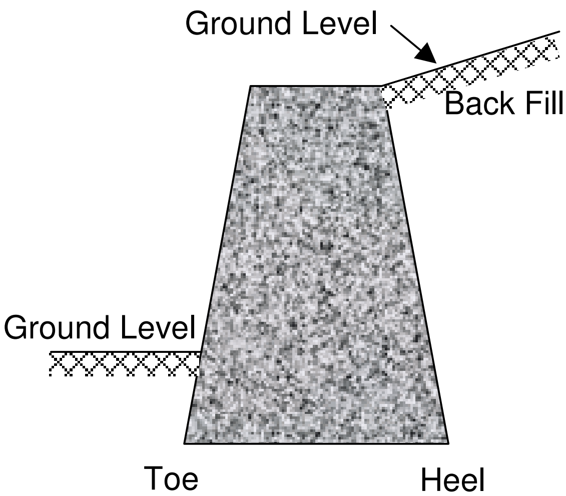
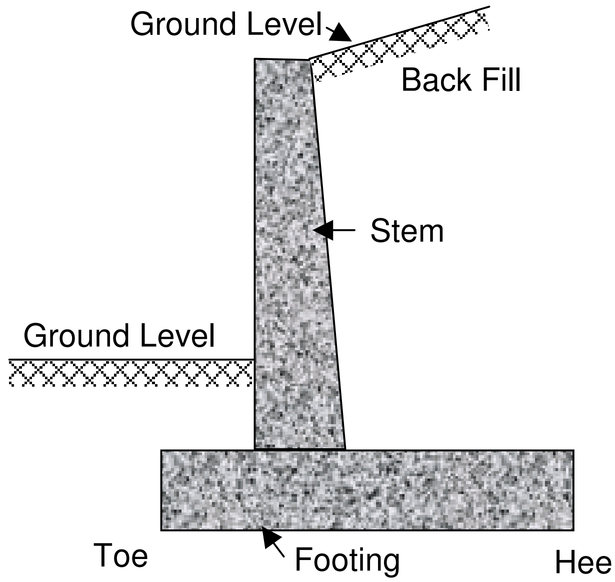
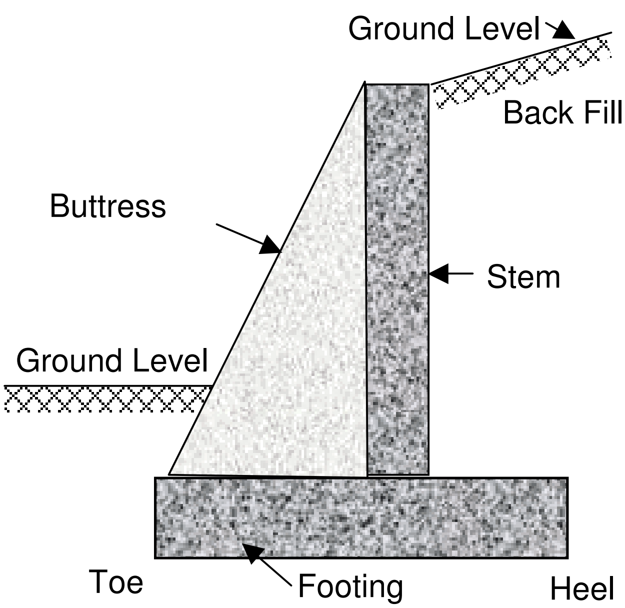
Common Retaining Walls



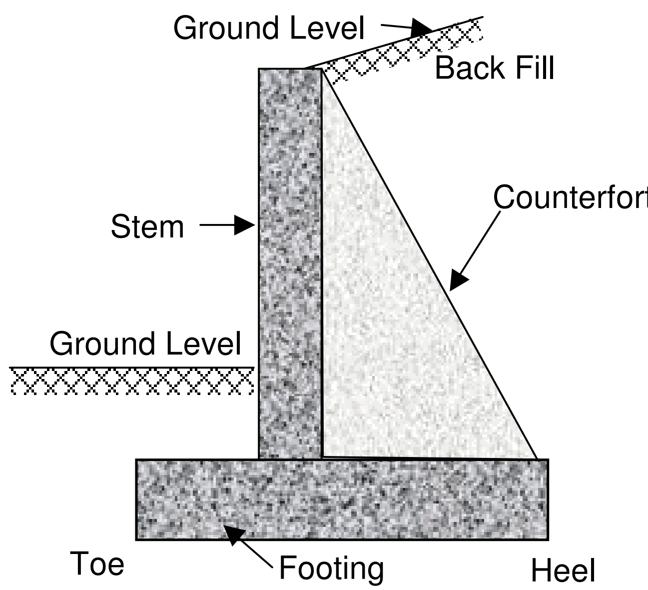
<u>Gravity or Semi-gravity Retaining wall</u>



