Swarnandhra College of Engineering & Technology (Autonomous)
Seetharampuram, NARSAPUR, W.G. Dt., 534 280.
Department of Civil Engineering

BASIC CIVIL AND MECHANICAL ENGINEERING (23ES1T01)

- **Dr M.S.V.K.V.PRASAD**

UNIT III - Transportation, Water Resources and Environmental Engineering

Syllabus: Transportation Engineering Importance of Transportation in Nation's economic development- Types of Highway Pavements- Flexible Pavements and Rigid Pavements - Simple Differences- Basics of Harbour, Tunnel, Airport and Railway Engineering.

Water Resources and Environmental Engineering: Introduction, Sources of water- Quality of water- Specifications- Introduction to Hydrology–Rainwater Harvesting-Water Storage and Conveyance Structures (Simple introduction to Dams and Reservoirs).

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UNIT-3A

1. Discuss about importance of Transportation in Nation's economic development?

ANSWER

Transport System:

1) A transport system plays a vital role in providing and improving access to different parts of a geographical region which is important for businesses as well as individuals.
2) A transport system supports both freight and personal movements. In the business sector, the business and supplier or the business and the market need an efficient transport system to work smoothly.
3) In the household sector transport is used as the means to go to offices, schools, shops, etc.
4) The transport system is used widely by individuals for personal and leisure activities as it connects them to recreational, social, and medical facilities.
5) Even for the people who are required to travel or for normal people, who are going to their work daily, they use the method of transport to travel to their workplace and this transport can be anything: a bike, a car, a bus or anything that will make the person reach their destination.
6) The transport system is the main thing that connects people all around the world.

Transport System and Economic Development

1) The Transport System and Economic Development are tightly coupled with each other. A well-knit transport system that is well-coordinated contributes to the sustained growth of any country.
2) One can say that it is the transport routes that govern the basic arteries of the economic system of a country. It is the link between production and consumption; hence a transport system can also be deemed as the controller of the national economy.
3) A country is progressing if there is transport moving in and out of it. If a product is produced at a place it is necessary for the producer to make that product to reach its consumer. For that this transport system will work.
4) Let's take an example: if you have ordered anything online from an app, your producer will produce the product and this app will have its own delivery people who will transport your product to your doorstep.
5) This provides them with the money and you with the thing of your necessity; it is as simple as that. Thus, it will only play a role in increasing the economic growth of the country also.

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2. Discuss about different types of transport systems and their importance in economic development of nation?

ANSWER

Different Forms of Transport

There is not just a single mode of transport for people to travel; there are many. The transport system has many forms like roads, railways, air, and water.

Road Transport:
Road transport is the oldest form of transport and comprises cars, hand-pulled rickshaws, bullock carts, auto, tempo, buses, etc. This is the transport where you need to use the roads. Short distances can be easily covered by using road transport, but only for long traveling, require other modes of transport like that of rail or air or water.

Rail Transport:
In India, the central government owns and manages the railway system. This system has numerous benefits, as outlined below:
It can be used for transporting bulky goods.
Rail transport is less polluted. As compared to other modes of transport, trains cause very less pollution.
It is economical for traveling longer distances. To travel long distances then the road or air mode of transport is going to cost you a lot so you can say this is the cheapest means of transportation.

Water Transport:
India has a long coastline as it is surrounded by water with the Bay of Bengal, the Indian Ocean, and the Arabian Sea bordering the country. Water transport in the form of the movement of goods and people on waterways is common in India. Water transport carries people and goods within, as well as outside of the country.

Air Transport:
Air transport is the fastest means of transportation and in India is a relatively recent development. Air transport is also the costliest means of transportation in general. The Indian air transport now ranks amongst the fastest growing aviation sectors in the entire world. If you want to reach a place a bit early or even if you are looking for an adventurous ride you should go for air transport. It provides you with a safe journey over long distances.

Classification of urban road
Classification of roads is a system of categorizing roads based on their function and level of importance. Typically, roads are classified into several categories such as highways, arterial roads, collector roads, and local roads, each with its own specific characteristics and purposes.

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3. What is meant by pavement or Highway Pavement and what are the requirements of a good pavement?

ANSWER:
A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution.
Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements.

Requirements of a pavement

1) An ideal pavement should meet the following requirements:
2) Sufficient thickness to distribute the wheel load stresses to a safe value on the sub-grade soil,
3) Structurally strong to withstand all types of stresses imposed upon it,
4) Adequate coefficient of friction to prevent skidding of vehicles,
5) Smooth surface to provide comfort to road users even at high speed,
6) Produce least noise from moving vehicles,
7) Dust proof surface so that traffic safety is not impaired by reducing visibility,
8) Impervious surface, so that sub-grade soil is well protected, and
9) Long design life with low maintenance cost

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4. Draw and discuss about different types of Highway Pavements?

Or

Discuss about flexible and rigid pavements?

ANSWER:

Types of pavements

The pavements can be classified based on the structural performance into two,

1. Flexible pavement and 2. Rigid pavement

1. Flexible pavements

The flexible pavement, having less flexural strength, acts like a flexible sheet (e.g. bituminous road). Flexible pavements will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the points of contact in the granular structure (see Figure 1).

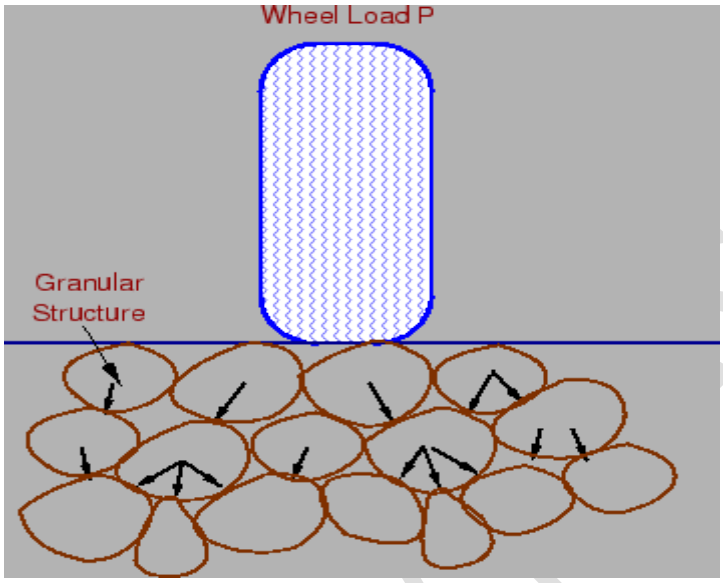

Figure 1: Load transfer in granular structure

Types of Flexible Pavements

The following types of construction have been used in flexible pavement:

a) Conventional layered flexible pavement,

b) Full - depth asphalt pavement, and

c) Contained rock asphalt mat (CRAM)

a) Conventional flexible pavements are layered systems with high quality expensive materials are placed in the top where stresses are high, and low quality cheap materials are placed in lower layers.

b) Full - depth asphalt pavements are constructed by placing bituminous layers directly on the soil sub-grade. This is more suitable when there is high traffic and local materials are not available.

c) Contained rock asphalt mats are constructed by placing dense/open graded aggregate layers in between two asphalt layers. Modified dense graded asphalt concrete is placed above the sub-grade will significantly reduce the vertical compressive strain on soil sub-grade and protect from surface water.

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5. With the help of a diagram discuss different layers of a flexible pavement?

