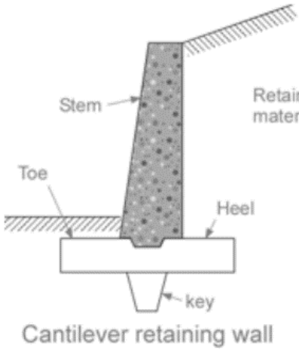
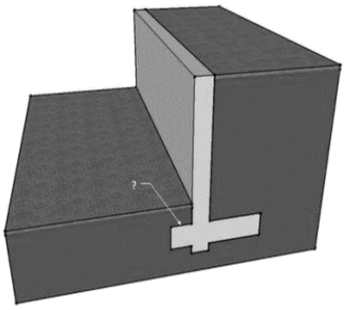
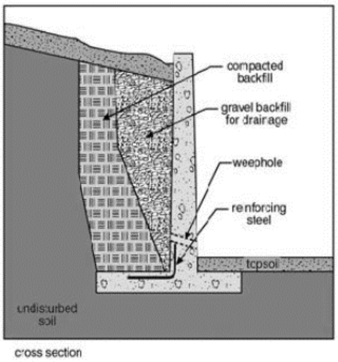
CANTILEVER RETAINING WALL

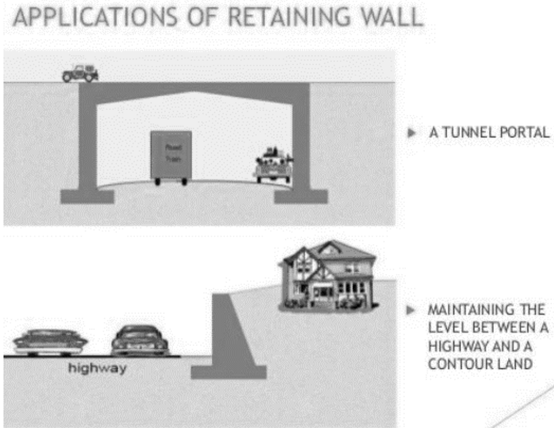
INTRODUCTION

Retaining walls are usually built to hold back soil mass. However, retaining walls can also be constructed for aesthetic landscaping purposes. Retaining walls are structures that are constructed to retail soil or any such materials which are unable to stand vertically by themselves.







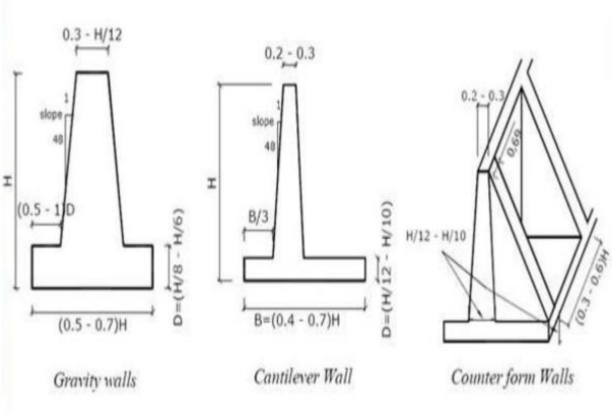


They are also provided to maintain the grounds at two different levels. In general, retaining walls can be divided into two major categories: (a) conventional retaining walls, and (b) mechanically stabilized earth walls.

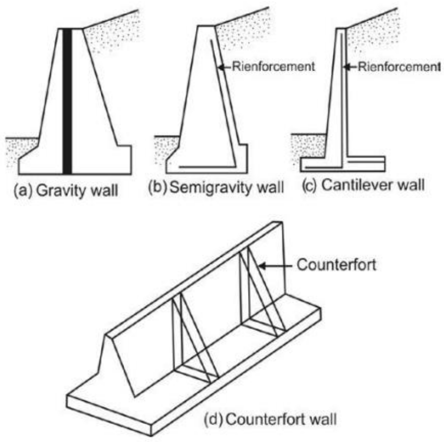
Conventional retaining walls can generally be classified as

