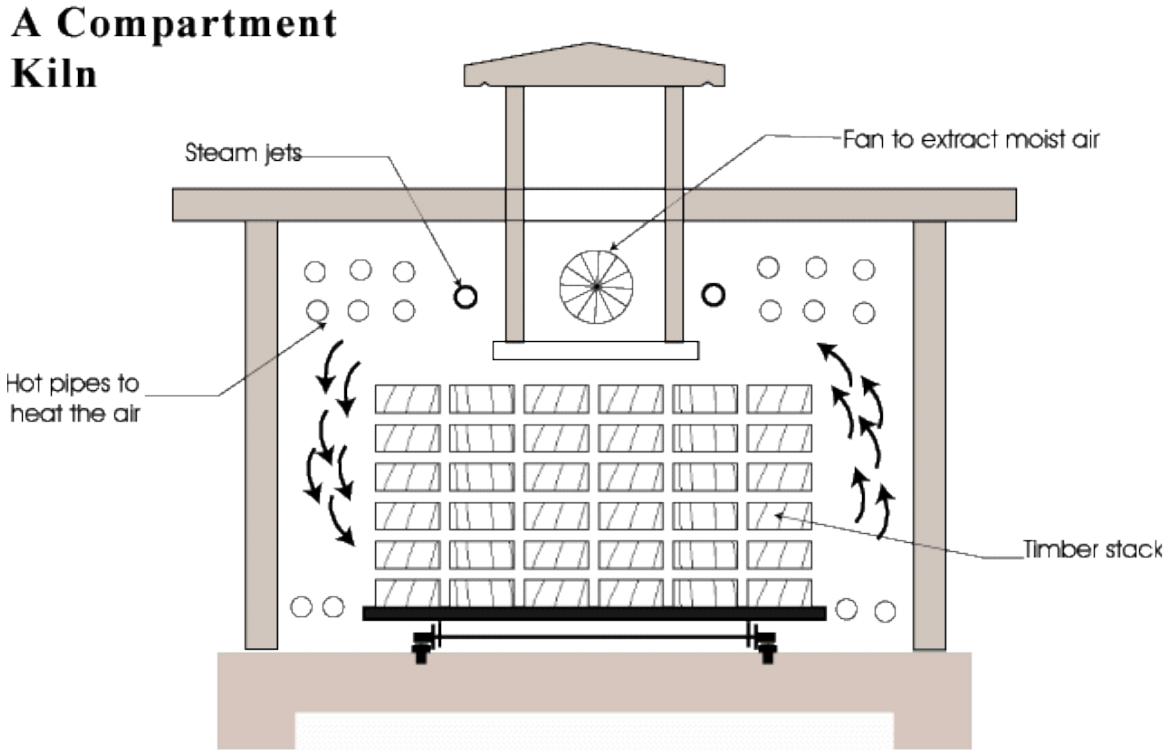
(a) Air seasoning is carried out in a shed with a platform. On about 300 mm high platform timber balks are stacked. Care is taken to see that there is proper air circulation around each timber balk. Over a period, in a natural process moisture content reduces. A well seasoned timber contains only 9-13% moisture. This is a slow but a good process of seasoning.

(b) Water seasoning is carried out on the banks of rivers. The thicker end of the timber is kept pointing upstream side. After a period of 2 to 4 weeks the timber is taken out. During this period sap contained in the timber is washed out to a great extent. Then timber is stalked in a shed with free air circulation.

Seasoning of Timber



Air seasoning



Kiln Seasoning

Seasoning of Wood

Artificial Seasoning :

In this method timber is seasoned in a chamber with regulated heat, controlled humidity and proper air circulation. Seasoning can be completed in 4 to 5 days only. The different methods of seasoning are:

(a) ***Boiling:*** In this method timber is immersed in water and then water is boiled for 3 to 4 hours. Then it is dried slowly. Instead of boiling water hot steam may be circulated on timber. The process of seasoning is fast, but costly.

(*b*) ***Kiln Seasoning:*** Kiln is an airtight chamber. Timber to be seasoned is placed inside it. Then fully saturated air with a temperature 35°C to 38°C is forced in the kiln. The heat gradually reaches inside timber. Then relative humidity is gradually reduced and temperature is increased, and maintained till desired degree of moisture content is achieved.

(*c*) ***Chemical Seasoning***: In this method, the timber is immersed in a solution of suitable salt. Then the timber is dried in a kiln. The preliminary treatment by chemical seasoning ensures uniform seasoning of outer and inner parts of timber.

(*d*) ***Electrical Seasoning:*** In this method high frequency alternate electric current is passed through timber. Resistance to electric current is low when moisture content in timber is high. As moisture content reduces the resistance increases. Measure of resistance can be used to stop seasoning at appropriate level. It is costly process. This technique has been tried in some plywood industries but not in seasoning of timber on mass scale.

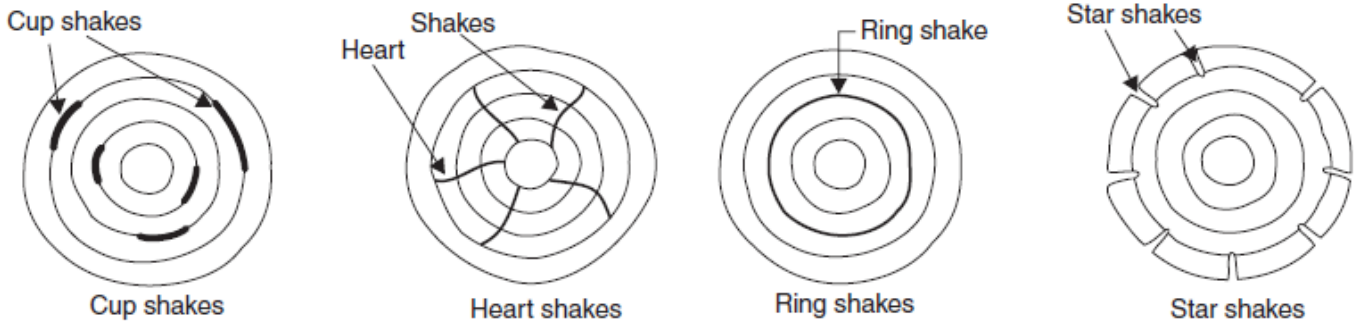
Defects of Timber

Various defects which are likely to occur in timber may be grouped into the following three:

(i) Due to natural forces

(ii) Due to defective seasoning and conversions

(iii) Due to attack by fungi and insects.



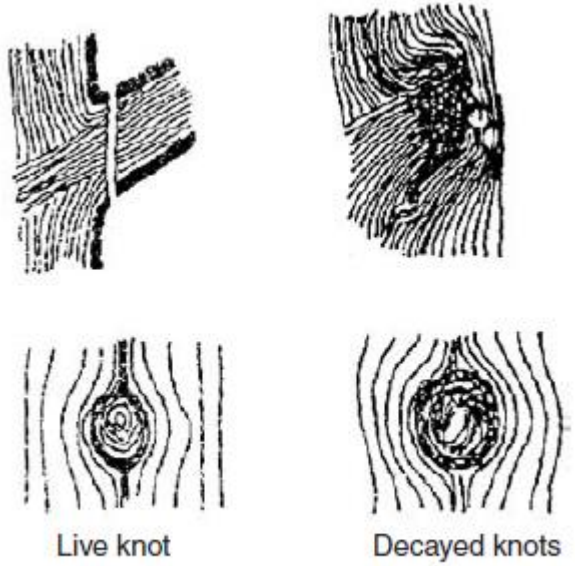


Fig. 1.9. Knots

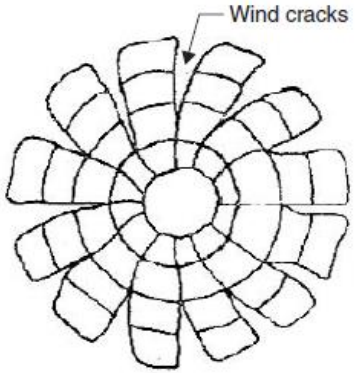


Fig. 1.11. Wind cracks

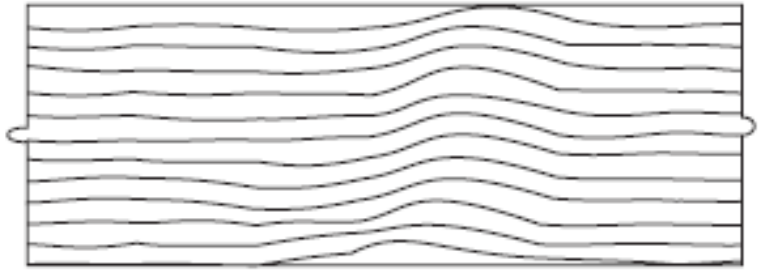


Fig. 1.12. Upset

Prevention of Timber

Preservation of timber means protecting timber from fungi and insects attack so that its life is increased. Timber is to be seasoned well before application of preservatives. The following are the widely used preservatives:

1. **Tar:** Hot coal tar is applied to timber with brush. The coating of tar protects the timber from the attack of fungi and insects. It is a cheapest way of protecting timber. Main disadvantage of this method of preservation is that appearance is not good after tar is applied it is not possible to apply other attractive paints. Hence tarring is made only for the unimportant structures like fence poles.
2. **Paints:** Two to three coats of oil paints are applied on clean surface of wood. The paint protects the timber from moisture. The paint is to be applied from time to time. Paint improves the appearance of the timber. Solignum paint is a special paint which protects the timber from the attack of termites.
3. **Chemical salt:** These are the preservatives made by dissolving salts in water. The salts used are copper sulphate, zinc chloride and sodium fluoride. After treating the timber with these chemical salt paints and varnishes can be applied to get good appearance.
4. **Creosote:** Creosote oil is obtained by distillation of coal tar. The seasoned timber is kept in an air tight chamber and air is exhausted. Then creosote oil is pumped into the chamber at a pressure of 0.8 to 1.0 N/mm^2 at a temperature of 50°C. After 1 to 2 hours timber is taken out of the chamber.