ANSWER:

Typical layers of a flexible pavement

Typical layers of a conventional flexible pavement includes seal coat, surface course, tack coat, binder course, prime coat, base course, sub-base course, compacted sub-grade, and natural sub-grade (Figure 2).

a) Seal Coat:

Seal coat is a thin surface treatment used to water-proof the surface and to provide skid resistance.

b) Tack Coat:

Tack coat is a very light application of asphalt, usually asphalt emulsion diluted with water. It provides proper bonding between two layers of binder course and must be thin, uniformly cover the entire surface, and set very fast.

c) Prime Coat:

Prime coat is an application of low viscous cutback bitumen to an absorbent surface like granular bases on which binder layer is placed. It provides bonding between two layers.

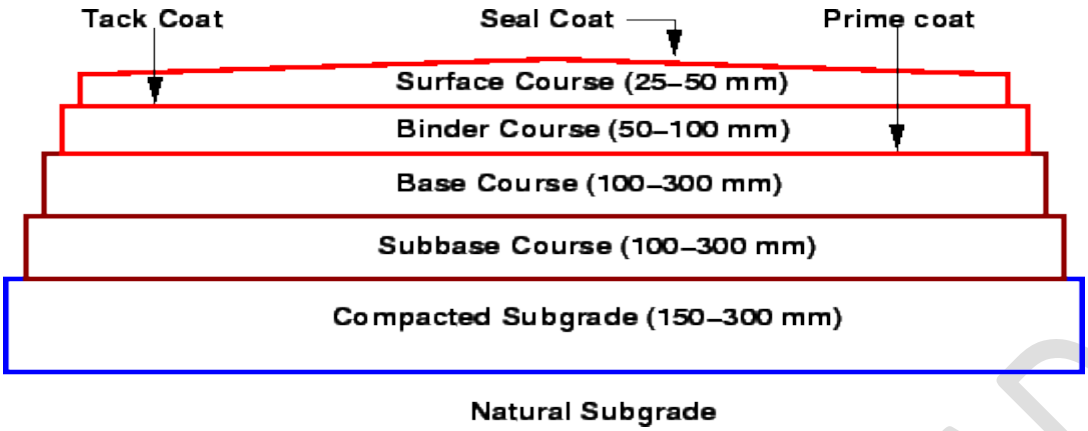

Figure 2: Typical cross section of a flexible pavement

d) Surface course

Surface course is the layer directly in contact with traffic loads and generally contains superior quality materials. They are usually constructed with dense graded asphalt concrete (AC).

e) Binder course

This layer provides the bulk of the asphalt concrete structure. Its purpose is to distribute load to the base course. The binder course generally consists of aggregates having less asphalt and doesn't require quality as high as the surface course.

f) Base course

The base course is the layer of material immediately beneath the surface of binder course and it provides additional load distribution and contributes to the sub-surface drainage. It may be composed of crushed stone, crushed slag, and other untreated or stabilized materials.

g) Sub-Base course

The sub-base course is the layer of material beneath the base course and the primary functions are to provide structural support, improve drainage, and reduce the intrusion of fines from the sub-grade in the pavement structure.

h) Sub-grade

The top soil or sub-grade is a layer of natural soil prepared to receive the stresses from the layers above. It is essential that at no time soil sub-grade is overstressed.

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6. With the help of a diagram discuss about a rigid pavement and also different types of rigid pavements?

ANSWER:

Rigid pavements

In rigid pavements, wheel loads are transferred to sub-grade soil by flexural strength of the pavement and the pavement acts like a rigid plate (e.g. cement concrete roads).

Rigid pavements have sufficient flexural strength to transmit the wheel load stresses to a wider area below. A typical cross section of the rigid pavement is shown in Figure 3. There is only one layer of material between the concrete and the sub-grade; this layer can be called as base or sub-base course. Rigid pavements are constructed by Portland cement concrete (PCC).

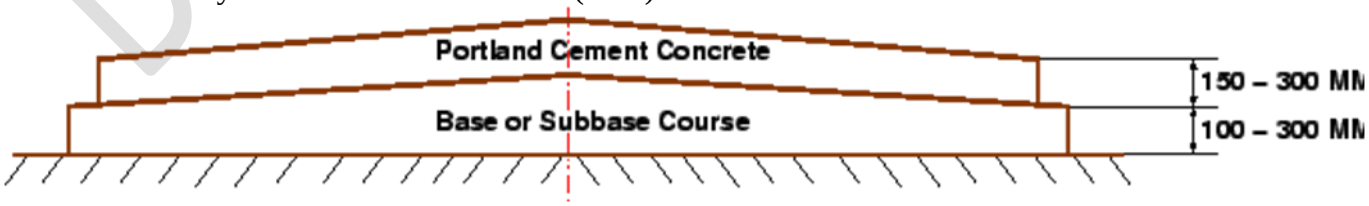

Figure 3: Typical Cross section of rigid pavement

Types of Rigid Pavements

Rigid pavements can be classified into four types:

1) **Jointed plain concrete pavement (JPCP),**
2) **Jointed reinforced concrete pavement (JRCP),**

3) **Continuous reinforced concrete pavement (CRCP), and**
4) **Pre-stressed concrete pavement (PCP)**

1. Jointed Plain Concrete Pavement

These pavements are plain cement concrete pavements constructed with closely spaced contraction joints. Dowel bars or aggregate interlocks are normally used for load transfer across joints. They normally has a joint spacing of 5 to 10m.

2. Jointed Reinforced Concrete Pavement

Although reinforcements do not improve the structural capacity significantly, they can drastically increase the joint spacing to 10 to 30m. Dowel bars are required for load transfer. Reinforcement's help to keep the slab together even after cracks.

3. Continuous Reinforced Concrete Pavement

Complete elimination of joints is achieved by this and

4. Pre-stressed concrete pavement (PCP)

Precast concrete panels that are fabricated or assembled off-site, transported to the project site and installed over a prepared foundation (new or re-graded existing base).

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7. Write the differences between flexible & rigid pavements?

ANSWER:

S.No	Flexible Pavements	Rigid Pavements
1	It is a multi-layer structure with materials of highest quality near the surface.	It consists mainly of cement concrete slab with flexural strength, which can also serve as a wearing course.
2	It reflects the deformations of subgrade, sub-base and base courses on the surface.	It can bridge over local weak spots & deformations without reflecting them on surface.
3	These pavements depend on subgrade strength for their performance, besides base and sub-base for safe transmission of loads.	These pavements depend on flexural strength of concrete slab for safe transmission of traffic loads.
4	Transmission of stresses to the subgrade is through the component courses.	Distribution of loads to wider area of subgrade depends on the rigidity, high elastic modulus and flexural strength of pavement.
5	Stability depends upon interlocking and friction between aggregates and soil cohesion.	Stability is derived by the structure strength of the pavement by its slab action.
6	The life of flexible pavement ranges from 10 to 20 years	The life of rigid pavement is about 40 years
7	Initial cost is less	Initial cost is more
8	Maintenance cost is more	Maintenance cost is less

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8. Define a "Harbour", the basic requirements of good Harbour and the classification of Harbours?

ANSWEER

Harbour:

It is partly enclosed area which provides safe and suitable accommodation for supplies, refueling, repair loading and unloading cargo.

Port:

A port is a harbour where marine terminal facilities are provided.

Port = Harbour + Storage Facility + Communication Facility + Other Terminal Facility

Requirements of Good Harbour:

1. It should be connected with roadway and railway.
2. Surrounding land should be fertile and densely populated.

3. Ship channels must have sufficient depth for draft or vessel.
4. Breakwaters must be provided to protect against destructive wave action.
5. The bottom should furnished secure anchorage to hold ships against the wind force.
6. Numbers of quay, piers and wharfs should be sufficient for loading and unloading cargo.
7. It should have facilities like fuel, repair and etc. for ships.
8. Harbour area should be sufficiently large.
9. It should have enough cold storage.

