EWCE 471—SB

LO1

15/06

Ocean v. Sea

↳ ends of ocean reaching land

Ø Ø Ø CT

Not impo

Difference

Ocean data

not impo for exam

Coastal science v. coastal engg.

Coast → water edge that never gets wet

Shore → land along the edge of sea

Coastline → boundary between coast & shore

Shoreline → highest mean water line

Beach → land along waterbody; loose particles

Coastal hinterland → land inwards of coast

Supplementary data on beaches

Ref book: #1, #2, . . .

Lec 2–4: Tides & current

Wave → transfer of energy; vert. movement of water

Tide → due to gravitational pull

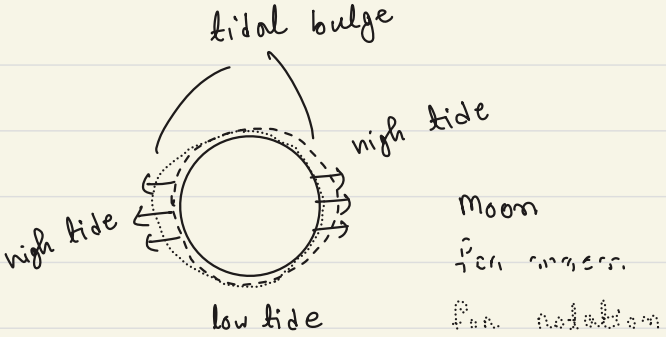
High tide → water reaches highest pos
happens on the side of moon

Low tide →

Intertidal zone → submerged during high tide
visible " low tide

Tide generating forces:

Gravitational pull
Centrifugal force



Tidal phenomena

Tidal range → diff in water lvl btwn high and low tides

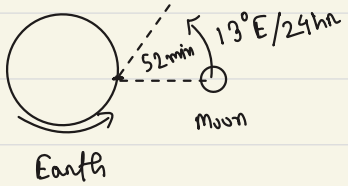
Tidal period → time between high tides

For Bangladesh,
two high tides
two low tides

12 hrs 25 mins
why not 12 hrs?

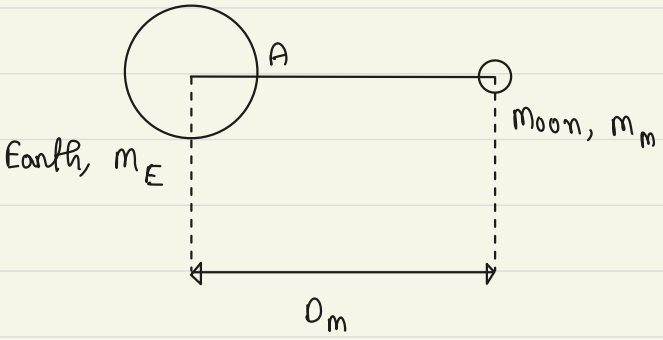
Earth rotation w.r. to sun → ~24 hrs
" " moon → 24 hrs 52 min

hourly 13°E ← Since, moon not fixed pos



Sun

$\frac{24 \times 60}{360} \times 13 = 52\text{min}$



Let, m_E = mass of Earth
m_m = mass of Moon
m_s = mass of Sun
D_m = mean dist from Earth to moon (C/C)
m_s = " " " " to Sun (C/C)
R = radius of Earth
K = const. of gravitation

Considering point A, facing the moon;
Tide producing force F_m of the moon on unit mass at A is given by,

$$F_m = Km_m \left[\frac{1}{(D_m - R)^2} - \frac{1}{D_m^2} \right]$$

$$= Km_m \left[\frac{R(2D_m - R)}{(D_m - R)^2 D_m^2} \right]$$

Assuming radius of the Earth R very small in comparison to the distance between Earth & moon,

$$F_m \simeq Km_m \left(\frac{2R}{D_m^3} \right)$$

Similarly, tide producing fonce f_s of the sun on unit mass at A is given by,

$$f_s \approx k m_s \left(\frac{2R}{D_s^3}\right)$$

Hence, $\frac{f_s}{f_m} = \frac{m_s}{m_m}\left(\frac{D_m}{D_s}\right)^3$

Now, mass of moon, $m_m = 7.3 \times 10^{19}$ metric tons

$D_s = 149758000$ km

$D_m = 384835$ km

$m_s = 2 \times 10^{27}$ metric tons

$$\frac{f_s}{f_m} = 0.464$$

Daily tide cycle

~~☆☆☆~~ Tidal pattern [learn examples, graph - qualitative]

Explain / Differentiate [10 - 12 marks]

LO4

24/06

Full, 14th d

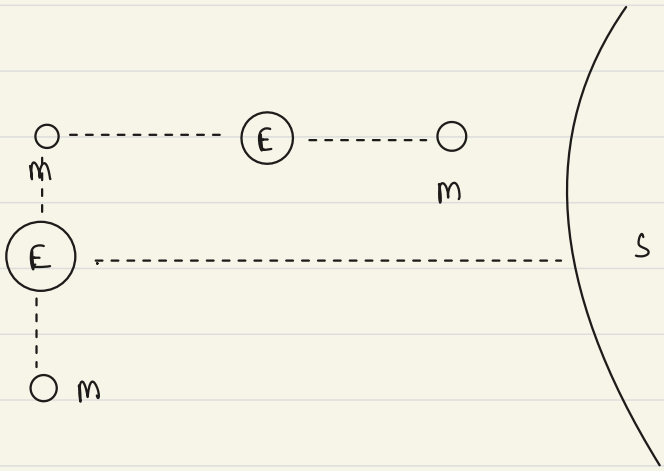
Moon Earth Sun

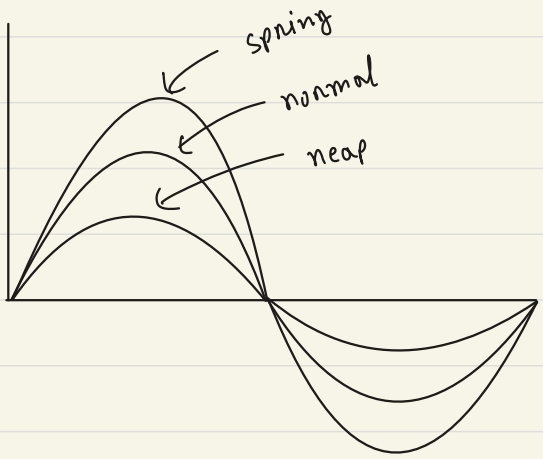
Earth Moon Sun

New, 0th d

Spring tide → strong tide

Neap tide → weak tide





Tidal current

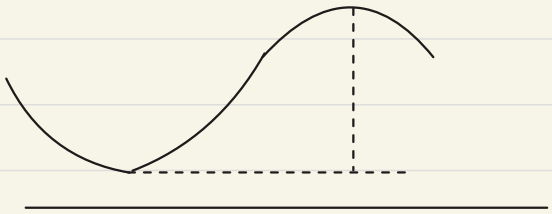
Coast → flood current → flood tide

Seaward → ebb current → ebb tide

Tidal curve

Tidal range

Tidal level



Graphical representation of tidal terms

MHWS → Mean High Water Springs

MLWS → Mean low water springs

MHWN → Mean High Water neaps

MLWN → Mean low water neaps

[on the day of highest tide, avg of two high

- - -

Highest/ lowest astronomical tide

CT → Tide

LO5 29/06

Tidal bones
Characteristics
not impo for exam { Tidal stream
Tidal flow
Tidal chans of Bangladesh [mems at least 8]

CT → up to this class

Simu... tide
Derivation
High tide gap 50 mins +
Graphical repne. of tidal terms
6 defn (e.g., mHWS)

Tide defn; high tide, low tide, intertidal zone
Tide generating forces: Sun-moon gravity, centrifugal force
Influence of sun/moon gravity on tide
Derivation, 46% why/how
Spring tide, neap tide
24 hrs 50 mins
Tidal patterns: Diurnal, semidiurnal (graph incl.)
Tidal terms diagram (6 defn)
Tidal bones, chans
chans of Bangladesh

LOG 01/06

Ports & Harbons

↳ ship maintenance mostly (repair, fuel, shelter, ...)

→ may contain one or more harbons

commercial, recreational, cargo storage, ...

Port types

Inland port

Fishing port

Dry port

Warm-water port → available all around the year → chit. port, singapore port

Seaport → cruise port or cargo port

Ocean port

Freeport

Harbor classification [Provide example]

Based on formation → Natural harbor

Semi-natural

Artificial

Based on function → Commercial

military harbor

...

Based on location → Sea harbor

River "

Canal "

Rough / CT - 1 04/07

Tides

Defⁿ: Waves caused by the gravitational attraction of the moon & the sun.

High tides: when water reaches its highest point. occurs at the side facing the moon.

Low tides: when water reaches its lowest point. occurs at 90° of high tides.

Intertidal zone: Strip of seashore that is submerged during high tides but exposed during low tide.

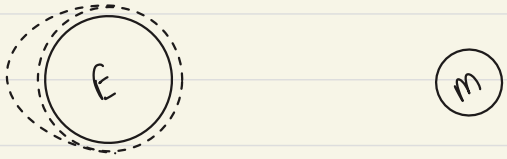
Tide generating forces (TGF)

Gravitational → moon & sun
Centrifugal

→ Due to gravitational attraction forces, a tidal buldge is created on the side facing the moon or sun

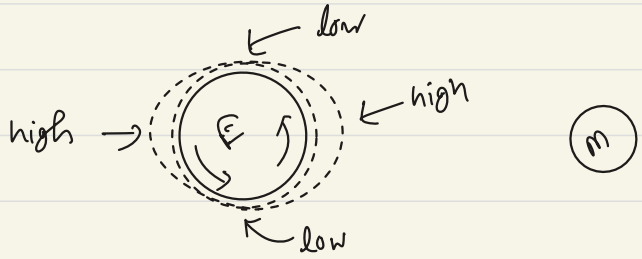


→ Due to centrifugal force (and due to water being left behind) a second buldge is created on the side facing away from the moon.



→ Together, they form two buldges; on each sides corresponding to high tides. And low tides occurs in places between the high tides.

→ As Earth rotates between these water bodies, different places on Earth observe these phenomenons throughout the day



→ similar to moon, Sun also has effect which is 46% of moon.

Why 46%:

Gravitational force between two objects: $F = G\frac{m_1 m_2}{R^2}$

Tides are created by the difference of gravitational pull between Earth surface and its center:

For moon: $F_m = KM_m\left[\frac{1}{(D_m - R)^2} - \frac{1}{D_m^2}\right]$

[assume force between moon & 1 unit mass of water: $Gm_1 = G \times 1 = K$]

$$= KM_m\left[\frac{D_m^2 - D_m^2 + 2RD_m - R^2}{(D_m - R)^2 D_m^2}\right]$$

$$= KM_m\left[\frac{R(2D_m - R)}{(D_m - R)^2 D_m^2}\right]$$

Considering $R \ll D_m$,

$$F_m = KM_m \left[\frac{R \times 2D_m}{D_m^4}\right]$$

$$= KM_m \left[\frac{2R}{D_m^3}\right]$$

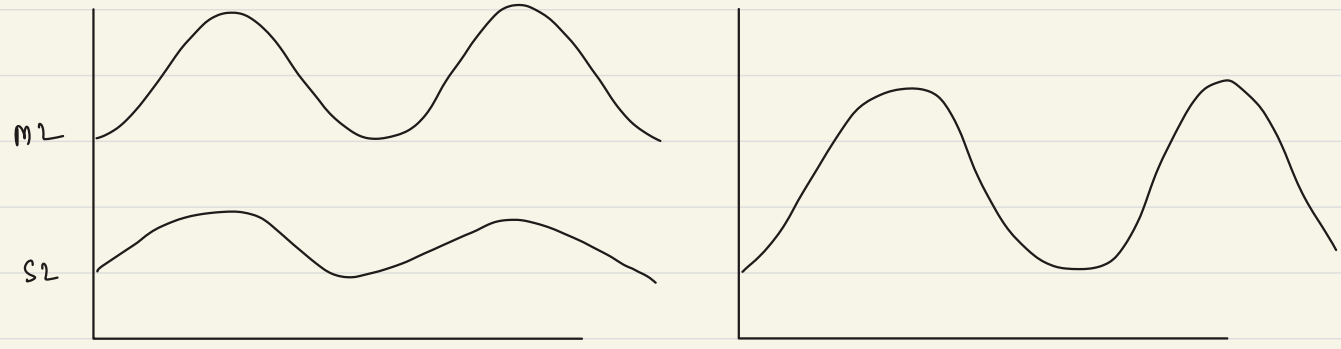
Similarly, for Sun, $F_S = KM_S \left[\frac{2R}{D_S^3}\right]$

Now, $$\frac{F_S}{F_m} = \frac{M_S}{M_m}\left[\frac{D_m^3}{D_S^3}\right]$$

$$= \frac{2\times10^{27}}{7.3\times10^{19}} \times \left[\frac{384\times10^3}{15\times10^7}\right]^3$$

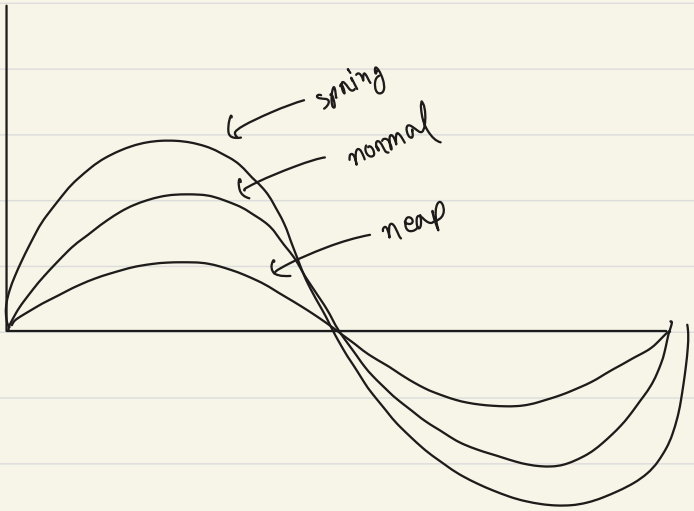
$$= 0.46 \qquad (46\%)$$

Spring tide: Occurs when moon and sun are on the same or opposite side of Earth.
Such that the tidal constituents M_2 and S_2's peaks align with each other. or gravitational bulges align.
As a result, high tides are higher than usual.



