These lecture materials are for the Marine Coastal and Delta Sustainability for Southeast Asia (MARE) (Project No. 610327-EPP-1-2019-1-DE-EPPKA2-CBHE-JP).

This project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be made responsible for any use which may be made from the information contained herein.

Co-funded by the Erasmus+ Programme of the European Union

Topic 4

Sediment Transport & Coastal Morphodynamics

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Course Learning Outcomes

Upon completion of this course, students should be able to:

1. Evaluate the properties of offshore and near shore waves and establish design wave specification.
2. Assess currents and tidal processes.
3. Formulate sediment budget and perform shoreline evolution analysis.

Learning Objectives

Learning Outcomes

Upon completion of this topic, students should be able:

- To estimate littoral transports
- To evaluate sediment budget of a littoral cell
- To assess shoreline responses towards an obstacle

Part 2: Sediment Budget

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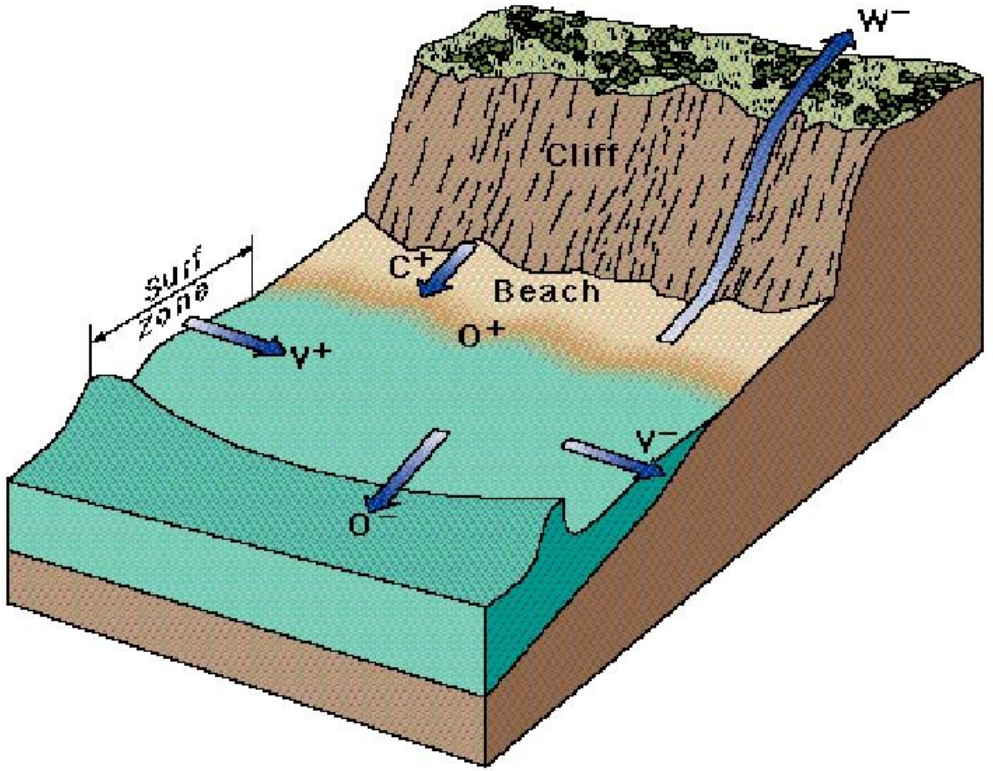
Sediment Budget

Sediment budget refers to the balance between **sediment** added to and removed from the coastal system.

Sediment budget applies the **principle of continuity/ conservation of mass** to the coastal sediments within a littoral cell.

When more material is added than is removed (net), there is a surplus of sediment and the shore builds seaward.