Classification of Harbours:

1. Natural Harbour: Harbour protected by storms and waves by natural land contours, rocky out crops, or island that is called Natural Contour. **(Eg. Kandla port, Cochin port & Mumbai Harbour)**

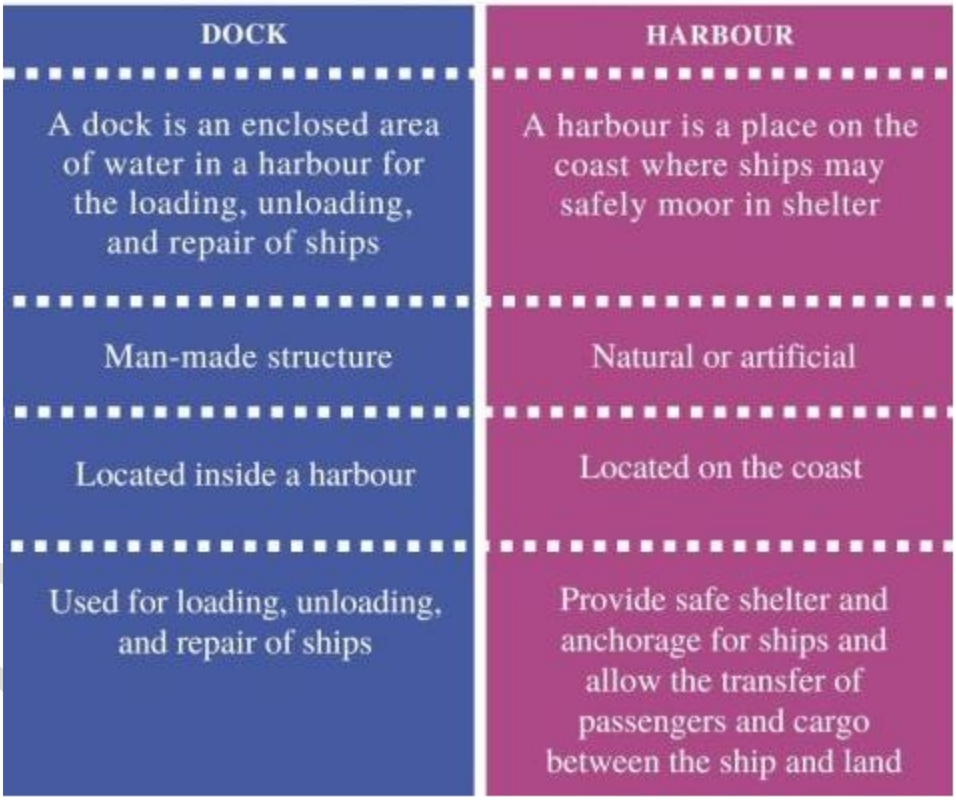
2. Semi - Natural harbour: A semi – natural harbour is protected on the sides by the contours of land and requires manmade protection only to the entrance. **(Eg. Mandvi, veraval & visakhapatnam port)**

3. Artificial Harbour: An artificial harbour is one which is manmade and protected from storms and waves by engineering works. **(Eg. Chennai Harbour)**

Site Selection for Harbour:

The guiding factors which play a great role in choice of site for a harbour are as follows:

1. Availability of cheap land and construction material;
2. Transport and communication facilities;
3. Natural protection from winds and waves;
4. Industrial development of the locality;
5. Sea – bed, subsoil and foundation conditions;
6. Traffic potentiality of harbour;
7. Availability of electrical energy and fresh water;
8. Favorable marine conditions.



DOCK	HARBOUR
A dock is an enclosed area of water in a harbour for the loading, unloading, and repair of ships	A harbour is a place on the coast where ships may safely moor in shelter
Man-made structure	Natural or artificial
Located inside a harbour	Located on the coast
Used for loading, unloading, and repair of ships	Provide safe shelter and anchorage for ships and allow the transfer of passengers and cargo between the ship and land

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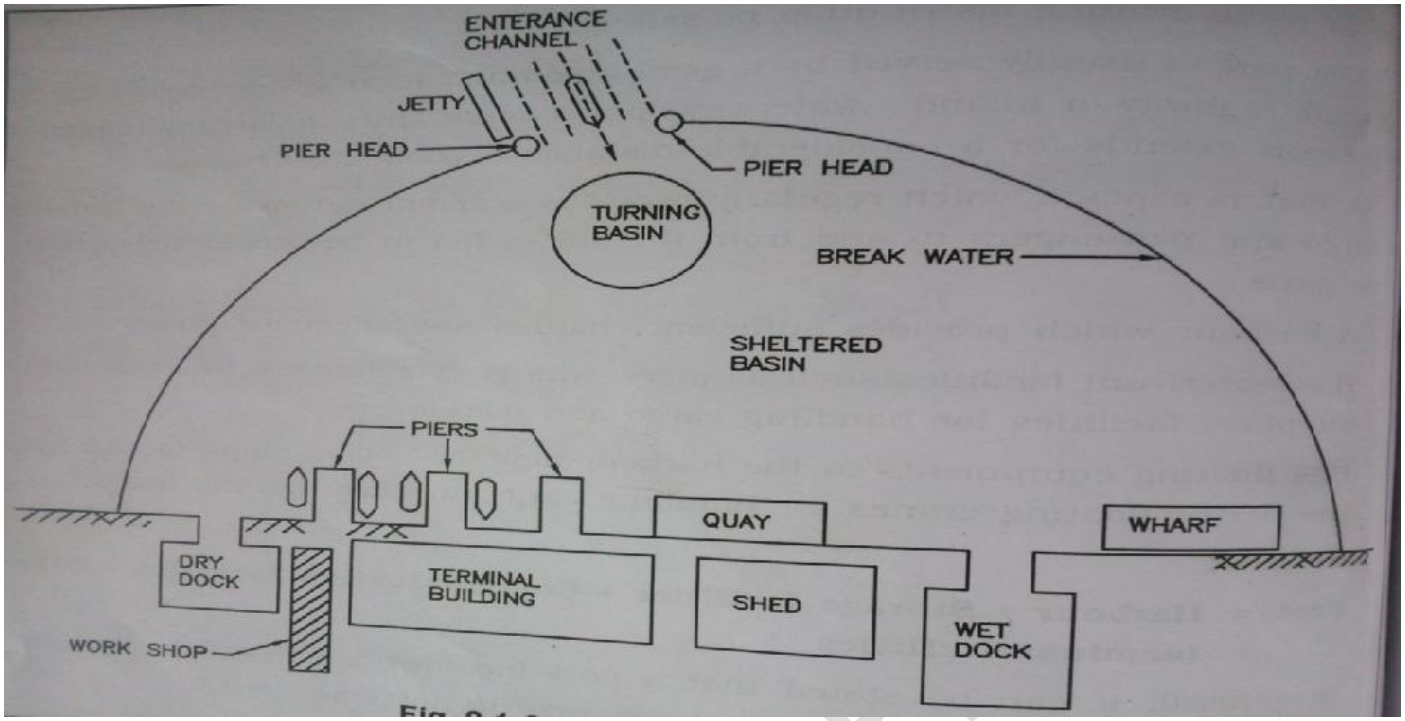
9. With the help of a diagram explain different components of a Harbor?
ANSWER:



The different components of a Harbour are
1. Entrance Channel
2. Break Water
3. Turning Basin
4. Shelter Basin
5. Pier
6. Wharf
7. Quay
8. Dry Dock
9. Wet Dock
10. Jetty

1. Entrance Channel - Water area from which ships enter in the harbour and it should have sufficient width, 100 for small harbour, 100 to 160m for medium and 160 to 260m for large harbour.

