LECTURE NOTES

ON

BASIC CIVIL ENGINEERING

2nd SEMESTER

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Basic civil engineer

LECTURE NOTE

MODULE-1

1.INTRODUCTION TO CIVIL ENGINEERING :-

- Civil engineering is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, airports, sewage systems, pipelines, structural components of buildings, and railways.

- Civil engineering is traditionally broken into a number of sub-disciplines. Civil engineering is the application of physical and scientific principles for solving the problems of society, and its history is intricately linked to advances in the understanding of physics and mathematics throughout history. Because civil engineering is a broad profession, including several specialized sub-disciplines, its history is linked to knowledge of structures, materials science, geography, geology, soils, hydrology, environmental science, mechanics, project management, and other fields.

1.2 DISCIPLINES OF CIVIL ENGINEERING

The various disciplines of civil engineering are

1.2.1ARCHITECTURE AND TOWN PLANNING

1. An art of shaping and guiding the physical growth of the town creating buildings and environments to meet the various needs such as social, cultural, economic and recreational etc. and to provide healthy conditions for both rich and poor to live, to work, and to play or relax, thus bringing about the social and economic well-being for the majority of mankind is known as town planning.

   OBJECTIVES OF TOWN PLANNING-

   - To create and promote healthy conditions and environments for all the people.
   - To make right use of the land for the right purpose by zoning
   - To ensure orderly development
   - To avoid encroachment of one zone over the other.

2. **BUILDING MATERIALS TECHNOLOGY**

   All the building structures are composed of various types of materials. These materials are either referred to as building materials or materials of construction. A builder, perhaps an

architect or engineer, or a contractor needs to become familiar totally with these building materials.These are some of the most commonly used building materials –

1. Stones

2. Bricks

3. Cement

4. Sand

5. Mortar

6. Concrete

7. Timber

8. Metals

9. Glass

10. Ceramics

11. Miscellaneous Building Materials

3. CONSTRUCTION TECHNOLOGY AND MANAGEMENT

It focuses on the knowledge and skills required for the planning, coordination and successful implementation of large Projects such as design and construction of structures and buildings, ship structures, aircraft, dams, roads, and bridges etc. It is a fusion of engineering and management.

4.ENVIRONMENTAL ENGINEERING:-

- This field is concerned with the study of the necessary methods and techniques of environment protection as well as the availability of the basic life elements such as water and air with a specific level of quality to protect the mankind health and environment.

- This includes design and construction of water distribution networks, wastewater and storm water collection systems, water treatment plants and wastewater treatment for reuse in industrial and agricultural fields.

- Environmental engineering involves also the study of the different techniques of controlling air, water and soil pollution as well as the proper disposal or recycle of solid and hazardous wastes.

5. GEOTECHNICAL ENGINEERING:-

- This field is concerned with the study of the soil properties of the construction site and its bearing capacity.

- Geotechnical engineering is concerned also with the suitable solutions for any problem in the soil as well as the choice of the best and secured methods of design and construction of the foundation of engineering structures.

6. HYDRAULICS AND WATER RESOURCES ENGINEERING-

- This field covers the basic concepts of water science and its related theorems and applications. This includes the methods of transporting water from sources to distribution sites through channels and pipelines, water sources and storage system, types of dams and their design methods.

- It involves also the study of seawater movements and shore protection

7. REMOTE SENSING ENGINEERING

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Some specific uses of remotely sensed images of the Earth include:

- Large forest fires can be mapped from space, allowing rangers to see a much larger area than from the ground.

- Tracking clouds to help predict the weather or watching erupting volcanoes, and help watching for dust storms.

- Tracking the growth of a city and changes in farmland or forests over several years or decades.

- Discovery and mapping of the rugged topography of the ocean floor (e.g., huge mountain ranges, deep canyons, and the “magnetic striping” on the ocean floor).

8. STRUCTURAL ENGINEERING:-

- This discipline deals with the analysis and design of concrete and steel structures, such as multi-story buildings, bridges, towers....etc. It deals also with the study of the durability and resistibility of such structures for live loads, wind and earthquake.

- The study involves also the study of the properties of building materials according to the international specifications.

9. SURVEYING:-

Surveying typically involves measurements of horizontal and vertical distances between points. It also includes descriptions of the exact characteristics of the land structure and surface.

10. TRANSPORTATION ENGINEERING:-

Transportation engineering is a branch of civil engineering that involves the planning, design, operation, and maintenance of transportation systems to help build smart, safe, and liveable communities

1.3 Importance of Civil Engineering in Infrastructure Development of the Country:-

Civil Engineers play a major role in the infrastructure development of a country. All structures constructed in the past exhibit the path of civilization and current infrastructures development express the practices followed by civil engineers.

Infrastructure can be defined as activities that provide society with services necessary to conduct daily life and to engage in productive activity and development in a country's economy.

In a country like India, the major infrastructural. Factors that are most significant in accelerating the pace of economic development are energy, transport, irrigation, finance, communications, education, and health.

The knowledge of basic areas of civil engineering can be of great use in providing the infrastructural facilities where constructional aspects are involved for development of regions.

♣ Good surface communication links such as tar or concrete rods.

♣ Provision of water supply distribution system i.e., construction of water storage reservation or sumps, laying of underground pipes etc.

♣ Provision of a drainage system which may include construction of surface drains as subsurface drains for the disposal of wastewater.

♣ Supply of electrical power for which construction of transmission line towers, construction of electrical substations.

1.4 TYPES OF BUILDING AS PER NBC (NATIONAL BUILDING CODE):-

Any structure made for whatsoever purpose with any material, used for human habitation or not which included foundation, plinth, walls, floor, roofs, chimney, plumbing, and building services, Verandah, Balcony, and cornice, etc. is called a building. Buildings are classified based on occupance and type of construction:

A. RESIDENTIAL

B. EDUCATIONAL

C. INSTITUTIONAL

D. ASSEMBLY

E. BUSINESS

F. MERCANTILE (included retail and wholeshale store)

G. INDUSTRIAL (low, moderate and high fire hazards)

H. STORAGE

I. HAZARDOUS

1. Residential Buildings

Any building in which sleeping accommodation is provided for normal residential purposes with or without cooking/dining.

These are further classified as: Group A-Residential

A1: Lodging or rooming houses.

A2: One or two-family private dwellings

A3: Dormitories

A4: Apartment houses

A5: Hotels (upto 4 star category)

A6: Hotels (Starred- five star and above)

(i) Lodging and rooming houses- These are buildings in which separate sleeping accommodation with or without a dining facility but without a cooking facility is provided. For instance, Inns, Clubs, Motels, and Guesthouses.

(ii) One or two-family private dwelling- A private dwelling which is occupied by members of one or two-family. Maximum sleeping accommodation is provided for 20 persons.

(iii) Dormitories- Any building in which group sleeping accommodation is provided with or without dining facilities. e.g., School and College Dormitories, Hostels, and Military Barracks.

2. Educational Buildings

Any building used for school, college, and other training institutions having a minimum of 20 students.

(i) Schools up to Senior Secondary level Minimum students should be 20.

(ii) All others/training institute Minimum students should be 100.

3. Institutional Buildings

Buildings that are used for medical or other treatment, care of persons suffering from physical and mental illness, care of infants, for inmates etc are called institutional buildings `

(i) Hospital and Sanatoria -Any building which is used for the treatment of patients e.g., hospitals, sanatoria, infirmaries, and nursing homes.

(ii) Custodial Institutions Any building used for custody and care of a person for instance children, old age homes, orphanages, etc

4. Assembly Buildings

Any building in which a minimum of 50 persons gathers for recreational, amusement, social, religious, patriotic purposes e.g., theatres, assembly halls, exhibition halls, museums, estaurants, places of worship, etc. These are classified into 7 types:

(i) The building having theatrical or motion pictures or any other stage having fixed seats for over 1000 persons.

(ii) The building having theatrical or motion pictures or any other stage having fixed seats for up to 1000 persons

5. Business Buildings

Any buildings used for the transaction of business, professional establishments, service facilities, etc. are termed as business buildings. These are further divided into 5 types –

(i) Offices, banks, professional establishments etc.

(ii) Laboratories, clinics, research establishments and libraries etc.

(iii) IT parks, call centers etc.

(iv) Telephone exchange

(v) Broadcasting stations, TV stations and air traffic control towers.

6. Mercantile Buildings

Any building which is used as a shop, store, market, etc. is known as mercantile buildings. These are further classified as:

(i) Shops, stores, departmental stores, markets (covered area up to 500 sq. m).

(ii) Shops, stores, departmental stores, markets (covered area more than 500 sq. m).

(iii) Underground shopping centres, storage and service facilities

7. Industrial Buildings

Any building in which products or materials are fabricated, assembled, manufactured, or processed. For instance, assembly plants, industrial laboratories, power plants, pumping stations, etc.

- Buildings for low hazard industry – ♣ Buildings in which those things are manufactured that have low combustibility.

- Buildings for moderate hazard industry- ♣ Buildings in which those things are manufactured which will burn with moderate rapidity.

- Buildings for high hazard industry- ♣ Buildings in which those things are manufactured which will burn with extreme rapidity and results in hazardous situations.

8. STORAGE BUILDINGS

- Any building which is used for storage of goods, ware or merchandise, vehicles or animals. e.g., warehouse, cold storage, garages, stables, etc.

9. HAZARDOUS BUILDINGS

- Buildings which are used for storage, handling, manufacture, or processing of highly combustible or explosive material. For instance, manufacture of explosives and fireworks, storage of highly flammable liquids, storage of LPG, rocket propellants, etc

1.5 SELECTION OF SITE FOR BUILDINGS :-

1. The soil of site should have good bearing capacity. Hard strata should be available at reasonable depth, around 1.2m to1.5m depth from ground level.

2. The site should be on elevated ground. It should have slope towards front street to afford good facility of drainage.

3. Sites nearer to ponds ,pools of water, water logged areas must be avoided as they remain in damp condition .

4. Sites near to high voltage power transmission lines are avoided.

5. Sites very nearer to big shopping complexes , markets, railway station ,airport are avoided

6. The surrounding of site should be pleasing and calm.

7. The orientation of site should be such that it receives natural light and air in plenty.

8. The location of site is such that the common facilities like school, transportation, medical facilities etc are within reasonable range.

9. Sites in developed colonies should be preferred.

10. The layout of the colony should be approved by local authorities. This will help in getting essential facilities like water , drainage ,electricity, telephone connection etc easily.

1.6 COMPONENTS OF RESIDENTIAL BUILDING

Building component means any subsystem, subassembly, or other system designed for use in, or as part of, a structure, which may include structural, electrical, mechanical, plumbing, and fire protection systems and other systems affecting health and safety. The basic function of a building is to provide structurally sound and environmentally controlled spaces to house and protect occupants and contents.A building is combination of various components. A Civil Engineer should have good knowledge of execution of each and every component with respect to design layouts given by Architect

The following are the basic component parts of a residential building:-

1. Foundation
2. Plinth
3. Walls and columns
4. Sills, lintels and chejjas
5. Doors and windows
6. Floors
7. Roofs
8. Steps, stairs and lifts
9. Finishing work
10. Building services.
11. Parapet

The functions of these elements and the main requirement of them are discussed below

1. Foundation:

   Foundation is the most important part of the building. Building activity start with digging the ground for foundation and then building it. It is the lower most part of the building. It transfers the load of the building to the ground.

2. Plinth:

   ♣ The portion of the wall between the ground level and the ground floor level is called plinth. It is usually of stone masonry. If the foundation is on piles, a plinth beam is cast to support wall

above floor level. At the top of plinth, a damp proof course is provided. It is usually 75 mm thick plain concrete course.

