Pile Capacity in Cohesionless Soils

$$Q_u = q_b A_b + f_s A_s$$

a) Base Resistance, q_b:

by Terzaghi equation for cohesionless soils

$$q_b = \gamma D_f N_q + 0.5\gamma B N_\gamma$$

As B or Dia. of pile is very small as compared with pile length, so B is ignored, so second term is taken as zero, therefore

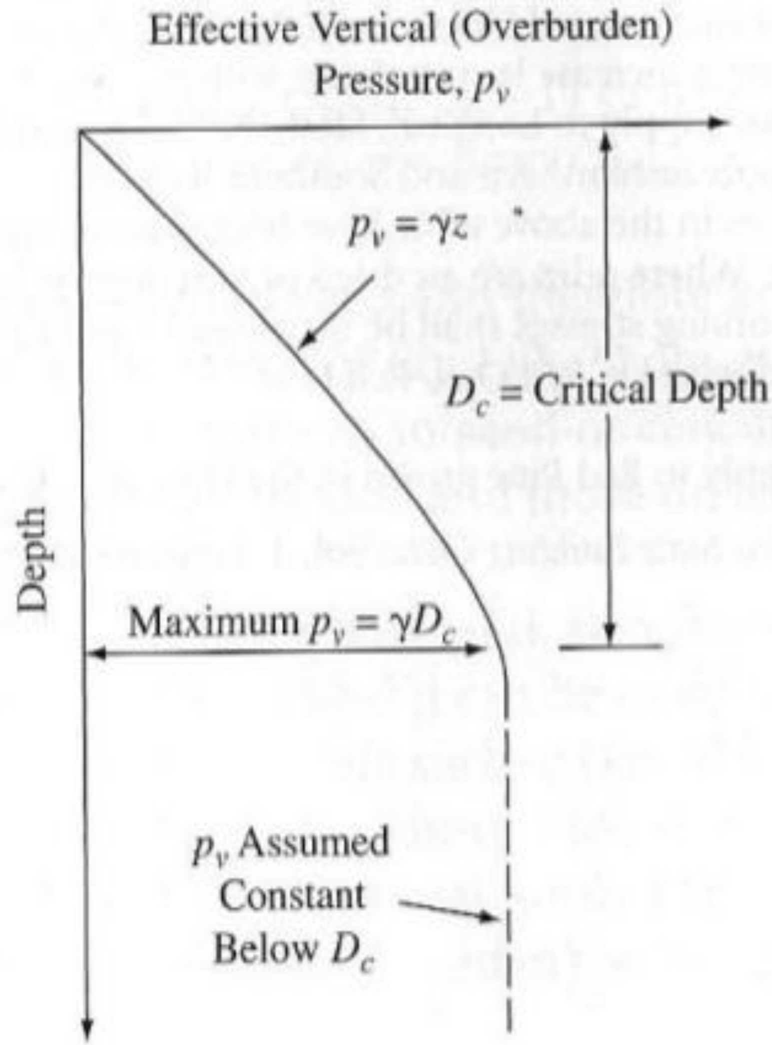
$q_b = \gamma D_f N_q^*$.. or .. . $q_b = p' \times N_q^*$

So $Q_b = q_b . A_b$

p'= effective overburden pressure at the base level

N_q^* = Bearing capacity factor including necessary shape factors and depends on ϕ

FIGURE Variation of effective vertical (overburden) pressure of soil adjacent to a pile with depth (McCarthy, 1977).



Pile Capacity in Cohesionless Soils

a) Base Resistance, q_b:

- As evident from previous equation that the base resistance in cohesionless soil depends on overburden pressure at the pile base, however, the increase of p' is limited to certain depth called critical depth 'L_c' or 'D_c' as below:
- Critical Depth =10D for loose sand
- Critical Depth = 15D for medium dense sand
- Critical Depth = 20D for dense sand
- Average Critical Depth =15D
- The concept of critical depth was introduced by Vesic and is attributed to arching action in granular soils
- As per Tomlinson, the base resistance to be limited to 11MPa.
- As per De Beer (1965) the base resistance q_b for a bored pile is about one third of that of a driven piles

  q_b (bored) =(1/3)q_b (driven pile)

