Fayoum University
Faculty of Engineering
Department of Civil Engineering

CE 402: Part C
Retaining Structures
Lecture No. (14):
Cantilever Sheet Pile Walls

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Applications of Sheet Pile Walls

Sheet pile walls are retaining walls constructed to retain earth, water or any other fill material. These walls are thinner in section as compared to masonry walls . Sheet pile walls are generally used for the following:

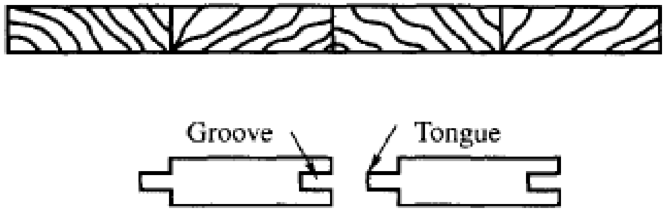
1. Water front structures, for example, in building wharfs, quays, and piers.
2. Building diversion dams, such as cofferdams.
3. River bank protection.
4. Retaining the sides of cuts made in earth.

Materials of Sheet Pile Walls

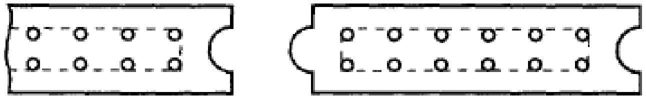
Sheet piles may be:

- Timber.
- Reinforced concrete .
- Steel.

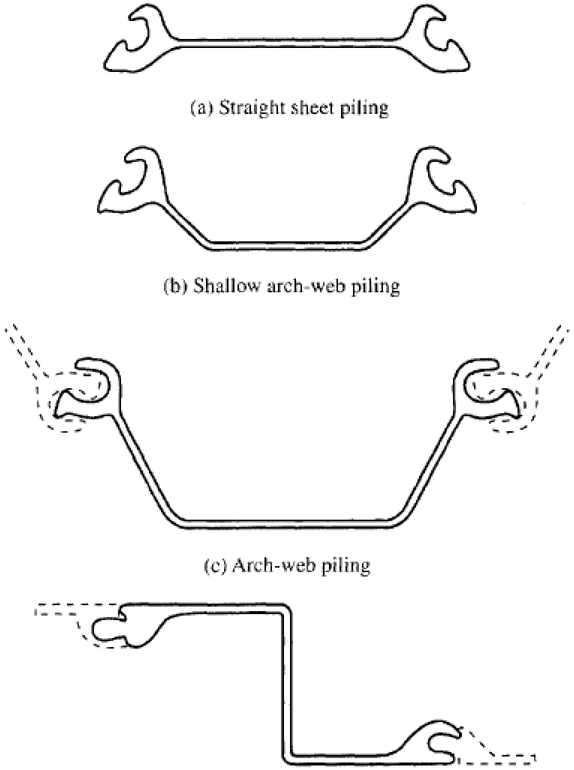
Materials of Sheet Pile Walls



Timber pile wall section



Reinforced concrete
Sheet pile wall section



Sheet pile sections

The advantages of using steel sheet-piling

1. Provides higher resistance to driving stresses;
2. Is of an overall lighter weight;
3. Can be reused on several projects;
4. Provides a long service life above or below the water table;
5. Easy to adapt the pile length by either welding or bolting; and
6. Their joints are less apt to deform during driving.

SHEET PILE STRUCTURES

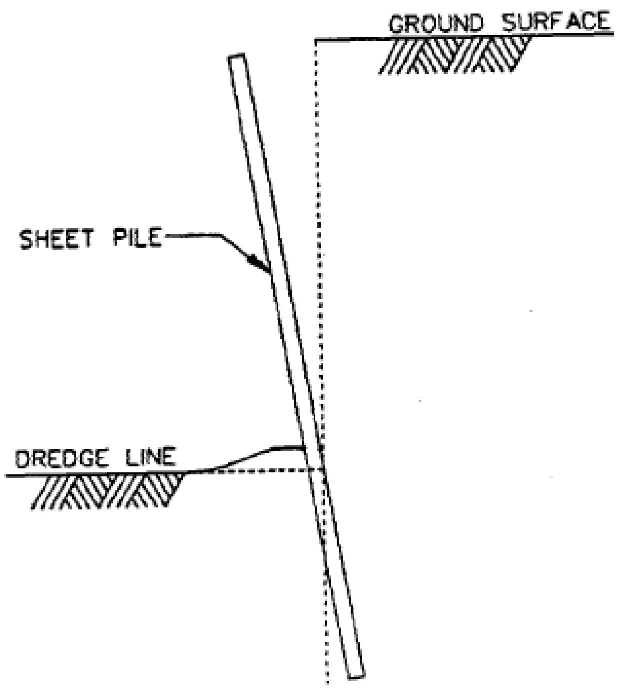
Steel sheet piles may conveniently be used in several civil engineering works. They may be used as:

1. Cantilever sheet piles
2. Anchored bulkheads
3. Braced sheeting in cuts
4. Single cell cofferdams
5. Cellular cofferdams, circular type
6. Cellular cofferdams (diaphragm)

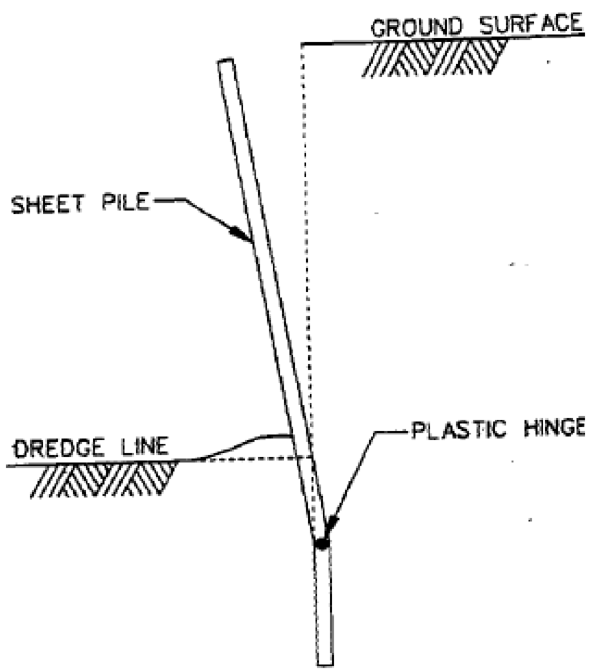
Cantilever Sheet pile Walls

- Cantilever walls are usually used as floodwall or as earth retaining walls with low wall heights (3 to 5 m or less).
- Because cantilever walls derive their support solely from the foundation soils, they may be installed in relatively close proximity to existing structures.