- ☐ Final **credit** balance (net gain) → System is accreting
- ☐ Final **debit** balance (net deficit) → System is eroding
- ☐ Final **balance** → State of equilibrium



Sediment Budget Analysis

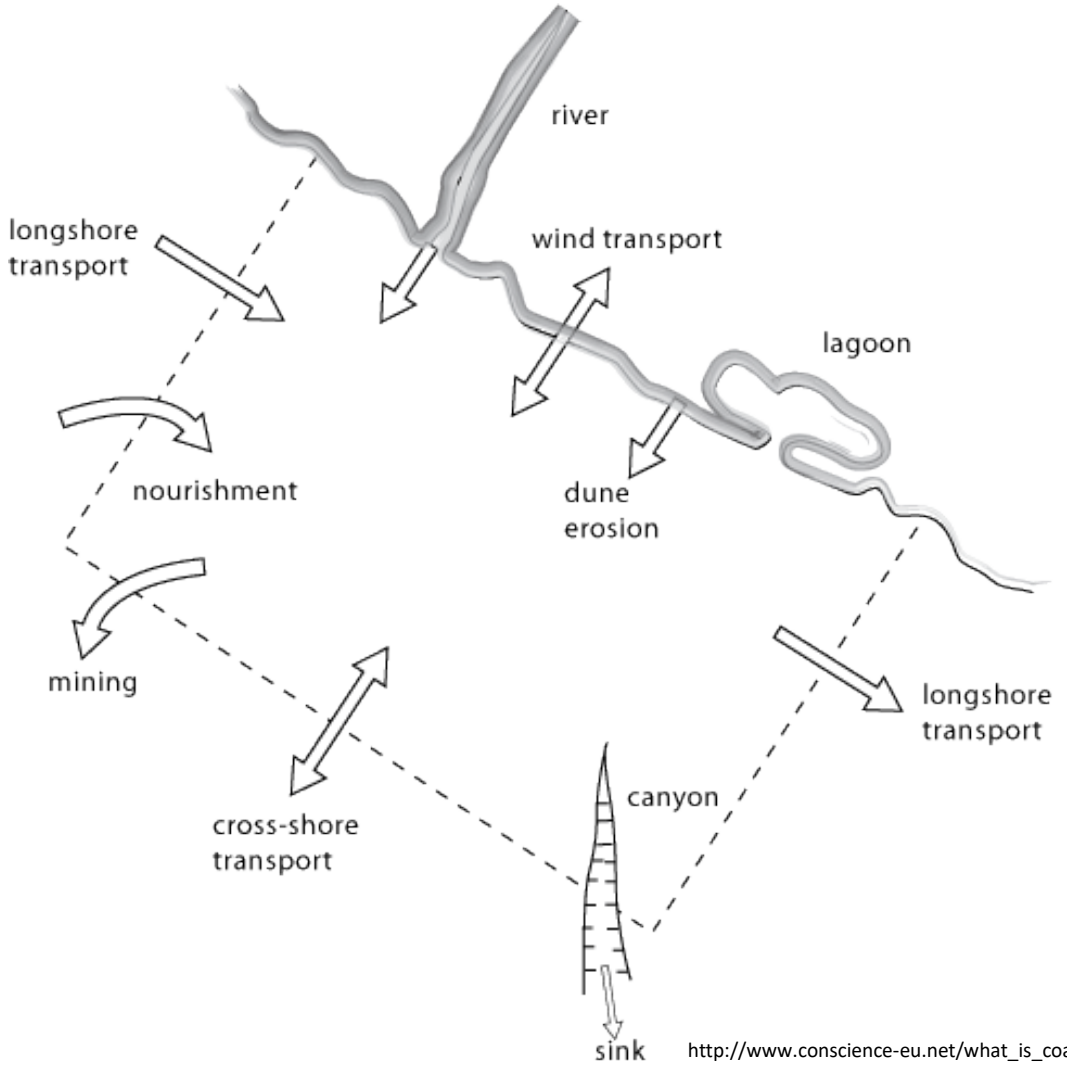
OBJECTIVES

To understand the **processes** causing coastal instability and to assess their **relative importance** correctly.

Procedures:

- Identify the sources and sinks for a particular system.
- Compute the quantities of sand supplied or trapped by them.
- Compare the total balance with that measured by beach surveys & direct observation in order to verify the accuracy of the computed results.

