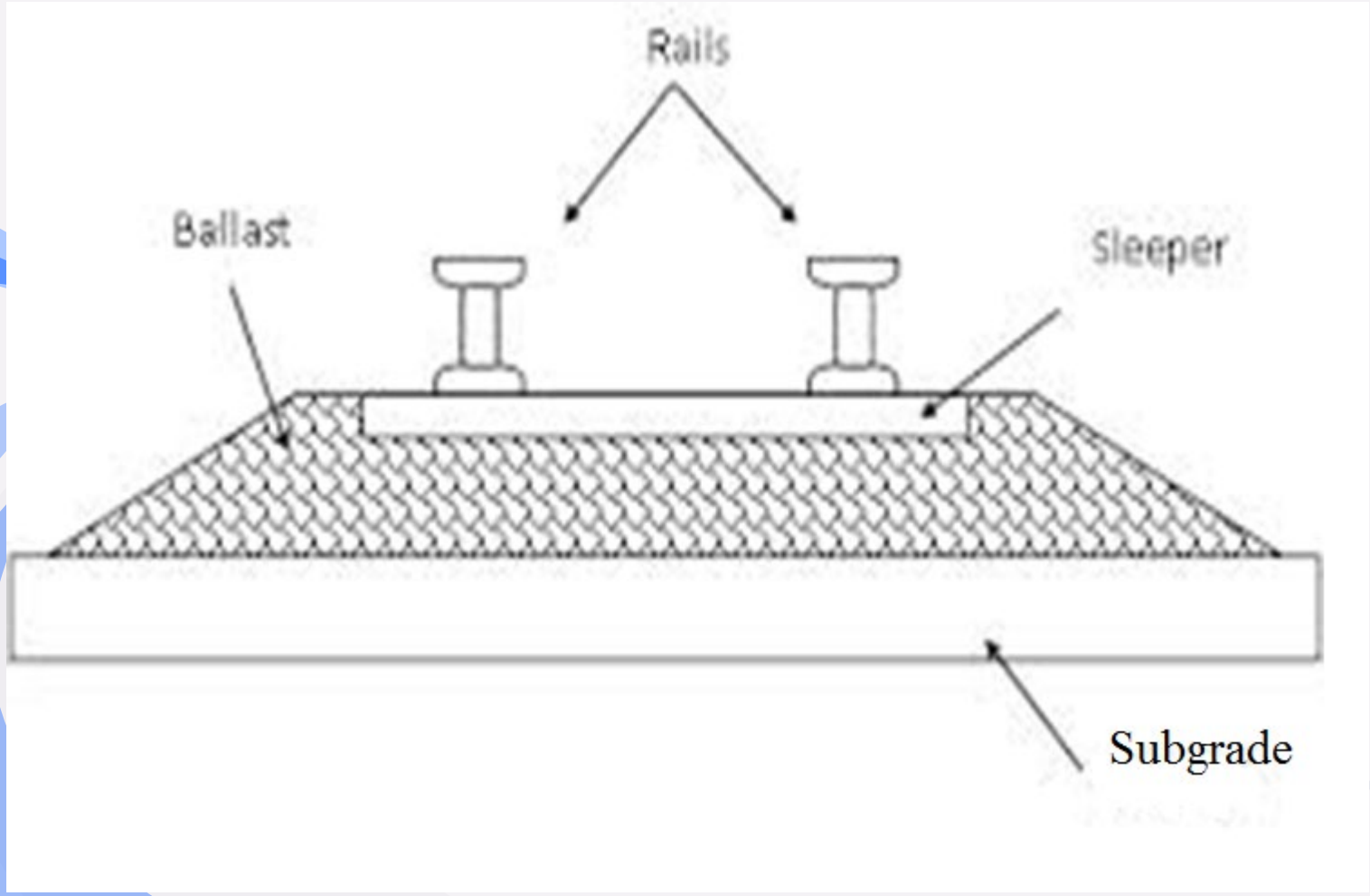
RAILWAY ENGINEERING..

RAILWAY TRACK

- COMPONENT PARTS OF A RAILWAY TRACK



RAILS

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RAILS

- Can be considered as steel girders for the purpose of carrying loads
- Made up of high carbon steel to withstand wear and tear
- Flat footed rails are mostly used in railway track

FUNCTIONS OF RAILS

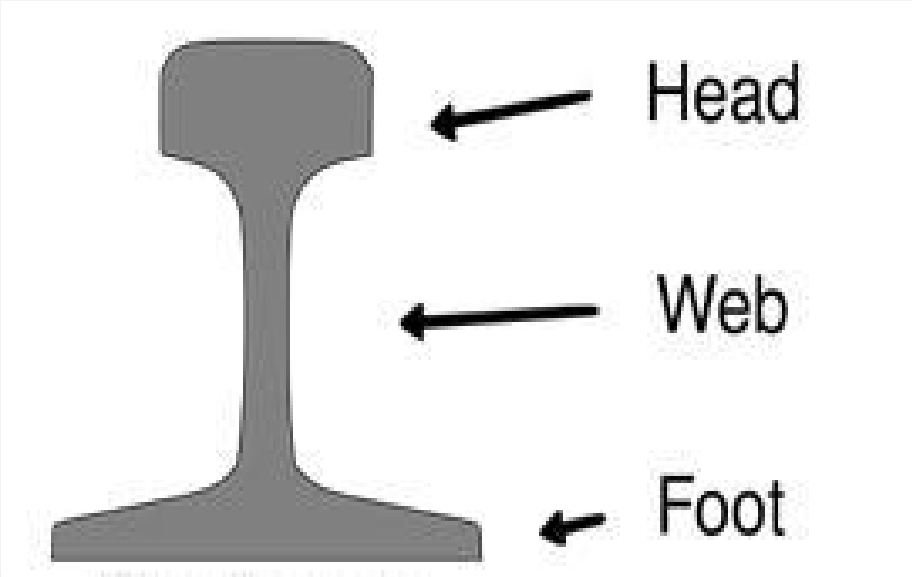
- Rails provide hard, smooth and unchanging surface for passage of heavy moving loads with minimum friction between steel rail and steel wheel

- Rails bear the stresses developed due to heavy vertical loads, lateral and braking forces and thermal stresses

- The rail material used is such that it gives minimum wear to avoid replacement charges and failure due to wear

- Rails transmit the loads to sleepers and consequently reduce pressure on ballast and formation below

REQUIREMENTS OF RAILS



- Rails should be designed for optimum nominal weight to provide for the most efficient distribution of metal in its various components

REQUIREMENTS (cntd..)

- The vertical stiffness should be high enough to transmit load to sleepers. The height of the rail should be adequate
- Rails should be capable of withstanding lateral forces. Large width of head and foot provides the rail with high lateral stiffness
- The depth of head of rail should be sufficient to allow for adequate margin of vertical wear. The wearing surface should be hard
- The web of rails should be sufficiently thick to bear the load coming to it and should provide adequate flexural rigidity in horizontal plane

REQUIREMENTS (cntd..)

- Foot should be wide enough so that the rails are stable against overturning especially on curves

- Bottom of the head and top of foot should be so as to enable the fish plates to transmit the vertical load efficiently from the head to the foot at rail joint

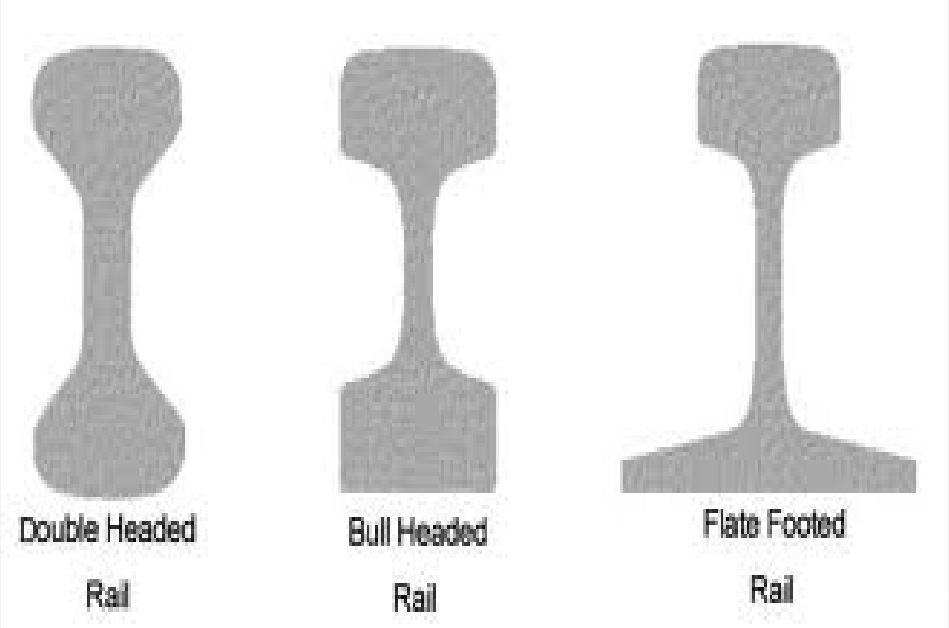
- The centre of gravity of rail section must lie approximately at mid height so that maximum tensile and compressive stresses are equal

REQUIREMENTS (cntd..)

- Tensile strength of rail shouldn't be less than 72 kg/m^2
- To bring down the contact stresses to minimum level, the contact area between the rail and wheel should be as large as possible

TYPES OF RAIL SECTIONS

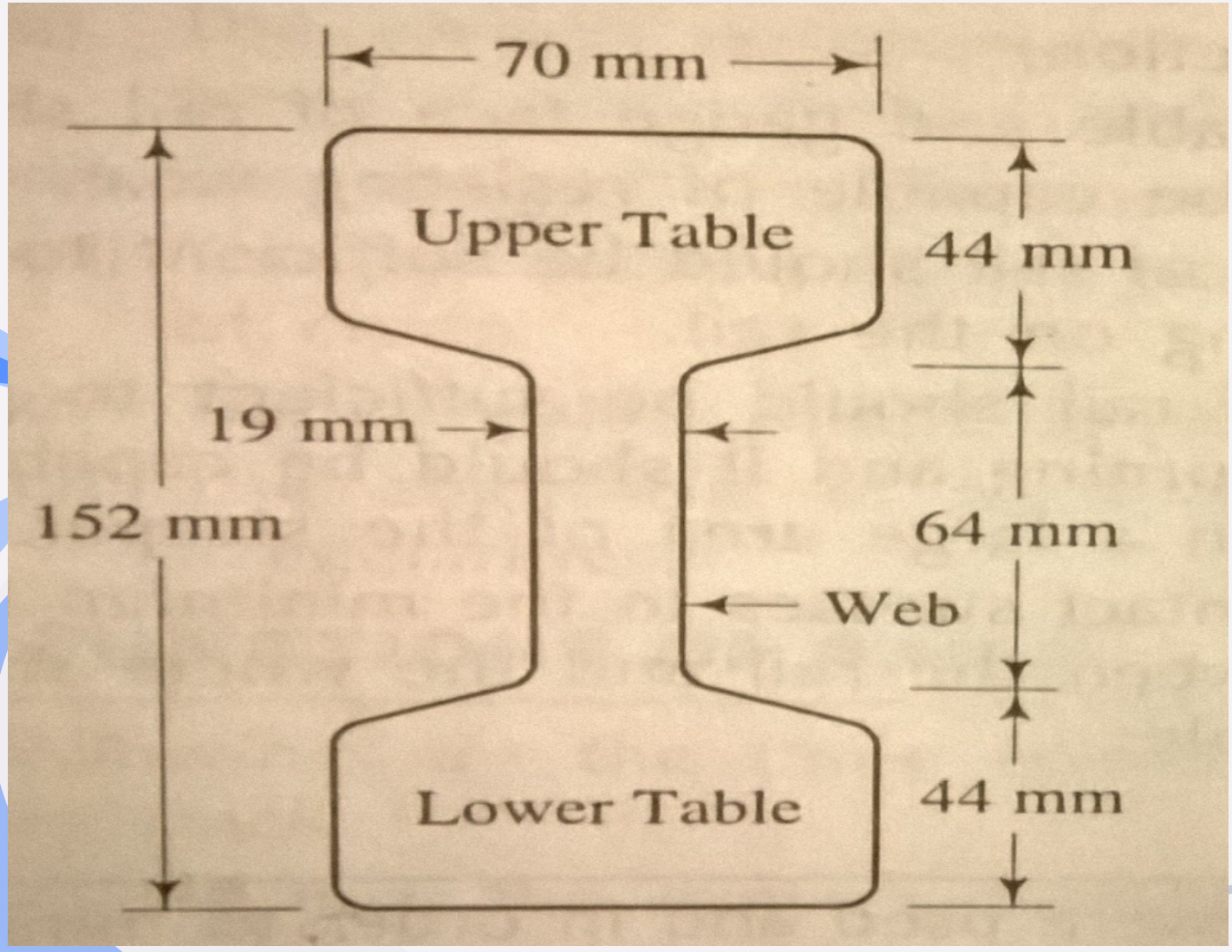
- **Double headed rails**
- **Bull headed rails**
- **Flat footed rails**



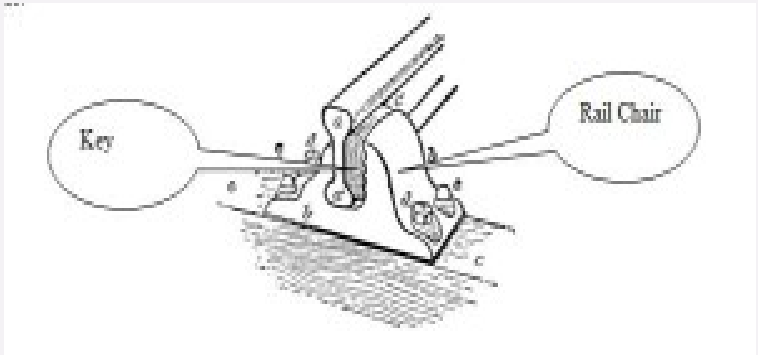
DOUBLE HEADED RAILS

- First stage of development of rails
- 3 parts:
  - Upper table
  - Web
  - Lower table
- Similar to dumb bell section
- Both upper and lower tables are identical
- When upper table was worn out, the rail can be reversed thus lower table can be brought into use
- Practically out of use
- Made of wrought iron
- Length varying from 610 cm to 732 cm

DOUBLE HEADED RAIL

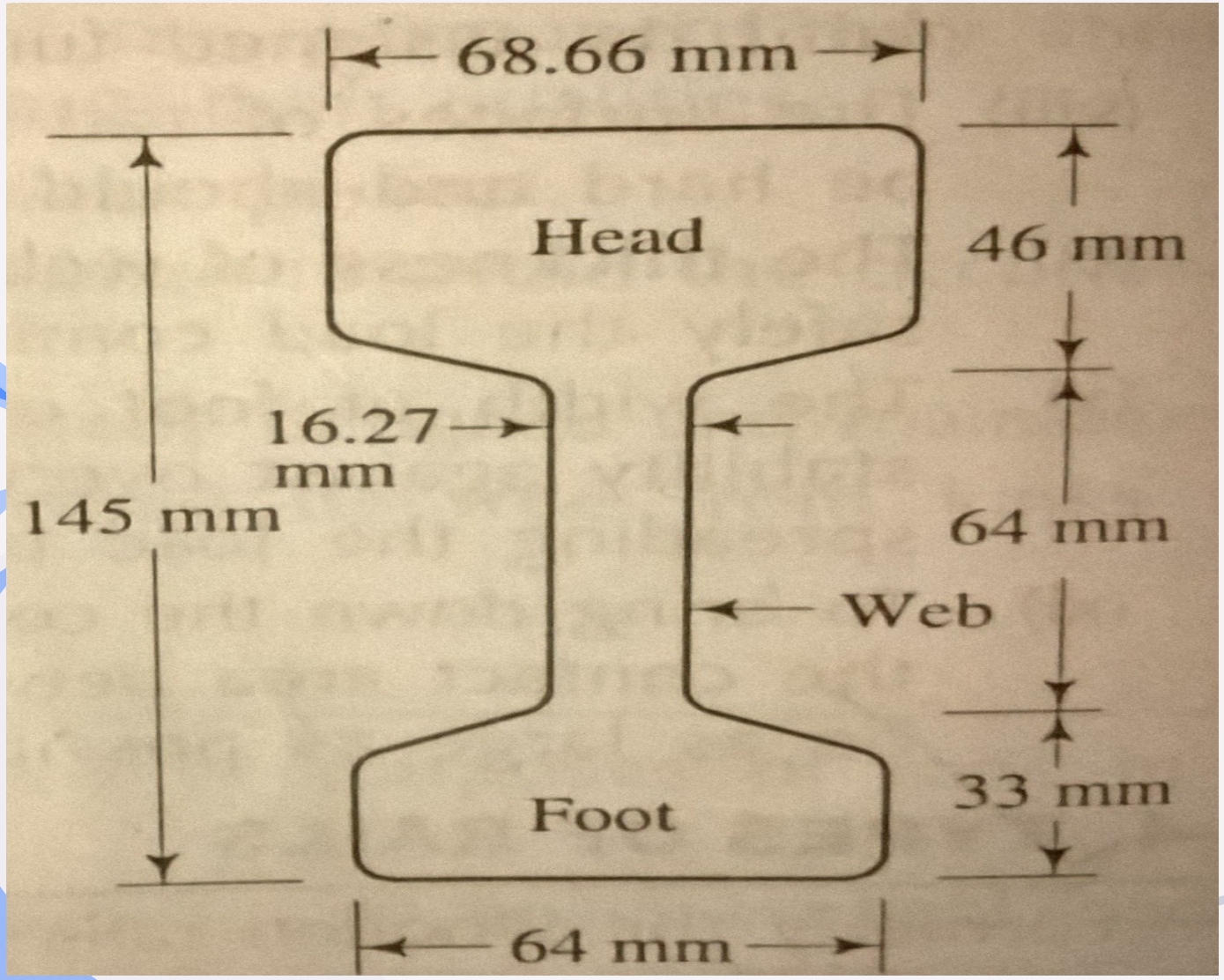


BULL HEADED RAIL



- Made up of steel
- Head is larger than foot
- Foot is designed only to hold the wooden keys with which rails are secured to chairs
- Extensively used in England
- Weight of standard rail or British rail is 47 kg/m of length for main lines and 42 kg/m length on branch lines
- Length of rail usually 18.29 m

