HATTI MENGAJAR VII 2021

Kamis, 19 Agustus 2021

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UNIVERSITAS KATOLIK PARAHYANGAN

Bakuning Hyang Mrih Guna Santyaya Bhakti

Type of Retaining Structures

Is it earth retaining structure?

Type of Retaining Structures

Type of Retaining Structures

Type of Retaining Structures

Type of Retaining Structures

Type of Retaining Structures

Type of Earth Retaining Structures

Fill Wall Construction

Externally Stabilized

Rigid Gravity, Semi-gravity Wall

1.Cast-in-place (CIP) concrete gravity wall
2. CIP concrete cantilever wall

Prefabricated Modular Gravity Wall

3. Crib Wall
4. Bin Wall
5. Gabion Wall

Non-Gravity Cantilever Wall

10. Sheet-Pile wall
11. Soldier pile and logging wall
12. Slurry (diaphragm) wall (with braced support)
13. Tangent/secant wall
14. Soil mix wall (SMW)

Non-Gravity Supported Wall

15. Anchored wall

Internally Stabilized

Mechanical Stabilized Earth (MSE) Wall

6. Segmental precast facing MSE wall
7. Prefabricated modular block facing MSE wall
8. Geotextile-Geogrid/ Welded wire facing wall

Reinforced Soil Slope (RSS)

9. RSS of various facings

In-situ Reinforced Wall

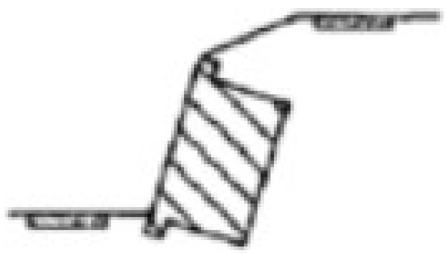
16. Soil-nailed wall
17. Micropile

Cut Wall Construction

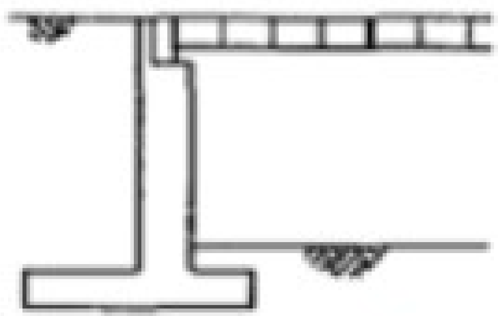
Type of Retaining Structures

Purpose:

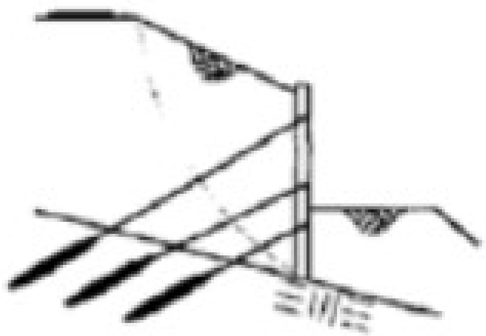
Stabilize the unstable masses



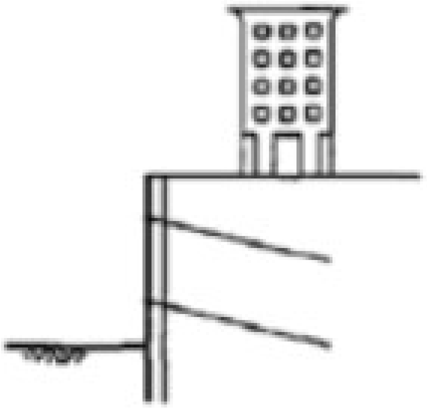
Grade separation



Superstructure support



Slope stabilization



Excavation support

Type of Retaining Structures

Soil Anchor

Gabion wall

Gravity wall

Reinforced wall

Cantilever wall

Identify the types, advantages and disadvantages of different earth retaining systems and select the most technically appropriate and cost-effective type of retaining wall for the application

Type of Retaining Structures

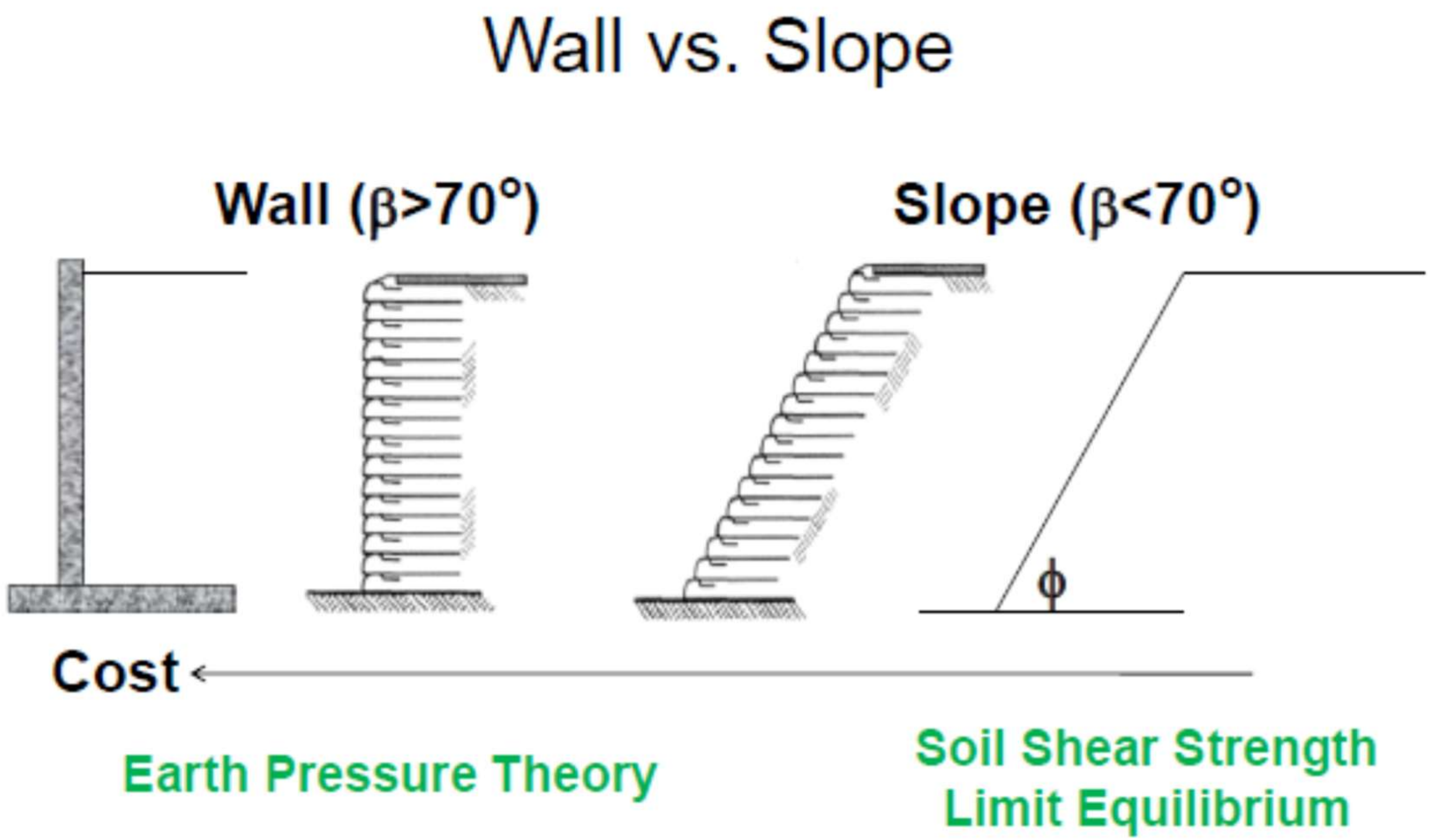
Wall ($\beta > 70^\circ$)

Slope ($\beta < 70^\circ$)

Mechanically Stabilized Earth (MSE) Wall

Reinforced Soil Slope (RSS)

Type of Retaining Structures



Type of Retaining Structures

Sheet pile retaining wall and lateral supporting system

1976

Courtesy from Dr J. Endicott)

