Module 5 : Design of Deep Foundations

Lecture 23 : Piles In Sand [Section 23.1 : Introduction]

Objectives

In this section you will learn the following

- Introduction

$$P_u = \int F_W . P \sigma_v' k_s \tan \phi_a' . dz + A_b \sigma_{vb}' N_q - W \qquad \text{---------(39)}$$

σ_{vb}' =effective vertical stress at the base of the pile.

N_q =bearing capacity factor

A_b =base area

σ_v' =mean effective vertical stress along the length of the pile.

F_w =correction factor for tapered pile

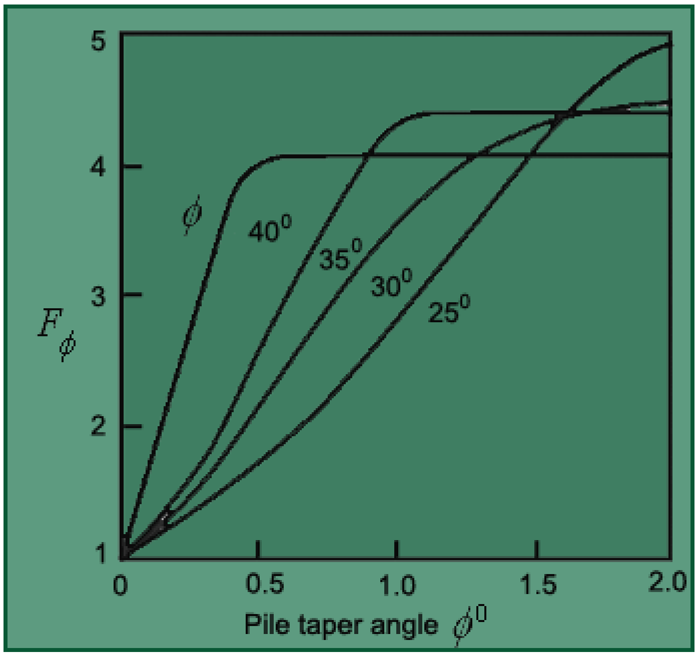


Fig. 5.36 Values of F_w

Recap

In this section you have learnt the following.

- Introduction

Module 5 : Design of Deep Foundations

Lecture 23 : Piles In Sand [Section 23.2 : Vesic's method]

Objectives

In this section you will learn the following

- Vesic's method
- Limited depth method – Vesic
- Problem

Vesic's method

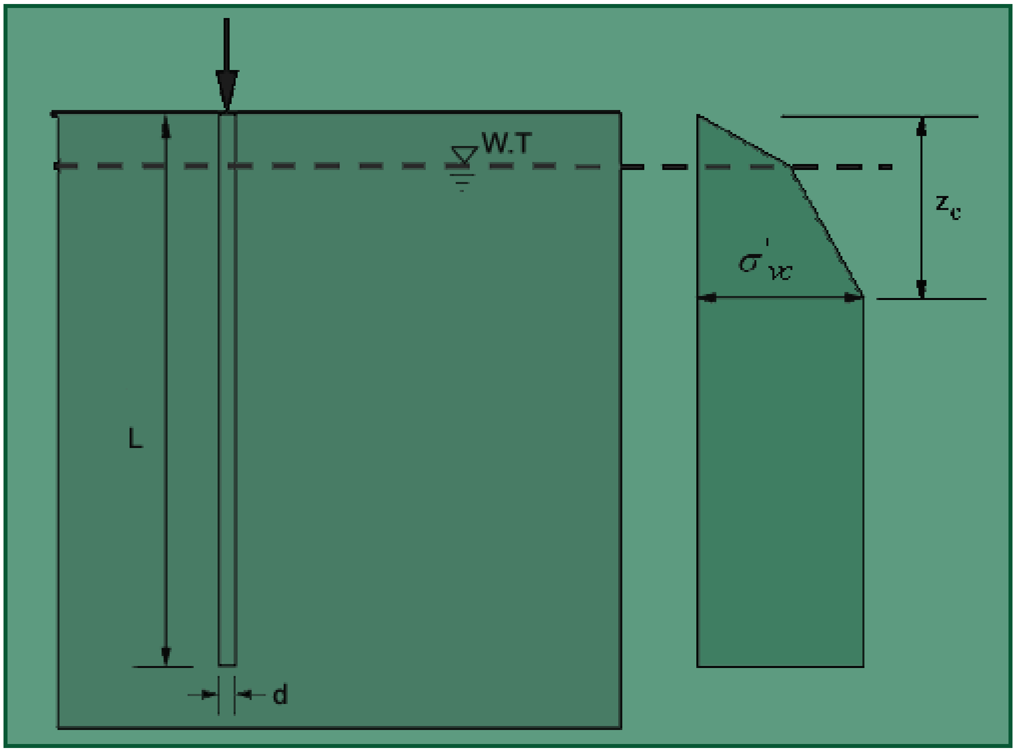
$\phi' = \frac{3}{4}\phi_1' + 10^0$ for driven pile