♣ The function of the plinth is to keep the ground floor above ground level, free of dampness. Its height is not less than 450 mm. It is required that plinth level is at least 150 mm above the road level, so that connections to underground drainage system can be made.

3.Walls and Columns:-

The function of walls and columns is to transfer the load of the structure vertically downwards to transfer it to foundation. Apart from this wall performs the following functions also:

(a) It encloses building area into different compartments and provides privacy.

(b) It provides safety from burglary and insects.

(c) It keeps the building warm in winter and cool in summer.

4. Sills, Lintels and Chejjas:-

- A window frame should not be directly placed over masonry. It is placed over 50 mm to 75 mm thick plain concrete course provided over the masonry. This course is called as sill.

- Lintels are the R.C.C. or stone beams provided over the door and window openings to transfer the load transversely so as to see that door or window frame is not stressed unduly. The width of lintels is equal to the width of wall while thickness to be provided depends upon the opening size

5. Doors and Windows:-

- The function of a door is to give access to different rooms in the building and to deny the access whenever necessary. Number of doors should be minimum possible. The size of the door should be of such dimension as will facilitate the movement of the largest object likely to use the door.

- Windows are provided to get light and ventilation in the building. They are located at a height of 0.75 m to 0.9 m from the floor level. In hot and humid regions, the window area should be 15 to 20 per cent of the floor area. Another thumb rule used to determine the size and the number of windows is for every 30 sq. m of inside volume there should be 1 sq. m window opening.

6. Floors:-

- Floors are the important component of a building. They give working/useful area for the occupants. The ground floor is prepared by filling brick bats, waste stones, gravel and well compacted with not less than 100 mm sand layer on its top. A lean concrete of 1 : 4 : 8, 100 mm

thick is laid. On this a damp proof course may be provided. Then floor finishing is done as per the requirement of the owner.

- Cheapest floor finish for a moderate house is with 20 to 25 mm rich mortar course finished with red oxide. The costliest floor finish is mosaic or marble finishing. Other floors are usually of R.C.C. finished as per the requirements of the owner.

7. Roof:-

- Roof is the top most portion of the building which provide top cover to the building. It should be leak proof. Sloping roof like tiled and A.C. sheet give leak proof cover easily. But they do not give provision for the construction of additional floor. Tiled roof gives good thermal protection. Flat roofs give provision for additional floors.

8. Step, Stairs and Lifts:-

- Steps give convenient access from ground level to ground floor level. They are required at doors in the outer wall. 250 to 300 mm wide and 150 mm rise is ideal size for steps. In no case the size of two consecutive steps be different. Number of steps required depends upon the difference in the levels of the ground and the floor.

- Stairs give access from floor to floor. They should consist of steps of uniform sizes. In all public buildings lifts are to be provided for the conveniences of old and disabled persons.

- In hostels G + 3 floors can be without lifts. Lift is to be located near the entrance. Size of the lift is decided by the number of users in peak hours. Lifts are available with capacity 4 to 20 persons.

Finishing:-

- Bottom portion of slab (ceiling), walls and top of floor need smooth finishing with plaster. Then they are provided with white wash, distemper or paints or tiles. The function of finishing work is: o Give protective cover o Improve aesthetic view o Rectify defective workmanship o Finishing work for plinth consists in pointing while for floor it consists in polishing.

- Building Services:-

- Water supply, sanitation and drainage works, electric supply work and construction of cupboards and show cases constitute major building services.

- For storing water from municipal supply or from tanker a sump is built in the house property near street. From the sump water is pumped to overhead tanks placed on or above roof level so as to get water all the 24 hours. Plumbing work is made so as to get water in kitchen, bathrooms, water closets, sinks and garden taps. For draining rain water from roofs, down take pipes of at least 100 mm diameters should be used. Proper slopes should be given to roof towards down take pipe. These

pipes should be fixed at 10 to 15 mm below the roof surface so that rain water is directed to the down take pipe easily.

11.Parapet:-

- The parapet is a minor wall around the edge of a roof, balcony, terrace, or stairway, usually covering the roof's perimeter. It protects the top and pre-built structures from corrosion and degradation.

1.7 INTRODUCTION TO INDUSTRIAL BUILDING AND TYPES-

- Any building structure used by the industry to store raw materials or for manufacturing products of the industry is known as an industrial building.

- Industrial buildings are generally used for steel plants, automobile industries, utility and process industries, thermal power stations, warehouse, assembly plants, storage, garages, etc.

Factors Considered while Selecting Site For Industrial Building:-

- Site should be located on an arterial road.

- Local availability of raw material.

- Facilities like water supply, electricity

- Topography of an area

- Soil conditions with respect to foundation design

- Waste disposal facilities

- Transportation facilities

- Sufficient space for storage of raw materials

1.8 BUILDING PLANNING AND BASIC REQUIREMENTS:-

Every family needs a building to reside in. Apart from residential purposes, buildings are required for educational, institutional, business, assembly, and industrial purposes. Buildings are necessary for the storage of materials also. This article will discuss the basic requirements of a building concerning orientation, the utility of space, energy efficiency, and other requirements,etc.

"The concept of positioning all the elements and units of a building in a systematic and practical manner to have the maximum and best utilization of the available space, area and facilities is termed as Principles of Building Planning."

1.8.1 PRINCIPLES OF BUILDING PLANNING:-

“The concept of positioning all the elements and units of a building in a systematic and practical manner to have the maximum and best utilization of the available space, area and facilities is termed as Principles of Building Planning.” There are several principles that affect the planning of a building. This article will give you a brief knowledge of all those principles. Factors Affecting Building Planning

1.8.2 FACTORS AFFECTING THE PLANNING OF THE BUILDING:

1. The function of the building e.g. residential, industrial, public, commercial, etc.

2. Shape and size of the plot

3. Topography

4. Climatic condition

5. Building by-Laws etc.

1.8.3 REQUIREMENTS OF BUILDING PLANNING AND THE CONSTRUCTION:

01. ASPECT in building planning

A building is a complete constitute of different rooms and blocks in it. All the rooms are located according to the standard use of components considering the proper access of natural resources, i.e., sunlight and wind. ASPECT is defined as a significant arrangement of doors and windows in abuilding, which are enough and efficient to provide sunlight, hygiene, wind, and eco-friendly environment. There must be sufficient light and ventilation in each room and across the house. The aspect of building can be achieved by arranging the rooms, kitchen, veranda, and many other components in proper directions.

02. PROSPECT principles in building planning

In these modern times, all the buildings and constructions are aimed to achieve an aesthetically appealing look from both exteriors and interior considerations. The appearance of a house or a building is defined as PROSPECT. The standards are raised to accomplish the building’s pleasant look by locating doors and windows at an accurate location to view nature’s beauty and avoid unwanted attributes from getting entry into the house.

03. GROUPING in building planning

GROUPING: It is to organize the different rooms in such a way that they are adequately interconnected with each other to form a functional and practical layout of the house. The accessibility of all the rooms is interlinked with each other, and this provision can be satisfied by grouping.

04. ROOMINESS of building planning

The meaning of ROOMINESS is to maximize the advantage of the available• space from the minimum dimension of a room. Both the size and shape of the room play a vital role in providing roominess.

POINTS TO UNDERSTAND THE ROOMINES

- A square room seems small in size when compared to a rectangular room.
- It is always advisable to plan a rectangular room with a proportion of 1.2 to 1.5 times
- the ratio of the length to the breadth. The increase in ratio due to length gives the tunnel experience as it looks longer.

05.CIRCULATION act as a principle of building planning

The internal access in a room in both ways i.e. in horizontal and vertical directions of a building is defined as CIRCULATION. The movement from one room to another on the same floor can be described as horizontal circulation. Likely, the movement from one floor to the other floor is termed as vertical circulation.

06. Flexibility in building planning

Flexibility means “to allow use of the particular element in another way possible to fulfil a specific purpose. An element is initially designed for one particular reason, but later the same element is used differently.”

07. Privacy in building planning

Privacy is an important factor that needs prior attention. Usually, the privacy can be considered in two ways:

a. Internal Privacy: This deals with the privacy inside a house, amongst the rooms. It covers the privacy between rooms and water closets, corridors, passage lobbies etc.

b. External Privacy: Privacy of a building with respect to other buildings and the things outside the building- such as streets, roads, etc., is external privacy

08. FURNITURE influence principles of building planning

According to rooms’ functions, the type of furniture varies. The architects and planner must consider the furniture’s relative positions to avoid the congestion of space. The furniture should match the purpose of the room and justify the effective use of a room and furniture as well. There are many points to consider while choosing furniture for your house.

09. SANITATION in building planning

The hygiene maintenance in a building is crucial. Light, ventilation, and sanitary conveniences, are essential factors that provide good sanitation in a building. Adequate sanitation can be achieved by placing doors, windows, and ventilators appropriately. Installing exhaust fans, lighting lamps, suitable absorbent flooring, and improvised plumbing equipment can lead to better sanitation.

1.9 BUILDING AREA TERMS:-

Plot area: The area which is surrounded by a boundary line (fencing) is called as Plot Area.

Plinth area or Built-up area

The total building area in plot area is referred as Built up area. In simple, Area excluding empty space around the building is called Built up area or Plinth area.

Built up Area = Carpet area+ Thickness of All walls + balcony

The plinth area is the area that lies within the outer-to-outer dimensions of the walls of the building and is obtained by multiplying the out-to-out dimensions of the building at any floor level. The space covered by pillars, pilasters, and other intermediate support are not calculated in the floor area. The built-up area and plinth area may or may not same.

Carpet Area: It is the area that can actually be covered by a carpet, or the area of the apartment excluding the thickness of inner walls. Carpet area does not include the space covered by common areas such as lobby, lift, stairs, play area, etc. Carpet area is usually around 70% of the built-up area.

Setback area: The empty space around the building is called Setback area. The setback area is decided by Municipal Authority. In India, we leave 4 ft from all the sides of the building. The reason behind leaving setback area is to make ease for moving vehicles, ventilation and during emergency purposes. However set back area increases for High rise building and may go up to several meters.

Setback area = Plot area – Built-up Area

Built-Up Area: Built-up area is the area that comes after adding carpet area (70%) and wall area (30%). Now, the wall area does not mean the surface area, but the thickness of the inner walls of a unit. The area constituting the walls is around 20% of the built-up area and totally changes the perspective. The built-up area also consists of other areas mandated by the authorities, such as a dry balcony, flower beds, etc., that add up to 10% of the built-up area. So, when you think about it, the usable area (carpet area) is only 70% of the built-up area.

Super Built-Up Area:- It is the area calculated by adding the built-up area and common area that includes the corridor, lift lobby, lift, etc. In some cases, builders even include amenities such as a pool, garden and clubhouse in the common area. A developer/builder charges you on the basis of the super built-up area which is why it is also known as ‘saleable’ area.

FOUNDATION:

It is a part of structural system that supports and anchors the superstructure of a building and transmits its loads directly to the earth. Foundation of a building as the name implies is the starting of a building construction on site really. Types of building, nature of soil and environmental conditions are the major determinant of type of foundation. Choosing a kind of foundation depends on, ground conditions, groundwater conditions, site – the environment (the buildings nearby) and structure of our building.

