Pile Capacity in Cohesive Soils

- **Q_b:**

  $Q_b = c_u \times N_c \times A_b$

  The value of N_c for $D_f/B > 4$ is proposed as 9 (Skempton)

  So $Q_b = c_u \times 9 \times A_b$

  $= 9 \times c_u \times A_b$

- **Q_s:**

There are different methods

(a) α - Method

(b) β - Method

- **α - Method:**

  $Q_s = f_s \times A_s$

  $= \alpha \times c_u \times A_s$ where α = Adhesion Factor

  α can be determined by using empirical correlations.

  Tomlinson (1986) proposed the relationship between α and c_u.

C_u (kN/m^2)	10	20	40	80	120	160	200	240
α	1.0	0.9	0.76	0.57	0.42	0.38	0.36	0.35

α ~ C_u by Dennis & Olson based on Tomlinson's information

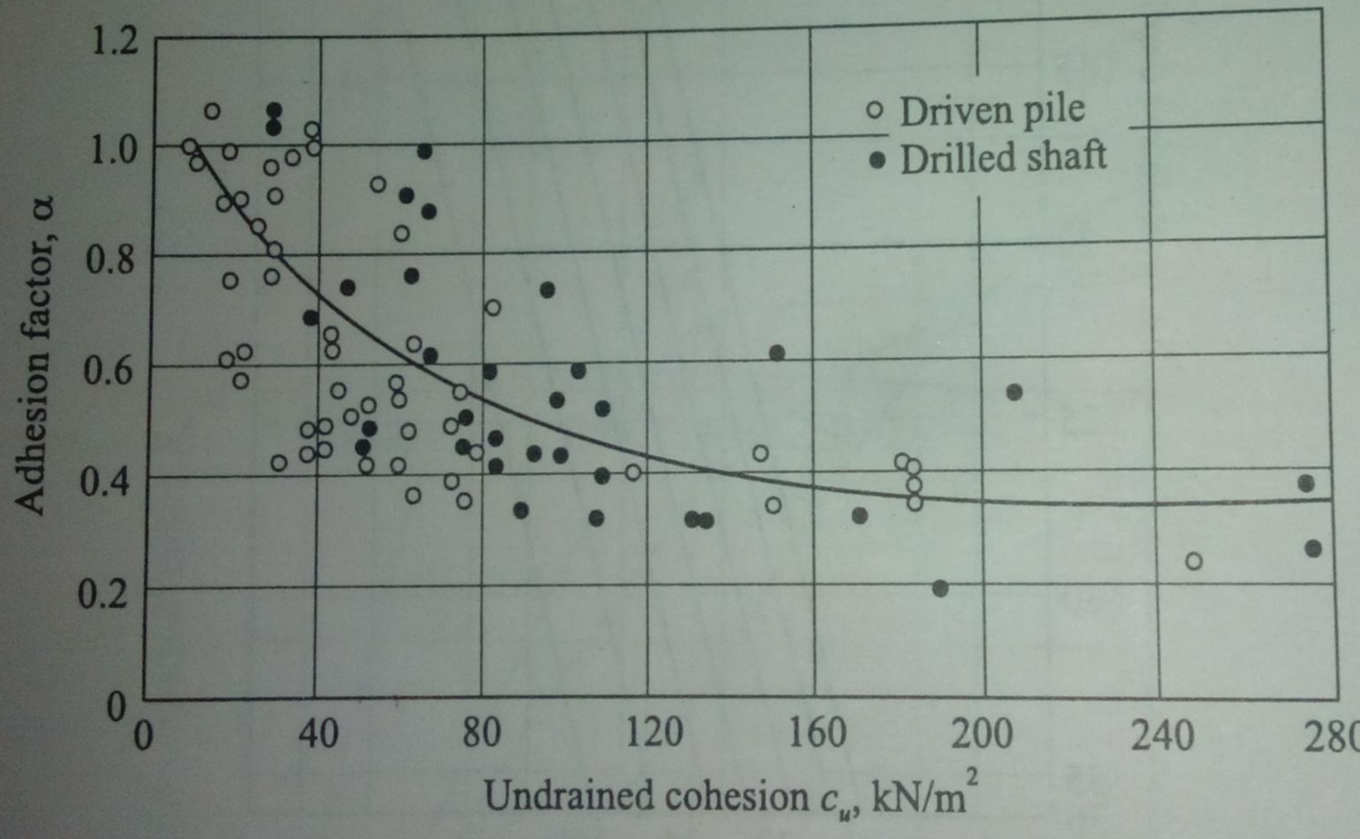


Fig. 8.15 Adhesion factor α for piles with penetration length less than 50 m in clay.