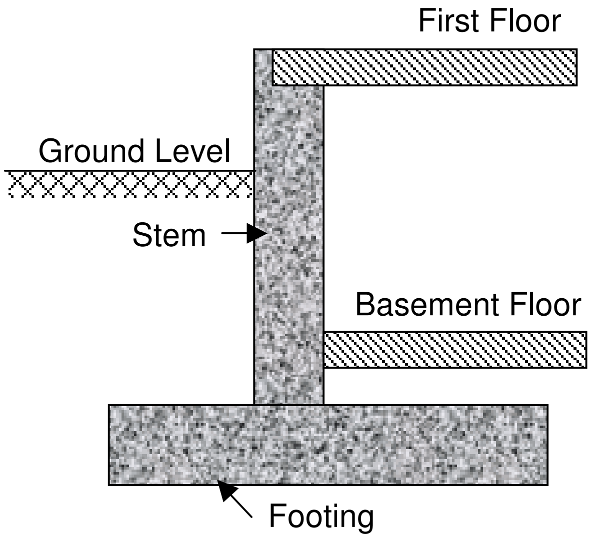
<u>Cantilever Retaining wall</u>



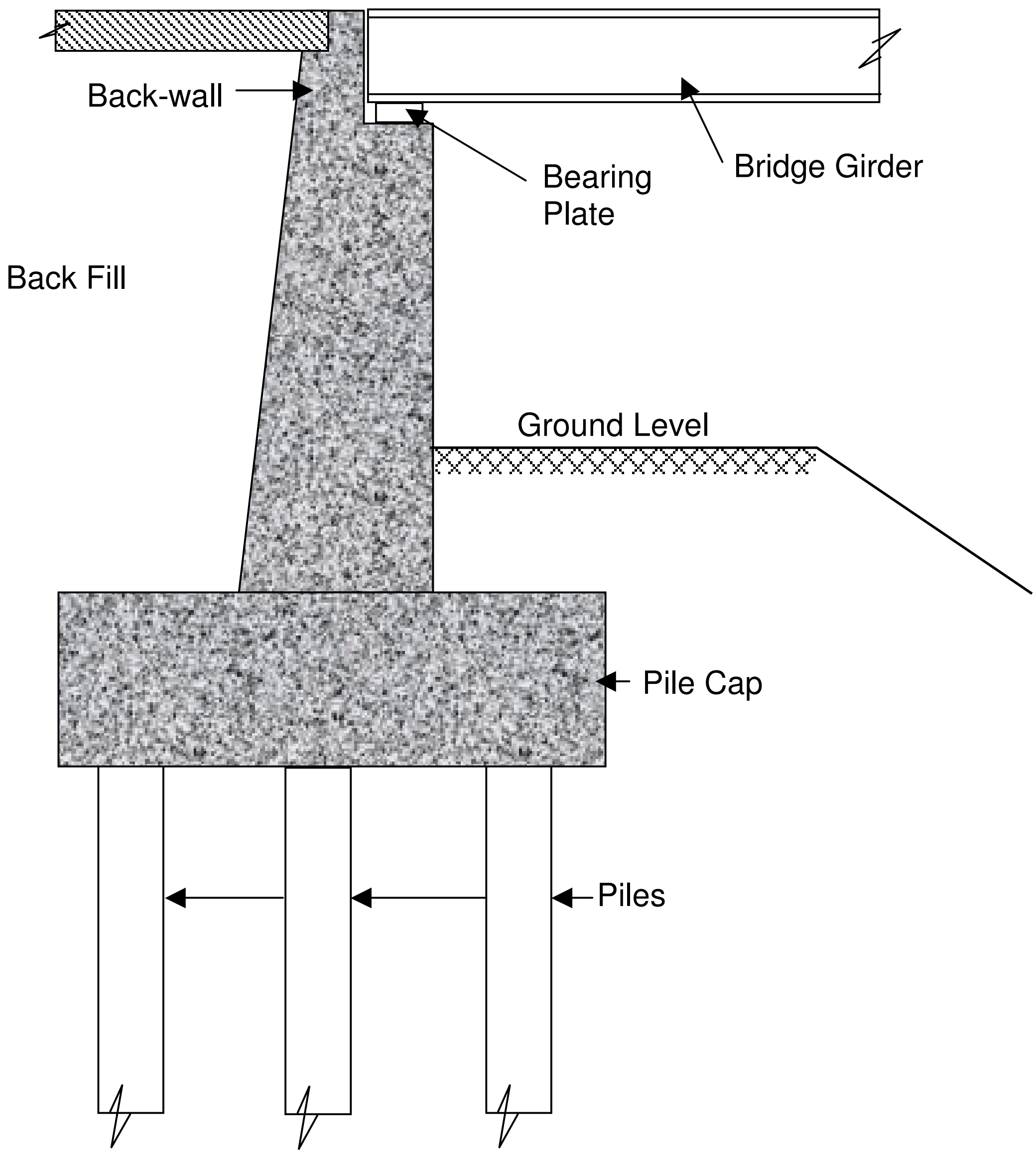
<u>Buttress Retaining wall</u>



<u>Counterfort Retaining wall</u>



Basement Wall Foundation



Bridge Abutment

External Stability of Cantilever Retaining Wall

