20.13. ANCHORED SHEET PILE WITH FREE-EARTH SUPPORT

The stability of anchored sheet pile depends upon the anchor force in addition to that upon the passive earth pressure. The embedment depth is considerably smaller than that in a cantilever sheet pile. Therefore, by this method, the total length of the sheet pile is reduced. Of course, the additional cost of anchors is also to be considered while judging the economy of the two types of construction.

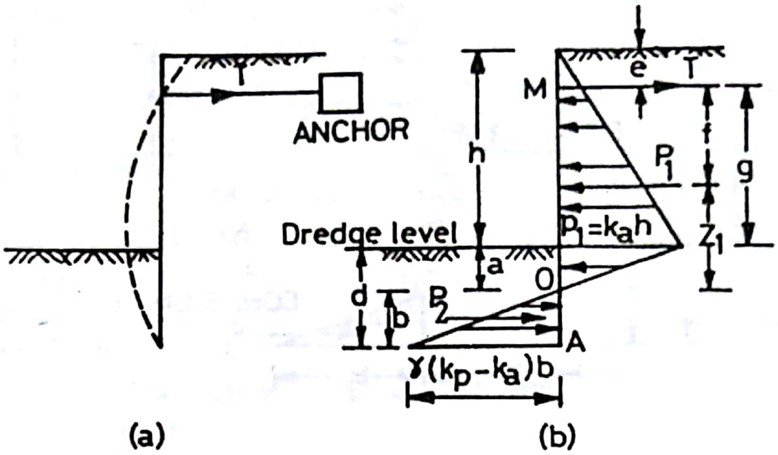

Fig. 20.22. Free Earth Support.

Fig. 20.22 (*a*) shows an anchored sheet pile with free earth support. The deflected shape is also shown. As already mentioned, there is no point of contraflexure below the dredge level. Thus, below the dredge level, no pivot point exists for the statical system. The statical analysis is based on the assumption that the soil into which the pile is driven does not produce effective restraint to induce negative bending moment at its support

The equations for the depth d are derived separately for the cohesionless and cohesive soils.

(*a*) Cohesionless Soils.

Fig. 20.22 (*a*) shows the forces acting on the pile, assuming that the material above and below the dredge level is cohesionless.

From equilibrium, $$T + P_2 - P_1 = 0 \qquad ...(20.36)$$

where T is the tensile force in anchor.

The depth a to the point of zero pressure can be determined as under.

$$\gamma K_a (h + a) - \gamma K_p a = 0$$

or $$a \gamma (K_p - K_a) = \gamma K_a h$$

or $$a = \frac{h K_a}{(K_p - K_a)} \qquad ...(20.37)$$

Therefore, $$P_2 = \frac{1}{2} p_2 b = \frac{1}{2} \gamma (K_p - K_a) b^2 \qquad ...(a)$$

where $$p_2 = \gamma (K_p - K_a) b$$

Taking moments of all the forces about anchor point M,

$$P_1 (a + h - e - \bar{Z}_1) - P_2 (h - e + a + 2b/3) = 0 \qquad ...[20.38(a)]$$

The distance $\bar{Z}_1$ is determined as in the case of cantilever piles.

Substituting the value of P_2 from Eq. (*a*) in Eq. 20.38 (*a*),

$$P_1 (a + h - e - \bar{Z}_1) - \gamma (K_p - K_a) b \times b/2 (h - e + a + 2b/3) = 0 \qquad ...[20.38(b)]$$

The above equation can be written as

$$b^3 (K_p - K_a)\gamma/3 + b^2 (K_p - K_a)\gamma/2 (g + a) - P_1 f = 0 \quad ...(20.39)$$

or

$$b^3 + 1.5b^2 (g + a) - \frac{3 P_1 f}{\gamma(K_p - K_a)} = 0 \quad ...(20.40)$$

where $f = a + h - e - \bar{Z}_1$ and $g = h - e$

Eq. 20.40 can be solved for b. Then d is determined as

$$d = b + a$$

The actual depth D is taken equal to 1.2 to 1.4 times d.

