ANCHOR WALL SYSTEMS

DESIGN OF RETAINING STRUCTURES

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anchors. The current section covers in more detail the various types of anchor generally used and the procedures for evaluating their ultimate holding capacities.

The general types of anchor used in sheet-pile walls are as follows:

1. Anchor plates and beams (deadman)
2. Tie backs
3. Vertical anchor piles
4. Anchor beams supported by batter (compression and tension) piles

Anchor plates and beams are generally made of cast concrete blocks. (See Figure 9.37a.) The anchors are attached to the sheet pile by *tie-rods*. A *wale* is placed at the front or back face of a sheet pile for the purpose of conveniently attaching the tie-rod to the wall. To protect the tie rod from corrosion, it is generally coated with paint or asphaltic materials.

In the construction of *tiebacks*, bars or cables are placed in predrilled holes (see Figure 9.37b) with concrete grout (cables are commonly high-strength, prestressed steel tendons). Figures 9.37c and 9.37d show a vertical anchor pile and an anchor beam with batter piles.

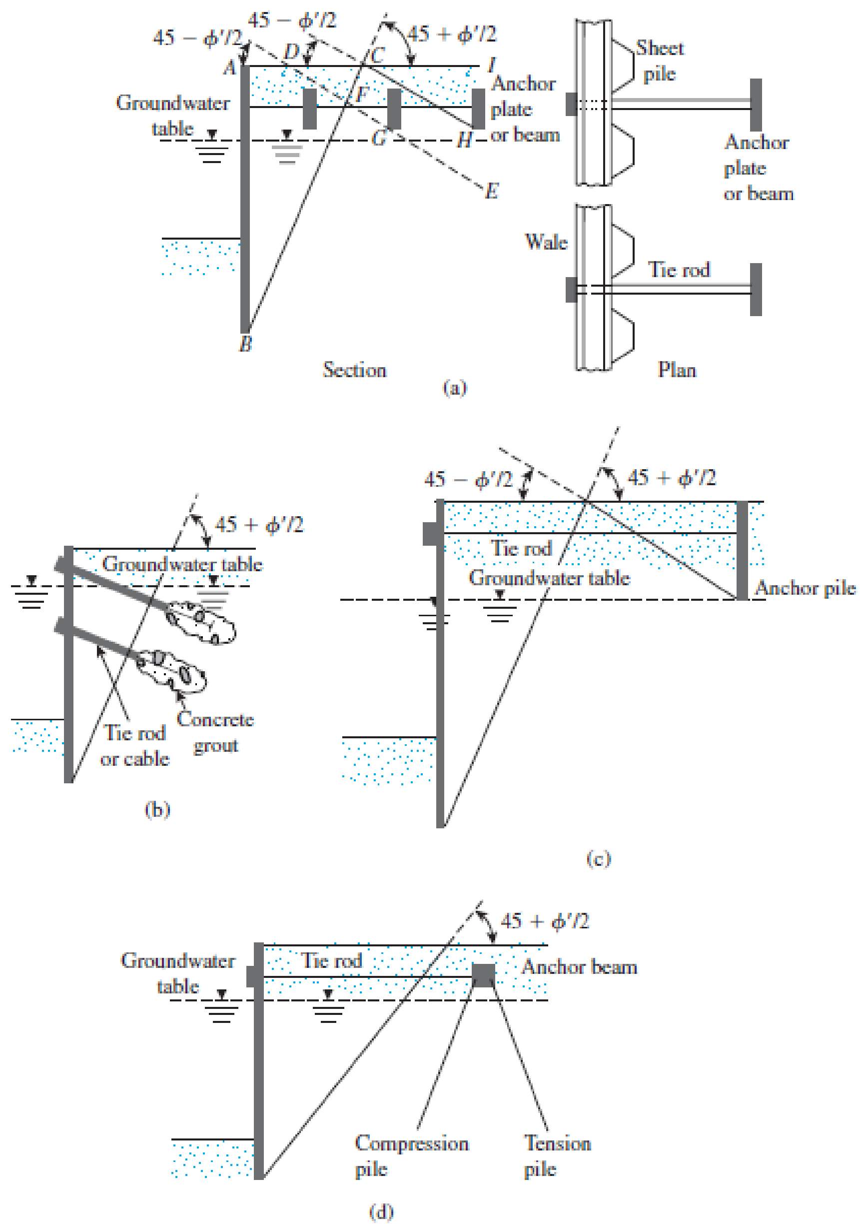

Figure 9.37 Various types of anchoring for sheet-pile walls: (a) anchor plate or beam; (b) tieback; (c) vertical anchor pile; (d) anchor beam with batter piles


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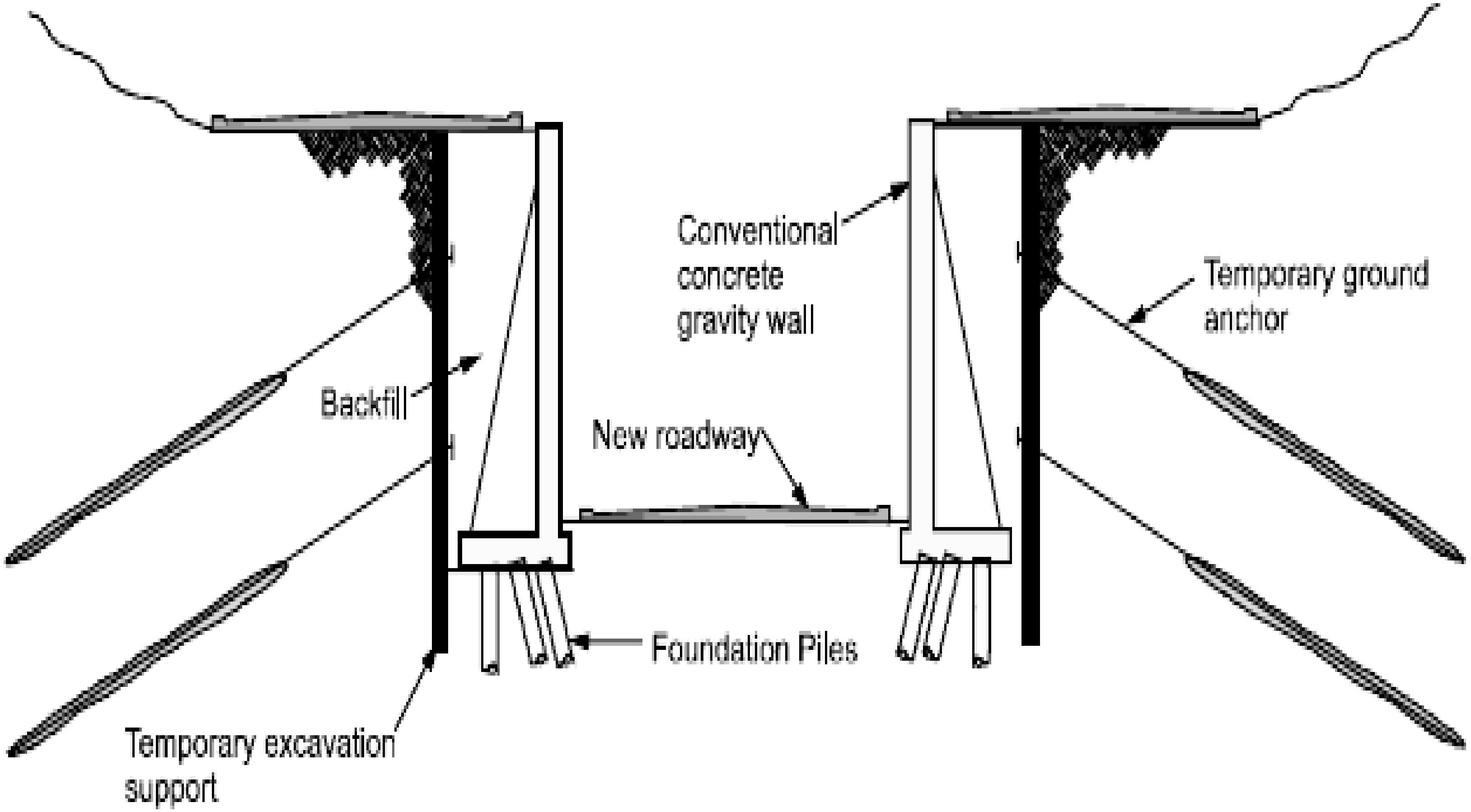
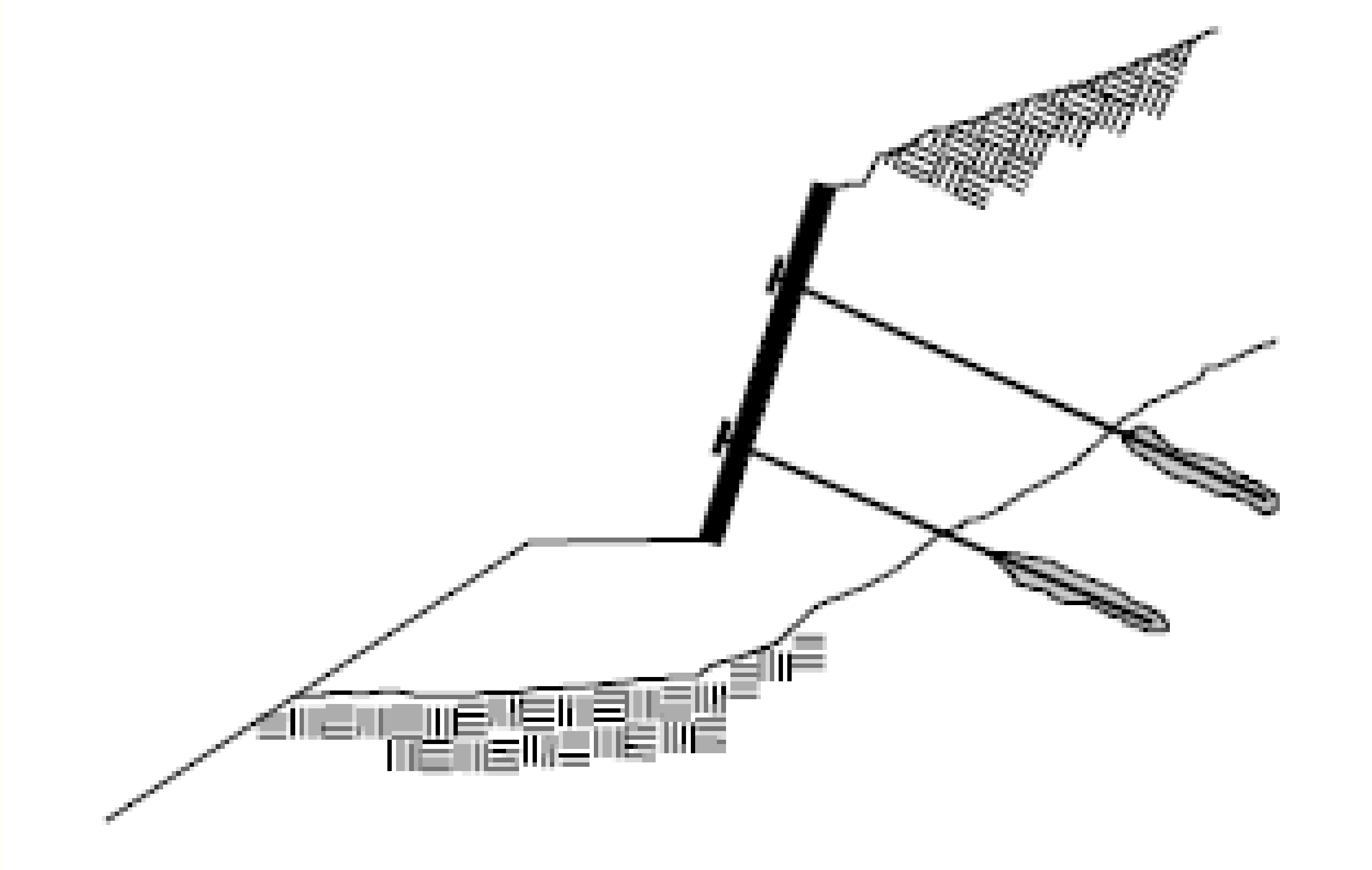
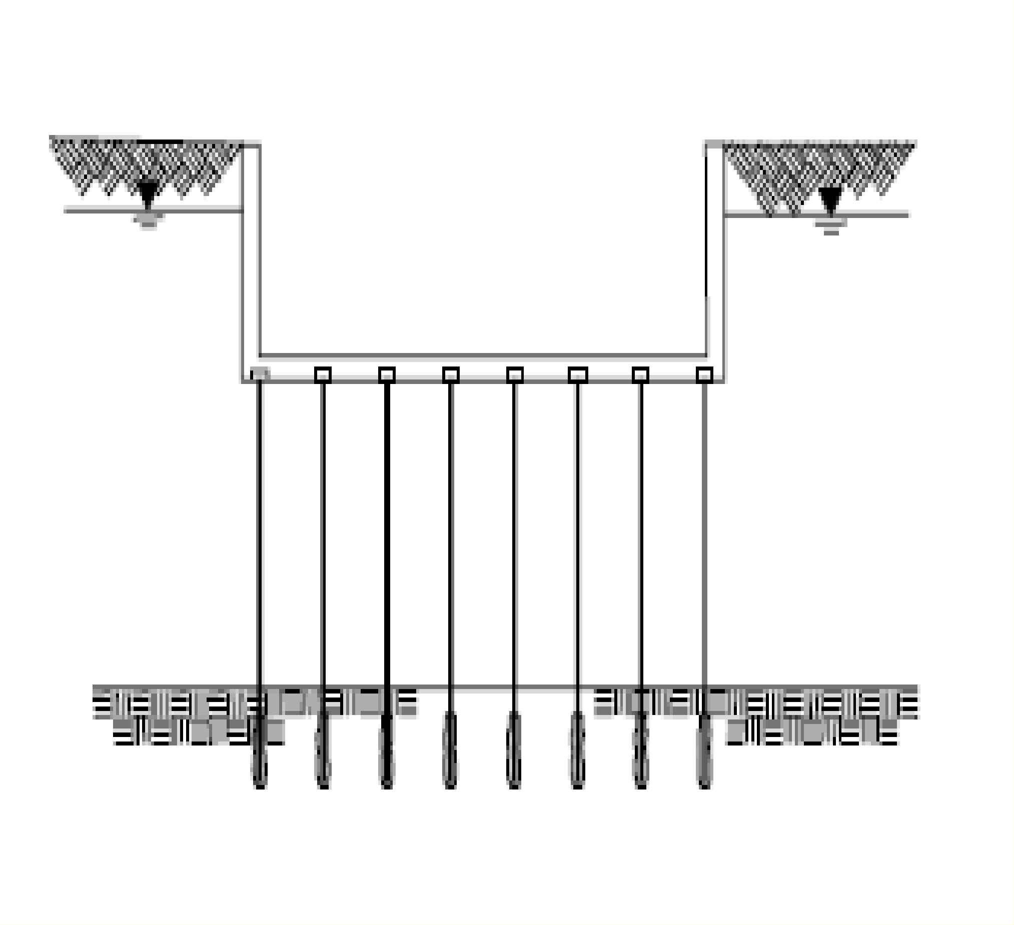