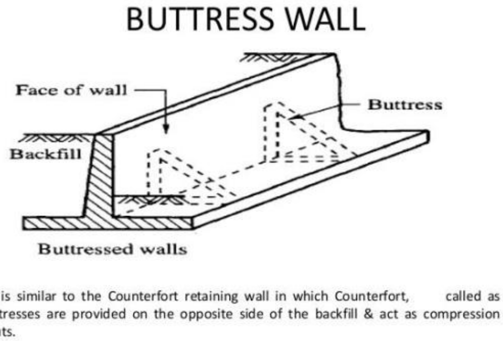
1. Gravity retaining walls
2. Semigravity retaining walls
3. Cantilever retaining walls (Inverted T and L)
4. Counterfort retaining walls

5. Buttress wall-RCC



Types of Retaining Wall





Gravity retaining walls are constructed with plain concrete or stone masonry. They depend on their own weight and any soil resting on the masonry for stability. This type of construction is not economical for walls greater than 3m.

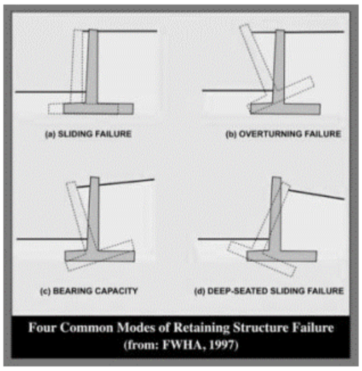
In many cases, a small amount of steel may be used for the construction of gravity walls, thereby minimizing the size of wall sections. Such walls are generally referred to as semigravity walls

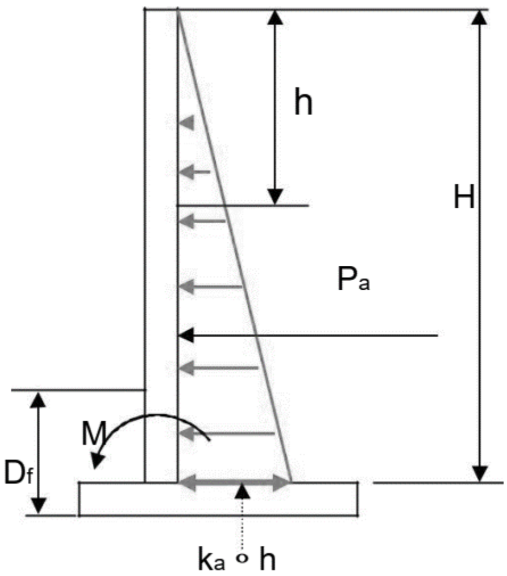
Cantilever retaining walls are made of reinforced concrete that consists of a thin stem and a base slab.They may be L or T type walls. This type of wall is economical to a height of about 6-7.5m.They Stability of the wall is provide by the weight of earth on heel slab and self weight of structure.

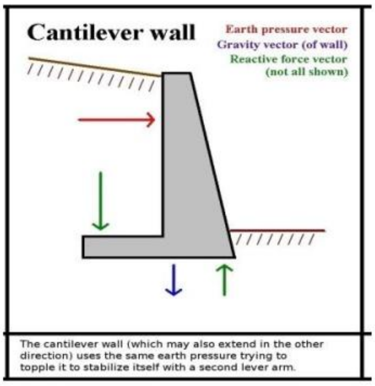
Counterfort retaining walls are similar to cantilever walls. When height of retaining wall exceeds about 6m and when thickness of stem, heel toe becomes uneconomical counterforts may be provided at regular intervals, they have thin vertical concrete slabs known as counterforts that tie the wall and the base slab together. The purpose of the counterforts is to reduce the shear and the bending moments.