Bearing Capacity Factor, Nq*

Naval Facilities Engineering Command (**NAVFAC**)

a) Base Resistance, q_b:

ϕ	26	28	30	32	34	36	38	40
Driven Piles	10	15	21	29	42	62	86	145
Bored Pile	5	8	10	14	21	30	43	73

a) ***Base Resistance, q_b:***

Bearing Capacity Factor, Nq*

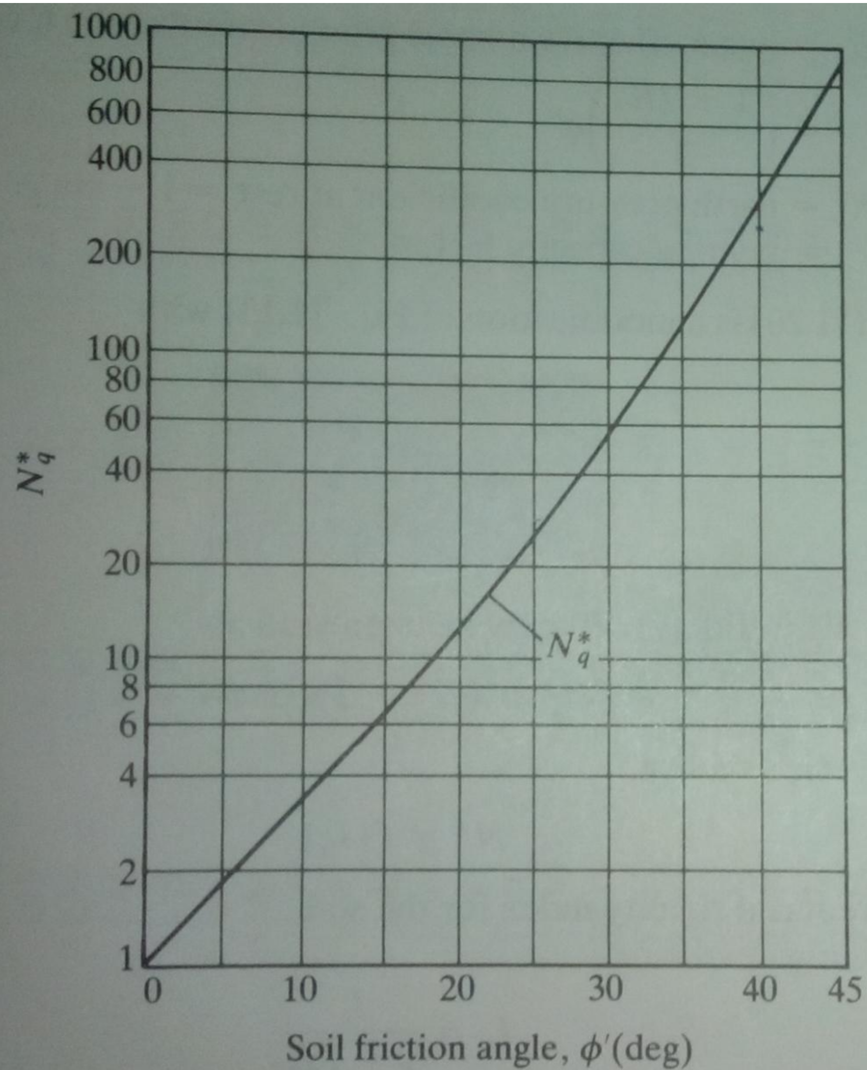


Figure 11.12 Variation of the maximum values of N_q^* with soil friction angle ϕ' (after Meyerhof, 1976)

Meyerhof, 1976

The values of N_q* are for driven piles; for bored pile N_q* is taken as 1/3 of driven piles

Bearing Capacity Factor, Nq*

a) Base Resistance, q_b:

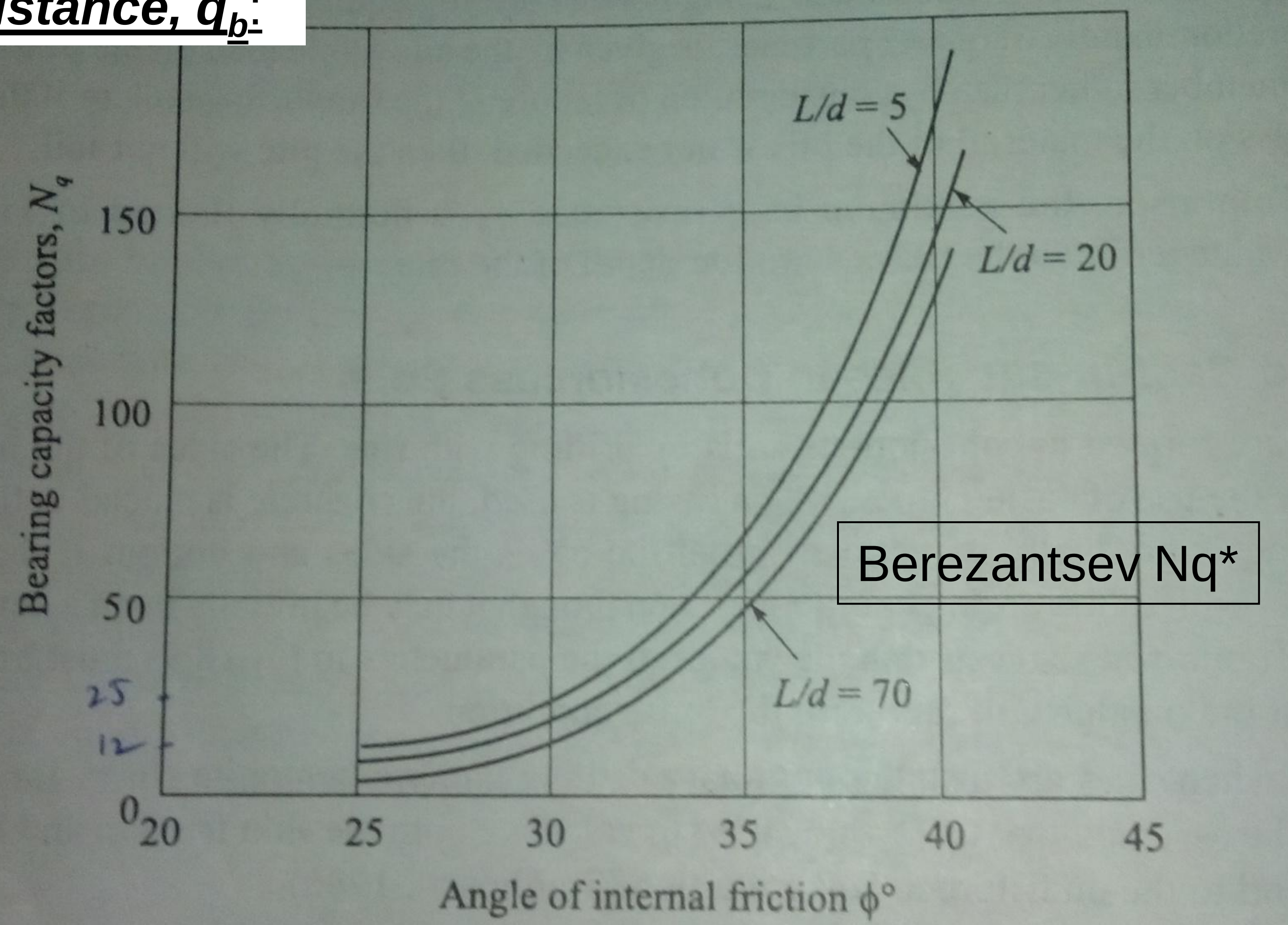


Fig. 8.9 Berezantsev's bearing capacity factor, N_q (after Tomlinson, 1986)

The values of N_q* are for driven piles; for bored pile N_q* is taken as 1/3 of driven piles

Pile Capacity in Cohesionless Soils

b) Shaft resistance

$f_s = p' K_s \tan\delta$ ---------- unit resistance

$Q_s = (p' K_s \tan\delta) A_s$ ----total skin capacity

K_s = coefficient of earth pressure
K_s=1-1.5 for driven pile, K_s=0.7 for bored pile
p' =effective overburden at mid depth
δ=angle of friction at pile/soil interface
δ =3/4ϕ for concrete pile, δ =20 for steel pile

Notes: **1.** As per Tomlinson, the shaft resistance, f_s, to be limited to 110 kPa

2. As per De Beer (1965) the shaft resistance for bored piles should be based on ϕ=28 deg. which corresponds to loose condition

- For bored pile q_b and f_s are approximately 1/3 & 1/2 , respectively of the corresponding value for driven piles.