Sediment Budget Analysis



http://www.conscience-eu.net/what_is_coastal_erosion_and_when_is_it_a_problem/index.htm

Procedures:

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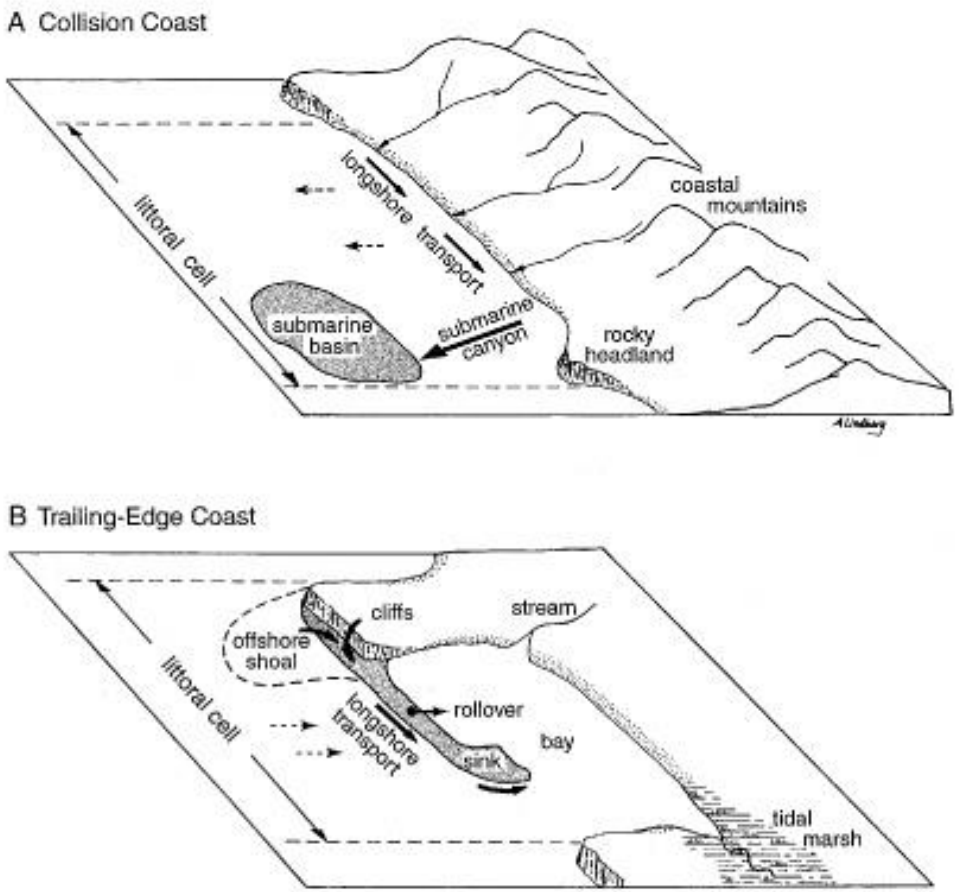
Littoral Cell



- Most coasts are formed of a series of individual systems (littoral cells) with each has its characteristics.
- A littoral cell is a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks.
- The cell boundaries delineate the geographical area within which the budget of sediment is balanced.
- The usual transport path is along the coast by waves and currents (longshore transport, littoral drift).
- The cross-shore (on/offshore) paths may include windblown sand, overwash, etc.

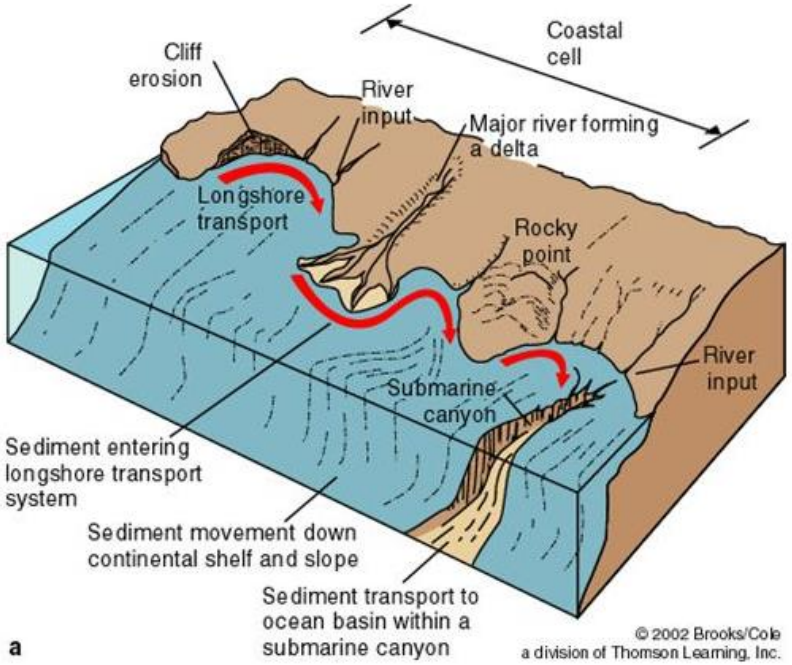
https://link.springer.com/referenceworkentry/10.1007%2F1-4020-3880-1_196

