XII. LECTURE NOTES

UNIT 1

Introduction

Bricks in India:

Bricks, one of the crucial components of the construction world, date back to 7,000 BC. They are also among the oldest known building materials used for advanced construction. Bricks bring better shapes, sturdiness, durability, and sound foundation for houses. Here's everything you need to know about different bricks types and the average cost:

Types of bricks

Sun-dried bricks

These are un-burnt bricks made of clay. They are molded and left under the sun to dry.

Burnt clay bricks

Burnt clay bricks are made of clay and put into the kiln for burning. They are used for building walls, foundations, and columns, among others. There are four different types of **burnt clay bricks**:

First class: Quality with excellent edges

Second class: Ground molded and a bit irregular in shape

Third class: Rough-edged and ground mounded, used for temporary construction

Fourth class: Over-burnt and highly irregular, dark in color with no water resistance feature

Fly ash bricks

Also called Self-cementing brick, these bricks contain Class F or Class C fly ash as a part of the formula. Fly ash is collected from the furnaces of industries where coal is burned. This ash has passed through 1, 000 degrees Celsius heat and contains calcium oxide.

Concrete bricks

These bricks are made using solid concrete. The concrete is prepared using sand, coarse aggregates, water, and cement. The shape and size can be tailored according to specific requirements.

Engineering bricks

This type of brick offers high compressive strength. They are used for construction where low porosity, frost resistance, acid resistance, and strength are mandatory. Such bricks are generally applied for creating the basements of buildings.

Calcium silicate bricks

Also called sand lime bricks, they are made by mixing fly ash, lime, and sand. It is used for masonry and ornamental works in different construction projects.

Eco bricks

Porotherm hollow bricks are suitable walling solutions. They offer significant thermal insulation and make walls stronger. The perforations in them can be either horizontal or vertical.

Qualities of good brick:

Uniform size and shape – a high-quality brick should have a standard shape and size, with plain and rectangular surfaces. The brick size (as standard) should be 215mm x 102.5mm x 65mm. However, sizes of brick vary across different countries, with UK bricks holding different uniform sizes to bricks in India and the USA.

Compressive strength – brick compressive strength should be between 2000 and 5000 psi (15 to 35 MPa).

Hardness – bricks should be sufficiently hard, with no impressions being left on them when lightly grazed.

Water absorption – bricks should not absorb more than 20% of their weight in water, when immersed for 24 hours or longer.

Texture – of course, brick texture varies considerably; the texture of glazed bricks will differ to that of long format bricks, for example. However, their surfaces should not be smooth to the point where mortars slip right off. They should also be free from cracks and stone nodules, with sharp and square edges.

Low thermal conductivity – this should be low as commercial buildings built from brick should ideally be cooler in the summer, and warmer in the winter.

Soundness – the brick should give a clear metallic sound, which rings when struck with another brick.

Colour – there are numerous brick colours available, which is influenced by the chemical constitution of the clay as well as its burning temperature, kiln conditions etc. Good quality

bricks should be well-burnt, as well as having a uniform colour. If bricks are under-burnt or over-burnt, they lose this uniformity.

Brick earth – brick earth should be free from physical materials such as stones and pebbles, as well as chemicals like potassium nitrate.

Durable – salt attack impacts brick durability. When excessive soluble salts are present, this causes efflorescence, and should not exceed 2.5% in burnt bricks.

Strong – brick strength should be a minimum of 5.50 N/mm^2.

Cement

A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together.

Cement Made of - Composition of Cement

There are eight major ingredients in cement. The following image is showing the ingredients of cement:

cement ingredients

The general percentage of these ingredients of which cement is made of is given below:

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

Types of Cement and their Uses

1. Ordinary Portland Cement (OPC)
2. Portland Pozzolana Cement (PPC)
3. Rapid Hardening Cement
4. Quick setting cement
5. Low Heat Cement
6. Sulphates resisting cement
7. Blast Furnace Slag Cement
8. High Alumina Cement
9. White Cement
10. Coloured cement
11. Air Entraining Cement
12. Expansive cement
13. Hydrographic cement

1. Ordinary Portland Cement (OPC)

Ordinary Portland cement is the most widely used type of cement, which is suitable for all general concrete construction. It is the most commonly produced and used type of cement around the world, with annual global production of around 3.8 million cubic meters per year. This cement is suitable for all kinds of concrete construction.

2. Portland Pozzolana Cement (PPC)

Portland pozzolana cement is prepared by grinding pozzolanic clinker with Portland cement. It is also produced by adding pozzolana with the addition of gypsum or calcium sulphate or by intimately and uniformly blending Portland cement and fine pozzolana.

This cement has a high resistance to various chemical attacks on concrete compared with ordinary Portland cement, and thus, it is widely used. It is used in marine structures, sewage works, sewage works, and for laying concrete underwater, such as bridges, piers, dams, and mass concrete works, etc.

3. Rapid Hardening Cement

Rapid hardening cement attains high strength in the early days; it is used in concrete where formworks are removed at an early stage and are similar to ordinary Portland cement (OPC).

This cement has increased lime content and contains higher c3s content and finer grinding, which gives higher strength development than OPC at an early stage.

The strength of rapid hardening cement at the three days is similar to 7 days strength of OPC with the same water-cement ratio. Thus, the advantage of this cement is that formwork can be removed earlier, which increases the rate of construction and decreases the cost of construction by saving formwork cost.

Rapid hardening cement is used in prefabricated concrete construction, road works, etc.

4. Quick setting cement

The difference between the quick setting cement and rapid hardening cement is that quick-setting cement sets earlier. At the same time, the rate of gain of strength is similar to Ordinary Portland Cement, while quick hardening cement gains strength quickly. Formworks in both cases can be removed earlier.

Quick setting cement is used where works is to be completed in very short period and for concreting in static or running water.

5. Low Heat Cement

Low heat cement is produced by maintaining the percentage of tricalcium aluminate below 6% by increasing the proportion of C2S. A small quantity of tricalcium aluminate makes the concrete to produce low heat of hydration. Low heat cement suitable for mass concrete construction like gravity dams, as the low heat of hydration, prevents the cracking of concrete due to heat.

This cement has increased power against sulphates and is less reactive and initial setting time is greater than OPC.

6. Sulphates Resisting Cement

Sulphate resisting cement is used to reduce the risk of sulphate attack on concrete and thus is used in the construction of foundations where the soil has high sulphate content. This cement has reduced the contents of C3A and C4AF.

Sulphate resisting cement is used in construction exposed to severe sulphate action by water and soil in places like canals linings, culverts, retaining walls, siphons, etc.

7. Blast Furnace Slag Cement

Blast furnace slag cement is obtained by grinding the clinkers with about 60% slag and resembles more or less in properties of Portland cement. It can be used for works where economic considerations are predominant.

8. High Alumina Cement

High alumina cement is obtained by melting a mixture of bauxite and lime and grinding with the clinker. It is a rapid hardening cement with initial and final setting time of about 3.5 and 5 hours, respectively.

The compressive strength of this cement is very high and more workable than ordinary Portland cement and is used in works where concrete is subjected to high temperatures, frost, and acidic action.

9. White Cement

It is prepared from raw materials free from Iron oxide and is a type of ordinary Portland cement, which is white. It is costlier and is used for architectural purposes such as precast curtain wall and facing panels, terrazzo surface, etc. and for interior and exterior decorative work like external renderings of buildings, facing slabs, floorings, ornamental concrete products, paths of gardens, swimming pools, etc.

10. Coloured cement

It is produced by mixing 5- 10% mineral pigments with ordinary cement. They are widely used for decorative works on floors.

11. Air Entraining Cement

Air entraining cement is produced by adding indigenous air-entraining agents such as resins, glues, sodium salts of sulphates, etc. during the grinding of clinker.

This type of cement is especially suited to improve the workability with a smaller water-cement ratio and to improve frost resistance of concrete.

12. Expansive Cement

Expansive cement expands slightly with time and does not shrink during and after the time of hardening. This cement is mainly used for grouting anchor bolts and prestressed concrete ducts.

13. Hydrographic cement

Hydrographic cement is prepared by mixing water-repelling chemicals and has high workability and strength. It has the property of repelling water and is unaffected during monsoon or rains.

Hydrophobic cement is mainly used for the construction of water structures such as dams, water tanks, spillways, water retaining structures, etc.

Grades of Cement

According to Indian Standards, it is classified into three types of Cement Grades,

1. OPC 33 Grade

2.OPC 43 Grade

3.OPC 53 Grade

Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time.

Types of concrete

1. Normal strength concrete

Normal strength concrete, or “regular” concrete, is the most common type of concrete with a basic mix of cement, aggregates, and water. Normal concrete has a mixing proportion of 1:2:4 (one part cement, two parts aggregate, four parts water), however, the amount of water used will depend on the humidity of the location and the desired consistency of the concrete. Normal strength concrete is typically used for pavements, home construction projects, and buildings that don’t require maximum tensile strength.

2. Plain concrete

Plain concrete is concrete in its simplest form. It is made using the same mixing proportions as normal strength concrete, but will have absolutely no reinforcement in it. It can be used to build structures that do not require intense tensile strength. Pavements and walkways are common uses of plain concrete.

3. Lightweight concrete

This type of concrete has a lower density and a higher water content than normal concrete. Lightweight concrete is made using lightweight aggregates, such as pumice, clay, or perlite. Since the specific aggregates chosen are what determines the density of the concrete, lightweight concrete is low in density, and is defined as any type of concrete with a density level of less than 1920kg/m3. Lightweight concrete is used in areas where the total “dead weight” of a building can be reduced to help prevent collapse, such as walls or flooring.

4. Ready mix concrete

Ready mix concrete is made at a manufacturing plant and delivered to a construction site using a truck with a mixer attached to it. It usually contains admixtures to make it so the cement doesn’t harden before arriving at the site, and is ready to pour.

5. Polymer concrete

Polymer concrete is concrete in which the lime and shale-based Portland cement is replaced with a polymer binder that cures and hardens, such as a polyester, epoxy mixtures, vinyl ester, acrylics, or many various types of polymer resins. The objective of polymer concrete depends on the type of resin used. Epoxy binders, for example, will aid in less shrinkage during curing while acrylic binders offer weather resistance and quicker setting times. Polymer plastic is stickier than cement, and therefore, when combined in a concrete mix, leads to a concrete of higher tensile strength than one composed of Portland cement. When mixing together a polymer binder with water and aggregates, a chemical reaction occurs that begins the curing process quicker than regular concrete. Polymer concrete has a good resistance to corrosion which is why it is used in swimming pools, sewer structures, and other structures that come into close contact with liquids and corrosion-causing chemicals.

6. Reinforced concrete

Reinforced concrete, also known as reinforced cement concrete, is made with reinforced bars, usually rebar, to improve the tensile strength of the concrete. The compressive strength of the concrete paired with the tensile strength of the reinforcement material improves the concrete’s overall durability. Contractors might encounter reinforced concrete in large-scale structures that require an immense amount of tensile strength, such as tall buildings, bridges, dams, or any construction situation that involves a structure needing to carry extremely heavy loads.

7. Prestressed concrete

Prestressed concrete is concrete that has compressive stresses applied to it during production and combines the high tensile strength of steel and the high compressive characteristic of concrete These initial compressive stresses are induced by steel tendons located inside of or adjoining to the concrete and are engineered to counteract the stresses that will eventually be placed upon the concrete during service. Since it has been formed under stress, a prestressed concrete structure will be more balanced and less likely to crack when carrying heavy loads. Bridges, roofs, water tanks, and floor beams are often made using prestressed concrete.

8. Precast concrete

Precast concrete is concrete that is poured in a mold and cured, usually offsite, and then transferred to a construction site. This allows for the concrete to be created in a more controlled environment, like a plant or a factory, with more oversight and surveillance, which is good for quality control. Factories can also use the same molds over and over again, saving time and money. Precast concrete allows for a speedier construction, as it shows up to the construction site ready to be installed without any waiting time for it to gain strength. Precast concrete also improves time efficiency in that the walls of a structure can be made off-site as the foundation is created onsite, resulting in the building being ready for use faster.

9. Air entrained concrete

Air entrained concrete is concrete containing microscopic air bubbles that help to relieve internal pressure in the concrete. An air entraining agent is added during the mixing process, reducing the surface tension and causing air pockets to form in the slurry. This type of concrete is suitable for structures in environments with freeze-thaw conditions, where the temperature shifts from below to above freezing, causing a water buildup. The tiny pockets allow space for water to expand, which prevents cracking and resists scaling in concrete, resulting in a structure that lasts longer over time. The microscopic air bubbles range from 5–7% of the concrete mix, and since adding air to concrete lessens its density, it is common for a higher amount of cement to be used to make up for the strength.

10. High-strength concrete

High strength concrete is any concrete that has a compressive strength of 6000 pounds per square inch (PSI) or higher. It is made using strong, durable aggregates and has a high cement content

and lower water to cement ratio, with superplasticizers added to improve any workability issues stemming from stickier concrete. Compared to normal strength concrete, the primary use of high-strength concrete is to reduce the weight, bleeding, and permeability issues, making the structure more resistant to corrosion and chemicals. High-strength concrete is commonly used in the construction of high-rise buildings servicing highly compressive loads.

Steel is an alloy made up of iron with typically a few tenths of a percent of carbon to improve its strength and fracture resistance compared to other forms of iron.

Types of steel

Carbon Steels

Alloy Steels

Stainless Steels

Tool Steels

Properties of cement concrete

1. The thermal expansion of concrete is approximately 0.4 mm per meter.

2. Concrete shrinks as it dries and expands again on wetting and extent of movement depends upon the modulus of elasticity of the cement.

3. It binds rapidly with steel and as it is weak in tension, the steel reinforcement is placed in concrete at suitable places.

4. It tends to be porous.

5. It has a high degree of abrasion resistance.

6. It has a high degree of electrical resistance.

7. It is more economical than steel.

8. It has high compressive strength.

9. It is free from corrosion so as it has no effects of atmospheric agents on it.

10. It hardens with time and process of hardening is continue to a long time and after a long time, it attains the sufficient strength.

11. It should be remembered that apart from other materials, the concrete comes to the site in the forms of raw materials only. Its final strength and quality depend entirely on local conditions and the person handling it. However, the materials of which concrete is composed may be subjected to rigid specifications.

Admixtures

Admixture is artificial or natural materials added to concrete, in addition to cement, water, and aggregates, to improve certain properties of concrete during casting, laying, or the service stage.

Types of Admixtures Used in Concrete

1. Water Reducing Admixture

Water-reducing Admixture, the name itself defines that they are used to minimize the demand for water in a concrete mix.

Workability is the important property of concrete, which is improved by adding water, but if the water is added more than necessary, the strength and durability properties of concrete will be affected.

water-reducing-superplasticizer-admixture-500x500

In addition, to increase workability, it also improves the strength of concrete, the good connection between concrete and steel, prevents cracking, segregation, honeycombs, bleeding, etc.

2. Retarding Admixture

Retarding Admixture decrease the rate of cement hydration in its initial stage and increase the initial hardening time of the concrete.

They are also called retarders and are used especially in high-temperature areas, where concrete hardens quickly.

The quick configuration in some situations can lead to discontinuities in the structure, the lack of connection between the surfaces creates unnecessary voids in the concrete, etc.

3. Accelerating Admixture

Accelerating Admixtures are used to reduce the initial hardening time of the concrete.

They speed up the process of the initial phase of concrete hardening, so they are also called accelerators.

These accelerators also improve the strength of the concrete in the initial stage, increasing the rate of hydration.

4. Air Entraining Admixtures

Air entrainment Admixture is one of the most important inventions in concrete technology. Its main function is to increase the durability of the concrete under freezing and thawing conditions.

When added to the concrete mix, these mixtures will form millions of non-coalescent air bubbles throughout the mix and improve the properties of the concrete.

5. Pozzolanic Admixture

Pozzolanic mixtures are used to prepare a dense concrete mix that is most suitable for water retention structures, such as dams, reservoirs, etc. They also reduce the heat of hydration and thermal shrinkage.

The best pozzolanic materials in an ideal quantity provide better results and avoid or reduce many risks, such as the reaction of alkaline aggregates, leaching, attack of sulfates, etc.

Building components

Lintel

A lintel is a sort of beam, which is placed across the opening. The width of a lintel is equal to the width

of the wall and the ends of which are built into the wall. Lintels are simple and easy to construct.

Lintels are classified into the following types according to the materials of the construction:

1.Timber Lintels: These are relatively costlier, structurally weak and vulnerable to fire. Sometimes

timber lintels are strengthened by the provision of mild steel plates at their top and bottom, such lintels are called Flitched Lintels.

2.Stone Lintels: These are common in usage where stone is abundantly available. Dressed stone lintels

give good architectural appearance. Stone is very weak in tension and cracks develop if subjected to

vibratory loads.

3.Brick Lintels: These are not structurally strong and they are used only when the opening is small and

loads are light.

