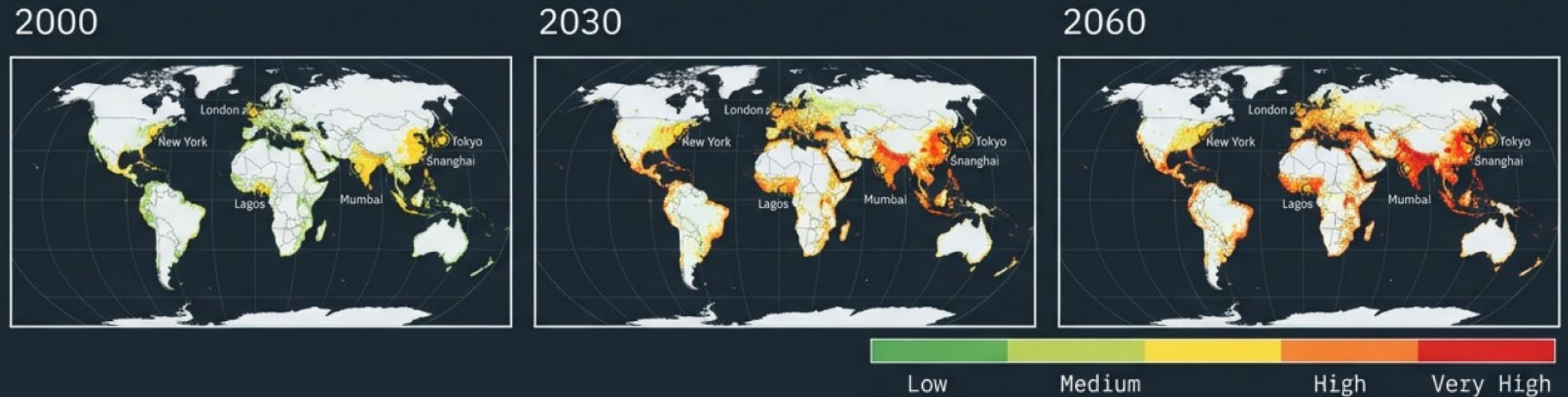


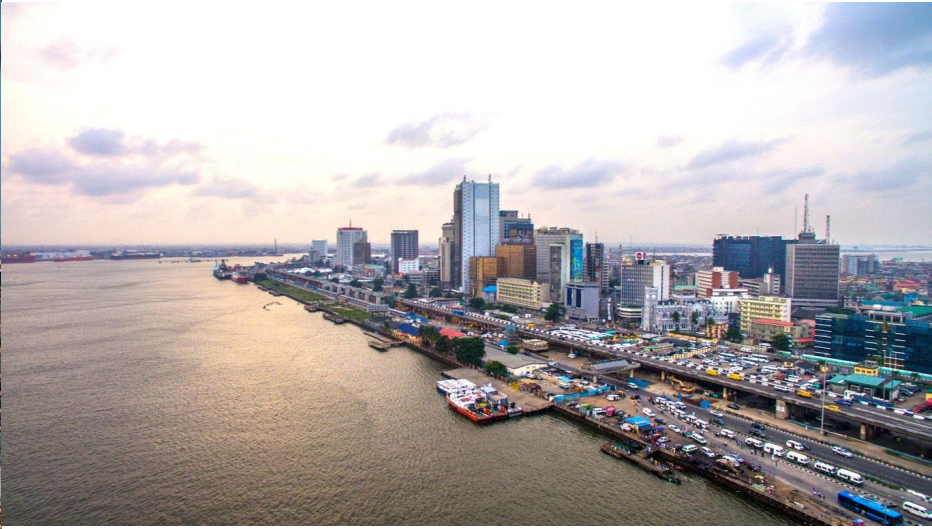
Coastal Engineering



Coastal Defences

- Coastal Zones occupy <15% of the Earth's land mass yet accommodate >40% of the global population.





Coastal Defences

1. Reduce risk of flooding by holding back waves.
2. Slow erosion to prevent land loss.





Coastal Defences

They can be categorised as
HARD and SOFT
engineering.



Wave Formation





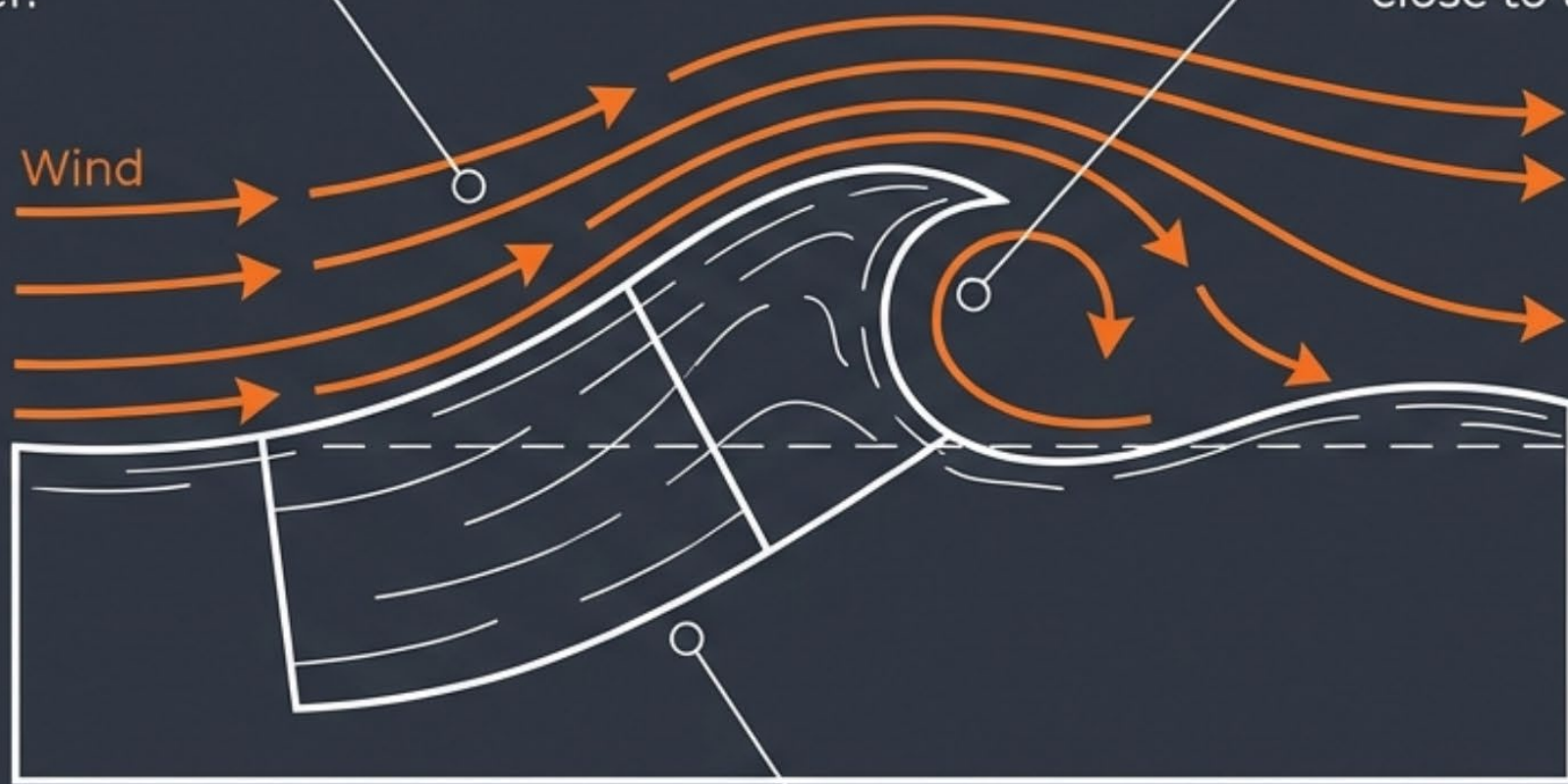
Wave Formation

- Waves are formed by wind blowing over the surface of water.
- Wave formation is dependent on 3 factors:



Tangential Stress: Air flows over the sea surface, dragging the water.

Turbulence: Rapidly varying pressure fluctuations occur close to the surface.



Feedback Loop: When pressure fluctuations are in phase with existing waves, growth accelerates.



Wave Formation



1. Wind Speed

The velocity of the airflow moving over the surface.

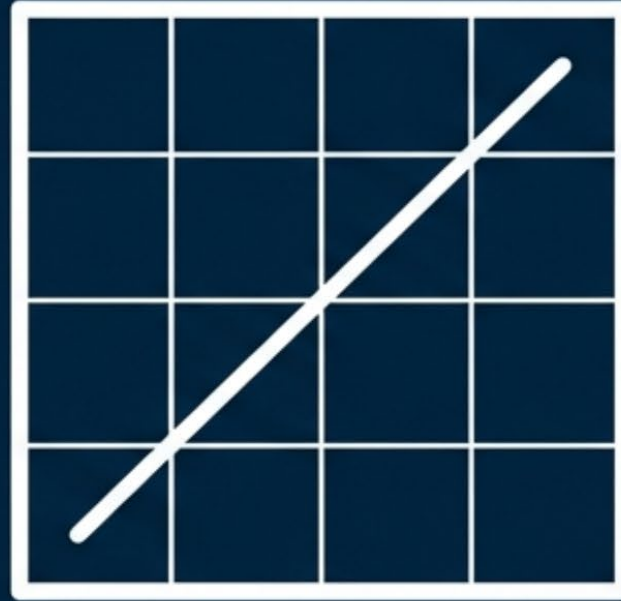


Wave Formation



1. Wind Speed

The velocity of the airflow moving over the surface.