Purpose:- There are numerous reasons a foundation is provided, some of which are: The most crucial purpose of providing Foundation is Structural Stability. Strength of

- the foundation determines the stability of the structure to be constructed. A properly designed and the constructed foundation provide an even surface for the

- development of superstructure at a proper level at over a firm bed. A well-designed foundation prevents the lateral movement of the supporting material

- (which is the soil in this case) and thus ensuring the safety of the superstructure from the detrimental effects of the lateral movements of soil. The foundation serves the purpose of completely distributing the loads from the

- structure to a large base area, and then the soil underneath. This uniform transfer of loads helps in avoiding unequal settlement of the building, which is one of the detrimental defects in building construction.

Types of Foundation:-

1. Shallow foundation: If the depth of foundation is less than the width of foundation then it is known as Shallow or stepped Foundation. It can be used where the bearing capacity of soil on which the structure is to be constructed is maximum. Minimum depth of this Foundation is 800mm and maximum depth not to be taken more than 4 meters.

2. Deep foundation: If the depth of footing greater or equal to the Width of footing, it is known as the deep Foundation. Deep Foundation is used where the bearing capacity of the soil is very low. The load coming from the superstructure is further transmitted vertically to the soil.

Difference between Foundation and Footing:

Foundation is a structure which transfers the loads from the superstructure to the ground,

- while footing is the foundation which is in contact with the earth. A foundation can be shallow and deep, while a footing is a type of a shallow foundation.

SHALLOW FOUNDATIONS

They are usually located no more than 6 ft below the lowest finished floor.¬ A shallow foundation system generally used when¬ The soil closes the ground surface has sufficient bearing capacity• Underlying weaker strata do not result in excessive settlement.•

The shallow foundations are commonly used most economical foundation systems¬

Types of spread footing: (either for Column or for Wall)¬

a) Single pad footing.

b) Stepped footing for a column.

c) Sloped footing for a column.

d) Wall footing without step.

e) Stepped footing for walls.

f) Grillage foundation.

(a) Isolated spread footings under individual columns which can be square, rectangular or circular

(b) Wall footing is a continuous slab strip along the length of wall

(c) Combined footings support two or more columns. These can be rectangular or trapezoidal in plan. A combined footing is necessary in following three reasons:

¬ Columns are placed very close to each other so that their individual footings overlap

• each other When bearing capacity of soil is less so it is required to have a more spread area for

• footing and so footing of adjacent column may overlap When external column is close to property line, it is not possible to provide isolated

• footing for that column because it may be extended beyond the property line and so combined footing solves the problem Footing Column Footing Wall The essential condition to satisfy in combined footing is that, centroid of footing area¬ should coincide with resultant of column loads so that soil pressure distribution is uniform under soil.

Types of combined footing:¬ Combined footing (Rectangular):

- Combined footing (Trapezoidal):

• If outer column near property line carries a heavier load Strap footing

- Raft / mat foundation

(d) Strap or Cantilever Footing Strap footings are similar to combined footings.

- Reasons for considering or choosing strap footing are identical to the combined one.
- In strap footing, the foundation under the columns is built individually and connected by
- a strap beam. Generally, when the edge of the footing cannot be extended beyond the property line,
- the exterior footing is connected by a strap beam with interior footing. (e) Raft / mat foundation: This is a large continuous footing supporting all the columns of the structure.
- This is used when soil conditions are poor but piles are not used.
- Raft foundation is provided
- When load transmitted by columns are so heavy or allowable soil pressure are so
- small that individual footings if provided would cover more than about half of the area, then it is better to provide a continuous footing called raft foundation under all columns and walls Raft foundations are used to reduce settlement of structure located above heavy
- compressible deposits i.e. they control differential settlement

Types of raft foundation:

- Solid raft (A continuous slab covering all the columns)
- Ribbed raft (mat with a central hollow region when all the columns are connected by
- a continuous beam which gets supported on the raft slab

DEEP FOUNDATION

1. PILE FOUNDATION

   A pile is a slender column provided with a cap to receive the column load and transfer
   - it to undelaying soil layer / layers. Pile foundation is a common type of deep foundation.
   - Pile is a slender member with a small cross-sectional area compared to its length.
   - It is used to transmit foundation loads to a deeper soil or rock strata when the bearing
   - capacity of soil near the surface is relatively low. Pile transmits load either by skin friction or bearing.
   - Piles are also used to resist structures against uplift and provide structural stability against• lateral and overturning forces. They are used to reduce cost, and when as per soil condition considerations, it is desirable
   - to transmit loads to soil strata which are beyond the reach of shallow foundations. Pile foundations are economical when
   - Soil with higher bearing capacity is at a greater depth. When the foundation is subjected to a heavily concentrated load The foundation is subjected to strong uplift force Lateral forces are

relatively pre dominant When there are chances of construction of irrigation canals in the nearby area. Mat or Raft Expansive soil like black cotton soil are present at the site In marshy places where soil is wet soil/ soft soil/ water logged/ low laying area When the topsoil layer is compressible in nature. In the case of bridges, when the scouring is more in the river bed. When it is very expensive to provide raft or grillage.

Bearing Capacity of Soil

When subjected to stress from loading, the soil has a tendency to distort.

The soil's ability to resist displacement is influenced by a number of different variables, including its moisture content, relative density, internal friction angle and the way in which force is transmitted to the soil.

The term "bearing capacity of soil" refers to the maximum weight per unit area that soil can support without succumbing or being displaced.

If the soil underneath a building cannot support the weight of the structure being constructed, the structure may become unstable, which can result in fractures and other forms of damage.

As a result, in order to circumvent this problem, the bearing capacity of soil must be taken into consideration while designing the foundation.

Types of Bearing Capacity of Soil

1. Ultimate bearing capacity (qu) The gross pressure at the base of the foundation at which soil fails is called ultimate bearing capacity.

2. Net ultimate bearing capacity (qnu) By neglecting the overburden pressure from ultimate bearing capacity we will get net ultimate bearing capacity.

3. Net safe bearing capacity (qns) By considering only shear failure, net ultimate bearing capacity is divided by certain factor of safety will give the net safe bearing capacity. qns = qnu/ F

4. Gross safe bearing capacity (as) When ultimate bearing capacity is divided by factor of safety it will give gross safe bearing capacity. qs = qu/F

5. Net safe settlement pressure (anp) The pressure with which the soil can carry without exceeding the allowable settlement is called net safe settlement pressure.

6. Net allowable bearing pressure (qna) This is the pressure we can used for the design of foundations. This is equal to net safe bearing pressure if gnp > qns. In the reverse case it is equal to net safe settlement pressure.

Factors Affecting Bearing Capacity of Soil

1. Foundation width Soil with little cohesiveness might have its bearing capacity reduced if the foundation is too narrow. In cohesionless soil, where internal friction contributes significantly to soil shear strength, a wider foundation will support a greater load. Soil with infinite depth, consistent shear strength, and cohesive properties may support loads of any width foundation.

2. Foundation depth A deeper foundation is necessary for increased bearing capacity. This is most noticeable in cohesive-free soil when the texture is homogeneous. The opposite is true if the foundations are pushed into a poor soil layer, which reduces their carrying ability. Unless the building is anchored by under-consolidated soil or compressible soil that is vulnerable to

wetness, appropriate bearing capacity is typically assured by foundations set at depths where the weight of the structure matches the weight of the displaced soil.

3. Surcharge and soil weight One cannot exclude the bearing capacity contribution of water table-influenced surcharge and subsurface soil. Construction, seepage, and elevation issues may be avoided if the water table is kept below the foundation's base. There will be no effect on the bearing capacity of soil from water table levels below the failure surface.

4. Spacing between foundations When designing a foundation, it is advised that a minimum separation between footings that is 1.5 times the width of the foundation be taken into consideration. This will help prevent a loss in the foundation's carrying capacity.

5. Dynamic motion and earthquake The bearing capacity of soil might diminish due to repeated movement, which would raise pore pressure. Earthquakes, vibrating equipment, and several other factors such as transportation, explosion, and pile driving all contribute to cyclic motions. When pore pressures are higher than the soil confining tension, the foundation soil may become liquefied. The effective stress drops to zero due to liquefaction, leading to significant deformation and a decrease in bearing capacity.

6. Frost action Changes in the bearing capacity of soil may occur gradually over time due to frost heave in particular soils that are in proximity to water and are exposed to subzero weather. Materials with a low cohesiveness, such as those made up of a lot of silt-sized particles, are more vulnerable to the effects of frost.

7. Subsurface voids The bearing capacity of soil is diminished when subsurface voids are present within a crucial depth under the foundation. The critical depth is determined by the depth at which the pressure exerted by the foundation on the soil is no longer significant.

8. Collapsible and expansive soils When the soil is somewhat dry, its sturdiness and bearing capacity may increase significantly, despite its tendency to collapse and expand. However, because of changes in moisture content, the proportion of these soils might shift. As a result, there will be shifts in the structure's base on a global and regional scale. Soil movement brought on by rain and dry spells may cause long-term, severe damage to buildings.

9. Potential heave Consolidometer testing, carried out in line with ASTM D 4546, may reveal the presence of a possible heave. The findings of this test are taken into account when deciding how to prepare the foundation soils so that they are better able to resist or isolate the anticipated soil heave.

10. Soil reinforcement The bearing capacity of weak or soft soil may be significantly boosted by the installation of different types of reinforcement in the soil. These reinforcements can take the shape of metal links, strips, arrays, geotextile fabrics, or coarse aggregates.

11. Seepage and soil erosion Seepage and erosion of the soil surrounding and beneath foundations may both lower the bearing capacity of the foundation soil and ultimately lead to its collapse

Module-II

BUILDING MATERIALS

Bricks: Properties and specifications

BRICK: A brick is a type of block used to build walls, pavements and other elements in masonry construction. Properly, the term brick denotes a block composed of dried clay, but is now also used informally to denote other chemically cured construction blocks. Bricks can be joined using mortar, adhesives or by interlocking them. Bricks are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities.

Chief Ingredients of Brick and Their Functions

Silica (Sand) and Alumina (Clay), these two are the most prominent ingredients in brick clay. When mixed with water in proper proportions, it gains plasticity. The plastic mass can be easily molded and dried. It should not go through cracking, shrinkage or warping.

Alumina

Alumina is the main constituent of clay. It acts as a cementing material in raw brick. Brick clay is plastic due to the presence of alumina. This plasticity ensures that bricks can be molded. An excess amount of alumina in clay may cause the bricks to shrink, warp or crack on drying and burning as any other cementing material.

Silica

Good quality bricks contain 50-60% silica. It is present in both free and combined form. As frees sand, it remains mechanically mixed with clay. In combined form, it reacts with alumina to form aluminosilicates. Silica prevents raw bricks from cracking, shrinking and warping. The higher the proportion of sand, the more and shapely and uniform in texture will be the brick. Although, excess silica destroys cohesion between the brick clay particles and makes brick brittle and weak. The durability of bricks largely depends upon the proper proportion of silica and alumina

Lime

Bricks should contain a little amount of finely powdered lime. It enables silica (of a required portion) to melt at the furnace temperature of 1650oC and binds the particles of brick together resulting in strong and durable bricks. At about 1100o C, lime acts as a catalyst to elevate the furnace temperature to 1650oC at which silica fuses. This slightly fused silica works as a strong cementing material. Excess lime in brick clay will cause vitrification of bricks. It causes bricks to melt, as more than the required amount of silica will fuse. The bricks then lose their shape and become disfigured

Iron Oxide

Bricks contain a small quantity of Iron Oxide. Iron Oxide acts a flux like lime, thus helps silica to fuse at low temperature. It imparts a red color to bricks upon burning. Iron also increases the durability and impermeability of the bricks.

Magnesia

A small proportion of magnesium decreases shrinkage and gives a yellow tint to the bricks. An excess amount of it causes bricks to decay.

