# DESIGN AND DRAWING OF WATER TANKS

## Question

**1) Design a counterfort type retaining wall by using the following data**

**Height of the backfill above groundlevel = 6m**

**SBC of soil ($q_0$) = 160 KN/m$^2$**

**Angle of repose of soil ($\Phi$) = 30$^o$**

**Unit weight of Soil ($\gamma$) = 16 KN/m$^3$**

**Friction coefficient between counterfort and soil $\mu$ = 0.5**

**Use M20 grade concrete and Fe 415 Steel**

## Solution

**Step 1: Minimum Depth of foundation**

$$Y_{min} = \frac{q0}{\gamma}((1 - \sin\Phi)/(1 + \sin\Phi))^2$$

$$Y_{min} = 160/16\ ((1\text{-}\sin 30)/(1+\sin 30))^2$$

$$= 1.11\ \text{m}$$

$\therefore$ Provide a minimum depth of foundation as 1.2 m

$\therefore$ Total height of retaining structure $= 6 + 1.2$

$$= 7.2\ m$$

**Step 2: Width of base slab**

$$b = 0.6H$$

$$= 0.6 \text{ x } 7.2$$

$$= 4.32\ m$$

∴ Provide width of base slab as 4.5 m

**Step 3: Width of toe slab**

Width of toe slab = αb

$$\alpha = 1 - (\frac{q0}{2.2\,\gamma H})$$

= 1-(160/(2.2 x 16 x 7.2)

α = 0.368

∴ ∝b= 0.368 x 4.5

= 1.656 m

∴ Provide the toe slab as 1.5 m

Assume thickness of stem as 200 mm and thickness of heel slab as 450 mm

**Note:** Last two assumptions are made from the reference of cantilever retaining wall.

Height of the stem (H1) =Total height (H) – Thickness of base slab

$$H1 = 7.2 - 0.45$$

$$H1 = 6.75m$$

Width of heel slab $= 4.5 - 1.5 - 0.3$

$= 2.7\,m$

300 mm

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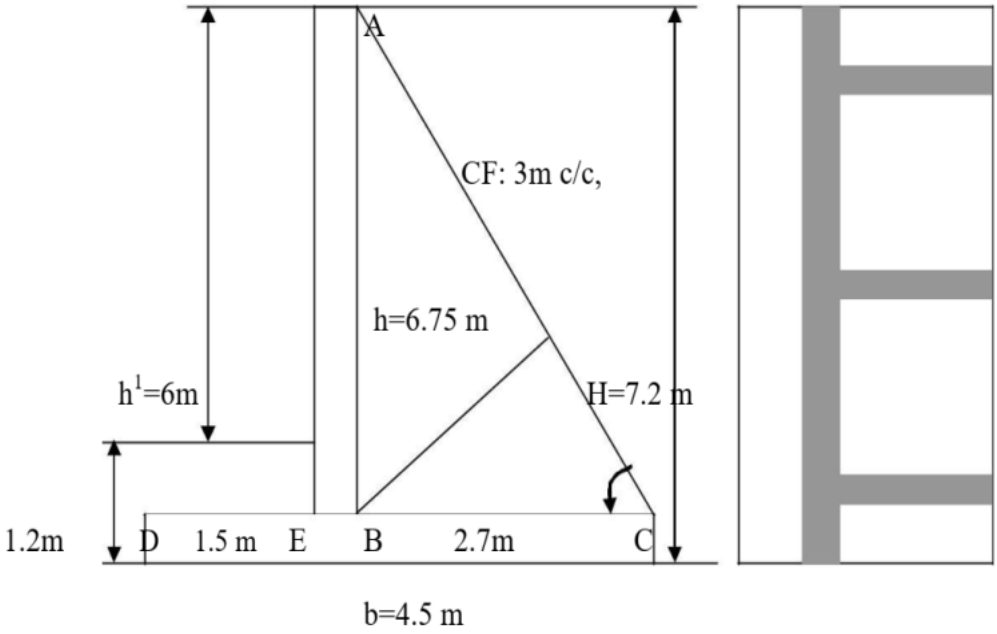


**Check for stability**

Let us assume

W1 = weight of stem / m length

W2 = weight of base slab / m length

W3 = weight of soil on heel slab / m length

| **Weights** | **Force (KN / m length)** | **Distance from D to location of force (m)** | **Moment of Resistance ($M_R$) KN- m** |
|---|---|---|---|
| W1 | 0.3 x 6.75 x 1 x 25) = 50.625 | (1.5 + 0.15) = 1.65 | 50.625 x 1.65 = 83.531 |
| W2 | 4.5 x 0.45 x 1 x 25 = 50.625 | (4.5 / 2) = 2.25 | 50.625 x 2.25 = 113.906 |
| W3 | 2.7 x 6.75 x 1 x 16 = 291.6 | 1.5 + 0.3 + (2.7 /2) = 3.15 | 291.6 x 3.15 = 918.54 |
| | **$\sum W$ = 392.85** | | **$\sum M_R$ = 1115.97** |

∴ Total resisting moment $\sum M_R$ = 1115.97 KN.m

Horizontal earth pressure, $P_H = K_a \alpha \left(\frac{H^2}{2}\right)$

$= 0.333 \times 16 \times (7.2^2/2)$

$P_H = 138.102\ KN$

Overturning moment $(M_o) = P_H \times \left(\frac{H}{3}\right)$

(Moment about at Point B)

$= 138.102 \times \frac{7.2}{3}$

$M_o = 331.444$ KN.m

Factor of safety against overturning

$= (\sum M_R)/ M0 = \frac{1115.977}{331.444} = 3.367 > 2$

$\therefore$ Safe in overturning

Resisting force = $\sum\mu.W = 0.5 \times 392.85 = 196.425$kN

Factor of safety against sliding = $\sum\mu.W / PH = 196.425/138.102 = 1.422 < 1.5$

$\therefore$ It's not safe against sliding, therefore need to provide shear Key.

**Pressure distribution at base**

Net moment = M = 1115.977 -531.444 = 784.533kN.m.

Let x be the distance from the toe where the resultant R acts,

$x = M / \sum W = 784.533/392.85 = 1.997$ m

Eccentricity = e = b/2 - x = 4.5/2 – 1.997 = 0.253 < b/6 (= 0.75 m) Whole base is under compression.

**Maximum pressure at toe**

$= P_D = \sum W / b \, ( 1+(6e/b))$

$= 392.85/4.5 \, ( 1+ 6 \times 0.253/4.5)$

$= 116.749 \text{ kN/m}^2$

**Minimum Pressure at heel**

$= P_B = \sum W / b \, ( 1- (6e/b))$

$= 57.851 \text{ kN/m}^2$