Neap tides: Occurs when moon & sun are at the right angle of each other.

High tides are lower than usual and low tides are higher than usual



12 hrs 25 mins between two high tides:

Earth rotates on its axis in 24 hours (west to east)

At the same time, moon changes its position (into east) by around 13°.

Earth takes around 50 minutes to catch up with moon's new position.

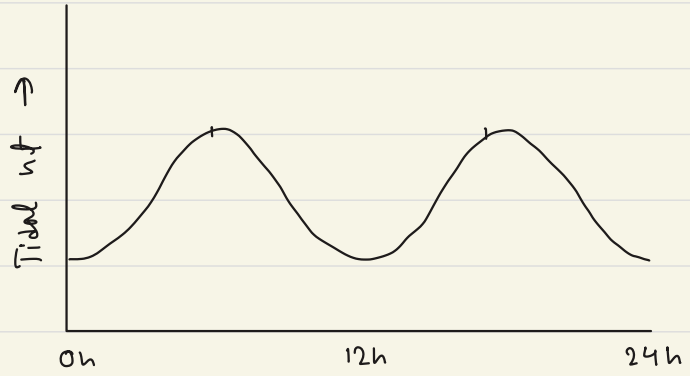
$$\frac{24 \times 60}{360} \times 13 = 52 \text{ minutes}$$

Tidal phenomenon:

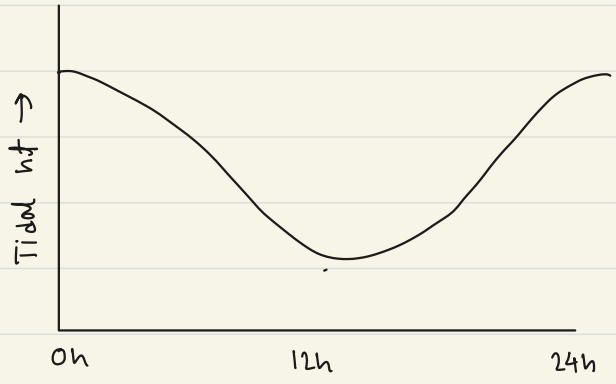
Tidal range: Diff. in water level between high and low tides
Tidal period: Time between two high tides

Tidal cycles / Tide patterns

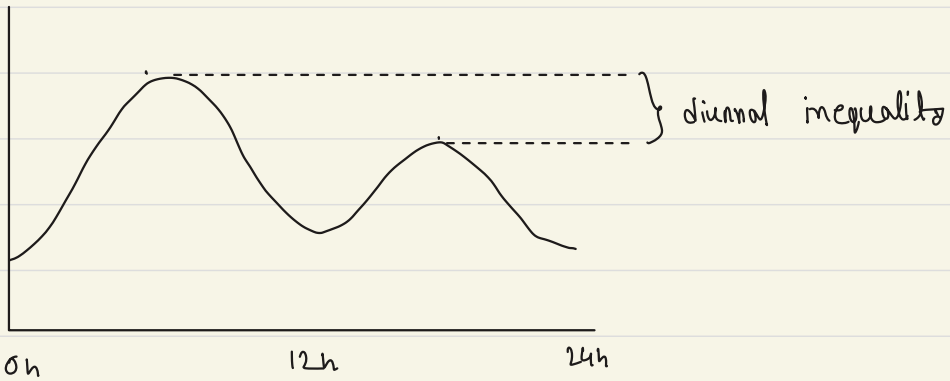
Semidiurnal: Cycle with two equal high and low tides each solar day. Period between two high tide is 12 hrs 25 mins.
Found on Bangladesh



Diurnal: Cycle with one high and low tide each solar day.
Period 24 hrs 50 mins.
Found on Gulf of Mexico



Mixed tidal cycle: Cycle with two high and low tides but of different sizes.
Along the western coast of North America

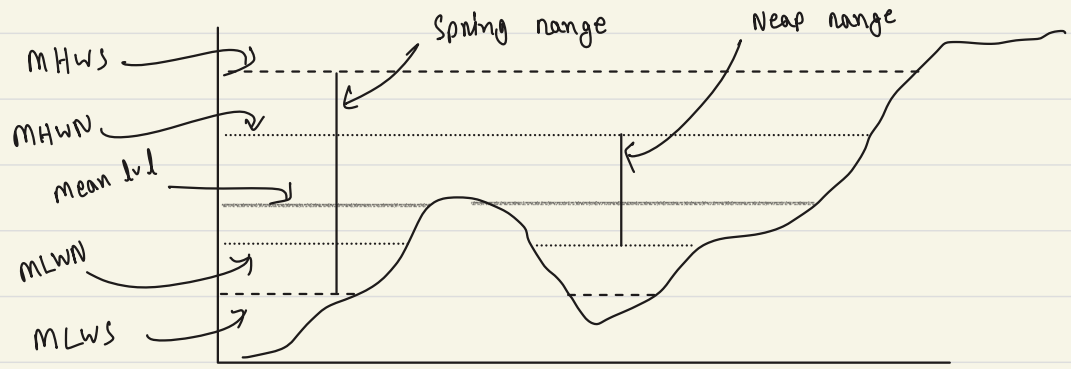


Tidal currents: Movements of water toward and away from the coast as a result of the rise and fall of tides

Ebb current: from coast towards ocean
Flood current: from ocean towards coast

Tidal terms:

Mean high water springs: Average of two successive high water during those periods of 24 hours when the range of the tides is at its greatest throughout the year.



Tidal bore: A phenomenon that occurs when the leading edge of a tide forms a wave that rushes up to a channel/ river/ narrow bay against the river's natural current.

Characteristics:

1. Extreme case of shallow water effect.
2. Happens inside a river or estuaries with steeply shelving btm.
3. Marked by a sudden & rapid rise of wall
4. Creates a distinct wall of water that moves aggressively u/s.
5. Height is about 0.3 m to 4.5 m
6. 3 to 20 knots
7. May or may not break depending on topography.

Tidal characteristics of Bangladesh

1. Originates in the Indian ocean
2. Travels deep into the Bay of Bengal, approaches coast from south of Hiran Point & Cox's Bazar.
3. Average tidal range is 1.5 m in west to 4 m in Sandwip channel. Spring tidal range can be 6 m
4. Seasonal variations in mean tide level due to pressure variations.
5. Semi-diurnal
6. Tide inequalities 0.55 m to 0.15 m
7. Tidal bore at south of Urinchar
8. Neap velocity ⅓ of spring vel

L07 06/07

Ports vs. Harbor

Port terms

- - -

offshore terminal

Site selection for ports

Features of harbor

Entrance

Approach Channel

Turning basin

Sheltered basin

Wharves & Quay

Jetties & Piers

Locked basin

Break water

Harbor layout

Components of Harbor (diagram) (Preferrably first one)

Requirements of a good harbor

L08

08/07

Coastal processes

Coast

Importance of wave

wave types → constructive / destructive

Continental shelf

Coastal processes (3 impacts w/ example + eff.)

L09 15/07

Coastal process

Denudation

Coastal flooding

Ø ØØ Processes of erosion

Not impo for final but for CT/Mid — Landforms of erosion

Erosion structures

Coastal deposition

Sediment transport

Beach sediment properties

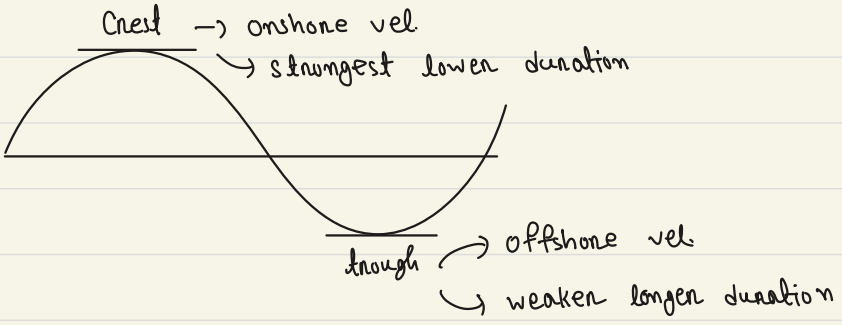
Modes of sediment transport

ØØØ Beach profile (draw and defⁿ components)

Combine two profiles into one or draw two separately
for second just mention the ~3 to 6 terms (upper labels)
Total 8 terms

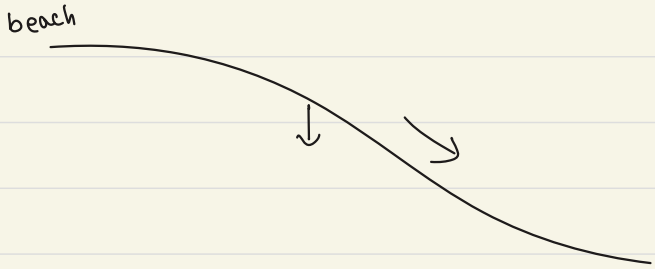
Sediment transport

ØØØ Mechanism causing beach profile change (Ref.: book; not slides)
P261



2. wave motion

2. Gravity:



L12

20/07

Mechanism causing beach profile change ← impo for final [less for Q]

3. Undertow & rip current
4. Turbulence from breaking wave
5. Wind effects

On exam may be asked to
- any two
- onshore, offshore

Sediment transport

Longshore transport

Processes

model theories for . . . ← just name except one

Energy flux model

- - -

Cross-shore transport

model theories ← just name

simple ← only first formula [$q_s = k(\cdots)$]

if $q_s \rightarrow + \rightarrow - - -$

sediment transport and coastal processes

- - -

Gabions

Longshore bar

Beach nourishment ← mostly recreational

Sand spit

Tombolo

Prediction of potential longshore transport rate

[Derivation won't be asked]

The potential longshore sediment transport rates

$$P_l = (EC_g)_b \sin\alpha_b \cos\alpha_b$$

$$= (EC_g)_b \frac{1}{2} \sin 2\alpha_b$$

where, E_b is the wave energy evaluated at the breaker line.

$$E_b = \frac{\rho g H_b^2}{8}$$

and, C_{g_b} = wave group speed at the breaker line

$$= \sqrt{g d_b} \quad = \sqrt{g \frac{H_b}{k}}$$

Here,

k = breaker index $= \frac{H_b}{d_b}$

H_b = breaker ht

d_b = water depth at breaker line

$(EC_g)_b$ = wave energy flux evaluated at the breaker zone

α_b = wave breaker angle relative to the shoreline

Immersed weight transport rate, $I_l = K D_l$

$$= K (EC_g)_b \, 1/2 \sin 2\alpha_b$$

$$= k \left(\frac{\rho g H_b^2}{8}\right) \left(g \frac{H_b}{k}\right)^{1/2} \frac{1}{2} \sin 2\alpha_b$$

$$I_l = k \left(\frac{\rho g^{3/2}}{16 k^{1/2}}\right) H_b^{5/2} \sin 2\alpha_b$$

The longshore sediment transport rate is expressed as the potential volumetric longshore transport rate (Q_l).

$$Q_l = \frac{I_l}{(\rho_s - \rho) g (1-n)}$$

where,

ρ_s = mass density of the sediment grains
= 2650 kg/m^3 for quartz density sand

ρ = mass density of water
= 1025 kg/m^3 for 33 ppt salt water

n = in place sediment porosity = 0.4
g = acceleration due to gravity = 9.81 ms^{-2}
K = 0.78 for flat beaches
> 2.0 (depending on beach slope)
$\kappa = 0.05 + 2.6 \sin^2(2\alpha_b) + 0.007 \frac{u_{mb}}{w_f}$
w_f = fall velocity
u_{mb} = maximum oscillating velocity magnitude
$= \frac{\kappa}{2} \sqrt{g d_b}$

Maths

$h_b = 2\ m$

$\rho_s = 2650\ kg/m^3$

$\alpha_b = 4.5$

$w_f = 13.1\ cm/s = 0.131\ m/s$

$T = 20°C$

$Q_l = ?$

$n = 0.4$

$K = 1$ ← for flat beach → 0.2

$$Q_l = K \left[\frac{\rho \sqrt{g}}{16 K^{1/2} (\rho_s - \rho)(1-n)} \right] H_b^{5/2} \sin 2\alpha_b$$

$$K = \frac{H_b}{d_b}$$

$$\Rightarrow 1 = \frac{2}{d_b} \Rightarrow d_b = 2$$

$$u_{mb} = \frac{K}{2} \sqrt{g d_b}$$

$$= \frac{1}{2} \sqrt{9.81 \times 2} = 2.21\ m/s$$

$$K = 0.05 + 2.6 \sin^2(2\alpha_b) + 0.007 \frac{u_{mb}}{w_f}$$

$$= 0.05 + 2.6 \sin^2(2 \times 4.5) + 0.007 \times \frac{2.21}{0.131}$$

$$= 0.232$$

$$\therefore Q_l = 0.232 \left[\frac{1025 \times \sqrt{9.82}}{16 \times 1^{1/2} (2650 - 1025)(1 - 0.4)} \right]$$