1. A Cantilever Retaining Wall must not slide horizontally

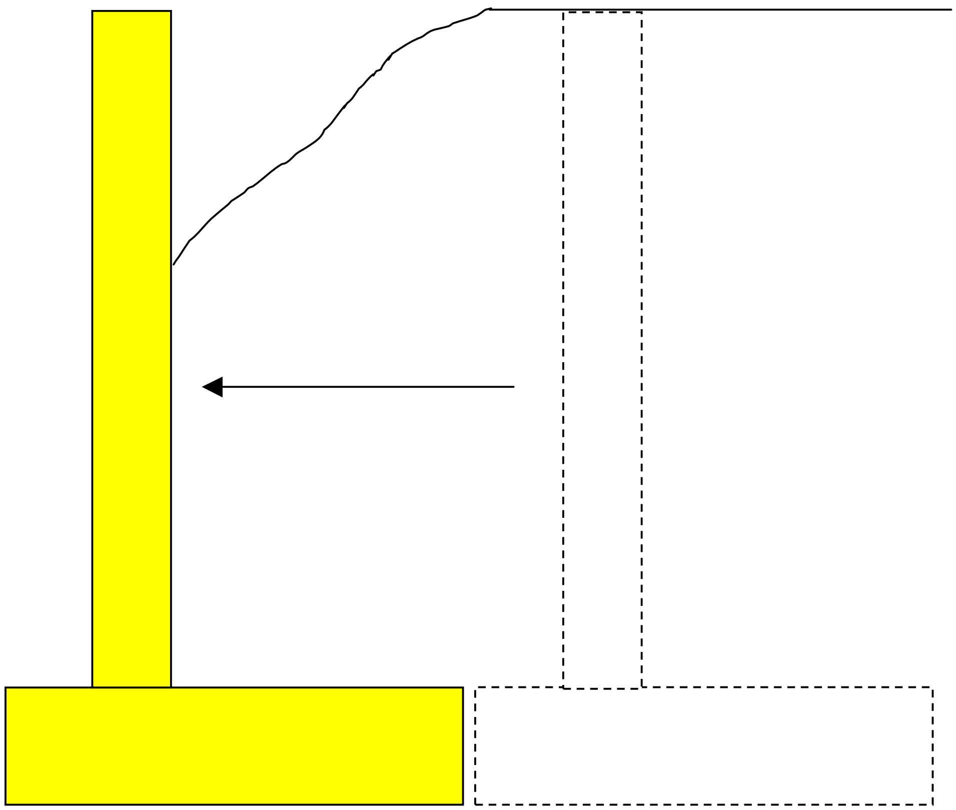


Fig 1. Sliding Failure of Cantilever Retaining Wall

2. A Cantilever Retaining Wall must not overturn.

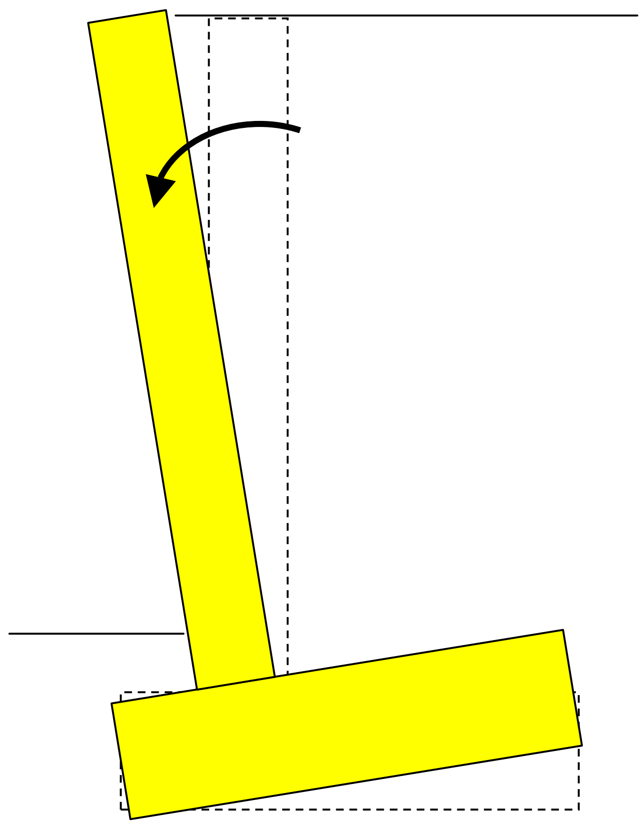
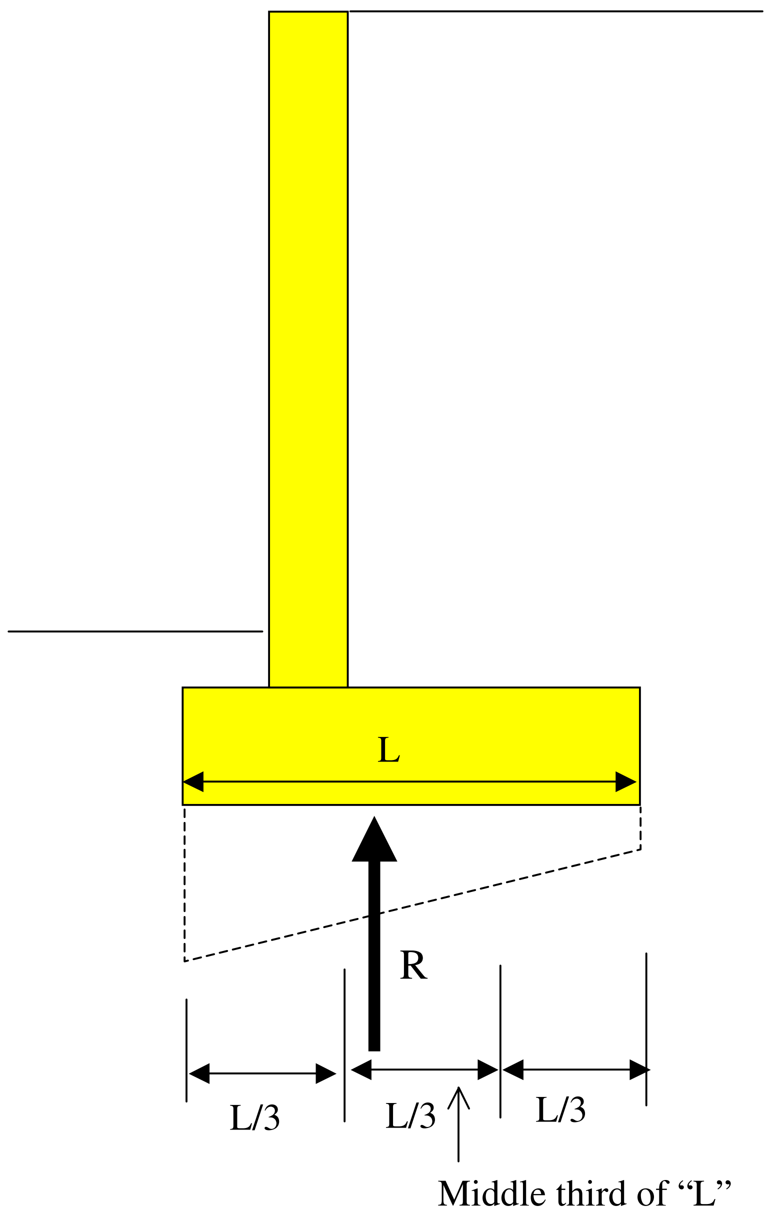