- **β - Method:**

$Q_s = f_s \times A_s$

$f_s = \bar{p}_o \times k_s \times \tan\phi'$ (based on effective overburden pressure)

$\bar{p}_o$ = Average Overburden Pressure

$\beta = k_s \times \tan\phi'$ where k_s = Coefficient of earth pressure

According to Burland (1973), β can be taken as

$\beta = k_o \times \tan\phi'$

$k_o = 1 - \sin\phi'$ for NCC

$k_o = (1 - \sin\phi')(OCR)^{0.5}$ for OCC

For clays ϕ' may be taken from 20° to 30°. In such cases, the value of β varies from 0.24 to 0.29.

Problem: A concrete pile 45 cm is driven through a system of layered cohesive soil as shown in figure. The length of pile is 16 m. Estimate Q_u and Q_a with FS = 2.5

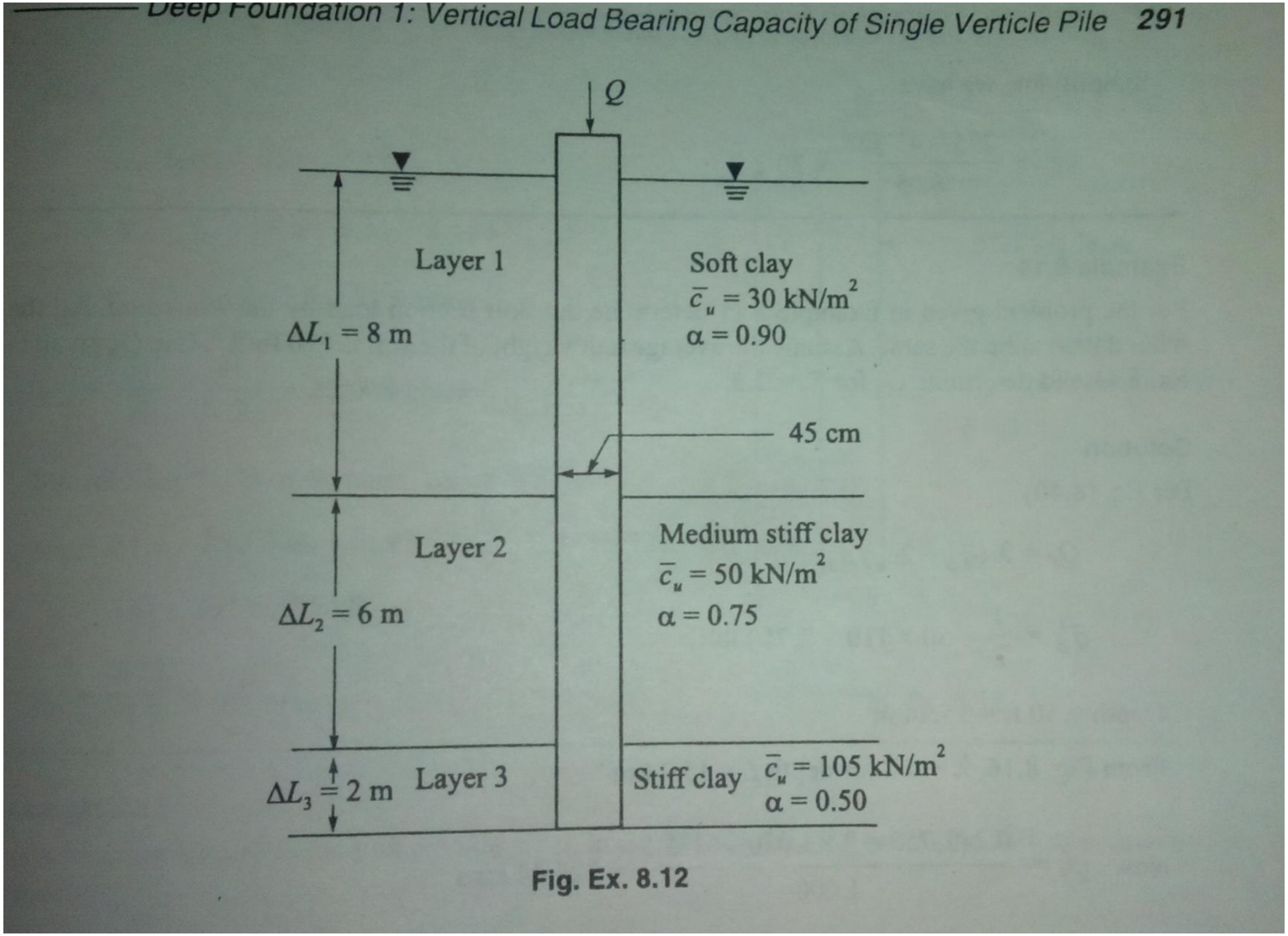


Fig. Ex. 8.12

Pile Capacity based on CPT Data

q_c = Cone Penetration Resistance at Pile Tip

(3d above & 1d below base; take average)

$\bar{q}_c$ = Average Cone Resistance along Pile or Shaft

$Q_b = q_b \times A_b$ $(q_b = q_c)$

$Q_s = f_s \times A_s$ (f_s in $kN/m^2 = \bar{q}_c/2$) here $\bar{q}_c$ is in kg/cm^2

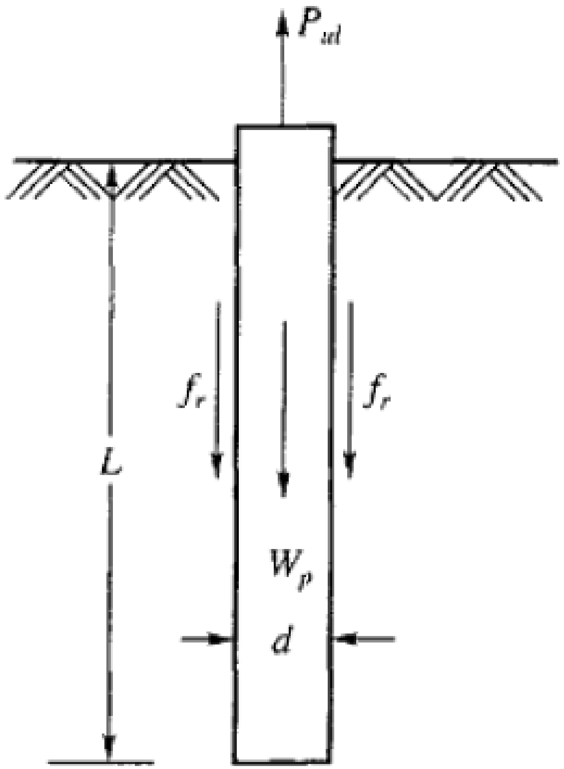
$c_u = q_c/N_K$ (N_K = Cone Factor = 20 **for mechanical cone**

= 15 **for electric cone**)

Note: **1 kg/cm^2 = 100 kN/m^2**

Uplift Resistance of Piles

Piles are called as Tension Piles or Uplift Piles or Anchor Piles.