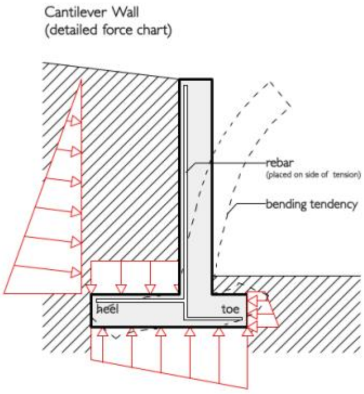
To design retaining walls properly, an engineer must know the basic soil parameters-that is, the unit weight, angle of friction, and cohesion-for the soil retained behind the wall and the soil below the base slab. Knowing the properties of the soil behind the wall enables the engineer to determine the lateral pressure distribution that has to be designed for.

There are two phases in the design of conventional retaining walls. First, with the lateral earth pressure known, the structure as a whole is checked for stability. That includes checking for possible overturning, sliding, and bearing capacity failures. Second, each component of the structure is checked for adequate strength, and the steel reinforcement of each component is determined.



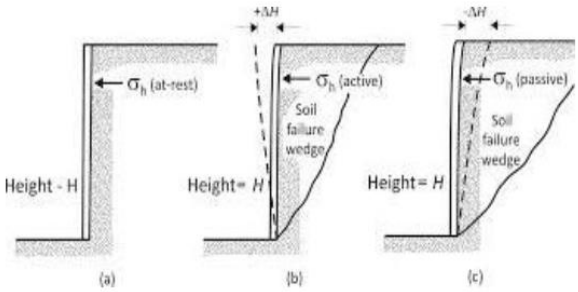


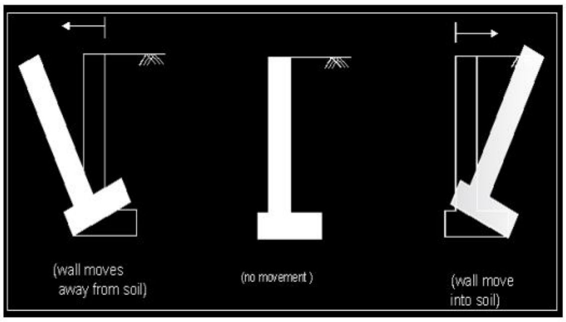




Earth Pressure (P)

Earth pressure is the pressure exerted by the retaining material on the retaining wall. This pressure tends to deflect the wall outward. There are two types of earth pressure and they are; Active earth pressure or earth pressure (Pa) and Passive earth pressure (Pp).



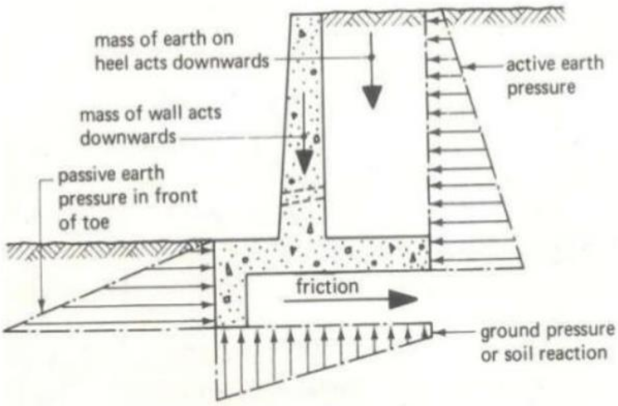


Active earth pressure:

Active earth pressure is the lateral pressure developed at the onset of shear failure by wall moving away from the soil in the direction of the acting earth pressure. The pressure exerted by the soil towards the structure. Active earth pressure tends to deflect the wall away from the backfill. Earth pressure depends on type of backfill, the height of wall and the soil conditions.

Passive earth pressure:

Passive earth pressure is lateral pressure developed at the onset of shear failure by wall moving (penetrating) in the direction opposite to the direction of acting earth pressure. The pressure exerted by the structure towards the soil.



Cantilever retaining walls

PROBLEM

Reinforced Concrete Cantilever Retaining Wall

Let it be required to design a cantilever type retaining wall that will project upward 10.4m above foundation (see figure below) and support a horizontal backfill whose unit wight of 20 KN/m^3 and whose ange of friction is 35° . the wall is to be founded on dense coarse sand with a unit wight of 20 KN/m^3 , and angle of friction of 35° , and allowable bearing capacity of 280 KN/m^2. It is expected that soil in front of the wall will be excavated in the future due to installation of water pipe. Therefore, the passive resistance of soil will be neglected in the design. Because of adequate drainage system behind of the wall, no water pressure will be considered in the backfill. Design the wall for the condition given below and shown in the figure.