Coastal Cell

https://www.youtube.com/watch?v=kYvT9VKAq6c

Source & Sink

Coastal Cells



Sections of coast in which sand input and sand output are balanced are referred to as **coastal cells.**

SOURCE	SINK
• Rivers and streams • Sea cliff erosion at upcoast • Alongshore transport into area • Wind transport onto beach • Beach nourishment • Coral fragments, and skeletons of small marine organisms	• Cliff erosion • Deposition into bays and estuaries • Deposition at submarine canyons • Alongshore transport out of area • Wind transport off beach (dune migration) • Offshore transport • Mining • Solution and abrasion

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Rivers and Streams

SOURCE

The principle sources of nearshore sediment, which may transport large quantities of sand directly to the ocean.

The amount and type of sediment load are determined by:

- ✓ Topography
- ✓ Type of rock present
- ✓ Density of vegetation
- ✓ Climate

Cliff Erosion

- Cliff erosion due to wave action may be an important source of sediments depending upon the nature of the material forming the cliffs.
- For instance, boulder clay break down into very fine clay and silt particles and are readily transported offshore out of the coastal system.

ALONGSHORE TRANSPORT INTO/OUT OF AN AREA

SOURCE

SINK

This is a principal agency supplying & removing sand from a coastal system.

The form of sedimentary coastal features indicates both the presence and direction of the net alongshore sediment transport.

LST can be evaluated in 2 ways:

(i) **Computation using local surf zone data** obtained by direct observation or by computation using offshore wave data and refraction-shoaling analysis

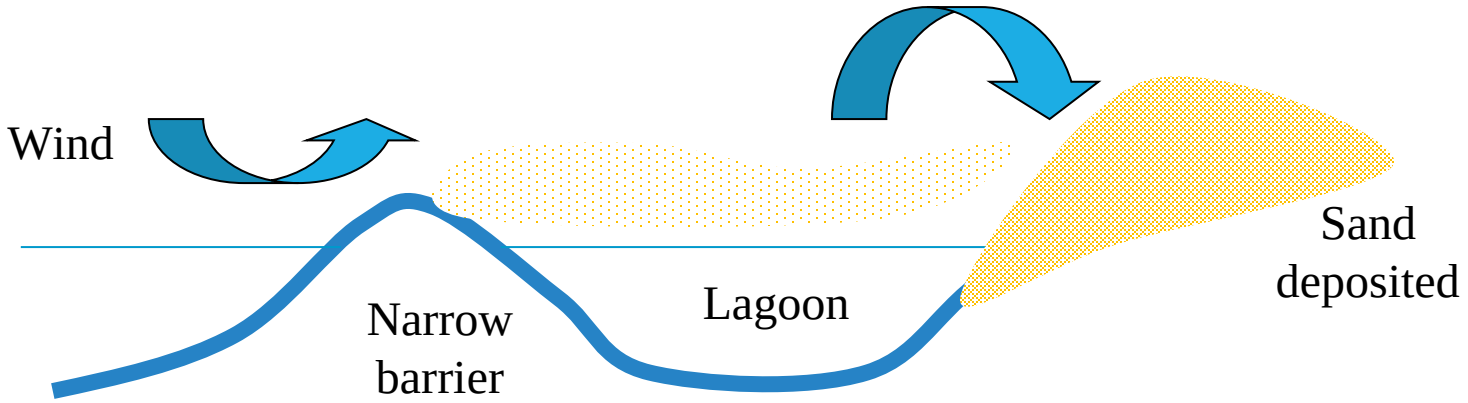
(ii) **Field measurements** of rates of accretion at a littoral barrier provide a reasonably reliable value of the alongshore transport rate

WIND TRANSPORT ONTO/OFF THE BEACH

SOURCE
SINK

Not all sand blown landward by onshore winds is retained within the beach system so it is necessary to allow for sand losses (and gains) from wind action.

In narrow barrier island, prevailing onshore winds may remove sand from the sand dunes and deposit it in the estuary or lagoon in the lee of the coastal dunes.