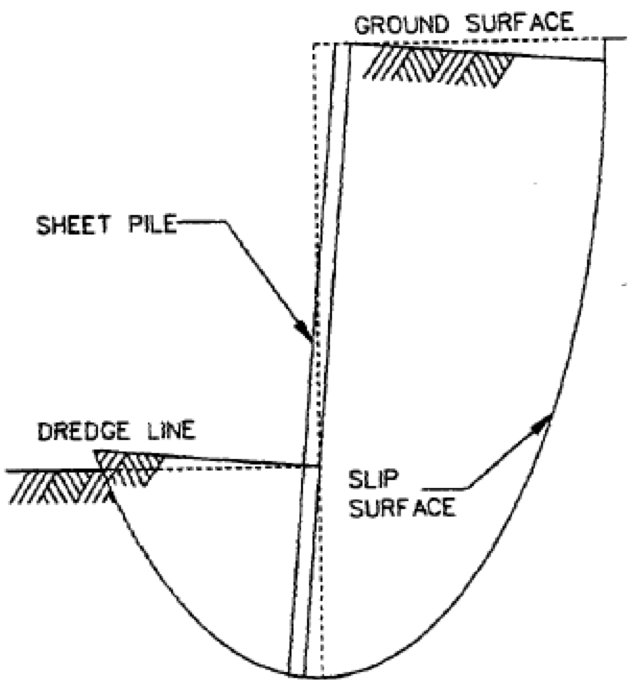
Failure Modes of Cantilever sheet Pile



Flexural failure

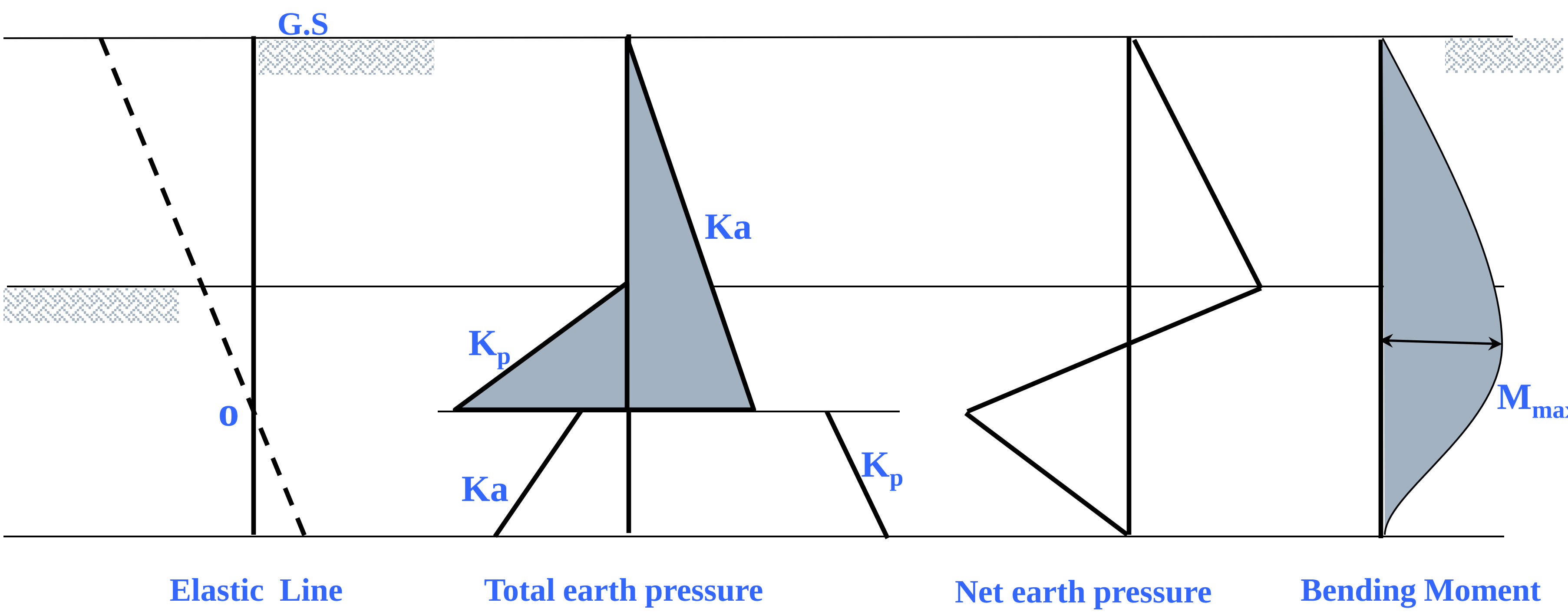


Rotational failure due to inadequate penetration



Deep-seated failure

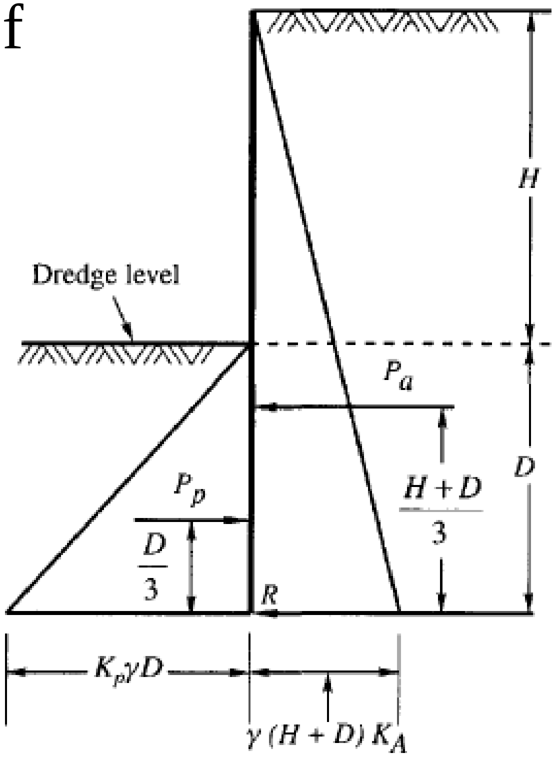
Elastic Line and straining Actions



Equilibrium of Cantilever Sheet Piles

For equilibrium, the moments of the active and passive Pressures on about the point of reaction *R* must balance.

$$\Sigma M = 0.0$$



•The depth calculated should be increased by at least 20 percent to allow extra length to develop the passive pressure *R.*

Analysis Cantilever Sheet Pile Walls

- Select a point O (arbitrary)
- Calculate the active and passive earth pressures.
- Calculate the pore water pressure and the seepage force.
- Determine the depth do by summing moments about O.
- Determine d = 1.2 to 1.3 d_o.
- Calculate R by summing forces horizontally over the depth (H_o+d).