Harmful Ingredients of Brick

Lime Excess lime melts the bricks and disfigures it. If $CaCO_3$ exists (in the purest form, i.e., if it contains at least 95% CaO) in lime-lump in brick clay, it converts into quicklime on burning. When these bricks come in contact with water, quicklime slakes and expands. And causes disintegration of bricks.

Alkalis

Alkalis are mainly salt of Sodium (Na) and Potassium (K). It acts as a flux in the kiln and causes fusion, warping, and twisting of bricks. Alkalis absorb moisture from the atmosphere and cause dampness and efflorescence in bricks (because of the presence of hygroscopic salts, e.g., $CaCl_2$, $MgCl_2$, etc.).

Pebbles, Stones & Gravels

Their presence does not allow thorough mixing of earth, thus the bricks produced are weaker. Such bricks cannot be broken at the desired section and they break very irregularly.

Iron Pyrites (FeS)

Iron Pyrites causes crystallization and disintegration of bricks while burning. It discolors bricks in the form of black slag. Organic Matter Organic matter in bricks makes bricks porous resulting in low density and weaker bricks.

CLASSIFICATION OF BRICKS:

Sun-dried bricks

Burnt clay bricks

Fly ash bricks

Concrete bricks

Engineering bricks

Calcium silicate bricks

Eco bricks

Sun-dried bricks: These are un-burnt bricks made of clay. They are moulded and left under the sun to dry.

Burnt clay bricks: These are made of clay and put into the kiln for burning. They are used for building walls, foundations, and columns, among others.

There are four different types of burnt clay bricks:

First class: Quality with excellent edges

- Second class: Ground moulded and a bit irregular in shape
- Third class: Rough-edged and ground moulded, used for temporary construction
- Fourth class: Over-burnt and highly irregular, dark in colour with no water resistance feature

Fly ash bricks: Also called Self-cementing brick, these bricks contain Class F or Class C fly ash as a part of the formula.

Concrete bricks: These bricks are made using solid concrete. The concrete is prepared using sand, coarse aggregates, water, and cement.

Engineering bricks: This type of brick offers high compressive strength. They are used for construction where low porosity, frost resistance, acid resistance, and strength are mandatory.

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

Eco bricks: Porotherm hollow bricks are suitable walling solutions. They offer significant thermal insulation and make walls stronger.

PROPERTIES OF BRICKS

1. Physical Properties of Bricks

These properties of bricks include shape, size, color, and density of a brick.

Shape.

¬ 1. The standard shape of an ideal brick is truly rectangular. It has Well defined and sharp edges. The surface of the bricks is regular and even.

2. These are generally modifications of rectangular shapes.

Size.

¬ 1. The size of brick used in construction varies from country to country and from place to place in the same country.

2. In India, the recommended standard size of an ideal brick is 19 x 9 x 9 cm which with mortar joint gives net dimensions of 20 x 10 x 10 cm.

Colour.

¬ 1. The most common color of building bricks falls under the class RED. It may vary from deep red to light red to buff and purple.

2. Very dark shades of red indicate over burnt bricks whereas yellow color is often indicative of under-burning.

Density.

¬ 1. The density of bricks or weight per unit volume depends mostly on the type of clay used and the method of brick molding (soft-mud, Stiff-mud, hard-pressed etc.).

2. In the case of standard bricks, density varies from 1600 kg/cubic meter to 1900 kg/cubic meter.

2. Mechanical Brick Properties

Under this heading of properties of bricks, compressive strength and flexure strength are included.

Compressive Strength of Bricks.

¬ 1. It is the most important property of bricks especially when they are used in load-bearing walls.

2. The compressive strength of a brick depends on the composition of the clay and degree of burning. It may vary from 35 kg/cm2 to more than 200 kg/cm2 in India.

Flexure Strength.

¬ 1. Bricks are often used in situations where bending loads are possible in a building. As such, they should possess sufficient strength against transverse loads.

2. It is specified that the flexural strength of a common building brick shall not be less than 10 kg/cm2 .

3. Best grade bricks often possess flexural strength over 20 kg/cm2 .

Thermal Properties of Building Bricks.

¬ 1. . Besides being hard and strong, ideal bricks should also provide an adequate insulation against heat, cold and noise.

2. The heat and sound conductivity of bricks vary greatly with their density and porosity.

3. Very dense and heavy bricks conduct heat and sound at a greater rate. They have, therefore, poor thermal and acoustic (sound) insulation qualities.

4. For this reason, bricks should be so designed that they are light and strong and give adequate insulation

Specification of Bricks

♣ A brick is small block of burnt clay with a size that can be held in one hand conveniently. Brick should be thoroughly burnt, of uniform color, having plane rectangular faces, sharp straight, right angle edges. S

tandard Modular size of common building brick is 190X90X90 mm

¬ The size of a Non-Modular brick is 9"X4-3/8"X2-11/16" (229X111X70 mm).

But it is¬ specified as 230X110X70 mm. The weight of a brick is about 3 to 4 kg

Visual Characteristics of Brick

Good bricks should be burnt thoroughly so that they become hard and durable.

- Satisfactory burning of the bricks is ascertained by hard ringing sound when two

- bricks are struck together. The bricks should have smooth and rectangular shapes with sharp corners and uniform

- colors. The bricks should be free from cracks, chips, warp age, large particles of lime and organic matters.

Water Absorption of Brick

Average water absorption of bricks after 24 hours of immersion in cold water should not be more than 20% of its own dry weight. The acceptable water absorption for clay bricks are between 12% and 20%. If you are using engineering bricks the closer you are to the 12% the better the result will be. When the water absorption is too low, i.e. below 12%, it may be difficult to obtain a proper bond between the mortar and the bricks.

Raw Materials for Brick

Sufficient samples of the earth available must be tested to check if the soil is suitable for composition of bricks and available abundantly in neighborhood. It is reasonable uniformity of composition in the soil. Mechanical composition of the soil may preferably confirm the following requirements. Clay 20 to 35 %

¬ Silt 20 to 35%

¬ Sand 35 to 45 %

CEMENT

A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together.

The principal raw materials used in the manufacture of Ordinary Portland Cement are:

1. Argillaceous or silicates of alumina in the form of clays and shales.

2. Calcareous or calcium carbonate, in the form of limestone, chalk and marl which is a mixture of clay and calcium carbonate.

Gypsum is added to control the “setting of cement”. If not added, the cement will set immediately after mixing of water leaving no time for concrete placing.

Physical Properties of Cement

Different blends of cement used in construction are characterized by their physical properties. Some key parameters control the quality of cement.

The physical properties of good cement are based on:

Fineness of cement

¬ Soundness

¬ Consistency

¬ Strength

¬ Setting time

¬ Heat of hydration

¬ Loss of ignition

¬ Bulk density

¬ Specific gravity (Relative density)

¬ These physical properties are discussed in details in the following segment. Also, you will find the test names associated with these physical properties. Fineness of Cement The size of the particles of the cement is its fineness. The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process. As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important

Soundness of Cement

Soundness refers to the ability of cement to not shrink upon hardening. Good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.

Consistency of Cement

The ability of cement paste to flow is consistency. It is measured by Vicat Test. In Vicat Test Cement paste of normal consistency is taken in the Vicat Apparatus. The plunger of the apparatus is brought down to touch the top surface of the cement. The plunger will penetrate the cement up to a certain depth depending on the consistency. A cement is said to have a normal consistency when the plunger penetrates 10±1 mm.

Strength of Cement

Three types of strength of cement are measured – compressive, tensile and flexural. Various factors affect the strength, such as water-cement ratio, cement-fine aggregate ratio, curing conditions, size and shape of a specimen, the manner of molding and mixing, loading conditions and age. While testing the strength, the following should be considered: Cement mortar strength and cement concrete strength are not directly related. Cement strength is merely a quality control measure. The tests of strength are performed on cement mortar mix, not on cement paste.

Compressive Strength

It is the most common strength test. A test specimen (50mm) is taken and subjected to a compressive load until failure. The loading sequence must be within 20 seconds and 80 seconds. Tensile strength Though this test used to be common during the early years of cement production, now it does not offer any useful information about the properties of cement.

Flexural strength

This is actually a measure of tensile strength in bending. The test is performed in a 40 x40 x 160 mm cement mortar beam, which is loaded at its center point until failure.

Setting Time of Cement

Cement sets and hardens when water is added. This setting time can vary depending on multiple factors, such as fineness of cement, cement-water ratio, chemical content, and admixtures. Cement used in construction should have an initial setting time that is not too low and a final setting time not too high. Hence, two setting times are measured: Initial set: When the paste begins to stiffen noticeably (typically occurs within 30-45 minutes) Final set: When the cement hardens, being able to sustain some load (occurs below 10 hours) Again, setting time can also be an indicator of hydration rate.

13 Types of Cement

Ordinary Portland Cement (OPC)

¬ Portland Pozzolana Cement (PPC)

¬ Rapid Hardening Cement

¬ Quick setting cement

¬ Low Heat Cement

¬ Sulphate resisting cement

¬ Blast Furnace Slag Cement

¬ High Alumina Cement

¬ White Cement

¬ Colored cement

¬ Air Entraining Cement

¬ Expansive cement

¬ Hydrographic cement

¬ Ordinary Portland Cement (OPC)

In usual construction work, Ordinary Portland Cement is widely used. Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates, (3 CaO·SiO2, and 2 CaO·SiO2), the remainder consisting of aluminium- and iron-containing clinker phases and other compounds. The ratio of CaO to SiO2 shall not be less than 2.0. The magnesium oxide content (MgO) shall not exceed 5.0% by mass. The composition of Ordinary Portland Cement: Argillaceous or silicates of alumina (clay and shale)• Calcareous or calcium carbonate (limestone, chalk, and marl)

• Uses of Ordinary Portland Cement It is used for general construction purposes.• It is also used in most of the masonry works.

Portland Pozzolana Cement (PPC)

Pozzolans are natural or synthetic materials that contain silica in reactive forms. It reacts with calcium hydroxide generated by hydrating cement to form additional cementations materials when it is finely divided.

The composition of Portland Pozzolana Cement:

OPC clinker

- Gypsum
- Pozzolanic Materials (Fly ash, volcanic ash, and Calcined clay or silica fumes.)

Rapid Hardening Cement

When finely grounded Tri-calcium silicate (C3S) is present in OPC with higher content, it gains strength more quickly than OPC. This type of OPC is called Rapid Hardening Cement. It's initial Setting Time 30 minutes and Final Setting Time 600 minutes.

Uses of Rapid Hardening Cement

Rapid hardening cement is mostly used where rapid construction is needed like the

- construction of pavement. It also gives high strength.
- We have published three articles on rapid hardening cement on our website. In case you want to learn more about RHC, you can visit the following link.

Quick Setting Cement

Quick setting cement is the cement which sets in a very short time. The initial setting time is 5 minutes and the final setting time is 30 minutes.

The composition of Quick Setting Cement: Clinker

- Aluminum sulfate (1% to 3% by weight of clinker)
- The aluminum sulfate increases the hydration rate of silicate.

Low Heat Cement

It is a spatial type of cement which produces low heat of hydration during the setting. Some chemical composition of Ordinary Portland Cement is modified to reduce the heat of hydration.

The chemical composition of low heat cement: A low percentage (5%) of tricalcium aluminate (C3A)

- A higher percentage (46%) of declaiming silicate (C2S).•

Uses of Low Heat Cement

It is used for the construction of dam's large footing, large raft slabs, and wind turbine

- plinths. It is also used for the construction of chemical plants.
- Sulphate Resisting Cement Sulfate resisting cement is used to resist sulfate attacks in concrete. Due to the lower percentage of Tricalcium aluminate, the production of calcium sulpho-aluminates gets reduced.