Type of Retaining Structures

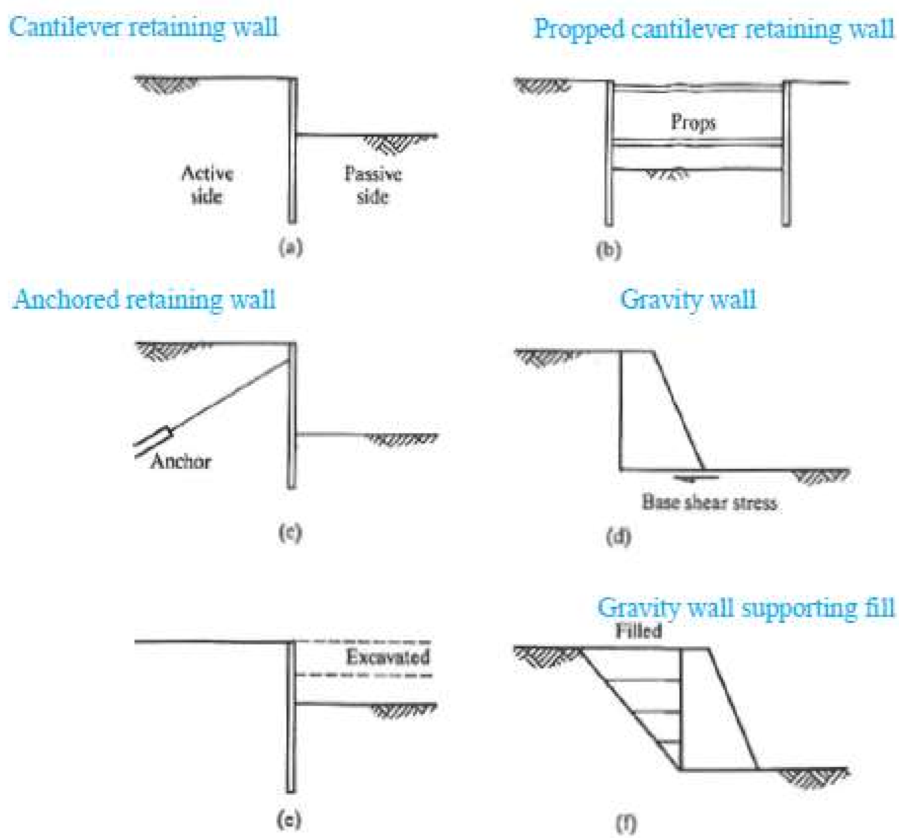


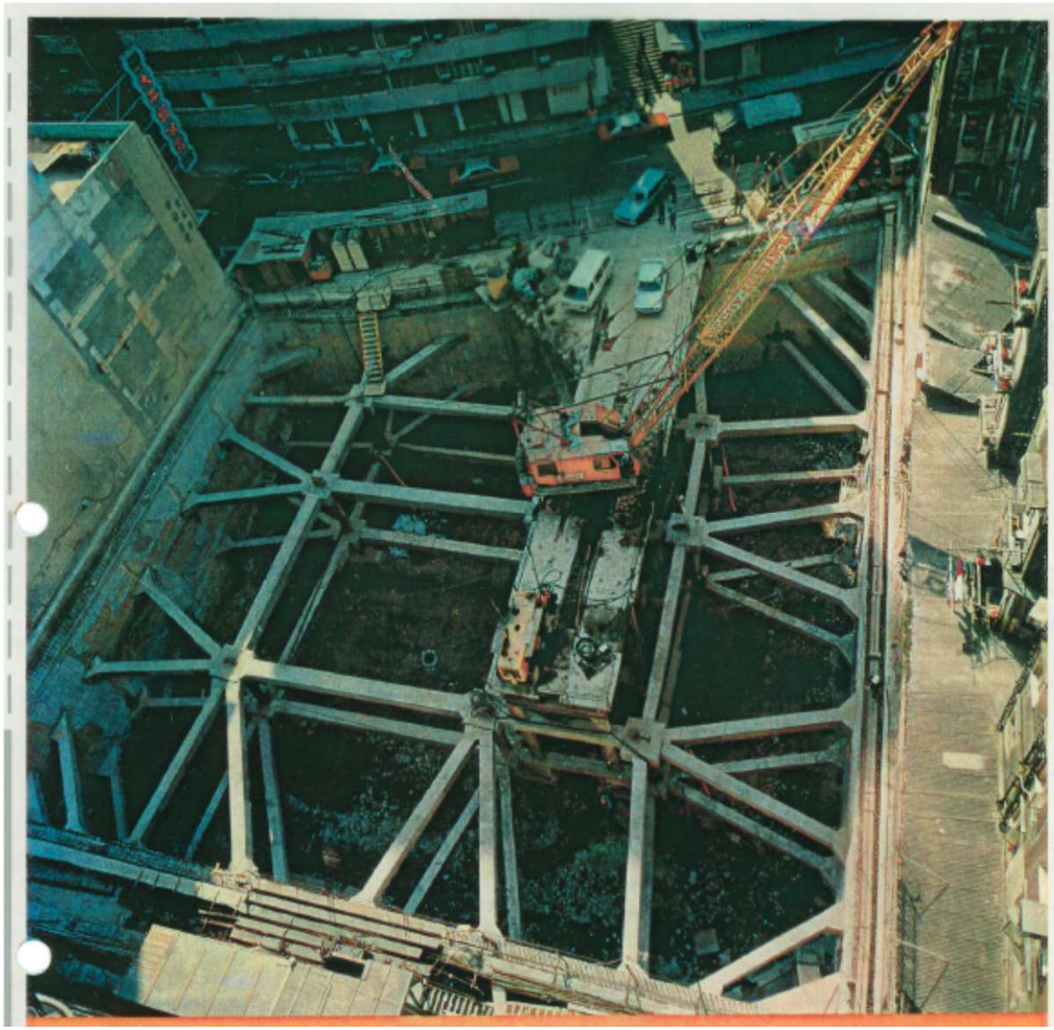
Figure 2-1 Principle types of retaining structure (Atkinson, 1993)

Type of Retaining Structures

Diaphragm wall

1. Excavation of barrette trench
2. Insertion of reinforcement cage
3. Placing of concrete by tremie pipe

Type of Retaining Structures



Type of Retaining Structures

Type of Retaining Structures

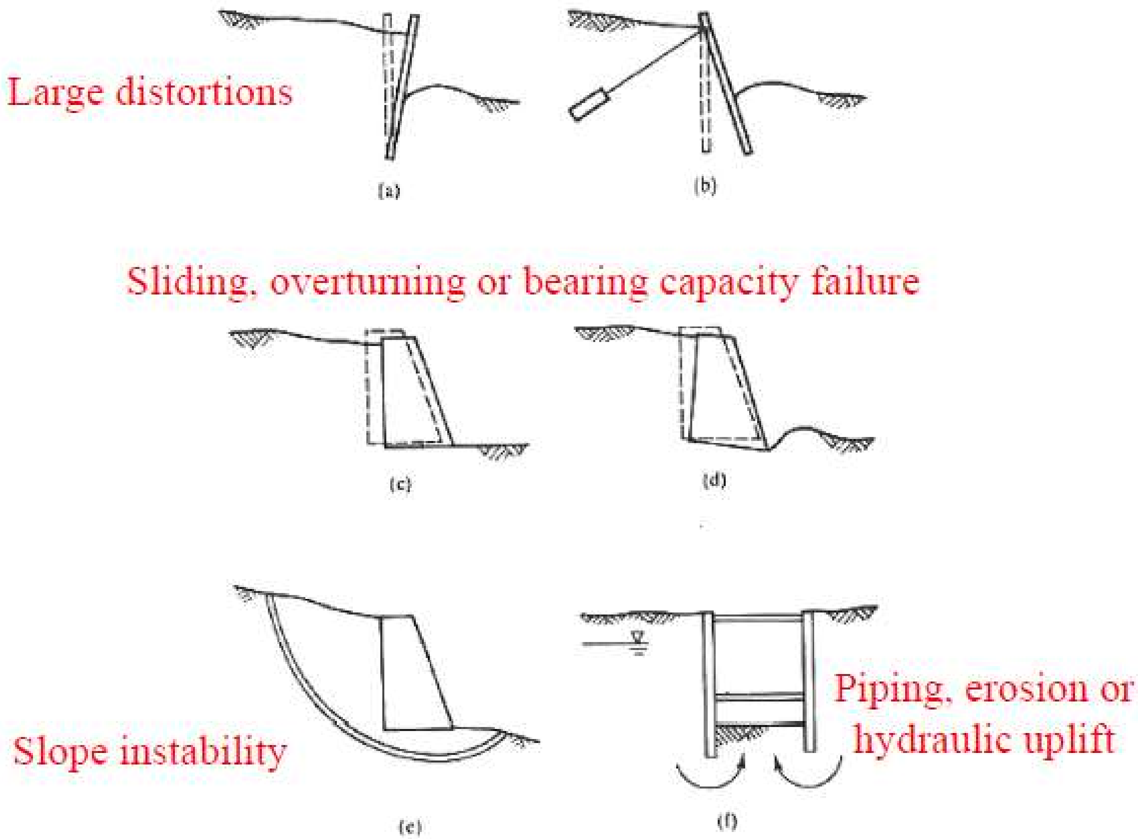


Figure 2-2 Mechanisms of failure of retaining walls (Atkinson, 1993)

Type of Retaining Structures

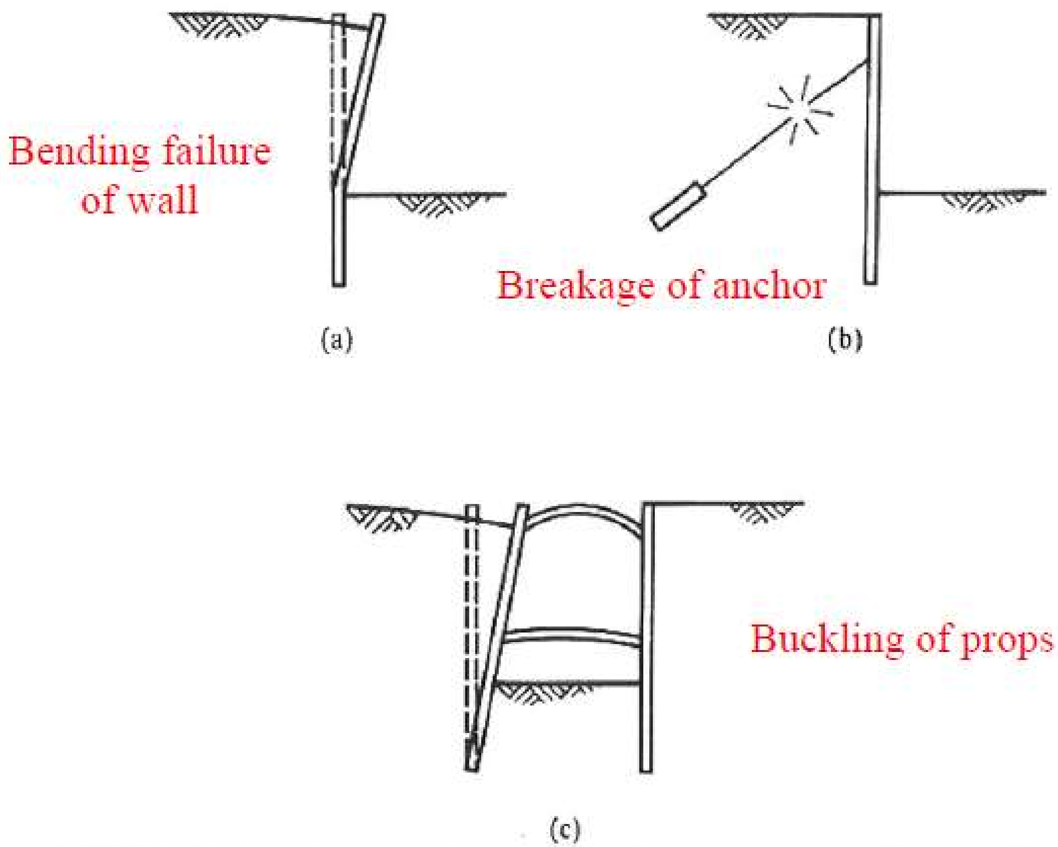
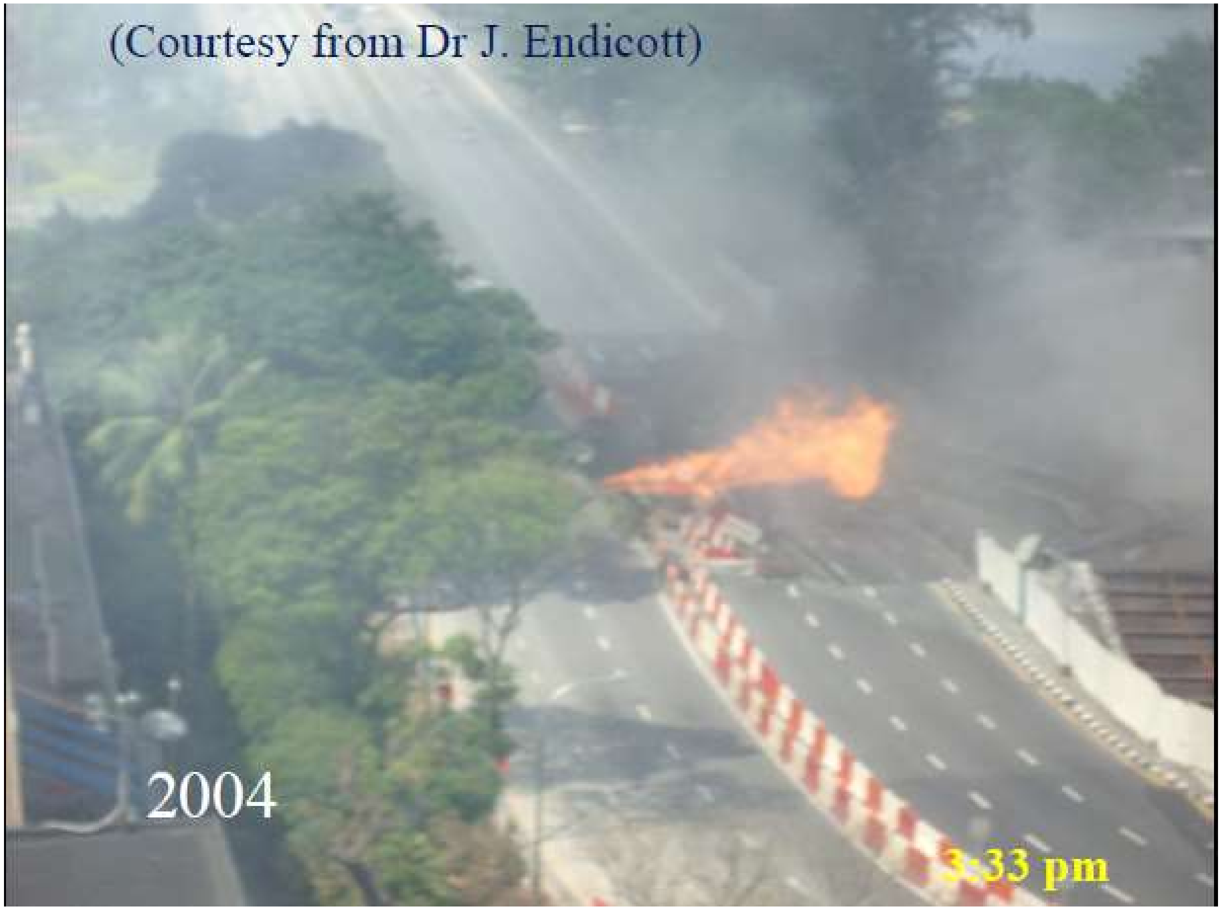