Prevention of Timber

5. **ASCO:** This preservative is developed by the Forest Research Institute, Dehradun. It consists of 1 part by weight of hydrated arsenic pentoxide ($As_2O_5.2H_2O$), 3 parts by weight of copper sulphate ($CuSO_4 \cdot 5H_2O$) and 4 parts by weight of potassium dichromate ($K_2Cr_2O_7$) or sodium dichromate ($Na_2Cr_2O_7 \cdot 2H_2O$). This preservative is available in powder form. By mixing six parts of this powder with 100 parts of water, the solution is prepared.

The solution is then sprayed over the surface of timber.

This treatment prevents attack from termites. The surface may be painted to get desired appearance.

Uses of Timber

Timber is used for the following works:

1. For heavy construction works like columns, trusses, piles.
2. For light construction works like doors, windows, flooring and roofing.
3. For other permanent works like for railway sleepers, fencing poles, electric poles and gates.
4. For temporary works in construction like scaffolding, centering, shoring and strutting, packing of materials.
5. For decorative works like showcases and furnitures.
6. For body works of buses, lorries, trains and boats
7. For industrial uses like pulps (used in making papers), card boards, wall papers
8. For making sports goods and musical instruments.

Plywood

“**Plywood** is a sheet material manufactured from thin layers or "plies" of wood veneer that are glued together with adjacent layers having their wood grain rotated up to 90 degrees to one another”

Forms of Plywood

3-ply and 5-ply: These common types of plywood get their name from their number of layers: e.g, 3-ply has three layers. *Uses include:* Boxing in or decorative internal uses

Multi-ply: This is composed of many layers. *Uses include:* Heavyweight construction, e.g., House Framing.

Soft Plywood: This plywood is usually made either of cedar, Douglas fir (or) spruce, pine and fir (SPF) and is typically used for construction and industrial process.

Hardwood Plywood: This is made out of wood from angiosperm trees and used for demanding end uses. Hardwood plywood is characterized by its excellent strength, stiffness and resistance to creep. Hardwood plywood has excellent surface hardness and damage and wear resistance.

Tropical Plywood: Tropical plywood is made of mixed species of tropical timber. Originally from the Asian region, it is now also manufactured in African and South American countries. These are superior to softwood plywood due to its density, strength, evenness of layers and high quality.

Uses of Plywood

Softwood Plywood Applications:

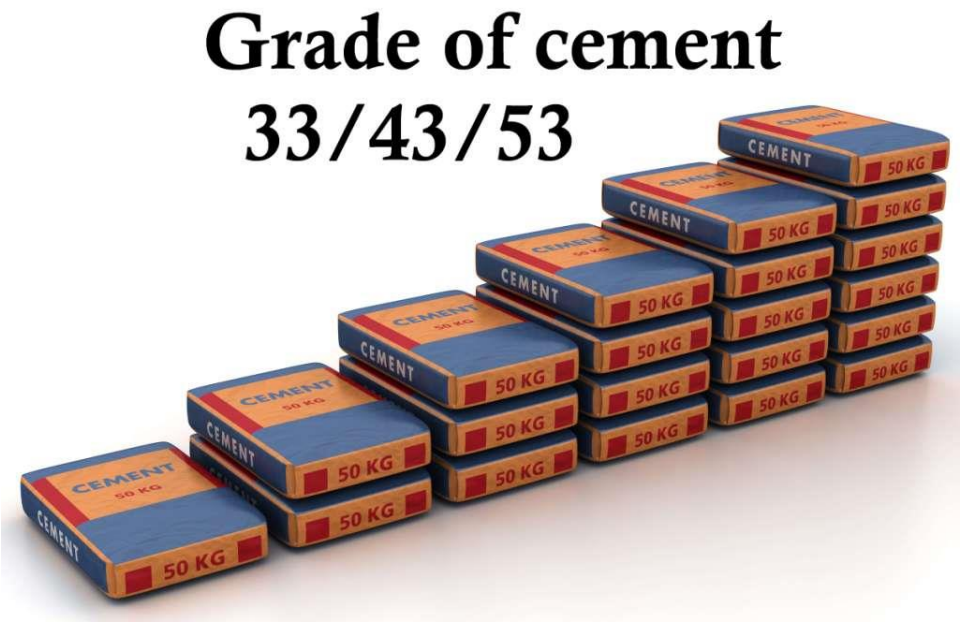
- Floors, walls and roofs in home construction
- Wind bracing panels
- Vehicle internal body work
- Packages and boxes
- Fences

Hardwood Plywood Applications:

- Panels in concrete form work system
- Floors, walls and roofs in transport vehicles
- Container floors
- Floors subjected to heavy wear in various buildings and factories

Tropical Plywood Applications:

- Common plywood
- Concrete panel
- Floor base
- Container flooring



Cement

“Cement is a commonly used binding material in the construction. The cement is obtained by burning a mixture of calcareous (calcium) and argillaceous (clay) material at a very high temperature and then grinding the clinker so produced to a fine powder”

It was first produced by a mason *Joseph Aspdin* in England in 1824. He patented it as ‘Portland cement’.

Properties of Ordinary Portland Cement

I. Chemical Properties:

Portland cement consists of the following chemical compounds ***(Bouge's Compounds):***

(a) Tricalcium Silicate - C_3S - 40%

(b) Dicalcium Silicate - C_2S - 30%

(c) Tricalcium Aluminate - C_3A - 11%

(d) Tetracalcium Alumino Ferrate - C_4AF - 11%

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

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

Physical Properties of OPC

(*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 centimetres per gram of cement. According to IS code specification weight retained on the sieve should not be more than 10 per cent.

(*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.

(*a*) ***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/mm^2 after 3 days and 22 N/mm^2 after 7 days of curing.

Grades of Cement

Grades of Cement are designated based on two factors:

(a) Fineness of cement

(b) Crushing Strength

According to the above factors, cement is designated with the following grades:

(a) 33 Grade

(b) 43 Grade

(c) 53 Grade

Facts:

- 33,43,53 Indicates the characteristic strength of cement cube on 28^{th} day of testing in N/mm^{2}.
- Fineness increases with the increase in grade of cement. So as the cost also.
- Setting time increases with the increase in grade of cement.
- Ordinary grade of cement used for construction purpose is 43 grade. 33 grade is preferred for unimportant and temporary works.
- 53 grade is preferred for high performance concrete.

Types of Cement

In addition to ordinary Portland cement there are many varieties of cement. Important varieties are briefly explained below:

(*i*) ***Coloured Cement:*** The cements of desired colours are produced by intimately mixing pigments with ordinary cement. The chromium oxide gives green colour. Cobalt produce blue colour. Iron oxide with different proportion produce brown, red or yellow colour. Addition of manganese dioxide gives black or brown coloured cement. These cements are used for giving finishing touches to floors, walls, window sills, roofs etc.

(*ii*) ***Quick Setting Cement:*** Quick setting cement is produced by reducing the percentage of gypsum and adding a small amount of aluminium sulphate during the manufacture of cement. This cement starts setting within 5 minutes after adding water and becomes hard mass within 30 minutes. This cement is used to lay concrete under static or slowly running water.

(*iii*) ***Rapid Hardening Cement:*** This cement can be produced by increasing lime content and burning at high temperature while manufacturing cement. Though the initial and final setting time of this cement is the same as that of Portland cement, it gains strength in early days. This property helps in earlier removal of form works and speed in construction activity.

Types of Cement

(iv) ***Low Heat Cement:*** In mass concrete works like construction of dams, heat produced due to hydration of cement will not get dispersed easily. This may give rise to cracks. Hence in such constructions it is preferable to use low heat cement. This cement contains low percentage (5%) of tricalcium aluminate (C_3A) and higher percentage (46%) of dicalcium silicate (C_2S).

(*v*) ***Expanding Cement:*** This cement expands as it sets. This property is achieved by adding expanding medium like sulpho aluminate and a stabilizing agent to ordinary cement. This is used for filling the cracks in concrete structures.

(*vi*) ***High Alumina Cement***: It is manufactured by calcining a mixture of lime and bauxite. It is more resistant to sulphate and acid attack. It develops almost full strength within 24 hours of adding water. It is used for under water works.

(*vii*) ***Acid Resistant Cement:*** This cement is produced by adding acid resistant aggregated such as quartz, quartzite, sodium silicate or soluble glass. This cement has good resistance to action of acid and water. It is commonly used in the construction of chemical factories.

