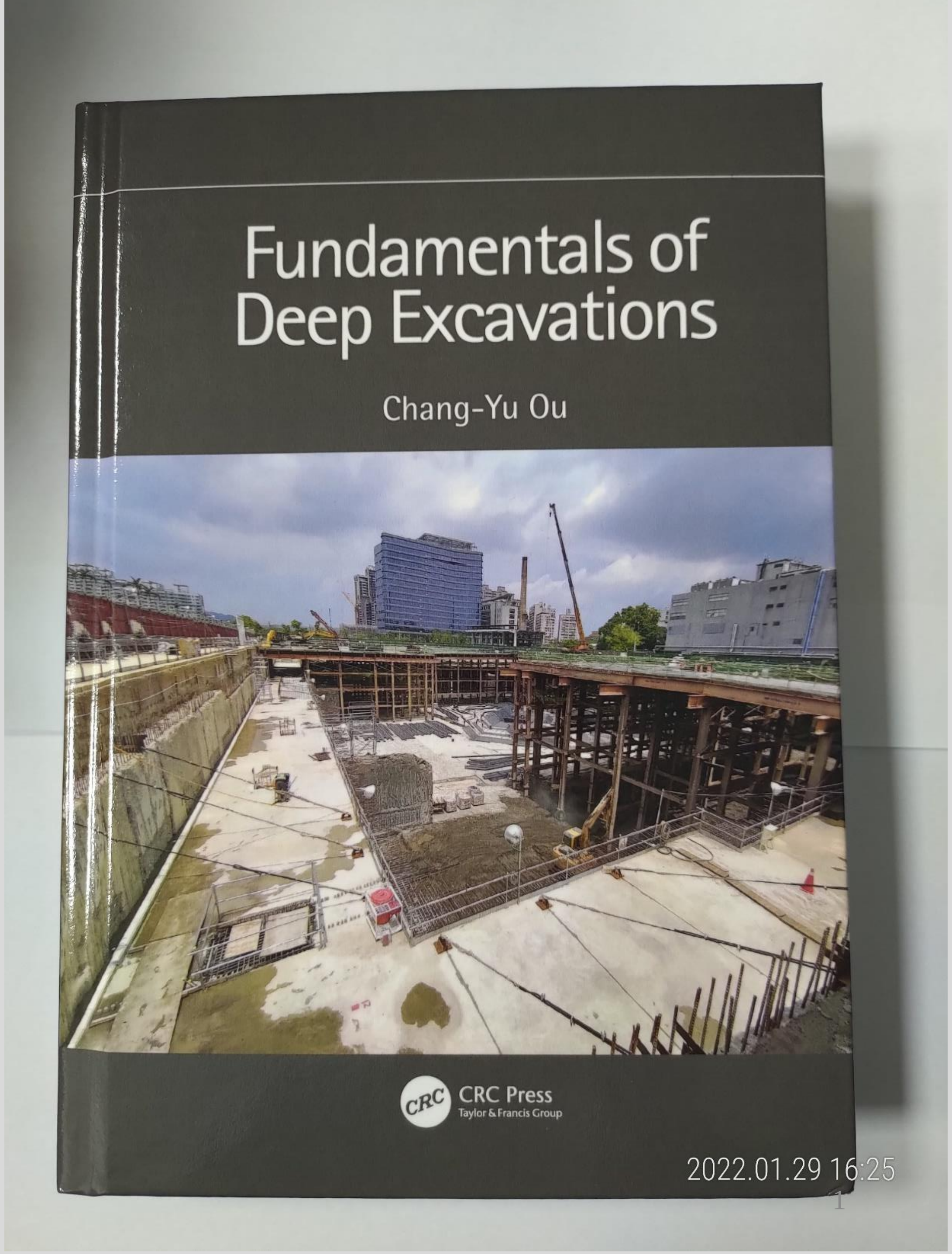
Chapter 1

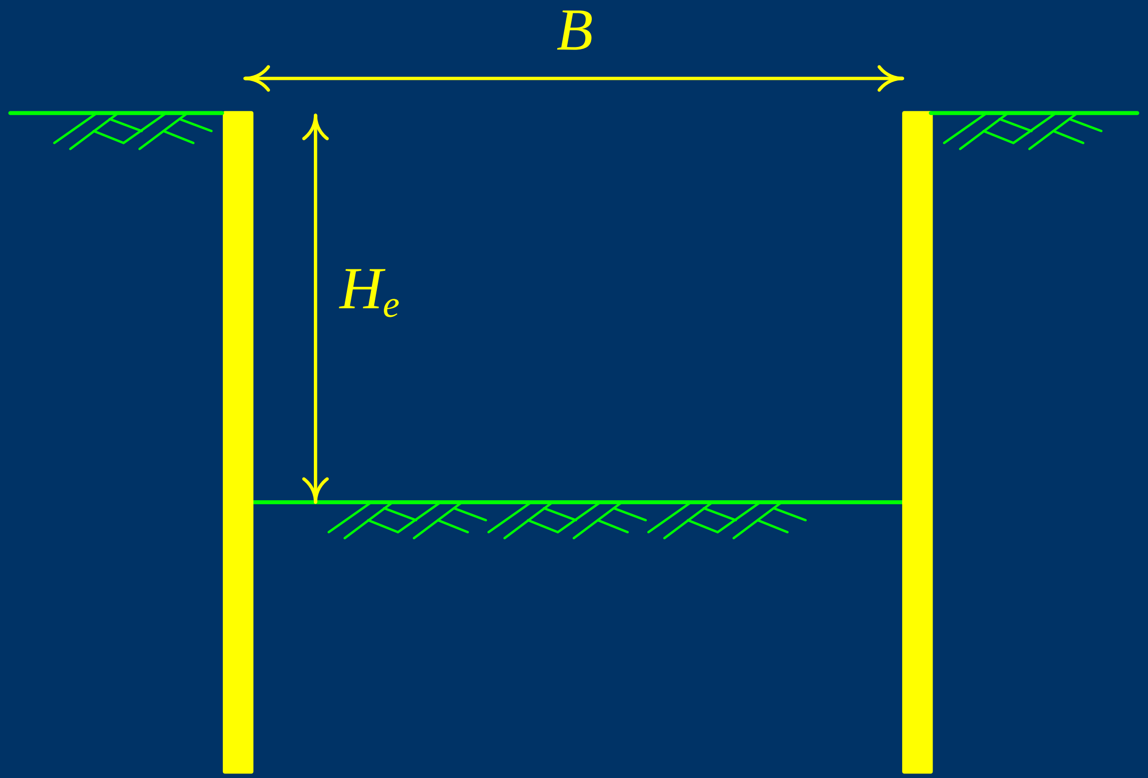
Introduction to the Analysis and Design of Excavations



Definition of deep excavation ：

Terzaghi(1943) :
Those excavation depths were larger than their widths ($H_e > B$)

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



Since modern geotechnical software has done most of the job of analysis and design, which applies to all excavation depths, following the same theories, it is not meaningful to distinguish between deep and shallow excavations.

A complete deep excavation design includes a retaining system, a strutting system, a dewatering system, excavation procedure, a monitoring system, building protection, etc. Figure 1.1 illustrates the general course of deep excavation design.

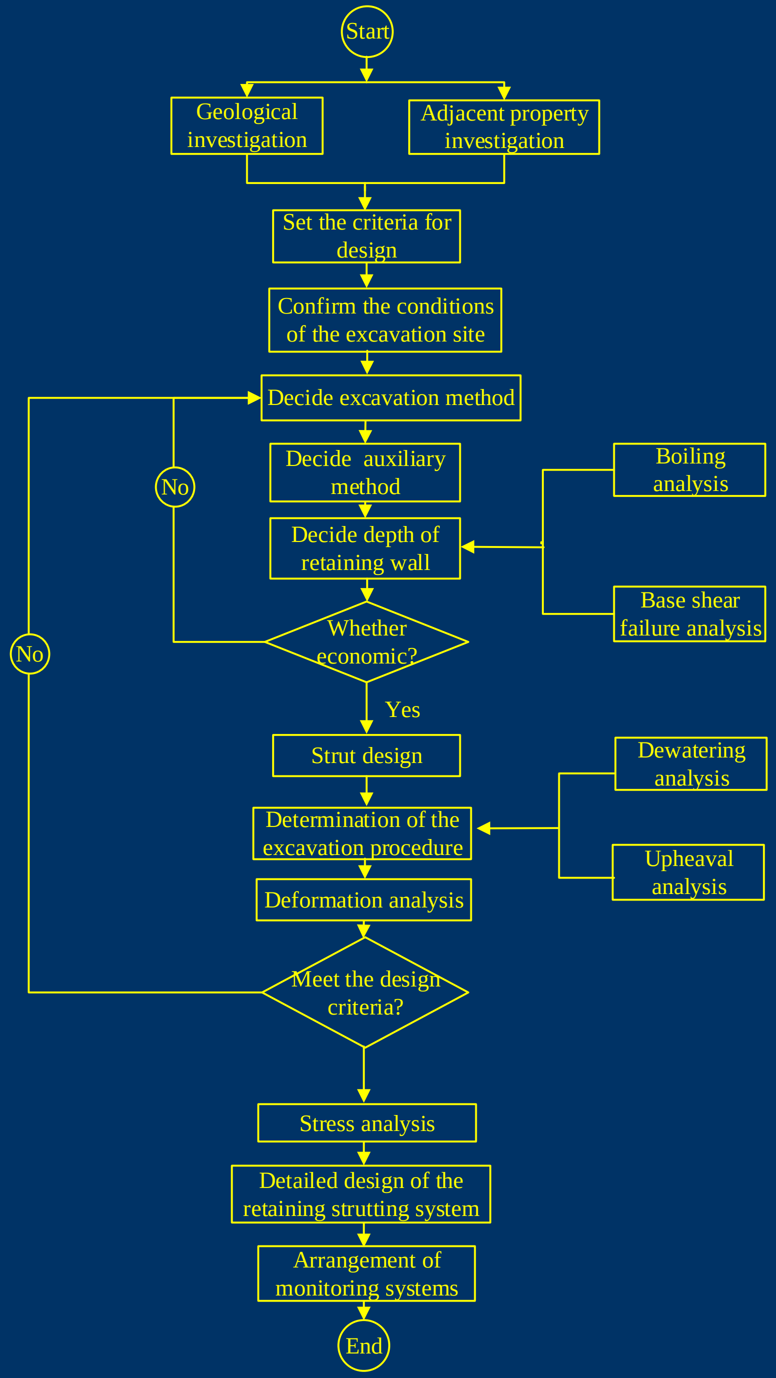
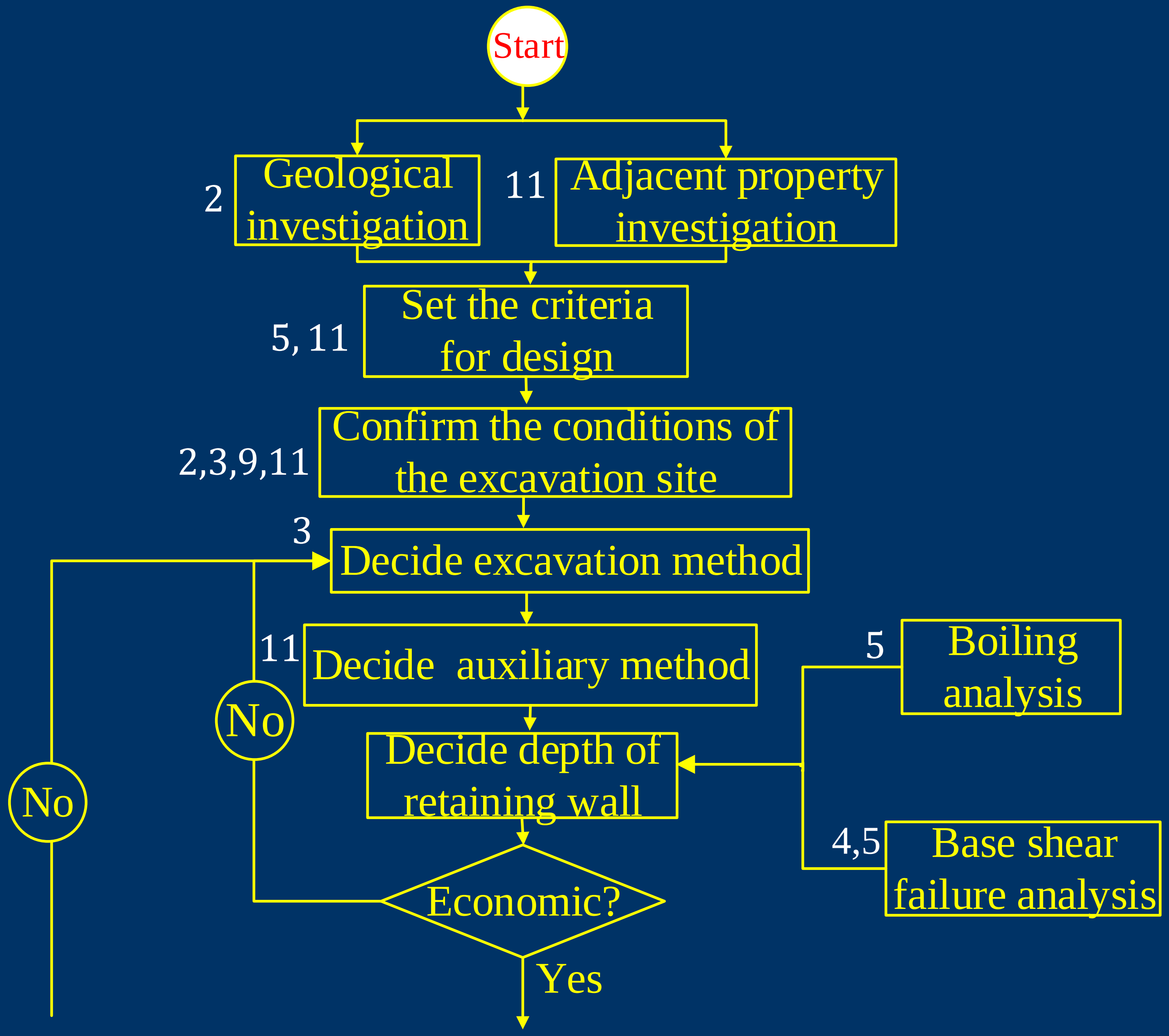
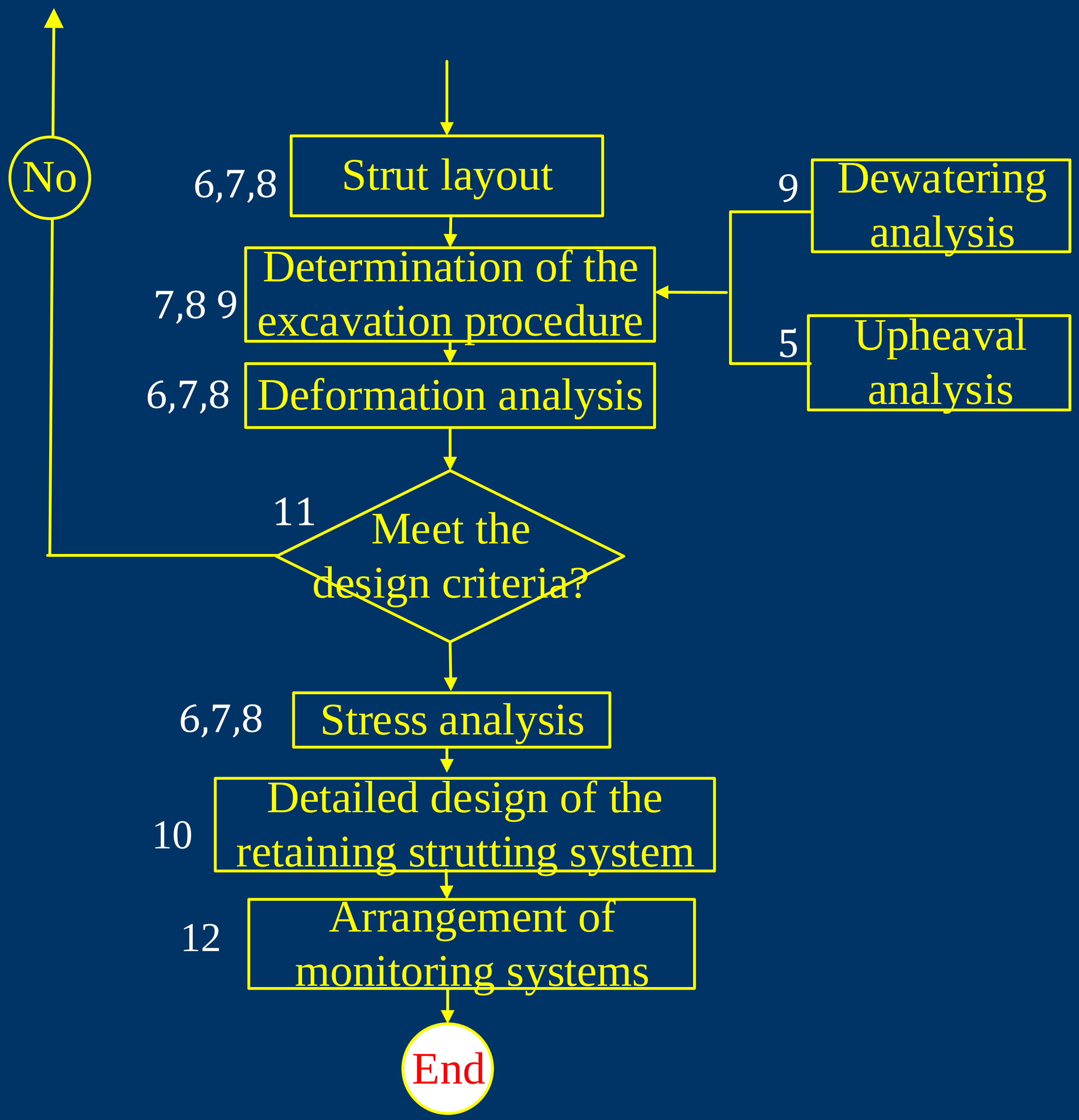


