Stability Analyses of a Composite Breakwater Subjected to Tsunami

Forces Acting on Breakwater during Combined Action of Earthquake and Tsunami

- Tsunami forces(P_t)
- ~~Seismic forces~~ ($\cancel{Q_H}$ & $\cancel{Q_v}$)
- ~~Hydrodynamic forces~~ ($\cancel{P_{dyn}}$)
- Hydrostatic forces (P_{st})
- Buoyancy force (U)
- Frictional force (F_f)

Forces Acting on Breakwater during Combined Action of Earthquake and Tsunami

- **Tsunami forces(P_t)**
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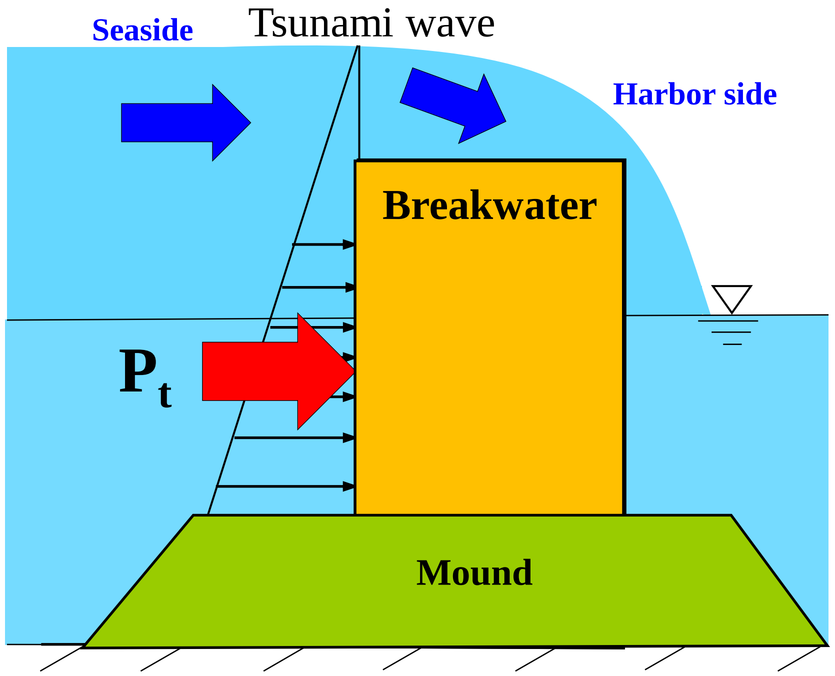