Types of Cement

(*viii*) ***Sulphate Resistant Cement:*** By keeping the percentage of ricalcium aluminate C_3A below five per cent in ordinary cement this cement is produced. It is used in the construction of structures which are likely to be damaged by alkaline conditions. Examples of such structures are canals, culverts etc.

(*ix*) ***Fly Ash Blended Cement:*** Fly ash is a by-product in thermal stations. The particles of fly ash are very minute and they fly in the air, creating air pollution problems. It is found that one of the best way to dispose fly ash is to mix it with cement in controlled condition and derive some of the beneficiary effects on cement.

Fly ash blended cements have superior quality of resistance to weathering action. The ultimate strength gained is the same as that with ordinary Portland cement. However strength gained in the initial stage is slow. Birla plus, Birla star, A.C.C. Suraksha are some of the brand name of blended cement.

(*x*) ***White Cement:*** The cement when made free from colouring oxides of iron, Maganese and chromium results into white cement. In the manufacture of this cement, the oil fuel is used instead of coal for burning. White cement is used for the floor finishes, plastering, ornamental works etc.

Uses of Cement

Cement is used widely for the construction of various structures. Some of them are listed below:

(i) Cement slurry is used for filling cracks in concrete structures.

(ii) Cement mortar is used for masonry work, plastering and pointing.

(iii) Cement concrete is used for the construction of various structures like buildings, bridges. water tanks, tunnels, docks, harbours etc.

(iv) Cement is used to manufacture lamp posts, telephone posts, railway sleepers, piles etc.

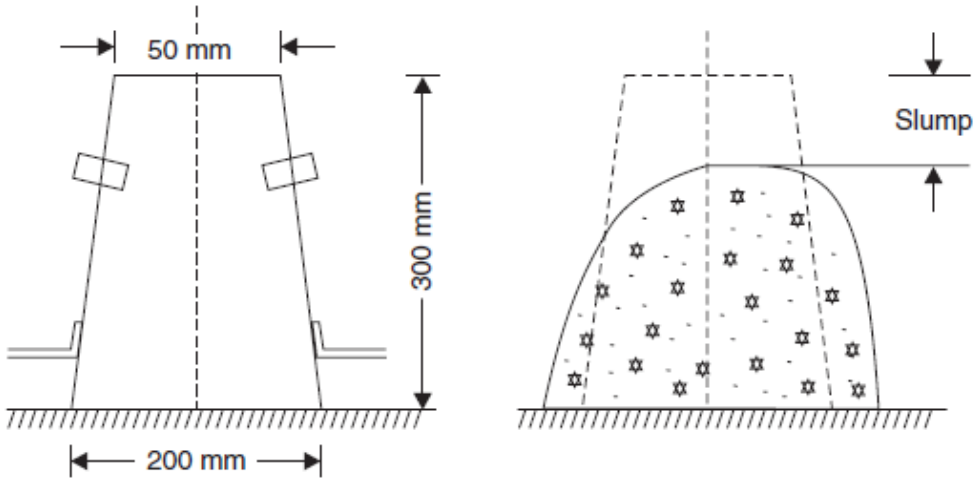
(v) For manufacturing cement pipes, garden seats, dust bins, flower pots etc. cement is commonly used.

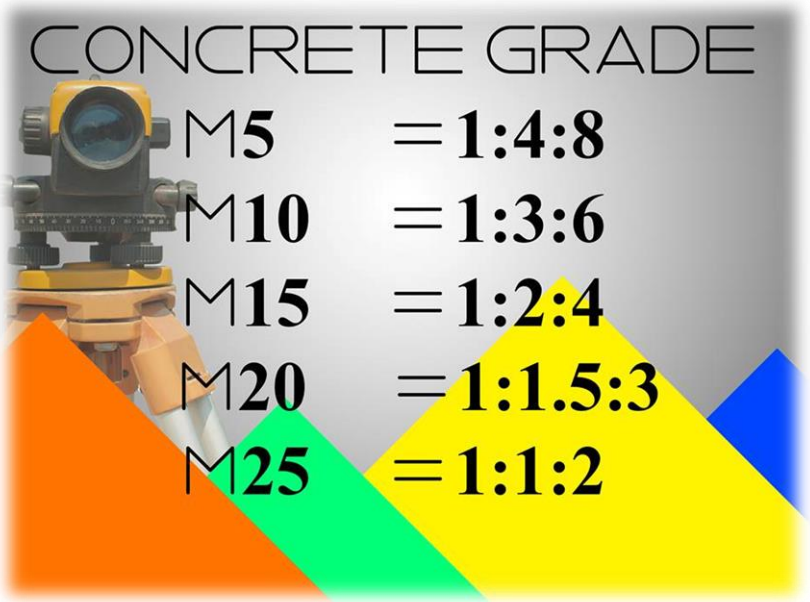
(vi) It is useful for the construction of roads, footpaths, courts for various sports etc.

Concrete

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

"Plain concrete is strong in compression but very weak in tension. The tensile property is introduced in concrete by inducting different materials and this attempt has given rise to ***RCC, RBC, PSC, FRC, cellular concrete and Ferro cement"***





Properties of Green (Fresh) Concrete

(i) Workability: This is defined as the ease with which concrete can be compacted fully without segregating and bleeding. It can also be defined as the amount of internal work required to fully compact the concrete to optimum density.

The workability depends upon the quantity of water, grading, shape and the percentage of the aggregates present in the concrete. It can be measured by:

(a) Slump Cone Test

(b) Compaction factor test

(c) Vee-Bee Consistometer test

(ii) 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.

Because of the segregation, the cohesiveness of the concrete is lost and honey combing results. Ultimately it results in the loss of strength of hardened concrete. Hence utmost care is to be taken to avoid segregation.

Properties of Green (Fresh) Concrete

(iii) 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 or due to excessive compaction.

Bleeding causes the formation of pores and renders the concrete weak.

(iv) 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 poorely graded aggregates.

With harsh concrete it is difficult to get a smooth surface finish and concrete becomes porous.

Properties of Hardened Concrete

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

IS 456 grades the concrete based on its characteristic strength as shown below:

Table 3.3. Grades of concrete

Grade	M_{10}	M_{15}	M_{20}	M_{25}	M_{30}	M_{35}	M_{40}
Characteristic strength in M N/mm^2	10	15	20	25	30	35	40

Till year 2000, M15 concrete was permitted to be used for reinforced concrete works. But IS 456–2000 specifies minimum grade of M20 to be used for reinforced concrete works.

Strength of concrete depends upon the amount of cement content, quality and grading of aggregates, water cement ratio, compaction and curing. Strength of concrete is gained in the initial stages.

Properties of Hardened Concrete

(ii) 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.

The permanent dimension change due to loading over a long period is termed as ***creep***. Its value depends upon the stress in concrete, the age of the concrete at the time of loading and the duration of the loading.

(iii) Durability: Environmental forces such as weathering, chemical attack, heat, freezing and thawing try to destroy concrete. The period of existence of concrete without getting adversely affected by these forces is known as durability. Generally dense and strong concretes have better durability.

(iv) 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. Since the permeability reduces the durability of concrete, it should be kept very low by using low water cement ratio, dense and well graded aggregates & good compaction.

Grades of Concrete

IS 456 grades the concrete based on its characteristic strength as shown below:

Table 3.3. Grades of concrete

Grade	M_{10}	M_{15}	M_{20}	M_{25}	M_{30}	M_{35}	M_{40}
Characteristic strength in M N/mm^2	10	15	20	25	30	35	40

Grade of Concrete	Mix Proportion	Nature of Work
M25	1:1:2	For machine foundation, footings for steel columns and concreting under water.
M20	1:1.5:3	Water tanks, shells and folded plates, for other water retaining structures.
M15	1:2:4	Commonly used for reinforced concrete works like beams, slabs, tunnel lining, bridges
M10	1:3:6	Piers, abutments, concrete walls, sill of windows, floors.
M5	1:4:8	Making concrete blocks.

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 pre-stressed concrete. Many structural elements like footings, columns, beams, lintels, roofs are made with R.C.C.

Advancements in Concrete

Plain concrete is strong in compression but very weak in tension. The tensile property is introduced in concrete by inducting different materials and this attempt has given rise to ***RCC, RBC, PSC, FRC, cellular concrete and Ferro cement.***

I. Reinforced Cement Concrete: (RCC)

Concrete is a brittle material and though it is good at resisting compression, it is quite weak at resisting tension. In many structural components, bending leads to compression on one side and tension on the other. Hence to increase the strength of the member, ***steel reinforcement*** is provided on the tensile side of the concrete.

This composite material of steel and concrete is called Reinforced Cement Concrete (RCC). Steel is the preferred reinforcement since its tensile strength is high and bond between steel and concrete is very good.

Uses:

(a) For the construction of footings, columns, beams, roofs and stairs

(b) For the construction of water tanks, dams, silos and bunkers

(c) For the construction of bridges, retaining walls

Advancements in Concrete

II. Reinforced Brick Concrete: (RBC)

It is a well-known fact that in flexural members like beams, lintels and slabs, concrete in tension zone does not play a role in resisting load but helps to keep the reinforcements at required distance.

Hence, to achieve economy, concrete in tensile zone may be replaced by cheap materials like bricks or tiles.

This composite material of reinforcements, bricks and concrete is known as Reinforced Brick Concrete.

