Summary and General Comments

This chapter covers the general topics of lateral earth pressure, including the following:

1. At-rest earth pressure
2. Active earth pressure — Rankine's and Coulomb's
3. Passive earth pressure — Rankine's and Coulomb's
4. Active and passive earth pressure, which includes earthquake forces. This is an extension of Coulomb's theory

For design, it is important to realize that the lateral active pressure on a retaining wall can be calculated using Rankine's theory only when the wall moves *sufficiently* outward by rotation about the toe of the footing or by deflection of the wall. If sufficient wall movement cannot occur (or is not allowed to occur), then the lateral earth pressure will be greater than the Rankine active pressure and sometimes may be closer to the at-rest earth pressure. Hence, proper selection of the lateral earth-pressure coefficient is crucial for safe and proper design. It is a general practice to assume a value for the soil friction angle (ϕ') of the backfill in order to calculate the Rankine active pressure distribution, ignoring the contribution of the cohesion (c'). The general range of ϕ' used for the design of retaining walls is given in the following table.

Soil type	Soil friction angle, ϕ' (deg)
Soft clay	0–15
Compacted clay	20–30
Dry sand and gravel	30–40
Silty sand	20–30

In Section 12.8, we saw that the lateral earth pressure on a retaining wall is increased greatly in the presence of a water table above the base of the wall. Most retaining walls are not designed to withstand full hydrostatic pressure; hence, it is important that adequate drainage facilities are provided to ensure that the backfill soil does not become fully saturated. This can be achieved by providing weepholes at regular intervals along the length of the wall.

Problems

12.1 through 12.4 Figure 12.43 shows a retaining wall that is restrained from yielding. For each problem, determine the magnitude of the lateral earth force per unit length of the wall. Also, state the location of the resultant, $\bar{z}$, measured from the bottom of the wall.

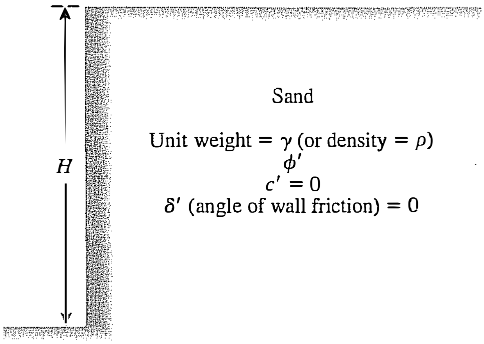

Figure 12.43

Problem	H	ϕ' (deg)	γ	Over-consolidation ratio, OCR
12.1	5 m	35	18.1 kN/m^3	2
12.2	16.5 ft	30	90 lb/ft^3	1
12.3	5 m	38	17 kN/m^3	2.5
12.4	18 ft	40	115 lb/ft^3	1.5

12.5 through 12.8 Assume that the retaining wall shown in Figure 12.43 is frictionless. For each problem, determine the Rankine active force per unit length of the wall, the variation of active earth pressure with depth, and the location of the resultant.

Problem	H	ϕ' (deg)	γ
12.5	10 ft	32	110 lb/ft^3
12.6	12 ft	28	98 lb/ft^3
12.7	3 m	36	17.6 kN/m^3
12.8	6 m	40	18.2 kN/m^3

12.9 through 12.12 Assume that the retaining wall shown in Figure 12.43 is frictionless. For each problem, determine the Rankine passive force per unit length of the wall, the variation of lateral earth pressure with depth, and the location of the resultant.

Problem	H	ϕ' (deg)	γ
12.9	10 ft	34	110 lb/ft^3
12.10	12 ft	36	105 lb/ft^3
12.11	5 m	31	14.4 kN/m^3
12.12	4 m	28	13.5 kN/m^3

12.13 through 12.15 A retaining wall is shown in Figure 12.44. For each problem, determine the Rankine active force, P_a, per unit length of the wall and the location of the resultant.

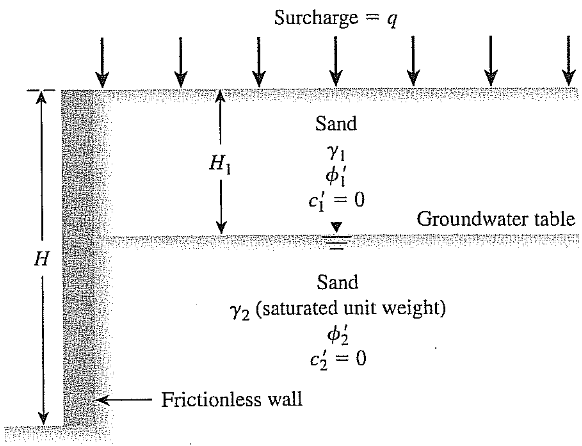

Figure 12.44

Problem	H	H_1	γ_1	γ_2	ϕ'_1 (deg)	ϕ'_2 (deg)	q
12.13	10 ft	5 ft	105 lb/ft^3	122 lb/ft^3	30	30	0
12.14	20 ft	6 ft	110 lb/ft^3	126 lb/ft^3	34	34	300 lb/ft^3
12.15	6 m	3 m	15.5 kN/m^3	19.0 kN/m^3	30	36	15 kN/m^3

12.16 Refer to the frictionless wall shown in Figure 12.10. Given: $H = 4$ m, $\theta = 5°$, and $\alpha = 10°$. For the granular backfill, $\phi' = 30°$ and $\gamma = 15$ kN/m^3.

a. Determine the magnitude of active earth pressure, σ'_a, at the bottom of the wall. Also, state the direction of application of σ'_a.

b. Determine P_a per meter length of the wall and its location and direction.