2. Fetch

The uninterrupted distance of open water over which the wind blows.

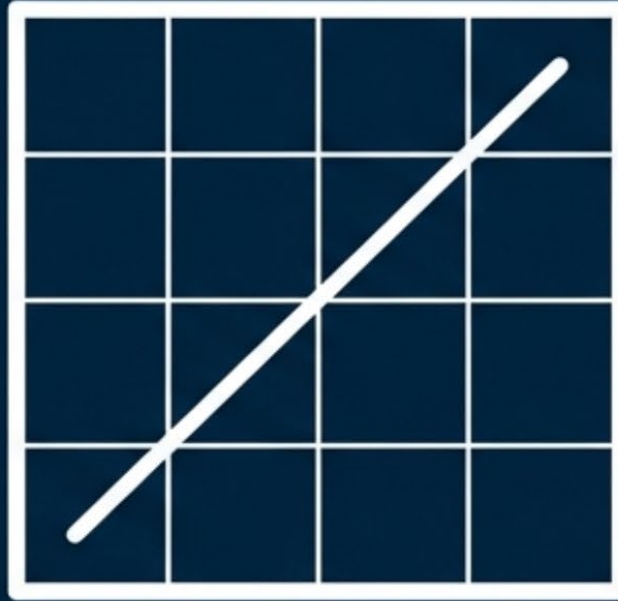


Wave Formation



1. Wind Speed

The velocity of the airflow moving over the surface.



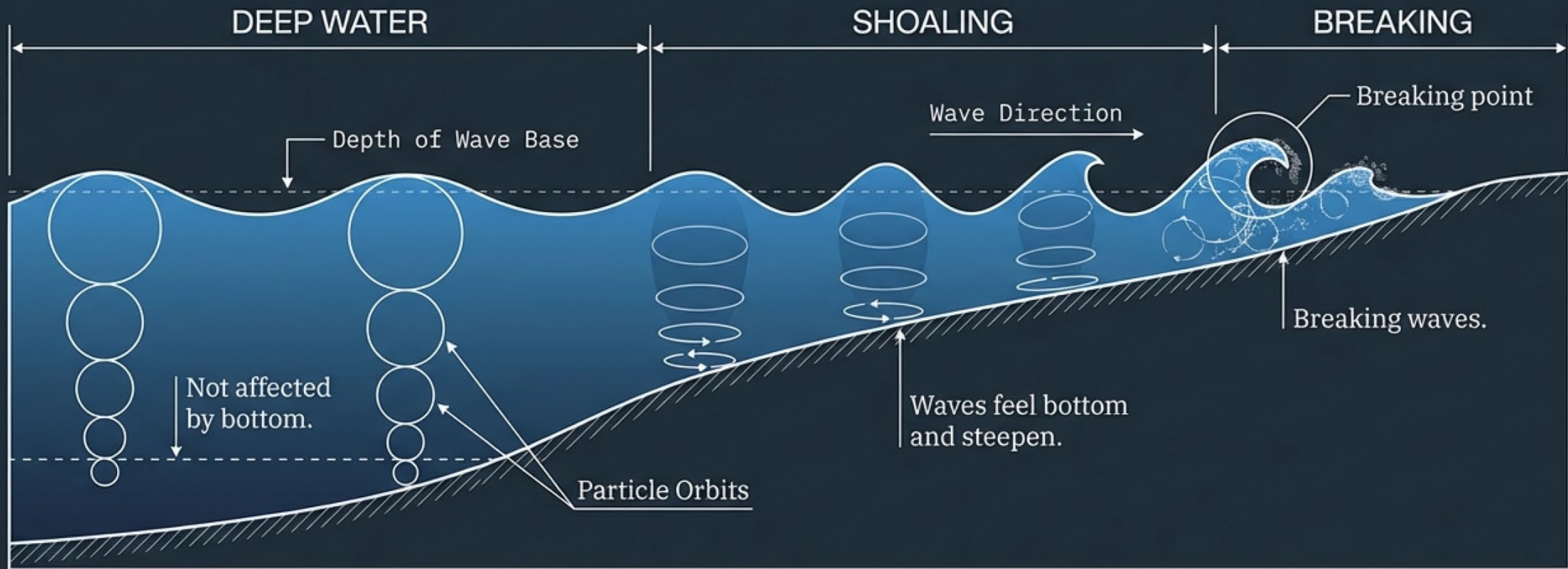
2. Fetch

The uninterrupted distance of open water over which the wind blows.



3. Duration

The length of time the wind has been blowing across the fetch.