III. Fibre Reinforced Concrete: (FRC)

Fibre reinforced concrete can be defined as a composite material of concrete or mortar with discontinuous and uniformly distributed fibres. Commonly used fibres are of steel, nylon, asbestos, coir, glass, carbon and polypropylene. The length to lateral dimension of fibres range from 30 to 150. The diameter of fibres vary from 0.25 to 0.75 mm. ***Fibre reinforced concrete is having better tensile strength, ductility and resistance to cracking.***

Uses:

1. For wearing coat of air fields, roads and refractory linings.

2. For manufacturing precast products like pipes, stairs, wall panels, manhole covers and boats.

3. Glass fibre reinforced concrete is used for manufacturing doors and window frames, park benches, bus shelters etc.

Advancements in Concrete

IV. Cellular Concrete:

It is a light weight concrete produced by introducing large voids in the concrete or mortar. Its density varies from 3 kN/m^3 to 8 kN/m^3 whereas plain concrete density is 24 kN/m^3. It is also known as aerated, foamed or gas concrete.

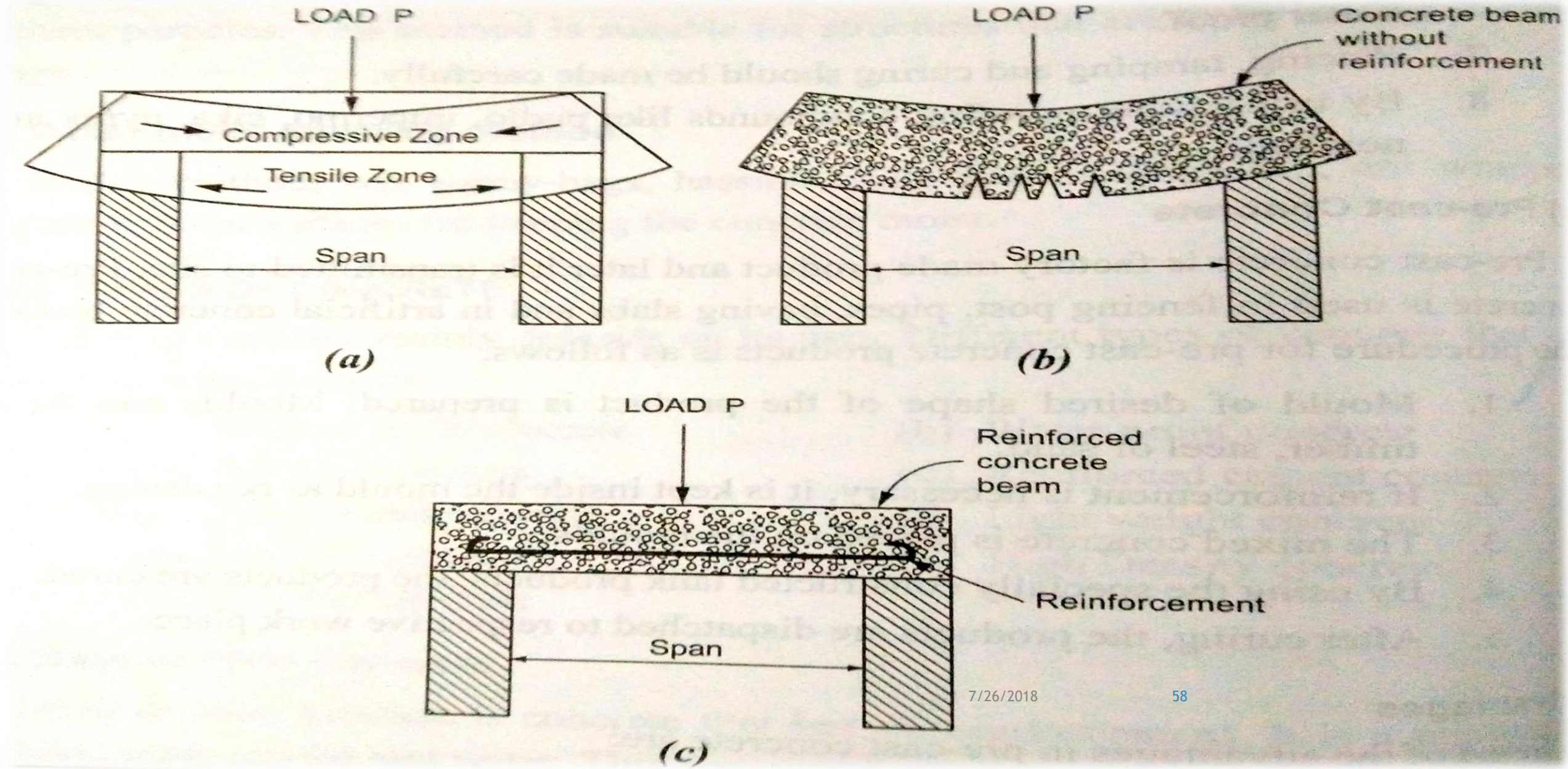
Properties of cellular concrete:

1. It has low weight.
2. It has good fire resistance.
3. It has good thermal insulation property.
4. Freezing and thawing problems are absent

Uses of Cellular Concrete:

1. It is used for the construction of partition walls.
2. It is used for partitions for heat insulation purposes.
3. It is used for the construction of hollow filled floors.

Concept of RCC



Pre-stressed Concrete

The principle of pre-stressed concrete is to introduce calculated compressive stresses in the zones wherever tensile stresses are expected in the concrete structural elements.

When such structural element is used, stresses developed due to loading has to first nullify these compressive stresses before tensile stresses gets introduced in concrete.

Thus in pre-stressed concrete entire concrete is utilized to resist the load. Another important advantage of PSC is hair cracks are avoided in the concrete and hence durability is high. The fatigue strength of PSC is also more. The deflections of PSC beam is much less and hence can be used for longer spans also.

PSC is commonly used in the construction of bridges, large column free slabs and roofs. PSC sleepers are commonly used.

Pre-stressed Concrete

Types of Pre-stressed Concrete:

(a) Pre-tensioning

(b) Post Tensioning

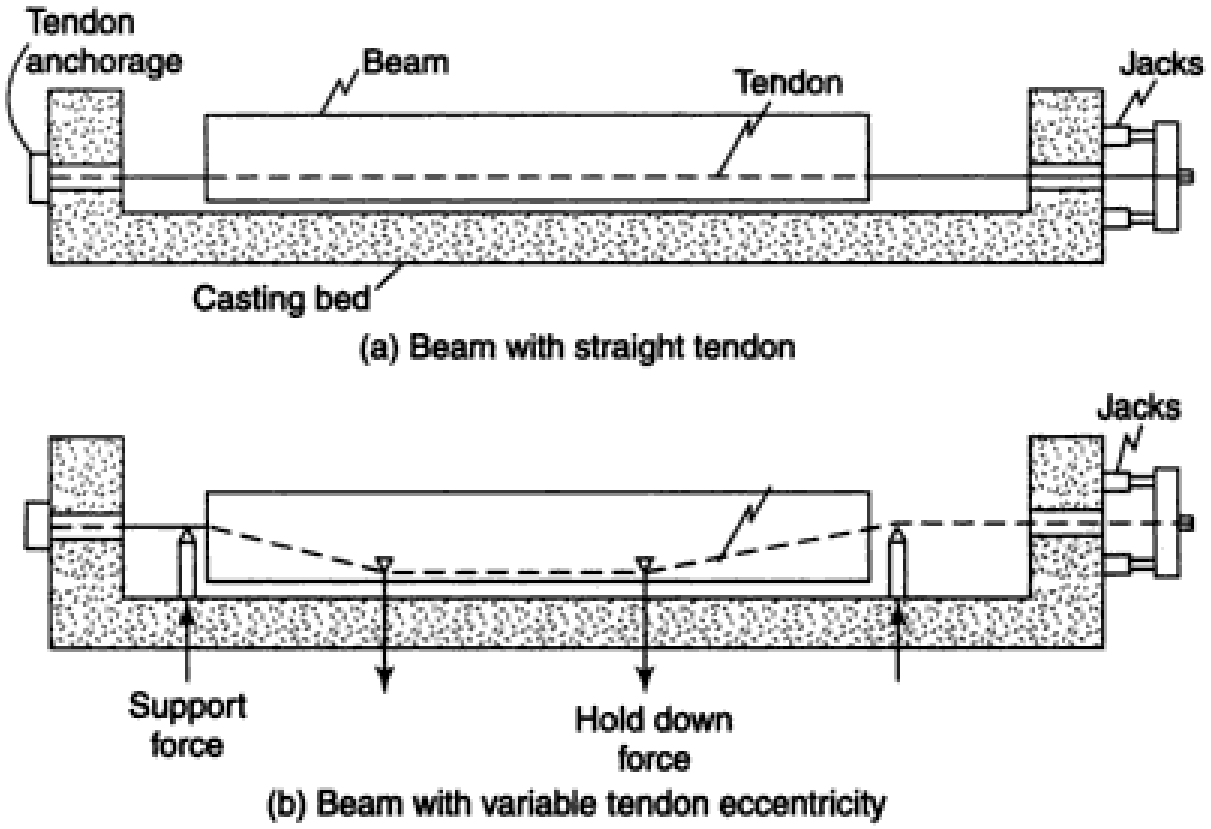
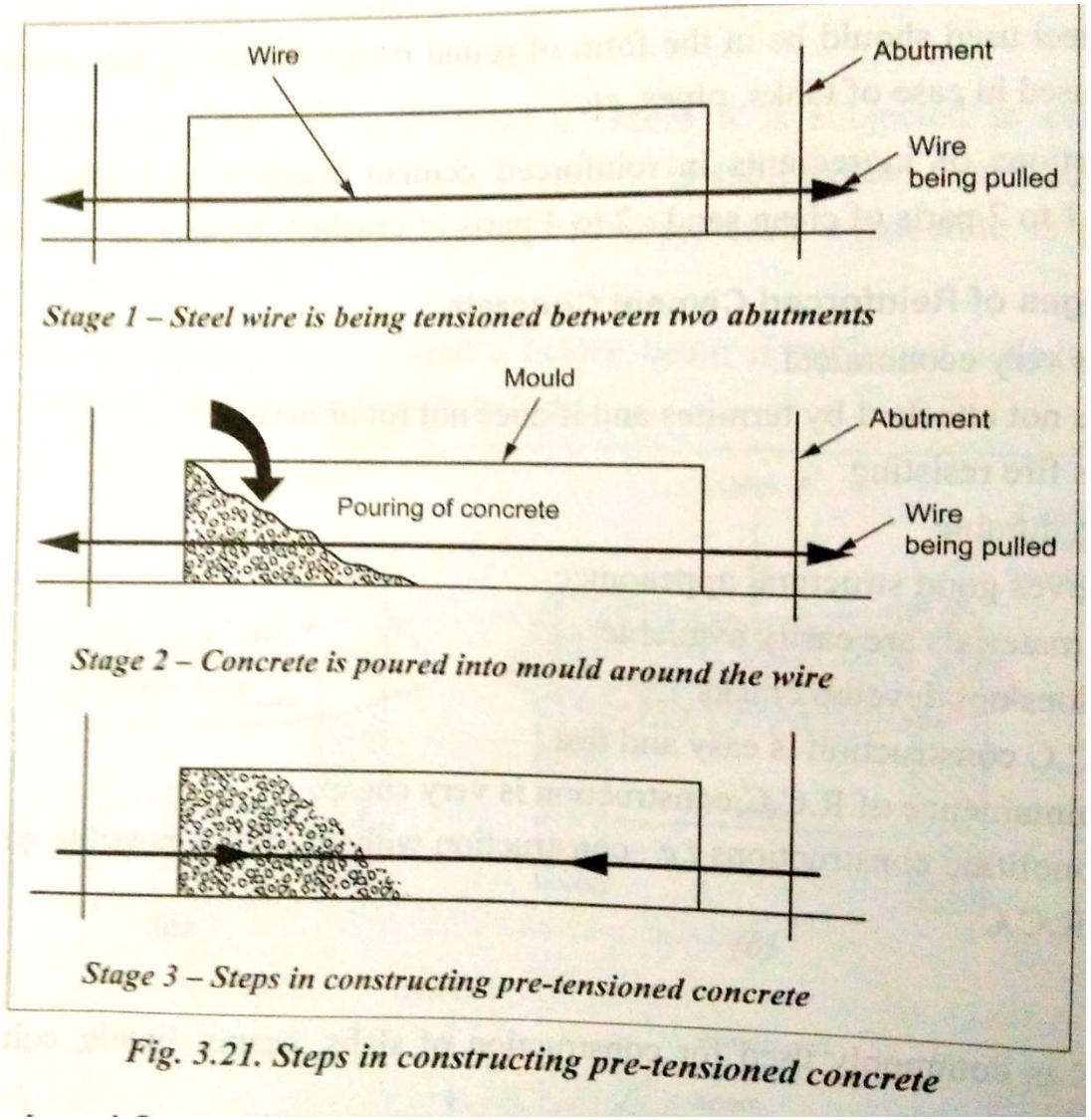


Fig. 3.1 *Methods of Pretensioning*

Methods of Pre-stressing

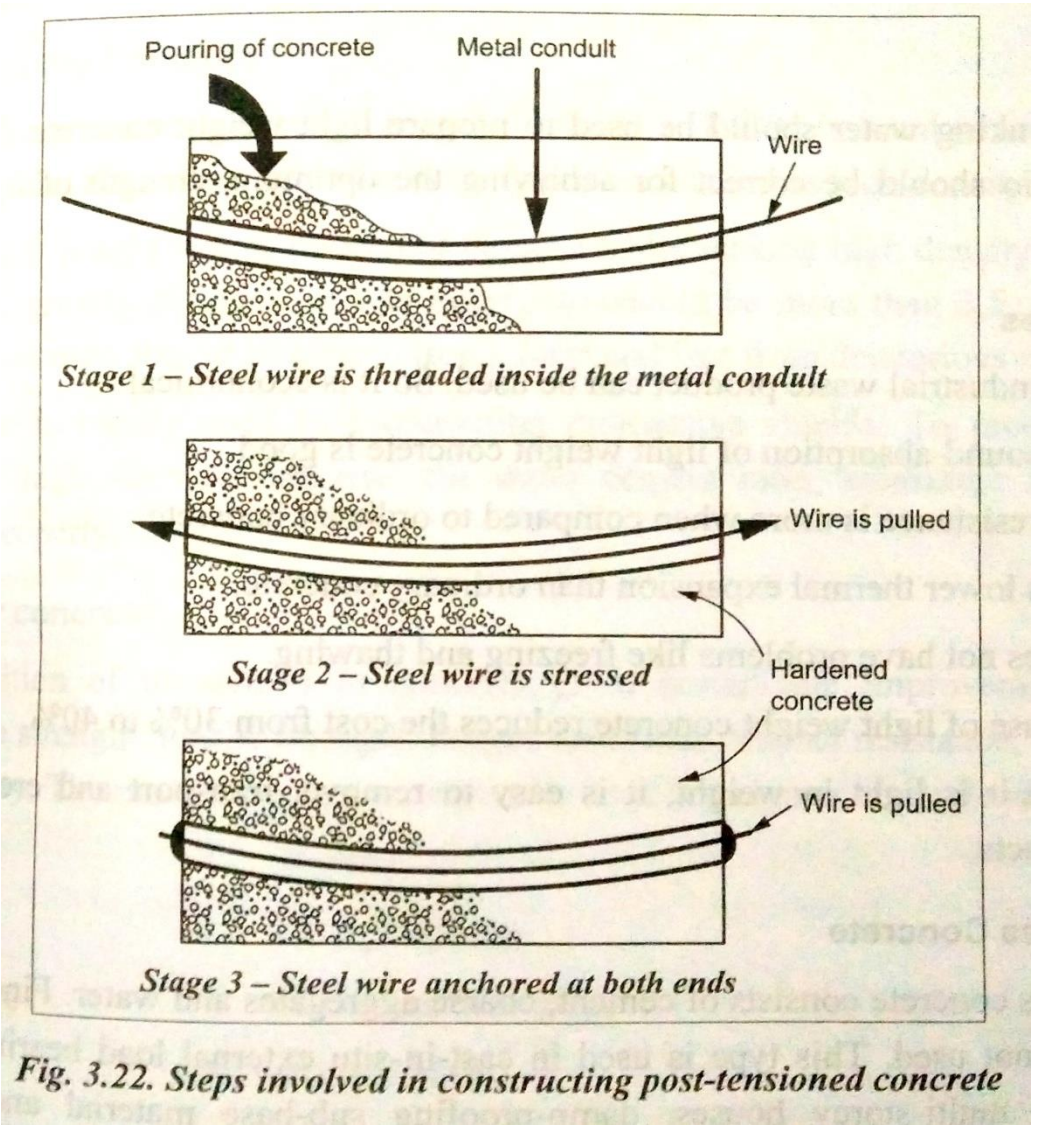


Stage 1 – Steel wire is being tensioned between two abutments

Stage 2 – Concrete is poured into mould around the wire

Stage 3 – Steps in constructing pre-tensioned concrete

Fig. 3.21. Steps in constructing pre-tensioned concrete



Stage 1 – Steel wire is threaded inside the metal condult

Stage 2 – Steel wire is stressed

Stage 3 – Steel wire anchored at both ends

Fig. 3.22. Steps involved in constructing post-tensioned concrete

Pre-Fabricated Concrete

The concept of precast (also known as “prefabricated”) construction includes those buildings, where the majority of structural components are standardized and produced in plants in a location away from the building, and then transported to the site for assembly.

These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost.

The main features of this construction process are as follows:

(i) The division and specialization of the human workforce.

(ii) The use of tools, machinery, and other equipment, usually automated, in the production of standard, interchangeable parts and products

(iii) Compared to site-cast concrete, precast concrete erection is faster and less affected by adverse weather conditions.