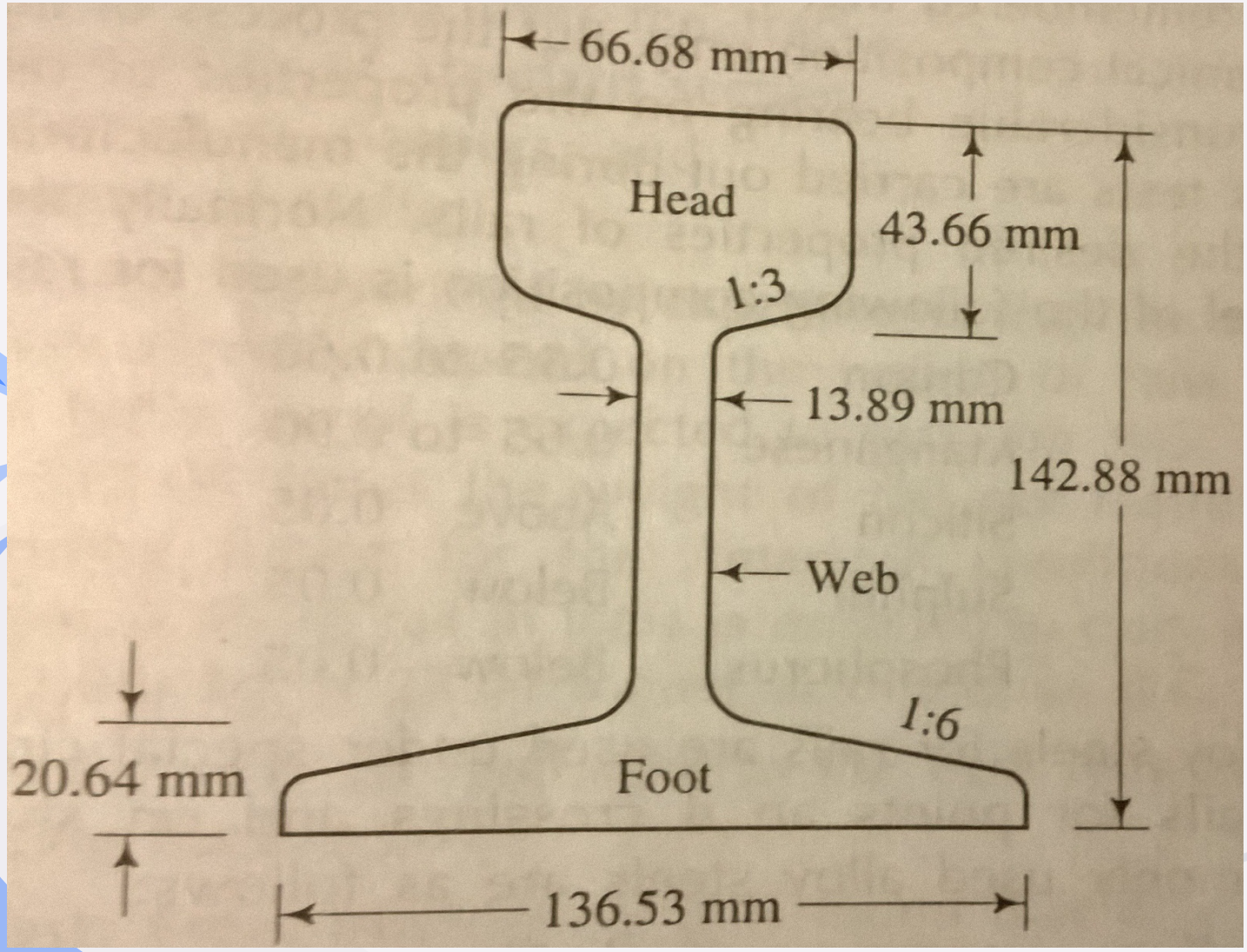
BULL HEADED RAIL



FLAT FOOTED RAIL

- Foot is spread out to form a base
- Invented by Charles Vignoles in 1836 and hence also known as “Vignoles Rails”
- 90 % of railway track is made up of flat footed rails

FLAT FOOTED RAIL



Advantages of flat footed rails

- Chairs
  - No chairs are required
  - Foot of rail directly spiked to sleepers
- Stiffness
  - Vertically and laterally stiffer than BHR of equal weight especially on curves
- Kinks
  - Less liable to develop kinks and maintains regular top surface than BHR
- Cost
  - Cheaper than BHR
- Load distribution
  - Distributes loads over large area
  - Results great track stability, longer life of rails and sleepers, reduced maintenance cost, less rail failures and few interruptions to traffic

WEAR ON RAILS

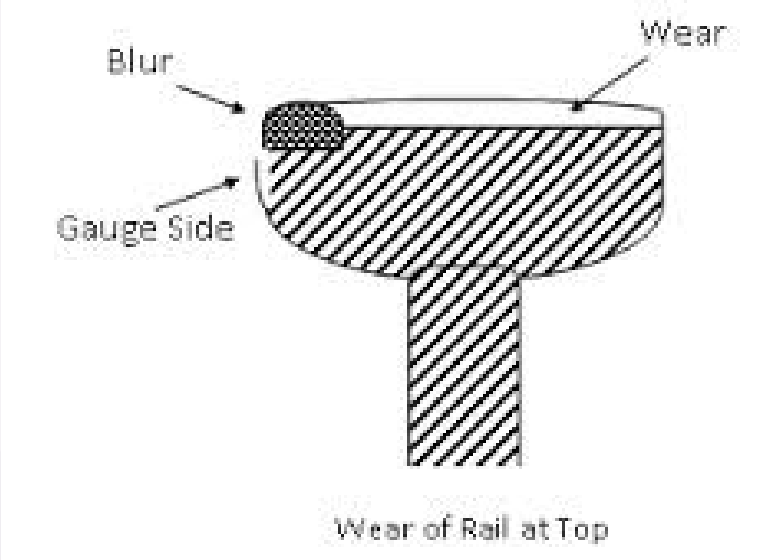
- The moving of number of wheels of train on rail cause wear on rails
- Depending on location wear of rail can be:
  - **Wear of rails on top or head of rail**
  - **Wear of rails at ends of rail**
  - **Wear of rail on the sides of head of rail**

Wear of rails on top or head of rail

- The metal from top of rail flows and forms projections
- These are known as “BURRS”
- Causes:
  - The rails are worn out on top due to abrasion of rolling wheels over them
  - The heavy wheel loads are concentrated on very small areas – results into flow of metal from top
  - Impact of heavy wheel load
  - Grinding action of sand particles between rails and wheels

Wear of rails on top or head of rail

- Causes:
  - The corrosion of metal of rails especially near sea
  - The metal on top of rail burns during starting when the wheels slip or when brakes are applied to the moving trains



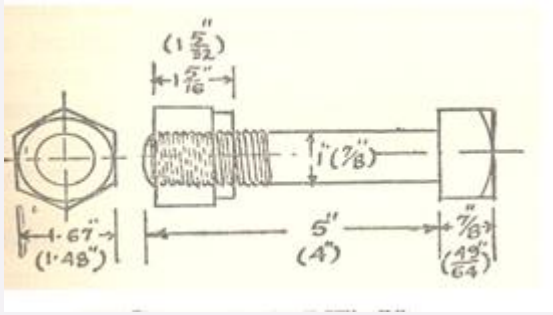
Wear of Rail at Top

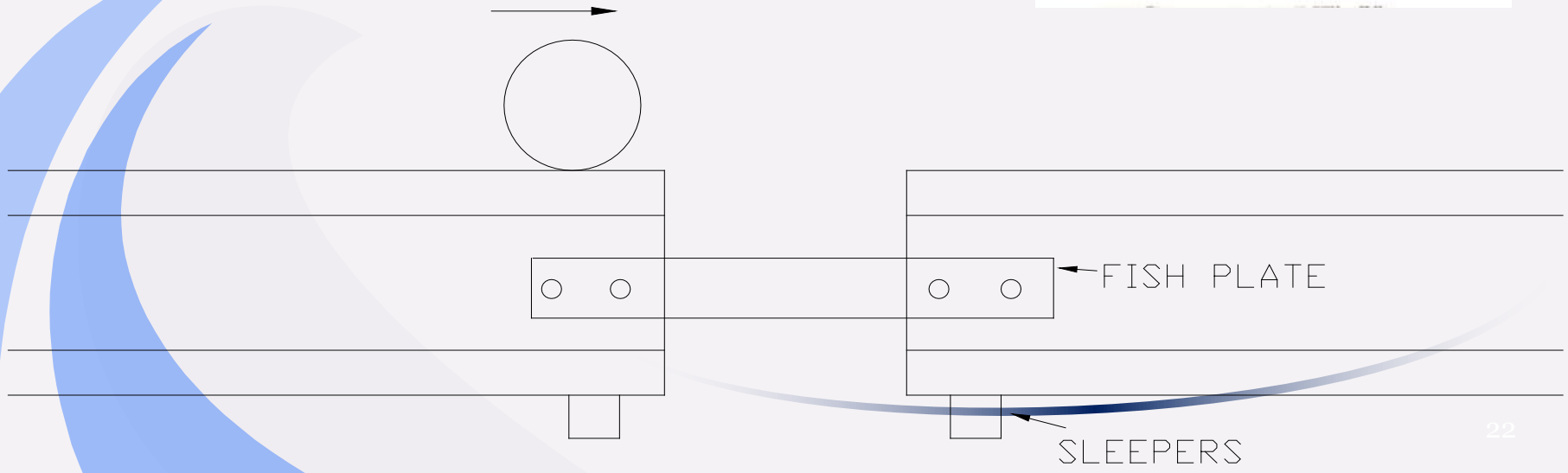
Wear of rails at end of rails

- Takes place at end of rail
- Much greater than wear at top of rails
- At expansion gap the wheels of the vehicle have to take a jump and during this jump, they impart a blow to the end of rail – causes wear of rail at end
- Wear due to high static pressure combined with impact blows
- End of rail gets battered – causes rough riding in the track, loosens the ballast under joints and disturbs sleeper

Wear of rails at end of rails

- Causes:
  - Loose fish plates & fish bolts
  - Heavy loads & large joint openings
  - Difference in rail levels at joints
  - Small wheels
  - Bad condition of vehicle springs
  - Poor maintenance of track



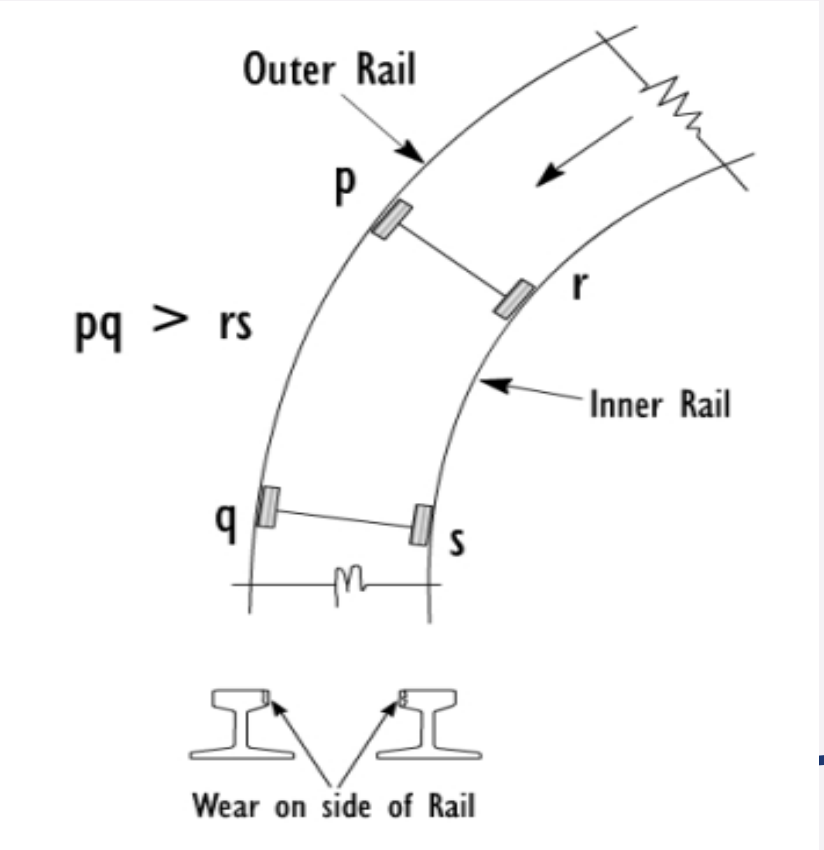


Wear of rails on the sides of rail head

- Most destructive type wear
- Occurs when tracks are laid on curves
- Causes:
  - Due to curvature, the pressure due to centrifugal force causes grinding action of wheel flanges on inner side of the head of outer rail
  - The vehicle don't bend to the shape of the curvature while moving over the curve – results into the biting of inner side of head of outer rail by wheel flanges

Wear of rails on the sides of rail head

- Causes:
  - The wear on inner side of head of inner rail is due to slipping action of wheel on curves



Allowable limits of wear

- In India, prescribed limit for wear is 5 % of rail weight.
- Allowable wear of 25 % of the section of head is also exceptionally adopted

Methods adopted to reduce wear of rails

- Use of special alloy steel
- Good maintenance of track
- Reduction of expansion gap
- Exchange of inner and outer rails on curves
- Introducing check rails
- Use of lubricating oil
- Head hardened rails

Good maintenance of track

- Joints should be lightened
- Well maintained track would definitely results in wear of rail

Reduction of expansion gap

- If expansion joint has increased beyond the limit, it should be reduced by packing the sleeper at the joints and lightening fish bolts
- Number of expansion joints should be reduced

Exchange of inner and outer rails on curves

- On curves sometimes inner and outer rails are interchanged
- Possible where there is heavy wear at top of head of inner rail and heavy wear of the side of head of outer rail
- Thus top wear is exchanged with side wear

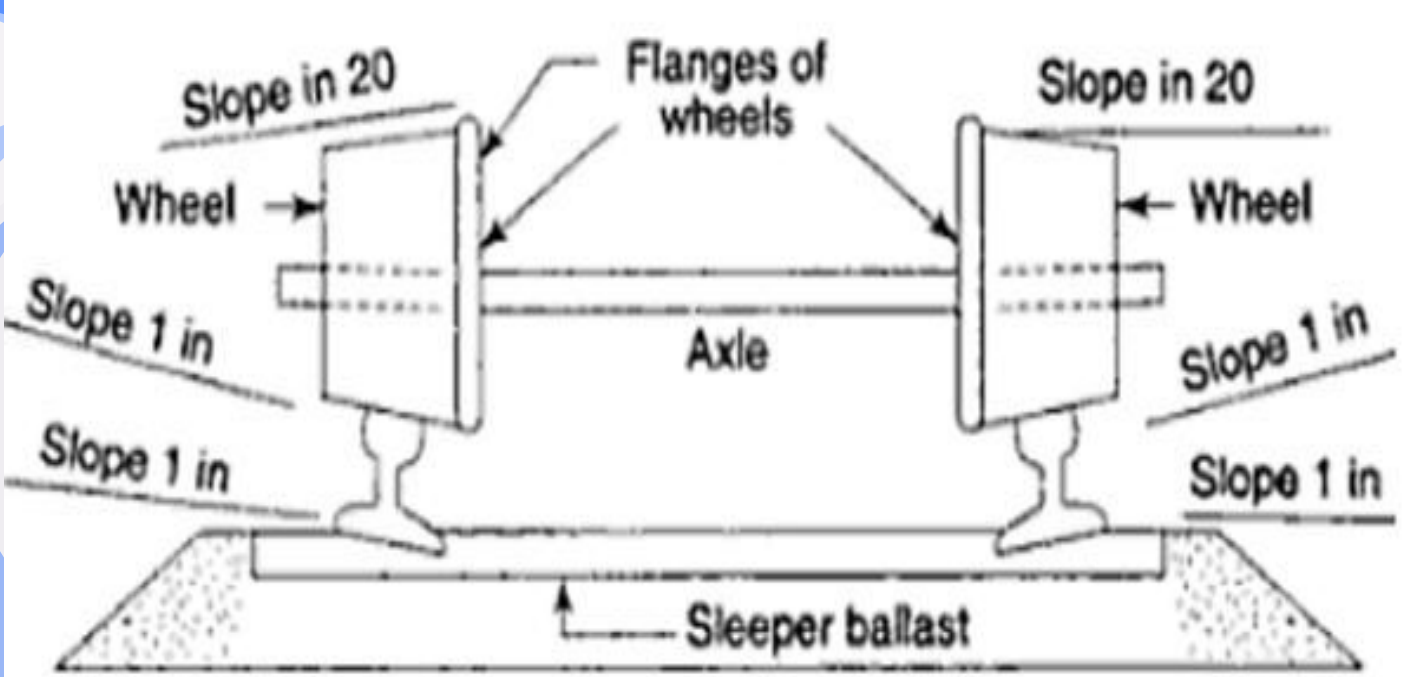
Introducing check rails

- Wear of rail on sharp curves can be reduced by introducing check rails all the way round the inner rail and parallel to it
- Hold back flange of inner wheel and prevents outer wheel to damage outer rail

WHEELS

CONING OF WHEELS

- The flanges of wheel is never made flat, but they are in the shape of cone with a slope of 1 in 20
- The coning of wheels is mainly done to maintain the vehicle in the central position with respect to the track

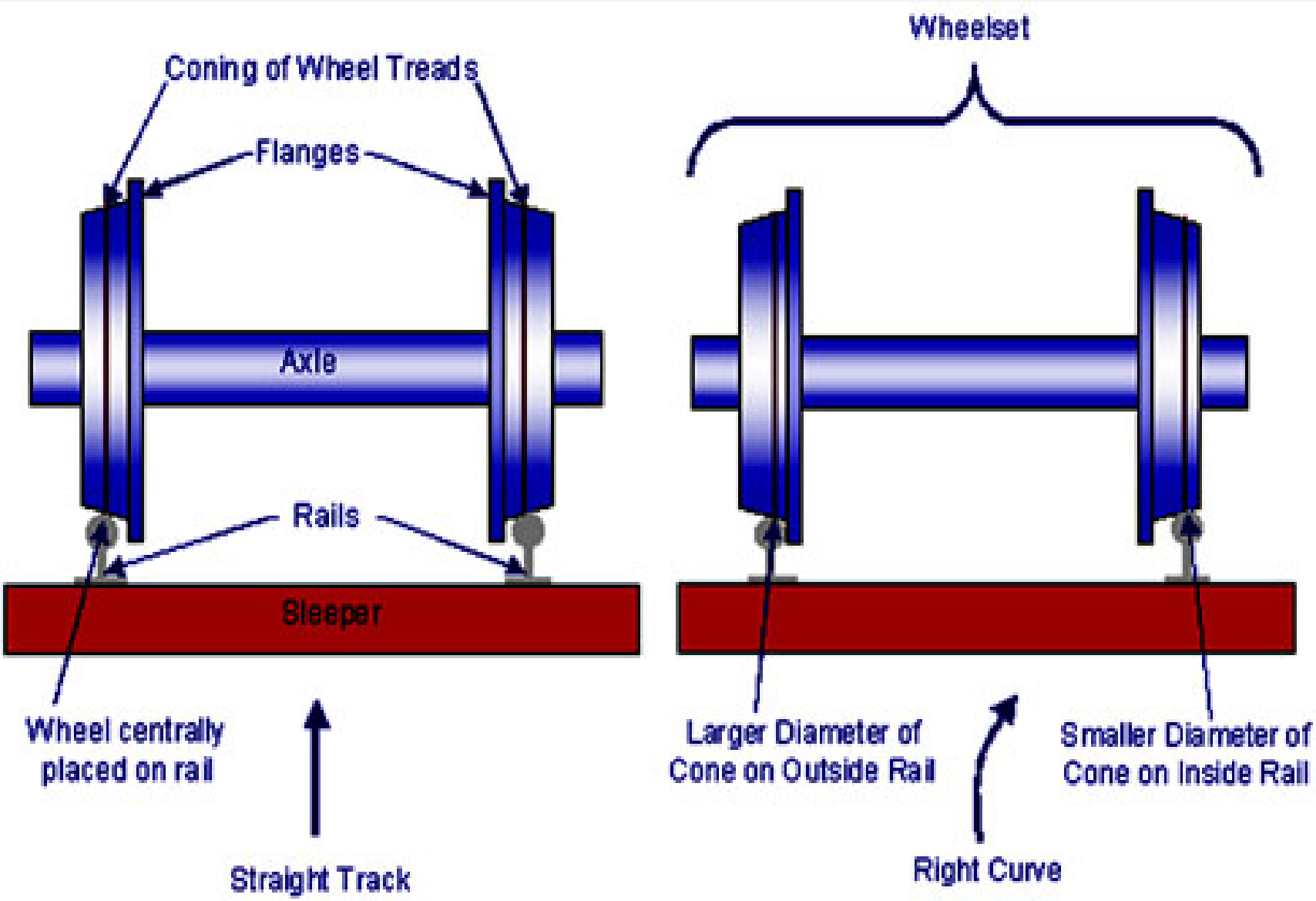


ADVANTAGES OF CONING THE WHEELS

- To reduce wear & tear of the wheel flanges and rails, which is due to rubbing action of flanges with inside face of the rail head
- To provide a possibility of lateral movement of the axle with its wheels
- To prevent the wheels from slipping to some extent

