DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 4.29: Hydrographic and Topographic Survey, Site selection for Harbour.

GTU Course Instructor

Civil Engineering

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Introduction to Coastal Surveys I

Coastal surveys are essential prerequisites for harbour planning and design. They provide the necessary geographical, topological, and bathymetric data required to ensure safe navigation and construct stable maritime structures. Accurate surveys reduce the risk of structural failure and navigational hazards.

Key Points

- Determine the configuration of the coastline and seabed.
- Identify navigational hazards such as shoals and submerged rocks.
- Establish baseline data for estimating dredging volumes.
- Provide inputs for hydraulic modeling and structural design.

Topographic Surveying for Harbours I

Topographic surveys focus on the land-side features adjacent to the proposed harbour site. This includes mapping the shoreline, existing infrastructure, elevations, and hinterland connectivity. The data is crucial for designing port facilities, storage yards, and access roads.

Key Points

- Mapping of the shoreline and coastal features.
- Establishment of horizontal and vertical control points.
- Identification of suitable locations for breakwaters and quays.
- Planning of land-based infrastructure (rail, road, buildings).

Hydrographic Surveying: Purpose & Scope I

Hydrographic surveying deals with the measurement and description of the physical features of the navigable portion of the earth's surface and adjoining coastal areas. In harbour engineering, it primarily involves bathymetry (depth measurement) and locating underwater obstructions to ensure safe draft for vessels.

Key Points

- Bathymetric mapping to determine water depths.
- Tidal and current measurements for hydrodynamic understanding.
- Detection of wrecks, reefs, and submerged utilities.
- Continuous monitoring of siltation and erosion patterns.

