BALASORE COLLEGE OF ENGINEERING AND TECHNOLOGY, SERGARH, BALASORE

Lecture Notes

On

BASIC CIVIL ENGINEERING

1st Year **2nd Semester**

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Checked by
(Name & Designation)

SYLLABUS

Basic Civil Engineering

Module-I(6 Classes)

Introduction to Civil Engineering: Various disciplines of Civil engineering, Importance of Civil engineeringin infrastructure development of the country, interdisciplinary nature of construction projects.

Residential Buildings: NBC Classification, Basic Components of a building: Basic requirement. Planning and Design of buildings: fundamental requirements, selection of sites, Introduction to building design: functional and structural design.

Foundations: Classification, Bearing Capacity of Soil and related terms (definition only)

Module-II(6 Classes)

Fundamental Properties of Construction Materials: Physical, mechanical and durability properties.

Construction materials: stone, bricks, cement, aggregate, mortar, concrete, timber, steel, non-ferrous metals,paint, plastic, glass, adhesive, tiles, composites(Definition, classification and application),

Module-III(6 Classes)

Importance of Transportation, Transportation modes i.e. Highway, railway, airways, water, pipe and conveyor – Basic Characteristics, advantages and disadvantages. Indian road transport system: Types of roads, classification of highway, urban roads: basic requirements and classification. Basic Components of a Road, Rigid and Flexible pavement (comparison only)

Module-IV(6 Classes)

Quantity of water: Sources of water, Per capita demand, drinking water standards, Public Water Supply System: Necessity and Basic lay out. Conventional water treatment process: Screening, Plain Sedimentation, Sedimentation aided with Coagulation, Filtration, and Disinfection (working principles only).

Module-V(6 Classes)

Irrigation: Importance of Irrigation, Classification of Irrigation projects, Irrigation system: Types, Field water distribution, Multipurpose river valley projects, Dams: Purpose, types. Layout of canal Irrigation system: components and definitions.

Essential Reading:

- Basic Civil engineering, Gopi, S., Pearson Publication
- Basic Civil Engineering, Bhavikatti, S. S., New Age.

MODULE 1 CHAPTER 1

INTRODUCTION SESSION 1

Learning objective:

Students will be able to understand

- *Introduction to civil engineer.*
- *Scopes in civil engineering.*

1.1 Introduction to civil engineering

Civil engineering as the profession in which a knowledge of the mathematical and physical science gained by study experience and practical applied with judgement to develop ways to utilize economically the materials forces of nature for the progressive well -being of man.

1.2 Scope of different fields of civil Engineering

- Surveying
- Building material
- Construction technology
- Structural engineering
- Geotechnical engineering
- Hydraulics
- Water resources and irrigation engineering
- Environmental engineering
- Architecture and town planning

1.3 Broad classification of civil engineering: -

Civil engineering Can be classified:

1.3.1 Structural engineering- This discipline deals with the analysis and design of concrete and steel structure such as multi story building, bridges, towers etc. It deals with the study of durability and resistibility of such str. For live loads, wind and earthquake.

1.3.2 Water resources ad hydraulics- it covers the basic concepts of Water science and its related theorems and application. This includes the methods of transporting water form sources to distribution sites through proper channels.

1.3.3 Geotechnology engineering- The study of soil proportion of the construction site and its bearing capacity.

1.3.4 Environmental engineering – The study of the necessary methods and techniques of environmental protection as well as the availability of the basic life elements such as water air with a specific level of quality to protect the mankind health and environment.

1.3.5 Transportation engineering – It is the application of scientific and technological principles in the planning, functional design, operation and facilities management for any means of transport (road, rail, water and air) in order to provide a safe, fast, comfortable, convenient, economic travel for people and goods.

1.3.6 Construction engineering and management- Management of projects including planning and control of cost time quality.

Probable questions

1. What is civil engineering? What are its scopes? (6 marks)
2. Write down the classification in civil engineering? (6marks)

MODULE 1 CHAPTER 1

SESSION 2

Learning objective:

Students will be able to understand the

- *Importance of Civil engineering in infrastructure development*

Relevance of Civil Engineering in Overall Infrastructural Development

The world has realised that a government should not involve itself in production and distribution but develop infrastructure to create an atmosphere for economical development. The visible signs of current shortfalls include increasingly congested roads, power failures, shortage of drinking water, etc. These illustrate the widening gap between demand and supply of infrastructure.

- Infrastructure can be defined as the physical and organizational structures and facilities like buildings, roads etc. needed for the operation of a society. They are required for the economic development of the country
- The infrastructure requirements can be broadly grouped under the following categories: Buildings, Roads, Railways, Bridges, Airports, Dams and Canals, Electric Power Stations, Factories, Industrial Town ships

The role of Civil Engineering activities in the infrastructural development can be summarised as follows:

- To plan, design, build, supervise, operate and maintain civil engineering infrastructural projects and systems in public and private system
- Has to carry out research and training programs to improve the technology
- Key to modern civilization and facilities like transportation, communication, irrigation facilities etc., for the economical development of a country
- Economic Infrastructure – Contributes directly to the economic development of the country
- Social Infrastructure - Education and training, social welfare, housing, water supply etc. which will influence indirectly on economic development

- A proper planning of towns and extension areas in the cities.
- Fast rate of urbanisation and increase in the cost of land has forced civil engineers to go for vertical growth in cities. This has resulted in new building technologies and sophisticated analysis methods. Civil engineers have to solve problems of rural areas as well. Low cost housing is the need of the hour to make poor people afford their own houses.
- Water is an important need for all living beings. Civil engineers have to explore into various water resources and ensure water supply to urban areas throughout the year. Water is required for agriculture also.
- Good roadways and transportation facilities include another important amenity of the public which civil engineers deliver.
- Other important infrastructural activities of civil engineers are controlling pollution of air, water and land.

The impact of infrastructural development of a country

► Provide protection from drought, famine, flood, etc.

► Improved irrigation facilities → Better sewage system

► Improved education facilities

►Improvement in transportation and communication

►Generation of electricity from natural resource

► Increase in food production » Improved , wealth, prosperity & standard of living

The Importance of Civil Engineers

Civil engineers are responsible for designing, constructing, and maintaining the infrastructure that supports societies. In developing nations, the need for such infrastructure is even more critical, as it directly impacts the quality of life and economic growth. Here are some key reasons why civil engineers hold great significance:

- **Improving transportation systems:**

Civil engineers develop efficient transportation networks, including roads, bridges, and mass transit systems, to facilitate the movement of goods and people. This improves accessibility, connectivity, and trade capabilities within the country.

- **Enhancing access to clean water:**

By designing and implementing water supply and sanitation systems, civil engineers ensure that communities have access to clean and safe water. This contributes to better health, sanitation, and overall well-being.

- **Building sustainable energy solutions:**

Civil engineers play a crucial role in developing renewable energy projects, such as solar and wind farms. These projects help reduce dependence on fossil fuels, promoting environmental sustainability.

- **Promoting disaster resilience:**

Civil engineers assess and mitigate risks associated with natural disasters by designing resilient structures and implementing appropriate disaster management strategies. This helps minimize potential damages and save lives.

MODULE 1 CHAPTER 2

SESSION 3

Learning objective:

Students will be able to explain about

- *NBC classification*

As per NBC 2016 Part IV buildings are classified based on their occupancies, under the following categories:

Group A: Residential

A-1: Lodging and rooming houses
A-2: One or two family private dwellings
A-3: Dormitories
A-4: Apartment houses
A-5: Hotels
A-6: Starred hotels

Group B: Educational

B-1: Schools up to senior secondary level
B-2: All others/training institutions

Group C: Institutional

C-1: Hospitals and sanatoria
C-2: Custodial institutions
C-3: Penal and mental institutions

Group D: Assembly

D-1: Buildings having a theatrical or motion picture or any other stage and fixed seats for over 1000 persons
D-2: Buildings having a theatrical or motion picture or any other stage and fixed seats up to 1000 persons
D-3: Buildings without a permanent stage having accommodation for 300 or more persons but no permanent seating arrangement
D-4: Buildings without a permanent stage having accommodation for less than 300 persons with no permanent seating arrangement
D-5: All other structures including temporary structures designed for assembly of people not covered by Subdivisions D-1 to D-4, at ground level
D-6: Buildings having mixed occupancies of assembly and mercantile (for example, shopping malls providing facilities such as shopping, cinema theatres, multiplexes and restaurants/food courts)
D-7: Underground and elevated mass rapid transit system

Group E: Business

E-1: Offices, banks, professional establishments, like offices of architects, engineers, doctors, lawyers, post offices and police stations
E-2: Laboratories, outpatient clinics, research establishments, libraries and test houses
E-3: Electronic data processing centres, computer installations, information technology parks and call centres
E-4: Telephone exchanges
E-5: Broadcasting stations, T.V. stations and air traffic control towers

Group F: Mercantile

F-1: Shops, stores, departmental stores, markets (any with covered area up to 500 m2)
F-2: Shops, stores, departmental stores, markets (any with covered area more than 500 m2)
F-3: Underground shopping centres

Group G: Industrial

G-1: Buildings used for low hazard industries
G-2: Buildings used for moderate hazard industries
G-3: Buildings used for high hazard industries

Group H: Storage

These shall include any building or part of a building used primarily for the storage or sheltering (including servicing, processing or repairs incidental to storage) of goods, ware or merchandise (except those that involve highly combustible or explosive products or materials)

Group J Hazardous

These shall include any building or part thereof which is used for the storage, handling, manufacture or processing of highly combustible or explosive materials or products.

MODULE 1 CHAPTER 3

SESSION 4

Learning objective:

Students will be able to understand the

- *Components of a Building.*

Components of a Building

A building can be divided into two general categories:
1. Sub-Structure: It is the portion of a building situated underneath the surrounding ground.
2. Superstructure: The portion which is situated above the ground level is called superstructure.
The components of a building can be further divided as under:

i. Foundation

Foundation is the lowest part of a structure below the ground level which transfers all the loads (dead load, live load, etc.) to the soil.

ii. Plinth

The portion of a building between the ground surrounding the building and the top floor just above the ground is termed as plinth, A plinth is provided to prevent the surface water from entering the building.

iii. DPC

DPC aur damp proof course is a layer of waterproofing materials like asphalt, bitumen waterproof cement, etc. on which the walls are constructed.

iv. Walls

Walls are the vertical members on which the roof finally rest. Walls are provided to divide the floor space in the desired pattern. Walls provide privacy, security and protect from the sun, rain, wind, cold, etc.

v. Columns

Columns are the isolated load bearing members which carry the axial compressive load of a structure.

vi. Floors

Floors can be defined as flat supporting elements dividing a building into different levels (e.g., first floor, second floor, etc.) to create more accommodation on a given land. They provide a firm and dry platform for people and other items like furniture, equipment, stores, etc.

vii. Doors, Windows and Ventilation

Doors are provided as a barrier secured in an opening left in a wall to access the building, room or a passage. A window may be defined as an opening left in a wall for the purpose of providing daylight, vision, natural air and ventilation.

viii. Stairs

Stairs can be defined as a structure comprising a number of steps arranged in a series connecting one floor to another. Stairs are used to access various floors of the building.

ix. Roofs

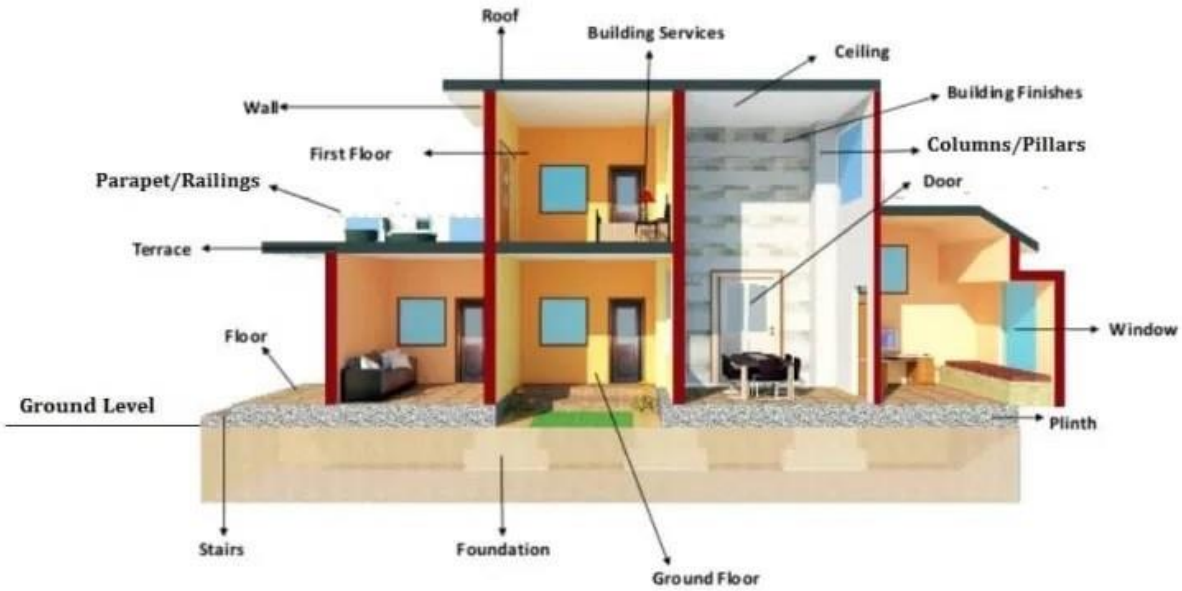
A roof is the top most part of a building that covers the space below and protects from rain, direct sunlight, snow, wind, etc.

x. Building Finishes

Building finishers include items like plastering, pointing, washing, painting, distempering, etc.

xi. Building Services

Building services includes services like water supply, drainage, lighting, sanitation, electricity, acoustics, ventilation, heating, air conditioning, fire detection and control, etc.



MODULE 1 CHAPTER 3

SESSION 5

Learning objective:

Students will be able to understand the

- *Basic requirements of a building planning and design.*

Here are some basic requirements for building planning and design:

- Design

  Building design should include proportion, continuity, harmony, simplicity, rhythm, and balance. Building elements should be balanced and in proportion to each other.

- Fire-resistive

  Fire protection is a critical consideration for architects, engineers, and contractors. It must also be considered in the ongoing maintenance of occupied spaces.

- Sound insulation

  Sound is one of the most important considerations in building design. The choice of building materials can have a significant impact on the amount of sound that is transmitted through a structure.

- Building permit

  A building permit is one of the most important things you need to get when you decide to build a home. This permit is required by the government since it helps them maintain and control the public and private structures located in a particular area.

- Location

  Location is THE most important aspect while building a house.

- Protection from termite

  Termite pretreatment is one of the most important things to include in any new home construction.

- Understand needs of special building types
  Most building projects will have building systems, assemblies, or performance features that will benefit from commissioning.

Some details about functional and structural design:

- Functional design

Functional design considers the needs and preferences of different users. It also considers the spatial needs, circulation, and defined function of a building. For example, a building should provide a well-lit environment both inside and outside.

- Structural design

Structural design is a methodical investigation of a structure's stability, strength, and rigidity. It involves modeling the structure's mechanical skeleton, including its foundations, columns, beams, frames, trusses, and other elements. Structural engineers use structural analysis to assess the forces that could act on a structure and to choose materials and reinforcements that will effectively withstand those forces.

The process of structural design involves the following steps:

1. Conceptual design
2. Load analysis
3. Structural analysis
4. System design
5. Element detailing
6. Iterative design and drafting
7. Construction administration

MODULE 1 CHAPTER 3

SESSION 5

Learning objective:

Students will be able to understand the

- *What is foundation and its types.*
- *What is bearing capacity?.*

FOUNDATION & BEARING CAPACITY OF SOIL

Bearing Capacity of Soil

This term is used to indicate the maximum load per unit area which the soil will resist safely without displacement. By dividing the ultimate bearing power of soil by a factor of safety, the safe bearing capacity is obtained. On completion of a structure, there may be some displacement in the position of the foundation. The maximum differential settlement should not exceed 25 mm in case of foundations on sandy soil and 40 mm in case of foundations on clayey soil.

In case of non-cohesive soils, such as sand and gravel, the allowable bearing capacity should be reduced by 50 per cent, provided that the water table is above or near the bearing surface of the soil. The bearing capacity of reclaimed soils or shrinkable soils can be taken as 50 kN/m2 in the absence of the site data. The bearing capacity of the soil can be found by loading the soil, noting the settlement and by dividing the maximum load by the area on which the load is applied. The maximum load is obtained from the graph between the load and settlement.

Methods of Improving Bearing Capacity of Soils

In some cases, the bearing capacity of soil is so low that the dimensions of the footings, work out to be very large and uneconomical. Under such situations, it becomes necessary to improve the bearing capacity of the soils, which can be done by the following methods.

(i) Increasing the depth of foundation
(ii) Compacting the soil.
(iii) Draining the subsoil water.
(iv) Confining the soil mass.
(v) Grouting with cement.

(vi) Chemical treatments like injecting silicates, etc.

Foundation

It is the portion of the building below ground level. This is given for stability of the building and to distribute the load coming from superstructure on a larger area.

Footings

These are stepped courses in the foundation having their base laid on concrete course and stepped inward by suitable offsets in stages till the thickness of the main wall is reached.

ESSENTIAL REQUIREMENTS OF A GOOD FOUNDATION

The following are the essential requirements of a good foundation:

1. The foundation should be so located that it is able to resist any unexpected future influence which may adversely affect its performance.

2. The foundation should be stable or safe against any possible failure.

3. The foundation should not settle or deflect to such an extent that will impair its usefulness.

TYPES OF FOUNDATION

Foundation may be broadly classified into the following two categories.

1. Shallow foundation

2. Deep foundation

A **shallow foundation** is one in which the depth is equal to or less than its width. When the depth is more than the width, it is termed as a **deep foundation.**

Shallow Foundation

When the depth of the foundation is less than or equal to its width, it is defined as a shallow foundation. The two main types of shallow foundation discussed in this section are the isolated footing and the combined footing. The various types of shallow foundations are

• Isolated column footing

• Wall footing

• Combined footing

• Cantilever footing

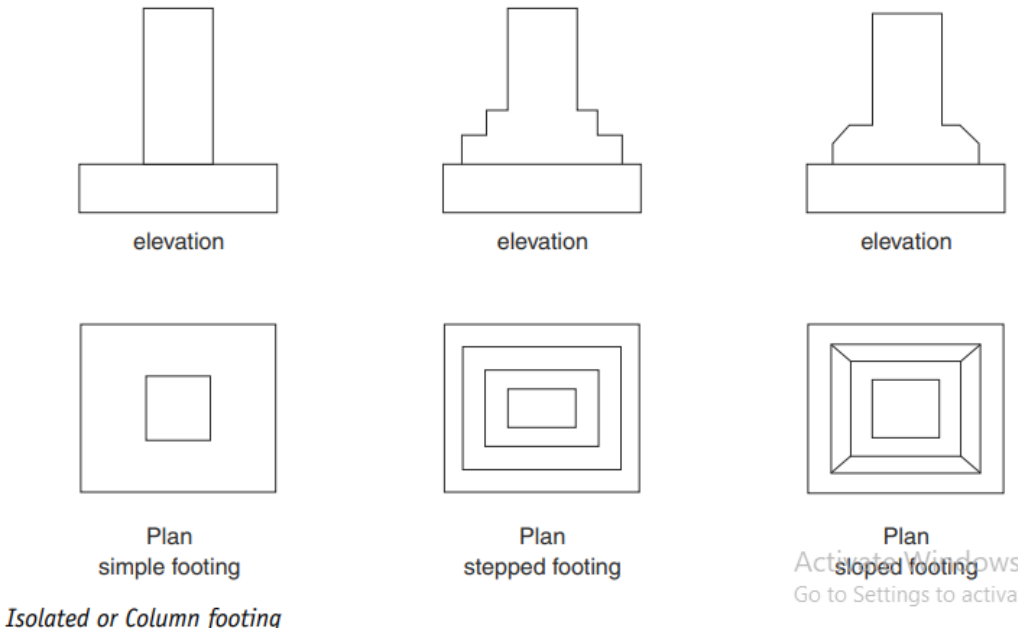
• Continuous footing

• Raft or Mat foundation

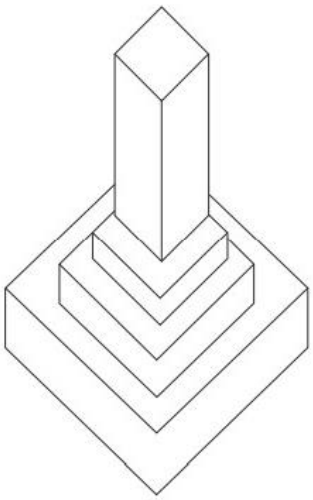
• Stepped Foundation

1. **Isolated footing**

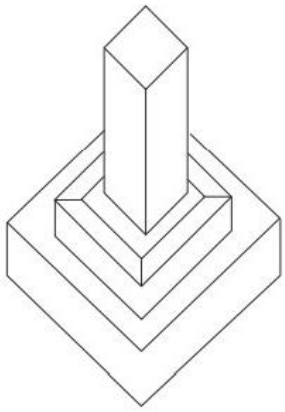
In framed structures where several columns are to be constructed, isolated footings can be adopted. The columns involved can be provided with masonry or concrete footing. If masonry footing is provided, steps are given and the foundation 4.18 Basic Civil Engineering area is thus increased so that the stresses developed at the base are within the limit. Concrete can be moulded to any shape and hence a concrete footing may be a sloping one to provide sufficient spread



Isolated or Column footing



Masonry footing



R.C.C. footing

2. Wall footing

If the footing is provided throughout the length of the wall in the case of load-bearing walls, then it is called wall footing. Wall footings can be either simple or stepped.