Factor of safety against overturning = 2.0

Factor of safety against sliding = 1.5

Factor of safety against bearing failure = 2.0 (deep seated shear failure)

Maximum allowable coefficient of friction at the base = 0.5

Unit wight of concrete = 24 KN/m^3

Surcharge on backfill (live load) = 20 KN/m^2

1) Determine :
   a- The width of the footing
   b- The shear and bending moment in the vertical stem, the toe projection and the heel projection.
2) Check :
   a- The stability of the wall against sliding and overturning.
   b- Base pressure.
   c- The stability of the wall against deep-seated shear failure along acurved surface passing through the soft clay layer.

Note: Acircle as potential failure surface whose center lies 2.0m above the top of wall and along the vertical line flush with the wall face may be tried.

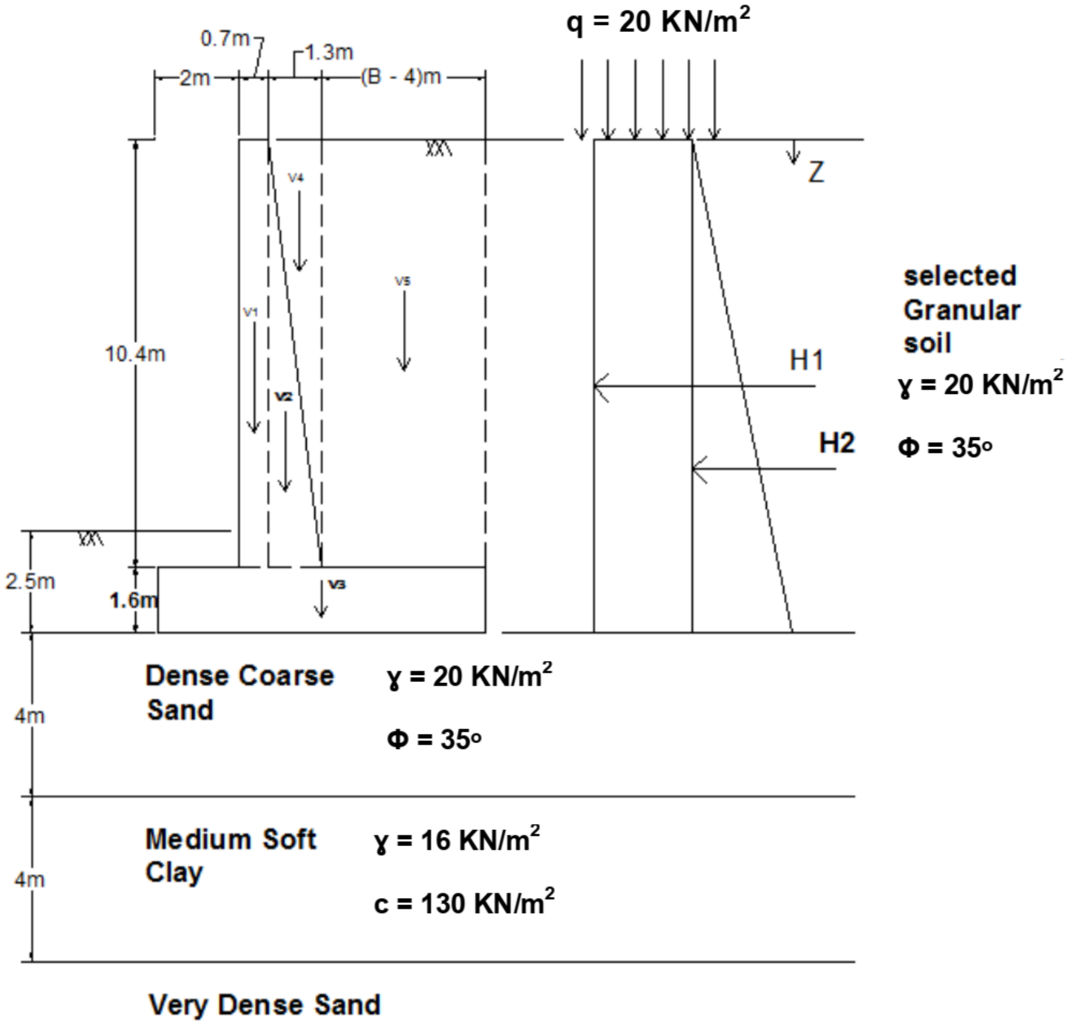


Figure: Reinforced Concrete Cantilever Retaining Wall

$K_a = \tan^2(45-35/2) = 0.27$

Assume B = 8.0 m

(Lateral Surcharge pressure)

$q * K_a = 20 \text{ X } 0.27 = 5.4 \text{ KN/m}^2$

(Active Pressure of soil)

@ Z = 0 $\quad$ $P_a = 0$

@ Z= 12m $\quad$ $P_a = 12 \text{ X } 20 \text{ X } 0.27 = 64.8 \text{ KN/m}^2$

