UNIT V

HARBOUR ENGINEERING

Harbour:
It is a protected inlet or branch of a sea where ships can anchor.

Harbour Engineering:
It is concerned with planning, construction and maintenance of infrastructure for efficient performance of harbours.

Definition of basic Terms:

Port:
It is a connecting link between sea and land traffic. It is a gateway to land from the sea and from sea to the land.

Docks:
They are enclosed areas for berthing of vessels to facilitate loading and unloading of cargo and embarkation and disembarkation of passengers for repairs, oiling, etc.
Tides:

The level of sea undergoes a constant oscillation, rising and falling generally twice within about 25 hours. This is due to the difference in combined gravitational attraction of sun and moon upon various parts of the earth’s surface wave.

They are undulations caused on the surface of sea water due to wind. It is the raised currelinear caused on the surface water. They are of 2 types:

1) Waves of oscillation
2) Waves of translation

It satellite port:

It depends on resources and facilities of another. It is a small port which is subordinate to a major port and depends upon the latter for higher order facilities.
Requirements of harbours:
The principal requirements are:
* shelter
  * accommodation

Shelter:
* An essential requirement for ships during slack & rough seasons against violent waves of sea.
* Ships have to be sheltered for many days of a year when it is not possible to load or unload them.

Accommodation:
* Accommodation is related to facilities and opportunities required for carrying on trade operations. Examples are:
  * Quays to berth ships alongside
  * Sheds & warehouses to deposit goods
  * Cranes and appliances for handling goods
  * Repairing workshops
  * Passenger Facilities
classification of harbours:

Primary classification

- Natural
- Protected
- Artificial

Natural or land locked harbours:
They are formed entirely by inlets from sea.

It may also be constituted by headlands or projecting parts of a coast converging towards each other.
They have narrow entrances leading to a sheltered area of water.

They may be coral reefs, series of islands forming lagoons with gaps in coral reef.

a) Head lands converging towards each other.

b) Inlet from sea.
Protected Harbours:

- Partly natural and partly artificial
- Formed in bays or positions in coastline.
- Artificial construction of breakwaters or entrance mole may supplement existing natural features.
- They give protection from wave action to vessels entering or entering harbours.

Artificial harbours:

They have to be created where there is no natural features.

Breakwater on an almost open coastline.

Sea -> Artificial structure -> Natural formation -> Land
necessary characteristics.

b) Harbour of Refuge:
- Provide a refuge during cyclones or when vessels are under disrepair.
- The best location for the construction of harbours is at readily accessible stations upon dangerous coasts.
- Naval harbours and bases during emergency, every type of harbour ranging from roadstead with min. facilities to one possess facilities for refuelling, repairs, with dockyard workshops may be used as naval bays.
Commercial harbours:
They provide accommodation for vessels for loading and unloading operations and transactions of trade.
They may be located on coasts, estuaries, mouth of rivers or on banks of rivers some distance inland.
There should be at least possible delay in reception and despatch of vessels.

Simple mole are built out into sea with level quay and covered sheds for reception of vessels in addition to breakwaters for shelters.

c) Fishing harbours:
Fishermen require max. time for fishing with min. delay in despatching fishes in view of perishable nature of fishes.
* Entrance - not to be made narrow;
  Fishing craft beam = 6 to 8 m. Allowance should be made for at least 3 to 4 vessels
* Size = 4 to 40 hectare.
* Depth = 3 to 5 m
Location of harbours:

Identification of a suitable location is the decisive factor in the process of planning a harbour.

Harbour Engineers can have accurate knowledge on wave characteristics, their action in terms of erosion and deposition to help decide pattern, location, size, and shape of coastal structures.

SITE INVESTIGATION FACTORS FOR LOCATION:

1. Speed of Water:

   * Speed of water that enters and leaves a harbour should neither be excessive nor slow.
   
   * If the speed is too slow in silts an area.
   
   * If it is too fast, it may erode the harbour & channel areas.
   
   * Speed of water should be studied during different seasons over years.
ii) Amount of dredging:

A site must be located such that the amount of initial dredging & amount of maintenance dredging should be lesser.

It is important when possession lies in an estuary of river or upon a coast, subject to coastal changes and littoral drift.

iii) Tidal range:

Vessels can be loaded and unloaded as quayside, berth or wharves if tide doesn’t exceed 5.5m.