4.Steel Lintels: These are provided where the opening is large and the loads are heavy. It consists of

steel channels either used singly or in combination of two or three units.

Reinforced Cement Concrete Lintels: Because of their strength, rigidity, fire resistance, economy and

ease of construction, the RCC lintels are widely used. These can be used on any span. It is kept equal to

the width of the wall. RCC lintels are also available as precast units.

Walls

Wall is a structure defining an exact area and providing safety & shelter. There are various types of walls used in the construction of buildings given below

Types of walls

1.Load Bearing Walls

Precast Concrete Wall

Retaining Wall

Masonry Wall

Pre Panelized Load Bearing Metal Stud Walls

Engineering Brick Wall

Stone Wall

2.Non-Load Bearing Wall

Hollow Concrete Block

Facade Bricks

Hollow Bricks

Brick Walls

3.Cavity Walls

Shear Walls

Partition Walls

Panel Walls

Veneered Walls

Faced Walls

Stairs

A well-planned and designed arrangement of a number of steps provided in a building for vertical movement of people is called stairs.

TYPES OF STAIRS

A stair is a series of steps arranged in such a manner as to connect different floors of a building. Stairs are designed to provide as easy and quick access to different floors. A staircase is an enclosure which contains the complete stairway.

Generally stairs are of following types

1. Straight stairs
2. Quarter turn stairs
3. Half turn stairs
4. Three quarter turn stairs
5. Circular stairs
6. Spiral stairs
7. Curved stairs
8. Geometric stairs
9. Bifurcated stairs and
10. Combination above types

Floors

A floor is the bottom surface of a room or vehicle. Flooring is the general term for a permanent covering of a floor, or for the work of installing such a floor covering.

Types of Floors

Following are some of the major types of floors:

1. Mud Floor:

Earthen Flooring also commonly known as Adobe flooring is made up of dirt, raw earth or other unworked ground materials. In modern times, it is usually constructed with mixture of sand, clay and finely chopped straw.

Mud flooring is commonly constructed in villages where by using stabilizers the properties of the soil are enhanced by manipulating its composition by adding suitable stabilizers. The tensile and shear strength of the soil is increased and shrinkage is reduced.

2. Brick floor:

Brick flooring is one of the types of floors whose topping is of brick. These are easy to construct and repair but the surface resulting from these is not smooth and is rough, hence, easily absorbs and retains moisture which may cause dampness in the building.

3. Tile floor:

The floor whose topping is of tiles is called tile floor. The tiles used may be of any desired quality, color, shape or thickness.

4. Flagstone floor:

The floors whose topping consists of stone slabs is called flagstone floor. The stone slabs used here may not be of the same size but should not be more than 75 cm length and not less than 35 cm in width and 3.8 cm in thickness.

5. Cement concrete floor:

The types of floors whose topping consists of cement concrete is called cement concrete floor or conglomerate floor. These floors consists of 2.5 cm to 5cm thick concrete layer laid over 10 cm thick base concrete and 10 cm thick clean sand over ground whose compaction and consolidation is done.

Roof

A Roof is a shield that gives protection to the buildings against rain, heat, snow, wind, etc.

The Roofs are the uppermost part of a building constructed using trusses, slabs, domes, etc. Roofs give a better appearance to the house.

The roofs have different types. Here are the 8 main types of roofs:

1. Shed Roof
2. Gabled Roof
3. Pitched Or Sloping Roofs
4. Curved Roofs
5. Hip Roof
6. Flat Or Terraced Roofs
7. Gambrel Roof
8. Pyramid Roof

Doors

Doors are movable barriers. Those held in position by a door frame. These door frames are provided in the opening of the wall which provides the access to the building or rooms.

various types of doors

1. Battened, ledged, braced and framed doors.
2. Framed and panelled doors.
3. Flush doors.
4. Collapsible steel doors.
5. Rolling steel doors.
6. Sliding doors.
7. Glazed or sash doors.
8. Louvered and wire gauged doors.
9. Revolving doors.
10. Swinging doors.

Window

A window is an opening in a wall or roof of a building that is typically covered with glass to allow light and air to enter.

Types of windows

1. Fixed Windows
2. Sliding Window
3. Pivoted window
4. Sash Window
5. Single Hung Window
6. Double Hung Window
7. Bow Windows
8. Round Windows
9. Arched Windows
10. Gable Window

Finishing

Finishing is one of the most important parts after the casting of the concrete because it gives aesthetical view to the surface of the concrete.

Finishing of the concrete surface is the process of compacting, levelling and smoothing the surface of the concrete.

Different Types of Concrete Finishes

1. Float and Troweled Finish
2. Broom Finish
3. Salt Concrete finish
4. Stamped Concrete Finish
5. Polished concrete
6. Exposed Aggregate Finish

Plastering

Plastering is the process of covering rough walls and uneven surfaces in the construction of houses and other structures with a plastic material, called plaster. It protects the masonry work.

Types of Plaster in civil engineering

1. Lime plaster
2. Cement plaster
3. Mud plaster
4. Waterproofing plaster

Paints

Paints are applied on the surfaces of timber, metals and plastered surfaces as a protective layer and at the same time to get pleasant appearance. Paints are applied in liquid form and after sometime the volatile constituent evaporates and hardened coating acts as a protective layer

Types of paints

1. Enamel paint:

It is an oil-based paint, having resinous matter, mostly composed of alkyd. After painting, they give a glossy finish, with a hard surface.

2. Oil paint:

Different oils like tung oil, nut oil, linseed oil, etc were used as base material, with suspended pigment particles. This paint is mostly used on metal surfaces like grills, gates, railings, etc., and also on wooden materials.

3. Emulsion paint:

They are made up of a variety of chemical ingredients like binders, pigments, solvents, additives, etc. It is a suspension of globules of one liquid part with another liquid, where these two liquids do not mix with each other.

4. Whitewash:

This is the low-cost paint, where slaked lime(calcium hydroxide) and chalk are used with water to form a solution. This mixture is mostly applied for whitening walls of less importance, or on rough surfaces.

5. Anti-corrosive paint:

These types of paints are mostly used as a protective coating against oxidation and corrosion, over steel or iron products.

Tiles

Tiles in building construction are thin plates or elements used to cover surfaces like roofs, floors, and walls.

Types of tiles

1. Ceramic Tiles
2. Vitrified tiles
3. Porcelain tiles
4. Mosaic tiles
5. Concrete pavers / tiles

UNIT 2

Road transport is one of the most common modes of transport. Roads in the form of track ways, human pathways etc. were used even from the pre-historic times. Since then many experiments were going on to make the riding safe and comfort. Thus road construction became an inseparable part of many civilizations and empires. In this chapter we will see the different generations of road and their characteristic features. Also we will discuss about the highway planning in India.

History of highway engineering

The history of highway engineering gives us an idea about the roads of ancient times. Roads in Rome were constructed in a large scale and it radiated in many directions helping them in military operations. Thus they are considered to be pioneers in road construction. In this section we will see in detail about Ancient roads, Roman roads, British roads, French roads etc.

Ancient Roads

The earliest mode of transport was by foot. These human pathways would have been developed for specific purposes leading to camp sites, food, streams for drinking water etc. The next major mode of transport was the use of animals for transporting both men and materials. Since these loaded animals required more horizontal and vertical clearances than the walking man, track ways emerged. The invention of wheel in Mesopotamian civilization led to the development of animal drawn vehicles. Then it became necessary that the road surface should be capable of carrying greater loads. Thus roads with harder surfaces emerged. To provide adequate strength to carry the wheels, the new ways tended to follow the sunny drier side of a path. These have led to the development of foot-paths. After the invention of wheel, animal drawn vehicles were developed and the need for hard surface road emerged. Traces of such hard roads were obtained from various ancient civilization dated as old as 3500 BC. The earliest authentic record of road was found from Assyrian empire constructed about 1900 BC.

Roman roads

The earliest large scale road construction is attributed to Romans who constructed an extensive system of roads radiating in many directions from Rome. They were a remarkable achievement and provided travel times acrossEurope, Asia Minor, and North Africa. Romans recognized that the fundamentals of good road construction were to provide good drainage, good material and good workmanship. Their roads were very durable, and some still exist. Roman roads were always constructed on a ram - formed sub grade strengthened where necessary with wooden piles. The roads were bordered on both sides by longitudinal drains. The next step was the

construction of the aggregate. This was a raised formation up to a 1 meter high and 15 m wide and was constructed with materials excavated during the side drain construction. This was then topped with a sand leveling course. The aggregate contributed greatly to moisture control in the pavement. The pavement structure on the top of the aggregate varied greatly. In the case of heavy traffic, a surface course of large 250 mm thick hexagonal ag stones were provided. A typical cross section of roman road is given in Figure. The main features of the Roman roads are that they were built straight regardless of gradient and used heavy foundation stones at the bottom. They mixed lime and volcanic pozzolana to make mortar and they added gravel to this mortar to make concrete. Thus concrete was a major Roman road making innovation.

French roads

The next major development in the road construction occurred during the regime of Napoleon. The significant contributions were given by Treasure in 1764 and a typical cross section of this road is given in Figure 1:2. He developed a cheaper method of construction than the lavish and locally unsuccessful revival of Roman practice. The pavement used 200 mm pieces of quarried stone of a more compact form and shaped such that they had at least one at side which was placed on a compact formation. Smaller pieces of broken stones were then compacted into the spaces between larger stones to provide a level surface. Finally the running layer was made with a layer of 25 mm sized broken stone. All this structure was placed in a trench in order to keep the running surface level with the surrounding country side. This created major drainage problems which were counteracted by making the surface as impervious as possible, cambering the surface and providing deep side ditches

Classification or Types of Roads

The roads are classified based on many factors as follows.

1. Materials
2. Location & function
3. Traffic volume
4. Width
5. Economy
6. Traffic type
7. Rigidity
8. Topography

1.Based on Materials

1. Earthen roads
2. Gravel roads
3. Murrum roads
4. Kankar roads
5. WBM roads
6. Bituminous roads
7. Concrete roads

1. Earthen Roads

Earthen roads are laid with soil. They are cheaper than all types of roads. This type of road is provided for fewer traffic areas or countryside areas. A good drainage system should be provided, which reflects excellent performance for a more extended period.

2. Gravel Roads

Gravel roads are also low-quality roads, but they are better when compared with earthen roads. A compacted mixture of gravel and earth is used as pavement material in this case.

3. Murrum Roads

Murrum is a matter obtained from the disintegration of igneous rocks by weathering agencies. This is used to make roads called murrum roads.

4. Kankar Roads

Kankar is an impure form of limestone. Kankar roads are provided where lime is available in a reasonable quantity. The Kankar roads are low quality and performance.

5. WBM Roads

Water Bound Macadam (WBM) roads contain crushed stone aggregate in its base course. The aggregates are spread on the surface and rolled after sprinkling water. WBM roads provide better performance compared to earthen, gravel, murrum, and kankar roads.

WBM roads are laid as layers of about 10cm thickness of each layer. They are very rough and may disintegrate immediately under traffic.

6. Bituminous Roads

Bituminous roads are prevalent roads around the world. They are the most used roads in the world. This road types are low in cost and suitable for driving conditions. The thickness of bituminous roads depends upon the subgrade soil conditions.

7. Concrete Roads

Cement concrete is used to construct the pavements in case of concrete roads. These are very popular and costlier than all other types of roads. They are not flexible, so they require less maintenance.

Concrete roads are suitable for high traffic areas. They are laid with joints and time of construction is more.

2.Based on Location and Function

1. National highways
2. State highways
3. District roads
4. Rural roads or village roads

1. National Highways

National highways are the main roads that connect all major cities to the capital of the country. They run throughout the length and breadth of the country. A minimum two-lane road is provided for national highways.

2. State Highways

State highways are the second main roads that connect significant parts of the state within it. State highway ultimately connects to the national highways.

3. District Roads

District roads are provided within the cities and connect markets and production places to state and national highways. Two types of district roads are there namely,

1. Major district roads
2. Minor district roads

Major district roads connect headquarters of the neighboring district with main parts of the area while minor district roads are laid within the region.

e

4. Rural Roads or Village Roads

Village roads connect the nearby villages. They lead to a nearby town or district roads. Usually, low-quality roads are provided as village roads because of low traffic.

Based on Traffic Volume

1. Light traffic roads
2. Medium traffic roads
3. High traffic roads

1. Light Traffic Roads

The roads which are carrying 400 vehicles daily on an average is called light traffic reoads.

2. Medium Traffic Roads

If a road is carrying 400 to 1000 vehicles per day, then it is said to be a medium traffic road.

3. High Traffic Roads

If a road is carrying is more than 1000 vehicles per day then it is considered as high traffic road.

Based on Economy

1. Low-cost roads
2. Medium cost roads
3. High-cost roads

The economy depends upon the location and function of roads and also on the traffic analysis.

Based on Traffic Type

1. Pedestrian ways
2. Cycle tracks
3. Motorways

1. Pedestrian Ways

Pedestrian ways are exclusively built for pedestrians, and no vehicles are permitted in this way.

2. Cycle Tracks

Cycle tracks or bicycle tracks are provided on both sides of the pavement for cyclists; hence they can travel safely.

3. Motorways

Motorways are also known as expressways. Only a few vehicles are accessible to use this type of road. The cars which can move with high-speed acceleration are permitted in this way. Motorways makes travel quick and provides comfort for high-speed vehicles.

Based on Rigidity

Flexible roads

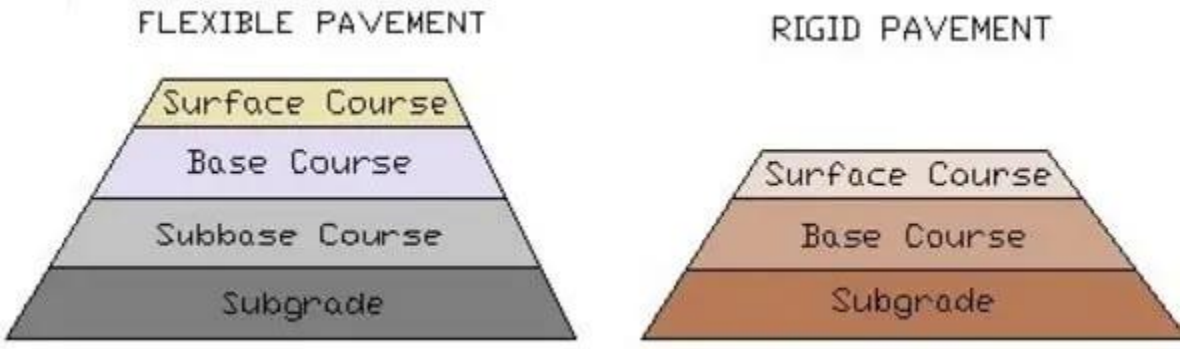
Rigid roads

1. Flexible Roads

Flexible roads consist of a flexible layer as a pavement surface, which requires proper maintenance; otherwise, it can be disintegrated easily with heavy traffic. All types of roads except concrete roads fall under this category.

2. Rigid Roads

Rigid pavements are non-flexible and cement concrete roads are fall under this category.



Based on Topography

1. Plain area road

2. Hilly area roads

1. Plain Area Road

The roads constructed on leveled surface is known as plain area roads.

2. Hilly Area Roads

Roads constructed in hilly regions are called as hill area roads or ghat roads. Generally these are provided around the hill in a spiral shape.

Highway Cross Section

1) Right of way: Right of way or permanent land stands for the area of land obtained and conserved for construction and formation of a road along its alignment. The width of right of way is termed as permanent land width or road land width.

2) Road way / Formation width: The top width of a highway embankment or bottom width of highway cutting exclusive of the side drain is known as roadway width or formation width. It belongs to the sum of width of carriageway and the shoulders.

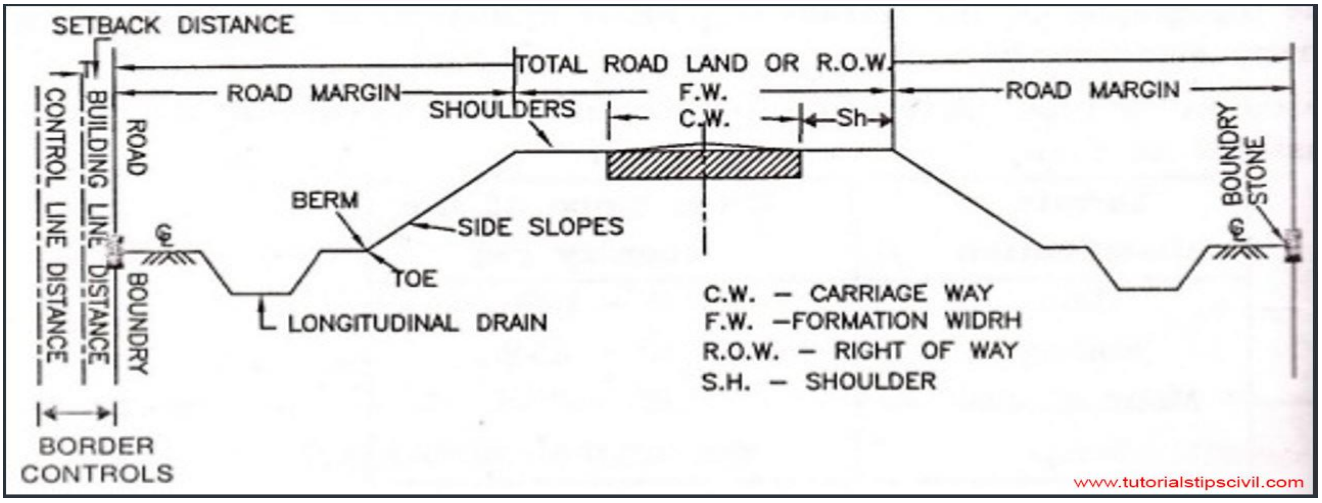
3) Carriageway: Carriageway or pavement or crust is defined as the segment of roadway developed for movement of vehicular traffic

4) Shoulder: The segments of roadway among the exterior edges of the pavement and edges of the top surface of the embankment or inside edges of the side drains in cutting are termed as shoulders.

