INSTITUTE OF AERONAUTICAL ENGINEERING
(AUTONOMOUS)
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TRANSPORATION ENGINEERING II

(A70133) JNTUH-R15

B .Tech IV YEAR I SEM

Prepared By:

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COURSE GOAL

- To introduce different transportation systems, their importance and their role in development
- The basic elements and Geometric designs of Railway, Airport, Seaport and harbour layouts

COURSE OUTLINE

UNIT	TITLE	CONTENTS
I	**INTRODUCTION TO RAILWAY**	Permanent way components –Cross section of permanent way-Functions of various components like rails, sleepers and ballast, Gauge –Creep of rails – Theories related to creep – sleeper density
II	**GEOMETRIC DESIGN OF RAILWAY TRACK**	Gradients – Grade compensation – Cant and Negative super elevation– Cant deficiency– Degree of curve – Points and crossings ,Rail joints and welding of joints, Railway stations and yards, Signalling and interlocking

UNIT	TITLE	CONTENTS
III	**AIRPORT ENGINEERING**	**Airport site selection– Runway orientation–Basic Runway length-Corrections for elevation, Temperature-Airport classification –Runway geometric design–Factors controlling Taxiway Layout–Terminal Area–Apron–Hanger–Blast considerations, Typical Airport Layouts–Wind rose diagram–Runway lighting system and marking**
IV	**Port and Harbour Engineering**	Requirements of Port and Harbour – Classification of port and Harbour. Features of a Harbour, Planning of Harbour, Breakwaters, Dry docks, jetties, Aprons, Transit shed and warehouses, Navigational aids, Maintenance of Port and Harbours, Inland water Transport.

UNIT	TITLE	CONTENTS
V	Intelligent Transport Systems	ITS definition, Benefits of ITS, user services, Detectors, Automatic Vehicle location (AVL), Introduction to ITS applications; Advanced Traffic Management systems (ATMS), Advanced Public Transportation systems (APTS), ITS architecture components and standards, Overview of ITS implementations in developed countries.

TEXT BOOKS

- Satish Chandra and Agarwal, M.M (2007) "Railway Engineering" Oxford Higher Education, University Press New Delhi.
- Airport Planning and Design S. K khanna and M.G Arora, Nemchand Bros.
- A Text book of transportation Engineering – S.P. Chandola S.Chand &Co.Ltd (2001)
- Transportation Engineering and Planning C.S Papacostas, P.D Prevedouros.

COURSE OBJECTIVES

- **To introduce** different transportation systems and their importance and their role in development
- **To understand** standards and norms of National and International organisations which are framed for efficient functioning of existing transport systems
- **To impart** Knowledge regarding the functioning of various components like rails, sleepers, Tracks, Geometric curves, Runways, Taxiways Aprons Wear houses, Jetties etc

- **To design** elements like horizontal curves, vertical curves, super elevation etc

- **Analyze** how signal systems ,visual aids and Markings etc help in safe working of transportation systems

- **Demonstrate** the basic design of Railway, Airport, Seaport and harbour layouts

- **To expose** students to new technologies used and trends adopted in present transport scenario

TEACHING STRATAGIES

- The course will be taught via Lectures. Lectures will also involve the solution of tutorial questions. Tutorial questions are designed to complement and enhance both the lectures and the students appreciation of the subject.
- Course work assignments will be reviewed with the students.
- Daily assessment through questioning and class notes.

UNIT-I

INTRODUCTION TO RAILWAY ENGINEERING

History of Indian Railways

- In the year 1832 the first Railway running on steam engine, was launched in England. Thereafter on 1st of August, 1849 the Great Indian Peninsular Railways Company was established in India. On 17th of August 1849, a contract was signed between the Great Indian Peninsular Railways Company and East India Company. As a result of the contract an experiment was made by laying a railway track between Bombay and Thane (56 Kms).
- • On 16th April, 1853, the first train service was started from Bombay to Thane.
- • On 15th August, 1854, the 2nd train service commenced between Howrah and Hubli.
- • On the 1st July, 1856, the 3rd train service in India and first in South India commenced between Vyasarpadi and Walajah Road and on the same day the section between Vyasarpadi and Royapuram by Madras Railway Company was also opened.

Railway zones

- Indian Railways is divided into several zones, which are further sub-divided into divisions.
- The number of zones in Indian Railways increased from six to eight in 1951, nine in 1952 and sixteen in 2003. Each zonal railway is made up of a certain number of divisions, each having a divisional headquarters.
- There are a total of sixty-eight divisions. Each of the sixteen zones is headed by a general manager who reports directly to the Railway Board.
- The zones are further divided into divisions under the control of divisional railway managers (DRM).

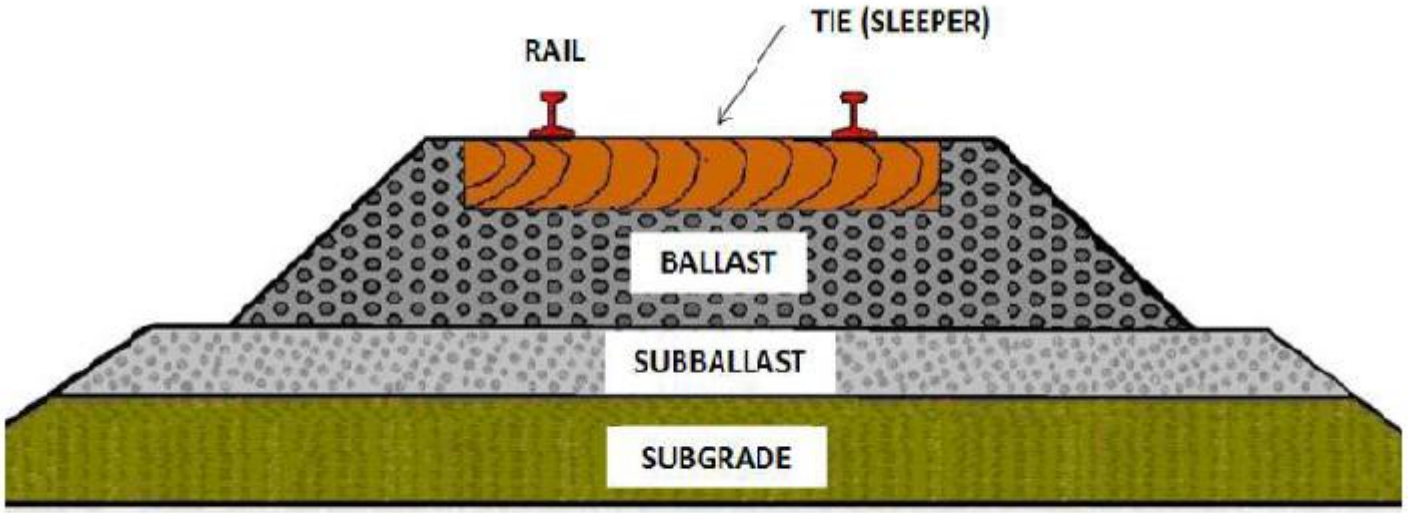
Subsidiaries of Indian Railways

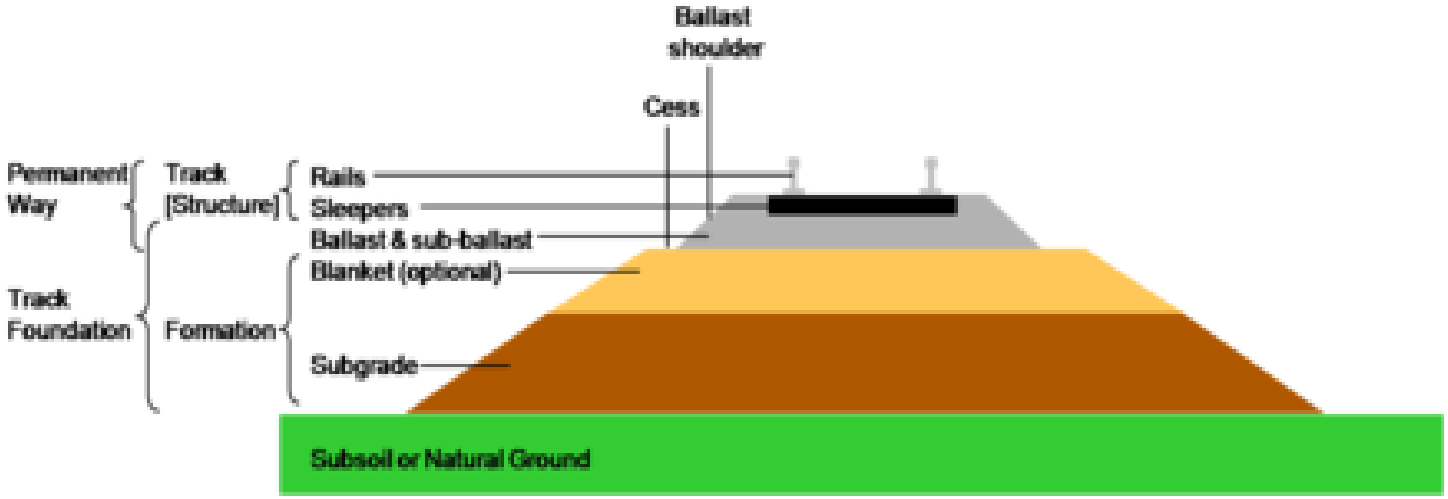
There also exist independent organizations under the control of the Railway Board for electrification, modernization, research and design and training of officers, each of which is headed by an officer of the rank of general manager

Bharat Wagon and Engineering Co. Ltd. (BWEL)

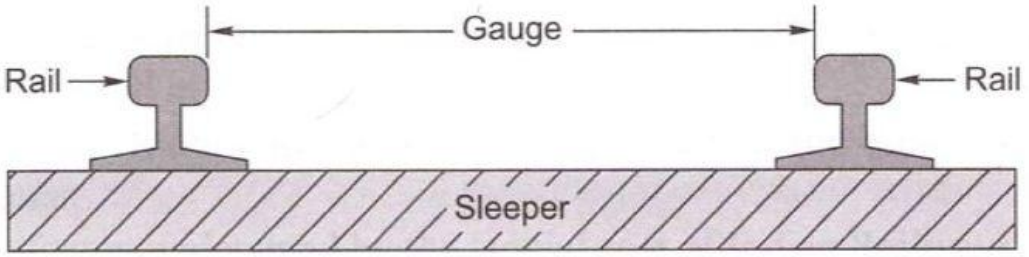
- Centre for Railway Information Systems (CRIS)[24]
- Container Corporation of India Limited (CONCOR)
- Dedicated Freight Corridor Corporation of India Limited (DFCCIL)
- Indian Railway Catering and Tourism Corporation Limited (IRCTC)
- Indian Railway Construction (IRCON) International Limited
- Indian Railway Finance Corporation Limited (IRFC)
- Konkan Railway Corporation Limited (KRCL)
- Mumbai Railway Vikas Corporation (MRVC)
- Railtel Corporation of India Limited (Rail Tel)
- Rail India Technical and Economic Services Limited (RITES)
- Rail Vikas Nigam Limited (RVNL)
- High Speed Rail Corporation of India (HSRC)
- Burn Standard Company

Component parts of railway track





- **GAUGE** The clear minimum horizontal distance between the inner (running) faces of the two rails forming a track is known as Gauge. Indian railway followed this practice. In European countries, the gauge is measured between the inner faces of two rails at a point 14 mm below the top of the rail.



TYPES OF GUAGES

Type of gauge	Gauge (mm)	Gauge (feet)	% of total length
Standard gauge	1435	4'8.5"	62
Broad gauge	1676	5 '6"	6
Broad gauge	1524	5'0"	9
Cape gauge	1067	3 '6"	8
Metre gauge	1000	3 '3.5"	9
23 various other gauges	Different gauges	Different gauges	6

Gauge Type	Width	% Route covered in India	Gauge Type
Broad gauge	1676 mm	63	Broad gauge
Meter gauge	1000 mm	31	Meter gauge
Narrow gauge	762 mm	6	Narrow gauge

Broad Gauge: -
Suitability: - Broad gauge is suitable under the following Conditions:-
When sufficient funds are available for the railway project.
When the prospects of revenue are very bright.
Meter Gauge: -
Suitability:- Meter Gauge is suitable under the following conditions:-
When the funds available for the railway project are inadequate.
When the prospects of revenue are not very bright.
. **Narrow Gauge**
Suitability: **-** Narrow gauge is suitable under the following conditions:-
When the construction of a track with wider gauge is prohibited due to the provision of sharp curves, steep gradients, narrow bridges and tunnels etc.
When the prospects of revenue are not very bright. This gauge is, therefore, used in hilly and very thinly populated areas.

CHOICE OF GAUGE

- Cost considerations
- Traffic considerations
- Physical features of the country
- Uniformity of gauge
- Speed

Classification of Meter gauges

- In the case of meter gauge track classification, we have three categories of track classifications

Meter gauges

Q -routes

- Speed> 75kmph
- Traffic density >2.5 GMT

R-routes

- Speeds < 75kmph and capable of travelling > 75kmph
- Traffic density little more than 1.5 GMT
- Sub classified into R1, R2,R3

S-routes

- Speeds < 75kmph
- Traffic density < 1.5 GMT

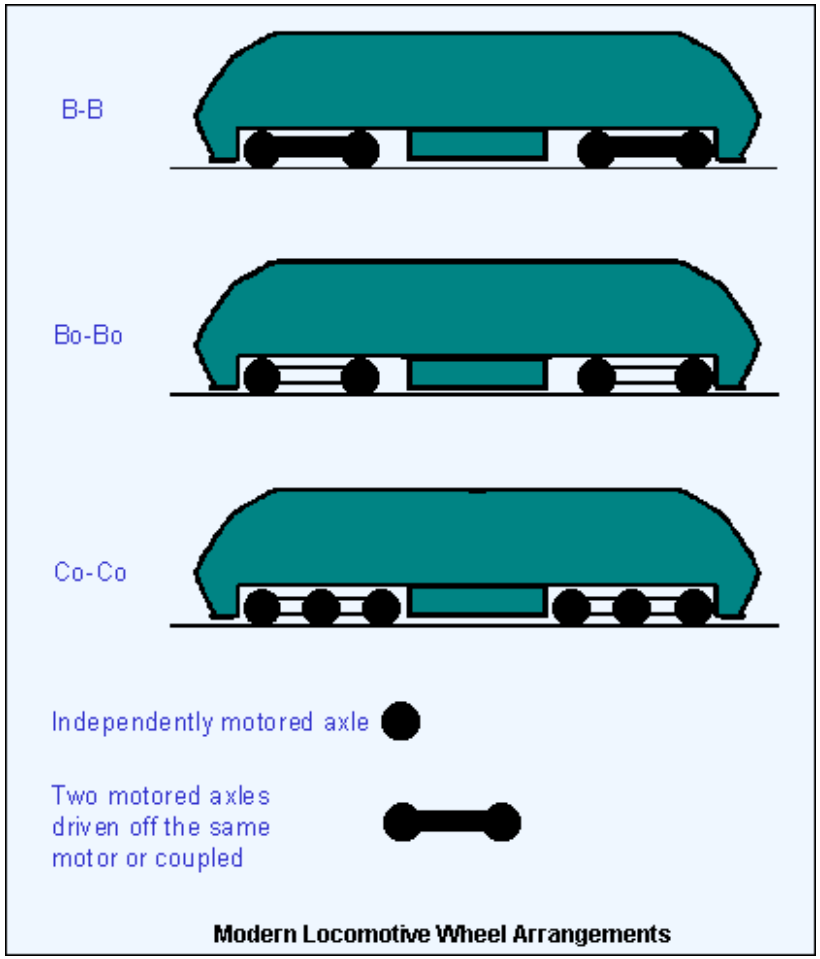
PROBLEMS OF MULTI GAUGE SYSTEM

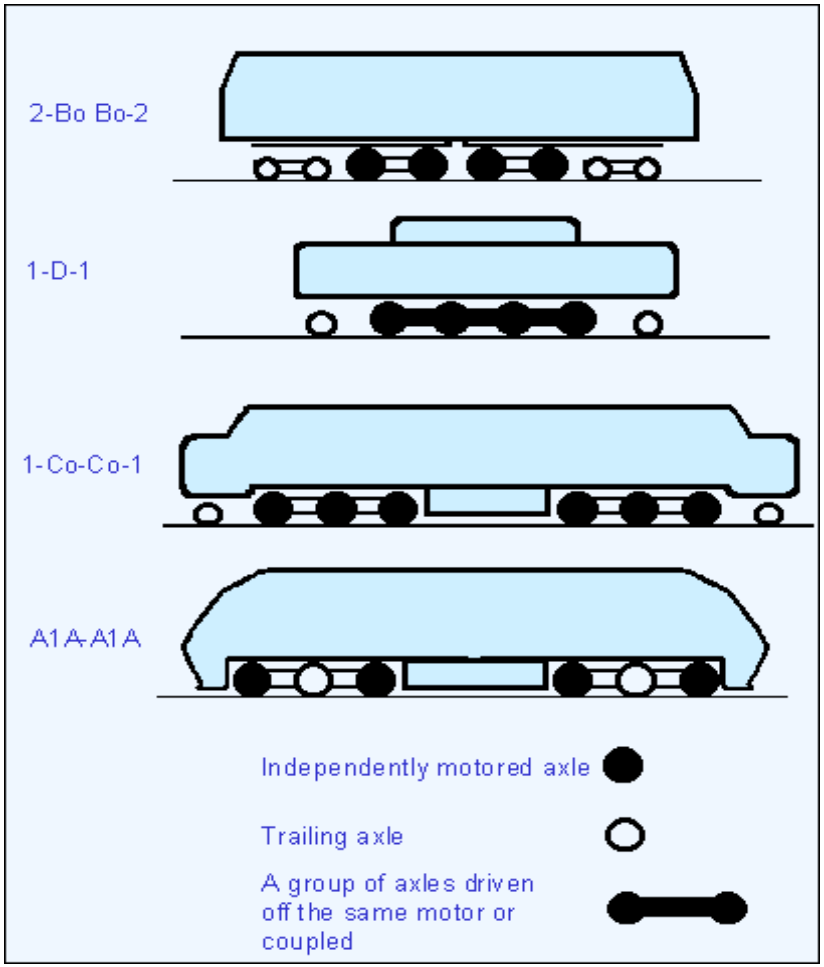
- Inconvenience to passengers
- Difficulty in trans-shipment of goods
- Inefficient use of rolling stock
- Hindrance to fast movement of goods and passenger traffic
- Additional facilities at stations and yards
- Difficulties in balanced economic growth
- Difficulties in future gauge conversion projects

- **UNI-GAUGE POLICY OF INDIAN RAILWAYS**

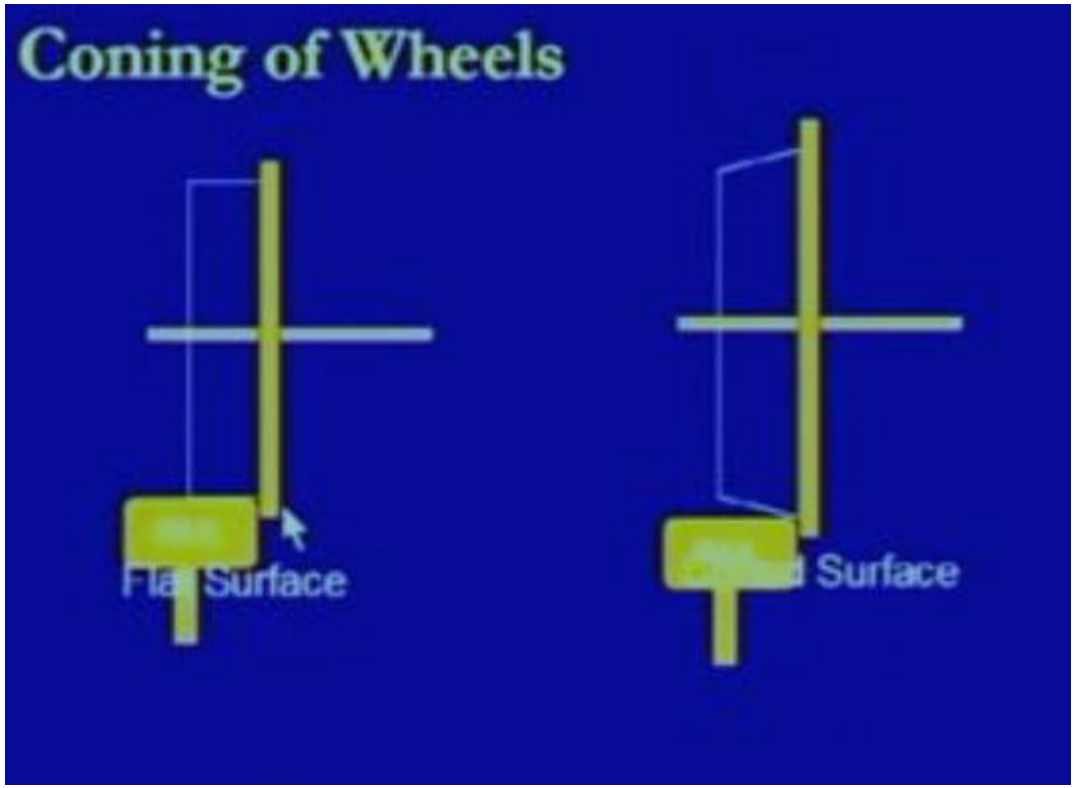
  The problems caused by a multi-gauge system in a country have been discussed in the previous section. The multi-gauge system is not only costly and cumbersome but also causes serious bottlenecks in the operation of the Railways and hinders the balanced development of the country. Indian Railways therefore took the bold decision in 1992 of getting rid of the multi-gauge system and following the uni-gauge policy of adopting the broad gauge (1676 mm) uniformly.

WHEEL ARRANGEMENT IN ELECTRIC LOCOMOTIVES





CONNING OF WHEELS



Permanent way

- it is defined as rail road's on which the train runs or in a more detailed form, we can define it in the form of it consists of two parallel rails which are placed at a specified distance in between them and which are fastened to the sleepers, which are embedded in a layer of ballast of specified thickness is spread over the formation.

SLEEPERS

- The main functions of sleepers are as follows:
- (a) Holding the rails in their correct gauge and alignment
- (b) Giving a firm and even support to the rails
- (c) Transferring the load evenly from the rails to a wider area of the ballast
- (d) Acting as an elastic medium between the rails and the ballast to absorb the blows and vibrations caused by moving loads
- (e) Providing longitudinal and lateral stability to the permanent way
- (f) Providing the means to rectify the track geometry during their service life

Adzing of Wooden Sleepers

- In order to enable the rails to be slightly tilted inwards at a cant of 1 in 20, wooden sleepers are required to be cut to this slope at the rail seat before laying. This process of cutting the wooden sleeper at a slope of 1 in 20 is known as ‘adzing of the wooden sleeper’.
- It may be pointed out that adzing or cutting of a wooden sleeper at a slope of 1in 20 is done with great care, otherwise the slope will vary from sleeper to sleeper resulting in a rough ride. The adzed surface of a wooden sleeper is treated with coal tar or creosote to ensure proper protection of the surface. Normally, adzing ofa wooden sleeper is done only when bearing plates are not provided.