2. Break Water - A protective barrier made up of Concrete or Course Rubble Masonry constructed from shore towards the sea to enclose harbour

3. Turning Basin - It is water area which is required for maneuvering the ship after entering to the harbour and it is large enough to permit free turning.

4. Shelter Basin - It is area protected by shore and breakwater.

5. Pier - It is a solid platform at which berthing of ships on both the sides are possible.

6. Wharf - It is a docking platform constructed parallel to shoreline providing berthing facility on one side only.

7. Quay - It is also dock parallel to the shore which is solid structure providing berthing on one side and retaining the earth on the other.

8. Dry Dock - It is a chamber provided for maintenance, repairs and construction of ships. It includes walls, floor and gate.

9. Wet Dock - Due to variation in tidal level, an enclosed basin is provided where in number of ships can be berthed. It has an entrance which is controlled by a lock gate.

10. Jetty - It is a solid platform constructed perpendicular to the shoreline for berthing of ships.

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10. Define what is a "Tunnel" and advantages and disadvantages of Tunnels?
ANSWER:
A tunnel can be defined as an underground passage for the transport of passengers, goods, water, sewage, oil, gas, etc. The construction of a tunnel s normally carried out without causing much disturbance to the ground surface.
Advantages of tunnel:

- Tunnels are more economical than open cuts beyond certain depths
- Tunnels avoid disturbing or interfering with surface life and traffic during construction
- Tunnels prove to be cheaper than bridges or open cuts to carry public utility services like water, sewer and gas
- if tunnels are provided with easy gradients, the cost of hauling is decreased
- In case of aerial warfare and bombing of cities, the tunnels would grant better protection as compared to bridges.
- The connect terminal station by short route
- Less route length result in less transportation cost
- They carry railway, road and water, oil, gas
- Avoiding holding up of traffic for long time
- To avoid acquisition of valuable land
- Protection against landslide, snow fall

Disadvantages of tunnels:

- Require skilled labour & supervision
- Require Special equipment
- Costly in construction
- Require more time
- May cause suffocation if ventilation not provided properly

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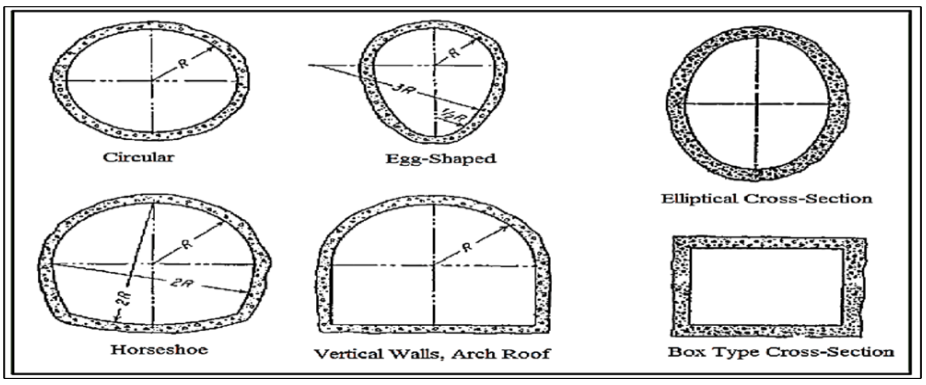
11. Discuss about size and shape of tunnels using simple diagrams?
ANSWER:
Size and shape of the tunnel
The shapes of tunnel linings are usually determined by their purpose, ground conditions, construction method and/or lining materials.
1. Rectangular shape: Rectangular shaped tunnels are usually adopted by the cut and cover method. It is particular suitable for pedestrian and highway tunnels. On the other hand, multilane submerged highway tunnels are often in rectangular shape.
2. Elliptical shape / Egg shape: Elliptical shape tunnels have the advantages for the transportation of sewer. The smaller cross section at the bottom maintains the flow at the required self cleaning velocity. However, due to the difficulty in construction, circular shape ones are more common.
3. Circular shape: A circular shape tunnel has the greatest cross-sectional area to perimeter ratio. They are often associated with the shield tunneling methods.
4. Horseshoe / segmental shape They are commonly used for rock tunneling. It has the advantages of utilizing the compressive strength of concrete in resisting the loading by means of arch action and the base is wide enough for traffic.



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12. What is an Airport and discuss about different types of airports, their important components?

ANSWER:

Airport is the location where aircraft take off and land; it connects both passengers and cargo with other airports. Generally, airport has runways, hangars and terminal buildings.

Wright brothers invented the first successful airplane in 1903 but it took 25 years to build the world's first airport in 1928 at London, England.

Airport Engineering deals with planning, design, construction, runways and provides safety for passengers and freight. An Airport Engineer should be technically sound enough to perform all the tasks coherently.

Types of airports: 1. International airports, 2. domestic airports and 3. Regional airports

1. International Airport

It has a connection with many other airports around the world and furnished with facilities like customs and immigration. These airports are usually massive with longer runways and larger aircraft.

2. Domestic Airport

It is an airport which connects flights within the country; these airports have shorter runways when compared with international airports with no facilities like customs and immigration.

3. Regional Airport

It is an airport located in a particular geographical area; it is majorly used by private and small business jets.

Important Components of airports

1. Runways

Runway is the most important component, it is the area where an aircraft lands and takes off called a runway, it could be grass or a hard surface such as asphalt or concrete.

2. Terminal building

Facilities such as cafes, lounges and bars are provided in terminal buildings for passengers and ticket counters, luggage check-in or transfer, security checks and customs are regarded as basics of any terminal building.

3. Aprons

The place where aircraft are parked is called apron.

4. Taxiway

A path that connects runway with facilities like aprons, hangars, terminals, and others.

5. Control tower

A control tower through which air traffic can be monitored and controlled.

6. Hanger

Aircraft hangars are commonly referred to as "glorified garages" for airplanes. They can vary from simple "shade" structures that protect all or parts of the aircraft from the elements to complicated environmentally controlled maintenance facilities in which robots apply radar absorbing coatings.

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13. Discuss about advantages and disadvantages of airport or air travelling?

ANSWER

Advantages:

1. High Speed: The supreme advantage of air transport is its high speed. It is the fastest mode of transport and thus it is the most suitable mean where time is an important factor.