5) Berm: The segments of land width kept among the toe of road embankment and the inner edges of borrow pits or the segments amid the top edges of road in cutting and the adjacent edges of spoil banks on either side are described as berm.

6) Building Line: It refers to the line, on either side of the road, among which and the road; no building activity can be done at all.

7) Control Line: It refers to the line which shows the nearby restraint of future unrestrained building activity concerning a road. It implies that though building activity is not entirely combined among the building line and control line, the nature of building allowable here is restricted.



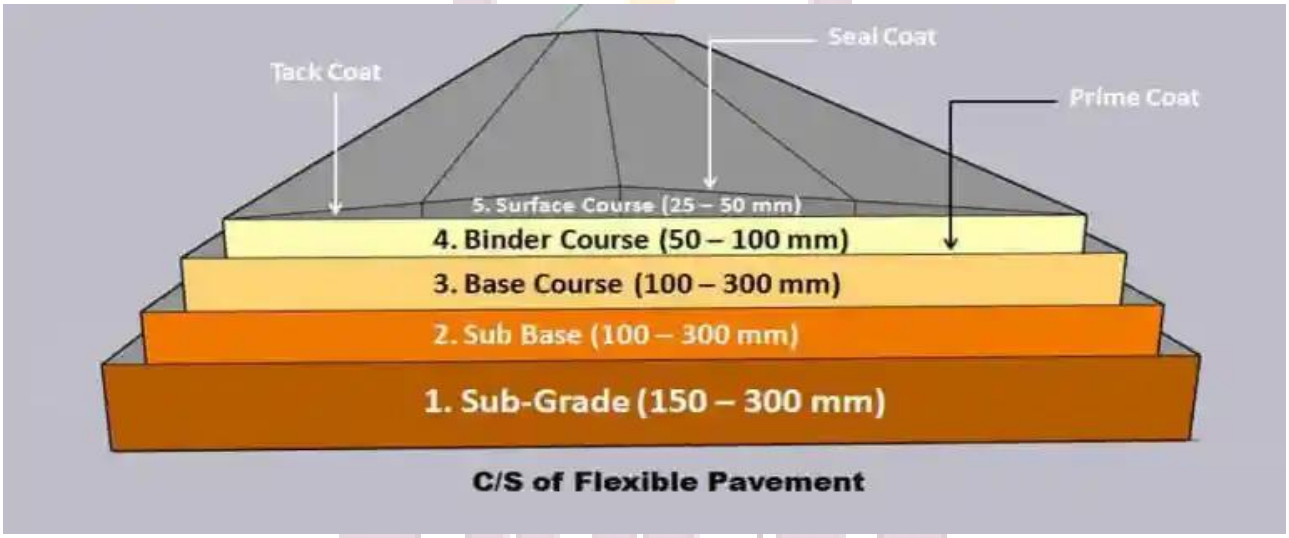
Types of Pavement

1. Flexible pavement
2. Rigid Pavement.

1. Flexible Pavements

In Flexible Pavement, wheel loads are transferred to subgrade by grain-to-grain transfer through the points of contact in the granular structure.

The wheel load stresses acting on the pavement are distributed to a larger area and the stress decreases with depth.



C/S of Flexible Pavement

Following are flexible pavement layers in road construction,

1. Compacted subgrade (150 – 300mm).
2. Sub-base Course (100 – 300 mm)
3. Base Course (100 – 300 mm)
4. Prime Coat
5. Binder Coat (50 -100 mm)
6. Tack Coat
7. Surface Course (25 – 50 mm)
8. Seal Coat.

2. Rigid Pavements

Rigid pavements are cable to transfer wheel load to a wider area as it has good flexural strength. In rigid pavement, there are not many layers of materials as in the case of flexible pavement.

In rigid directly placed on a well-compacted subgrade or on a single layer of granular or stabilized material.

As there is only a single layer between the concrete and the subgrade, this layer can be called a base or sub-base course.

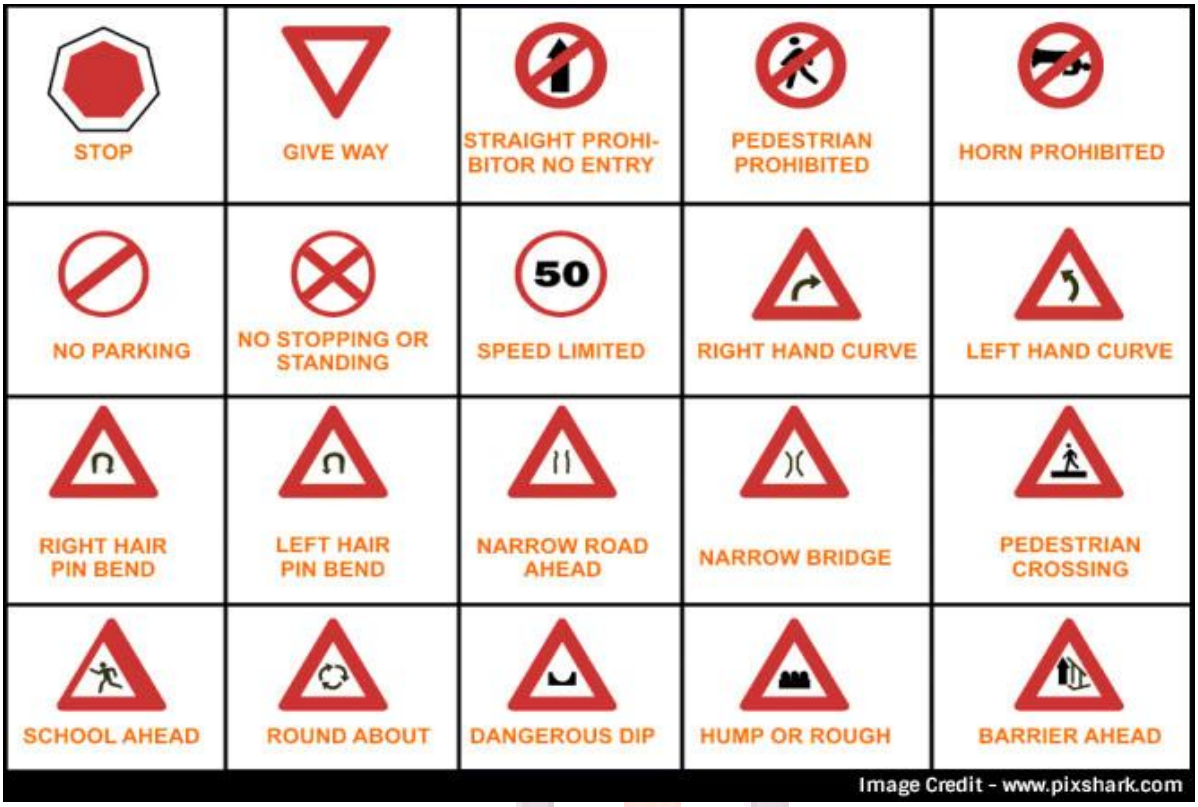
Types of Rigid Pavements

1. Jointed plain concrete pavement (JPCP),
2. Jointed reinforced concrete pavement (JRCP),
3. Continuous reinforced concrete pavement (CRCP), and
4. Pre-stressed concrete pavement (PCP).

Road Safety Signs

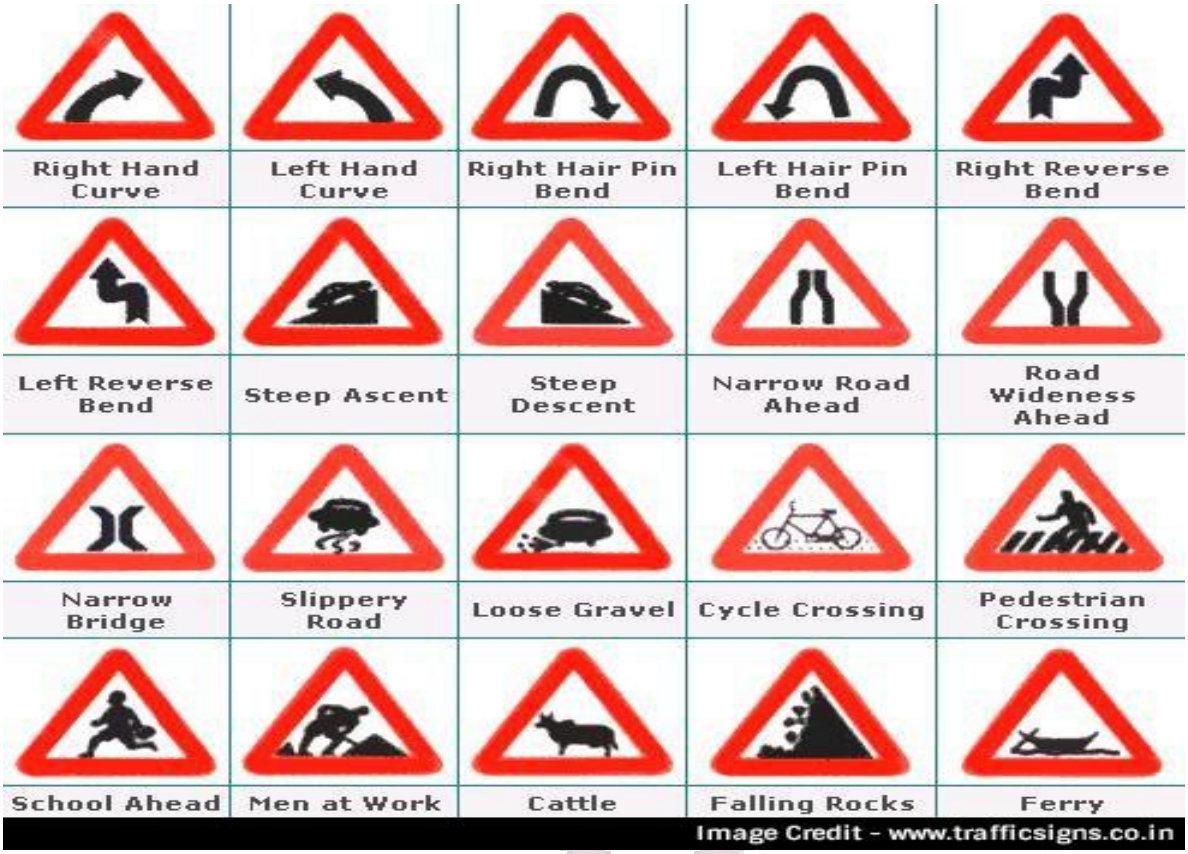
1.Mandatory Signs

These traffic signs are used to ensure free movement of traffic and make the road users cognisant of specific laws and regulations, restrictions and prohibitions. Violation of these road safety signs is an offence, as per law.

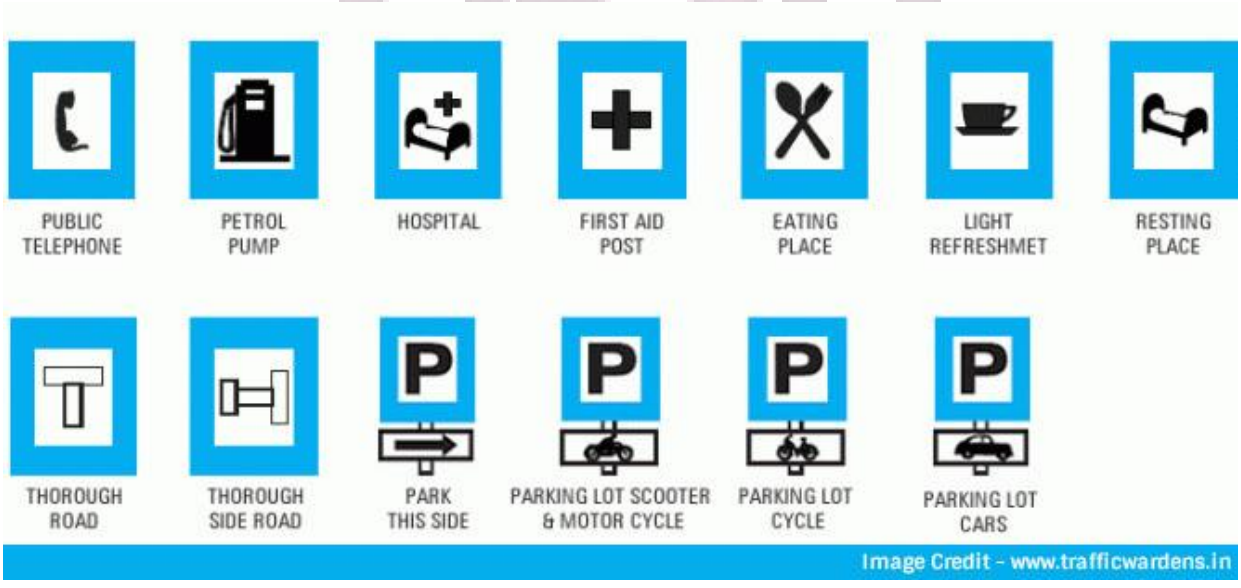


2.Cautionary Signs

These traffic signs make road users conscious of hazardous conditions on the road beforehand. The drivers, accordingly, take necessary actions to handle the situation.



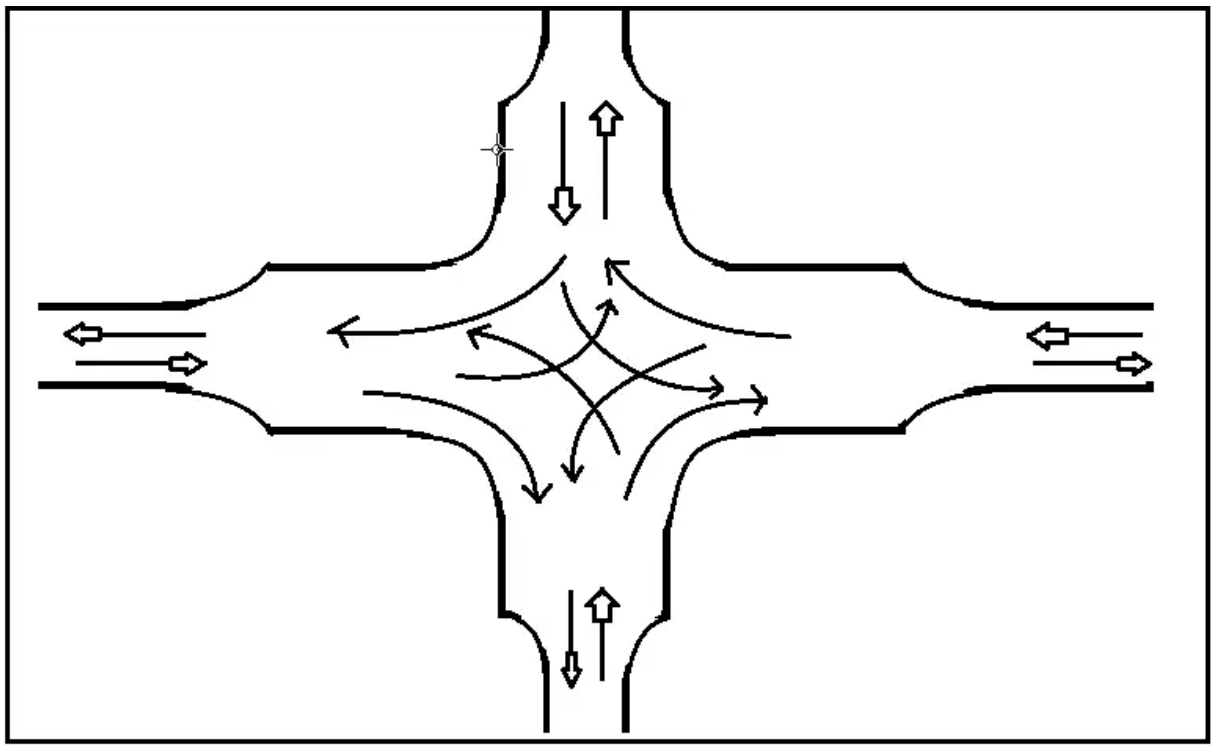
3.Informatory Signs – These traffic signs guide road users about destinations, distances, alternative routes, and prominent locations like food joints, public toilets, nearby hospitals, etc.