$= 0.048\ m^3/s$ | $0.042\ m^3/s$

$= 4125\ m^3/d$ | $3628.8\ m^3/d$

L12

22/07

Deltas and its characteristics

Introduction
How delta is formed
Flocculation process
Composition of delta [Include figure]
Morphology
Lower deltaic plain

~~PP~~ How delta form / process } same
How triangular shape }

L13

27/06

Stages in Delta Formation

[Include figure]

Types of delta based on shape

[memo examples]

Types based on controls of deposition

Causes of sea lvl rise

Impacts " " " "

L14 29/07

Bangladesh Delta Plan (BDP) 2100 (exclude pages not mentioning)

Delta challenges
Delta opportunities
} may skip numerical values / areas / blue

Hotspot: Planning & implementation → skip → Def^n, area
Hotspot: Issues & challenges → memo at least four
→ skip in between

Strategies for hotspot under BDP 2100

↳ Memo min five measures (+ main strategy)

—— EOL

L15 10/08

Tidal Theories & Tide Tables

Tidal theories:

- Newton equib theory (what, explains what, limitations)
- Laplace theory
- Priming and lagging of tide
  - Characteristics
  - figure

Tide tables:

- Tide gauges
- Prediction of tides
- Age of tide

L16

17/08

Prediction of tides

Age of tide :
Lunitidal interval :
mean establishment :
vulgar "

Height of tide → memo formula & what
prediction by use of Harmonic constant) → name & time period

math/

we know that the moon falls behind the sun at a rate of 50m per day. Hence, at the birth of tide, 2 days earlier, the time of moon's transit,

$= 4h\ 40\ m - (2 \times 50)\ m$

$= 3h\ 0\ m$

From the table, corresponding to the time of moon's transit of 3h 0m

The connection for priming $= -41\ m$

Therefore, Lunitidal interval = mean est. + connection

$= 3h\ 10\ m - 41\ m$

$= 2h\ 29\ m$

Now, the time of high water = time of moon's transit + lunitidal interval

$= 4h\ 40m + 2h\ 29\ m$

$= 7h\ 09\ m = 7:09\ PM$

Moon transit on the day = 3h 20 min

mean establishment = 3h 15 min

Age of tide = 3days

---

we know that the moon falls behind the sun at a rate of 50m per day.

Hence, at the birth of tide, 3 days earlier, the time of moon's transit,

$$= 3h\ 20\ min - (3 \times 50)\ m$$

$$= 00h\ 50\ m$$

From the table, corresponding to the time of moon's transit of 0h 50m

The correction for priming = $-13.33\ m \sim -13\ min$

Therefore, lunitidal interval = mean est. + correction

$$= 3h\ 15m - 13\ m$$

$$= 3h\ 02\ m$$

Now, the time of high water = time of moon's transit + lunitidal interval

$$= 3h\ 20m + 3h\ 02\ m$$

$$= 6h\ 22m\ =$$

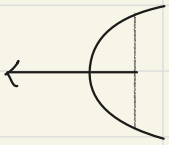
L17

24/08

what do coastal structures do

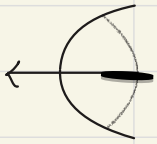
1. Stop water
2. Hold water

Compulsory from this cls likely



Coastal struct: High / Soft

Advantages of hard over soft



Objective

Study each struct from separate PDF (P 8/51)

Sea dikes

Seawalls

Revetment

Bulkhead

Groins

Rough / Midterm 26/08

Lec 07-08: Ports & Harbor

Harbor: An enclosed water area protected from storms providing safe accommodation to vessels seeking refuge, anchorage, refueling, and transfer of cargo.

Port: A commercial shore facility containing one or more harbors where vessels dock to transfer passengers or freight to/from land

Types of port:

1. Inland port: On canal/river connected to sea/ocean.
2. Fishing port: Handling & distributing fish; env. concerns.
3. Dry port: Center for transshipment of sea cargo to inland destination. Connected by road/rails directly to sea port.
4. Warm water port: water doesn't freeze in winter, enabling year around commercial activity.
5. Sea port: Subdivided into cruise port (home port / ports of call) and cargo port (bulk, break-bulk, container port)
6. Ocean port: Deep-water ports of call built in bays, estuaries, open ocean accomodating large ocean-going vessels. E.g., Kolkata
7. Free port: Isolated, policed duty free zone for handling, manufacturing repackaging goods w/o customs intervention. E.g., Singapore

Classification of harbours:

By formation: Natural, semi-natural, artificial
Function: Military, commercial, refuge
location: sea, river, canal

By formation:

1. Natural: Protected by natural contours, rocky-headlands, islands. E.g., New York
2. semi-artificial: Natural headlands on the sides but require man-made protections at the entrance. E.g., Plymouth
3. Artificial: On open water, created by dredging and breakwaters. E.g., Chennai.

By function:

1. Commercial: Busiest of all; designed with docking and berthing, and single commodity or general cargo handling facilities. E.g, madras.
2. Military: Large naval base providing maintenance, berths, supply depot for warships and aircraft carriers. E.g, Pearl Harbor.
3. Refuge: sheltered refuge during natural storms; require strong bottom anchorage and easy sea access. E.g., Sound Bay.

By location:

1. Sea: Along seashore; international shipping & logistics.
2. River: Along rivers connecting to sea; inland transportation.
3. Canal: Along canals " " " ; " "

Harbor vs. Ports:

	Harbor	Port
Defn	Small natural/man-made area providing shelter to vessels from stormy weather.	Large man-made commercial hub used for import/export, docking, boat storage, etc.
Function	Provide shelter, anchorage, recreational water sports.	Docking, passengers in/out, freight in/out.
Accessibility	Easy access from sea for safety reasons.	Accessed via commercial sea routes, road/rail linkage, canals/rivers.
Facilities	Minimal commercial facilities; focus solely on safety.	Lifts, cranes, fuel/chemical storage, repair areas, rail/road links.
value	valuable safety refuge for vessels.	Economic asset to country.
Construction	Man-made/natural	Man-made and large

Port terms:

1. Port of call: Intermediate stops for a ship on its sailing routes where cargo, supplies, fuels, or passengers are taken in/off.
2. Marine terminal: Designated area on a port for docking, cargo handling, and transit storage. Classified passenger terminal, oil terminal.
3. Offshore terminal: Mooring structure on open deep water when nearshore berths are impractical.

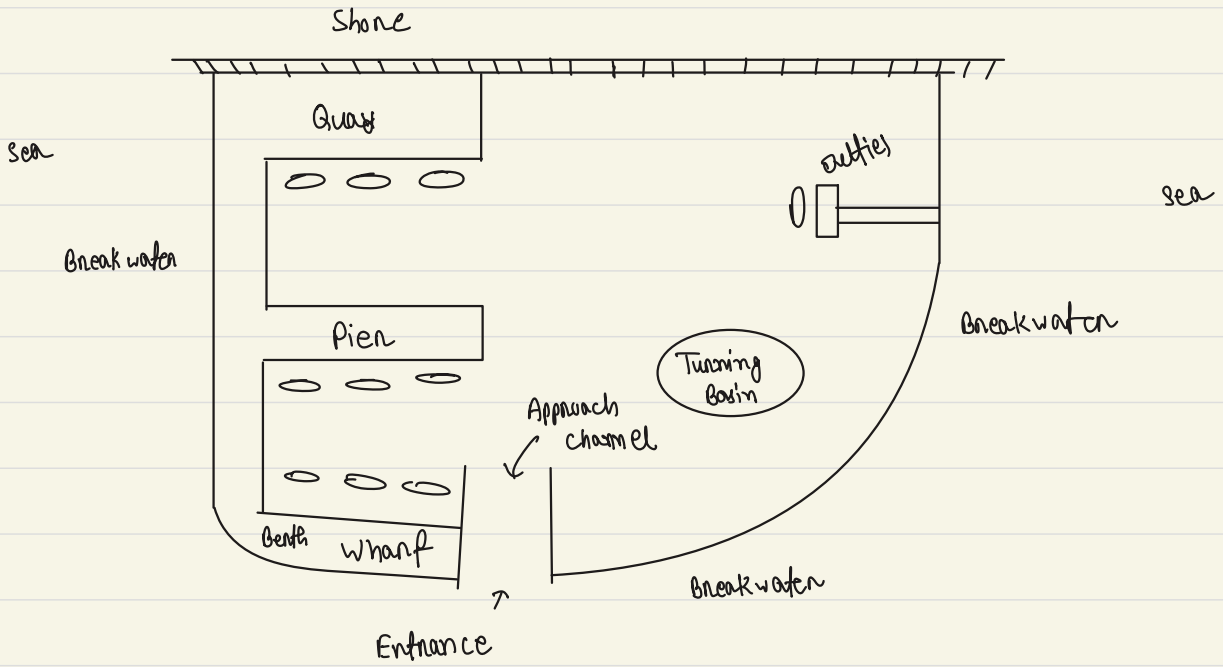
Factors for port site selection:

1. Marine condition & approaches
2. Seabed & subsoil cond.
3. Connectivity & transport link to hinterland transport network.
4. Existing & forecasted seaborne traffic.
5. Hinterland economic base
6. Reliable & sufficient availability of supplies, electricity
7. Land & material availability.

Factors for harbor layout:

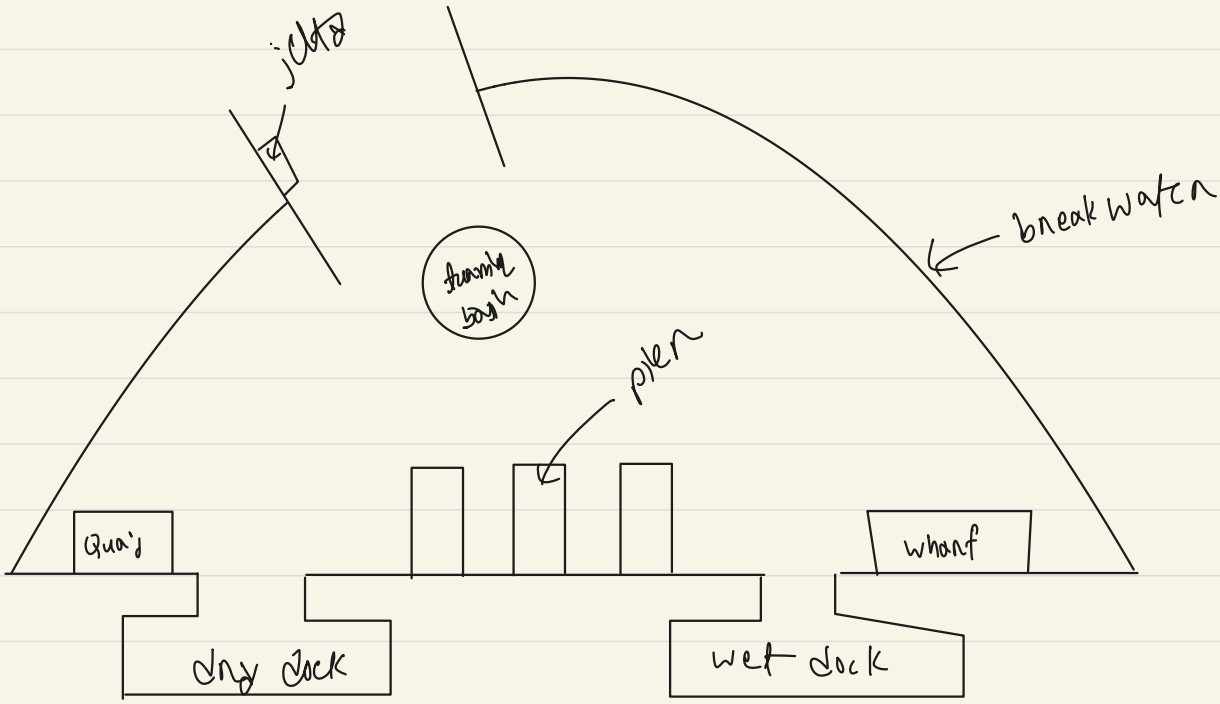
1. Littoral drift
2. Protection from storm waves
3. Eff. of submarine waves
4. Shape & size of harbor
5. Layout of wharves & jetties

Components of harbor:



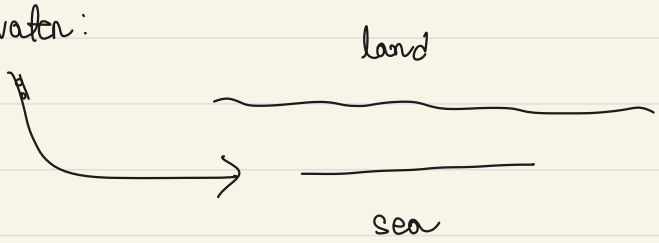
Requirement of good harbor design:

1. Sufficient water depth
2. Secure anchorage
3. Protection from wave action
4. Approtection from


jetty
breakwater
pier
quay
wharf
dry dock
wet dock

L18 30/08

Detached breakwater:



what - how does it work - drawing (why) → type of mat, crest
short note on specific

Reef breakwater:

Submerged sills

Beach drain

POG → obj & func

fefe

Chap 6: 52 page PDF

1.0.1, 3, 7, 8, 10, 13, 17

1.2.25

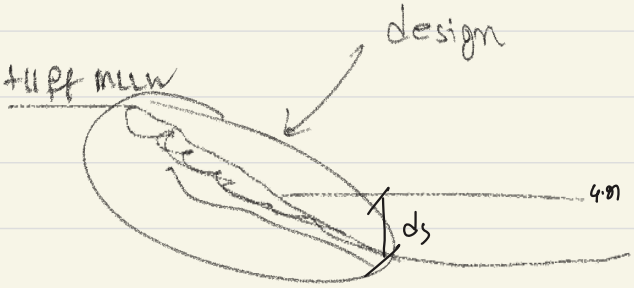
Failure

Rubble mound failure mode

Seawall / revetment: only failure mode (5)

Floating struct - failure (4)

Revetment design



Design wave ht, H = 4.2 ft
Design wave period, T = 4.25 s
RL of the rd lvl = + 11 ft MLLW
Storm surge ht = 3'
50 yr high water lvl = + 1.91 ft MLLW
MHHW = + 1.42' MLLW
Bed lvl at the end of beach slope = + 1.00 MLLW
Bottom slope of sea lvl = 1:10

Design water lvl = Storm surge ht + 50 yr water lvl
= 3' + 1.91' = 4.91' (MLLW)

a. Breaking wave criteria:

d_s = water depth at the structure
= 4.91 − 1.00 = 3.91

T = 4.25 sec

nearshore btm slope, m = 1/10 = 0.1

$$\frac{d_s}{gT^2} = \frac{3.91}{32.2 \times 4.25^2} = 0.0067$$

From graph, $\frac{H_b}{d_s}$ vs $\frac{d_s}{gT^2}$

$$\frac{H_b}{d_s} = 1.45$$

$\therefore H_b = 1.45 \times 3.91 = 5.67'$) 4.2 ft

$H_b = 3.65$
$H = 7$
} 3.65

$\therefore$ using H = 4.2 ft for design

b. Armor size def.:

$$W = \frac{\gamma_r H^3}{K_D \left(\frac{\gamma_r}{\gamma_w} - 1\right)^3 \cot\theta}$$

W = req. individual armor unit wt, lb (or W_{50} for graded riprap)

γ_r = specific wt of the armor unit lb/ft^3

γ_w = specific wt of water at the site

K_D = stability coeff.