Behaviour of coned wheel

- At level surface
  - Flanges of wheels have equal circumference
  - Equal diameters on both rail
  - Equal pressure on both rail
- At curves
  - Outer rails has to cover great distance than inner rail
  - Vehicle has tendency to move sideways towards outer rail
  - Circumference of flange of outer wheel will be greater than that of inner wheel
  - Helps the outer wheel to cover longer distance than inner rail

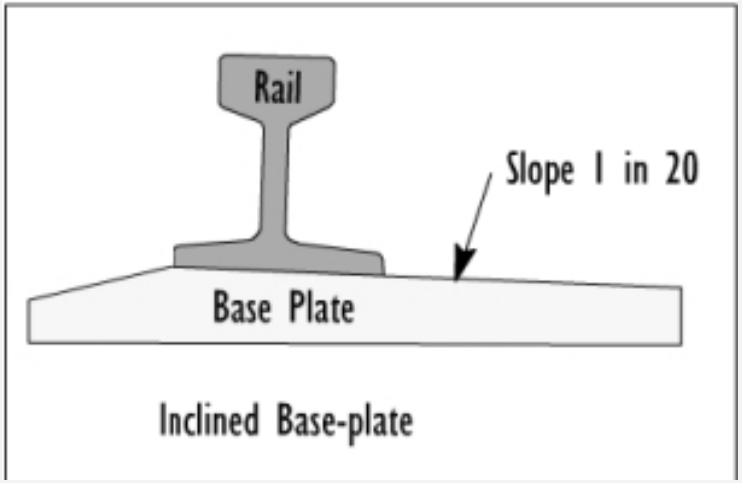

Coning of Wheel Treads
Flanges
Axle
Rails
Sleeper
Wheel centrally placed on rail
Straight Track
Wheelset
Larger Diameter of Cone on Outside Rail
Smaller Diameter of Cone on Inside Rail
Right Curve

Disadvantages of coning

- Smooth riding is produced by coning of wheels. But the pressure of the horizontal component near the inner edge of the rail has a tendency to wear the rail quickly
- The horizontal component tends to turn the rail outwardly and hence the gauge is widened sometimes
- If no base plate are provided, the sleepers under the outer edge of the rail are damaged

TILTING OF RAIL

- To minimize the disadvantages of coning
- Rails are tilted inwards
- Inclined base plates are used
- Slope of base plate is 1 in 20



Advantages

- Maintains gauge properly
- Wear of the head of rail is uniform due to tilting of rails
- Increase life of sleepers as well as rails

CREEP OF RAILS

- Longitudinal movement of rails in a track
- Rails have tendency to move gradually in the direction of dominant traffic

Indications of creep

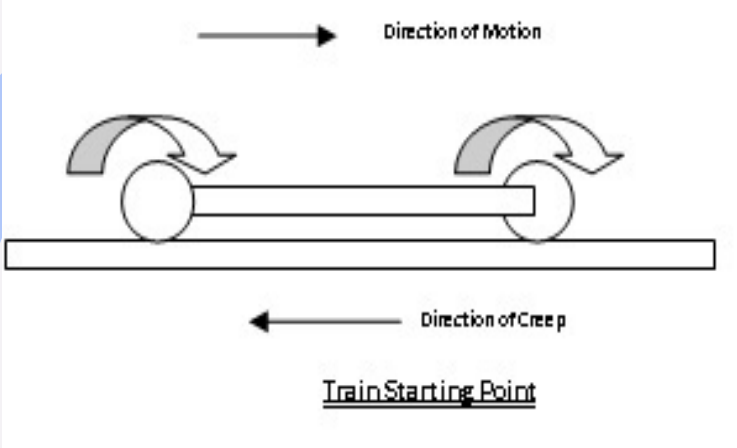
- Closing of successive expansion spaces at rail joints in the direction of creep and opening out of joints at the point from where creep starts
- Marks on flanges and webs of rails made by spike heads by scratching as the rail slide

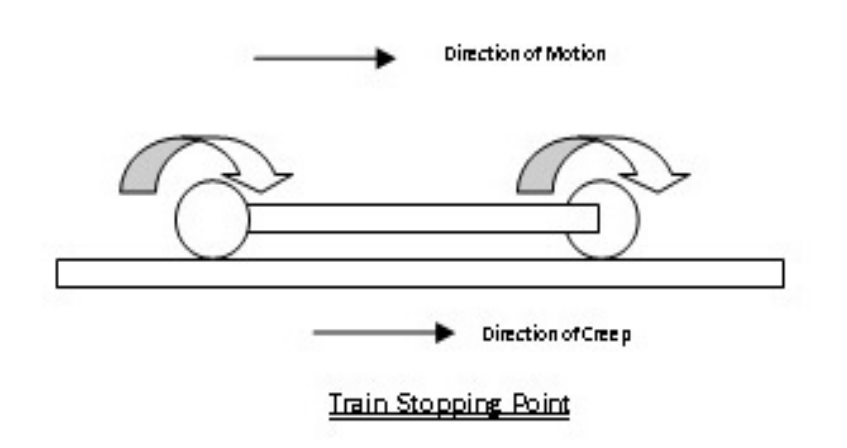
Causes of creep

- Changes in temperature
- Unbalanced traffic
- Alignment of track
- Grade of track
- Type of rail
- Poor maintenance of track components

BRAKES

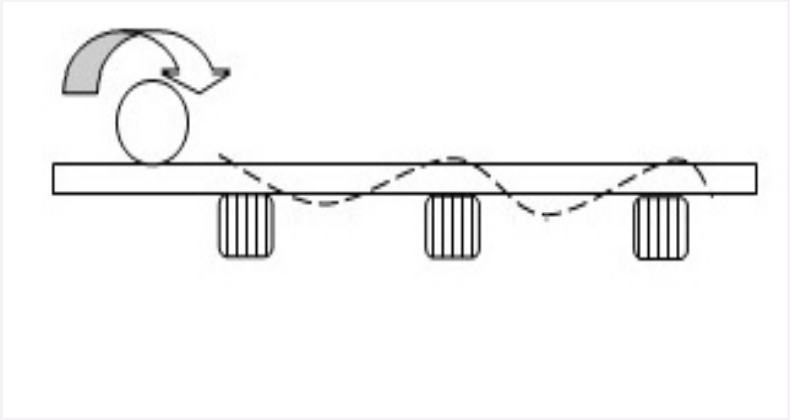
- Starting, accelerating, slowing down or stopping a train
- During starting – wheels push the rails backward
- During stopping – wheels push the rails forward
- When train is slowing down or decelerating – the braking effect tends to push the rail forward





WAVE ACTION OR WAVE THEORY

- Creep is developed due to wave motion of wheels on rails
- Due to movement of wheel loads on rails, the rail deflects as a continuous beam and crests are formed near supports
- When wheels of train strike against these crests, creep is developed
- The wheels push the wave with a tendency to force the rail in the direction of traffic

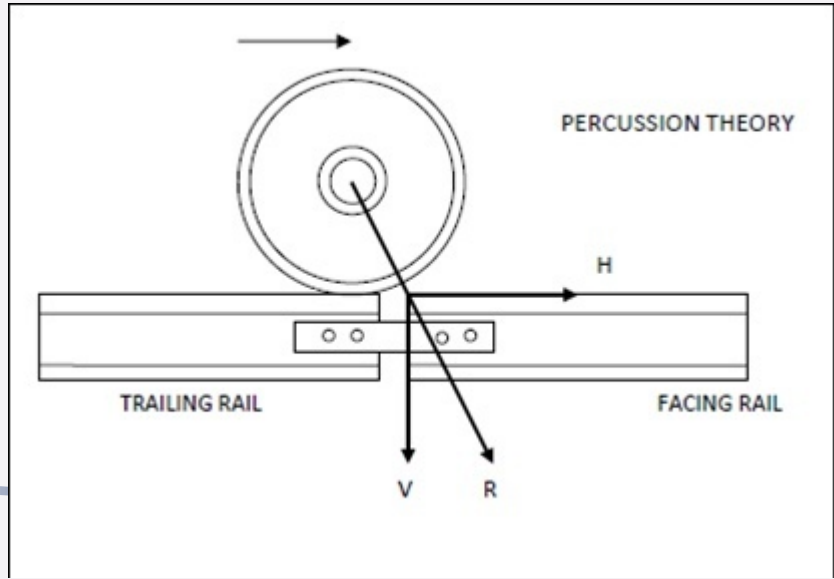


WAVE ACTION OR WAVE THEORY

- Pitch and depth of wave depends on
  - Track modulus
  - Stiffness of track
  - Stability of formulation
- Wave action can be reduced by
  - Angular and heavy ballast which develops good interlock
  - Increased stiffness of track
  - Lesser sleeper spacing
  - Bigger section of rail

PERCUSSION THEORY

- Creep is due to impact of wheels at the rail end ahead at joints
- Reaction R is normal to the surface of contact
- Horizontal component H causes creep
- Vertical component V tends to bend the rail vertically – results battering of rail end



Engineering survey through modern methods

- Planning needs precious and cost effective methods of surveying. Innovative techniques like remote sensing and advancement in hardware and software technology had led to sophisticated and scientific methods.
- Remote sensing data products such as aerial photos and high resolution satellite imageries, modern surveying equipment/systems such as Electronic Distance Meter (EDM)
- Total Station
- Global positioning System (GPS)
- Geographical Information System (GIS)

GPS

- This instrument measures any point any where on the globe. This system uses a set of satellites at a distance of about 10000 km above earth.
- All weather and day and night surveying is possible with the instrument. It is capable if measuring distances even up to thousands of kilometres.

EDM

- Works on the principle of time taken for electromagnetic waves to travel between the given origin and destination.
- Typical EDM equipment can measure a distance up to 5 - 10 km with an accuracy of one to two cm.

Geometric Design of Track

- Geometric design should be such as to provide maximum efficiency in the traffic operation with maximum safety at reasonable cost.

Gradient :

- It is the rate of rise or fall of the track. Expressed in V:H

Purpose of providing gradient:

- To provide uniform rate of rise or fall,
- To reduce cost of earth work,
- To reach different stations at different level.

Types of Gradient

1)Ruling gradient: The steepest gradient allowed on the track section. It determines the max load that the locomotive can haul that section. The steep gradient needs more powerful locomotives, smaller train loads, lower speed, resulting in costly hauling.

- -In plains: 1 in 150 to 1 in 200
- -In hilly regions: 1 in 100 to 1 in 150

2) Momentum Gradient: The gradient on a section which are steeper than the ruling gradient acquire sufficient momentum to negotiate them are known as momentum gradient.

3) Pusher gradient: A ruling gradient limits the maximum weight of a train which can be hauled over the section by a locomotive. If the ruling gradient is so severe on a section that, it needs the help of **extra engine** to pull the same load then this gradient is known as pusher or helper gradient.

- In Darjeeling Railways 1 in 37 pusher gradient is used on Western Ghats BG Track.

4) Gradient at stations: At stations gradient are provided sufficient low due to following reason:

- -To prevent movement of standing vehicle
- -To prevent additional resistance due to grade.
- On Indian railways, maximum gradient permitted is 1 in 400 in station yards & min is 1 in 1000 for easy drainage of rain water.

Super elevation on Curves (Cant)

- Cant is defined as the difference in height between the inner and outer rails on the curve. It is provided by gradually raising the outer rail above the inner rail level. The inner rail is considered as the reference rail and normally is maintained at its original level. The inner rail is known as the gradient rail.

Function of super elevation:

- Neutralizes the effect of lateral force.
- It provides better load distribution on the two rails.
- It reduces wear and tear of rails and rolling stock.
- It provides smooth running of trains and comforts to the passengers.

Widening of Gauge on Curves

- Due to rigidity of the wheel base, when the outer wheel of the front axle strikes against the outer rail, the outer wheel of the rear axle cheers a gap with the outer rail.
- This can be accounted by widening the gauge failing which there is every possibility of tilting of rail outwards on curves.
- Extra width of gauge d, in cm,

- $d = 13(B+L)^2 / R$
- B = rigid wheel base in m
- B=6 → B.G, B=4.88 m → M.G
- R = radius of the curve in m
- L = lap flange, $L = 0.02 \sqrt{(h^2 + Dh)}$

Points and Crossings

1st time on Indian Railways

1st time on SCR

1 in 4 ¼ 'X' OVER AT KZJ yard

1 in 4 ¼ 'X' OVER AT KZJ yard

1 in 4 ¼ 'X' OVER AT KZJ yard

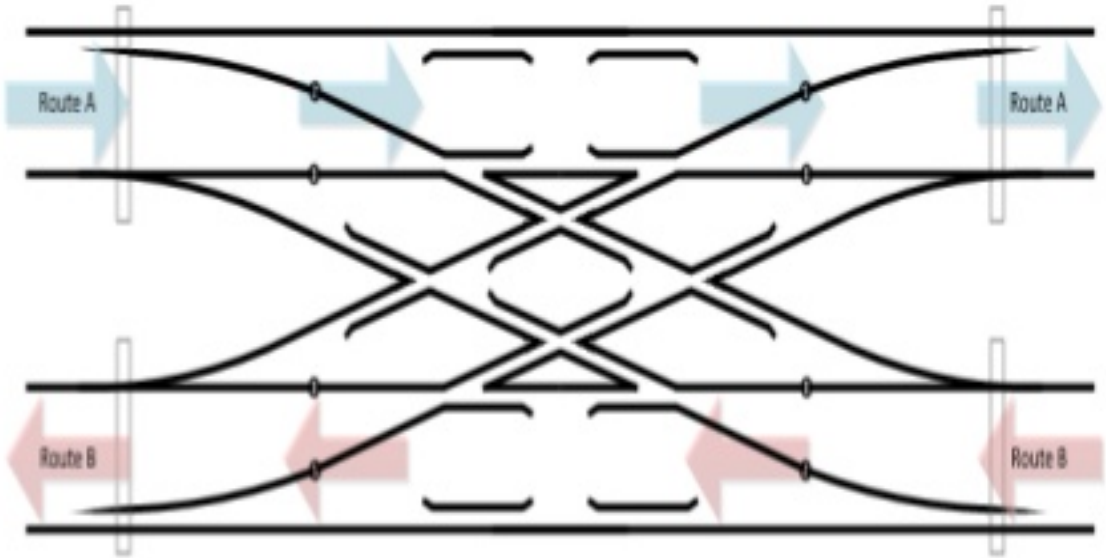
1 in 8 ½ SINGLE SLIP AT KZJ with Malaysian Balu Sleepers

Crossings - Types

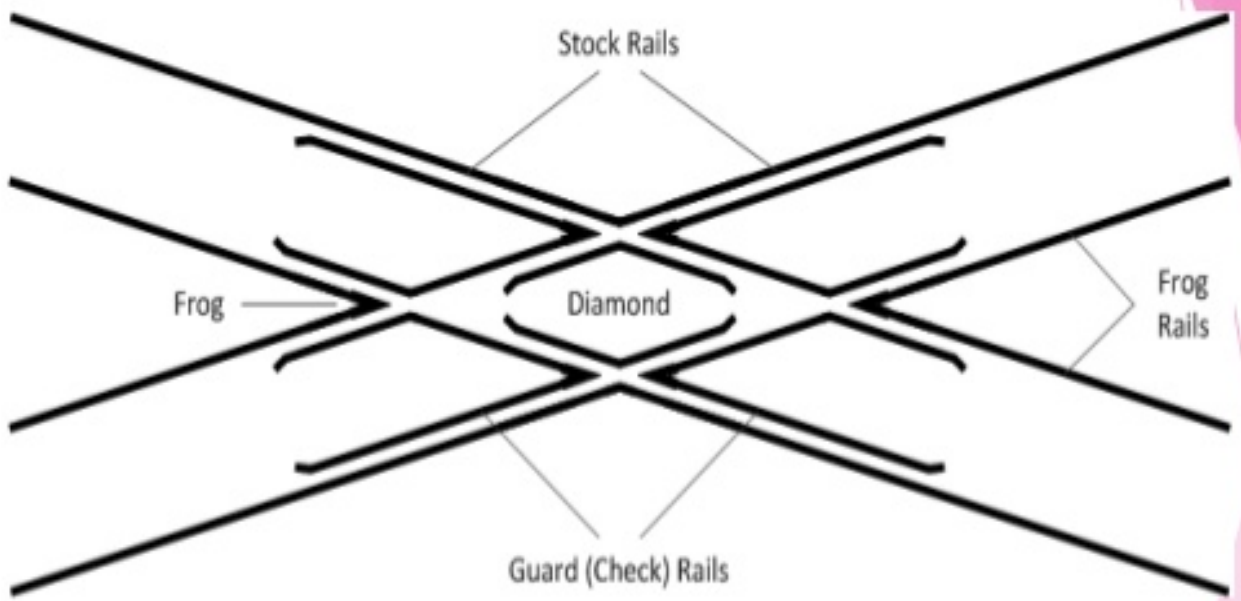
- Cast steel crossing:
  - One piece crossing with no bolts and require little maintenance.
  - More rigid as it is one single piece.
  - High initial cost
  - High maintenance cost
  - Replaced by Cast Manganese Steel crossings these days
- Combined rail and cast crossing
  - Combination of built up and cast steel crossing
  - Consists of a cast steel nose finished to ordinary rail faces