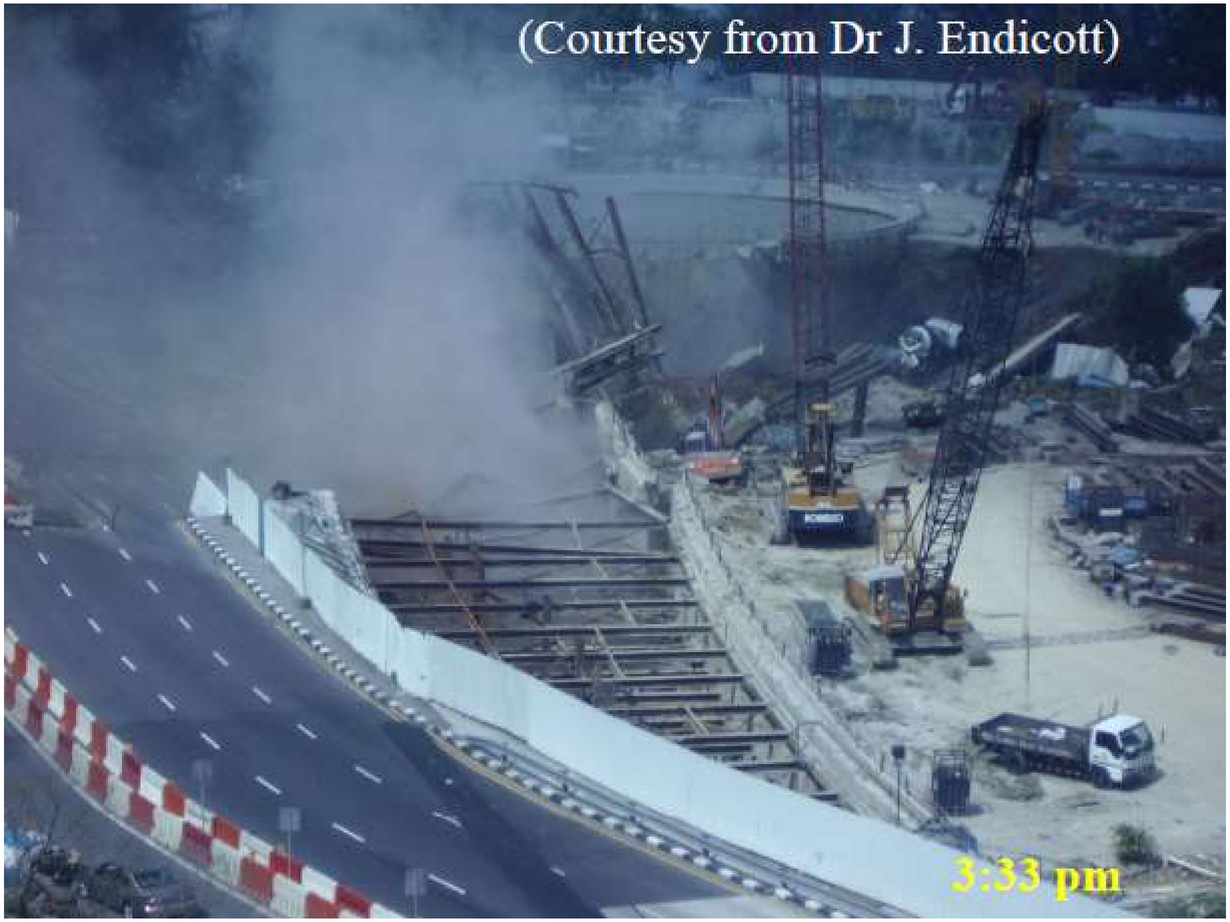
Figure 2-3 Structural failures of retaining walls (Atkinson, 1993)

Retaining Wall Failure

Retaining Wall Failure



Retaining Wall Failure



Retaining Wall Failure

Retaining Wall Failure

Retaining Wall Failure

(a). Before Failure

(b). After Failure

Retaining Wall Failure

(b). After Failure

Conceptual Design

- In **DESIGN** a retaining wall, we need to know

–. The basic soil properties of soil behind the wall, such as unit weight, friction angle, cohesion.

–. Two major steps in design

- Calculate the lateral earth pressure, and check for stability including overturning, sliding and bearing capacity failures

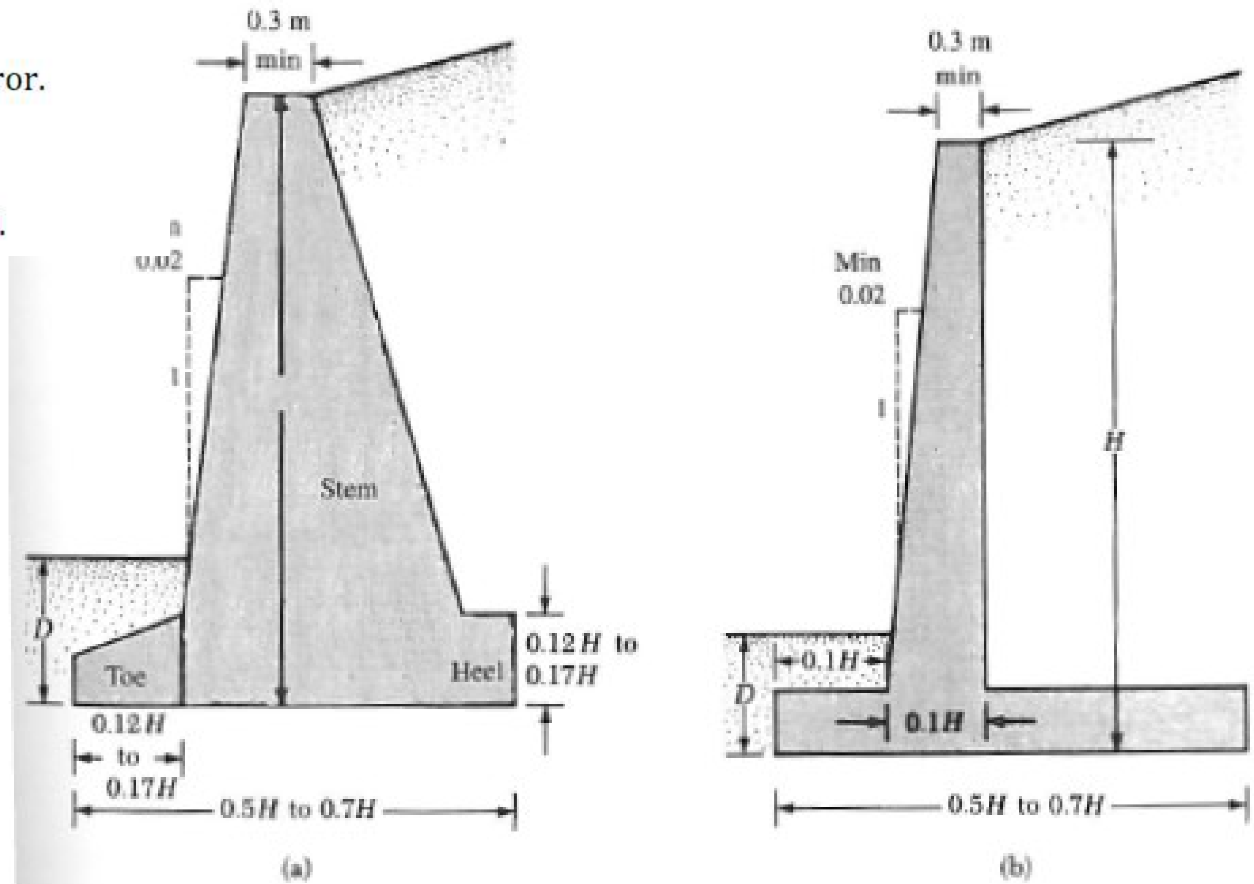
  -.Use lateral earth pressure theory and bearing capacity theory

