Fayoum University

Faculty of Engineering

Department of Civil Engineering

# CE 406: Part B

## Retaining Walls

### Lecture No. (12): Over all Stability

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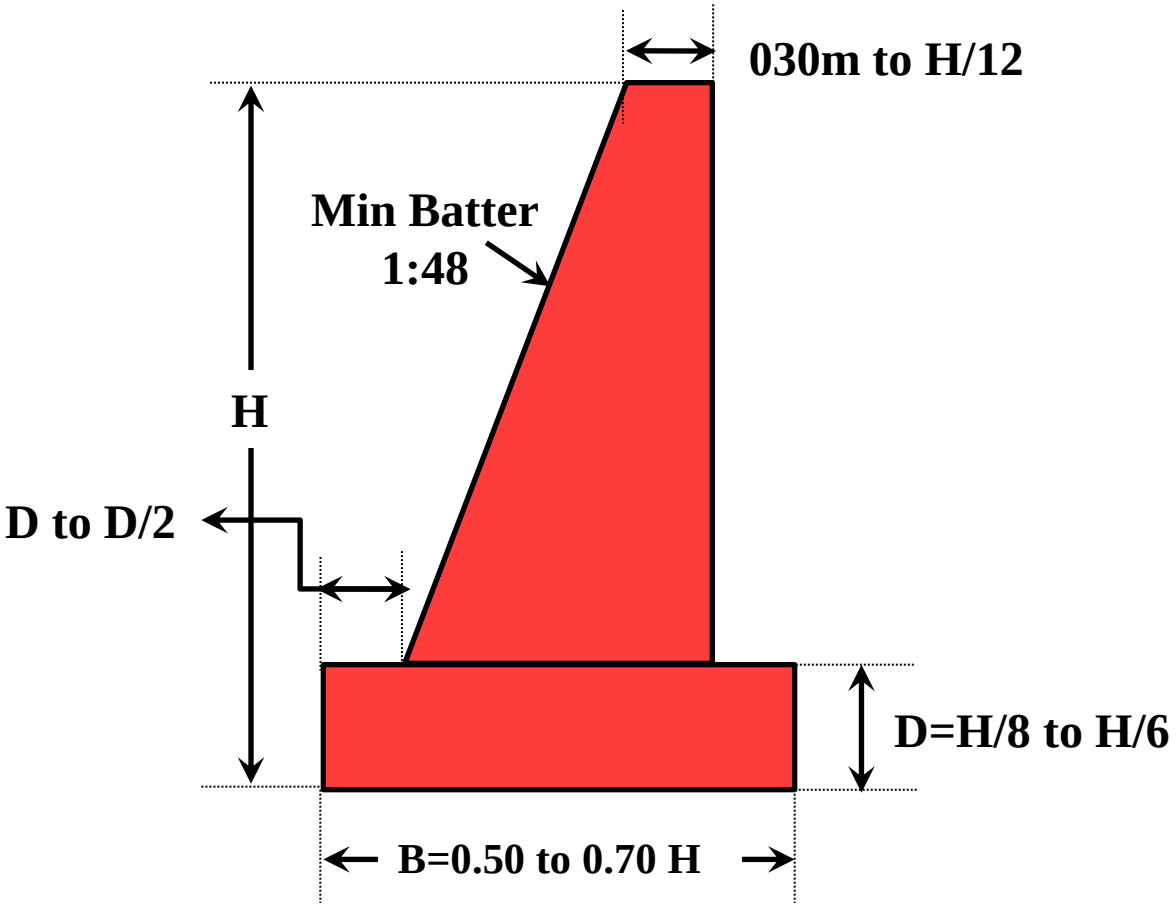
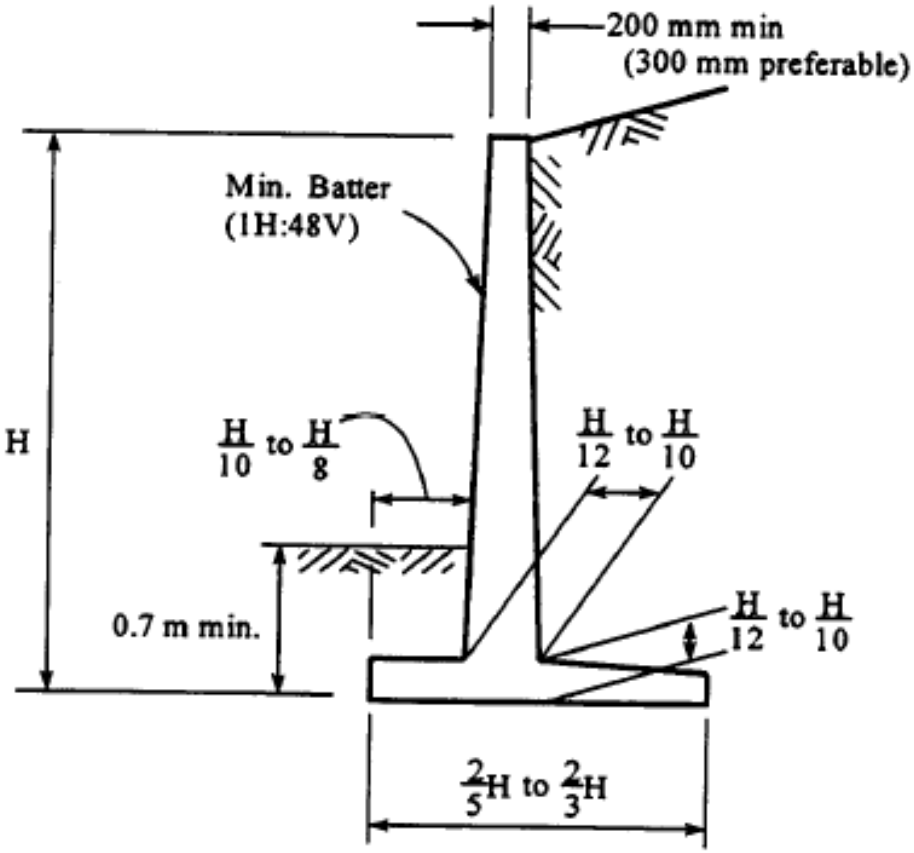
# Design Steps