ONSHORE-OFFSHORE TRANSPORT

SOURCE
SINK

Comparatively small losses to the coastal system.

Conditions will occur at times which will result in sand being removed from beach and not replaced.

Fine sediments placed in suspension by the breaking waves are usually carried offshore into deep water.

Net Offshore Losses	Net Onshore Gains
Regions where relatively large storm waves occur but where there is very little swell may experience a net offshore loss of sediment, particularly if the offshore zone is relatively deep.	Sediment eroded from unconsolidated offshore sources in a relatively shallow sea/continental shelf is transported shoreward by mass transport action and ultimately onto the beach.

BEACH NOURISHMENT VS. MINING

SOURCE
SINK

Beach Nourishment

Sand is supplied from outside a coastal system to build a new beach to stabilize and protect an eroding coastline.

Mining

Mining of the beach and frontal sand dunes remove sediment from the system.

DEPOSITION INTO BAYS & ESTUARIES

SINK

Not all the sediment brought down by the rivers reaches the beach.

Estuaries may trap some or all the sediment before it reaches the beach. Under such conditions the estuary becomes a sink for littoral sediments.

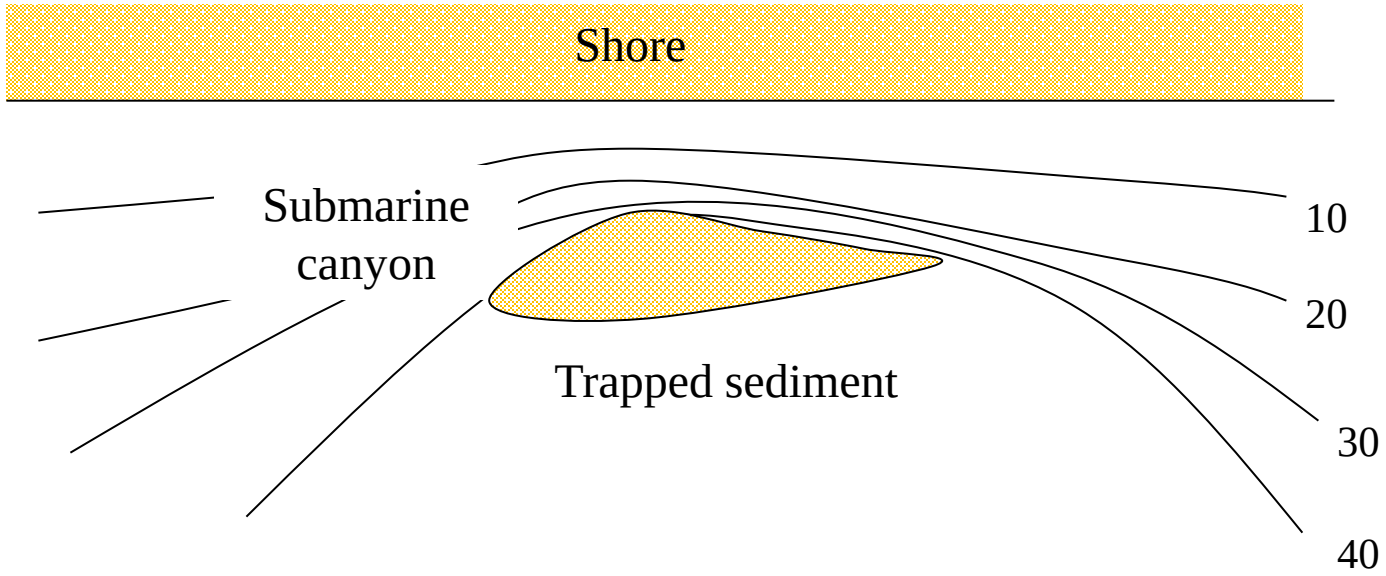
Sand may also be stored in sandy spits.

DEPOSITION AT SUBMARINE CANYONS

SINK

Submarine canyons close to the shore intercept the sediment being transported along the shore and direct it offshore.

The sand trapped in this manner cannot be returned to the beach.



BIOGENOUS & HYDROGENEOUS DEPOSITION

SOURCE

Shell and coral fragments are important sediment sources on some beaches especially those in the tropics where biological productivity is high.

Sediment can also be formed by direct precipitation from sea water (hydrogeneous deposition). This produces spherical sand sized calcium carbonate grains called oolites.