It is important to select a site with a minimum tide range.

iv) Waves & their characteristics:

The incidence and magnitude of storm & direction and velocity of maximum and prevailing winds have to be decided.

Waves & their effects form & design of breakwaters, pattern of site, shoaling, shallowness, beach building.
v) Wind characteristics:

- Wind causes waves.
- Velocity and height of waves depend on the direction, duration, and velocity of prevailing wind.
- Waves of greater heights and velocity have greater impact on efficient and economy of ports.
- Wind data plays a vital role in site selection for harbours.

vi) Tidal currents:

- They are caused by earthquakes on sea beds.
- They may cause great damage to stability of coastal structures.
- Direction and velocity of the tidal currents at various states of tides are studied with greater accuracy.
Planning and Design of harbours:

Surveying is the first factor in planning a design of harbour to ascertain the soil profile, its geological characteristics, and fitness for anchorage. Special considerations are:

- Direction & intensity of winds
- Frequency of storms
- Height and force of waves
- Field range and velocity of currents
- Littoral drift, erosion, and siltation.

Design Elements in Planning of Harbours:

- Area for free movement and depth:
  * Area depends on class of harbour, maximum number of vessels to be accommodated simultaneously, and size of the greatest vessel.
  * Steady increase of vessels' size makes it important to allow ample area and depth for harbours. Modern vessels are around 300m long & about 30m wide.
Area must be adequate for free movement for large no. of ships. It takes up their positions at berth.

* Area should not be adequate for reception but also for manoeuvring them into and out of the berth.

* There should be sufficient space for manoeuvring.

**Harbour Entrance:**

* It should be wide enough for access to shipping.

* It should be so sited as to exclude waves and its impacts.

* It is a trade-off blu the efficiency of port operations by precluding violent sea from entering into harbour & facilitates easy entry & exit of vessels into and out of harbour.
Entrance channel:

* The basic principle should be that the depth should be adequate to permit the largest commercial vessels that frequently use harbours without undue delay or hazard.

* The entrance channel is long & tidal; ships arrival and departure are usually timed so that it enters and leaves on tide & not against it.

* In a channel, there must be sufficient draft, the depth of water below the keel to permit safe and efficient navigation of a ship underway by its own power.

* Where reduced speeds are imposed, a minimum draft should be at least one meter.
light house:

It is a tall tower on a high pedestal, in an ideal planning of harbour, the light house should be in alignment with the centre line of entrance channel.

Packing, loading & unloading space:

Along with railway track and approach roads, sufficient parking and loading and unloading of inland transport carriers should be provided on port side.

Harbour layout and Terminal Facilities:

Terminal facilities:

They are essential requirements of harbours. The elements of Terminal facilities are:

1) Inter-modal Transport services;

They are other modes of transport such as roadways and railways. Therefore other modes of transport are needed.
Passengers and cargo to reach or to leave harbours.
Coastal structures for accommodation:
Quays & jetties are coastal structures alongside which ships are berthed.
Adequate no. of berthing facilities should be available in any harbour.
Hence: adequate and efficient berthing facilities are crucial for successful port operations.
Transit sheds are warehouses:
They are attached to unloading platforms.
They are used as central collection & check area from where it is taken to loading platform when required. Requirement are:
(a) adequate space to adjacent position to quay (b) cranes & other equipments.
Mooring accessories:

In addition to berths @ regular wharves or quays, the port should also provide facility of mooring for vessels on open waters. In any harbour, considerable amount of unloading often proceeds at moorings.

Navigational aids:

The primary purpose is to ensure safer and speed movement of vessels.

Coastal structures:

Piers:

It refers to iron cylindrical structure. They exist at seaside resorts for use by visitors and for landing and embarkation of passengers.

Pier head is termination of breakwater. It is subjected to most unfavourable conditions than any other maritime structures.
Breakwaters:

Its function is to breakup and disperse heavy seas.

It prevents waves from exerting their destructive influence within enclosed area of the harbour.

Classification of breakwaters:

1. Wall of masonry or concrete blocks or mass concrete.
a) Wall type block breakwater.

b) Heap or mound breakwater.

c) Mound with superstructure:


Advantages of These Types of Breakwaters:

- Cost of construction
- Comparative cost of maintenance
- Efficiency

Wharves:

They are wide stone walls built along edge or out into sea or river, where ships can be tied up to unload goods.