Figure 1.1 Flow chart for analysis and design of an excavation


Start
2
Geological investigation
11
Adjacent property investigation
5, 11
Set the criteria for design
2,3,9,11
Confirm the conditions of the excavation site
3
Decide excavation method
11
Decide auxiliary method
5
Boiling analysis
Decide depth of retaining wall
4,5
Base shear failure analysis
No
No
Economic?
Yes


No
6,7,8
Strut layout
7,8 9
Determination of the excavation procedure
6,7,8
Deformation analysis
9
Dewatering analysis
5
Upheaval analysis
11
Meet the design criteria?
6,7,8
Stress analysis
10
Detailed design of the retaining strutting system
12
Arrangement of monitoring systems
End

End of Chapter 1

Thank you for your attention!

Chapter 2

The specific gravity:

The unit weight:

The water content:

The Atterberg limits:

The permeability:

The compression and swelling indices:

The strength characteristics

Soil type	*LL*	*PL*	*PI*
Kaolinite	35~100	25~35	—
Illite	50~100	30~60	—
Montmorillonite	100~800	50~100	—
San Francisco bay mud (CH)	85~88	35~44	43~54
Boston blue clay (CL)	40~49	20~25	18~23
Chicago silty clay (CL)	30~42	17~22	14~20
London clay (CH)	70~80	24~29	47~70
Mexico city clay (MH)	425~550	57~150	300~493
Bangkok clay (CH)	76~102	29~47	23~27
Singapore marine clay (CH)	75~100	22~30	52~62
Shanghai clay (CL)	28~42	17~24	10~19
Taipei silty clay (CL)	25~40	17~24	8~16

2.5 Characteristics of drained shear strength of soils

2.6 Characteristics of undrained shear strength of saturated cohesive soils

- 2.6.1 Principle of undrained shear strength
- 2.6.2 Characteristics of undrained shear strength
- 2.6.3 Methods to obtain the undrained shear strength

2.7 Undrained shear strength of unsaturated cohesive soils

Chapters 2, 3, 9, 11

A thorough understanding of the conditions of the excavation site, including:

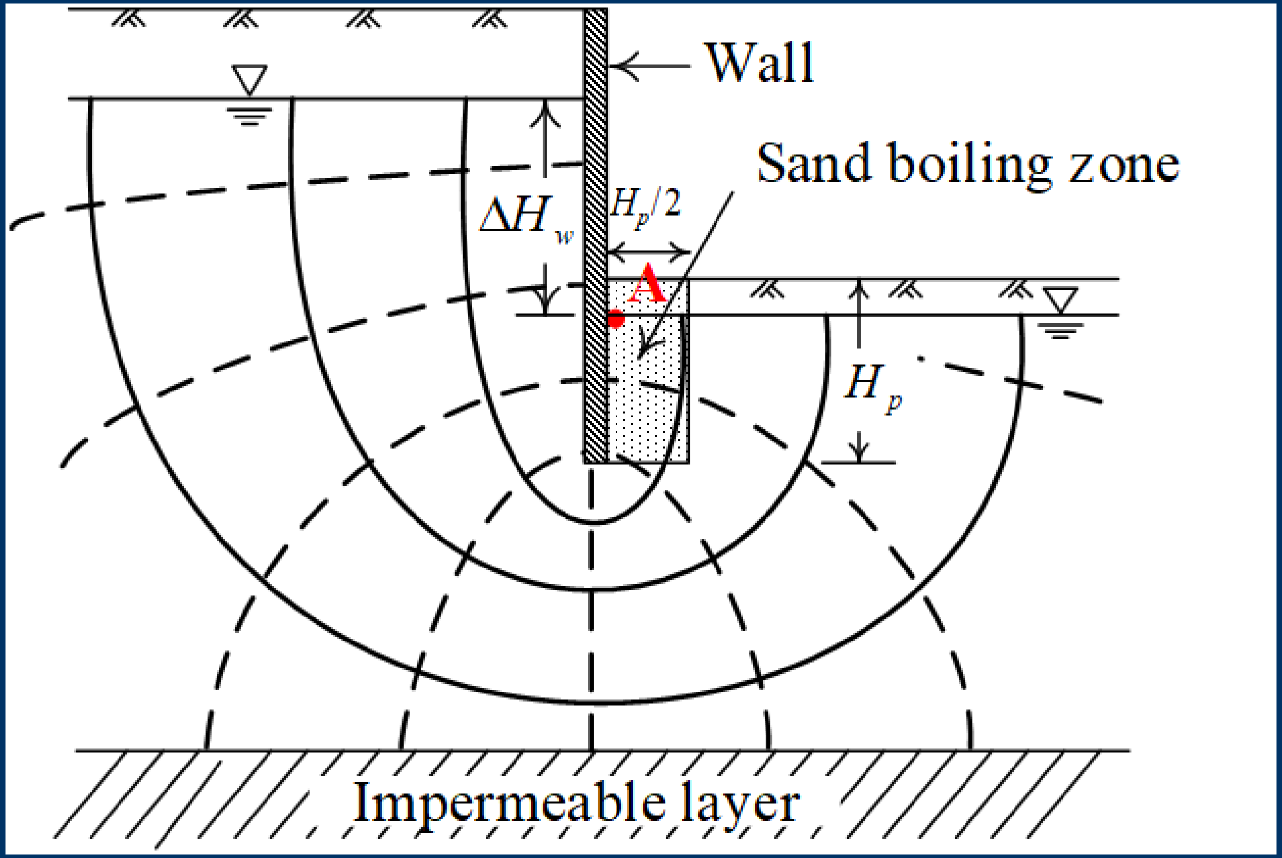
- Shape, area and elevation of the excavation site
- Geological conditions
- Condition of groundwater
- Condition of adjacent buildings