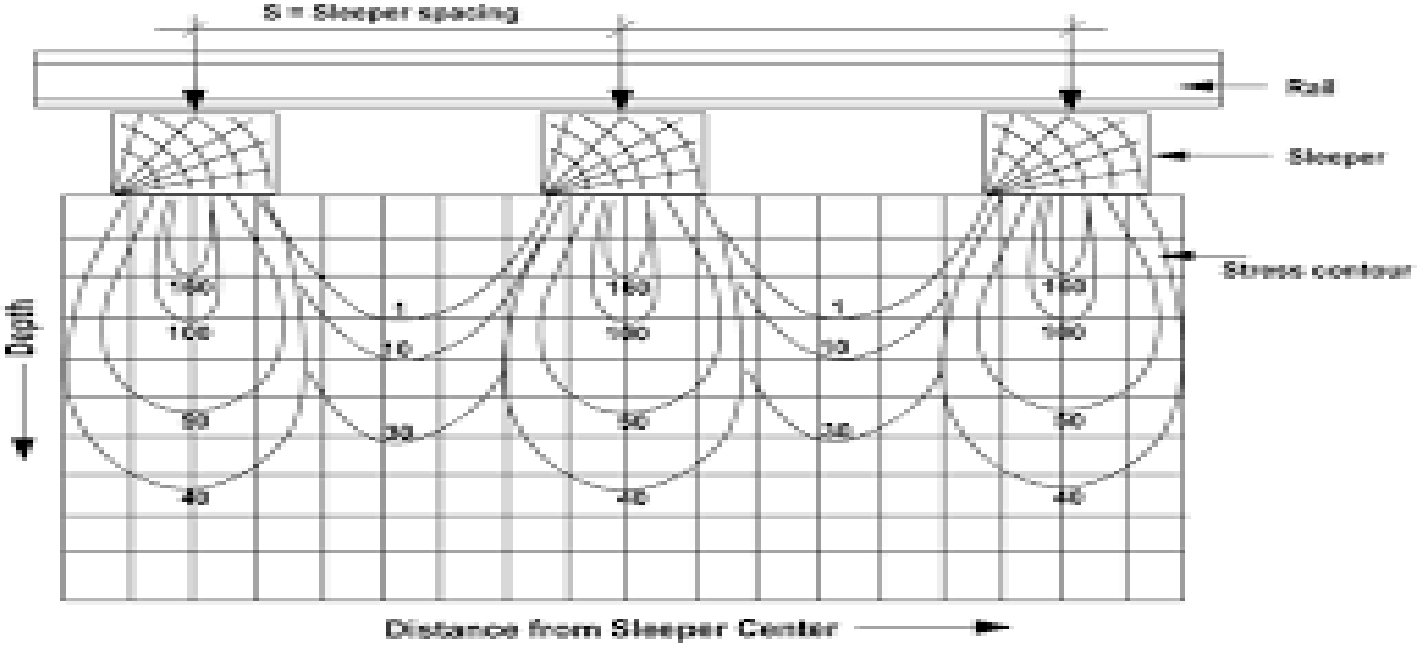
BALLAST

Ballast

- **Track ballast** forms the track bed upon which railway sleepers are laid

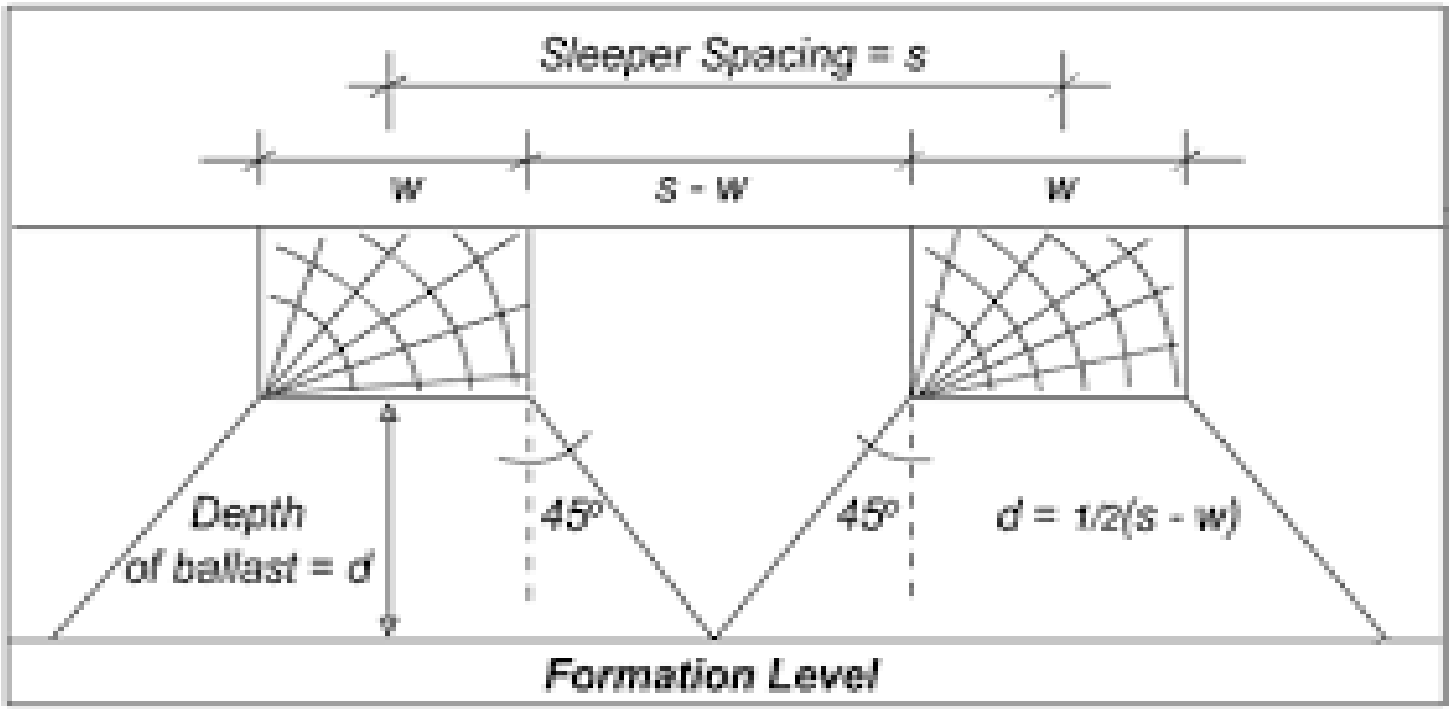
Stress distribution

- The load on the sleeper is transferred through the medium of the ballast to the formation. The stress distribution in the ballast section depends upon the size and shape of the ballast and the degree of consolidation.
- The load distribution can be observed as shown in figure

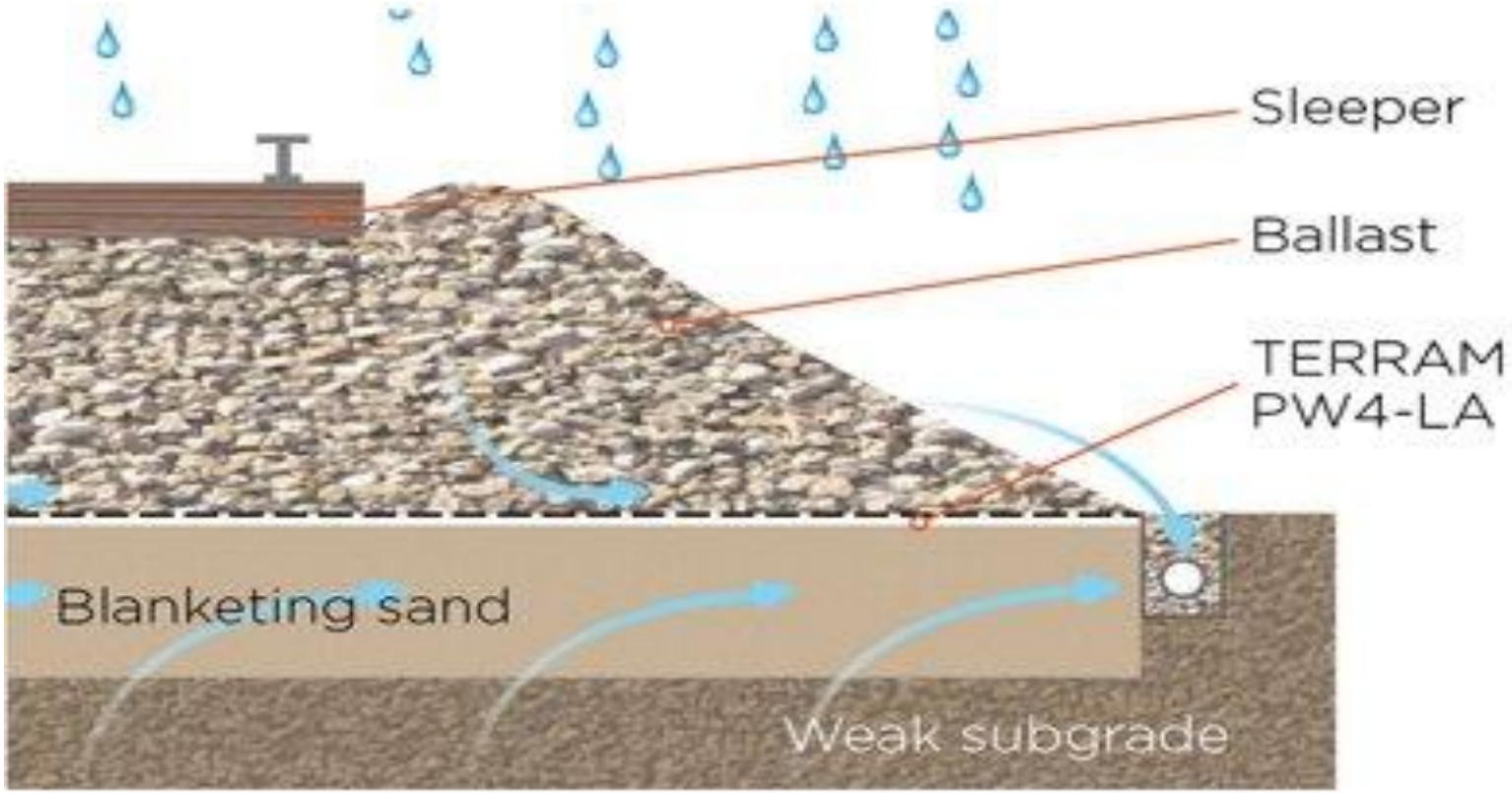


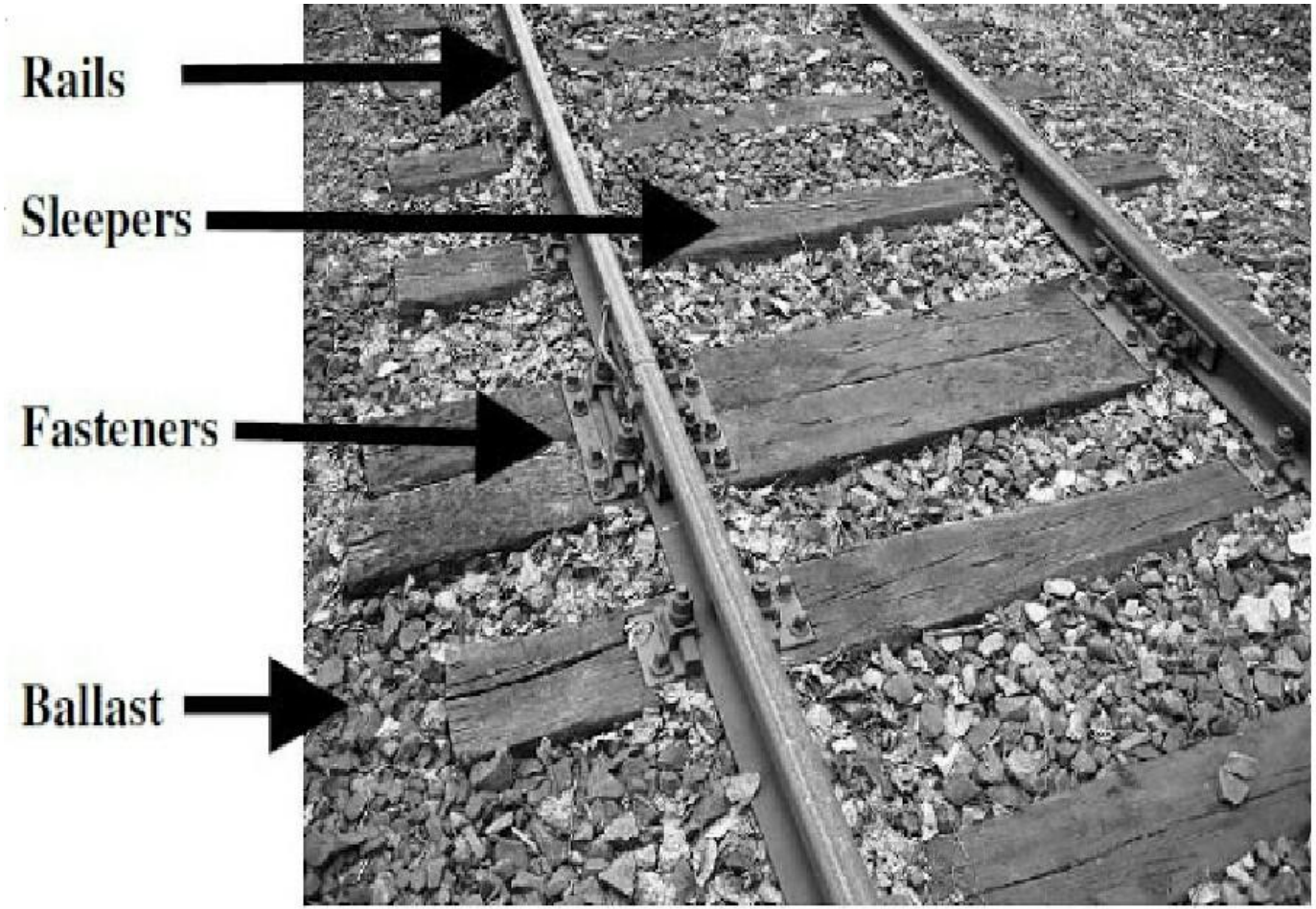
DEPTH OF BALLAST CUSHION

- For the even distribution of load on the formation, the depth of the ballast is determined by the following formula:
- Sleeper spacing = width of the sleeper + 2 x depth of ballast

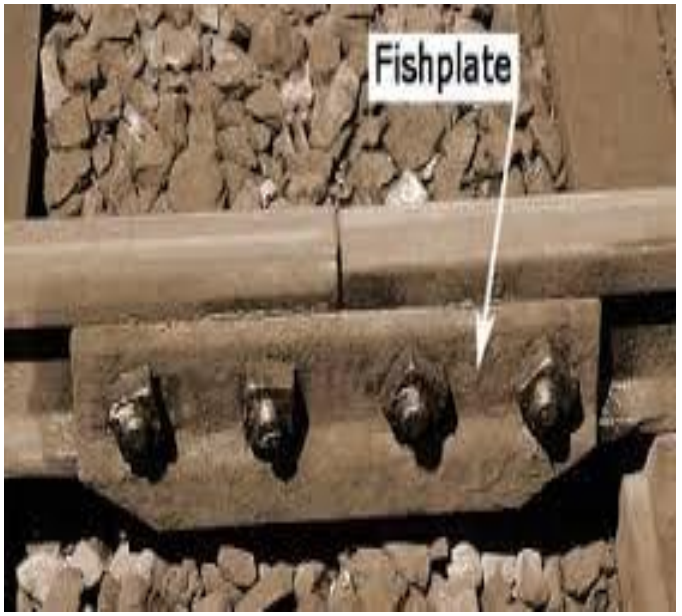


Typical layout of ballast cushion

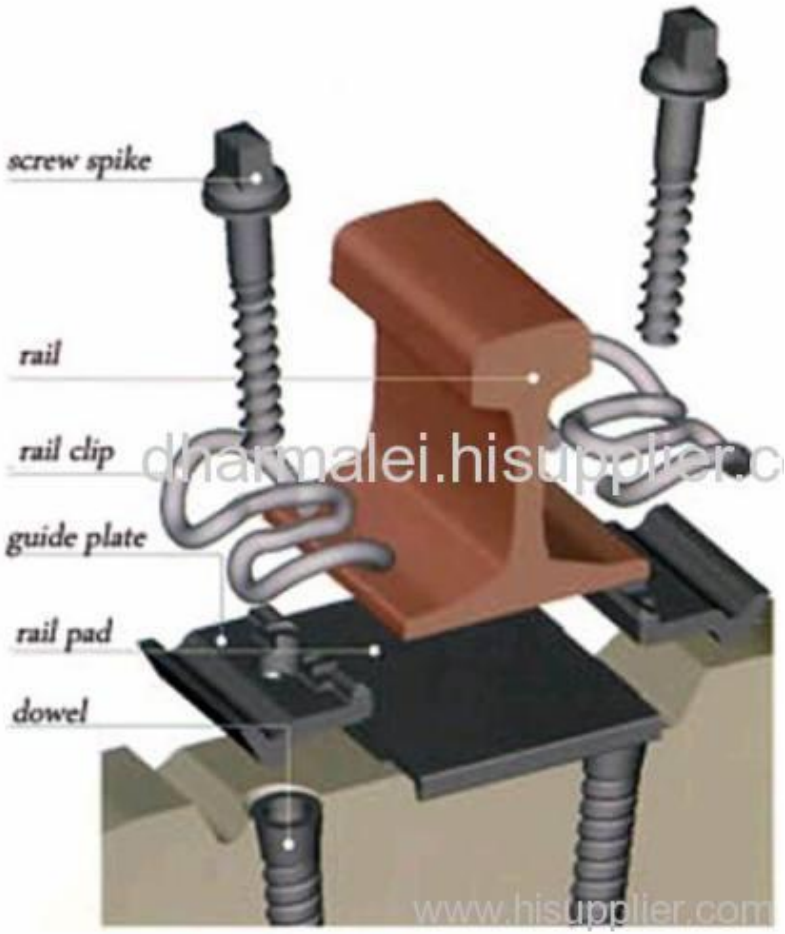
- 


Rails
Sleepers
Fasteners
Ballast

Fish plates



Fasteners


screw spike
rail
rail clip
guide plate
rail pad
dowel
www.hisupplier.com

CREEP

- The creep can be defined as the longitudinal movement of rails in a track
- Creep is location specific. We may not found a creep that is the longitudinal movement of the rails happening along whole of the length of the railway track. It is mostly being found only at a certain specific location
- The magnitude of the creep at one point is not necessarily is the same at the other point.

- **Creep Indicators**

The following symptoms indicate creep over a rail section

- Closing of joints in the direction of creep In the creep effected location the first rail is trying to move in to that gap which is being provided at this joint and that is how the closing of the joint will happen in the direction of creep.
- Opening of joint at point from where the creep starts It is another end of rail section which is moving. At one end of rail section it is trying to close the joint at which it is being jointed with the other rail section whereas when it is trying to move in one direction obviously on the other end of that rail section it will try to open out.

Scrapping or scratching marks on the rail flanges or the webs due to spike head.

- The rail sections are being fastened to sleepers and the spike head is one of the fastener which tries to fix the rail section to the sleeper. Now if there is any movement in the rail section the spike head tries to remain in its position and because it is abetting with the flange or the web of the rail section it will start putting the scrapping or the scratching mark on that section because of the movement of the rail

Creep Theories

- Wave motion theory

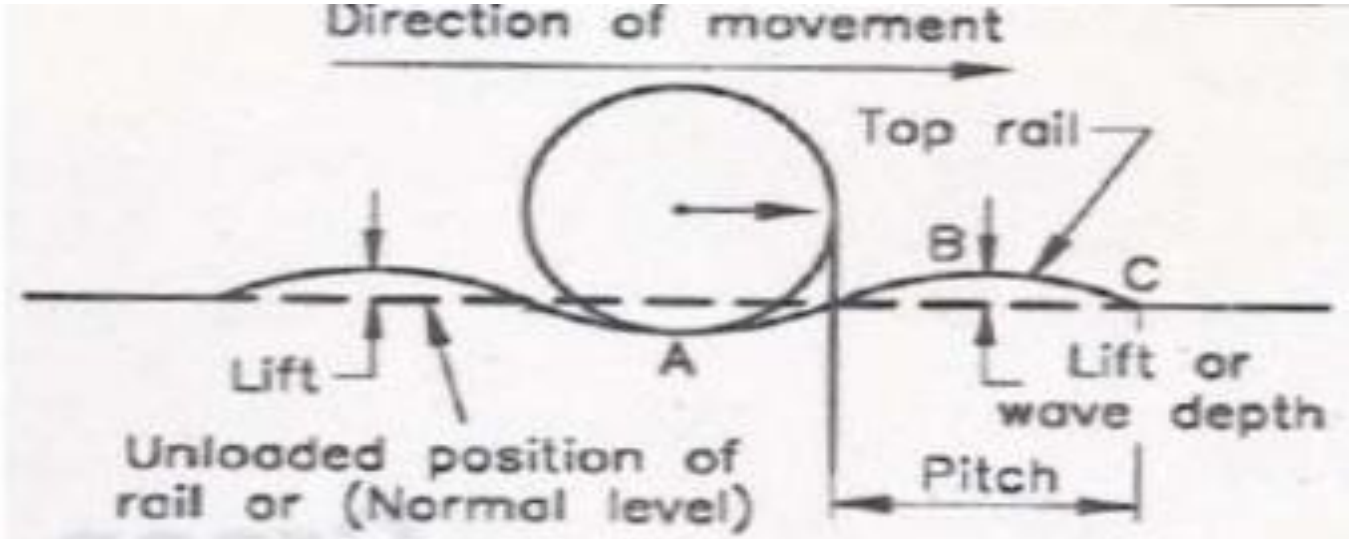
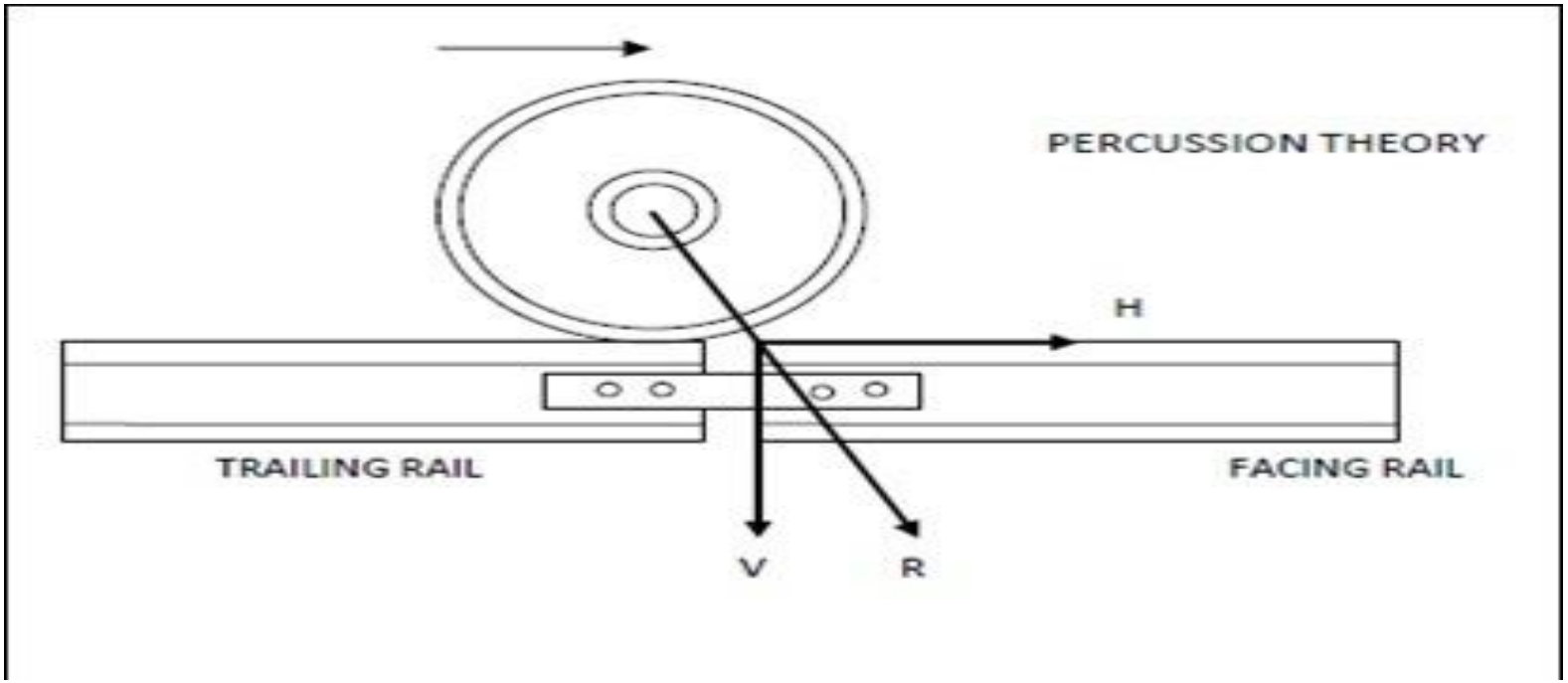


Fig. 8.2. Wave Theory of Creep (Formation of Wave)

- **percussion theory**



Causes of creep

The main factors responsible for the development of creep are as follows.