Depth of footing

The minimum depth of footing is given by the Rankine's formula as

, $D = P/W \left(\frac{1-\sin \emptyset^2}{1-\sin \emptyset}\right)$

D = minimum depth of footing

P = safe bearing capacity of soil in kg/m2

W = unit weight of soil in kg/m3

$\emptyset$ = angle of repose of soil in degrees

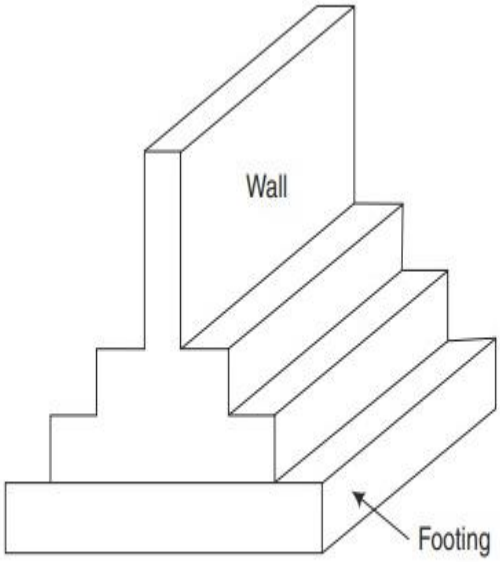


Fig. 4.4 *Wall footing*

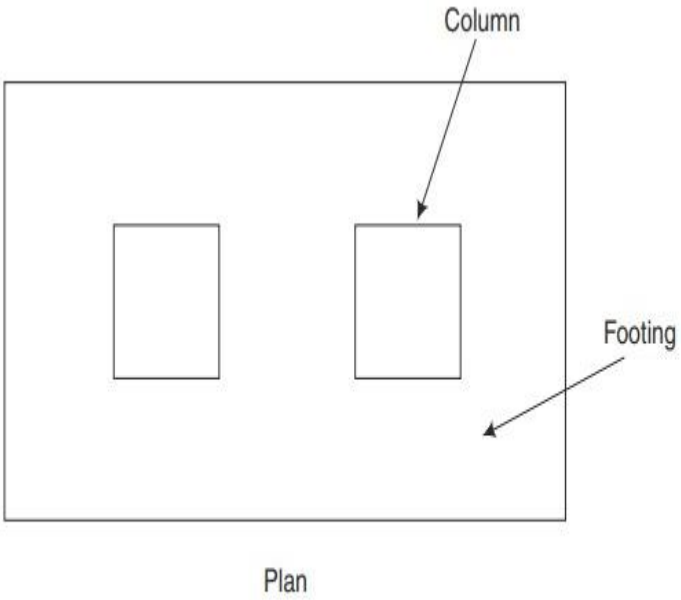


Fig. 4.5 *Combined footing*

3. Combined footing

This type of footing is adopted when the space between two columns is so small that the foundation for individual columns will overlap. Combined footings are proportioned in such a way that the centre of gravity of the loads coincides with the centre of gravity of the foundation. Hence these footings have either a trapezoidal or a rectangular shape. The plan of a combined footing is shown in Fig. If a footing is constructed for two or more columns, it is called combined footing. The shape of the combined footing is proportional in such a way that the centre of gravity of the resultant area is in the same vertical line as the centre of gravity of the loads. Generally, the shape of the footing is rectangular or trapezoidal as shown in Fig.

MODULE 2 CHAPTER 4

SESSION 7

Fundamental Properties of Construction Materials:

Physical, mechanical and durability properties

PROPERTIES OF BUILDING MATERIALS

1. Introduction

Building materials are found to be the basic elements for all engineering structures. So the behaviour of the structure depends on the behaviour of the basic elements, i.e. on the various characteristics and properties of the building material. Such properties may be classified into various categories as follows.

1. Physical properties
2. Mechanical properties
3. Chemical properties
4. Electrical properties
5. Magnetic properties
6. Optical properties
7. Thermal properties

From constructional aspects, the physical and mechanical properties are predominant. Hence it is essential for a civil engineer to have knowledge on the various physical and mechanical properties of building materials.

Physical Properties

Various physical properties of a building material are as follows.

- Bulk density
- Chemical resistance
- Coefficient of softening
- Density
- Density index
- Durability
- Porosity
- Specific heat
- Thermal conductivity
- Thermal capacity
- Water absorption
- Permeability

(i) **Bulk Density** It is defined as the mass per unit volume of material in its natural state, i.e., including volume of pores and voids.

(ii) **Chemical Resistance** The ability of the material to resist against the action of acids, alkalies, gases and salt solution is known as its chemical resistance. Chemical

resistance is carefully examined while selecting material for sewer pipes, hydraulic engineering installations, sanitary facilities, etc.

(iii) **Coefficient of Softening** It is the ratio of compressive strength of material saturated with water to that in dry state. Materials having coefficient of softening more than or equal to 0.8 are referred to as the water-resisting materials.

(iv) **Density** It is defined as the mass per unit volume of the material in its homogeneous state, i.e. neglecting the volume of pores and voids.

(v) **Density Index** The ratio of bulk density of the material to its density is known as its density index. Thus, it denotes the degree to which its volume is filled up with solid matter. Density index for most of the building materials is less than unity.

(vi) **Durability** The property of a material to resist the combined action of atmospheric and other factors is known as its durability. The life and maintenance cost of any structure depends upon the durability of the materials which it is composed of.

(vii) **Porosity** The degree by which the volume of material is occupied by pores is termed as porosity. It is the ratio of volume of voids to the total volume of the specimen.

(viii) **Specific Heat** The term specific heat indicates the quantity of heat (expressed in kilocalories) required to heat one N of material by one degree centigrade.

(ix) **Thermal Conductivity** Thermal conductivity of a material is defined as the amount of heat in kilocalories, that will flow through a unit area of the material with unit thickness in unit time and when the difference of temperature on its faces is also unity. The reciprocal of thermal conductivity of a material is termed as its thermal resistivity.

(x) **Water Absorption** The ability of a material to absorb and retain water is termed as its water absorption. It is expressed either as percentage of weight or percentage of volume of dry material. It mainly depends on the bulk density and porosity of the material.

(xi) **Permeability** The capacity of a material to allow water to pass through it under pressure is referred as its permeability. It denotes the quantity of water that will pass through a unit cross-sectional area of the material in one hour at constant pressure.

Mechanical Properties

The various mechanical properties of building material are as follows.

(i) Abrasion
(ii) Elasticity
(iii) Plasticity
(iv) Strength
(v) Impact strength
(vi) Wear
(vii) Fatigue
(viii) Hardness
(ix) Brittleness
(x) Ductility
(xi) Malleability
(xii) Toughness

(i) **Abrasion** It is the property of a material by which it resists the action of moving load. It is found by dividing the difference in weights of the specimen, before and after abrasion with the area of abrasion.

(ii) **Elasticity** The property by which a material regains its original shape and position after the removal of external load is known as elasticity.

(iii) **Plasticity** It is the property of a material, by which no deformation vanishes, when it is relieved from the external load.

(iv) **Strength** The ability of a material to resist failure under the action of external load is known as its strength. The loads to which a material is commonly subjected to are compression, tension and bending. The corresponding strength is obtained by dividing the ultimate load with the cross-sectional area of the specimen.

(v) **Impact strength** It is defined as the quantity of work required to cause failure per unit of its volume. Thus, the impact strength indicates the toughness of the material.

(vi) **Wear T**he failure of a material under the combined actions of abrasion and impact is known as its wear. It is usually expressed as a percentage of loss in weight and it is very important to decide the suitability of a material for use of road surfaces, railway ballast, etc.

(vii) **Fatigue** When the materials are subjected to repetitive fluctuating stress, they will fail at a stress much lower than that required to cause fracture under steady loads. This property is known as fatigue.

(viii) **Hardness** It is the ability of a material to resist penetration by a harder body. It plays an important role in deciding the workability and use of a material for floors and road surfaces. For stone materials, hardness can be determined with the help of Mohr's scale of hardness.

(ix) **Brittleness** A material is said to be brittle when it cannot be drawn into a wire by tension. A brittle material fails suddenly under pressure without appreciable deformation preceding the failure. Concrete, glass, cast-iron, rock materials, etc. are some of the examples of brittle materials.

(x) **Ductility** It is a property of a material by which it can be drawn into a wire by tension.

(xi) **Malleability** The property by which a material can be uniformly extended in a direction without rupture is known as malleability. This property finds its applications in many operations such as forging, hot rolling, etc.

(xii) **Toughness** Toughness is the property of a material that enables it to absorb energy without fracture. This property is useful in shock loading.

MODULE 2 CHAPTER 5

SESSION 7

Learning objective:

Students will be able to understand

- *What is stone?*
- *Different types of classification of stone.*

3.1 STONES:

Stones are derived from rocks, which form the earth's crust and have no definite shape or chemical combination but are mixture of two or more minerals.

3.1.1 Classification:

ROCKS are classified in four different ways.

1. Geological classification
2. Chemical Classification
3. Physical classification
4. Practical

1. Geological Classification

According to the mode of origin rocks are divided into three principal classes or groups.

i- Igneous Rock
ii- Sedimentary Rock
iii- Metamorphic Rock

i- Igneous Rock

The molten material present in the inside portion of earth's surface is known as magma and this magma occasionally tries to come out to the earth's surface through cracks or weak portions. This Rocks which are formed by the cooling of magma called igneous rock magma. Igneous reck are classified into the following three types.

a Plutonic Rock: - Formed by the cooling of magma at considerable depth from the earth's surface. These are coarsely gained crystalline structure. Used for construction. E.g.: - Granite

b **Hypabyssal Rock: -** Formed at a relatively shallow depth. These are also finely gained crystalline structure. E.g.- Dolerite

c **Volcanic Rock: -** Solidification on or near the surface of earth. Cooling is very rapid. E.g.: Basalt

ii- Sedimentary Rocks:

Formed by weathering action and subsequent transportation by air, river, glacier and sea. Ex:- Sandstone, limestone gypsum.

4 types

a. **Residual deposit: -** some portion of the products of wearing remains at the site of origin
b. **Sedimentary deposit: -** Product of weathering are carried away in suspension, and when such products are deposited, they give rise to sedimentary rocks
c. **Chemical deposit: -** Some material that is carried away in sol may be deposited by some physicochemical process such as evaporation and precipitation.
d. **Organic deposit: -** Product of weathering gets deposited through the agency of organisms.

iii- Metamorphic Rocks:

Formed by the change in character of the pre-existing rocks.

Igneous as well as sedimentary rocks change in character when they are subject to great heat and pressure. The process of change is known as metamorphism.

The four types of metamorphism that occur with various combination of heat, uniform pressure and directed pressure.

a Thermal Metamorphism: - Heat is predominant.
b Cataclastic Metamorphism: - Metamorphism is done by pressure
c Dynamo thermal Metamorphism: - Heat in combination with stress brings about the changes in the rock.
d Plutonic Metamorphism: - stress is effective only up to a certain depth. Metamorphism changes at great depths are therefore, brought about by uniform pressure and heat.

Example of metamorphic rock: - Marble, Quartzite. Slate.

1. **Chemical Classification:** - On the basis of dominant chemical composition the building stone may fall into a following category.
   - **i- Silicious Rock: -** silica predominates, hard & durable, not easily affected by weathering agencies. Silica is a weaker mineral may disintegrate easily. Ex-granite, quartzite etc.
   - **ii- Argillaceous Rocks: -** clay predominates. Such rocks may be dense and compact or they may be soft. Ex-Slates, laterites etc.
   - **iii- Calcareous Rocks:** Calcium carbonate predominates. Durability of these rocks will depend upon the constituents present in the surrounding atm. Ex Limestone, marbles etc.
3. **Physical Classification:** -classification is based on the general structure of rocks. 3 types.
   - **i- Stratified Rocks: -** Rocks possess planes of stratification. They can easily split up along these planes. E.g.: - sedimentary rock.
   - **ii- Unstratified Rocks:** - Rocks are unstratified. These str may crystalline granular or compact granular. E.g. – Igneous rock
   - **iii- Foliated Rocks: -** These rocks have a tendency to be split up in a definite direction only. E.g.: Metamorphic Rocks (gneiss)
4. **Practical Classification: -** Based on the usage. These are classified as granite, basalt laterite, marble, limestone, sandstone and slate.

3.1.2 Characteristics of stone: -

- **Density:** It simply refers to the cot. of a stone and is measured relative to the density of water. Most type of stone in the earth's crust have similar densities. A dense stone like granite will offer Superior durability and strength. Other example of dense stones include basalt, dolomite and slate.
- **Porosity: -** Porosity is the amount of open space between mineral grains in a stone (and generally dictates permeability). A very porous stone like sandstone, will absorb liquids quickly, they susceptible to staining, etching, spalling etc.
- **Permeability: -** Permeability is the ability of liquids to move through a store. While permeability is closely linked to porosity, a stone can have low porosity and high permeability depending on its grain structure.
- **Absorption**- Moisture reduced the strength of the rock and such rocks that contain or absorb great amount of moisture show lower strength values.
- **Durability**- It denotes the period in years for which a stone may stand practically unaltered after being used in

- **Hardness-** For use in structure subjected to vary heavy loading such as for constructing bridges, piers and abutments are marine structure and particularly where they are subjected and abrasion hardness of the stone is a necessary requirement.

3.1.3 Composition of stone-

- Silicate- These stones are mostly of quartz –like particles called silica. They are very hard, durable and generally acid resistance.
- Ex- Granite, sand stone, slate and quartzite.
- Calcium Carbonate- The minerals in these stones were formed under pressure over million years from the bodies of tiny fossilized creatures. These stones are softer, less durable.
- Ex- lime stone, marble.

Probable Questions:

1 Write the definition of stone? (2 marks)

Ans: Stones are derived from rocks, which form the earth's crust and have no definite shape or chemical combination but are mixture of two or more minerals.

2 Write down classification of stones/rocks? (6 marks)

3 Write down the composition of rock. (2 marks)

Ans: Silicate- These stones are mostly of quartz –like particles called silica. They are very hard, durable and generally acid resistance. Ex- Granite, sand stone, slate and quartzite.

Calcium Carbonate- The minerals in these stones were formed under pressure over million years from the bodies of tiny fossilized creatures. These stones are softer, less durable. Ex- lime stone, marble.

MODULE 2 CHAPTER 6

SESSION 8

Learning objective:

Students will be able to understand

- *What is brick?*
- *Importance of brick in construction.*

1.1 BRICK:

In the world of construction, bricks play a vital role. Traditionally the bricks were made of clay. The great wall of China was made of both burnt and sun-dried bricks.

2.1.1 Importance of brick:

- Fire protection: The brick does not catch fire or get affected by the heat very easily. Clay bricks have high temp resistance up to 2000-degree Fahrenheit.
- Wind Protection: - The houses made by bricks can bear stronger wind energy in comparison to houses constructed with vinyl and fiber.
- Moisture Control: - If the bricks are made with perfect clay heat and water combination, they become the best source of moisture control. These porous bricks can control moisture in the room better. than any other material.
- Minimal waste: - As it is mostly a just mixture of naturally occurring material the waste product is minimal.
- Countless recycling: - Bricks, are used in houses and when these houses are torn down for some reason, the remaining pieces can be used as a base for the foundation of the house or of a road.

Probable question

1 What is Brick? Explain. (2 marks)

2 What is importance of brick in construction? (6 marks)

MODULE 2 CHAPTER

Session

Learning objective:

Students will be able to understand

- *Factors for a good quality brick.*

2.1.2 Qualities of good bricks: -

A good brick should possess the following Properties

1. The brick should be uniform in shape and should be of standard size.
2. The brick when broken should show a uniform compact and homogeneous Structure free from voids.
3. The brick should not absorb water more than 20% of first-class brick and 22% fore and class bricks when soaked in cold water for a period of 24 hours.
4. The brick should be hard enough.
5. The brick should not break into pieces when dropped from a height of 1m.
6. The brick when soaked in water for 24 hours should not show deposits of white salts when allowed to dry in shade.
7. The brick should have low thermal conductivity and should be sound proof.
8. The crushing strength of brick should not be below 5.5 N/mm².

Probable question

What are the factors for a good quality brick? (6 marks)

MODULE 2 CHAPTER 7
SESSION 9

Learning objective:

Students will be able to understand

- *What is cement?*
- *Classification of cement.*

1.1 CEMENT

Cement is anything that binds, particularly a substance made of burned lime, clay, sand and water to make mortar or sand, water and gravel to make concrete.

4.1.1 Constituents of Cement

The general percentage of these ingredients in cement 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

4.1.2 Bogue's compound in cement

The Bogue's compounds (basic compounds) of Ordinary Portland Cement and their function are given in the table:

Bogue's Compounds	% by mass of cement	Properties & Function of bogue's compounds
Tri-calcium silicate (C3S)	25-50	It hydrates at a faster rate and produces higher heat of hydration. It is responsible for rapid hardening with an early gain in strength & has less resistance to chemical attack.
Di-calcium silicate(C2S)	20-45	It hydrates & hardens slowly and produces less heat of hydration. It provides much of the ultimate strength & has greater resistance to chemical attack.
Tri-calcium aluminate(C3A)	5-12	It is the first compound which starts hydrating. It produces the highest heat of hydration & responsible for the setting of cement.
Tetra-calcium alumino-ferrite (C4AF)	6-12	It hydrates rapidly but its individual contribution to the overall strength of cement is insignificant.

4.1.3 Classification of Cement

In the construction industry, there are different types of cement. The differences between each type of cement are its properties, uses and composition materials used during the manufacturing process.

Different Types of Cement:

1. Ordinary Portland Cement (OPC)

Ordinary Portland Cement also known as OPC is a type of cement that is manufactured and used worldwide. It is widely used for all purposes including:

- Concrete: When OPC is mixed with aggregates and water, it makes concrete, which is widely used in the construction of buildings
- Mortar: For joining masonry
- Plaster: To give a perfect finish to the walls

Ordinary Portland cement is also used to manufacture grout, wall putty, solid concrete blocks, AAC blocks, and different types of cement.

2. Portland Pozzolana Cement (PPC)

To prepared PPC or Portland Pozzolana cement, you need to grind pozzolanic clinker with Portland cement. PPC has a high resistance to different chemical assaults on concrete. It is widely used in construction such as:

- Marine structures
- Sewage works
- Bridges
- Piers
- Dams
- Mass concrete works

3. Rapid Hardening Cement

Rapid Hardening Cement is made when finely grounded C3S is displayed in OPC with higher concrete. It is commonly used in rapid constructions like the construction pavement.

4. Extra Rapid Hardening Cement

As the name suggests, Extra rapid hardening cement gains strength quicker and it is obtained by adding calcium chloride to rapid hardening cement. Extra rapid hardening cement is widely used in cold weather concreting, to set the cement fast. It is about 25% faster than that of rapid hardening cement by one or two days.

5. Low Heat Cement

Cement manufacturers offers low heat cement that is prepared by keeping the percentage of tricalcium aluminate below 6% and by increasing the proportion of C2S.

This low heat cement is used in mass concrete construction like gravity dams. It is important to know that it is less reactive and the initial setting time is greater than OPC.

6. Sulfates Resisting Cement

This type of cement is manufactured to resist sulfate attack in concrete. It has a lower percentage of Tricalcium aluminate. Sulfates resisting cement is used for constructions in contact with soil or groundwater having more than 0.2% or 0.3% g/l sulfate salts respectively. It can also be used in concrete surfaces subjected to alternate wetting and drying like bridge piers.

7. Quick Setting Cement

Cement suppliers offer quick setting cement which sets faster than OPC but the strength remains the same. In this formula, the proportion of gypsum is reduced. Quick setting cement is used for constructions that need a quick setting, like underwater structures and in cold and rainy weather conditions.

8. Blast Furnace Slag Cement

This type of cement is manufactured by grinding the clinker with about 60% slag and it is similar to Portland cement. It is used for constructions where economic considerations are important.

9. High Alumina Cement

High alumina cement is obtained by mixing calcining bauxite and lime with clinker during the manufacturing process of OPC. To be considered high alumina cement, the total amount of alumina content should be at least 32%, and the ratio of the weight of alumina to lime should be kept between 0.85 to 1.30. The most common uses are in constructions that are subject to high temperatures like a workshop, refractory, and foundries.

10. White Cement

This type of cement is manufactured by using raw materials that are free from iron and oxide. White cement needs to have lime and clay in a higher proportion. It is similar to OPC but it is more expensive.

Probable questions

1.2 What are main constituents in cement? (2 marks)

2.2 What is bogue's compound in cement what are its properties? (6 marks)

3.2 Write the types of cement? Explain. (16 marks)

MODULE 2 **CHAPTER 7**

SESSION 10

Learning objective:

Students will be able to understand

- *Tests for cement.*
- *Uses of cement.*

4.2 Tests for Cement

4.2.1 The following tests are conducted on cement in the laboratory are as follows:

1. Fineness Test

The fineness of cement is responsible for the rate of hydration, rate of evolution of heat and the rate of gain of strength. Finer the grains more is the surface area and faster the development of strength.

The fineness of cement can be determined by Sieve Test or Air Permeability test.

Sieve Test: Air-set lumps are broken, and the cement is sieved continuously in a circular and vertical motion for a period of 15 minutes. The residue left on the sieve is weighed, and it should not exceed 10% for ordinary cement. This test is rarely used for fineness.

Air Permeability Test: Blaine's Air Permeability Test is used to find the specific surface, which is expressed as the total surface area in sq.cm/g. of cement. The surface area is more for finer particles.

2. Consistency Test

This test is conducted to find the setting times of cement using a standard consistency test apparatus, Vicat's apparatus.

Standard consistency of cement paste is defined as that water content which will permit a Vicat plunger of 10 mm diameter and 50 mm length to penetrate depths of 33-35 mm within 3-5 minutes of mixing.

The test has to undergo three times, each time the cement is mixed with water varying from 24 to 27% of the weight of cement.

This test should be conducted at a constant temperature of 25°C or 29°C and at a constant humidity of 20%.

3. Setting Time Test

Vicat's apparatus is used to find the setting times of cement i.e., initial setting time and final setting time.

Initial Setting Time: For this test, a needle of 1 mm square size is used. The needle is allowed to penetrate into the paste (a mixture of water and cement as per the consistency test). The time taken to penetrate 33-35 mm depth is recorded as the initial setting time.

Final Setting Time: After the paste has attained hardness, the needle does not penetrate the paste more than 0.5 mm. The time at which the needle does not penetrate more than 0.5 mm is taken as the final setting time.