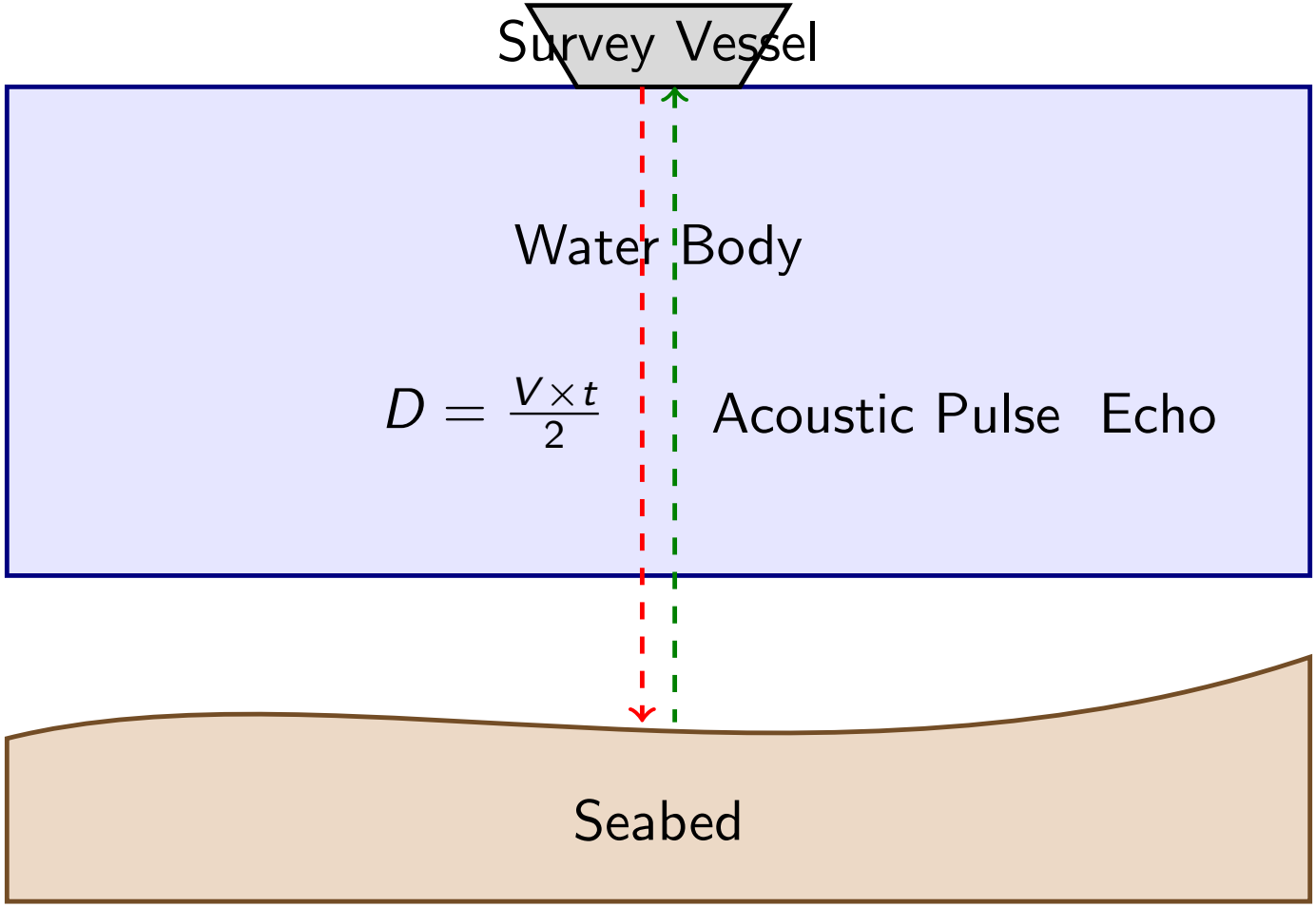
Key Hydrographic Equipment I

| Equipment | Primary Purpose | Application in Harbours | |—|—|—| | **Echo Sounder** | Depth Measurement | Bathymetric mapping and dredging surveys | | **DGPS / RTK** | Positioning | Accurate vessel tracking during sounding | | **Tide Gauge** | Water Level Monitoring | Correcting sounded depths to a common datum | | **Side Scan Sonar** | Seafloor Imaging | Identifying obstructions and seabed texture |

Key Points

- Modern surveys rely heavily on acoustic and satellite technologies.
- Data integration is performed using specialized hydrographic software.
- Real-time corrections are essential for high-accuracy outputs.

Principle of Echo Sounding I



Principle of Echo Sounding II

Key Points

- An acoustic pulse is transmitted from the vessel's transducer.
- The time taken (t) for the echo to return is measured.
- Depth (D) is calculated using the velocity of sound in water (V).

Tide Measurement & Chart Datum I

Depths measured during a hydrographic survey must be reduced to a standard reference plane known as the Chart Datum (usually Lowest Astronomical Tide, LAT). Tide gauges are installed temporarily or permanently at the site to record water level variations during the survey period.

Key Points

- Chart Datum provides a conservative estimate of available depth.
- Measured Depth = Sounded Depth - Tide Height above Datum.
- Tidal currents also influence vessel maneuverability.
- Long-term tidal data aids in defining extreme water levels.

Factors for Harbour Site Selection I

Selecting an optimal site for a harbour is a complex process that balances natural advantages with engineering constraints and economic viability. The goal is to minimize construction and maintenance costs while maximizing operational efficiency and safety.

Key Points

- Availability of natural protection from waves and winds.
- Adequate natural depth for the design vessels, minimizing dredging.
- Favorable geological conditions for foundations and dredging.
- Proximity to a productive hinterland and existing transport networks.