Tsunami force due to tsunami

Forces Acting on Breakwater during Combined Action of Earthquake and Tsunami

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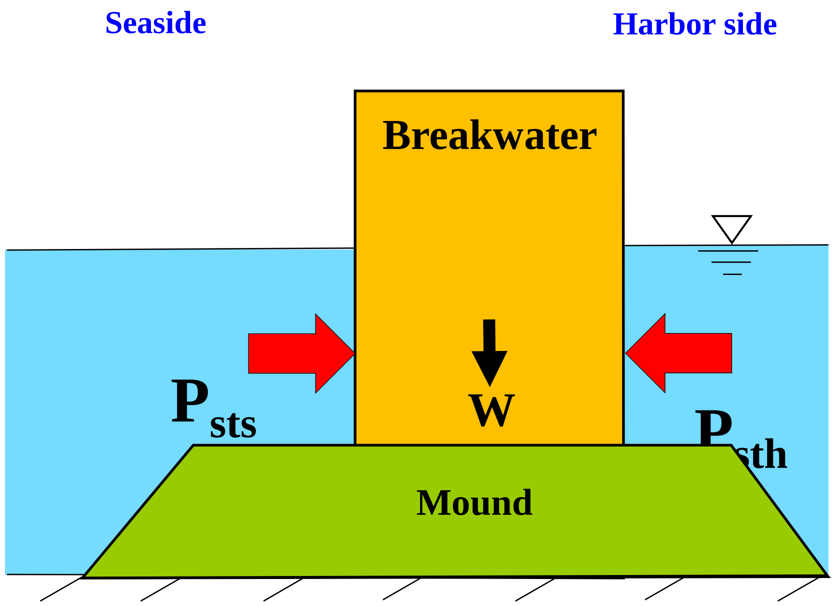
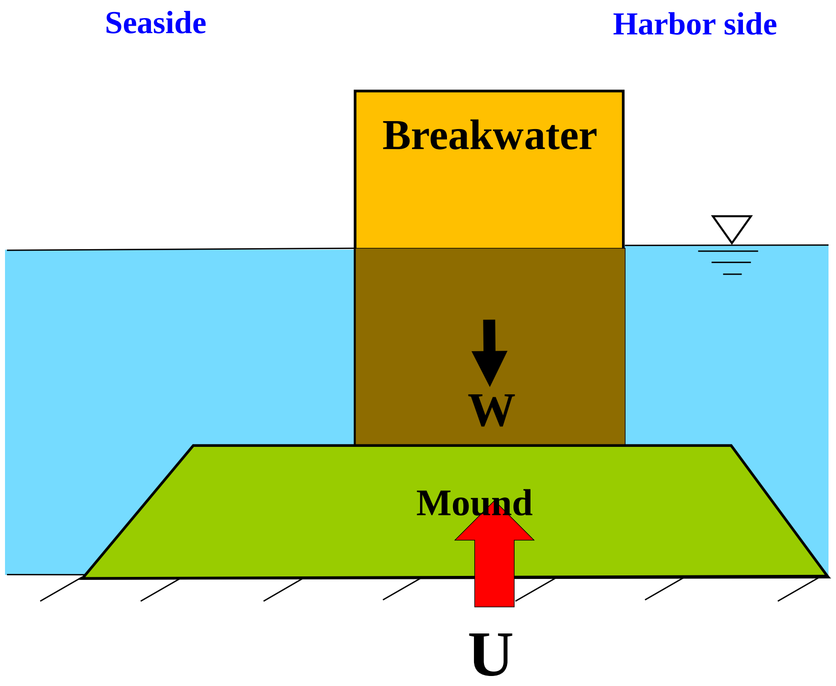


Hydrostatic forces due to presence of seawater

Forces Acting on Breakwater during Combined Action of Earthquake and Tsunami

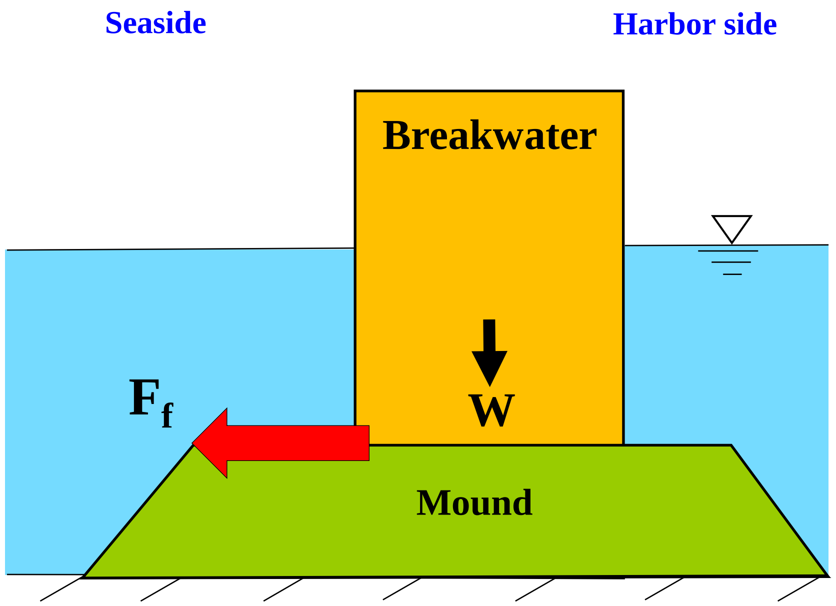
- ◆Tsunami forces(P_t)
- ◆Hydrostatic forces (P_{st})
- ◆**Buoyancy force (U)**
- ◆Frictional force (F_f)



Buoyancy force due submergence of breakwater in seawater

Forces Acting on Breakwater during Combined Action of Earthquake and Tsunami

- ◆Tsunami forces(P_t)
- ◆Hydrostatic forces (P_{st})
- ◆Buoyancy force (U)
- ◆Frictional force (F_f)