The force in anchor rod can be obtained from Eq. 20.36 as,

$$T = P_1 - P_2$$

The values of P_1 and P_2 are obtained from pressure diagrams.

(b) Cohesive Soils

Let us now consider the case when the anchored sheet pile is driven in clay ($\phi = 0$), but has the backfill of cohesionless, granular material (Fig. 20.23). The pressure distribution above the dredge line is the same as that in the case of cohesionless soils. However, below the dredge line, the pressure is given by

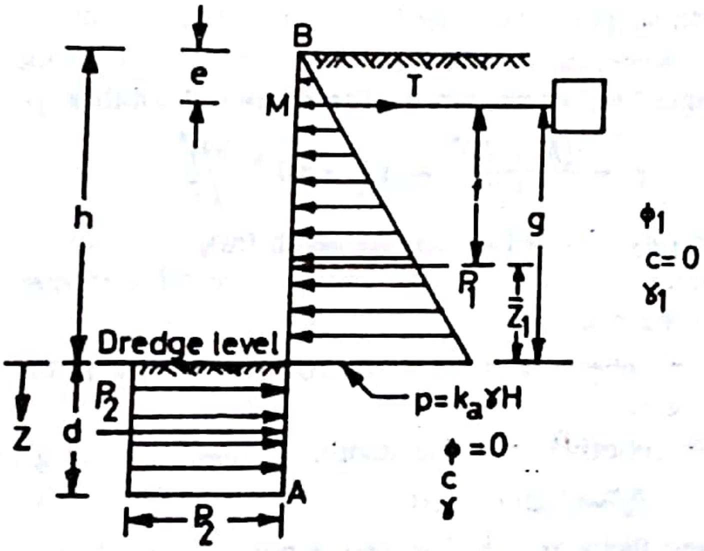

Fig. 20.23. Anchored Sheet Pile driven in Clay.

$$p_2 = (K_p \gamma Z + 2c\sqrt{K_p}) - [K_a(Z + h)\gamma - 2c\sqrt{K_a}]$$

For $\phi = 0$, $K_p = K_a = 1.0$. Therefore

$$p_2 = 2c + 2c - \gamma h = 4c - \gamma h$$

From equilibrium of forces, $P_1 - P_2 = T$

or

$$P_1 - p_2 \times d = T \quad ...(20.41)$$

Taking moments of all forces about M,

$$P_1 \times f - p_2 d (g + d/2) = 0$$

Substituting $p_2 = 4c - \gamma h$,

$$P_1 \times f - (4c - \gamma h) d (g + d/2) = 0$$

or

$$d^2 + 2gd - \frac{2 P_1 f}{4c - \gamma H} \quad ...(20.42)$$

Eq. 20.42 can be solved for d. The actual depth (D) provided is 20 to 40% more than d.

It may be noted that the wall becomes unstable when $p_2 = 0$, *i.e.*, $4c - \gamma H = 0$

or
$$\frac{c}{\gamma H} = \frac{1}{4} = 0.25 \qquad \text{...(20.43)}$$

The left hand side is equal to the stability number (S_n) defined in chapter 18. In other words, the walls becomes unstable when S_n is equal to or less then 0.25. If the adhesion of clay with the sheet pile (c_a) is considered, Eq. 20.43 is modified as

$$S_n = \frac{c}{\gamma H} \sqrt{1 + \frac{c_a}{c}} \qquad \text{...(20.44)}$$

Taking, $\sqrt{1 + c_a/c} = 1.25$,

$$S_n = 0.25 \times 1.25 = 0.31$$

Therefore, the minimum stability number (S_n) required is 0.31. If the factor of safety required is F, the stability number (S_n) should be equal to 0.31 F or more.