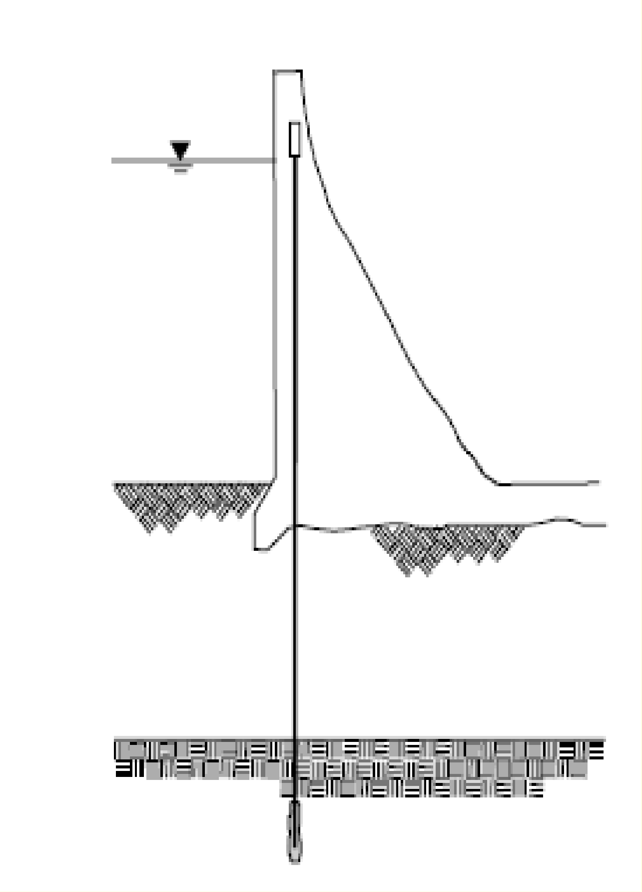
a-) Highway Retaining Structures



b-) Improvement Slope Stability



b-) To reinforce/support the excavation base

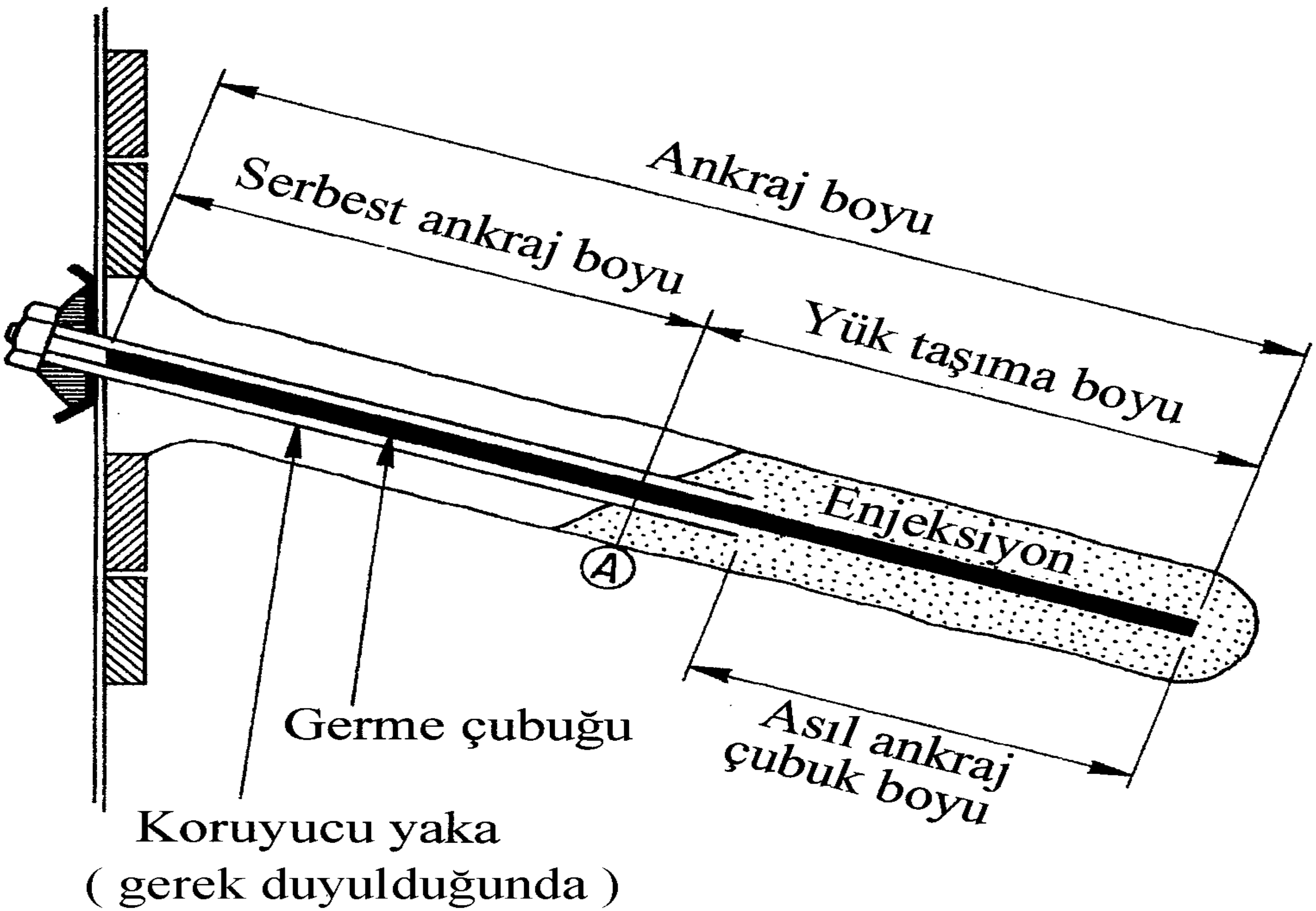


c-) In the construction of concrete Dams

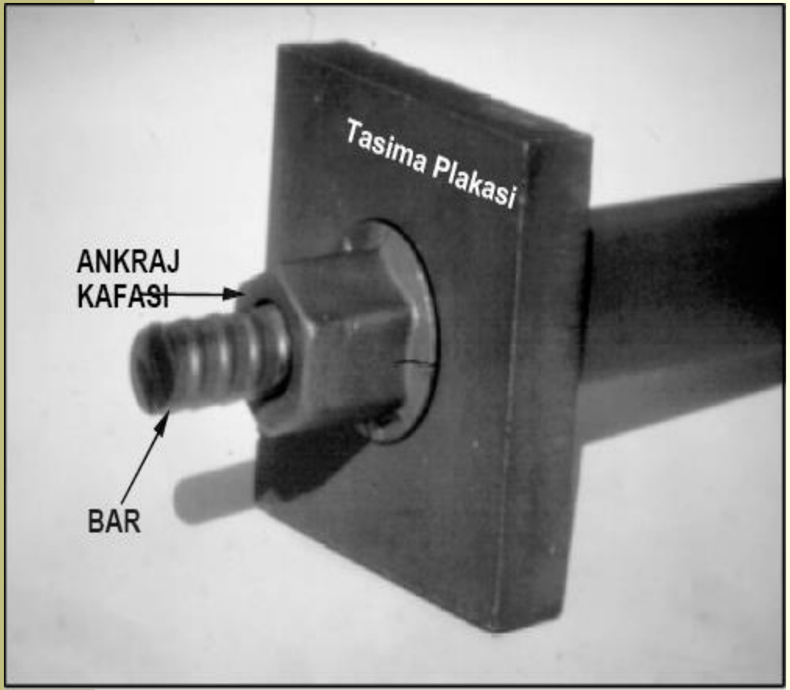
Structural Member of Anchors

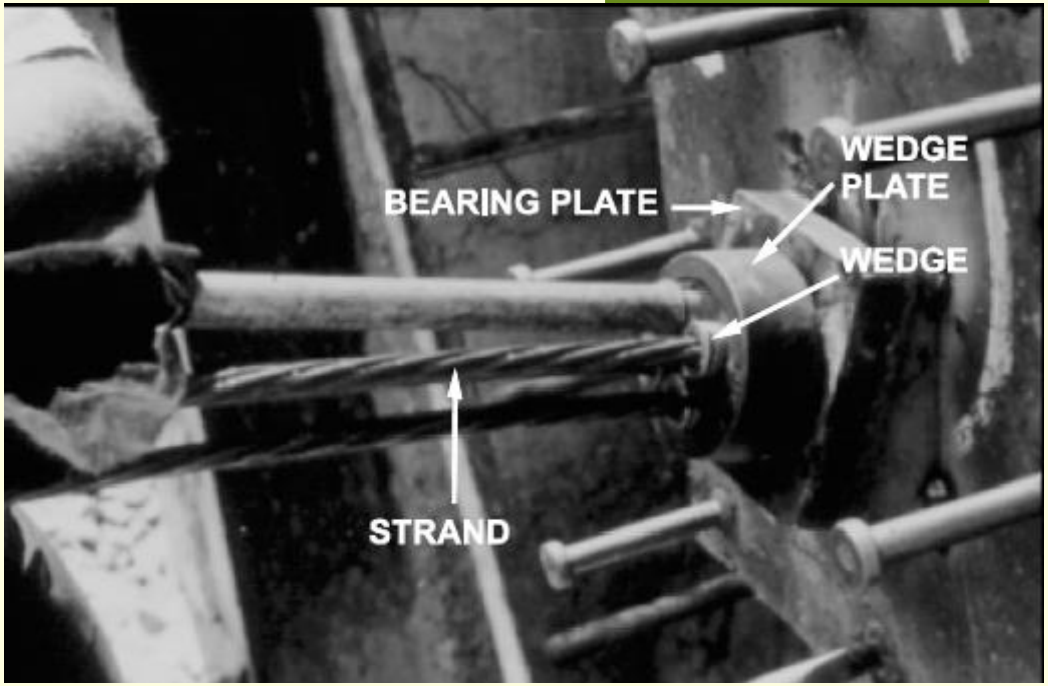
- Anchor add,
- Tie rod or cable (Free length) ,
- Anchor root

Structural Member of Anchors



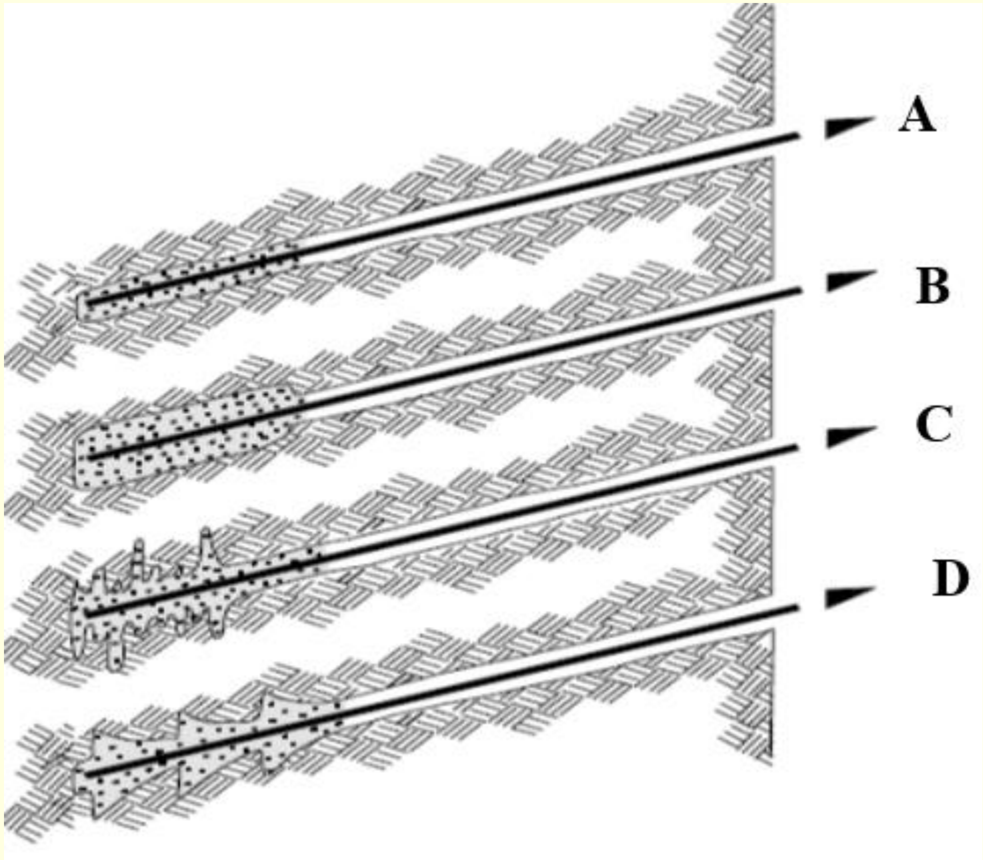
Anchor Head





- Anchor Head is composed of Bearing plate, strand, Wedge Plate

Different Types of Anchors



Rock Anchors

Design Steps For an anchored wall

Table 4. Typical design steps for an anchored wall (modified after FHWA-RD-81-150, 1982)

Step 1.	Establish project requirements including all geometry, external loading conditions (temporary and/or permanent, seismic, etc.), performance criteria, and construction constraints.
Step 2.	Evaluate site subsurface conditions and relevant properties of in situ soil and rock.
Step 3.	Evaluate design properties, establish design factors of safety, and select level of corrosion protection.
Step 4.	Select lateral earth pressure distribution acting on back of wall for final wall height. Add appropriate water, surcharge, and seismic pressures and evaluate total lateral pressure. A staged construction analysis may be required for walls constructed in marginal soils.
Step 5.	Calculate horizontal ground anchor loads and wall bending moments. Adjust vertical anchor locations until an optimum wall bending moment distribution is achieved.

Design Steps For an anchored wall

Step 6.	Evaluate required anchor inclination based on right-of-way limitations, location of appropriate anchoring strata, and location of underground structures.
Step 7.	Resolve each horizontal anchor load into a vertical force component and a force along the anchor.
Step 8.	Evaluate horizontal spacing of anchors based on wall type. Calculate individual anchor loads.
Step 9.	Select type of ground anchor.
Step 10.	Evaluate vertical and lateral capacity of wall below excavation subgrade. Revise wall section if necessary.
Step 11.	Evaluate internal and external stability of anchored system. Revise ground anchor geometry if necessary.
Step 12.	Estimate maximum lateral wall movements and ground surface settlements. Revise design if necessary.
Step 13.	Select lagging. Design walers, facing drainage systems, and connection devices.