Force	Vertical Force (KN)/m	Horizontal Force (KN)/m	Arm of moment (m)	Moment (KN.m)/m
V1	0.7X10.4X24 = 174.7	__	2.35	+ 410.545
V2	0.5X10.4X1.3X24 = 162.2	__	3.13	+ 507.686
V3	1.6X8X24 = 307.2	__	4	+ 1228.8
V4	0.5X10.4X1.3X20 = 135.2	__	3.57	+ 482.664
V5	4X10.4X20 = 832	__	6	+ 4992
H1	__	5.4X12 = 64.8	6	- 388.8
H2	__	0.5X64.8X12 = 388.8	4	- 1555.2
sum	1611.3	453.6		+ Σ M = 7621.695 - Σ M = 1944

Where + Σ M Resisting Moment

– Σ M Driving Moment

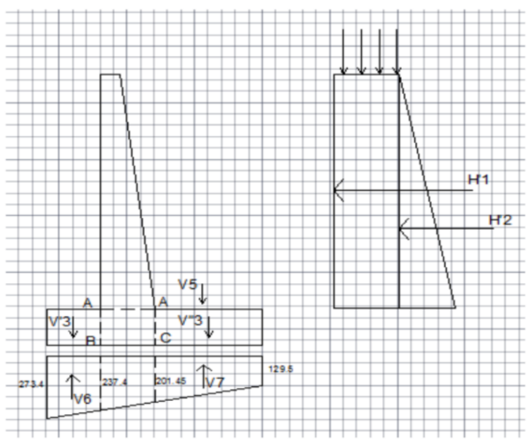
Overturning F.S = $\frac{+\Sigma M}{-\Sigma M} = \frac{7621.695}{1944} = 3.92 > 2\ ok$

Sliding F.S = $\frac{\Sigma V \text{ X } f}{\Sigma H} = \frac{1611.3 \text{ X } 0.5}{453.6} = 1.78 > 1.5\ ok$

e (eccentricity) = $\frac{8}{2} - \frac{7621.8-1944}{1611.3}$ = 0.48m

Base pressure

Max , Min q = $\frac{1611.3}{8} \text{ X } (1 \pm \frac{6 \text{ X } 0.48}{8}) = 273.4 \text{ KN/m}^2 (<280 \text{ KN/m}^2) , 129.5 \text{ KN/m}^2 (> 0)$ ok



Section A-A

Force	Vertical Force (KN)/m	Moment Arm (m)	Moment (KN.m)/m
H' 1	20X10.4X0.27 = 56.16	5.2	292
H' 2	0.5X10.4X10.4X20X0.27 = 292	3.47	1012.3
Sum	(Shear force)= 348.16		(Moment)= 1304.3

(tension along inner face)