- **Ironing effect of the wheel** The ironing effect of moving wheels on the waves formed in the rail tends to cause the rail to move in the direction of traffic, resulting in creep.
- **Starting and stopping operations** When a train starts or accelerates, the backward thrust of its wheels tends to push the rail backwards. Similarly, when the train slows down or comes to a halt, the effect of the applied brakes tends to push the rail forward. This in turn causes creep in one direction or the other.
- **Changes in temperature** Creep can also develop due to variations in temperature resulting in the expansion and contraction of the rail. Creep occurs frequently during hot weather conditions.

Ill effects of creep

- Opening or jamming of joints
- Kink formation at joints
- Sleepers get out of position-It affects gauge and alignment
- Bucking of trains- It can derail the train
- Points, crossing, switches, interlocking gets distorted

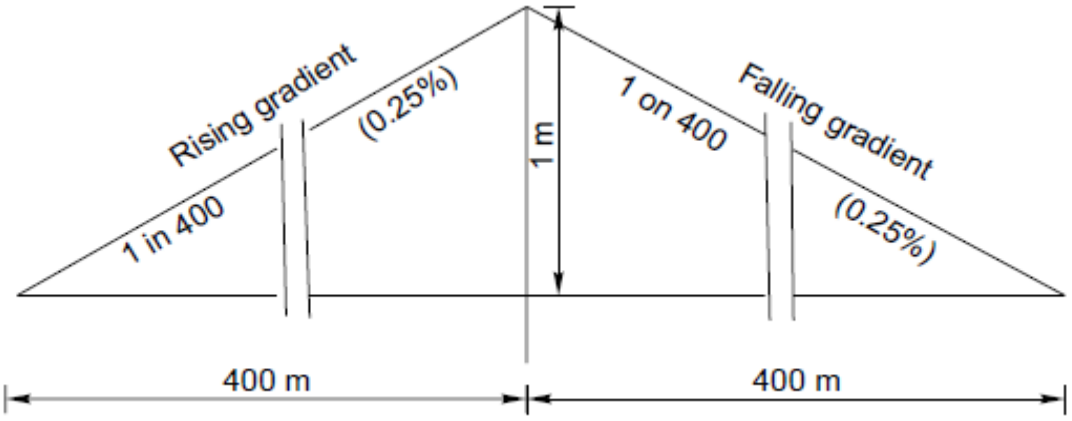
UNIT 2

- **GEOMETRIC DESIGN OF RAILWAYS**

GRADIENTS

- Gradients are provided to negotiate the rise or fall in the level of the railway track.
- A rising gradient is one in which the track rises in the direction of the movement of traffic and a down or falling gradient is one in which the track loses

- A gradient is normally represented by the distance travelled for a rise or fall of one unit. Sometimes the gradient is indicated as per cent rise or fall



TYPES OF GRADIENTS

- The following types of gradients are used on the railways.
- (a) Ruling gradient
- (b) Pusher or helper gradient
- (c) Momentum gradient
- (d) Gradients in station yards

- Generally, the following ruling gradients are adopted on Indian Railways when there is only one locomotive pulling the train.
- In plain terrain: 1 in 150 to 1 in 250
- In hilly terrain: 1 in 100 to 1 in 150

PUSHER OR HELPER GRADIENT

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

Gradients in Station Yards

- The gradients in station yards are quite flat due to the following reasons.
- (a) To prevent standing vehicles from rolling and moving away from the yard due to the combined effect of gravity and strong winds.

  (b) To reduce the additional resistive forces required to start a locomotive to the extent possible.
- It may be mentioned here that generally, yards are not leveled completely and certain flat gradients are provided in order to ensure good drainage.
- The maximum gradient prescribed in station yards on Indian Railways is 1 in 400, while the recommended gradient is 1 in 1000.

Grade Compensation on Curves

- Curves provide extra resistance to the movement of trains. As a result, gradients are compensated to the following extent on curves
- (a) On BG tracks, 0.04% per degree of the curve or 70/*R, whichever is minimum*
- (b) On MG tracks, 0.03% per degree of curve or 52.5/*R, whichever is minimum*
- (c) On NG tracks, 0.02% per degree of curve or 35/*R, whichever is minimum*

  where *R is the radius of the curve in meters. The gradient of a curved portion of the* section should be flatter than the ruling gradient because of the extra resistance offered by the curve.

PROBLEMS

- Find the steepest gradient on a 2° curve for a BG line with a ruling gradient of 1 in 200.

  Ruling gradient = 1 in 200 = 0.5%

  Compensation for a 2° curve = 0.04 × 2 = 0.08%

  Compensated gradient = 0.5 – 0.08 = 0.42% = 1 in 238

- The steepest gradient on the curved track is 1 in 238.

- To what extent should a ruling gradient of 1 in 150 on a broad gauge line be downgraded to accommodate a 3° curve?
- Ruling gradient= 1 in 150 =0.006=0.66%
- Compensation for a 3° curve in BG= 3 ×0.04%

=0.12%

Compensated gradient= 0.66-0.12= 0.54%

=0.0054

=1 in 183

CURVES

Purpose

- To bypass obstacles
- To pass a railway line through obligatory or desirable locations.
- Horizontal curves are provided when a change in the direction of the track is required and
- vertical curves are provided at points where two gradients meet or where a gradient meets level ground.

RADIUS OR DEGREE OF CURVE

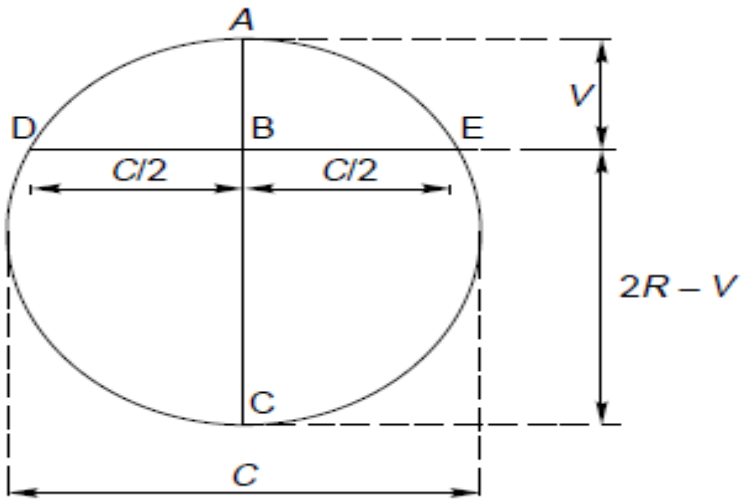
- A curve is defined either by its radius or by its degree.
- The degree of a curve (*D) is* the angle subtended at its centre by a 30.5-m or 100-ft chord.
- The value of the degree of the curve can be determined as indicated below.
- Circumference of a circle = $2\pi R$
- Angle subtended at the centre by a circle with this circumference = 360°
- Angle subtended at the centre by a 30.5-m chord, or degree of curve = $(360/ 2\pi R) *30.5$

  = 1750/R (approx, R is in meters)

- In cases where the radius is very large, the arc of a circle is almost equal to the chord connecting the two ends of the arc. The degree of the curve is thus given bythe following formulae
- *D = 1750/R (when R is in meters)*
- *D = 5730/R (when R is in feet)*
- A 5° curve, therefore, has a radius of 1750/5 = 350 m.
- ***Maximum degree of a curve*** The maximum permissible degree of a curve on a track depends on various factors such as gauge, wheel base of the vehicle, maximum permissible superelevation, and other such allied factors

VERSINE OF A CURVE

- The versine is the perpendicular distance of the midpoint of a chord from the arc of a circle
- Let *R be the radius of the curve, C be the length of the chord* and *V be the versine of a chord of length C.*



- The relationship between the radius and versine of a curve can be established as shown
- AC and DE being two chords meeting perpendicularly at a common point B,
- simple geometry can prove that

$AB \times BC = DB \times BE$

or

$V(2R - V) = (C/2) \times (C/2)$

or

- $2RV - V^2 = C^2/4$

V being very small, V^2 can be neglected. Therefore,

- $2RV = C^2/4$
- $V = C^2/8R$

V, C, and R are in the same unit, say, metres or centimeters. This general equation can be used to determined versines if the chord and the radius ofa curve are known.

SUPER ELEVATION

- It is the difference in height between the outer and the inner rail on a curve. It is provided by gradually raising the outer rail above the level of the inner rail.
- The inner rail, also known as the gradient rail, is taken as the reference rail and is normally maintained at its original level.
- The main functions of super elevation are the following:

  (a) To ensure a better distribution of load on both rails (b) To reduce the wear and tear of the rails and rolling stock

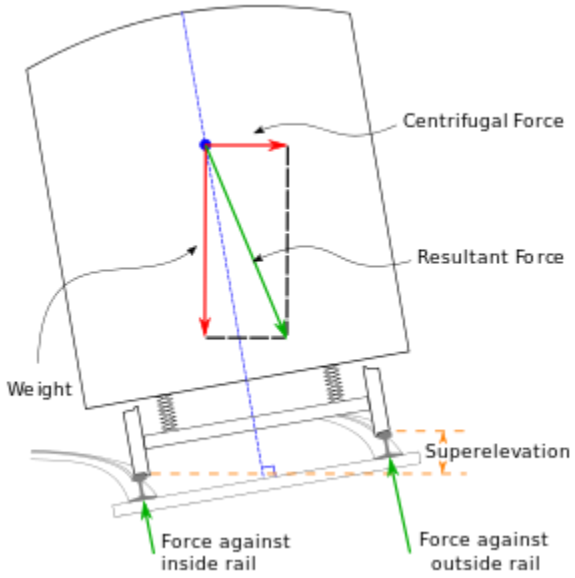
  (c) To neutralize the effect of lateral forces

  (d) To provide comfort to passengers

g is the acceleration due to gravity (meter/sec2), and

R is the radius of the curve (meters).

To counteract the effect of the centrifugal force, the outer rail of the curve is elevated with respect to the inner rail by an amount equal to the *super elevation*. A state of equilibrium is reached when both the wheels exert equal pressure on the rails and the super elevation is enough to bring the resultant of the centrifugal force and the force exerted by the weight of the vehicle at right angles to the plane of the top surface of the rails. In this state of equilibrium, the difference in the heights of the outer and inner rails of the curve known as *equilibrium super elevation*.

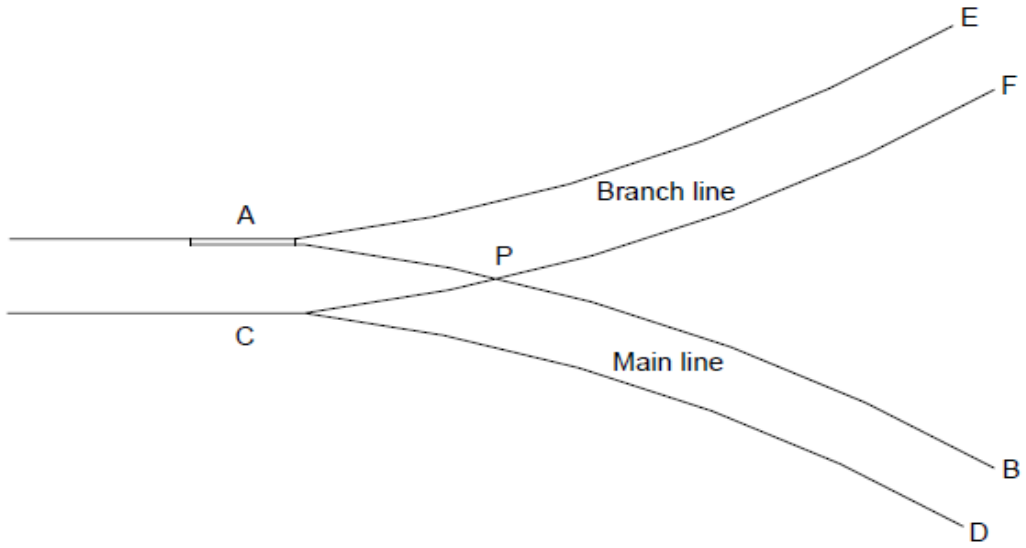

Centrifugal Force
Resultant Force
Weight
Superelevation
Force against
inside rail
Force against
outside rail

- **Cant deficiency (Cd)** It occurs when a train travels around a curve at a speed higher than the equilibrium speed. It is the difference between the theoretical cant required for such high speeds and the actual cant provided.
- **Cant excess (Ce)** It occurs when a train travels around a curve at a speed lower than the equilibrium speed. It is the difference between the actual cant provided and the theoretical cant required for such a low speed.

NEGATIVE SUPER ELEVATION

- When the main line lies on a curve and has a turnout of contrary flexure leading to a branch line, the super elevation necessary for the average speed of trains running over the main line curve cannot be provided.

- In Fig, AB, which is the outer rail of the main line curve, must be higher than CD. For the branch line, however, CF should be higher than AE or point C should be higher than point A. These two contradictory conditions cannot be met within one layout. In such cases, the branch line curve has a negativ n both tra branch



SAFE SPEED ON CURVES

- For all practical purposes safe speed refers to a speed which protects a carriage from the danger of overturning and derailment and provides a certain margin of safety. Earlier it was calculated empirically by applying Martin's formula:
- But this now not followed in Indian railways

- The maximum speed for transitioned curves is now determined as per the revised formulae given below:
- **For BG**

$$V = ((Ca + Cd) \times R / 13.76)^{1/2} = 0.27((Ca + Cd) \times R)^{1/2}$$

where *V is the maximum speed in km per hour,*

Ca is the actual cant in millimeters,

Cd is the permitted cant deficiency in millimeters,

and R is the radius in millimeters.

This equation is derived from Eqn for equilibrium super elevation and is based on the assumption that G = 1 750 mm, which is the centre-to-centre distance between the rail heads of a BG track with 52 g rails.

- **For MG**

V = 0.347((Ca + Cd) x R)1/2

For NG (762 mm.)

V = 3.65(R – 6)1/2

(subject to a maximum of 50 kmph)

Maximum sanctioned speed of the section

- **This is the maximum permissible speed authorized by the commissioner of railway safety. This is determined after an analysis of the condition of the track, the standard of interlocking, the type of locomotive and rolling stock used, and other such factors**

SWITCHES

- A **railroad switch**, **turnout** or *[set of]* **points** is a mechanical installation enabling railway trains to be guided from one track to another, such as at a railway junction or where a spur or siding branches off.

TURN OUT

- Points and crossings are provided to help transfer railway vehicles from one track to another.
- **Turnout** It is an arrangement of points and crossings with lead rails by means of which the rolling stock may be diverted from one track to another. Figure 14.1(a) shows the various constituents of a turnout.

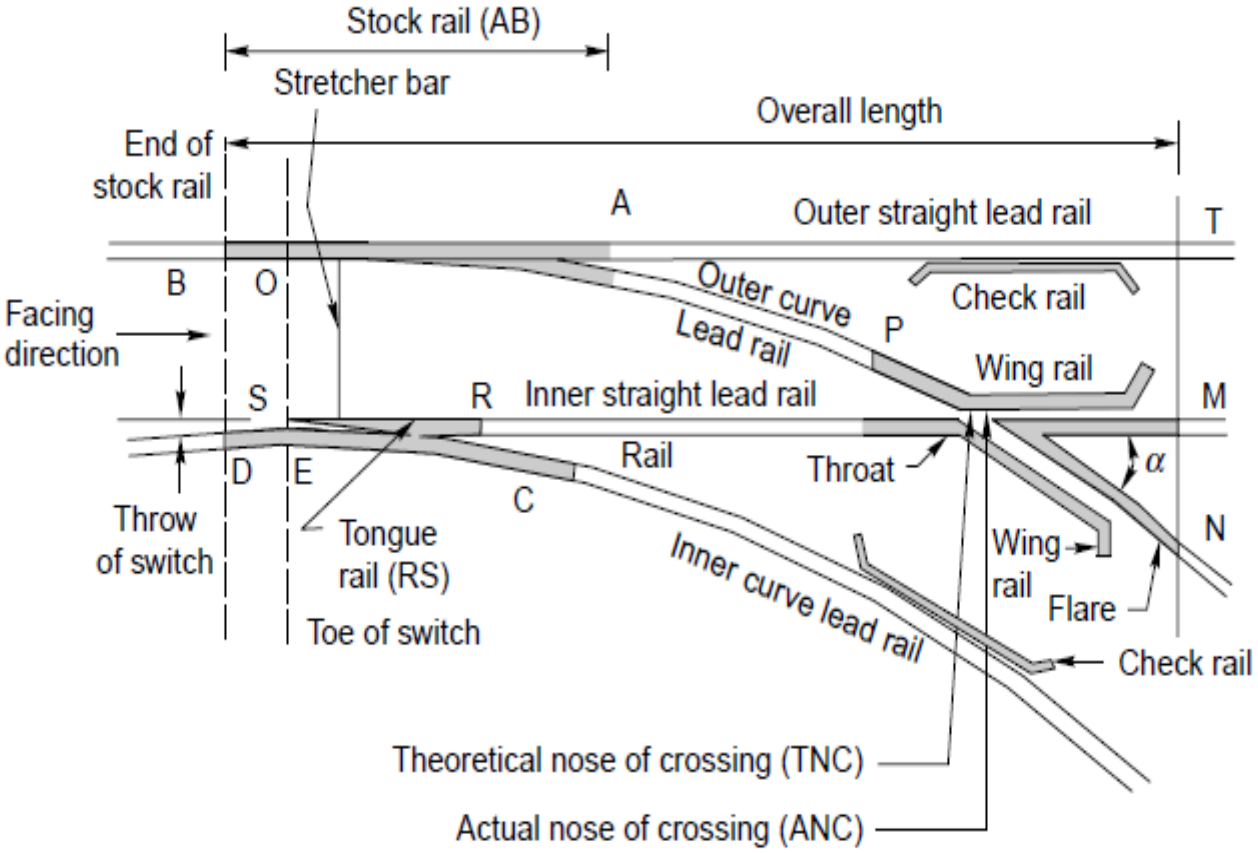


Fig. 14.1 (a) Constituents of a turnout

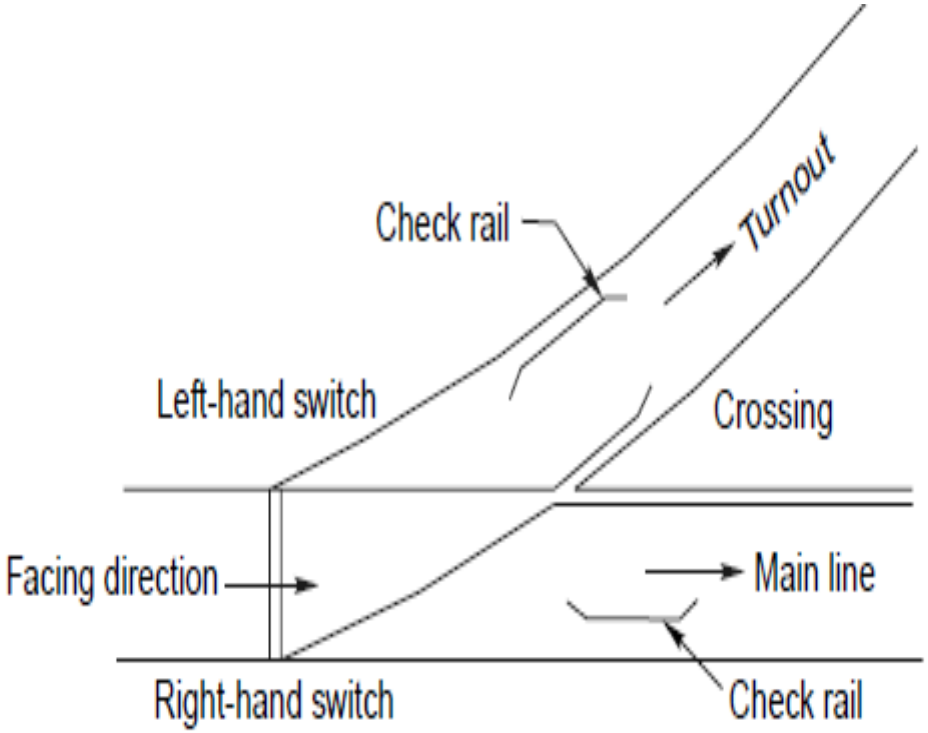
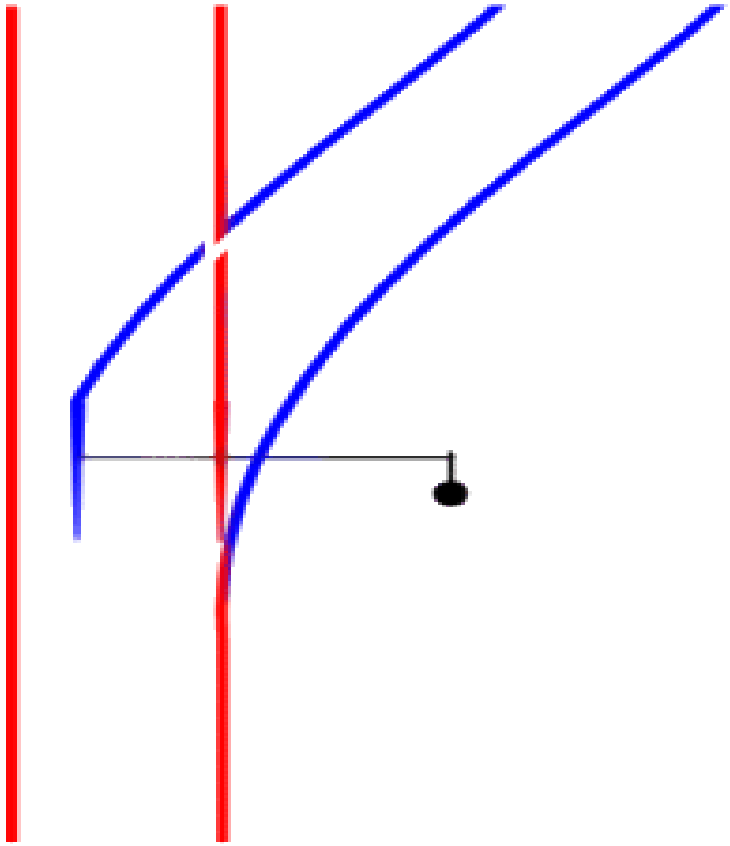


Fig. 14.1 (b) Left-hand turnout

Points or switches

- **Points (point blades)**
- The *points* (*switch rails* or *point blades*) are the movable rails which guide the wheels towards either the straight or the diverging track. They are tapered on most switches, but on *stub switches* they have square ends.
- Points or switch consists of a pair of tongue and stock rails with the necessary connections and fittings forms a switch.

POINTS



Crossing

- A crossing or *frog* is a device introduced at the point where two gauge faces cross V each other to permit the flanges of a railway vehicle to pass from one track to another
- https://www.youtube.com/watch?v=ZuR5QTlfOzk

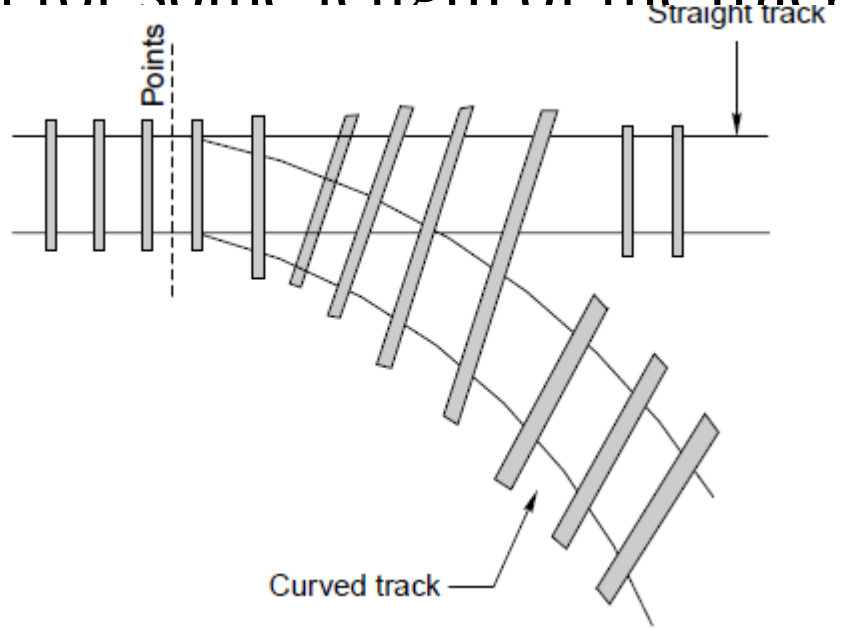
Combined rail and cast crossing

- This is a combination of a built-up and cast steel crossing and consists of a cast steel nose finished to ordinary rail faces to form the two legs of the crossing.
- Though it allows the welding of worn out wing

rails, the nose is still liable to fracture suddenly.