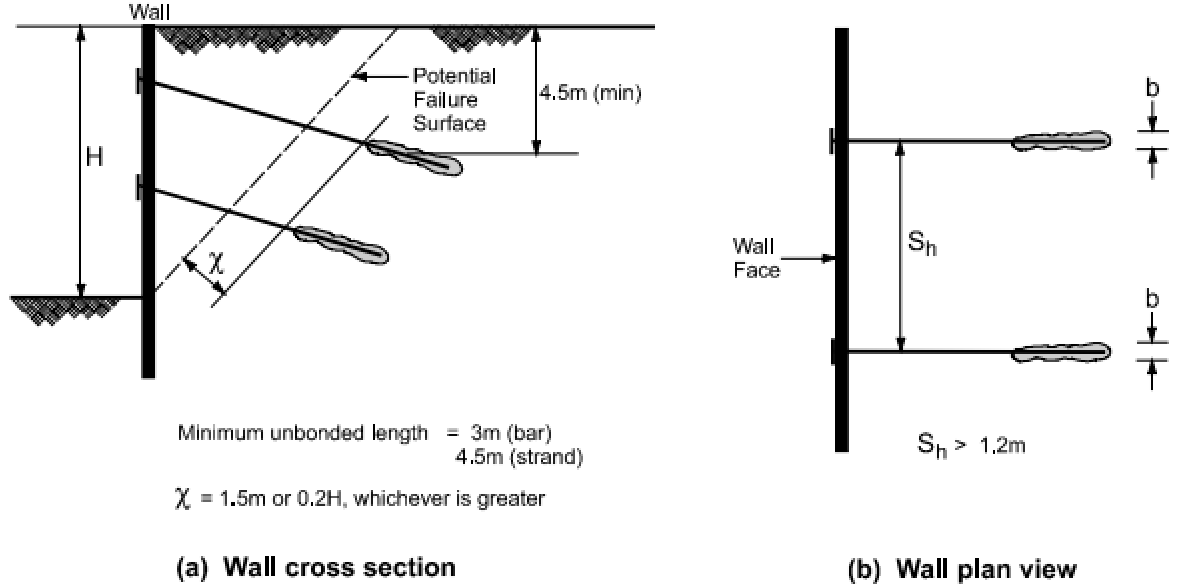


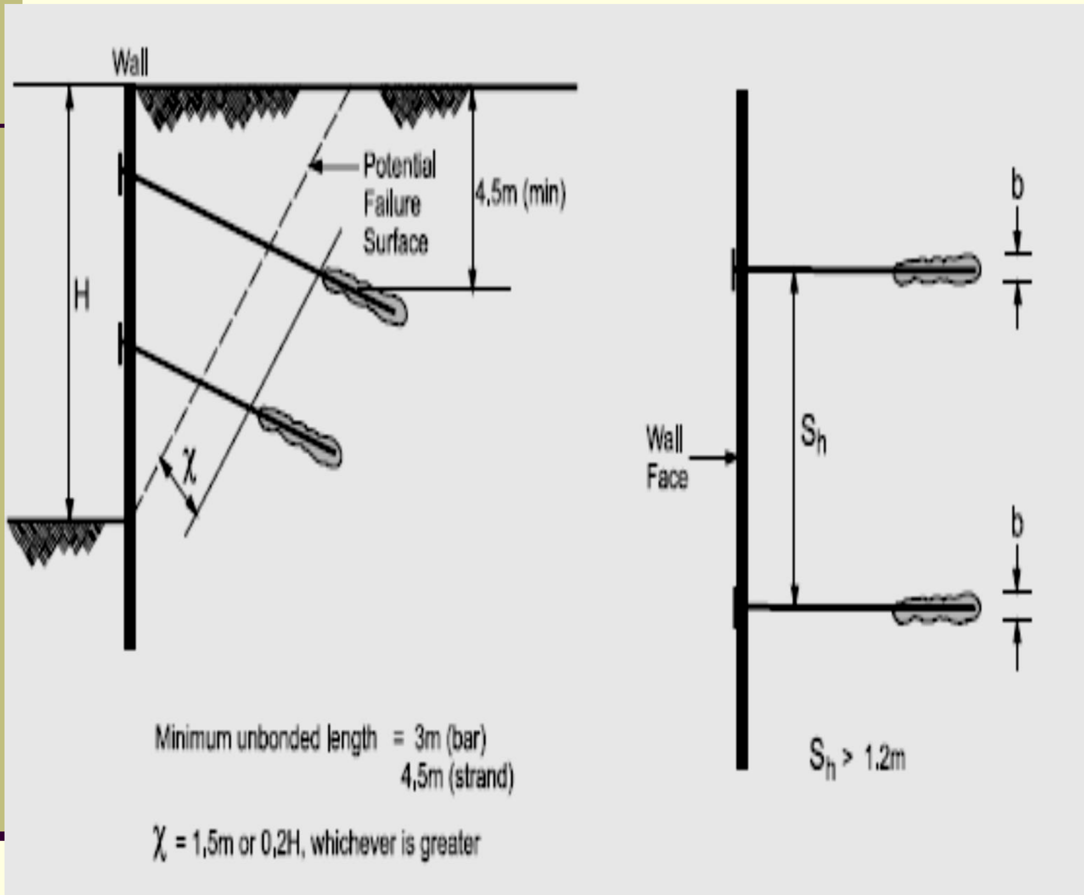
Figure 37. Vertical and horizontal spacing requirements for ground anchors.

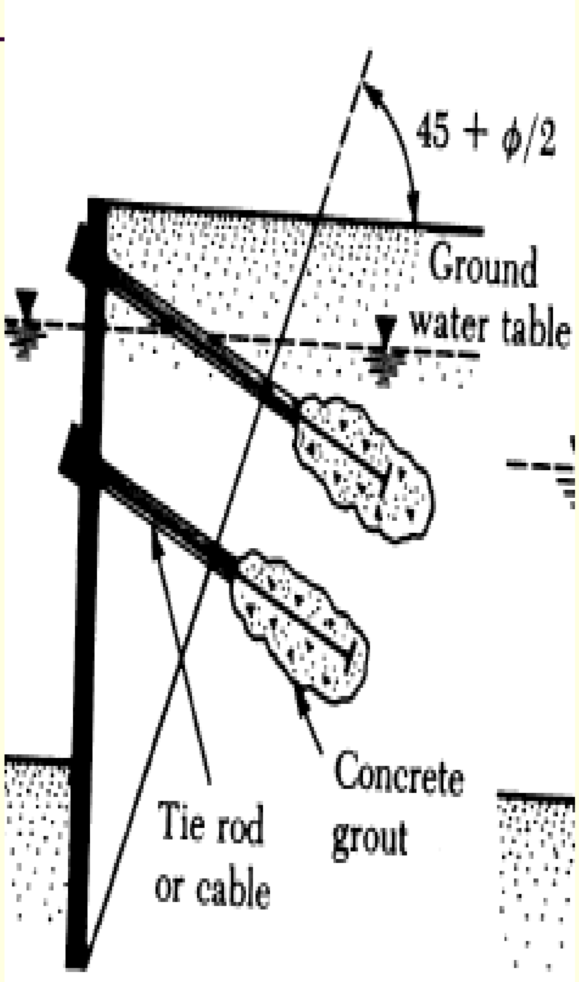
Interaction Between the Anchors:

- In order to prevent the interaction between the anchoo roots;
- The distance between the centers of the two adjacent root should not exceed 4D
- In practice, a minimum interval of 1.5m-2.0m is applied.

- The distance between the root of the anchor and any subground structure (foundation, tunnel) must be greater than 3m.