12.17 Refer to the retaining wall shown in Figure 12.45. Given: $\gamma = 16.5$ kN/m^3, $H = 3$ m, and $\delta' = 0$. Determine the magnitude of the passive force per unit length of the wall, its location, and its direction of the line of action.

12.18 For the retaining wall described in Problem 12.13, determine the Rankine passive force per unit length of the wall and the location of the resultant.

12.19 A 4.5-m-high retaining wall with a vertical back face retains a homogeneous saturated soft clay. The saturated unit weight of the clay is 19.6 kN/m^3. Laboratory tests showed that the undrained shear strength, c_u, of the clay is equal to 19.3 kN/m^2.

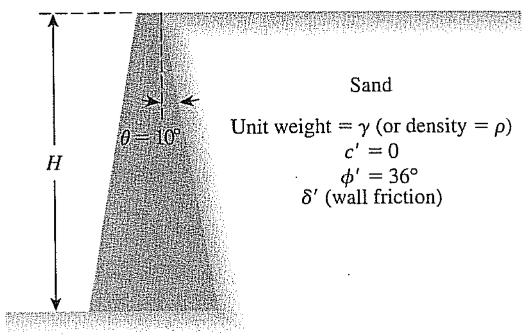

Figure 12.45

a. Make the necessary calculations and draw the variation of Rankine's active pressure on the wall with depth.
b. Find the depth up to which a tensile crack can occur.
c. Determine the total active force per unit length of the wall before the tensile crack occurs.
d. Determine the total active force per unit length of the wall after the tensile crack occurs. Also, find the location of the resultant.

12.20 Redo Problem 12.19 assuming that the backfill is supported by a surcharge of 8 kN/m^2.

12.21 A 5-m-high retaining wall with a vertical back face has a $c' - \phi'$ soil for backfill. For the backfill, $\gamma = 19$ kN/m^3, $c' = 26$ kN/m^2, and $\phi' = 16°$. Considering the existence of the tensile crack, determine the active force, P_a, on the wall for Rankine's active state.

12.22 Consider a 15-ft-high frictionless retaining wall with a vertical back and inclined backfill. The inclination of the backfill with the horizontal, α, is 10°. For the backfill, given: $\gamma = 110$ lb/ft^3, $\phi' = 25°$, and $c' = 88$ lb/ft^2. Determine the Rankine active force, P_a, per unit length of the wall after the occurrence of the tensile crack.

12.23 Consider the retaining wall shown in Figure 12.45. The height of the wall is 5 m, and the unit weight of the sand backfill is 18 kN/m^3. Using Coulomb's equation, calculate the active force, P_a, on the wall for the following values of the angle of wall friction.
a. $\delta' = 18°$
b. $\delta' = 24°$
Comment on the direction and location of the resultant.

12.24 Referring to Figure 12.46, determine Coulomb's active force, P_a, per unit length of the wall for the following cases.
a. $H = 15$ ft, $\beta = 85°$, $n = 1$, $H_1 = 20$ ft, $\gamma = 128$ lb/ft^3, $\phi' = 38°$, $\delta' = 20°$
b. $H = 18$ ft, $\beta = 90°$, $n = 2$, $H_1 = 22$ ft, $\gamma = 116$ lb/ft^3, $\phi' = 34°$, $\delta' = 17°$
c. $H = 5.5$ m, $\beta = 80°$, $n = 1$, $H_1 = 6.5$ m, $\rho = 1680$ kg/m^3, $\phi' = 30°$, $\delta' = 30°$
Use Culmann's graphic construction procedure.

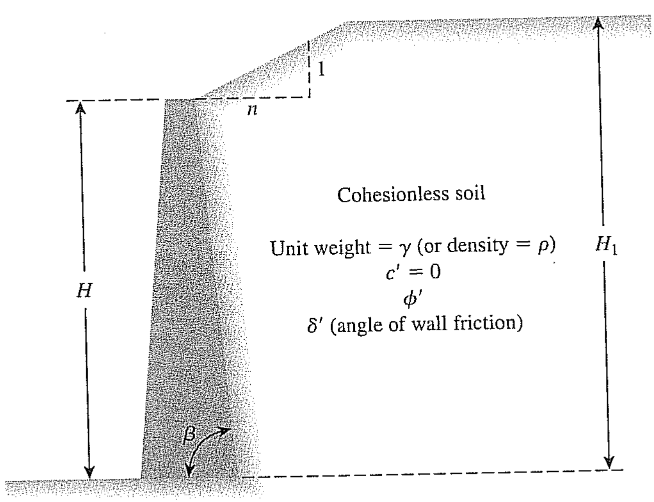

Figure 12.46