4. Strength Test

The strength of cement cannot be defined directly on the cement. Instead the strength of cement is indirectly defined on cement-mortar of 1:3. The compressive strength of this mortar is the strength of cement at a specific period.

5. Soundness Test

This test is conducted in Le Chatelier's apparatus to detect the presence of uncombined lime and magnesia in cement.

6. Heat of Hydration Test

During the hydration of cement, heat is produced due to chemical reactions. This heat may raise the temperature of concrete to a high temperature of 50°C. To avoid these, in large scale constructions low-heat cement has to be used. This test is carried out using a calorimeter adopting the principle of determining heat gain. It is concluded that Low-heat cement should not generate 65 calories per gram of cement in 7 days and 75 calories per gram of cement in 28 days.

7. Tensile Strength Test

This test is carried out using a cement-mortar briquette in a tensile testing machine. A 1:3 cement-sand mortar with the water content of 8% is mixed and moulded into a briquette in the mould. This mixture is cured for 24 hours at a temperature of 25°C or 29°C and in an atmosphere at 90% relative humidity. The average strength for six briquettes tested after 3 and 7 days is recorded.

8. Chemical Composition Test

Different tests are conducted to determine the amount of various constituents of cement. The requirements are based on IS: 269-1998, is as follows:

- The ratio of the percentage of alumina to that of iron oxide should not be less than 0.66.
- Lime Saturation Factor (LSF), i.e., the ratio of the percentage to that of alumina, iron oxide and silica should not be less than 0.66 and not be greater than 1.02.
- Total loss on ignition should not be greater than 4%.
- Total Sulphur content should not be greater than 2.75%.
- Weight of insoluble residue should not be greater than 1.50%.
- Weight of magnesia should not be greater than 5%.

4.2.2 The following tests should undergo before mixing the cement at construction sites:

1. Colour Test of Cement

The colour of the cement should not be uneven. It should be a uniform grey colour with a light greenish shade.

2. Presence of Lumps

The cement should not contain any hard lumps. These lumps are formed by the absorption of moisture content from the atmosphere. The cement bags with lumps should be avoided in construction

3. Cement Adulteration Test

The cement should be smooth if you rubbed it between fingers. If not, then it is because of adulteration with sand.

4. Float Test

The particles of cement should flow freely in water for some time before it sinks.

4.3 Uses of Cement

Cement is a very useful binding material in construction. The applications of cement over various fields of construction have made it a very important civil engineering material.

Some of the numerous functions of cement are given below.

1. It is used in mortar for plastering, masonry work, pointing, etc.
2. It is used for making joints for drains and pipes.
3. It is used for water tightness of structure.
4. It is used in concrete for laying floors, roofs and constructing lintels, beams, stairs, pillars etc.
5. It is used where a hard surface is required for the protection of exposed surfaces of structures against the destructive agents of the weather and certain organic or inorganic chemicals.
6. It is used for precast pipes manufacturing, piles, fencing posts etc.
7. It is used in the construction of important engineering structures such as bridges, culverts, dams, tunnels, lighthouses etc.
8. It is used in the preparation of foundations, watertight floors, footpaths etc.
9. It is employed for the construction of wells, water tanks, tennis courts, lamp posts, telephone cabins, roads etc.

Probable Questions

1. Narrate various tests on cement.
2. What are the uses of cement?

MODULE 2 CHAPTER 8

SESSION 11

Learning objective:

Students will be able to understand

- *What is aggregate.*
- *Types and Uses of aggregate.*

AGGREGATE

Aggregates are coarse to medium grained materials used in construction, such as sand, gravel, crushed stone, slag, recycled concrete, and geo artificial aggregates. They are also known as "metal" in the construction industry. Aggregates are used in construction to provide drainage, fill voids, protect pipes, and to provide hard surfaces. They are also used in water filtration and sewage treatment processes.

Aggregates are an indispensable ingredient in the construction and maintenance of rigid structures because they help to make concrete mixes more compact, decrease the consumption of cement and water, and contribute to the mechanical strength of the concrete. Aggregates generally account for 92 to 96 percent of Bituminous concrete and about 70 to 80 percent of Portland cement concrete by volume

Some basic properties of aggregates include:

- Mineralogical composition
- Surface texture and grain shape
- Dustiness
- Porosity
- Frost resistance
- Resistance to abrasion and polishing
- Asphalt absorption capacity

Some aggregates should be:

- Chemically inert
- Strong
- Hard
- Durable
- Of limited porosity
- Free from adherent coating
- Free from clay lumps
- Free from coal and coal residues

Aggregates can be of many types based on the different parameters. These parameters can be shape, size, strength, etc. Based on the size of the aggregates, they can broadly be classified as fine aggregate and coarse aggregate.

- **Fine aggregate:** This is the aggregate for which its size ranges between 4.75 mm to 0.075 mm. These are also called sand. These are the natural particles that the mining process can generate. It consists of the particle of the crushed stone or the sandy material.

- **Coarse aggregate:** These aggregates have a size of more than 4.75 mm. These aggregates are used in the construction of concrete structures. Such aggregates include river gravel and stone particles made from rock stratum.

Aggregates have many uses in the construction of various structures. Its use depends on the aggregates' size, shape and strength parameters. Aggregates are used to construct buildings, railway bridges, dams and other concrete structures. Using aggregates in concrete structures helps to bind the other ingredients in the concrete structures.

Aggregate enhances the strength of the concrete structures. The crushing strength of concrete is enhanced by using aggregate material. It increases the compactness of the aggregate. Its uses in concrete structures reduce the cement quantity in the concrete. Aggregates are used in different sizes in the concrete mix based on the required strength and compactness.

Classification of Aggregate

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

1. **Based on origin:** Natural and artificial
2. **Based on size:** According to size, aggregates are classified as coarse aggregate, fine aggregate and all-in-aggregate
   The aggregate retained on the 4.75 mm sieve is identified as coarse aggregate.
   Aggregate passing through a 4.75 mm sieve is defined as fine aggregate.
   Naturally available aggregates of different fractions of fine and coarse sizes are known as all-in-aggregate.
3. **Based on shape:** Aggregates are classified as rounded, irregular, angular, and flaky.

1. **Rounded aggregate:** These are generally obtained from rivers or sea shore and produce minimum voids (about 32 per cent) in the concrete.
2. **Irregular aggregate:** They have about 36 per cent voids and require more cement paste than the rounded aggregate. Because of their irregular shapes, they develop a good bond and are suitable for making ordinary concrete.
3. **Angular aggregate:** They have sharp, angular and rough particles having maximum voids (about 40 per cent). Angular aggregate provides a very good bond than the earlier two, are most suitable for high-strength concrete and pavements; the requirement of cement paste is relatively more.
4. **Flaky aggregate:** The least lateral dimension of flaky aggregate (thickness) should be less than 0.6 times the mean dimension.

Advantages of Aggregate in Concrete structures

Aggregate in civil engineering is hard structures made from the disintegration of rocks. It can be used in the designing of concrete structures and other structures. It is a durable and high-strength material. It has many advantages in the construction of concrete structures. Here are some advantages based on various **aggregate properties** in concrete structures.

- Aggregates provide more strength to the concrete.
- The use of aggregates in concrete structures increases the compactness of the structures.

- The use of aggregate reduces the quantity of cement in the concrete mix.
- It also reduces the water requirement in the concrete mix.
- It reduces the shrinkage of concrete in the dry mix.
- It reduces the voids in the concrete.

Different Tests on Aggregate

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

- **Crushing test:** This test is carried out to determine the aggregate's crushing strength according to IS code 2386 (part IV) 1963. The crushing value of an aggregate indicates the resistance against the crushing of the aggregates. If the crushing value of the aggregate is on or above 35, it will be considered a weak aggregate.
- **Abrasion test:** Los angles abrasion test is carried out to know the abrasion resistance of the coarse aggregate. It determines the percentage wear of the aggregate due to relative rubbing. It also indicates the hardness property of the aggregates.

- **Impact test:** Aggregate may be supposed to impact load during its life cycle, so it's important to get the impact strength of the aggregate. It measures the strength of the aggregate against the impact load acting over the aggregate. It indicates the toughness of the aggregate.

- **Soundness test:** This test indicates the durability of the aggregate. It also indicates the aggregate's resistance property against adverse weather conditions.

- **Shape test:** This test is carried out to know the shape of the aggregate. The flakiness index and elongation index are the main important parameters to define the shape of the aggregates.

MODULE 2 CHAPTER 9

SESSION 12

Learning objective:

Students will be able to understand

- *What is Mortar.*
- *Types and Uses of Mortar.*

Construction Mortar: Its Importance, Preparation, and Uses

Mortar is a combination of sand, a binding agent like cement or lime and water, used in masonry buildings to bridge the space between building blocks. It is applied in the form of a paste which then hardens and binds the masonry units such as stones, bricks, or concrete used in the construction. This article deals with the importance of construction mortar, its preparation, mortar mixes used for the various work and important points to be remembered regarding the mortar mix.

What is the Importance of Mortar in Construction?

The uses of masonry mortar used in construction are:

1. Construction mortar is used as a bed to even out the irregularities of the individual masonry units. The more even the individual stone or bricks surface, the thinner will be the mortar bed.
2. The mortar should provide some adhesiveness between the individual stones or bricks.
3. The mortar used in construction must transfer the compressive, tensile, and shear stresses between adjacent units and it must be sufficiently durable to continue to do so.
4. A hollow like a volcano crater is made at the top of the pile and the water is added.
5. The dry material is then mixed with the water, starting with the inside of the ring. When enough water has been incorporated to make the mortar mix of the right workable consistency, the process of turning over is again performed three times wet.

Types of Mortars in Civil Engineering

Mortars are classified based on different classification criteria. These include:

- Based on the Materials Used
- Based on the Applications
- Based on Bulk Density
- Based on Strength
- Based on Special Purpose of Mortars
- Based on the Materials Used
- Based on the materials used, mortars are of the following types:

→ Cement Mortar
→ Lime Mortar
→ Surki Mortar
→ Gauged Mortar
→ Mud Mortar

Cement Mortar:

Cement mortar, a widely employed type of mortar in construction, employs cement as the binding material and sand as the fine aggregate. The ratio of cement to sand varies between 1:2 to 1:6, depending on the desired strength of the mortar. This versatile mortar is valued for its durability and strength, making it suitable for various construction applications.

Lime Mortar:

Lime mortar, another essential mortar type, utilises lime, which can be either fat lime or hydraulic lime, as the binding material, with sand as the fine aggregate. The proportion typically maintained is 1 part lime to 2 parts sand. Notable for its historical significance, lime mortar has been used for centuries in iconic structures like the pyramids at Giza.

Gauged Mortar:

Gauged mortar is a modified mortar type that incorporates both cement and lime as binding materials, with sand as the fine aggregate. Adding cement to lime, known as gauging, enhances the mortar's strength. The cement-to-lime ratio in gauged mortar varies from 1:6 to 1:9. This mortar combines the cost-effectiveness of lime mortar with the increased strength of cement, making it a preferred choice in construction.

Surki Mortar:

Surki mortar features lime as the binding material and surki, a type of brick or tile dust, as the fine aggregate. This mortar is known for its cost-efficiency and is often used in construction projects where economic considerations are paramount.

Mud Mortar:

Mud mortar, in contrast to the previous types, relies on mud as the binding material and fine aggregates such as sawdust, rice husk, or cow dung. Mud mortar is a practical choice in regions where lime or cement might not be readily available, and it is appreciated for its sustainability and adaptability in certain construction scenarios.

Functions of Mortar

- Bonding building materials together.
- Providing uniform bedding for bricks or stones.
- Creating a protective layer on masonry surfaces.
- Filling gaps and voids in construction.
- Transmitting loads and providing structural integrity.
- Enhancing thermal and acoustic insulation.
- Aiding in waterproofing and preventing dampness.
- Supporting the workability of construction materials.
- Offering an aesthetic finish to structures.
- Facilitating repairs and restoration of masonry.

MODULE 2 **CHAPTER 10**

SESSION 13

Learning objective:

Students will be able to understand

- *Fundamentals of Concrete.*
- *Advantages and disadvantages of concrete*

6.1 Concrete:

Concrete is a composite material composed mainly of water, aggregate, and cement. Often, additives and reinforcements are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses.

The aim is to mix these materials in measured amounts to make concrete that is easy to: Transport, place, compact, finish and which will set, and harden, to give a strong and durable product. The amount of each material (i.e. cement, water and aggregates) affects the properties of hardened concrete.

6.2 Advantages of Concrete:

1 Ingredients of concrete are easily available in most of the places.
2 Unlike natural stones, concrete is free from defects and flaws.
3 Concrete can be manufactured to the desired strength with an economy.
4 The durability of concrete is very high.
5 It can be cast to any desired shape.
6 The casting of concrete can be done in the working site which makes it economical.
7 The maintenance cost of concrete is almost negligible.
8 The deterioration of concrete is not appreciable with age.
9 Concrete makes a building fire-safe due to its noncombustible nature.
10 Concrete can withstand high temperatures.
11 Concrete is resistant to wind and water. Therefore, it is very useful in storm shelters.
12 As a soundproofing material concrete could be used.

5.3 Disadvantage of Concrete:

1 Compared to other binding materials, the tensile strength of concrete is relatively low.
2 Concrete is less ductile.
3 The weight of compared is high compared to its strength.
4 Concrete may contain soluble salts. Soluble salts cause efflorescence.

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5.4 Grade of Concrete:

Grades of concrete are defined by the strength and composition of the concrete, and the minimum strength the concrete should have following 28 days of initial construction. The grade of concrete is understood in measurements of MPa, where M stands for mix and the MPa denotes the overall strength.

Concrete mixes are defined in ascending numbers of 5, starting at 10, and show the compressive strength of the concrete after 28 days.

Different mixes (M) come in various mix proportions of the various ingredients of cement, sand and coarse aggregates. For instance, M20 comes in the respective ratio of 1:1:5:3.

5.5 Corresponding Strength of Concrete:

Concrete Grade	**Mix Ratio (Cement: sand: aggregates)**	**Compressive Strength MPa (N/mm2)**
M5	1: 5: 10	5 MPa
M7.5	1: 4: 8	7.5 MPa
M10	1: 3: 6	10 MPa
M15	1: 2: 4	15 MPa
M20	1: 1.5: 3	20 MPa
Standard Grade of Concrete		
M25	1: 1: 2	25 MPa
M30	Design Mix	30 MPa
M35	Design Mix	35 MPa
M40	Design Mix	40 MPa
M45	Design Mix	45 MPa
High Strength Concrete Grades		
M50	Design Mix	50 MPa
M55	Design Mix	55 MPa

M60	Design Mix	60 MPa
M65	Design Mix	65 MPa
M70	Design Mix	70 Pa

5.6 Uses of different grades of Concrete:

1. M 5, M 10, and M 15 are used for PCC (Plain cement concrete) work such as Levelling course, bedding for footing, etc.
2. M 20 is used for RCC (Reinforced Cement Concrete) work such as Slab, Beams, Columns, footing etc (for mild exposure).
3. M 25, M 30, and M 35 are used for RCC (Reinforced Cement Concrete) like foundations, footings columns, beams, slabs etc.
4. M-40 grade is used for pre-stressed concrete work, slabs, beams, columns, footing etc.
5. M45 and M50 grades are used for RCC, Runways, Concrete Roads (POQ) Prestressed concrete girders, RCC columns, Prestressed beams etc.
6. M-55 grade is used for pre-stressed concrete girders and piers etc.
7. M-60, M-65, and M-80 are used for RCC work where high compressive strength is required such as high-rise buildings, long Span bridges, ultra-thin white topping and spillways of dams, coastal construction etc.

Probable Questions

1. What do you mean by Concrete? (2 marks)
2. What are the advantages and disadvantages of Concrete? (6 marks)
3. What are the grades and Strength of Concrete? (6 marks)
4. What are the uses of Concrete? (2 marks)

MODULE 2 CHAPTER 11

SESSION 14

Learning objective:

Students will be able to understand

- *Fundamentals of Timber*
- *uses of Timber*

Timber is a term used to describe the softwood and hardwood trees that are cut and milled into lumber. Different types of timber classification of timber can be done in different ways based on the type of wood used and the hardness of the timber. According to one of the classifications, there are four different types of timber.

→ Sapwood

→ Heartwood

→ Softwood

→ Hardwood

Sapwood

Sapwood is the outermost part of a tree's trunk or branch, which is usually lighter in color than the rest. It contains living cells that transport water and nutrients between inner tissues and outer bark (which is more like skin). The sapwood also has an important role in regulating water loss through evaporation as well as protecting against insects and other pests.

The sapwood gets its name from its sticky appearance after it dries out; this makes it difficult to remove without damaging your timber.

Heartwood

Heartwood is the darker-colored wood in the center of a tree trunk. It's made up of dead cells, which means that it isn't affected by water and doesn't float during transport. Heartwood is used for construction and furniture because it's strong but also light in weight.

Softwood

Softwood are types of timber that's used for construction. It has a higher density than hardwood, but its strength isn't as great. Softwoods are made from conifers—pine, spruce, and fir trees, among others.

Hardwood

Hardwoods are the densest and strongest of all woods. They're also more expensive than softwoods, but their strength makes them ideal for furniture construction, flooring, and cabinetry. Hardwood species include ash, birch, maple, and oak.

The best hardwood floors are made with planks that have been kiln-dried at temperatures between 950°F and 1120°F (500°C to 600°C). This process allows the wood to retain its shape while protecting it from warping or cracking when exposed to moisture in damp environments like kitchens or bathrooms.

Different Types of Timber Based on Wood

Types of timber classification based on different wood are discussed herein.

Some of the most frequently used types of timber are as follows.

- Bamboo
- Brich
- Mahogany
- Oak
- Cedar
- Cherry
- Walnut
- Fir
- Pine
- Plywood
- Cross-laminated timber
- Cane
- Oriented strand board
- Padauk wood
- Sycamore
- Tulipwood
- Walnut
- Wood ash
- Teak
- Nun
- Jak

Bamboo, a plant species in the grass family Poaceae, is native to warm temperate regions of all continents except Antarctica. The most common species is the white-striped bamboo (Bambusa multiplex), which grows in the wild to heights of 70 feet, with a lifespan of about 150 years. However, other varieties are cultivated for use in construction and as building materials.

Bamboo is native to Asia. It's often used for furniture since it grows in a square shape that can be cut into pieces with a saw. Other types of bamboo are grown specifically for use as building materials. Bamboo is an excellent material for building because it's lightweight, strong, and flexible. It has many uses in construction, including building partitions and furniture.

Bamboo is an environmentally friendly and sustainable resource. It can be harvested sustainably, and it provides a variety of benefits to the environment.

MODULE 2 **CHAPTER 12**

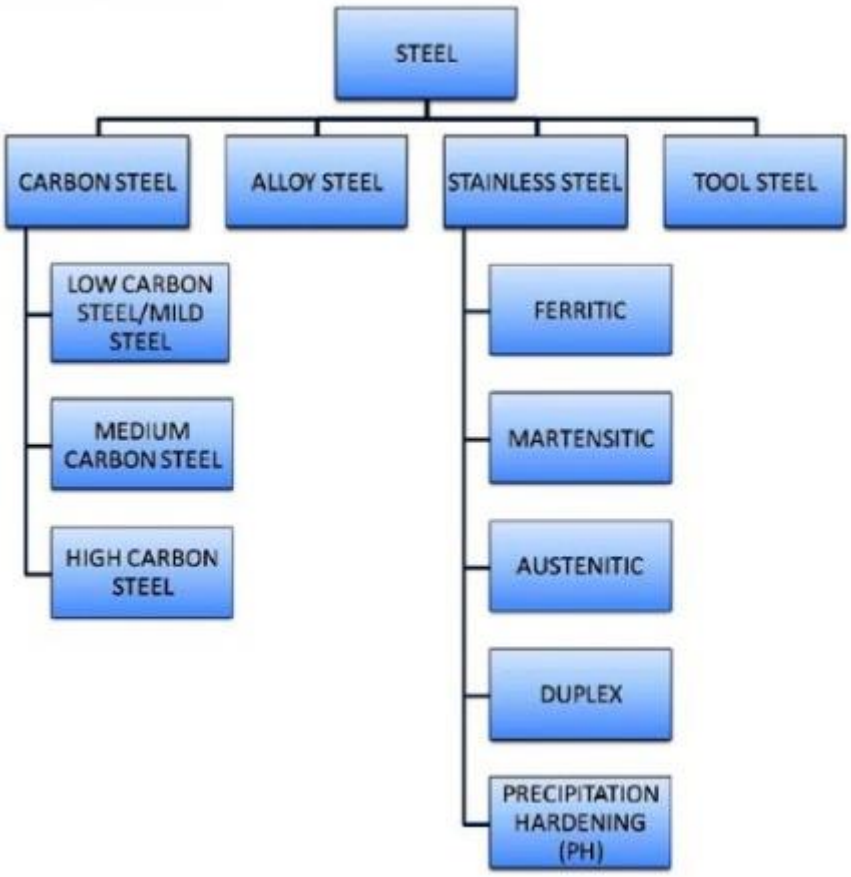
SESSION 15

Learning objective:

Students will be able to understand

- *What is steel?*
- *Advantages and disadvantages of steel?*

Steel is an alloy that contains up to 2% of carbon, the most important commercial component of steel. There are many types and classification of steel – some look at its chemical composition, steels are grouped into the most frequently used types of steel – the plain carbon steel, low-alloy steel, and high-all.



Carbon Steel: Steel with a carbon content of between 0.05 wt % and 2.1 wt % is known as carbon steel. These are the most used type in the manufacturing industries. Based on the composition of carbon, classification can be done into four types of carbon steel.

Mild Steel (Low Carbon steel) - 0.05 wt % to 0.30 wt % carbon

Medium Carbon Steel - 0.3 wt % to 0.5 wt % carbon

High Carbon Steel - 0.5 wt % to 1.5 wt % carbon

Ultra High Carbon Steel - 1.5 wt % to 2.1 wt % carbon.