Types of intersection on the road

I) Unchannelized Intersections

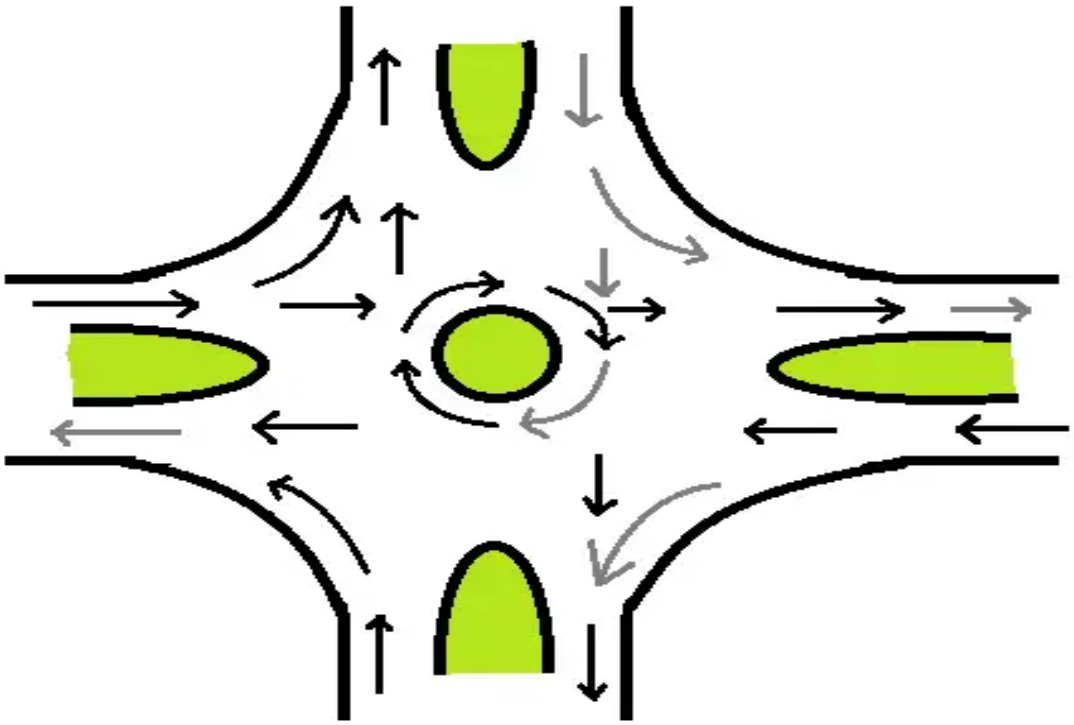
The most common type of intersection is the unchannelized, consisting of the crossing of two roadways at the same elevation connected by radius returns to accommodate the wheel paths of turning vehicle.



Typical characteristics of unchannelized intersections are low turning movements and low overall traffic volumes. The driving through unchannelized intersection is unsafe as there is greater possibility of collision.

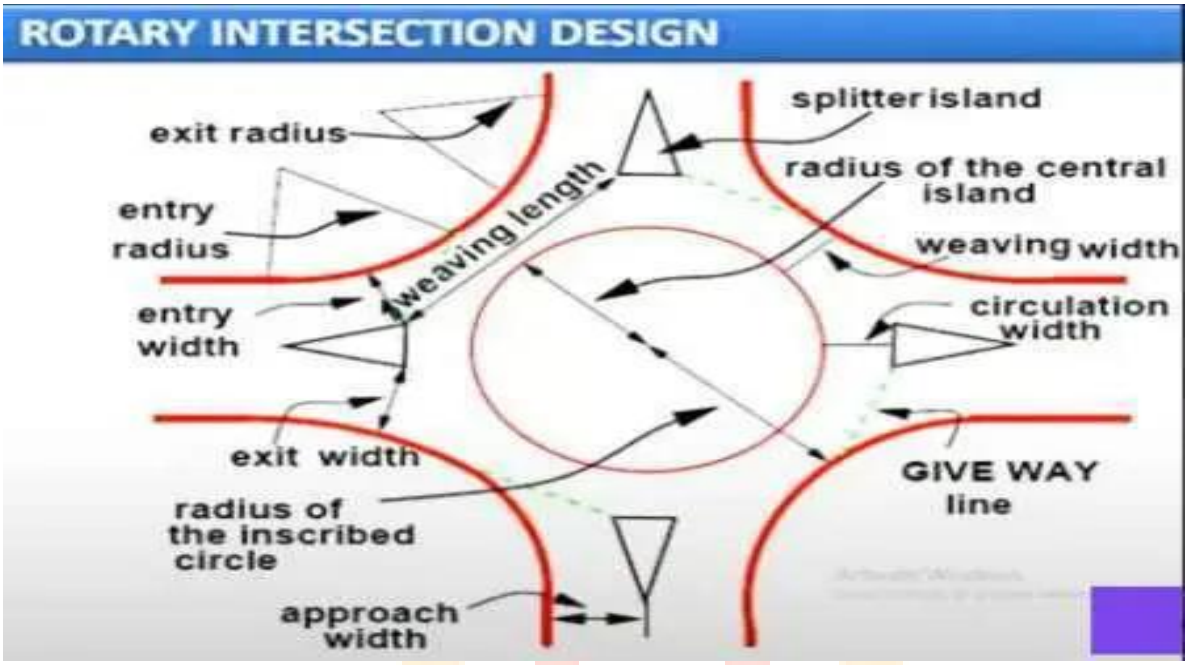
II) Channelized intersection

Vehicles approaching an intersection are directed to definite paths by islands, marking etc. and this method of control is called channelization. Channelized intersection provides more safety and efficiency.



III) Rotary Intersection

Rotary intersections are special form of at-grade intersections laid out for the movement of traffic in one direction around a central traffic island. ‘Essentially all the major conflicts at an intersection namely the collision between through and right-turn movements are converted into milder conflicts namely merging and diverging.



Railway

Also called trackway. any line or lines of rails forming a road of flanged-wheel equipment.

The components of a railway track are rail sections, sleepers, ballast, fasteners and roadbeds.

1. Rail sections

Guide rails provide a hard, smooth and unchanging surface for moving heavy loads to pass over. The rails are made of high-carbon steel and can withstand wear and tear. Flat-legged rails are mostly used for railway tracks.

2. Sleepers

The supports that keep the track at the required distance, support it and distribute the load to the ballast are called sleepers. Sleepers are available in different materials, such as wood, steel, cast iron, crushed concrete and prestressed concrete.

3. Railway fasteners

Railway fasteners are used to join rails and sleepers together in the proper position. Fixings and fasteners used in rail fittings include: Arch Clamp, Fish Bolts, Rail Clamp, Tie Plate, Rail Turnout, Rail Spike, Joint Bar, etc.

4. Ballast

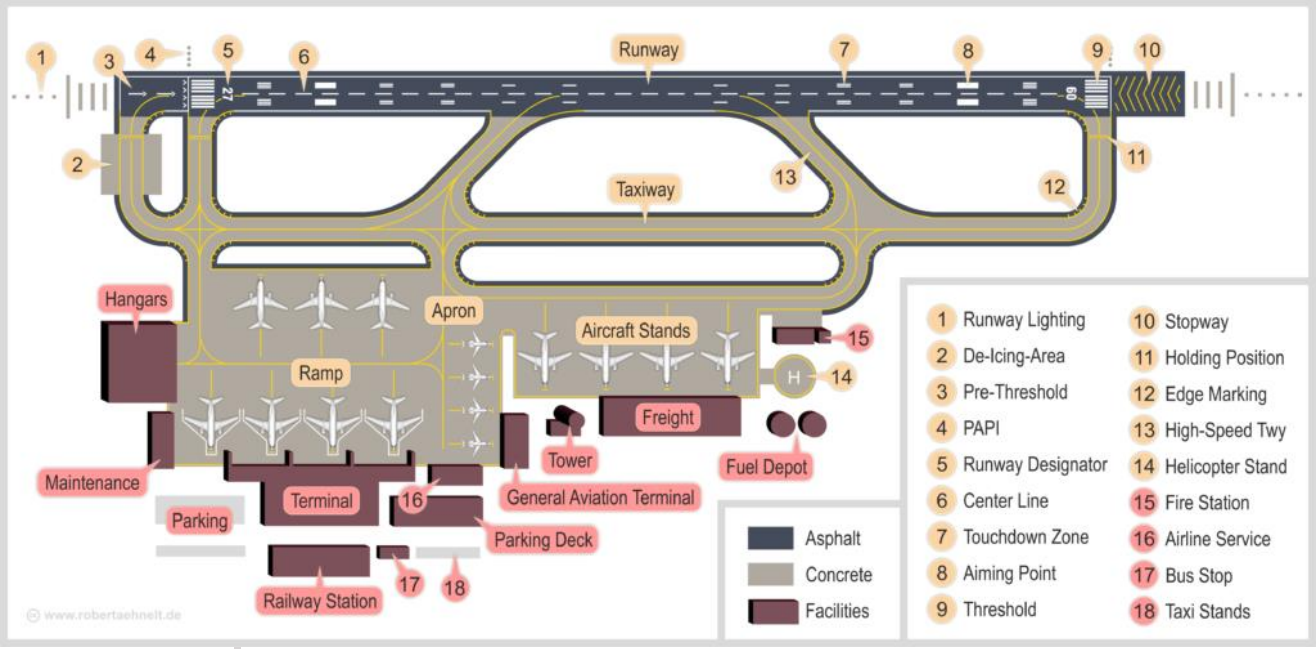
Ballast is gravel placed or packed beneath the sleepers to transfer the load from the sleepers to the ground and to allow the track to drain.

5. Roadbed

The roadbed is the ground level. The rails are fixed to the sleepers by welding and using different types of fasteners. The sleepers are placed properly and ballast is fitted. The ballast is placed on what is known as the formed and prepared roadbed. So, this is where the importance of the roadbed lies. It holds everything up.

Airway

It is the area beyond landside area inside the airport. It includes runways, taxiways, and ramps.



Functions of airway

Functions of the airway include phonation, olfaction, digestion, humidification, and warming of inspired air

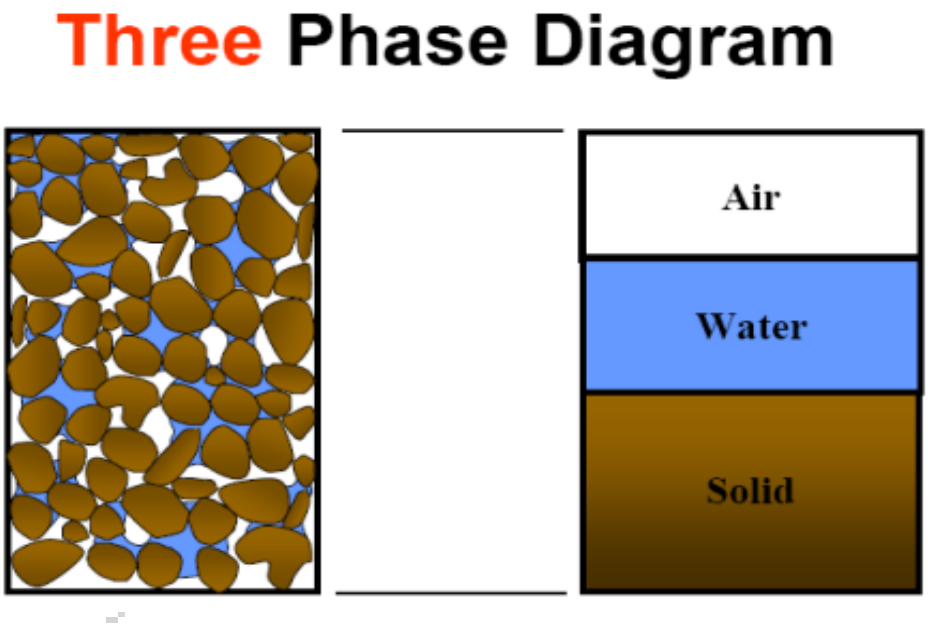
UNIT 3

Formation of Soils

In the Earth's surface, rocks extend up to as much as 20 km depth. The major rock types are categorized as igneous, sedimentary, and metamorphic.

1. Igneous rocks: formed from crystalline bodies of cooled magma.
2. Sedimentary rocks: formed from layers of cemented sediments.
3. Metamorphic rocks: formed by the alteration of existing rocks due to heat from igneous intrusions or pressure due to crustal movement.

Soils are formed from materials that have resulted from the disintegration of rocks by various processes of physical and chemical weathering.



VOLUMETRIC RELATIONSHIPS

Void Ratio

Void ratio is the volume of voids to the volume of solids. It is denoted by 'e'

$$e=Vv/Vs$$

It is expressed as a decimal.

Porosity

It is defined as the ratio of volume of voids to the total volume. It is denoted by 'n'

$$n=Vv/V$$

It is generally expressed as a percentage

$$1/n=V/Vv= (Vv+vs)/Vv$$

$$1/n= 1+ (1/e) = (1+e)/e$$

$$n=e/ (1+e) \qquad (a)$$

$$1/e= (1/n)-1= (1-n)/n$$

$$e=n/ (1-n) \qquad (b)$$

In equations (a) and (b), the porosity should be expressed as a ratio and not percentage.

Degree of saturation

The degree of saturation is the ratio of the volume of water to the volume of voids. It is denoted by 'S'.

$$S=Vw/Vv$$

The degree of saturation generally expressed as a percentage. It is equal to zero when the soil is absolutely dry and 100% when the soil is fully saturated.

Percentage air voids

It is the ratio of volume of air to the total volume.

$$na= Va/V$$

It is also expressed as a percentage.

Air content

Air content is defined as the ratio of the volume of air to the volume of voids

$$ac= Va/Vv$$

Also,

$$na=n\ ac$$

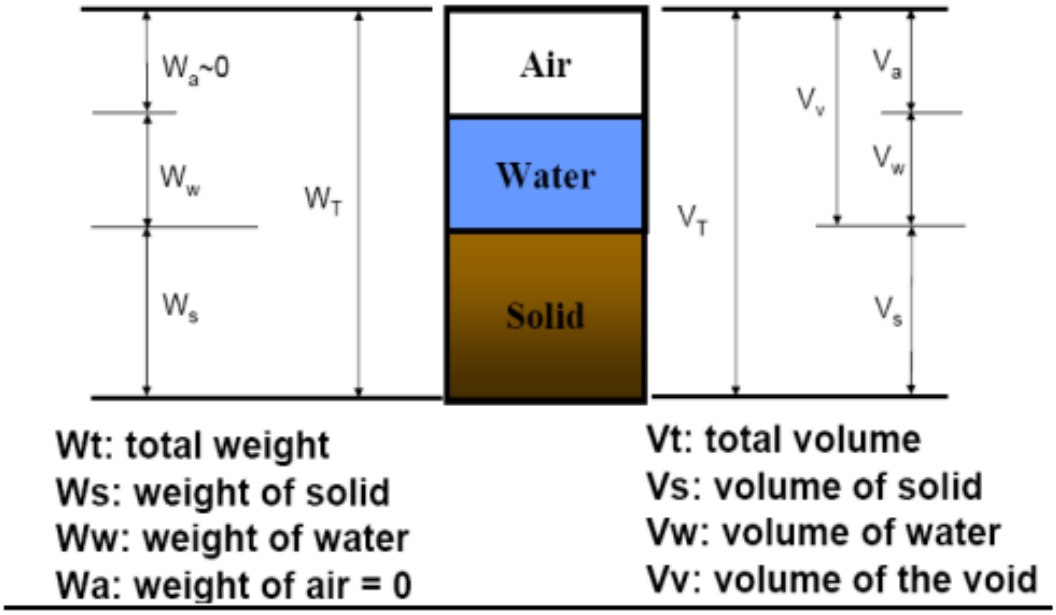
Water content

The water content (w) is defined as the ratio of the mass of water to the mass of solids

$$w= Mw/Ms$$

It is also known as the moisture content (m). It is expressed as a percentage but used as a decimal in computation.