- Check each component of the structure for adequate strength and determine the steel reinforcement of each component

Proportioning Retaining Wall

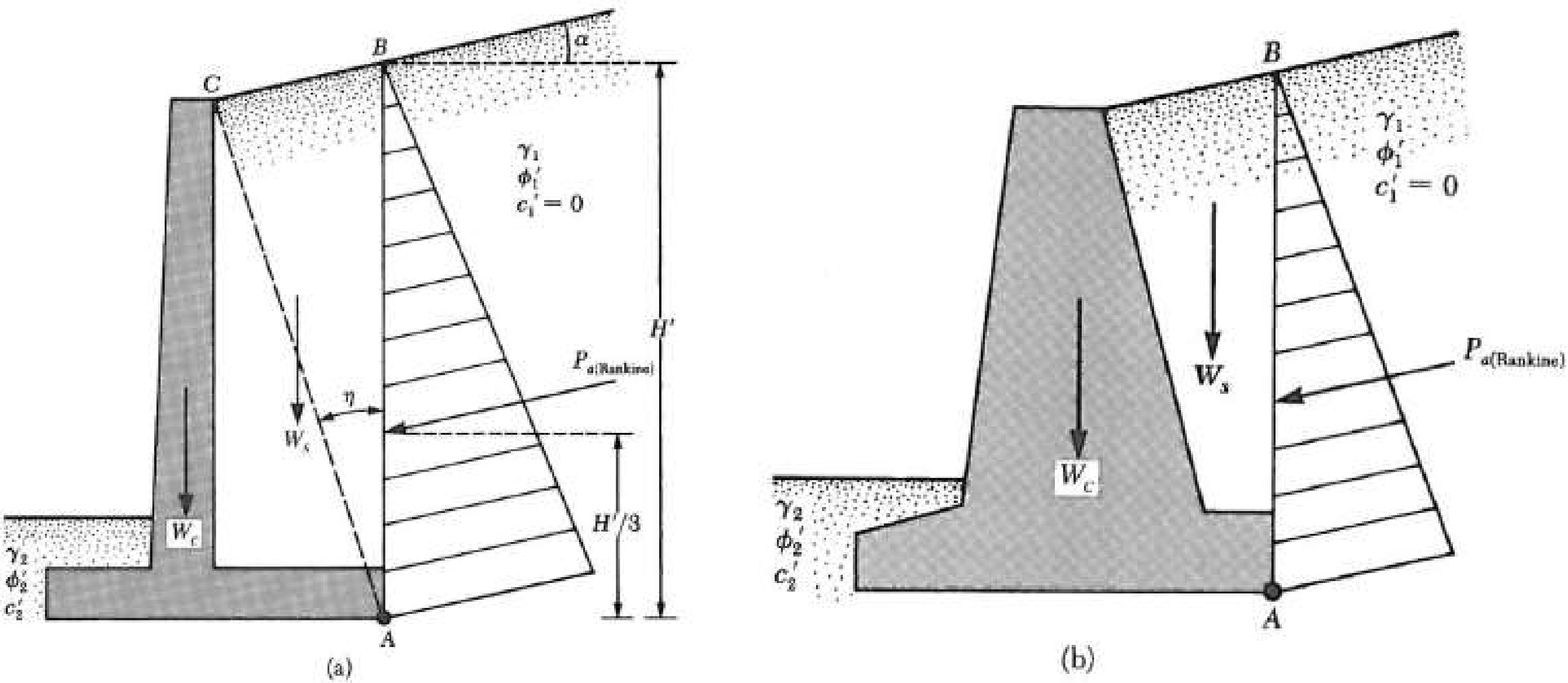
Assume the dimensions first – proportioning

- And then check the stability, essential try-and-error.
- Minimum
  - Top: 0.3m; D: 0.6m
  - Counter-fort slabs: 0.3m thick spaced at 0.3H-0.7H.



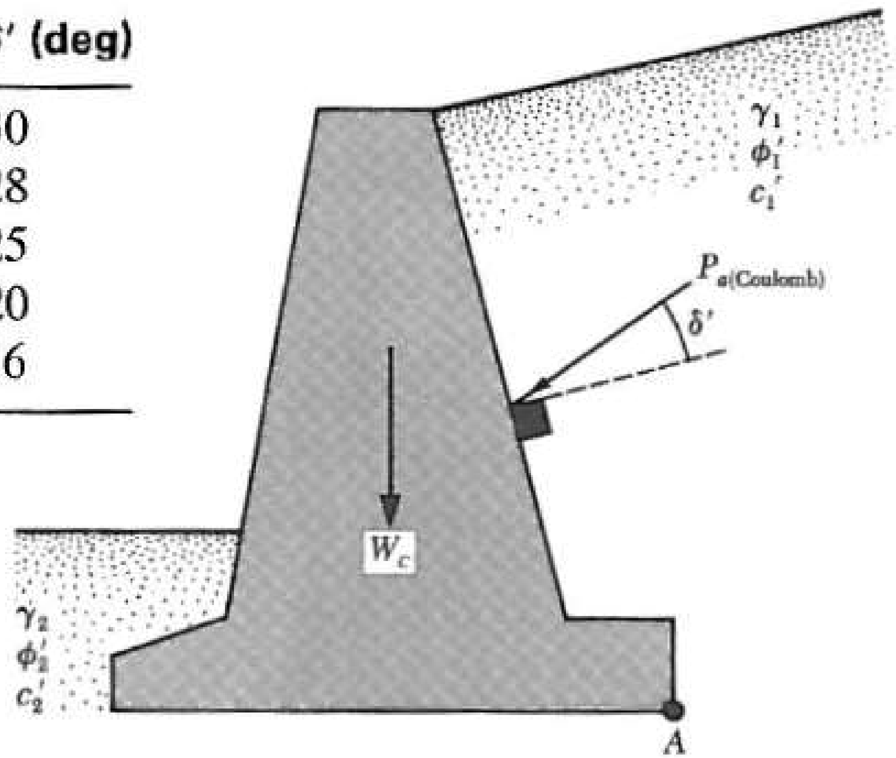
- Use of lateral earth pressure theories
  - Simplifications and approximations
    - Vertical plane AB
    - Rankine's active earth pressure
    - W_s and W_c counted.

$$\eta = 45 + \frac{\alpha}{2} - \frac{\phi_1'}{2} - \sin^{-1}\left(\frac{\sin\alpha}{\sin\phi_1'}\right)$$



Coulomb's active pressure theory

Backfill material	Range of δ' (deg)
Gravel	27–30
Coarse sand	20–28
Fine sand	15–25
Stiff clay	15–20
Silty clay	12–16

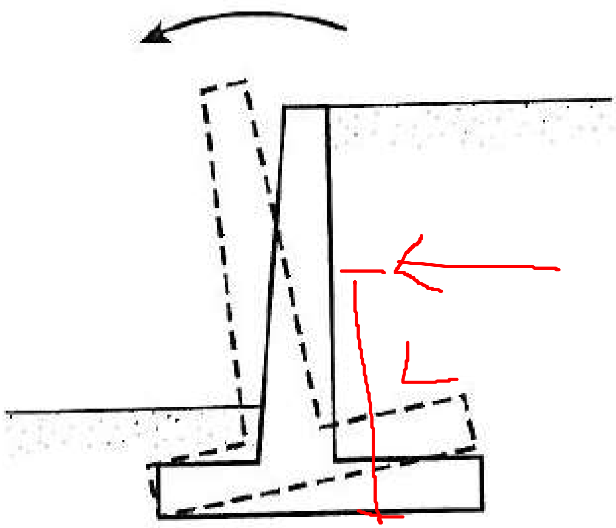


(c)

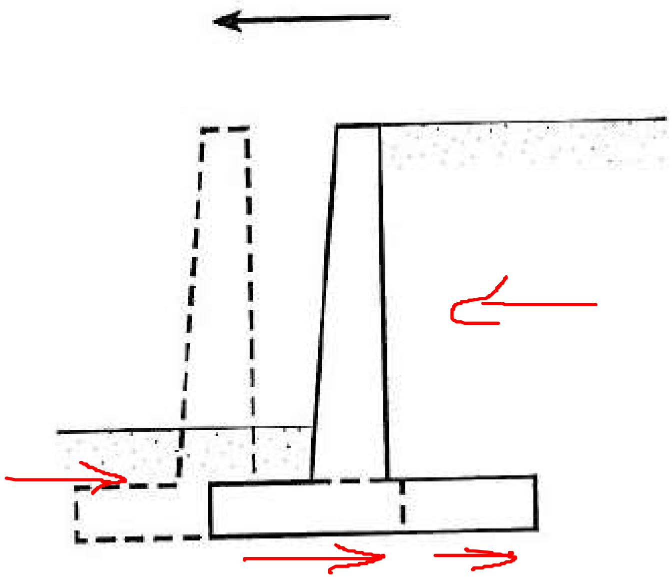
Main steps for stability check

1. Check for overturning about its toe (a)

2. Check for sliding failure along its base (b)



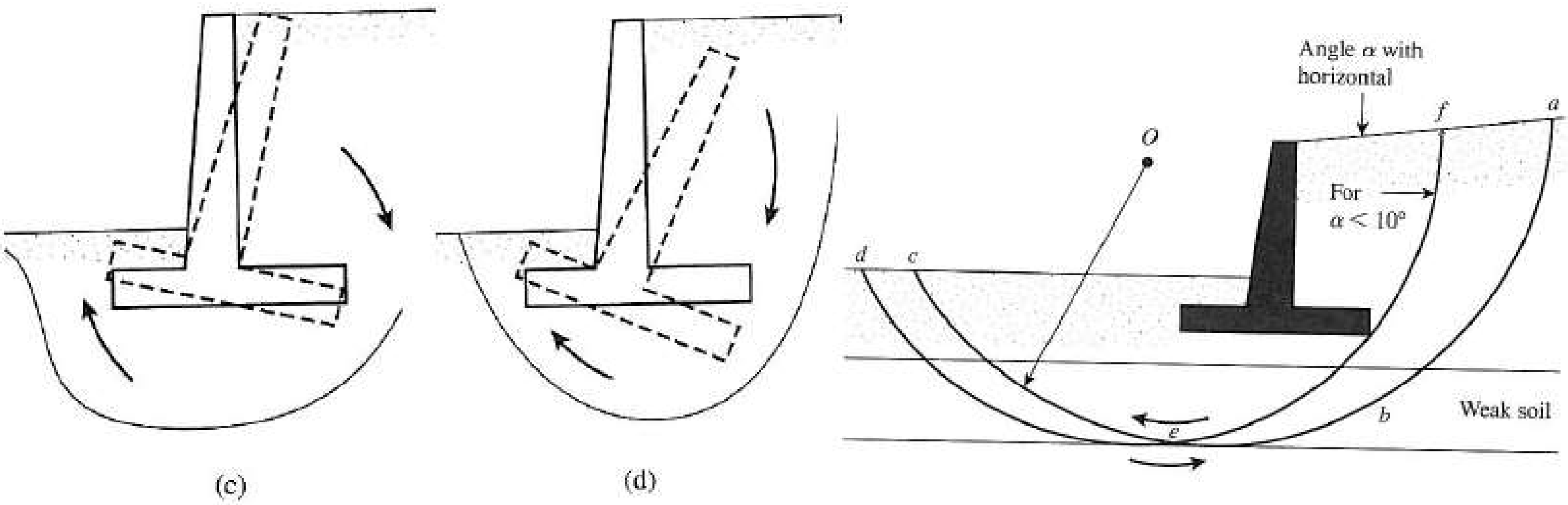
(a)