Single pile subjected to uplift

Uplift Resistance of Pile in Clay:

For piles embedded in clay, equation may be written as

$$P_{ul} = W_p + A_s \alpha \bar{c}_u$$

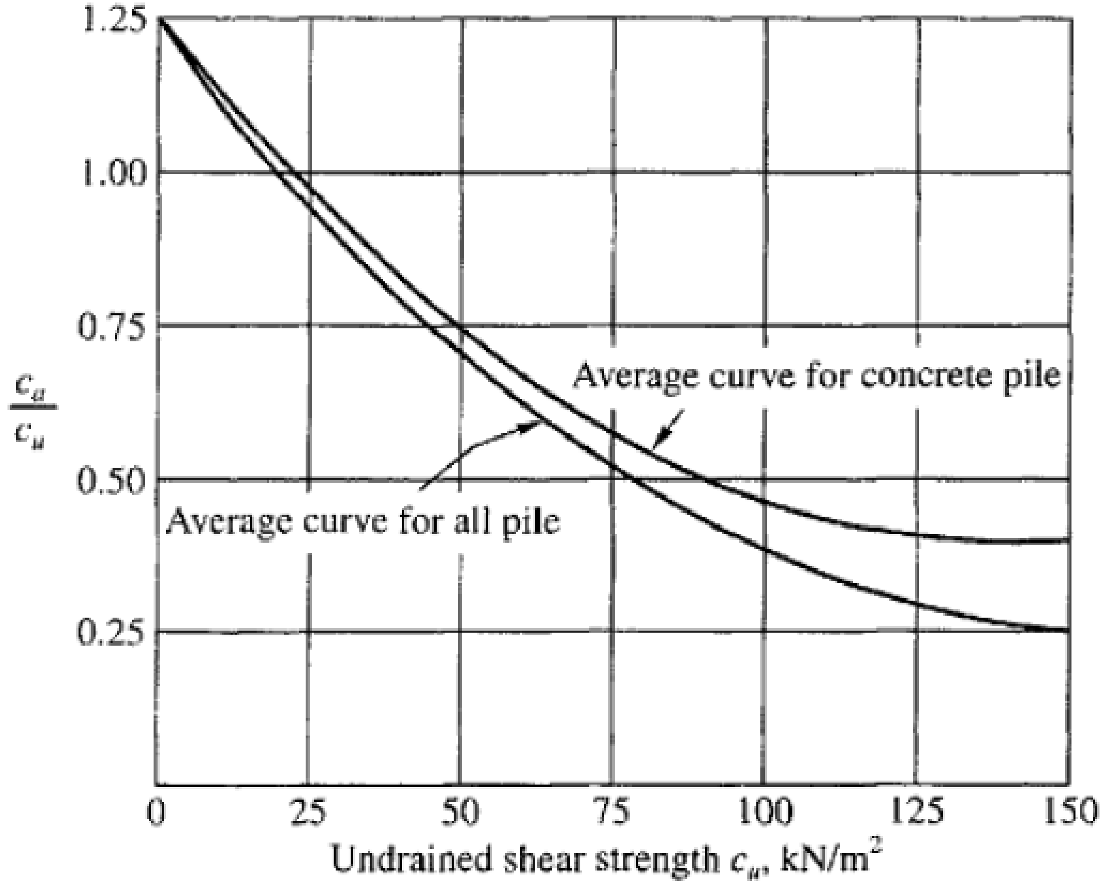
where, $\bar{c}_u$ = average undrained shear strength of clay along the pile shaft,

α = adhesion factor (= c_a/c_u),

c_a = average adhesion.

P_{ul} = Uplift Capacity of Pile

Figure below, gives the relationship between c_a and c_u based on pull out test results as collected by Sowa (1970). As per Sowa, the values of c_a agree reasonably well with the values for piles subjected to compression loadings.



Relationship between adhesion factor α and undrained shear strength c_u

(Source: Poulos and Davis, 1980)

Uplift Resistance of Pile in Sand:

Adequate confirmatory data are not available for evaluating the uplift resistance of piles embedded in cohesionless soils. Ireland (1957) reports that the average skin friction for piles under compression loading and uplift loading are equal, but data collected by Sowa (1970) and Downs and Chieurzzi (1966) indicate lower values for upward loading as compared to downward loading especially for cast-in-situ piles. Poulos and Davis (1980) suggest that the skin friction of upward loading may be taken as two-thirds of the calculated shaft resistance for downward loading.

A safety factor of 3 is normally assumed for calculating the safe uplift load for both piles in clay and sand.