Uses of Sulphates resisting Cement

Construction in contact with soils or groundwater having more than 0.2% or 0.3 % g/l

- sulfate salts respectively. Concrete surfaces subjected to alternate wetting and drying such as bridge piers,

- concrete surface in the tidal zone, apron, Building near the seacoast. Effluent treatment plans, Chimney, Chemical industries, water storage, sumps,

- drainage works, Cooling towers, Coastal protective works such as sea walls, breakwaters, tetrapods, etc. Blast Furnace Cement Portland cement clinker and granulated blast furnace slag are intergraded to make blast furnace cement. A maximum of 65 percent of the mixture could be comprised of blast furnace slag. Uses of Blast Furnace Cement It is highly sulfate resistant

- Frequently used in seawater construction.

- High Alumina Cement High Alumina cement is obtained by mixing calcining bauxite (it's an aluminum ore) and ordinary lime with clinker during the manufacture of OPC. In which the total amount of alumina content should not be lesser than 32% and it should maintain the ratio by weight of alumina to the lime between 0.85 to 1.30.

Uses of High Alumina Cement

It is used where concrete structures are subjected to high temperatures like workshops,

- refractory, foundries, etc. It also used where the concrete is subjected to frost and acidic action.

- White Cement White cement is quite similar to Ordinary Portland Cement except for color. Amounts of iron oxide and manganese oxide are low in White Cement. It is expensive then OPC so not economical for ordinary work.

Uses of White Cement It is usually used in decorative work.

- It can also use for traffic barriers, tile grouts, swimming pools, roof tiles patching

- materials, and terrazzo surfaces. Colored Cement To make 5 to 10 percent of suitable pigments are ground with OPC. Types of pigments are selected according to the desired color. Uses of Colored Cement Colored cement is used for different decorative work.

Air Entraining Cement

It is seen that entrainment of air or formation of gas bubbles while applying cement increases resistance to frost action, fire, scaling, and other similar defects. Air-entraining cement is a special type of cement which entrains tinny air bubbles in concrete. It is produced by grinding minute air entertaining materials with clinker by adding some resinous materials e.g. vinsol resin to ordinary portland cement. When the water in concrete gets frizzed due to low temperature, it expands.

When airentraining cement, the air voids in concrete provides space for water to expand without cracking concrete. But this type of cement does not provide high strength in concrete.

Uses of Air-Entraining Cement

Especially it is used in areas where the temperature is very low.

- It also resists the Sulphet attack.
- It is used where the de-icing chemical is used.

Expansive Cement

In the hydration process, the expansive cement expands its volume. It can be possible to overcome shrinkage loss by using expansive cement.

Uses of Expansive cement It is used in the construction of the pre-stressed concrete component.

- It is also used for sealing joints and grouting anchor bolt
- In the construction of different hydraulic structures, this type of cement is used.

Hydrophobic Cement

To resist the hydration process in the transportation or storage stage, clinkers are ground with water repellent film substance such as Oleic Acid or Stearic Acid. These chemicals form a layer on the cement particle and do not allow water to mix and start the hydration process. When cement and aggregate are thoroughly mixed in the mixer, protective layers break and start normal hydration with some air-entrainment which increases workability.

Uses of Hydrophobic Cement

it is used in the construction of water structures such as dams, spillways, or

- other submerged structures. It is also used in the construction of underground structures like tunnel etc.

Uses of Cement Following are the different uses of cement in construction works:

1. To prepare cement mortar

2. To prepare cement concrete

3. To build fire proof and thermal proof structures

4. To build hydrographic and frost resistant structures

5. To build chemical proof structures

6. As a grout material

7. To construct Cement concrete roads

8. To manufacture precast members

9. For aesthetic concrete construction

MORTAR

Preparation Mortar is an intimate mixture of binding material, fine aggregate and water. When water is added to the dry mixture of binding material and the inert material, binding material develops the property that binds not only the inert material but also the surrounding stones and bricks.

TYPES OF MORTAR

- CEMENT MORTAR
- LIME MORTAR
- SURKI MORTAR
- GAUGED MORTAR
- MUD MORTAR

CEMENT MORTAR

Cement mortar composite has wide application in masonry work, plastering,repairing damaged concrete, patching or filling, rendering, floor leveling, andthe development of precast products.The composite is composed of binder,sand, water, and fibers with a maximum.size of fine-grain material of 2 mm. The binder may be cement, mineral with polymeric or chemical admixtures .

CONSTITUENTS OF CEMENT MORTAR:- Cement mortar should be composed of cement, sand, and water, be well-mixed, and have the proper consistency to obtain a dense, homogeneous lining that will adhere firmly to the substances surface. Cement-mortar lining should be applied by spinning, mechanical placement (line traveling), the pneumatic process (shotcrete or gunite), and hand troweling.

PREPARATION:-

- Selection of Raw Materials

¬ Proportion of cement mortar

¬ Mixing of ingredient

1.SELECTION OF RAW MATERIALS:-

The production of cement mortar can be done with a variety of materials, but it is

¬ important to choose the correct ones for the job based on the construction's kind and intended use. Mortar is created using Portland cement. For most construction tasks, ordinary¬ Portland cement is best. Lime is Sand must be of good quality and devoid of contaminants like clay, dust, iron oxide, etc. Before combining it with cement, it needs to be thoroughly cleaned. used to make composite mortars. Sand gives concrete strength and resistance to breaking and shrinkage. It gives mortars¬ bulk, which makes it affordable. It would be not only very expensive but also useless to use simply cement.

2.PROPORTION OF CEMENT MORTAR:- The Proportion means the relative quantity of different components to be mixed to make good mortar, or simply the ratio between different materials. Following are the proportions of cement mortar which is commonly recommended for different works:

01. Masonry Construction:-

For ordinary masonry work with brick/ stone as a structural unit. – 1:3 to 1:6

Forreinforced brick work – 1:2 to 1:3.

¬ For all work in moist situations – 1:3

¬ For Architectural work – 1:6

¬ For load bearing structures – 1:3 or 1:4

02. Plaster Work:-

For External Plaster and Ceiling Plaster – 1:4

¬ Internal Plaster (If sand is not fine i.e. Fineness Modulus

¬> 3) – 1:5 For Internal Plaster (if fine sand is available) – 1:6

03. Flooring Work:

Mortar ratio of 1:4 to 1:8 (cement: sand, water to be judgmental), for 5 to 7 times

¬ thickness of verified tiles, should be given as bed between RCC floor and tiles.

04. Pointing Work: For pointing work proportion of cement mortar should be 1:1 to 1:3

3. MIXING OF INGREDIENTS:- Sand and cement are appropriately combined in a dry environment to create cement¬ mortar. After that, water is gradually added and combined using a shovel. Clay and other pollutants should not be present in the water.Either manually (Hand Mixing) or mechanically mixing cement mortar is an option (Machine Mixing). Hand mixing is frequently employed in modest projects. When mortar is needed in big amounts and must be used continuously, mechanical mixing is necessary

CONCRETE

types:PCC and RCC, Grades of Concrete Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. Concrete is the second-mostused substance in the world after water, and is the most widely used building material.

PLAIN CEMENT CONCRETE

Plain concrete, also known as plain cement concrete or PCC, is most commonly used for paving and flooring.

Major ingredients of concrete are: Binding materials (like cement, lime, polymer)

- Fine aggregate (sand)
- Coarse aggregate (crushed stone, jelly)
- Water

A small quantity of admixtures like air entraining agents, water proofing agents, workability agents etc. may also be added to impart special properties to the plain concrete mixture.

The objective of plain cement concrete alias PCC is to arrange a firm impermeable bed to RCC in the foundation where the soil is soft and flexible. It is mostly applied over brick flat soling or devoid of brick flat soling. It is also known as Cement Concrete (CC) or Blinding Concrete.

RCC

Reinforced concrete, concrete in which steel is embedded in such a manner that the two materials act together in resisting forces.

The reinforcing steel—rods, bars, or mesh— absorbs the tensile, shear, and sometimes the compressive stresses in a concrete structure.

Reinforced concrete is used for construction on a large scale, such as bridges, dams, piers,

- tall buildings and stadiums. It is most commonly used in domestic construction for the footings and foundations of smaller everyday dwellings. Reinforced concrete (RC), also called reinforced cement concrete (RCC) and

- ferroconcrete, is a composite material in which concrete's relatively low tensile strength and ductility are compensated for by the inclusion of reinforcement having higher tensile strength or ductility.

NOTE Depending upon the proportion of ingredient, strength of concrete varies. It is possible to

• determine the proportion of the ingredients for a particular strength by mix design procedure. In the absence of mix design the ingredients are proportioned as 1:1:2, 1:3/2:3, 1:2:4, 1:3:6 and 1:4:8, which is the ratio of weights of cement sand to coarse aggregate. In proportioning of the concrete, it is kept in mind that voids in coarse aggregates are filled

• with sand and the voids in sand are filled with cement. In terms of strength, naturally, RCC is stronger because the reinforcement helps in loadcarrying capacity. PCC is weaker and is only used for layering surfaces like plastering

• work or flooring and most importantly in the layering if excavation to cast footings. Concrete Grades Proportion of ingredients usually adopted for various works are shown in table below.

Functions of Various Ingredients

Concrete Ingredients Concrete has been used as a building material for thousands of years. The main ingredients have been the same, but new admixture technologies allow designers and engineers to finely tune the final properties of the fully set concrete.

Four Main Ingredients

Concrete is made up of four main ingredients: water, Portland cement, aggregates, and air. The ratio of the ingredients changes the properties of the final product, which allows the engineer to design concrete that meets their specific needs. Admixtures are added to adjust the concrete mixture for specific performance criteria. Concrete ingredients: water, cement, aggregate, and air

Water

The water in the concrete mix should be clean and free of impurities. The amount of¬ water relative to the amount of cement changes how easily the concrete flows, but also affects the final strength of the concrete. More water makes for easier flowing concrete, but also makes for lower strength concrete upon curing.

Portland Cement

Cement hardens when mixed with water, which binds all of the ingredients together.¬ Portland cement is the most common cement used and is composed of alumina, silica, lime, iron, and gypsum. Small amounts of other ingredients are also included.

Aggregates

The majority of a concrete mixture is made up of both coarse and fine aggregates,¬ which help increase the strength of the concrete beyond what cement can provide on its own. Sand, gravel, and crushed stone are used as aggregates. Recycled materials, including blast furnace slag, glass (mostly for decorative purposes), and ground-up concrete are starting to be used as concrete aggregates.

Air

The fourth main ingredient of concrete is entrained air. While it usually isn't¬ considered an ingredient, the fact is that a concrete mix includes anywhere from 1% to 9% entrained air. Higher quantities of air should be included when the concrete will be exposed to very cold or freezing conditions.

Admixtures

Admixtures accomplish a variety of goals. This can be as simple as adding a pigment¬ to color the concrete. Other admixtures are used for faster curing times in cold weather, creating extremely high-strength concrete, or for increasing the flowable nature of concrete without compromising the strength. Unfortunately, admixtures can generate unwanted results such as poor adhesion of finish-flooring. For this reason, many structural engineers and architects are hesitant to use admixtutres. We have an article that covers a number of different admixtures.

Hydration: A Chemical Reaction

While the moisture content reduces as the concrete sets, it is important to know that¬ concrete doesn't "dry." Rather, concrete sets through a chemical reaction called hydration. This is why concrete can be placed under water. The concrete starts to set as soon as water is added to the mix. Therefore, the mix¬ should be constantly moved to help keep the particles from binding together (thus rotating concrete trucks.) Most job sites require the concrete to arrive and be placed within 90 minutes from initial mixing, but admixtures can extend that time.

