# DI04006071: Railway, Harbour & Tunnel Engineering

## Lecture 4.24: Growth of ports in India, Requirements of good harbour, Element of harbour and their function

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# Historical and Modern Growth of Ports in India I

India has a coastline of over 7,500 km, leading to a significant maritime heritage. The growth of ports has transitioned from ancient trade hubs to modern, mechanized ports capable of handling ultra-large vessels. Post-independence, initiatives like the Sagarmala project and increasing private sector participation have accelerated capacity expansion, automation, and hinterland connectivity.

## Key Points

- Transition from manual cargo handling to fully mechanized container terminals.
- Development of 12 Major Ports and over 200 Non-Major (Minor/Intermediate) Ports.
- Focus on port-led industrialization and reducing logistics costs.
- Emergence of deep-draft private ports (e.g., Mundra, Krishnapatnam) competing globally.

# Major Ports of India and their Characteristics I

| Port Name | State | Coastal Location | Primary Cargo Focus |
|---|---|---|---|
| Deendayal (Kandla) | Gujarat | West Coast | POL, Fertilizers, Bulk |
| Jawaharlal Nehru (JNPT) | Maharashtra | West Coast | Containerized Cargo |
| Paradip | Odisha | East Coast | Iron ore, Coal, Bulk |
| Visakhapatnam | Andhra Pradesh | East Coast | Bulk cargo, Iron ore |
| Chennai | Tamil Nadu | East Coast | Containers, Automobiles |

## Key Points

- Major ports are governed by the Major Port Authorities Act, 2021.
- Strategic locations along the east and west coasts facilitate international trade.
- Specialization in cargo types optimizes specialized handling equipment and storage.