Fig 2. Overturning Failure of Cantilever Retaining Wall

3. The resultant of the normal force at the base of footing must be within middle third of the width of footing.



4. The foundation must not experience a soil bearing capacity failure.

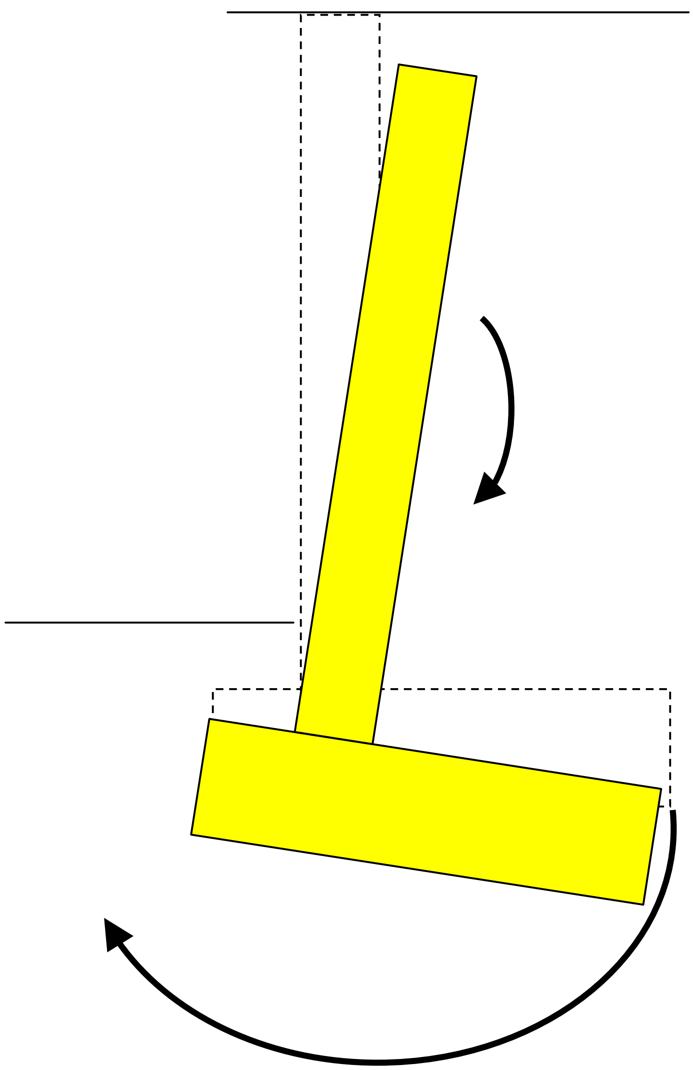


Fig 4. Bearing Capacity Failure of Cantilever Retaining Wall

5. The foundation must not experience a deep-seated shear failure.

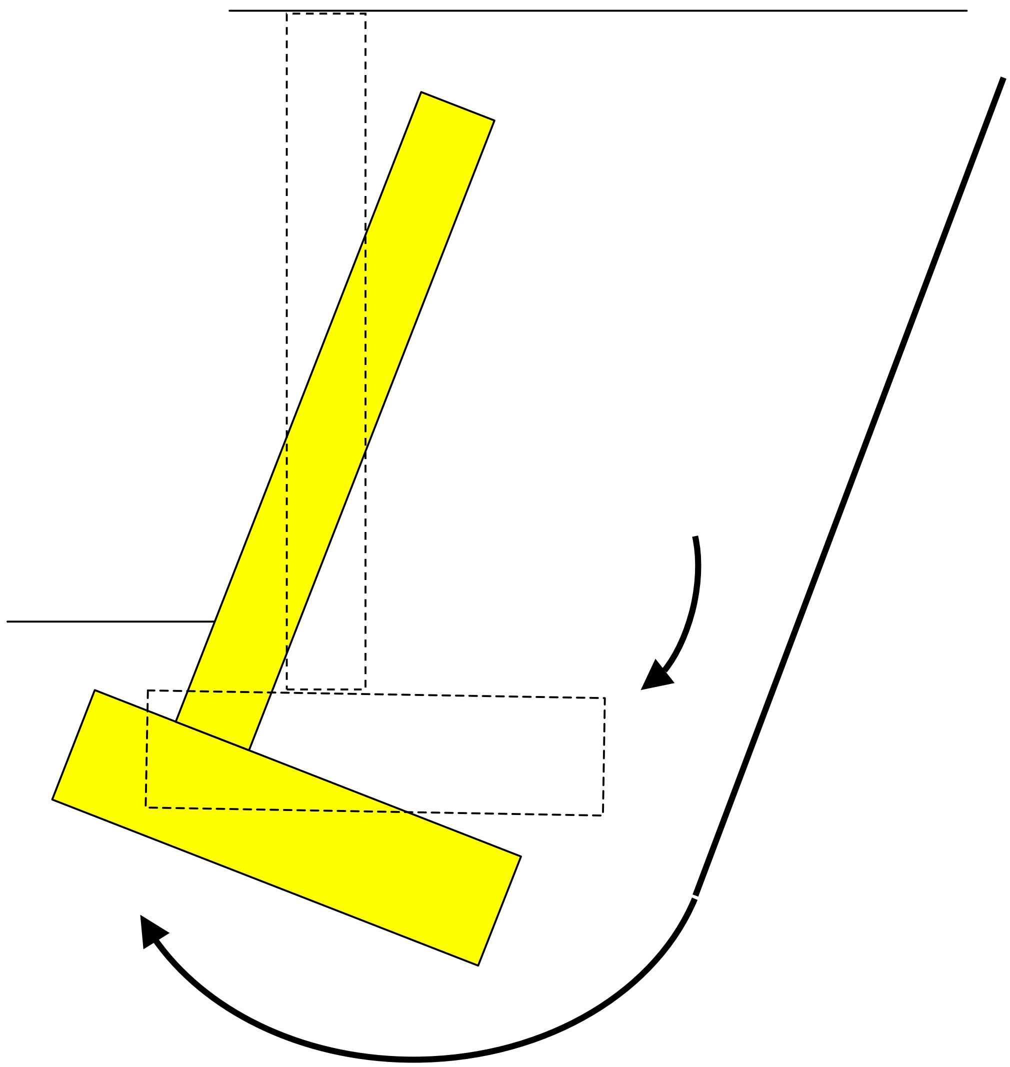


Fig 5. Deep-seated shear Failure of Cantilever Retaining Wall

6. The foundation must not experience an excessive settlement.

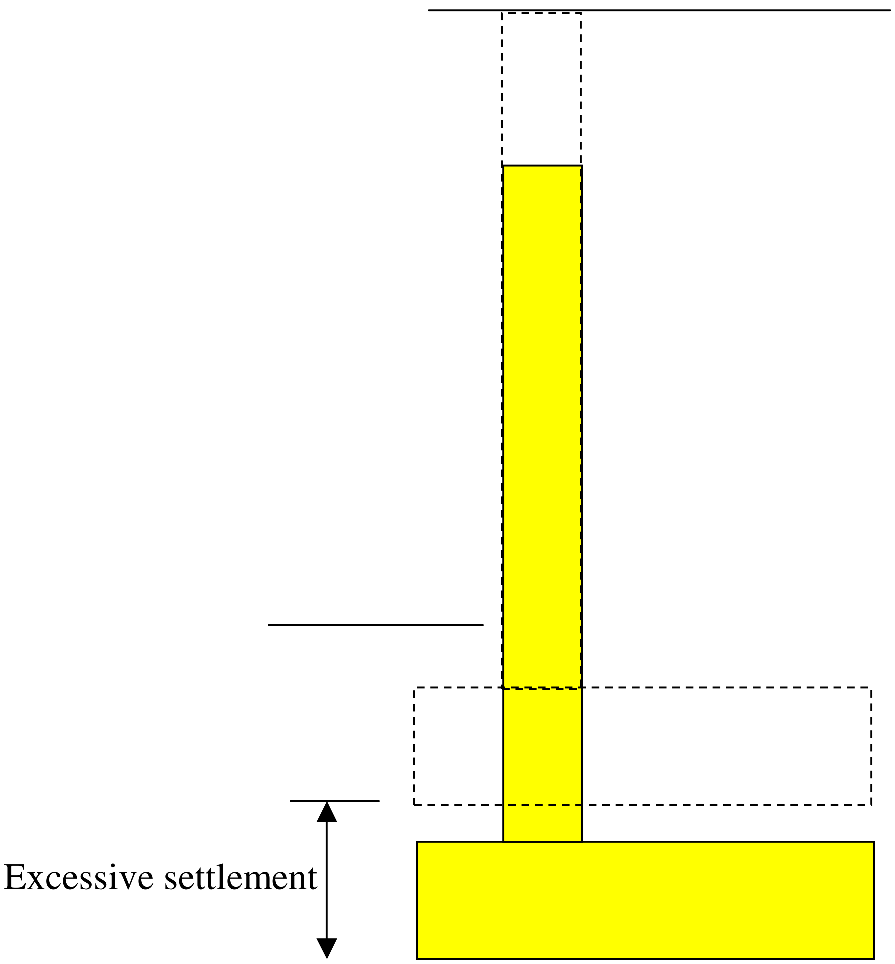