Criteria for Anchor Design





Minimum Free Length of Anchor =4.5 m

Z_c çekme çatlağının belirlenmesi

$$\sigma_a = \gamma z K_a - 2c\sqrt{K_a}$$

where K_a = coefficient of Rankine active pressure

For determining the depth of tensile crack,

$$\sigma_a = 0 = \gamma z_c K_a - 2c\sqrt{K_a}$$

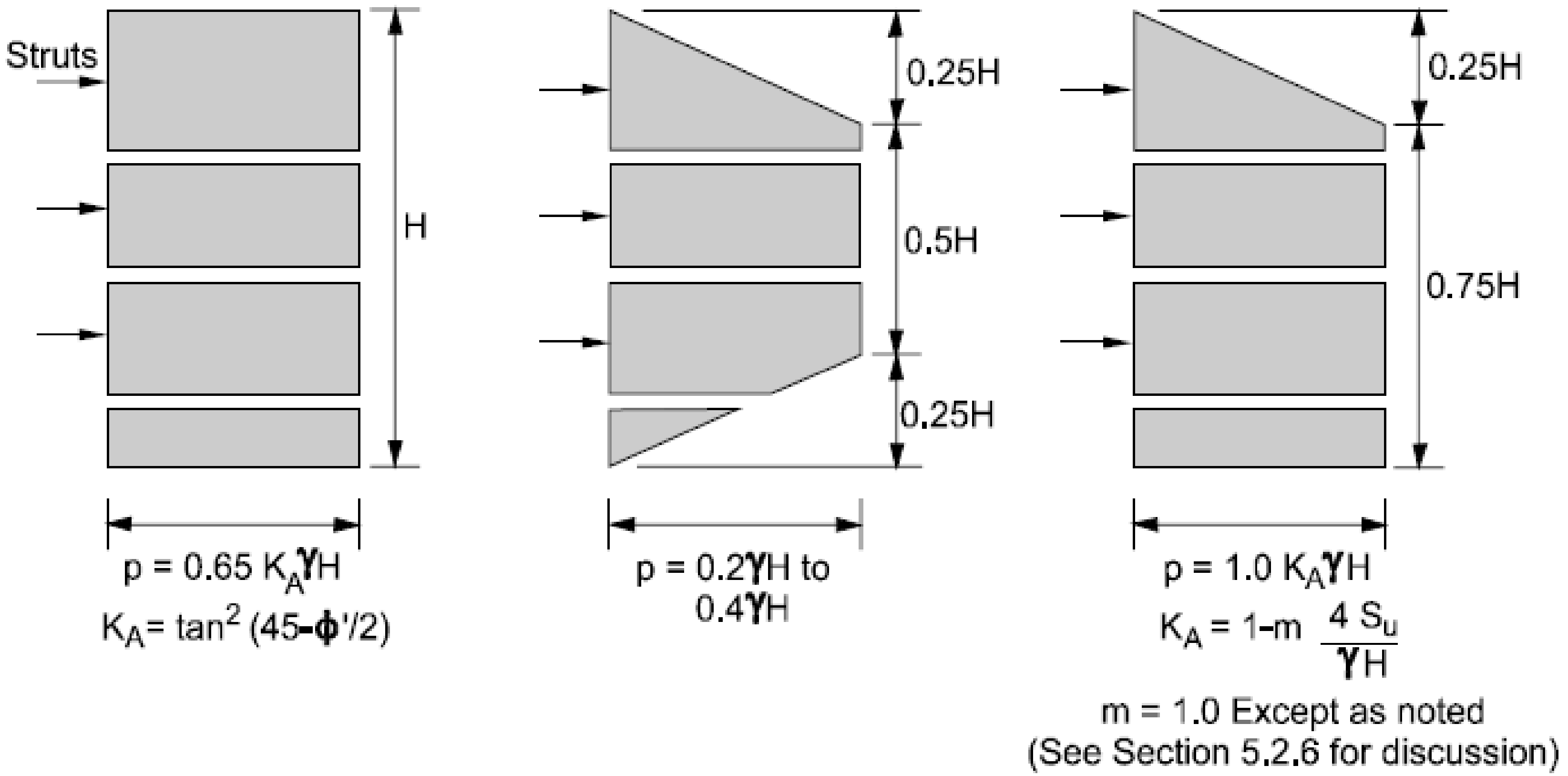
or

$$z_c = \frac{2c}{\sqrt{K_a}\gamma}$$

With $\phi = 0$, $K_a = \tan^2(45 - \phi/2) = 1$, so

$$z_c = \frac{2c}{\gamma}$$

Lateral Earth Pressure Distribution

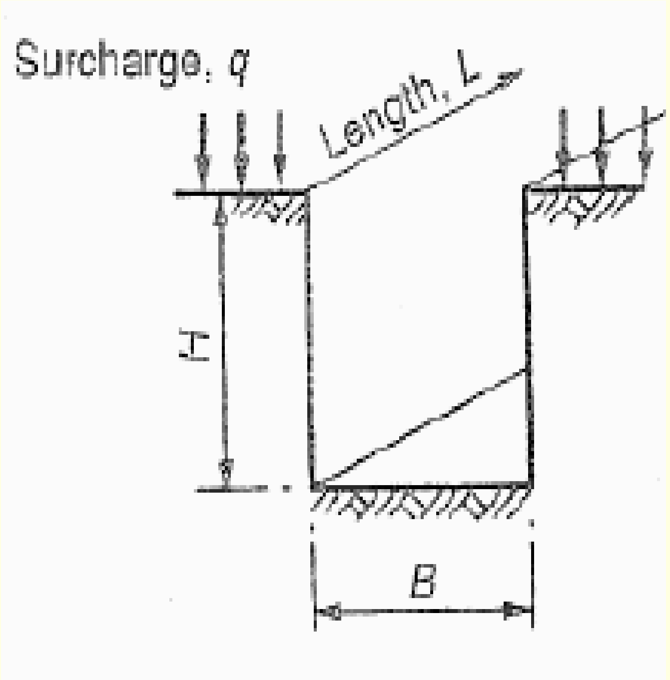


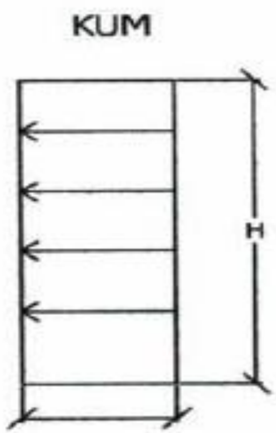
a-Sands

b- Stiff Clays

c-Soft to medium stiff clays

Lateral Earth Pressure Distribution in cohesive and cohesionless soils (Terzaghi and Peck 1967)



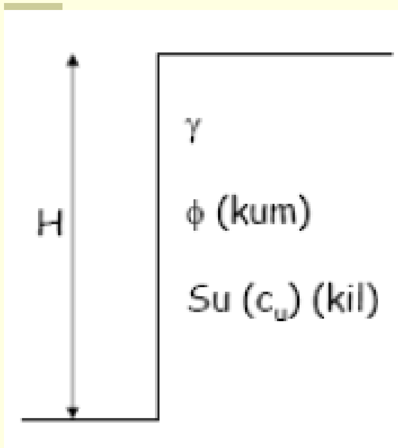


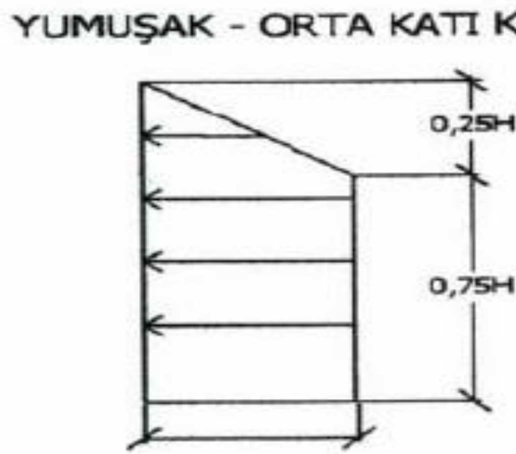
$P_a = (0.65)\gamma H K_A$

$P_a = 0.65\gamma H K_A$

$K_A = tg^2(45 - \phi'/2)$

Lateral Earth Pressure Distribution in cohesive and cohesionless soils (Terzaghi and Peck 1967)





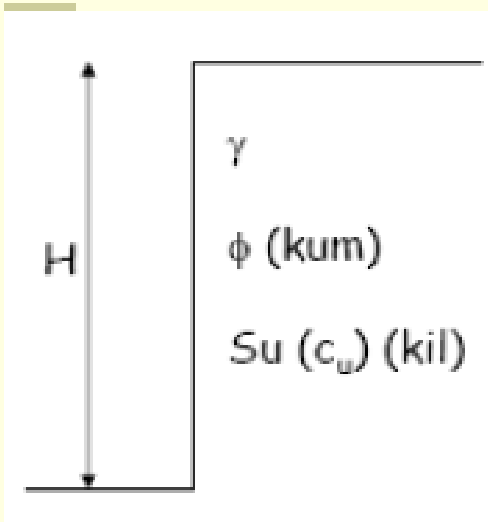
P_a

$$N_O = \frac{\gamma H}{c_u} > 6$$

$$P_a = \left(1 - m\frac{4c_u}{\gamma H}\right)\gamma H > 0.25$$

Normal konsolide kilde m=0.4
Aşırı konsolide kilde m=1

Lateral Earth Pressure Distribution in cohesive and cohesionless soils (Terzaghi and Peck 1967)



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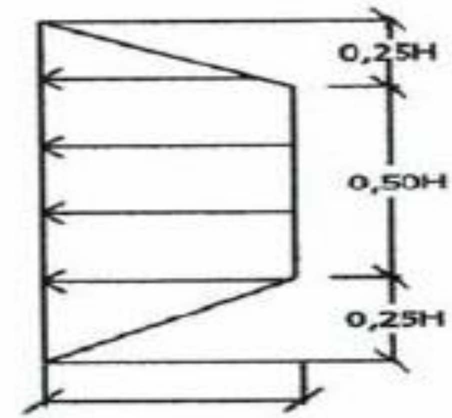