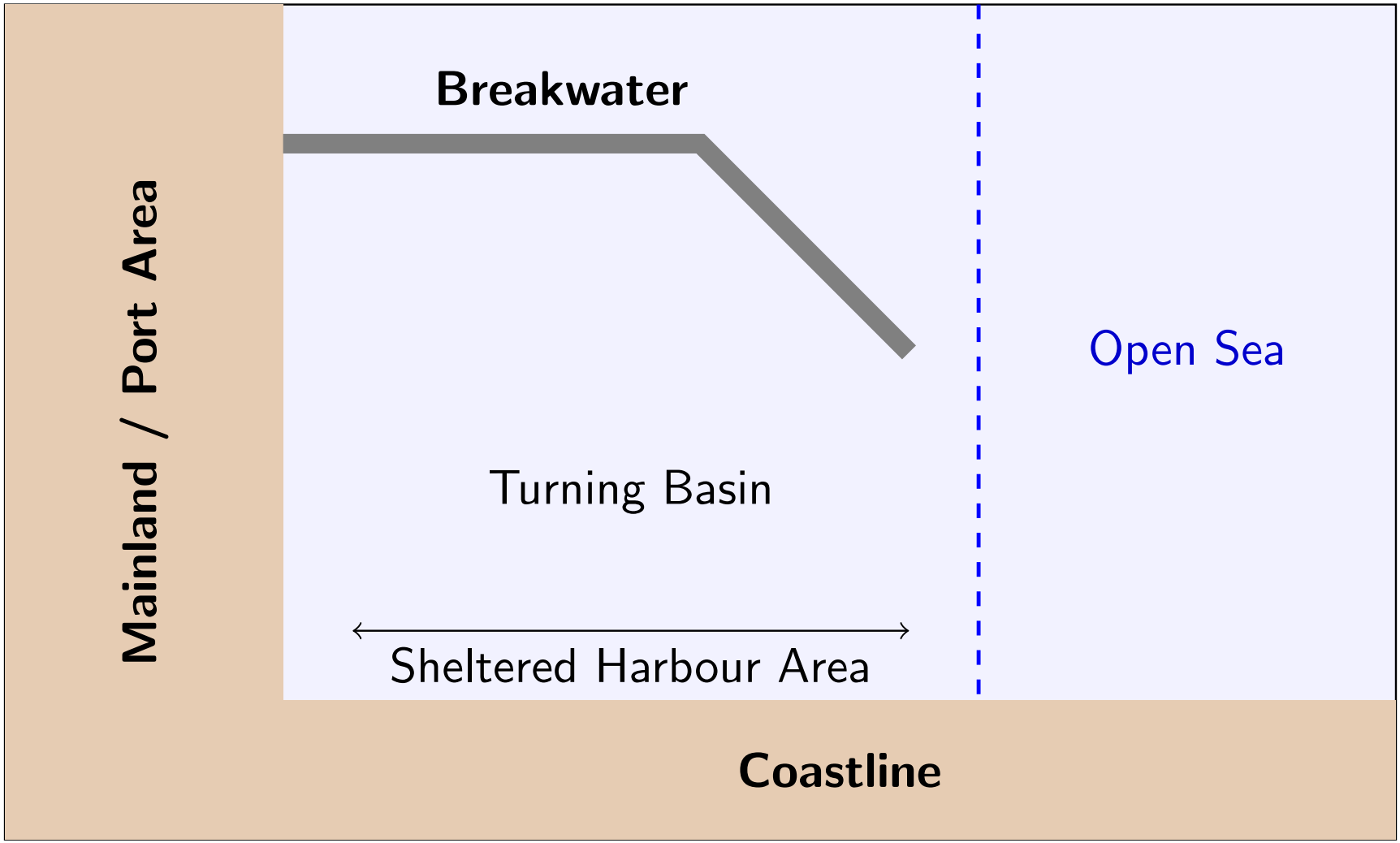
# Requirements of a Good Harbour I

A good harbour must provide a safe, calm, and accessible environment for ships to anchor, load, and unload cargo. It requires a combination of favorable natural geography and robust engineering interventions to ensure year-round operability.

## Key Points

- Adequate depth of water for the deepest draft vessels, even during low tides.
- Protection from destructive wave action, strong currents, and severe winds.
- Sufficient anchorage area with good holding ground (seabed material) for ship anchors.
- Availability of a wide, well-marked approach channel for safe navigation.

# Schematic Layout of a Harbour I



# Schematic Layout of a Harbour II

## Key Points

- Visual representation of mainland, coastline, and open sea.
- The breakwater shields the inner basin from open sea waves.
- The turning basin allows sufficient space for vessels to rotate and position.

# Primary Elements of a Harbour I

Harbours consist of several interconnected elements designed to facilitate safe navigation, vessel berthing, and efficient cargo handling operations. Each element serves a specific civil engineering and navigational function.

## Key Points

- Approach Channel: The dredged navigational path connecting the open sea to the harbour basin.
- Breakwaters: Protective barriers constructed to reduce wave energy within the harbour.
- Turning Basin: A widened area of water allowing ships to maneuver and turn around.
- Berthing Structures (Piers, Wharves): Structures where ships tie up for loading and unloading.