1. Select the suitable type of wall
2. Determine the dimensions of the wall (empirical)
3. Estimate Earth Pressures.
4. Estimate uplift forces
5. Estimate gravity forces (weights)
6. Determine external forces
7. Check factor of safety against sliding
8. Check factor of safety against overturning
9. Check soil over stress
10. Check deep seated Failure (slope failure)

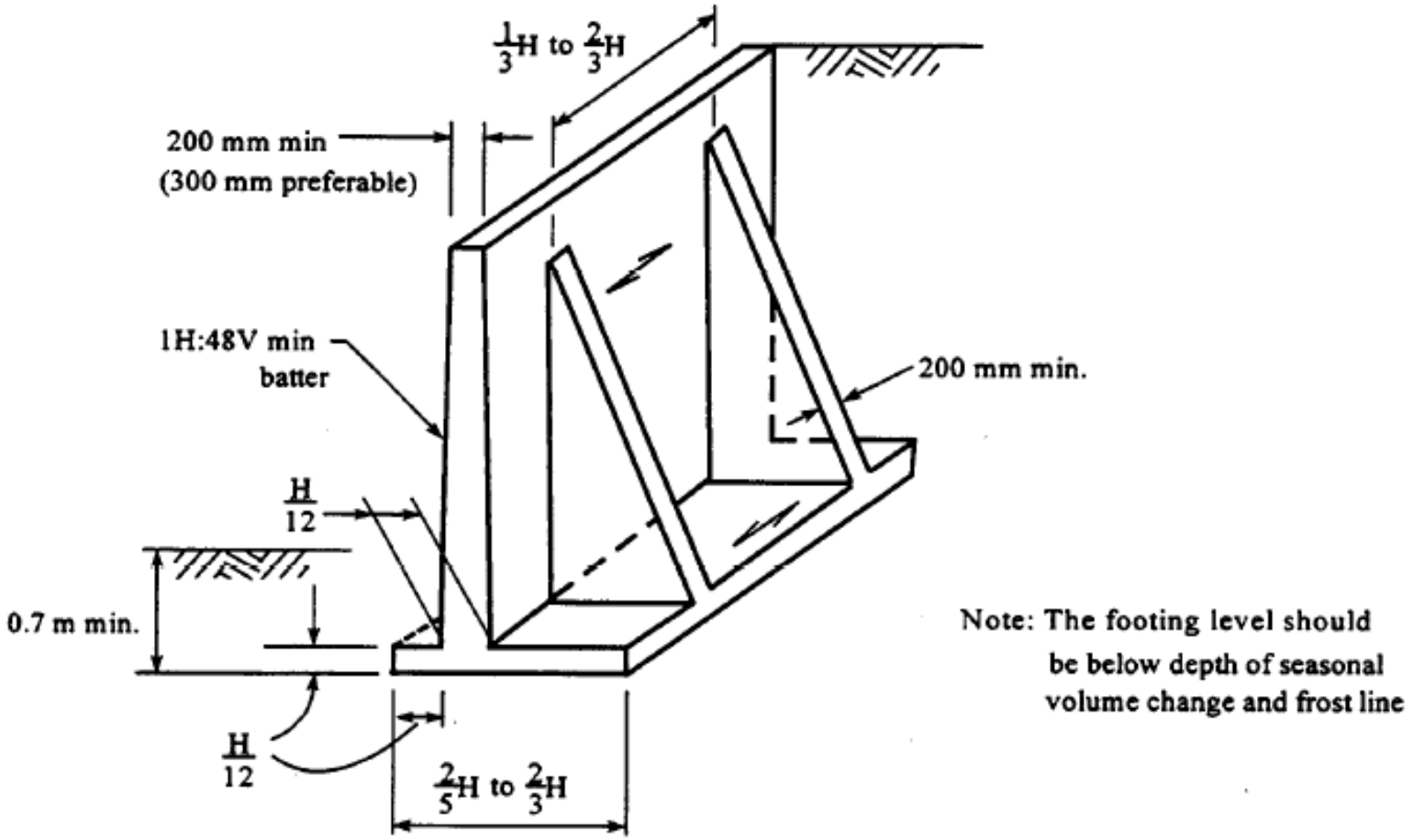
# Step (2)
# Proportioning of Gravity RW



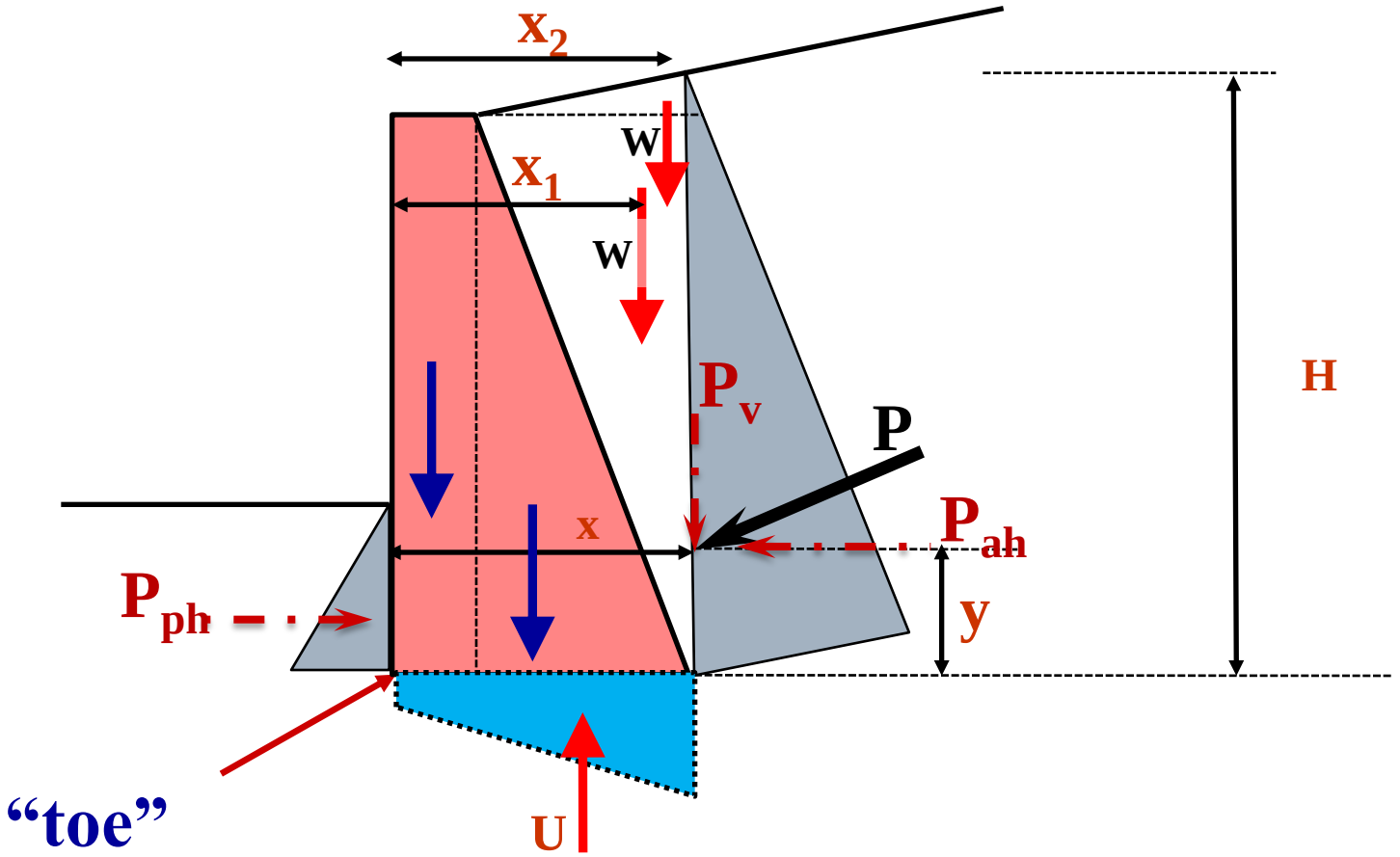
# Step (2)
# Proportioning of Cantilever RW