Position of Sleepers at Points and Crossings

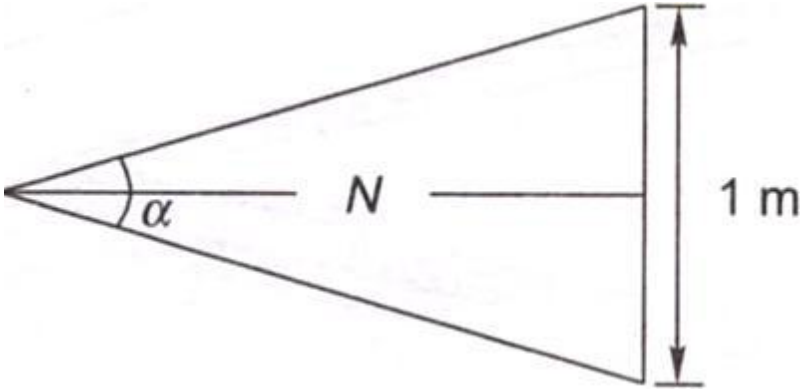
- Sleepers are normally perpendicular to the track. At points and crossings, a situation arises where the sleepers have to cater to the main line as well as to the turnout portion of the track. For this purpose, longer sleepers are used for some length of the track as shown



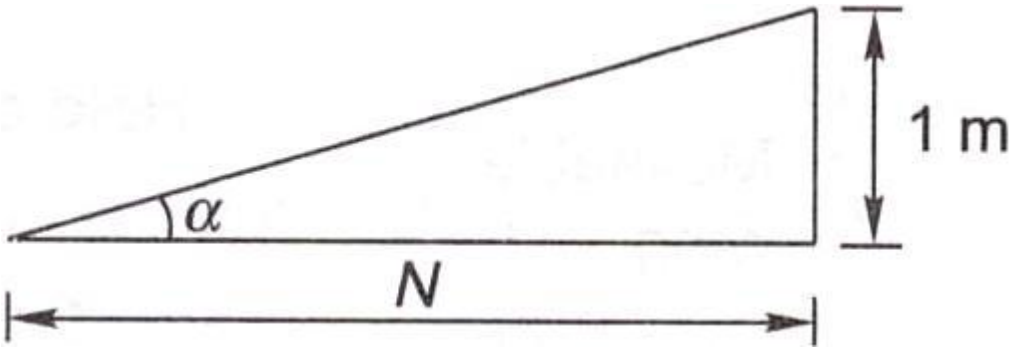
Number and Angle of Crossing

- A crossing is designated either by the angle the gauge faces make with each other or, more commonly, by the number of the crossing, represented by *N*. *There are* three methods of measuring the number of a crossing,

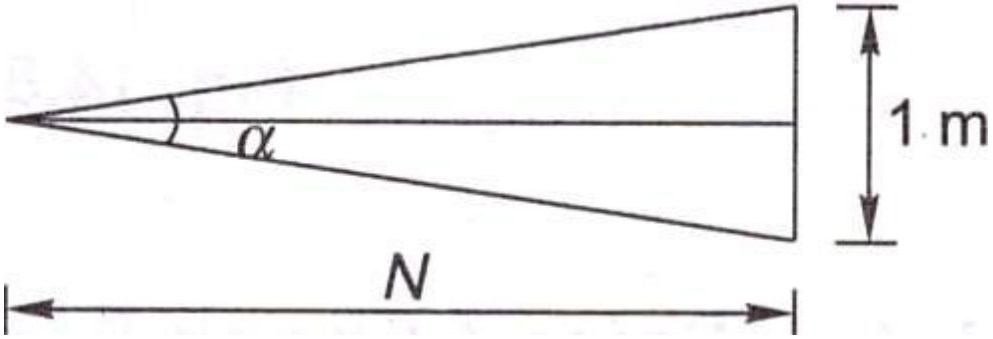
- **Centre line method** This method is used in Britain and the US. In this method, N is measured along the centre line of the crossing
- . *Cot α/2= N/(1/2)*
- N=(1/2) *Cot α/2*



- **Right angle method**
- This method is used on Indian Railways. In this method, *N* is measured along the base of a right-angled triangle. This method is also called Coles method. *Cot α= N/1*
- *or N = cot α*

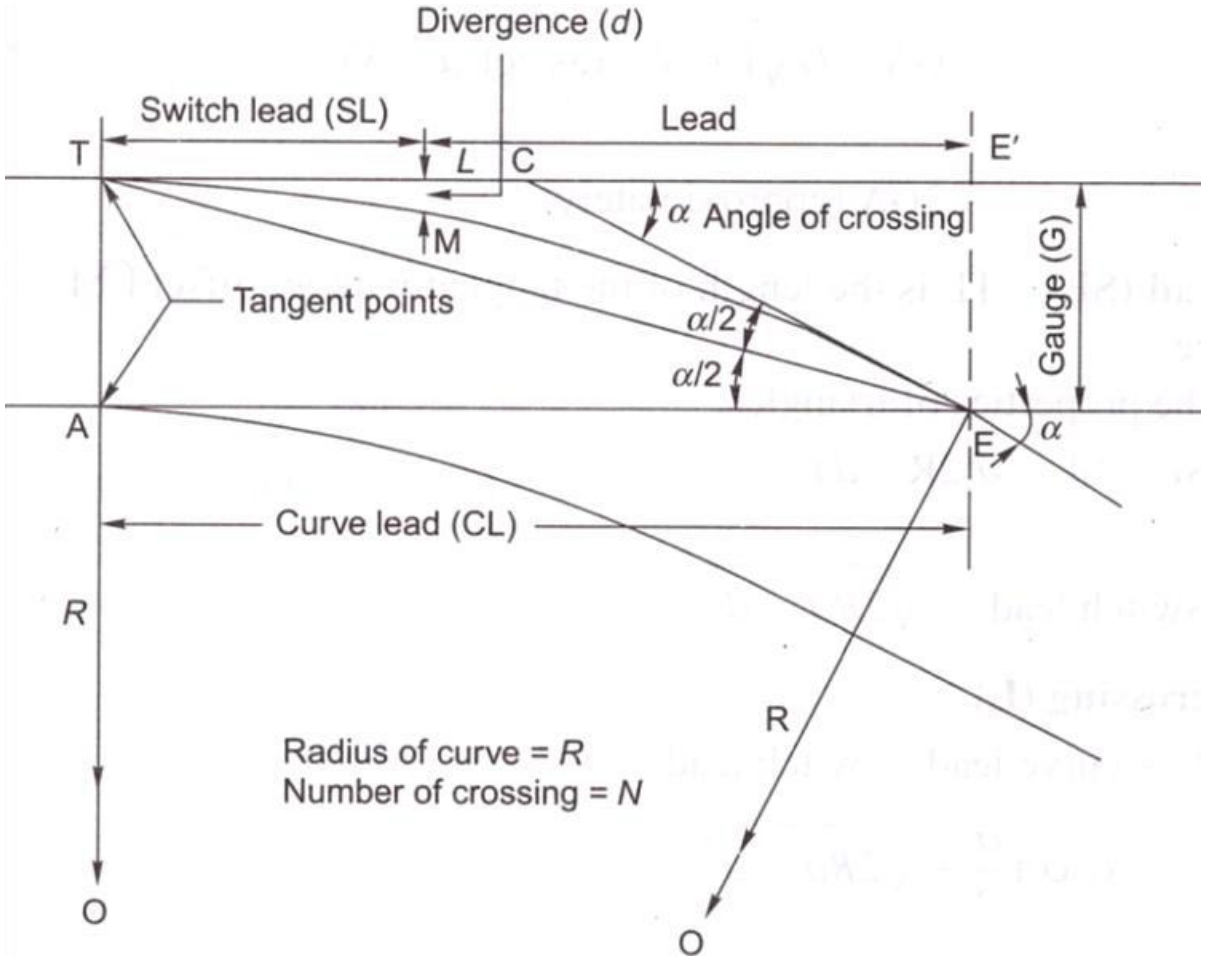


- **Isosceles triangle method**
- In this method, N is taken as one of the equal sides of an isosceles triangle.



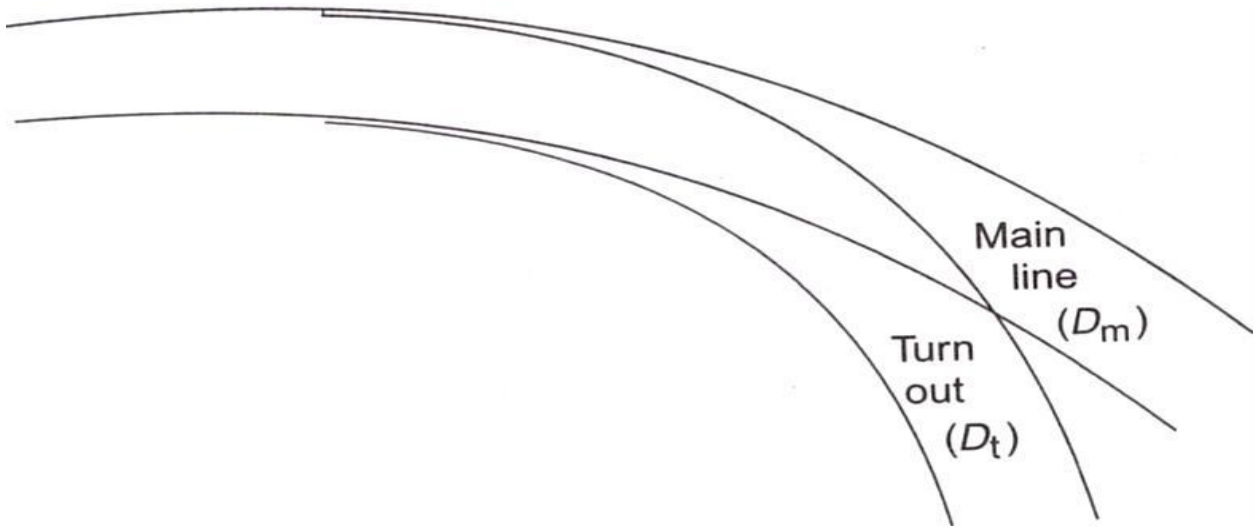
- Sin α/2 = ½ /N or N = 1/2N
- Cosec α/2 = 2N
- N = ½ Cosec α/2

- **Heel divergence (d)** This is the distance between the main line and the turnout side at the heel.
- **Angle of crossing (α)** This is the angle between the main line and the tangent of the turnout line.


Divergence (d)
Switch lead (SL)
Lead
T
L
C
E'
α Angle of crossing
M
Tangent points
α/2
α/2
Gauge (G)
A
E
α
Curve lead (CL)
R
R
Radius of curve = R
Number of crossing = N
O
O

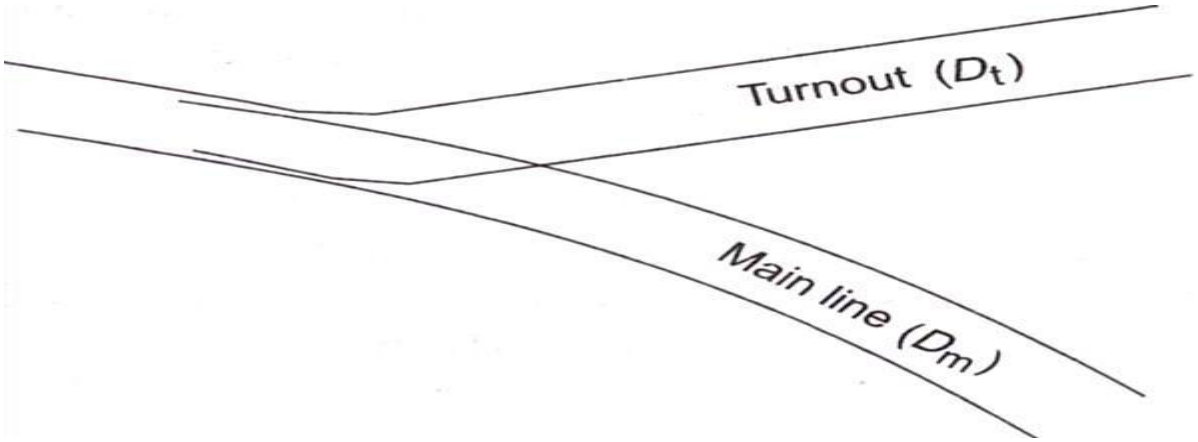
TURNOUT OF SIMILAR FLEXURE

- A turnout of similar flexure (Fig.) continues to run in the same direction as the main line curve even after branching off from it. The degree of the turnout curve will be higher than that of the main line curve.



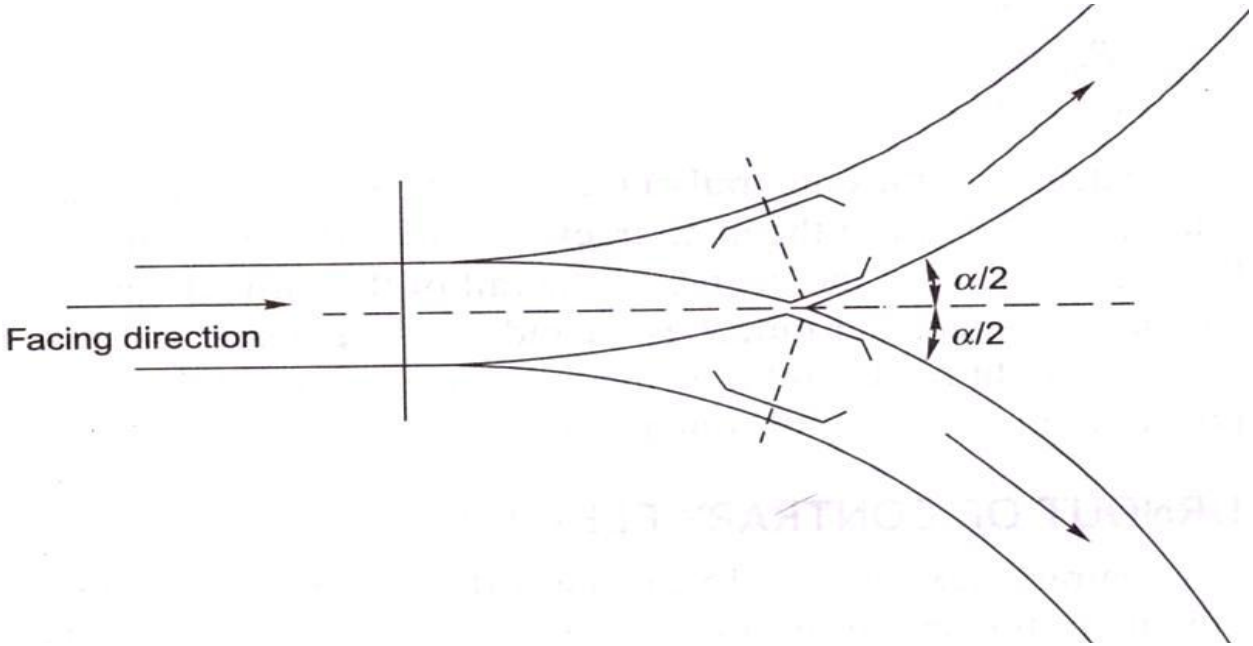
TURNOUT OF CONTRARY FLEXURE

- A turnout of contrary flexure (Fig) takes off towards the direction opposite to that of the main line curve



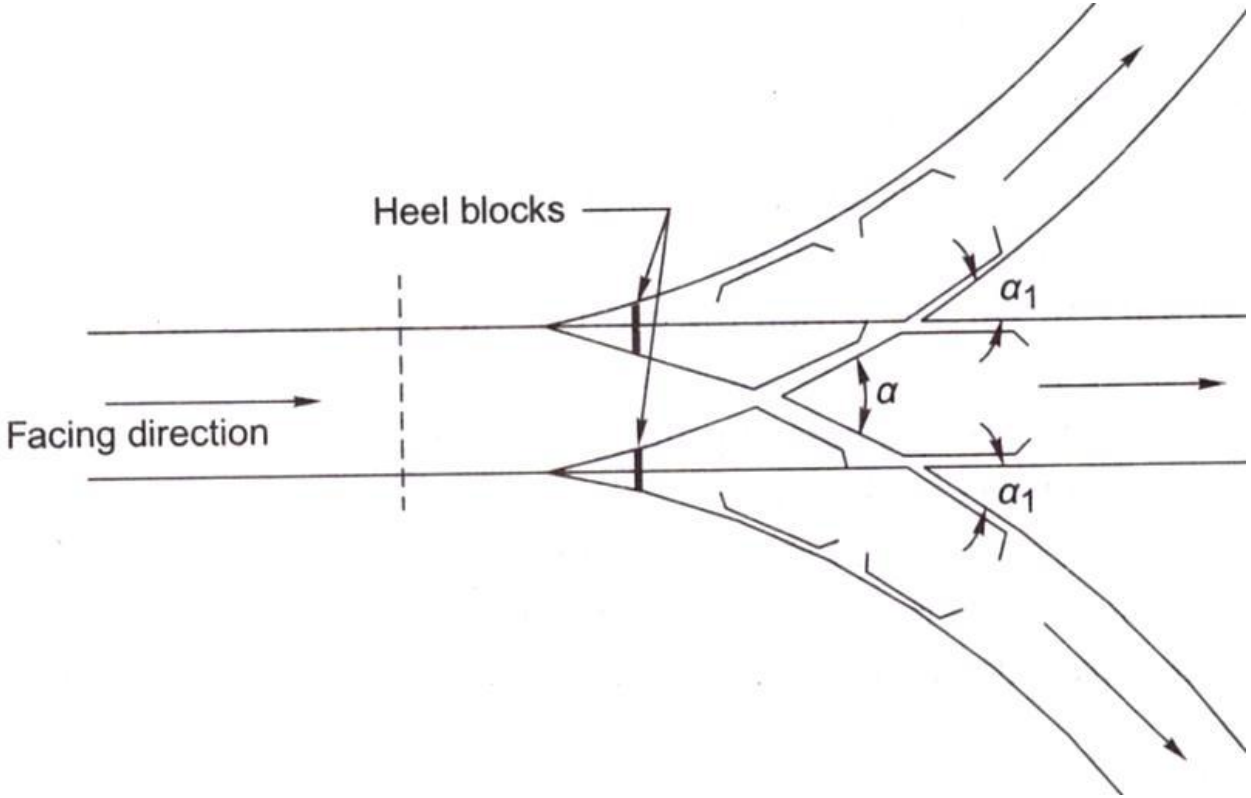
SYMMETRICAL SPLIT

- When a straight track splits up in two different directions with equal radii, the layout is known as a symmetrical split
- In other words, a symmetrical split is a contrary flexure in which the radii of the two curves are the same.

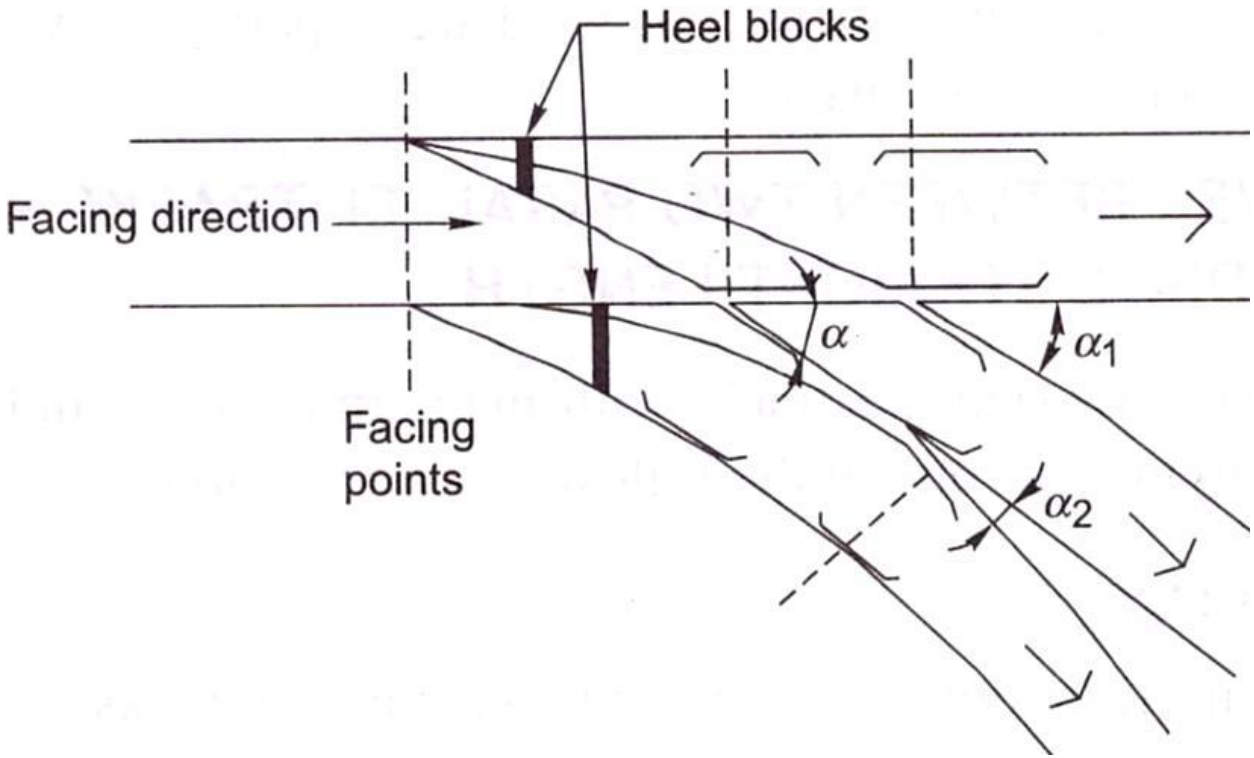


THREE-THROW SWITCH

- In a three-throw arrangement, two turnouts take off from the same point of a main line track

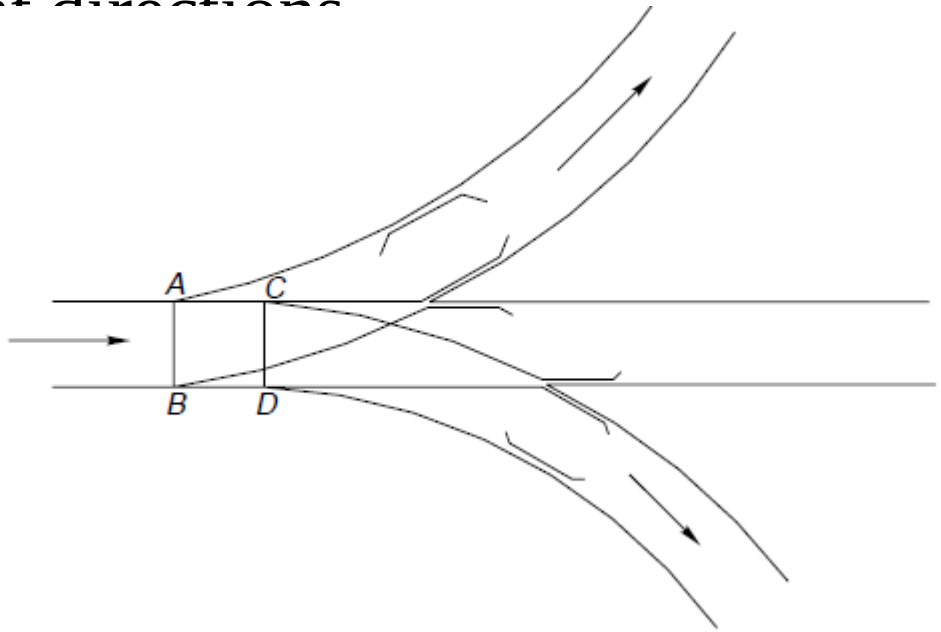


- Three-throw switches are used in congested goods yards and at entry points to locomotive yards, where there is a great limitation of space.
- A three-throw switch can have contrary flexure or similar flexure, as shown

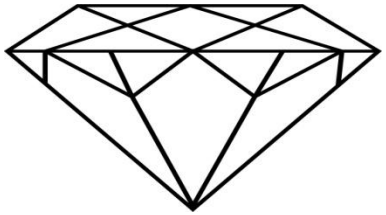


- A three-throw switch has two switches and each switch has two tongue rails placed side by side.
- The switches can be operated in such a way that movement is possible in three different directions, i.e., straight, to the right, and to the left.