Determine a provisional retaining method and an excavation method

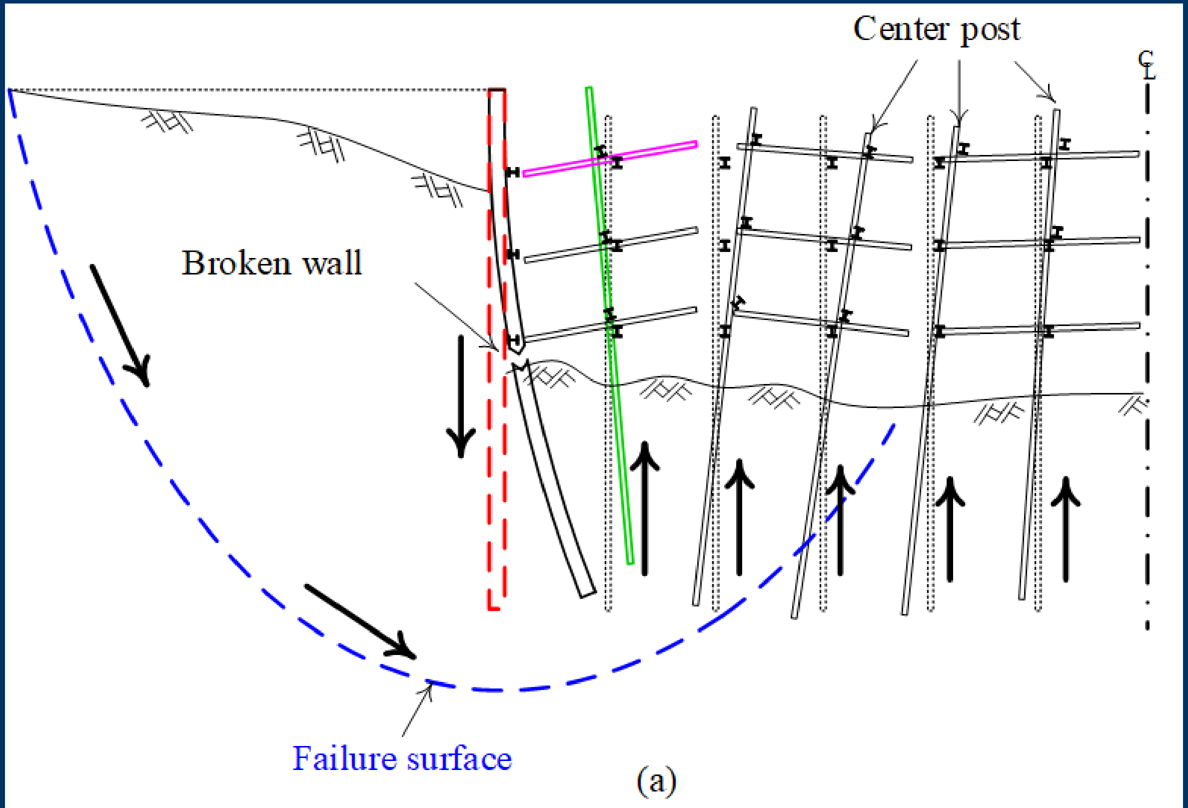
Chapter 3

Chapter 5

Sand boiling analysis

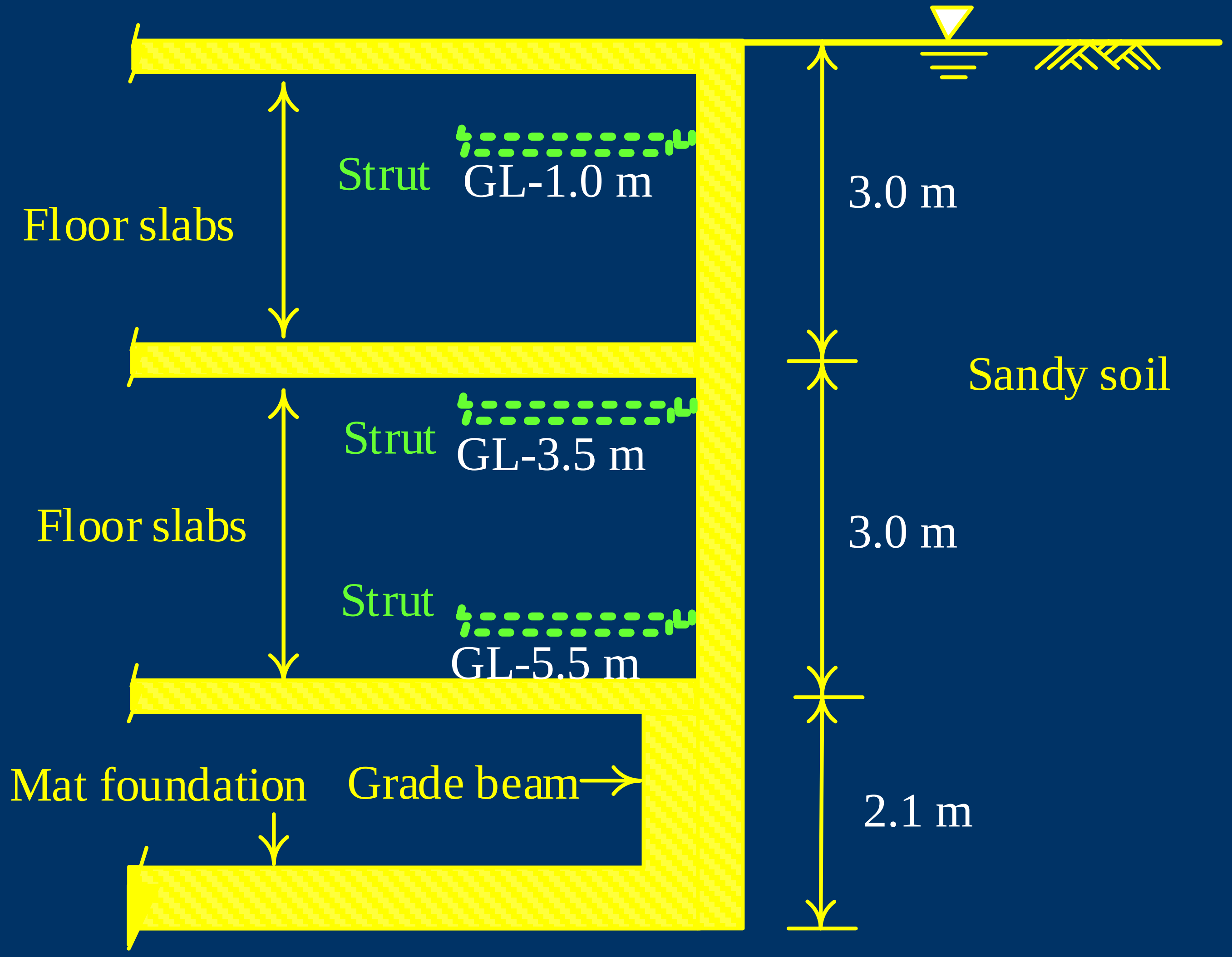


Base shear (basal heave) analysis

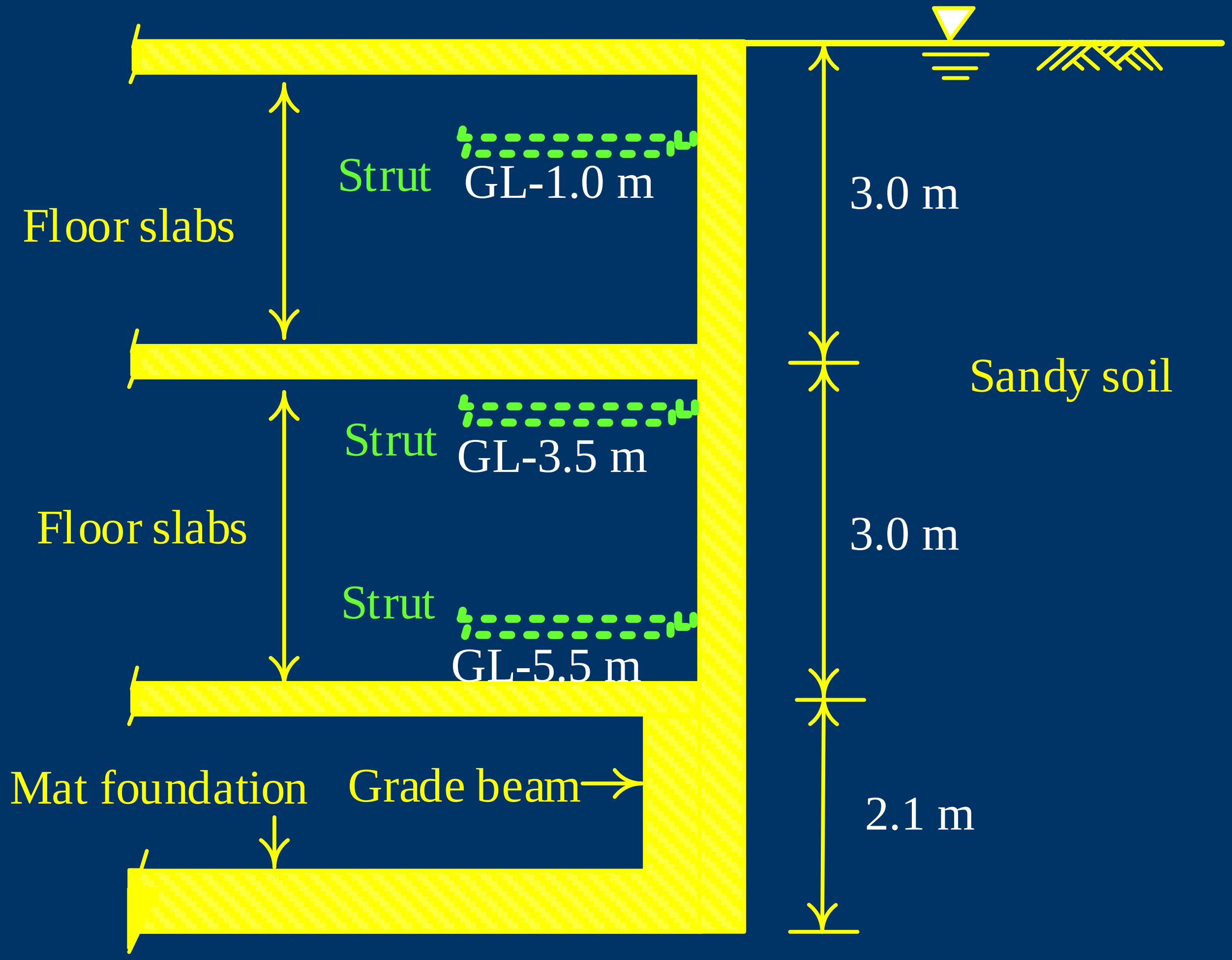


Chapter 7

The procedure of installation and of the later removal of the struts for the construction of floor slabs basically determines the locations and vertical distances of the struts.

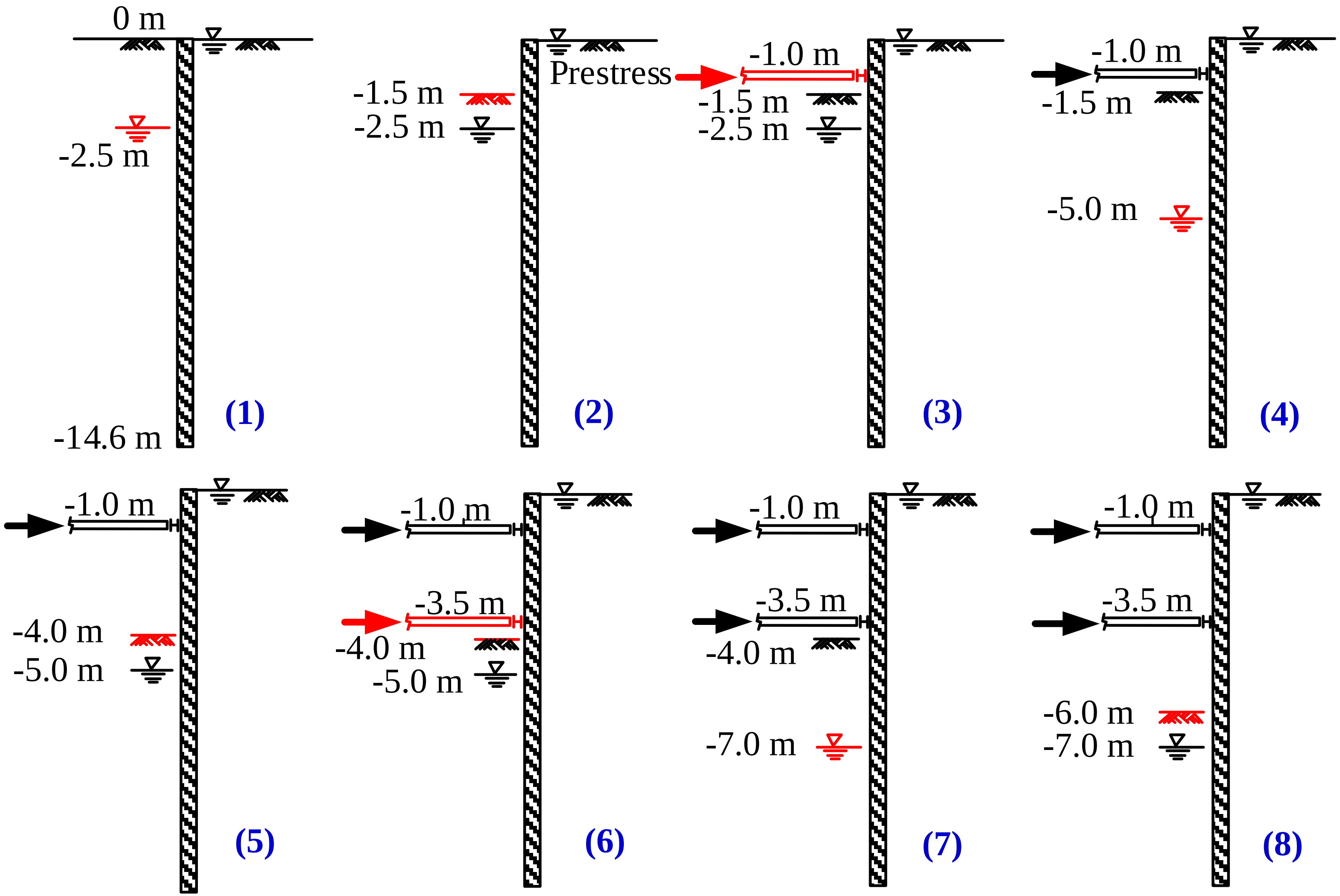


Chapters 7, 8



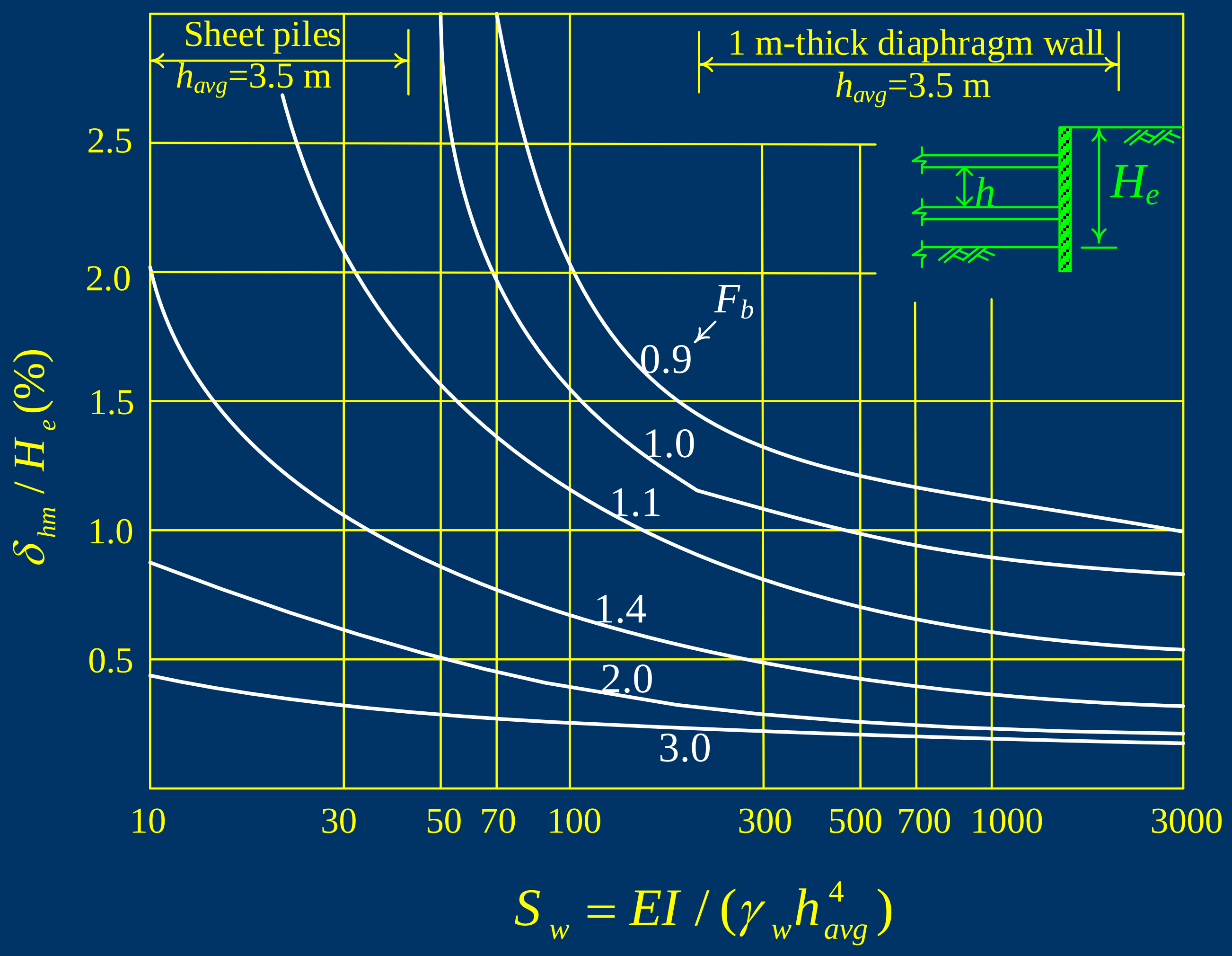
Strut
GL-1.0 m
Floor slabs
3.0 m
Sandy soil
Strut
GL-3.5 m
Floor slabs
3.0 m
Strut
GL-5.5 m
Mat foundation
Grade beam
2.1 m

Chapters 7, 8

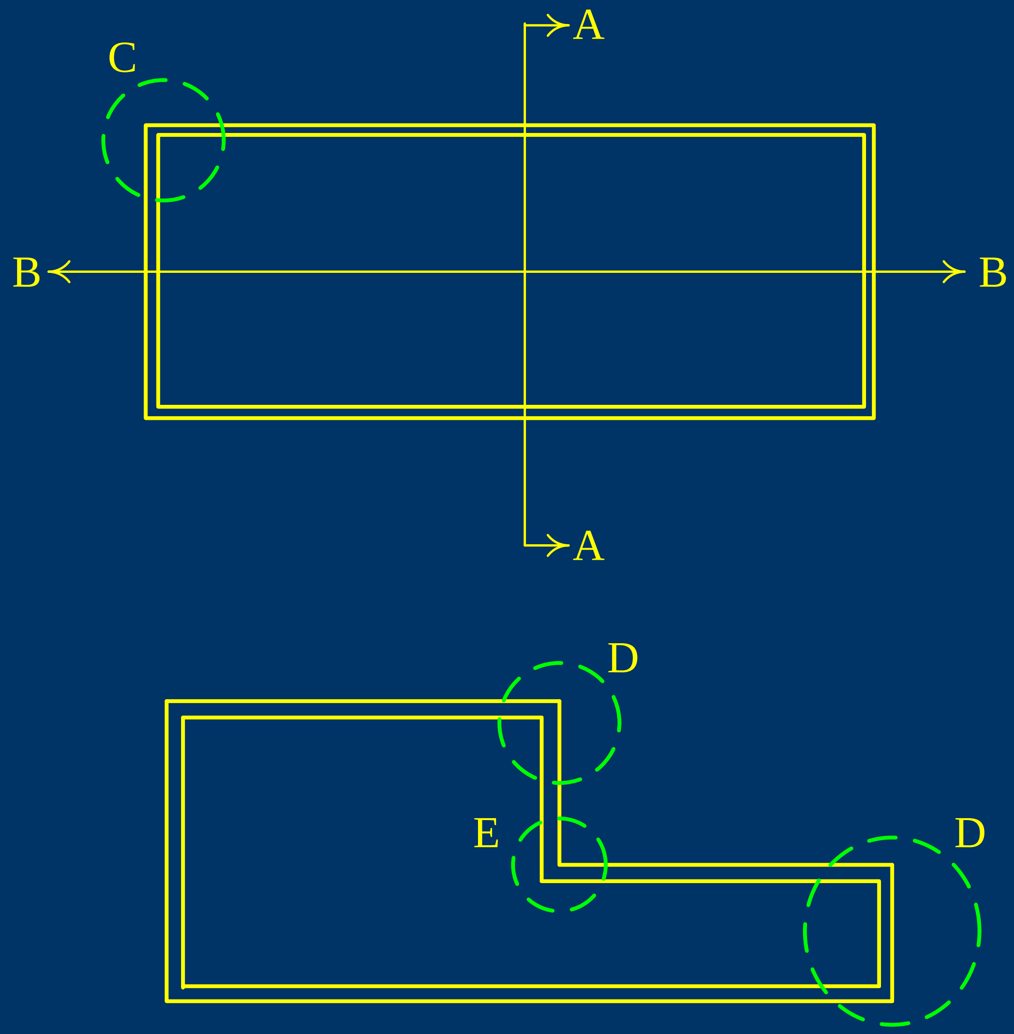


0 m
-2.5 m
-14.6 m
(1)
-1.5 m
-2.5 m
Prestress
(2)
-1.0 m
-1.5 m
-2.5 m
(3)
-1.0 m
-1.5 m
-5.0 m
(4)
-1.0 m
-4.0 m
-5.0 m
(5)
-1.0 m
-3.5 m
-4.0 m
-5.0 m
(6)
-1.0 m
-3.5 m
-4.0 m
-7.0 m
(7)
-1.0 m
-3.5 m
-6.0 m
-7.0 m
(8)