Frictional force due to mass of breakwater

Forces Acting on Breakwater

▪ Tsunami Forces

Japanese design guidelines for coastal structure (MLIT, 2013*)

- Tsunami wave pressure acting on vertical face of the breakwater

$$p_1 = \alpha_f \gamma_w (h_t + h_w)$$

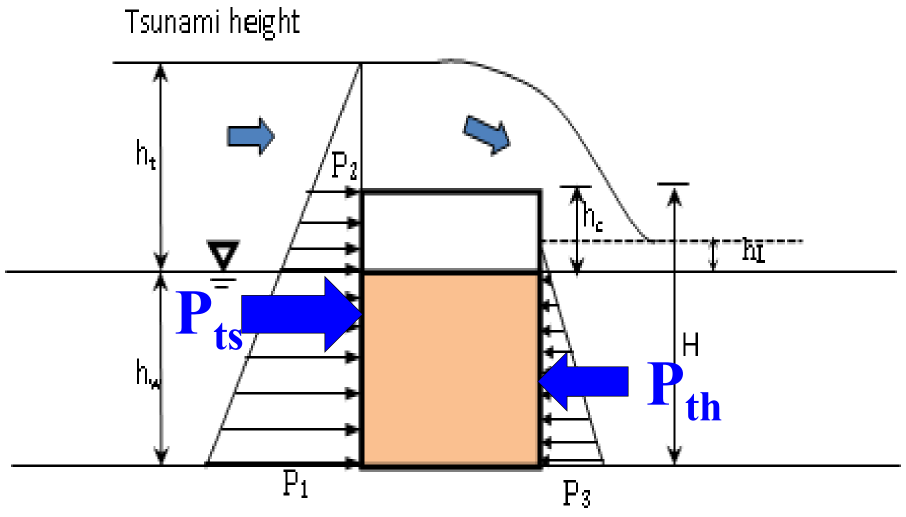
$$p_2 = [(h_t - h_c)/(h_t + h_w)]P_1$$

$$p_3 = \alpha_r \gamma_w (h_L + h_w)$$

- The tsunami wave forces acting on

$$\boxed{\text{Seaside, } P_{ts} = \frac{1}{2}(P_1 + P_2)H}$$

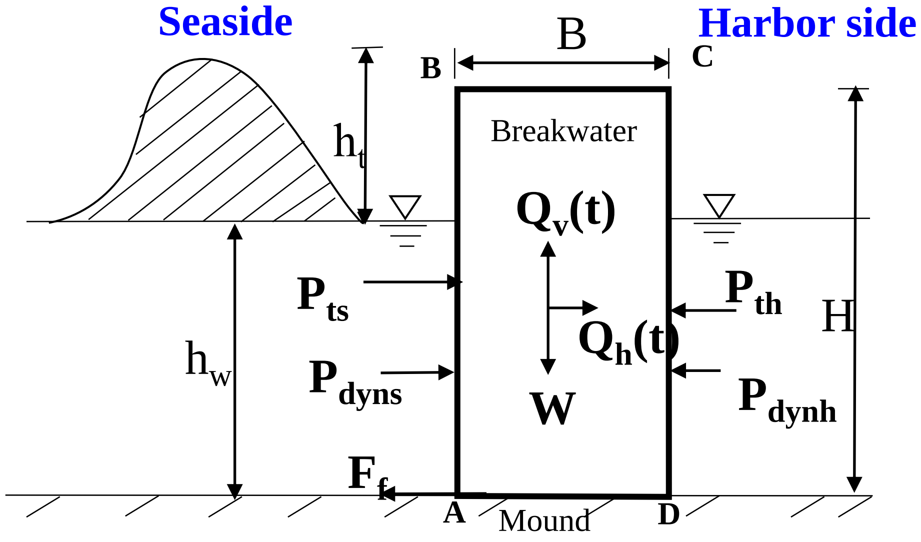
$$\boxed{\text{Harbour side, } P_{th} = \frac{1}{2}P_3(h_w + h_L)}$$



Where,
α_r=0.9 and α_f=1.05 from hydraulic experiments, h_t = height of tsunami wave, h_L=Increase in height of sea water level on harbour side during tsunami,

*MLIT (Ministry of Land, Infrastructure, Transport and Tourism, Japan), 2013. Guidelines for tsunami resistant design of the breakwater, Bureau of Port and harbor, Ministry of Land, Infrastructure, Transport and Tourism, Japan (Japanese).