Diamond Crossing

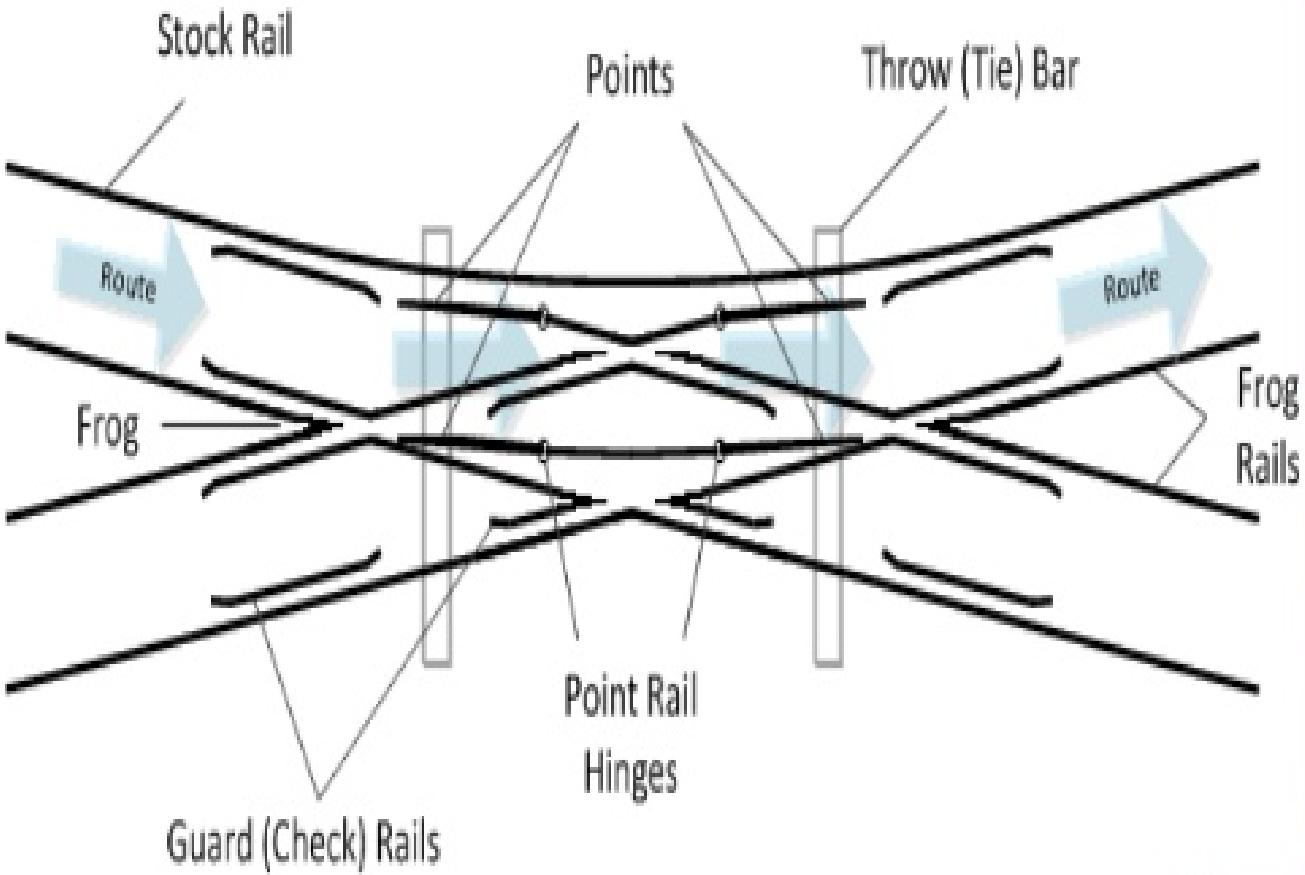
When two tracks crosses each other at less than 90 angle then it forms diamond shape so it is called Diamond Crossing



Double cross



Diamond Crossing



Diamond Crossing

UNIT II

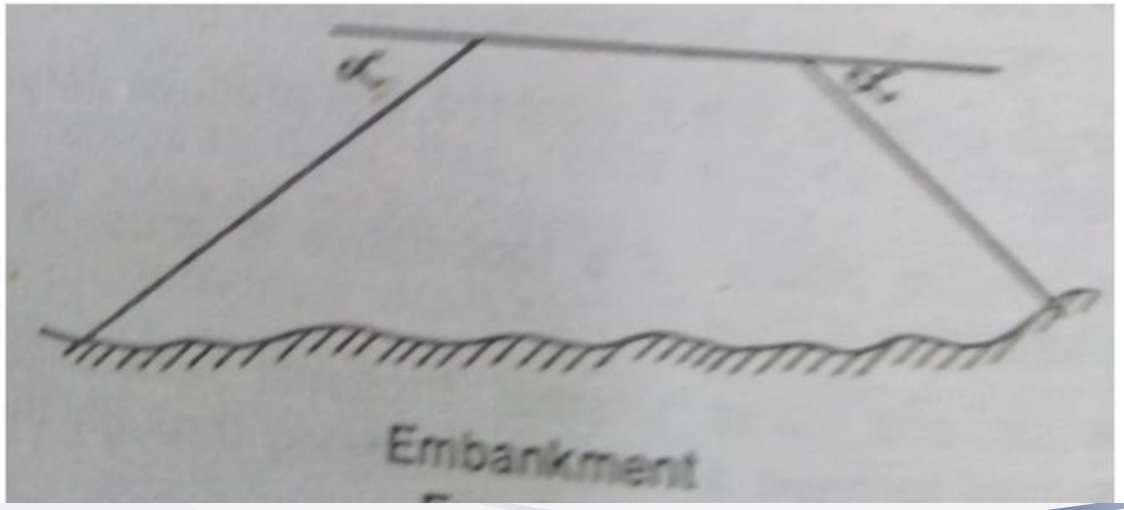
RAILWAY CONSTRUCTION AND MAINTENANCE

T-28 IN OPERATION

EARTHWORK

Usual forms of cross-sections:

- *The naturally occurring soil is known as the subgrade and when it is prepared to receive the ballast and track, it is called the **formation**.*
- *When the formation is raised on bank of earth, it is called an **embankment**.*



2


Soil stabilisation cement-GLORIT Step 2

Stabilization of track on poor soil:

Following are four usual methods of stabilization of track on poor soil:

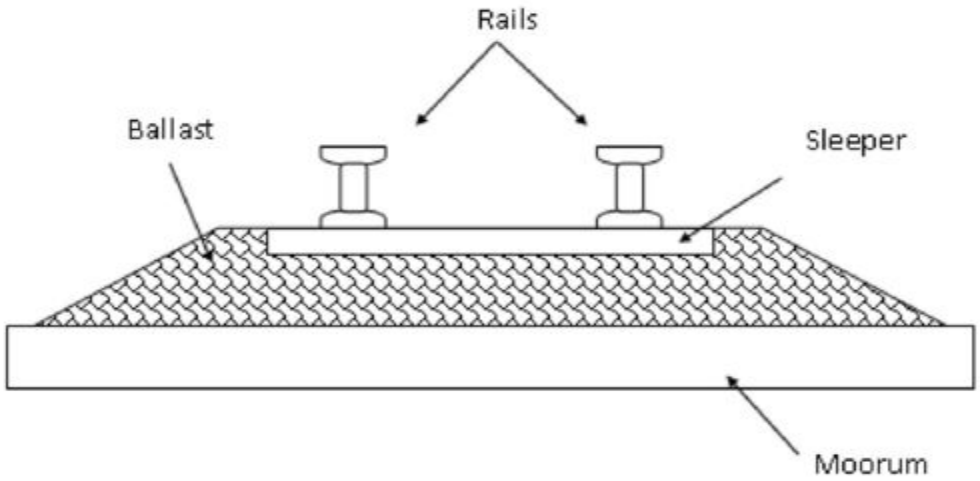
i. **Layer of moorum**

ii. **Cement grouting**

iii. **Sand piles**

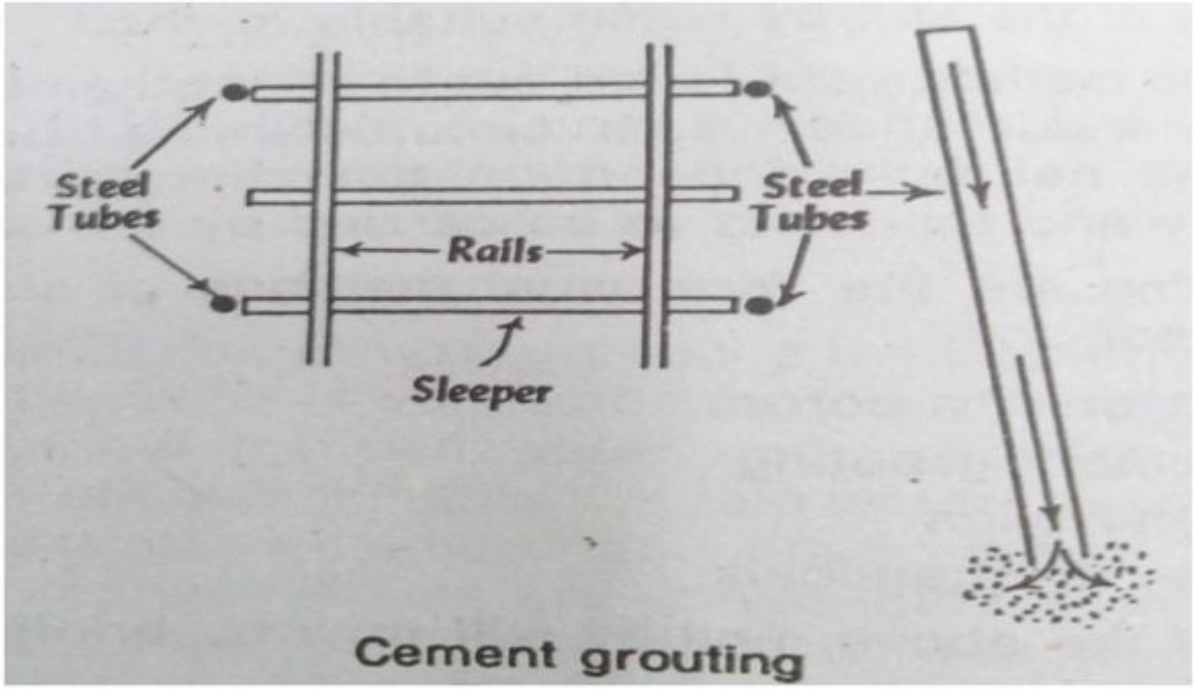
iv. **Use of chemicals**

- ***Layer Of Moorum:***
- *In very poor soil such as black cotton soil which swells and shrinks considerably by contact with moisture and by the loss of moisture to the extent of 20% to 30% of its volume, a layer of moorum is provided under the ballast, as shown:*



ii. Cement Grouting:

- *In this method, the steel tubes about 30 mm diameter are driven into the formation at every alternate sleeper.*
- *They are driven near the ends of the sleepers as shown:*



Cement grouting

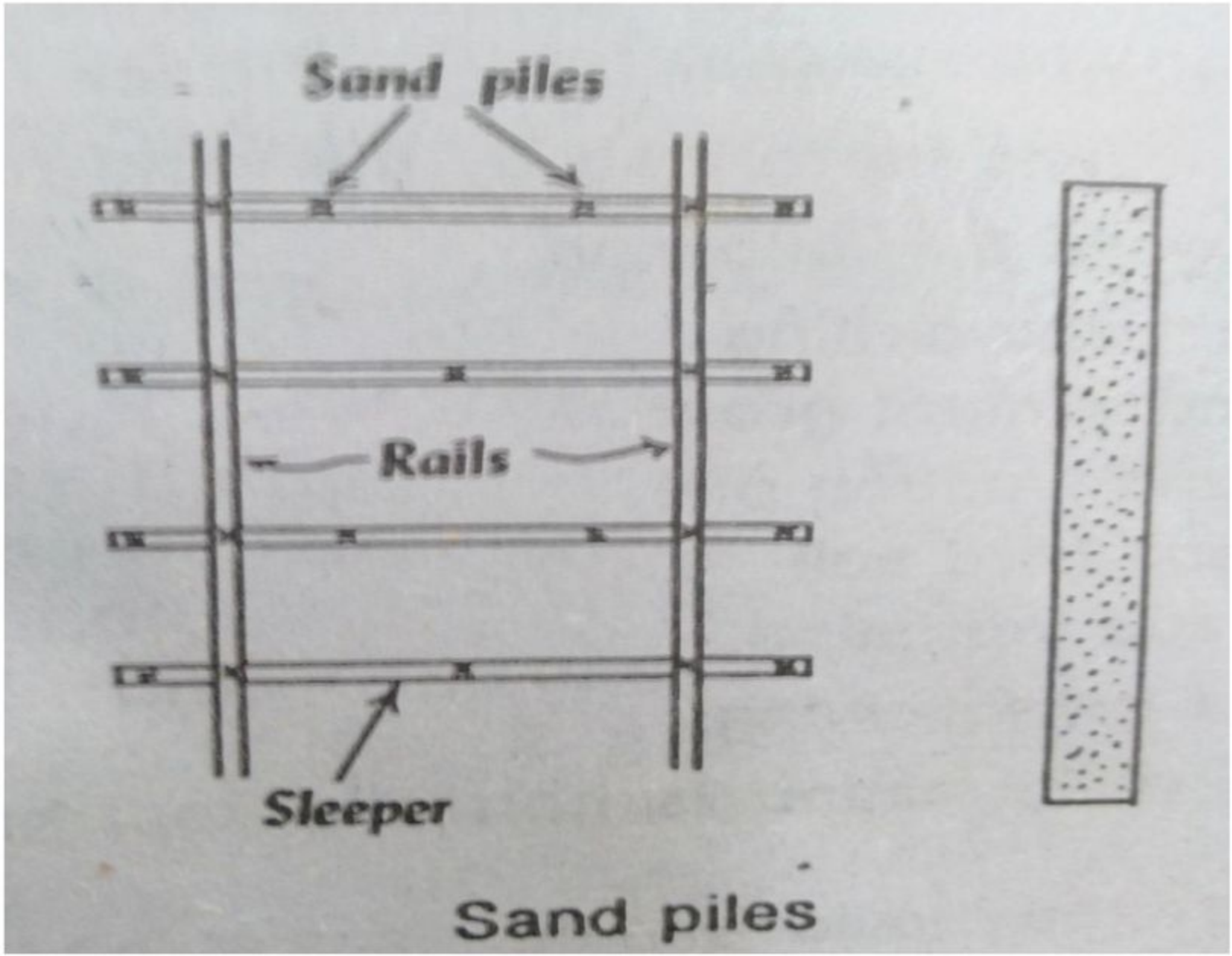
iii. Sand Piles:

- *In this method, a vertical bore of about 300 mm diameter is made in the ground by driving wooden pile;*
- *The wooden pile is then withdrawn and the space is filled with sand and is well-rammed;*
- *The functions performed by the sand piles are as follows:*

a. *They can function as timber piles.*

b. *They provide an arrangement of vertical drainage.*

c. *They provide good mechanical support.*


Sand piles
Rails
Sleeper
Sand piles

iv. Use Of Chemicals:

- *In this method, the chemicals are used in place of cement grout to consolidate the soil;*
- *The silicate of soda followed by calcium chlori is effective for sandy soils containing less than 25% clay and silt.*

Track Drainage:-

Drainage of a track, Station Yards and platforms are the three places Where Drainage arrangements are needed. Track Drainage Comprises of Interception, Collection and disposal of from the track. This is done by adopting proper Surface and Subsurface Drainage System

Types of track Drainage

Surface Drainage

Surface Water due to rain or Snow or Flow From Adjacent areas have to be Disposed of Through Surface Drainage. Surface Drainage has to be attended to in three locations. Drainage in mid- Section Between railway Stations