Section A-B

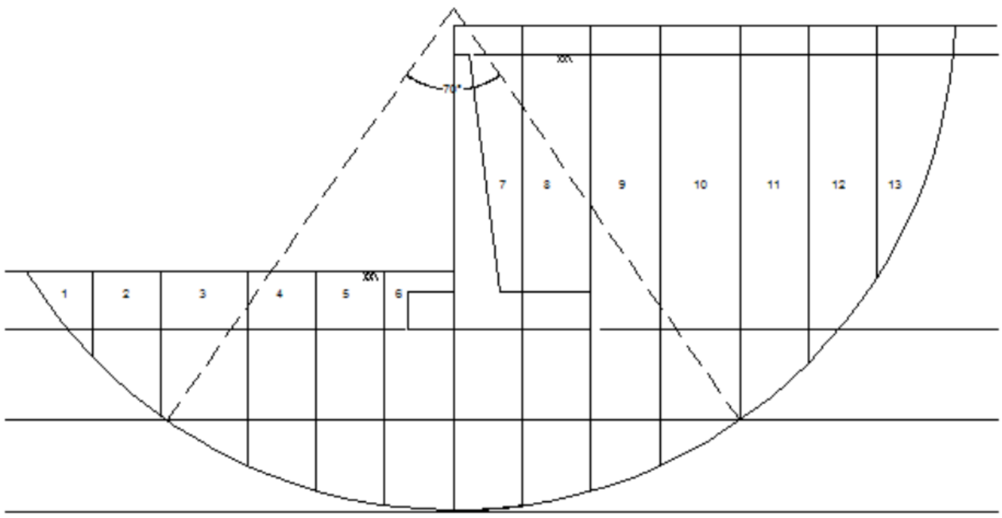
Force	Vertical Force (KN)/m	Moment Arm (m)	Moment (KN.m)/m
V' 3	-2X1.6X24 = -76.8	1	-76.8
V 6	(237.4+273.4)/2X2X24 = 510.8	1.023	522.8
Sum	(Shear force)= 434		(Moment)= 446

(tension along bottom face)

Section A-C

Force	Vertical Force (KN)/m	Moment Arm (m)	Moment (KN.m)/m
V 5	-10.4X20X4 = -832	2	-1664
V'' 3	-1.6X4X24 = -153.6	2	-307.2
V 7	(129.5+201.45)/2X4 = 661.9	1.855	1227.87
Sum	(Shear force)= - 323.7		(Moment)= -743.38

(tension along top face)



Slice	W (KN/m)	N(KN/m)	T(KN/m)
1	0.5X3X4X20 = 120	80	-90
2	0.5X(4+6.4)X20X3 = 312	240	-200
3	6.4X20X3.8 + 0.5X2.2X16X3.8 = 553	480	-220
4	20X6.4X3 + 0.5X(2.2+3.2)X16X3 = 514	480	-170
5	6.4X20X3 + 0.5X(3.2+3.8)X16X3 = 552	540	-115
6	6.4X20X3 + 0.5X(3.8+4)X16X3 + 1.6X2X4 = 584	585	-40
7	17.2X3X20 + 0.5X(3.8+4)X16X3 + (10.4X0.7+0.5X1.3X10.4+2X1.6)X4 = 1295	1195	-110
8	17.2X3X20 + 0.5X(3.8+3.2)X16X3 + 1.6X3X4 = 1219.2	1205	230
9	17.2X3X20 + 0.5X(3.2+2)X16X3 = 1156.8	1095	330
10	17.2X3.5X20 + 0.5X2.1X16X3.5 = 1262.8	1100	620
11	(17.2+14.8)X0.5X20X3 = 960	755	610
12	(14.8+11)X0.5X20X3 = 774	480	600
13	0.5X10.8X4.4X20 = 484	200	430
Sum			2145