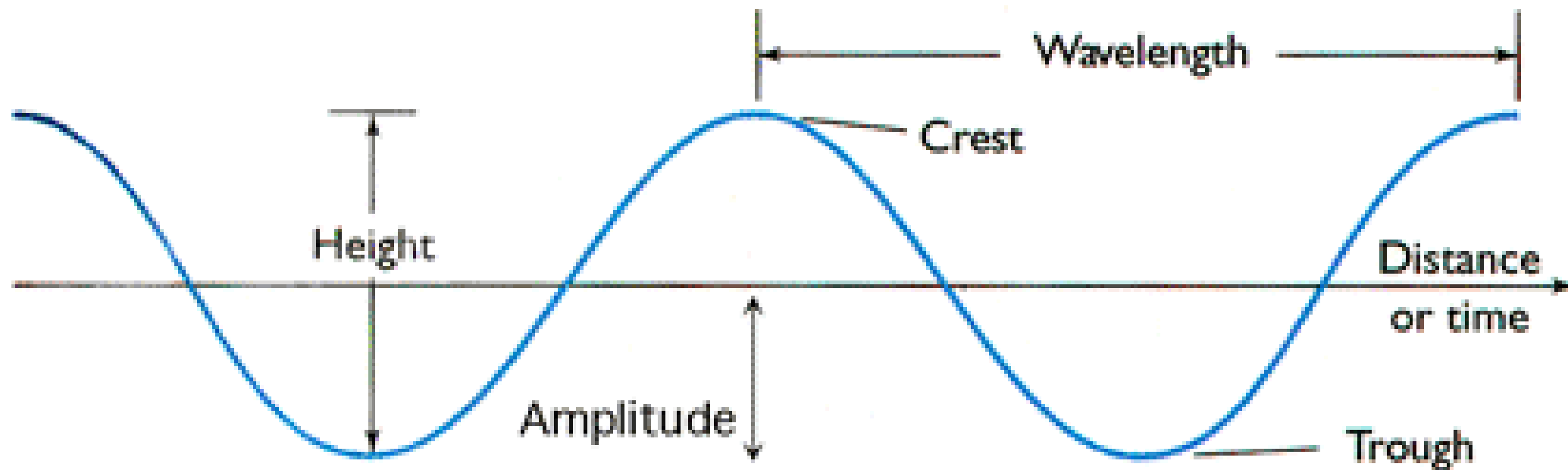


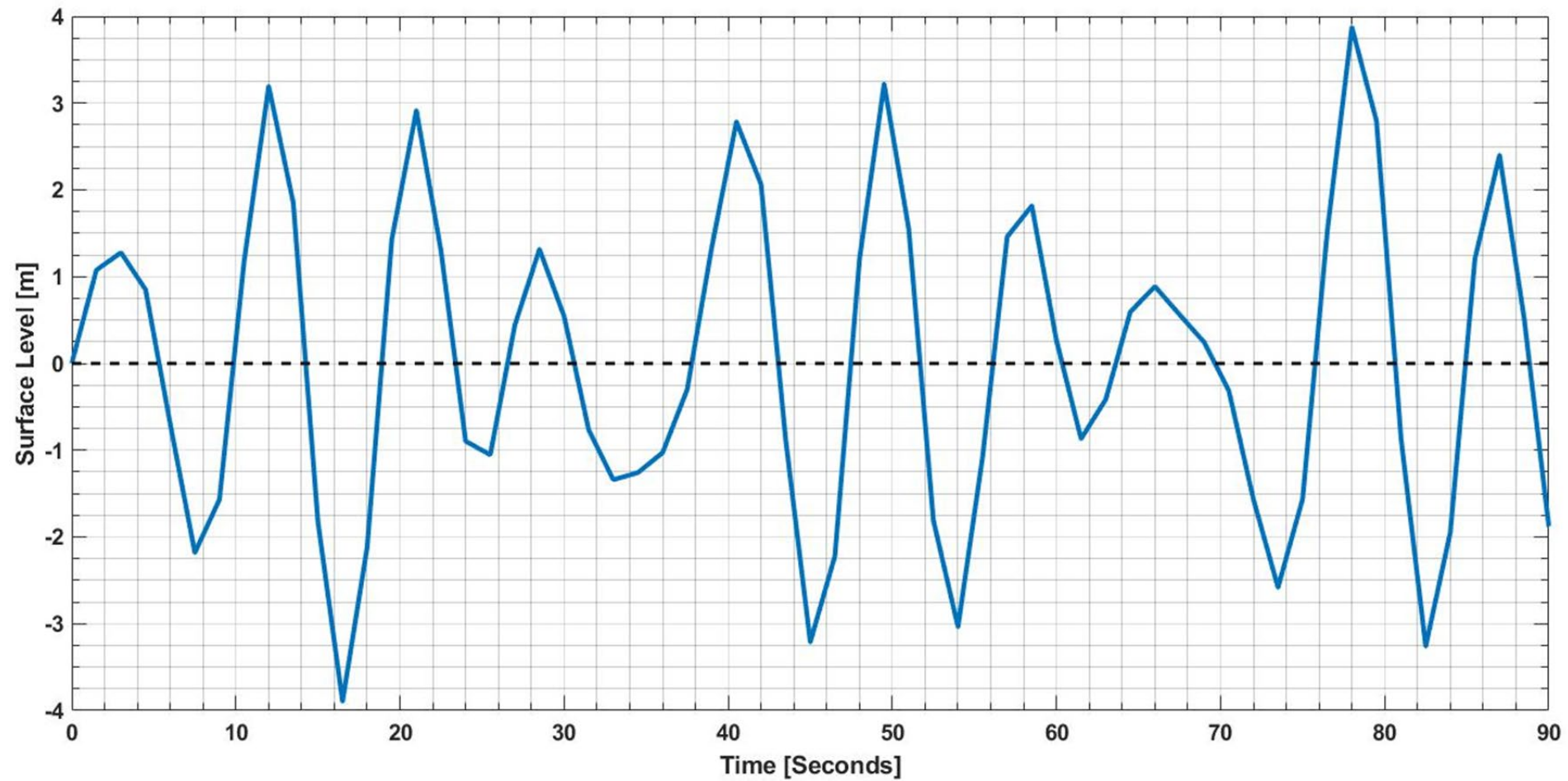


Wave Breaking

Eventually they will become so steep they can no longer support themselves and breaking will occur.