(iv) Plant casting allows increased efficiency, high quality control and greater control on finishes

Pre-Fabricated Concrete

Types of Prefabricated Systems:

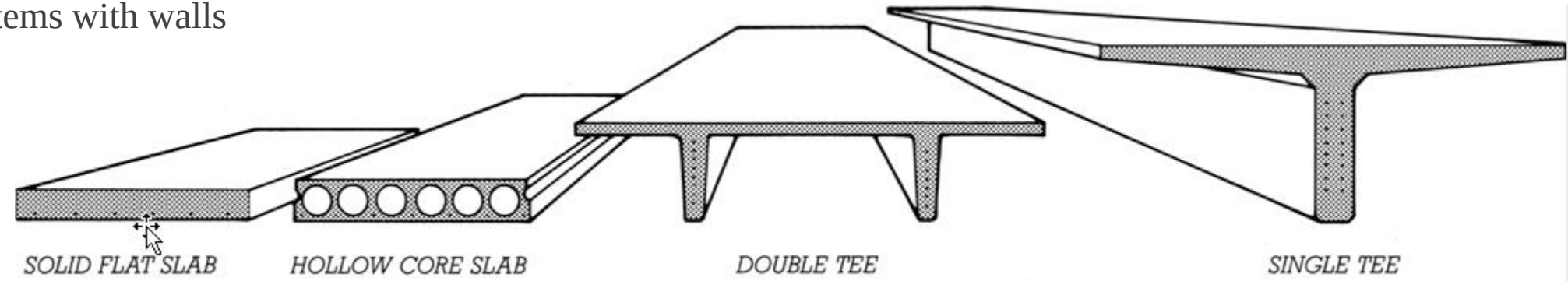
Depending on the load-bearing structure, precast systems can be divided into the following categories:

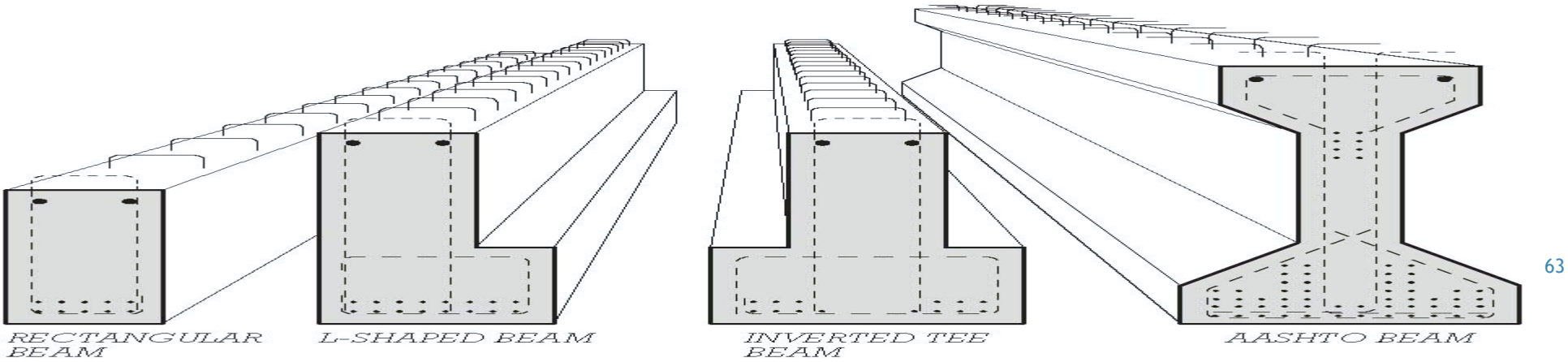
(i) Large-panel systems

(ii) Frame systems

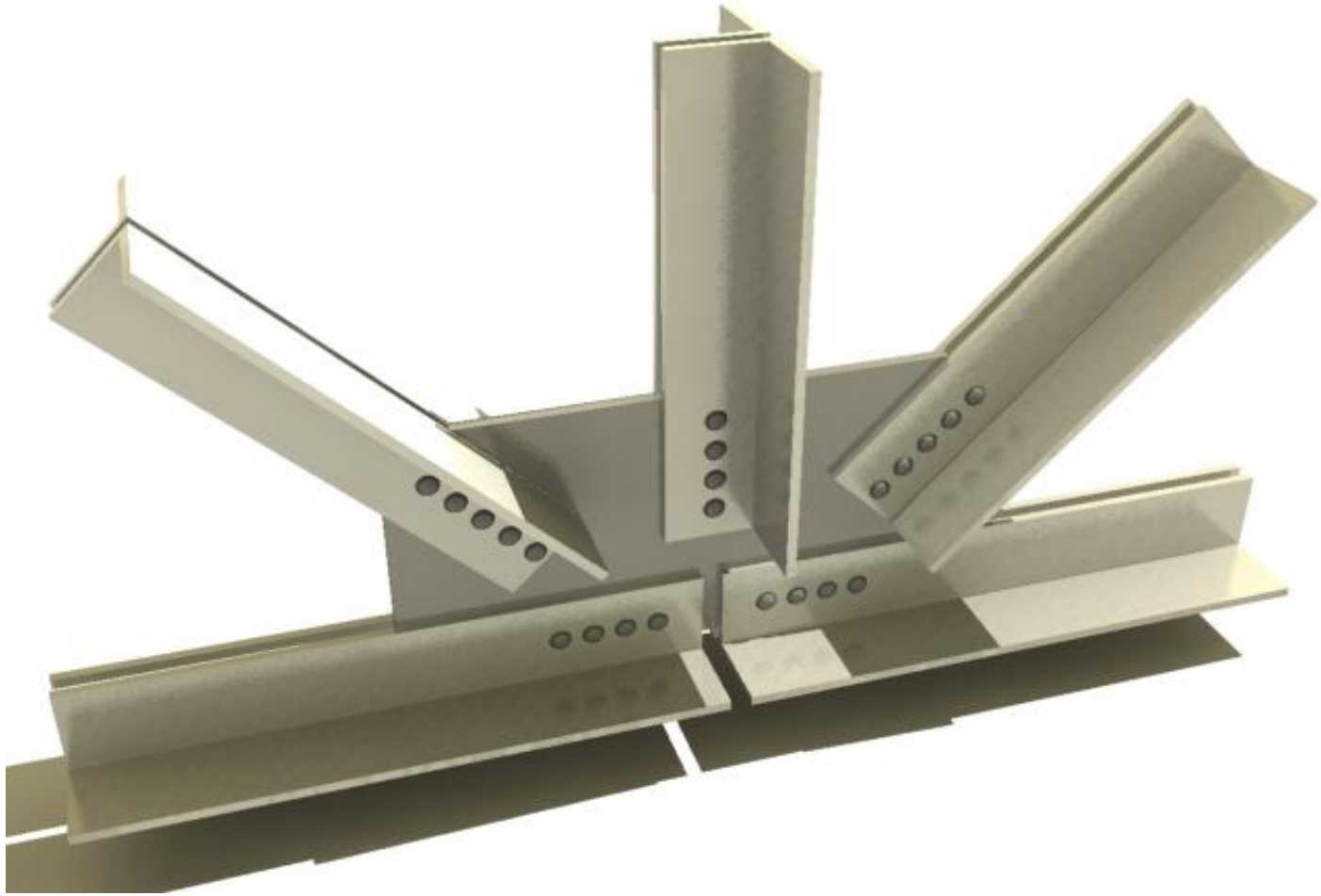
(iii) Slab-column systems with walls

(iv) Mixed systems





Steel



“Steel is an alloy of ferrous metal with 0.25 to 1.5 per cent of carbon. Higher the carbon content, harder is the steel. Steel bars of circular cross sections are mainly used as reinforcement to strengthen concrete structures”

Types of Steel

Steel is an alloy of iron and carbon. Carbon contents varies from steel to steel. Depending upon the percentage of carbon, it is divided into three groups:

(i) Mild Steel

(ii) Medium hard steel

(iii) Hard steel

(i) Mild Steel:

- It is also known as low carbon steel. This type of steel has carbon content up to ***0.25%.***
- Mild steel are widely used in construction works. It is used in manufacturing tools, machine parts, tubes, rails, cranes and transmission towers.

Properties:

- It has excellent ductile and malleable property.
- It can be easily forged and welded
- It has fibrous structure.
- Its tensile strength is up to 555 N/mm^2 and compressive strength is up to 1200 N/mm^2

Types of Steel

(ii) *Medium Steel:*

- It is also known as medium carbon steel. This type of steel has carbon content from ***0.25% to 0.7%.***
- It is used in manufacturing hammers pressing dies, valve, springs, crank pins, crankshafts, clutch discs, etc.

Properties:

- It is tougher and harder than mild steel.
- It cannot be forged or welded.
- It can withstand shocks and vibrations
- Its tensile strength is up to 1230 N/mm^2.

Types of Steel

(iii) *Hard Steel:*

- It is also known as high carbon steel or high tensile steel. This type contains carbon content from ***0.7% to 1.5%*** or even more.
- It is used in the manufacture of the metal cutting tools, wood working tools, drilling bits, stone mason's tools, stamping dies, knives, forks, etc.

Properties:

- It is very hard and tough when compared to other steels.
- It cannot be readily forged and welded.
- Its melting point is 1300 degree Celsius.
- Its tensile strength is up to 1400 $N/mm^{2.}$

Market Forms of Steel

Steel Sections are manufactured in industries. Steel sections are generally rolled one. Some of the steel sections are:

(a) Ribbed Torsteel bar

(b) Round bar

(c) Square bar

(d) Plates

(e) Flats

(f) I-sections

(g) Channel sections

(h) Angle sections

(i) T-sections

(j) Expanded metal

(k) Corrugated sheets

Market Forms of Steel

I. Ribbed Torsteel bar:

These bars are produced from ribbed torsteel which is deformed high strength steel. These bars have ribs (or) projections on their surfaces and they produced by cold twisting of hot rolled bars.