Clough and O'Rourke's chart



3D effect

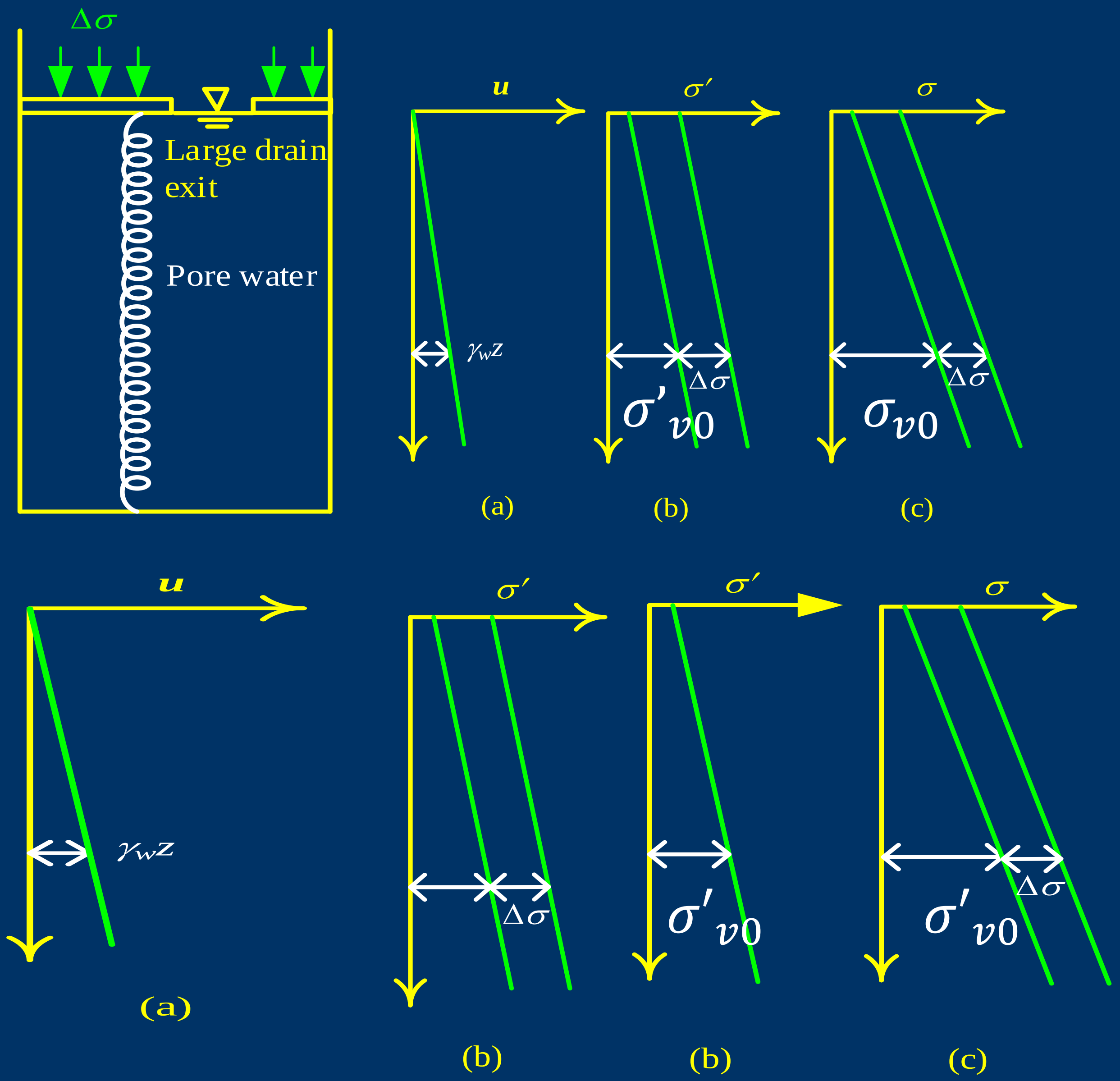


Chapters 2 and 8

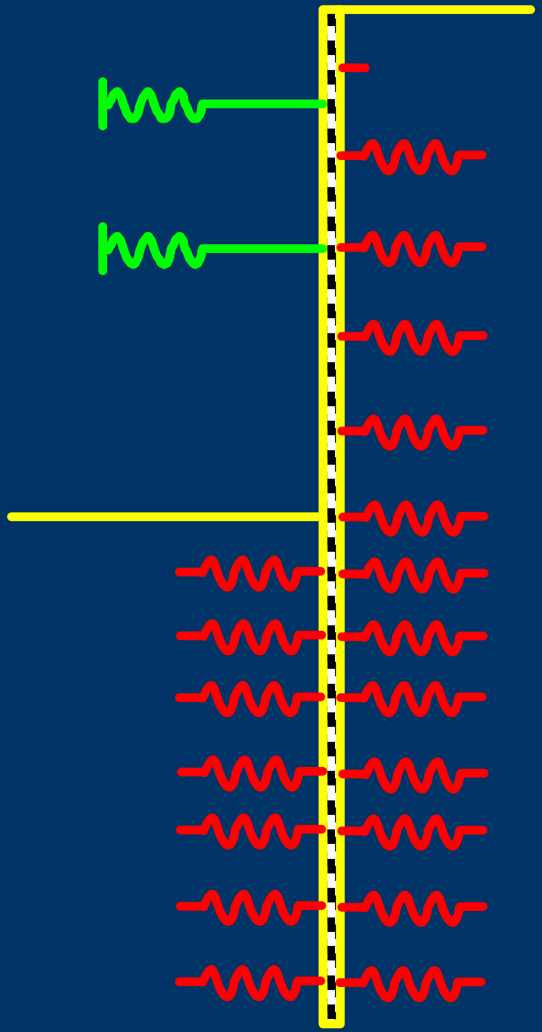
Effective stress (drained) analysis:

Effective stress (undrained) analysis:

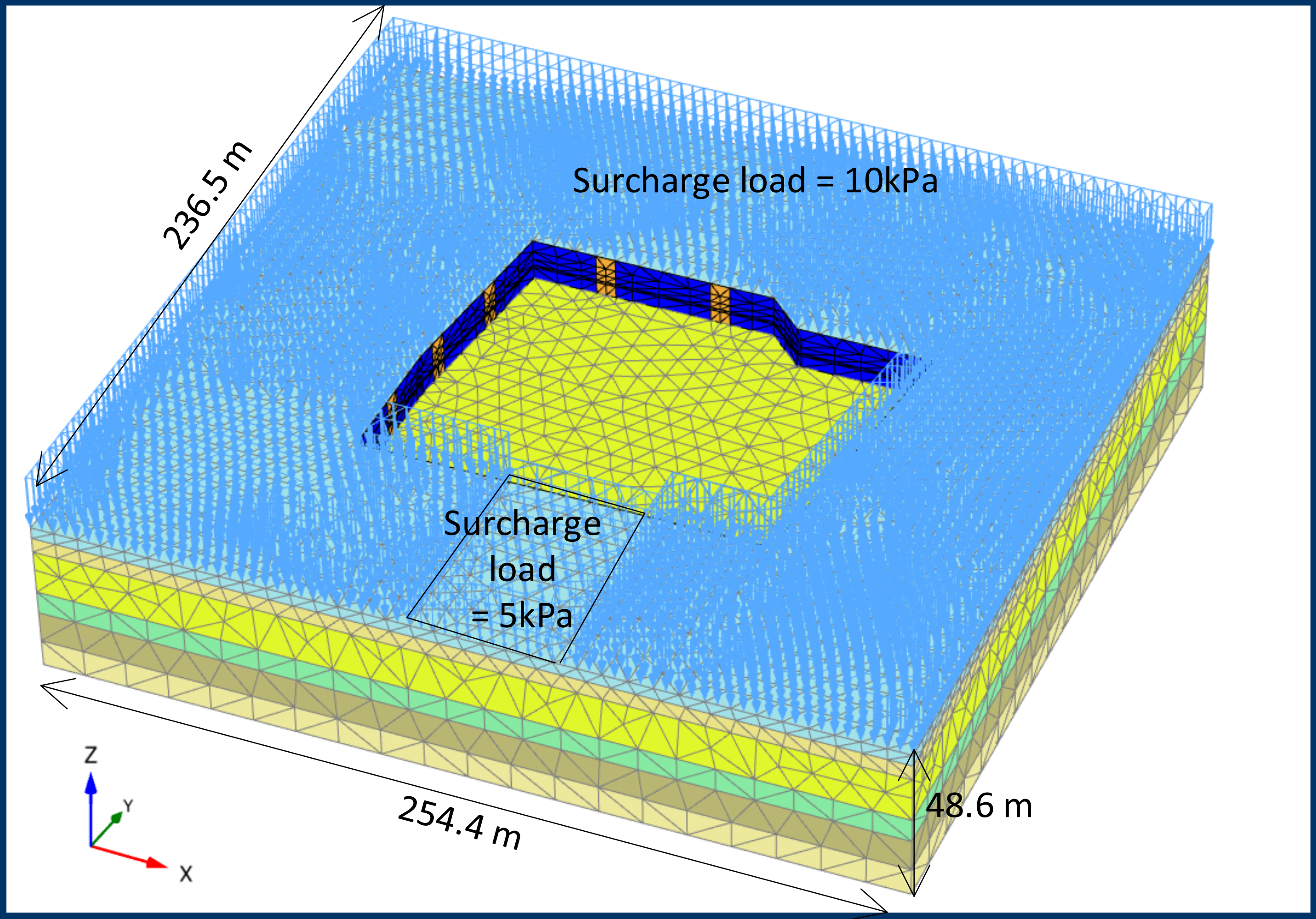
Total stress (undrained) analysis:

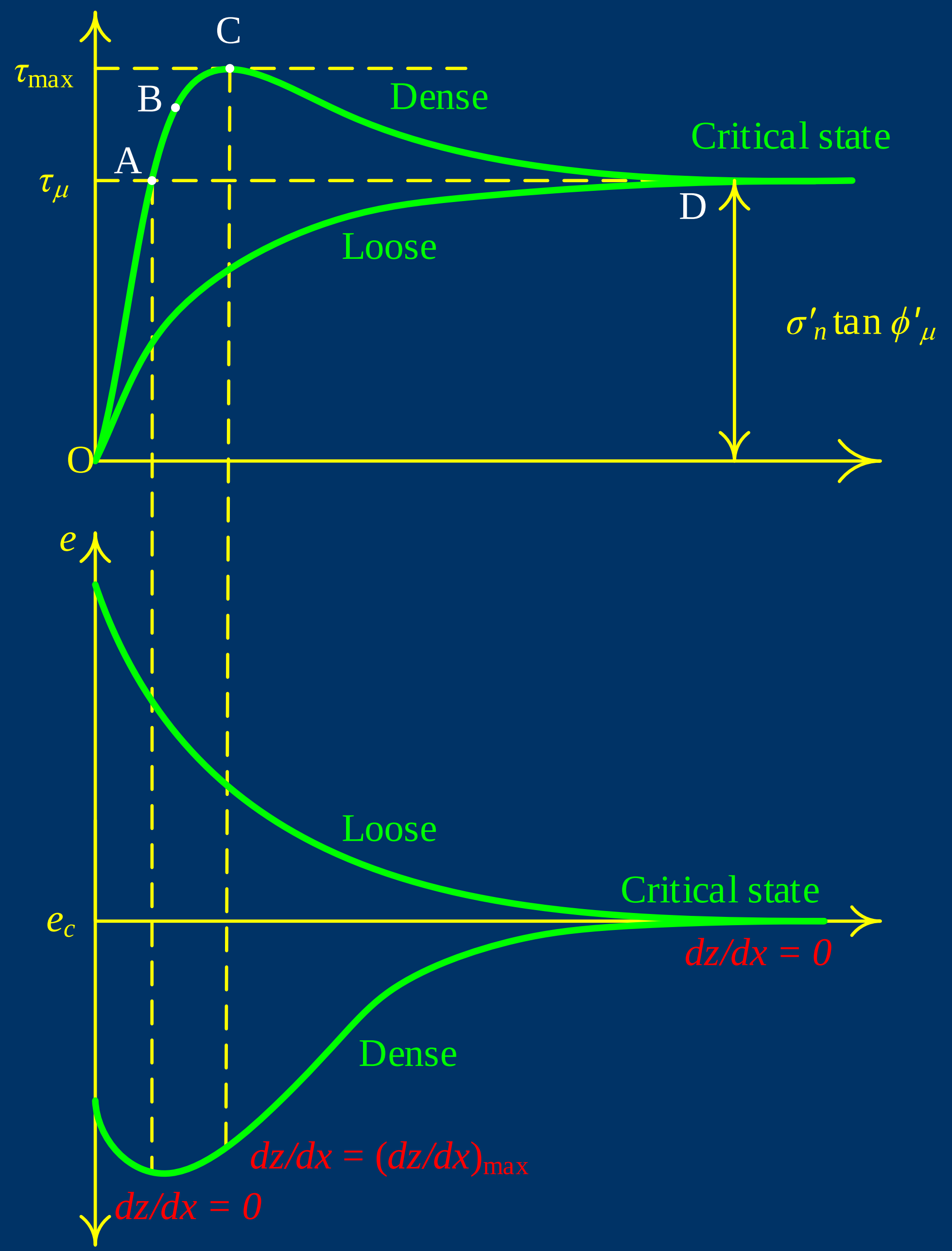


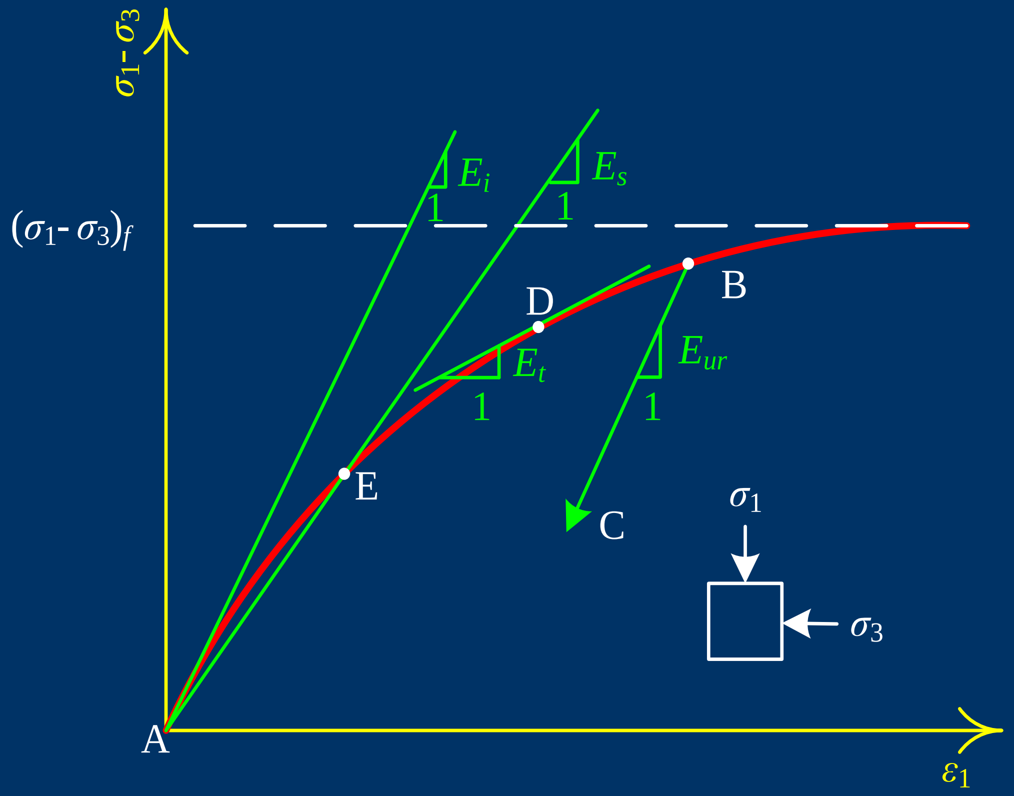
Chapter 7



Chapter 8

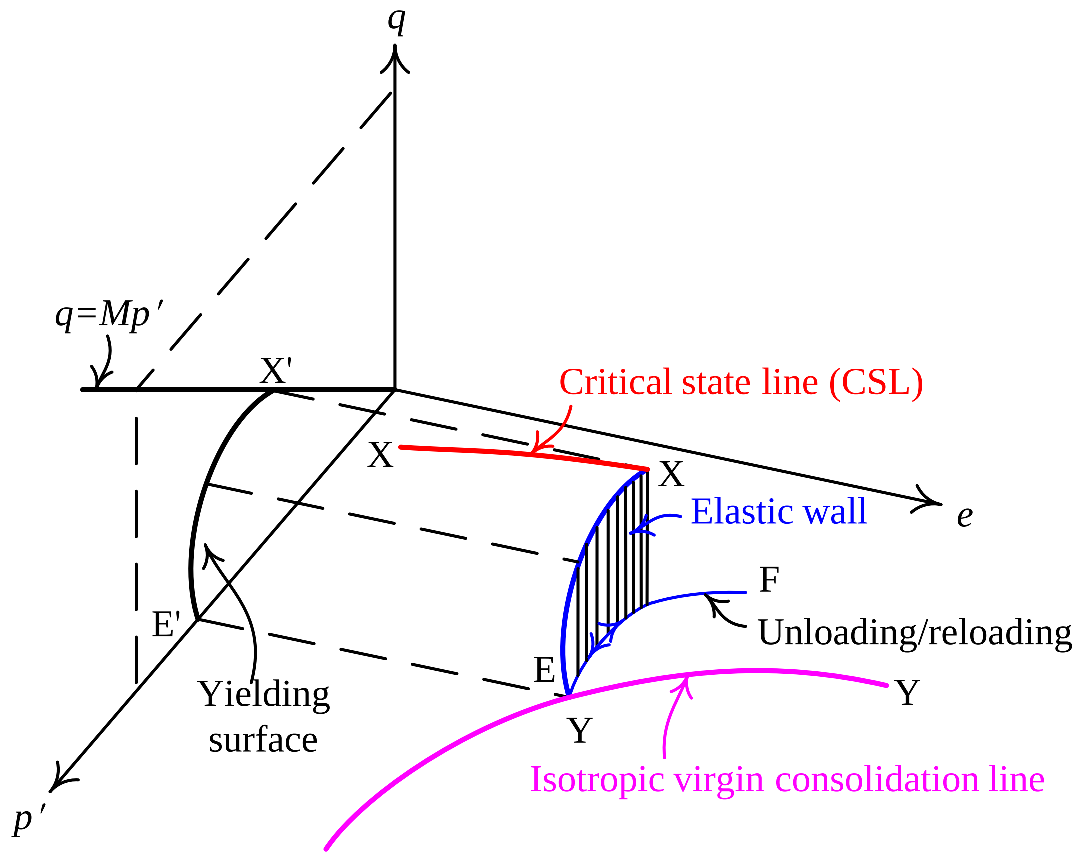



C
τmax
B
Dense
Critical state
A
τμ
D
Loose
σ′n tan φ′μ
O
e
Loose
Critical state
ec
dz/dx = 0
Dense
dz/dx = (dz/dx)max
dz/dx = 0


σ1- σ3
Ei
Es
1
1
(σ1- σ3)f
D
B
Et
Eur
1
1
E
C
σ1
σ3
A
ε1

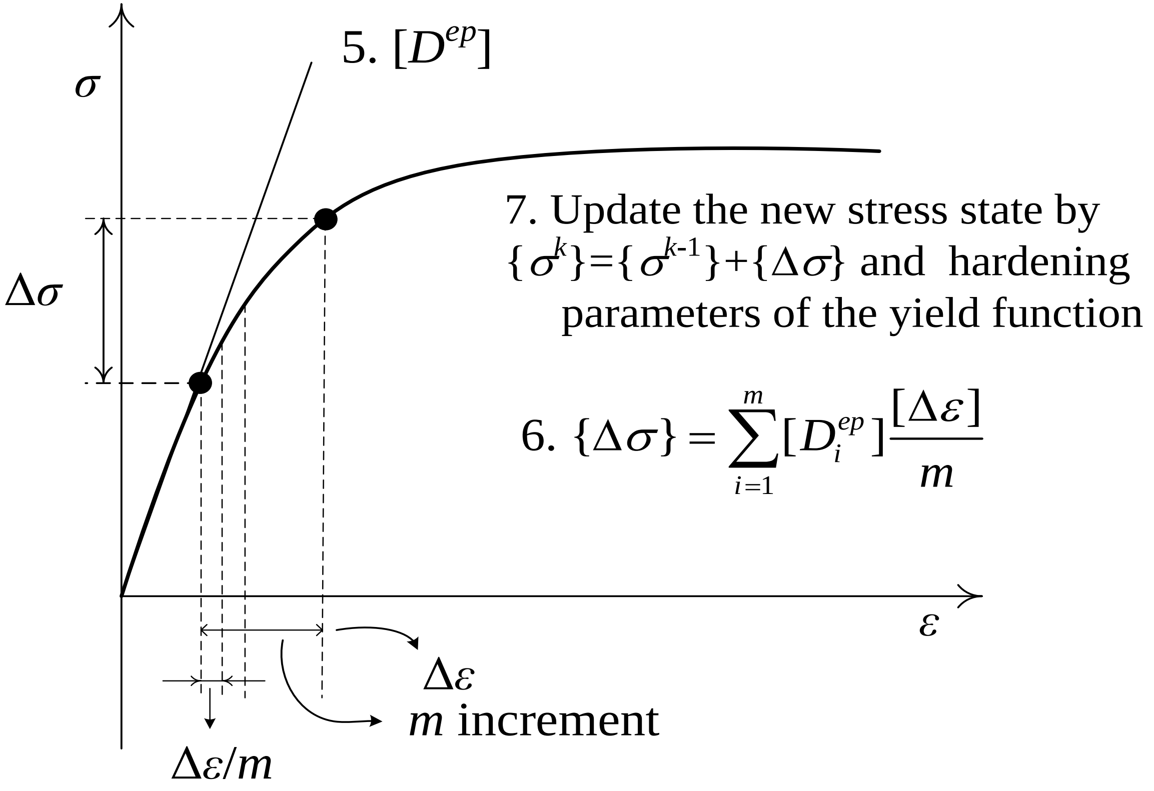
Chapter 8

Mohr-Coulomb model
Duncan-Chang model
HS model, HSS model

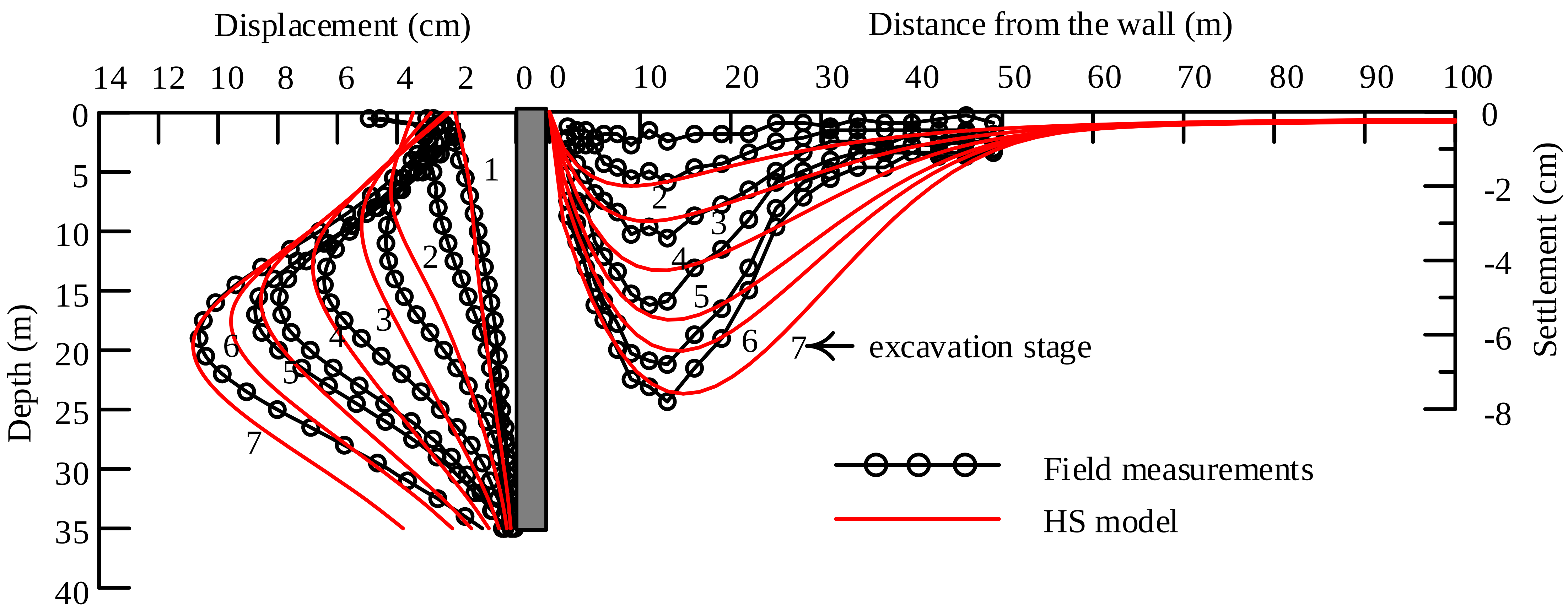


Nonlinear FE computation procedure

Stress integration scheme(e.g. Forward Euler method with subincrements)

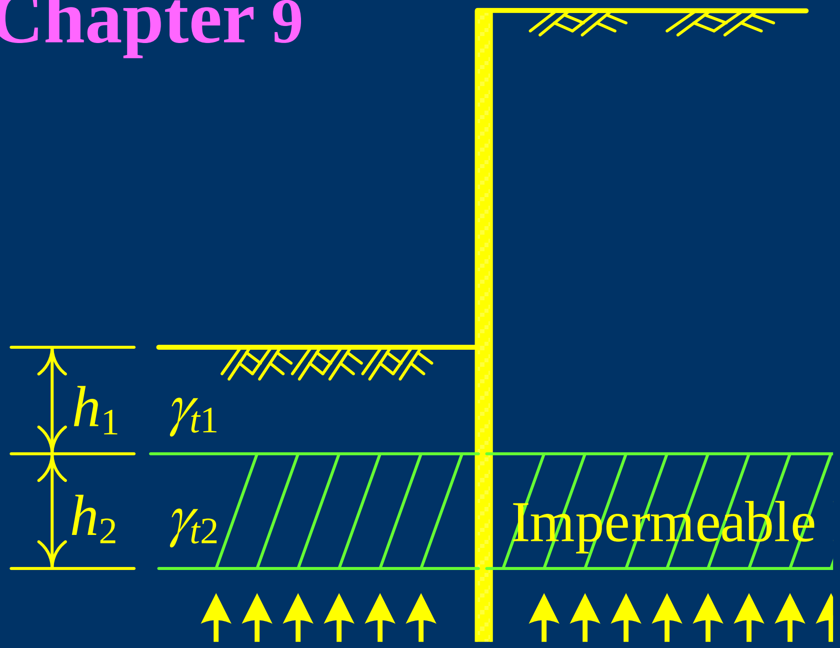


Chapter 8



Displacement (cm)
Distance from the wall (m)
14 12 10 8 6 4 2 0
0 10 20 30 40 50 60 70 80 90 100
Depth (m)
0 5 10 15 20 25 30 35 40
Settlement (cm)
0 -2 -4 -6 -8
1 2 3 4 5 6 7
2 3 4 5 6 7
excavation stage
Field measurements
HS model