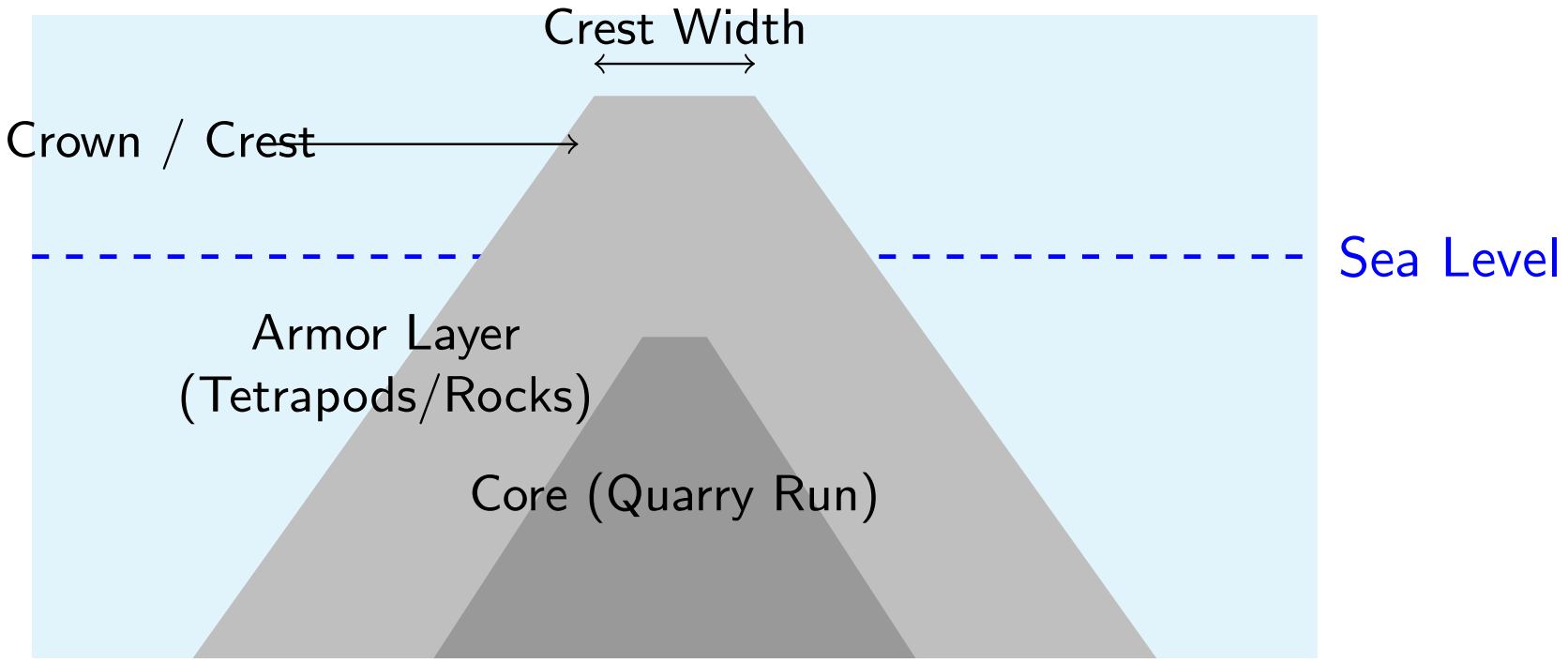
# Approach Channel and Turning Basin I

The navigational waterways must be meticulously designed to prevent ship grounding and allow smooth traffic flow. The geometric dimensions depend entirely on the design vessel's length, beam, draft, and maneuverability.

## Key Points

- Approach channels are aligned with natural currents to minimize cross-wind effects.
- Channel depth includes allowances for ship squat, tidal variations, and wave-induced motion.
- The turning basin diameter is generally maintained at 1.5 to 2.0 times the length of the largest ship.
- Capital and maintenance dredging are frequently required to sustain design depths.

# Cross-Section of a Rubble Mound Breakwater I



# Cross-Section of a Rubble Mound Breakwater II

## Key Points

- Core: Consists of smaller quarry run materials to prevent transmission of wave energy.
- Underlayer/Filter: Intermediate stone sizes that prevent core material from washing out.
- Armor Layer: Massive rocks or concrete blocks (tetrapods) designed to withstand wave impact.
- Crest: The top section, often paved, designed above the highest high-water level.

# Function of Breakwaters I

Breakwaters are massive, critical infrastructure elements constructed in the sea to enclose a water area, protecting it from the destructive action of sea waves. They create the necessary calm water conditions required for safe harbour operations.

## Key Points

- Absorb or reflect incident wave energy to maintain calm water inside the harbour basin.
- Prevent littoral drift (coastal sand movement) from silting up the navigational approach channel.
- Can be classified into mound types (rubble), vertical wall types (caissons), or composite types.
- Design requires rigorous statistical analysis of wave heights, tidal variations, and seabed soil conditions.

# Berthing Structures: Quays, Wharves, and Piers I

Once inside the protected basin, ships require robust, stationary structures to moor against. These marine structures also provide the essential platform for operating heavy cargo handling equipment like gantry cranes and pipelines.

## Key Points

- Wharf/Quay: Built parallel to the shore, backed by earth fill, providing a continuous solid waterfront.
- Pier/Jetty: Structures projecting outwards into the water, allowing ships to berth on both sides.
- Dolphins: Isolated marine structures used primarily for mooring or breasting (often for liquid bulk tankers).
- Fenders: Rubber or pneumatic energy-absorbing devices fitted to the face of these structures to prevent impact damage.

# Docks, Locks, and Navigational Aids I

In estuarine areas or regions with extremely high tidal variations, enclosed docks with lock gates are used to maintain a constant water level. Additionally, safe day-and-night navigation relies on a network of visual and electronic aids.

## Key Points

- Wet Docks: Enclosed basins equipped with lock gates to keep water levels constant for uninterrupted cargo handling.
- Dry Docks: Specialized basins with watertight gates that can be pumped dry for ship maintenance, repair, and inspection.
- Buoys and Beacons: Floating or fixed physical markers indicating channel limits, shallow waters, and submerged hazards.
- Lighthouses: Tower structures equipped with powerful rotating lights to guide ships from the open sea toward the approach channel.

# Summary and Conclusion I

The strategic development of port infrastructure is vital for India's economic growth and global trade competitiveness. A well-designed harbour requires a holistic approach to civil engineering, integrating natural protective features with robust artificial structures.

## Key Points

- India's port sector is rapidly evolving to accommodate ultra-large vessels and increasing cargo volumes.
- A good harbour ensures navigational safety, sufficient basin depth, and adequate space for maritime operations.
- Key elements like breakwaters, dredged channels, and turning basins are essential for wave protection and ship maneuverability.
- Berthing structures and docks provide the critical, seamless interface between sea transport and land-based logistics.