Green Concrete and Hardened concrete

Concrete has completely different properties when it is in its plastic stage. Concrete in• its plastic stage is known as also green concrete. The properties of green concrete include:• 1. Workability 2. Segregation 3. Bleeding 4. Harshness The properties of hardened concrete include: 1. Strength 2. Resistance to wear 3. Dimensional changes 4. Durability 5. Impermeability

STEEL

It is highly elastic, ductile, malleable and weldable. Steel has high tensile and compressive strength and also stands wear and tear much better.

USE OF STEEL IN BUILDING WORKS:

Steel can be used for various purposes in building works –

1. As structural material in trusses , beams, etc

2. As non-structural material for grills, doors, windows etc

3. In steel ,pipes , tanks etc

4. In sanitary and sewer fittings, rainwater goods etc

5. Corrugated sheets

6. As reinforcement for concrete STEEL AS A REINFORCEMENT IN CONCRETEAlthough plain concrete is very strong in compression , it is very weak in tensile strength .So, steel is being used in concrete reinforcement . It is equally strong in compression and tension. The steel for reinforcing bars of other forms of round bars varying in diameter from 5 to 40 mm , sometimes bars of other forms as mentioned above are also used. Reinforced cement Concrete (RCC) is more rigid, highly durable and fire resistant. It posses high tensile strength and it is economical in ultimate cost.

TYPES OF STEEL SECTION:

1.Mild Steel- It has a carbon content of about 0.23 -0.25% .¬ For bars with a diameter of minimum 20mm, a higher value of this carbon content is¬ acceptable. Size ranges from 6mm up to 32mm (6,12,16,20,25¬ &32mm) depending on length and diameter. The ultimate tensile strength is 250 N/mm^2¬ & young modulus is 2*10^5 N/mm^2 for this material. Reinforcement in concrete was a typical usage for it window bars , grills¬ & steel gates are example of this type of materials.

2.HYSD bars- High yielding strength deformed bars¬ Two types of HYSD bars termed as Fe-415 and Fe-500 tensile strength N/mm62.¬ Have ribs on the surface make bond between concrete and steel greater.¬ Bars come in diameter 8,10,12,16,20,22,25,28¬ & 32mm The bars are now being used as reinforcement instead of mild steel bar because their¬ higher strength in tensile & bond is stronger. These are called wind bars.

3.HIGH TENSILE BARS- Made with 0.8% carbon and .6% manganese as well as small amount of silicon,¬ sulphur, phosphorous to make them strong. The bars have tensile strength as high as 1400 to 1900 n/m^2 . The young modulus¬ steel is also same as that of mild steel. In prestressed concrete, reinforcing is provided by high tensile bars.¬ Fig- Types of steel

MARKET FORMS OF STEEL :

1.Angle Section- Angle section may be of equal legs or unequal legs. Equal angles available in sizes 20mm*20mm*3mm to 200mm*200mm*25mm . The corresponding weights per meter lengths are .95Kg to 73.60 kg. Unequal angles varies size forms 30mm*20mm*3mm to 200mm*150mm*18mm. Corresponding weights are from 1.10kg to 46.90 kg. Angle sections are extremely used in structural steel work especially in the construction of steel roof trusses and filler joist floors.

2.Channel Section – Channel section consist of a web and two flanges. A channel section is designated by the height of the web and width of flanges. It varies size from 100mm*45mm to 400mm*100mm . The corresponding weight per meter length are respectively 5.80 kg to 49.40 kg. The ISI has classified channel sections as junior channel, light channel and medium channel. It used as structural members in steel framed structures.

3.Corrugated Sheets – These are formed by passing steel sheets through grooves. These grooves bend and press steel sheets and corrugations are formed on the sheets. They are usually galvanized and known as GI sheets. They are usually used in roof covering.

4.Expanded metal – This form of steel is available in different shapes and sizes. It is prepared from sheets of mild steel, which are machine cut and drawn out or expanded. These are widely used for reinforcing concrete in foundation , roads, floors and bridges etc.

5. Flat bars – These are available in suitable widths varying from 10mm to 400mm with thickness varying from 3mm to 40mm. They are widely used in construction of steel grillwork for windows and gates.

6. I sections – These are known as rolled steel joists and beams. The two flanges connected through a web. They are available sizes from 75mm*50mm at 6.10kg to 600mm *210mm at 99.50Kg. Beams are suitable for columns are available in H sections 150mm*100mm to 600mm*250mm size.

7.PlatesThe plate sections of steel varies from 5 to50 mm thickness. They are mainly used for purposes- ¬ To connect steel beams for extension of the length¬ ¬ To serve as tension members of steel roof truss.¬ ¬ To form a built up sections of steel.¬

8.Ribbed torsteel beamsThey are varies from 6 to 50 mm size. They are widely use in reinforcement in concrete structure such as buildings , bridges, roads, irrigation works. These bars have ribs on their surface and they are produced by controlling twisting. Fig- Various c/s of steel

9. T-sections – It consists of flanges and web. They are available from size 20mm*20mm*3mm to 150mm*150mm*10mm size. These sections are widely used as members of steel root truss and to form built up sections.

Module-III

Introduction to Planning and Design Aspects of Transportation Engineering

Modes of transportation

In general, transportation is used for moving of people, animals, and other goods¬ from one place to another.

The different modes of transport are air, water, and land transport (rails or railways,¬ highways and off-road transport). Components of a mode of transportϖ A transport mode is a combination of the following:

1. Transportation infrastructure: Thoroughfares, networks, hubs (stations, bus terminals, airport terminals), etc.

2. Vehicles and containers: motor vehicles, automobiles, motorcycles, trucks, wagons, trains, ships, and aircraft

3. A stationary or mobile workforce

4. Propulsion system and power supply (traction)

5. Operations: driving, management, traffic signals, railway signalling, air traffic control, etc. Highway Engineering Highway engineering is an engineering discipline branching from civil engineering that involves the planning, design, construction, operation, and maintenance of roads, bridges, and tunnels to ensure safe and effective transportation of people and goods. Historical Highways

The beginning of road construction could be dated to the time of the Romans. With the advancement of technology from carriages pulled by two horses to vehicles with power equivalent to 100 horses, road development had to follow suit. The construction of modern highways did not begin until the late 19th to early 20th century.

I. Roman Roads Romans recognized that the fundamentals of good road construction were to provid

♣ good drainage, good material and good workmanship. Their roads were very durable, and some are still existing. Roman roads were always constructed on a formed subgrade, strengthened where necessary with wooden piles. The roads were bordered on both sides by longitudinal drains. The next step was the construction of the agger. This was a raised formation up to

♣ a 1-meter-high and 15 m wide and was constructed with materials excavated during the side drain construction. This was then topped with a sand levelling course. The agger contributed greatly to moisture control in the pavement. The pavement structure on the top of the agger varied greatly. In the case of heavy

♣ track, a surface course of large 250 mm thick hexagonal ag stones were provided. The main features of the Roman roads are that they were built straight regardless of gradient and used heavy foundation stones at the bottom.

II. **French Roads** The next major development in the road construction occurred during the regime of

♣ Napoleon. The significant contributions were given by Tresaguet in 1764. He developed a cheaper method of construction than the lavish and locally unsuccessful revival of Roman practice. The pavement used 200 mm pieces of quarried stone of a more compact form and

♣ shaped such that they had at least one at side which was placed on a compact formation. Smaller pieces of broken stones were then compacted into the spaces between larger stones to provide a level surface. Finally the running layer was made with a layer of 25 mm sized broken stone. All this

♣ structure was placed in a trench in order to keep the running surface level with the surrounding country side. This created major drainage problems which were counteracted by making the surface as impervious as possible, cambering the surface and providing deep side ditches. They gave much importance for drainage. He also enunciated the necessity for

♣ continuous organized maintenance, instead of intermittent repairs if the roads were to be kept usable all times. For this he divided the roads between villages into sections of such length that an entire road could be covered by maintenance men living nearby.

III. **British Roads** The British government also gave importance to road construction. The British engineer John Macadam introduced what can be considered as the first scientific road construction method. Stone size was an important element of Macadam recipe. By empirical observation of many roads, he came to realize that 250 mm layers of well compacted broken angular stone would provide the same strength a better running surface than an expensive pavement founded on large stone blocks. Thus he introduced an economical method of road construction. Highway Planning and Development Highway planning involves the estimation of current and future traffic volumes on a road network. The Highway planning is also a basic need for the Highway development. Highway engineers strive to predict and analyse all possible civil impacts of highway systems.

The Objectives of Highway Planning:

i. Planning a highway network for safe, efficient and fast movement of people and goods.
ii. The overall cost of construction and maintenance of the roads in the network.
iii. Planning for future development and anticipated traffic needs for a specific design period.
iv. Phasing road development programmes from considerations of utility and importance as also of financial resources.
v. Evolving a financing system compatible with the cost and benefits. The Basic Principles Highway planning:⎫ The proposed road links should be a part of the planned road network for the¬ state/nation.

The importance of the road shall be based on the traffic demand, and hence its type¬ should fall under the standard classification.

The maintenance needs of the roads should receive prompt attention by setting aside¬ funds for this purpose. Statutory provisions for traffic regulation should be in place.¬ Steps in Planning⎭

1. Monitoring existing condition and forecasting future population and employment growth, including assessing projected land uses in the region and identifying major growth corridors.

2. Identifying current and projected future transportation problems and needs and analysing through detailed planning studies.

3. Developing long range plans and short range programme of alternative capital improved and operation strategic for moving people and goods

4. Estimating the impact recommended future improvements to the transportation system on environment features, including air quality and

5. Developing a financial for security sufficient revenue to cover the costs of implementing strategic.

Classification of Highways

¬ The Indian Road Congress or IRC is the prime body that looks over the road development in the country. Established by the government in 1934, this apex body consists of qualified highway engineers. The IRC offers the following classification of roads in India.

National highways

- State highways
- District roads
- Rural roads

1) National highways

in India National highways are the roads that stretch between the cities in the country. These are the main roads that connect the capitals of most states with each other. Some national highways even connect India with other neighbouring countries and make many famous tourist destinations easily accessible.

A highway is typically a large-width, well-designed road with traffic signs, lights,bridges, etc., at appropriate locations. These roads are indicated by "NH" with a hyphen and a numeral code like "NH-1", "NH-10", etc.

The following are the types of national highways in India.

- Single-lane highway
- Double-lane highway
- Four-lane highway
- Six-lane highway
- Eight-lane highway

The following authorities take care of the development, management and¬ maintenance of national highways in India. 1. National Highways Authority of India or NHAI National Highways and Infrastructure Development Corporation Limited or NHIDCL

2) State highways

in India State highways include roads that conne¬ct all major cities in a state. At the same time, they offer connectivity with neighbouring state highways and national highways. These highways are indicated by "SH" along with a designated state code. Some of the largest shares of state highways are in Maharashtra, Karnataka, Gujarat,¬ Rajasthan, and Tamil Nadu. The development and maintenance of these highways fall on the authorities of their respective states.

3. District roads in India

District roads or urban roads in India connect different parts of a city. Hence, locals use these roads to travel to offices, markets, educational institutions, hospitals, etc. These

roads also allow connectivity with neighbouring state/national highways. Based on the location and function, district roads are divided into major and minor roads. Major roads in a district offer connectivity with the main locations of neighbouring districts. On the other hand, minor roads in a district connect all major areas inside that district.