2. Comfortable and Quick Services: It provides a regular, comfortable, efficient and quick service.
3. No Investment in Construction of Track: It does not require huge capital investment in the construction and maintenance of surface track.
4. No Physical Barriers: It follows the shortest and direct route as seas, mountains or forests do not come in the way of air transport.
5. Easy Access: Air transport can be used to carry goods and people to the areas which are not accessible by other means of transport.
6. Emergency Services: It can operate even when all other means of transport cannot be operated due to the floods or other natural calamities.
7. Quick Clearance: In air transport, custom formalities can be very quickly complied with and thus it avoids delay in obtaining clearance.
8. Most Suitable for Carrying Light Goods of High Value: It is most suitable for carrying goods of perishable nature which require quick delivery and light goods of high value such as diamonds, bullion etc. over long distances.
9. National Defense: Air transport plays a very important role in the defense of a country. Modern wars have been fought mainly by aero planes. It has upper hand in destroying the enemy in a very short period of time. It also supports over wings of defense of a country.
10. Space Exploration: Air transport has helped the world in the exploration of space.
Disadvantages:
In spite of many advantages, air transport has the following limitations
1. Very Costly: It is the costliest means of transport. The fares of air transport are so high that it is beyond the reach of the common man.
2. Small Carrying Capacity: Its carrying capacity is very small and hence it is not suitable to carry cheap and bulky goods.
3. Uncertain and Unreliable: Air transport is uncertain and unreliable as it is controlled to a great extent by weather conditions. Unfavorable weather such as fog, snow or heavy rain etc. may cause cancellation of scheduled flights and suspension of air service.
4. Breakdowns and Accidents: The chances of breakdowns and accidents are high as compared to other modes of transport. Hence, it involves comparatively greater risk.
5. Large Investment: It requires a large amount of capital investment in the construction and maintenance of aero planes. Further, very trained and skilled persons are required for operating air service.
6. Specialized Skill: Air transport requires a specialized skill and high degree of training for its operation.
7. Unsuitable for Cheap and Bulky Goods: Air transport is unsuitable for carrying cheap, bulky and heavy goods because of its limited capacity and high cost.
8. Legal Restrictions: There are many legal restrictions imposed by various countries in the interest of their own national unity and peace.
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14. What are the Criteria for airport site selection?
ANSWER
Criteria for airport site selection
The selection of a suitable site for an airport depends upon the class of airport under consideration. The factors listed below are for the selection of a suitable site for a major airport installation:
1. Regional plan
2. Airport use
3. Proximity to other airport
4. Ground accessibility
5. Topography
6. Obstructions
7. Visibility
8. Wind
9. Noise nuisance
10. Grading, drainage and soil characteristics

11. Future development
12. Availability of utilities from town
13. Economic consideration

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15. Define railway engineering and list out advantages and disadvantages of railway transportation?

ANSWER

Railway engineering is a multi-faceted engineering discipline dealing with the design, construction and operation of all types of rail transport systems.

Advantages of Railways:

Economical aspects:

- Due to railways, the industrial development in for off places is possible, increasing the land values & standard of living of the people.
- Mobility of labour has contributed to industrial development.
- During famines, railways have played the vital role in transporting food & clothing to the affected areas.
- Commercial farming is very much helped by the railway network throughout the country.
- Speed movement of the commodities is possible through railways.

Cultural & Social aspects:

- Railway has made it easier to reach places of religious importance.
- Railway provides a convenient & safe mode of transport throughout the country.
- During travel as people of different caste & religions sit together the interaction is developed.

Political aspects:

- Railways have helped in the mass migration of the population.
- Railways have created the sense of unity among the people of different religions, areas, castes & traditions.
- With adequate network of railways, the central administration has become easy & effective.

Disadvantages of Railways:

- Although railway transport has many advantages, it suffers from certain serious limitations:
- The cost of construction, maintenance and overhead expenses are very high as compared to other modes of transport.
- In case the traffic is not sufficient, the investments may mean wastage of huge resources.
- Another disadvantage of railway transport is its inflexibility. Its routes and timings cannot be adjusted to individual requirements.
- Rail transport cannot provide door to door service as it is tied to a particular track.
- Intermediate loading or unloading involves greater cost, more wear and tear and wastage of time.
- Even if controlled and managed by the government, lack of competition may breed inefficiency and high costs.
- Railway transport is unsuitable and uneconomical for short distance and small traffic of goods.

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UNIT-3B- Water Resources and Environmental Engineering

16. What are the sources of Raw Water?

ANSWER

The various sources of water can be classified into two categories:

1. Surface sources, such as

a. Ponds and lakes;

b. Streams and rivers;

c. Storage reservoirs; and

d. Oceans, generally not used for water supplies, at present.

2. Sub-surface sources or underground sources, such as

a. Springs;

b. Infiltration wells and

c. Wells and Tube-wells

Define an aquifer

An aquifer is an underground layer of porous rocks or permeable rocks that store and retain groundwater levels in the soil. The underground aquifer is built with all types of porous or permeable rock materials, such as sand, gravel, or silt, making it a suitable water absorber.

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17. Discuss about water quality parameters? Or

Write about physical, Chemical and bacteriological characteristics of drinking water?

ANSWER:

Water Quality

The raw or treated water is analysed by testing their physical, chemical and bacteriological characteristics:

1. Physical Characteristics:

- Turbidity
- Colour
- Taste and Odour
- Temperature

2. Chemical Characteristics:

1. pH
2. Acidity
3. Alkalinity
4. Hardness
5. Chlorides
6. Sulphates
7. Iron
8. Solids
9. Nitrates

3. Bacteriological Characteristics:

Water polluted by sewage contains one or more species of disease producing pathogenic bacteria. Pathogenic organisms cause water borne diseases, and many non pathogenic bacteria such as E.Coli, a member of coliform group, also live in the intestinal tract of human beings.

The methods to estimate the bacterial quality of water are:

- Standard Plate Count Test
- Most Probable Number
- Membrane Filter Technique

INDIAN STANDARDS FOR DRINKING WATER (IS 10500(2012)

Parameter	Desirable-Tolerable	*If no alternative source available, limit extended upto*
Turbidity (NTU unit)	< 10	25
Colour (Hazen scale)	< 10	50
Taste and Odour	Un-objectionable	Un-objectionable
Chemical		
pH	7.0-8.5	6.5-9.2
Total Dissolved Solids mg/l	500-1500	3000
Total Hardness mg/l (as $CaCO_3$)	200-300	600
Chlorides mg/l (as Cl)	200-250	1000
Sulphates mg/l (as SO_4)	150-200	400
Fluorides mg/l (as F)	0.6-1.2	1.5
Nitrates mg/l (as NO_3)	45	45
Calcium mg/l (as Ca)	75	200
Iron mg/l (as Fe)	0.1-0.3	1.0

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18. Define "HYDERLOGY" and discuss about 'hydrological cycle' or 'water cycle'?

ANSWEER:

Hydrology is the science that treats the waters of the Earth, their occurrence, circulation and distribution, their chemical and biological properties and their reaction with their environment, including their relation to living things. The domain of hydrology embraces the full life history of water on the Earth.

Engineering hydrology, however, includes those segments of hydrology that are important for the design and operation of engineering projects responsible for the control and use of water.

THE HYDROLOGICAL CYCLE OR WATER CYCLE

The hydrological cycle consists of Evaporation, condensation, precipitation, interception, infiltration, percolation, transpiration, runoff, and storage.

1. Evaporation

In this process energy from the sun heats up the lakes, rivers, oceans, swamps and other water bodies which subsequently increase the temperature of the water present in them. This leads to evaporation of some water into air and the rising air current takes the vapour up in the sky.

Along with this process at the same time plants and trees also lose water to the atmosphere in the form of vapour which rises up in the sky.

2. Transpiration

Water from plants evaporates through stomata during transpiration. Small apertures called stomata, which are related to vascular plant tissues can be seen on leaves. The atmosphere's humidity and the soil's moisture content play a significant role in controlling the passive process of transpiration in the majority of plants.

3. Condensation

Condensation is the process by which atmospheric water vapor transforms into a liquid state. Condensation in the atmosphere can take the form of clouds or dew. Condensation is the opposite of evaporation. Since water vapor has a higher energy level than that liquid water, when condensation occurs, excess energy in the form of heat energy is released. The dew point, in its simplest form, is the temperature at which dew can develop. Water vapor condenses with any further cooling. When the dew point and air temperature are the same, foggy conditions frequently develop.

4. Precipitation

When the tiny condensation particles grow too large through collision and coalescence for the rising air to support, they form precipitation and fall to the ground. There may be precipitation in the form of snow, sleet, hail, or rain. On Earth, precipitation is the main source of fresh water.

5. Runoff

When the earth cannot absorb any more water, runoff occurs. Runoff causes rivers and lakes to form. Although some runoff evaporation occurs in the atmosphere, most of the water in rivers and lakes flows back into the oceans. This runoff evaporates into the atmosphere, restarting the hydrologic cycle.