VOLUME-MASS RELATIONSHIPS



1. BULK MASS DENSITY

The bulk mass density (ρ) is defined as the total mass (M) per unit volume (V)

$$\rho=M/V$$

2. DRY MASS DENSITY

The dry mass density (ρd) is defined as the mass of solids per unit total volume

$$\rho d = Ms/V$$

3. SATURATED MASS DENSITY

The saturated mass density (ρsat) is the bulk density of the soil when it is fully saturated

$$\rho sat = Msat/V$$

4. SUBMERGED MASS DENSITY

When the soil exists below water, it is in a submerged condition. The submerged mass density (ρ') of the soil is defined as the submerged mass per unit total volume.

$$\rho' = Msub/V$$

5. MASS DENSITY OF SOLIDS

The mass density of solids (ρs) is equal to the ratio of the mass of solids to the volume of solids

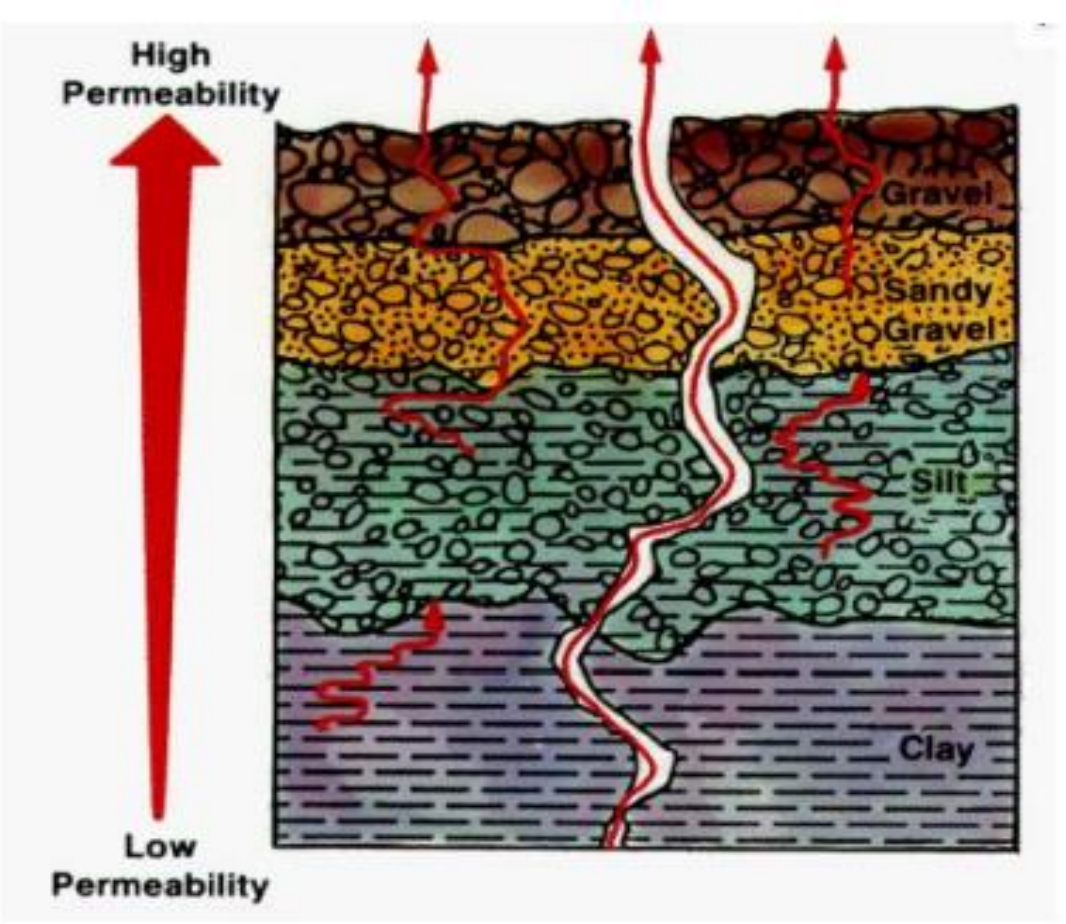
$$\rho s = Ms/Vs$$

PERMEABILITY OF SOILS:

The property of soil which permits flow of water through it is called the permeability. Permeability is a very important property of soil. It will affect the

settlement of buildings, yield of wells, seepage through and below the earth structures.

It controls the hydraulic ability of soil masses.



FACTORS AFFECTING PERMEABILITY OF SOILS

1. Particle size
2. Structure of soil mass
3. Shape of particles
4. Void ratio
5. Properties of water
6. Degree of saturation
7. Adsorbed water
8. Impurities in water

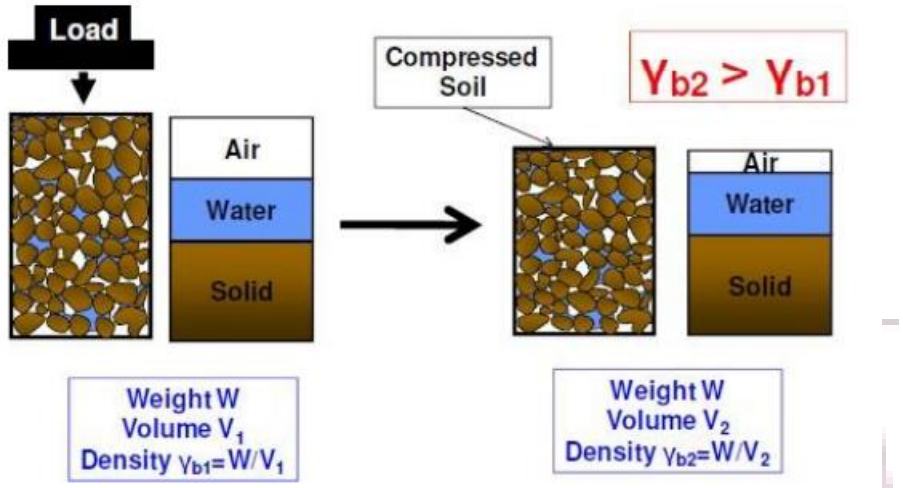
Capillary Rise DEFINITION:

A rise in a liquid above the level of zero pressure due to a net upward force produced by the attraction of the water molecules to a solid surface, e.g. glass, soil

COMPACTION OF SOILS

Compaction means pressing of soil particles close to each other by mechanical methods.

Air during compaction is expelled from the void space in the soil mass and therefore the mass density is increased. Compaction is done to improve the engineering properties of the soil. Compaction of soil is required for the construction of earth dams, canal embankments, highways, runways and many other structures.



FACTORS AFFECTING COMPACTION

Water Content

At low water content, the soil is stiff and offers more resistance to compaction. As the water content is increased, the soil particles get lubricated. The soil mass becomes more workable and the particles have closer packing. The dry density of the soil increases with an increase in the water content till the O.M.C is reached.

Amount of compaction

The increase in compactive effort will increase the dry density at lower water content to a certain extent.

1. Type of soil

The dry density achieved depends upon the type of soil. The O.M.C and dry density for different soils are different

2. Method of compaction

The dry density achieved depends on the method of compaction

Geology

Geology describes the structure of the Earth on and beneath its surface, and the processes that have shaped that structure. Geologists study the mineralogical composition of rocks in order to get insight into their history of formation.

Properties of Minerals

The following physical properties of minerals can be easily used to identify a mineral:

1. Color
2. Streak
3. Hardness
4. Cleavage or Fracture
5. Crystalline Structure
6. Diaphaneity or Amount of Transparency
7. Tenacity
8. Magnetism
9. Luster
10. Odor
11. Taste
12. Specific Gravity

Properties of Rocks

1. The qualitative and quantitative mineral composition of the rock.

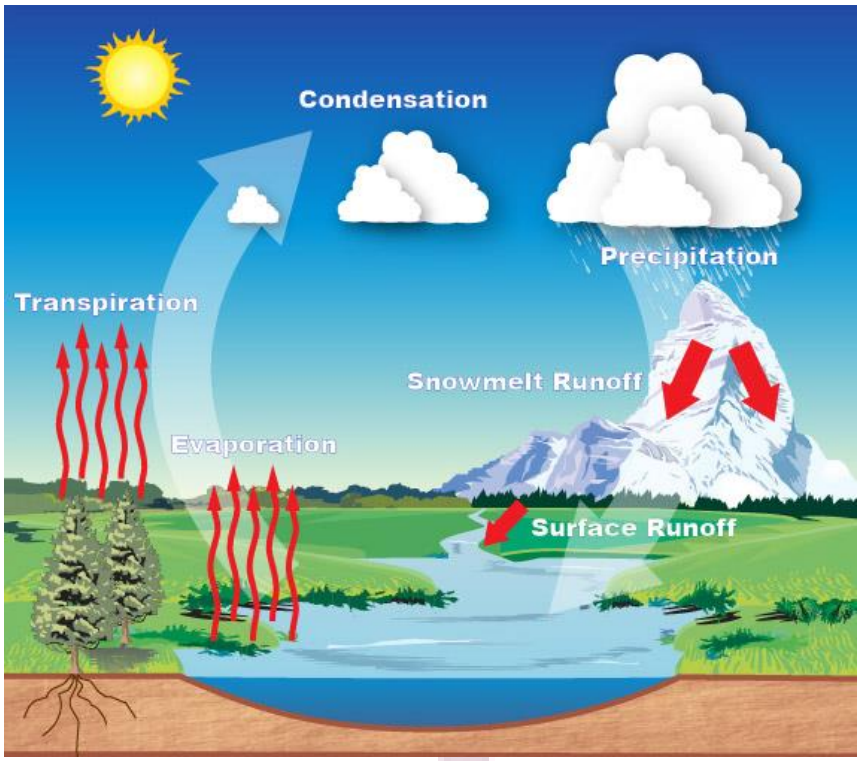
2. The structure (granulomere composition) and texture of the rock,

the internal structure of the crystals,

the character and properties of the inter crystalline cement.

UNIT 4

The Hydrologic Cycle



The basic hydrologic (water) cycle

The hydrologic cycle involves the continuous circulation of water in the Earth-Atmosphere system. At its core, the water cycle is the motion of the water from the ground to the atmosphere and back again. Of the many processes involved in the hydrologic cycle, the most important are…

- Evaporation
- Transpiration
- Condensation
- Precipitation
- Runoff

Evaporation

Evaporation is the change of state in a substance from a liquid to a gas. In meteorology, the substance we are concerned about the most is water.

For evaporation to take place, energy is required. The energy can come from any source: the sun, the atmosphere, the earth, or objects on the earth such as humans.

Everyone has experienced evaporation personally. When the body heats up due to the air temperature or through exercise, the body sweats, secreting water onto the skin.

The purpose is to cause the body to use its heat to evaporate the liquid, thereby removing heat and cooling the body. It is the same effect that can be seen when you step out of a shower or swimming pool. The coolness you feel is from the removing of bodily heat to evaporate the water on your skin

Characteristics of Precipitation in India

India experiences a monsoon climate with two major and two transitional periods of rainfall. These are caused by monsoon winds generated at different times and moving inland from the Arabian Sea in the west and the Bay of Bengal in the east.

(i) South-West Monsoon (June–Sep)

The south-west monsoon is popularly known as monsoon. It is the principal rainy season of India, when 75% of annual rainfall is received over a major portion of the country, except south-eastern part and Jammu & Kashmir. The heavy rainfall areas are:

Assam and north eastern region (200-400 cm)

West coast and Western Ghats (200-300 cm)

West Bengal (120-160 cm)

UP, Haryana and Punjab (100-120 cm)

(ii)Transition I, Post-Monsoon (Oct-Nov)

In this period rainfall occurs in the south eastern part (Tamil Nadu), often accompanied by cyclonic storms coming from over Bay of Bangal, that also affect the neighbouring state of Andhra Pradesh.

(iii)Winter Season (Dec-Feb)

In this period moderate to heavy rainfall and snowfall (25 cm) occurs in the Himalayas and Jammu & Kashmir. The areal spread of winter rain is experienced over many regions in north India but with reduced quantity. The rainfall in India during the non-monsoon seasons (particularly, winter) is also augmented by ‘Western Disturbances’, which normally refers to the

movement of water vapour laden air from the Mediterranean sea towards east. Winter rain is useful for the winter season (Rabi season) crops in meeting a part of their water requirement.

(iv) Transition II, Summer (March-May)

There is very little rainfall in India in this season.

Annual Rainfall

Considerable areal variation exists in the annual rainfall in India with high rainfall of the magnitude 200cm in Assam and north-eastern parts and the Western Ghats, and scanty rainfall in eastern Rajasthan and parts of Gujarat, Maharashtra and Karnataka. The average annual rainfall for the entire country is estimated as 119 cm.

7.2 Raingauge

Raingauge measures the depth and intensity of rainfall.

Types of Raingauge:

(a) Non-recording

(b) Recording

(a) Non-Recording Type Raingauges:

There are two types of non-recording raingauges

(i) Symon's gauge.

(ii) Standard raingauge

(i) Symon's Gauge

The non-recording type rain gauge commonly used in India is the Symon's gauge.

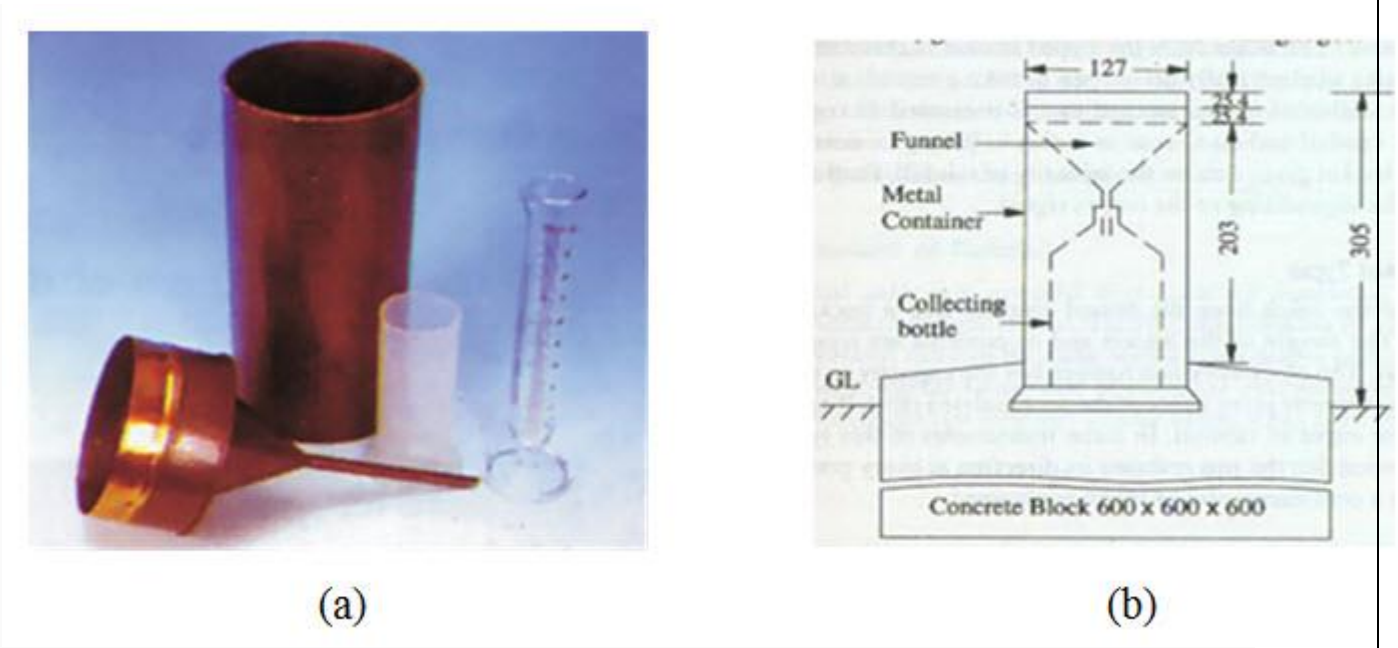


Fig. 7.1. Symon's gauge.

It consists of a circular collecting area of 127 mm diameter which is connected to a funnel. The rim of the collector is set at a height of 30.5 cm above the ground level. The funnel discharges the rainfall into a receiving vessel. The funnel and receiving vessels are housed in a metallic container. The receiving bottle normally holds a maximum of 10 cm of rain and in case of heavy rainfall the measurement must be done frequently. Last reading must be taken at 8.30 AM and the sum of the previous readings in the past 24 hours entered as the total rainfall of the day.

(ii) Standard Raingauge

This is a basic storage device that measures the cumulative amount of rain. A common type of these gauges is called the 8-inch Standard Rain Gauge (SRG), which has been used by the weather offices of US National Weather Service (NWS) for over 100 years. The standard gauge is simply a large cylinder with a funnel and a plastic measuring tube inside the cylinder.

ABSTRACTIONS FROM THE PRECIPITATION

• Abstraction from precipitation are losses from precipitation that do not show up as storm water runoff.

• Abstractions include:

• interception

• surface storage and detention

• bank storage

• evaporation

• transpiration

• infiltration

Rainfall Excess = Total rainfall - Abstraction

• Rainfall excess, or effective rainfall, is that rainfall that is neither retained on the land surface nor infiltrated into the soil. After flowing across the watershed surface, rainfall excess becomes direct runoff at the watershed outlet

Runoff Process

• Before Runoff can occur, precipitation must satisfy the demands of evaporation, interception, infiltration, surface storage, surface detention, and channel detention.

