DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 4.34: Types of Dredger and Necessity of Dredging

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Civil Engineering

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Introduction to Dredging I

Dredging is the underwater excavation of soils and rock. The process involves excavating material from the sea, river, or lake bed, transporting it to a different location, and discharging or disposing of it. It is a critical activity for the development and maintenance of ports, waterways, and coastal protection infrastructure.

Key Points

- Involves excavation, vertical transport, horizontal transport, and disposal.
- Essential for safe navigation of ships with deep drafts.
- Utilized in river regulation and flood control projects.
- Facilitates the extraction of valuable underwater mineral deposits.

Necessity of Dredging I

The necessity of dredging primarily stems from the need to maintain adequate water depth for marine vessels, ensuring safe and efficient maritime transport. Ports are subject to continuous siltation due to river discharges, littoral drift, and tidal currents, which naturally reduce the depth of navigational channels and berths.

Key Points

- Navigation: To create and maintain required depths for ships to avoid grounding.
- Construction: To prepare underwater foundations for structures like breakwaters or bridge piers.
- Reclamation: To provide fill material for creating new land or expanding port facilities.
- Environmental Remediation: To remove contaminated sediment and improve water quality.

Categories of Dredging Operations I

Type of Dredging	Purpose	Material Characteristics
Capital Dredging	Creating new channels or harbour basins	Often undisturbed, compact soils or rock
Maintenance Dredging	Restoring navigable depths lost to siltation	Soft, loose, and unconsolidated sediments
Environmental Dredging	Removing contaminated materials safely	Hazardous sludges and polluted silts
Mining/Reclamation	Extracting minerals or fill materials	Sand, gravel, and specific mineral ores

Categories of Dredging Operations II

Key Points

- Capital dredging involves heavy duty equipment due to virgin soil consolidation.
- Maintenance dredging is a recurring requirement for almost all operational ports.
- Environmental dredging requires specialized equipment to prevent secondary pollution.
- Mining focuses on material recovery rather than altering channel dimensions.

Classification of Dredgers I

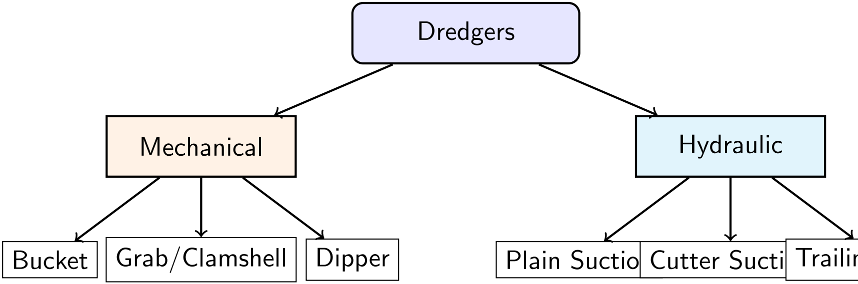
Dredgers are broadly classified into two main categories based on the method of excavation: Mechanical dredgers and Hydraulic dredgers. Mechanical dredgers use buckets, grabs, or dippers to physically dig and lift the material, similar to dry land excavators. Hydraulic dredgers use centrifugal pumps to fluidize the sediment and transport it as a slurry through pipelines.

Classification of Dredgers II

Key Points

- Mechanical Dredgers: Work well in confined spaces and can handle stiff materials and debris.
- Hydraulic Dredgers: Highly efficient for moving large volumes of loose material over long distances.
- Some modern dredgers combine both mechanical and hydraulic principles for optimal efficiency.
- The choice between them depends on soil type, required depth, and disposal method.

Classification Tree of Dredgers I



Classification Tree of Dredgers II

Key Points

- Mechanical types physically scoop the material from the seabed.
- Hydraulic types use suction pipes and pumps to transport a soil-water mixture.
- Hybrid forms exist, but this represents the fundamental industry classification.

Mechanical Dredgers: Bucket and Grab I

Bucket ladder dredgers feature a continuous chain of buckets that scoop material and empty it into barges. They are robust and can handle various soil types including soft rock. Grab (or Clamshell) dredgers use a crane-mounted grab bucket; they are highly maneuverable and ideal for working in corners of docks, near quay walls, and handling debris, though their production rate is relatively low.

Mechanical Dredgers: Bucket and Grab II

Key Points

- Bucket Ladder Dredger: Continuous excavation, good for uniform channel beds, very noisy.
- Grab Dredger: Simple operation, easy to deploy, capable of deep dredging.
- Dipper (Backhoe) Dredger: Basically a floating excavator, excellent for hard rock and stiff clay.
- Excavated material from mechanical dredgers usually requires auxiliary barges for transport.