These are available in sizes varying from ***6mm to 50mm diameter.***

Uses:

It is widely used as reinforcement in concrete structures such as buildings, bridges, irrigation works, pile foundations and pre-cast concrete works.

II. Round Bars:

These are available in circular cross section with diameter varying from ***5mm to 250mm.*** The commonly used cross section have diameter from ***5mm to 25mm.***

Uses:

It is used as reinforcement in concrete structures, construction of steel, grill works

Market Forms of Steel

III. Square Bars:

These are available in square cross section with sides varying from ***5mm to 250mm***. The commonly used cross section has sides varying from ***5mm to 25mm***.

Uses:

It is used in construction of steel grill works, for windows, gates

IV. Plates:

Thickness of plates lies in between ***5mm to 30mm***. When the thickness of the plate is below ***5mm,*** then they are called as sheets. In case of large plates, centre of the plate is thick than at the edges.

Uses:

It is used to connect steel beams for extension of the length. It is also used to built-up steel sections and serves as tensional member of steel roof trusses.

Market Forms of Steel

V. Flats:

Flats are longer than plates but their width is short. Thickness varies from ***3 to 80mm*** and width varies from ***20mm to 500mm.***

Uses:

Flats are used in railways and grill works.

VI. I-Section beam:

The I-section beams are also known as rolled steel joints. The I-section consists of web which connects two flanges. These are designated by depth, width and weight. Beams are available in sizes from ***75mm x 50mm to 600mm x 210mm*** at ***60 N/m to 990 N/m.***

Uses:

These sections are suitable for traverse loading. Heavy I-sections are used for columns. Heavy weight unequal I sections are used as rails. Combination of sections are employed as post.

Market Forms of Steel

VII. Channel Sections:

Channel sections are designed by the height of web and width flange. The standard sizes are as 100cm x 4.5cm to 40cm x 10cm. Channel sections consists of web which connects two flanges of equal length.

Uses:

- Combination of two channel sections is used in columns. It is also used in beams and steel bridges.
- It is widely used in structural members of the steel framed structures like industrial roofs and trusses.

VIII. Angle Sections:

Angle sections are of two types: *Equal Angle section* and *Unequal Angle section*.

Uses:

Angle sections are used as tension and compression members in trusses. It is used as steel columns, beams, steel bridges and steel roof trusses.

Market Forms of Steel

IX. T-Sections:

T-sections consists of a horizontal flange and a vertical web. T-sections are designated by overall dimension and thickness. The sizes of T-sections varies from ***20mm x 20mm x 3mm*** to ***150mm x 150mm x 10mm***.

Uses:

T-sections are used in frames of doors, windows and as compression or tension members. It is also used as steel roof trusses, steel water tanks, steel chimney, steel bridges, etc.

X. Expanded Metal:

When we cut and expand either plain sheets or ribbed sheets of steel expanded metal is obtained. These may be either of diamond mesh or ribbed mesh.

Uses:

It is used in partition of walls, plaster in reinforcing, concrete, roads, floors, bridges, etc.

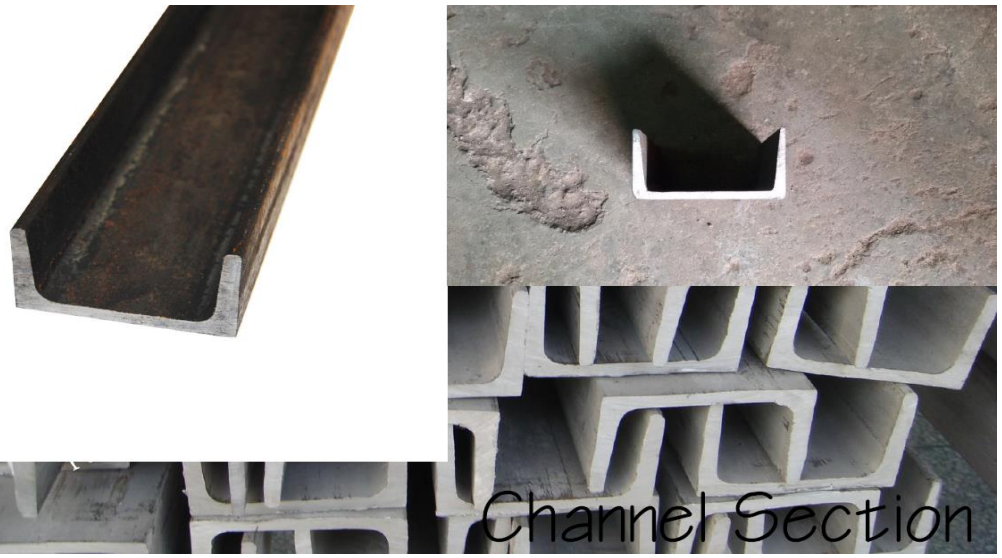
Market Forms of Steel

XI. Corrugated Sheets:

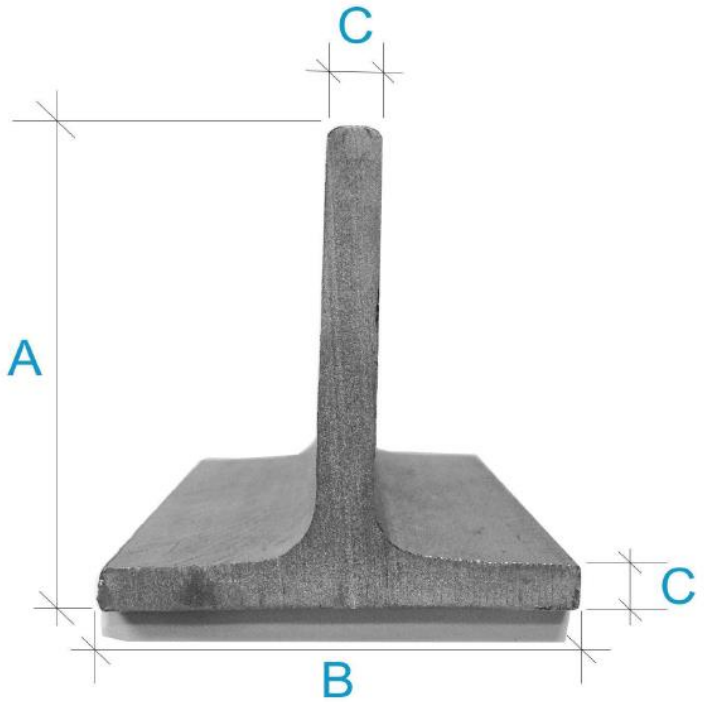
These are formed by passing steel sheets through grooves. These grooves bend and press sheets and corrugations are formed on sheets. These are usually galvanized and they are known as galvanized iron sheets or GI sheets.

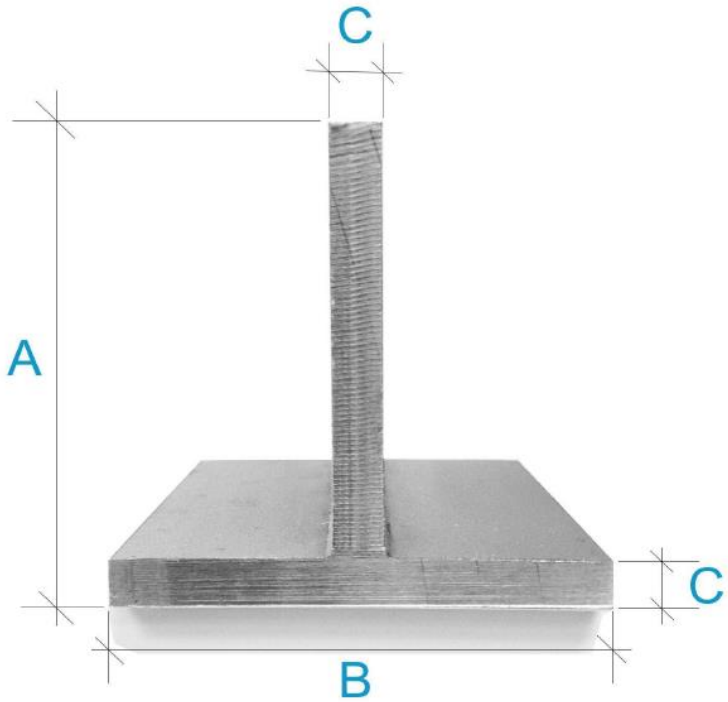
Uses:

These are widely used as roof covers.