Forces Acting on Breakwater



- **Effective Weight of the Breakwater**

$$W' = W - U - Q_v(t)$$

- **Frictional force**

$$F_f = \mu N = \mu W'$$

➢ **Stability of the breakwater**

$$\boxed{\text{Total resisting forces, } F_R = F_f + P_{dynh} + P_{th}}$$

$$\boxed{\text{Total driving forces, } F_D = Q_h(t) + P_{dyns} + P_{ts}}$$

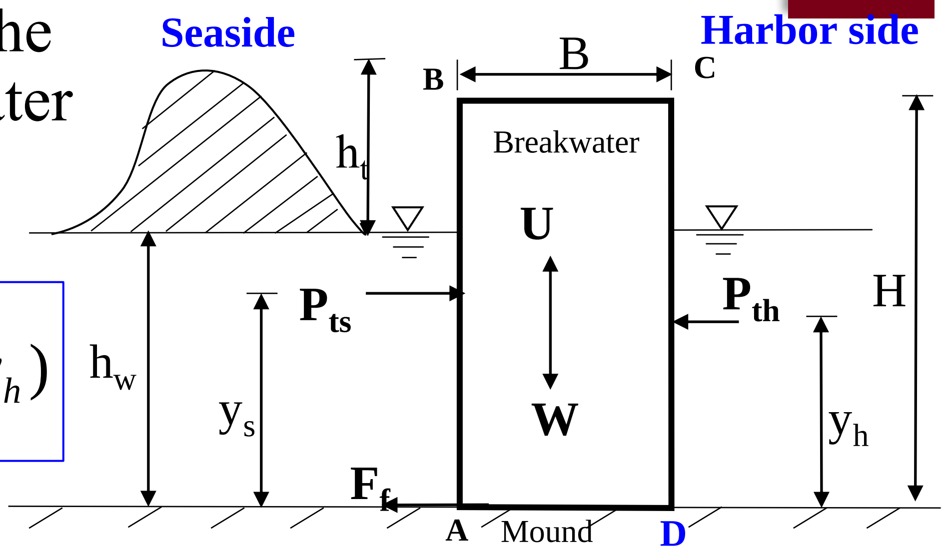
Where, W=weight of breakwater, U=buoyancy force N=normal reaction at the base of breakwater and μ=coefficient of friction at base of the breakwater

◆ **Factor of safety (FOS) against sliding mode of failure**

$$\boxed{FOS_s = \frac{F_R}{F_D}}$$

Forces Acting on Breakwater

- Moments of all the forces about the bottom point (D) of the breakwater



- Total resisting moment (M_r)

$$M_r = W'\left(\frac{B}{2}\right) + P_{dynh}(0.4h_w) + P_{th}(y_h)$$

- Total driving moment (M_d)

$$M_d = Q_H\left(\frac{H}{2}\right) + Q_v\left(\frac{B}{2}\right) + P_{dyns}(0.4h_w) + P_{ts}(y_s)$$