Wave Characteristics

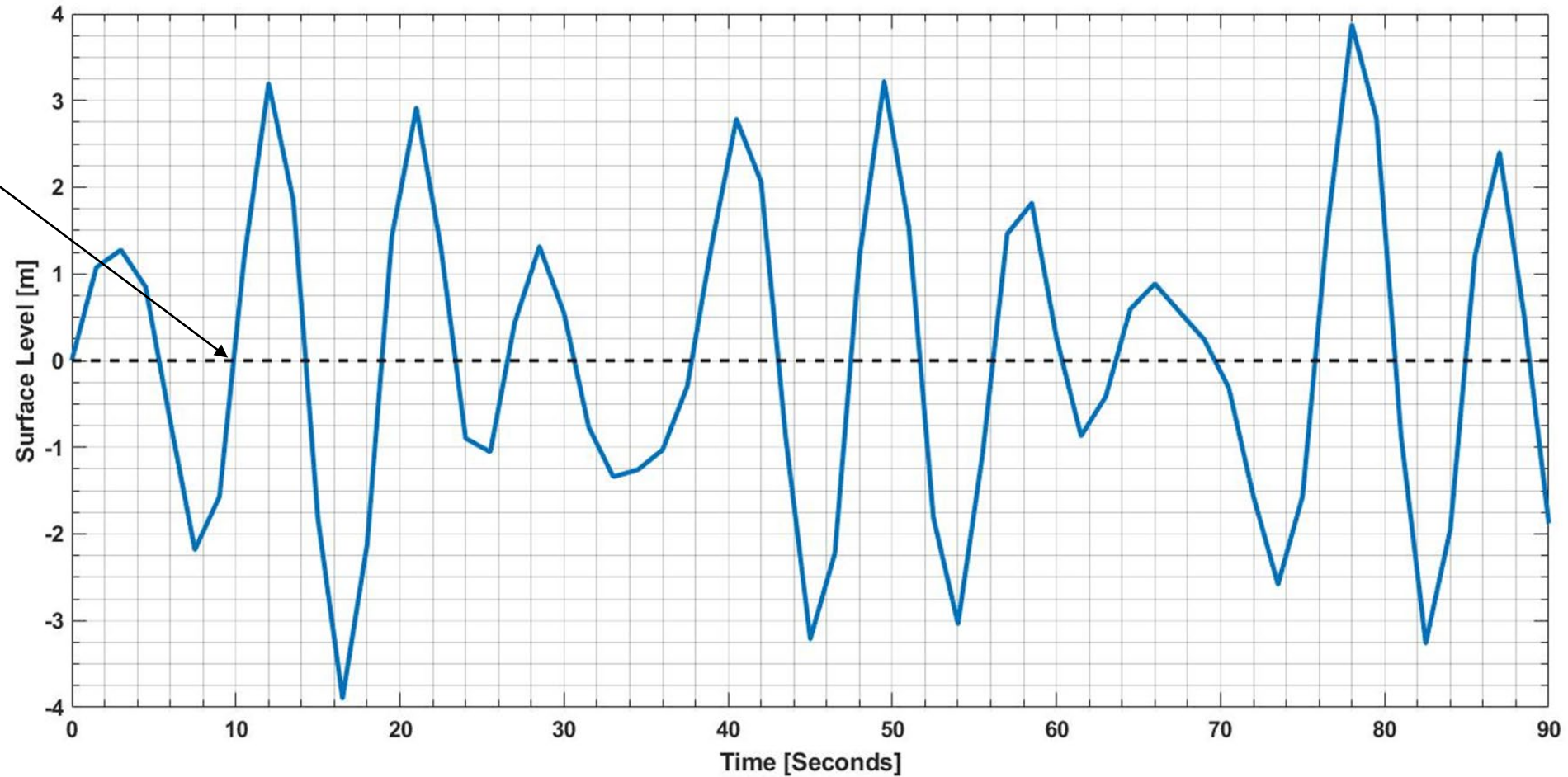




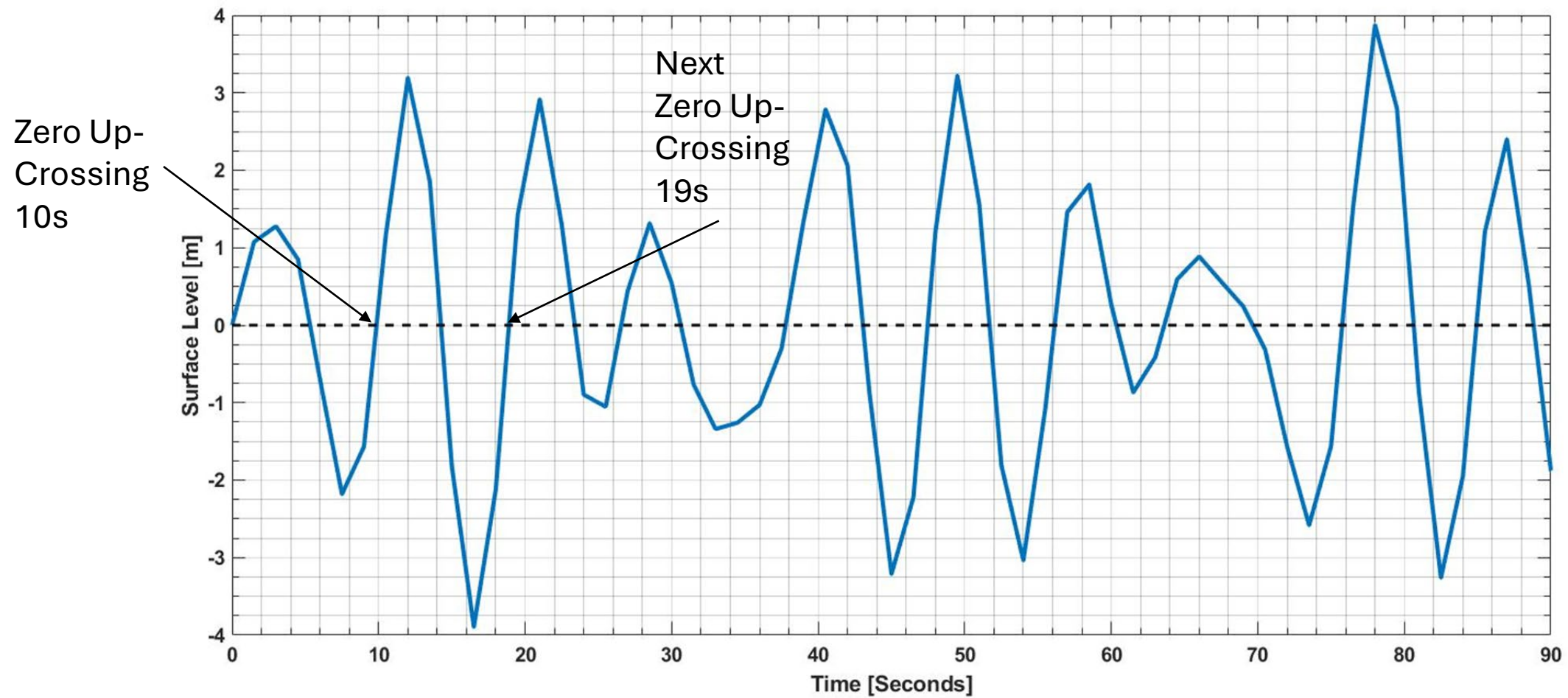
Irregular Waves



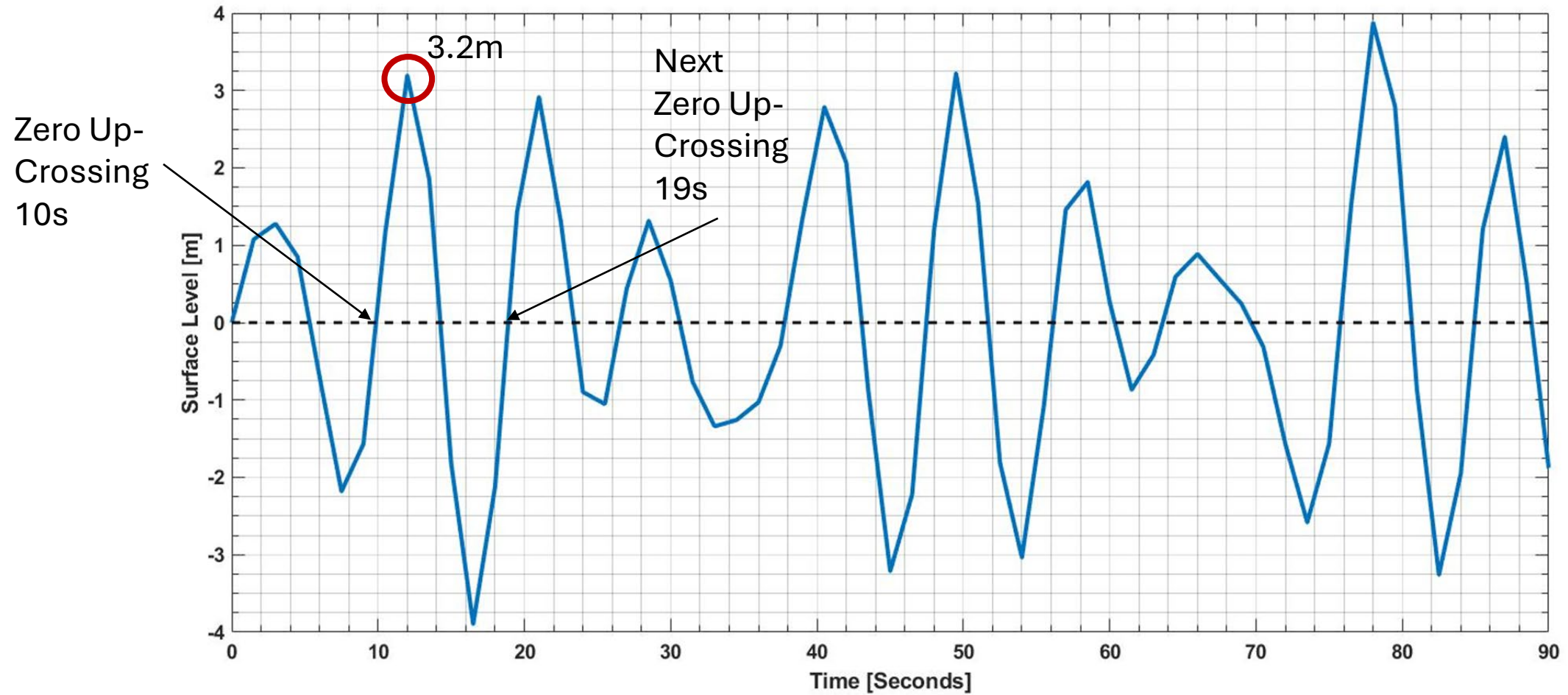
Zero Up-
Crossing
10s



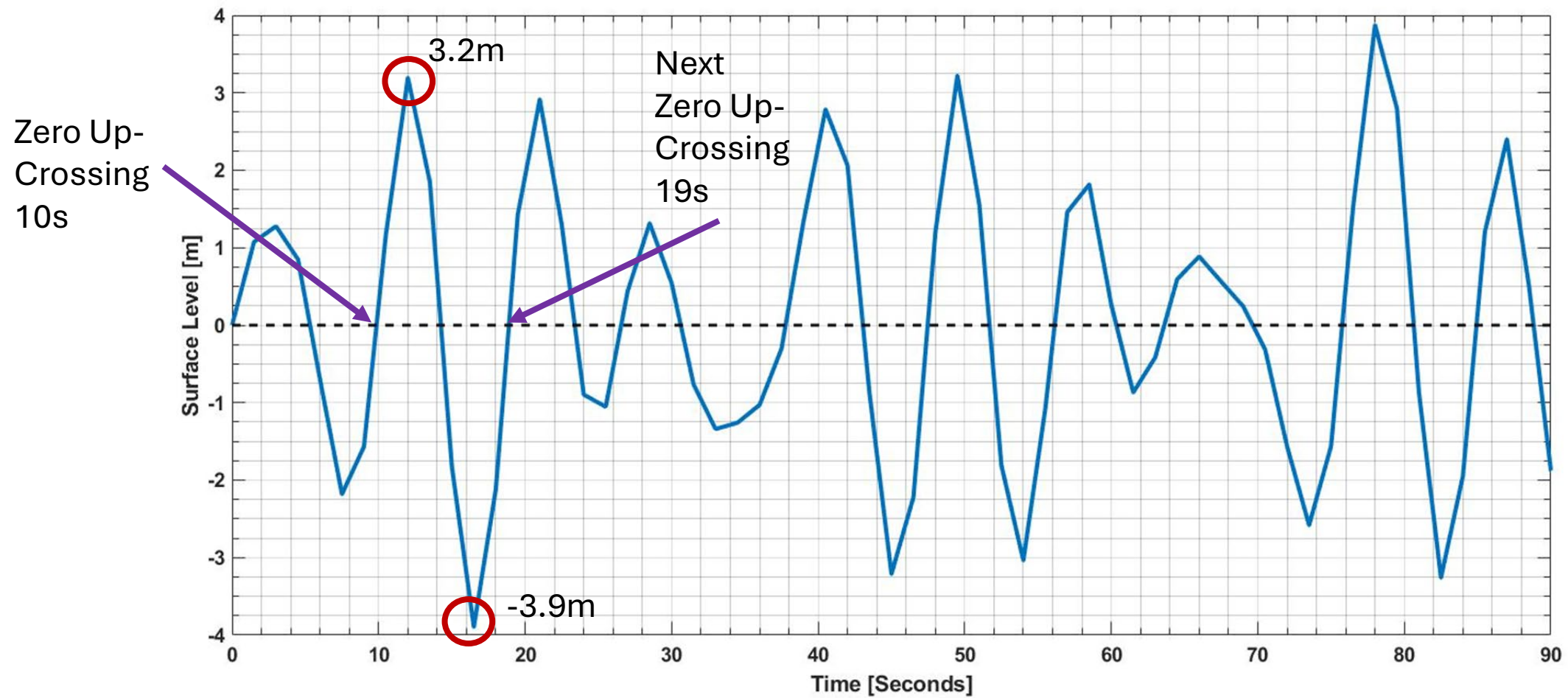
Zero Crossing Analysis



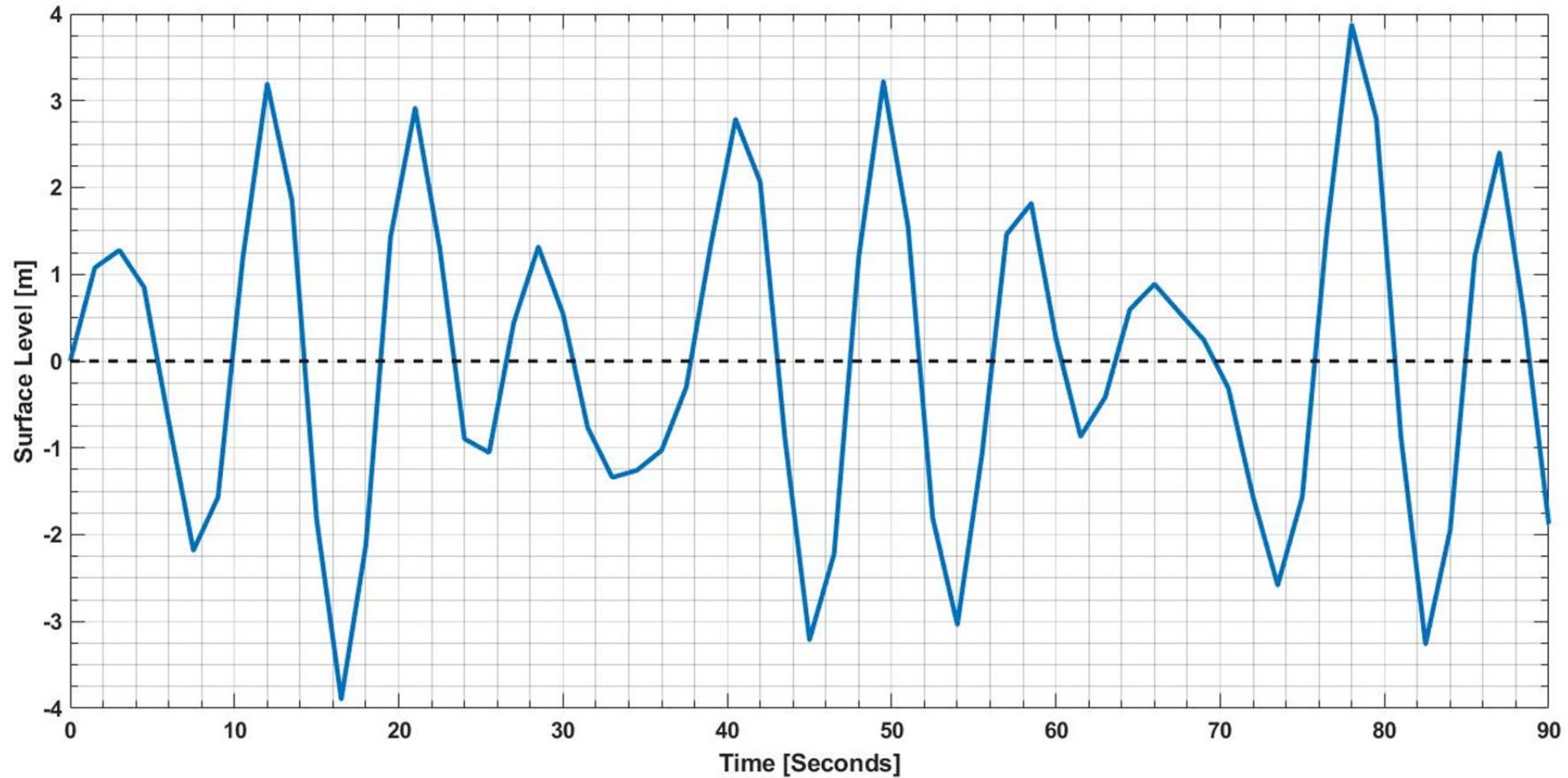
$$T = 19 - 10 = 9s$$



Zero Crossing Analysis

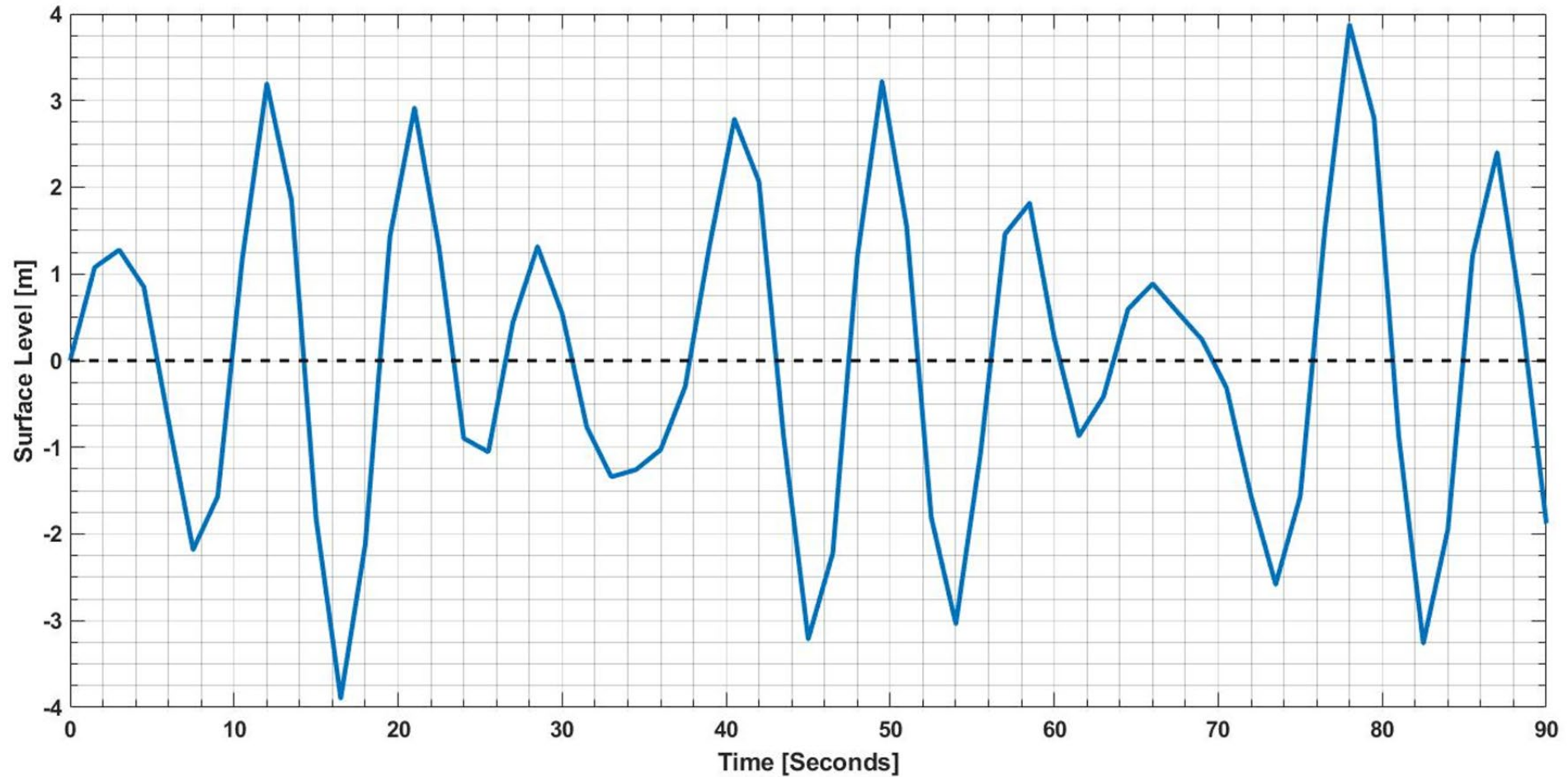


$$H = 3.2 - -3.9 = 7.1\text{m}$$



Significant Wave Height

Significant wave height, H_s , is approximately equal to the average of the highest one-third of the waves, as measured from the trough to the crest of the waves



Mean Wave Period

Mean Wave Period, T_m , is the average period of all waves.