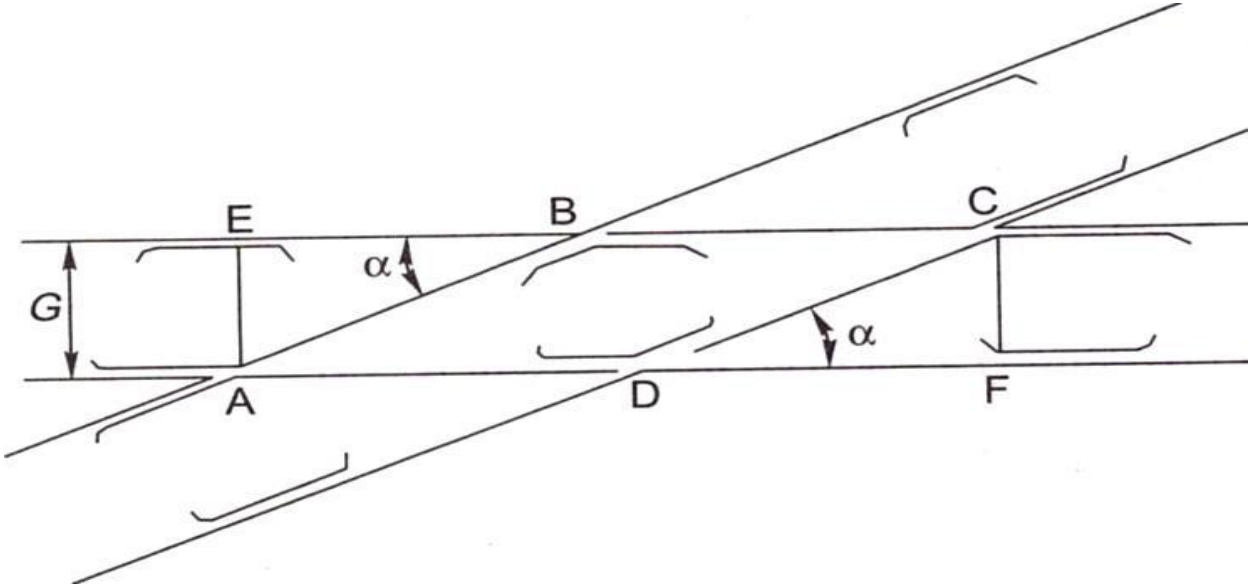
- Double turnouts are mostly used in congested areas, particularly where traffic is heavy, so as to economize on space.
- Double turnouts can be of similar flexure, when the two turnouts take off on the same side of track or of contrary flexure, when the two turnouts take off in two different directions.



DIAMOND CROSSING



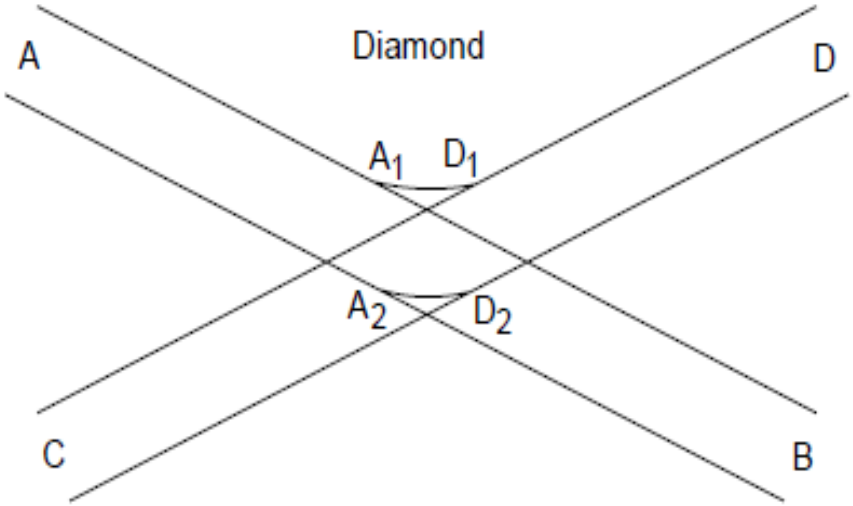
- A diamond crossing is provided when two tracks of either the same gauge or of different gauges cross each other. It consists of two acute crossings (A and C) and two obtuse crossings (B and D).

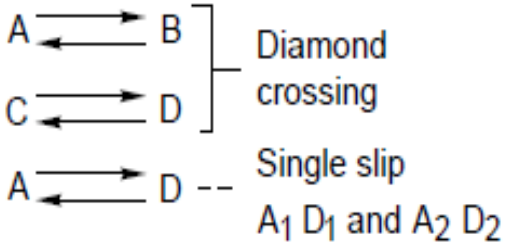


DIAMOND CROSSING

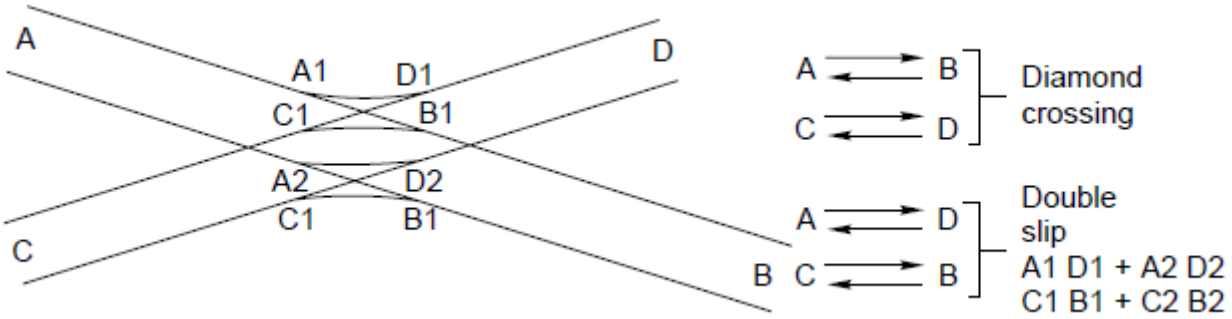

Diamond Crossing At Bhusaval

SINGLE SLIP


Diamond
A
D
A_1
D_1
A_2
D_2
C
B


A
B
C
D
Diamond crossing
A
D
Single slip
A_1 D_1 and A_2 D_2

DOUBLE SLIP


A
D
A1
D1
C1
B1
A2
D2
C1
B1
C
B
A
B
C
D
Diamond
crossing
A
D
B
C
B
Double
slip
A1 D1 + A2 D2
C1 B1 + C2 B2

SIGNALLING SYSTEMS

Component	***Mechanical***	***Electrical***
Operated units signals	Mechanically operated signals as per lower quadrant or upper quadrant and modified lower quadrant signalling	Coloured light signals with two- aspect, three-aspect or four-aspect signalling
Points	Mechanically operated points; locking with the help of point locks, stretcher bars, and detectors	Electrically operated points (by converting the rotary movement of electric motors into linear push or pull); locking with the help of slides and solid rods
Level crossing gates	Interlocking of manually operated swing leaf gate or operation and Interlocking of mechanically operated lifting barriers	Operation and Interlocking of electrically operated lifting barriers
Transmission systems	Single or double wire transmission to the requisite points by means of rods or double wires	Electrical transmission through overhead wires or underground cables
Operating units	Hand levers with a range of 500 to 2000 m used in collaboration with single wire or double wire lever frames	Push buttons, rotary switches, or electrical signalling equipment
Interlocking units	Mechanical interlocking with plungers attached with levers and tappets moving across in a locking trough	Interlocking through electromagnetic switches known as relays or solid-state switching devices
Monitoring units	Monitoring of points with the help of mechanical detectors; monitoring of the passage of trains using a treadle, which is an electro-mechanical device	Monitoring with the help of direct current track circuits, alternating current track circuits, electronic track circuits, axle counters, etc.

UNIT3

AIRPORT ENGINEERING

Airport Classification

- Airports are presently classified in the following manner:
- International Airports
- Custom Airports:
- Model Airports:
- Other Domestic Airports:
- Civil Enclaves in Defense Airport:

MAJOR PROBLEMS FACED BY AIRLINES

- Need for replacement of old Aircrafts
- Congestion at airports
- Inadequacy of infrastructure
- Shortage of trained personnel

AIRCRAFT CHARACTERISTICS THAT GOVERN AIRPORT DESIGN

- Aircraft characteristics which govern design of airport are
- Speed
- Size and dimensions
- Weight, Landing gear and Tire pressure

Runway Configurations

- The term ―runway configuration‖ refers to the number and relative orientations of one or more runways on an airfield. Many runway configurations exist. Most configurations are combinations of several basic configurations. The basic configurations are
- single runways,
- parallel runways,
- intersecting runways, and
- open-V runways.

The basic runway length is determined form the performance characteristics of aircraft using airport. The following cases are usually considered

- Normal landing case
- Normal takeoff case
- Engine failure case

passenger terminal system

- The passenger terminal system is the major connection between the ground access system and the aircraft. The purpose of this system is to provide the interface between the passenger airport access mode, to process the passenger for origination, termination, or continuation of an air transportation trip, and convey the passenger and baggage to and from the aircraft.

UNIT4

- PORTS AND HARBOUR ENGINEERING

INTRODUCTION

- **Water Transportation** is concerned with conveyance of people and goods in vehicles that float upon water.
- **Waterways** have great historic importance in the development of civilizations and in the growth of nations.
- Rivers and seas provided primitive man with his first facility for **mass transportation of goods**.
- Waterways can be classified broadly as ***Oceanic waterways*** **and** ***inland waterways*****.**

- ***Oceanic waterways*** are concerned with the conveyance of people and goods primarily across the ocean between continents or island.
- ***Inland waterways*** consist of water transportation on rivers, lakes and canals within the main land.
- River transportation became popular in **India since 1855**.
- The total perennial waterways in India are **65,600 km** out of which **41,600 km** are of rivers and **24,000 km** canals.

ADVANTAGES OF WATER TRANSPORTATION

- **Around the world 82%** of International trade in tons and **94% of world trade** in tons-kilometers are moved by shipping and thereby through ports.
- Specific function, objectives and the advantages derived from water transportations facilities are summarized below:

- ❑ Easiest and cheapest mode of communication by utilization of natural surfaces of canals, rivers and oceans, as the element of friction during traction and maintenance are less than road transport.
- ❑ Require cheap manual, wind and steam motive power.
- ❑ Higher load carrying capacity **for bulky and heavy commodities**.
- ❑ Development of industry.
- ❑ Development of **commerce and expansion of trades**.

- Development of **agriculture.**
- Development of **natural resources and their effective use**.
- Discovery of **new island is possible**.
- Development of economic progress and international contact.
- Provide **enhanced mobility** and **promotes social and political unity.**
- Assistance in the problem of national defense.

DISADVANTAGES OF WATER TRANSPORTATION

- It requires **more time** due to slow speed and circuitous routes. Final docking stages require greater skill.
- Mountainous rivers and waterfalls hinder water transportation. **Require better position fixing and obstruction** detecting systems to avoid surface collision.
- Frequent storms results in great **loss of life and material.**
- **Rapid growth** in demand which is more than the **capacity of existing facilities.**
- **Vessels** oil spillage, noise smoke and fumes cause **pollution and endanger marine lives.**
- Uncertainty problem, **like energy shortage problem** due to political and natural causes.
- **Energy conservation** concern because of energy problem of transportation development.

MODERN TRENDS IN WATER TRANSPORTATION

- Integration of transportation system and the environment.
- Application of system analysis.
- Optimization using operations research techniques.
- Computer application for data processing and analysis.
- Minimization of energy use.
- Increased utilization and efficiency of existing facilities.
- Compatibility between water transportation and other modes through the use of innovative equipments.

ENVIRONMENTAL IMPACT SYSTEM (EIS)

1. Determine Existing Conditions
2. Predict Future Effects
3. Consider Alternatives
4. Present Resource Commitments
5. Identify Environmental Monitoring Processes to be used if action is implemented.

PORT AUTHORITIES, BODIES AND ASSOCIATIONS

- National Association of port Authorities
- National Coast Guard
- National Bureau of Customs
- Immigration and Naturalization Service
- National maritime Administration
- The Bureau of Foreign Commerce
- Interstate Commerce Commission
- Department of Agriculture
- Quarantine
- Security Associations
- Waterfront Commissions

HARBOUR & PORT:-

- **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.

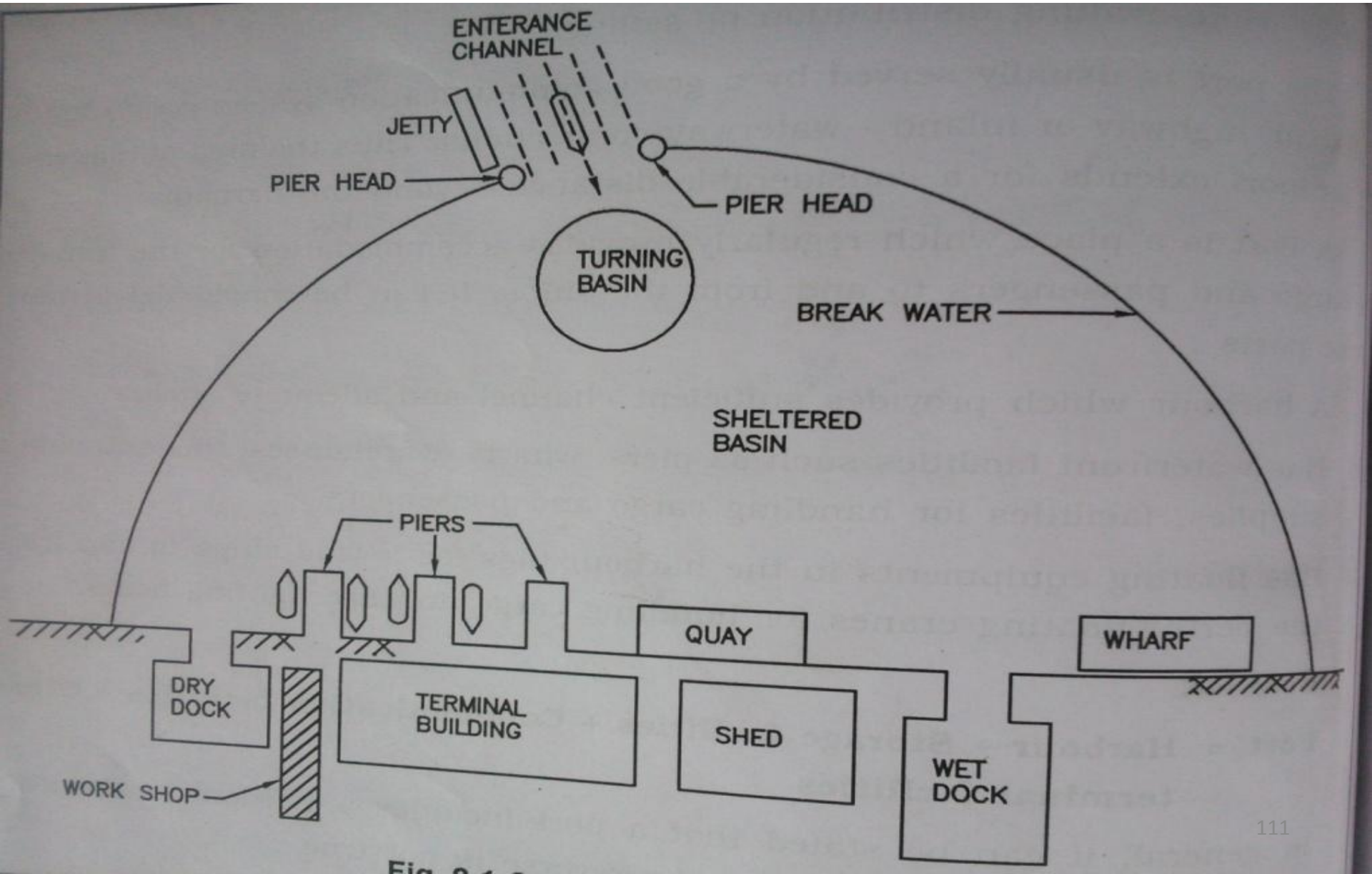
  A port is a place which regularly provides accommodation for the transfer of cargo and passengers to and from the ships.

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

From above,

It can be stated that a port includes a harbour i.e. every port is a harbour.

Harbour Components:-



Harbour Components:-

- ✓Entrance Channel
- ✓Break Water
- ✓Turning Basin
- ✓Shelter Basin
- ✓Pier
- ✓Wharf
- ✓Quay
- ✓Dry Dock
- ✓Wet Dock
- ✓Jetty

HARBOUR COMPONENTS:-

- **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.

- **BREAK WATER:-**

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

- **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.

- **SHELTER BASIN:-**

  It is area protected by shore and breakwater.

HARBOUR COMPONENTS:-

- **PIER:-**

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

- **WHARF:-**

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

- **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.

- **DRY DOCK:-**

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

HARBOUR COMPONENTS:-

- **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.

- **JETTY:-**

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

- **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.

- **DRY DOCK:-**

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

Requirements Of Good Harbour:-

- ✓ It should be connected with roadway and railway.
- ✓ Surrounding land should be fertile and densely populated.
- ✓ Ship channels must have sufficient depth for draft or vessel.
- ✓ Breakwaters must be provided to protect against destructive wave action.
- ✓ The bottom should furnished secure anchorage to hold ships against the wind force.
- ✓ Numbers of quay, piers and wharfs should be sufficient for loading and unloading cargo.
- ✓ It should have facilities like fuel, repair and etc. for ships.
- ✓ Harbour area should be sufficiently large.
- ✓ It should have enough cold storage.

Classification Of Harbours:-

- **CLASSIFICATION BASED ON THE PROTECTION NEEDED**
  - ✓**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)**

Classification Of Harbours:-

- **CLASSIFICATION BASED ON THE PROTECTION NEEDED**
  - ✓**Artificial Harbour:-**

An artificial harbour is one which is manmade and protected from storms and waves by engineering works.

(Eg. Chennai Harbour)

Classification Of Harbours:-

- **CLASSIFICATION BASED ON UTILITY**
  - ✓**Commercial Harbour:-**

    It is an harbour in which docks are provided with necessary facilities for loading and unloading of cargo.

    (Eg. Chennai Harbour)

  - ✓**Refuge Harbour:-**

    These are used as a heaven for ships in a storm or it may be part of a commercial harbour.

    (Eg. Chennai Harbour & Visakhapatnam Harbour)

Classification Of Harbours:-

- **CLASSIFICATION BASED ON UTILITY**

✓**Military Harbour:-**

It is a naval base for the purpose of accommodating naval ships or vessels and it serves as a supply depot.

(Eg. Mumbai Harbour & Cochin Harbour)

✓**Fishing Harbour:-**

These harbours have facilities for departure and arrival of fishing ships. They have also necessary arrangement to catch fish.

Classification Of Harbours:-

- **CLASSIFICATION BASED ON LOCATION**

  - ✓Ocean Harbour
  - ✓River Harbour
  - ✓Canal Harbour
  - ✓Lake Harbour

Classification Of Ports:-

✓**Ocean Port:-**

This is a port intended for large ocean going ships.

✓**River Port:-**

River port is located on the banks of the river inside the land.

✓**Entry Port:-**

This is location where foreign citizens and goods are cleared through custom house.

✓**Free Port:-**

This is an isolated and enclosed area within which goods may be landed, stored, mixed, repacked, manufactured and reshipped without payment of duties.

Harbour Planning:-

Harbour Planning:-

- ✓It is necessary to carry out a topography survey of the neighborhood including the foreshore and the depths of water in the vicinity.
- ✓The borings and soundings should be taken to ascertain the character of the ground.
- ✓The borings on land should also be made so as to know the probable subsurface conditions on land. It will be helpful in locating the harbour works correctly.
- ✓The nature of harbour, whether sheltered or not, should be studied.
- ✓The existence of sea insects which undermine the foundations should be noted.
- ✓The problem of silting or erosion of coastline should be carefully studied.
- ✓The natural meteorological phenomena should be studied at site especially with respect to frequency of storms, rainfall, range of tides, maximum and minimum temperature, direction and intensity of winds, humidity, direction and velocity of currents, etc.

Site Selection For Harbour:-

Great care ahs to be exercised at the time of making selection of site for a harbour. The guiding factors which play a great role in choice of site for a harbour are as follows:

- ✓Availability of cheap land and construction material;
- ✓Transport and communication facilities;
- ✓Natural protection from winds and waves;
- ✓Industrial development of the locality;
- ✓Sea – bed, subsoil and foundation conditions;
- ✓Traffic potentiality of harbour;
- ✓Availability of electrical energy and fresh water;
- ✓Favorable marine conditions;
- ✓Defense and strategic aspects; etc.

Size Of Harbour:-

Size of harbour depends upon the number and size of ships likely to use the harbour at one time. Some of the biggest modern ships are 275m to 300m long and about 30m wide. There should be sufficient area for maneuvering them without collision. Thus, the size is determined by:

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

Size Of Harbour:-

❑WIDTH OF ENTRANCE TO THE HARBOUR:-

The entrance width should be in proportion to the size of the harbour and ships using it. To reduce the wave height with in the harbour, the entrance width should not be more than that necessary to provide safe navigation and also to prevent dangerous currents, when the tide is coming in and going out.

- ✓**For Small Harbours = 90m**
- ✓**For Medium Harbours = 120 to 150m**
- ✓**For Large Harbours = 150 to 250m**

BREAKWATER

Breakwater is a **protective barrier** constructed to form an artificial harbour with a water area so **protected from** the effect of **sea waves** as to **provide safe accommodation for shipping.**

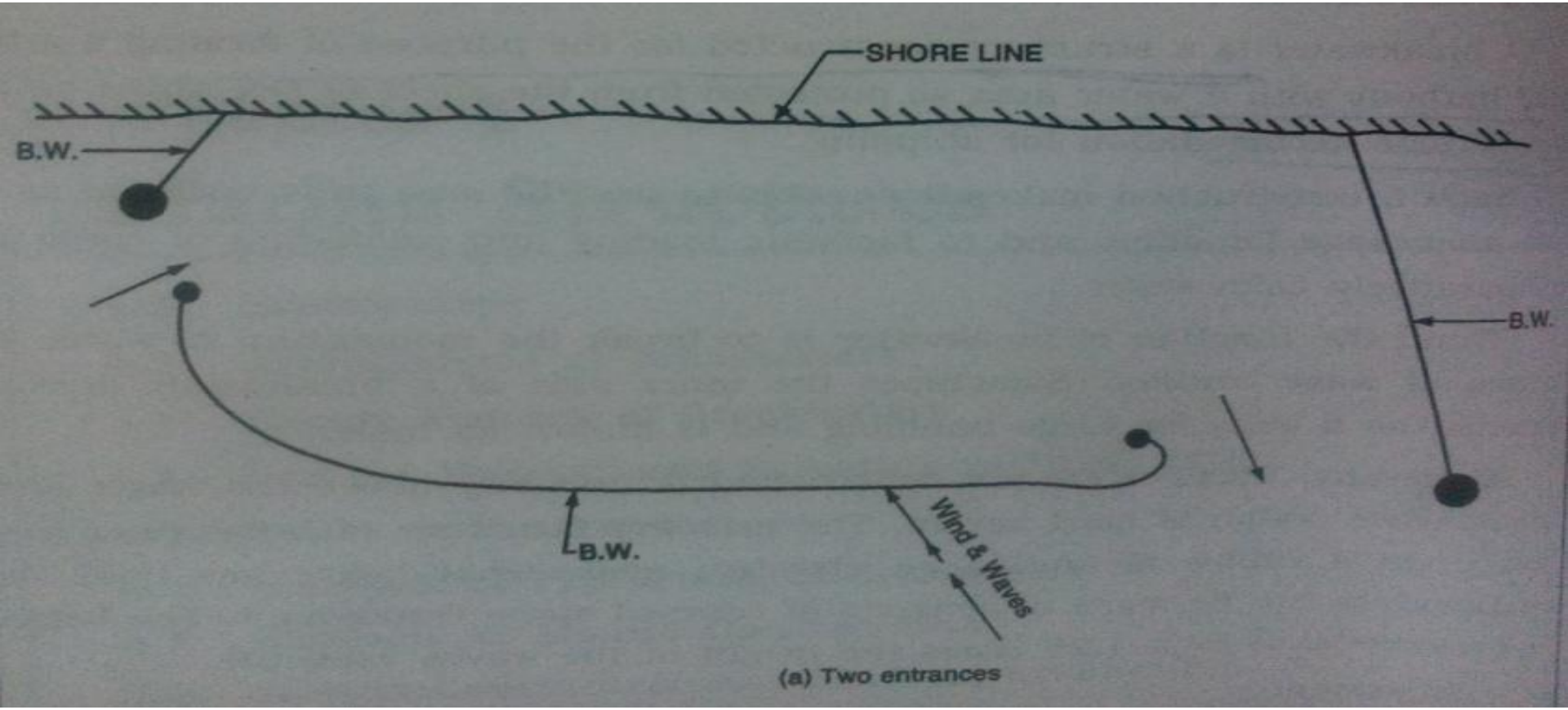
➢ **Alignment Should be…..**

- ✓ As straight as possible
- ✓ Intersection angle not >60°
- ✓ In open sea, alignment should be curved to reduce the effects of waves.