Stainless Steel: Stainless steel is a steel alloy containing 10.5% chromium. With a thin coating of Cr_2O_3 on its surface, stainless steel shows corrosion-resistant qualities. There are various types of stainless steel: Ferritic, Martensitic, Austenitic, Duplex, and Precipitation-Hardening (PH) Stainless Steels.

Tool Steel: Tool steels contain between 0.5 wt % and 1.5 wt % carbon. Increased carbon content increases hardness and strength. Typically, these steels are used to manufacture tools and die. There are not many types of tool steel but one prominent is High-Speed Steel

ADVANTAGE AND DISADVANTAGES

Durability: Steel is incredibly durable. It is very resistant to corrosion and can last for decades in the right conditions. Steel is also fire-resistant and won't rot or decay like other materials.

Strength: Steel is solid. It has an incredibly high tensile strength and can withstand a large amount of pressure and weight. It makes it great for structural applications and ensures that used in a wide range of projects.

Cost-effective: Steel is much more cost-effective than other materials. It is cheaper to manufacture than other materials, and because it is so durable, it won't need to replace.

Versatility: Steel is incredibly versatile. It can use in many applications, from residential to commercial. It is also available in various sizes, shapes, and finishes, making it suitable for many projects.

Eco-Friendly: Steel is an eco-friendly material. It means that it is a much more sustainable option than other materials.

Disadvantages

High Cost: Steel is usually more expensive than other building materials due to its strength and durability, and the production process requires a lot of energy and raw materials.

Corrosion: Steel is vulnerable to rust and corrosion, especially when exposed to air or ground moisture. A protective coating or sealant must protect the metal from rust.

Weight: Steel is much heavier than other building materials, making it difficult to transport and install. It can be a disadvantage when working in a confined area or on a limited budget.

Heat Conductivity: Steel is an excellent conductor of heat, which can lead to thermal bridging in buildings. It means that heat can escape easily through steel walls, leading to an overall decrease in energy efficiency.

Maintenance: Steel requires regular maintenance to prevent corrosion and rust.

Noise: Steel is a great conductor of sound, meaning that it can make buildings noisier. It can be an issue in homes or workplaces, where noise levels should be minimal.

MODULE 2 CHAPTER 12

SESSION 15

Learning objective:

Students will be able to understand

- *What is paints?*
- *Advantages and disadvantages of paints?*

Paints are a mixture of pigments and binders generally available in a liquid state. Different types of paints and their applications in construction are discussed. Paints form a solid film when applied on a surface. This film protects the surface from many dangers like corrosion, weathering, chemical attacks, etc. Timber or metal structures can extend their life by coating them with paint. They also provide aesthetic appearances to the surfaces. So, paints play a major role in construction works and projects.

As we know, Paint is the last but the most important stage of construction when it comes to giving a great finish to a structure. It not only enhances the aesthetic appearance of the building but also provides a protective layer to the underneath surface.

Why is Painting Done?

Paints are used to protect metals, timber, or plastered surfaces from the corrosive effects of weather, heat, moisture or gases, etc. and to improve their appearance.

Painting is done to protect the surface from the effects of weathering, to prevent the wood from decay and metal from corrosion, to provide a decorative finish and to obtain a clean, hygienic and healthy living atmosphere.

Types of Paints

Different types of paints are as follows:

Aluminium paints

Asbestos paints

Anti-corrosive paints

Bituminous paints

Cement-based paints

Synthetic rubber paints

Silicate paints

Graphite paints

Plastic paints

Casein paints

Cellulose paints

Enamel paints

Emulsion paints

Bronze paints

Colloidal paints

Oil paints

Aluminium Paint

Aluminium paints are made by mixing finely ground aluminium with the spirit or oil varnishes. Spirit varnish makes the drying period shorter, and oil varnish imparts a slow drying facility. So, varnish can be used according to the requirement. This type of paint is used for painting wood works, metallic surfaces, etc. The layer of paint is hardened by the evaporation of spirit or oil. Aluminium paint has many advantages, such as it is waterproof, resistant to electricity, corrosion, and weathering, it can be visible in the dark and provides a good appearance.

Asbestos Paint

Asbestos paint is a special-purpose paint that is made of fibrous asbestos. It is used for covering leakage in metal roofs, for patchworks, and for protecting surfaces from acid gases and steam. Rusting of pouts, flashings, gutters, etc., can also be prevented using asbestos paint coating.

Anti-corrosive paints

Anti-corrosive paints are used to resist corrosion. So, this type of paint is widely used for metal surfaces like pipes, and external structures, which may allow corrosive nature etc. Linseed oil is generally used as a vehicle and along with it a strong driver is used to make anti corrosive paint. It is very cheap and lasts longer.

Bituminous Paints

Bituminous paints are obtained by dissolving tar or asphalt in petroleum or white spirit. They provide black appearance to the surface. Bituminous paints are used for metal structures in under water conditions, iron pipes carrying water. Bituminous paints have good alkali resistant properties.

Cement-based Paints

Cement-based paints contain cement as the base material. These paints contain cement, accelerator, pigment and other additives. They are available in powder form. The paint is obtained by mixing water with this powder and stirring to the required consistency. Cement-based paint is waterproof and can be applied on internal or external surfaces.

Synthetic Rubber Paints

Synthetic rubber paints are made by dissolving synthetic resins in suitable solvents. By adding suitable pigments to this mixer, the colour can vary. This type of paint is widely used on cement concrete surfaces like concrete walls etc. This paint is less affected by rain, sunlight etc. It has good resistant properties against acids, alkalis and moisture conditions. It dries very quickly and maintains uniform colour throughout the surface.

Silicate Paints

Silicate paint is a mixture of silica and resinous substances. Silica gives good adhesion to the paint, which will form a hard surface after drying. This surface can resist extreme heat with great resistance. Silicate paints never react chemically with metals. So, this type of paint can be used in hot conditions and for metal structures.

Graphite Paints

Graphite paint is made of graphite which is in black colour. It is used for painting underground structures like mines etc. Iron structures are coated with graphite paints.

Plastic Paints

Plastic paints contain plastic as the base. Plastic paints dry very quickly, provide a better appearance and have high covering power. They are used for coating walls, slabs, decks etc.

Casein Paints

Casein is a protein that is available in milk curd, is taken and is mixed with white pigments to get casein paints. It is available in powder form or paste form. Coloured pigments can be used to get the required colour. Casein paints are used for coating walls, ceilings, wood works etc. But for exterior usage, this paint should be mixed with driers.

Cellulose Paints

Cellulose paints are a special type of oil paint. They are made of celluloid sheets, nitrogen cotton, amyl acetate and photographic films. In the case of normal oil paints, the layer is hardened by oxidation, but in this case, the layer is hardened by the evaporation of the solvent. It provides a smooth finish and is not affected by smoke, water, acids etc. It is very costly and onlTypes of Paints

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Silicate Paints

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MODULE 2 CHAPTER 13
SESSION 16

PLASTIC:

Before we focus on the **types of** plastics **and their applications**, let's find out what they actually are. The term "plastic" refers to a wide group of materials manufactured using industrial methods. The materials are made of polymers, i.e. chemical compounds, most often consisting of organic molecules. Due to their composition, plastics are otherwise known as polymer materials. Some, for simplicity's sake, refer to plastics simply as plastic. However, it is worth knowing that there are many different types of plastics of different purpose and a defining name.

Types of plastics and their properties: duroplasts, thermoplasts and elastomers

All plastics react to high temperatures in a certain way. When exposed to heat, some types of plastic shrink and deteriorate faster than others. Other types easily tolerate even very high temperatures and change their state of matter. Due to the reaction to heat, polymer materials are classified into three groups:

DUROPLASTS

are high-quality, non-melting thermosetting materials that harden under thermal treatment or due to the action of a suitable hardener. Examples of duroplasts include: synthetic resins and polyacrylonitrile polymers. Duroplasts are used by laminate manufacturers and chemical, electrical, automotive, interior design and injection mould companies.

THERMOPLASTS

(otherwise known as thermoplastics) are materials that change shape and become malleable under the influence of increasing temperature. Unlike duroplasts, thermoplasts can be reshaped many times and retain their shape when cooled. Examples of thermoplasts are: polyethylene and polystyrene. Thermoplastics are used e.g. in the production of packaging, films, toys, footwear or insulation materials.

ELASTOMERS

are synthetic organic materials with the ability to stretch and return to their original form. The category of elastomers includes both synthetic and natural rubber, as well as other materials: polyurethane elastomers and silicones. The material is used on a large scale by manufacturers in the construction and finishing, medical, electrotechnical and automotive industries.

Recycled plastics: production and use

A separate group of plastics having various applications in industry and everyday life, are recycled materials. These are usually bottles, packaging or films made of LDPE, HDPE, PP or PET. Selectively

collected, plastic waste goes to special plants where it is recycled. Semi-finished products (e.g. granules) are made from used plastics. Later, these are used to produce:

- films, tapes, packaging and non-woven fabrics (used in construction, courier services, agriculture, food industry, etc.),
- toys, home accessories, sports equipment,
- clothing and footwear,
- water and sewage pipes, wiring elements,
- disposable dishes, containers, trays, etc.

GLASS:

It is obtained from the fusion of a mixture of silica, lime, soda and alumina. Powdered glass too may be added. This glass is also termed as Soda-ash glass, Soda glass or Soft glass. It is used for glazing doors, windows and making ordinary glass wares.

Different types of glass used in construction are as follows:

1. Float glass
2. Shatterproof glass
3. Laminated glass
4. Extra clean or self-cleaning glass
5. Chromatic glass
6. Tinted glass
7. Toughened glass
8. Soda glass
9. Lead glass
10. Glass block

Soda lime glass

- It is obtained from the fusion of a mixture of silica, lime, soda and alumina.
- Powdered glass too may be added
- This glass is also termed as Soda-ash glass, Soda glass or Soft glass
- It is used for glazing doors, windows and making ordinary glass wares

Lead glass:

- It is obtained from the fusion of a mixture of silica, lead and potash
- Powdered glass too may be added
- This glass is also termed as Flint glass
- Lead glass has highly shining appearance
- It is not affected by temperature
- Cut glass work, electric bulbs and optical glass are made from it
- **Sheet Glass:**
- Most extensively used in engineering works
- Size ► Thickness of 2, 2.5, 3, 4, 5 5.5 and 6.5 mm ► sheets up to 175 cm x 110 cm sizes are also available
- Ordinary glazing quality: Used for general glazing
- Selected glazing quality: Used for better quality works
- Special selected quality: Used for superior quality works such as show cases etc
- **Plate glass:**
- It is made in thickness varying from 3mm to 32 mm and sizes up to 275cm x 90cmm.
- It is stronger and more transparent than the sheet glass
- **Tempered plate glass:**
- Glass plate is heated and then suddenly cooled to tamper it
- Tempered glass is much stronger than ordinary sheet glass.
- Used for glazing entrance doors, table tops, shelves, counters etc

MODULE 2 CHAPTER 14
SESSION 17

ADHESIVE:

Adhesives used in building and construction are versatile. Traditional and newly developed construction materials like concrete, plastics, wood panels, etc. need adhesives to display good adhesion, improved performance and easier application. Due to these benefits, the use of adhesives is increasing in the construction industry.

Learn the fundamentals of different types of adhesives, their bonding techniques and methods of application used in building and construction industry.

Different types of adhesives used in construction

Adhesives may be found naturally or produced synthetically. There are different kinds of adhesives used in construction, some of them are given below.

Polymer adhesives

A polymer adhesive is a synthetic bonding substance made from polymers and is considered to be stronger, more flexible, and has greater impact resistance than other forms of adhesives. These bonding products are used in multiple industries including automotive, aerospace, aviation, construction, electronics, and electrical. Polymer adhesives are broadly classified as thermoplastic, or thermosetting, depending on the molecular structure. Many polymer adhesives are dispersed in water and are suitable for use with both solid and engineered wood flooring.

Hot melt adhesives

Hot melt adhesive (HMA), is a form of thermoplastic adhesive that is commonly sold as solid cylindrical sticks of various diameters designed to be applied using a hot glue gun. The gun uses a continuous-duty heating element to melt the plastic glue, which the user pushes through the gun either with a mechanical trigger mechanism on the gun or with direct finger pressure. In industrial use, hot melt adhesives provide several advantages over solvent-based adhesives. Volatile organic compounds are reduced or eliminated, and the drying or curing step is eliminated. Hot melt adhesives have a long shelf life and usually can be disposed of without special precautions. Some of the disadvantages involve a thermal load of the substrate, limiting use to substrates not sensitive to higher temperatures, and loss of bond strength at higher temperatures, up to complete melting of the adhesive. Hot melt adhesives can also be applied by dipping or spraying, and are popular with hobbyists and crafters both for affixing and as an inexpensive alternative to resin casting.

Acrylic adhesives

Acrylic adhesives are key to large sections of modern industry, providing high strength bonds that work well as an alternative to rivets or other more mechanical joining techniques. Acrylic adhesives are useful for a wide range of surfaces, they can also be used to join acrylics. Acrylic adhesives are either thermoplastics, which can be moulded above a certain temperature or thermosetting polymer, which ‘cure’ once and cannot be remoulded. Acrylic adhesives have traditionally been used

for their strong structural adhesive properties. As a good structural adhesive, acrylic adhesives are naturally in high demand. As an inexpensive structural adhesive, they can be very useful to very many projects! Acrylic adhesives also look good and bond easily to several different materials. This gives them great flexibility in terms of applications

Resin adhesives

Resin adhesive provides superior bonding capabilities. It is manufactured in powdered, spray, emulsion, and liquid forms. Resin adhesives are used to enhance the retention of both composites and compomers and hence prevent bacterial microleakage. It can be used with various materials, including, wood, fabric, glass, china or metal. It's important to note, however; the epoxy resin is not considered to be water-resistant. Repeated moist or wet conditions can cause deterioration over time which will affect durability.

Anaerobic adhesives

Anaerobic adhesives are one-part adhesives composed of dimethacrylate monomers that cure only in the absence of air. They are less toxic than other acrylics, have a mild, inoffensive odor, and are not corrosive to metals. Anaerobic adhesives are stored in partially filled polyethylene containers, in which the ratio of air-exposed surface to volume is high. Anaerobic adhesives are used for structural bonds, primarily with materials such as metals and glass and to a lesser extent, wood and plastic (thermosets and some thermoplastics). An activator is applied to one or both joint surfaces; adhesive is then applied to one surface to begin curing. Joints produced using anaerobic adhesives can withstand exposure to organic solvents and water, weathering, and temperatures of up to about 200°C

Epoxy adhesives

Epoxy adhesives can adhere to a wide variety of materials, their high strength, their resistance to chemicals and environments, and their ability to resist creep under sustained load, epoxies are the most widely used structural adhesive. They are available in one component, heat curing and two-component, room temperature curing systems. Unmodified epoxies cure hard, brittle solids. Most adhesive formulations include modifiers to increase the flexibility or toughness of the cured adhesive. This results in bond lines that can resist more peel and cleavage stress as well as impact. As the most widely used structural type adhesive, epoxy adhesives are commonly offered as either one component or two-component systems. One component epoxy adhesives are generally cured at temperatures between 250-300°F, conditions that engineer a product of high strength, excellent adhesion to metals, and outstanding environmental and harsh chemical resistance. Check out the selection of epoxy adhesives from Gluegun.com .

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Advantages

- The adherents are not affected by heat
- Uniform stress distribution
- Possibility to join large surfaces
- Possibility to join different materials
- Possibility to join very thin adherents
- Gas-proof and liquid-tight
- No crevice corrosion
- No contact corrosion
- No precise fits of the adherent surfaces are necessary
- Good damping properties
- High dynamic strength

Disadvantages:

- Limited stability to heat
- Long-term use may alter the properties of the bond-line
- Cleaning and surface preparation of the adherents is necessary in many cases
- Specific production requirements to be met
- Specific clamping devices are often required to fix the joint
- Non destructive quality testing is only possible to a certain extent

MODULE 2 **CHAPTER 15**
SESSION 18

TILES:

A tile is a natural or manufactured piece of hard- wearing material that could generally be used for. covering, protection and/or decorating finished or. unfinished surfaces like roofs, floors, walls, ceilings, facades, slabs, etc.

Types of Tiles based on Application

There is a different type of tiles used in building construction which are unique to the type of surface where it must be applied. Following are the types of tiles based on surface of application:

- Roofing tiles,
- Flooring tiles,
- Wall tiles, and
- Partition tiles.

Ceramic Tiles

- Ceramic tiles are used for the interior floors, swimming pools, exterior floors, walls and for special installation both in interior and exterior cases. Most types of tiles come under the category of ceramic tiles. They are made from a mixture of clay and other materials. They are fired in a kiln.

Glazed and Vitrified Ceramic Tiles

Glazed and vitrified tiles ceramic are developed presently. The glazed tiles were only used for walls, at initial stages. Glazed ceramic tiles are mainly manufactured by two processes.

- **Step 1:** With the help of special white clay that is fired at a temperature of 1200 degree Celsius, the body of the tiles are made. These final elements are called biscuits.
- **Step 2:** The biscuits are accompanied by glazing and decorations if any, and are fired in the oven

.

Porcelain Tiles

- The manufacture, absorbing capacity and the breaking strength of porcelain tiles differ from the ceramic tiles. The porcelain tiles are also made from clay. But compared with the ceramic tiles, they make use of heavy or denser clay. Porcelain tiles during manufacture are subjected to heavy temperature for a longer time. This baking is carried out until all the water present in the element is evaporated. This unique method of manufacture makes these tiles harder and denser compared to ceramic tiles. This is the reason why **porcelain tile** is regarded as a superior product when factors of durability,

design, color and value factors are considered. Porcelain tiles are highly impervious to water. It has a water absorption rate lesser than 0.5%.

ADVANTAGES:

Polished tiles - shiny but slippery and stain-prone

Polished tiles are made of clay and stone powder that are pressed and fired at high temperatures. They have the same color on both sides, and no glaze is applied. After firing, the surface is polished to make it smooth and glossy. They are also called full-body tiles, as the color and texture run through the entire tile.

Pros: Polished tiles have a bright and elegant appearance that can make the space look more spacious and luxurious. They are also very hard and durable.

Cons: Polished tiles have a smooth surface that can be very slippery when wet, so they are not suitable for bathrooms or kitchens. They also have tiny pores that can absorb liquids and stains easily, making them hard to clean.

Glazed tiles - glossy but less wear-resistant

Glazed tiles are similar to polished tiles, but they have a higher density and a lower water absorption rate (less than 0.5%). They are also fired at higher temperatures, making them more glass-like. Glazed tiles have a layer of glaze on the surface that gives them a shiny finish and various colors and patterns. They are also called vitrified tiles or porcelain tiles.

Pros: Glazed tiles have a smooth and bright surface that is resistant to stains and liquids. They can also create different effects with different glaze colors and designs.

Cons: Glazed tiles have a lower wear resistance than polished tiles, as the glaze layer can be scratched or chipped over time. They also have a smooth surface that can be slippery when wet.

Antique tiles - rustic but less stain-resistant

Antique tiles are a type of glazed porcelain tiles that imitate the style and color of old-fashioned tiles. They have a rough and uneven surface that gives them a vintage and nostalgic feel. They are also called rustic tiles or matt tiles.

Pros: Antique tiles have a strong slip resistance and water resistance, making them suitable for bathrooms or kitchens. They also have a rich and warm color that can create a cozy and comfortable atmosphere.

Cons: Antique tiles have a rough surface that can trap dirt and dust easily, making them less stain-resistant than polished or glazed tiles. They also have limited color choices, so they may not match well with modern or minimalist styles.

Full-glazed tiles - bright but less wear-resistant

Full-glazed tiles are a type of glazed porcelain tiles that have a special formula glaze on the surface that can be polished. They combine the advantages of polished tiles and antique tiles, as they have a smooth and glossy surface with rich colors and patterns. They are also called microcrystalline stone or crystal jade.

Pros: Full-glazed tiles have a smooth and bright surface that is easy to clean and maintain. They also have a variety of colors and patterns that can create different styles and moods.

Cons: Full-glazed tiles have a lower wear resistance than polished or glazed tiles, as the glaze layer can be scratched or chipped over time. They also have a smooth surface that can be slippery when wet.

Ceramic tiles - light but high water absorption

Ceramic tiles are mainly used for wall decoration, as they are lighter and easier to install than other types of tiles. They are made of clay that is glazed and fired at low temperatures. They have a smooth surface with different colors and designs.

Pros: Ceramic tiles are cheap and easy to install, as they do not require special tools or adhesives. They also have a smooth surface that is easy to clean and maintain.

Cons: Ceramic tiles have a high water absorption rate (more than 10%), which means they can expand and contract when exposed to moisture. This can cause cracking or peeling of the glaze layer over time. They are also not suitable for outdoor use.

Full-body tiles - simple but less colorful

Full-body tiles are a type of porcelain tile without glaze, and they have the same material and color on both sides. They have a rough and textured surface that gives them a good slip resistance and wear resistance. They are also called non-slip tiles or matte-finish tiles.

Pros: Full-body tiles are simple and affordable, and they are ideal for balconies, patios or other outdoor areas. They are also very hard and durable, with low water absorption.

Cons: Full-body tiles have limited color choices, as they do not have glaze or patterns. They also have a rough surface that can trap dirt and dust easily, making them less stain-resistant than glazed tiles.

DISADVANTAGES:

Time Consuming

Whether you choose to fit your tiles yourself or use the services of a skilled tradesman, it will be a time-consuming job. You may have to wait for a professional

to be available before starting – and finishing – your project. If you decide to undertake the job, you must be prepared to spend a lot of time on the job if you want a professional finish.

Preparation

Unlike PVC wall panels, which can be installed on rough surfaces or even on top of existing wall coverings, traditional tiles need a smooth, even surface. This means you need to strip the wall you are working on of everyth

COMPOSITION:

The **Composite materials** are combined to produce a material with characteristics that are distinct from the constituent parts despite having chemical or physical qualities that are noticeably different. Composites are, to put it simply, a combination of components. Composite materials are created by combining two or more natural or synthetic elements (with various physical or chemical properties) to form a stronger whole than the sum of its parts.