θ = structural slope

(i) Riprap:

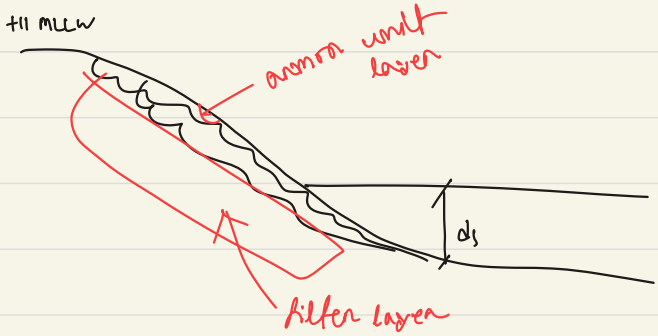
same; no need to read chart

$\cot\theta = 2$

$\gamma_r = 165$ lb/ft^3

$\gamma_w = 64$ lb/ft^3

$K_D = 2.2$



$$W_{50} = \frac{165 \times (4.2)^3}{2.2\left(\frac{165}{64} - 1\right)^3 \times 2}$$

$= 705$ lb $>$ 500 lb

Graded riprap this large may be difficult to obtain economically

② Quarry stone:

$\cot\theta = 1.5$ to 3

Assume $\cot\theta = 2$

$K_D = 2$

$$W = \frac{165 \times (4.2)^3}{2\left(\frac{165}{64} - 1\right)^3 \times 2} = 780 \text{ lb}$$

(P) The range of armor stone weights for a cover layer of 2 quarrystones could be vary from 0.75 W to 1.25 W or 585 lb to 975 lb with about 50 perc of the individual stones weighing more than W (780 lb)

Armor layer thickness:

$$r = n K_\Delta \left(\frac{W}{\gamma_r}\right)^{1/3}$$

r = layer thickness in feet

n = number of armor units layer

K_Δ = layer coeff. = 1.00

$$r = 2 \times 1 \times \left(\frac{780}{165}\right)^{1/3},$$

$$= 3.4 \text{ ft}$$

number of quarrystones per area,

$$N_r = A n K_\Delta \left(1 - \frac{P}{100}\right)\left(\frac{\gamma_r}{W}\right)^{2/3}$$

P = avg porosity of the cover layer

= 37 %

using $A = 1000 \text{ ft}^2$

$$N_r = 1000 \times 2 \times 1 \times \left(1 - \frac{37}{100}\right)\left(\frac{165}{780}\right)^{2/3}$$

450 stone per 1000 ft^2

d. wave runup est. :

$$\frac{H_s}{H_{mo}} = \exp\left[C_0 \left(\frac{d}{gT_p^2}\right)^{-C_1}\right]$$

C_0, C_1 = regression coeff. given as 0.00089 and 0.834 respectively

g = acceleration gravity

T_p = period of peak energy density of wave spectrum

H_{mo} : energy based ht of the zeroth moment

$$\frac{4.2}{H_{mo}} = \exp\left[0.00089 \left(\frac{15}{32.2 \times 4.25^2}\right)^{-0.834}\right]$$

$$\frac{4.2}{H_{mo}} = 1.019$$

$$\Rightarrow H_{mo} : 4.12 \text{ ft}$$

Maximum runup :

$$\varepsilon = \frac{\tan\theta}{\left(\frac{2\pi H_{mo}}{gT_p^2}\right)^{1/2}} = \frac{0.5}{\left(\frac{2\pi \times 4.12}{32.2 \times 4.25^2}\right)^{1/2}} \simeq 2.37$$

$$R_{max} = \frac{a\varepsilon}{1 + b\varepsilon}$$

R_{max} = max vert. ht of the runup above the SWL

a & b = regression coeff. determined as 1.022 and 0.247 respectively

ε = surf parameter

$$\frac{R_{man}}{4.12} = \frac{1.022 \times 2.37}{H(0.247 \times 2.37)} = 1.53$$

$\therefore R_{man} = 6.29$ ft

crest elv. $= 4.91 + 6.29 = 11.2$ ft

≈ 11.25 ft

Page 97/110

Sample PDF

Table 2.3, 2.4 not be given

may appear as diagram

30 marks

- Filter req ← incl.

comp. → math

may mention specific

Design of seawall

$H = 1.524$ m

$d = 2.524$ m [if 'd' not given, $d = H + 2$]

$T = 7.468$ sec

$K_D = 2$ [stability coeff.]

Unit wt of armor unit, $\rho_a = 2.65$ T/m^3

Density of seawater, $\rho_w = 1.025$ T/m^3

Layer coeff., $K_D = 1$

Slope, ϕ = 1 in 1.5

$\cot \phi = 1.5$

Armor layer design

Wt of armor unit:

$$W_a = \frac{\rho_a H^3}{K_D \left(\frac{\rho_a}{\rho_w} - 1\right)^3 \cot\theta}$$

$$= \frac{2.65 \times 1.524^3}{2\left(\frac{2.65}{1.025} - 1\right)^3 \times 1.5}$$

$$= 0.78467 \text{ T} = 785 \text{ kg}$$

Crest width of armor layer

$$B = n K_D \left(\frac{w_a}{\rho_a}\right)^{1/3}$$

$$= 3 \times 1 \times \left(\frac{0.785}{2.65}\right)^{1/3}$$

$$= 1.9998 \text{ m}$$

n = number of stones = 3

Thickness of armor layer

$$t = n K_D \left(\frac{w_a}{\rho_a}\right)^{1/3} \quad ; \quad n = 2$$

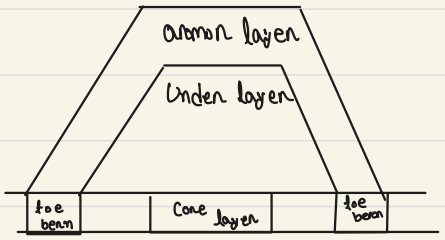
$$= 2 \times 1 \times \left(\frac{0.785}{2.65}\right)^{1/3}$$

$$= 1.3332 \text{ m}$$

$$\frac{d}{gT^2} = \frac{2.524}{9.81 \times 7.468^2} = 0.00461$$

$$\frac{H}{gT^2} = \frac{1.524}{9.81 \times 7.468^2} = 0.00279$$

Cross section



filter layer / bedding layer

Geotextile / sand

From graph: ← be given

$$\frac{r_c}{H} = 0.86 \Rightarrow r_c = 0.86 \times 1.524$$
$$= 1.31\,m$$

Crest elv. $= (2.524 + 1.31) = 3.834\,m$

Under layer design:

wt of under layer $= \frac{wa}{10}$ to $\frac{wa}{15}$

$= \frac{0.785}{10}$ to $\frac{0.785}{15}$

$= 0.0785\,T$ to $0.0523\,T$

Thickness of under layer = depth of armor $= 1.3332\,m$

Core layer design:

wt of core layer $= \frac{wa}{100}$ to $\frac{wa}{400} = 0.00785\,T$ to $0.00196\,T$

Toe berm design:

Wt of the berm $= \frac{wa}{10}$ to $\frac{wa}{15} = 0.0785$ to $0.0523\,T$

width ——— $= 2H = 2 \times 1.524 = 3.048\,m$

Depth ——— $= 0.4\,d = 0.4 \times 2.524 = 1.0096\,m$

Depth ——— = Depth of toe berm $= 1.0096\,m$

structure ht := thickness (armor + under + bedding layer) + depth (toe beam)

= 1.3332 + 1.3332 + 1.0096 + 1.0096

= 46.56 m

ht of struct = wt (armor unit + under + core layer) + toe berm

= 0.94985 T

Compulsory → either today or last lec's math

each type math may be asked

W14 21/09

math → all; see 2024/25 ques

Coastal struct func & purpose [table] 5-7 count
Failure mode ... a, b, c, d fail defn, why fail
Breakwater 1st fig → sloping ... str. breakwater fig
Seawall → caption only
overcomming → failure
sea dikes → — - · caption only
X vert. strc —
sloping something
floating struct → 4 failure name only

Types & comm ✓ figs — spring wk, loe

Ports & ... → diagram comp · layout
delta → morph, stage, diag —
— → Beach profile zone
math theory —
memo unit wk ✓
Coastal proc · → 5 something on one [slide ??]
bed ld trans., wash ld
Delta plan → hotspot, challenges issue
strategy, measure } 4 points
Tidal theo → harmonic non-harm — / theory, assump
mark

dia needed ← diagram most need ✓

seawall, revetment ✓ math

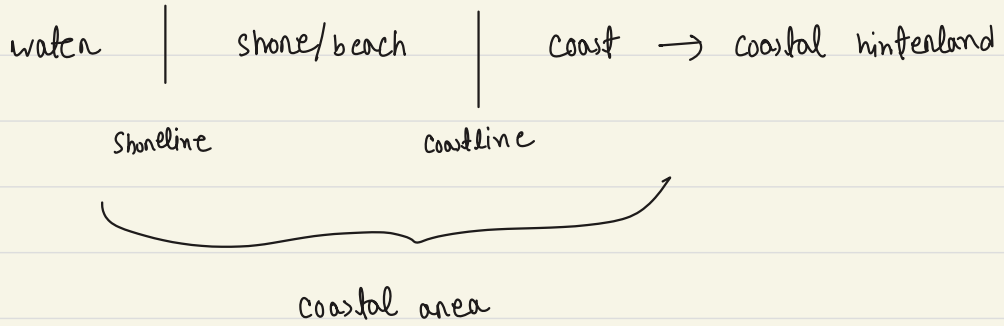
Comp · →

Rough / Final 02/11

Lec 1 Introduction

Ocean → larger body of water (total 5)
Sea → part of an ocean; partially enclosed by land

Coastal engineering → study of processes going on at the shoreline & construction within the coastal zone.



Lec 2 Tides & Currents

Tides: Periodic rise & fall of the ocean's surface due to moon & the sun's gravitational pull.

High tide: when water reaches its highest point at the side facing the moon

Low tide: when water reaches its lowest point At 90° of the side facing the moon.

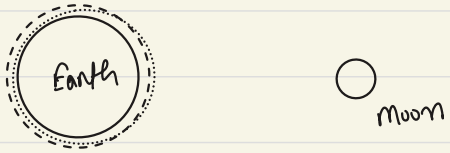
Intertidal zone: the strip of shore that is submerged during high tide and exposed during low tide.

Causes of tides (constituents):

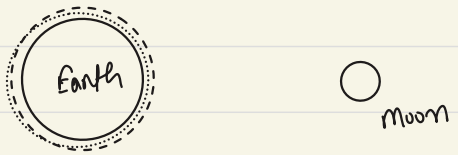
1. Gravitational interaction between the sun, moon, and the Earth.
2. centrifugal force of Earth

Formation of tides: Due to Tide Generating Forces (TGF - Grav., Centri.)

→ Due to gravitational forces btwn Earth & the moon, a tidal bulge is created on the side facing the moon:

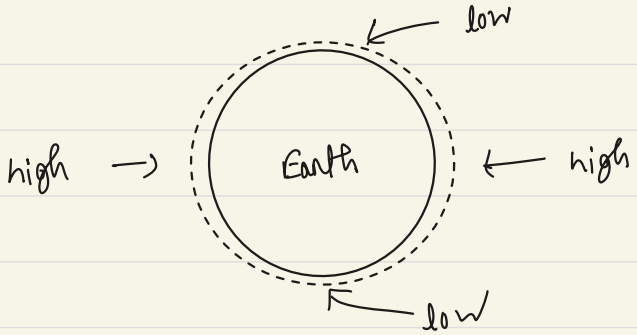


→ Due to Earth's rotation, and due to water being left behind, a second buldge is created on opposite side of Earth:



→ Together the form two buldges of water on two sides, experiencing high tides on regions that rotates through these sides.