• After the infiltration rate is satisfied, water begins to fill the depressions, small and large, on the soil surface.

• As the depressions are filled overland flow begins.

• The depth of water builds up on the surface until it is sufficient to result in runoff in quilibrium with the rate of infiltration less infiltration and interception.

• The volume of water involved in the depth buildup is surface detention.

• As the flow moves into defined channels there is a similar build-up of water in channel detention.

Infiltration

• Infiltration is the passage of water into the soil surface and is distinguished from percolation, which is the movement of water through the soil profile.

Evaporation

Process whereby water in the liquid or solid state is returned to the Atmosphere.

Transpiration

Plants retain only a small amount of the water they actually need. Most moves from the roots, through the stem and trunk, and is Diffused into the atmosphere via the leaves (large tree, 180 lit/day: Small plant, 2 lit/day).

Evapotranspiration

An 'all-in' term combining evaporation and transpiration. 61% of Annual precipitation on land is returned to the atmosphere by Evapotranspiration.

It is defined as, "The quantity of water required by a crop in a given period of time for normal growth under field conditions." It includes evaporation and other unavoidable wastes. Usually water requirement for crop is expressed in water depth per unit area.

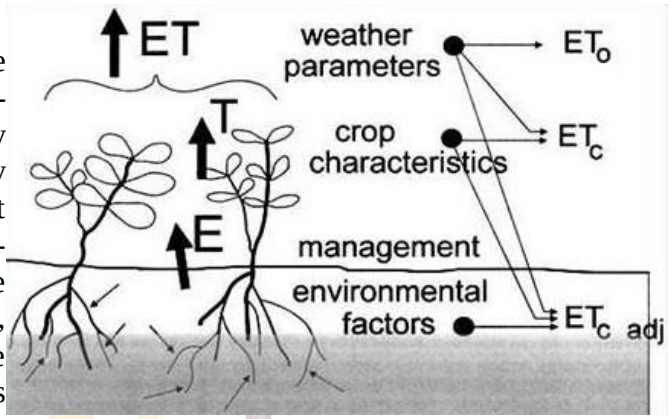
IRRIGATION WATER NEED = Crop water need — available rain fall

The first thing you need to consider when planning your garden is what growing zone you live in. This is based on both the temperature range of your climate and the amount of precipitation. Take a close look at the area in which you are going to plant your garden. If the ground tends to be very moist, choose plants that can tolerate constantly wet soil, and even standing water.

If you live in an area that suffers from frequent droughts, however, select plants that can tolerate going long periods without water, especially in light of the frequent watering restrictions

imposed on such areas. If you are lucky enough to live in an area that has a balanced climate, you have a wider range of choices for your plants.

Low Water Requirement Plants



Plants that require low levels of water are often called drought tolerant. Drought-tolerant plants can thrive in hot, dry conditions with very little water. They include both perennials and annuals. Most drought-tolerant plants only have to be hand-watered when they are planted and while they are establishing themselves. After that, they can be left to the natural cycle of the elements. Popular drought tolerant trees include the red cedar. live oak, crape myrtle, and the windmill and saw palmetto palm trees. All citrus trees are also drought tolerant. Many homeowners in areas prone to drought, such as parts of the southern United States, use shrubs and ground covering vines as part of their landscaping. These include Texas sage, orange jasmine and Chinese fountain grass. There are not many perennial drought-tolerant plants, but amaryllis is one that is very popular, along with the African iris. Popular drought-tolerant annuals include marigold, cosmos and the Dahlberg daisy.

Mid-Level Water Requirement Crops

Most plants land in this range when it comes to water requirements. These plants do not need to be watered every day, but they need to be watered when the soil has been dry for over a week or two. Sometimes these plants are classified as plants lying in the "occasional water zone". These include popular plants such as geraniums, most roses, wisteria, clematis and other vine plants, sunflowers, spring flowering bulbs, and most flowering perennial shrubs. Note that flowering annuals planted in containers will need watering at least once or twice a week, while annuals planted in the ground will need watering less often.

High Water Requirement Plants

Some plants require large amounts of water. These plants typically grow in marshy areas or bogs, or along the banks of rivers, streams and lakes. The soil for these plants should always be kept moist. Standing water is not a concern for these plants, so you don't have to worry about root rot. Perennials are especially good for wet areas because they don't have to be replanted year after year, which can be difficult in marshy areas. Popular perennials for wet soil include iris plants, cannas, bee balms, ferns, and bog salvia. Aquatic mint is a pleasant ground cover that likes wet soil. The red osier dogwood does very well in wet conditions. Most annual flowering plants also do well in constantly moist soil.

Amount of water required by a crop in its whole production period is called water requirement. The amount of water taken by crops vary considerably. What crops use more water and which ones less.....

Canal Lining is an impermeable layer provided for the bed and sides of canal to improve the life

Crop	Water Requirement (mm)
Rice	900-2500
Wheat	450-650
Sorghum	450-650
Maize	500-800
Sugarcane	1500-2500
Groundnut	500-700
Cotton	700-1300
Soybean	450-700
Tobacco	400-600
Tomato	600-800
Potato	500-700
Onion	350-550
Chillies	500
Sunflower	350-500
Castor	500
Bean	300-500
Cabbage	380-500
Pea	350-500
Banana	1200-2200
Citrus	900-1200
Pineapple	700-1000
Gingelly	350-400
Ragi	400-450
Grape	500-1200

and discharge capacity of canal. 60 to 80% of water lost through seepage in an unlined canal can be saved by construction canal lining.

Fig 1: Canal Lining

Types of Canal Linings

Canal linings are classified into two major types based on the nature of surface and they are:

1. **Earthen type lining**
2. **Hard surface lining**

1. Earthen Type lining

Fig 4: Cement Concrete Lining

Brick Lining

In case of brick lining, bricks are laid using cement mortar on the sides and bed of the canal. After laying bricks, smooth finish is provided on the surface using cement mortar.

Fig 5: Construction of Brick Canal Lining

Plastic Lining

Plastic lining of canal is newly developed technique and holds good promise. There are three types of plastic membranes which are used for canal lining, namely:

- Low density poly ethylene
- High molecular high density polythene
- Polyvinyl chloride

Advantages of Canal Lining

1. It reduces the loss of water due to seepage and hence the duty is enhanced.
2. It controls the water logging and hence the bad effects of water-logging are eliminated.
3. It provides smooth surface and hence the velocity of flow can be increased.
4. Due to the increased velocity the discharge capacity of a canal is also increased.
5. Due to the increased velocity, the evaporation loss also can be reduced.
6. It eliminates the effect of scouring in the canal bed
7. The increased velocity eliminates the possibility of silting in the canal bed.
8. It controls the growth of weeds along the canal sides and bed.
9. It provides the stable section of the canal.
10. It reduces the requirements of land width for the canal, because smaller section of the canal can be used to produce greater discharge.
11. It prevents the sub-soil salt to come in contact with the canal water. 12. It reduces the maintenance cost for the canals.

Disadvantages of Canal Lining

1. The initial cost of the canal lining is very high. So, it makes the project very expensive with respect to the output.

2. It involves many difficulties for repairing the damaged section of lining.
3. It takes too much time to complete the project work.
4. It becomes difficult, if the outlets are required to be shifted or new outlets are required to be provided, because the dismantling of the lined section is difficult.

Various types of dams

Dams can be classified in number of ways. But most usual ways of classification of dams are mentioned below:

Based on the functions of dam, it can be classified as follows:

Storage dams: They are constructed to store water during the rainy season when there is a large flow in the river. Many small dams impound the spring runoff for later use in dry summers. Storage dams may also provide a water supply, or improved habitat for fish and wildlife. They may store water for hydroelectric power generation, irrigation or for a flood control project. Storage dams are the most common type of dams and in general the dam means a storage dam unless qualified otherwise.

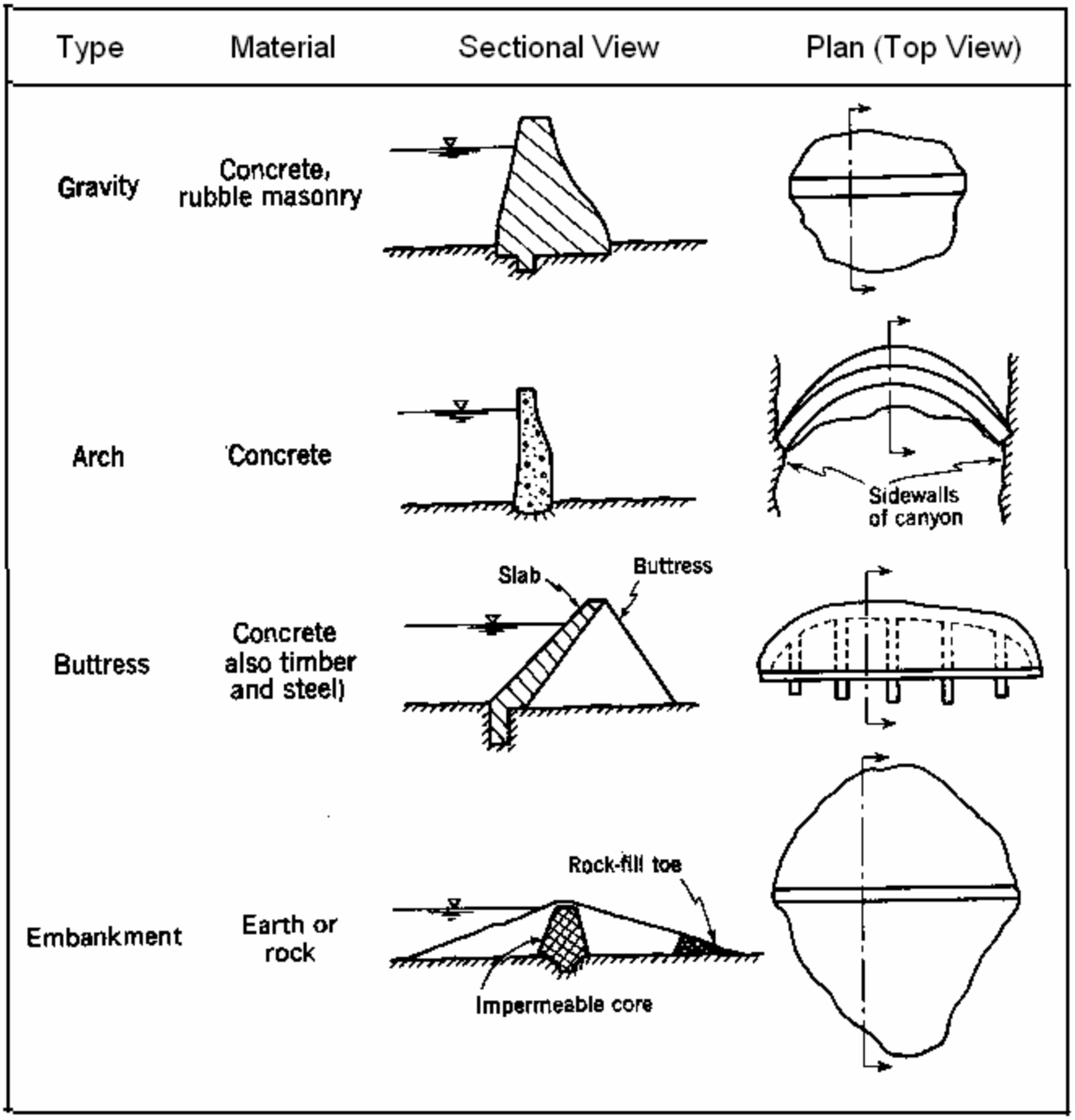
Diversion dams: A diversion dam is constructed for the purpose of diverting water of the river into an off-taking canal (or a conduit). They provide sufficient pressure for pushing water into ditches, canals, or other conveyance systems. Such shorter dams are used for irrigation, and for diversion from a stream to a distant storage reservoir. A diversion dam is usually of low height and has a small storage reservoir on its upstream. The diversion dam is a sort of storage weir which also diverts water and has a small storage. Sometimes, the terms weirs and diversion dams are used synonymously.

Detention dams: Detention dams are constructed for flood control. A detention dam retards the flow in the river on its downstream during floods by storing some flood water. Thus the effect of sudden floods is reduced to some extent. The water retained in the reservoir is later released gradually at a controlled rate according to the carrying capacity of the channel downstream of the detention dam. Thus the area downstream of the dam is protected against flood.

Debris dams: A debris dam is constructed to retain debris such as sand, gravel, and drift wood flowing in the river with water. The water after passing over a debris dam is relatively clear

Coffer dams: It is an enclosure constructed around the construction site to exclude water so that the construction can be done in dry. A **cofferdam** is thus a temporary dam constructed for facilitating construction. A coffer dam is usually constructed on the upstream of the main dam to divert water into a diversion tunnel (or channel) during the construction of the dam. When the flow in the river during construction of the dam is not much, the site is usually enclosed by the coffer dam and pumped dry. Sometimes a coffer dam on the downstream of the dam is also required.

Based on structure and design, dams can be classified as follows:



Gravity Dams: A gravity dam is a massive sized dam fabricated from concrete or stone masonry. They are designed to hold back large volumes of water. By using concrete, the weight of the dam is actually able to resist the horizontal thrust of water pushing against it. This is why it is called a gravity dam. Gravity essentially holds the dam down to the ground, stopping water from toppling it over.

Gravity dams are well suited for blocking rivers in wide valleys or narrow gorge ways. Since gravity dams must rely on their own weight to hold back water, it is necessary that they are built on a solid foundation of bedrock.

Examples of Gravity dam: Grand Coulee Dam (USA), (Nagarjuna Sagar Dam (India) and Itaipu Dam (Between Brazil and Paraguay).

Earth Dams: An earth dam is made of earth (or soil) built up by compacting successive layers of earth, using the most impervious materials to form a core and placing more permeable substances on the upstream and downstream sides. A facing of crushed stone prevents erosion by wind or rain, and an ample spillway, usually of concrete, protects against catastrophic washout should the water overtop the dam. Earth dam resists the forces exerted upon it mainly due to shear strength of the soil. Although the weight of the earth dam also helps in resisting the forces, the structural behavior of an earth dam is entirely different from that of a gravity dam. The earth dams are usually built in wide valleys having flat slopes at flanks (abutments).The foundation requirements are less stringent than those of gravity dams, and hence they can be built at the sites where the foundations are less strong. They can be built on all types of foundations. However, the height of the dam will depend upon the strength of the foundation material.

Examples of earthfill dam: Rongunsky dam (Russia) and New Cornelia Dam (USA).

Rockfill Dams: A rockfill dam is built of rock fragments and boulders of large size. An impervious membrane is placed on the rockfill on the upstream side to reduce the seepage through the dam. The membrane is usually made of cement concrete or asphaltic concrete. In early rockfill dams, steel and timber membrane were also used, but now they are obsolete.

A dry rubble cushion is placed between the rockfill and the membrane for the distribution of water load and for providing a support to the membrane. Sometimes, the rockfill dams have an impervious earth core in the middle to check the seepage instead of an impervious upstream membrane. The earth core is placed against a dumped rockfill. It is necessary to provide adequate filters between the earth core and the rockfill on the upstream and downstream sides of the core so that the soil particles are not carried by water and piping does not occur. The side

slopes of rockfill are usually kept equal to the angle of repose of rock, which is usually taken as 1.4:1 (or 1.3:1). Rockfill dams require foundation stronger than those for earth dams.

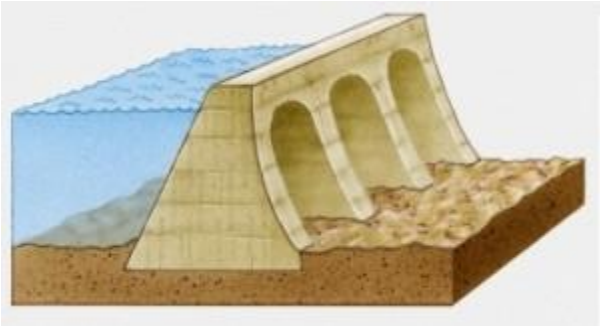
Examples of rockfill dam: Mica Dam

Arch Dams: An arch dam is curved in plan, with its convexity towards the upstream side. An arch dam transfers the water pressure and other forces mainly to the abutments by arch action. An arch dam is quite suitable for narrow canyons with strong flanks which are capable of resisting the thrust produced by the arch action.

The section of an arch dam is approximately triangular like a gravity dam but the section is comparatively thinner. The arch dam may have a single curvature or double curvature in the vertical plane. Generally, the arch dams of double curvature are more economical and are used in practice.