Types of Composite Material

Currently, composites are widely used in consumer goods and construction materials as a lightweight, economical replacement for metals. Composite materials are being used to create parts that are as massive as passenger aeroplane fuselages. The various types of composite materials are as follows:

- Ceramic matrix composite
- Metal matrix composite
- Reinforced concrete
- Glass fibre reinforced concrete
- Translucent concrete
- Engineered wood
- Plywood
- Engineered bamboo
- Parquetry
- Wood-plastic composite
- Cement-bonded wood fibre
- Fibreglass
- Carbon Fiber reinforced polymer
- Sandwich panel
- Composite honeycomb
- Papier-mache
- Plastic coated paper

Advantages of Composite Material

Our daily lives are surrounded by composites: they are found in the vehicles we drive, the golf clubs we use, the pipelines that transport sewage from our communities, and much more. Some applications, like rocket ships, might not even exist without composite materials.

Composites have a lot of advantages. Strength, lightness, resistance to corrosion, design flexibility, and durability are essential attributes among them.

Strength

Composites outperform traditional materials like steel in terms of strength per kilogram. Composites' two main ingredients, fibres and resins, both contribute to their tensile strength. The weight is carried by the fibres, and the resins distribute it appropriately throughout the composite part.

Lightweight

Compared to most woods and metals, composite materials are lightweight. In both automobiles and aircraft, lighter weight improves fuel efficiency. Furthermore, lighter materials, from bridge decks to utility poles, are simpler to carry and assemble.

Durable

Composite-built structures are durable and require little care. Boats and other items built of composites have been in use for more than 50 years.

Flexible

Composites have a broad range of material combinations that can be used, which promotes design flexibility. The materials can be specially made to meet the particular requirements of each application. Additionally, composites are simple to mould into complex designs.

Resistant

Disadvantages of Composite Materials

- Manufacturing composites can be expensive.
- Repairs may require specialised techniques.
- Layers can separate under stress.
- Some composites degrade in sunlight.
- Some composites are not fire-resistant.

- Disposal can be challenging.
- Recycling composites can be difficult.
-

APPLIOCATION:

Composites are used in a wide variety of markets, including aerospace, architecture, automotive, energy, infrastructure, marine, military, and sports and recreation. Read about interesting applications of composites in select industries below and check back often as we continue to add new applications to this site.

- Aerospace
- Architecture
- Automotive
- Energy Production
- Energy storage
- Infrastructure
- Marine
- Pipe & Tank
- Sports & Recreation

MODULE 3 CHAPTER 16
SESSION 19

TRANSPORTATION ENGG

Transportation engineering is the application of technology and scientific principles to the planning, functional design, operation and management of facilities for any mode of transportation in order to provide for the safe, efficient, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods from one place to other.

MODES OF TRANSPORTATION:-

- **Highways -** Car, Bus, and Truck, non- motorized .etc.
- **Railways -** Passenger and Goods
- **Airways -** Aircraft and Helicopters
- **Waterways -** Ships, boats**.**
- **Continuous Flow systems -** Pipelines, belts, elevator, ropeway etc**.**

ROLE OF TRANSPORTATION:-

- Economic Development
- Social Development
- Spatial Development
- Cultural Development
- Political Development

MERITS AND DEMERITS: BASED ON ACCESSIBILITY, MOBILITY, COST, AND TONNAGE:-

AIRWAYS

- Fastest among all other modes.
- More comfortable.
- Time saving.
- Uneconomical.

WATER WAYS

- Slowest among all other modes.
- It needs minimum energy to haul unit load. .
- Routes or along the river.
- Economical.

RAILWAYS

- The transportation along the railways track.
- It depends upon the road transport i.e. road.
- Could serve as a feeder system.
- Unit distance by the railway is only ¼ to 1/5 of that required by road.

- Safety.

HIGHWAYS

- It gives the maximum service to one and all
- It gives maximum flexibility for travel with reference
- to route, direction, time and speed of travel
- It provide door to door service

CLASSIFICATION OF HIGHWAYS

Depending on weather

- ❖ All weather roads
- ❖ Fair weather roads

Depending the type of Carriage way

- ❖ Paved roads(WBM)
- ❖ Unpaved roads(earth way act (gravel road) National hi road or 1956)

Depending upon the pavement surface

- ❖ Surfaced roads(bituminous or cement concrete road)
- ❖ Un surfaced roads.

CLASSIFICATION OF HIGHWAYS

Based on the Traffic Volume

- Heavy
- Medium
- Light

Based on Load or Tonnage

- Class 1 or Class 2 etc or Class A , B etc Tonnes per day

Based on location and function (Nagpur road plan)

- National highway (NH)
- State highway (SH)
- Major district road (MDR)
- Other district road (ODR)
- Village road (VR)

Based on Modified system of Highway classification

Primary

- Expressways
- National Highways

Secondary

- State Highways
- Major District Road

Tertiary

- Other District Road
- Village Road

EXPRESS HIGHWAY

• Heavy traffic at high speed (120km/hr), Land Width (90m) • Full access control

• Connects major points of traffic generation

• No slow moving traffic allowed

• No loading, unloading, parking.

The Mumbai-Pune Expressway as seen from Khandala

NATIONAL HIGHWAYS

• NH are the main highways running through the length and breadth of India, connecting major parts, foreign highways, capital of large states and large industrial and tourist centers including roads required for strategic movements for the defense of India.

• The national highways have a total length of 70,548 kms. Indian highways cover 2% of the total road network of India and carry 40% of the total traffic.

• The highway connecting Delhi-Ambala-Amritsar is denoted as NH-1, whereas a bifurcation of this highway beyond Jalandar to Srinagar and Uri is denoted NH-1-A

• The longest highway in India is NH7 which stretches from Varansi in Uttar Pradesh to Kanyakumari in the southern most point of Indian mainland. The shortest highway is NH47A which stretches from Ernakulam to Kochi and covers total length of 4 Kms.

Golden Quadrilateral - (5,846 Kms) connecting Delhi- Kolkata-Chennai-Mumbai

- NH-2 Delhi- Kol (1453 km)
- NH 4,7&46 Che-Mum (1290km) NH5 & 6 Kol- Che (1684 m)

- NH 8 Del- Mum(1419 km)

STATE HIGHWAYS

- They are the arterial roads of a state, connecting up with the national highways of adjacent states, district headquarters and important cities within the state.
- Total length of all SH in the country is 1, 37,119 Kms. Speed 80 kmph .

MAJOR DISTRICT ROADS

• Important roads with in a district serving areas of production and markets, connecting those with each other or with the major highways. India has a total of 4,70,000 kms of MDR. Speed 60-80kmph.

OTHER DISTRICTS ROADS

- Serving rural areas of production and providing them with outlet to market centers or other important roads like MDR or SH.
- Speed 50-60kmph.

VILLAGE ROADS

- They are roads connecting villages or group of villages with each other or to the nearest road of a higher category like ODR or MDR.
- India has 26, 50,000 kms of ODR+VR out of the total 33, 15,231 kms of all type of roads.
- Speed-40-50kmph.

URBAN ROAD CLASSIFICATION

Arterial Roads, Sub Arterial, Collector, Local Street, Cul-de-sac, Pathway, Driveway

ARTERIAL ROADS

- No frontage access, no standing vehicle, very little cross traffic.
- Design Speed : 80km/hr. • Land width : 50 - 60m
- Divided roads with full or partial parking
- Pedestrian allowed to walk only at intersection.

SUB ARTIAL ROADS

- Bus stops but no standing vehicle.
- Less mobility than arterial. Spacing for CBD : 0.5km
- Design speed : 60 km/hr.
- Land width : 30 - 40 m

COLLECTOR STREET

- Collects and distributes traffic from local streets
- Provides access to arterial roads
- Located in residential, business and industrial areas.
- Full access allowed.
- Parking permitted.
- Design speed : 50km/hr • Land Width : 20-30m

LOCAL STREET

- Design Speed: 30km/hr.
- Land Width: 10 - 20m.
- Primary access to residence, business or other abutting property
- Less volume of traffic at slow speed
- Unrestricted parking, pedestrian movements. (with frontage access, parked vehicle, bus stops and no waiting restrictions)

MODULE 3 CHAPTER 17
SESSION 20

HIGHWAY ELEMENTS

Carriageway-It is the travel way which is used for movement of vehicle, it takes the vehicular loading .It may be cement concrete road or bituminous pavement. Width of carriageway is determined on the basis of the width of the vehicle and the minimum side clearance for safety.

- As per IRC specification, the maximum width of vehicle is 2.44m, minimum clearance of 0.68 in case of single lane and 1.02m in case of double lane.

Shoulder- It is provided along the road edge to serve as an emergency lane for vehicle.

- It act as a service lane for vehicles that have broken down.
- The minimum shoulder width of 4.6 m so that a truck stationed at the side of the shoulder would have a clearance of 1.85m from the pavement edge.
- IRC recommended the minimum shoulder width is 2.5 m
- It should have sufficient load bearing capacity even in wet weather.

Kerb

• It indicates the boundary between the pavement and shoulder. • It is desirable to provide kerbs in urban areas. It is of three types

1-Low or mountable kerb:

• It allow the driver to enter the shoulder area with little difficulty. The height of this type of shoulder kerb is about 10 cm above the pavement edge with slope to help the vehicle climb the kerb easily.

2-Semi-barrier kerb:

• It is provided on the periphery of a roadway where the pedestrian traffic is high. Height of about 15 cm above the pavement edge with a batter of 1:1 on the top 7.5 cm. It prevents parking the vehicle but during emergency it is possible to drive over this kerb with some difficulty.

3-Barrier type kerb:

• It is provided in built-up area adjacent to the foot paths with considerable pedestrian traffic. The height of the kerb is about 20 cm above the pavement edge with a steep batter of 1V:0.25H.

Roadway width- It is the sum of the width of the carriageway or pavement including if any and the shoulders.

Guard rail - It is provided at the edge of the shoulder when the road is constructed on a fill exceeds 3 m. It is also provided on horizontal curve so as to provide a better night visibility of the curves under the head light of the vehicle.

Right of way-It is the total area of land acquired for the road along its alignment. It depends on the importance of the road and possible future development. It is desirable to acquire more

width of land as the cost of adjoining land invariably increases very much, soon after the new highway is constructed.

Building line - In order to reserve sufficient space for future development of roads, It is desirable to control the building activities on either side of the road boundary, beyond the land width acquired for the land.

Control line -In addition to "building line", it is desirable to control the nature of building up to further "set back distance"

Median Separator- The main function is to prevent head on collision between the vehicles moving in opposite direction.

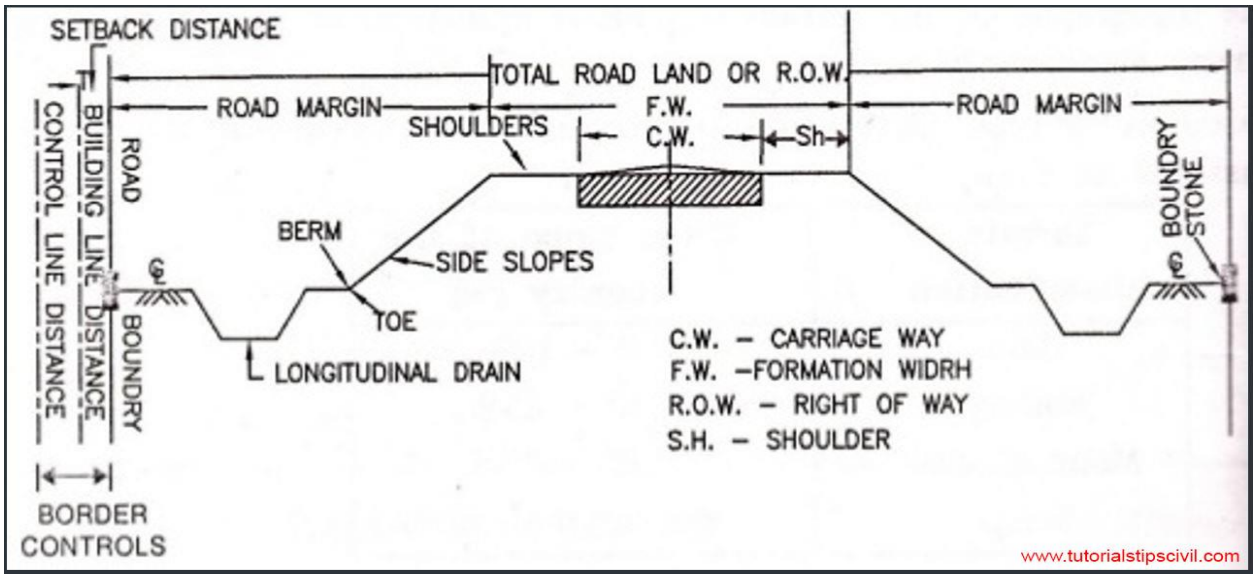
• Channelize traffic into streams at intersection. Segregate slow traffic and to protect pedestrians. IRC recommends a minimum desirable width of 5 m and may be reduce to 3 m where land is restricted. The minimum width of median in urban area is 1.2m.

Camber/ cross slope

- It is the slope provided to the road surface in the transverse direction to drain off the rain water from the road surface.
- To prevent the entry of surface water into the subgrade soil through pavement. To prevent the entry of water into the bituminous pavement layer.
- To remove the rain water from the pavement surface as quick as possible and to allow the pavement to get dry soon after the rain. It is expressed as a percentage or 1V: N h. It depends on the pavement surface and amount of rainfall.

Shape of the cross slope

- Parabolic shape (fast moving vehicle)
- Straight line
- Combination of parabolic and straight line



Airport Engineering:-

- Airport is allocation where facilities for landing and take-off operation for aircrafts are made available.
- It have elements such as runways, taxiways & building with passengers facilities, apron, hanger, visual aids and air traffic control.
- Landing area and terminal area are the two Principal Components of airports.

Types of Airports:

- International Airports
- Domestic Airports
- Regional Airports

Airport Characteristics:

- Rapidity, continuity and accessibility are the hallmark of air transport.
- It is faster mode of transport. Its velocity is faster than the sound.
- It is capable of navigation continuously over mountains and oceans without any break in journey.
- However, it has serious limitations by way of lesser carrying capacity and prohibitive cost.

Components of Airport

1. Runway
2. Taxiway
3. Apron
4. Terminal building
5. Control tower
6. Hanger
7. Parking

Runway

Runway is a paved land strip on which landing and takeoff operations of aircrafts takes place. It is in leveled position without any obstructions on it.

Many factors are considered for design of runway. The direction of runway should be in the direction of wind. Sometimes cross winds may happen, so, for safety considerations second runway should be laid normal to the main runway.

The number of runways for an airport is depends upon the traffic. If the traffic is more than 30 movements per hour, then it is necessary to provide another runway.

Runway can be laid using bitumen or concrete. Bitumen is economic but concrete runways have long span and requires less maintenance cost.

The width of runway is dependent of maximum size of aircrafts utilizing it. The length of runway is decided from different considerations like elevation of land, temperature, take off height, gradients etc.

Taxiway

Taxiway is path which connects each end of the runway with terminal area, apron, hanger etc. These are laid with asphalt or concrete like runways.

In modern airports, taxiways are laid at an angle of 30 degree to the runway so that aircrafts can use it to change from one runway to other easily. The turning radius at taxiway and runway meets should be more than 1.5 times of width of taxiway.

Apron

Apron is a place which is used as parking place for aircrafts. It is also used for loading and unloading of aircrafts. Apron is generally paved and is located in front of terminal building or adjacent to hangers.

The size of area to be allotted for apron and design of apron is generally governed by the number of aircrafts expected in the airport. The aircraft characteristics also considered while design.

Proper drainage facilities should be provided with suitable slope of pavement. Sufficient clearances must be provided for aircrafts to bypass each other.

Terminal Building

Terminal building is a place where airport administration facilities takes place. In this building, pre-journey and post journey checking's of passengers takes place.

Lounges, cafes etc. are provided for the passengers. Passengers can directly enter the plane from terminal buildings through sky bridge, walkways etc.

Similarly, the passengers from plane also directly enter into the terminal building.

Control Tower

The control tower is a place where aircrafts under a particular zone is controlled whether they are in land or in air. The observation is done by the controller through radars and information is carried through radio.

The controller from the control tower observes all the aircrafts with in that zone and informs pilots about their airport traffic, landing routes, visibility, wind speeds, runway details, etc. based on which the pilot decides and attempts safe landing. So, control tower is like nerve system of an airport.

Hanger

Hanger is a place where repairing and servicing of aircrafts is done. Taxiway connects the hanger with runway so, when a repair needed for an aircraft it can be moved to hanger easily.

It is constructed in the form of large shed using steel trusses and frames. Large area should be provided for Hanger for comfortable movement of aircrafts.

Parking

This is a place provided for parking the vehicles of airport staff or passengers which is outside the terminal building or sometimes under the ground of terminal building.

Factors affecting selection of site for Airport:

- Availability of adequate area.
- Accessibility.
- Topography, soil condition & drainage
- Availability of construction materials
- Cost of development
- Cost of maintenance
- Traffic volume
- Cross-wind component
- Proximity of airways

Why is transportation engineering important?

Transportation engineering is an engineering field that involves the study, design and construction of roads, bridges and other transportation infrastructure and transportation engineering plays a major role in the development of the general infrastructure of the region and is an important factor in the economy of any country. It is also interested in safety issues such as preventing vehicle accidents.

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BENEFITS OF ROAD TRANSPORTATION:

There are following benefits of road transportation such as;

1. Scheduled and quick delivery.
2. Cost-effectiveness.
3. Deliveries in local, over the border, even in rural areas.
4. Flexible service.
5. Compared to other modes of transportation this mode saves the packing cost.
6. Complete door to door service and more economical.

BENEFITS OF RAIL TRANSPORTATION:

There are following benefits of rail transportation such as;

1. Reliable schedules and transit times.
2. Most efficient form of land transportation.
3. Over long distance fast and cost-effective.
4. The safety record of rail is strong.
5. It helps in alleviating road congestion.

BENEFITS OF AIR TRANSPORTATION:

There are following benefits of air transportation such as;

1. Quick transit & less handling of cargo.
2. Less documentation.
3. Reliable departures and arrival.
4. For cargo enhanced level of security.

BENEFITS OF WATER TRANSPORTATION:

There are following benefits of water or maritime transportation such as;

1. It can transport large volumes at low cost.
2. They can transport heavy loads.
3. More eco-friendly.
4. Reduces the distance compared to land transport.

BENEFITS OF MULTIMODAL TRANSPORTATION:

There are following benefits of this transport such as;

1. To any part of the world cargo can be moved using these modes of transport.

2. Between the manufacturers and customers, it reduces the distance for the goods.
3. Delivery options are cost-effective and efficient.

Among the important factors that understand the importance of transportation engineering are the following:

1. Design and construction of roads, bridges and other transportation infrastructure.
2. Traffic flow management and monitoring
3. Traffic safety and accident prevention.
4. mass transit, Including buses, railways and light rail.
5. Shipping and logistics networks.
6. vehicle technologies, Such as self-driving vehicles and connected vehicles.
7. Energy efficiency and emission reduction.
8. Sustainable transport planning and policy.
9. Accessibility for all users.
10. Land use and development planning.

BENIFITES OF TRASPORTATION ENGG

The benefits of transportation engineering come from the application of science and technology to the planning, design, operation, management and maintenance of transportation systems. Its primary objective is to provide efficient, safe, cost-effective and environmentally sustainable mobility services. **The advantages of transportation engineering include:**

Improved safety:

Transportation engineering can be used to find solutions that reduce the risk of accidents and improve the safety of roads, highways and other transportation infrastructure.

Increased mobility:

Transportation engineering can be used to create solutions that improve access to transportation services and increase the number of people who can access them.

Reduced emissions:

Transportation engineering can be used to find solutions that reduce emissions from vehicles and other sources of air pollution.

Improving efficiency:

Transportation engineering can be used to create solutions that reduce travel times, and improve the efficiency of vehicles, It reduces energy consumption.

Reduce congestion:

Transportation engineering can be used to create solutions that reduce traffic congestion and improve traffic flow.

Improving air quality:

Transportation engineering can be used to create solutions that improve air quality by reducing the number of pollutants and pollutants in the air.

Lower costs:

Transportation engineering can be used to create solutions that reduce the costs associated with transportation, Such as fuel costs and maintenance costs.

CHARACTERISTICS OF DIFFERENT MEANS OF TRANSPORT

Type of transport	**Characteristics**	**Advantages**	**Disadvantages**
Air (airplanes)	• Urgent need • In case of emergency • No other way to reach the area • High value low weight freight • Starting up large-scale operation • When there are no other means	• Quick and reliable • Can reach far-away areas • Makes it possible to come closer to the area of operations	• High cost • Depending on size of plane, cargo capacity may be small • Subject to weather conditions • Requires special fuel and safe conditions to operate
Air helicopters	• Much more versatile than planes	• Can land in difficult areas	• Has limited cargo space
Land (motor vehicle)	• Use depends on the physical and safety conditions of the access routes to the delivery points • Within a region or country	• Highly flexible • Inexpensive and readily available • Given its availability, cargo space increases	• Routes might be in bad shape, impassable or simply not exist • May be dangerous (floods, armed conflict, bandits, etc.)

Type of transport	Characteristics	Advantages	Disadvantages
Land (rail)	• Use depends on existence, route and conditions • Not used much	• Large load capacity • Operating costs are generally low	• Limited network • Need to use other transport to take the supplies to the warehouse or operations sites
Maritime (sea)	• Large lower value freight, less urgent • More and more used during the second phase of a crisis, whenever possible • Used mostly for transporting supplies from abroad • Need access to a harbour or pier	• Large load capacity • Economical	• Slow • Need to use other transport to take the supplies to the warehouse or operations sites
River	• Useful for supplying riverside and nearby communities with moderate amounts of aid, for moving people or supplies in the event of a flood	• Low cost • Access to areas hard to reach by other forms of transport	• Limited load capacity, depends on size of the vessel • Use depends on the characteristics of the river and waterways
Human and animal	• Small loads, generally in remote areas where vehicles can't reach	• Low operational cost • Access to difficult areas	• Limited load capacity • Slow

MODULE 3 CHAPTER 18
SESSION 22

Different Classes of Urban Roads

The urban road are classified as under

- Express way
- Arterial streets
- Sub-arterial streets
- Collector streets
- Local streets

1. Expressways

The city roads which are reserved for motor traffic with full or partial control access and are provided with grade separation at intersections are called expressways. These are generally constructed to have direct connection between major points of traffic generation in industrial or commercial or business districts. Along expressways, the motor traffic attains very high speeds. Neither the loading nor unloading of the goods is permitted on these expressways. Pedestrians too cannot cross the expressways.