→ Low tidal zones are the places between these two buldges.



→ Similar to Moon, Sun has effect that is 46% of Moon's

Tides are formed due to the gravitational forces difference on a unit mass between Earth's surface and its center.

$$F_m = KM_m\left[\frac{1}{(D_m-R)^2} - \frac{1}{D_m^2}\right]$$

$$= KM_m\left[\frac{D_m^2 - D_m^2 + 2D_mR - R^2}{(D_m-R)^2 D_m^2}\right]$$

$$= KM_m \frac{2R(D_m-R)}{(D_m-R)^2 D_m^2}$$

Since $R \ll D_m$,

$$f_m = KM_m \frac{2RD_m}{D_m^4}$$

$$= KM_m \frac{2R}{D_m^3}$$

Similarly, $F_s = K m_s \frac{2R}{D_s^3}$

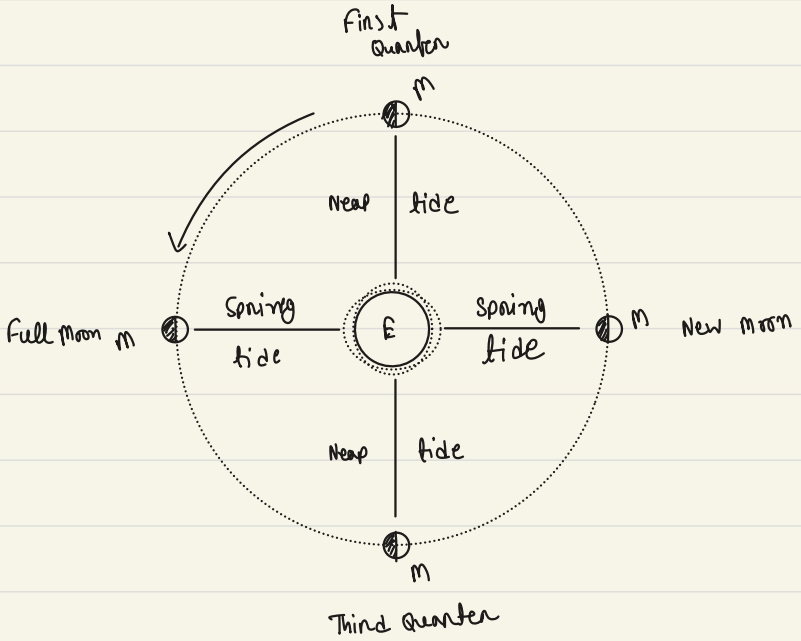
$$\therefore \frac{F_s}{F_m} = \frac{m_s}{m_m} \frac{D_m^3}{D_s^3}$$

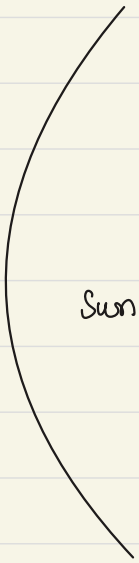
$$= \frac{1.99 \times 10^{30}}{7.34 \times 10^{22}} \times \frac{(384 \times 10^3)^3}{(15 \times 10^7)^3}$$

$$\simeq 0.46$$

$$\Rightarrow F_s = 0.46 F_m$$

Tidal force envelope:





Tidal phenomena:

Tidal range → diff in water lvl btwn high & low tides

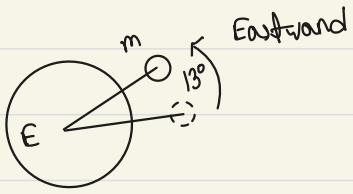
Tidal period → time diff btwn two successive high tides

→ 12hr 25 min for Bangladesh

two high, two low tides

Lunar day → time diff betwn two successive moon overheads

→ 24 hr 50 mins



$\frac{24 \times 60}{360} \times 13 = 52$ mins

→ 50 mins

↖ mean time
orbit elliptical

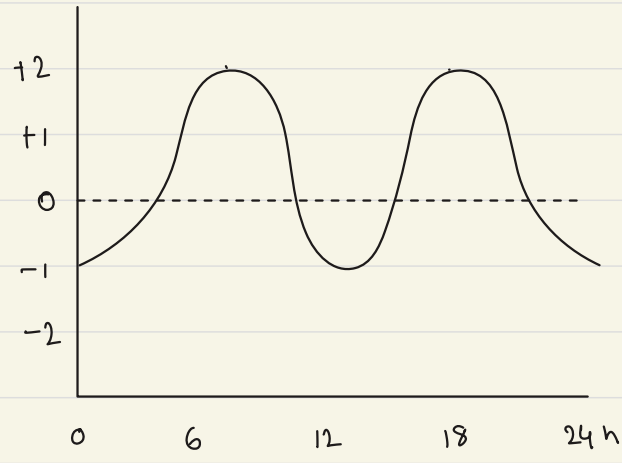
Tidal cycle: Semi-diurnal, diurnal, mixed-tidal cycle

Semi-diurnal: Each lunar day has two nearly equal high and low tides. Each is 12h 25m apart.
Ex. Coast of Bangladesh.

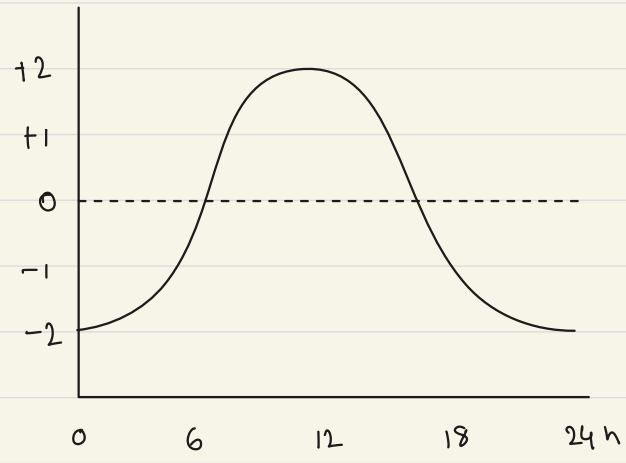
Diurnal: Each lunar day has one high and one low tides.
Ex. Gulf of mexico

Mixed: Each lunar day has two cycles but they're of varying heights.
Ht diff is called tidal inequalities.
Ex. western coast of North America.

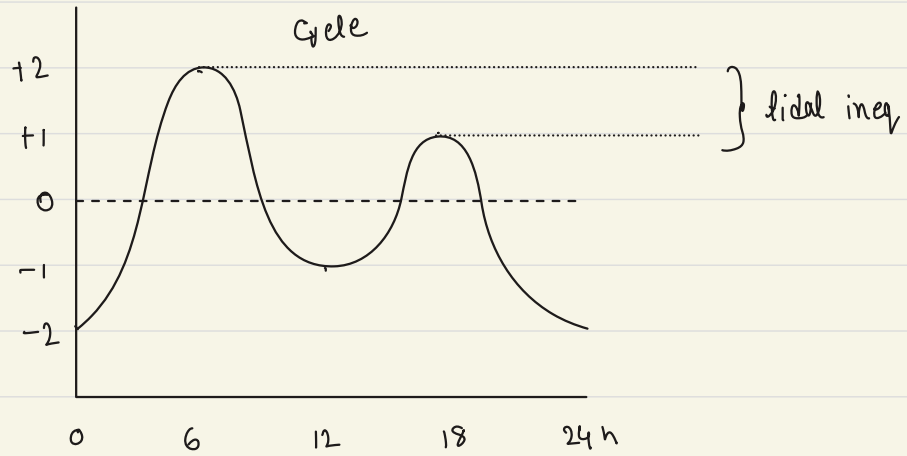
Semi-diurnal



Diurnal



Mixed tidal cycle



Tidal cycle: Range of low and high tides throughout the years across the country.

Spring tide: when the moon, Earth, and the sun fall in a straight
Strong tide line and their tidal forces are additive
Higher/lower Occurs during new moon & full moon.

Neap tide: when the moon and the sun pull at right angles to each
Weak tide other, their tidal forces are substractive.
Less high/low Occurs during first and third quarters of moon.

Tidal current:

movement of water towards & away from coast as a result of rise and fall of tides.

Flood tide : current flows inward ; water lvl rising
Ebb tide : current flows seaward ; " " falling

Tidal curve: Graphical rep; $x \rightarrow$ time
$y \rightarrow$ ht

Tidal range : consecutive high/low height, diff

Tidal lvl: contour hts defined using astronomical tide over duration, loc.

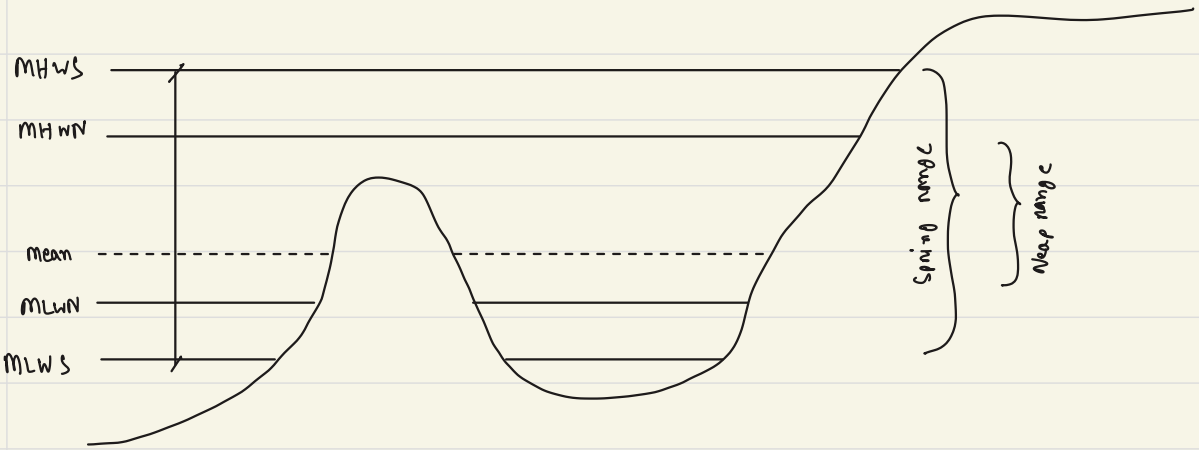
Astronomical tide, meteorological tide

Mean High water spring (MHWS): The average ht of two successive high tides during the 24 hrs period when the range of tide is highest throughout the year.

MLWS : Avg ht of two successive low waters
MHWN
MLWN

Mean spring range : Diff between MHWS & MLWS
mean neap range : " " MHWN & MLWN

Highest astronomical tide
Lowest " "



Tidal bore: Sudden and rapid rush of water through a channel due to tidal rise.

Chars: 1. Extreme case of shallow water eff.
2. Sudden & vertical rise and rush of water through open channel
3. Ht varies from 0.3 m to 4.5 m
4. Speed 3 to 20 knots
5. May or may not break

Tidal chars of Bangladesh:

1. Originates at Indian ocean
2. Travels across Bay of Bengal & reaches cox's Bazar & Hiron Point
3. Mean tide range 1.5 m to 4.5 m
4. Seasonal variation in tidal lvl due to pressure & wind variation
5. Semi-diurnal
6. Tidal inequ ≈ 0.55 m to 0.15 m
7. Tidal bores at Hatiya
8. Vel of neap tide lower.

Lec 3

Harbor: An enclosed watery area protected from storms to provide safe accommodation to vessels seeking shelter, repair, refuelling, transfer of cargo, supplies.

Port: A commercial shore facility containing one or more harbor where vessels dock to transfer people / freight to / from land.

Types of port:

1. Inland port: port on a navigable lake, canal, river connected to sea.
2. Fishing port: port for handling, loading fishing. Env. concern.
3. Dry port: Intermodal port connected by road and rail to land destination. center for transshipment of sea cargo.
4. warm port: water remains unfrozen year-around.
5. Sea port: Subdivided into cargo ports cruise port.
   Cargo port: Handling of cargo; bulk port, break-bulk, container port.
   Cruise port: boarding / unboarding cruise
6. Ocean port: port of call for large ocean-going vessels.
7. Free-port: Isolated, customs free port for manufacturing, repacking, repairing.

Classification of harbor:

Based on formation:

1. Natural: Formed by natural geographic features such as bays, mountains, islands.
   Protected by land contours.
   E.g., New York
2. Semi-natural: Require man-made structure for additional protection, typically at the entrance.
   Protected by head lands on the sides and man-made struct at entrance.
   E.g, Plymouth.
3. Artificial: Man-made harbors, where natural protection is insufficient, protected by breakwater or created using dredging.
   E.g, Madras.

Based on function:

1. Commercial: loading / unloading of cargo
   busiest of all; docks & berths available for handling cargo
   E.g, madras.
2. Military: used as naval base for nesting or repairing warcraft.
   may work as supply depot. Require large area
   E.g, Pearl Harbor.
3. Refugee: provides safe and easy access to vessels during troubling situations like storm.
   Req: good anchorage, safe & easy access.
   E.g., Madras.

Based on location:

1. Sea harbour: Along seashore. International shipping.
2. River " : River connected to sea. Inland transportation.
3. Canal harbour: Canal " " " . " "

Port v. harbour:

Component	Harbour	Port
Definition	Water enclosed area protected from storms to provide accomodation to vessels.	Commercial place for docking, loading/unloading of cargo.
Primary func	Safety, anchorage to vessels	Handling of cargo
Features	Minimal; focused on safety	Extensive, incl. cranes, lifts, special storage, offices, hotels.
Construction	Natural or man-made	Man-made & large
Usage	Recreational acti., watery sports.	Trade & commerce btwn countries.
Accessibility	Marine channel	Sea route, river or canal (dry port), roads & rails.
Value	Valuable for safety	Economic asset to country, commercial enterprise.