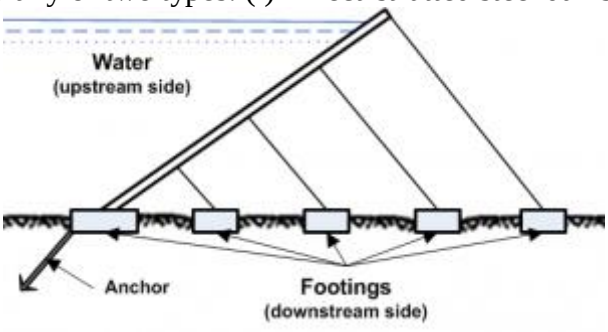
Examples of Arch dam: Hoover Dam (USA) and Idukki Dam (India)

Buttress Dams: Buttress dams are of three types : (i) Deck type, (ii) Multiple-arch type, and (iii) Massive-head type. A deck type buttress dam consists of a sloping deck supported by buttresses. Buttresses are triangular concrete walls which transmit the water pressure from the deck slab to the foundation. Buttresses are compression members. Buttresses are typically spaced across the dam site every 6 to 30 metre, depending upon the size and design of the dam. Buttress dams are sometimes called hollow dams because the buttresses do not form a solid wall stretching across a river valley.The deck is usually a reinforced concrete slab supported between the buttresses, which are usually equally spaced.



In a multiple-arch type buttress dam the deck slab is replaced by horizontal arches supported by buttresses. The arches are usually of small span and made of concrete. In a massive-head type buttress dam, there is no deck slab. Instead of the deck, the upstream edges of the buttresses are flared to form massive heads which span the distance between the buttresses. The buttress dams require less concrete than gravity dams. But they are not necessarily cheaper than the gravity dams because of extra cost of form work, reinforcement and more skilled labor. The foundation requirements of a buttress dam are usually less stringent than those in a gravity dam.

Steel Dams: A steel dam consists of a steel framework, with a steel skin plate on its upstream face. Steel dams are generally of two types: (i) Direct-strutted steel dams, and (ii)



Steel Dam

Cantilever type steel dams. In a direct strutted steel dam, the water pressure is transmitted directly to the foundation through inclined struts. In a cantilever type steel dam, there is a bent supporting the upper part of the deck, which is formed into a cantilever truss. This arrangement introduces a tensile force in the deck girder which can be taken care of by anchoring it into the foundation at the upstream toe. Hovey suggested that tension at the upstream toe may be reduced by flattening the slopes of the lower struts in the bent. However, it would require heavier sections for struts. Another alternative to reduce tension is to frame together the entire bent rigidly so that the moment due to the weight of the water on the lower part of the deck is utilised to offset the moment induced in the cantilever. This arrangement would, however, require bracing and this will increase the cost. These are quite costly and are subjected to corrosion. These dams are almost obsolete. Steel dams are sometimes used as temporary coffer dams during the construction of the permanent dams. Steel coffer dams are supplemented with timber or earthfill on the inner side to make them water tight. The area between the coffer dams is dewatered so that the construction may be done in dry for the permanent dam.

Timber Dams: Main load-carrying structural elements of timber dam are made of wood, primarily coniferous varieties such as pine and fir. Timber dams are made for small heads (2-4 m or, rarely, 4-8 m) and usually have sluices; according to the design of the apron they are divided into pile, crib, pile-crib, and buttressed dams.

Timber Dam

The openings of timber dams are restricted by abutments; where the sluice is very long it is divided into several openings by intermediate supports: piers, buttresses, and posts. The openings are covered by wooden shields, usually several in a row one above the other. Simple hoists—permanent or mobile winches—are used to raise and lower the shields.

Factors Affecting Selection of Type of Dam

Whenever it is decided to construct a dam, the first question that one face is which type of dam will be most suitable and most economical? Following are the factors affecting selection of dam site by dam type.

1. Topography
2. Geology and Foundation Conditions
3. Availability of materials
4. Spillway size and location
5. Earthquake zone
6. Height of the Dam
7. Other factors such as cost of construction and maintenance, life of dam, aesthetics etc.

Tunnel and importance of tunnel

Tunnel construction for transport routes is becoming increasingly important worldwide. Transport is accelerated and optimum protection is provided for the environment and the landscape. Many tunnels are considered technological masterpieces and governments have honored tunnel engineers as heroes. Constructing a tunnel, however, is one of the most complex challenges in the field of civil engineering. Tunnels are attractive solutions for railways, roadways, public utilities and telecommunications

Tunnel and their types;

The Tunnel is the underground routes or passages driven through the ground without disturbing the overlying soil or rock cover. Their types of tunnel and classification of the tunnel.

Tunnels on the basis of their purpose can be classified into following three chief classes-

- Traffic tunnels
- Hydropower tunnels
- Public utility Tunnel

Traffic tunnel

Tunnels that are excavated to divert traffic load from the surface to subsurface routes for a short length to facilitate. The flow of traffic at the desired speed, maximum convenience and at minimum cost, are called traffic tunnels.

The railway tunnels, the highway tunnels, and the pedestrian tunnels all are types of traffic tunnels.

Traffic tunnels provide a convenient and cost-effective alternative to direct transportation like between two places separated by large obstacles such as mountains, hills, water bodies or even densely populated areas in the metropolitan cities.

Hydropower Tunnel

As the name suggests these tunnels are excavated for hydropower generation. They are driven through rocks carrying the water under gravity.

Public Utility Tunnel

These specific purpose tunnels excavated for disposal of urban waste, for carrying pipes, cables, and supplies of oil, also water, etc. Nowadays, they also excavated for underground parking and storage in densely populated cosmopolitan cities.

***Classification*:**

- Based on the purpose of the tunnel :
    1. Traffic tunnels
    2. Conveyance tunnels
- Based on the type of material for the construction of the tunnel :
    1. Tunnel in hard rock.
    2. Tunnel in soft rock.

3. Open cut tunnel.
4. The tunnel underneath the river bed or submarine tunnel.
5. Tunnel in quicksand.

- Based on the alignment of the tunnel :
    1. Saddle and base tunnel.
    2. Spiral tunnel.
    3. Off spur tunnel.
    4. Slope tunnel.
- Based on the shape of the tunnel :
    1. Circular tunnel.
    2. Egg-shaped tunnel.
    3. Horseshoe tunnel.
    4. Elliptical tunnel.
    5. Vertical walls with arch roof type.
    6. Polycentric.

Purposes of tunnel:

- They provide passageways for the railroad and automative vehicles through the mountain and underbodies of water.
- They provide access to mines.
- They act as conduits for water.
- They relieve congestion on surface roads.

Necessity of tunnels

1. To avoid long circuitous routes around a mountain or spur.
2. To avoid sliding of open-cut sides in sifter soils.
3. To connect by the shortest route to the two-terminal stations.
4. To avoid steep gradients in mountainous terrain, and maintain a high speed.
5. Tunnels under a riverbed are often economical.
6. To divert water for the generation of power.
7. To avoid valuable land or property.
8. To save maintenance cost which is generally lesser.

UNIT 5

Determination of water demand is indispensable when it comes to the design of a proper water work project. An accurate estimation of water demand helps to determine the quantities of water and moments when the water will be used therefore generating various demand patterns. The demand arises mainly for residential, institutional, industrial and public uses.

The different types of water demands and their variations are briefly described in this article.

- **Types of Water Demands**
    - 1. Domestic Water Demand
    - 2. Industrial Water Demand
    - 3. Institutional and Commercial Water Demand
    - 4. Public and Civil Use
    - 5. Fire Demand
    - 6. Waste and Thefts
- Per Capita Demand (q)
- Variations in Water Demand
    - 1. Maximum Daily Consumption
    - 2. Maximum Hourly Consumption
    - 3. Maximum Hourly Demand of maximum day
    - 4. Coincident demand or Coincident draft

Types of Water Demands
Water demands can be classified into:

1. Domestic Water Demand
2. Industrial Water Demand
3. Institutional and Commercial Water Demand
4. Demand for Public
5. Fire Demand
6. Waste and Theft

Variations in Water Demand
There are different variations in water demands which are calculated for the specific design of pipe mains, service reservoirs, source of supply, distribution system and pumps.

1. Maximum Daily Consumption
Maximum Daily Consumption = 180% of Average Daily Demand = 1.8q

Maximum daily consumption is the design water consumption for source of supply and pipe mains.

2. Maximum Hourly Consumption
Maximum hourly consumption = 150% of avg. hourly demand of max.day

= 1.5 x (Maximum daily demand/24)

= 1.5 x (1.8q/24) = 2.7 x (q/24)

Maximum hourly consumption = 2.7 x Annual Average hourly demand

3. Maximum Hourly Demand of maximum day

Maximum Hourly Demand of maximum day = 2.7q

4. Coincident demand or Coincident draft

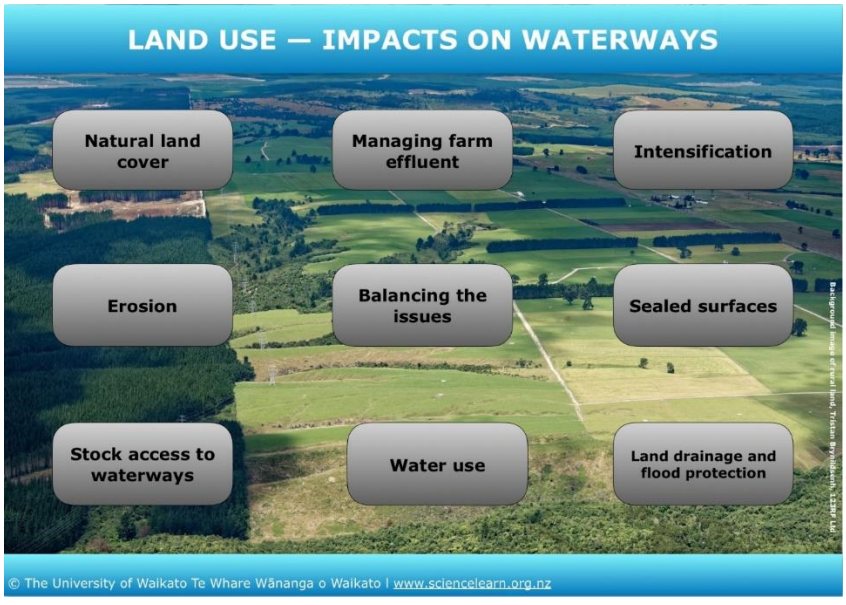
Maximum daily demand plus fire demand gives the coincident draft. This design water consumption is used for **distribution system.**

.**Factors affecting water quality**

The surveys test the water for ecological health (the ability of the waterway to support plants and animals) and the suitability for human use such as swimming and general water supply.

Many factors affect water quality, including:

- the geology of a stream – what the bottom or substrate of the stream is formed from
- the surrounding land cover, soil types and activities carried out on the land
- topography – the steepness of surrounding land
- the source – how much it is fed by overland flow or by water from springs and wetlands
- flow – affected by rainfall, catchment vegetation and soil and by water that is removed
- inputs such as run-off from the land, stormwater or discharges from industry
- the plants and animals that live in the stream and can change conditions within it – for example, introduced koi carp stir up sediment on the bed, making water muddy.



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Factors that Affect Water Quality

Many people take their water quality for granted. When you turn on a tap or faucet, you might not give the safety and cleanliness of your water a second thought. However, if you've ever been under a boil water notice, or if you notice a change in your water, you might be curious how to improve water quality at your home.

Whether you get your water from a water company or from a well, there are a number of factors that affect water quality in your home.

1. **Usage**. Interestingly enough, use (or overuse) of water can strain the water system and impact your water quality. In most cases (unless you use a private well), your family shares its water supply with others in the community. That collective use can put a strain on the system. Some areas might need to upgrade older wastewater treatment systems, leading to high water prices or water restrictions. Reduced ground water tables can also lead to increased concentrations of human-caused or natural pollutants.
2. **Pollution.** Dumping oil, grease, detergents, or pesticides down drains or in storm drains can pollute local sources of water that water companies draw on. Loose grass clippings and leaves can clog drainage systems, and pet droppings and septic tank overflows can have dangerous results when they reach drinking water. Water companies treat water to remove and eliminate contaminants and bacteria that reach the water supply. Many of these issues can be stopped by people taking action. Throw debris and garbage into the trash (not down any drain), don't flush prescriptions, and follow manufacturer instructions when applying fertilizer, pesticide, or herbicide.
3. **Runoff and sedimentation**. Unlike much of this list, both of these factors are environmental factors. Sediment can come from a variety of natural sources, like soil erosion or from the decomposition of living things. Water (or ice) and wind can carry thee particles into bodies of water and, later, your water supply. That mineral buildup
4. **Household plumbing and fixtures.** From your pipes to your taps, each part of your plumbing system can impact your water quality. Older household plumbing, including potential lead sources, can lead to water contamination. Even faucet aerators can make an impact: clean them and replace as needed to prevent sediment and metal buildup.
5. **Water heaters**. If you don't drain your water heater every year, you could see a buildup of sediment and bacteria. This buildup can negatively impact water quality and water pressure.

Drinking Water Quality Standards

WATER QUALITY PARAMETERS AND BIS STANDARDS FOR VARIOUS CHEMICAL AND BIOLOGICAL CONSTITUENTS

S.No.	Parameters	Drinking water IS 10500 : 2012	
		Permissible Limit	Maximum Limit
1	Odor	Agreeable	Agreeable
2	Taste	Agreeable	Agreeable
3	pH	6.5 to 8.5	No relaxation
4	TDS (mg/l)	500	2000
5	Hardness (as CaCO3) (mg/l)	200	600
6	Alkalinity (as CaCO3) (mg/l)	200	600
7	Nitrate (mg/l)	45	No relaxation
8	Sulfate (mg/l)	200	400
9	Fluoride (mg/l)	1	1.5
10	Chloride (mg/l)	250	1000
11	Turbidity (NTU)	5	10
12	Arsenic (mg/l)	0.01	0.05
13	Copper (mg/l)	0.05	1.5
14	Cadmium (mg/l)	0.003	No relaxation
15	Chromium (mg/l)	0.05	No relaxation
16	Lead (mg/l)	0.01	No relaxation
17	Iron (mg/l)	0.3	No relaxation
18	Zinc (mg/l)	5	15
19	Fecal Coliform (cfu)	0	0
20	E. Coli (cfu)	0	0

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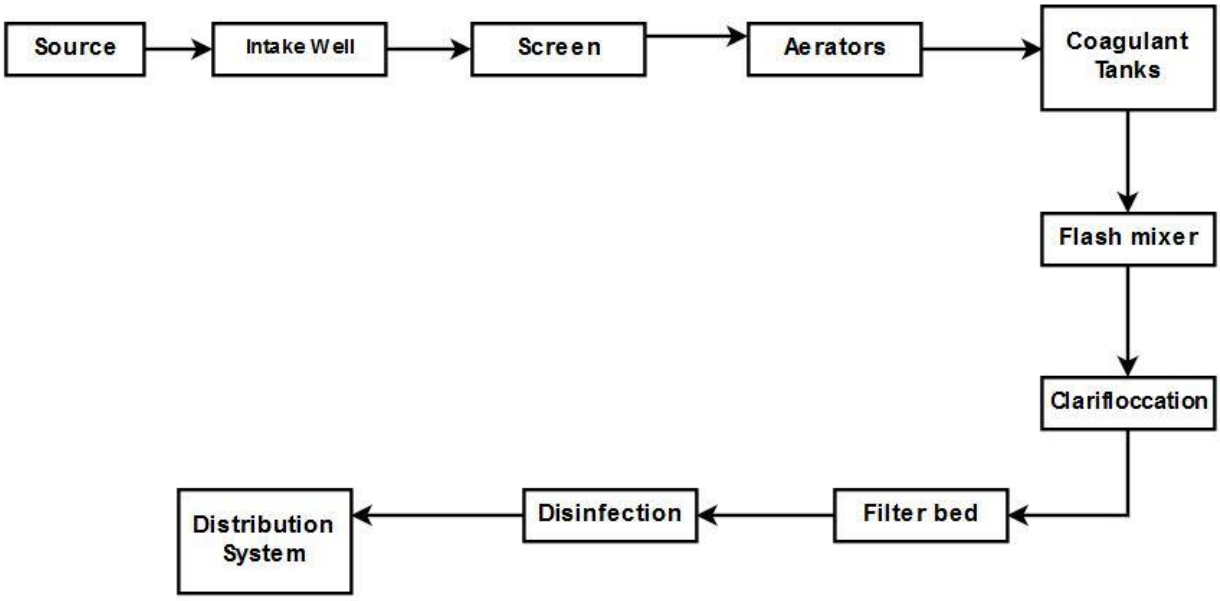
layout of water treatment units

Functions of each unit

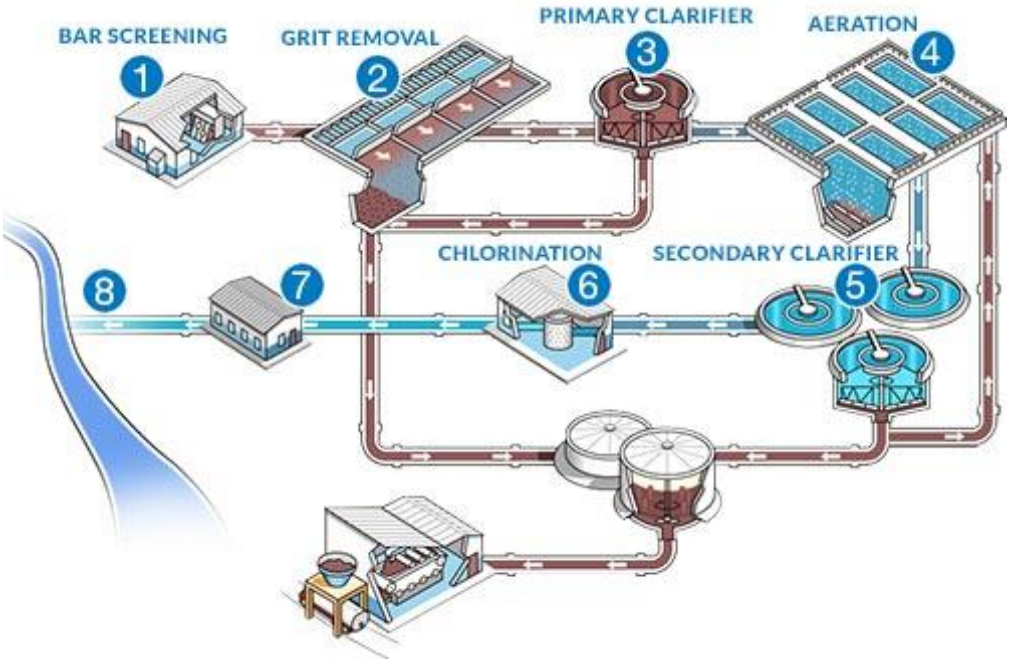
1. Intake well The raw water admitted from the source, in these wells, through the inlet opening having screen to separate the floating material.
2. Screen Screen are used to remove the floating, suspended material.
3. Aerators To remove the gases from the water, the raw water exposed to the air.
4. Coagulant tank It is Used to add the coagulant into the water.
5. Flash mixer In this unit, added coagulators are properly mixed.
6. Clari Floccurator • In this unit two process are done i.e. Flocculation and sedimentation. • Flocculation Floc are formed and in sedimentation Floc get settleddown.
7. Filter beds It helps to remove the fine and colloidal matter from the water.