The image shows a coastal defense structure, likely a seawall or breakwater, under attack by large, turbulent waves. Three specific failure modes are highlighted with yellow and white arrows. 'REFLECTION' is shown with an arrow pointing back towards the incoming waves. 'OVERTOPPING' is shown with an arrow pointing over the top of the structure into the landward area. 'SCOURING' is shown with a circular arrow indicating the erosion of sediment at the base of the structure. The background is a dark, stormy sea with white foam from the waves.

REFLECTION

Energy bounces back, causing turbulence.

OVERTOPPING

Water exceeds freeboard height, flooding the safe zone.

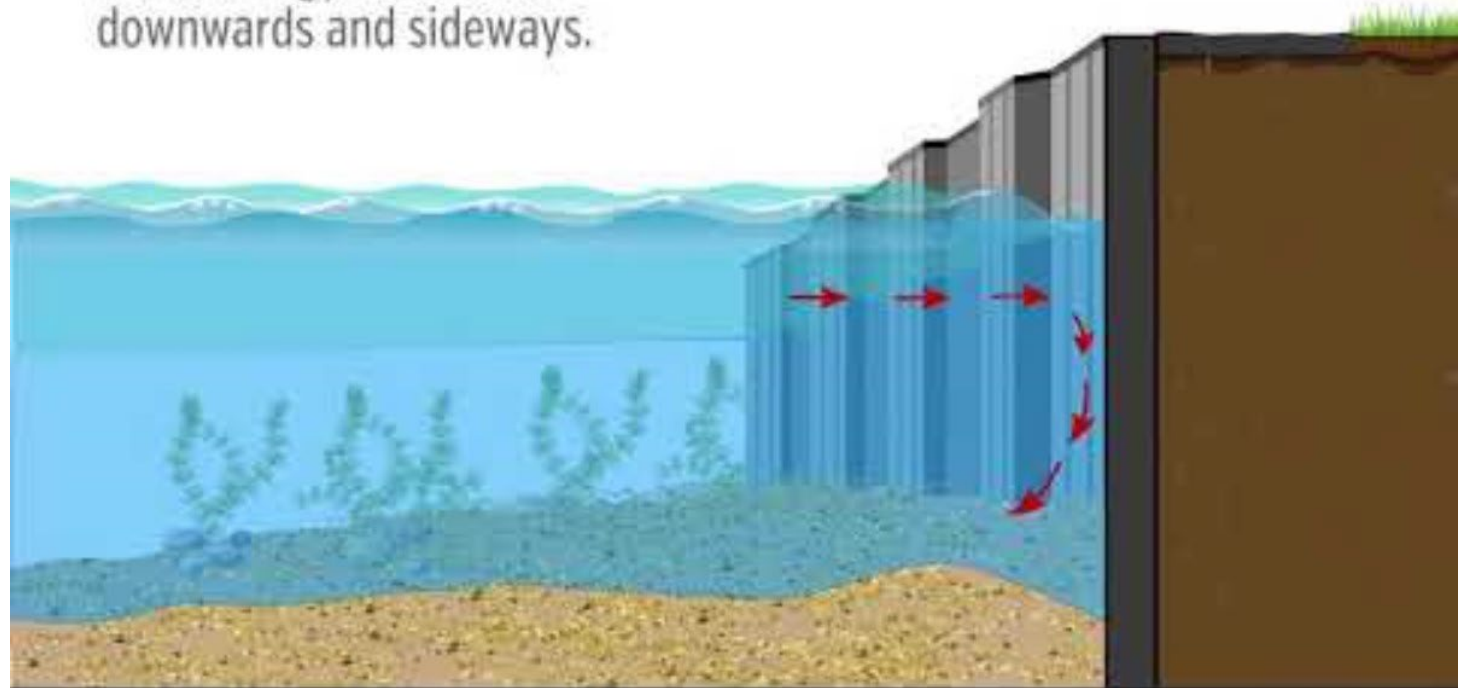
SCOURING

Turbulence eats away sediment, undermining the foundation.