4) Other district roads in India

Some of the roads connect major parts of a rural area to a district. These roads are highly important to enable the transportation of goods and raw materials required for people living in rural towns. Similarly, it allows farmers from rural towns to transport their produce to the markets situated in neighbouring districts.

5) Village/rural roads in India

The rural roads in India are found in the villages and rural towns. These are not as sophisticated as national or state highways but offer connectivity for the villagers to commute to markets, farms, fields, offices, residences, etc.

PARAMETERS FOR GEOMETRIC DESIGN OF RAILWAYS

Geometric design of a railway track discusses all those parameters which affect the geometry of the track.These parameters are as follows:

1. Gradients in the track including grade compensation, rising gradient, and falling gradient.

2. Curvature of the track, including horizontal and vertical curves, transition curves, sharpness of the curvein terms of radius or degree of the curve, cant or super elevation on curves, etc.

3. Alignment of the track, including straight as well as curved alignment.

NECESSITY FOR GEOMETRIC DESIGN

It is very important for tracks to have proper geometric design in order to ensure the safe and smoothrunning of trains at maximum permissible speeds, carrying the heaviest axle loads. The speed and axle loadof the train are very important and sometimes are also included as parameters to be considered while arriving at the geometric design of the track.

The need for proper geometric design of a track arises because of the following considerations:

• To ensure the smooth and safe running of trains

• To achieve maximum speeds

• To carry heavy axle loads

• To avoid accidents and derailments due to a defective permanent way.

• To ensure that the track requires least maintenance

• For good aesthetic

The geometric design of a railway track includes all those parameters which determine or affect the geometry of the track.

These parameters are as follows.

1. **GRADIENTS IN THE TRACK**

Gradients are provided to negotiate the rise or fall in the level of the railway track. A rising gradient isone in which the track rises in the direction of movement of traffic and in a down or falling gradient the track loses elevation the direction of movement of traffic. A gradient is normally represented by the distance travelled for a rise or fall of one unit. Sometimes the gradient is indicated as per cent rise or fall.

For example, if there is a rise of 1 m in 400 m, the gradient is 1in 400 or 0.25 per cent. Gradients in the track, including grade compensation, rising gradient, and falling gradient.

Objectives of providing Gradients:

- To reach various stations at different elevations
- To follow the natural contours of the ground to the extent possible
- To reduce the cost of earthwork

The following types of gradients are used on the railways:

- Ruling gradient
- Pusher or helper gradient
- Momentum gradient

Gradients in station yards

1. Curvature of the track, including horizontal and vertical curves, transition curves, sharpness of the curve in terms of radius or degree of the curve, cant or superelevation on curves, etc.
2. Alignment of the track, including straight as well as curved alignment.
3. The speed and axle load of the train are very important and sometimes are also included as parameters to be considered while arriving at the geometric design of the track.

RULING GRADIENT

The ruling gradient is the steepest gradient that exists in a section. It determines the maximum load that can be hauled by a locomotive on that section. While deciding the ruling gradient of a section, it isnot only the severity of the gradient, but also its length as well as its position with respect to the gradients on both sides that have to be taken into consideration. The power of the locomotive to be put into service on the track also plays an important role in taking this decision, as the locomotive should have adequate power to haul the entire load over the ruling gradient at the maximum permissible speed. In plain terrain: 1 in 150 to 1 in 250 In hilly terrain: 1 in 100 to 1 in 150 Once a ruling gradient has been specified for a section, all other gradients provided in that section should be flatter than the ruling gradient after making due compensation for curvature. The extra force P required by a locomotive to pull a train of weight W on a radiant with an angle of inclination q is P =W Sin q = W tan q (approximately, as q is very small) = W x gradient

MOMENTUM GRADIENT

The momentum gradient is also steeper than the ruling gradient and can be overcome by a train because of the momentum it gathers while running on the section. In valleys, a falling gradient is sometimes followed by a rising gradient. In such a situation, a train coming down a falling gradient acquires good speed and momentum, which gives additional kinetic energy to the train and allows it tonegotiate gradients steeper than the ruling gradient. In sections with momentum gradients there are no obstacles provided in the form of

- signals, etc.,which may bring the train to a critical juncture. Steeper than ruling gradient, but do not determine the maximum load of train
- Train need to acquire sufficient momentum to negotiate this gradient before reaching it
- Signals should not be provided at momentum gradients

PUSHER OR HELPER GRADIENT

In hilly areas, the rate of rise of the terrain becomes very important when trying to reduce the lengthof the railway line and, therefore, sometimes, gradients steeper than the ruling gradient are provided to reduce the overall cost. In such situations, one locomotive is not adequate to pull the entire load, and an extra locomotive is required. When the gradient of the ensuing section is so steep as to necessitate the use of an extra engine for pushing the train, it is known as a pusher or helper gradient.

Gradient steeper than ruling gradient requiring extra locomotive.

- It reduces the length of a railway section.
- It also reduces the overall cost.

GRADIENTS IN STATION YARDS

The gradients in station yards are quite flat due to the following reasons:

- It prevents standing vehicles from rolling and moving away from the yard due to the combined effect ofgravity and strong winds.
- It reduces the additional resistive forces required to start a locomotive to the extent possible.

It may be mentioned here that generally, yards are not levelled completely and certain flat gradients are provided in order to ensure good drainage. The maximum gradient prescribed in station yards on Indian Railways is 1 in400, while the recommended gradient is 1 in 1000.

GRADE COMPENSATION ON CURVES

- If a curve is provided on a track with with ruling gradient, the resistance of the track will be increasedon this curve. In order to avoid resistance beyond the allowable limits, the gradients are reduced on curves and this reduction in gradient is known as grade compensation for curves. In India, Compensation for curvature is given by.

BG track: 0.04% per degree of curve
MG track: 0.03 % per degree of curve
NG track: 0.02 % per degree of curve

CURVATURE OF THE TRACK

2. The measurement of curvature of curved track is expressed in radius. The shorter the radius, the sharper the curve is. For sharper curves, the speed limits are lower to prevent an outward horizontal centrifugal force to overturn the trains by directing its weight toward the outside rail. Therefore, curvatures are provided inevitably on a railway track to bypass obstacles, to provide longer and easily traversed gradients and to pass a railway line through desirable location. Horizontal curves are provided when a change in the direction of the track

• is required Vertical curves are provided at points where two gradients meet or where a gradient
• meet level ground

DISADVANTAGE IN PROVIDING CURVATURE

Restriction in speed, limiting the length of trains and prevent the use of
• heavy type of locomotive Maintenance cost of track increases due to increase in the wear and tear
• of parts of track Danger of collision, derailment or other form of accident is increased
• Running of train is not smooth

RESTRICTION OF PROVIDING CURVATURE

- Bridge and tunnel
- Approaches to bridges
- Steep gradient
- Stations and yards
- Level crossing

DEGREE OR RADIUOS OF CURVATURE

A simple curve is designated either by its degree or by its radius
• The degree of a curve (θ) is the angle subtended at its centre by a chord of 30
• m length SUPER-ELEVATION OR CANT When a train is moving
• on a curved path, it has a constant radial acceleration which produces centrifugal force. In order to counteract this force, the outer rail of the track is raised slightly higher
• than the inner rail. This is known as Super-elevation or Cant.

PURPOSE OF PROVIDING SUPERELEVATION

To ensure safe and smooth movements of passengers and goods on the track

- It counteracts the effect of the centrifugal force by producing centripetal
- force on the train It prevents derailment and reduces the creep and as well as side wear of rails
- It provides equal distribution of wheel loads on two rails
- It results in the decrease of maintenance cost of the track

3. ALIGNMENT OF THE TRACK

The direction and position given to the centre line of the railway track on the ground is called track alignment. Horizontal alignment refers to the direction of the railway track in the plan including

- the straight path and the curves it follows. Includes- Straight path, width, deviation in width, and horizontal curves. Vertical alignment refers to the direction it follows in a vertical plane including the
- level track, gradients, and vertical curves. Includes- Change in gradient and vertical curves.

MODULE- IV

IRRIGATION

♣ The process of supplying water artificially to the crops in an adequate amount for cultivation is known as Irrigation. Crops require water for their production at frequent intervals but in a controlled manner.

ASPECTS OF IRRIGATION

♣ 1. Engineering Aspects i. Storage, diversion, lifting ii. Conveyance of water to field iii. Water application in Field iv. Drainage and relieving water logging v. Water power generation

2. Agricultural Aspects i. Water depth maintenance in crop field ii. Uniform periodic water distribution in field iii. Irrigation with respect to soil capacity iv. Reclamation of waste and alkaline land

ADVANTAGES OF IRRIGATION

♣ i. Increase in food production.

ii. Optimum benefits (max crop yield with minimum use of water)

iii. Elimination of mixed cropping

iv. General prosperity

v. Hydro power generation (Canal falls used for power generation) vi. Domestic water supply vii. Communication facilities (Irrigation channel with embankment and inspection roads) viii. Inland navigation ix. Afforestation (Trees along river bank)

DISADVANTAGES OF IRRIGATION

♣ i. Pollution of ground water through seepage of nitrates, causing anaemia.

ii. Colder and damper climate, causing malaria.

iii. Water logging due to over irrigation

iv. Complex and expensive

TYPES OF IRRIGATION

♣ A. Surface irrigation consists of a broad class of irrigation methods in which water is distributed over the soil surface by gravity flow. The irrigation water is introduced into level or graded furrows[[Furrow is a long, narrow irrigation trench made in the ground used for an optimal supply of water. Furrows can be level and are very similar to long narrow basins. However, a minimum grade of 0.05% is recommended so that effective drainage can occur following irrigation or excessive rainfall]] or basins, using siphons, gated pipe, or turnout structures, and is allowed to advance across the field. Surface irrigation is best suited to flat land slopes, and medium to fine textured soil types which promote the lateral spread of water down the furrow row or across the basin.

IRRIGATION

- SURFACE IRRIGATION
- FLOW IRRIGATION
- PERRENIAL IRRIGATION
- DIRECT IRRIGATION
- STORAGE IRRIGATION
- FLOOD IRRIGATION
  - FLOODING METHOD
  - FURROW METHOD
  - CONTOUR METHOD
- LIFT IRRIGATION
- SUBSURAFCE IRRIGATION
  - NATURAL METHOD
  - ARTIFICIAL METHOD
  - MODERN METHODS
- SPRINKLER IRRIGATION
- DRIP IRRIGATION

Surface Irrigation

Surface Irrigation is further classified into two major types:

1. Flow irrigation: Here water is supplied from higher altitude to lower altitude by the action of gravity.

   It can be further divided into two types: Perennial Irrigation: Here constant and continuous water supply is

   • available to crops throughout the crop period. It can be achieved in two ways: i. Direct irrigation: When water is directed into canal by constructing weir or barrage across the river.

   E.g.: Ganga canal system.

2. Storage irrigation:

   When water is stored in dams with reservoir across the river, and supplied through off taking channels during low flow.

E.g.: Ram Ganga Dam. Flood irrigation: It is otherwise known as inundation irrigation. Soil is kept

- submerged and thoroughly flooded with water.

2. Lift irrigation: Here water is lifted up by mechanical or manual means such as pumps etc. Surface irrigation can be achieved by the following methods:⎫

i. Flooding method : It is most common form of irrigation where water is applied and distributed over the soil surface by gravity. Three major types of flooding irrigation are level basin, furrow, and border strip. Fig. Flooding method
ii. Furrow method: Its's probably one of the oldest methods of irrigating fields, where farmers flow water down small trenches running through their crops. Humans' first invention after learning how to grow plants from seeds was probably a bucket. Fig. Furrow method
iii. Contour method: Helps evenly distribute the water in the soil between the furrows as the water runs slowly and adequately. As the irrigation water runs off quite slowly but deeply into the furrows, it makes the absorption of water in the soil much better. Fig. Contour method B.

