

DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 4.35: Coastal zone and Beach profile, Causes of beach erosion, coastal protection work

GTU Course Instructor

Civil Engineering

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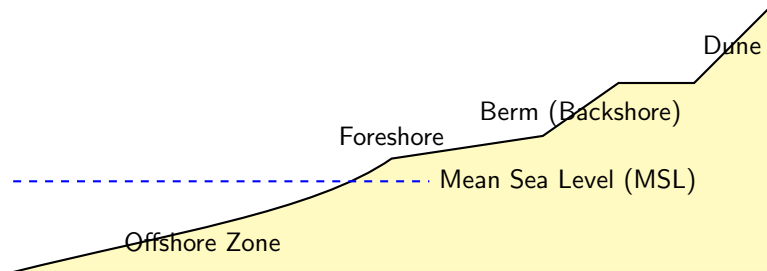
Introduction to the Coastal Zone I

The coastal zone is the dynamic interface between land and sea, characterized by complex interactions among geomorphological, biological, and hydrodynamic processes. It serves as a vital natural buffer against coastal hazards and supports diverse ecosystems.

Key Points

- Dynamic interface between terrestrial and marine environments.
- Continuously shaped by waves, tides, currents, and wind.
- Crucial for ecological balance and human activities (e.g., ports, tourism).

Standard Beach Profile Components I



Key Points

- Illustrates the cross-section from the offshore seabed to inland dunes.
- Delineates distinct morphological zones based on tidal action and wave reach.

Understanding Beach Profile Dynamics I

A beach profile represents a cross-sectional view of the coastal landscape from the offshore zone to the inland limit of the beach. Its shape varies seasonally, primarily influenced by wave energy. Winter storms tend to flatten the beach, pulling sand offshore to form bars, while gentle summer waves push sand back onshore, building up the berm.

Key Points

- Offshore: Seaward of the breaker zone, where wave action doesn't significantly disturb the seabed.
- Foreshore: The intertidal zone exposed at low tide and submerged at high tide.
- Backshore: Dry region above the high-tide line, wetted only during severe storms.
- Berm: Nearly horizontal portion formed by deposition of sediment.

Natural Causes of Beach Erosion I

Beach erosion is the permanent or temporary loss of sand and sediment from the coastal profile. Natural causes are primarily driven by hydrodynamic forces and climatic events that remove sediment faster than it can be naturally replenished.

Key Points

- Wave action and longshore currents transporting sediment away from the beach.
- Severe storms, hurricanes, and cyclones causing sudden, massive sand displacement.
- Tidal variations and storm surges increasing the reach of destructive waves.
- Relative sea-level rise due to tectonic subsidence and climate change.

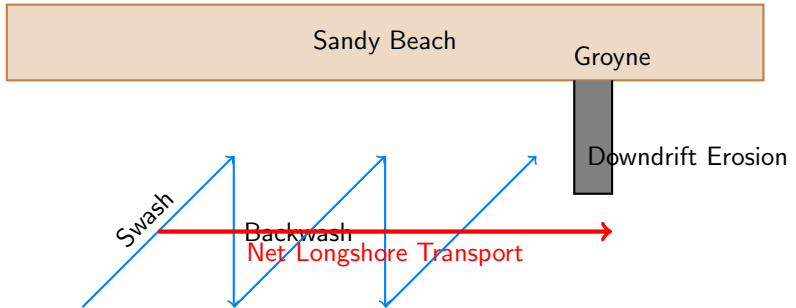
Anthropogenic Causes of Beach Erosion I

Human activities significantly exacerbate coastal erosion by altering natural sediment transport pathways and disrupting the delicate balance of coastal ecosystems. Infrastructural development and resource extraction are primary culprits.

Key Points

- Construction of upstream dams trapping sediment that would otherwise nourish beaches.
- Improperly designed coastal structures (e.g., groynes) causing downdrift erosion.
- Sand mining from riverbeds and beaches for construction materials.
- Destruction of natural defenses like mangroves, coral reefs, and coastal dunes.

Mechanism of Longshore Drift and Erosion I



Key Points

- Swash moves sand up the beach at an angle; backwash pulls it straight down.
- Structures like groynes block transport, causing accumulation updrift and starvation downdrift.

Introduction to Coastal Protection Works I

Coastal protection works are engineering interventions designed to mitigate coastal erosion, prevent flooding, and stabilize the shoreline. The selection of an appropriate protection method depends on the specific coastal dynamics, environmental impact, and economic considerations.

Key Points

- Primary goal: Reduce wave energy and control sediment transport.
- Hard engineering: Involves building solid structures to resist waves.
- Soft engineering: Uses natural processes and materials to dissipate wave energy.
- Integrated Coastal Zone Management (ICZM) combining both approaches is often preferred.

Comparison of Coastal Protection Methods I

Feature		Hard Engineering	Soft Engineering
barriers	Natural energy dissipation	**Mechanism**	Rigid physical
Breakwaters	Beach Nourishment, Dune Grass Planting	**Examples**	Seawalls, Groynes,
High initial construction cost		**Cost**	Ongoing maintenance cost
Environmental Impact	Can disrupt local ecosystems	**Aesthetics**	
friendly, enhances habitat		Unnatural appearance	
		Preserves natural landscape	

Key Points

- Hard structures provide immediate, robust protection but can cause downdrift issues.
- Soft structures are sustainable and adaptable but require continuous monitoring.

Hard Engineering: Seawalls and Groynes I

Seawalls are massive concrete or stone structures built parallel to the shoreline to reflect wave energy and protect the land behind them. Groynes are perpendicular structures extending into the sea to interrupt longshore drift and trap sand, widening the beach on the updrift side.

Key Points

- Seawalls: Highly effective for cliff and settlement protection, but often cause scouring at their base.
- Groynes: Effective at building up local beaches, but can cause severe erosion downdrift.
- Breakwaters: Built offshore to break waves before they reach the shore, creating a calm water zone.
- Revetments: Sloped structures placed on banks or cliffs to absorb wave energy.

Soft Engineering: Beach Nourishment I

Beach nourishment involves artificially adding sand to an eroding beach from an external source (e.g., offshore dredging). This creates a wider beach that acts as a natural buffer, dissipating wave energy before it reaches inland infrastructure.

Key Points

- Maintains the natural aesthetic and recreational value of the beach.
- Provides a sacrificial layer of sand that protects underlying structures.
- Requires periodic renourishment as the new sand will eventually erode.
- Must carefully match the grain size and type of the native beach sand.

Summary I

The coastal zone is a highly dynamic environment shaped by continuous interaction between land and sea. Understanding the beach profile and the natural and anthropogenic drivers of erosion is critical for effective coastal management. Coastal protection requires a balanced approach, utilizing both hard engineering structures and soft, nature-based solutions to achieve sustainable shoreline stabilization.

Key Points

- Beach profiles are divided into offshore, foreshore, backshore, and dune zones.
- Erosion is driven by waves, storms, sea-level rise, and human interference.
- Protection works encompass rigid structures (seawalls) and natural methods (nourishment).
- Sustainable coastal management demands holistic, site-specific strategies.