The general water balance equation is:

P - R - G - E - T = DS

Where:

P	Precipitation
R	Runoff $R = R_{out} - R_{in}$ R_{out} = runoff as the outflow from the water body/hydrologic region R_{in} = runoff as influx into the water body/hydrologic region
G	Groundwater flow $G = G_{out} - G_{in}$ G_{out} = groundwater as the outflow from the water body/hydrologic region G_{in} = groundwater as influx into the water body/hydrologic region
E	Evaporation
T	Transpiration
DS	Change in storage

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19. What is meant by “Rainwater harvesting”, discuss about need, advantages and disadvantages of rainwater harvesting?

ANSWER:

Rain Water Harvesting:

Rain Water Harvesting is the term used to indicate the collection and storage of rain water used for human, animals and plant needs. It involves collection and storage of rain water at surface or in sub-surface aquifer, before it is lost as surface run off. The collected water is stored and pumped in a separate pipe distribution.

Need of rain water harvesting:

i. To overcome the inadequacy of surface water to meet our demands.
ii. To arrest decline in ground water levels.
iii. To enhance availability of ground water at specific place and time and utilize rain water for sustainable development.
iv. To increase infiltration of rain water in the subsoil this has decreased drastically in urban areas due to paving of open area.
v. To improve ground water quality by dilution.
vi. To increase agriculture production.
vii. To improve ecology of the area by increase in vegetation cover etc.

Advantages of rain water harvesting

i. The cost of recharge to sub-surface reservoir is lower than surface reservoirs.
ii. The aquifer serves as a distribution system also.
iii. No land is wasted for storage purpose and no population displacement is involved.
iv. Ground water is not directly exposed to evaporation and pollution.
v. Storing water under ground is environment friendly.
vi. It increases the productivity of aquifer.
vii. It reduces flood hazards.
viii. Effects rise in ground water levels.
ix. Mitigates effects of drought.
x. Reduces soil erosion.

Disadvantages of Rainwater Harvesting

In addition to the great advantages, the rainwater harvesting system has a few disadvantages like unpredictable rainfall, unavailability of the proper storage system, etc.

Listed below are a few more disadvantages of the rainwater harvesting process.

- Regular maintenance is required.
- Requires some technical skills for installation.
- Limited and no rainfall can limit the supply of rainwater.

- If not installed correctly, it may attract mosquitoes and other waterborne diseases.
- One of the significant drawbacks of the rainwater harvesting system is storage limits

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20. Discuss about different methods of rain water harvesting?

Or

Discuss about different methods of rain water harvesting suitable for urban areas?

ANSWER:

Methods and Techniques:

The methods of ground water recharge mainly are:

For Urban Areas:

Roof top rain water/storm runoff harvesting through

(i) Recharge Pit

(ii) Recharge Trench

(iii) Tube well

(iv) Recharge Well

For Rural Areas:

Rain water harvesting through

(i) Gully Plug

(ii) Contour Bund

(iii) Gabion Structure

(iv) Percolation Tank

(v) Check Dam/Cement Plug/ Nala Bund

(vi) Recharge Shaft

(vii) Dug well Recharge

(viii) Ground Water Dams/Subsurface Dyke

For Urban Areas:

In urban areas, rain water available from roof tops of buildings, paved and unpaved areas goes waste. This water can be recharged to aquifer and can be utilized gainfully at the time of need. The rain water harvesting system needs to be designed in a way that it does not occupy large space for collection and recharge system. Roof top rain water harvesting can be a very effective tool to fight the problem of water shortage particularly in urban areas. Roof top rain water harvesting depends upon the amount of rainfall and the roof top area. More the amount of rainfall more is the harvested water from roof top. Similarly, larger amount of roof top rain water is harvested from roofs with large area.

A few techniques of roof top rain water harvesting in urban areas are described as under:

(i) Roof Top Rainwater Harvesting through Recharge Pit:

a. In areas where permeable rocks are exposed on the land surface or at very shallow depth, roof top rain water harvesting can be done through recharge pits.

b. The technique is suitable for buildings having a roof area of 100 sq m and is constructed for recharging the shallow aquifers.

c. Recharge Pits may be of any shape and size and are generally constructed 1 to 2 m wide and 2 to 3 m deep which are back filled with boulders (5-20 cm), gravels (5-10 mm) and coarse sand (1.5-2 mm) in graded form— Boulders at the bottom, gravels in between the coarse sand at the top so that the silt content that will come with runoff will be deposited on. For smaller roof area, pit may be filled with broken bricks/cobbles.

d. A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the pit and a desalting/collection chamber may also be provided at the ground to arrest the flow of finer particles to the recharge pit.

e. The top layer of sand should be cleaned periodically to maintain the recharge rate.

f. By-pass arrangement is provided before the collection chamber to reject the first showers.

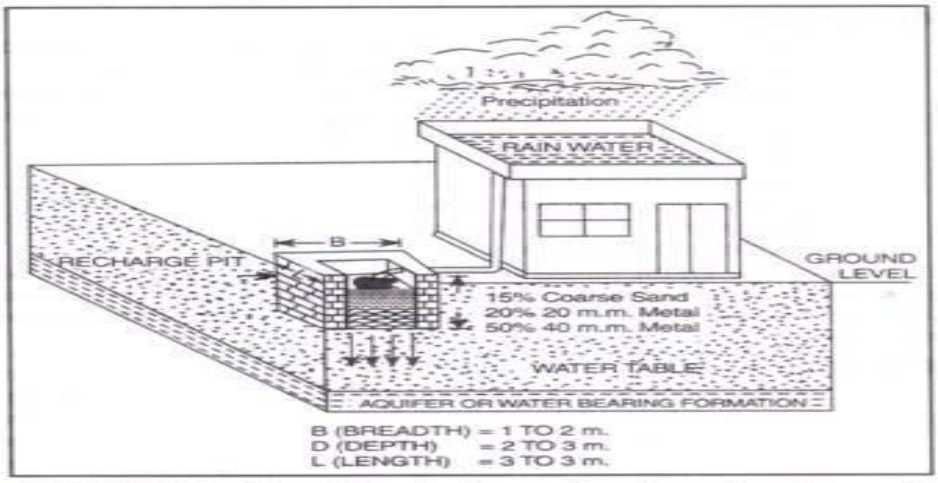

FIG. 16.7. Roof top rain water harvesting through recharge pit

(ii) Roof Top Rain Water Harvesting through Recharge Trench:

a. Recharge trenches are suitable for buildings having roof area of 200-300 sq m and where permeable strata are available at shallow depths.

b. Trench may be 0.5 to 1 m wide, 1 to 1.5 m deep and 10 to 20 m long depending upon availability of water to be recharged.

c. These are back filled with boulders (5-20 cm), gravels (5-10 mm) and coarse sand (1.5-2 mm) in graded form—boulders at the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the sand layer and can easily be removed.

d. A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the trench and a collection chamber may also be provided on ground to arrest the flow of finer particles to the trench.

e. By-pass arrangement is provided before the collection chamber to reject the first showers.

f. The top layer of sand should be cleaned periodically to maintain the recharge rate.