# Step (2)
# Proportioning of Counterfort RW



# Step (3 to 6)
# Forces effecting on Gravity R.W.



# Step (3 to 6)
# Forces effecting on Cantilever R.W.

**DEFINITIONS**

B = width of the base of the footing

$\tan \delta_b$ = friction factor between soil and base

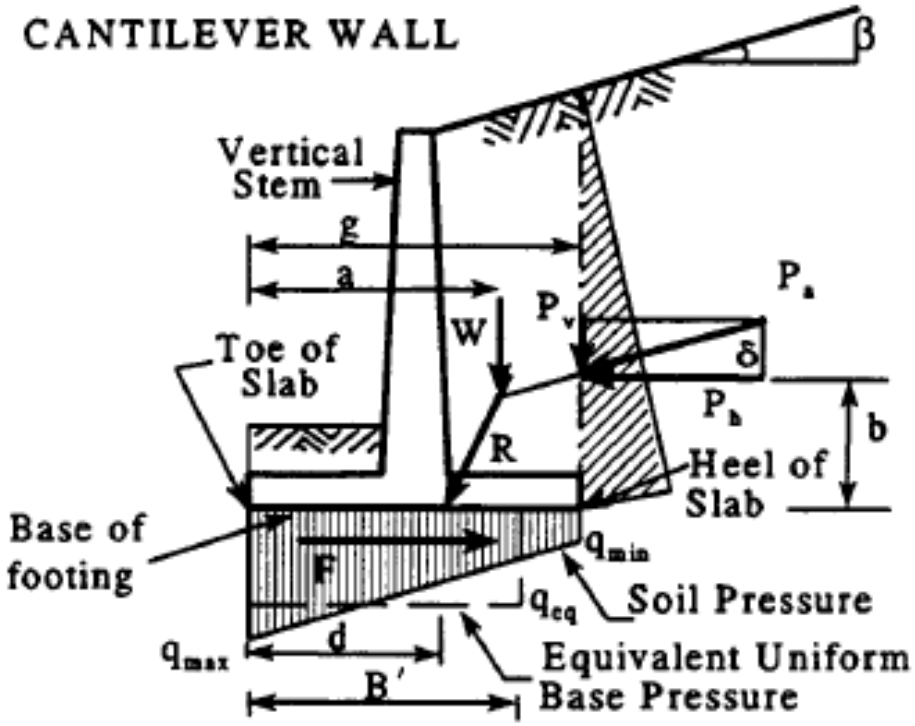
W = weight at the base of wall. Includes weight of wall for gravity walls. Includes weight of the soil above footing for cantilever and counterfort walls