2. Arterial Streets

The city roads which are meant for through traffic usually on a continuous route are called arterial streets. Arterial streets are generally spaced at less than 15 km in developed business centres whereas in less important areas, these may be 8 km apart. Arterial roads are also divided highways with fully or partially controlled access. Parking, loading and unloading are carefully regulated. Pedestrians are permitted to cross them at intersection only.

3. Sub-arterial Streets

The city roads which provided lower level of travel mobility than arterial streets, are called sub-arterial streets. Their spacing may vary from 0.5 km in central business districts to 3 to 5 km in sub-urban areas. Loading and unloading are usually restricted. Pedestrians are allowed to cross these highways at intersections.

4. Collector Streets

The city roads which are constructed for collecting and distributing the traffic to and from local streets, and also to provide an access to arterial and sub-arterial streets, are called collector streets. These are located in residential, business and industrial areas. These roads are accessible from the buildings along them. Parking restrictions are few and that too during peak hours.

5. Local Streets

The city roads which provide an access to residence, business and other buildings, are called local streets. The traffic carried either originates or terminates along the local streets. Depending upon the important of the adjoining areas, a local street may be residential, commercial or industrial. Along local streets pedestrians may move freely and parking may be permitted without any restriction.

What is Classification of Roads?

Classification of roads is a system of categorizing roads based on their function and level of importance. Typically, roads are classified into several categories such as highways, arterial roads, collector roads, and local roads, each with its own specific characteristics and purposes. The classification helps in planning and managing the transportation network efficiently

Classification of Roads

Classification of roads is a system that categorizes roads based on their function and location. This approach helps to organize and prioritize road maintenance and construction, making transportation more efficient and safe.

1. Materials
2. Location/function
3. Traffic volume
4. Rigidity

Classification of Roads Based on Materials

- Earthen roads
- Gravel roads
- Murrum roads

- WBM roads
- WMM roads
- Bituminous roads
- Concrete roads

Earthen Roads

Soil is used to lay earthen roads. They are less expensive than all other types of roads. This type of road is designed for low-traffic areas or rural areas. A good drainage system that provides excellent performance over a longer period of time should be provided.

Gravel Roads

Even though gravel roads are of poor quality, they are preferable to earthen roads. This pavement material is a compact blend of gravel and earth.

Murrum Roads

Murrums are materials formed by the disintegration of igneous rocks by different weathering processes.

WBM Roads

WBM stands for Water Bound Macadam. Crushed stone aggregate is used in the base course of WBM roads. After sprinkling water on the surface, the aggregates are spread and rolled. WBM roads outperform earthen, gravel and kankar roads in terms of performance.

WMM roads

WMM is the acronym for Wet Mix Macadam. In this construction technique, on a prepared GSB layer or an existing pavement, depending on the needs of the project, clean, crushed, graded aggregate and granular material are laid and compacted to form a dense mass.

Bituminous Roads

Bituminous roads are common all over the world. They are the world's busiest roads. These road types are low-cost and appropriate for driving conditions. The subgrade soil conditions determine the thickness of bituminous roads.

Concrete Roads

Pavement construction on concrete roads is done with cement concrete. These are the most common and expensive types of roads. Because they are not flexible, they require less

upkeep. Concrete roads are appropriate for high-traffic areas. They are laid with joints, and the construction time is longer.

Classification of Roads Based on Location and Function of Roads

This classification of roads in India was proposed by Indian Road Congress (IRC).

- National highways
- State highways
- Major district roads
- Other district roads
- Village roads

National Highways

These are the main highways running through the length and breadth of the country, connecting major ports, foreign highways and capitals of state/ union territories and also large industrial and tourist centres.

State Highways

These are arterial roads of a state linking district headquarters and important cities within the state and connecting them with national highways and highways of neighbouring states.

Major District Roads

These are important roads within a district serving areas of production and markets and connecting them with each other or the main highways.

Other District Roads

These are roads serving rural areas of production and providing them with outlets to market centres, block development headquarters or other main roads.

Village Roads

These are the roads connecting villages or groups of villages with each other and to the nearest road of higher quality.

Classification of Roads Based on Traffic Volume

- Light roads
- Medium roads

- Heavy roads
- Very heavy roads

Light Roads

The roads which are carrying less than 70 vehicles per day on average are called light traffic roads.

Medium Roads

If a road is carrying 70 to 250 vehicles per day, then it is said to be a medium-traffic road.

Heavy Roads

If a road is carrying 251-600 vehicles per day, then it is considered a high/heavy traffic road.

Very heavy roads

If the traffic volume is more than 600 vehicles per day, then the roads are called very heavy traffic roads.

MODULE 3 CHAPTER 18

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Based on Rigidity

- Flexible pavements
- Rigid pavements

Difference Between Flexible Pavement And Rigid Pavement

Flexible Pavement	**Rigid Pavement**
It has a low initial cost.	It has a high initial cost.
Loads are transferred through grain-to-grain action.	The load gets distributed by slab action.
It has less flexural strength.	It has a high flexural Strength.
Less durable.	More durable.
Its service life is 15 years.	Its service life is 30 years.
No requirement for Joints.	Requirement for joints.
Four layers	It has Three layers
Requirement for frequent repair.	No requirement for frequent repair.
High maintenance costs.	Low maintenance costs.
It can get damaged due to oils and chemicals.	It cannot be damaged by oils and chemicals.
The design is based on the subgrade strength.	The design is based on flexural strength.
No stresses are produced by Temperature variations.	Heavy Stresses are produced due to Temperature variations.
Subgrade deformation gets transferred to the top layers.	Subgrade deformation gets transferred to the immediate layers.
More thickness.	Lesser thickness.
Composed of bituminous materials.	Composed of Portland cement.
It can open to traffic shortly after construction.	Requires curing, which can cause delays in the opening of traffic.
Poor night visibility.	Good night visibility.
Resistant to vehicle loads.	Less resistant to vehicle loads.
Suitable for all types of traffic.	Noisy under iron-wheeled traffic.
Corrugations get developed.	No corrugations get developed.
More tractive resistance.	Lesser tractive resistance.
Easy laying and easy repairing if underground pipes.	Difficulty in repairing underground pipes.
No sunlight glares.	Glare is caused due to the reflected sunlight.
Stage development is possible.	Stage development is not practicable.
Requires a strong subgrade.	A strong subgrade is not necessary.
Skilled labour is not required.	Skilled is labour required.

MODULE 4 CHAPTER 19
SESSION 24

Sources of Water

Water is an essential part of our lives. We need water for the smooth functioning of our lives. However, there isn't much water left on the planet which is capable of consuming. The sources of water are also running out to s great extent. We must recognize these signs and learn how to restore these sources of water for a better future.

Four Sources of Water

While there are some of the sources which we easily recognize, there are many which are not that obvious. These sources are depleting gradually and posing a great threat to life on earth.

When we understand the various sources of water, we will recognize how limited freshwater is. No matter how much water is present on earth, a little amount is only suitable for consumption.

Ocean Water

We know that oceans are a great source of water. However, what most people do not know is that while it contributes to 97% of the water, the water is not feasible to consume directly.

The ocean water contains a large amount of salt and impurities. It requires a number of processes like desalination to make the water fit for consumption.

Furthermore, we can also apply reverse osmosis as well. We can easily remove salt and the other particles using many ways. But, this method is quite favourable.

The saltwater goes through microscopic pores filters to eliminate any salt or microbes from it. However, it is a very expensive procedure due to the large energy required.

Thus, we see that ocean water is surely in abundance. But, it requires a lot of energy and capital to get filtered. Therefore, it is not easy to consume.

Surface Water

Surface water is quite a broad term when we look at it. It consists of any above-ground water which gets collected. For instance, we have ponds, rivers, lakes, oceans and more.

Surface water is the most used source of water. It accounts to at least 80 per cent of the water used by living beings.

The underground aquifers also contribute to maintaining the level of surface water.

While surface water is easily accessible and found in abundance, we have been misusing it for a long time now.

The rivers and oceans are getting polluted due to religious practices and industrial waste.

Therefore, we need to carefully this water as it won't last long.

Ground Water

When we say groundwater, we mean the source of water which is found beneath the layer of soil. It exists in the soil and between rocks and other things. Groundwater contributes to 30% of water which we use in our daily lives.

Nowadays, almost everyone is installing a submersible pump at their house.
Moreover, pollution and seawater contamination has led to its depleting.
It has indeed become a matter of concern because of overuse. If everyone keeps using it for personal purposes at this speed, the groundwater level will soon drop and we won't be able to recover it.

IceCaps and Glacial Melting

The ice caps and glaciers are great sources of water. However, the process of making it fit for consuming is too expensive. Nonetheless, these ice caps and glaciers have at least 70% of the water which we may consume.
Moreover, these substances are very important for regulating the climate of the earth and its temperature. Therefore, we need to preserve them for a better future.

INTRODUCTION

Absolutely pure water is never found in nature but the water found in nature contains number of impurities in varying amounts. The rainwater which is originally pure, also absorbs various gases, dust and other impurities while filling. This water when moves on the ground further carries silt, organic and inorganic impurities.

Wholesome water is defined as the water which containing the minerals in small quantities at requisite levels and free from harmful impurities. The water that is fit for drinking safe and agreeable is called potable water. The following are the requirements of wholesome water.

It should be free from bacteria¬
It should be colourless and sparkling¬
It should be tasty, odour free and cool¬
It should be free from objectionable matter¬
It should not corrode pipes¬
It should have dissolved oxygen and free from carbonic acid so that it may remain¬ fresh

SOURCES OF WATER

All the sources of water can be broadly divided into
1. Surfaces sources
2. Sub surface sources

The surface sources further divided into

i. Streams
ii. Rivers
iii. Ponds
iv. Lakes
v. Impounding reservoirs etc.

The subsurface sources further divided into

Infiltration galleries
(ii) Infiltration wells
(iii) Springs etc

Types of Intake structures

Depending upon the source of water the intake works are classified as following

• Lake Intake

- Reservoir Intake
- River Intake
- Canal Intake

MODULE 4 CHAPTER 20
SESSION 25

WATER DEMANDS

While designing the water supply scheme for a town or city, it is necessary to

¬ determine the total quantity of a water required for various purposes by the city. As a matter of fact the first duty of the engineer is to determine the water demand of

¬ the town and then to find suitable water sources from where the demand can be met. But as there are so many factors involved in demand of water, it is not possible to

¬ accurately determine the actual demand.

Certain empirical formulae and thumb rules are employed in determining the water¬ demand, which is very near to the actual demand.

TYPES OF WATER DEMANDS

Domestic water demand

¬ Industrial demand

¬ commercial demand

¬ Demand for public use

¬ Fire demand

¬ Loses and wastes

DOMESTIC WATER DEMAND

As per IS:1172-1963, under normal conditions, the domestic consumption of water in India is about 135litres/day/capita. But in developed countries this figure may be 350 litres/day/capita because of use of air coolers, air conditioners, maintenance of lawns, automatic household appliances.

Bathing :55 litres
Toilet flushing :30 litres
Washing of clothes :20 litres
Washing the house :10 litres
Washing utensils :10 litres
Cooking :5 litres
Drinking :5 litres.

FIRE DEMAND

During the fire breakdown large quantity of water is required for throwing it over the fire to extinguish it, therefore provision is made in the water work to supply sufficient quantity of water or keep as reserve in the water mains for this purpose. In the cities fire hydrants are provided on the water mains at 100 to 150 m apart for fire demand.

The quantity of water required for fire fighting is generally calculated by using different empirical formulae.

For Indian conditions kuichings formula gives satisfactory results.

PER CAPTIA DEMAND

If 'Q' is the total quantity of water required by various purposes by a town per year and

'p' is population of town, then per capita demand will be

Per capita demand = [Q/ (P x 365)] litres/day

Per capita demand of the town depends on various factors like standard of living and type of commercial places in a town etc.

Domestic purpose : 135 litres/day

Industrial use : 40 litres/day

Public use : 25 litres/day

Fire Demand : 15 litres/day

Losses, Wastage and thefts : 55 litres/day

Total : 270 litres/capita/day.

FACTORS AFFECTING PER CAPITA DEMAND

The following are the main factors affecting for capita demand of the city or town.

- ¬ Climatic conditions
- ¬ Size of community
- ¬ Living standard of the people
- ¬ Industrial and commercial activities
- ¬ Pressure in the distribution system
- ¬ System of sanitation
- ¬ Cost of water¬

Drinking Water — Drinking water is water intended for human consumption for drinking and cooking purposes from any source. It includes water (treated or untreated) supplied by

any means for human consumption.

Table 1 Organoleptic and Physical Parameters

(*Foreword* and *Clause* 4)

Sl No.	Characteristic	Requirement (Acceptable Limit)	Permissible Limit in the Absence of Alternate Source	Method of Test, Ref to Part of IS 3025	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
i)	Colour, Hazen units, *Max*	5	15	Part 4	Extended to 15 only, if toxic substances are not suspected in absence of alternate sources
ii)	Odour	Agreeable	Agreeable	Part 5	a) Test cold and when heated b) Test at several dilutions
iii)	*p*H value	6.5-8.5	No relaxation	Part 11	—
iv)	Taste	Agreeable	Agreeable	Parts 7 and 8	Test to be conducted only after safety has been established
v)	Turbidity, NTU, *Max*	1	5	Part 10	—
vi)	Total dissolved solids, mg/l, *Max*	500	2 000	Part 16	—

NOTE — It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.

INDIAN STANDARD SPECIFICATIONS FOR DRINKING WATER IS: 10500

S. No	Parameter	Requirement desirable Limit	Remarks
1	Colour	5	May be extended up to 50 if toxic substances are suspected
2	Turbidity	10	May be relaxed up to 25 in the absence of alternate
3	pH	6.5 to 8.5	May be relaxed up to 9.2 in the absence
4	Total Hardness	300	May be extended up to 600
5	Calcium as Ca	75	May be extended up to 200
6	Magnesium as Mg	30	May be extended up to 100
7	Copper as Cu	0.05	May be relaxed up to 1.5
8	Iron	0.3	May be extended up to 1
9	Manganese	0.1	May be extended up to 0.5

10	Chlorides	250	May be extended up to 1000
11	Sulphates	150	May be extended up to 400
12	Nitrates	45	No relaxation
13	Fluoride	0.6 to 1.2	If the limit is below 0.6 water should be rejected, Max. Limit is extended to 1.5
14	Phenols	0.001	May be relaxed up to 0.002
15	Mercury	0.001	No relaxation
16	Cadmium	0.01	No relaxation
17	Selenium	0.01	No relaxation
18	Arsenic	0.05	No relaxation
19	Cyanide	0.05	No relaxation
20	Lead	0.1	No relaxation
21	Zinc	5	May be extended up to 1
22	Anionic detergents (MBAS)	0.2	May be relaxed up to 1.5
23	Chromium as Cr^{+6}	0.05	No relaxation
24	Poly nuclear aromatic Hydrocarbons	--	0
25	Mineral Oil	0.01	May be relaxed up to 0.03

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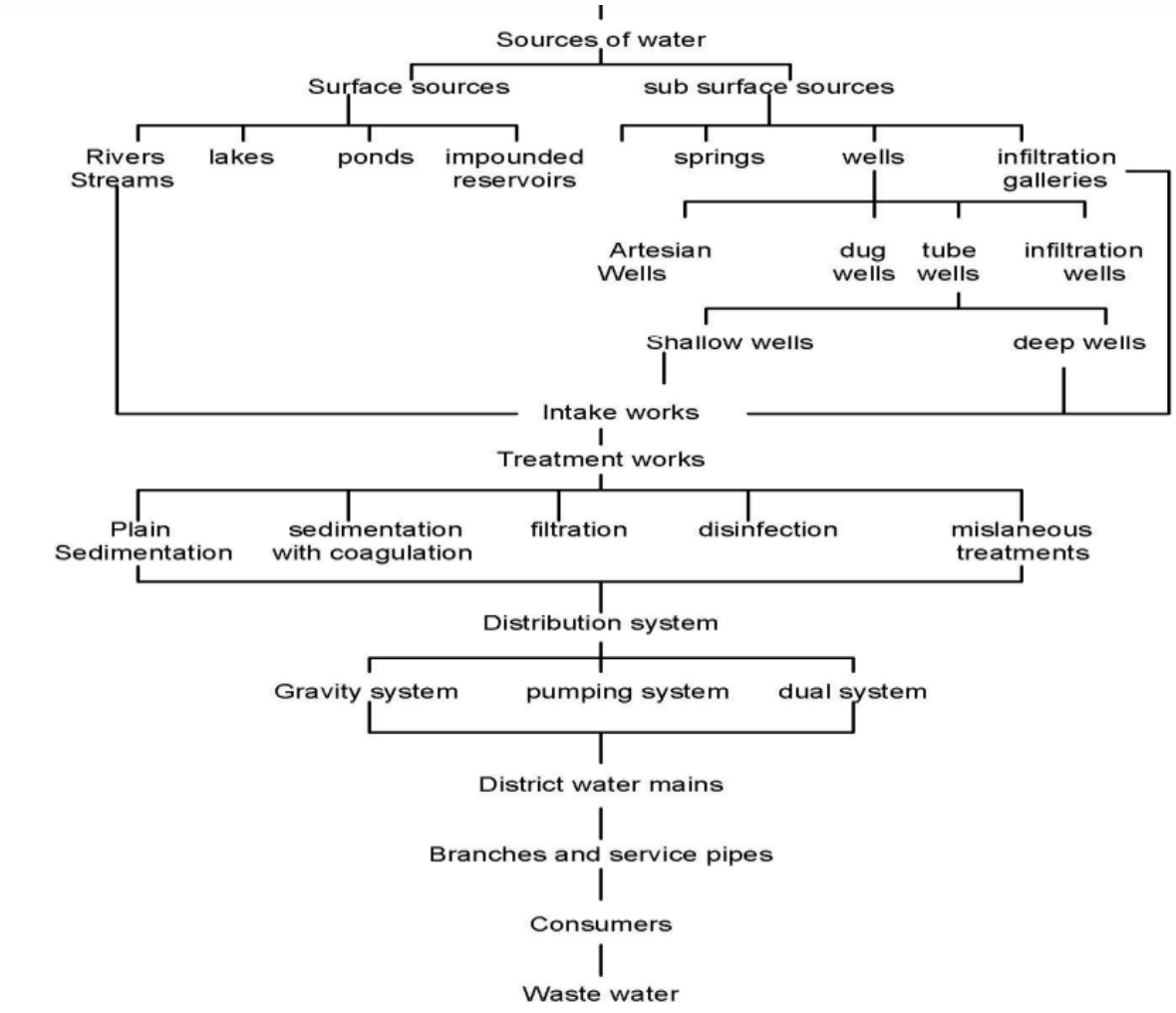


MODULE 4 CHAPTER 20

SESSION 26

SOURCES OF WATER

All the sources of water can be broadly divided into

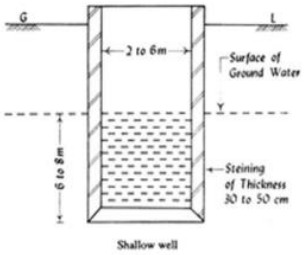
1. **Surfaces sources**
2. **Sub surface sources**

The **surface sources** further divided into

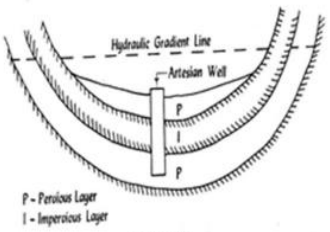
i. **Streams**
ii. **Rivers**
iii. **Ponds**
iv. **Lakes**
v. **Impounding reservoirs etc.**

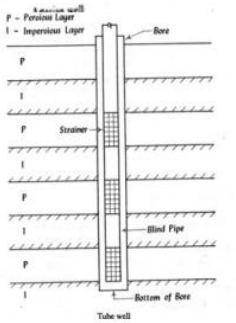
The sub**surface sources** further divided into