◆**Factor of safety (FOS) against overturning mode of failure**

$$FOS_o = \frac{M_r}{M_d}$$

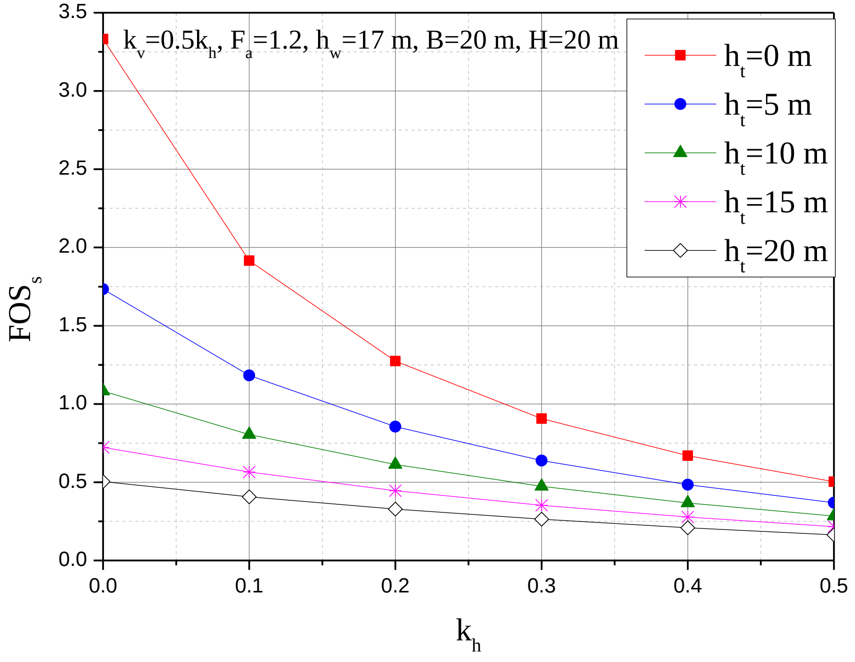
Parameters for the Study

Items	Value
Unit weight of breakwater (γ)	23 kN/m^3
Height of breakwater (H)	20 m
Width of breakwater (B)	12-28 m
Depth of seawater before tsunami (h_w)	12-20 m
~~Velocity of shear wave~~ ($\cancel{V_s}$)	~~2500 m/s~~
~~Velocity of primary wave~~ ($\cancel{V_p}$)	~~3900 m/s~~
~~Horizontal seismic acceleration coefficient~~ ($\cancel{k_h}$)	~~0-0.5~~
~~Vertical seismic acceleration coefficient~~ ($\cancel{k_v}$)	$\cancel{0\text{-}k_h}$
~~Amplification factor~~ ($\cancel{F_a}$)	~~1-1.4~~
Unit weight of seawater (γ_w)	10.3 kN/m^3
Height of tsunami above sea water level (h_t)	0-20 m
~~Time period of earthquake motion (T)~~	~~0.4s~~
Coefficient of friction between mound and breakwater (μ)	0.6

Parametric Studies

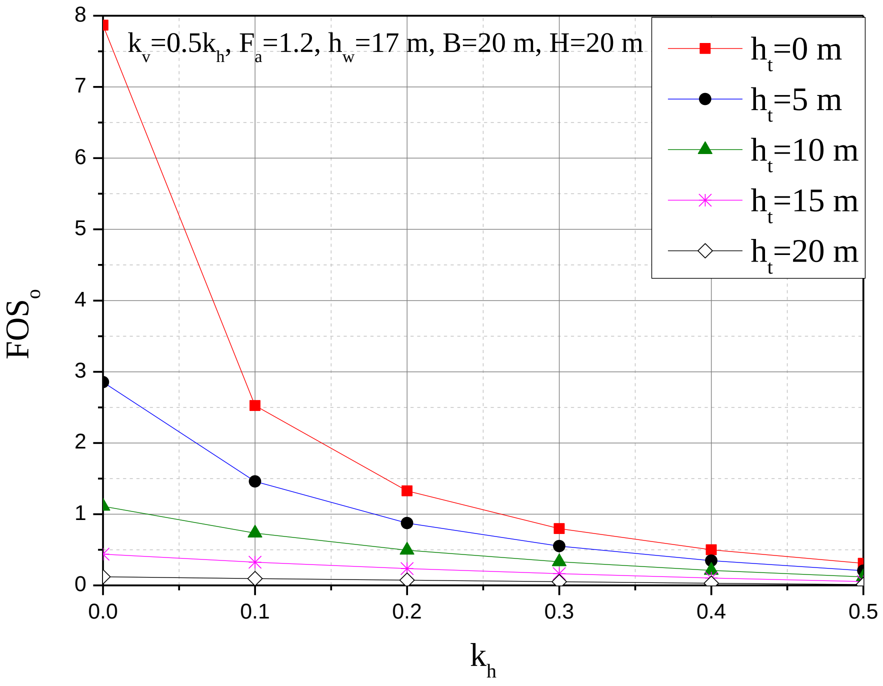
❑ Effects of height of tsunami (h_t)

FOS against sliding mode of failure



FOS_s decreases with increase in h_t

FOS against overturning mode of failure



FOS_o decreases with increase in h_t

Report Preparation

- Chapter 1- Introduction
- Chapter 2-Methodology
- Chapter 3-Results and discussions
- Chapter 4-Conclusions
- References