Chapter 9



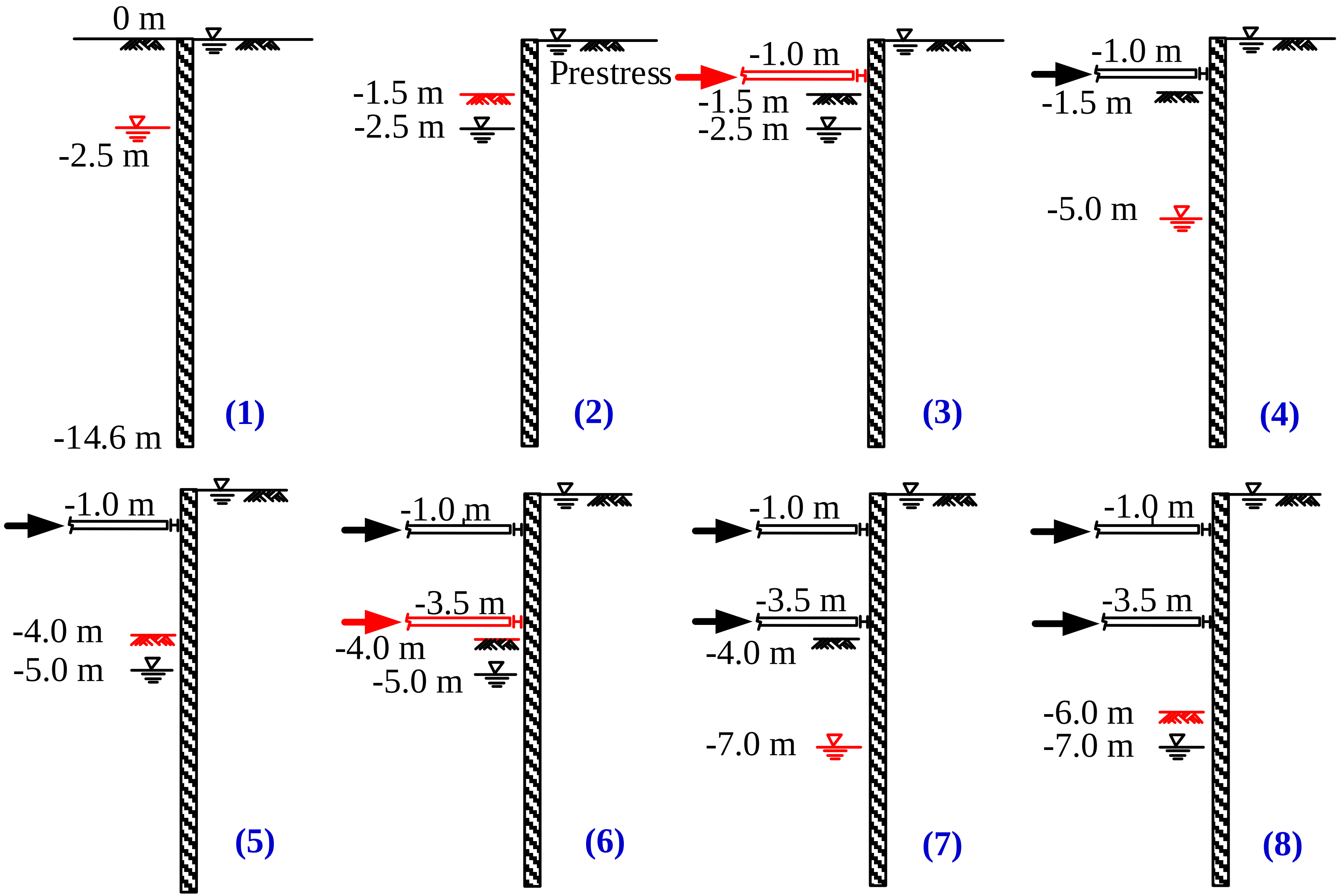
Well formulas:

$$s = \frac{Q}{4\pi kD} W(u) = \frac{Q}{4\pi T} W(u) \qquad (9.1)$$

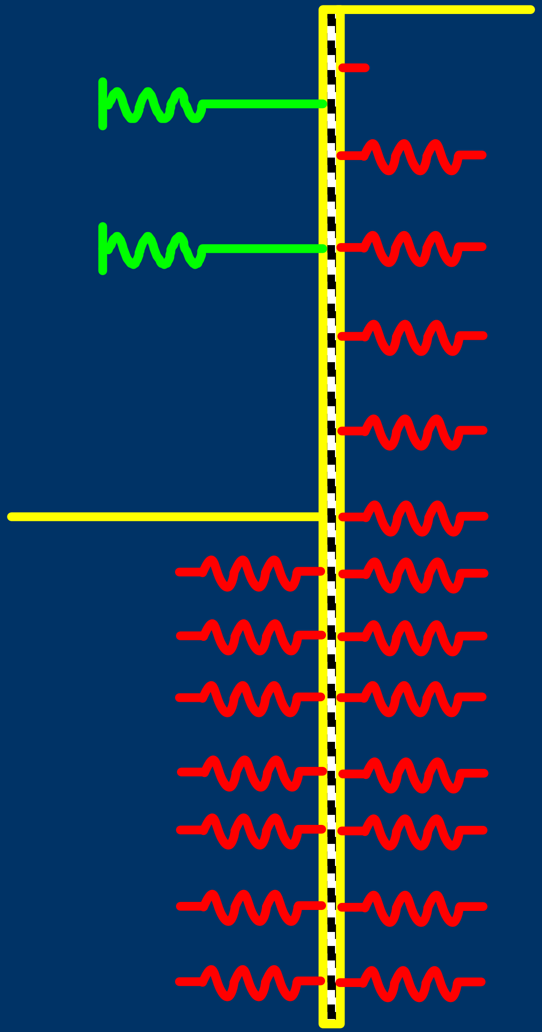
$$W(u) = \int_u^{\infty} \frac{e^{-u}}{u} du = -0.5772 - \ln u - \sum_{n=1}^{\infty} (-1)^n \frac{u^n}{n \times n!} \qquad (9.2)$$

$$u = \frac{r^2 S}{4Tt} \qquad (9.3)$$

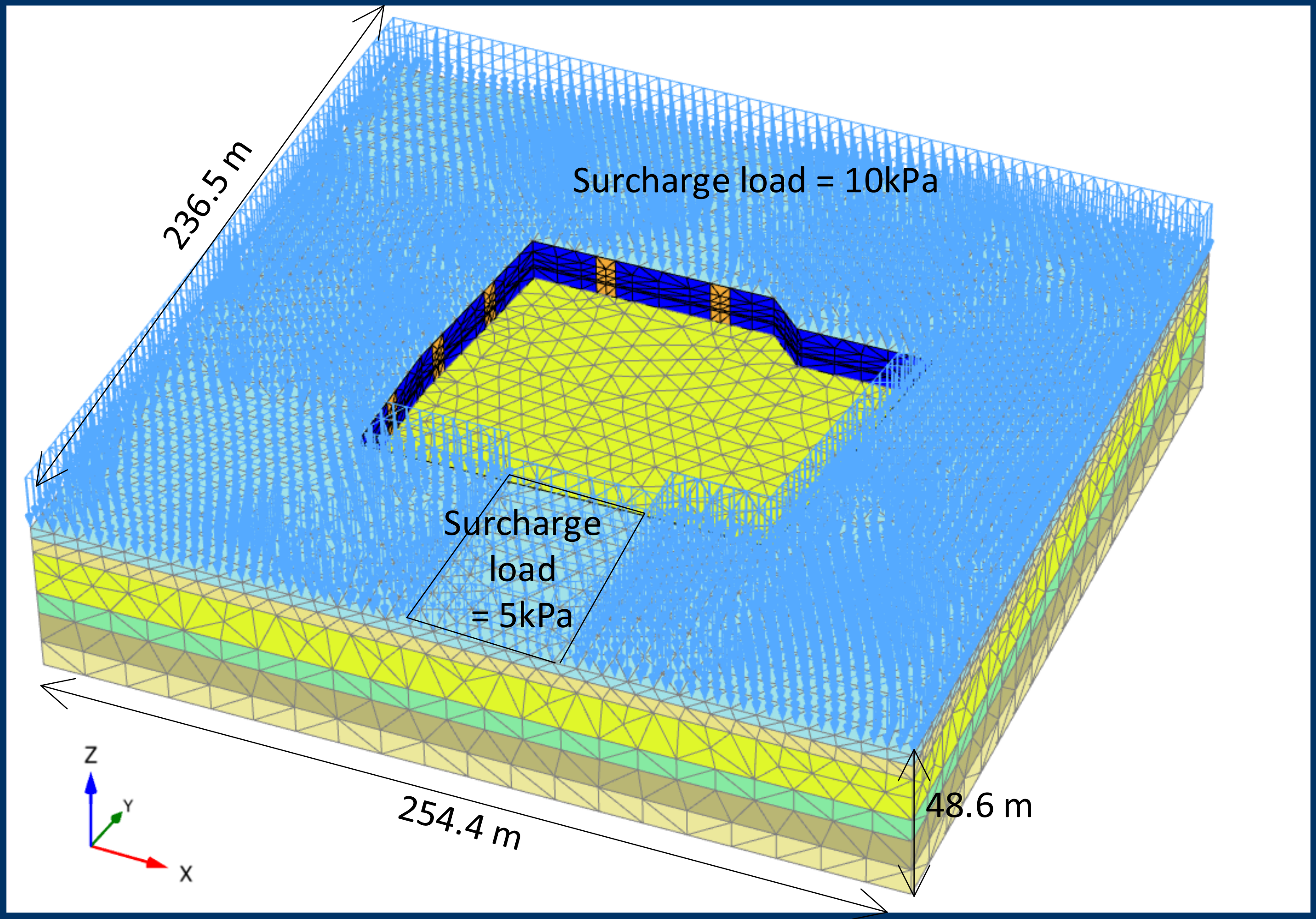
Chapters 7, 8

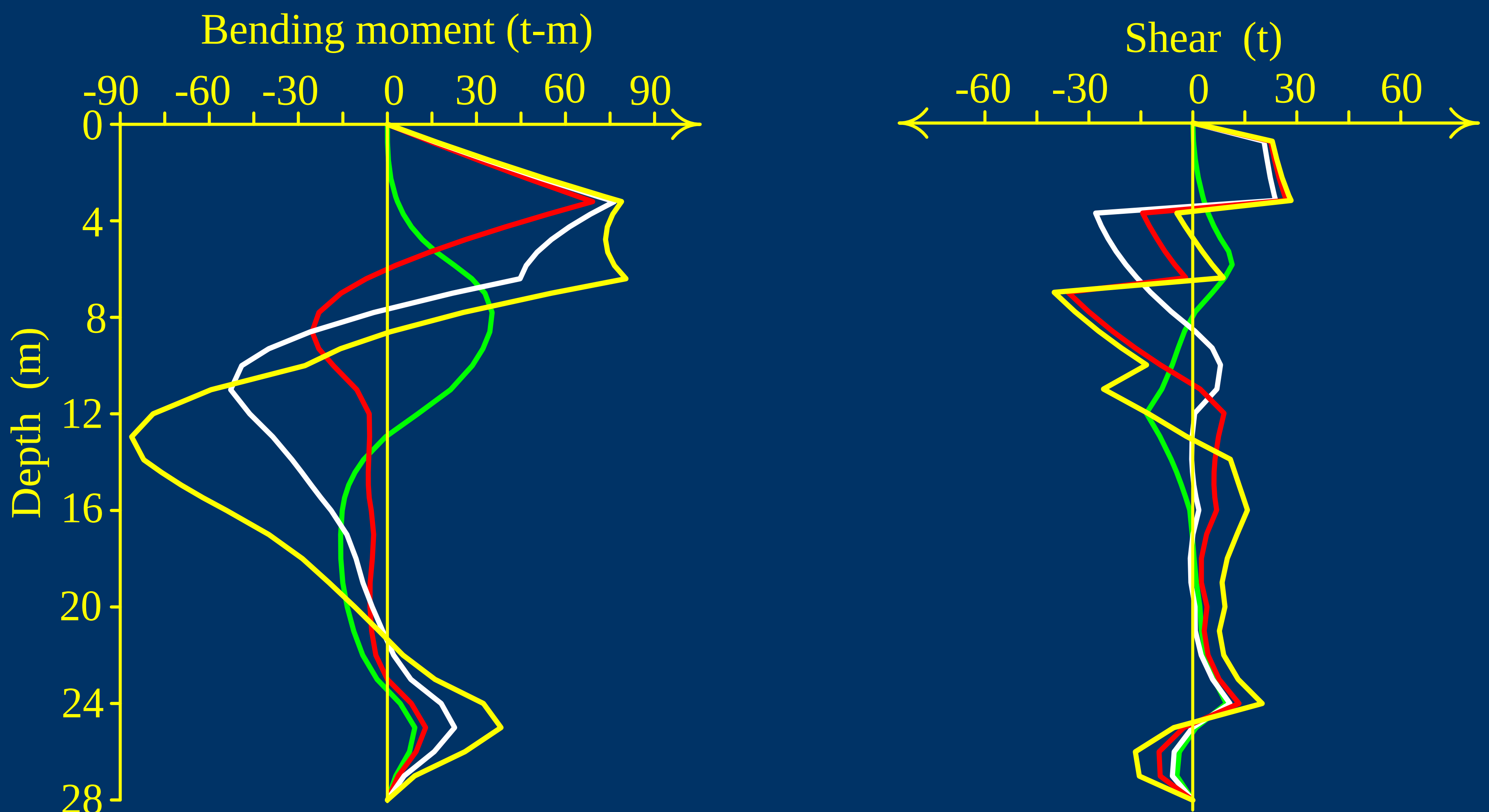

0 m
-2.5 m
-14.6 m
(1)
-1.5 m
-2.5 m
Prestress
(2)
-1.0 m
-1.5 m
-2.5 m
(3)
-1.0 m
-1.5 m
-5.0 m
(4)
-1.0 m
-4.0 m
-5.0 m
(5)
-1.0 m
-3.5 m
-4.0 m
-5.0 m
(6)
-1.0 m
-3.5 m
-4.0 m
-7.0 m
(7)
-1.0 m
-3.5 m
-6.0 m
-7.0 m
(8)