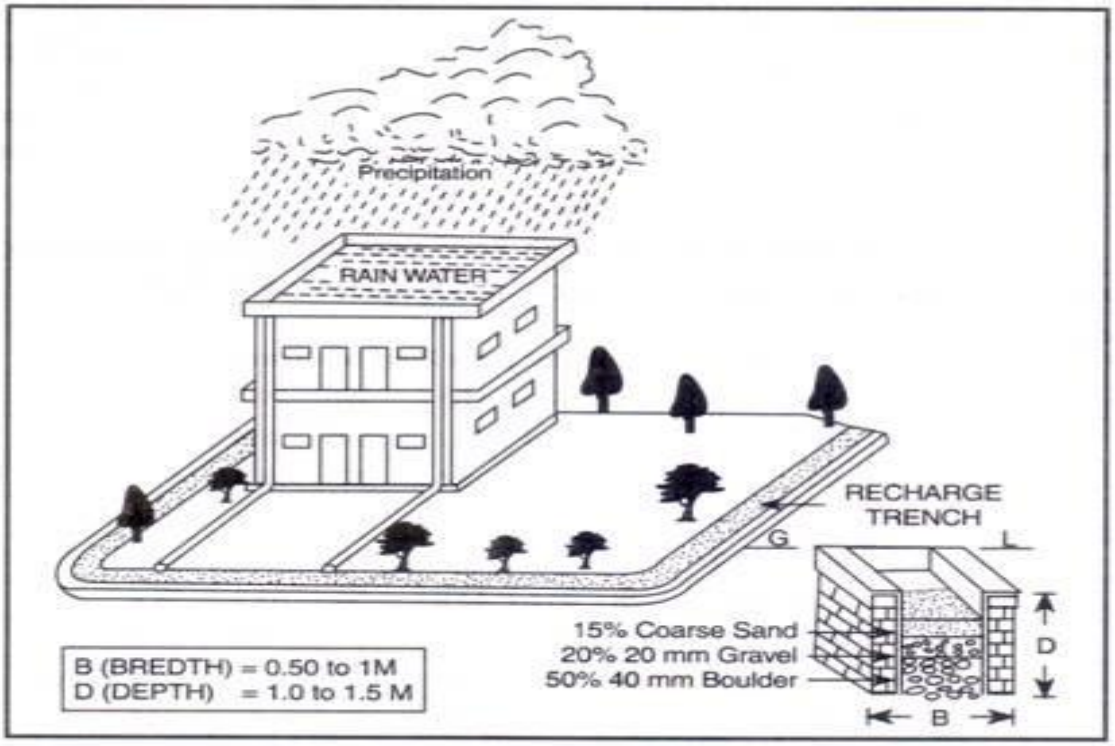

FIG. 16.8. Roof top rain water harvesting through recharge trench

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21. Discuss about different methods of rain water harvesting suitable for rural areas?

Rural Areas:

In rural areas, rain water harvesting is taken up considering watershed as a unit. Surface spreading techniques are common since space for such systems is available in plenty and quantity of recharged water is also large. Following techniques may be adopted to save water going waste through slopes, rivers, rivulets and nalas.

(i) Rain Water Harvesting through Contour Bund:

a. Contour bunds are effective method to conserve soil moisture in watershed for long duration.

b. These are suitable in low rain fall areas where monsoon run off can be impounded by constructing bunds on the sloping ground all along the contour of equal elevation.

c. Flowing water is intercepted before it attains the erosive velocity by keeping suitable spacing between bunds.

d. Spacing between two contour bunds depends on the slope of the area and the permeability of the soil. Lesser the permeability of soil, the close should be spacing of bunds.

e. Contour bunding is suitable on lands with moderate slopes without involving terracing.

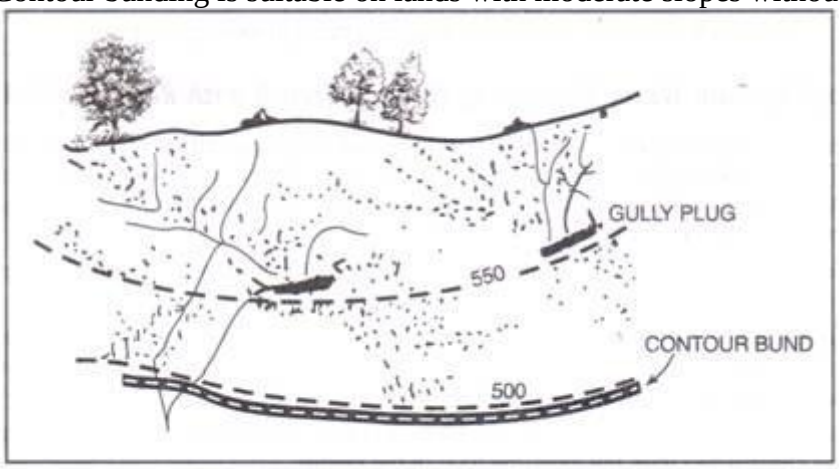

FIG. 16.10. Rain water harvesting through gully plug and contour bund

(ii) Rain Water Harvesting through Gabion Structure:

a. This is a kind of check dam commonly constructed across small streams to conserve stream flows with practically no submergence beyond stream course.

b. A small bund across the stream is made by putting locally available boulders in a mesh of steel wires and anchored to the stream banks.

c. The height of such structures is around 0.5 m and is normally used in the streams with width of less than 10 m.

d. The excess water over flows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders in due course and with growth of vegetation, the bund becomes quite impermeable and helps in retaining surface water runoff for sufficient time after rains to recharge the ground water body.

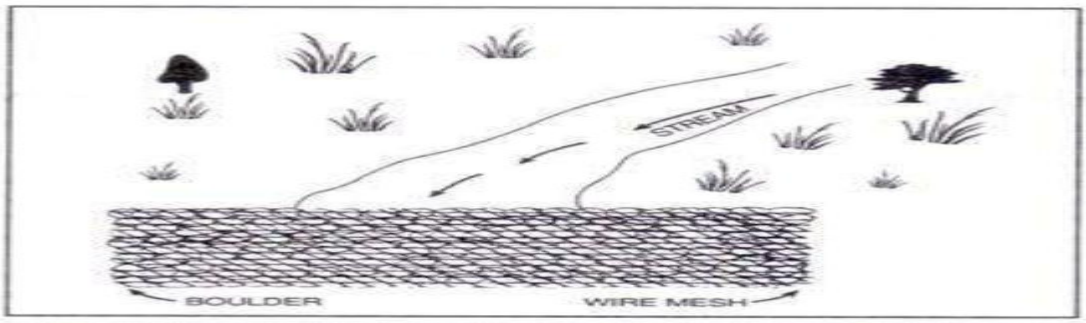

FIG. 16.11. Rain water harvesting through Gabian Structure

(iii) Rain water harvesting through Check Dams/Cement Plugs/ Nala Bunds:

a. Check dams are constructed across small streams having gentle slope. The site selected should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time.

b. The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side.

c. To harness the maximum run off in the stream, series of such check dams can be constructed to have recharge on regional scale.

d. Clay filled cement bags arranged as a wall is also being successfully used as a barrier across small nalas. At places, shallow trench is excavated across the nala and asbestos sheets are put on two sides. The space between the rows of asbestos sheets across the nala is backfilled with clay. Thus a low cost check dam is created. On the upstream side clay filled cement bags can be stacked in a slope to provide stability to the structure.

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22. What is a DAM; discuss different parts of a Dam using a diagram?

ANSWER

DAMS AND ITS USES:

- ✓ A dam is a prestigious civil engineering structure which blocks a river channel and compels the running water to accumulate within the reservoir.
- ✓ Dams are the multipurpose civil engineering constructions. They deliver beneficial results for a long time to mankind.
- ✓ But the same dams, if they fail, create a heavy toll of life and property through lightning floods.
- ✓ They may even cause the failure of other dams built along the downstream course.
- ✓ Each dam consumes millions of tons of building materials including cement, aggregates, sand and steel and other items.
- ✓ In India, more than 90% of the dams operating are primarily for irrigation.