(i) **Infiltration galleries**
(ii) **Infiltration wells**
(iii) **Springs etc**

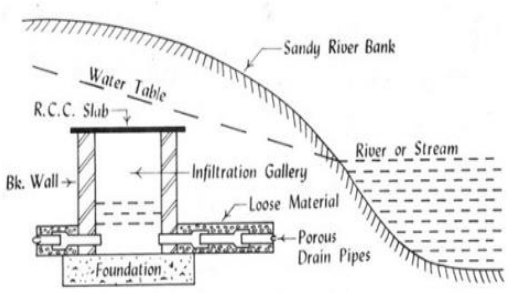


Shallow well

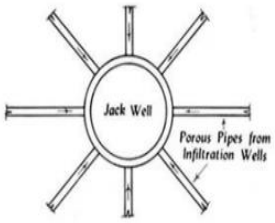




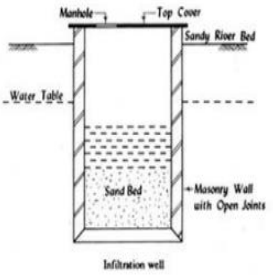
Tube well



Infiltration gallery

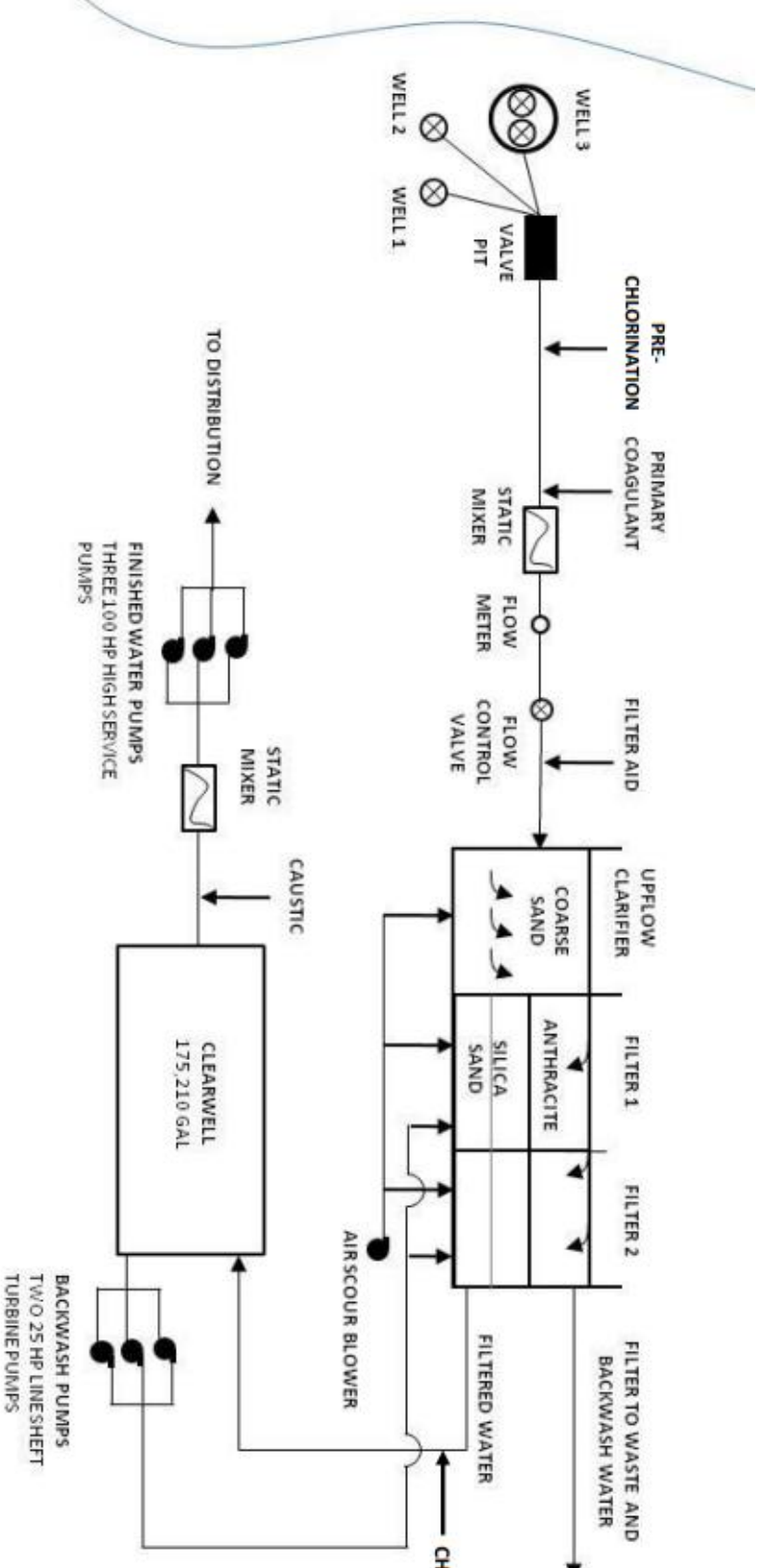


Plan of jack well with connections from infiltration wells



Infiltration well

Water Treatment Plant



MODULE 5 CHAPTER 21
SESSION 26

IRRIGATION

Irrigation is the process of watering crops, pastures, and plants using water, which is supplied through pipes, sprinklers, canals, sprays, pumps, and other man-made features, rather than purely relying on rainfall.

In other words, irrigation is a method of an advanced watering system for helping plants grow because it is applied as an alternative to rain-fed farming.

It is also a technique of fulfilling plant or crop water requirements as they need it as an essential resource for growth. At the same time, it aids in providing plants with the nutrients required for development and growth and achieving high yields by enabling the penetration of roots in the dry fields.

Types of Irrigation

1. Surface Irrigation

It is one of the most common types of irrigation as it simply employs gravity to distribute water over a field by following the contour of the land. In surface irrigation, for example, water will flow downhill from an area of higher elevation, reaching all the crops.

It is only applicable if the area or the land **has sufficient water and is naturally sloped.** Otherwise, it becomes very labor-intensive. It utilizes the furrow system technique, whereby channels are used to direct water down a slope across a paddock where crops or plants are grown – about 1 meter apart.

The best example is rice paddies grown in East Asia. In those areas, the land is dug into terraces, and water flows downhill, allowing each plot of land to be watered.

However, surface irrigation is unsuitable for highly sandy soils with high infiltration, as it can lead to uncontrolled water distribution, resulting in floods and soil erosion. Also, it can only work in areas with an unlimited water supply.

2. Localized Irrigation

For localized irrigation, water is distributed to each plant under low pressure. Tubes or piped networks are used throughout the field, delivering water to each plant.

The aim of this type of irrigation is to only wet a small area, typically the root zone of the plant as water is applied just around the base of the plant. The flow rate of the water is also very low, applied regularly and in small amounts either below or above the soil surface.

The application devices used in localized irrigation include nozzles, perforated pipes, small tubes, nozzles, and orifices, whereas the main components include pressure and flow regulators, main lines, laterals, filtration systems, and distributors. **Localized irrigation is touted as highly efficient, up to 90%, owing to its high water-saving attribute.**

3. Drip Irrigation

Drip irrigation, sometimes called trickle irrigation, is a sub-type of localized irrigation, where droplets of water are delivered directly to or near the roots of a plant at a very low flow rate.

It is an effective type of irrigation as it minimizes evaporation and water runoff. It is also very suitable for all types of topography and soils and perfect for areas with limited amounts of water or with high water costs. **The pressure needed in drip irrigation is between** 0.7 and 1.4 kg/cm^2(10 and 20 psi)**.**

4. Sprinkler Irrigation

As the name suggests, sprinklers irrigate in a way that simulates natural rainfall. The system is operated in a way that ensures water is applied uniformly. Overhead high-pressure sprinklers or guns are used to distribute water from a central location in the field, usually by pumping.

The sprinklers could also be attached to moving platforms. In center pivot irrigation, for example, sprinklers are attached to wheeled towers in a circular pattern to spray water overhead the plants, and it is common in flat areas. Sprinkler irrigation can be used to irrigate lawns, golf courses, crops, and landscapes and can be used for agricultural, residential, and industrial purposes.

5. Subsurface Irrigation

In this type of irrigation, the soil's surface is not made wet. Instead, the water is fed directly to the ground through capillarity to reduce airborne drift and lessen runoff. This way, the water table is raised, making it easier for crops to access the required water.

It uses buried pipes, tubes, or drip tape to provide for the water needs of the crops or plants. Its advantage is that it saves water loss from evaporation and improves crop yields by minimizing disease and weeds.

6. Flood Irrigation

Also known as inundation irrigation, flood irrigation is whereby flooded land conditions are intentionally created, making the soil completely saturated. After this process, naturally occurring rainfall is sufficient for the maturity of the crops.

7. Perennial Irrigation

It is a system of irrigation that relies on a continuous water supply. A canal distribution system takes water from a reservoir or weir to the crops.

MODULE 5 CHAPTER 22
SESSION 27

Importance of Irrigation

Of course, irrigation plays a significant role in plant health and the welfare of the surrounding community. Some of the notable benefits of embracing this practice include:

1. Compensating For When There is no Rainfall

Irrigation kicks in when there is insufficient rainfall or uncertainty about when the rain will fall. **Without rain or irrigation as an alternative, the crops are adversely affected, which can lead to a** food shortage **or crop/plant failure.**

2. Increasing the Amount of Cultivatable or Agriculturally Productive Land

Some areas of the world are dry, naturally. Irrigation has been responsible for turning such lands into cultivatable lands. Today, about 18% of the world's cropland **is now irrigated**. Irrigation is also responsible for bringing the most out of fallow lands, traditionally left idle after harvest, before the next cultivation season.

3. Helps Meet Food Demands

Expanding irrigated land has made desert ecosystems**, such as Jordan and Israel, adopt farming to boost food demands without necessarily depending on rain.**

Such areas use groundwater from wells and aquifers and in doing so,they're able to meet the world's demand for food by producing food crops such as cereals, potatoes, and vegetables.

Furthermore, countries and regions that practice top-level and large-scale irrigation, are best known for exporting food, which brings an economic advantage to such a region or country.

4. Increased Productivity

Irrigation, by default and in many instances, is employed when rainfall is insufficient. However, it can be applied at any time, even if there is sufficient rainfall to boost crop productivity.

According to a publication by Olayide, Tetteh, and Popoola (2016) on climate-smart agriculture**, crop productivity on irrigated land is higher than in the unirrigated areas, which primarily rely on rainfall.**

5. Enables Multiple Cropping

In most tropical countries, the rainy seasons are specific, making it impossible to grow multiple crops simultaneously. Moreover, their water requirements differ, and over-irrigation spoils the crop production. Optimum irrigation makes it possible to grow more than one crop at a time in most areas of a country.

6. It is Effective

When crops or plants are watered irregularly and with a mere hosepipe, it is not consistent, and they get just one pass. This means hard-to-reach areas and those that do not experience steady rainfall may not get sufficient water. **A well-designed irrigation system delivers even to hard-to-reach land areas by using efficient irrigation systems such as drip irrigation.**

7. Defeating and Efficient Nature!

We cannot control when it will rain. If it rains during the day and it gets a bit warm, evaporation rates will be high, meaning the crops and the soil will not consume enough water.

Irrigation systems can be set to sprinkle water early in the morning or at night when evaporation levels are low. This saves on the water used and maximizes the moisture required by the crops, flowers, or even the soil itself.

8. Contribution to Economic Growth

Irrigation ensures food production continues, regardless of the season or climatic condition. This means there is continuous income and employment, thereby reducing poverty.

The substantial increase in income achieved through irrigation means the economy can continue to thrive. This is also achieved by the export of food to other regions or countries.

MODULE 5 CHAPTER 23

SESSION 28

Irrigation Projects

In India irrigation has always been the largest user of water. Irrigation projects mainly consists engineering (or hydraulic) structures which collect, convey, and deliver water to areas on which crops are grown.

Irrigation projects may range from a small farm unit to those serving extensive areas of millions of hectares. A small irrigation project may consist of a low diversion weir or an inexpensive pumping plant along with small ditches (channels) and some minor control structures. A large irrigation project includes a large storage reservoir, a huge dam, hundreds of kilometres of canals, branches and distributaries, control structures, and other works (Asawa, 2005).

Irrigation Projects Classification

Irrigation projects are classified in different ways, however, in Indian context it is usually classified as follows:

Based on Cultural Command Area (CCA)

- **Major Irrigation Projects:** The area envisaged to be covered under irrigation is of the order over 10000 hectare (CCA>10,000 ha). This type of project consist huge storage reservoirs, flow diversion structures and a large network of canals. These are often multi-purpose projects serving other aspects like flood control and hydro power.

- **Medium Irrigation Projects:** Projects having CCA less than 10,000 ha but more than 2,000 ha are classified as medium irrigation projects. These are also multi-purpose surface water projects. Medium size storage, diversion and distribution structures are the main components of this type of project.

- **Minor Irrigation Projects:** Projects having CCA less than or equal to 2,000 ha are termed as minor irrigation project. The main sources of water are tanks, small reservoirs and groundwater pumping. A number of minor irrigation projects may exist individually within the command area of a major or medium irrigation project.

The Major and Medium Irrigation (MMI) projects are further classified into two types based on irrigation method adopted.

- **Direct Irrigation method:** In this method water is directly diverted from the river into the canal by the construction of a diversion structure like weir or barrage across the stream without attempting to store water. This method is practiced where the stream has adequate perennial supply. Direct irrigation is usually practiced in deltaic tracts that is, in areas having even and plane topography.

Indirect or Storage Irrigation Method: In this system, water is stored in a reservoir during monsoon by construction of a dam across the river. The stored water is diverted to the fields through a network of canals during the dry period. Evidently indirect irrigation is adopted where the river is not perennial or flow in the river is inadequate during lean period.

Based on the Way of Water Application

The Irrigation schemes are classified into two types based on way of water application.

Gravity/Flow Irrigation Scheme: This is the type of irrigation system in which water is stored at a higher elevation so as to enable supply to the land by gravity flow. Such irrigation schemes consists head works across river to store the water and canal network to distribute the water. The gravity irrigation scheme is further classified as:

Perennial Irrigation Scheme: In this scheme assured supply of water is made available to the command area throughout the crop period to meet irrigation requirement of the crops.

Non-Perennial Irrigation (Restricted Irrigation) Scheme: Canal supply is generally made available in non-monsoon period from the storage.

Lift Irrigation Scheme: Irrigation systems in which water has to be pumped to the field or canal network

.

MODULE 5 CHAPTER 24

SESSION 29

DAMS

A dam is a barrier that stops or restricts the flow of surface water or underground streams. Reservoirs created by dams not only suppress floods but also provide water for activities such as irrigation, human consumption, industrial use, aquaculture, and navigability. Hydropower is often used in conjunction with dams to generate electricity. A dam can also be used to collect or store water which can be evenly distributed between locations. Dams generally serve the primary purpose of retaining water, while other structures such as floodgates or levees (also known as dikes) are used to manage or prevent water flow into specific land regions.

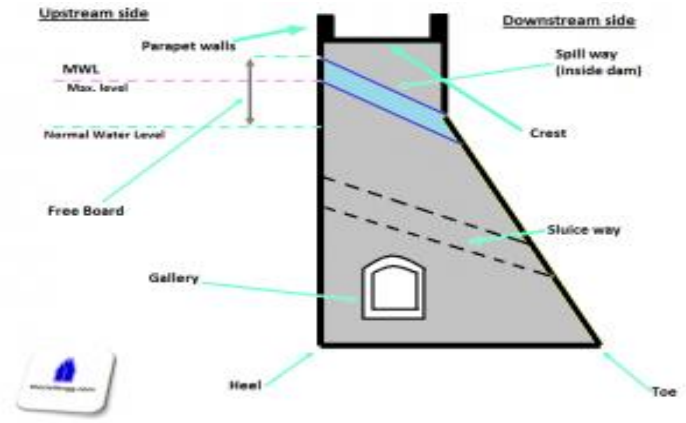
Dams and reservoirs can serve a variety of purposes. The purpose of a reservoir and dam can be singular or multiple [iii] and can also change over time as a result of changing needs or preferences.

Dams and reservoirs serve **various purposes** [iv]. Some are listed below:

- **Water storage**: Water can be stored to provide water supply for industrial, municipal or irrigation purposes.
- **Hydroelectric generation**: Dams can be used to generate hydroelectricity. Roughly $1/6^{th}$ of the world's electricity generation is by hydroelectric dams [v].

- **Recreation**: Reservoirs may allow for recreational activities such as boating and fishing.
- **Flood protection:** Some dams are designed specifically for flood protection. These specific dams are usually designed to reduce flood peaks. In some cases, a dam may have a secondary function that can be used for flood protection. If appropriate planning is undertaken, the level of a reservoir can be lowered to hold back some floodwater.
- **Waste containment**: Reservoirs can be built to contain tailings from mining operations.
- **Navigation:** some dams are used to raise water levels to allow for improved navigation upstream of the dam.

Different parts & terminologies of Dams:

- 

Dam illustration

Crest: The top of the Dam. These may in some cases be used for providing a roadway or walkway over the dam.

- Parapet walls: Low Protective walls on either side of the roadway or walkway on the crest.
- Heel: Portion of Dam in contact with ground or river-bed at upstream side.
- Toe: Portion of dam in contact with ground or river-bed at downstream side.
- Spillway: It is the arrangement made (kind of passage) near the top of dam for the passage of surplus/ excessive water from the reservoir.
- Abutments: The valley slopes on either side of the dam wall to which the left & right end of dam are fixed to.
- Gallery: Level or gently sloping tunnel like passage (small room like space) at transverse or longitudinal within the dam with drain on floor for seepage water. These are generally provided for having space for drilling grout holes and drainage holes. These may also be used to accommodate the instrumentation for studying the performance of dam.
- Sluice way: Opening in the dam near the base, provided to clear the silt accumulation in the reservoir.
- Free board: The space between the highest level of water in the reservoir and the top of the dam.
- Dead Storage level: Level of permanent storage below which the water will not be withdrawn.
- Diversion Tunnel: Tunnel constructed to divert or change the direction of water to bypass the dam construction site. The dam is built while the river flows through the diversion tunnel.

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.

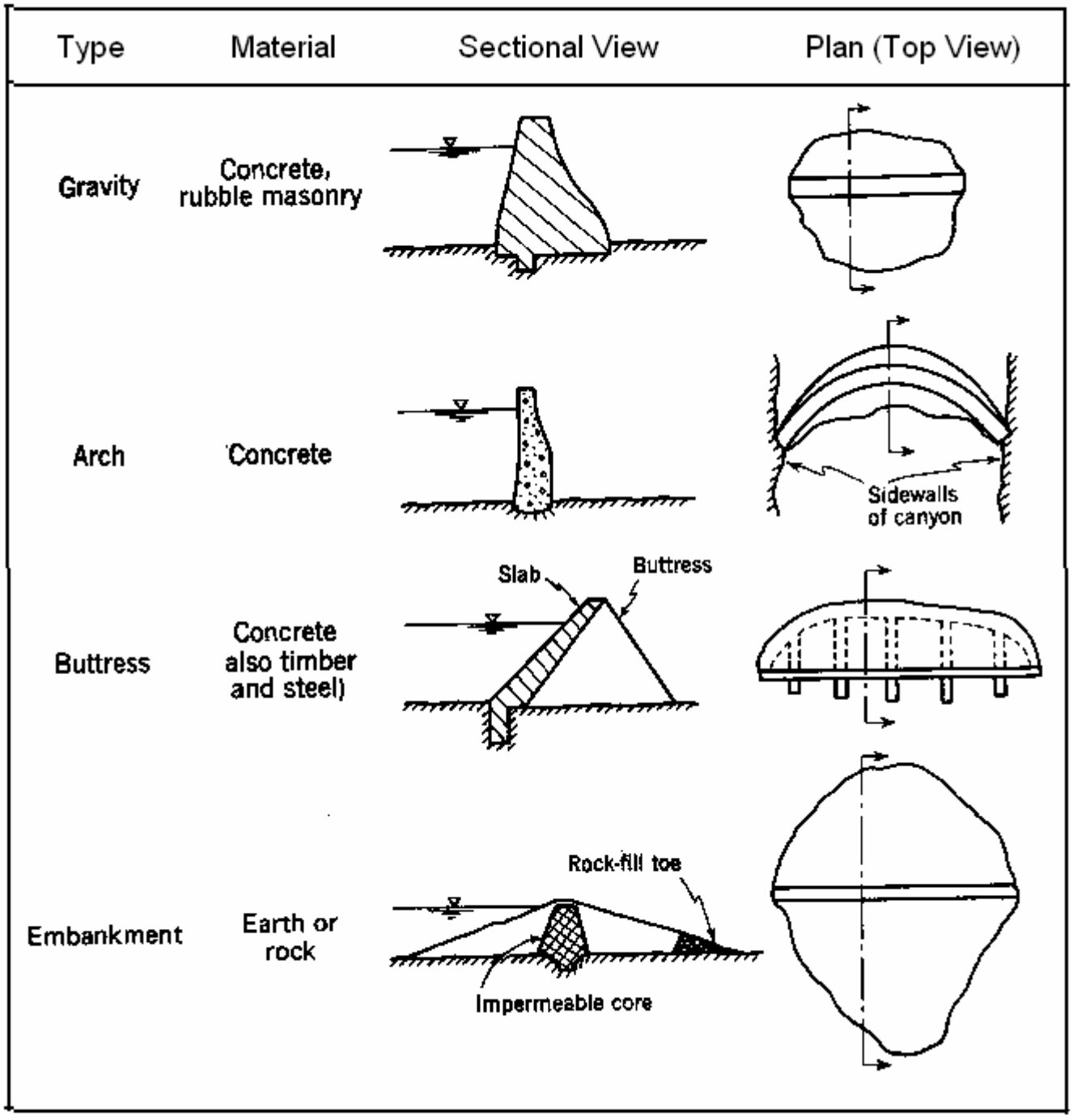
Diversion dams: A diversion dam is constructed for the purpose of diverting water of the river into an off-taking canal (or a conduit). They provide sufficient pressure for pushing water into ditches, canals, or other conveyance systems. Such shorter dams are used for irrigation, and for diversion from 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.

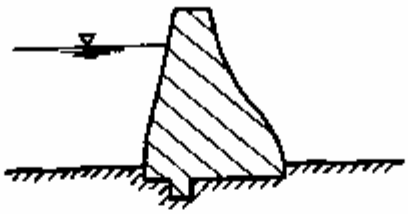
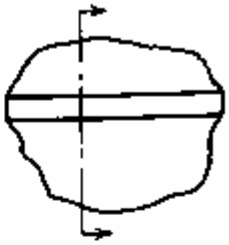
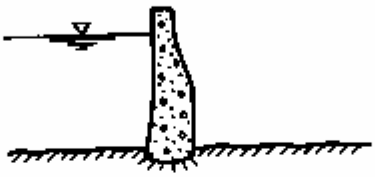
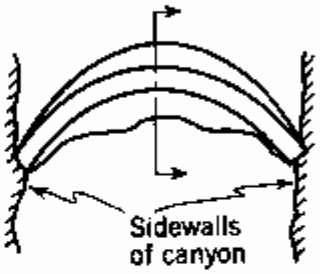
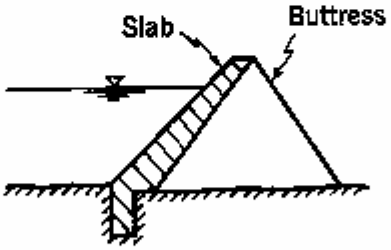
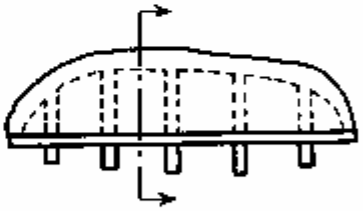
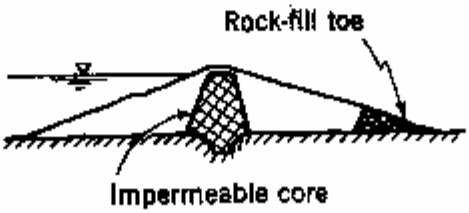
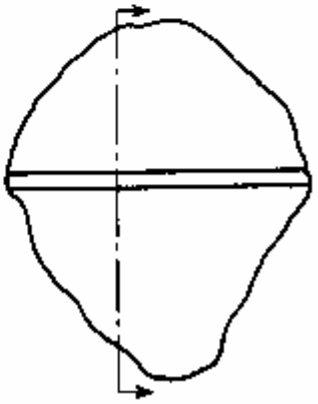
Coffer dams: It is an enclosure constructed around the construction site to exclude water so that the construction can be done in dry. A cofferdam is thus a temporary dam constructed for facilitating construction. A coffer dam is usually constructed on the upstream of the main dam to divert water into 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.