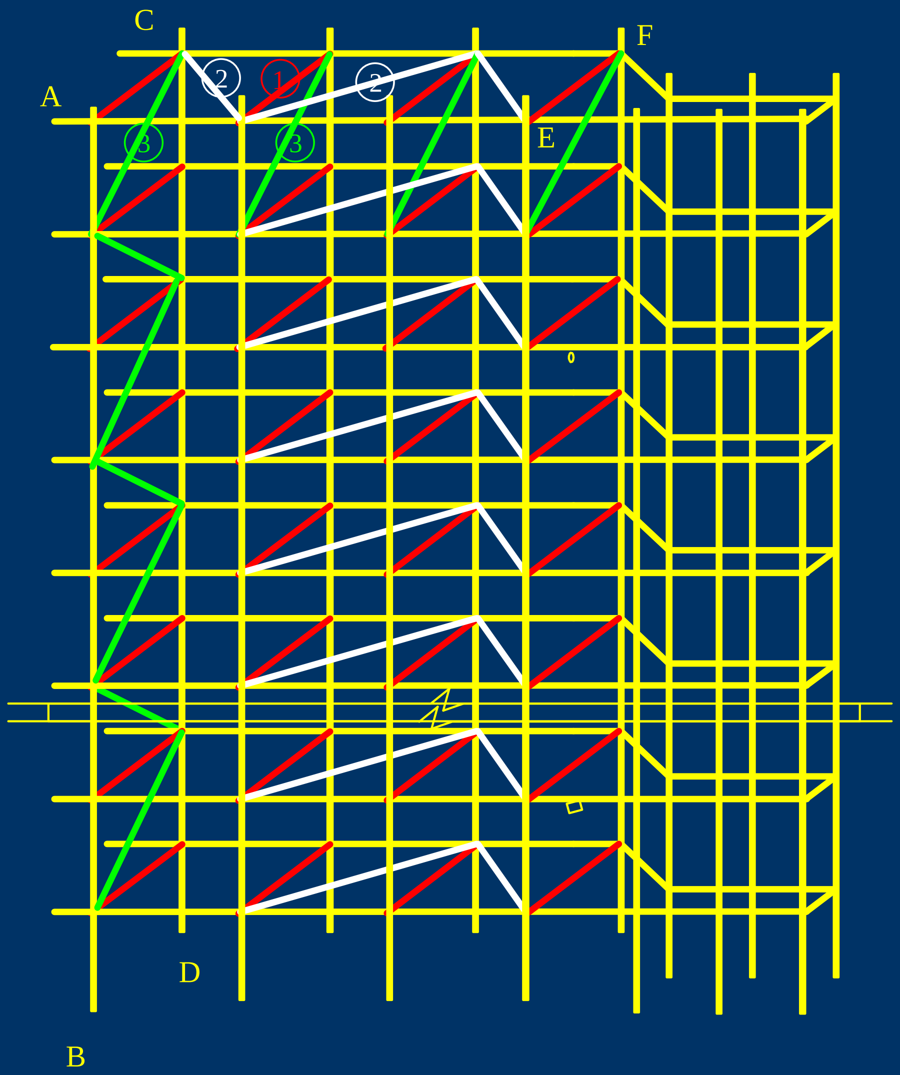
Chapter 7



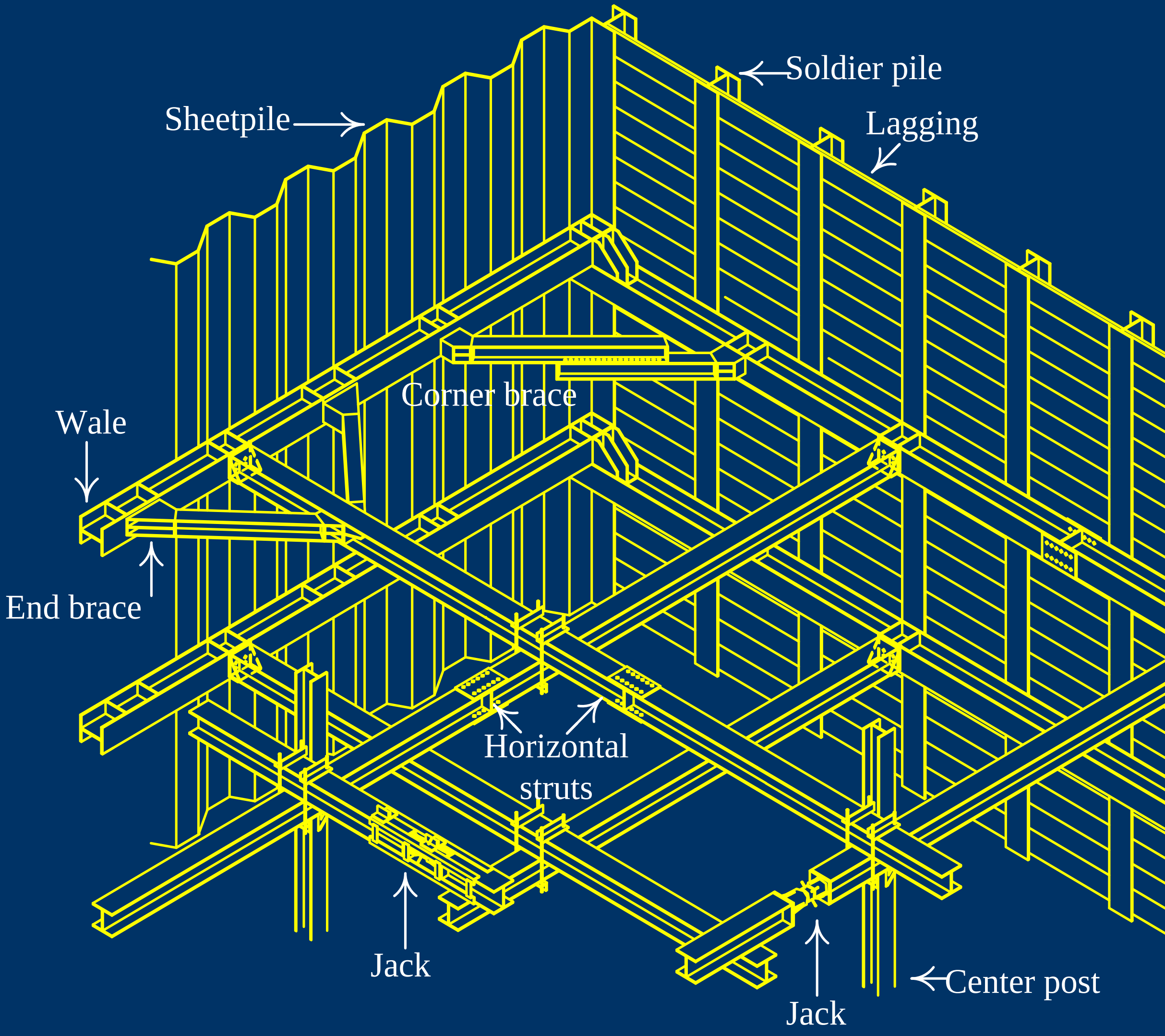
Chapter 8




Bending moment (t-m)
-90
-60
-30
0
30
60
90
0
4
8
12
16
20
24
28
Depth (m)
Shear (t)
-60
-30
0
30
60



Steel cages in diaphragm wall

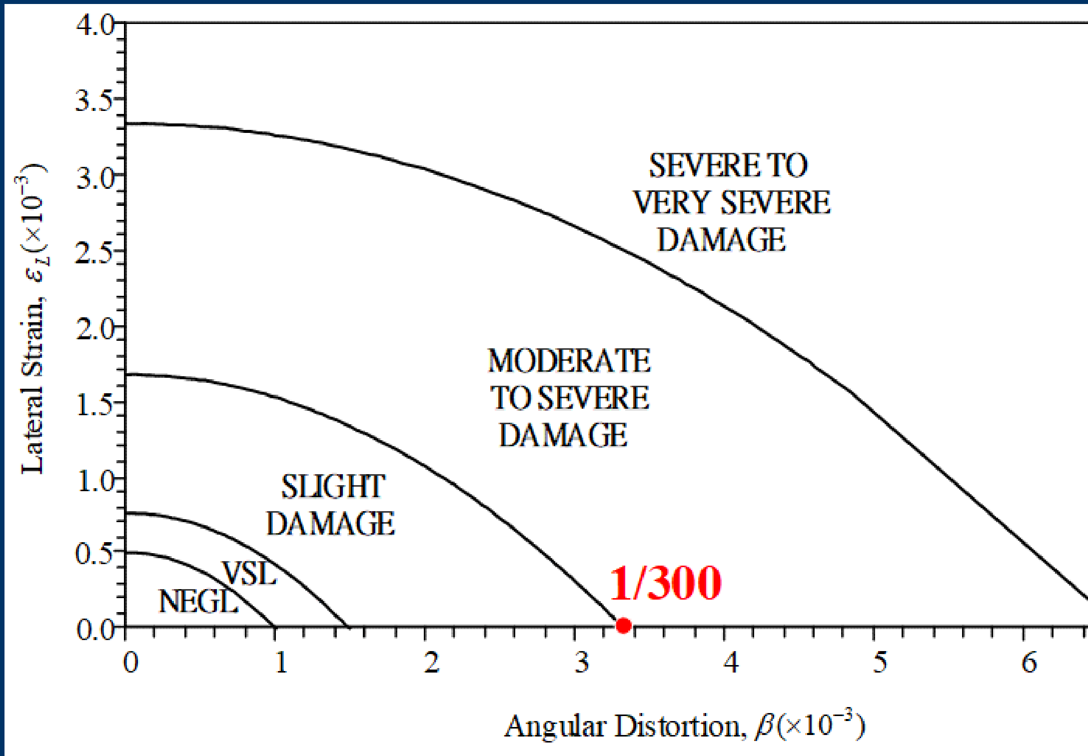


Strut system

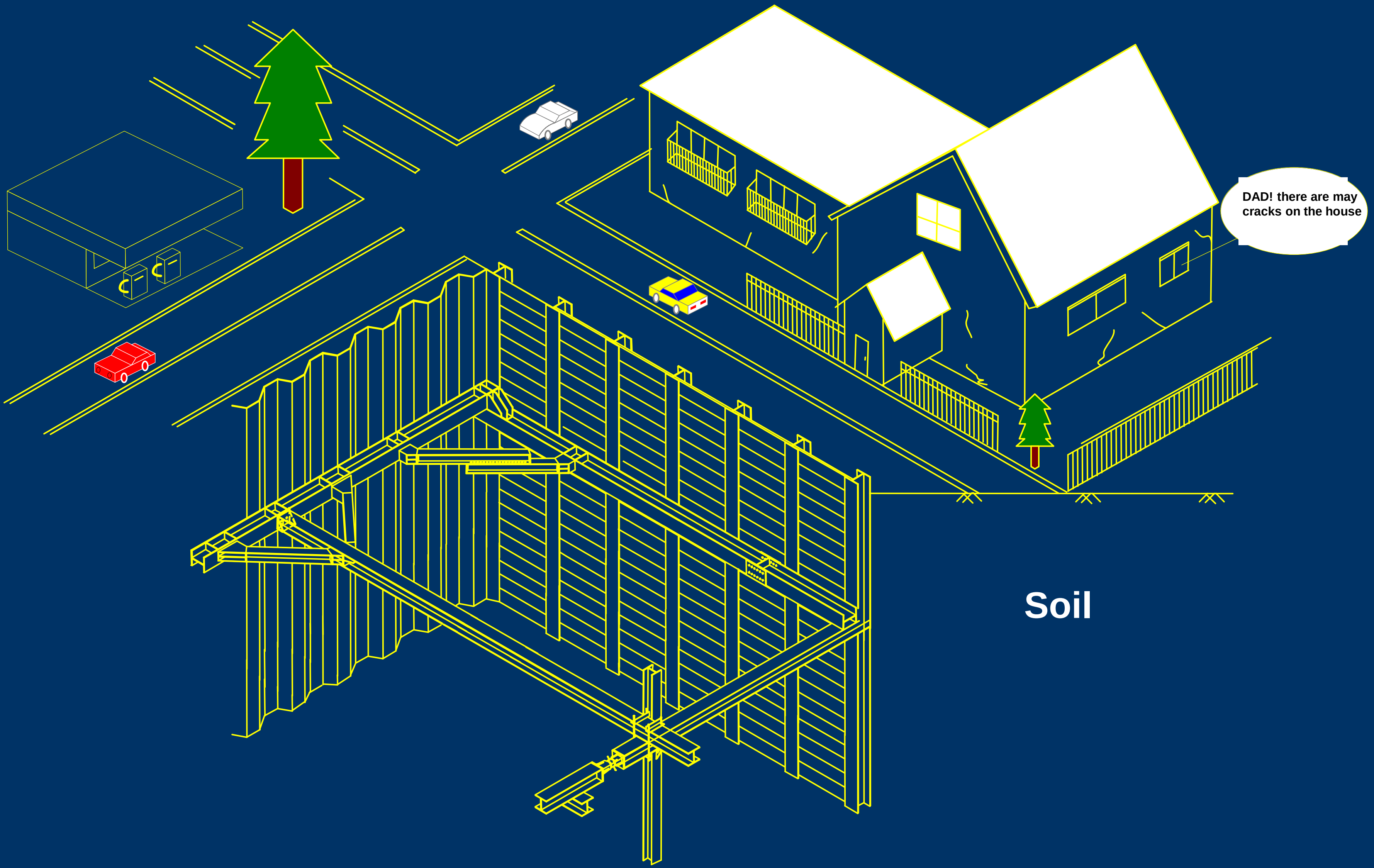
Table 11.1 Limiting values of angular distortion (Bjerrum, 1963)

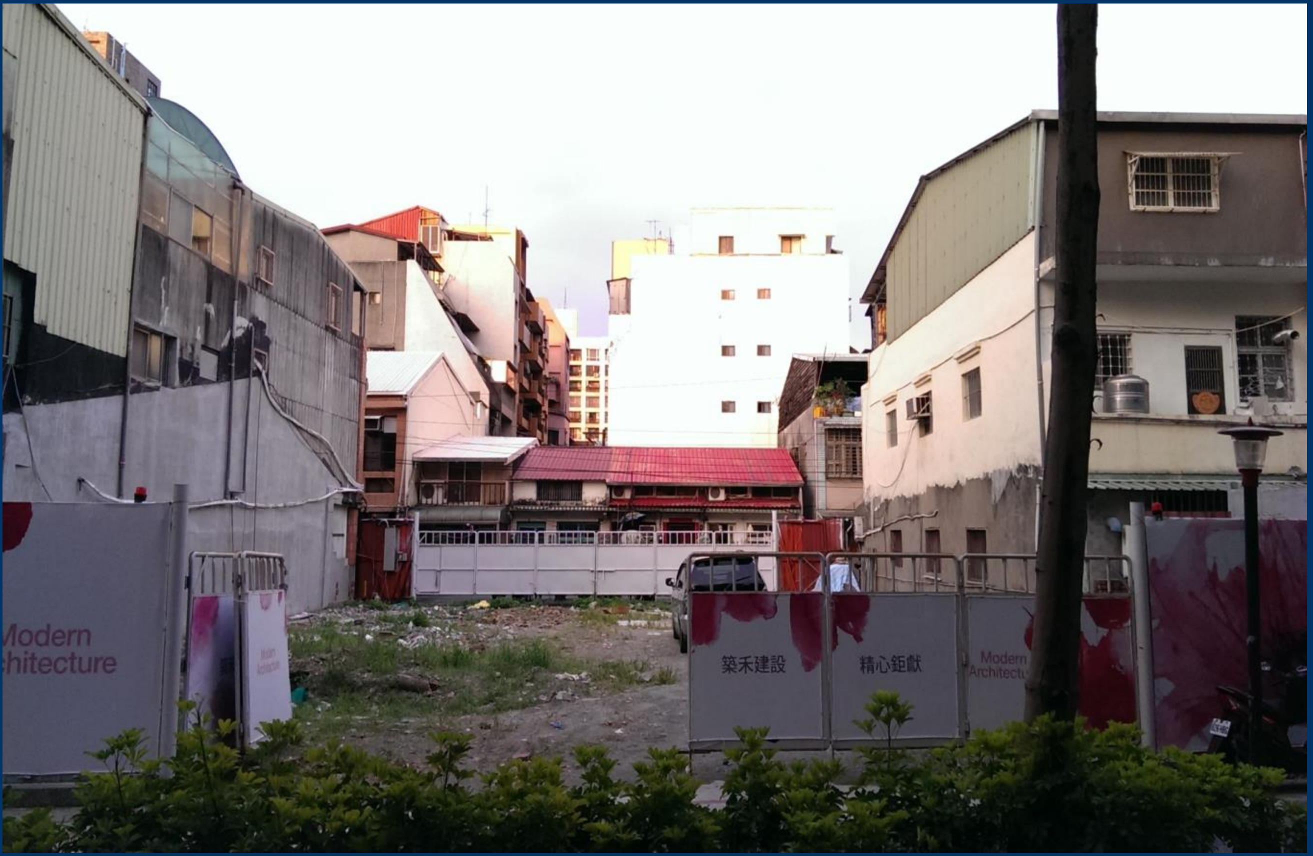
Angular distortion	Type of damage
1/750	Dangerous to machinery sensitive to settlement
1/600	Dangerous to frames with diagonals
1/500	**Safe limit to assure no cracking of buildings (factor of safety included)**
1/300	**First cracking of panel walls (factor of safety not included)**
1/300	Difficulties with overhead cranes
1/250	Tilting with high rigid buildings become visible
1/150	Considerable cracking of panel and brick walls
1/150	**Danger of structural damage to general buildings**
1/150	Safe limit for flexible brick walls (factor of safety not included)

Type of foundation	Maximum settlement (mm)	Tilt angle	Angular distortion	Deflection ratio (hogging)	Deflection ratio (sagging)
RC raft foundation	45	1/500	1/500	0.0008	0.0012
RC individual footings	40	1/500	1/500	0.0006	0.0008
Brick individual footings	25	1/500	1/2500	0.0002	0.0004
Temporary buildings	40	1/500	1/500	0.0008	0.0012