Various purposes of dam construction are:

- ➢ To generate hydro-electric power
- ➢ For flood control
- ➢ For water supply to meet domestic, industrial

PARTS OF A DAM:

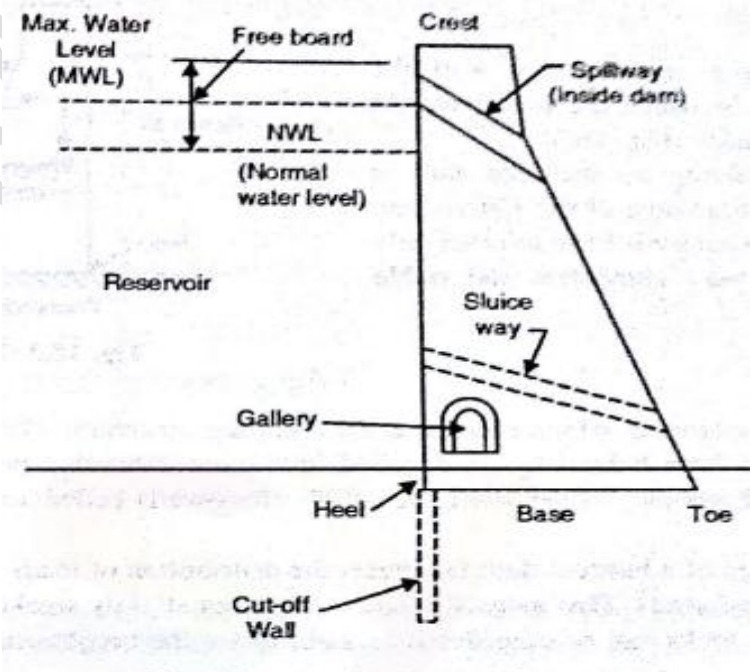

Fig. 18.2 A gravity dam and its parts

The chief parts of a dam are as follows:

Heel: It is the part where the dam comes in contact with the ground on the upstream side

Toe: It is that part where the dam comes in contact with the ground on the downstream side

Free board: It is the difference in level between the top of the dam wall and the highest storage level.

Galleries: These are small rooms left within the dam for checking operations.

Spillway: An arrangement is made in a dam near the top or inside to allow excess water of the reservoir to the downstream side

Sluice: It is an opening in the dam near the ground level. It is useful in clearing the silt of the reservoir.

Cut-off wall: It is an underground wall-like structure of concrete in the heel portion. It is useful in preventing leakage under the foundation.

Abutment: These are the sides of the valley on which the dam structure rests.

TYPES OF DAMS

1. Gravity dams
2. Buttress dams
3. Arch dams
4. Earth Dams

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23. How to select the geological location of a dam?

ANSWER

The ideal site for location of a dam should satisfy the following requirements:

- A narrow river valley along with steeper side slopes
- Stable slopes both at the dam location and along the reservoir sides
- Absence of weathered formations
- Competent geological formations devoid of weak zones
- Absence of clay and fractured material
- Absence of fault zones
- Stability of formations below the dam and reservoir area
- Easy access and supply of materials for construction of the structure

It may be mentioned here that all these attributes never exist in any one particular site. Consequently, appropriate foundation treatments are resorted for making the dam site and reservoir area most suitable.

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24. What is meant by reservoir and write few uses of a reservoir

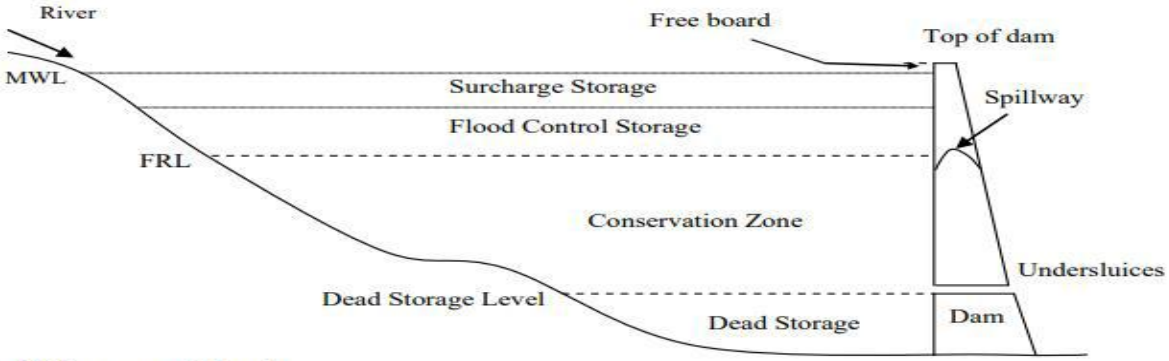
ANSWER:

When a barrier is constructed across some river in the form of a dam, water gets stored on the upstream side of the barrier, forming a pool of water, generally called a dam reservoir or an impounding reservoir or a river reservoir.

Reservoirs are the results of human attempts to make effective use of the run-off water which is otherwise going waste i.e., flowing into the sea.

The main purposes of reservoirs are given below:

- Water supply
- Flood control
- Environmental management
- Hydroelectric power management
- Navigation
- Irrigation
- Development of fish and wildlife
- Soil conservation



FRL: Full reservoir level
MWL: Maximum water level

Schematic diagram of a reservoir showing the various storage zones

Geological investigations are carried out in advance to study the suitability of the site to serve as the reservoir. In addition, non- geological aspects such as

- Water tightness of the reservoir site
- The life of the reservoir (rate of silting)
- The capacity of the reservoir
- The area covered by the reservoir
- The effect of evaporation
- Possible submerge of economic minerals
- Submerge of fertile land, forests.
- Submerge of places of interest like temples and historical monuments.

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25. What are differences between dams and reservoirs?

ANSWER:

DAMS	RESERVOIR
Structural barriers built across, rivers valleys, streams etc for the purpose of storing and managing water flow.	Reservoir is a large water body formed behind the constructed dam structure across a river, stream, etc
Dams are reinforced concrete structures or structures made of bricks rubble etc erected across water bodies to control the water flow.	The reservoir is the water that accumulates behind the constructed dam.
Create site for hydro electric power generation. This can improve the industrial development and living standards of people living in that region.	Stores water for later usage, water for human consumption and excess water for agricultural and industrial uses.
Dams fluctuates oxygen levels and restricts migration of fishes in the river.	A reservoir leads to the displacement of people.
Dams are tourist attraction sites	Helps in water transportation

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Essay Questions (10M)

1. What is the importance of Transportation engineering? (Q-1)
2. Explain any two modes of transportation with their functions. (Q-2)
3. Define flexible pavement and different layers of the pavement. (Q-4)
4. List out different types of rigid pavements. (Q-5)
5. What are the merits and demerits of tunnels? (Q-10)
6. Discuss the components of Airport with their functions. (Q-12)
7. Distinguish between natural and artificial harbour. (Q-8)
8. Describe about uses of harbour. (Q-8)

9. Discuss in brief various sources of water. (Q-16)
10. Describe types of dams? (Q-22)
11. What are the functions of reservoirs? (Q-24)
12. Describe rain water harvesting. (Q-21)
13. What are the requirements of domestic water quality? (Q-17)

Short answer questions (2M)

1. Classify urban roads. (Q-2)
2. Differentiate between harbour and dock. (Q-8)
3. Differentiate between flexible and rigid pavements. (Q-7)
4. Define Aquifer. (Q-16)
5. What is Hangar in Airport? (Q-12, 6th point)
6. Define hydrology. (Q-18)
7. List out the types of dams (Q-22)

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