(b)

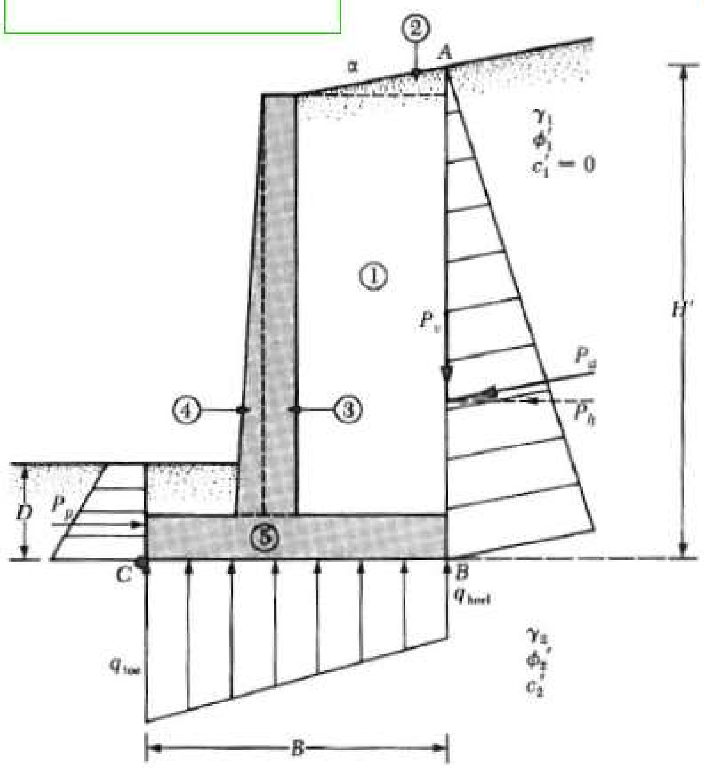
Main steps for stability check

3. Check for bearing capacity failure of the base
   - Bearing capacity failure (c)
   - Deep seated shear failure (d)
4. Check for excessive settlement
5. Check for overall stability



(1). Stability against Overturning

Cantilever Retaining wall



Rankine's active pressure acting on AB;

Rankine's pasive pressure acting on the vertical line at the toe;

$$P_p = \frac{1}{2} K_p \gamma_2 D^2 + 2c_2' \sqrt{K_p} D$$

$$FS_{(\text{overturning})} = \frac{\sum M_R}{\sum M_o}$$

$$\sum M_o = P_h \left(\frac{H'}{3} \right)$$

$$P_h = P_a \cos \alpha$$

$$\sum M_R$$

$$P_v = P_a \sin\alpha$$

$$M_v = P_v B = P_a \sin\alpha B$$

Procedure for calculation of $\sum M_R$

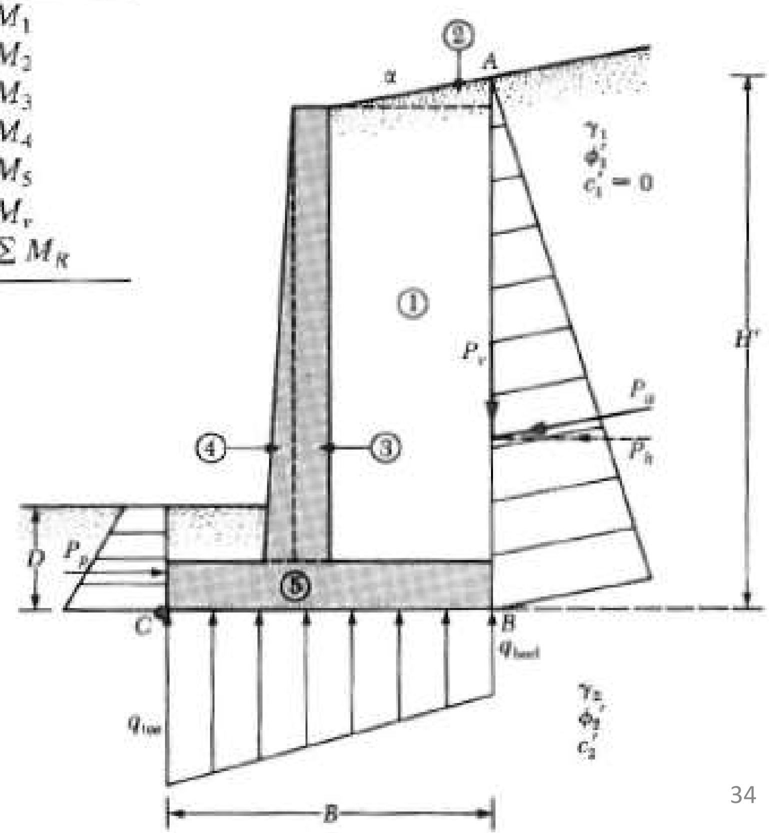
Section (1)	Area (2)	Weight/unit length of wall (3)	Moment arm measured from C (4)	Moment about C (5)
1	A_1	$W_1 = \gamma_1 \times A_1$	X_1	M_1
2	A_2	$W_2 = \gamma_1 \times A_2$	X_2	M_2
3	A_3	$W_3 = \gamma_c \times A_3$	X_3	M_3
4	A_4	$W_4 = \gamma_c \times A_4$	X_4	M_4
5	A_5	$W_5 = \gamma_c \times A_5$	X_5	M_5
		P_v	B	M_v
		$\sum V$		$\sum M_R$

Note: γ_1 = unit weight of backfill
γ_c = unit weight of concrete

$$FS_{(\text{overturning})} = \frac{M_1 + M_2 + M_3 + M_4 + M_5 + M_v}{P_a \cos\alpha (H'/3)}$$

$$FS_{(\text{overturning})} = \frac{M_1 + M_2 + M_3 + M_4 + M_5}{P_a \cos\alpha (H'/3) - M_v}$$

$$FS_{(\text{overturning})} \approx 1.5 \sim 2.0$$



Gravity Retaining wall

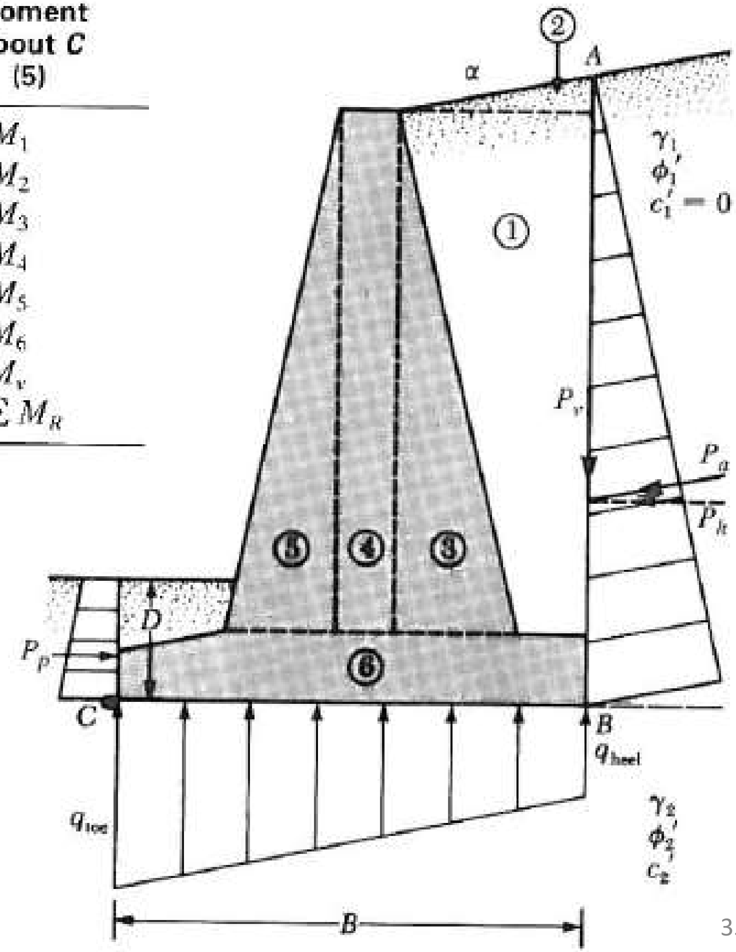
Table 13.1 Procedure for calculation of $\sum M_R$

Section (1)	Area (2)	Weight/unit length of wall (3)	Moment arm measured from C (4)	Moment about C (5)
1	A_1	$W_1 = \gamma_1 \times A_1$	X_1	M_1
2	A_2	$W_2 = \gamma_1 \times A_2$	X_2	M_2
3	A_3	$W_3 = \gamma_c \times A_3$	X_3	M_3
4	A_4	$W_4 = \gamma_c \times A_4$	X_4	M_4
5	A_5	$W_5 = \gamma_c \times A_5$	X_5	M_5
6	A_6	$W_6 = \gamma_c \times A_6$	X_6	M_6
		P_v	B	M_v
		$\sum V$		$\sum M_R$

Note: γ_1 = unit weight of backfill
γ_c = unit weight of concrete

$$FS_{(\text{overturning})} = \frac{M_1 + M_2 + M_3 + M_4 + M_5 + M_6 + M_v}{P_a \cos\alpha (H'/3)}$$

$$FS_{(\text{overturning})} = \frac{M_1 + M_2 + M_3 + M_4 + M_5 + M_6}{P_a \cos\alpha (H'/3) - M_v}$$