c = cohesion of the foundation soil

$c_a$ = adhesion between concrete and soil

$\delta$ = angle of wall friction

$P_p$ = passive resistance

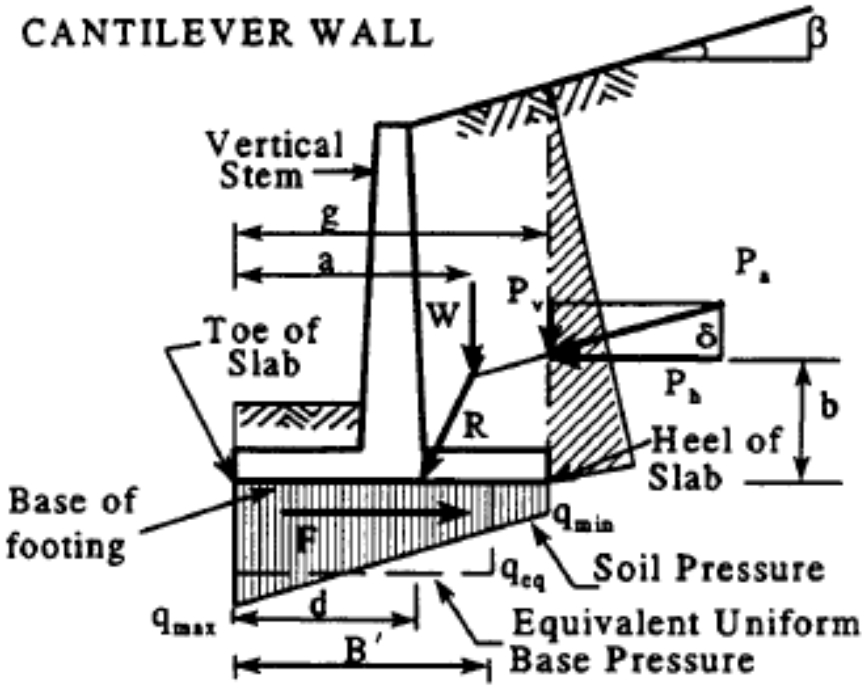


# Step (7)
# Sliding Criteria

## Factor of safety against Sliding

$$FS_s = \frac{(W + P_v)\tan\delta_b + c_a B}{P_h} \geq 1.5\,(\min)$$

**Sliding: $FS_s \geq 1.5$**



# Step (7)
# Sliding Criteria

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**Note that:**

- Passive resistance provided by soil at the toe of the wall is ignored due to the potential for the soil to be removed through natural or manmade processes during the service life of the structure.

- The live load surcharge is not considered as a stabilizing force over the heel of the wall when sliding resistance is being checked.

# Step (7)
# Sliding Criteria

**If adequate sliding resistance cannot be achieved, design modifications may include:**

(1) Increasing the width of the wall base.

(2) Using an inclined wall base or battering the wall to decrease the horizontal load.

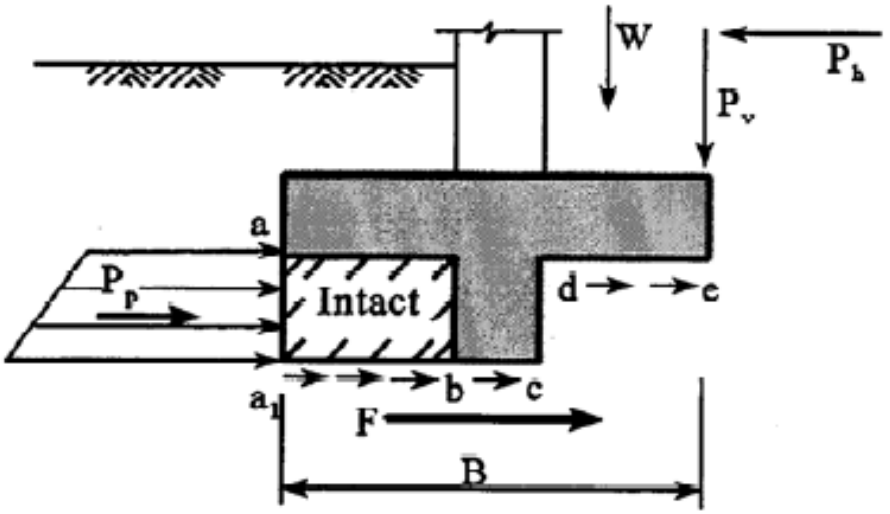
(3) Incorporating deep foundation support.