1.Drainage in mid-section

2.Drainage in Station Yards

3.Drainage at Station Platforms

Tunnelling Methods

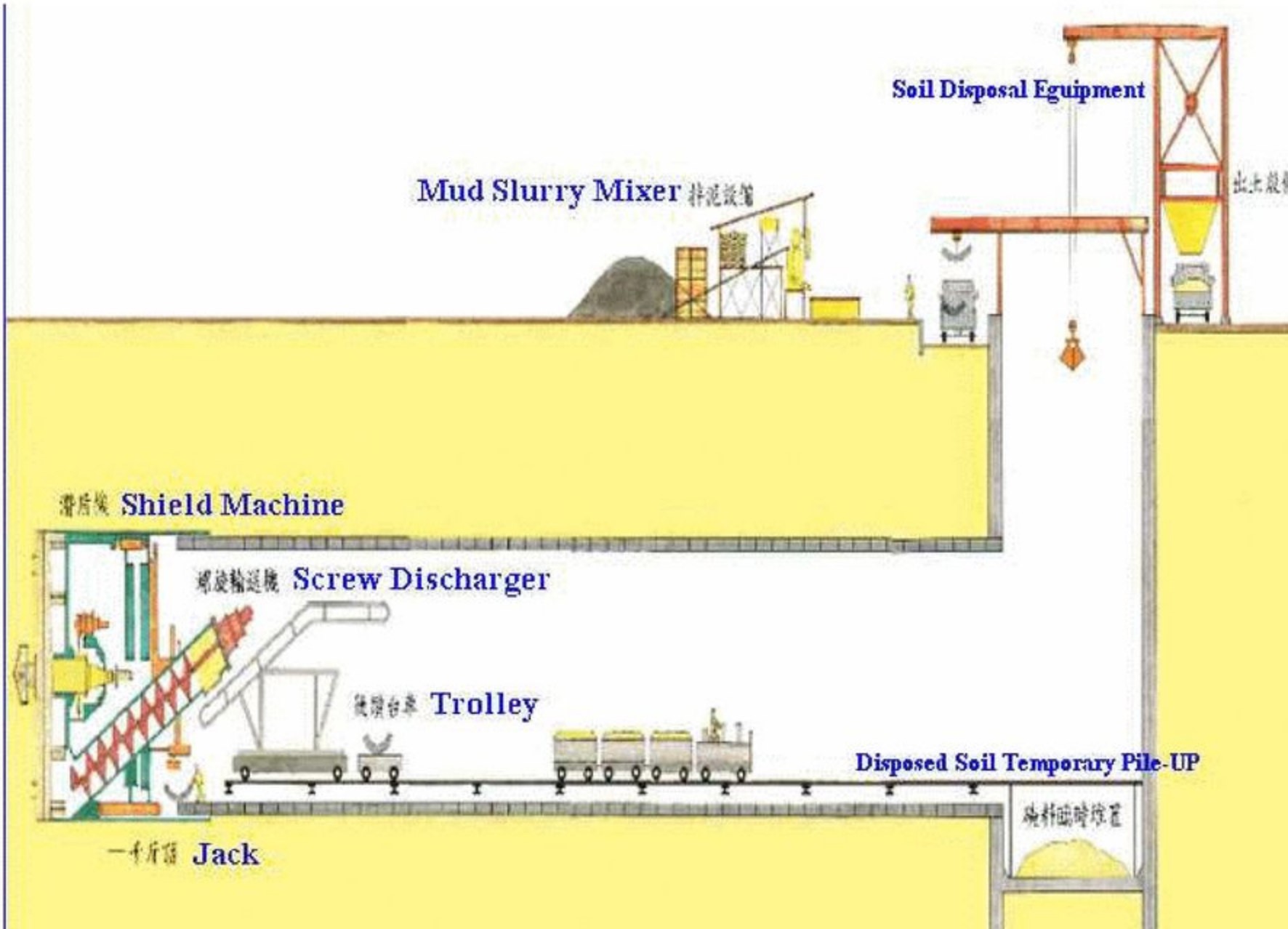
TUNNEL DESCRIPTION

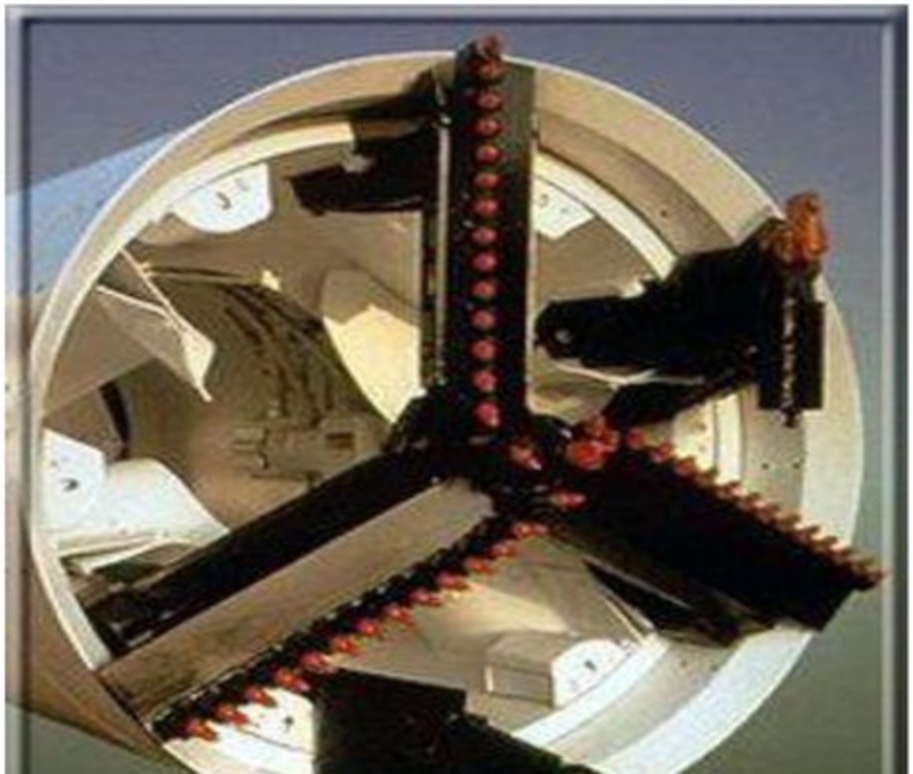
- A tunnel can be defined as an underground passage for the transport of passengers, goods, water, sewage, oil, gas, etc. The construction of a tunnel is normally carried out without causing much disturbance to the ground surface. Made into natural material (rocks)

1. Empty inside
2. Carry the loads itself
3. Both ends are open to atmosphere
4. Generally horizontal
5. Thick walled structure looks like cylinder

TUNNEL CONSTRUCTION METHODS:

- Classical methods
- Mechanical drilling/cutting
- Cut-and-cover
- Drill and blast


Soil Disposal Eguipment
Mud Slurry Mixer
Shield Machine
Screw Discharger
Trolley
Disposed Soil Temporary Pile-UP
Jack



Cut and Cover Method

Ventilation of Tunnels

A tunnel should be properly ventilated during as well as after the construction for the reasons.

(a) To provide fresh air to the workers during construction.

(b) To remove the dust created by drilling, blasting, and other tunnelling operations.

(c) To remove dynamite fumes and other objectionable gases produced by the use of dynamites and explosives.

Methods of Ventilation

- Natural method of ventilation
- Mechanical ventilation by blow-in method
- Mechanical ventilation by exhaust method
- Combination of blow-in and blow-out methods

Drainage of Tunnels

- The sources of water for this purpose include ground water and water collected from the washing of bore holes.

- Water seeping in up through the ground as well as from the washing of bore holes is collected in sump wells and pumped out. If the tunnel is long, a number of sump wells are provided for the collection of water.

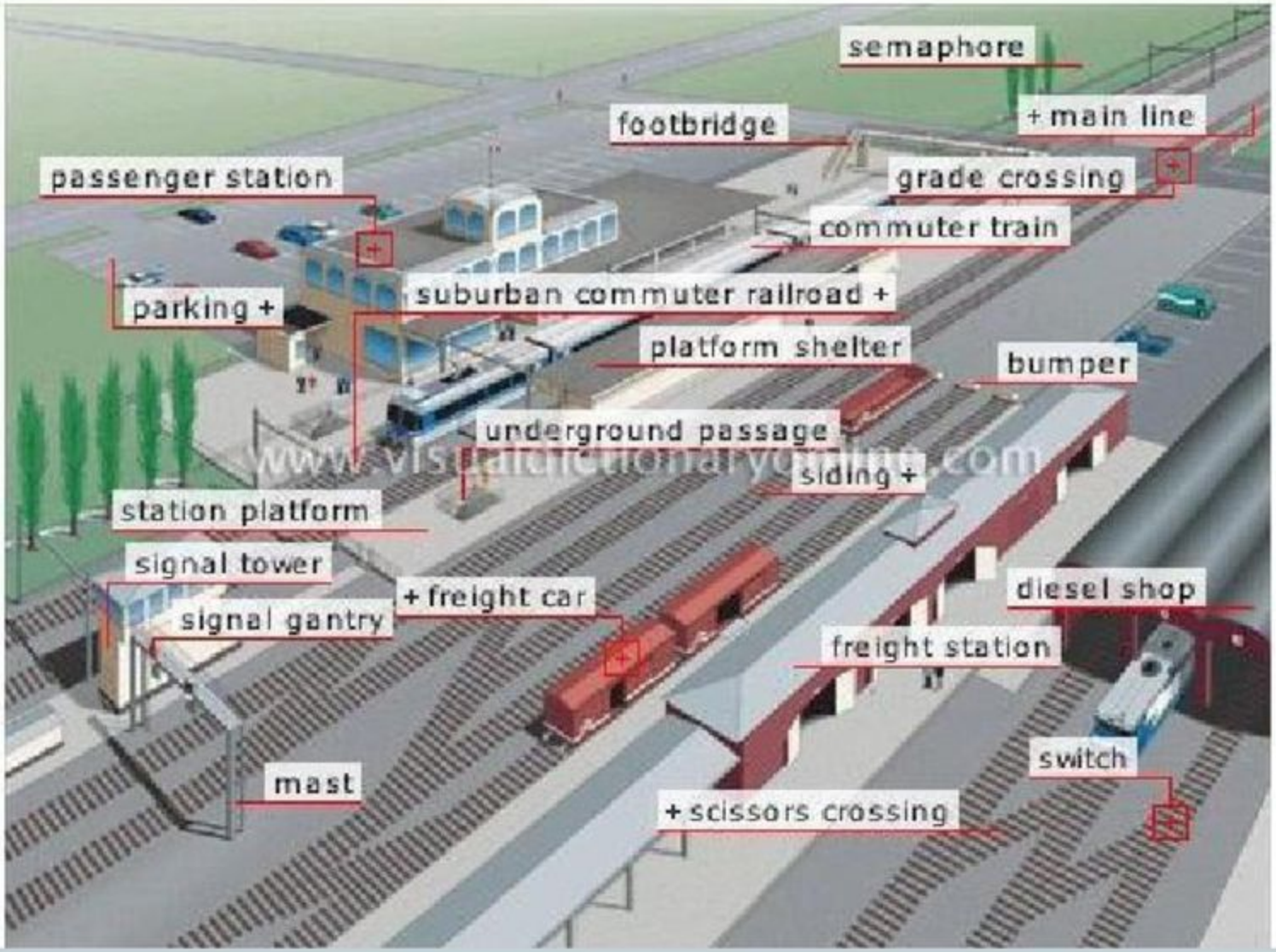
- After the construction is over, drainage ditches are provided along the length of the portion of the tunnel that slop from the portal towards the sump well and are used for pumping the water out.

Station and Yards

Definition of Station

- A railway station or a railroad station and often shortened to just station, is a railway facility where trains regularly stop to load or unload passengers and/or freight

Station and Yards



Types of Stations

- Wayside Stations, Junction Stations, Terminal Stations

Wayside Stations

In this type arrangements are made for crossing or for overtaking trains.

Wayside stations are of the following types.

i.Halt stations,

ii.Flag Stations,

iii.Crossing stations

Halt Stations

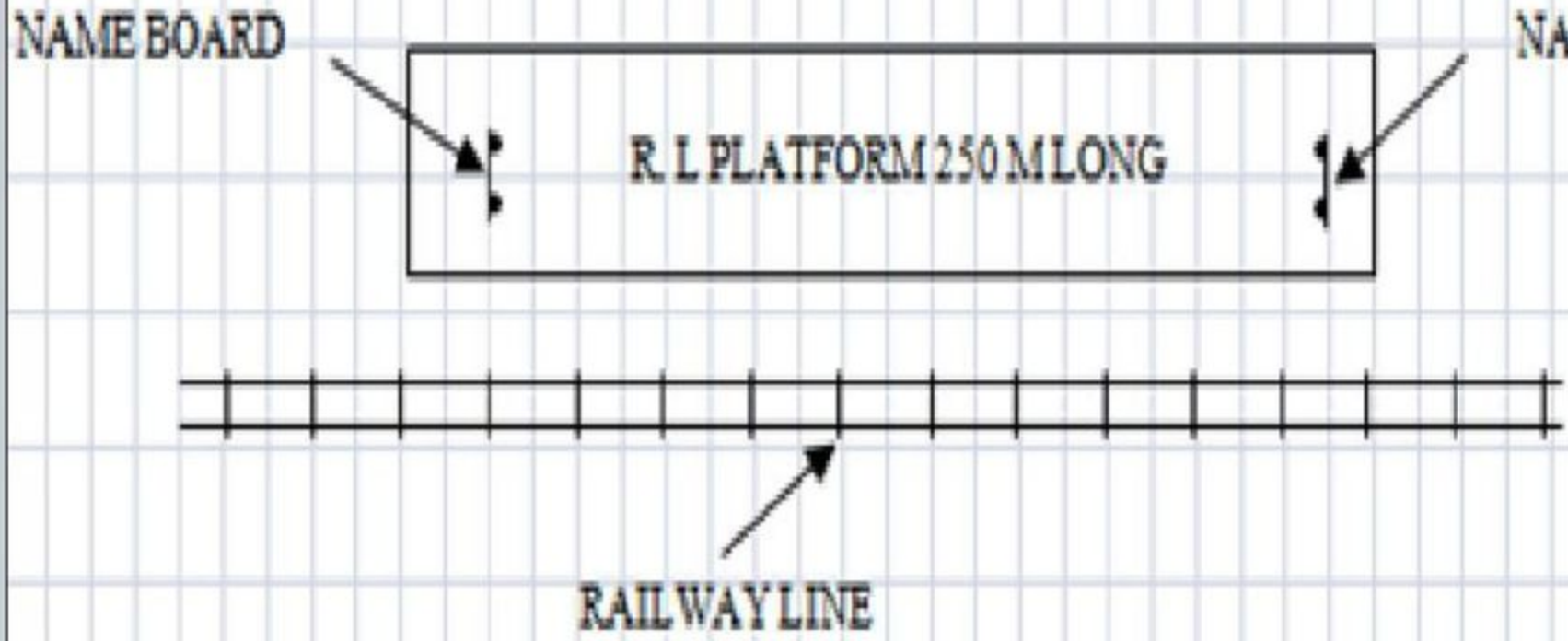


Fig : LAYOUT OF HALT STATION

Flag Stations

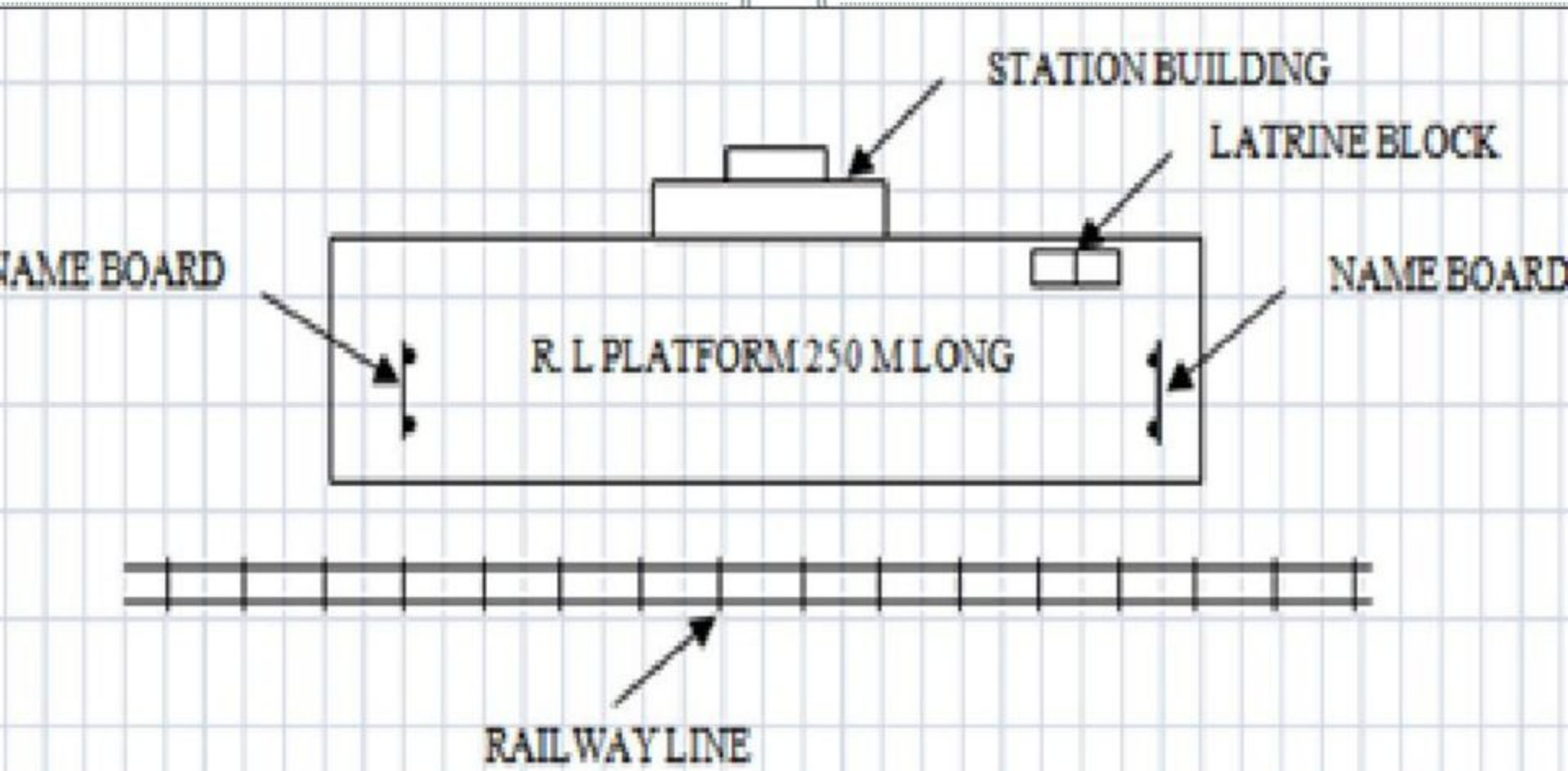


Fig : LAYOUT OF FLAG STATION

Crossing Stations

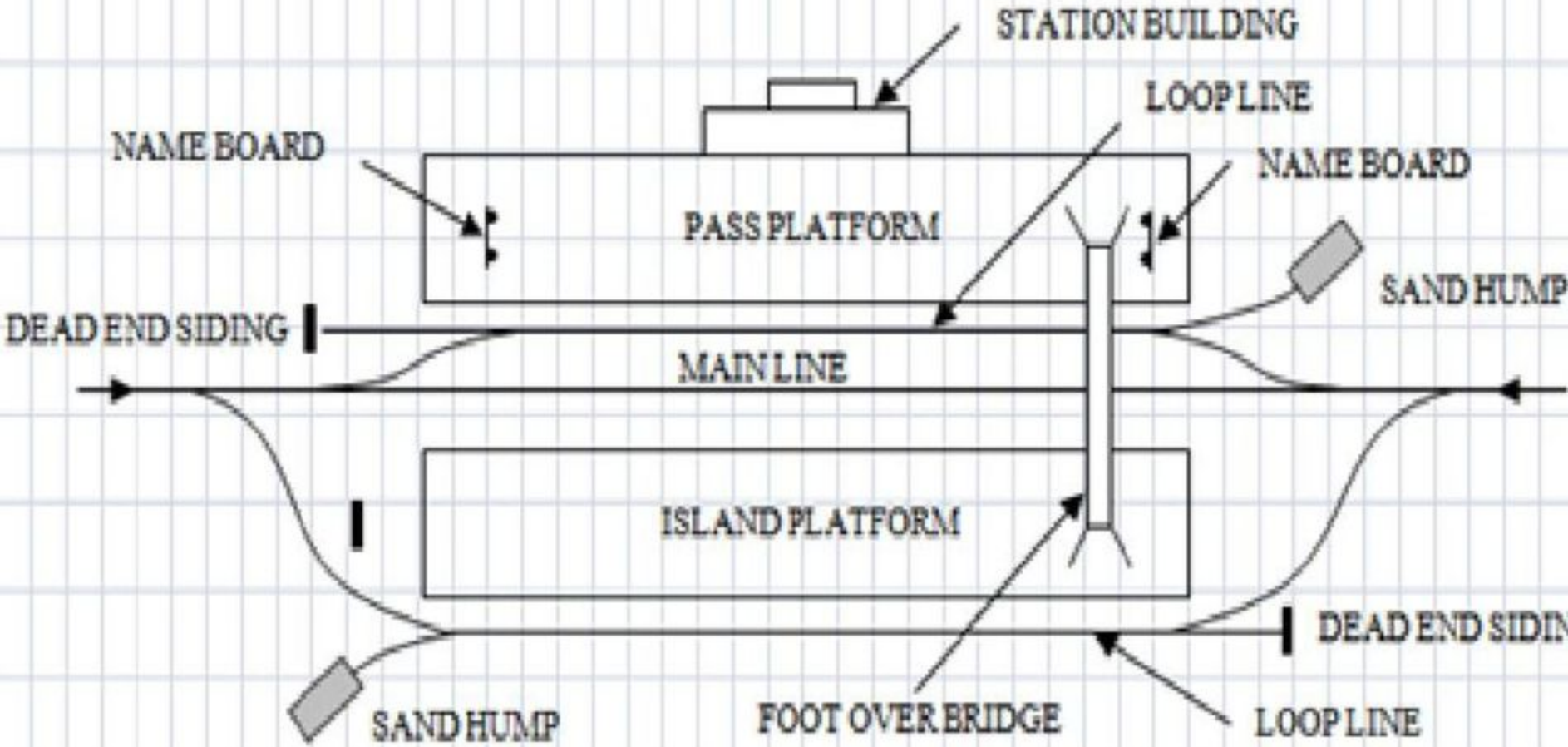


Fig : LAYOUT OF ROAD SIDE OR CROSSING STATION

Junction stations:

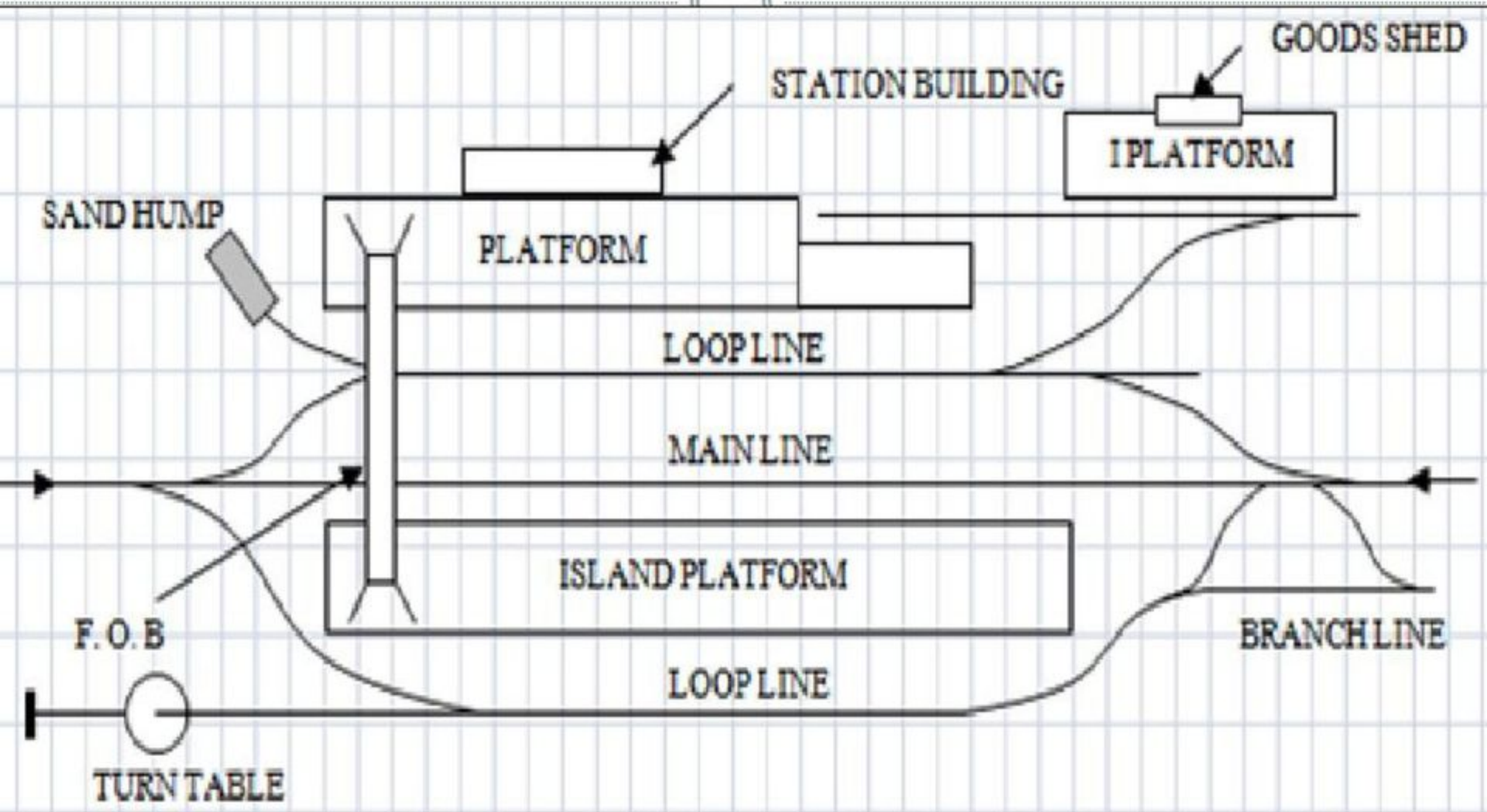


Fig : LAYOUT OF JUNCTION STATION

Railway Yard

Types of Yards:

- Passenger yards,
- Goods yards,
- Marshalling yards,
- Locomotive yards

Goods yards

PLATFORMS

- Generally two types of platforms
- Passenger Platforms
- Goods platforms
- **Passenger Platforms**

➢ Minimum length = 61m

➢ Minimum width 3.6m

➢ Depends on longer train used the minimum length may be 183m

Passenger Platform

Track laying or plate laying

- Plate laying includes laying of rails, sleepers and fastenings. Normally three methods are adopted for plate laying.

- **Methods of plate laying**
- Tram line method
- American method
- Telescopic method

Track maintenance

- **Necessity of track maintenance.**
- The railway track should be maintained properly in order enable trains to run safely at the highest permissible speeds a to provide passengers a reasonable level of comfort during t ride. Track maintenance becomes a necessity due to followi reasons.
    - Due to the constant movement of heavy and high-spe trains, the packing under the sleepers becomes loose a track geometry gets disturbed.
    - Due to the vibrations and impact of high-speed trains, t fittings of the track come heavy wear and tear of t track and its components.
    - The track and its components get worn out as a result the weathering effect of rain, sun, and sand.

- Railway tracks can be maintained either conventionally by manual labour or by the application of modern methods of track maintenance such as mechanical tamping or measured shovel packing.

Conventional methods:

- As per the timetable or calendar, the 12-month cycle of maintenance consists of the following operations.
- (a) Through packing
- (b) Systematic overhauling
- (c) Picking up slacks

Rapid Transport System:

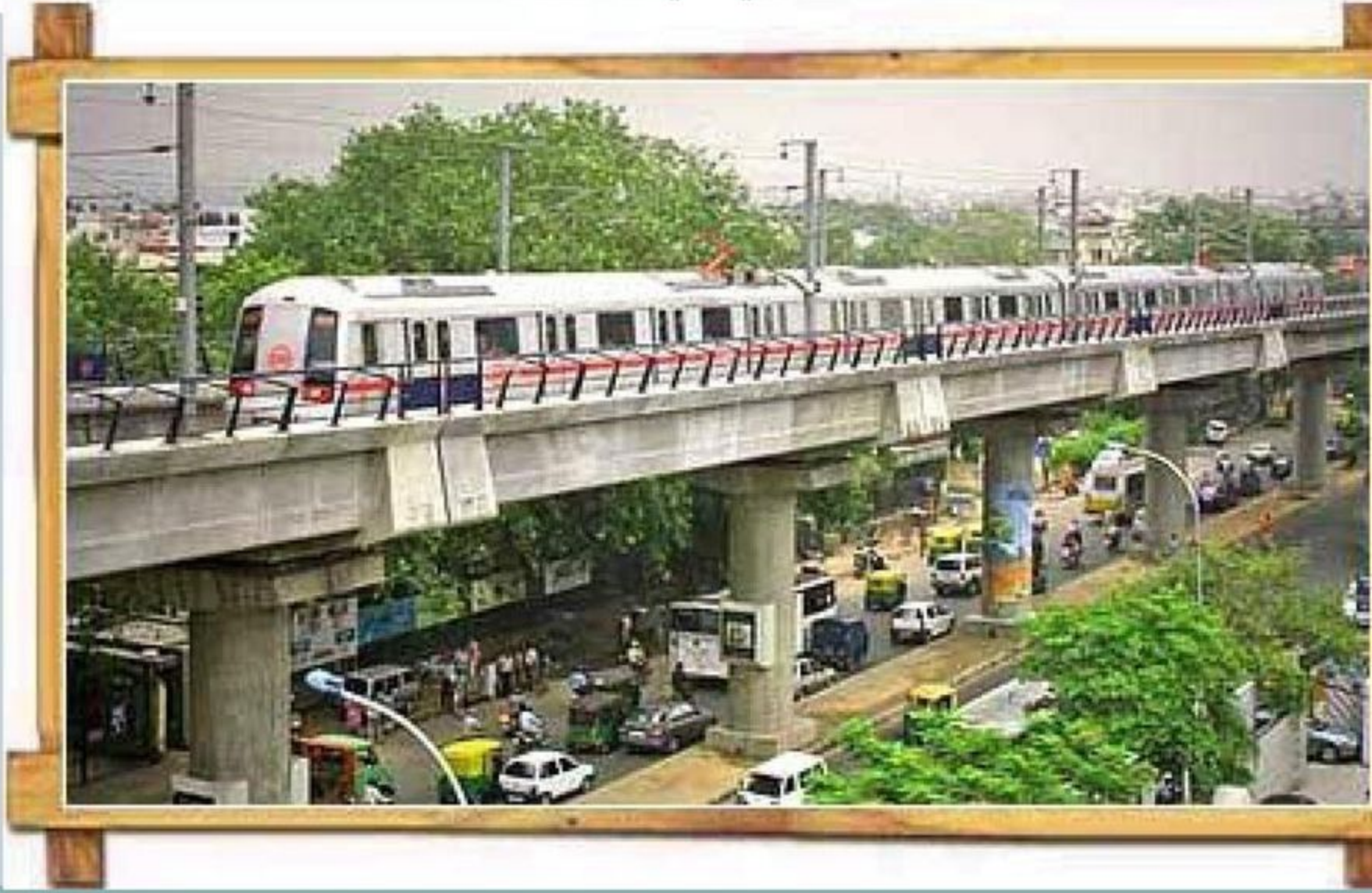
General

- **Rapid transport** is a type of high-capacity public transport generally found in urban areas.
- Unlike buses and trains, rapid transport systems operate on an exclusive right-of-way which is usually grade separated in tunnels or elevated railways.
- *Metro* is the most common term for underground rapid transport systems
- Rapid transport is used in cities, agglomerations, and metropolitan areas to transport large numbers of people often short distances at high frequency. The extent of the rapid transport system varies greatly between cities, with several transport strategies

Elevated railways

Mono Rail

Metro Rail in Chennai



Under ground railways:

- The railways provided just below ground level are called –low level or underground railways‖.
- In this system of Railways, *tunnels* are constructed for carrying tracks through them and a over - bridge is necessary at every road crossing to carry the road traffic over the railway traffic.
- Due to ventilation problems in tunnels, *electricity* is the only source of power for traction in under ground railways.

Under ground railways:

Advantages :

- This system provides rapid and unobstructed transportation.
- This system helps in reducing traffic congestion problems.
- This system provides safety during aerial attack in war.

Suitability :

- Underground railways are suitable in the heavily congested urban areas where the traffic intensity on roads is heavy.

Under ground railways

Tube railways :

- The railway provided underground at a greater depth of about 18 m or more (up to 52 m) are called tube railways.
- This system of railways is so called as the section of the underground tunnels, carrying the track, is to avoid the interference of the tracks with *water* and *gas pipes*, *sewerage systems* and *oil* or *drainage pipes*, etc
- An electrically powered railroad with tracks runnin through a tunnel underground; a subway.

Tube railways :

METHODS OF LAYING

- **IN-SITU LAYING** – In openline, construction ar Yard Remodelling (sometimes)

- **Assembly – Shifting – Laying**
  - Complete Renewal/Laying : Mechanised
  - Renewal/Laying by Parts : Either Manual or Mechanised
  - Prefabrication in Depot – Assembly can be done using road crane.

UNIT III

AIRPORT PLANNING


Planning and Design of Airports
Harshit P Jain
1RV13CV048

Introduction

Planning and Design is a part of **Airport Engineering** involving Construction of terminals, Runways, and Navigation Aids.

- Landside
  - Parking Lots
  - Public Transportation
  - Access Way to Roads
- Airside
  - Runways
  - Taxiways
  - Aprons

Airport Authority of India (AAI)

Airport Authority of India (AAI) was formed in 1994 by merging **International Airport Authority of India (IAAI)** and **National Airports Authority (NAA)**.

Functions:

- Control and management of the Indian airspace extending beyond the territory limits
- Design, development and operation of domestic and international airports
- Construction and management of facilities
- Development of cargo ports and facilities
- Provision of passenger facilities and information systems
- Expansion and strengthening of operating area
- Provision of visual aids
- Provision of communication and navigational aids (ex: Radar systems)

Influencing characteristics of aircraft on design of airport

- Engine type and propulsion
- Size
- Aircraft weight and wheel configuration
- Minimum turning radius
- Minimum circling radius
- Speed capacity
- Noise
- Vortices at tail ends
- Jet blast
- Fuel spillage

Engine type and propulsion

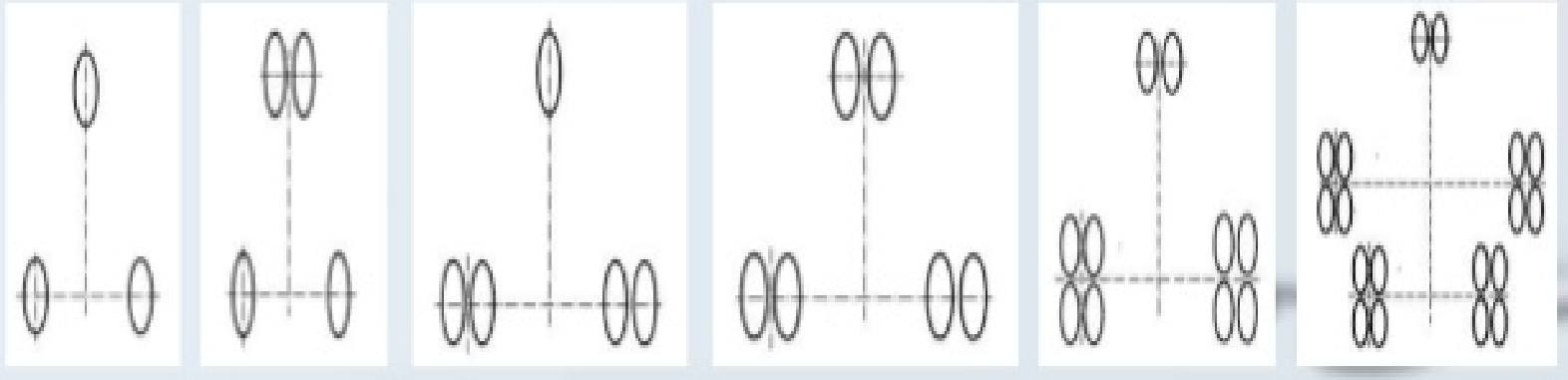
- length of the runway
- Weight
- Carrying capacity
- Noise
- Circling radius
- Range
- Maintenance facilities
- Ballast pads

Size of Aircraft

- Load carrying capacity
- Facilities like apron, terminal area etc.
- Wing span :
  - Taxiway width
  - Separation between traffic lanes
  - Size of gate, apron size, width of hanger etc.
- Length :
  - Taxiway on curves, apron, hangers, width of exit way
- Height : Hanger gate
- Wheel base, gear tread also changes

Aircraft Wheel Configuration

- Thickness of runway, taxiway, apron
- Distribution of load to ground
- Turning (difficult for more weight in case of sharp curves)
- Stability (depends on the support system provided and also depends on wheel configuration)



Speed

- Reduces journey time
- Increase in frequency of operations
- Improving and broadening the air network system

Capacity

- Processing terminals
- Passenger and baggage handling facilities
- Cargo processing
- Size of apron, special equipments etc.

Selection Of Site For Airport

- ✓ Air traffic potential
- ✓ Adequate access
- ✓ Sufficient airspace
- ✓ Sufficient land
- ✓ Atmospheric and meteorological conditions
- ✓ Availability of land for expansion
- ✓ Availability of utilities
- ✓ Development of surrounding area
- ✓ Ground accessibility
- ✓ Presence of other airports
- ✓ Regional plan
- ✓ Soil characteristics
- ✓ Surrounding obstructions
- ✓ Use of Air Port

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- ✓ Presence of other airports
- ✓ Regional plan
- ✓ Soil characteristics
- ✓ Surrounding obstructions
- ✓ Use of Air Port

Size of Airport

- ✓ Defined by the space for operators, controlling systems, facilities, manpower etc.
- ✓ Controlled by peak aircraft traffic, aircraft characteristics
- ✓ Elevation of airport size above MSL
  - density and air pressure reduces
  - Effects runway requirements, lift, drag etc.
  - Aircraft performance varies altitude, air density, pressure , temperature
- ✓ Meteorological conditions
  - Wind, temperature
  - Effects runway orientation, length and no of runways required
- ✓ Performance characteristics of aircraft
- ✓ Volume of air traffic (peak hour volume, size of aircraft, nature of air traffic, runways, taxiways etc.,)

Visual Aids

Airport Markings

- Apron marking
- Landing direction indicator
- Runway marking
- Shoulder marking
- Taxiway marking
- Wind direction indicator

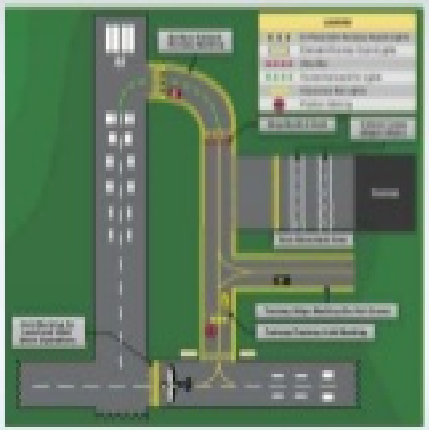
Airport Lighting

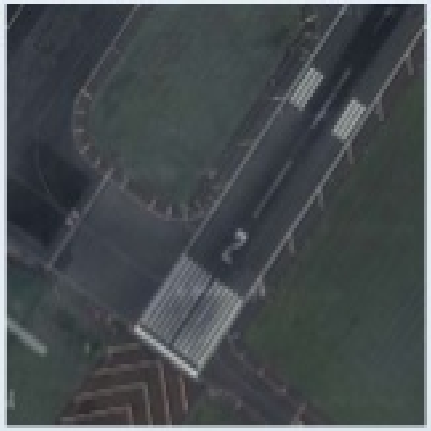
- Runway Edge Lighting
- Approach Lighting System
- Pilot Controlled Lighting

Signage

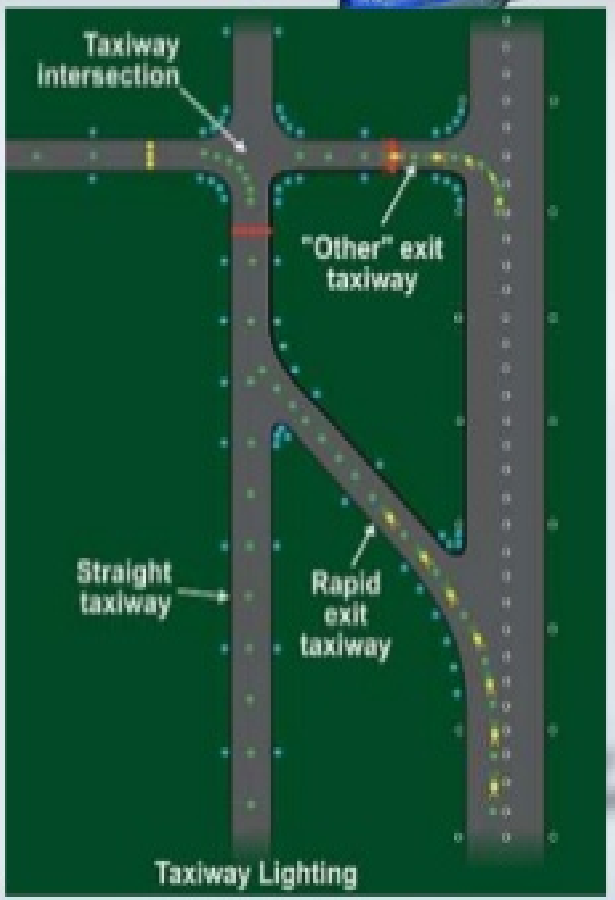
- Mandatory Instruction Signs
- Location Signs
- Direction Signs
- Destination Signs
- Information Signs
- Aircraft Arresting Systems

Visual Aids






28


Taxiway intersection
"Other" exit taxiway
Straight taxiway
Rapid exit taxiway
Taxiway Lighting

Major Problems faced during Design of Airport

- Requires heavy funds during provision and maintenance
- Highly dependent on weather conditions compared to other modes
- Requires highly sophisticated machinery
- Adds to outward flow of foreign exchange
- Purchase of equipment, airbuses etc.
- Safety provisions are not adequate
- Providing a support system during the flight is complicate
- Specific demarcation of flight paths and territories is essential

HARBOUR ENGINEERING

CONTENTS

- Introduction
- Water Transportation
- Harbours
- Classification of Harbours
- Accessibility
- Size of Harbours
- Site Selection
- Shape of Harbour
- Harbour Depth
- Marine Surveys
- Harbour Planning
- Features of a Harbour
- Defects in Harbours
- Requirements of a Good Harbour

INTRODUCTION

- Importance of waterways
  - Comparison with railways and roadways
- Need for a place of approach

WATER TRANSPORTATION

- Importance
- Types
  - Inland water transportation
    - River or canal
  - Ocean water transportation
    - Adopted for trade and commerce
    - 75 % of Indian trade
    - No limitations and high flexibility

Water Transportation contd...