Analysis Cantilever Sheet Pile Walls

– Determine net passive resistance between do and d.

– Check that R is greater than net passive resistance. If not extent the depth of embedment and determine new R.

– Calculate the maximum bending moment M_{max}.

– Determine the section modulus: $S = M_{max}/\sigma_{allow}$ (for steel sheet pile)

Penetration Depth (d)

Approximate penetration depth (d) of cantilever sheet piling

Relative density	Depth, *D*
Very loose	2.0 H
Loose	1.5 H
Firm	1.0 H
Dense	0.75 H

Secant Pile Walls

- These walls are formed by the intersection of individual reinforced concrete piles.
- These piles are built by using drilling mud (bentonite) and augering.
- The secant piles overlap by about 3 inches.
- An alternative are the tangent pile walls, where the piles do not have any overlap. These piles are constructed flush with each other.

Secant Pile Walls.

- The important advantage of secant and tangent walls is the increased alignment flexibility.
- The walls also may have increased stiffness, and the construction process is less noisy.
- Among the disadvantages are that waterproofing is difficult to obtain at the joints, their higher cost, and that vertical tolerances are hard to achieve for the deeper piles.

Slurry Walls.

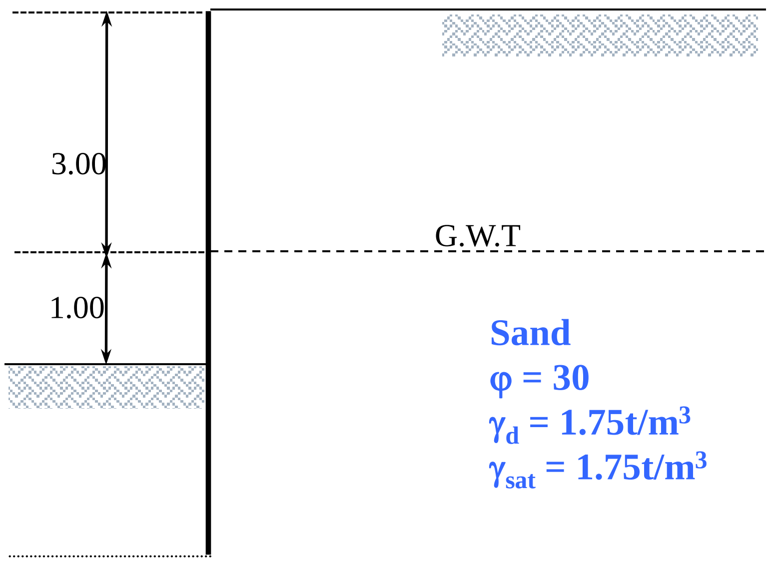
- A slurry wall refers to the method of construction. Specifically, the digging of a deep trench with a special bucket and crane.
- As the trench becomes deeper, the soil is prevented from collapsing into the trench by keeping the hole filled with a "slurry".
- This slurry is a mixture of water with bentonite (a member of the Montmorrillonite family of clays).
- The bentonite makes the slurry thick, but liquid. This keeps the soil lateral walls from collapsing into the excavation.
- When the excavation reaches the intended depth, the slurry filled excavation is reinforced with steel and carefully filled with concrete.

Slurry Walls.

- These walls have been built to 100 foot depths and range from 2 feet to 4 feet in thickness.
- The panels are typically 15 feet to 25 feet long, and are linked with one another through tongue and groove type seals (to prevent the intrusion of groundwater into the future underground site.
- Slurry walls have the advantage of being stiffer than sheet pile walls, and hold back the soil better than soldier piles, lagging and steel sheeting. They also tend to be more watertight than other excavation methods.

Example (1)

Design the cantilever sheet pile wall that satisfy the requirements for stability of the wall. For this height of sand, determine the maximum bending moment in the sheet pile wall.