P_a=(0.2-0.4)γH

$$N_O = \frac{\gamma H}{c_u}$$

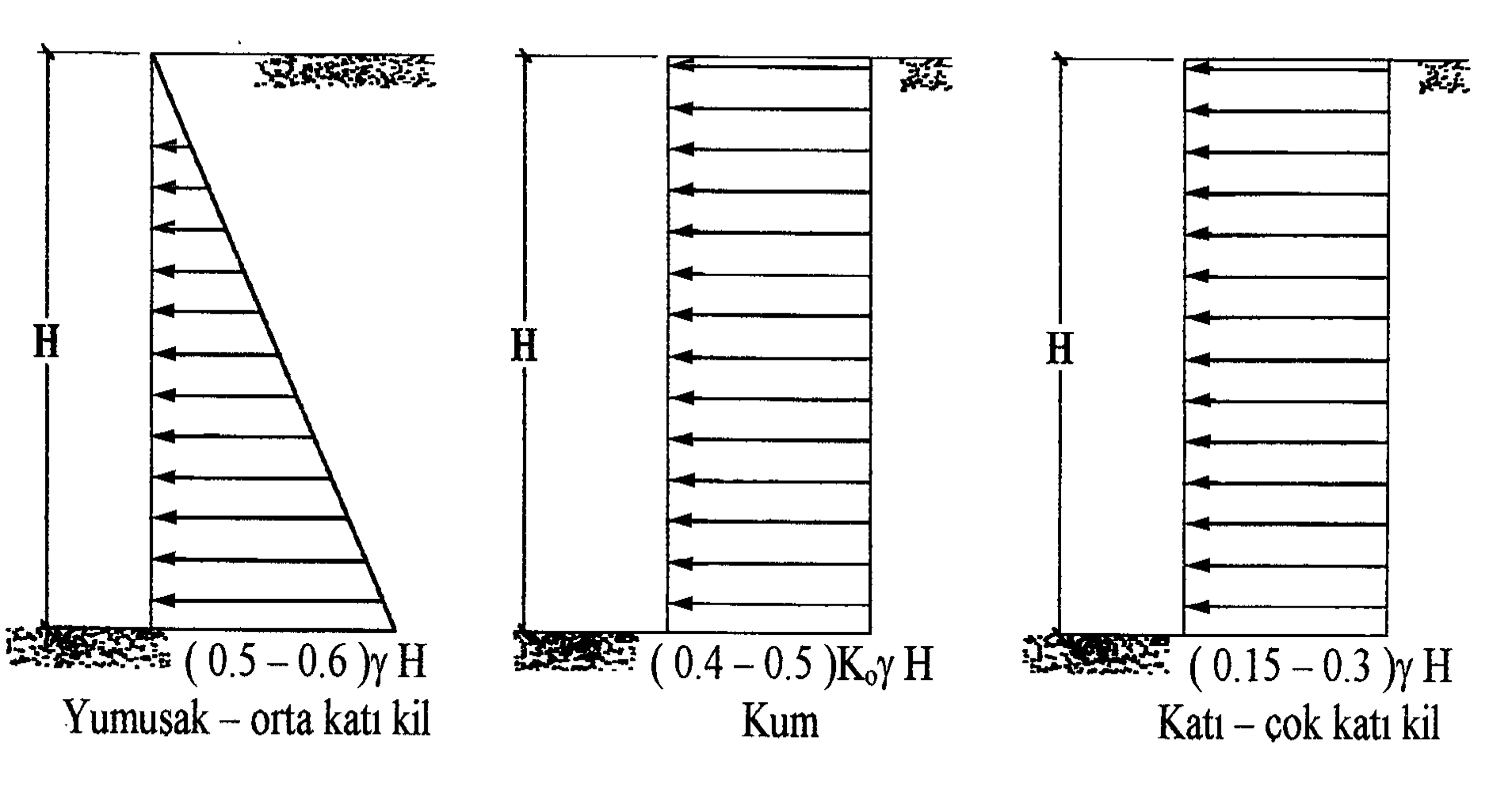
$$N_O < 4$$

$$P_a = 0.2\gamma H - 0.4\gamma H$$

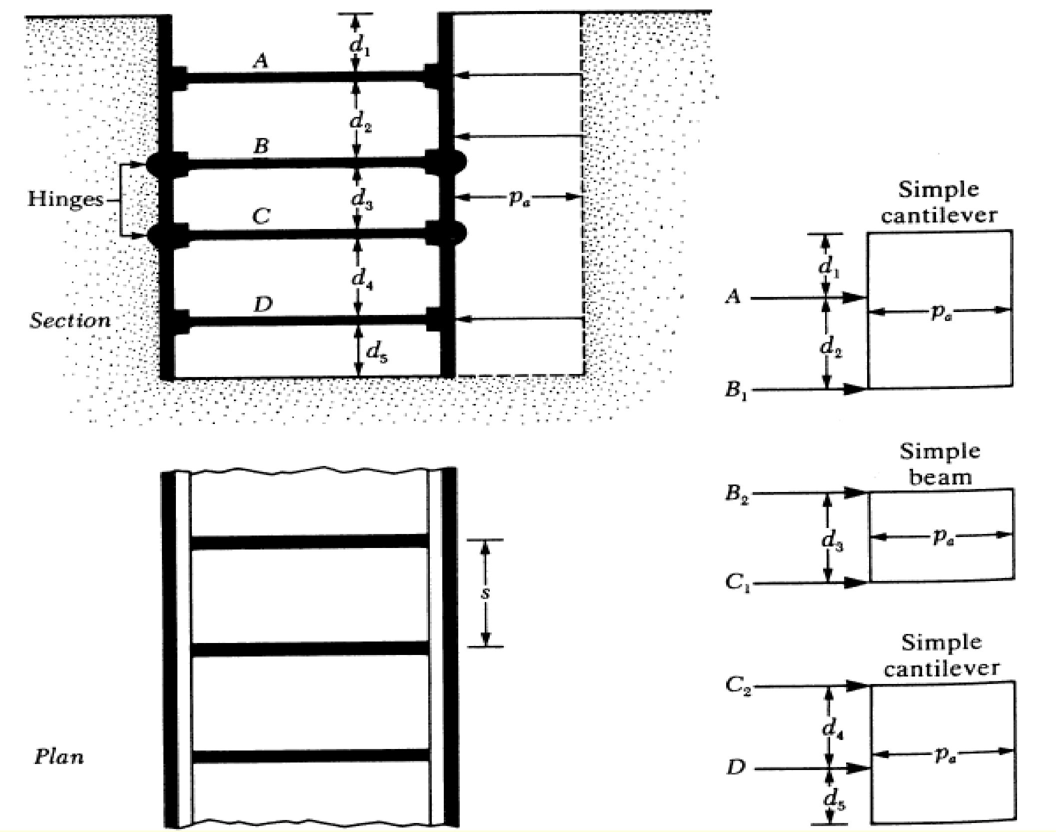
hareketler az ve kısa süreli

inşaatlarda 0.2γH tersi durumda 0.4γH

Lateral Earth Pressure Distribution (NAVFAC)

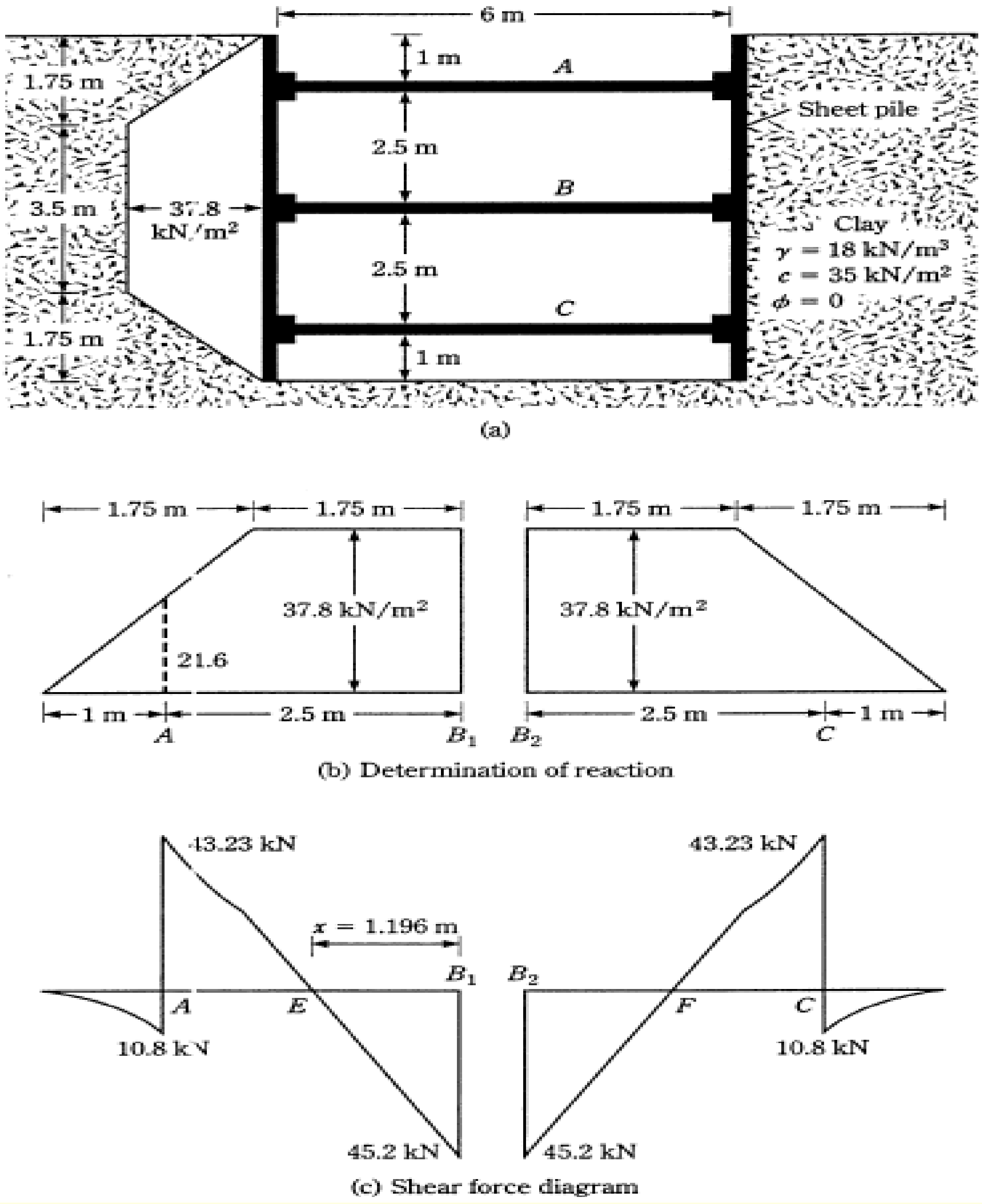


Determination of Anchor Loads



$$P_A = A \times s$$
$$P_B = (B_1 + B_2) \times s$$
$$P_C = (C_1 + C_2) \times s$$
$$P_D = D \times s$$

s= spacing between the struts


6 m
1 m
A
1.75 m
Sheet pile
2.5 m
B
3.5 m
37.8 kN/m²
Clay
γ = 18 kN/m³
c = 35 kN/m²
φ = 0
2.5 m
C
1.75 m
1 m
(a)
1.75 m
1.75 m
37.8 kN/m²
21.6
1 m
2.5 m
A
B1
B2
C
(b) Determination of reaction
43.23 kN
x = 1.196 m
A
E
F
C
10.8 kN
45.2 kN
(c) Shear force diagram

Anchor Capacity in Granular Soils

Anchor Type B

1st Method

$$P_i = L*n*\tan\phi'$$

ϕ'= Internal friction angle

L= Anchor Root length(m)

n= coefficient based on permeability,injection pressure

n≈400-600 kN/m (coarse sands ve gravels $k>10^{-4}$ m/sn)

n≈130-165 kN/m (fine sands),$k=10^{-4}-10^{-6}$ m/sn

Anchor Capacity in Granular Soils

Anchor Type B

2nd method -. Yöntem (Based on Bearing Capcity Theory)

Expanded Diameter =38-61 cm (High permeable soils)

$$P_i = \pi \,.\, D \,.\, L \,.\, \sigma_v' \,.\, \tan\phi + \pi/4 \,.\, (D^2 - d^2) .\, Nq .\, \gamma \,.\, h$$

- σ_v': Vertical Effective stress in the mid point of root(kPa)
- L : Root length(m)
- ϕ: Internal friction angle
- N_q: Bearing capacity factor
- γ : Unit weight of soil(kN/m^3)
- h : Distance from mid point of root to the ground surface
- D : Root diameter
- d : Diameter of drill hole

- $P_i = K \cdot \pi \cdot D \cdot L \cdot \sigma_v' \cdot \tan\delta + \left(\pi/4 \cdot (D^2 - d^2) \cdot Nq \cdot \gamma \cdot h\right) \longrightarrow$ neglected.
  - $\mathbf{P_i = K \cdot \pi \cdot D \cdot L \cdot \sigma_v' \cdot \tan\delta}$

K= depends on injection Pressure, Relative denisty ve installation type

Soil Type	Pressure	K
Dense sand,Gravel	Low	1.4-2.3
Fine sand and sandy silts	Düşük	0.5-1.0
Dense sand	Düşük	1.4

Anchor Capacity in Cohesive Soils

ANCHOR <u>TYPE D</u>

$$P_i = \pi \, . \, D \, . \, L \, . \, c_u + \pi/4 \, . \, (D^2 - d^2) \, . \, Nc \, . \, c_{ub} + \pi \, . \, d \, . \, l \, . \, c_a$$

- D : Anchor Root Diameter
- L : Root Length
- C_u : Average Undrained Shear Strength along the anchor root
- $N_c = 9$
- c_{ub} : Undrained Shear Strength at the root bottom
- l : shaft length (m)
- c_a : adhesion along the shaft =0.3-0.35 c_u (kPa)