BREAKWATER (CONTI...)

BREAKWATER (CONTI...)

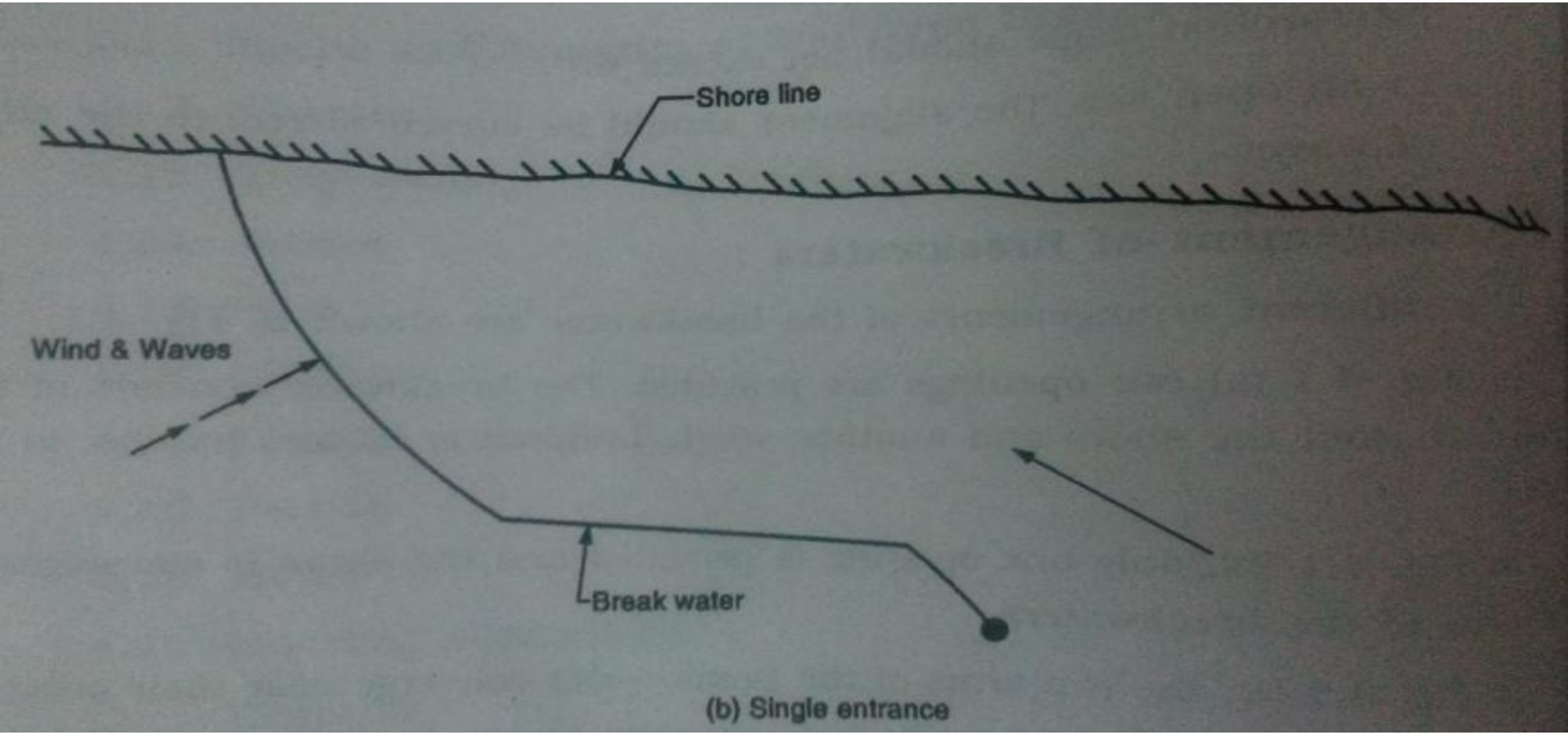
- **Arrangement of Breakwater:-**



Having Two Entrance Gate

BREAKWATER (CONTI...)

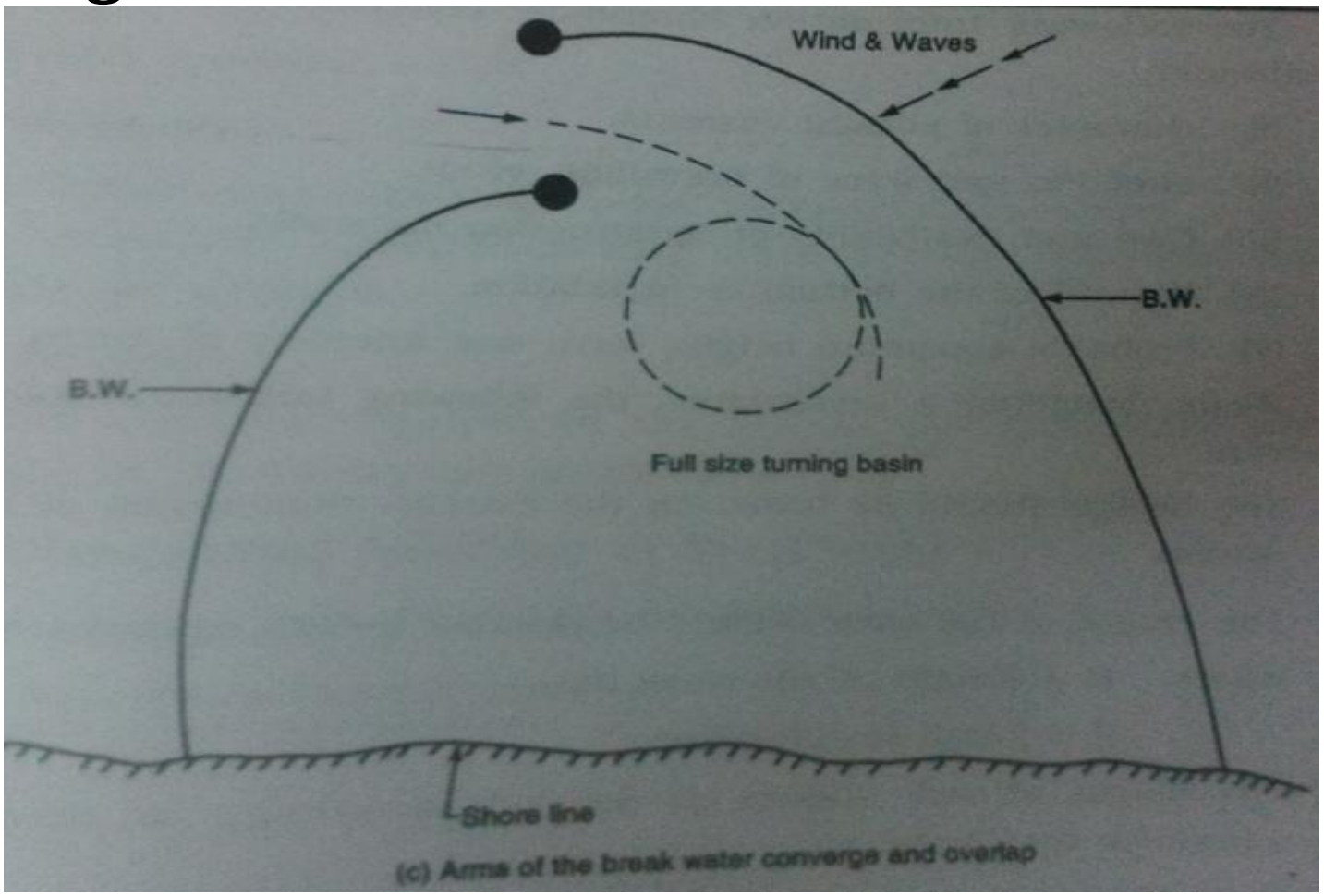
- **Arrangement of Breakwater:-**



Having One Entrance Gate

BREAKWATER (conti…)

- **Arrangement of Breakwater:-**



Arms of the Breakwater Converge and Overlap

BREAKWATER (conti…)

❑ Design Process of Breakwater:-

➢ Pre-feasibility Stage:-

- ✓ What is required?

➢ Feasibility Stage:-

- ✓ Suitable data Collection
- ✓ Initial Design
- ✓ Cost/Benefit Analysis

BREAKWATER (conti…)

❑ Design Process of Breakwater:-

➢ Detailed Design Stage:-

- ✓ Further data collection,
- ✓ Refined design parameters,
- ✓ Final design,
- ✓ Model test,
- ✓ Preparation of drawing and specification.

➢ Construction Stage:-

- ✓ Monitoring & Maintenance

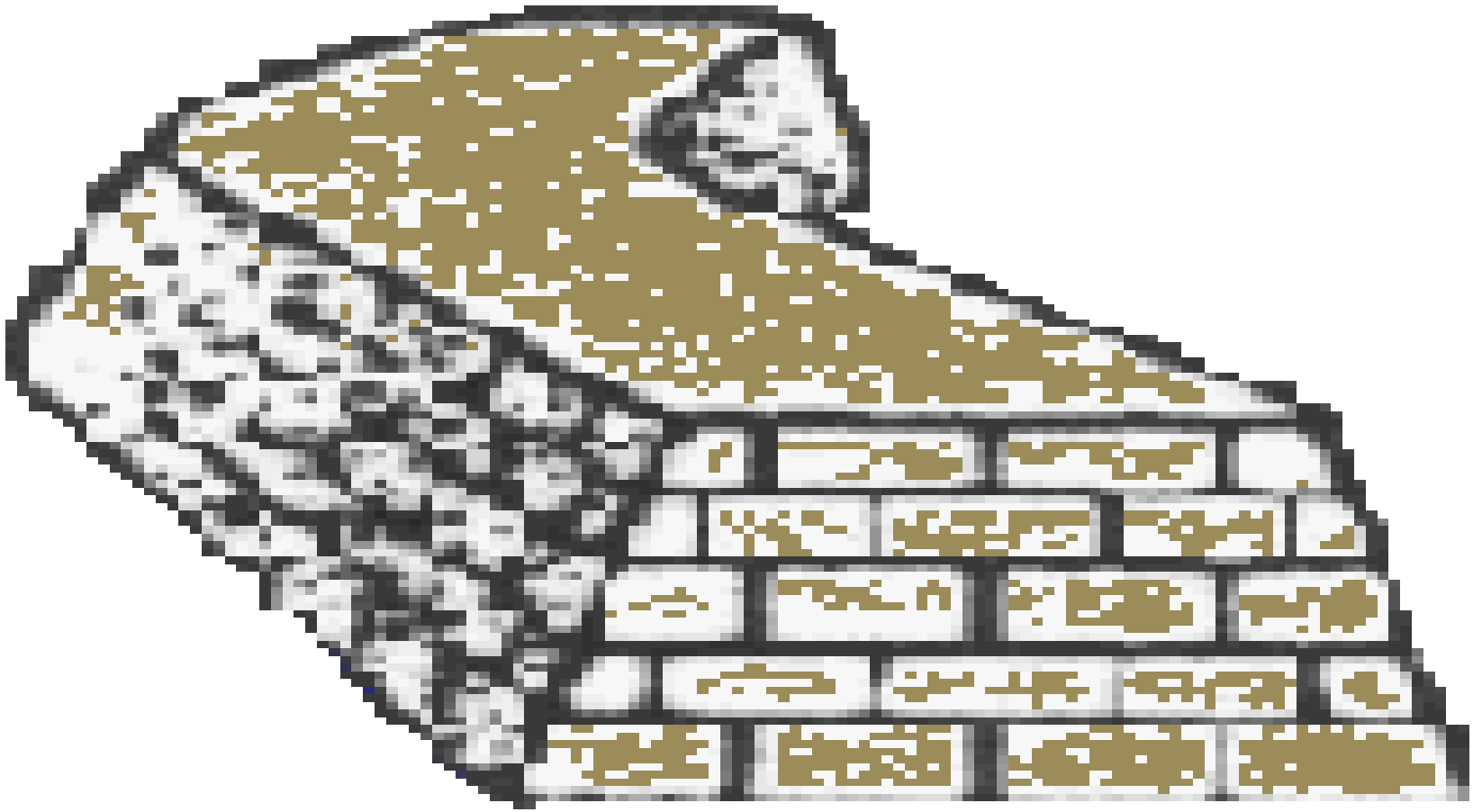
BREAKWATER (CONTI…)

- **Factors Determining Selection of Breakwater:-**

  - ✓ Availability of Construction Material
  - ✓ Depth of Water
  - ✓ Condition of Sea Foundation
  - ✓ Availability of Equipment

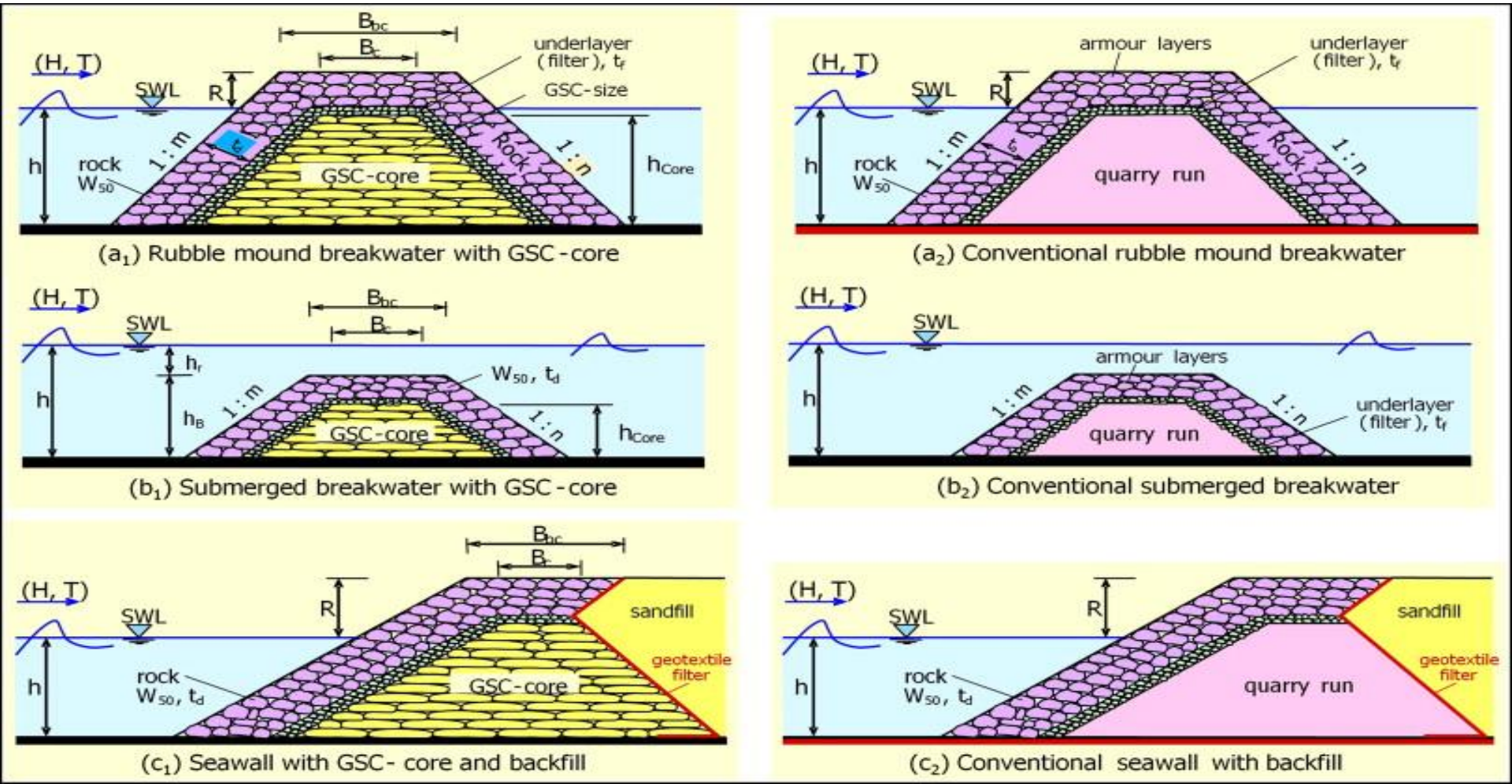
BREAKWATER

- **Vertical Wall Type Breakwater:-**



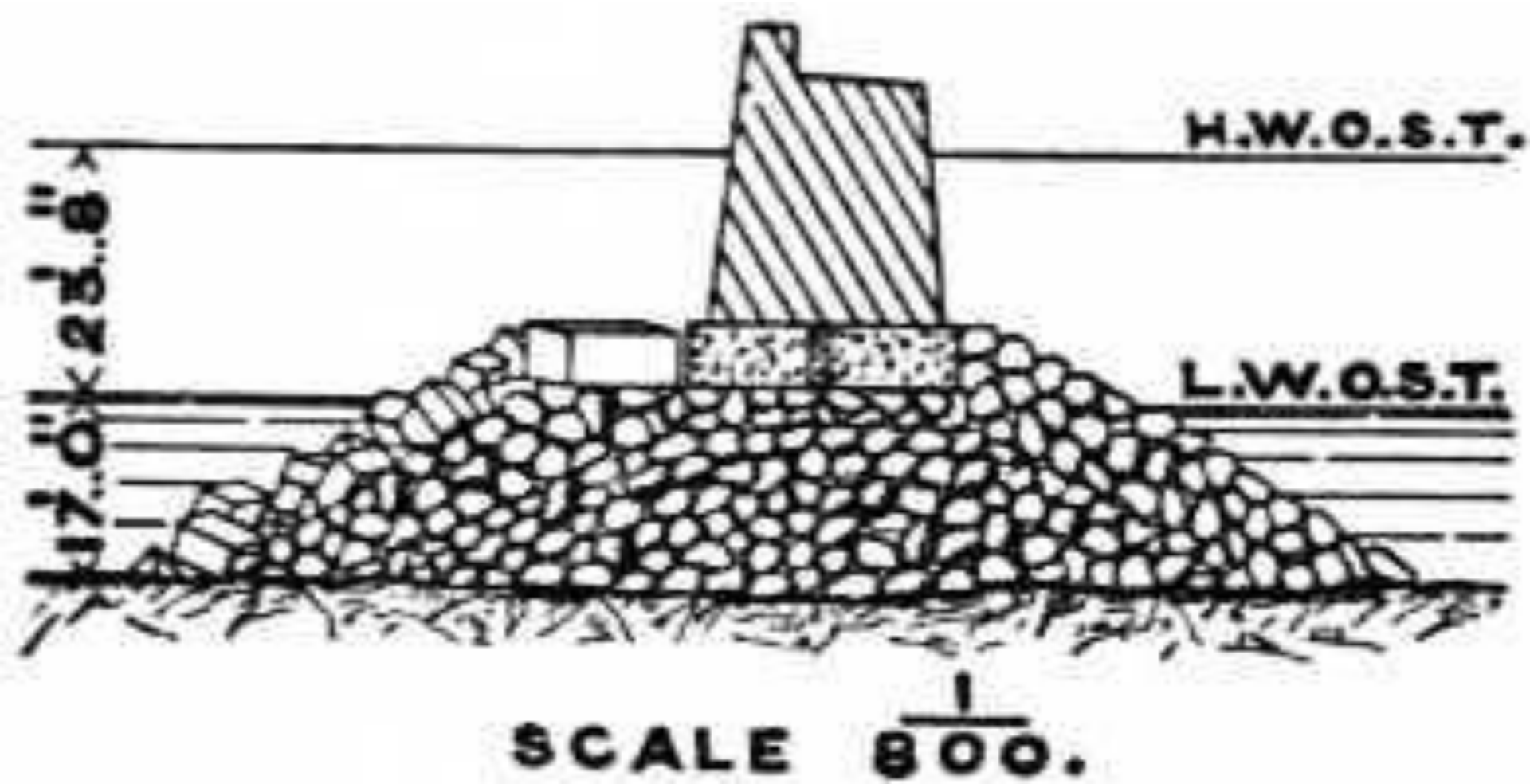
BREAKWATER

❑ Rubble Mound Type Breakwater:-



BREAKWATER

- **Composite Type Breakwater:-**

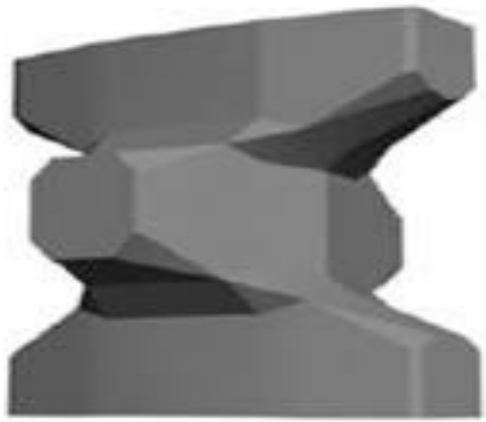


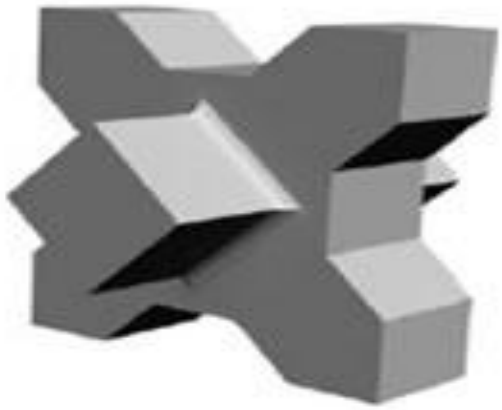
BREAKWATER

- **Methods of Protection of Breakwater:-**

  - ✓ By arrangement of heavy concrete blocks,
  - ✓ By paving using granite blocks,
  - ✓ Using tetrapodes and tribars.


Tetrapod


Accropode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BREAKWATER

❑ **Comparison of Mound type & Vertical Wall type Breakwater:-**

Mound Type	Vertical Wall Type
Wave breaks at the breakwater.	Reflect the wave energy.
Large entrance.	Narrower entrance.
Regular maintenance necessary.	Maintenance is practically eliminated.
Can be constructed on any type of foundation.	Require a firm foundation.
Recommended where plenty of rocks available.	Recommended when there is shortage of rock.
Require unskilled labour.	Require skilled labour.

BREAKWATER (CONTI…)

- **Merits of Mound type Breakwater:-**

  - ✓ No special equipment needed,
  - ✓ Require unskilled labour,
  - ✓ Large size rubbles can be used without dressing,
  - ✓ Constructed on any type of foundation,
  - ✓Construction is porous, hence no possibility of uplift.

BREAKWATER (CONTI…)

- **Demerits of Mound type Breakwater:-**

  - ✓ Require huge quantity of material,
  - ✓ Initial cost high,
  - ✓Regular maintenance,
  - ✓ Harbour side can not be used for mooring ships,
  - ✓ Occupancy large area of basin.

BREAKWATER (CONTI…)

- **Merits of Wall type Breakwater:-**

  - ✓ Narrower entrance, hence greater protection to the sheltered area,
  - ✓ Harbour side of the breakwater can be used for mooring ships,
  - ✓ recommended where shortage of rock,
  - ✓ Maintenance is practically eliminated,
  - ✓ It increase size of harbour basin,
  - ✓ Reduces the amount of material.