Wave Overtopping

Wave energy is directed
downwards and sideways.



Scour



Coastal Structures

- Many different structures may be used in coastal, shoreline or port engineering.
- Most structures serve to reduce wave action at the shoreline, some will serve a single purpose, but most are required to fulfil several different purposes.





Coastal Structures

Coastal Protection & Sea Defence

- Limit wave action reaching (sections of) the shoreline;
- Restrict movement (particularly loss) of beach materials;
- Protect areas of "soft" shoreline, natural or imported, against erosion;
- Restrict extent and frequency of flooding of reclaimed or low-lying areas by wave overtopping, or by defence breaching;



Coastal Structures

Coastal Protection & Sea Defence

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Harbour, Marina & Related Facility Protection

- Limit wave disturbance within harbour or marina areas;
- Restrict wave overtopping into working areas in or near harbours;
- Limit wave motions in water intakes for power or desalination plants



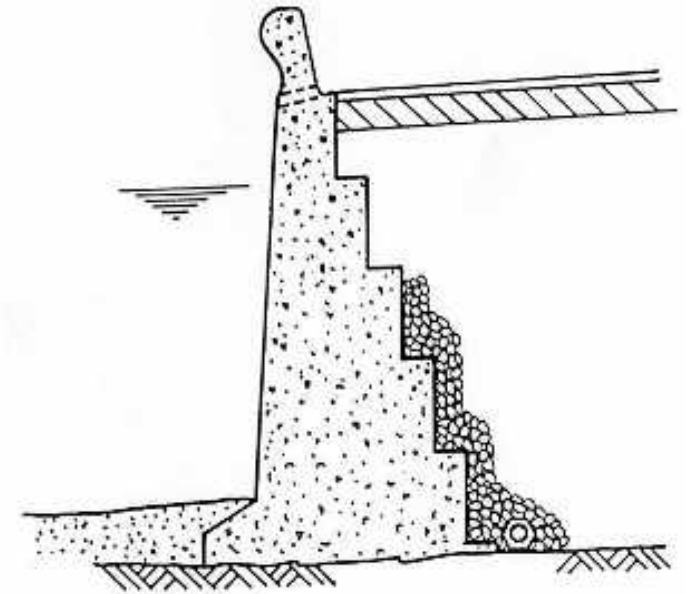
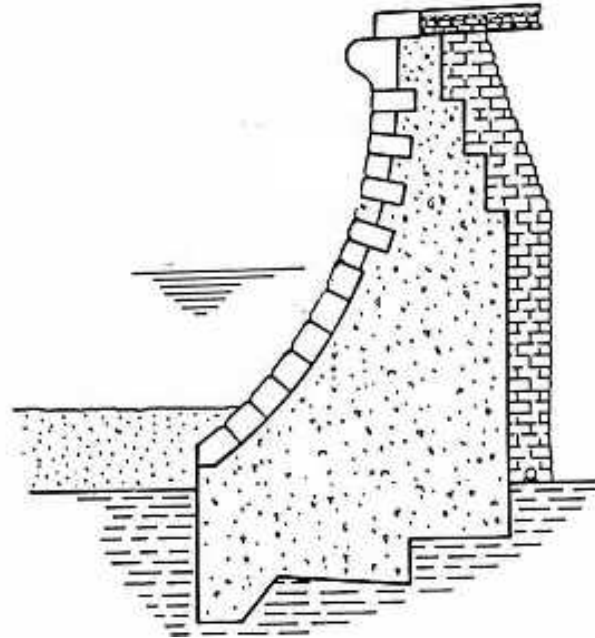
Structure Types

The structures most discussed in design manuals are:

- simple vertical walls or breakwaters;
- impermeable and usually smooth revetment slopes;
- rubble mound breakwaters or slopes

Vertical Walls

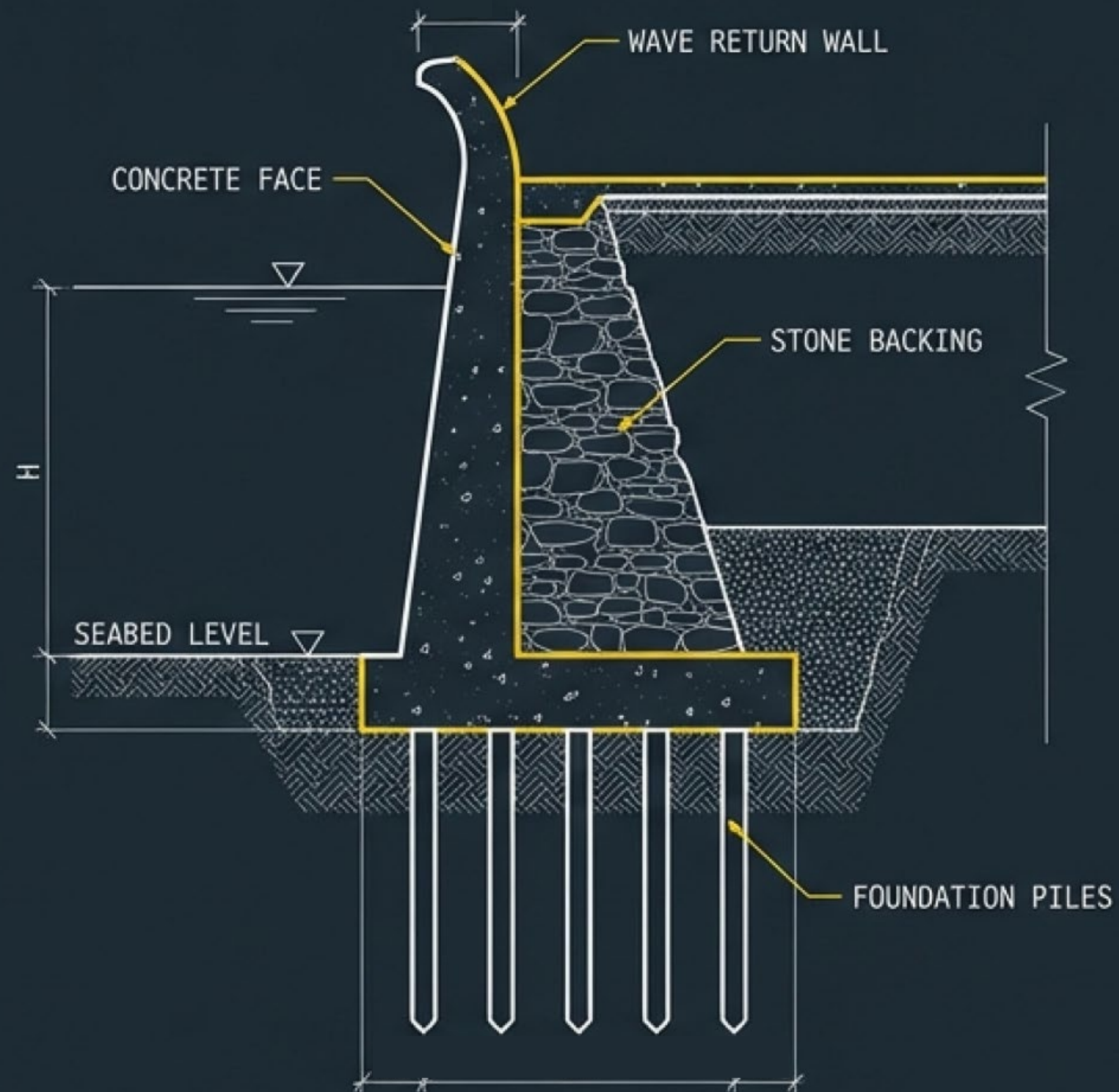
- Designed with a vertical or near-vertical face and are often constructed from concrete, stone, or other durable materials.
- These walls are commonly used in urban coastal areas where space is limited, and high levels of protection are required.