Example (1)

1. Draw earth pressure diagram

$$k_a = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 30}{1+\sin 30} = 0.33$$

$$k_p = \frac{1+\sin\varphi}{1-\sin\varphi} = 3.00$$

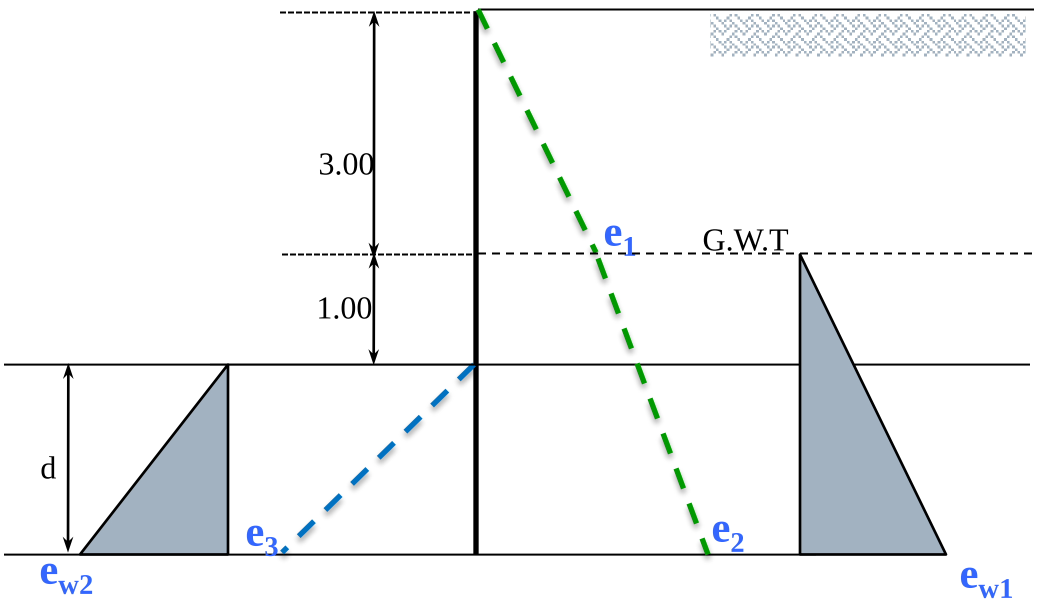
$$e_a = \gamma * h * k_a \qquad e_P = \gamma * h * k_P$$

$$e_1 = 1.75 * 3.00 * 0.33 = 1.75$$

$$e_2 = e_1 + 0.95 * 0.33(1+d) = e_1 + 0.31(1+d)$$

$$e_3 = 0.95 * 3.00 * d = 2.85d$$

$$e_{w1} = 1 + d \qquad e_{w2} = d$$



Example (1)

2. Estimate earth pressure forces

$E_1 = 1.75 * 3.00 / 2 = 2.63$ $\quad y_1 = 2 + d$

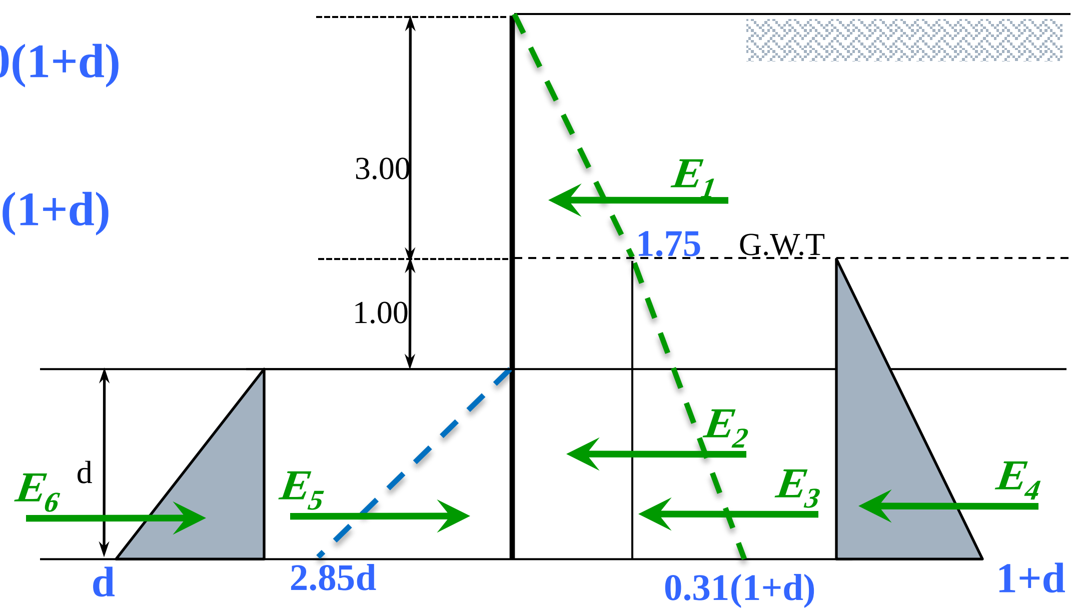
$E_2 = 1.75(1 + d)$ $\quad y_2 = 0.50(1 + d)$