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

Type	Material	Sectional View	Plan (Top View)
Gravity	Concrete, rubble masonry		
Arch	Concrete		
Buttress	Concrete also timber and steel)		
Embankment	Earth or rock		

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 earth fill dam: Rongunsky dam (Russia) and New Cornelia Dam (USA).

Rock fill Dams: A rock fill dam is built of rock fragments and boulders of large size. An impervious membrane is placed on the rock fill 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

Plain sedimentation – *Sedimentation and coagulation processes are done simultaneously is called plain sedimentation*. It means, Sedimentation are removed the suspended particles and coagulation removes the colloidal particles.

In plain sedimentation, very fine suspended particles are not removed because silt particles 0.06 mm size require 10 hrs for settling down in 3 m sedimentation tank and 0.002 mm size of suspended particles are required for 4 days for settling down in sedimentation tank. In colloidal particles water contains electrically charged so colloidal particles continuously in motion and due to gravitational force particles never settle down in the sedimentation tank. So it is necessary to remove the fine clay and colloidal particles. *Sedimentation with coagulation* is the process to easily remove colloidal particles from water.

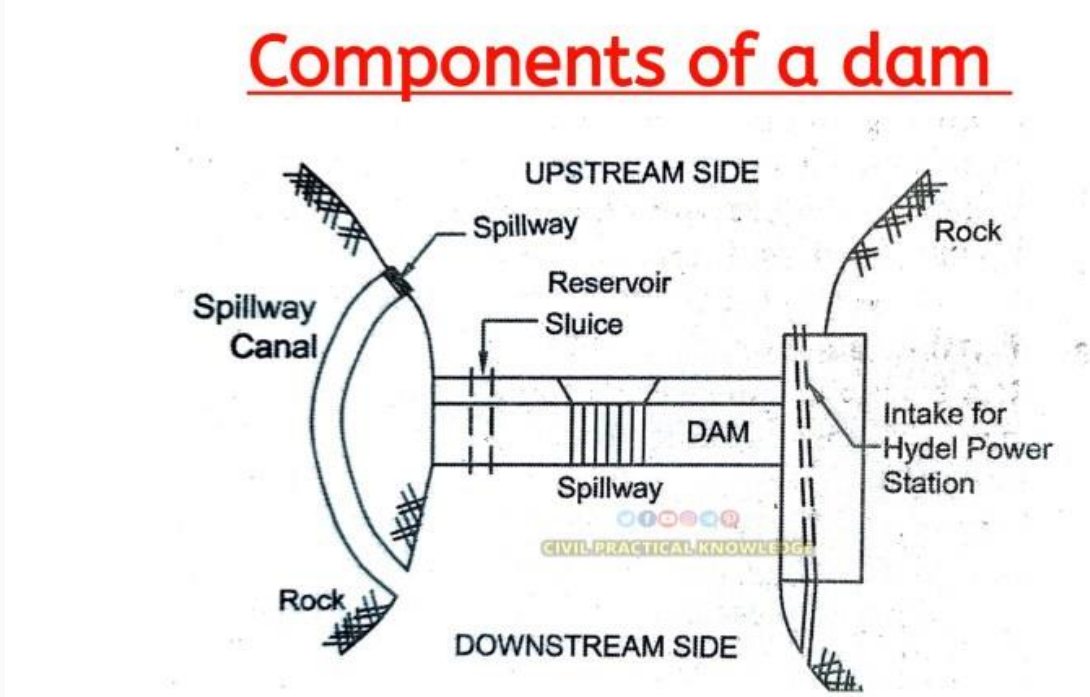
Advantage of plain sedimentation

- Reduce the cost of cleaning chemicals in the coagulation basin.
- In this treatment process low chemical quantities are required.

- No chemical loss in the plain settling basin for sludge discharged.
- It lightens the load on further processes of the water treatment plant.
- Further purification processes can be controlled easily, because plain sedimentation delivers less variable quality of water.

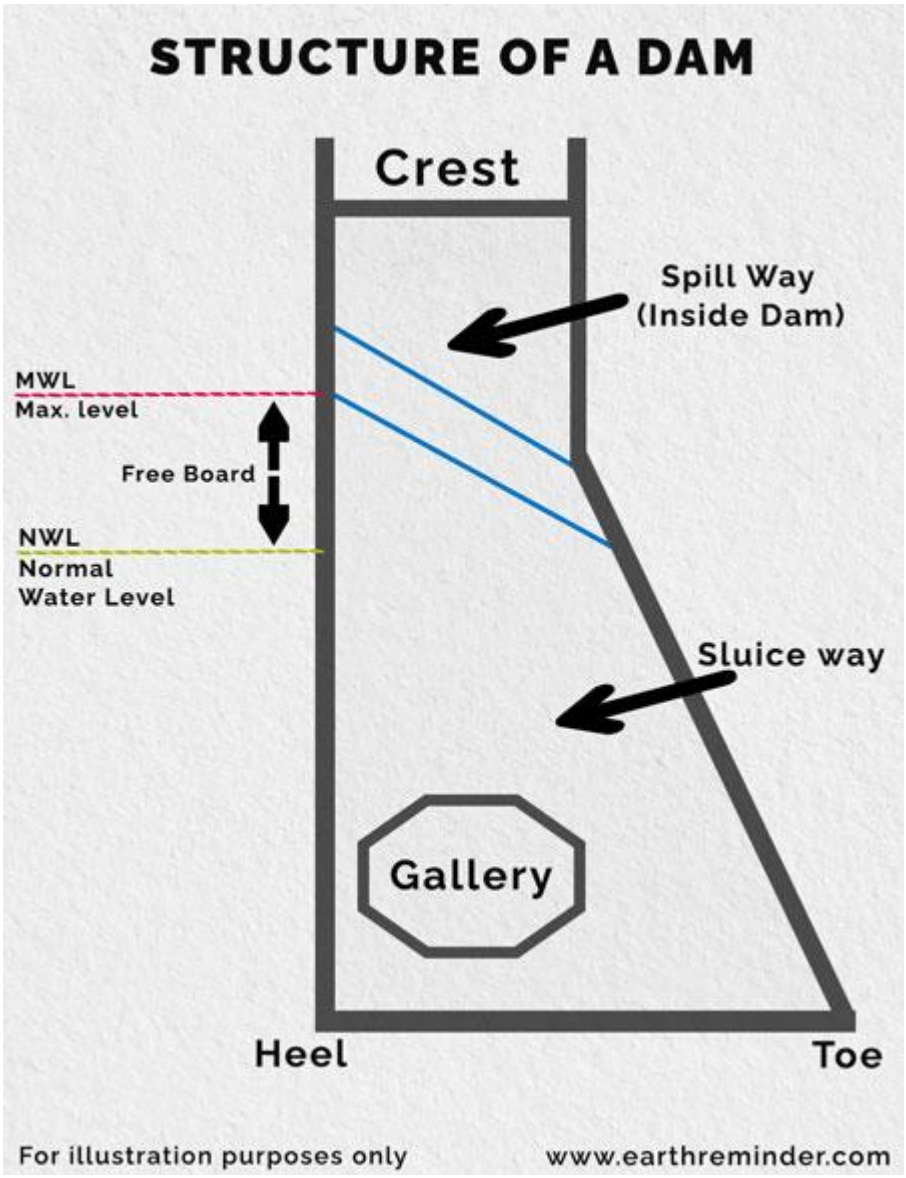
MODULE 5 **CHAPTER 25**

SESSION 30



Components (Structure) of Dam

There are **different kinds of dams**, but various dam components remain the same in each case. Dam generally has an **upstream slope** and a **downstream slope**, and both have different sections. Thus, several parts of a dam are given below:



Crest:

The crest is the top part of a Dam, used for providing a walkway above.

Heel:

The heel is the part that touches the ground on the upstream side of a dam.

Toe:

Like the heel, the toe is a structure that remains in contact with the river-bed on a downstream slope.

Parapet walls:

Parapet walls are the less protecting walls on each side of the roadway or walkway of the crest.

Gallery:

The gallery is a small room like space that is transverse or longitudinal in shape inside the dam. The gallery is required as a drilling grout holes and drainage hole and for monitoring the dam's operation.

Spillway:

For the surplus water movement from the pool, a sort of passage was made known as a spillway. The spillway is of two types; one is **controlled** where gates control the water flow, and another one is **uncontrolled**, where the only control is the elevation of spillway crest. Further, four types of spillways are present according to the structure: auxiliary, fuse plug, bell mouth, and siphon.

Abutments:

On either side of the dam wall, which serves as an abutment for the left and right ends of the dam, the valley slopes.

Sluice way:

Aperture in the structure near the bottom part arranged for cleaning the silt gathering in the reservoir.

Freeboard:

The freeboard is the gap between the uppermost level of water in the reservoir and the structure's cap.

Dead Storage level:

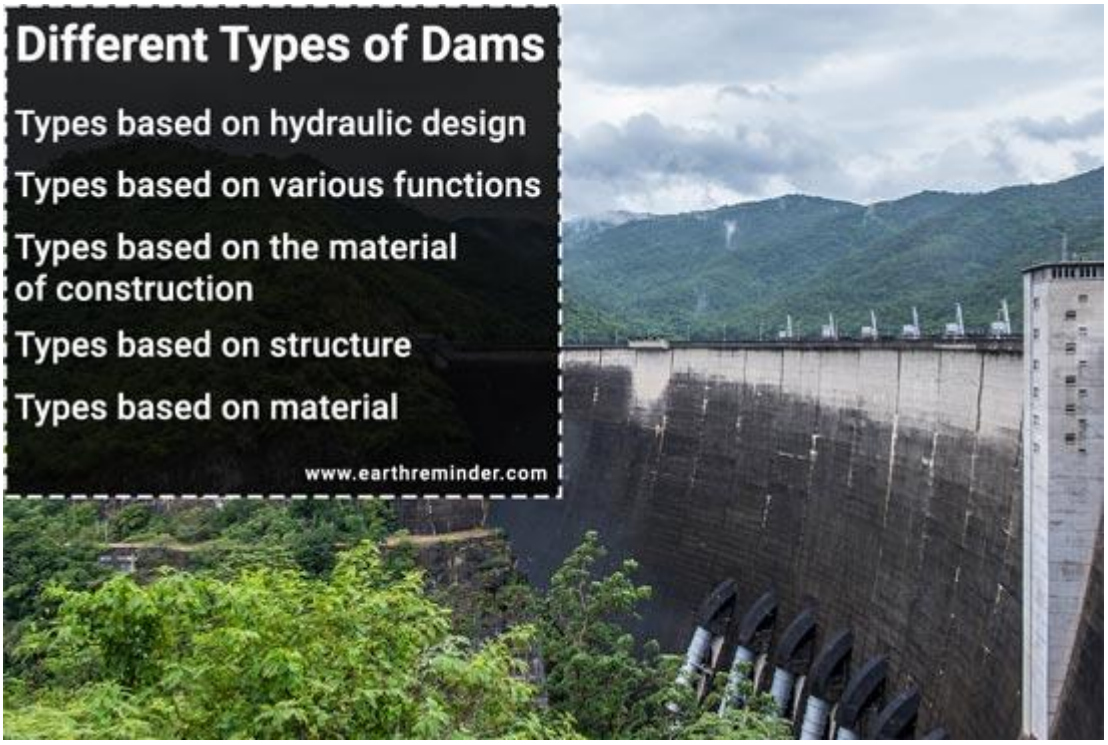
It's the permanent storage level below which water won't be taken out.

Diversion Tunnel:

A diversion tunnel is a channel made to divert the way of water flow to bypass it to the construction site. Therefore, the river flows through it during the construction of hydraulic structures.

Different Types of Dams

Dams are classified into various types based on multiple factors like hydraulic design, functions, the material of construction, structure, or even materials. So, let us know the different kinds of dams according to various aspects.



Types Based on Hydraulic Design

Based on the hydraulic design, there are two types of dams;

Overflow dam

Overflow dams are made for the passage of excess water which cannot store in the reservoir. Such dams permit the overflow of water over the entire length of the dam crest. Furthermore, overflow dams are the concrete type of dams.

Non-overflow dam

In some cases, there is no spillway made for the passage of surplus or overflow water. So, these are known to be non-overflow dams.

Types Based on Various Functions

According to the various functions, five kinds of dams are found;

Storage Dam or Impounding Dam

The storage or impounding dams are the most common types used to retain water, especially in the rainy season, when most of the rainwater surpasses and wastes. That stored water can be used in the summer when water is scarce. We can also use such a reservoir for the fishery or any other similar purpose. Further, we can use that stored water for agriculture, **hydropower generation**, or water supply to different locations. So, as we can use these dams for various purposes, these come under multi-purpose dams.

Detention Dam

These are otherwise known as flood control dams as their function is to prevent a flood. During floods, detention dams store some flooded water to avoid the downstream area from being damage by a surge. Thus, when the situation improves, it allows the excessive water in a control spillage and thus protects the city.

Diversion Dam

For diversion of water into different canals, ditches, and other conveyance systems, diversion dams are constructed. In other words, a diversion dam can also be called a storage weir, otherwise used as a compact storage dam for irrigation.

CofferDam

Coffer is a temporary dam made for constructing full form in a dry condition that eases building. However, the cofferdam encloses the construction site during the low flow of water.

Debris Dam

A debris dam is made for the retention of debris such as sand, driftwood, and debris in the flowing river water. So, the pure water is released from the other side, supplied and used as drinking water to various regions through canals and pipelines.

Types Based on the Material of Construction

If we classify the dams according to the construction material, we get two types. That is,

Rigid Dam

If the dams are constructed with rigid materials such as stone, timber, steel, masonry, or concrete, they are called rigid dams.

Non-rigid Dam

Unlike the above one, the non-rigid dam is formed of non-rigid materials like tailing, rockfill, etc.

Types Based on Structure

Again, based on the structure, there are the following types of dams;

Arch Dams

For transferring the water pressure and other forces, the upstream of some dams are curved, known as arch dams. **Idukki dam** is an example of an arch dam in **India**. There are many benefits of an arch dam as they are powerful, need less constructing material hence cheaper, and are suitable for narrow regions.

Gravity Dams

Gravity dams are triangular-shaped made up of masonry. Generally, four different kinds of gravity dams are found, such as straight, curved, hollow, and solid gravity dams. Moreover, these are of massive size for retaining a large quantity of water. **The Grand Coulee Dam (USA)** is an example of a gravity dam**.**

Buttress Dams

It is supported by a series of buttresses (triangular concrete walls) and consists of sloping membranes (protected concrete slabs) and decks for water retention. It is similar to that of gravity dams in structure and can be classified under a gravity dam. Such dams are of three types; multiple-arch type, deck type, and massive head type. However, these are sometimes called hollow dams as they don't form the stable wall. Examples of Buttress dams are **Bartlett dam (USA)** and **The Daniel-Johnson Dam (Canada).**

Barrages

The particular kind of dam formed with many gates for controlled passage of water is known as barrages. These are also used at the lagoon to extract tidal energy, and such type is known as **a tidal barrage**.

Embankment Dams

These dams are trapezoidal in structure and form of the earth (clay, sand, and gravel), relatively smaller in size, and broader at the bottom used for support in a region where concrete dams are weakened. Furthermore, this is a **non-rigid dam**.

Types Based on Material

And finally, based on the varieties of materials, two dam types are found. These are such as;

Steel dams

So, Steel dams are generally named so as the upper stream of such dams is made up of steel plates. This is of two types, such as Direct strutted and cantilever.

Timber dams

Timber dams are made up of some kind of pine and fir. Hence, these are short head dams that can be classified as pile, crib, pile-crib, and buttress type.

Disadvantages

We discussed various purposes of dams, which can otherwise be considered as advantages of their construction. So, now let us know some of the limitations of it.

- Nature has its settings, but these artificially made dams are ruining the natural beauty of water resources.
- Due to river valley flooding, several wildlife animals are suffering.
- The local people are said to be displaced for the construction projects.
- The dams also ruin the seasonal migration of fishes.
- Expensive to build.
- Soil erosion happens downstream due to over spillage of water.
- It's destroying the aquatic ecosystem.

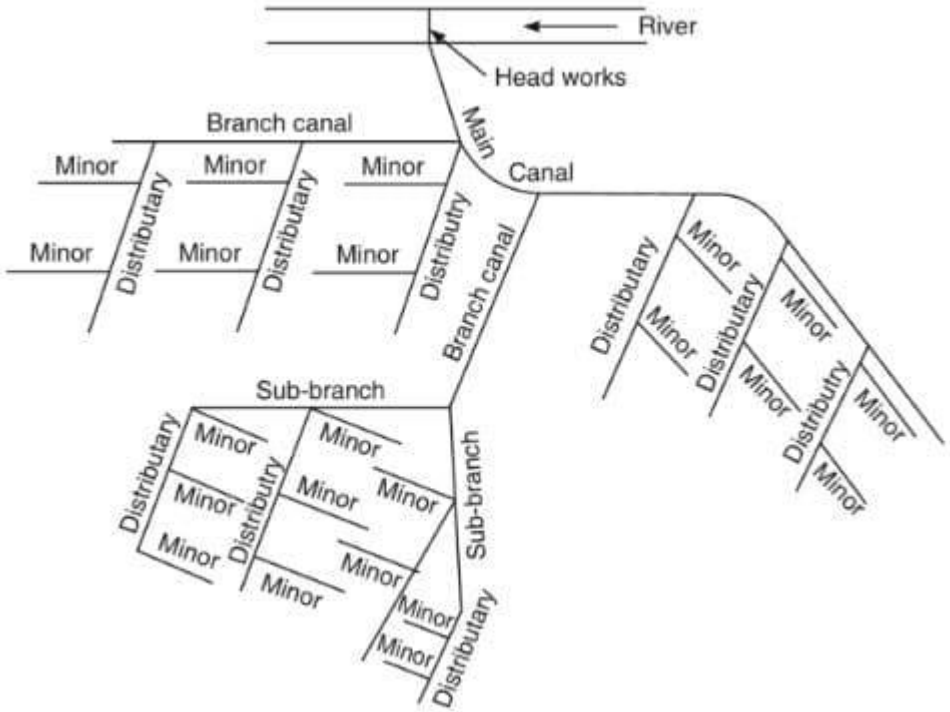
MODULE 5 CHAPTER 26

SESSION 31

What is Canal Irrigation?

A canal is a man-made waterway constructed for diverting water from the rivers to the fields for irrigation. A typical canal irrigation system comprises the Main Canal, Branch Canal, Major Distributory, Minor Distributory, and Water course. Different methods can be used for the Design of canals. The methods of irrigation canal design include Kennedy's theory and Lacey's theory.

Classification of Canals



Canal Irrigation System: Distribution Network

The water carried from the source gets divided into different channels for its subsequent delivery to different locations. The various components in the distribution network of the canal irrigation system are enumerated below:

Main Canal

- The discharge in the Main canals is greater than or equal to 10 cumecs.
- It forms the primary canal in the irrigation system and is used for conveying water from other drainage canals to the water intake.
- Notably, the main canal cannot be used for direct irrigation.

Branch Canal

- The discharge in the branch canals varies between 5 to 10 cumecs.
- The branches of the main canal can run in either direction at regular intervals.
- Besides conveying the water for irrigation, the branch canal also functions as a feeder channel for large and small tributaries.

Major distributary

- Major distributaries receive water from the Main Canal or the Branch Canal.
- The output of the major distributary canals is lesser as compared to the branch canals.
- At times, the major distributary canals directly draw water from the main canal.
- These canals are also called irrigation canals because water is piped from these channels onto the field.

Minor Distributary

- The discharge in the Minor distributary canals is between 0.25 to 3 cumecs.
- These extract water from the branch canals.
- Minor distributaries supply water to the courses through faucets installed beside them.

Watercourse or Field Channel

- The discharge in the watercourse or the field channel is less than 0.25 cumecs.
- Water course can originate from a major distributary or a minor distributary, depending on the scope of the irrigation.
- If the area of the land to be irrigated is large, then these draw water from the major distributaries. On the contrary, for smaller areas, these draw water from minor distributary canals.
- At times, water is directly supplied to the field by the branch canal.

Notably, the dimensions of the canal irrigation system go on reducing from the main canal to the water course. Water from the river gets diverted to the main canal, from where it goes into the branch canal, followed by the major distributary and the minor distributary canals. Finally, it goes into the Water Course, from where it is eventually supplied to the field.

Types of Canal Irrigation Systems

In canal irrigation systems, there are primarily two types of canals used.

Inundation Canals

- These canals extract water from the rivers and do not have any flow-regulating structure like a weir or a barrage at the head of the river.
- Inundation canals can be found in the Brahmaputra valley and the plains of Ganga.

Perennial Canals

- These canals maintain a steady water flow throughout the year.
- Perennial canals get their supply of water from the rivers or from reservoirs.

- A flow-regulating structure in the form of a weir is constructed under the canal intake.
- The intake has sluice gates for controlling the flow of water.