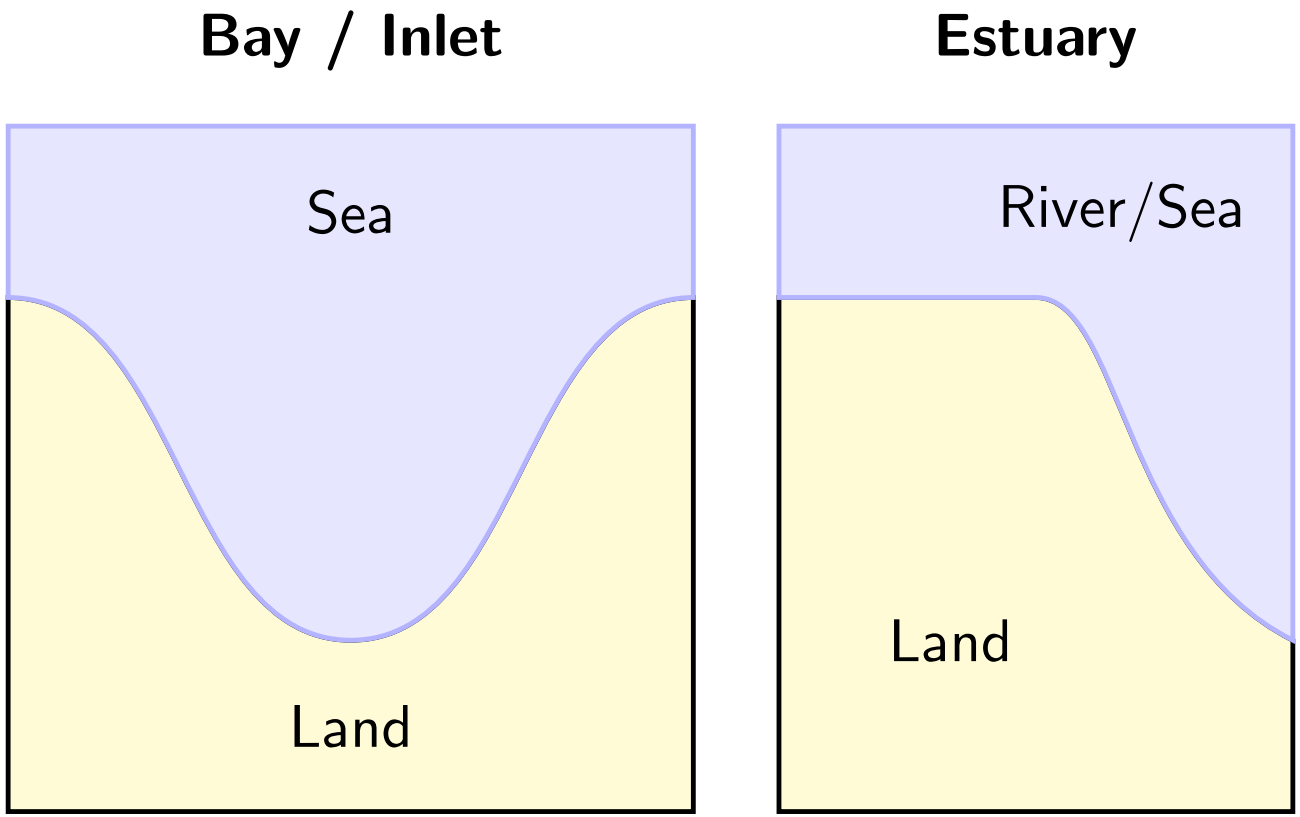
Meteorological and Oceanographic Factors I

A thorough understanding of the local climate and marine environment is critical. These factors dictate the alignment of breakwaters, the orientation of berths, and the overall downtime of port operations due to adverse weather.

Key Points

- Wind roses determine the direction of maximum wind fetch.
- Wave climate (height, period, direction) influences breakwater design.
- Littoral drift (sediment transport) affects maintenance dredging.
- Currents impact ship handling during berthing and unberthing.

Coastal Configurations for Harbours I



Coastal Configurations for Harbours II

Key Points

- Bays provide natural protection, requiring smaller breakwaters.
- Estuaries offer inland access but often suffer from siltation.
- Straight coastlines require massive artificial protection (breakwaters).
- Islands or offshore reefs can act as natural wave barriers.

Geotechnical Investigations I

Sub-surface exploration is essential to understand the soil strata beneath the seabed and the coastal land. This determines the feasibility of dredging (capital vs. maintenance) and the foundation design for heavy marine structures like breakwaters, piles, and quay walls.

Key Points

- Boreholes and cone penetration tests (CPT) on land and offshore.
- Seismic refraction and sub-bottom profiling for bedrock mapping.
- Assessment of soil bearing capacity and settlement characteristics.
- Identification of hard rock that might require underwater blasting.

Summary I

Hydrographic and topographic surveys provide the foundational data for harbour engineering. The careful selection of a harbour site requires a holistic evaluation of physical surveys, environmental conditions, and geotechnical data to ensure a safe, economical, and sustainable port facility.

Key Points

- Topographic surveys map the land-side features and infrastructure.
- Hydrographic surveys determine seabed bathymetry and hazards.
- Site selection balances natural protection, depth, and hinterland access.
- Comprehensive environmental and geotechnical data mitigate engineering risks.