(4) Constructing a shear key

(5) Embedding the wall base to a sufficient depth so that passive resistance can be relied upon.

# Step (7)
# Sliding Criteria

**The method for calculating the contribution of the key to sliding resistance:**




Cohesive Soils:

$$F = (W + P_v)\tan\delta_b + c_a(B - \overline{a_1 b}) + c(\overline{a_1 b}) + P_p$$

Granular Soils:

$$F = (W + P_v)\tan\delta_b + P_p$$

Factor of Safety $FS = F/P_h$

# Step (8)
# Over Turning Criteria

## over turning moment

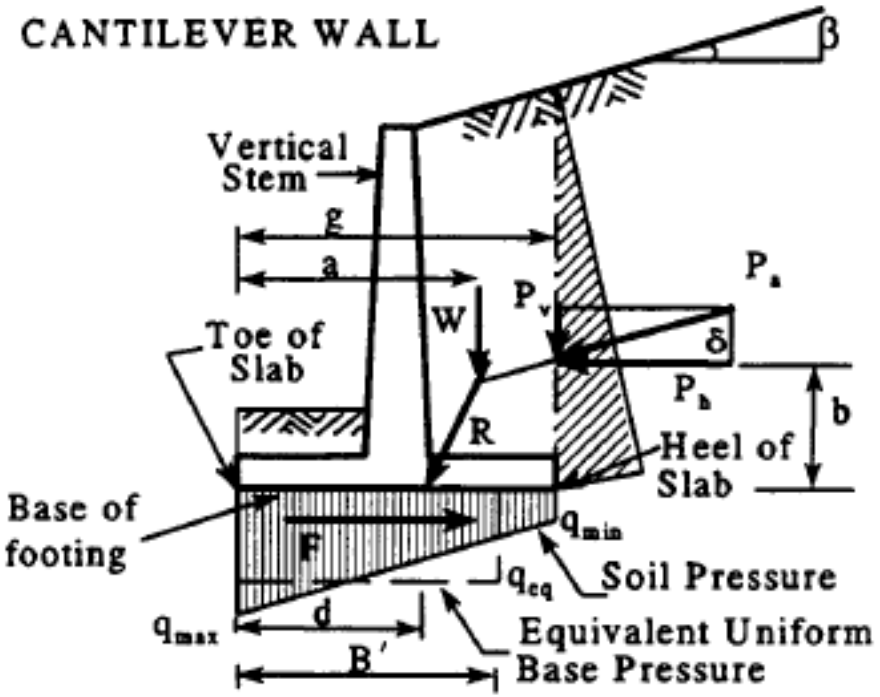
$$M_d = P_h b$$

## Resisting moment

$$M_r = Wa + p_v g$$

## Factor of safety

$$F.S = \frac{Wa + p_v g}{P_h b} \geq 1.50$$



# Step (9)
# Soil Over Stress Criteria

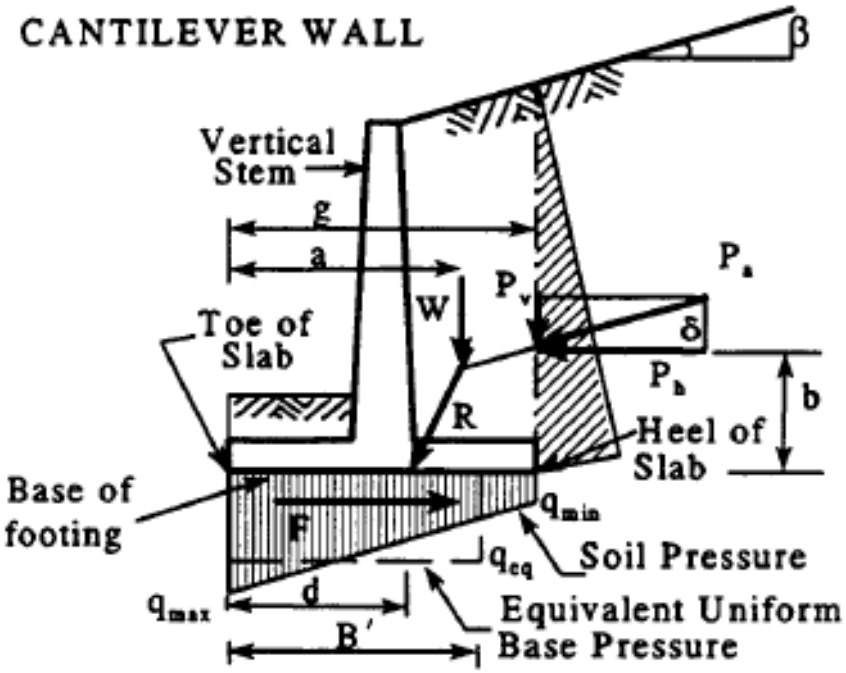
**LOCATION OF RESULTANT, R**

Based on moments about toe (assuming $P_p$=0)

$$d = \frac{Wa + P_v g - P_h b}{W + P_v}$$

**CRITERIA FOR ECCENTRICITY, e**

$$e = d - \frac{B}{2} \quad ; e \leq B/6 \text{ for soils; } e \leq B/4 \text{ for rocks}$$