Port terms:

Port of call: Intermediate stops for a ship on its sailing routes; used for docking, cargo handling, passenger in/out, fueling, supplies.

Marine terminal: Designated area on a port for ships to dock and handle cargo, load/unload passenger → oil terminal, passenger terminal.

Offshore terminal: Mooring structure on open, deep water when nearshore berths are impractical.

Factors for port site selection:

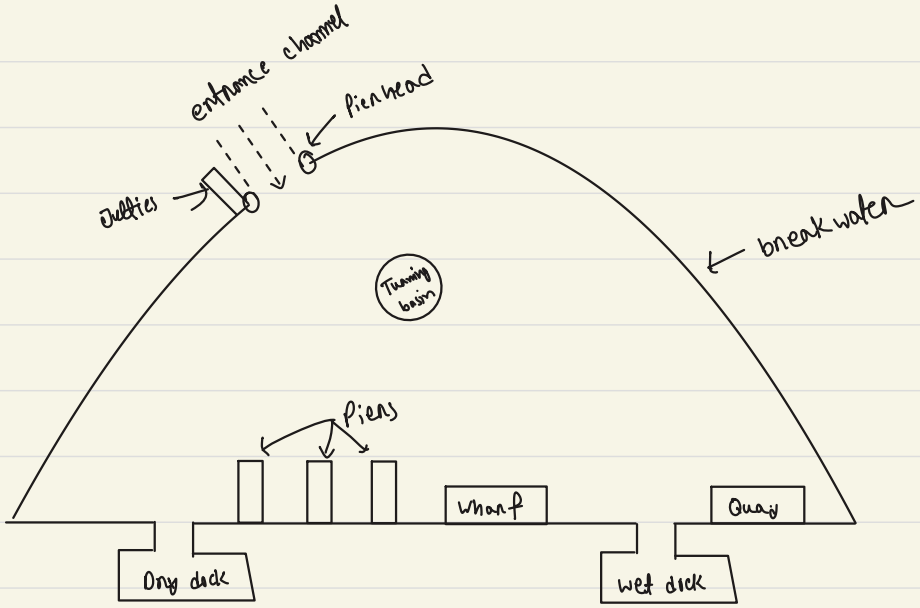
1. Marine cond. & approaches
2. Seabed & subsoil cond.
3. Connectivity to hinterland transport network
4. Hinterland economic base
5. Existing & forecasted seaborne traffic
6. Reliable access to supplies & electricity
7. Availability of land and materials.

Factors for harbor layout:

1. Littoral drift
2. Size & shape of harbor
3. Protection from storm waves
4. Layout of wharves and jetties
5. Submarine waves

PPP

Components of harbor:



Req of good harbor:

1. Deep enough for all visiting ships
2. Entrance wide enough for passage
3. Bottom to provide secure anchorage
4. Breakwater to prevent destructive action of waves.

Lec 4 Coastal Processes & sediment Transport

wave types:

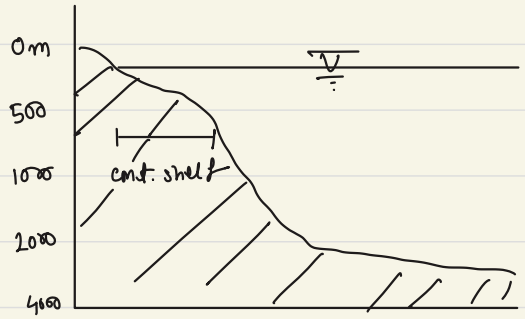
Constructive v. destructive:

Component	Constructive	Destructive
Wavelength	Long	Short
Energy	Low	High
Swash	Strong	weak
Backwash	weak	Strong
Beach shape	wide & flat	steep & narrow
Wave ht	Low	High
Frequency	Low (8-10 / min)	High (10-14 / min)

Swash → washing up of water as wave breaks.
Backwash → running down of " " " " .

Continental shelf:

Gently sloping submerged surface extending out from shoreline.



Coastal development to coastal process interference:

1. Change sediment transport rate
   E.g, construction of dam that traps sediment
2. Reduce wave energy flux
   E.g, breakwater to prevent wave energy reaching shore
3. Directly interfere sediment transport
   E.g., transverse structure like groin to directly interrupt wave

Processes:

Erosion: Removal of sediment by action of wind / water

Transportation: movement of sedi.

Accretion: Deposition of sedi.

Denudation: weaning, lowering, stripping away of coastal landforms (shoreline or nearshore zones)

Coastal flooding: Permanent or temporary inundation of normally not dry coastal land by sea water.

Process of erosion:

1. Hydraulic action – water force
2. Abrasion — grinding down
3. Compressed air – trapped, mini explosion
4. Attrition – crashing into eachother
5. Corrosion – acids in water
6. Wave refraction — waves bend → concentrated on certain area

Coastal deposition

Sediment transport: Process by which sediments are moved by nat. agents.

Process: waves.
current
stream outflow
chng in water lvl
tides

Beach sediment props: Physical

2 chemical constituents
2. Porosity, permeability
3. Sp. Gn., bulk sp. gn.
4. Grain shape
5. representative size and size distn.

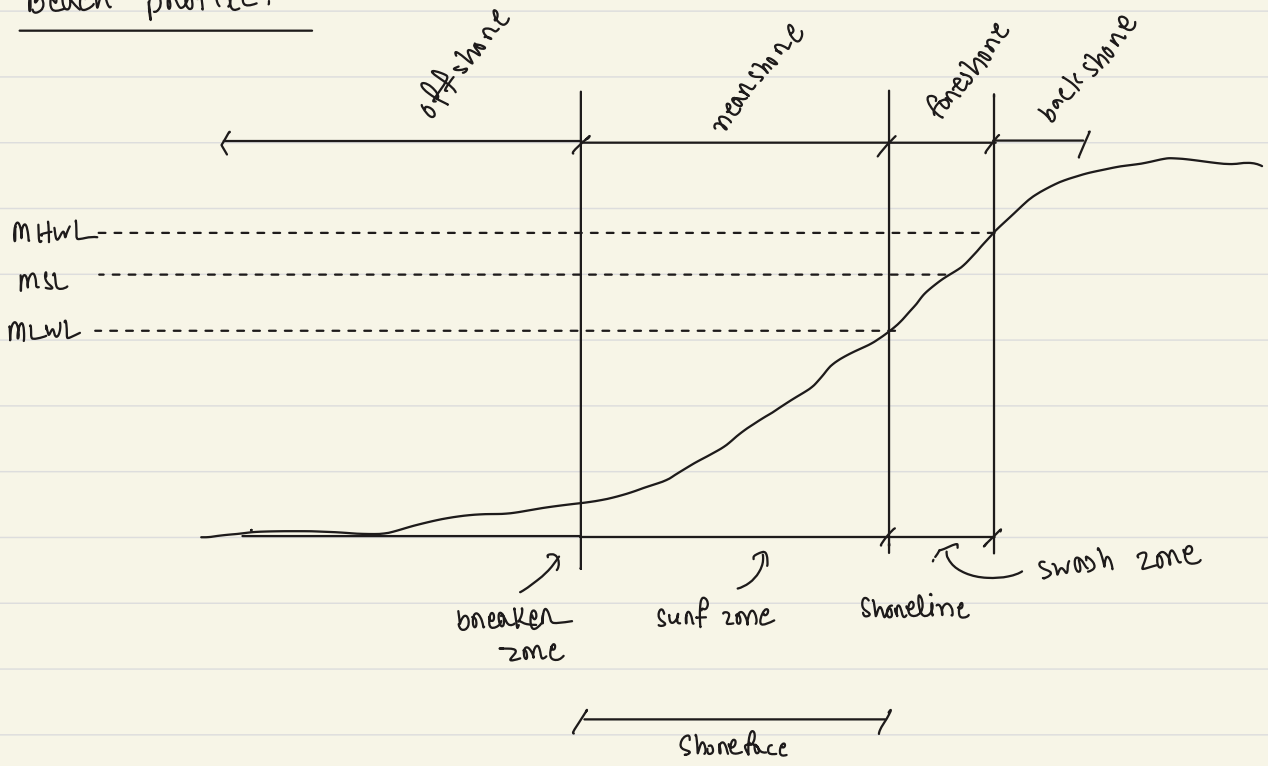
Modes of sediment transport:

Bed ld: Part of the total ld that remains more or less in contact with the bed during transport.

Suspend ld: Part of total ld that moves in suspension

Wash ld: very fine particles transported in water

Beach profile:



Recap:

Backshore: landward after high tide

Foreshore: btwn high & low tide

Nearshore: btwn low tide & where wave breaks at low tide

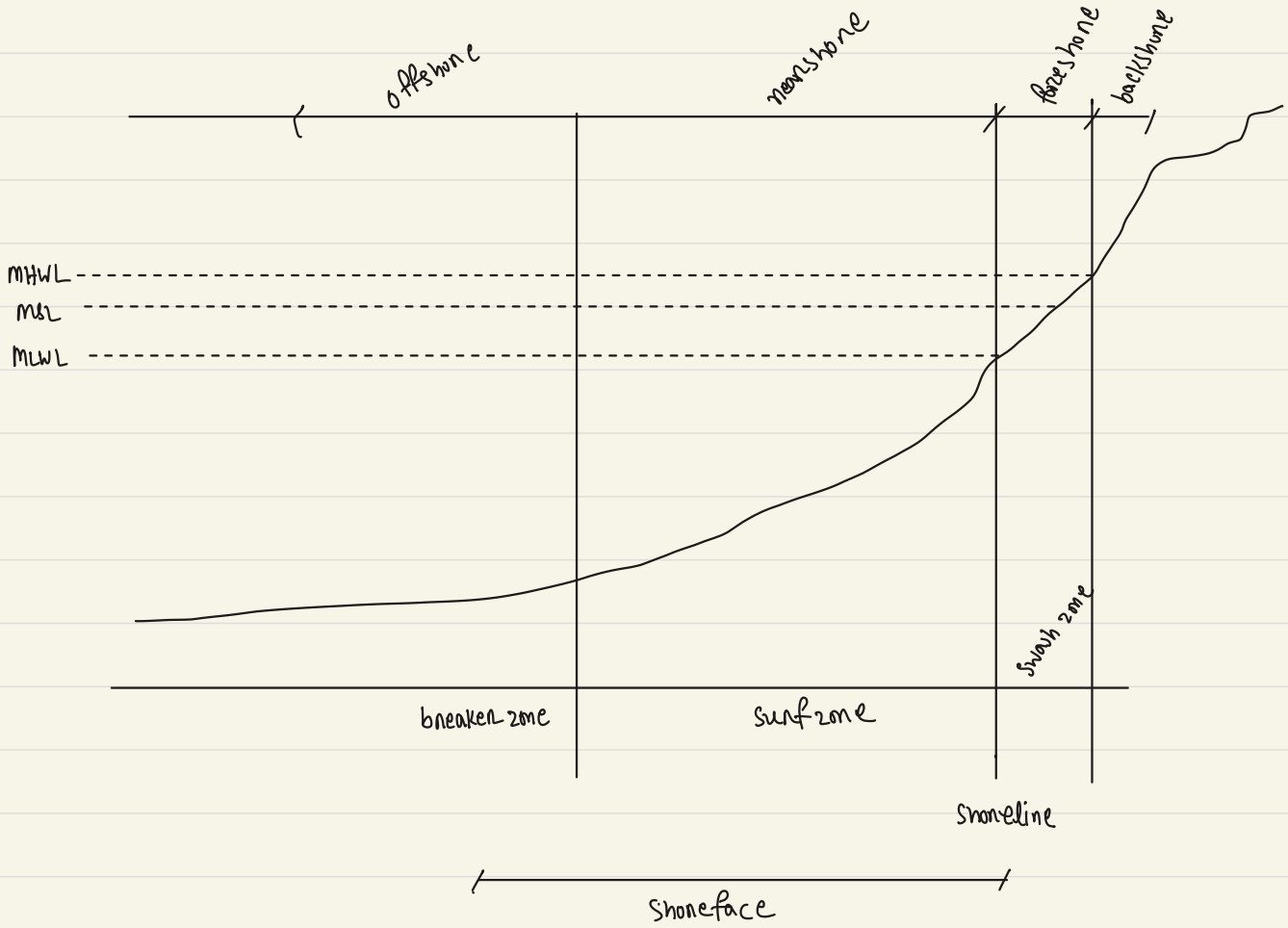
Offshore: seaward after breaker zone.

Swash zone: btwn low & high tide where waves break and washes up/down.

Surf zone: btwn shoreline & breaker zone.

Breaker zone: outer edge of surf zone where wave breaks.

Shoreface zone: btwn foreshore and offshore.


offshore
nearshore
foreshore
backshore
MHWL
MSL
MLWL
swash zone
breaker zone
surf zone
shoreline
shoreface

Sediment transport:

Offshore transport: sediments away from the shore
Onshore " : " towards the shore

Mechanisms of beach profile change:

Onshore 1. wave motion: wave reaches the shore at higher velocity and return at much lower.
Because there's a threshold shear velocity for sediment to move it moves sediment onshore.

Offshore 2. Gravity: Beach profile is sloped downward seawards. So, gravity drags some sediments into the sea.

Offshore 3. Under tow: Breaking waves move some extra water into the shore, this water, when escapes toward the sea, drags sediment
Rip current: when wave moves along a stretch on beach the may concentrate and return back to sea at a higher velocity.

