DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 4.27: Ship Characteristics, Harbour Design, Turning Basin, & Harbour Entrances

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Civil Engineering

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Introduction to Ship Characteristics I

The physical dimensions and operational capabilities of ships directly dictate the design parameters of a harbour. Key characteristics include vessel length, beam, draft, and tonnage. These properties influence channel depth, turning basin diameter, and berth sizes.

Key Points

- Overall Length (LOA) determines the length of berths.
- Beam (width) affects channel width and gate clearances.
- Draft dictates the required navigable depth in the approach channel.
- Displacement and tonnage impact the design of mooring structures and fenders.

Typical Ship Dimensions I

A comparative overview of common commercial vessel types and their typical dimensions, which serve as foundational data for port engineering.

Key Points

- | Vessel Type | Capacity (DWT) | LOA (m) | Draft (m) |
- |——————-|————————-|—————|—————|
- | Handysize Bulk | 10k - 35k | 130 - 150 | 10 |
- | Panamax | 65k - 80k | 294 | 12 |
- | Suezmax | 120k - 200k | 275 | 16 |
- | VLCC / ULCC | 200k - 500k+ | 330 - 415 | 20 - 25 |

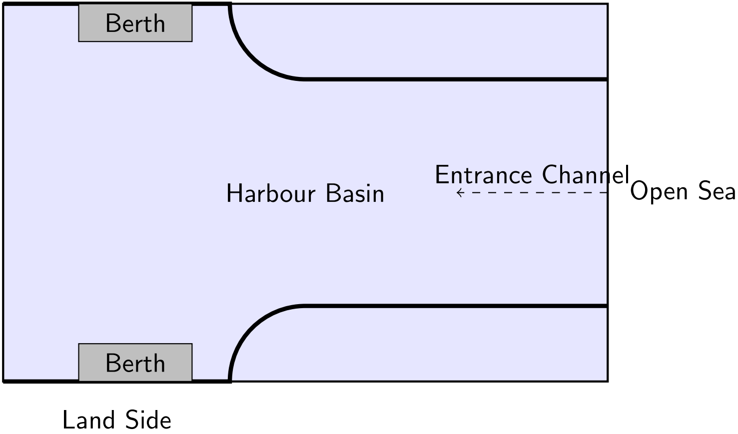
Harbour Design Principles I

Harbour design involves creating a protected water area to provide safe anchorage, mooring, and transfer of cargo and passengers. The layout must minimize wave action, ensure adequate depth, and provide sufficient area for vessel maneuvering.

Key Points

- Site selection relies on hydrographic, geotechnical, and meteorological surveys.
- Layout planning optimizes the placement of breakwaters, channels, and berths.
- Water depth is determined by the maximum loaded draft of the design vessel plus an under-keel clearance.
- Wave protection ensures tranquility within the harbour basin for safe cargo handling.

Harbour Layout Diagram I



Harbour Layout Diagram II

Key Points

- Schematic representation of a harbour showing the entrance channel, basin, and berths.
- Breakwaters protect the basin from open sea waves.

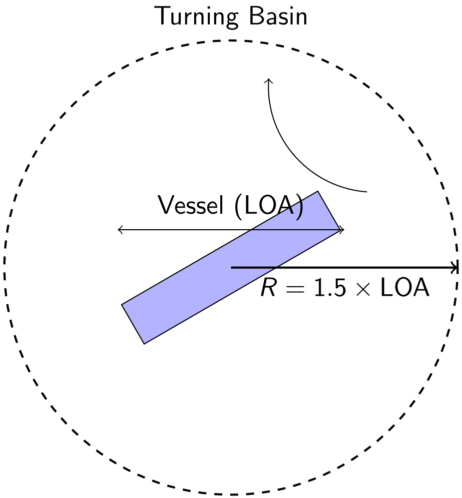
The Turning Basin I

A turning basin is a designated water area within a harbour where ships can maneuver and reverse their direction. It must be sufficiently large to accommodate the turning circle of the largest design vessel under anticipated wind and current conditions.

Key Points

- Diameter is typically 2.0 to 4.0 times the LOA of the design vessel, depending on tug assistance.
- Location is usually near the inner end of the entrance channel or adjacent to major berths.
- Shape is often circular or elliptical to facilitate smooth maneuvers.
- Depth should match or exceed the channel depth to prevent grounding during turns.

Turning Basin Dimensions I



Turning Basin Dimensions II

Key Points

- The radius (R) of the basin is often taken as 1.5 times the length overall (LOA).
- This allows a turning diameter of 3.0 times LOA, providing a safe margin.
- Vessels often pivot around their center with the assistance of tugboats.

Harbour Entrances I

The harbour entrance connects the open sea to the protected basin. Its design is critical for navigational safety and minimizing wave energy transmission into the harbour. The entrance width and orientation must account for prevailing winds, waves, and cross-currents.

Key Points

- Width is generally 0.7 to 1.0 times the length of the design vessel, but not less than 100 meters.
- Orientation should ideally allow ships to enter head-on into the prevailing waves.
- A bell-mouth shape is often used to facilitate easier entry and exit.
- Cross-currents at the entrance must be carefully evaluated to prevent vessels from being pushed against breakwaters.

Wave Penetration at the Entrance I

When designing the entrance, engineers must balance navigational width with the need to limit wave energy entering the basin. Wider entrances allow easier navigation but permit more wave energy, compromising basin tranquility.

Key Points

- Diffraction occurs as waves pass through the entrance gap.
- Overlapping breakwaters can be used to trap wave energy before it reaches the main basin.
- Stevenson's formula is historically used to estimate wave height reduction inside the harbour.
- Physical models and numerical simulations are employed for detailed wave penetration studies.

Channel Depth and Under-Keel Clearance I

Navigational channels and harbour entrances require adequate depth to ensure ships do not strike the seabed. The total required depth is the sum of the ship's draft and the Under-Keel Clearance (UKC).

Key Points

- Draft is the submerged depth of the ship, which increases with cargo load.
- Squat effect: Ships sink deeper and trim (tilt) when moving through shallow water.
- Wave response: Pitching and rolling in the entrance channel temporarily increase draft.
- UKC typically ranges from 10% to 15% of the maximum draft, depending on channel conditions.

Design Vessel Concept I

All harbour design elements (channels, basins, berths, breakwaters) are dimensioned based on a 'Design Vessel'. This is a hypothetical or existing ship representing the largest, deepest, or most critical vessel expected to use the port.

Key Points

- Ensures that all infrastructure is harmonized for safety and efficiency.
- Different port zones may have different design vessels (e.g., oil terminal vs. container terminal).
- Future trends in shipbuilding (e.g., ultra-large container ships) must be considered.
- Economic analysis determines if the cost of accommodating larger vessels is justified by increased trade.

Summary I

The integrated design of ship characteristics, harbour layout, turning basins, and entrances is vital for safe and efficient port operations. Understanding vessel dimensions directly informs the engineering of water areas and protective structures.

Key Points

- Ship dimensions (LOA, beam, draft) dictate harbour geometry.
- Harbour layout aims to provide tranquility and safe maneuvering.
- Turning basins require adequate space, typically 2 to 4 times LOA.
- Entrances must balance safe navigation widths with wave protection.