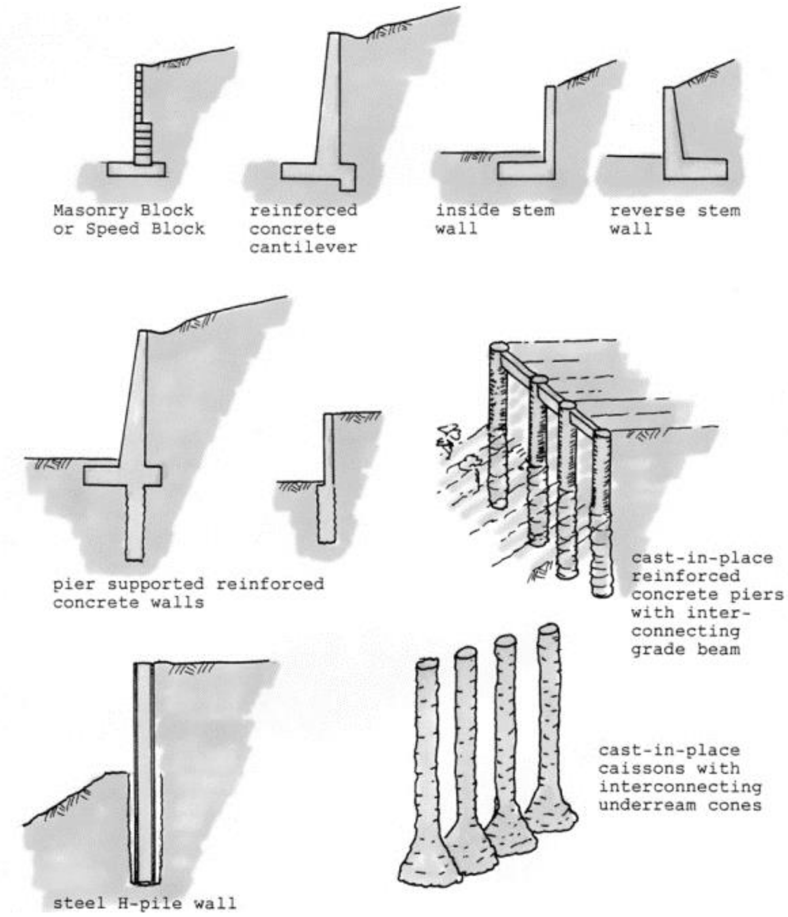
$$F.S = \frac{\Sigma(N\tan\Phi)+cl}{\Sigma T} = \frac{(80+240+755+480+200)*\tan(35)+2*22*\left(\frac{70}{360}\right)*\pi*130}{2145} = 2.2 \quad \text{ok}$$

SUMMARY

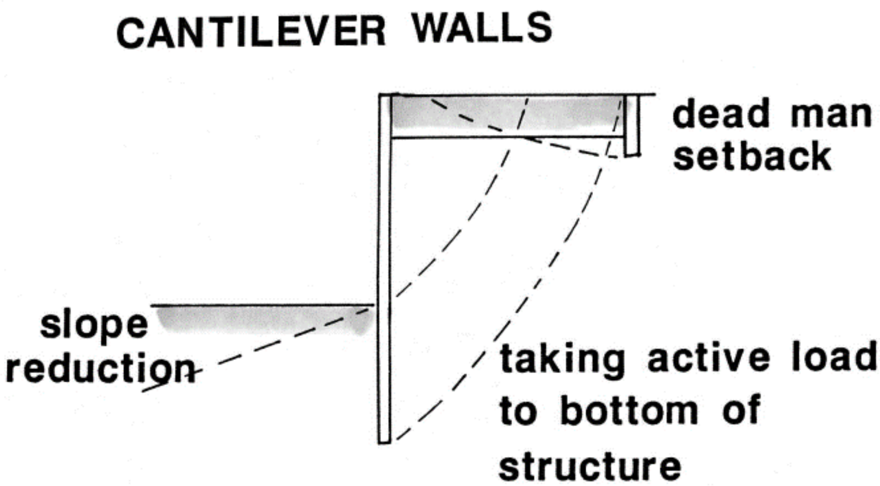
CANTILEVER WALLS

• Cantilever theory was introduced by Galileo in the 16th Century, then advanced by Sir John Fowler and Sir Benjamin Baker in the 19th Century