On/Offshore 4. Turbulence from breaking wave: Turbulence lifts up bottom sediment into suspension. They goes onshore and offshore.

Offshore 5. Wind: Onshore wind applies a shear stress at water surface, pushing them toward shore. The compensating bottom return flow transports sand grains offshore.

Longshore transport: or littoral drift

Is the process by which sediments move along a coastline due to waves approaching at an angle.

→ waves approach at an angle
→ swash carries sediment at same angle
→ backswash carries down at 90°
→ zig-zag

Model theories for calculating longshore drift:

Energy-flux → total sediment moved
based on total energy arriving at shoreline

Energetic

Suspended transport model

Cross-shore transport:

Movement of sediments perpendicular to shoreline
btwn beach & nearshore

Onshore + offshore

Models: Simple cross-shore transport model
Fall time
Traction
Energetics
Ripple model

Simple cross shore transport model:

Equilibrium beach w/ uniform sand size maintance a constant wave energy dissipation rate

If actual energy dissipates more -> offshore

$$q_s = K(D - D^*)$$

Coastal struct/ activities:

Groin, gabion, longshore bars, beach nourishment, sand spits, tombolo

Longshore sediment transport rate:

Potential volumetric longshore trans. rate,

$$Q_l = \frac{I_l}{(\rho_s - \rho) g (1-n)}$$

$$I_l = K \left(\frac{\rho g^{1/2}}{16 \kappa^{1/2}} \right) H_b^{5/2} \sin 2\alpha_b$$

(3/2)

$$K = 0.057 + 2.6 \sin^2(2\alpha_b) + 0.007 \frac{u_{mb}}{w_f}$$

Kappa

$$u_{mb} = \frac{K}{2} \sqrt{g d_b}$$

Kappa

K = breaker index

$= H_b / d_b$ [breaker ht / water depth at breaker line]

$K = 0.7$ for flat beach

> 1.0

α_b : wave breaker angle (to shoreline)

I_l = immersed wt transport rate

u_{mb} : maximum osc. vel. magnitude

w_f = fall vel.

$$Q_l = \frac{I_l}{(\rho_s - \rho) g (1-n)}$$

$$I_l = K \left(\frac{\rho g^{1/2}}{16 K^{1/2}} \right) H^{5/2} \sin 2\alpha_b$$

(3/2)

$$K = 0.05 + 2.6 \sin^2(2\alpha_b) + 0.007 \frac{u_m}{w_f}$$

$$u_m = \frac{K}{2} \sqrt{g d}$$

$$K = \frac{H_b}{d_b}$$

P47/

$H_b = 2m$

$\rho_s = 2650 \ kg/m^3$

$\alpha_b = 4.5°$

$w_f = 0.131 \ m/s$

$K = 1.0$

$$Q_l = \frac{I_l}{(\rho_s - \rho) g (1-n)}$$

$$I_l = K \left(\frac{\rho g^{1/2}}{16 K'^{1/2}} \right) H_b^{5/2} \sin(2\alpha_b)$$

$$= 2.232 \times \left(\frac{1025 \times 9.81^{1/2}}{16 \times 1^{1/2}} \right) 2^{5/2} \sin(2 \times 4.5)$$

$$= 396.31$$

$$\therefore Q_l = \frac{396.31}{(2650 - 1025) \times 9.81 \times (1 - 0.4)}$$

$$= 0.041 \ m^3/s$$

$$= 3580 \ m^3/d$$

$$K = 0.05 + 2.6 \sin^2(2\alpha_b) + 0.007 \frac{u_{mb}}{w_f}$$

$$u_{mb} = \frac{K}{2} \sqrt{g d_b} \ ; \quad K = \frac{H_b}{d_b} = 1$$

$$= \frac{1}{2} \sqrt{9.81 \times 2} \qquad \Rightarrow H_b = d_b = 2m$$

$$= 2.21$$

$$\therefore K = 0.05 + 2.6 \sin^2(2 \times 4.5) + 0.007 \frac{2.21}{0.131}$$

$$= 0.232$$

Recap :

$$Q_l = \frac{I_l}{(\rho_s - \rho) g (1-n)}$$

$$K = \frac{H_b}{d_b}$$

$$I_l = R X \left(\frac{\rho \sqrt{g}}{16 \sqrt{K}} \right) H_b^{5/2} \sin(2\theta_b)$$

$$R = 0.05 + 2.6 \sin^2(2\theta_b) + 0.007 \frac{u_{mb}}{w_f}$$

$$u_{mb} = \frac{K}{2} \sqrt{g d_b}$$

Lec 6 Tidal theories & tide prediction

Newton's equil theory:

First theory to attempt to explain the tides in ocean:

→ Shows that gravitational pull between Earth and Moon is strongest on the side nearest to moon.
→ Pull is lower on the opposite side than at solid Earth's center.
→ As a result, water is pulled more on the nearest causing a tidal bulge.
→ Because other side is pulled less than center, a second bulge is formed there.
→ Shows Sun also has similar effects.

Explains → 1. semi-diurnal tidal cycle
2. Spring tide, neap tide
Sun – Earth – Moon on same line → additive → spring
Sun – Earth → cancels out → neap tide
|
Moon

Limitations: 1. Assumes Earth is enveloped with a ocean of uniform depth.
why may only be true in southern ocean.
2. Assumes fluid particles are in instantaneous equil. with astronomical forces.
which, if were true, we'd see high tides whenever moon passes over a local meridian.
3. Fails to account for the time lag/advance observed.

Laplace theory:

considers disturbance due to Earth's rotation.
A.K.A dynamical theory

Time of occurence of high/ low tide:

The periodic acceleration of time of occurence of high/ low tide changes due to relative positioning of moon and sun.

Priming of tide:

Defn: The periodic acceleration in time of occurence of high/ low tide, as well as the initial rise of water level before high tide arrives.

Moon's pos: 1st & 3rd quandant

Effect: High tide occurs before moon passes over.

Interval: < 12h 25m

Lagging of tide:

Defn: The delay in the occurence of high/ low tide at a specific loc compared to predicted delay.

Moon's pos: 2nd & 4th quandant

Eff: High/ low tides after moon passes over

Interval: > 12h 25m

Prediction by use of non-harmonic constants:

1. Age of tide: The time difference between astronomical generation of a tide and its actual arrival.
2. Lunitidal interval: The time difference between moon's local meridian transit and subsequent high water.
3. vulgar establishment: The lunitidal interval on the full moon and new moon day.
4. mean establishment: Average of all lunitidal interval over at least a lunation or 29 days. ⟶ = vulgar - lagging

Find time of afternoon high water:

Time of moon's transit today : 4:40 m
mean establishment : 3h 10 m
Age of tide : 2 days

---

1. Time of moon's transit on the day of tide generation:

$$4:40 - 50m \times 2 = 3:00m$$

2. Connection from table = −41 m
3. Lunitidal interval = mean + conn. = 3:10 m − 41 m = 2:29 m
4. Therefore, time of high tide = 4:40 + 2:29 = 7:09 m

Height of tide: Not used

vert. dist. of high water above some ref.

$$H = h + \tfrac{1}{2} n \cos\theta$$

Harmonic constituents: 36 total; 9 listed

Lunar semi-diurnal
Solar "
Langen-elliptic "
Luni-solar "
Luni-solar diurnal
Langen-eliptic "
Solar "
First overtake of semi-diurnal

Lec 7 Types and func of coastal structs

Func & purpose: Stop water, hold soil

1. Protect infrastructure
   from flooding → high water level
   from erosion, wave impact
2. Protect boats
   from wave & wave impact
3. Protect nav. channel
   by preventing sedimentation & inlet migration
4. Prevent erosion by beach stabilization
5. Enhance beauty and recreation.

Soft. v. hard :

Hard: Engineed soln designed to prevent erosion and damage
Soft: Nature based soln.

Hard / non-erodible	Soft / erodible
Groin	Dunes
Seawall	Fill
Revetment	marshes
Jetties	Bioengineered
Bulkhead	

Coastal struct / Defence schema / Obj:

1. Prevent shoreline erosion
2. Prevent flooding on hinterland
3. Protect harbor basin
4. Stabilize navigation channel
5. Protect water inlet / outfalls

Failure modes of typical structure:

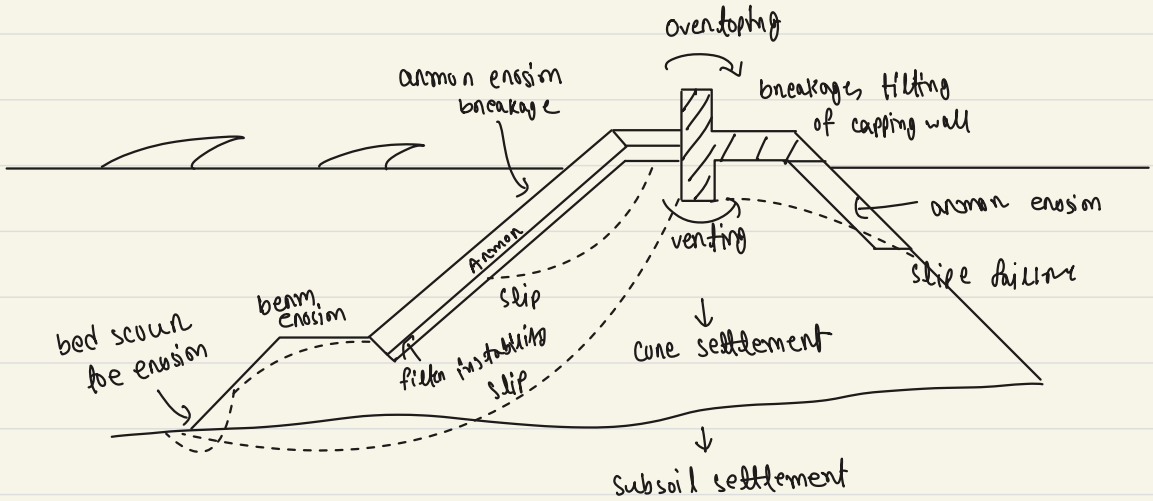
Defn: Damage to a struct. that results in performance and functionality below minimum anticipated by design.

Common failure reasons:

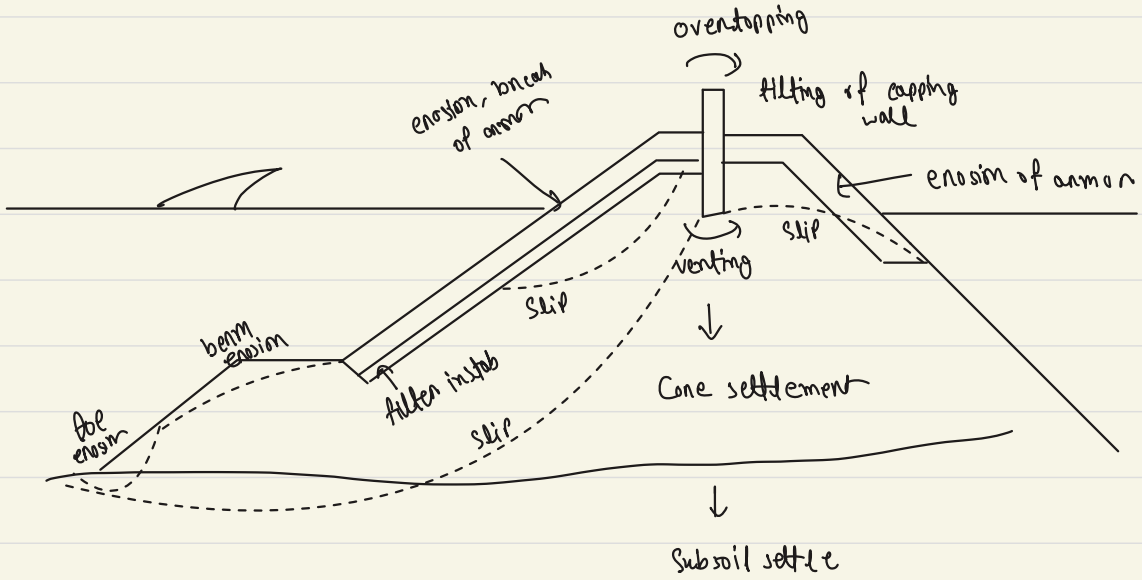
i) Design failure: struct as a whole or it components can't withstand ld within its design criteria
ii) Load excedence: Anticapated lds were exceeded.
iii) Construction failure: Bad constn. or constn. mats.
iv) Deterioration failure: Result of struct deterioration or lack of proj. maintenance.

Failure mode relevant to rubble mound breakwater:

Overtopping
venting
slip failure (x3)
Bed scour & toe erosion
Berm erosion
Erosion & breakage of armor
Erosion of rear armor
Breakage, sliding, tilting of capping wall
Cone settlement
Sub-soil settlement
Filter instability



Recap:


overtopping
tilting of capping wall
erosion, breach of armor
erosion of armor
slip
venting
slip
beam erosion
filter instab
Cone settlement
toe erosion
slip
Subsoil settle

Seawall/revetments:

1. Back scour failure due to overtopping
2. Rubble slope failure due to toe erosion
3. Push out of slab ef. due to uplift press
4. Failure of sheet pile toe wall

→ excess overtopping → hinterland erosion → collapse of top of seawall

Dike:

1. Erosion of dike slope protection
2. Toe erosion
3. Back scouring
4. Dike crest erosion
5. Dike slip surface failure

Floating struct:

i) Failure of floating sec
ii) " " " connectors
iii) " " anchorage or pile sys
iv) Flooding or sinking

Beach drain → prevent erosion of beach
accumulate beach mats on the drained portion of beach.