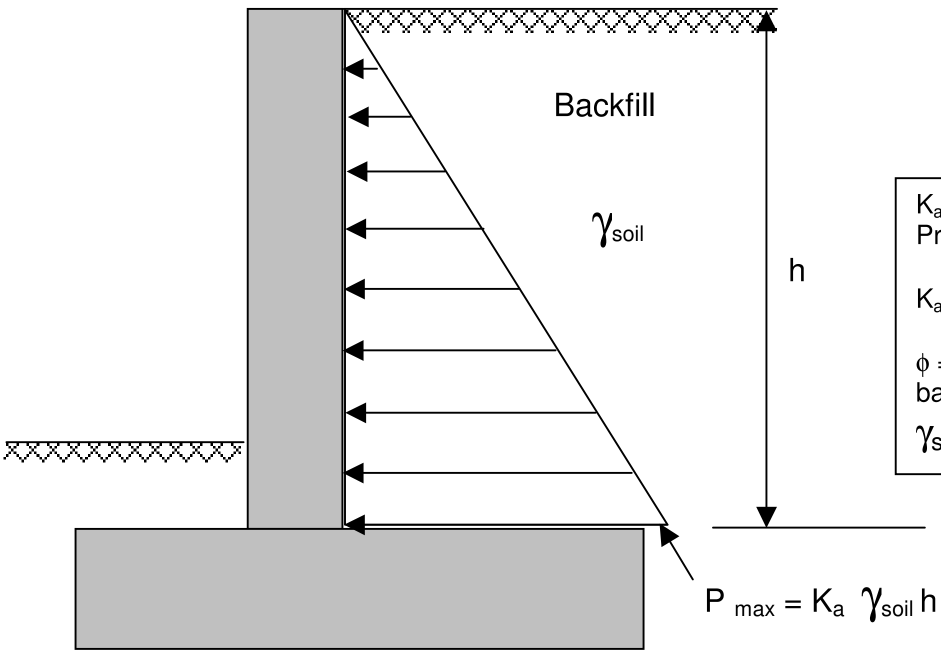


Fig 6. Excessive settlement of Cantilever Retaining Wall

Lateral Soil Pressure on Retaining Walls



K_a = Coefficient of Active Soil Pressure

$K_a = \tan^2 (45^0 - \phi/2)$

ϕ = Angle of Internal Friction for backfill soil

γ_{soil} = Unit weight of Soil (pcf)

Fig. 1: Soil Pressure on the back of wall (No surcharge)

Typical Angle of Internal Friction for backfill soil	
Soil Type	ϕ (Degree)
Gravel and coarse sandy backfill soil	33-36
Medium to fine sandy backfill soil	29-32
Silty sand	27-30

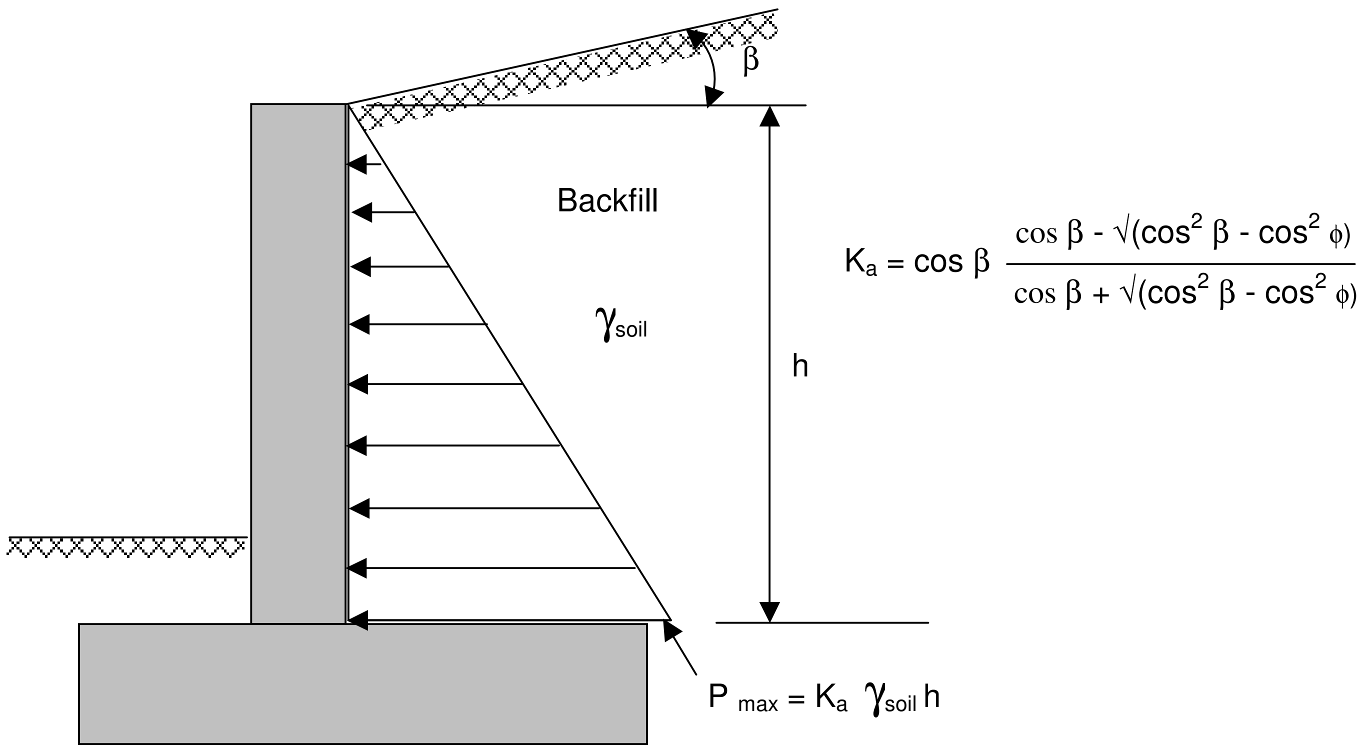


Fig. 2: Soil Pressure on the back of wall (Sloping Backfill)