BREAKWATER (CONTI…)

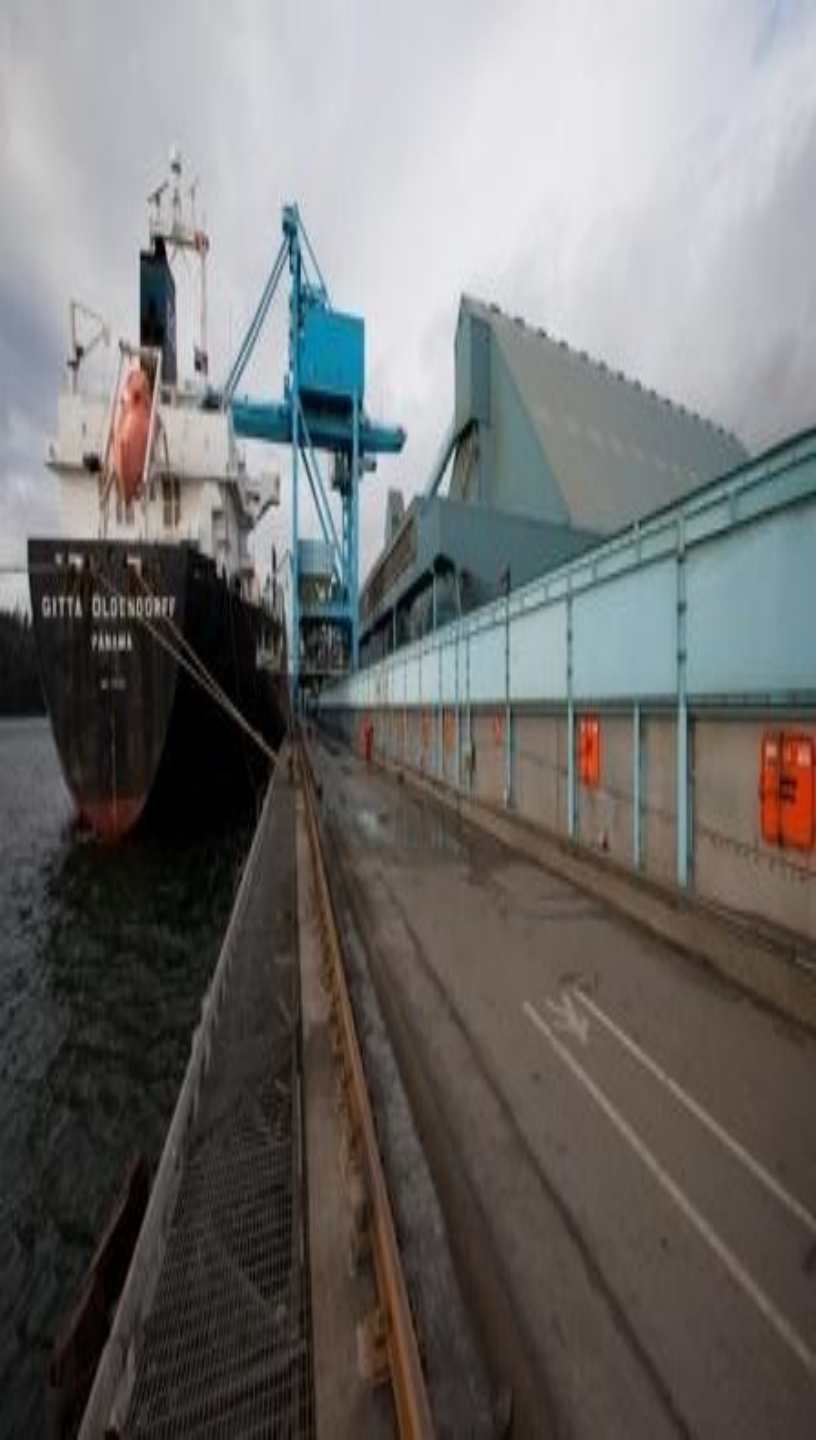
- **Demerits of Wall type Breakwater:-**

  - ✓ Skilled labourers are required,
  - ✓ Special equipments are required for construction,
  - ✓ Repairing is difficult,
  - ✓ Require a firm foundation.

WHARVES

These are platforms at which vessels take on and discharge passengers and cargo on one side and earth retained on other.

- ✓ It's a platform built **parallel to shoreline,**
- ✓ Should give **sufficient depth** of water for the ship to float,
- ✓ Wharves **built parallel with the shore are called quays**,
- ✓ Built **to retain or protect the embankment or filling.**


CITTA OLDENDORFF
PANAMA

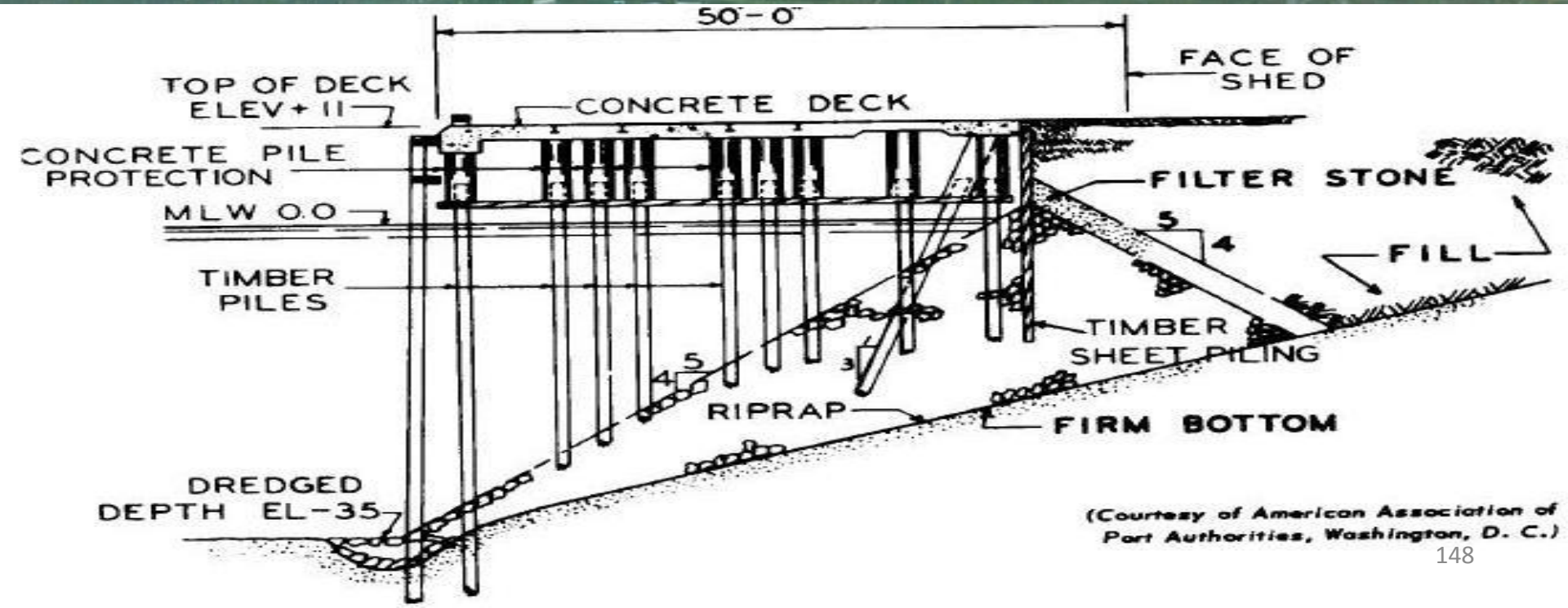

Skylights
17'-
19'-6"
15'
17'-8"
26'-6"
21'-6"
Package & Platform
Elevators, Chutes
Hatches, etc.
42'
L.W.
180' wide
Dock 30-feet deep
· SOUTHWARK PIERS, Nos 38 & 40 S.W. ·
· TYPICAL CROSS SECTION ·
· CITY OF PHILADELPHIA ·
· DEPARTMENT OF WHARVES DOCKS AND FERRIES ·

TYPES OF WHARVES

1. Open construction wharves:-

Wharves of open construction have their **decks supported by piles or cylinders.**

- ✓ It can be either **high level** decks or relieving type platforms,
- ✓ Can be made of **timber, R.C.C**, or both,
- ✓ **Pre cast** or **pre stressed slab** or **beam** are **economical.**



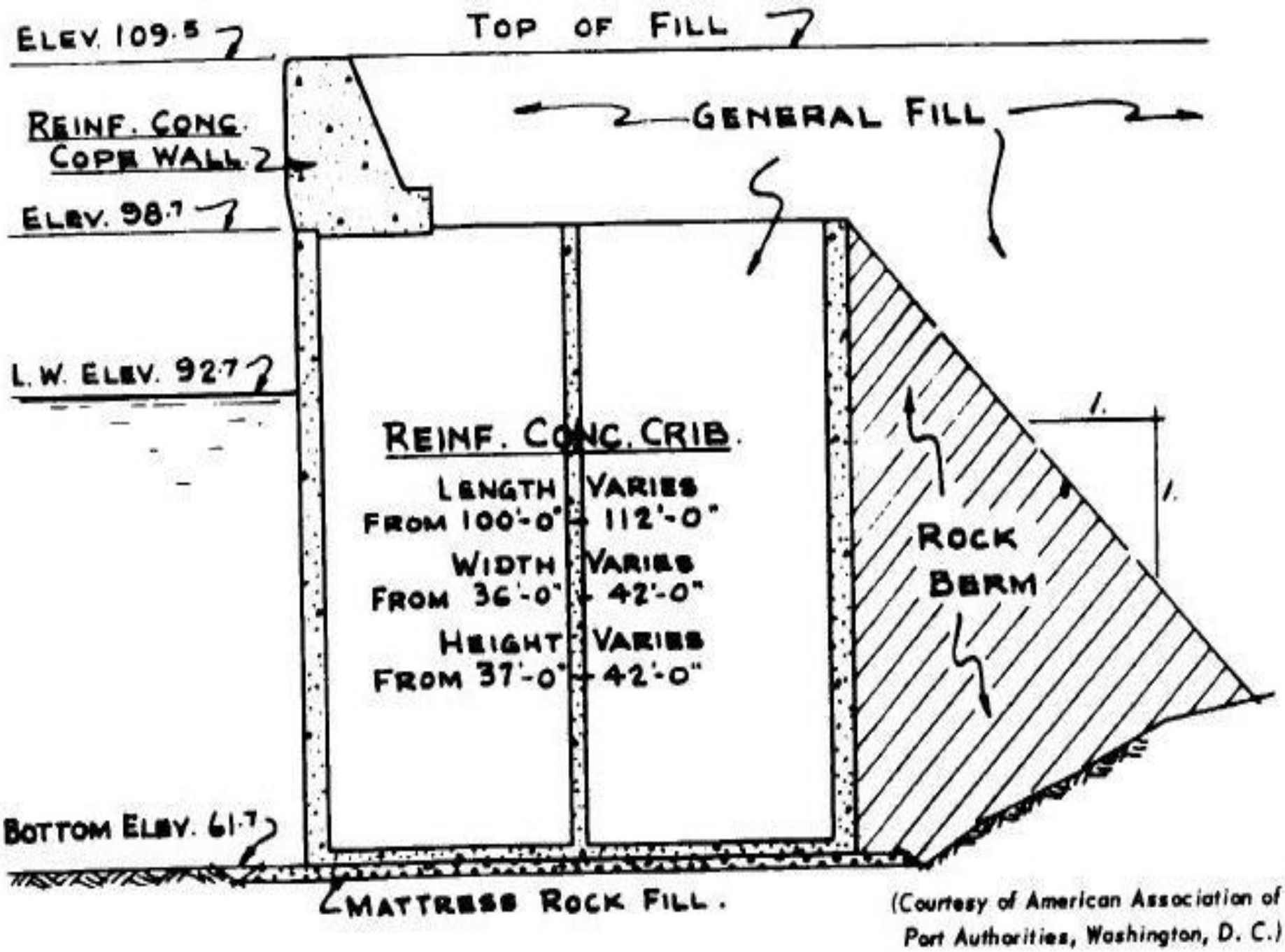
(Courtesy of American Association of Port Authorities, Washington, D. C.)

TYPES OF WHARVES

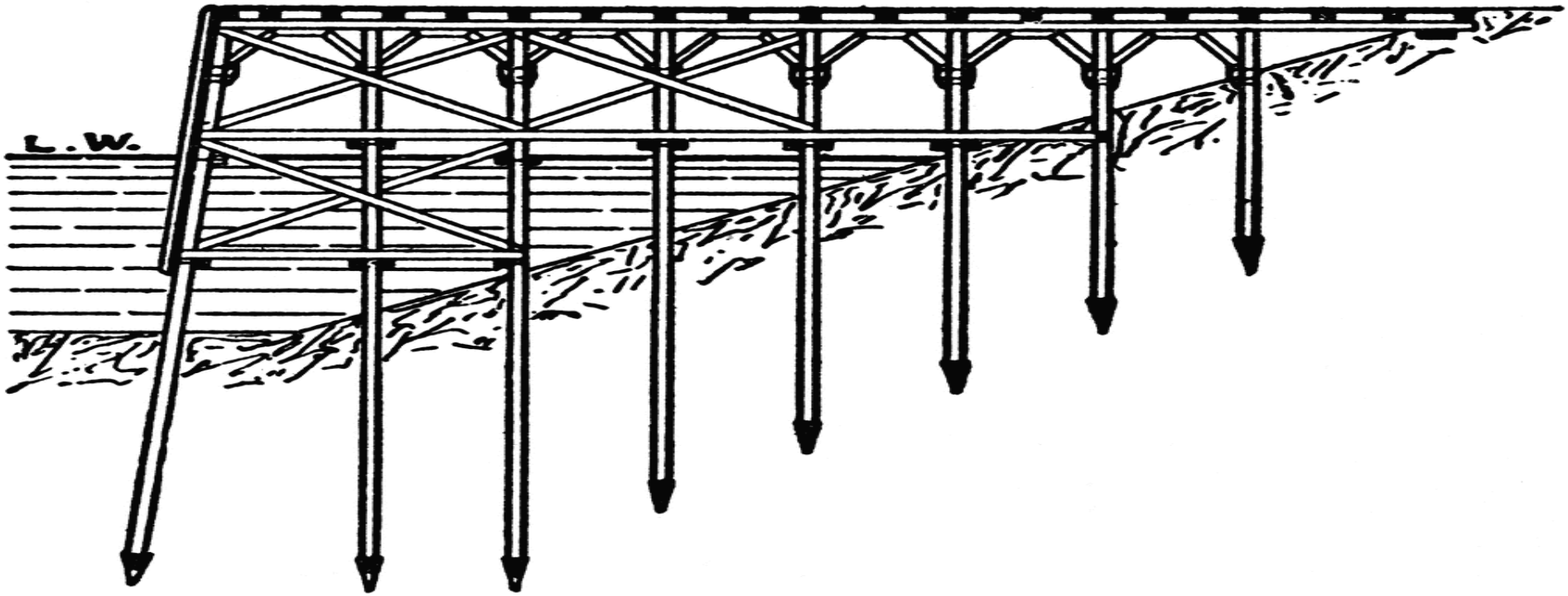
2. Solid type wharves:-

These are **composed of earth or rock fill** partly confined by some sort of bulkhead.

- ✓**Depth less than 15m,** bottom suitable for support of gravity type of structure, steel pile cells are best suited,
- ✓Cells act as a gravity wall of sufficient weight,
- ✓**Resist over turning or sliding at base.**

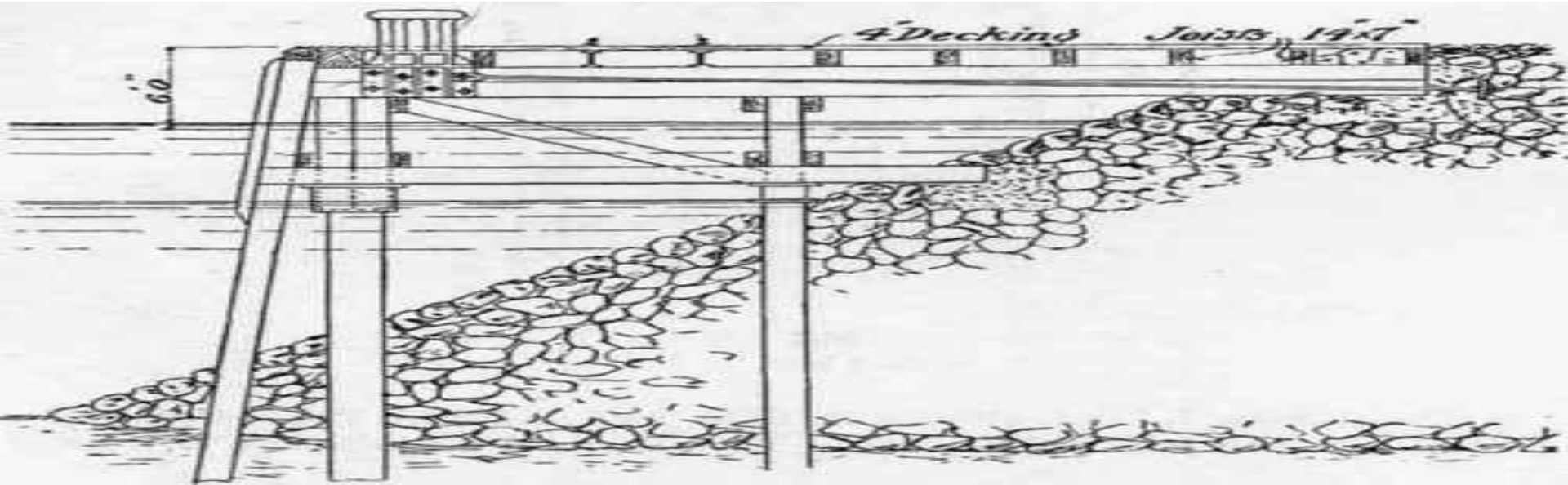


(Courtesy of American Association of Port Authorities, Washington, D. C.)



Piled and cylinder jetties

- ✓Piles are completely encased in concrete cylinders
- ✓Piles carry loads of whole structure and cylinders don’t
- ✓Capable of sustaining heavy impacts from ships



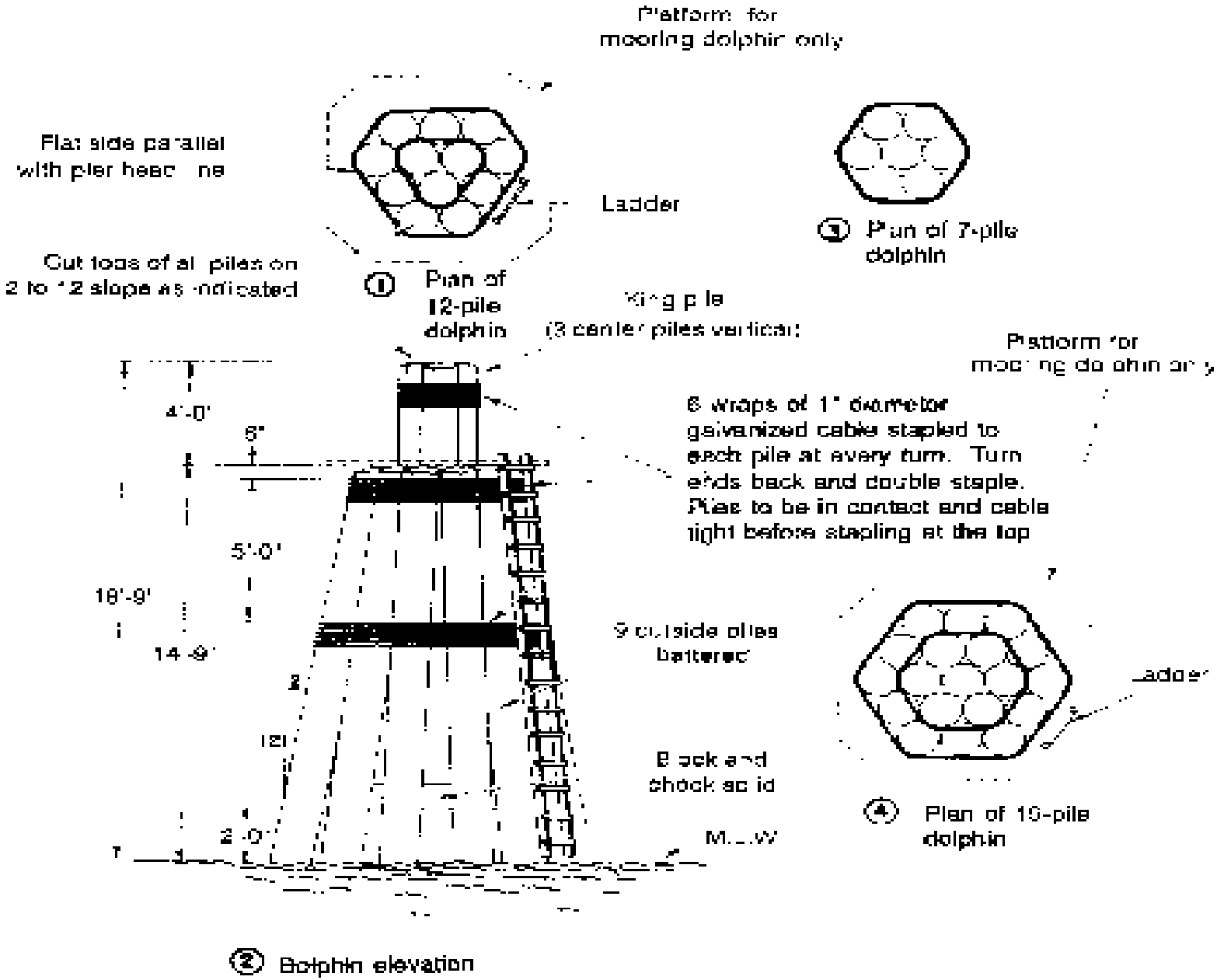
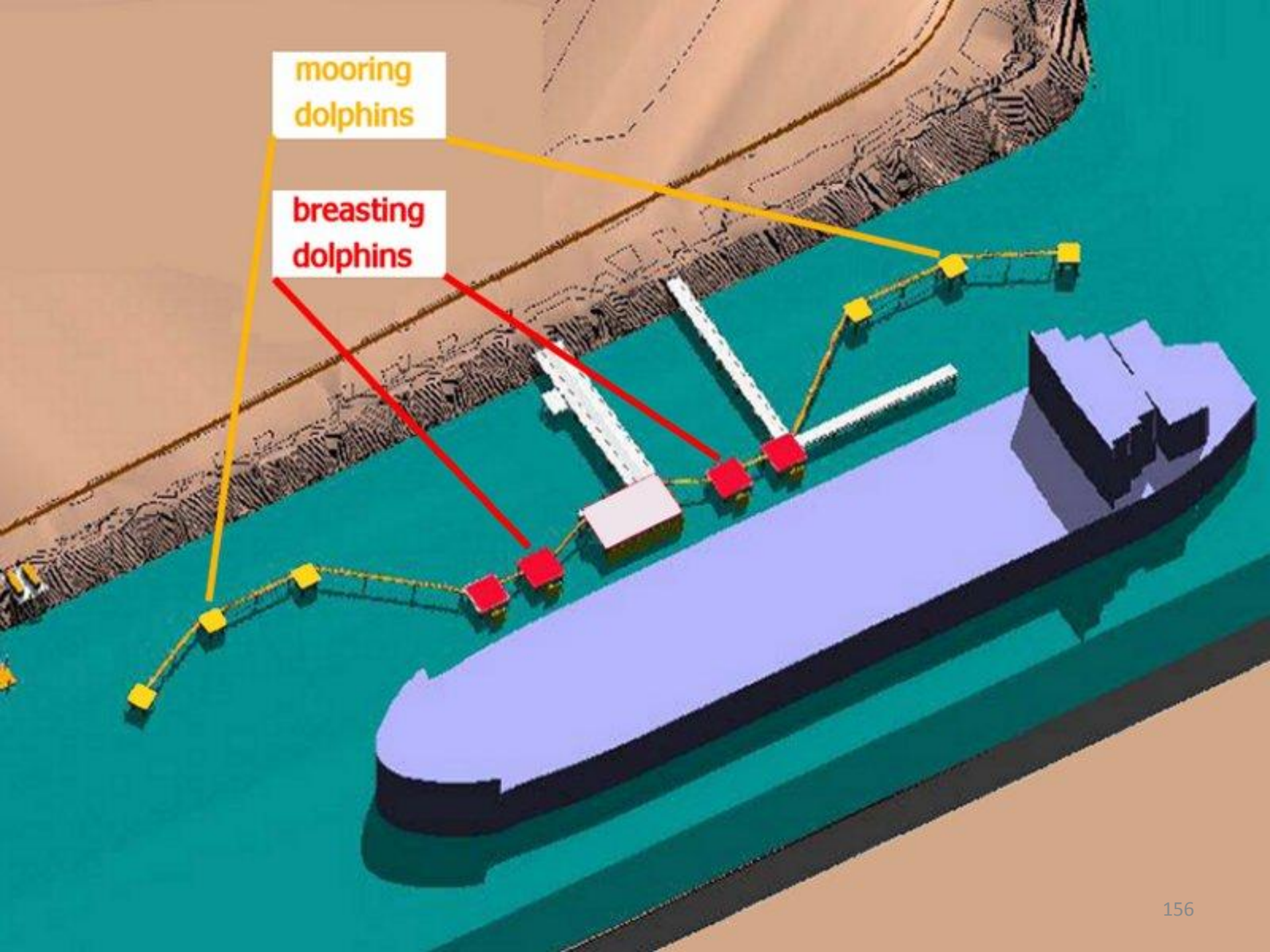


Figure 9-10. Timber Pile Cluster Dolphins


mooring
dolphins
breasting
dolphins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FERRY

- ✓ A ferry is a boat or ship (a merchant ship) used to carry (or ferry) primarily passengers and sometimes vehicles and cargo as well, across a body of water.