It is a structure for berthing purpose distinct from quays.

It is constructed of piles and framing instead of solid masonry or concrete.

Both wharves and quays are provided with adjacent space for receiving and loading of cargo.
Jetties:

It denotes projecting structures built out into deep water from shore. Structures in harbours which perform duties of loading and unloading platforms with breakwater are termed as jetties.
They are situated more or less in the nearest position inside harbour or wet docks where vessels are manoeuvred in still water for comparative safety.

Types of jetties:

- Solid or open

Types of jetties:

- Timber
- Steel
- Etc.

- Open
- Filled cylinders

- Etc.
Quays:

They are artificial structures where vessels can land. They are parallel to the coast and made up of monolithic structures. It is constructed in water.
Spring Fenders:

Fenders are objects such as a mass of rope, an old tyre and lump of wood that hangs over the side of a boat to protect it from damage by other boats when coming to land.

Different Ways of Fending:

A Simple Fender:

Simple Fenders are separate rails or driven in front of structures. It is efficient for berthing of vessels of low draught.
spring fenders,

they are more appropriate in open or tidal waters. It provides for absorption of K.E and for limiting travel of vessels after impact.

dolphins;

It refers to a buoy, pile or cluster of piles for mooring a vessel. It is shock absorbing.

It shows the Baker bell dolphins.
The weight of the bell when ballasted with concrete block is 170 t. It is @ a speed of 98 cm/sec.
Inland water Transport:

Inland water Transport refers to water transport away from coast. Inland waterways are integral part of transport system. Rivers were principal means of transportation of goods.

Landing stage & Floating landing stage (FLS): It is a raised platform along which vessels could be berthed for loading and unloading of cargo and embarkation & deembarkation of passengers.
The FLS in its simplest form is a single pontoon or a large low boat with a flat bottom. The pontoon is fixed by timber dolphins or group of piles.

It is to overcome the problem due to tides. The FLS overcome this problem by maintaining the same level by landing stage and the vessel irrespective of sea water level because the pontoon rises and falls with tides.
2.8

Waves and their action on coastal structures

Types of Waves

- Waves of oscillation
- Waves of Translation
- Tidal waves

Ordinary unbroken waves

when they enter shallow water

Frequently occur as a result of Earth's rotation.

Beach zones:

- A - upper zone
- B - lower beach
- S - separation of two beaches
- C - crest, the highest point

\( \phi \) - beach angle
\( H \) - wave

Amplitude.
Littoral Drift:
It refers to the movement along a coast.

Profile A:
Initial attack of storm waves.

Profile B:
Accretion
Mechanics of littoral drift:

Wave breaking and
throw sediments
and suspension on
the beach

Wave breaks

Wave characteristics
change

Wave action on coastal structures

9 Fathom
e Fathom
5 Fathom

Sand erosion

5 km

Sand accretion and Erosion

1876
Harbour
1912
1912
1876
Yadnya Thar
Environmental concern in Port Operations

Environmental concern is vital for any project. It is more important in case of projects. The impacts are:

* Accretion & Erosion
* Infiltration of saline water into seawater
* Dislocation & disturbance to precious eco-system
* Devastation to marine life
* Pollution due to cargo handling
* Impact on soil due to cutting
* Pollution due to spillover of oil & grease

Coastal Protection Works:

Coastal erosion causes lot of devastation in terms of life & property. Types of coastal protection work
a) seawall e/s

backfill

foundation piles

sheet piles

b) groin e/s

filter layer

1:1.5

42.76 m

70.00

3 m

-2.9 m

3 m

-3.2 m
c) Offshore breakwaters.

There are two types:
   a) Exposed type
   b) Submerged type.

a) Exposed type.

Exposed type.

Single detached BW

Erosion

Resulting surface

b) Submerged type.