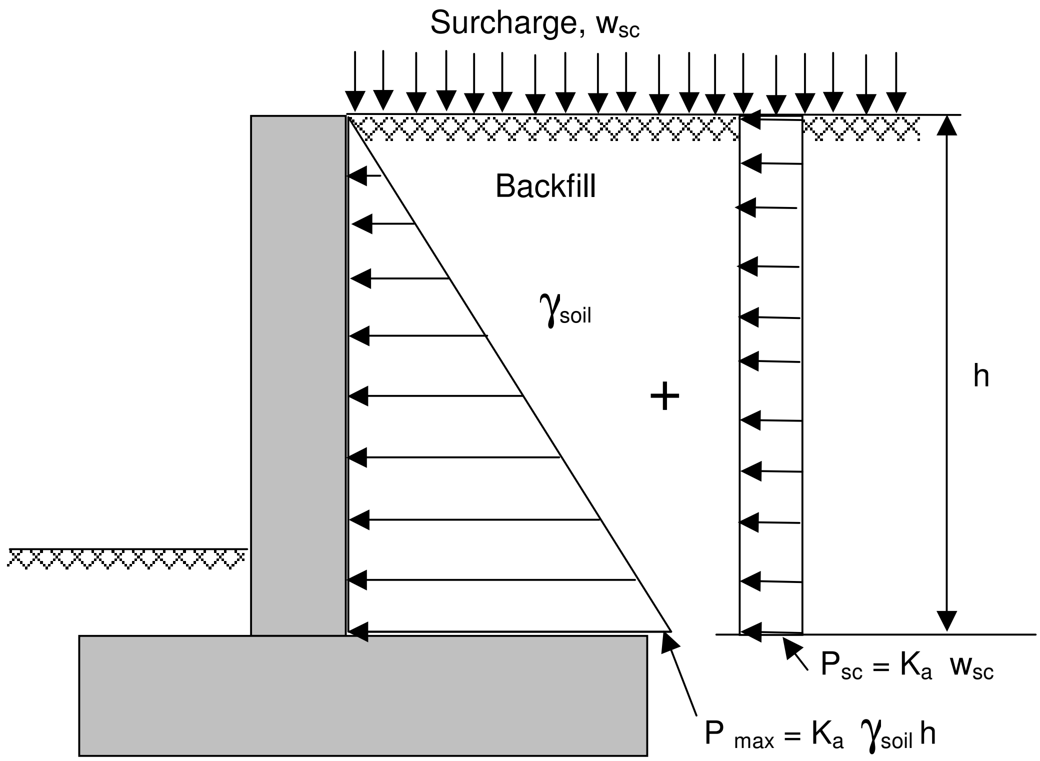
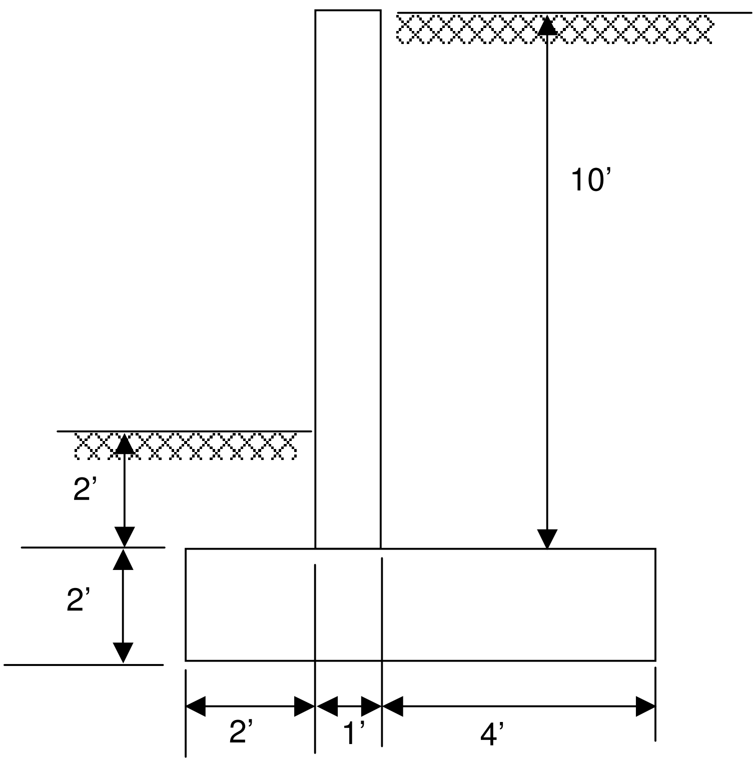


Fig. 3: Soil Pressure on the back of wall (with uniform surcharge)

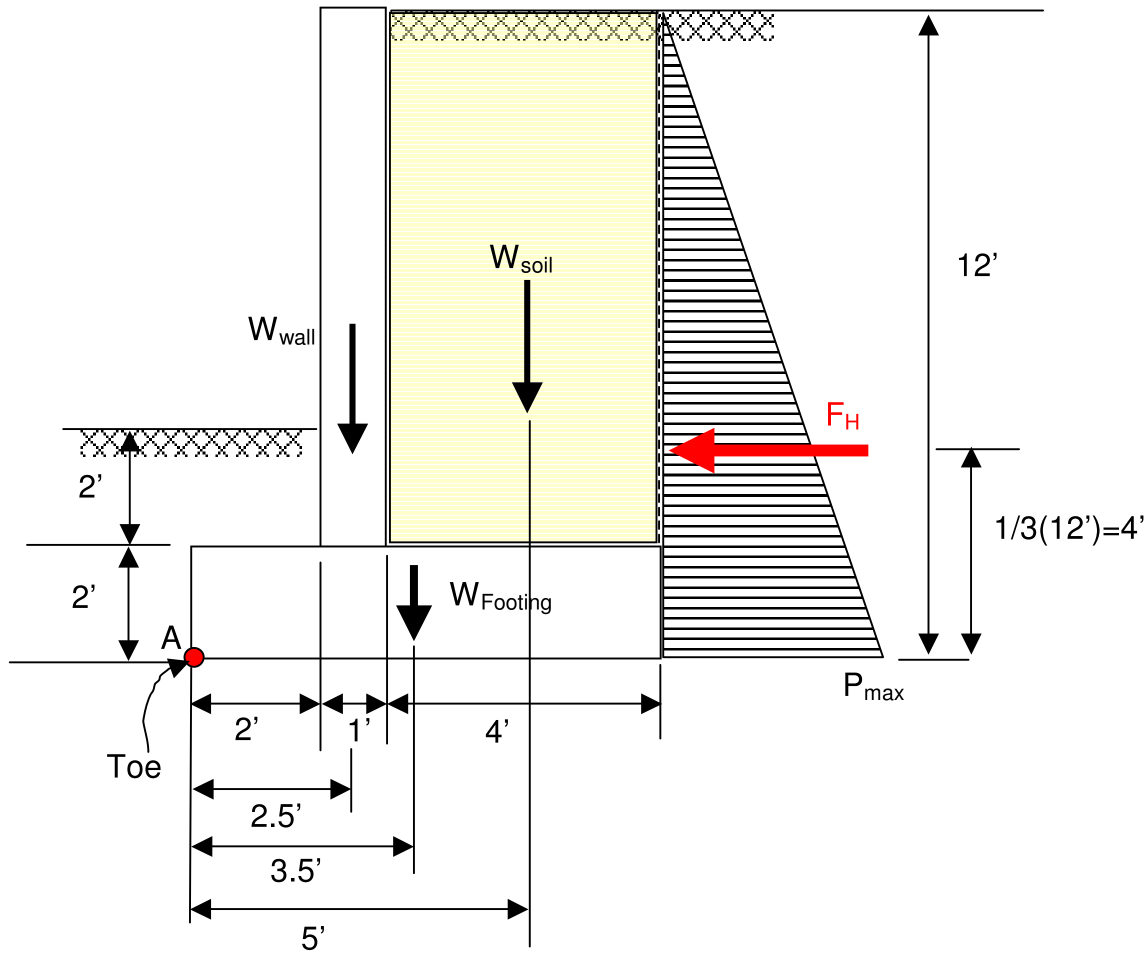
Q1(a): Analyze the stability of the reinforced cantilever retaining wall as shown in Figure.