- ✓ Most ferry operates on regular, frequent, return services.

- ✓ Also known as **water bus** or **water taxi**.

TYPES OF FERRIES

- Ferry design depend on the **length of the route**, passenger or **vehicle capacity** required, **speed** requirements and the **water conditions** the craft must deal with.
- **DOUBLE ENDED:-**

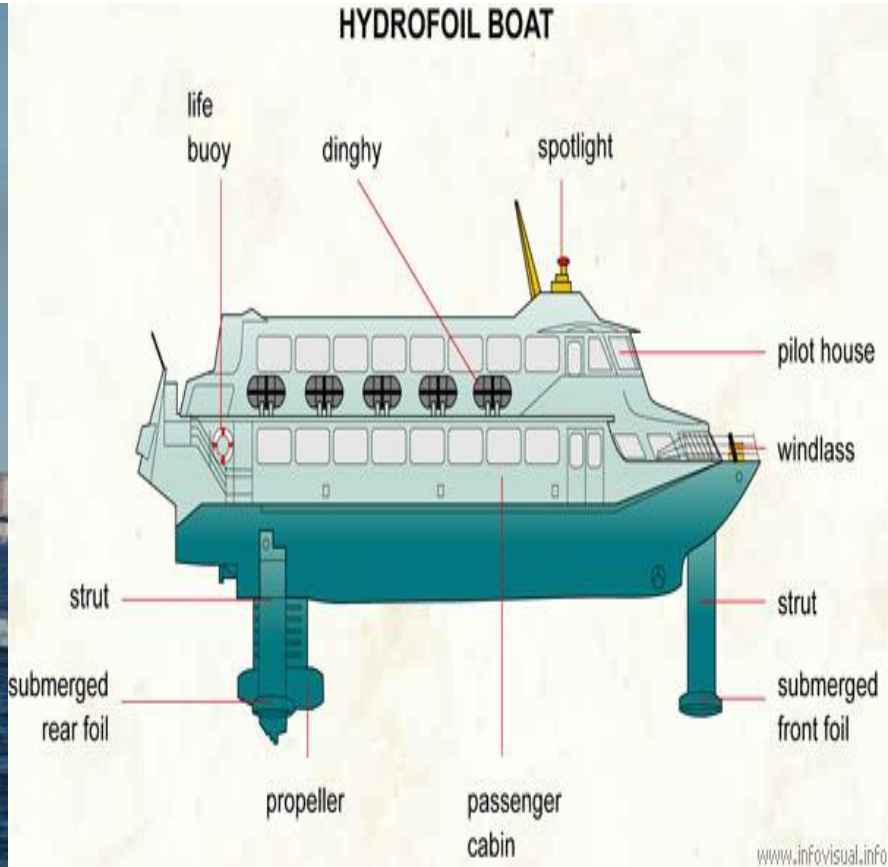
  It has inter changeable bows and sterns, allowing them to shuttle back and forth between two terminals without having to turn around.

  Ex. Staten Island ferry, Washington State ferry, etc.

DOUBLE ENDED

✓HYDROFOIL:-

- –Higher cruising speeds,
- –Only passenger ferry
- –Used at English channel and Canary Island



✓HOVERCRAFT:-

- Were developed in 1960 and 1970 **to carry cars,**
- SR.N4 was largest
- It was superseded by catamarans which are nearly as fast and are less affected by sea and weather conditions

✓CATAMARAN:-

- It is normally associated with high speed ferry service,
- Water jet powered vessels

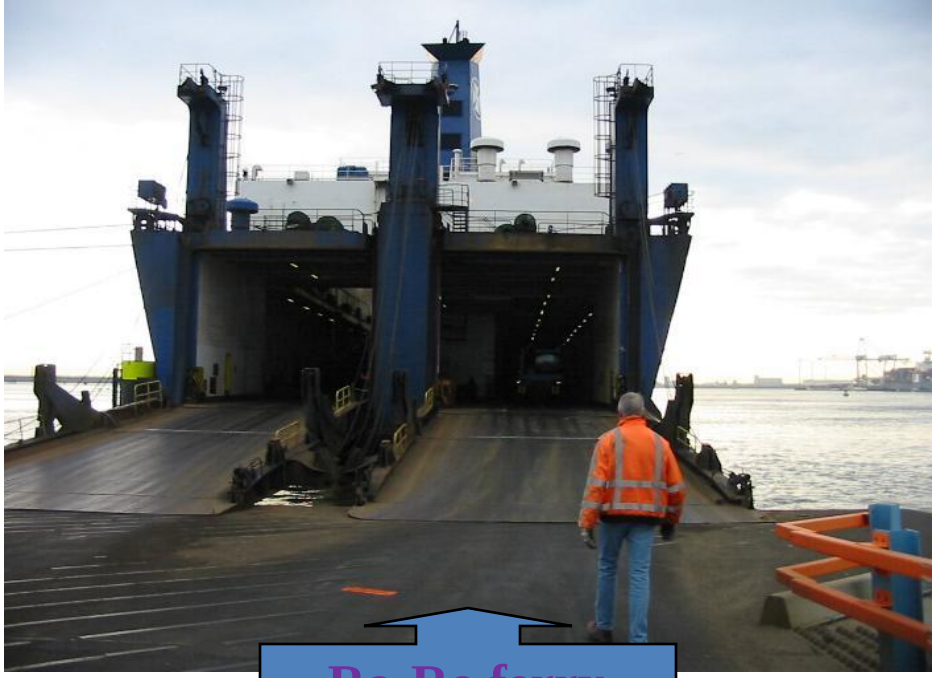
✓RO-RO:-

- Roll on/ roll off ferries are large, conventional ferries named for the ease by which vehicles can board and leave

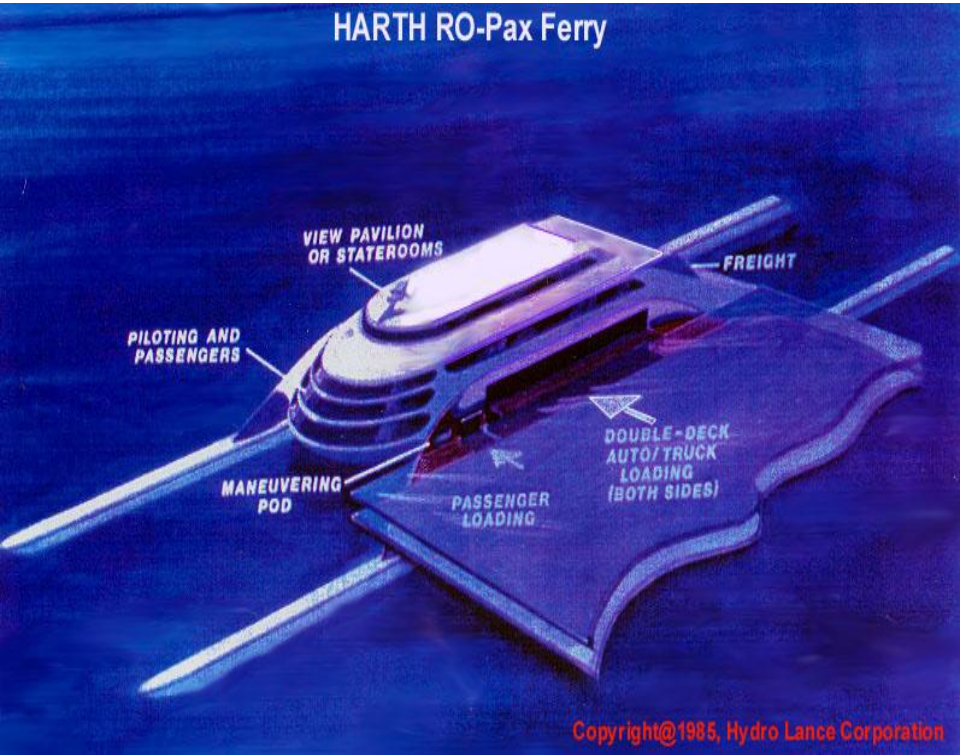
✓CRUISEFERRY:-

- A ship that combines features of a cruise ship with a Ro-Ro ferry

Catamaran ferry



Ro-Ro ferry




TURNTABLE FERRY
GLENACHULISH


PONTOON FERRY


FOOT FERRY

✓CABLE FERRY:-

- Very short distance may be crossed by cable or chain ferry,
- Human powered,
- Reaction ferries are cable ferries that use the perpendicular force of the current as a source of power.

✓DOCKING:-

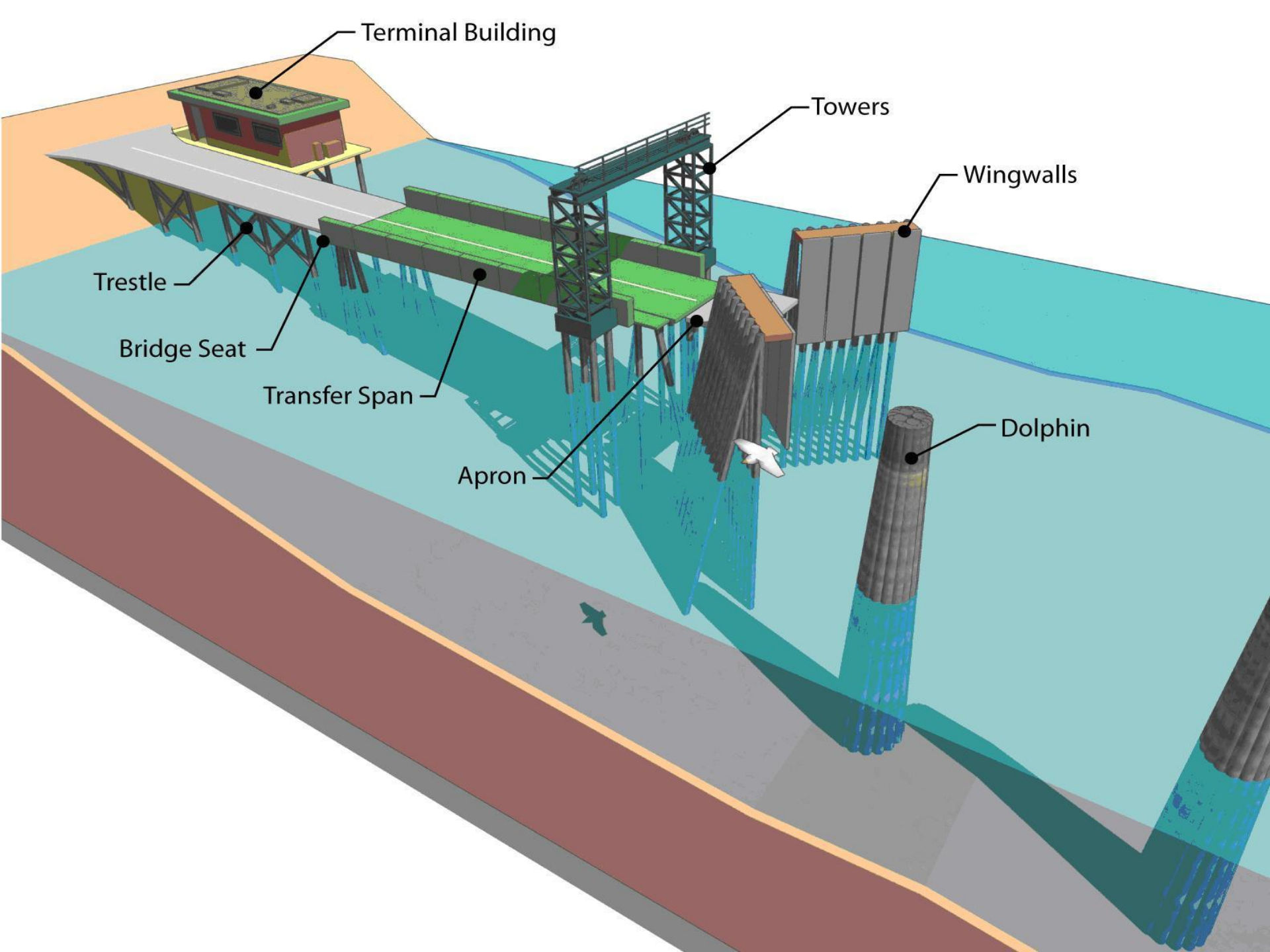
- Ferry boats often dock at specialized facilities designed to position the boat for loading and unloading called ferry slip,
- The apron ramp will be a part of ferry itself.

CABLE FERRY

DOCKING

TRANSFER BRIDGE/ FERRY SLIP

- ✓ A ferry slip is a specialized docking facility that receives a ferry boat or train ferry,
- ✓ A similar structure called a barge slip receives a barge or car float that is used to carry wheeled vehicles across a body of water,
- ✓ In other cases, the ramp is installed at the ferry slip and is called a linkspan or apron,
- ✓ Such ramp is adjustable to accommodate varying water heights and ferry loadings and to move it out of the way during approach and exit.


Terminal Building
Towers
Wingwalls
Trestle
Bridge Seat
Transfer Span
Apron
Dolphin

FLOATING LANDING STAGES

- ✓ It is a platform which is used for the purpose of loading and unloading people and goods from ocean going vessels, including boats and ships of all shapes, style and sizes
- ✓ In areas with shallow water or limited space, the landing stage may be designed for use with tenders and ship's boats
- ✓ Landing stage may also house customs warehouses, immigration offices, and other government facilities
- ✓ They can also house things like tourist information centers

TRANSIT SHEDS

- ✓ These are covered **temporary structures** located adjacent or on the pier or wharf for temporary storage of cargo.

PURPOSE:-

- ✓ To protect the cargo from rain, sun, cold, dust etc,
- ✓ To protect the cargo from damage or theft,
- ✓ To separate and stack the individual consignments,
- ✓ Storage of goods discharged from vessels and awaiting clearance through customs and distribution to warehouses,
- ✓ Storage of goods arriving by land and awaiting export.

WAREHOUSE (GODOWNS)

- ✓ **Permanent structure,** usually provided on shore or directly behind transit sheds for relatively long term storage of cargo,
- ✓ Made of RCC, timber framing and siding with roofing covering of appropriate roofing materials,
- ✓ It should be light in weight, fire resisting,
- ✓ It should be adjacent to pier or wharves to be served,
- ✓ Road and rail services are provided at the back and front of the warehouses with roads at the end.

COLD STORAGE

- ✓ For the purpose of storage of perishable materials like fruits, green vegetables, fish, eggs, food, etc. the cold storage will have to be provided to suit the necessary requirements,
- ✓ The food items which require refrigeration are to be shipped by refrigerated boats,
- ✓ It should be located on the deck as close as possible to ship,
- ✓ The operation of a cold storage plant is a specialized area,
- ✓ The maintenance of correct temperatures, air circulation and humidity are of great importance to maintain the quality of the food item.

Unit 5

Intelligent Transportation System

ITS

- Intelligent Transportation Systems (ITS) is the application of computer, electronics, and communication technologies and management strategies in an integrated manner to provide traveler information to increase the safety and efficiency of the road transportation systems.

- ITS improves transportation safety and mobility and enhances global connectivity by means of productivity improvements achieved through the integration of advanced communications technologies into the transportation infrastructure and in vehicles. Intelligent transportation systems encompass a broad range of wireless and wire line communication based information and electronics technologies to better manage traffic and maximize the utilization of the existing transportation infrastructure

IT USER SERVICES

1. Travel and traffic management
2. Public transportation operations
3. Electronic payment
4. Commercial vehicle operations
5. Advance vehicle control and safety systems
6. Emergency management
7. Information management
8. Maintenance and construction management

Travel and traffic management

- The main objective of this group of services is to use real time information on the status of the transportation system to improve its efficiency and productivity and to mitigate the adverse environmental impacts of the system. This group of user service is further divided in 10 user services.
- **Pre trip information**
- This user service provides information to the travelers about the transportation system before they begin their trips so that they can make more informed decisions regarding their time of departure, the mode to use and route to take to their destinations.

- **En-route driver information**

This user service provides travel related information to the travelers en route after they start their trips through variable message signs (VMS), car radio, or portable communication devices.

- **Route guidance**

  This service provides information to the travelers with a suggested route to reach a specified destination, along with simple instructions on upcoming turns and other maneuvers. This also provides travelers of all modes the real-time information about the transportation system, including traffic conditions, road closures, and the status and schedule of transit systems.

- **Ride matching and reservation**

  This user service provide real-time ride matching information to travelers in their homes, offices or other locations, and assists transportation providers with vehicle assignments and scheduling.

- **Traveler Services Information**

  This service provides a business directory of information on travel-related services and facilities like the location, operating hours, and availability of food, lodging, parking, auto repair, hospitals, gas stations and police facilities.

- **Traffic Control**

  This service collects the real time data from the transportation system, processes it into usable information, and uses it to determine the optimum assignment of right-of-way to vehicles and pedestrians
- **Incident Management**

  This service aims to improve the incident management and response capabilities of transportation and public safety officials, the towing and recovery industry, and others involved in incident response.

Travel Demand Management

- 1. Congestion pricing
- 2. Parking management and control
- 3. Mode change support
- 4. Telecommuting and alternate work schedule.

Public transportation operations

- Public Transportation Management
- En-Route Transit Information
- Personalized Public Transit
- Public Travel Security

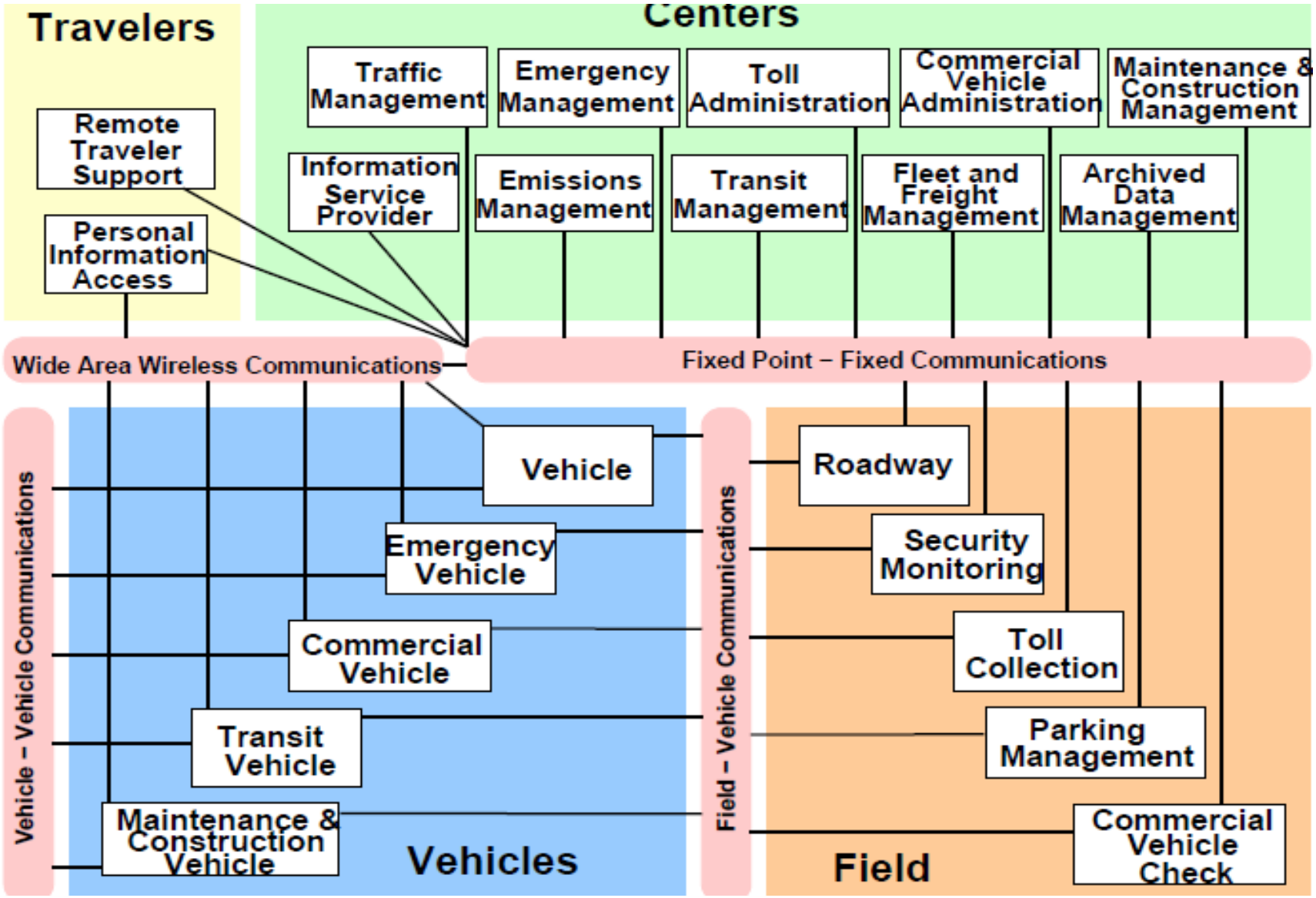
Electronic payment

- This user service allows travelers to pay for transportation services with a common electronic payment medium for different transportation modes and functions. Toll collection, transit fare payment, and parking payment are linked through a multi-modal multi-use electronic system. With an integrated payment system a traveler driving on a toll road, using parking lot would be able to use the same electronic device to pay toll, parking price and the transit fare.

Commercial Vehicle operations

- The aim is to improve the efficiency and safety of commercial vehicle operations. This involves following services:

1. CV electronic clearance
2. Automated road side safety inspection
3. On-board safety monitoring administrative process
4. Hazardous material incident response
5. Freight Mobility


Travelers
Centers
Traffic Management
Emergency Management
Toll Administration
Commercial Vehicle Administration
Maintenance & Construction Management
Remote Traveler Support
Information Service Provider
Emissions Management
Transit Management
Fleet and Freight Management
Archived Data Management
Personal Information Access
Wide Area Wireless Communications
Fixed Point – Fixed Communications
Vehicle – Vehicle Communications
Vehicle
Emergency Vehicle
Commercial Vehicle
Transit Vehicle
Maintenance & Construction Vehicle
Vehicles
Field – Vehicle Communications
Roadway
Security Monitoring
Toll Collection
Parking Management
Commercial Vehicle Check
Field

Transportation planning and ITS

The steps in traditional transportation planning are as follows:

- 1. Establish goals and objectives
- 2. Inventory existing conditions
- 3. Analyze existing conditions
- 4. Long range/ short range element
- 5. Forecast land use, population/employment
- 6. Forecast future travel/trips
- 7. Develop and evaluate alternative transportation plans
- 8. Prepare recommended plans and programs

Smart car

- As mentioned earlier the car is equipped with all the new electronic gadgets. It helps the user
- to use service efficiently. Some of the features of SMART CAR are:
- GPS and on-board communications
- Anti-collision sensors

Smart road

As mentioned earlier SMART CAR alone cannot operate in a system. Thus along with the SMART CAR, the infrastructure should also be improved. The infrastructure also should be well prepared for taking care of smart car. The road equipment will communicate with the vehicle and provide real time assistance to the user. Provision of Smart road along with Smart car will complete the Smart features of any facility