Subsurface irrigation

consists of methods whereby irrigation water is applied below the soil surface. The specific type of irrigation method varies depending on the depth of the water table. When the water table is well below the surface, drip or trickle irrigation emission devices can be buried below the soil surface (usually within the plant root zone).

This method can be further classified as:⎫

i. Natural sub-surface irrigation: Leakage water from sources of water such as streams, lakes, ponds, canals, etc. goes underground and during the passage to the subsoil, it may irrigate crop by capillarity.
ii. ii. Artificial sub-surface irrigation: In this method, water is applied beneath the land surface through a network of buried perforated or open jointed pipes. As water is passed under pressure in these pipes, it comes out through open joints. The depth of pipes should not be less than 40 cm so that these do not cause any interference to the cultivation. Evaporation losses are reduced. The method is expensive because of the high cost of pipes and the installation. The water used should be of good quality so the perforation does not get clogged. Fig. Subsurface Irrigation

C. Modern Irrigation methods: A. Sprinkler irrigation is a method of irrigation in which water is sprayed, or sprinkled through the air in rain like drops. The spray and

sprinkling devices can be permanently set in place (solid set), temporarily set and then moved after a given amount of water has been applied (portable set or intermittent mechanical move), or they can be mounted on booms and pipelines that continuously travel across the land surface (wheel roll, linear move, center pivot).

Drip/trickle irrigation systems are methods of micro-irrigation wherein water is applied through emitters to the soil surface as drops or small streams. The discharge rate of the emitters is low so this irrigation method can be used on all soil types. (Trickle irrigation involves the slow release of water to each plant through small plastic tubes. This technique is adapted both to field and to greenhouse conditions) Fig. Drip Irrigation

TYPES OF HYDRAULIC STRUCTURES

♣ Hydraulic structures play an important role in drainage, irrigation, and hydraulic projects. If hydraulic structures fail, it may cause serious damages of wealth, properties, and environment as well as losses of life and injury to economy. Hydraulic structures can be classified, based on their functions as below:

1. Flow control structures: They are used to regulate the flow and pass excess flow. They might be gates, spillways, valves,or outlets.

2. Flow measurement structures: They are used to measure discharge. They are weirs, orifices, flumes etc.

3. Division structures: They are used to divert the main course of water flow. They are coffer dams, weirs, canal headworks, intake works.

4. Conveyance structures: They are used to guide the flow from one place to another. They areopen channels, pressure conduit, pipes, canals and sewers.

5. Collection structures: They are used to collect water for disposal. They are Drain inlets, infiltration galleries, wells.

6. Energy dissipation structures: They are used to prevent erosion and structural damage. They are stilling basins, surge dams, check dams.

7. River training and water stabilizing structures: They are used to maintain river channel and water transportation. Levees, cut-offs, locks, piers, culverts 8. Sediment and quality control structures: They are used to control or remove sediments and other pollutants. They are racks, screens, traps, sedimentation tanks, filters, sluiceways.

9. Hydraulic machines: They are used to convert energy from one form to another. They are turbines, pumps, ramps

10. Storage structures: They are used for the purpose of storage of water. These may be dams or tanks. 11. Shore protection structures: They are used to protect banks. These are dikes, groins, jetties, revetments.

DAM♣ & WEIRS Dam:

A dam is a barrier that restricts or stops the flow of water; helps suppress

♣ floods, as well as providing irrigation, industrial, and aquaculture uses. A dam holds water for later use, irrigation, navigation, hydroelectricity, flood control, fishing, and recreation.

Weir Weir: A weir is a small barrier built across a stream or river to raise the water level♣ slightly on the upstream side; essentially a small-scale dam. Weirs allow water to pool behind them, while allowing water to flow steadily over top of the weir. Additionally, the term weir can be used to refer to the crest of a spillway on a large embankment dam.

FUNCTIONS OF DAM♣ Most of the dams are multipurpose. Almost all dams have at least some flood⎫ mitigation effect in addition to their primary purpose. Flood control dams may have some of their storage capacity kept empty to store excess water inflow under flood conditions.

1. Water Supply Water stored in reservoirs of the dam is used to provide adequate amounts of♣ quality freshwater to residential, industrial facilities and mining sites. Dams can be used to regulate the flow of water in rivers. This is to say that water♣ can be released from the reservoir to support wildlife and ecosystems downstream during a drought and water can be released for agricultural uses during the same drought.

2. Irrigation In many countries, cropland irrigation is done using water stored behind dams.♣ Example: Burrinjuck Dam, an irrigation dam of Australia, which was built as the main♣ headwater storage for the Murrumbidgee Irrigation Area in New South Wales.

3. Electrical Generation To generate electricity in hydroelectric power stations♣ Hydropower is considered clean because it does not contribute to global warming, air♣ pollution, acid rain, or ozone depletion.

4. Flood Control For centuries, people have built dams to help control devastating floods. It helps to♣ prevent the loss of life and property. Flood control dams

impound floodwaters and then either release them under control to♣ the river below the dam or store or divert the water for other uses.

5. Water Storage Dams create reservoirs that supply water for uses, including industrial, municipal, and♣ agricultural. Water captured during the wet season can be stored for use during the dry season.♣

6. Mine Tailings It allows the mining and processing of coal and other vital minerals while protecting♣ the environment. Mount Polley is a mine tailing dump of British Columbia, Canada.♣

7. Debris Control Dams provide enhanced environmental protection, such as the retention of hazardous♣ materials and detrimental sedimentation.

8. Navigation Dams and locks provide for a stable system of inland river transportation throughout♣ the heartland of the Nation. Bonneville Dam of Washington, USA is a river navigation dam.♣

9. Recreation Dams provide prime recreational facilities throughout the United States. Boating,♣ skiing, camping, picnic areas and boat launch facilities are all supported by dams. Scrivener Dam is a recreation dam of Canberra, Australia.♣

TYPES OF DAM: Based on the FUNCTIONS of dam, it can be classified as follows:⎪

1 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.

2 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.

3 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.

4 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.

5 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 HYDRAULIC DESIGN, dams can be classified as:⁾

1. OVERFLOW & NON-OVERFLOW DAM Overflow dams: An overflow dam is designed to act as an overflow structure. The surplus water which cannot be retained in the reservoir is permitted to pass over the crest of the overflow dam which acts as a spillway. The overflow dam is made of a material that does not erode by the action of overflowing water. Generally, cement concrete is used in overflow dams and spillways. Most of the gravity dams have overflow sections for some length and the rest of the length as a non-overflow dam. However, sometimes the entire length of the dam of low height is designed as an overflow dam. The overflow dam is also called the spillway section. Overflow dam Non-overflow dams: A non-overflow dam is designed such that there is no flow over it. Because there is no overflow, a non-overflow dam can be built of any material, such as concrete, masonry, earth, rock fill, and timber. As already mentioned, the nonoverflow dam is usually provided in part of the total length of the dam. However, sometimes the non-overflow dam is provided for the entire length, and a separate spillway is provided in the flanks or in a saddle away from the dam. Fig. Non-overflow dam

2. RIGID & NON-RIGID DAM: Rigid dams: A rigid dam is quite stiff. It is constructed of stiff materials such as concrete, masonry, steel and timber. These dams deflect and deform very little when subjected to water pressure and other forces. Non-rigid dams: A non-rigid dam is relatively less stiff compared to a rigid dam. The dams constructed of earth and rock fill are non-rigid dams. There are relatively large settlements and deformations in a non-rigid dam. Based on MATERIAL OF CONSTRUCTION dams can be classified as below:⁾

A. Older Dams Earth dam: An earth dam is made of earth (usually local soils), it

♣ resists the forces exerted upon it mainly due to shear strength of the soil. Although the weight of the dam also helps in resisting the forces, the structural behaviour of an earth dam is entirely different from that of a gravity dam. Gravity/Solid Masonry Dam: resists the water pressure and other

♣ forces due to its weight (or gravitational forces). Thus, the stability of a gravity dam depends upon its weight. The gravity dams are usually made of cement concrete. In the past, the gravity dams were made of stone masonry, but now the masonry dams are rarely constructed, except for very small heights. Rock fill Dam: It is made up of loose rocks and boulders piled on river

♣ beds. RCC slab is used in upstream side to make water tight. The side slopes of rock fill are usually kept equal to the angle of repose of rock, which is usually taken as 1.4:1 (or 1.3:1).

B. Modern Dams

1. Arch Dam: An arch dam is curved in plan, with its convexity towards the upstream side. Main Features of Arch Dam:⎫ An arch dam transfers the water pressure and other forces mainly to

♣ the abutments by arch action. An arch dam is quite suitable for narrow canyons with strong

♣ abutments which are capable of resisting the thrust produced by the arch action. The section of an arch dam is approximately triangular like a gravity

♣ dam but the section is comparatively thinner.

2. Steel Dams: These are used for major works.

♣ These are used as temporay coffer dams for construction of permanent dams.

♣ These are usually reinforced with timber or concrete.

♣ 3. Hollow masonry/Gravity dam: The design is the same as that of a solid masonry gravity dam. It contains 35-40% less concrete or masonry.

4. Timber Dam: These are suitable for agricultural areas. These dams have a short life span of less than 30 years as they deteriorate due to rotting.

FACTORS AFFECTING DAM SITE SELECTION

♣ The selection of the site for a dam is

1. Catchment Area The catchment area should be able to contribute an adequate supply of water to the reservoir of the dam

2. Foundation Soil Sound foundation soil should be available at the site to carry a heavy load. For earth dams, any type of foundation is suitable. however, for gravity or concrete or masonry dams, sound rocks at the surface or within a reasonable depth, are essential. Foundation is important for The selection of the site for a dam.

3. Ecology The balance of ecology (means nature environment) should not be disturbed.

4. River Cross-Section at the site The river cross-section at the site should have a narrow gorge (valley) to allow largely should be minimum for the intended storage of water.

5. Height of the Dam The dam cost is proportional to the square of the dam height. Therefore, the height should be minimum for the intended storage of water. 6. Storage Capacity The dam should provide adequate storage capacity for the reservoir

7. Costs The dam should have minimum construction and maintenance costs.

8. Reservoir Silting The site should be such that reservoir silting is minimum

9. Spillway A suitable location for the spillway should be available in the near vicinity

10. Submergence The value of the land submerged by the proposed dam should be as low as possible. It should be less than the benefits expected from the dam. The rehabilitation of the people displaced due to submergence is a problem to be tackled in the case of large dams.

11. Bed-Level The bed level of the dam should preferably be on a higher level than that of the river basin to facilitate drainage.

12. Watertight The reservoir should be water-tight. Otherwise, the stored water may escape through its bed and banks.

13. Topography The topography of the site should be such that the length of the dam should be as small as possible. Also, for a given height, the storage capacity should be as high as possible. Therefore, the river valley at the site should be as narrow as possible for maximum storage capacity.

ADVANTAGES AND DISADVANTAGES OF DAM

Advantages of Dams

♣ 1. Water can be stored and used for irrigation using dams.

2. Water can be distributed to the nearest places for drinking purposes.

3. Water stored in dams can be used for generating electricity.

4. During floods, dams can be used for storing or diverting water. 5

. Dams also provide recreational areas like boating, parks, etc.

Disadvantages of dams

1. When making dams much biodiversity near the dams are affected.

2. A huge amount of money is needed for construction as well as for the maintenance of the dams.

3. Many inhabitants near the dam construction are displaced