Hydraulic Dredgers: CSD and TSHD I

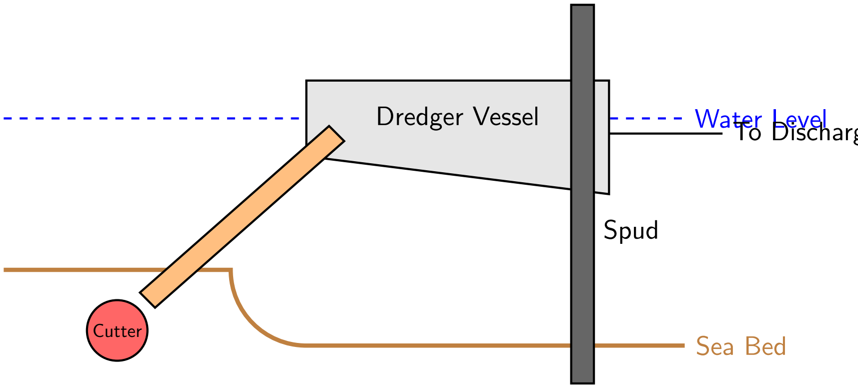
Cutter Suction Dredgers (CSD) use a rotating cutter head to loosen hard soil, which is then sucked up by a dredge pump and transported via floating pipelines. Trailing Suction Hopper Dredgers (TSHD) are self-propelled vessels that trail a suction pipe along the seabed while moving, storing the dredged slurry in an onboard hopper for later transport and dumping.

Hydraulic Dredgers: CSD and TSHD II

Key Points

- CSD: Stationary during dredging (anchored by spuds), suitable for hard soils, continuous pipeline discharge.
- TSHD: Highly mobile, no obstruction to other shipping, ideal for open water and maintenance dredging.
- Plain Suction Dredgers: Used for easily fluidizable materials like loose sand without mechanical cutting.
- Hydraulic dredgers generally have higher production rates compared to mechanical types.

Schematic of a Cutter Suction Dredger I



Schematic of a Cutter Suction Dredger II

Key Points

- The Cutter Head rotates to loosen the bed material (rock, clay, or compacted sand).
- The Suction Ladder houses the suction pipe and sometimes an underwater pump.
- Spuds anchor the dredger and act as a pivot point during the sweeping motion.
- The fluidized mixture is pumped through a floating pipeline to the disposal or reclamation area.

Selection Criteria for Dredgers I

Selecting the appropriate dredger for a specific project is crucial for technical feasibility and economic viability. The decision depends on the physical and geotechnical properties of the seabed material, the depth of dredging, the required production rate, the distance to the disposal site, and the prevailing hydrodynamic conditions (waves and currents).

Key Points

- Soil Characteristics: Hard rock requires CSD or Dipper; soft silt is suited for TSHD or Grab.
- Disposal Distance: Long distances favor TSHD; short distances or reclamation favor CSD with pipelines.
- Water Depth: Grab dredgers and TSHDs can operate at greater depths than CSDs.
- Traffic and Space Constraints: TSHDs maneuver easily in busy ports; CSDs require stationary anchoring.

Environmental Considerations in Dredging I

Dredging operations can have significant environmental impacts if not properly managed. The excavation and disposal of sediments can increase water turbidity, disrupt benthic habitats, and potentially release toxic contaminants trapped in the seabed into the water column. Modern dredging techniques prioritize minimizing these impacts through specialized equipment and strict monitoring.

Environmental Considerations in Dredging II

Key Points

- Turbidity Control: Use of silt curtains and eco-friendly cutter heads to minimize sediment suspension.
- Noise and Vibration: Mitigation measures are essential to protect marine life, especially mammals.
- Contaminated Sediment Management: Requires sealed grabs and controlled disposal in confined facilities.
- Beneficial Reuse: Using dredged uncontaminated sand for beach nourishment or habitat creation.

Summary and Conclusions I

Dredging is an indispensable operation in harbour and marine engineering, ensuring navigability and enabling marine construction. Understanding the necessity—whether for capital development, maintenance, or environmental restoration—guides the approach. The selection of the right dredger type (mechanical or hydraulic) must balance technical requirements with environmental stewardship.

Summary and Conclusions II

Key Points

- Dredging maintains port depths and provides materials for coastal development.
- Mechanical dredgers (Grab, Backhoe, Bucket) excel in confined spaces and hard/debris-filled soils.
- Hydraulic dredgers (CSD, TSHD) are optimal for high-volume, long-distance sediment transport.
- Environmental impacts must be meticulously evaluated and mitigated in all dredging projects.