(2). Stability against Sliding along the base

- The factor of safety against sliding

$$FS_{(\text{sliding})} = \frac{\sum F_{R'}}{\sum F_d} \qquad \tau_f = \sigma' \tan \phi_2' + c_2'$$

$$R' = \tau_f \left(\text{area of cross section}\right)$$

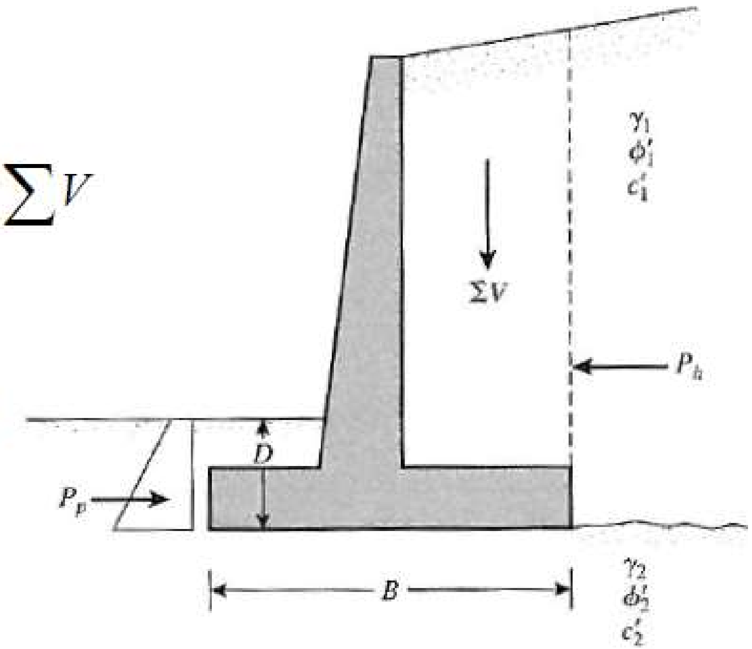
$$= \tau_f \left(B \times 1\right) = B\sigma' \tan \phi_2' + Bc_2'$$

$$B\sigma' = \text{sum of the verticle force} = \sum V$$

$$R' = \left(\sum V\right) \tan \phi_2' + Bc_2'$$

$$\sum F_{R'} = \left(\sum V\right) \tan \phi_2' + Bc_2' + P_p$$

$$\sum F_d = P_a \cos \alpha$$



$$FS_{(\text{sliding})} = \frac{\left(\sum V\right)\tan\phi_2' + Bc_2' + P_p}{P_a \cos\alpha} \geq 1.5$$

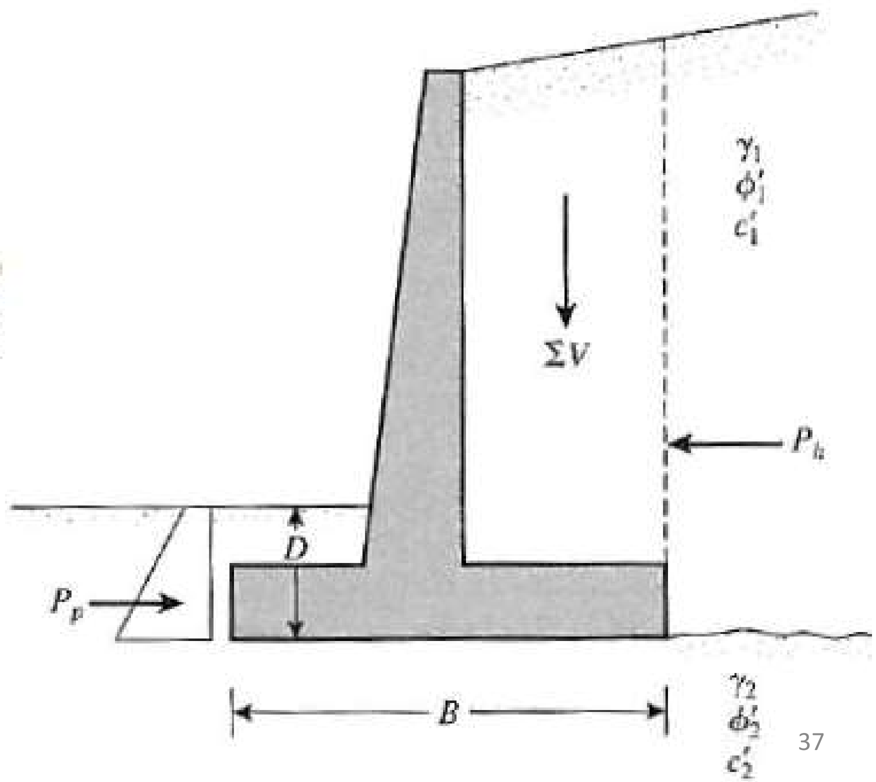
Without a base key

$$P_p = \frac{1}{2}\gamma_2 D^2 K_p + 2c_2' D\sqrt{K_p}$$

Ignore P_p and reduce ϕ_2' and c_2'

$$FS_{(\text{sliding})} = \frac{\left(\sum V\right)\tan\left(k_1\phi_2'\right) + Bk_2c_2'}{P_a \cos\alpha}$$

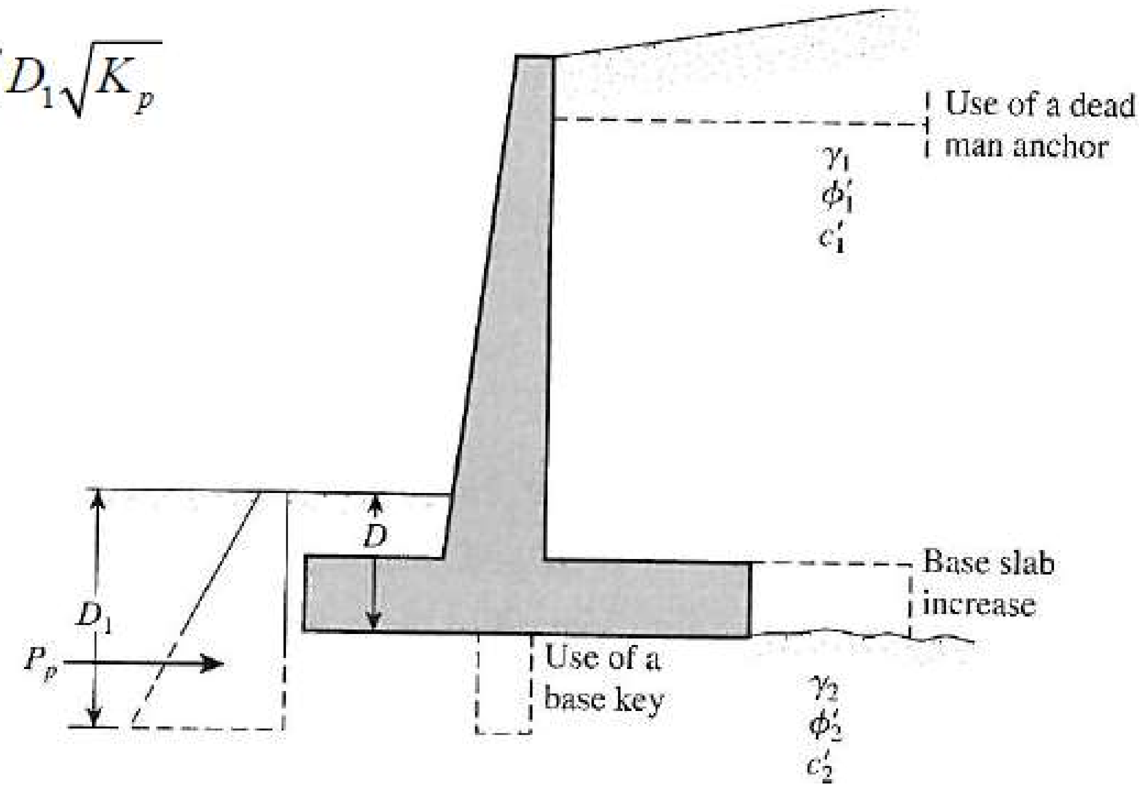
$$\left(\frac{1}{2} \leq k_1, k_2 \leq \frac{2}{3}\right)$$



- Use a base key (normally some main steel) to increase stability

$$P_p = \frac{1}{2}\gamma_2 D_1^2 K_p + 2c_2' D_1 \sqrt{K_p}$$

$$D_1 > D$$



(3). Stability against Bearing Capacity

$$\vec{R} = \overrightarrow{\sum V} + \overrightarrow{(P_a \cos\alpha)}$$

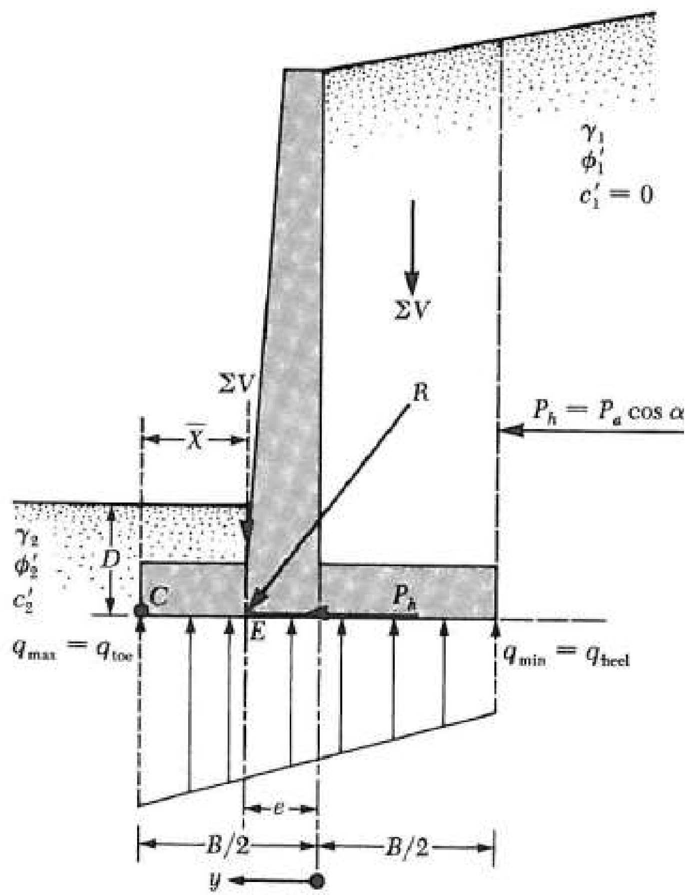
$$M_{\text{net}} = \sum M_R - \sum M_o \qquad \overline{CE} = \overline{X} = \frac{M_{\text{net}}}{\sum V}$$

$$e = \frac{B}{2} - \overline{CE} \qquad q = \frac{\sum V}{A} \pm \frac{M_{\text{net}}\, y}{I}$$

$$q_{\max} = q_{\text{toe}} = \frac{\sum V}{(B)(1)} + \frac{e\left(\sum V\right)\frac{B}{2}}{\left(\frac{1}{12}\right)(B^3)} = \frac{\sum V}{B}\left(1 + \frac{6e}{B}\right)$$

$$q_{\min} = q_{\text{heel}} = \frac{\sum V}{B}\left(1 - \frac{6e}{B}\right)$$

$\frac{e}{B} \geq \frac{1}{6}, q_{\min} \leq 0$ Needs re-proportioning



$$q_u = c_2' N_c F_{cd} F_{ci} + q N_q F_{qd} F_{qi} + \frac{1}{2}\gamma_2 B' N_\gamma F_{\gamma d} F_{\gamma i}$$