Submerged BW

Artificial beach

Original shoreline

Drift

Down drift erosion
Protection against natural calamities

* construction of coastal retaining wall along coast
* Aforestation along the coastal area
* construction of groins of low walls built in to the sea to protect the erosion of sand
* In coasts with beaches it is not necessary to construct a wall
* Planting and ocean self tolerant plants like salicornia, adriplax, caesuaria, Thespedia & bamboo
As per Coastal Regulation Zones (CRZ)

1. Designation of areas
   - CRZ: Often referred to as regulated coastal areas. It has to be
     classified as (i) Conservation (ii) Control (iii) Restricted areas. Generally, a homogeneous
     area with common characteristics

2. CRZ: Refers to stretches along coasts, within certain
   rules are essential to any development in land or building.
   Construction activities in these areas are governed by sets of
   regulations. CRZ varies from area to area, from high tide line (HTL) to the area
   between low tide line (LTL) and the sea.

3. Regulations were notified in the year 1991 and 1995
   under Environment (Protection) Act, 1986, and rules made thereafter.
   Effective in 1996, CRZ was up to Baran from 1994 onwards.
   It has been reduced to Baran from HTL.

High Tide Line (HTL): The line on land where the highest
   water level reaches during spring tide. It is the average
   water level determined HTL, universally in all parts of the country.

4. All activities prohibited within CRZ.
   - Notifications issued by minister of Environment
     and Forest include additional restrictions on industrial, structural
     provisions in the CRZ.

The following activities are not normally permitted:

1. Setting up of new industries and extension of existing
   industries. However, such developments are permitted if they
   are directly related to water front or are directly needed
   for water facilities.
(i) Manufacture or handling or storage or disposal of hazardous substances.

(ii) Setting up and expansion of fish processing units including warehousing, however, hatchery and natural fish drying in permitted areas may not be prohibited.

(iv) Setting up and expansion of units/machinery for disposal of waste and effluent excepting those it is, permitted under Water Act 1974.

(v) Dumping of solid waste for purposes of land filling or otherwise, or ash or any other waste from thermal power stations.

(vi) Land reclamations, bunding or any other action to cause distribution to natural course of sea water, there is no bar for these activities if they are required for control of coastal erosion, maintenance of cleaning of cleaning of water ways and for prevention of sand banks.

(vii) Harvesting or draw of ground water and construction of mechanism therefore for such activities shall be permitted if done-

(viii) Winnowing, through ordinary well for purpose of drinking, horticulture, agriculture and fisheries.

(ix) Construction activities for residential buildings, office building, hospital complexes and workshops shall not be permitted.

(x) Any construction activity except facilities to carry treated effluents and waste water discharge into sea, facilities for carrying sea water for cooling purpose, oil, grease and similar pipelines and facilities essential for permissible activities.
(xi) Dressing or altering of sand dunes, hills, natural features including landscapes, changes for beautification, recreation and other such purposes.

4.17.3 Regulation of Permissible Activities

(i) Any activity which requires water from foreshore facilities.

(ii) Activities permitted with clearance from the ministry of Environment and Forest.

(a) Construction activities related to defence facilities requirements for which foreshore facilities such as slipways and jetties are essential.

(b) Coastal structures such as jetties, piers, breakwaters and lighthouses.

(c) Normal Power Plants.

4.17.4 Coastal Zone Management Plan (CZMP)

As per notification for CRZ all coastal states and union territory administration in India shall prepare CZMP. The plan shall be submitted within a period of one year from the date of notification. (21st Feb 1991) Ministry of Environment and Forest (MECF) shall approve the CZMP for coastal states and union territory and local governments, within the frame work of the CZMP.

4.17.5 Norms and Guidelines for development of beach resorts

Hotel in CRZ:

(i) No construction

(ii) (a) Plot size – not less than 0.4 ha.
(ii) FSI - shall not exceed 0.83
(iii) (a) over-all overall height - shall not exceed 9.0 m
     (b) No. of Flows - not to exceed two
(iv) Ground water shall not be tapped.
(v) Extraction of sand, mixing or digging of sandy stretches for structural foundation of building and swimming pool shall not be discharged into the sea.
(vi) At least a gap of 30 m width shall be provided between any two hotels/beach resorts to allow public access to beach.
(vii) Construction of beach resorts and hotels shall not be permitted in ecologically sensitive areas.

4.11.6 Classification of CRZ

For regulation of developmental activities coastal stretches within Ecom are classified into four zones:

(i) Coastal Regulation zone-I (CRZ-I)
(ii) Coastal Regulation zone-II (CRZ-II)
(iii) Coastal Regulation zone-III (CRZ-III)
(iv) Coastal Regulation zone-IV (CRZ-IV)

Table depicts details of regulations enforced in each zone.