Revetment design:

Design wave ht, $H = 4.2'$

" " period, $T = 4.25$ s

RL of rd lvl = $+11'$ MLLW

Storm surge ht = $3'$

50 y high WL = $+19.1'$ MLLW

MHHW = $+14.2$ MLLW

Bed lvl at the end of bank slope = $+1.00$ MLLW

Bottom slope of sea lvl = 1:10

Step 1: Design water lvl → highest

2: Find H

$d_s \rightarrow$

$T \rightarrow$

$\frac{d_s}{gT^2} \rightarrow$

H_b from $\frac{d_s}{gT^2}$ vs $\frac{H_b}{d_s}$

3 Armor size

$$W = \frac{\gamma_r H^3}{K_D \left(\frac{\gamma_r}{\gamma_w} - 1\right)^3 \cot\phi} \quad ; \text{ in lb} \; ; \; \gamma_r = 165 \text{ lb/ft}^3$$

Trial rip-rap: $K_D = 2.2$, $\cot\phi = 2$

$W \leq 500$ lb ✓ else

Trial Quarry stone: $K_D = 2$, $\cot\phi = 2$

Filter layer: Two stage stone filter beneath armor layer

12" crushed stone, 12" pea gravel

4. Armor layer thickness :

$$r = n K_\Delta \left(\frac{W}{\gamma_r}\right)^{1/3} \quad ; \quad \text{in ft} ; \qquad n = 2, \; K_\Delta = 1.00$$

Number of quarrystone per area :

$$N_r = A n K_\Delta \left(1 - \frac{P}{100}\right) \left(\frac{\gamma_r}{W}\right)^{2/3} \quad ; \quad P = 37\%$$

5. Wave run-up est.

$$\frac{Hs}{H_{mo}} = \exp\left(C_0 \left(\frac{d}{gT^2}\right)^{-C_1}\right) \quad ; \quad C_0 = 0.00089$$

$$C_1 = 0.834$$

$$d = 15'$$

$$\varepsilon = \frac{\tan\phi}{\left(\frac{2\pi H_{mo}}{gT^2}\right)^{-1/2}}$$

$$\frac{R_{max}}{H_{mo}} = \frac{a\varepsilon}{1+b\varepsilon} \quad ; \quad a = 1.022, \; b = 0.247$$

6. Crest elv $\rightarrow$ max ht + R_{max}

Revetment design:

Design wave ht, $H = 4.2'$

" " period, $T = 4.25$ s

RL of rd tvl $= +11'$ MLLW

Storm surge ht $= 3'$

50 y high wl $= +1.91'$ MLLW

MHHW $= +1.42$ MLLW

Bed tvl at the end of bank slope $= +1.00$ MLLW

Bottom slope of sea tvl $= 1:10$

---

1. Design water tvl $= 3 + 1.91 = 4.91'$ MLLW
2. H:

$d_s = 4.91 - 1 = 3.91'$, $m = 1/10 = 0.1$

$\therefore \frac{d_s}{gT^2} = \frac{3.91}{32.2 \times 4.25^2} = 0.0067$

$\therefore \frac{H_b}{d_s} = 1.45 \Rightarrow H_b = 3.91 \times 1.45 = 5.67' > 4.2'$

$\therefore H = 4.2'$

3. Armor size:

$$W = \frac{\gamma_r H^3}{K_D \left(\frac{\gamma_r}{\gamma_w} - 1\right)^3 \cot\phi}$$

$$W = \frac{\gamma_r H^3}{K_D \left(\frac{\gamma_r}{\gamma_w} - 1\right)^3 \cot\phi}$$

$$\text{Riprap} = \frac{165 \times 4.2^3}{2.2 \left(\frac{165}{64} - 1\right)^3 \times 2} = 706.9 \text{ lb} > 500 \text{ lb}$$

$$\frac{\gamma_r H^3}{K_D \left(\frac{\gamma_r}{\gamma_w} - 1\right)^3 \cot\phi}$$

$$\text{Quarry stone} = \frac{165 \times 4.2^3}{2 \left(\frac{165}{64} - 1\right)^3 \times 2} = 778 \text{ lb}$$

4 Armor thickness,

$$r = n k_\Delta \left(\frac{W}{\gamma_r}\right)^{1/3}$$

$$= 2 \times 1 \times \left(\frac{778}{165}\right)^{1/3} = 3.41'$$

$r = n k_\Delta \left(\frac{W}{\gamma_r}\right)^{1/3}$

$N = A n k_\Delta \left(\frac{\gamma_r}{W}\right)^{2/3} \left(1 - \frac{P}{100}\right)$

$\frac{H}{H_{mo}} = \exp\left(C_0 \left(\frac{d}{gT^2}\right)^{-C_1}\right)$

$C_0 = 0.00089$, $C_1 = -0.834$

$\varepsilon = \frac{\tan\phi}{\left(\frac{H_{mo} 2\pi}{gT^2}\right)^{1/2}}$

Num of quarrystone per area:

$$N_r = A n k_\Delta \left(1 - \frac{P}{100}\right) \left(\frac{\gamma_r}{W}\right)^{2/3}$$

$$= 1000 \times 2 \times 1 \times \left(1 - \frac{37}{100}\right) \left(\frac{165}{778}\right)^{2/3} = 448.1$$

$$\approx 450 / 1000\ ft^2$$

5. Wave runup est.:

$\frac{R}{H_{mo}} = \frac{a\varepsilon}{1 + b\varepsilon}$

$a = 1.022$, $b = 0.247$

$$\frac{H}{H_{mo}} = \exp\left(C_0 \left(\frac{d}{gT^2}\right)^{-C_1}\right)$$

$$= \exp\left(0.00089 \times \left(\frac{15}{32.4 \times 4.25^2}\right)^{-0.834}\right) = 1.019$$

$$\Rightarrow H_{mo} = 4.2 / 1.019 = 4.12'$$

$$\varepsilon = \frac{\tan\phi}{\left(\frac{H_{mo} 2\pi}{gT^2}\right)^{1/2}} = \frac{0.5}{\left(\frac{4.12 \times 2\pi}{32.4 \times 4.25^2}\right)^{1/2}} = 2.38$$

$$\frac{R_{max}}{H_{mo}} = \frac{a\varepsilon}{1 + b\varepsilon} = \frac{1.022 \times 2.38}{1 + 0.247 \times 2.38} = 1.53$$

$$\Rightarrow R_{max} = 4.12 \times 1.53 = 6.3$$

$$\text{Crest} = 6.3 + 4.91 = \approx 11.25'$$

Recap:

$$W = \frac{\gamma_r H^3}{K_D \left(\frac{\gamma_r}{\gamma_w} - 1\right)^3 \cot\phi}$$

$$n = n K_D \left(\frac{W}{\gamma_r}\right)^{1/3}$$

$$N = A n K_D \left(\frac{\gamma_r}{W}\right)^{1/3} \left(1 - \frac{P}{100}\right)$$

$$\frac{H}{H_{mo}} = \exp\left(C_0 \left(\frac{d}{gT^2}\right)^{-C_1}\right)$$

$C_0 = 0.0049$, $C_1 = 0.834$

$$\varepsilon = \frac{\tan\phi}{\left(\frac{2\pi H_{mo}}{gT^2}\right)^{1/2}}$$

$$\frac{R}{H_{mo}} = \frac{a\varepsilon}{1 + b\varepsilon}$$

$a = 1.022$

$b = 0.247$

1. Design water lvl
2. H:

$d_s =$; $m =$

$$\frac{d_s}{gT^2} = \cdots \rightarrow \frac{H_b}{d_s} \rightarrow H_b \rightarrow H$$

3. Armor size:

$$W = \frac{\gamma_r H^3}{K_D \left(\frac{\gamma_r}{\gamma_w} - 1\right)^3 \cot\phi}$$

4. Armor thickness:

$$n = n K_D \left(\frac{W}{\gamma_r}\right)^{1/3}$$

# of Quarrystone: $N_r = A n K_D \left(1 - \frac{P}{100}\right) \left(\frac{\gamma_r}{W}\right)^{2/3}$

5. wave runup est.:

$$\frac{H}{H_{mo}} = \exp\left(C_0 \left(\frac{d}{gT^2}\right)^{-C_1}\right)$$

$\rightarrow H_{mo}$

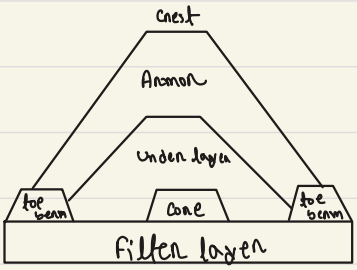
$$\varepsilon = \frac{\tan\phi}{\left(\frac{2\pi H_{mo}}{gT^2}\right)^{1/2}}$$

$$\frac{R}{H_{mo}} = \frac{a\varepsilon}{1 - b\varepsilon}$$

Design of seawall:

1. wt of armon unit:

$$W = \frac{\rho_a H^3}{K_D \left(\frac{\rho_a}{\rho_w} - 1\right)^3 \cot\phi}$$



2. Crest width:

$$B = n K_D \left(\frac{W}{\rho_a}\right)^{1/3} \quad ; n = 3 \; ; \; W \text{ in ton if } \rho_a \text{ in ton/m}^3$$

3. Thickness, armon layer

$$t = n K_D \left(\frac{W}{\rho_a}\right)^{1/3} \quad ; \quad n = 2$$

4. Crest elv:

$$d/gT^2 \; ; \; \frac{H}{gT^2} \rightarrow n_c \text{ from graph}$$

Crest elv: $d + n_c$

5. under layer design:

$$Wt = \frac{W_a}{10} \text{ to } \frac{W_a}{15}$$

thickness : armon layer thickness

6. Core layer design: $W_t = \frac{W_a}{100}$ to $\frac{W_a}{400}$

7. Toe beam design:

$$wt = \frac{Wa}{10} \text{ to } \frac{Wa}{15}$$

Width = 2H

Depth = 0.4 d

Depth of core layer = Depth of toe beam

8. Struct. wt = thickness (armor + under + bedding) + depth (toe)

wt = wt (armor + under + core) + toe berm

Ex /

$H = 1.524\ m$

$d = 2.524\ m$ [$d = H + 2$ if not given]

$T = 7.468\ s$

$K_D = 2$

$\rho_a = 2.65\ T/m^3$

$\rho_w = 1.025\ T/m^3$

$K_\Delta = 1$

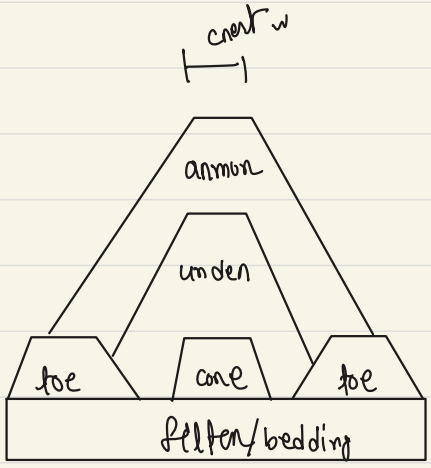
$\cot\phi = 1.5$ [ϕ = 1 in 1.5]

---

1. wt of armor layer:

$$W_a = \frac{\rho_a H^3}{K_D\left(\frac{\rho_a}{\rho_w} - 1\right)^3 \cot\phi}$$

$$= \frac{2.65 \times 1.524^3}{2\times\left(\frac{2.65}{1.025} - 1\right)^3 \times 1.5} = 0.785\ T$$



$$\text{Thickness} = n K_D \left(\frac{W}{\rho_a}\right)^{1/3}$$

$$= 2 \times 1 \times \left(\frac{0.785}{2.65}\right)^{1/3} = 1.33\ m$$

$$\text{Crest width} = n K_D \left(\frac{W}{\rho_a}\right)^{1/3}$$

$$= 3 \times \cdots \therefore 2.00\ m$$

$$W_a = \frac{\gamma_a H^3}{K_D\left(\frac{\gamma_a}{\gamma_w} - 1\right)^3 \cot\phi}$$

$$t_a = n K_D \left(\frac{W}{\gamma_a}\right)^{1/3};\ n = 2$$

$$t_B = n \cdots ;\ n = 3$$

$$W_u = \frac{W_a}{10} \text{ —— } \frac{W_a}{15}$$

$$t_u = t_a$$

$$W_u = \frac{W_a}{100} \text{ —— } \frac{W_a}{130}$$

$W_f = W_u$

$h_f = 0.4d$

$w = 2h$

2. Crest elv.:

$$\frac{d}{gT^2} = \frac{2.524}{9.81 \times 7.468^2} = 0.0046$$

$$\frac{H}{gT^2} = 0.0028$$

$$\frac{n_c}{H} = 0.86$$

$$\Rightarrow n_c = 1.31 \text{ m}$$

$\therefore$ elv $= 1.31 + 2.524 = 3.83$ m

3. Under layer:

$$\text{wt} = \frac{Wa}{10} \text{ to } \frac{Wa}{15}$$

$$= 0.0785 \text{ T to } 0.0523 \text{ T}$$

thickness = ornmn = 1.33 m

4. Core:

$$\text{wt} = \frac{Wa}{100} \text{ to } \frac{Wa}{200} = 0.00785 \text{ T to } 0.00196 \text{ T}$$

5. Toe:

wt = 0.0785T to 0.0523 T

ht = 0.4d = 1.01 m

width = 2H = 3.05 m

ht of bedding = 1.01 m

$\therefore$ Total struct ht = 4.68 m

wt = —— = 0.95 T on 1.03 T ??

toe x2