$E_3 = 0.31(1 + d)^2 / 2$ $\quad y_3 = 0.33(1 + d)$

$E_4 = (1 + d)^2 / 2$ $\quad y_4 = 0.33(1 + d)$

$E_5 = 2.85 * d^2 / 2 = 1.43 d^2$ $\quad y_5 = 0.33d$

$E_6 = d^2 / 2 = 0.5 d^2$ $\quad y_6 = 0.33d$



Example (1)

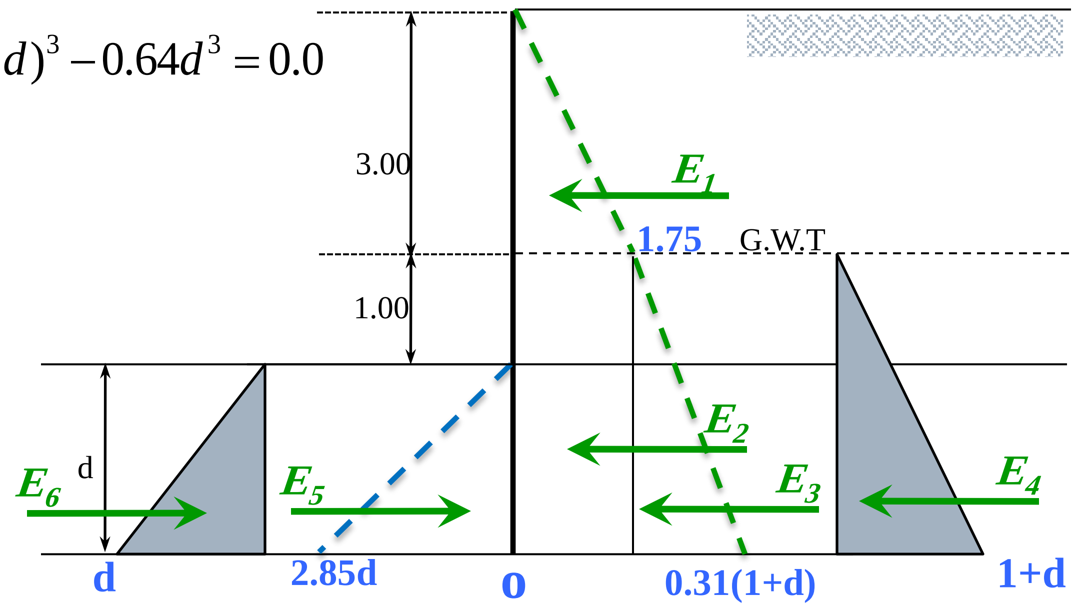
3. Stability of wall

$$\sum M_o = 0.0$$

$$2.63(2+d)+0.88(1+d)^2+0.165*0.31(1+d)^3-0.64d^3=0.0$$

Trial and Error

d = 6.00m



Example (1)

4. Maximum bending Moment

Maximum bending moment at distance x below dredge line:

at point of zero shear

$$2.63+1.75(1+x)+0.33*0.95(1+x)^2/2+(1+x)^2/2$$

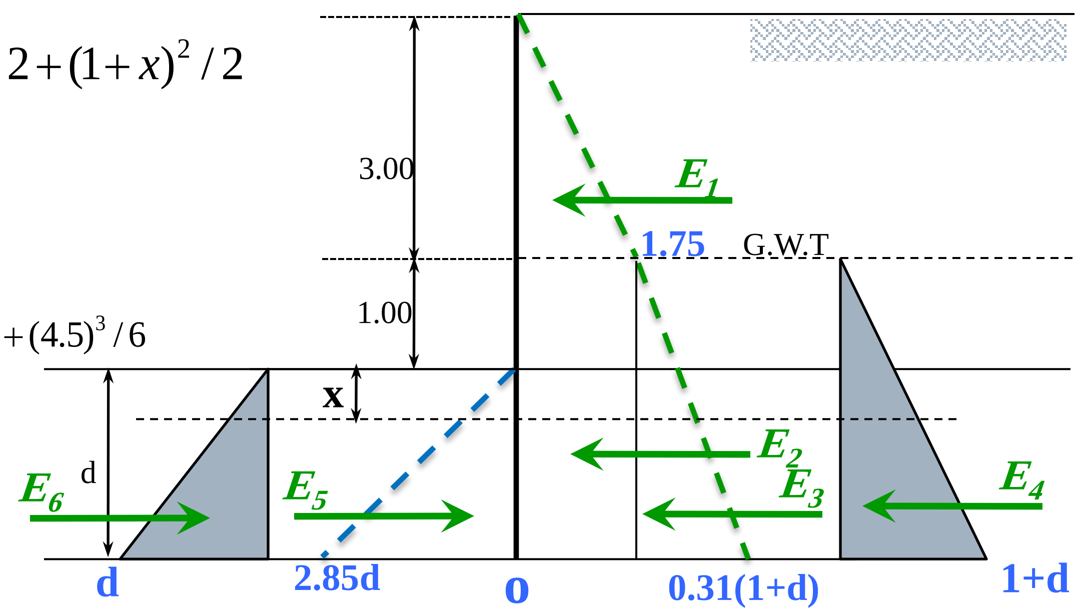
$$-x^2/2-3*0.95x^2/2=0.0$$

x= 3.5m

$$M_{max}=2.63*5.5+1.75*4.5^2/2+0.33*0.95(4.5)^3/6+(4.5)^3/6$$

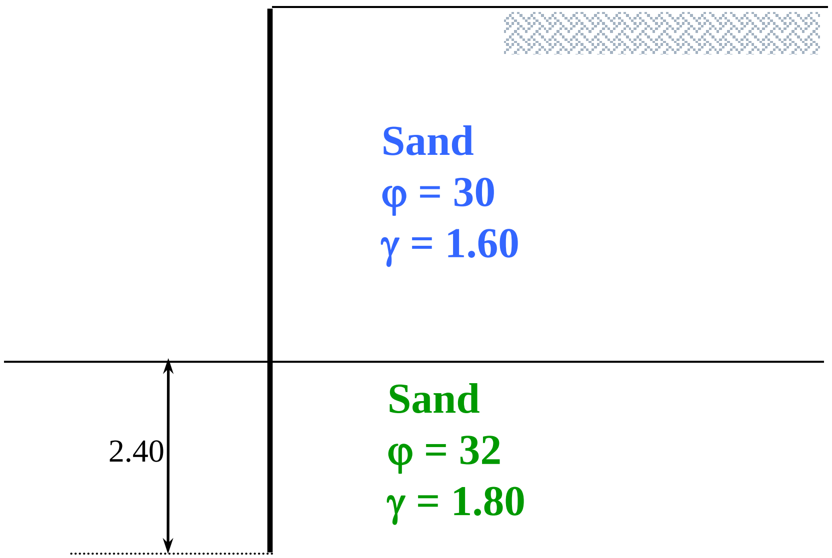
$$-3.5^3/6-3*0.95*3.5^3/6=24.68m.t/m'$$

$$z=\frac{M_{max}}{\sigma}=\frac{24.68*100}{1.4}=1762.5cm^3$$



Example (2)

Find the maximum height of sand fill behind the sheet pile wall that satisfy the requirements for stability of the wall. For this height of sand, determine the maximum bending moment in the sheet pile wall.



Example (1)

1. Draw earth pressure diagram

$$k_{a1} = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 30}{1+\sin 30} = 0.33$$

$$k_{a2} = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 32}{1+\sin 32} = 0.307 \qquad k_{a2} = \frac{1+\sin\varphi}{1-\sin\varphi} = 3.25$$