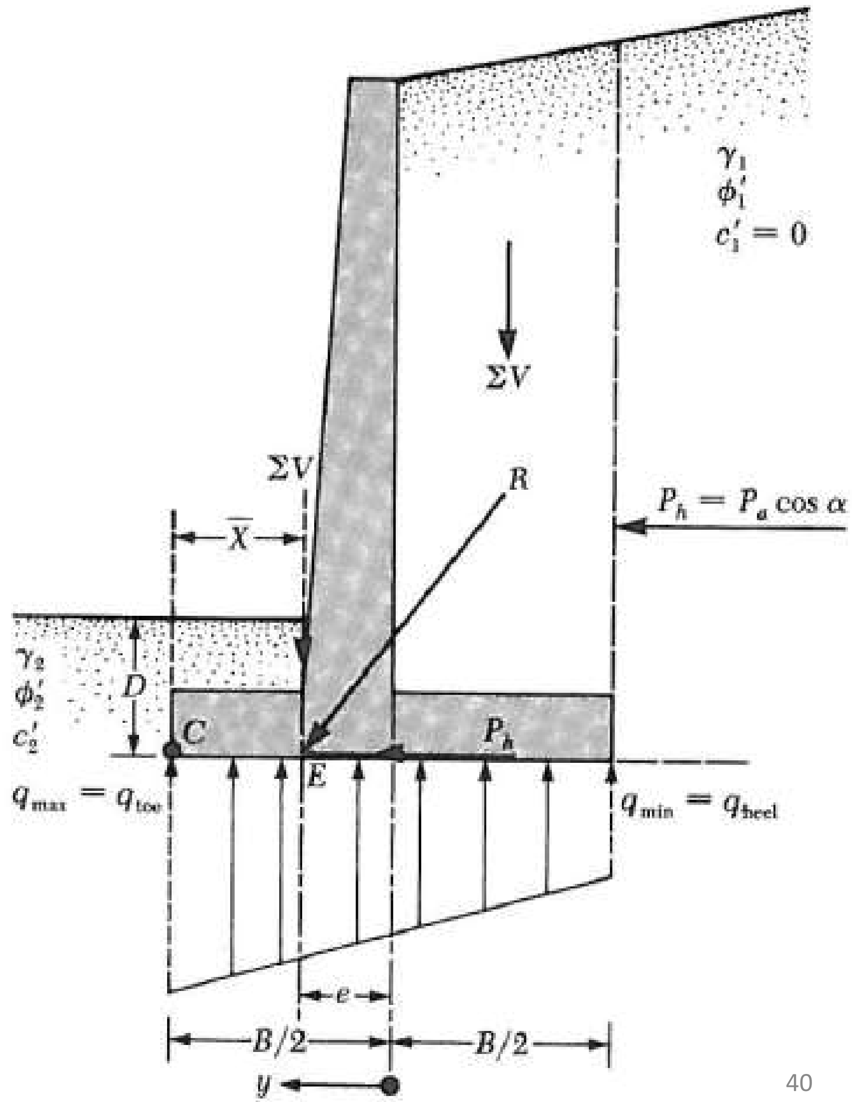
$$q = \gamma_2 D \qquad B' = B - 2e \qquad F_{cd} = 1 + 0.4\frac{D}{B'}$$

$$F_{qd} = 1 + 2\tan\phi_2' \left(1 - \sin\phi_2'\right)^2 \frac{D}{B'} \qquad F_{\gamma d} = 1$$

$$F_{ci} = F_{qi} = \left(1 - \frac{\psi^\circ}{90^\circ}\right)^2 \qquad F_{\gamma i} = \left(1 - \frac{\psi^\circ}{\phi_2'^\circ}\right)^2$$

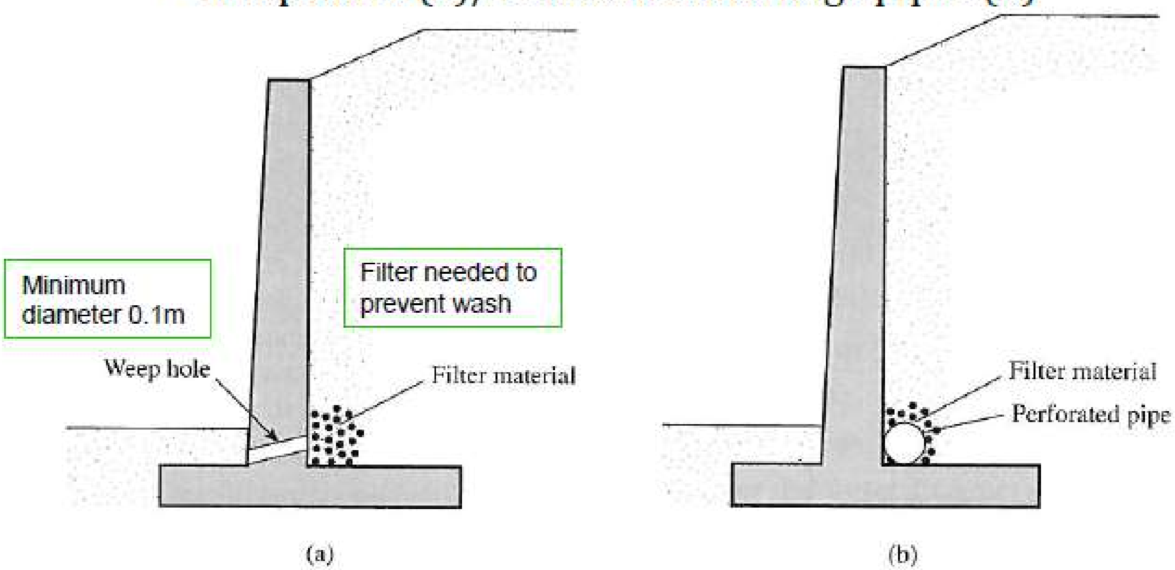
$$\psi^\circ = \tan^{-1}\left(\frac{P_a \cos\alpha}{\sum V}\right) \qquad F_{\gamma s} = F_{qs} = F_{cs} = 1$$

$$FS_{(\text{bearing capacity})} = \frac{q_u}{q_{max}}$$



Drainage

- Drainage from the backfill
  - Saturated soil (due to rainfall or other conditions) may increase the pressure on the wall
    - Create instability problem
  - Drainage types
    - Weep holes (a)/ Perforated drainage pipes (b)



- Drainage
  - Weep hole/perforated pipe
  - Need filter to prevent wash up of sand/clog
  - Factors on the choice of filter materials – the grain size distribution of backfill materials be such that
    - The soil to be protected is not washed into the filter
    - The excessive hydrostatic pressure head is not created in the soil with a lower hydraulic conductivity

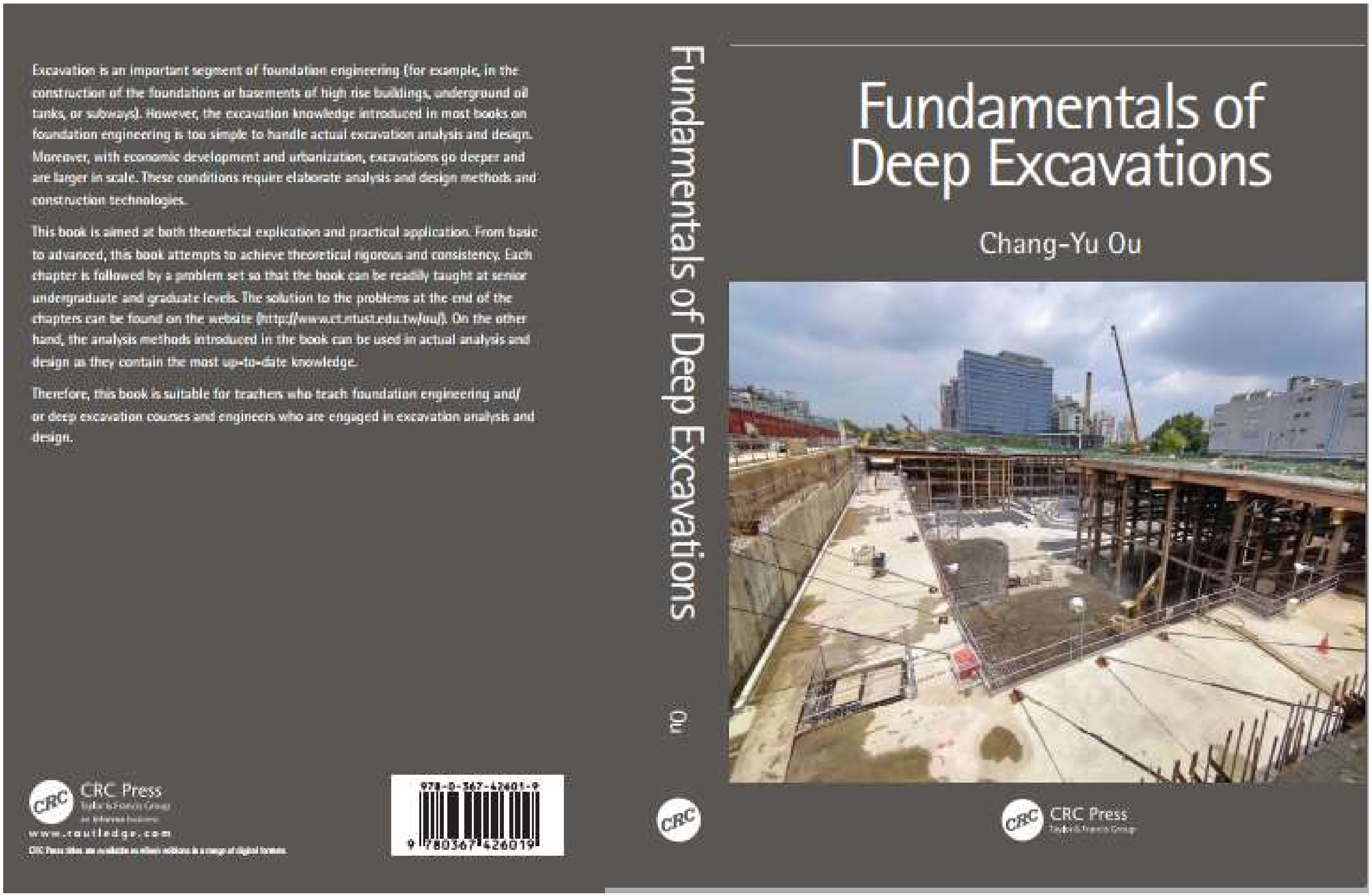
$$\frac{D_{15(F)}}{D_{85(B)}} < 5 \qquad [\text{to satisfy condition (a)}]$$

$$\frac{D_{15(F)}}{D_{15(B)}} > 4 \qquad [\text{to satisfy condition (b)}]$$

(Terzaghi and Peck, 1976)

F: Filter; B: Base.