Use the following values:
Concrete unit weight = 150 pcf

Soil unit weight, γ_{soil} =110 pcf
Coefficient of Active Soil Pressure, K_a = 0.33
(Neglect Coefficient of passive Soil Pressure, K_p)
Coefficient of friction between the bottom of footing and soil, μ = 0.5



Solution:



Step 1: Calculate lateral soil pressure and overturning moment

$P_{max} = K_a \ \gamma_{soil} h$ = 0.33 (110)(12) = **435.6 psf**

$F_H = ½ P_{max} h$ = ½ (435.6)(12)= **2613.6 lb/ft of wall**

Sliding Force, **F_H = 2613.6 lb/ft of wall**

Overturning Moment, **M_{OT}** about toe = 2613.6 x 4 = **10454.4 lb-ft /ft of wall.**

Step 2: Calculate weights, Resisting Moment, Sliding Resisting Force;

W_{soil} = (4 x 10)(110) = 4400 lb./ft of wall

W_{wall} = (1 x 10)(150) = 1500 lb / ft of wall

$W_{Footing}$ = (2 x 7)(150) = 2100 lb / ft of wall

W_{Total} = 4400 + 1500 + 2100 = 8000 lb / ft of wall

Resisting moment , $\mathbf{M_R}$ about toe = (4400 x 5) + (1500 x 2.5) + (2100 x 3.5)
= 33100 lb-ft/ft of wall

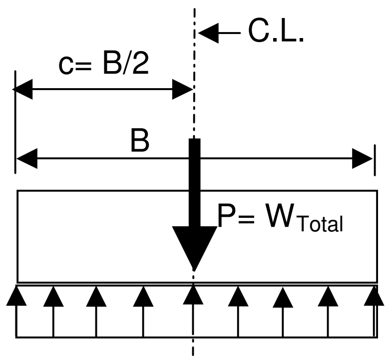
Sliding Resisting Force, $\mathbf{F_R}$ = μ X W_{Total} = 0.5 (8000) = **4000 lb**

Step 3: determining the Factor of Safety (FS) against overturning and sliding.

$FS_{OT} = M_R / M_{OT}$ = 33100 / 10454.4 = 3.17 > 2.0 OK

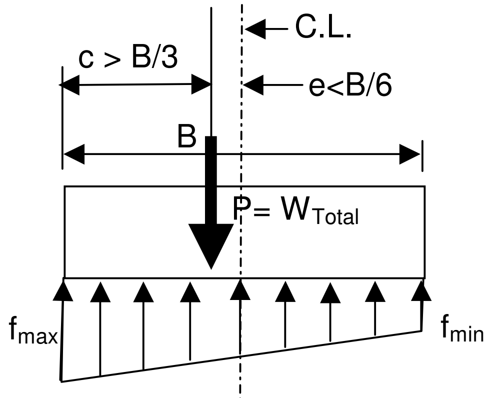
$FS_{Sliding} = F_R / F_H$ = 4000 / 2613.6 = 1.53 > 1.5 OK

Soil Pressure under the footing of the Retaining Wall



$f = f_{max} = P/A$
$= P/(Bx1)$

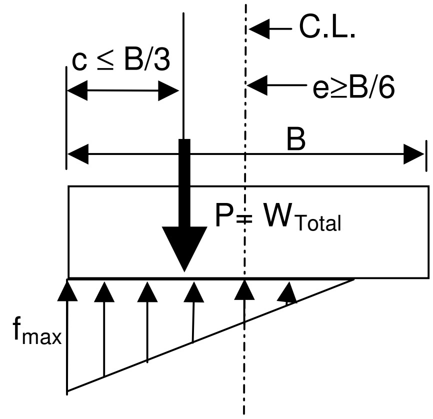
Case I: Load, P with zero eccentricity (e=0)



$f_{max} = P/A + (P\ e\ /S_m)$
$f_{min} = P/A - (P\ e\ /S_m)$

where
$A = 1xB$
$S_m = 1x(B^2)/6$

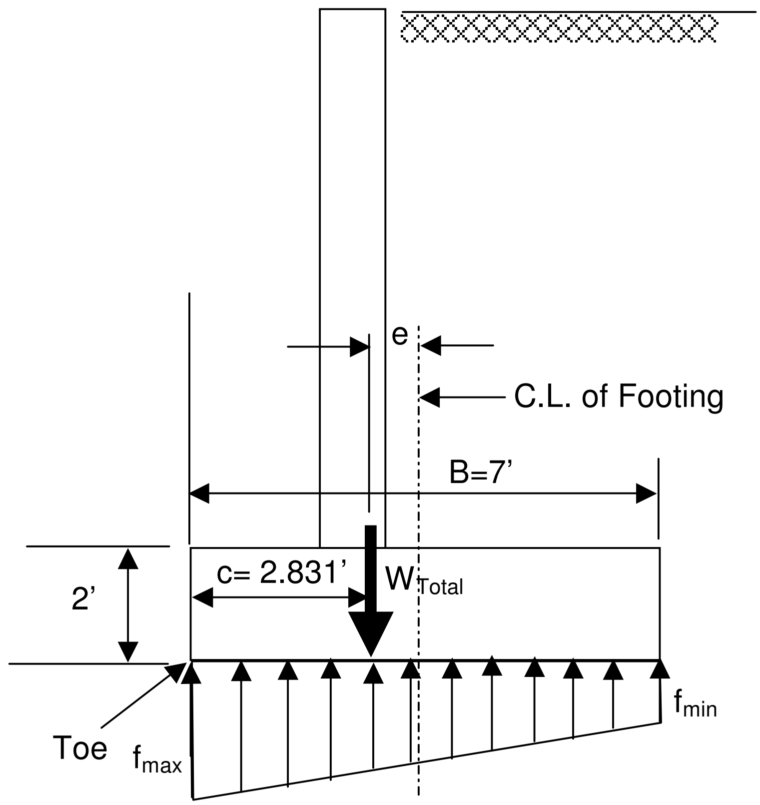
Case II: Load, P with small eccentricity (e<B/6)