- Advantages
  - Provides means of defence.
  - Cheapest mode
  - Leads to overall development of commerce, industry and international trade.
  - High load carrying capacity.
  - Encourages consumption of foreign goods.
  - Requires cheap motive power for its working.
  - Brought countries separated by oceans very near.

Water Transportation contd...

- Disadvantages
  - Slow in operation, consumes more time
  - Useful only when water is available as mode of transport
  - May lead to accident In case of frequent ocean storms
  - More chances of attack by other countries
  - The fluctuations in water level causes rubbing of ships against the berths
  - Mountainous rivers, waterfalls e.t.c. hinder water transportation

HARBOUR

- Sheltered area
- For loading and unloading of cargo
- Vessels are also built, repair, and launch

"A harbour can be defined as a basin or haven or road-stead of navigable waters well protected naturally or artificially from action of wind and waves , and is situated along sea-shore, river estuary, lake or canal connected to sea"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Harbour contd...

- Basin
  - water reservoir of required area
  - Navigable when depth of water in the basin is greater than draft required for largest ship likely to visit the harbour.
- Draft
  - Vertical linear immersion of the ship below the water surface for the ship to float in a stable condition.
- Min. vertical clearance for safe floating.

CLASSIFICATION OF HARBOURS

1. Classification depending upon the protection needed.
2. Classification depending upon the utility.
3. Classification based upon the location.

Classification of Harbours Contd..

1. Classification depending upon the protection needed.

   a) Natural Harbour or Natural Roadsteads

   b) Semi Natural Harbour

   c) Artificial Harbour or Artificial Roadsteads

Classification of Harbours Contd..

1. Classification depending upon the protection needed.

   a) Natural Harbour or Natural Roadsteads

   b) Semi Natural Harbour

   c) Artificial Harbour or Artificial Roadsteads

Classification of Harbours Contd..

NATURAL HARBOURS

- Inlet protected from storms and waves by natural configuration of land.
- Natural formations affording safe discharge facilities for ships on sea coast in form of creeks and basins.
- E.g.: Bombay, Kandla


Natural harbour
13
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1
14
2
4
3
Mumbai port
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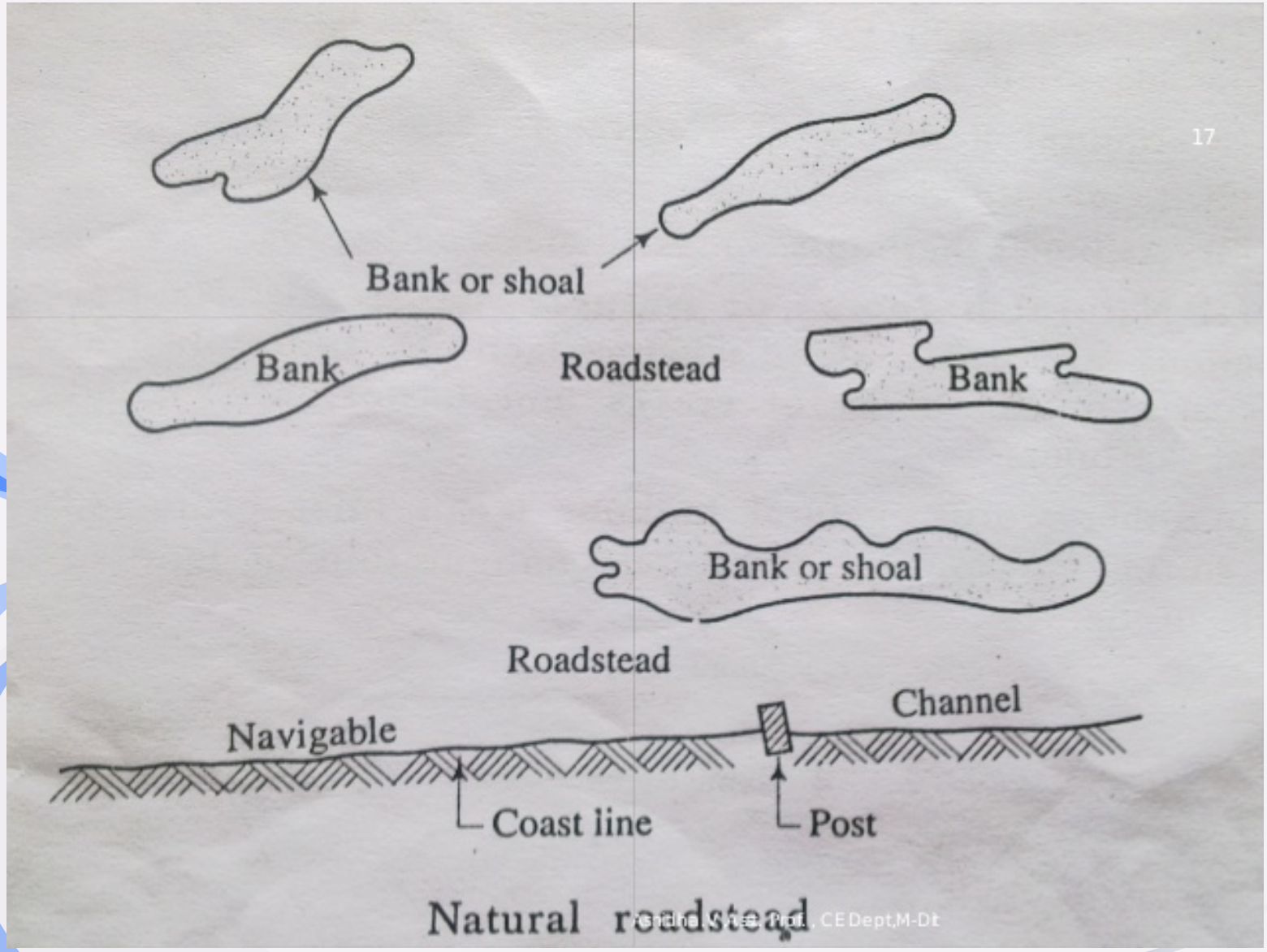
Kandla port
15
Gandhidham
New Kandla, Gandhidham, Gujarat, India
Kandla Port Trust
© 2010 Mapabc.com
Image © 2010 DigitalGlobe
© 2010 Google
Image © 2010 TerraMetrics
Google
©2009
23°00'56.82" N 70°12'40.95" E elev 13 ft
Eye alt 18.24 mi

Classification of Harbours Contd..

NATURAL ROADSTEADS

- A deep navigable channel with a protective natural bank or shoal to seaward is a good example of a natural roadstead.
- Circumscribed natural roadstead.



Natural roadstead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Natural Roadstead
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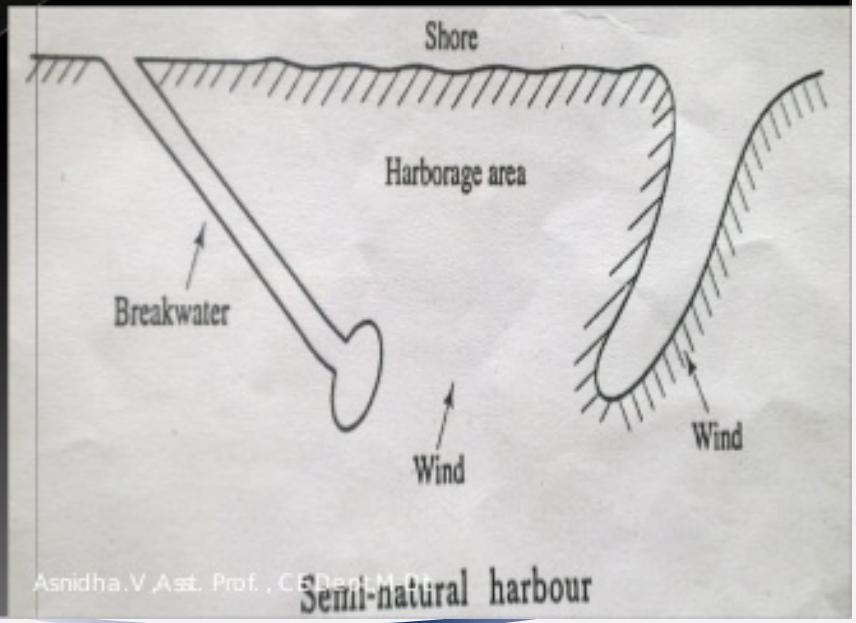
Classification of Harbours Contd..

SEMI NATURAL HARBOUR

- Protected on sides by headlands and it requires man-made protection only at the entrance.
- Eg: Vishakhapatnam



Semi-natural harbour


21
Semi Natural Harbour
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22
Vishakhapatnam
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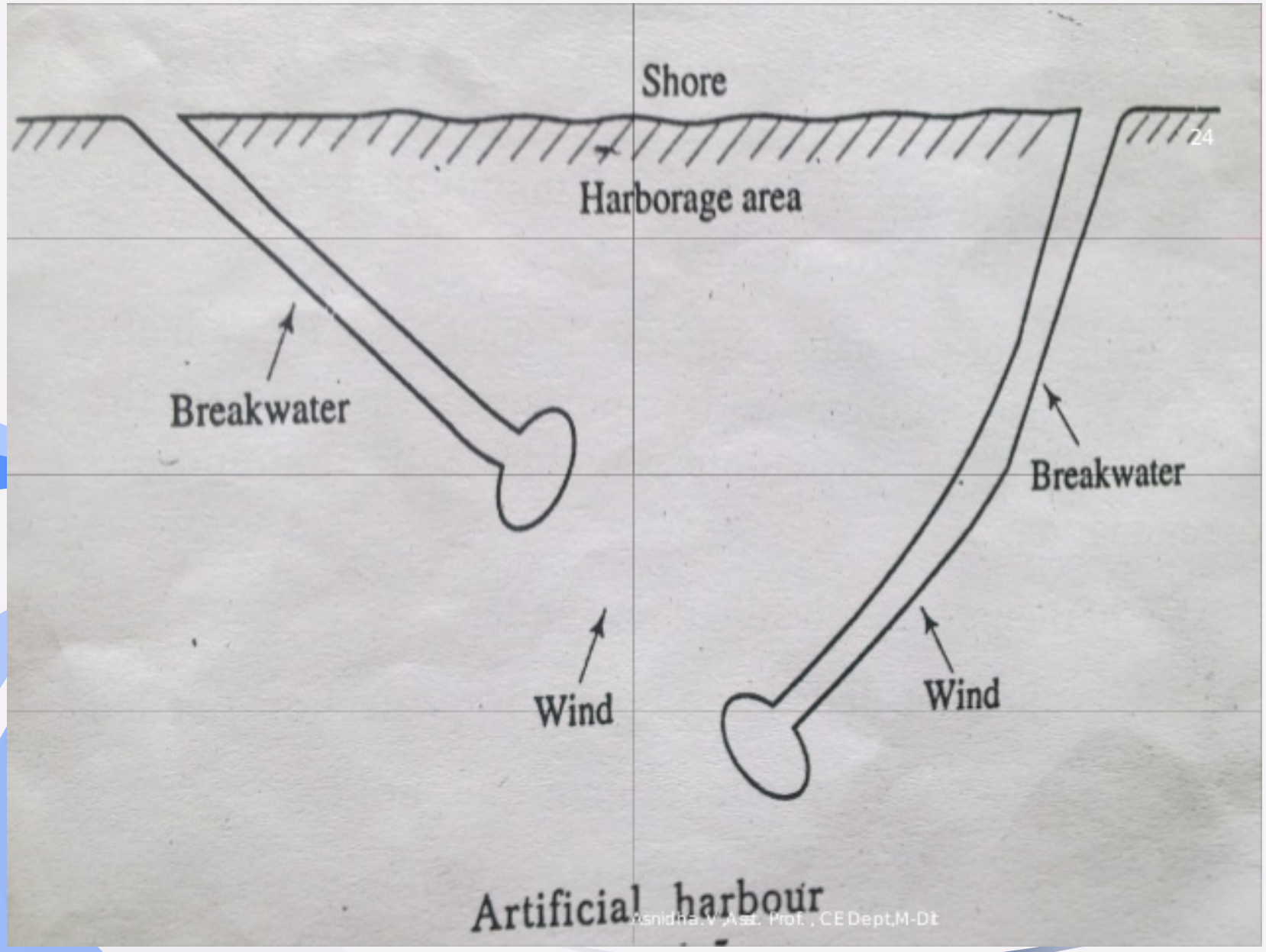
Classification of Harbours Contd..

ARTIFICIAL HARBOURS

- Harbour having no natural protection but artificial arrangement are made to protect the harbour from storm and wind.
- Area protected from the effect of waves either by breakwaters or by dredging.

ARTIFICIAL ROADSTEADS

- created by constructing a breakwater or wall parallel to the coast or curvilinear from the coast.


Shore
24
Harborage area
Breakwater
Breakwater
Wind
Wind
Artificial harbour


Artificial Harbours
Palm island ,dubai
26
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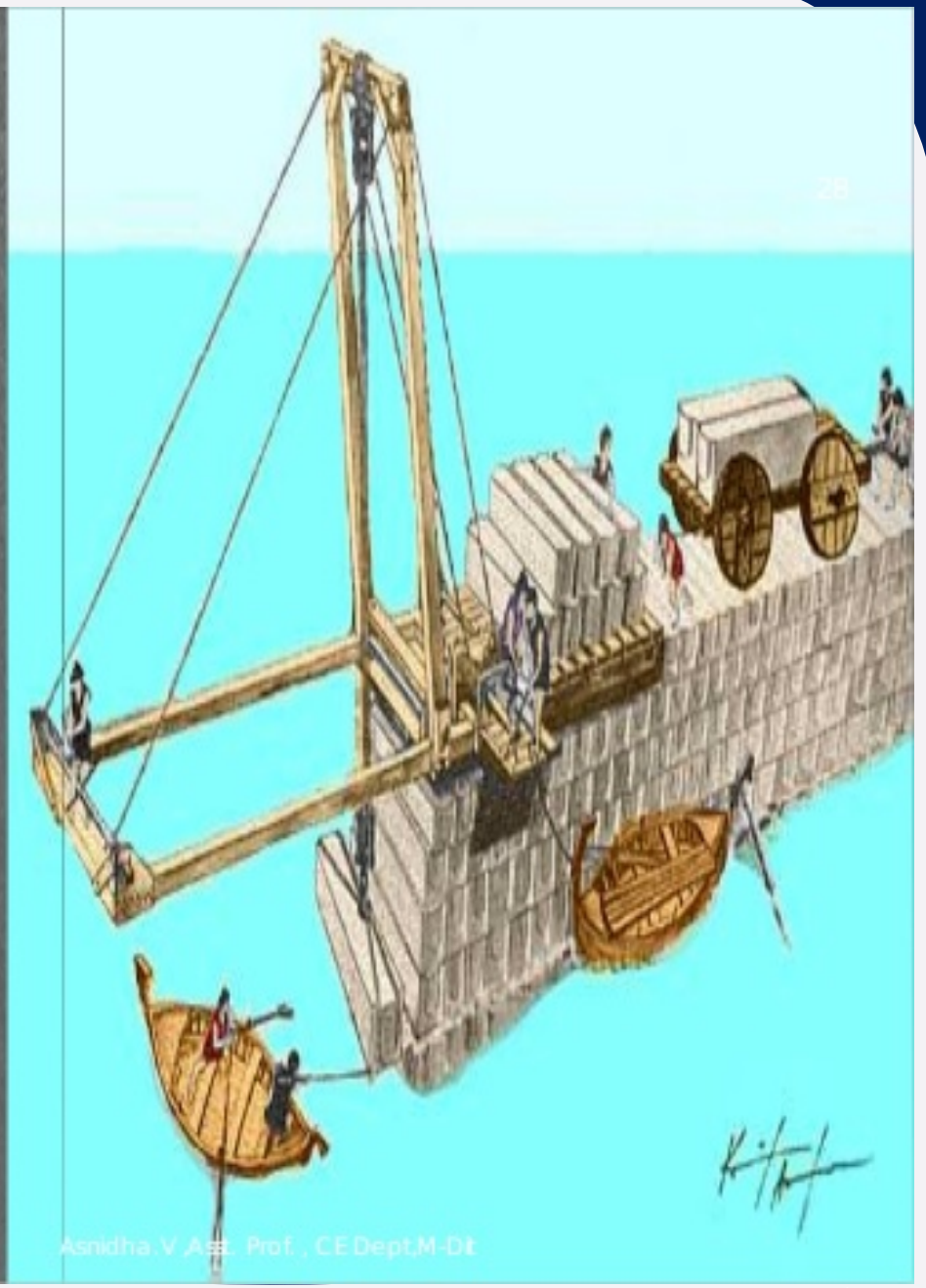