8. Disinfection It helps to kill microorganisms and also to destroy organic impurities. This is important process for water treatment.



9. Distribution System Treated water convey to household.

Wastewater Process



Stage One — Bar Screening

Removal of large items from the influent to prevent damage to the facility's pumps, valves and other equipment.
The process of treating and reclaiming water from wastewater (any water that has been used in homes, such as flushing toilets, washing dishes, or bathing, and some water from industrial use and storm sewers) starts with the expectation that after it is treated it will be clean enough to reenter the environment.

The quality of the water is dictated by the Environmental Protection Agency (EPA) and the Clean Water Act, and wastewater facilities operate to specified permits by National Pollutant Discharge Elimination System (NPDES). According to the EPA, The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under the CWA, EPA sets wastewater standards for industry. The EPA has also developed national water quality criteria recommendations for pollutants in surface waters. EPA's National Pollutant Discharge Elimination System (NPDES) permit program controls discharges.

As an example of expected standards, the Biochemical Oxygen Demand (BOD) of average wastewater effluent is 200 mg/L and the effluent after treatment is expected to be >30 mg/L. It is crucial a wastewater facility meets these expectations or risk stiff penalty.

The physical process of wastewater treatment begins with screening out large items that have found their way into the sewer system, and if not removed, can damage pumps and impede water flow. A bar screen is usually used to remove large items from the influent and ultimately taken to a landfill.

Stage Two — Screening

Removal of grit by flowing the influent over/through a grit chamber.
Fine grit that finds its way into the influent needs to be removed to prevent the damage of pumps and equipment downstream (or impact water flow). Too small to be screened out, this grit needs to be removed from the grit chamber. There are several types of grit chambers (horizontal, aerated or vortex) which control the flow of water, allowing the heavier grit to fall to the bottom of the chamber; the water and organic material continue to flow to the next stage in the process. The grit is physically removed from the bottom of the chamber and discarded.

Stage Three — Primary Clarifier

Initial separation of solid organic matter from wastewater.
Solids known as organics/sludge sink to the bottom of the tank and are pumped to a sludge digestor or sludge processing area, dried and hauled away. Proper settling rates are a key indicator for how well the clarifier is operating. Adjusting flow rate into the clarifier can help the operator adjust the settling rates and efficiency.

After grit removal, the influent enters large primary clarifiers that separate out between 25% and 50% of the solids in the influent. These large clarifiers (75 feet in diameter, 7½ inches at the edges and 10½ feet in the center as an example) allow for the heavy solids to sink to the bottom and the cleaner influent to flow. The effectiveness of the primary clarification is a matter of appropriate water flow. If the water flow is too fast, the solids don't have time to sink to the bottom resulting in negative impact on water quality downstream. If the water flow is too slow, it impacts the process up stream.

The solids that fall to the bottom of the clarifier are know as sludge and pumped out regularly to ensure it doesn't impact the process of separation. The sludge is then discarded after any water is removed and commonly used as fertilizer.

Stage Four — Aeration

Air is pumped into the aeration tank/basin to encourage conversion of NH3 to NO3 and provide oxygen for bacteria to continue to propagate and grow.
Once converted to NO3, the bacteria remove/strip oxygen molecules from the nitrate molecules and the nitrogen (N) is given off as N2↑ (nitrogen gas).

At the heart of the wastewater treatment process is the encouragement and acceleration of the natural process of bacteria, breaking down organic material. This begins in the aeration tank. The primary function of the aeration tank is to pump oxygen into the tank to encourage the breakdown of any organic material (and the growth of the bacteria), as well as ensure there is enough time for the organic material to be broken down. Aeration can be accomplished with pumping and defusing air into the tank or through aggressive agitation that adds air to the water. This process is managed to offer the best conditions for bacterial growth. Oxygen gas [O2] levels below 2 ppm will kill off the bacteria, reducing efficiency of the plant. Dissolved oxygen monitoring at this stage of the plant is critical. Ammonia and nitrate measurements are common to measure how efficient the bacteria are in converting NH3 to N2↑.

A key parameter to measure in wastewater treatment is Biochemical Oxygen Demand (BOD). BOD is a surrogate indicator for the amount of organic material present and is used to determine the effectiveness of organic material breakdown. There are a number of other tests used to ensure optimal organic material breakdown (and BOD reduction) such as measuring pH, temperature,

Dissolved Oxygen (DO), Total Suspended Solids (TSS), Hydraulic Retention Time (flow rate), Solids Retention Time (amount of time the bacteria is in the aeration chamber) and Mixed Liquor Suspended Solids. Ongoing and accurate monitoring is crucial to ensure the final required effluent BOD.

Stage Five — Secondary Clarifier

Treated wastewater is pumped into a secondary clarifier to allow any remaining organic sediment to settle out of treated water flow.
As the influent exits the aeration process, it flows into a secondary clarifier where, like the primary clarifier, any very small solids (or fines) sink to the bottom of the tank. These small solids are called activated sludge and consist mostly of active bacteria. Part of this activated sludge is returned to the aeration tank to increase the bacterial concentration, help in propagation, and accelerate the breakdown of organic material. The excess is discarded.

The water that flows from the secondary clarifier has substantially reduced organic material and should be approaching expected effluent specifications.

Stage Six — Chlorination (Disinfection)

Chlorine is added to kill any remaining bacteria in the contact chamber.
With the enhanced concentration of bacteria as part of the aeration stage, there is a need to test the outgoing effluent for bacteria presence or absence and to disinfect the water. This ensures that higher than specified concentrations of bacteria are not released into the environment. Chlorination is the most common and inexpensive type of disinfection but ozone and UV disinfection are also increasing in popularity. If chorine is used, it is important to test for free-chlorine levels to ensure they are acceptable levels before being released into the environment.

Stage Seven — Water Analysis & Testing

Testing for proper pH level, ammonia, nitrates, phosphates, dissolved oxygen, and residual chlorine levels to conform to the plant's NPDES permit are critical to the plant's performance.
Although testing is continuous throughout the wastewater treatment process to ensure optimal water flow, clarification and aeration, final testing is done to make sure the effluent leaving the plant meets permit specifications. Plants that don`t meet permit discharge levels are subject to fines and possible incarceration of the operator in charge.

Stage Eight — Effluent Disposal

After meeting all permit specifications, clean water is reintroduced into the environment. Although testing is continuous throughout the wastewater treatment process to ensure optimal water flow, clarification and aeration, final testing is done to make sure the effluent leaving the plant meets permit specifications. Plants that don`t meet permit discharge levels are subject to fines and possible incarceration of the operator in charge.

AIR POLLUTION:

Every day, we take 23,000 breaths. I'm at home. I'm at work. You're in your automobile. On your way to work. That's quite a few breaths.

Breathing is something that most of us don't think about because it isn't something we can see. It's difficult to tell what's in the air around you when you can't see pollutants like invisible gases or particles.

Most people are unaware that according to the World Health Organization, more than 90% of the world's population breathes polluted air. Everyone is affected by this frightening figure, notably youngsters, the elderly, and asthmatics.

If you take a look at the causes of air pollution, you will realize that humans are primarily responsible for air pollution. The growing industrialization has positive and negative impacts on mankind and the environment. Also, the increasing rate of environmental pollution is one of the significant drawbacks that we are facing, resulting from our deeds. Before talking about the control of air pollution, we will have to understand their meaning.

Air Pollution Definition

Air pollution means contamination of air, water, or soil by any substance that is harmful to live organisms. It's like an introduction or release of a toxic substance into the environment, that can harm the elements in the environment. The pollution can take place because of natural (such as volcanic eruption), and man-made reasons. But nowadays, it's man-made reasons that are causing more pollution than natural ones. From the increasing number of vehicles to ever-growing industrial wastages in the form of air or water, each contributes to air pollution in some way.

Air Pollution

The air pollution definition says that when any physical, chemical, or biological change takes place in the air and contaminates it, then it is called air pollution. The contamination of air can be caused due to many factors such as poisonous or harmful gases, smoke, fog, smog, dust, etc. air pollution affects both plants as well as animals.

Types of Air Pollutants:

The air pollutants are divided into primary and secondary pollutants. Pollutants are those substances that cause air pollution.

- **Primary Pollutants:**

  The primary pollutants responsible for air pollution are the ones that directly cause air pollution. These include harmful gases such as sulfur dioxide coming from the factories. Primary pollutants are those that are produced as a direct result of the process. Sulfur dioxide, generated by factories, is a classic example of a primary pollutant.

- **Secondary Pollutants:**

  The secondary pollutants are formed by the process of intermixing or intermingling of primary pollutants. Smog, which is a combination of fog and smoke, is a secondary pollutant.

Causes of Air Pollution:

To prevent the pollution of air around, you have to understand the causes of air pollution at first. The main causes are –

- **Burning of Fossil Fuels:**

  Fossil fuel emits harmful gases such as sulfur dioxide and carbon monoxide into the air. One of the biggest causes of air pollution is sulfur dioxide, which is emitted through the combustion of fossil fuels such as coal, petroleum for energy in power plants, and other industry combustibles.

- **Automobiles:**

  The emission of harmful gases is caused by the excessive use of automobiles.

- **Agricultural Activities:**

  Various processes take place during agricultural activities such as the emission of ammonia, overuse of insecticides, pesticides, and fertilizers. Ammonia is a typical byproduct of agriculture and one of the most dangerous gases in the atmosphere. Insecticides, pesticides, and fertilizers have all become increasingly common in agricultural practices. They release hazardous chemicals into the atmosphere and can pollute water.

  Farmers also set fire to the fields and old crops to clear them up for the new cycle of sowing. According to reports, burning to clean up fields pollutes the air by emitting toxic pollutants.

- **Factories and Industries:**

  Emission of harmful gases and chemicals into the air by the increasing industrial activities. Manufacturing companies emit a significant amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air, lowering air quality.

  Manufacturing industries may be found in every corner of the globe, and no region has escaped their influence. Petroleum refineries also emit hydrocarbons and a variety of other pollutants, which damage the air and soil.

- **Mining Activities:**

  Increasing emission of harmful substances through mining activities. Mining is the extraction of minerals from under the earth's surface utilizing heavy machinery. Dust and chemicals are released into the air throughout the process, resulting in significant air pollution.

  This is one of the factors contributing to the deteriorating health of workers and inhabitants in the area.

- **Domestic Resources:**

  Effects of domestic sources such as the use of chemical paints and overuse of air conditioners. Household cleaning products and painting supplies release hazardous chemicals into the air, polluting the environment. Have you ever observed that when you paint your house's walls, it emits a noxious odor that makes it nearly impossible to breathe?

  Another source of pollution is suspended particle matter, sometimes known as SPM. SPM refers to the particles that float in the air and is typically caused by dust, combustion, and other factors.

Diseases caused by air pollution:

Air Pollution can lead to increasing diseases like throat infections and lung cancer in humans. Every year, diseases related to air pollution kill and hospitalize millions of people. According to

World Health Organization estimates, one out of every eight fatalities worldwide is caused by conditions related to air pollution. New research has found significant correlations between the development of respiratory and cardiovascular disorders and both outdoor and indoor air pollution. Ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD), lung cancer, and acute lower respiratory infections in children are among the most prevalent diseases induced by air pollution.

"Ischemic heart disease, or coronary heart disease," adds Kevin Wood, Vice President Sales & Marketing at Camfil USA, "is connected to the deposition of calcium or other materials like fat within the coronary artery." "This causes blockages, preventing blood from reaching the heart and other vital organs." According to new research, air pollution hastens the occlusion of arteries, increasing the risk of ischemic heart disease."

Effects of Air Pollution:

The air pollution information shows that increasing air pollution can have an adverse effect on plants, animals, and humans.

- **Global warming**

  Air Pollution can increase the amount of global warming as the temperature of the earth will keep rising with the emission of harmful gases. With rising global temperatures, rising sea levels, melting ice from colder places and icebergs, relocation, and habitat loss, an imminent crisis has already been signaled if preservation and normalization measures are not done soon.

- **Acid rain**

  When water droplets combine with harmful chemicals and pollutants, it will lead to acid rain. When fossil fuels are burned, harmful chemicals such as nitrogen oxides and sulfur oxides are emitted into the environment. When it rains, the water droplets interact with the contaminants in the air, becoming acidic and falling to the earth as acid rain. Acid rain has the potential to harm humans, animals, and agriculture.

- **Ozone layer Depletion**

  All this will eventually lead to depletion of the ozone layer that protects us from harmful UV sun rays. The presence of chlorofluorocarbons and hydrochlorofluorocarbons in the atmosphere is degrading the ozone layer on Earth.

  As the ozone layer thins, damaging rays are emitted back to Earth, potentially causing skin and eye problems. UV rays have the power to harm crops as well.
  Thus, we have to work on the prevention of air pollution.

Effects on Animals:

Increasing air pollution affects animals and aquatic life, leading them to stray and wander for food. Many of the animals are on the verge of extinction because of this. Animals, sometimes known as wildlife, are particularly vulnerable to the effects of air pollution. Acid rain, heavy

metals, persistent organic pollutants (POPs), and other harmful compounds are all pollution concerns.

Insects, worms, clams, fish, birds, and mammals all have diverse ways of interacting with their surroundings. As a result, each animal's exposure to and vulnerability to the effects of air pollution is unique.

Air pollution has two major effects on wildlife.

It has an impact on the area or habitat in which they reside, as well as the food supply's availability and quality.

Air Pollution Control

It is not easy to control air pollution, but it will require some simple steps like:

- **Avoid Using Vehicles**

  Prefer using public transport as it will reduce the emission of CO into the air. The availability of carpools can help in the reduction of vehicles which in turn reduces pollution. Prefer walking or cycling to nearby places and many such.

- **Energy Conservation**

  Use energy-efficient electrical devices at the workplace and home place. You can keep your lights switched off when not in use. The electrical appliances should be checked on a regular notice period so that it won't affect the conservation.

- **Use of Clean Energy Resources**

  It will help to reduce the pollution level. Instead of using fossil fuels, we can use natural resources to produce energy like Solar Energy, Wind Energy, etc.

  By decreasing and eliminating the usage of fire and fire-related items.

  Because industrial emissions are one of the leading causes of air pollution, the pollutants can be reduced by controlling or treating them at the source. If a given raw material's reactions produce a pollutant, for example, the raw materials can be replaced with less harmful materials.

  Another method of reducing pollution is to use different fuels. CNG – Compressed Natural Gas–powered vehicles are replacing petrol and diesel vehicles in many parts of India. Vehicles that aren't fully equipped with optimal emission engines are the most likely to use these.

  Although India has a number of practices aimed at improving air quality, most of them have been forgotten or are not well implemented. There are still many automobiles on the road that haven't had their emissions tested.