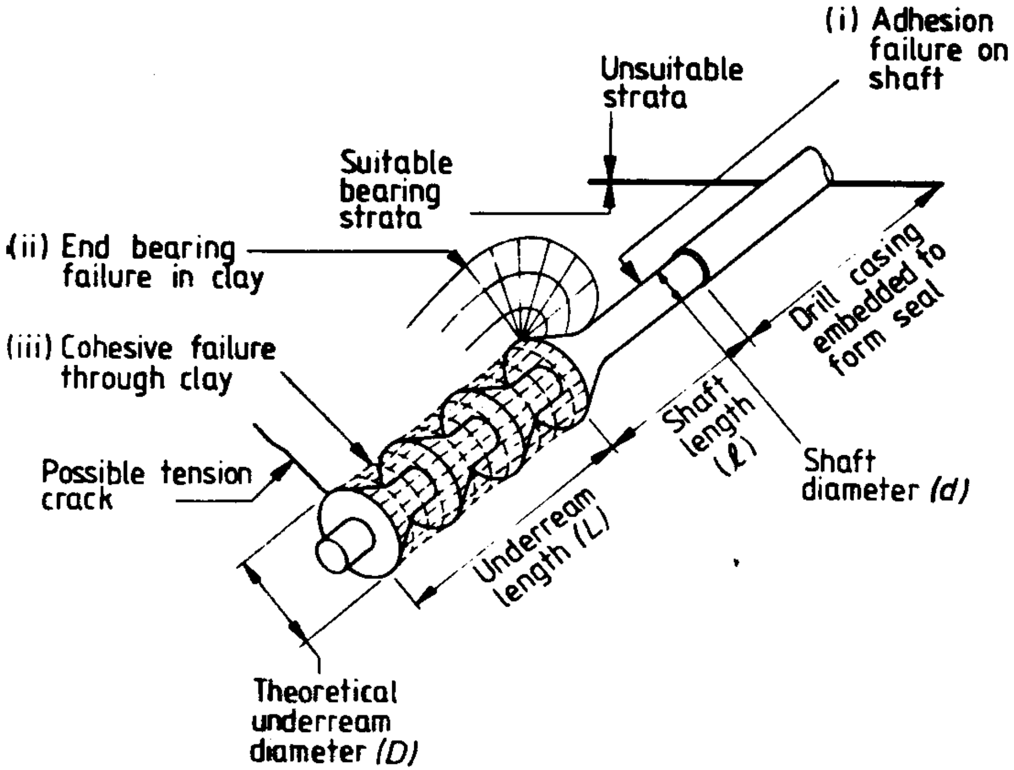


Figure 10. Diagram of multi-underream anchorage at ultimate capacity (after Bassett (1970))

Anchor Capacity in Rocks

- $P_i = \pi \cdot D \cdot L \cdot \delta$
  - D : Shaft diameter
  - L : Injection length at the rooth
  - δ : Strength between injection and Rock

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Bearing Capacity of Anchors

- Anchor Capacity ($P_{root\ capacity}$) = $\dfrac{\sum P_i}{GS}$

Minimum FS=1.5

- Horizontal spacing (s_h)= Anchor capacity*(Cos β)/P_a

P_a= Resultant of lateral earth distribution(kN/m)

Bearing Capacity of Anchors

- For the purposes of preliminary design, the ultimate load transferred from the bond length to the soil may be estimated for a small diameter, straight shaft gravity-grouted anchor from the soil type and density (or SPT blowcount value) (Table 6). The maximum allowable anchor design load in soil may be determined by multiplying the bond length by the ultimate transfer load and dividing by a factor of safety of 2.0.

Bearing Capacity of Anchors

Table 6. Presumptive ultimate values of load transfer for preliminary design of small diameter straight shaft gravity-grouted ground anchors in soil.

Soil type	Relative density/Consistency (SPT range)[1]	Estimated ultimate transfer load (kN/m)
Sand and Gravel	Loose (4-10) Medium dense (11-30) Dense (31-50)	145 220 290
Sand	Loose (4-10) Medium dense (11-30) Dense (31-50)	100 145 190
Sand and Silt	Loose (4-10) Medium dense (11-30) Dense (31-50)	70 100 130
Silt-clay mixture with low plasticity or fine micaceous sand or silt mixtures	Stiff (10-20) Hard (21-40)	30 60

Note: (1) SPT values are corrected for overburden pressure.

Çelik cinsi	Çap (mm)	Spesifik Dayanım (kN)	Alan (mm^2)
Alaşımsız çelik			
Tel	7.0	60.4	38.5
7 telli örgü tel	12.9	186	100
	15.2	232	139
	15.7	265	150
7 telli drawn örgü tel	12.7	209	112
	15.2	300	165
	18.0	380	223
Düşük Alaşımlı Çelik Çubuk			
1030/835	26.5	568	552
	32	830	804
	36	1048	1018
	40	1300	1257
1230/1080	25	600	491
	32	990	804
	36	1252	1018
Paslanmaz Çelik			
Tel	7	44.3	38.5
Çubuk	25	491	491
	32	804	804
	40	1257	1257

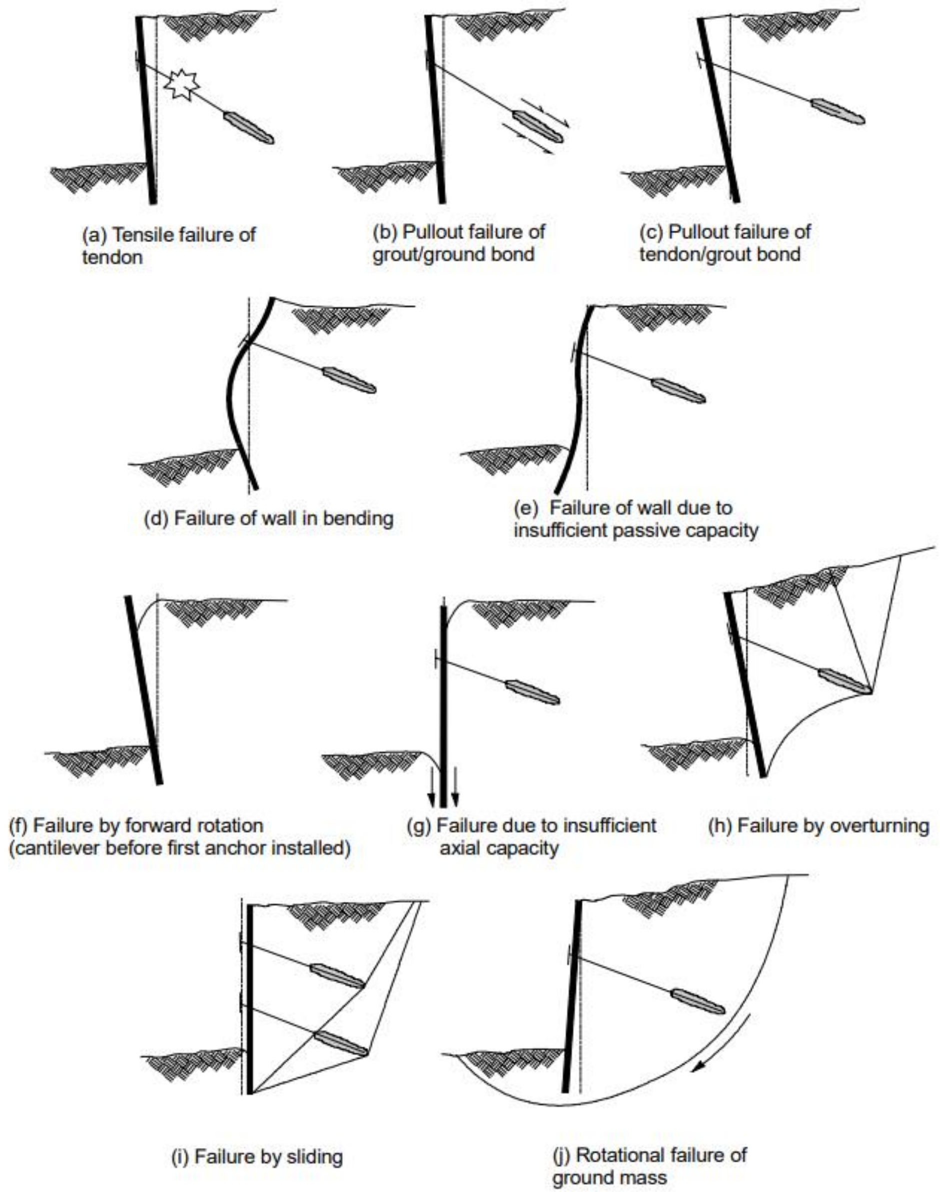
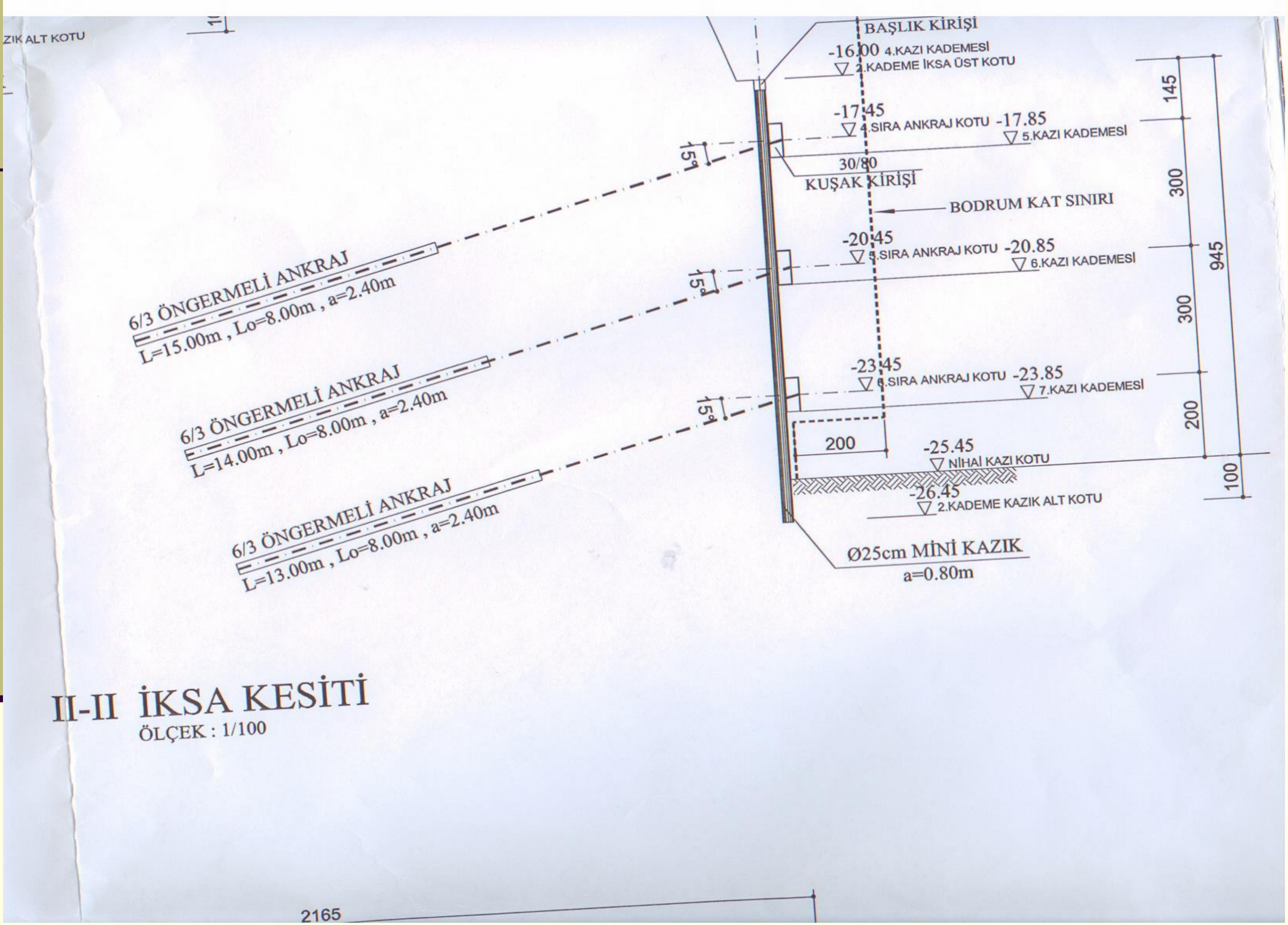