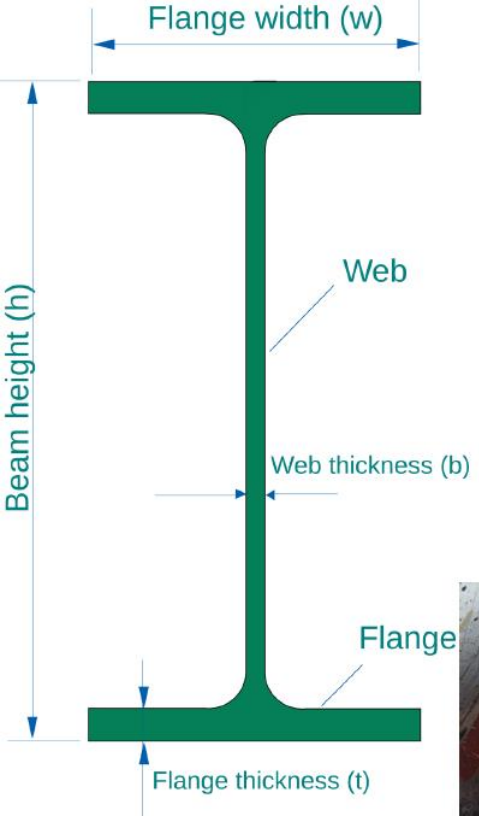


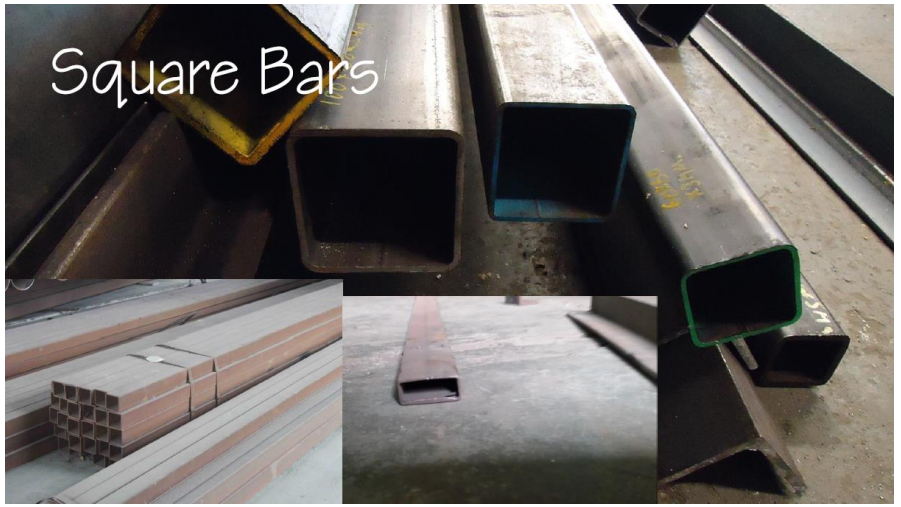
T - Section

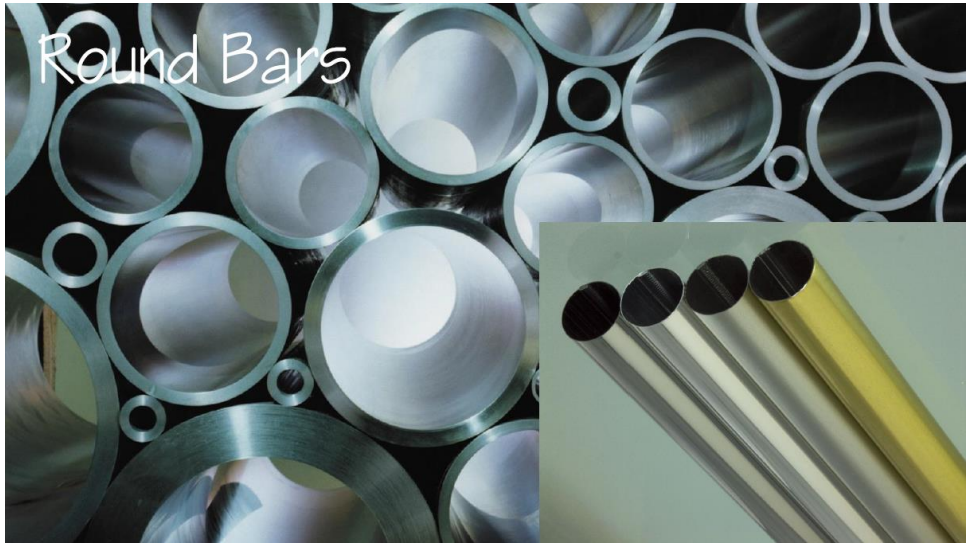




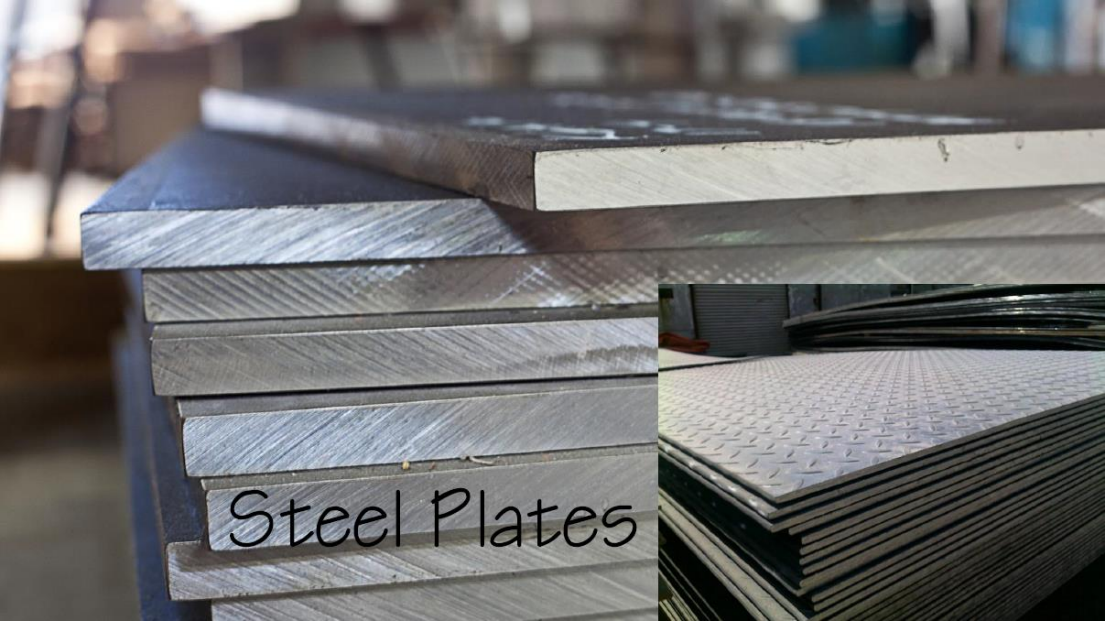
I - Section

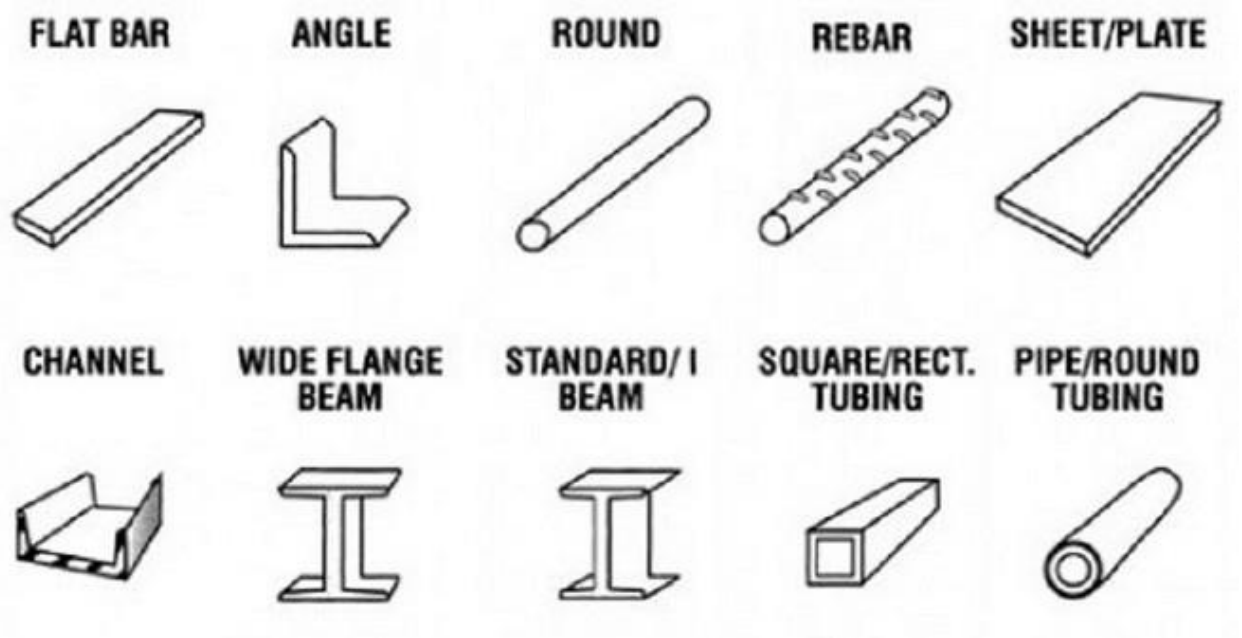

Flange width (w)
Beam height (h)
Web
Web thickness (b)
Flange
Flange thickness (t)


Square Bars


Round Bars


Flat Bars


Steel Plates


FLAT BAR
ANGLE
ROUND
REBAR
SHEET/PLATE
CHANNEL
WIDE FLANGE BEAM
STANDARD/ I BEAM
SQUARE/RECT. TUBING
PIPE/ROUND TUBING


Corrugated Sheets