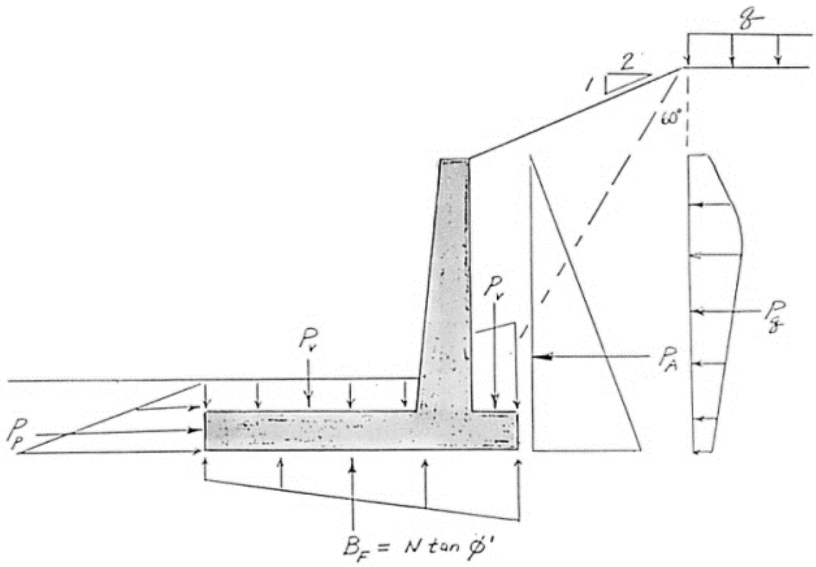
• Reinforced concrete retaining walls were introduced by the Chicago, Burlington and Quincy Railroad in the 1880s



- **Common types of cantilever retaining wall systems**
- **Pile driving dates back to the time of the Romans**
- **Large diameter augers allow structures to extend into any kind of material**

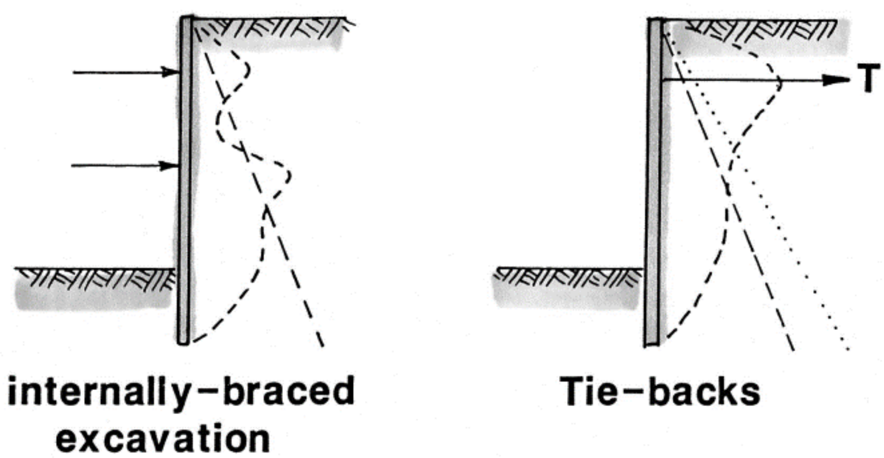


- **The basic design precepts employed in cantilever walls include considerations of dead man tiebacks, taking active pressures to the bottom of the wall and considering any reductions in passive resistance for inclined slopes. Deflection generally governs design for cantilever walls more than 18 feet high.**



- **Design components for conventional cantilever walls on spread footings.**
- **The resultant thrust should project through the middle third of the footing or eccentric loading may result in localized bearing failure.**

ACTUAL LOAD DISTRIBUTIONS



- **The Rankine linear approximation tends to under and overestimate actual loads, as sketched above.**
- **The period of relaxation between excavation and placement of struts also affects measured soils loads, sketched at left.**

Lecture 07

REFERENCE:

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