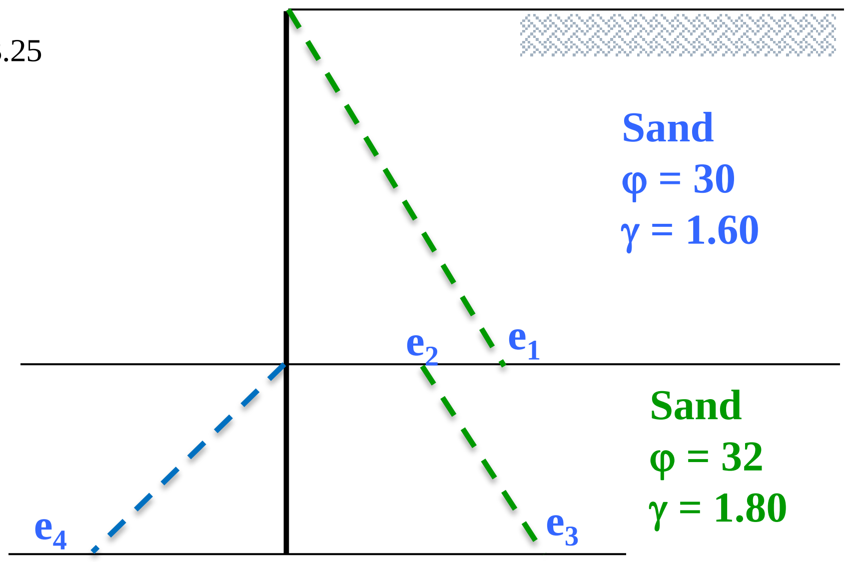
$$e_a = \gamma * h * k_a \qquad e_P = \gamma * h * k_P$$

$$e_1 = 1.60 * h * 0.33 = 0.53h$$

$$e_2 = 1.60 * h * 0.307 = 0.49h$$

$$e_3 = e_2 + 1.80 * d * 0.307 = e_2 + 1.11$$

$$e_4 = 1.80 * 2 * 3.26 = 11.74$$



Example (1)

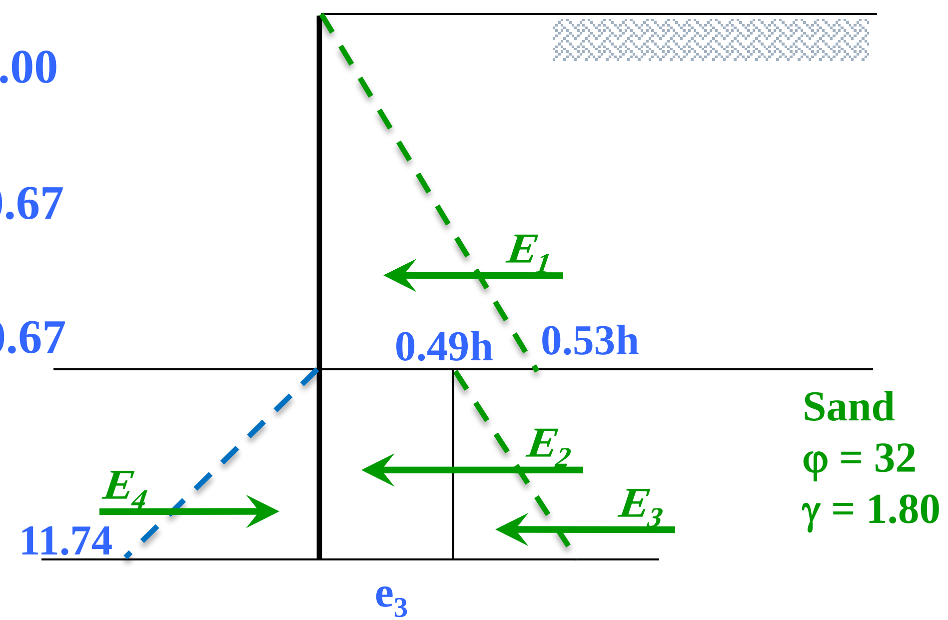
2. Estimate earth pressure forces

$$E_1 = 0.53h * h/2 = 0.265h^2$$ $y_1 = 2 + h/3$

$$E_2 = 0.49h * 2 = 0.98h$$ $y_2 = 1.00$

$$E_3 = 1.11 * 2/2 = 1.11$$ $y_3 = 0.67$

$$E_4 = 11.74 * 2/2 = 11.74$$ $y_4 = 0.67$



Example (2)

3. Stability of wall

$$\sum M_o = 0.0$$

$$0.265h^2 * (2 + h/3) + 0.49h + 1.11 * .67 - 11.74 * 0.67 = 0.0$$

Trial and Error

h = 2.72