D_{15}/D_{85}: the diameters through which 15% and 85% of the soil will pass


Excavation is an important segment of foundation engineering (for example, in the construction of the foundations or basements of high rise buildings, underground oil tanks, or subways). However, the excavation knowledge introduced in most books on foundation engineering is too simple to handle actual excavation analysis and design. Moreover, with economic development and urbanization, excavations go deeper and are larger in scale. These conditions require elaborate analysis and design methods and construction technologies.
This book is aimed at both theoretical explication and practical application. From basic to advanced, this book attempts to achieve theoretical rigorous and consistency. Each chapter is followed by a problem set so that the book can be readily taught at senior undergraduate and graduate levels. The solution to the problems at the end of the chapters can be found on the website (http://www.ct.ntust.edu.tw/ou/). On the other hand, the analysis methods introduced in the book can be used in actual analysis and design as they contain the most up-to-date knowledge.
Therefore, this book is suitable for teachers who teach foundation engineering and/or deep excavation courses and engineers who are engaged in excavation analysis and design.
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Fundamentals of Deep Excavations
Ou
Fundamentals of Deep Excavations
Chang-Yu Ou
CRC Press
Taylor & Francis Group

Deep Excavation

Terzaghi (1943):
Whose excavation depths were larger than their widths

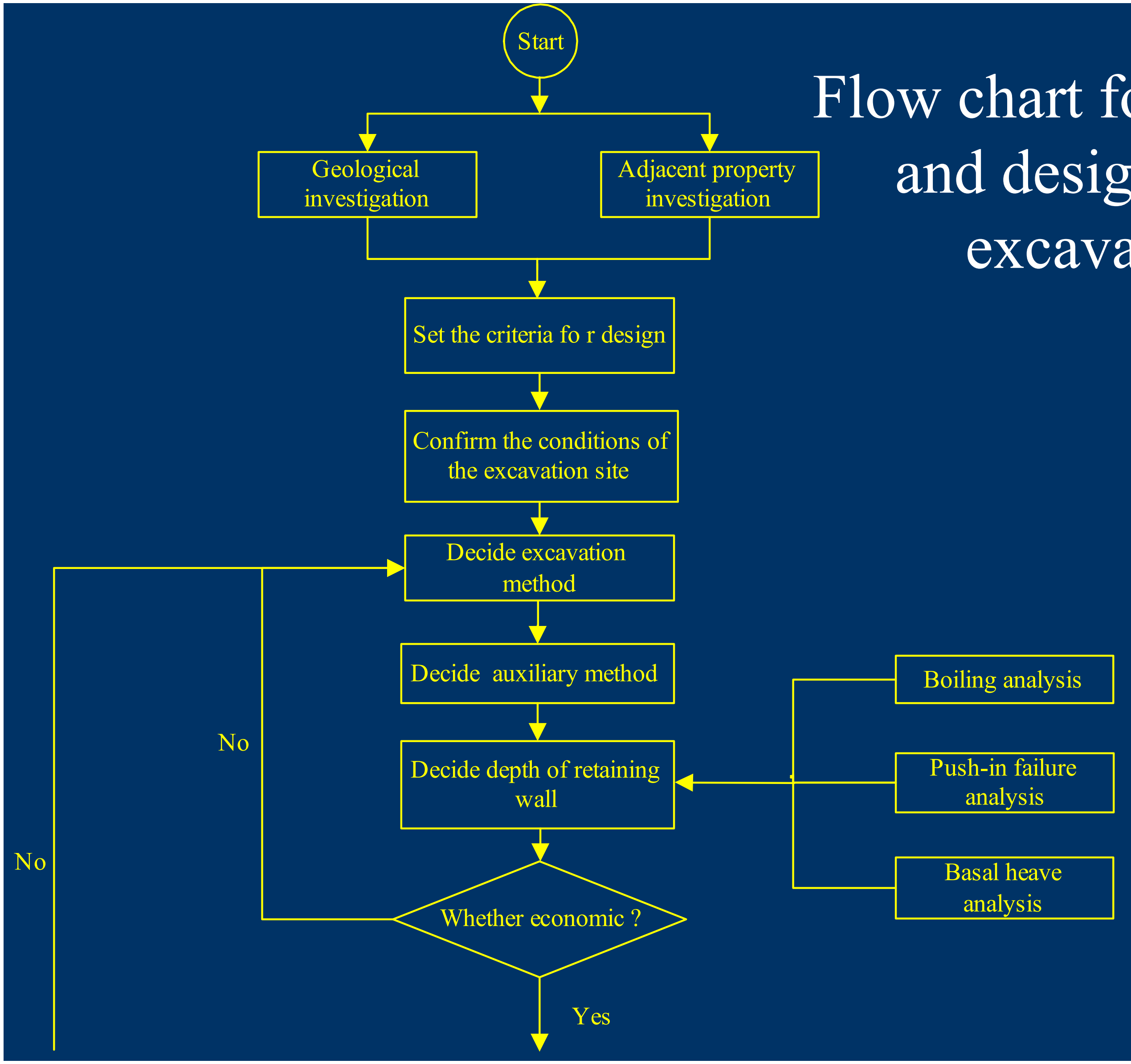
Terzaghi and Peck (1967) ; Peck et al. (1977):
Whose depths were deeper than 6 meters.

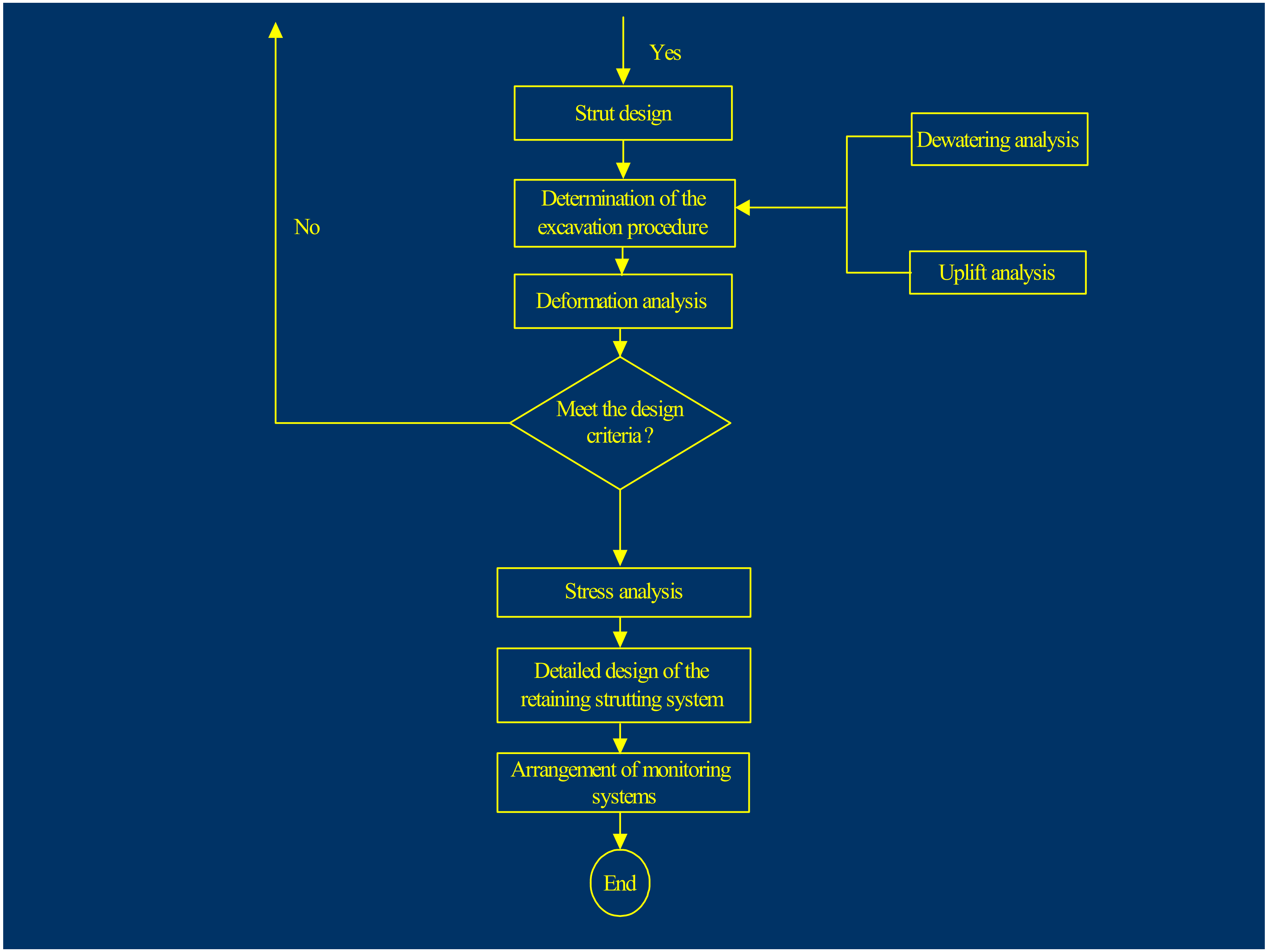
Deep Excavation

A complete deep excavation design includes :

- Retaining system
- Strutting system
- Dewatering system
- Excavation procedure
- Monitoring system
- Building protection

Flow chart for analysis and design of an excavation




Yes
No
Strut design
Dewatering analysis
Determination of the excavation procedure
Uplift analysis
Deformation analysis
Meet the design criteria ?
Stress analysis
Detailed design of the retaining strutting system
Arrangement of monitoring systems
End