$f_{max} = (2/3)P/c$

Case III: Load, P with large eccentricity (e≥B/6)

Q1(b) Calculate the soil pressure under the footing of the retaining wall of Q1(a).



Determine the resultant vertical force, W_{Total} intersects the bottom of the footing:

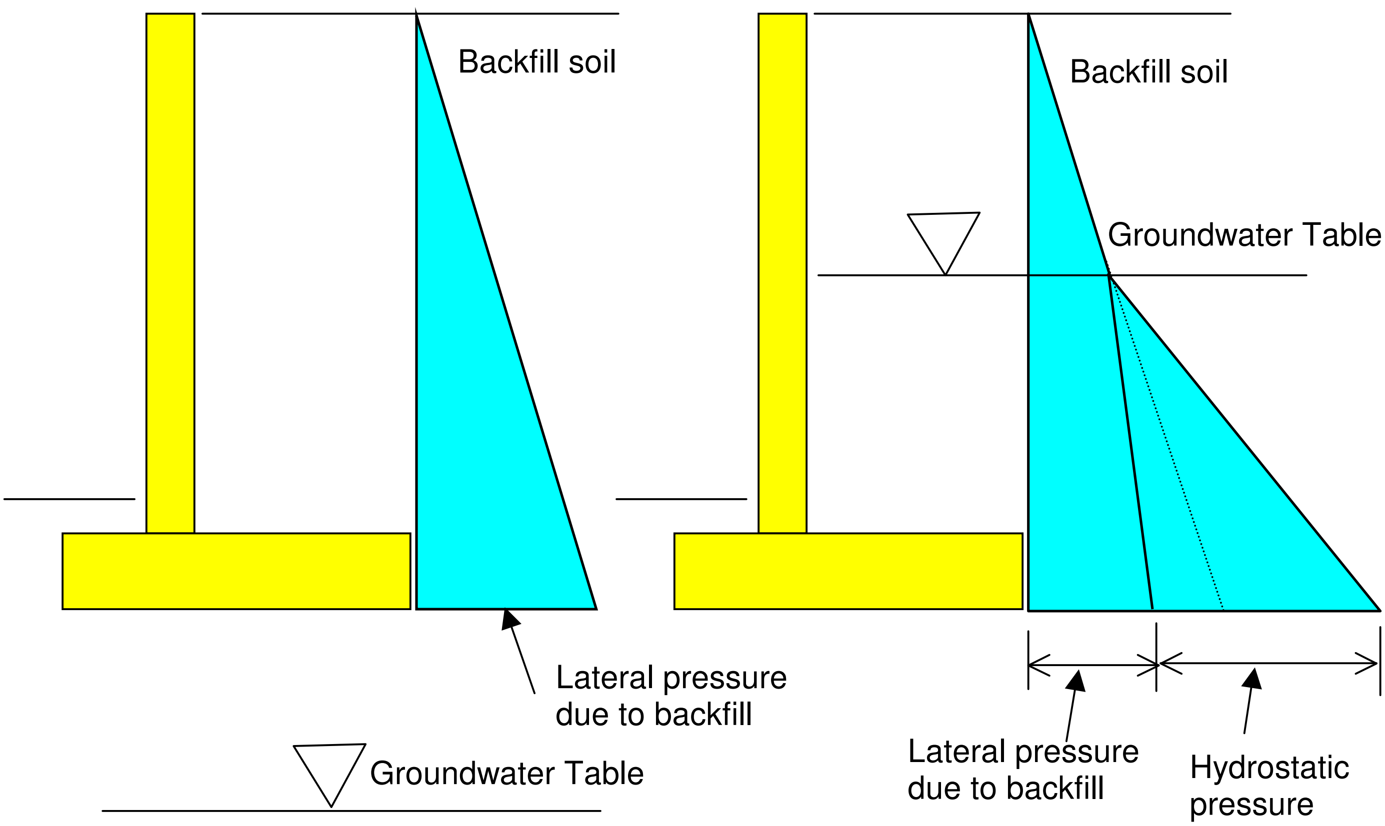
$c = (M_R - M_{OT})/ W_{Total} =$ (33100 - 10454.4) / 8000 = 2.831 ft. from the Toe.

Eccentricity, e = B/2 – c = (7/2) – 2.831 = 0.6693' < B/6 (=7/6=1.1667')
Therefore, <u>Case II is applicable</u>.

Calculate soil pressures, f_{max} and f_{min} under the footing:

A= 1xB = 7 sqft.
$S_m = 1x(B^2)/6 = 7^2 / 6 = 8.1667$ ft^3
P= W_{Total} = 8000 lb.
$f_{max} = P/A + (P\ e /S_m)$ = (8000/7) +(8000x0.6693/8.1667)
=1142.86 + 655.64 = **1798.5 psf**
$f_{min} = P/A - (P\ e /S_m)$ = =1142.86 - 655.64 = **487.22 psf**

Groundwater effects



(a) Groundwater Table at or below the bottom of footing

(b) Groundwater Table above the bottom of footing

If the groundwater table rises above the bottom of wall footing (Fig b), following three important changes occur:

1. The effective stress in the soil below the groundwater table will decrease, which decreases the soil active, passive, and at-rest pressures.
2. Horizontal hydrostatic pressure due to groundwater will act against the wall, and will be added to lateral earth pressure.
3. The increased hydrostatic pressures (item 2 above) more than offset the decreased effective stress (item 1 above), and the net effect is a large increase of total horizontal pressure acting on the wall (Fig b).
4. The effective stress between the bottom of the footing and soil will decrease, which decreases sliding frictional resistance.