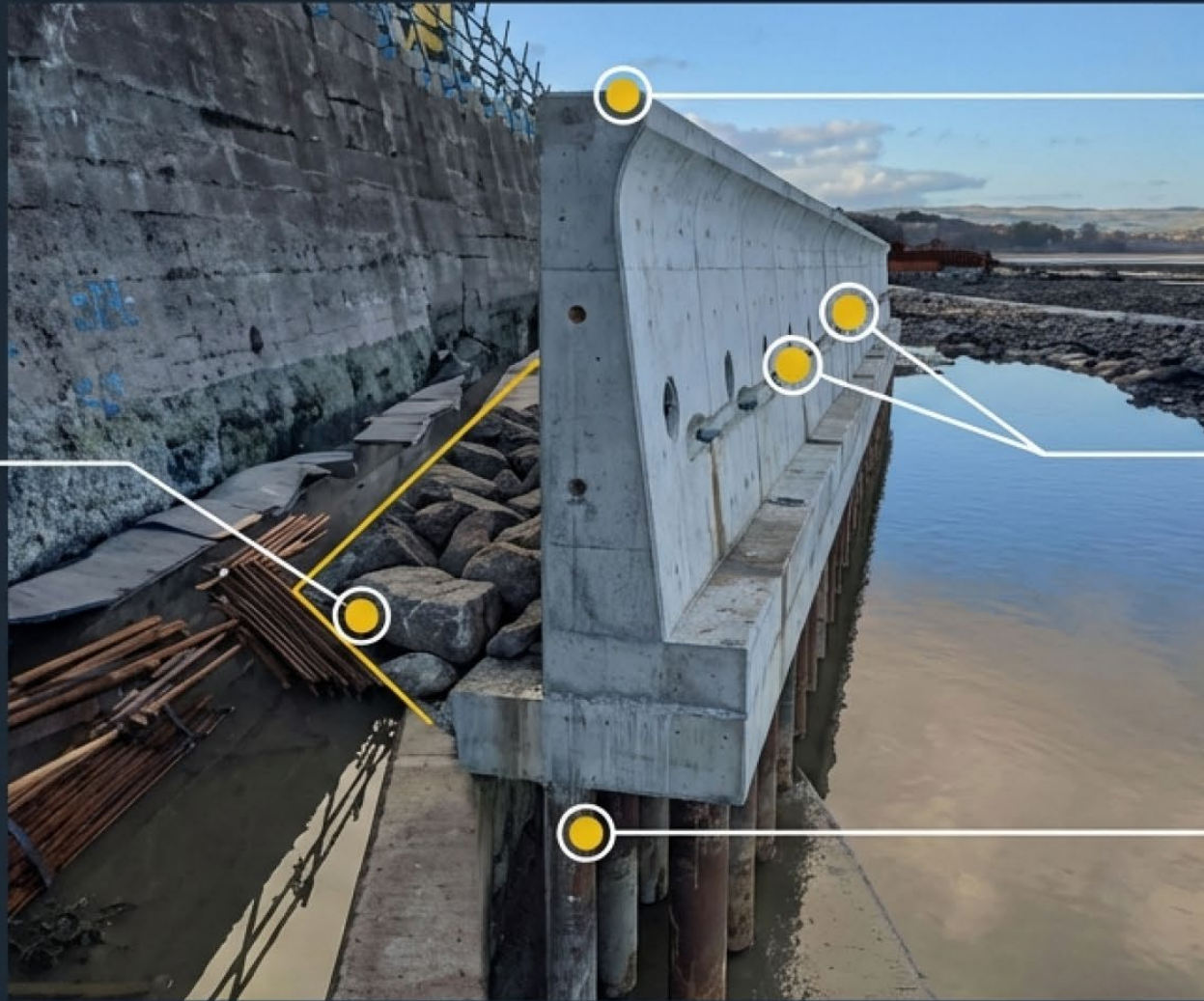
Vertical Walls

- They are liable to experience intense local wave impact pressures, may overtop severely, and will often reflect much of the incident wave energy.
- Can require a deep, stable foundation to prevent undermining by wave action and scouring



TOE PROTECTION

Rock armor prevents scouring and undermining.



CREST HEIGHT

Calculated limit for wave run-up and overtopping.

DRAINAGE

Relief valves for hydrostatic pressure from the land side.

FOUNDATION

Deep piles resist static and dynamic wave loads.



Advantages

- High Level of Protection
- Space-Efficient
- Durability
- Reduced Land Loss



Disadvantages

- Wave Reflection
- High Cost
- Environmental Impact
- Structural Vulnerability



Wave Interaction

- Wave Reflection
- Scouring
- Overtopping



Design Considerations



Wave Forces:

Must withstand dynamic and static forces from breaking waves.

.



Foundation Stability:

Requires deep foundations and sometimes additional scour protection



Crest Height:

Determined based on expected wave run-up and overtopping levels.



Drainage:

Includes features to allow water behind the wall to drain



Applications

- Urban Coastlines
- Harbours and Ports
- Tourist Beaches

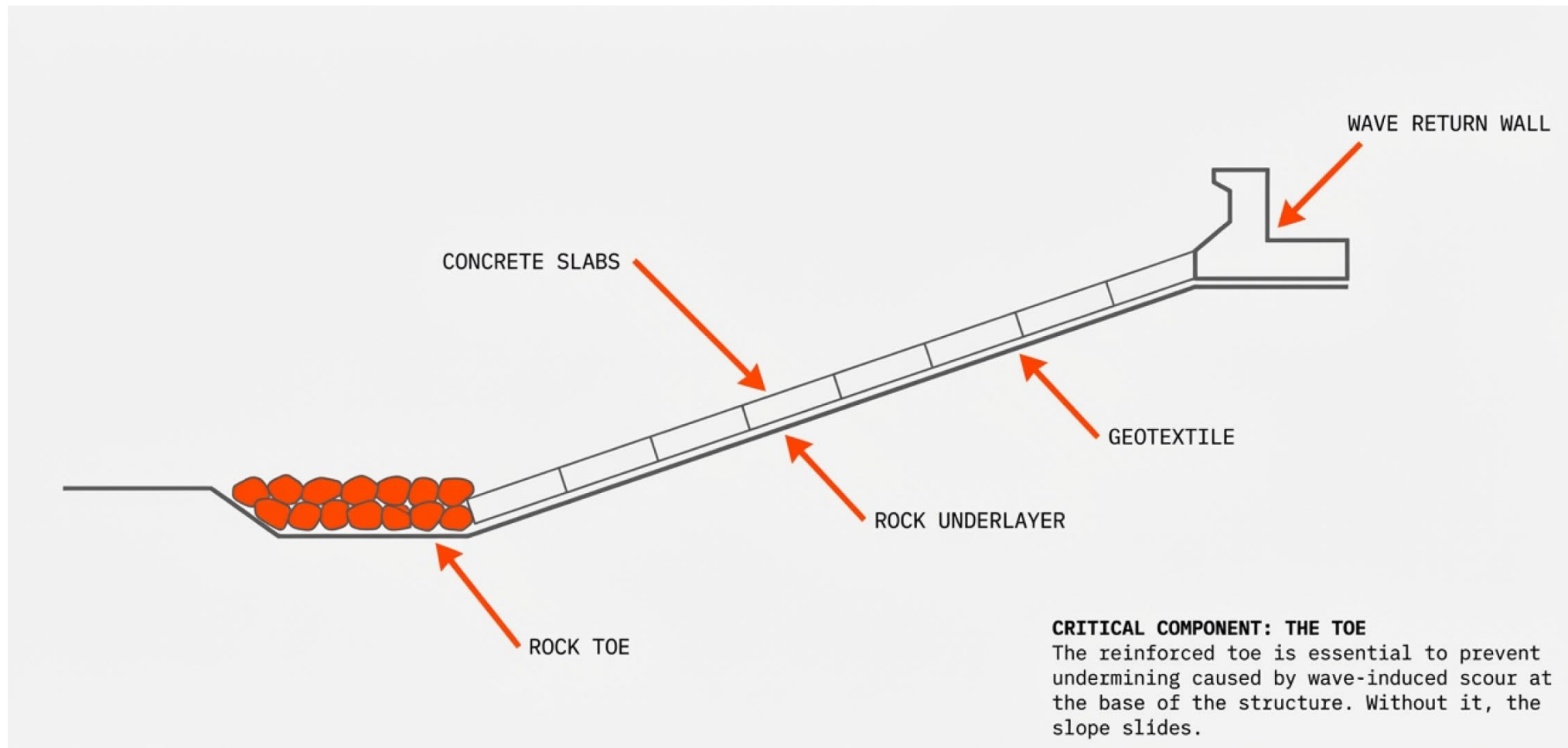
Revetments

- An impermeable coastal revetment is a sloped structure constructed along coastlines to protect the shore from erosion and wave attack
- Designed with materials that do not allow water to pass through, such as concrete, asphalt, or large stone slabs sealed together.



Revetments

- Built at an angle to dissipate wave energy gradually, reducing wave impact.
- Often includes a smooth surface to prevent water infiltration and reduce structural degradation.
- Reinforced toe to prevent undermining by wave-induced scour.