Figure 11. Potential failure conditions to be considered in design of anchored walls.



II-II İKSA KESİTİ

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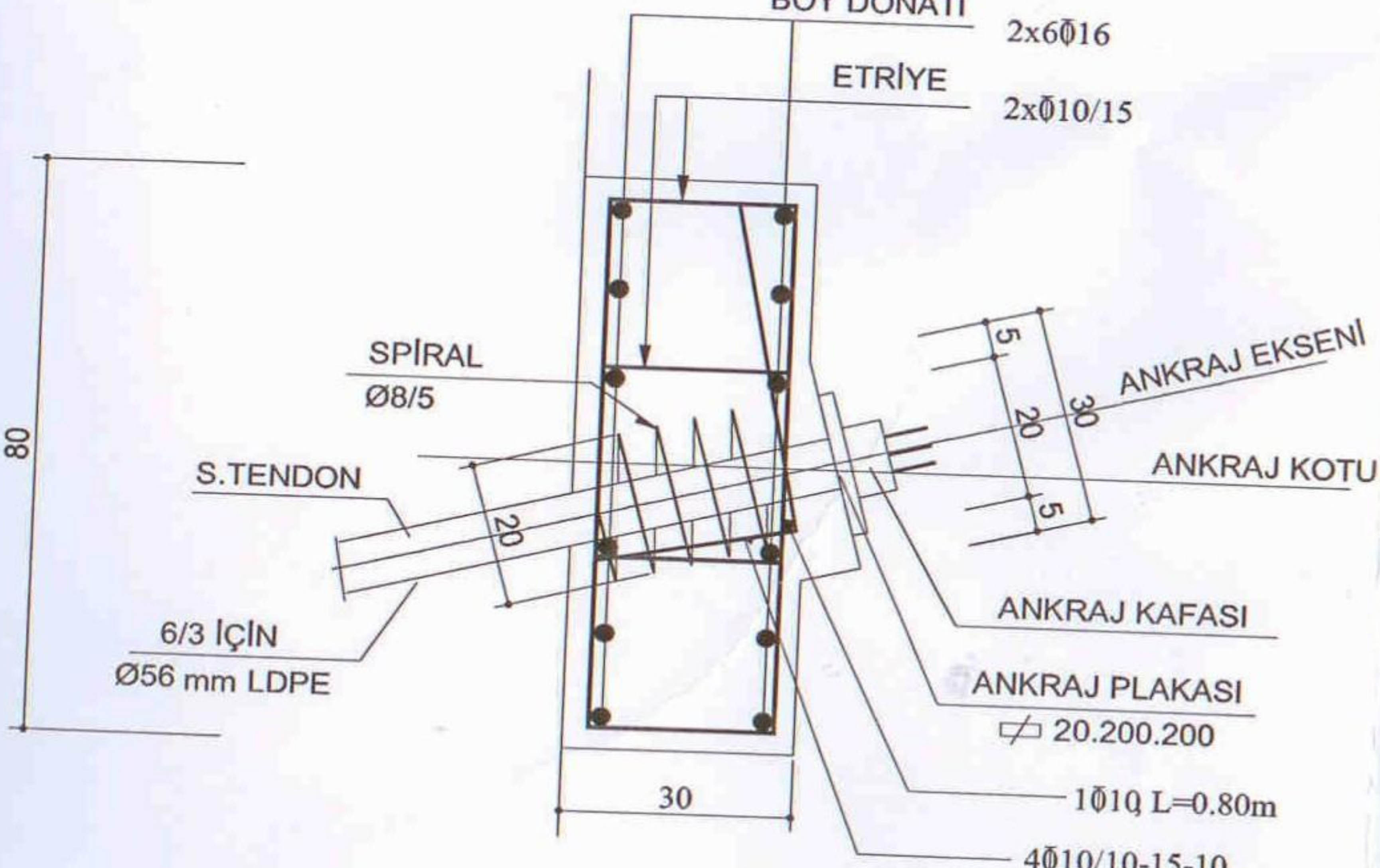
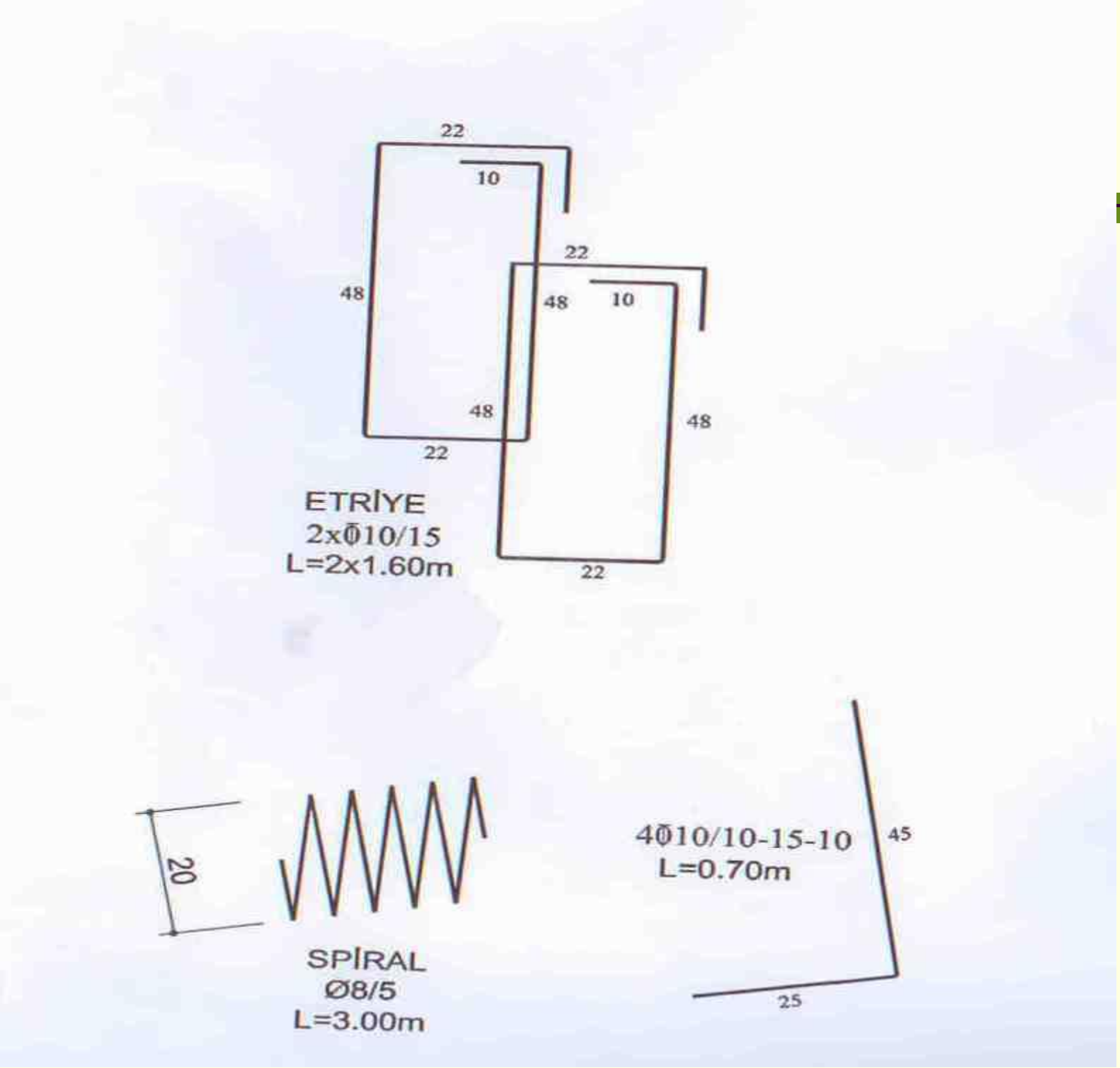


30/80 KUŞAK KİRİŞİ DETAYI

ÖLÇEK : 1/10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ETRİYE
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L=2x1.60m
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L=3.00m
4Φ10/10-15-10
L=0.70m
45
25