Chapter 11




築禾建設
精心鉅獻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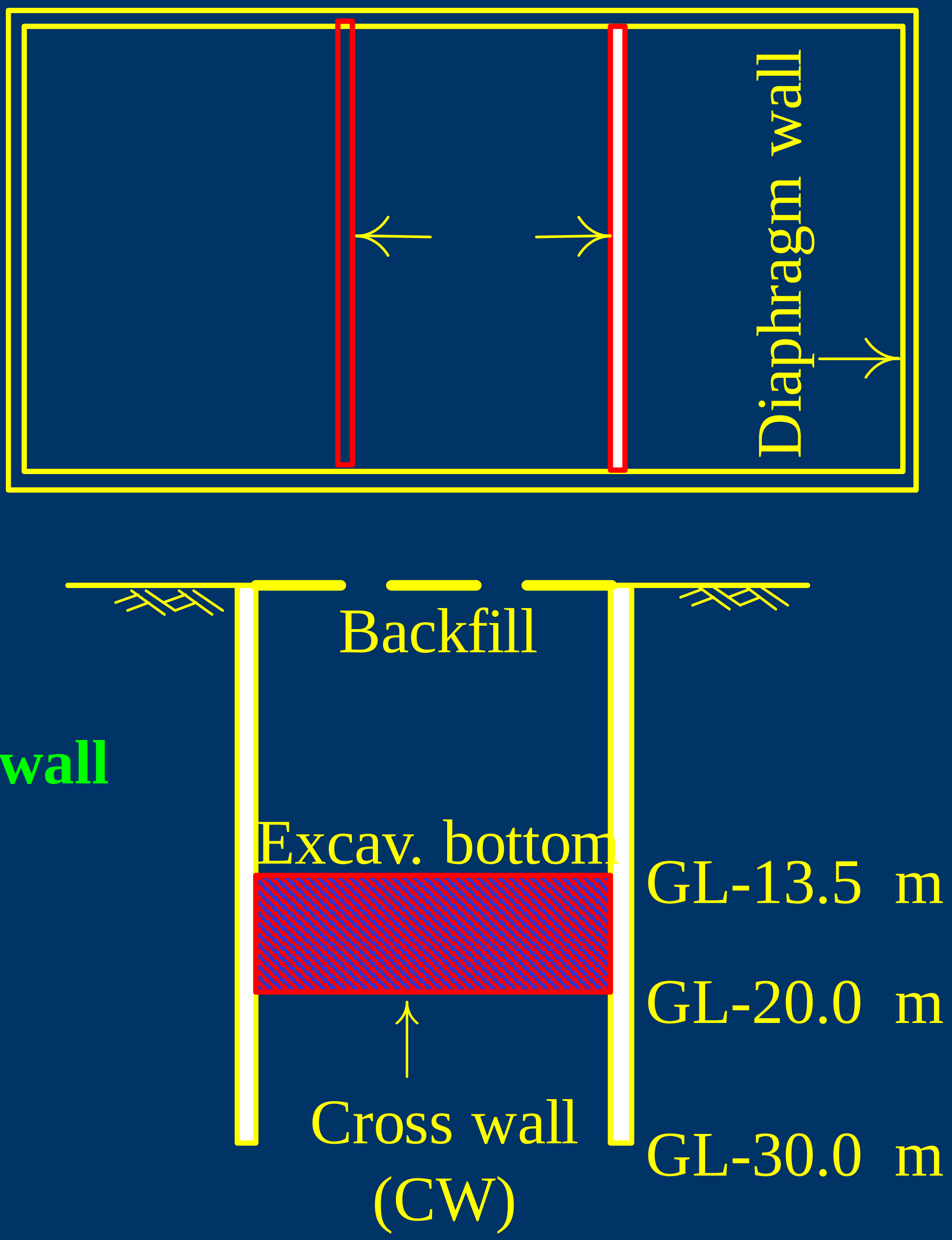
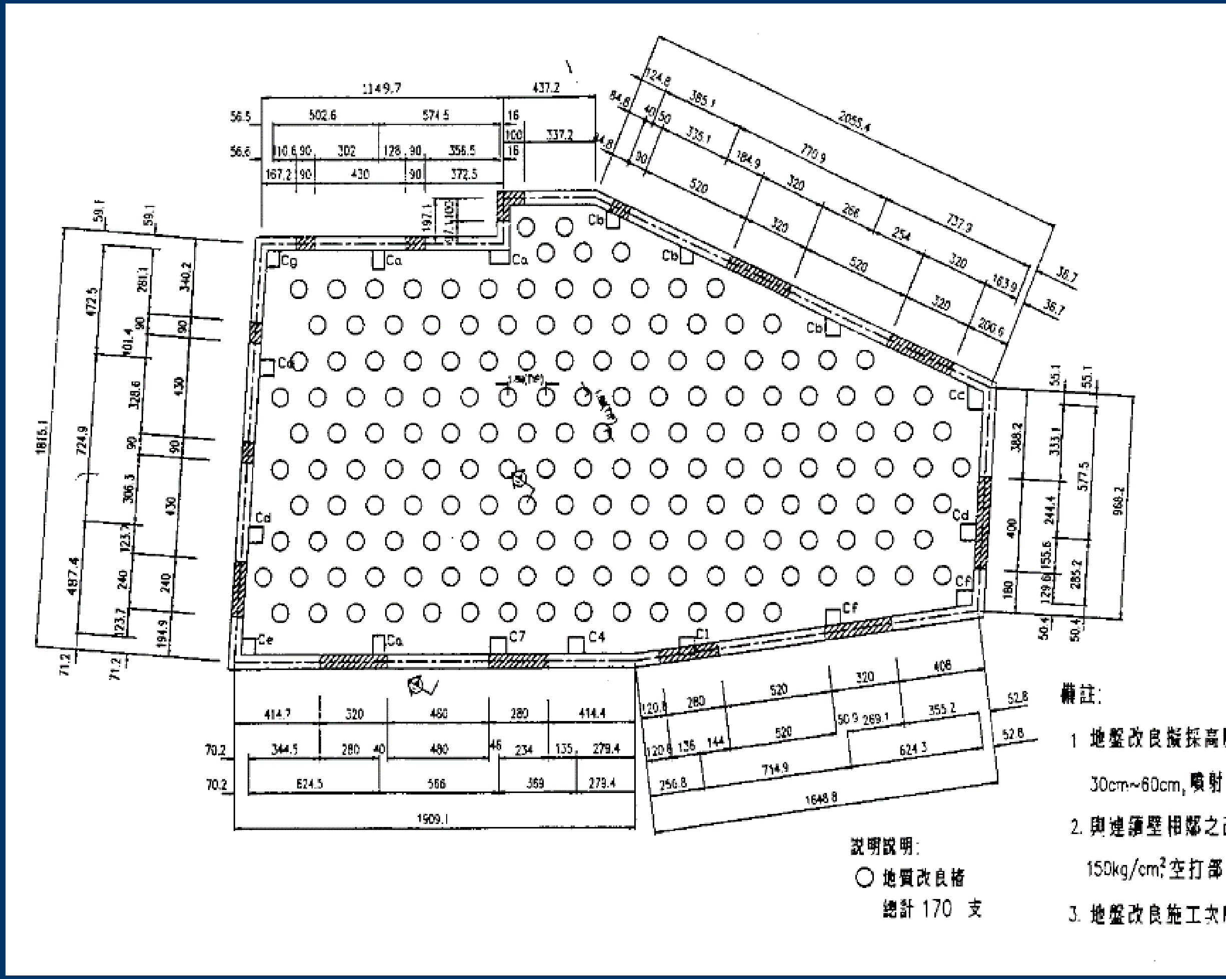
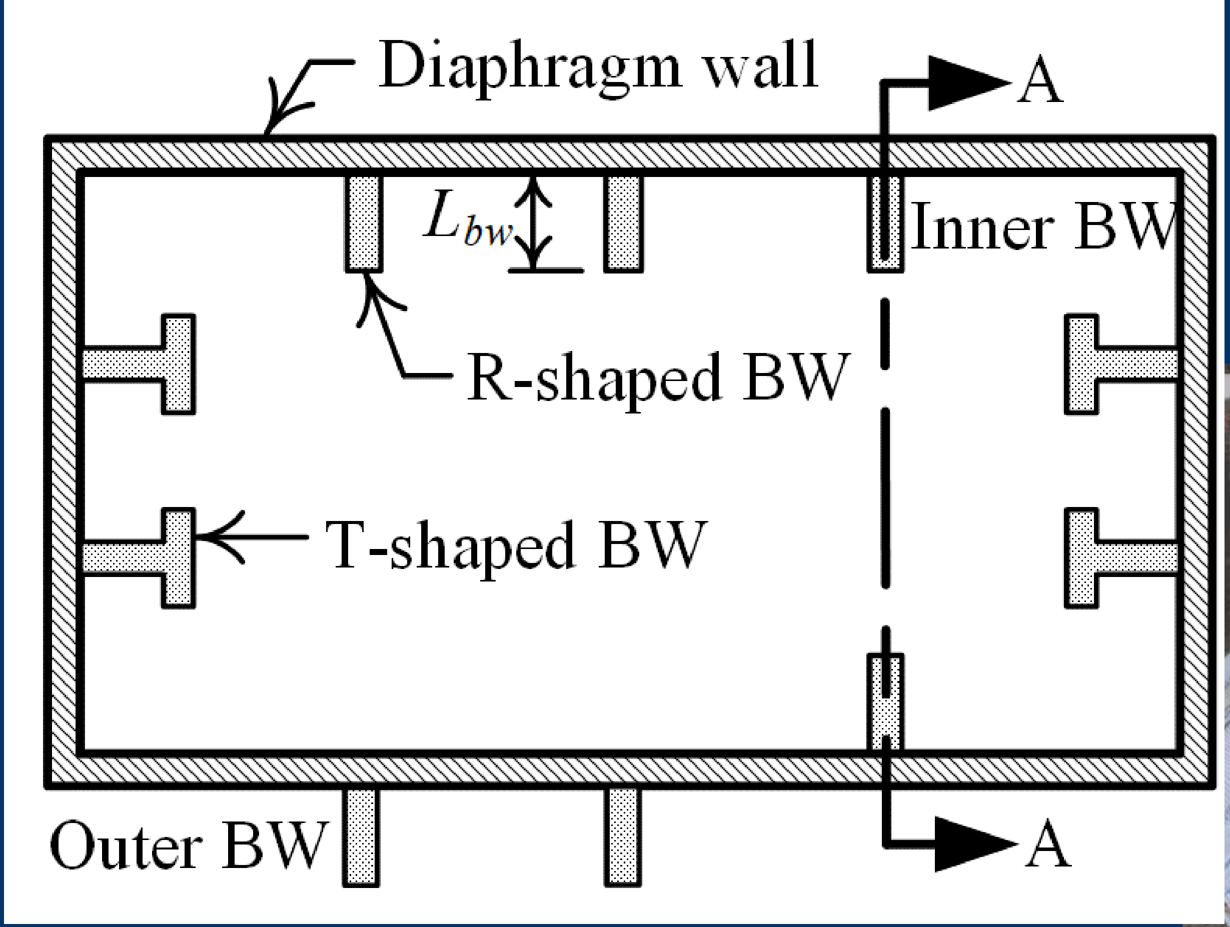
源春


Cross wall

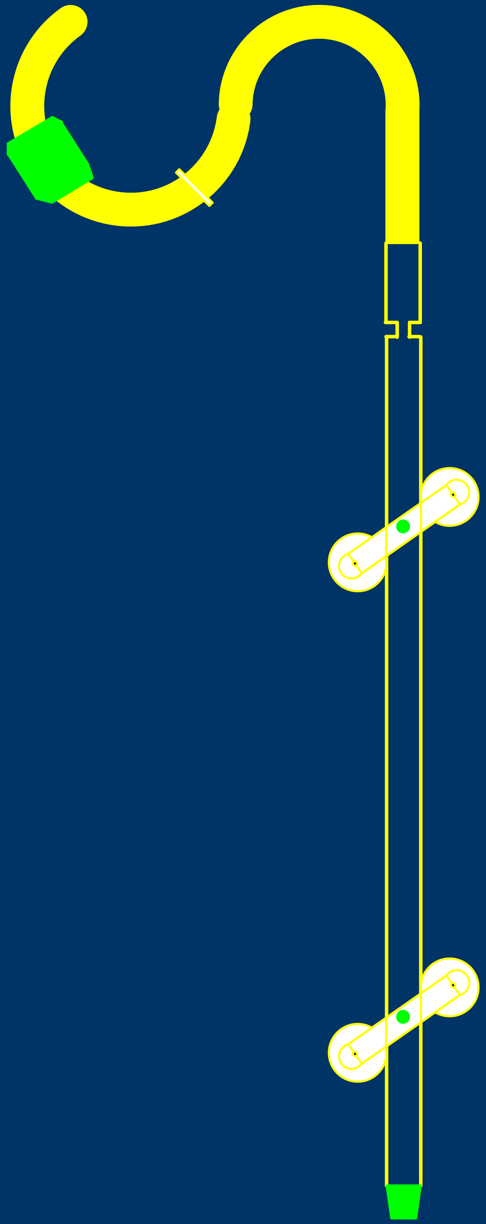


Ground improvement

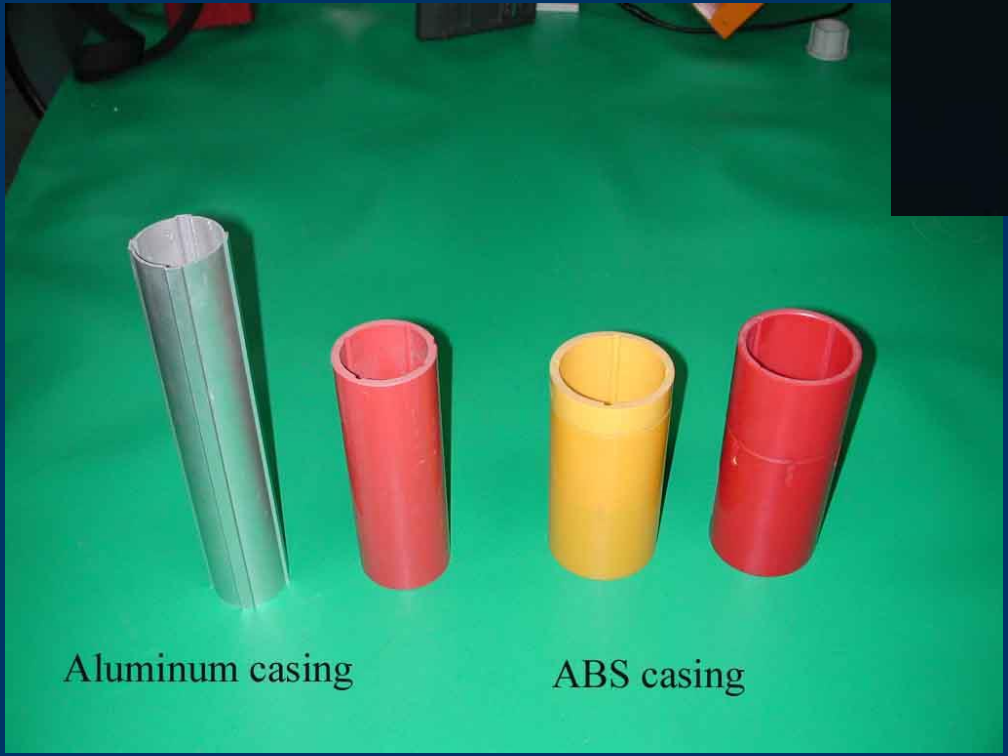




Buttress wall



Inclinometer



Strain gauges