Advantages

- Strong Protection
- Durability
- Low Maintenance
- Space-Efficient



Disadvantages

- Wave Reflection
- High Construction Costs
- Environmental Impact
- Aesthetic Concerns



Wave Interaction

- Wave Energy Interaction
- Reflection and Scour
- Overtopping Protection



Design Considerations



Wave Forces:

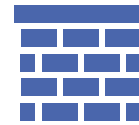
Designed for maximum expected wave height, period, and energy

.



Toe & Scour Protection:

Requires robust toe design to prevent undermining



Crest Height:

Must account for wave overtopping potential.



Durability:

Materials must withstand repeated wave impact and exposure to seawater.



Applications

- Urban Coastlines
- Harbours and Ports
- Road and Railway Defence



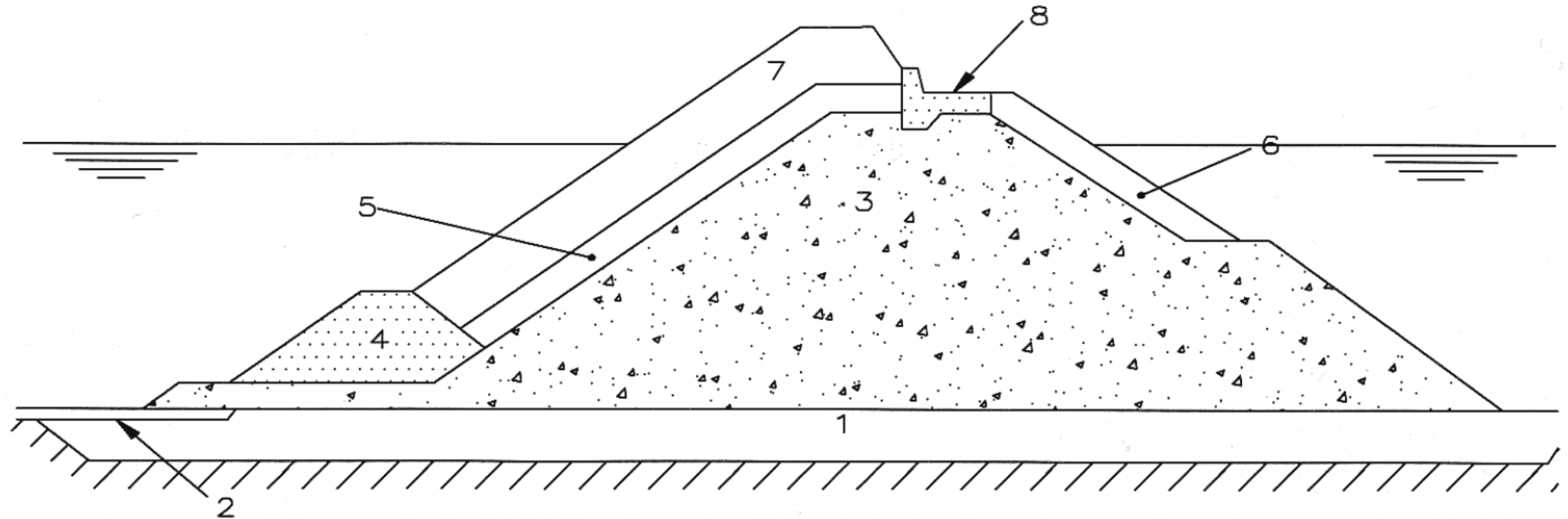
Rubble mound

- A rubble mound wall is a coastal structure composed of layers of loose, interlocking stones or rock fragments (commonly called "rubble") designed to protect shorelines, harbours, and other coastal areas from wave action and erosion.



Rubble mound

- | | | |
|--------------------------|---------------|----------------------------|
| 1 Foundation | 4 Toe mound | 7 Main armour |
| 2 Scour protection apron | 5 Underlayer | 8 Concrete crest structure |
| 3 Core | 6 Rear armour | |





Advantages

- Wave Energy Dissipation
- Durability
- Flexibility
- Environmental Benefits



Disadvantages

- Space Requirements
- Material and Transport Costs
- Maintenance
- Aesthetic Impact



Wave Interaction

- Energy Loss
- Erosion Prevention



Design Considerations



Wave Forces:

Armour stones must be sized based on maximum expected wave height and energy



Slope:

Gentle slopes are preferred for stability



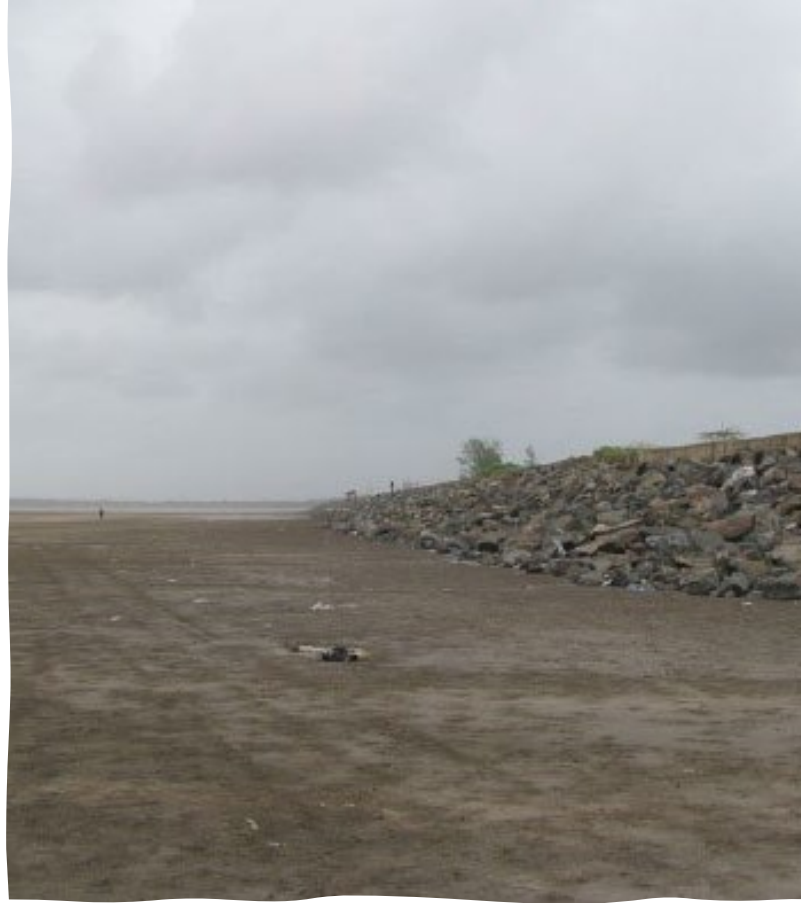
Material Durability:

Stones must resist weathering, abrasion, and movement under high-energy waves.



Foundations:

Seabed must be stabilised to prevent settlement or sliding.



Applications

- Breakwaters
- Seawalls
- Detached Breakwaters



Armour Units

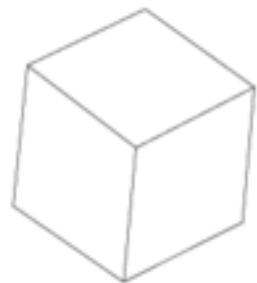
- When obtaining rock large enough to withstand the wave climate is difficult or expensive, armour units can be used.
- These are specially designed, man-made concrete blocks which serve as the outermost layer.



Armour Units

- Unique Geometric Shapes
- High Stability
- Cost Efficiency

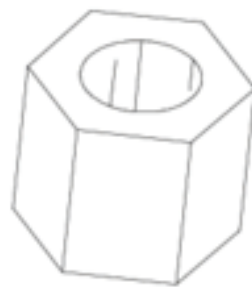
Armour Units



(a)



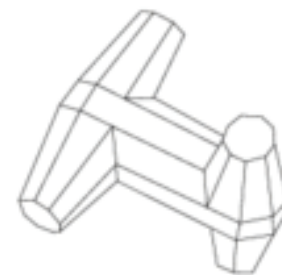
(b)



(c)



(d)



(e)



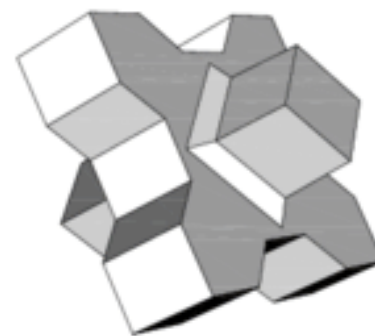
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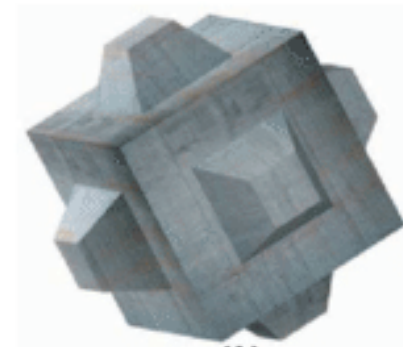
(g)



(h)



(i)



(j)

Comparison



Feature	Vertical Seawall	Revetment	Rubble Mound Wall
Wave Energy Dissipation	Low	Medium	High
Durability	High	Medium	Medium
Cost	High	Medium	High
Environmental Impact	Positive	Negative	Neutral to Negative