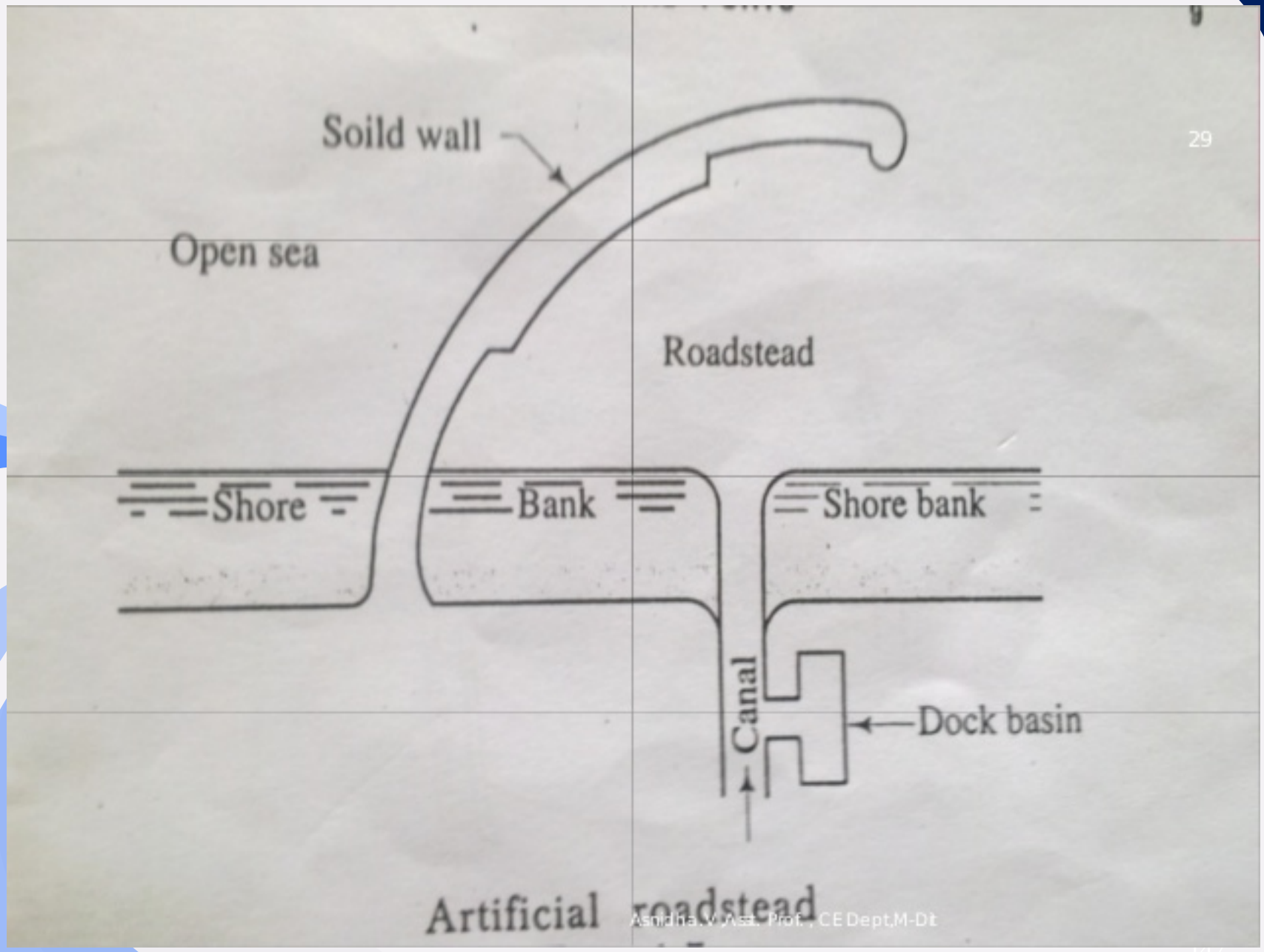

Artificial roadstead

Classification of Harbours Contd..

2) Classification based on utility

a) Harbours of refuge
b) Commercial harbours
c) Fishery harbours
d) Military harbours
e) Marina harbours

Classification of Harbours Contd..

HARBOURS OF REFUGE

- The harbor used for ships in storms or emergency condition.
- good anchorage and safe and easy access from the sea.
- e.g.: Dover in England

Requirements

i. Ready accessibility from the high seas
ii. Safe and convenient anchorage against the sea.
iii. Facilities for obtaining supplies and repairs.

Classification of Harbours Contd..

COMMERCIAL HARBOURS

- may be a part of bigger complex harbor or Independent unit or single commodity harbor.
- Terminal as oil terminal, coal port.

Requirements

i. Specious accommodations for mercantile marine.
ii. Storage sheds for cargo.
iii. Ample space for transportation, loading and unloading cargo.
iv. Good and quick repair facilities.
v. More sheltered conditions.


Commercial Harbours
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dreamstime.com


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Commercial Harbours
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Classification of Harbours Contd..

FISHERY HARBOUR

- Provided for fishing crafts and trawlers.

Requirements

i. Constantly open for departure and arrival of fishing ships.
ii. Loading and unloading facilities & quick dispatch facilities for the perishable fish catch.
iii. Refrigerated stores with ample storing space for preserving the catch.


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Fishery Harbour
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Classification of Harbours Contd..

MILLITARY HARBOR:

- This harbor is meant for accommodating naval crafts and serves as a supply deport.
- The layout of this type of harbor is greatly influenced by its location.

Requirements

i. Should accommodate the navel vessels.

ii. They serve as supply depots also.
Bombay and Cochin harbours have navel bases.


Millitary Harbour

Classification of Harbours Contd..

MARINA HARBOURS

Definition

Marina is a harbour providing facilities of fuel, food, showers, telephones etc. for small boat owners having temporary or permanent berths.

Classification

(a) Large marinas -have 200 or more berths.

(b) Small marinas -have less than 100 berths.


Marina Harbours
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Marina Harbours
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Classification of Harbours Contd..

3.Classification based on the location

a) Canal harbour - harbour located along canals for sea navigations.

b) Lake Harbour - harbour constructed along the shore of lake.

c) River Harbour or Estuary Harbour - harbour constructed along the banks of river.

d) Sea or Ocean Harbour - harbour located on the coast of sea or an ocean.

ACCESSIBILITY

- Depends on location of harbours
- The harbour entrance should be designed and located for quick and easy navigation by ships
- The harbour entrance should be narrow enough not to expose the harbour to the effect of stormy sea .
- Maximum dimension up to 180m

SIZE OF A HARBOUR

Size depends upon

- No. and size of ships likely to use the harbour at one time.
  - length: 275m to 300m,
  - width: 30m
- There should be sufficient area for maneuvering them without collision

Size determined by

- Accommodation required
- Convenience for maneuvering and navigation
- Adaptability to natural features

SITE SELECTION

Following factors play a great role in the choice of site of a harbour.

- Availability of cheap land & contruction material.
- Natural protection from waves & winds
- Transport & communication facilities
- Industrial development of the locality
- Sea-bed, subsoil and foundation conditions
- Traffic potentiality of harbour.
- Availability of electrical energy & freshwater.
- Favourable marine conditions.
- Defence and strategic aspects. Etc

SHAPE OF HARBOUR

Principles

- Pierheads – one should project a little beyond the other - to protect from sea waves
- Pier heads - width should widen very rapidly
- General approach - series of straight length - no reentrant angles are allowed

HARBOUR DEPTH

- Determined by

$$D = D1 + H/3 + D2$$

Where, D_1 = draft for largest ship to be accomodated

D_2 = allowance for squat of moving ship

H = height of storm waves

- Harbour and approach channel should have sufficient depth to allow navigation even at low water when ships are fully loaded.
- No obstructions
- Max. harbour depth = loaded draft + 1.2m when bottom is soft

  Max harbour depth = loaded draft + 1.8m when bottom is rock

MARINE SURVEYS

- Collect sufficient information about the area before finalising the layout of the harbour and design of its various components

Two surveys

- Hydrographic survey
- Topographic survey

HARBOUR PLANNING

It should be carried out after collecting necessary information of the existing features at the proposed site.

Following important facts should be studied.

- A thorough survey of the neighborhood including the foreshore & depths of water is necessary
- Nature of a harbour weather sheltered or not, should be studied

Harbour Planning contd...

- The existence of sea insects & various animals residing at site should be noted.
- Borings and soundings should be carried out.
- Problem of silting or erosion of coastline should be carefully studied.
- Natural phenomena's concerning planning of a harbour like Storms,Rainfall,Range of tides,Maximum & minimum temperatures,Direction & intensity of wind etc. should be studied.

FEATURES OF A HARBOR

- Entrance Channels
- Berthing & Turning Basin
- Break Water
- Pier Head
- Quays & Wharves
- Jetties& piers
- Docks
- Slipways
- Other go downs, shed, buoys, lights, fire protection towers...

Features of a Harbour Contd...

ENTRANCE CHANNEL

- When sea around the harbour has depth less than draft required for the largest ship visiting the harbour a separate approach demarcated and dredged for required depth is necessary.
- Entrance:- path through which ship can enter the harbour safely.
- Depth and width are kept more at entrance.
- Width depends upon density of traffic and no: of entrances.


Entrance & Entrance Channel
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Entrance & Entrance Channel
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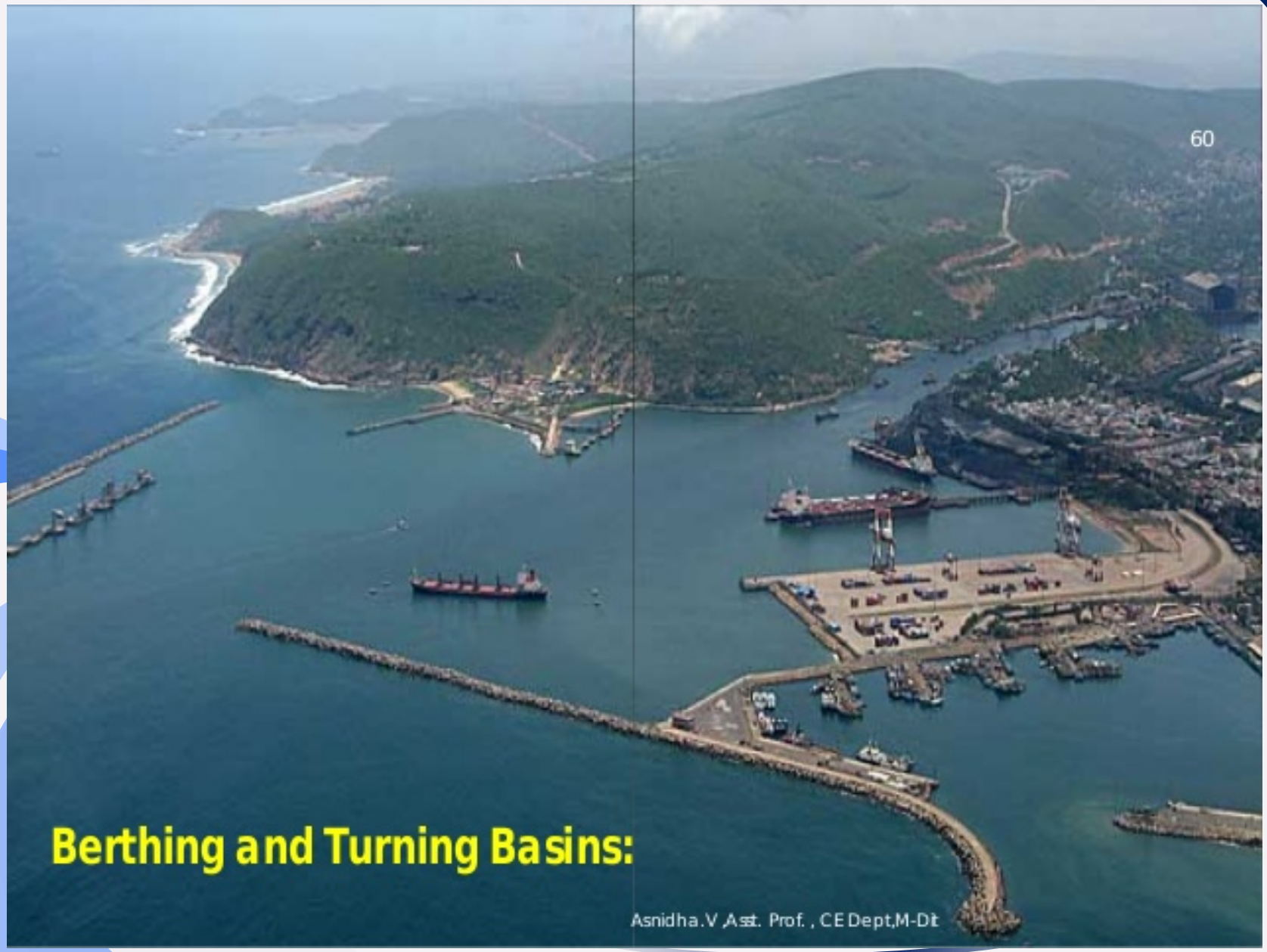
Features of a Harbour Contd...

BERTHING AND TURNING BASINS:

- Berthing basins are used for the parking of ships.
- While turning for the turning of ships.


60
Berthing and Turning Basins:
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Features of a Harbour Contd...

BREAK WATER:

It is the protective barrier constructed to enclose harbours and to keep the harbour waters undisturbed by the effect of heavy and strong seas.

- The structure constructed to protect harbour from storm waves
- They are generally stone masonry


Break Water:
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Break Water:
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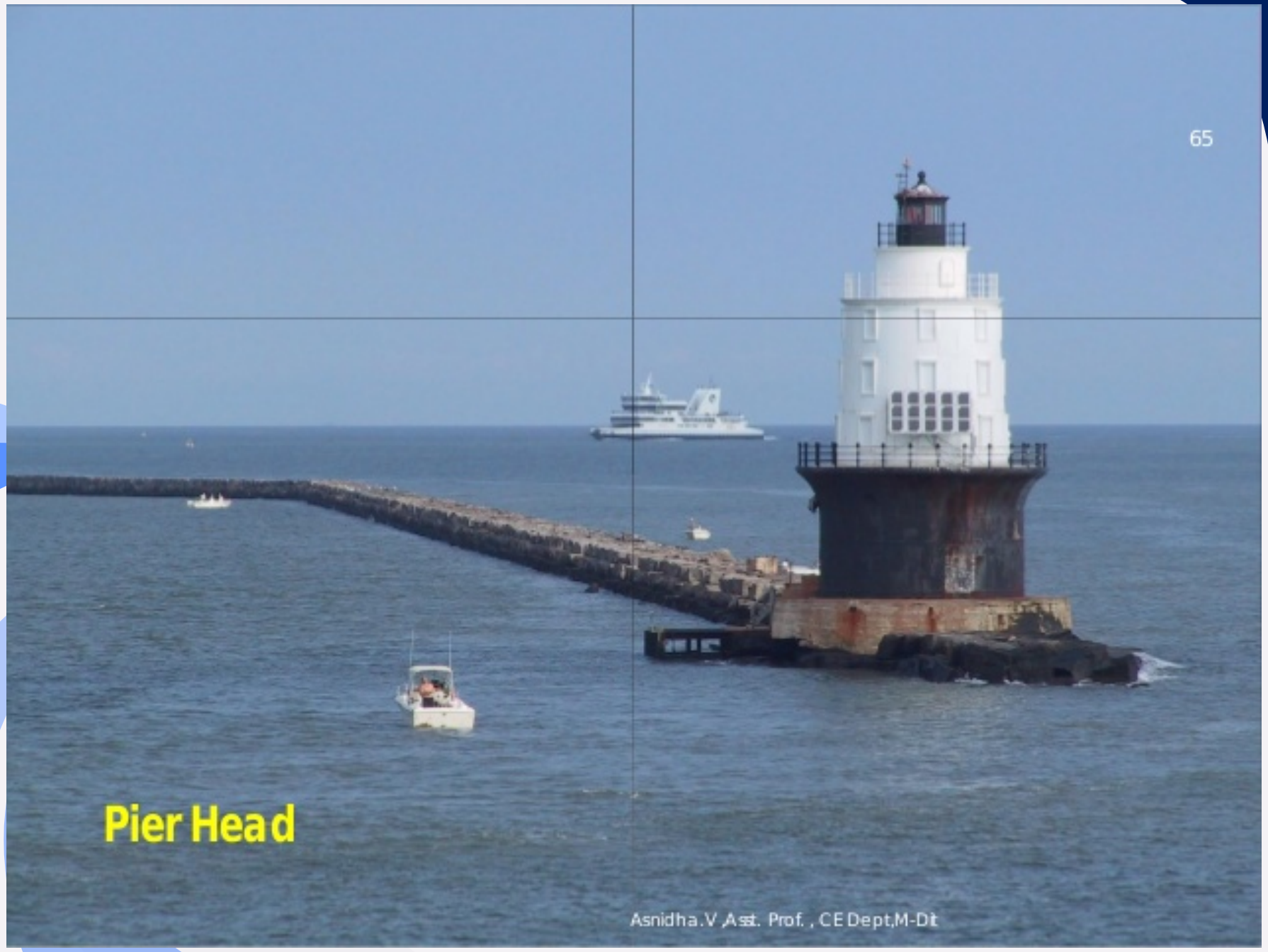
Features of a Harbour Contd...

PIER HEAD:

- The structure provided at the tip of break water
- Serves the purpose of entrance mark.
- Such as light house


Pier Head

Features of a Harbour Contd...

WHARVES

- Platforms or loading places necessary for ships to come close enough to the shore they are called wharves.
- wharves constructed parallel to the shore or break water are called quays.
- wharves those project into the ships fair way or basin at right angles or oblique from shore are called piers.
- Function is to permit berthing of vessel along side for cargo working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Quays.
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Piers

Features of a Harbour Contd...

JETTIES:

- Piled projections from shore to berth vessels.
- Used for loading and unloading of cargo
- Made usually from shore towards sea water to prevent silting and dredging to allow free flow of tidal currents.
- divert the current away from the river bank
- scouring action is prevented


Jetties
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DEFECTS IN HARBOUR

- Depth of water is found insufficient for different ships.
- The size of harbour is found insufficient to accommodate the increased traffic.
- The quay and landing area between the berths is very narrow and there is no enough room for the cargo to be stored.
- Obstruction

These defects can easily be avoided at the time of planning and designing.

REQUIREMENTS OF A GOOD HARBOUR:

- The depth of a harbour should be sufficient for every type of visiting ships.
- The bottom of harbor should provide secured anchorage to hold the ships against high winds.
- To prevent destructive wave action break water are provided.
- The entrance of a harbor should be wide enough to provide the easy passage of ships.