# Step (9)
# Soil Over Stress Criteria

**APPLIED STRESS AT BASE** ($q_{max}$, $q_{min}$, $q_{eq}$)

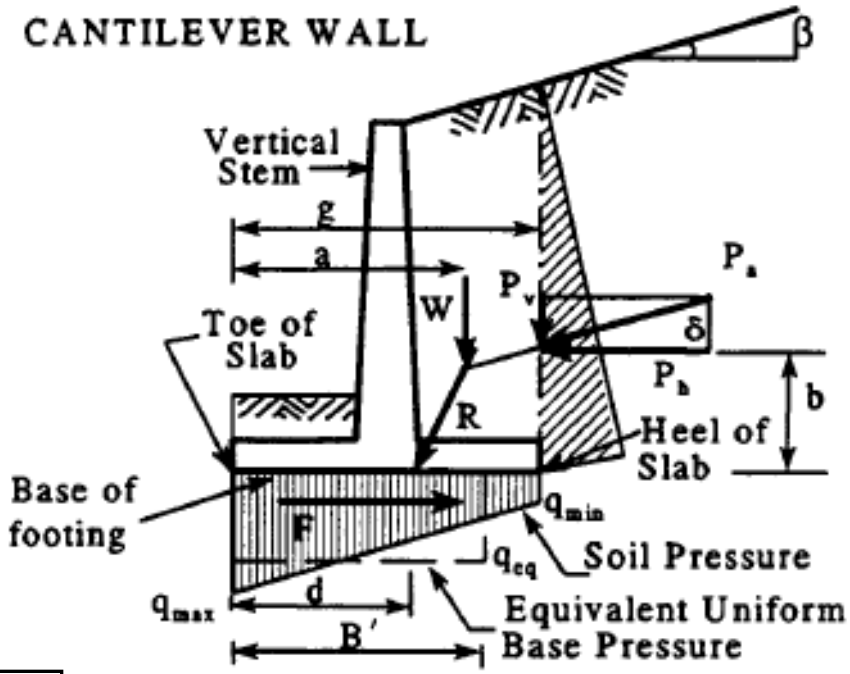
$$q_{max} = \frac{(W + P_v)}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{min} = \frac{(W + P_v)}{B}\left(1 - \frac{6e}{B}\right)$$

Equivalent uniform (Meyerhof) applied stress, $q_{eq}$, is given as follows:

$$q_{eq} = \frac{(W + P_v)}{B'} \quad \text{where } B' = B - 2e$$

Use uniform stress, $q_{eq}$, for soils and settlement analysis; use trapezoidal distribution with $q_{max}$ and $q_{min}$ for rocks and structural analysis



# Step (10)
# Deep Seated Failure (slope Failure)

- If the base soil consists of medium to soft clay, a circular slip surface failure may develop as shown in Fig.
- The most dangerous slip circle is actually the one that penetrates deepest into the soft material.
- The critical slip surface must be located by trial.
- Such stability problems may be analyzed either by the method of slices or any other method discussed later