$Q_{u\ (bored\ pile)} = [Q_{b\ (driven\ pile)}/3] + [Q_{s\ (driven\ pile)}/2]$

Above concept is used in the case of cohesionless soils. The sand in the case of bored piles is loosened as a result of the boring operation, even though it may initially be in a dense or medium dense state. The value of ϕ to be used to obtain N_q should be for the loose condition. (assume $\phi = 28^o$)

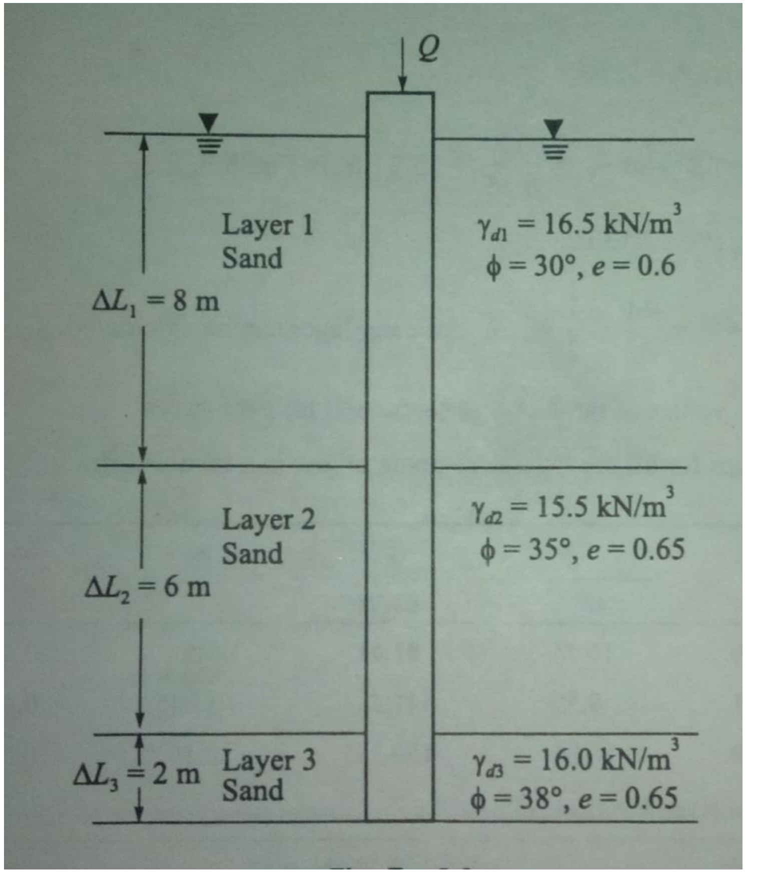
ASSIGNMENT PROBLEM

For the soil profile shown in figure, calculate Q_u and Q_a for a concrete pile of 45 cm with overall FS=2.5.
Use conventional method for calculation of Q_s and Berezantsev's method for calculating Q_b.

Data:
Take $\delta = 3/4\phi$ and $K_s = 1/2 K_p$ for each layer

Hint: from given data calculate G_s by using Eq: $\gamma_d = \gamma_w G_s/(1+e)$
Calculate γ_{sat} by Eq:

$$\gamma_{sat} = (G_s+1)\gamma_w/(1+e)$$



Pile Capacity based on SPT (N):

(For cohesionless soils)

q_b (kN/m²) $= 40\ N\ D_b/B \leq 400\ N$

N = SPT N-value in the vicinity of pile base *(2B below & 4B above the pile base)*

D_b = Length of pile embedded in sand

f_s (kN/m²) $= 2\ \overline{N}$

$\overline{N}$ = Average SPT N-value along pile embedded length