Modern ooids from a beach on Joulter's Cay, The Bahamas

Ooids on the surface of a limestone; Carmel Formation (Middle Jurassic) of southern Utah

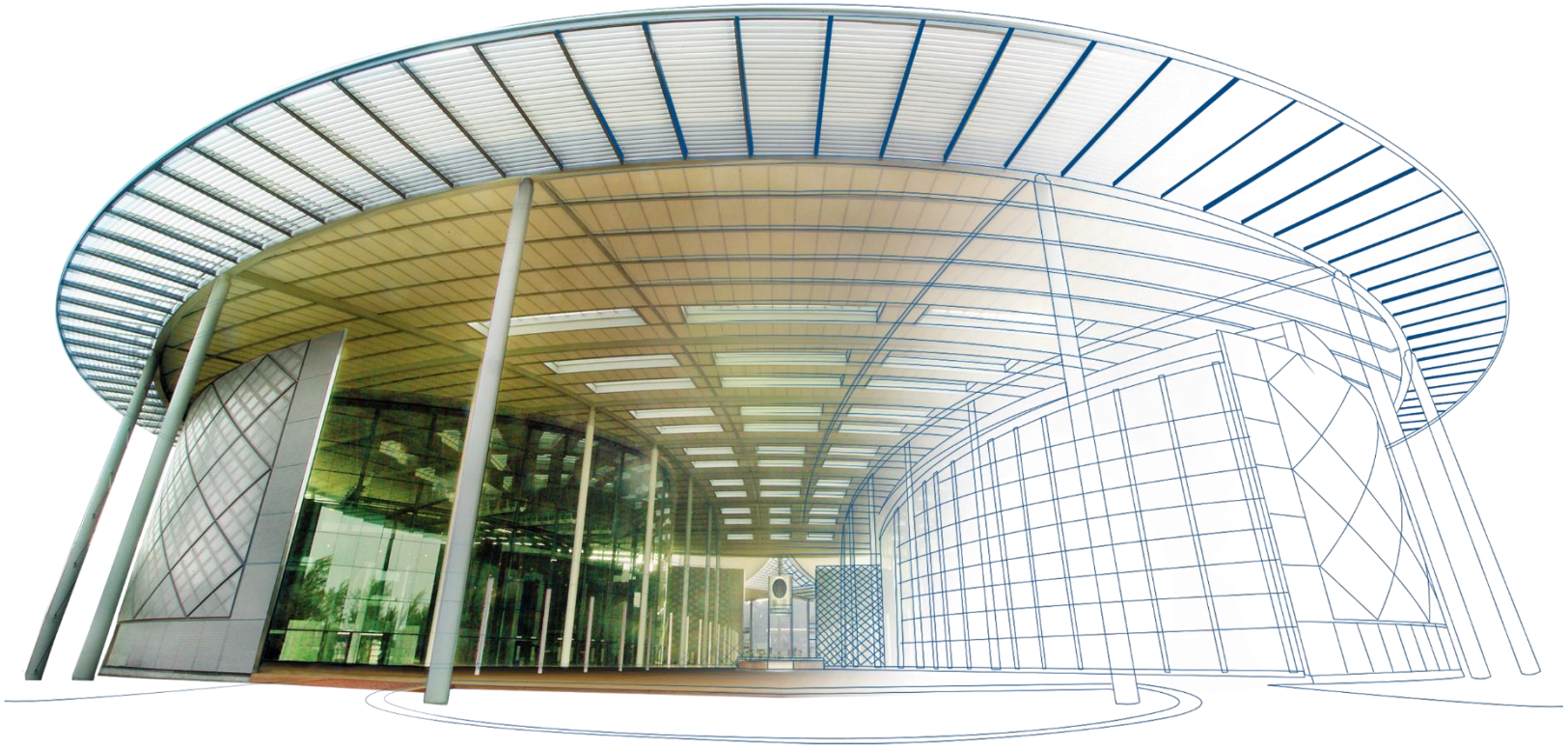
SOLUTION & ABRASION

SINK

The size of sediment particles, particularly pebbles and shingle is gradually reduced by abrasion. The very fine material produced in this process will be carried away offshore.

Quartz sand is virtually indestructible as the effect of solution and abrasion upon it are insignificant.

Calcareous sand is much more susceptible to abrasion and solution.



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