$\phi_1' - 3^0$ for bored pile

ϕ_1' = before installation

ϕ' = after installation

Vesic (1967) on the basis of model tests, that the vertical effective stress reaches a limiting value at a certain (critical or limiting) depth, beyond which there is assumed to be no increase (see figure). The limiting vertical (and therefore horizontal) stress effect has been attributed to arching in the soil and particle crushing.



$\frac{\sigma_{vb}'}{\sigma_v'}$ is constant for a particular type of sand and does not depend on size of soil.

σ_{vb}' = effective vertical stress

σ_v' = mean effective vertical stress along the length of the pile.

Limited depth method – Vesic

Based on the test results obtained by Vesic (1967), Poulos and Davis (1980) have developed a means of estimating the critical depth, z_c , in the form of the ratio z_c /d as a function of the effective angle of friction; ϕ'.This is shown in the accompanying figure. It should be noted that the value of ϕ' used in this figure should be the value that has been adjusted to reflect the method of installation as follows. Once the value of z_c /d is known, the diameter of the pile 'd' and the Pile capacity can be calculated.

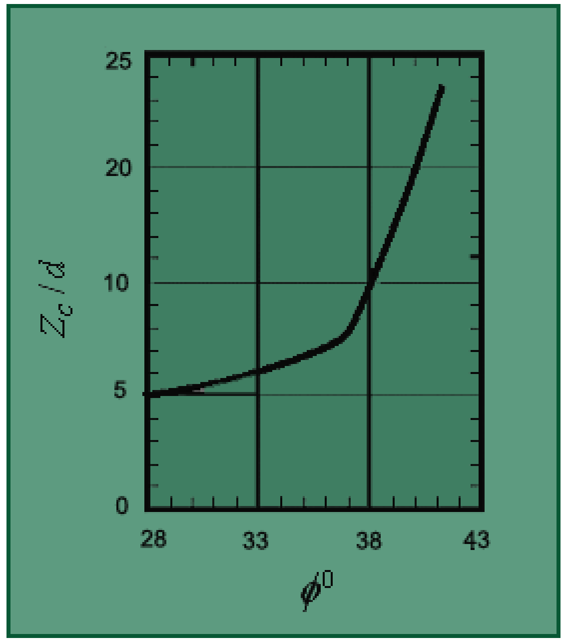


Fig. 5.37 Vesic's Chart for determining the pile diameter

On the basis of Vesic's (1967) test results, Poulos and Davis (1980) have suggested a relationship between *K* tan δ and ϕ' as shown in figure given below. The value of ϕ' is the postdriving value. It should be 5. noted that Vesic's tests were conducted on steel piles, and it is likely that the values given in this figure are conservative for other (rougher) surface finishes.

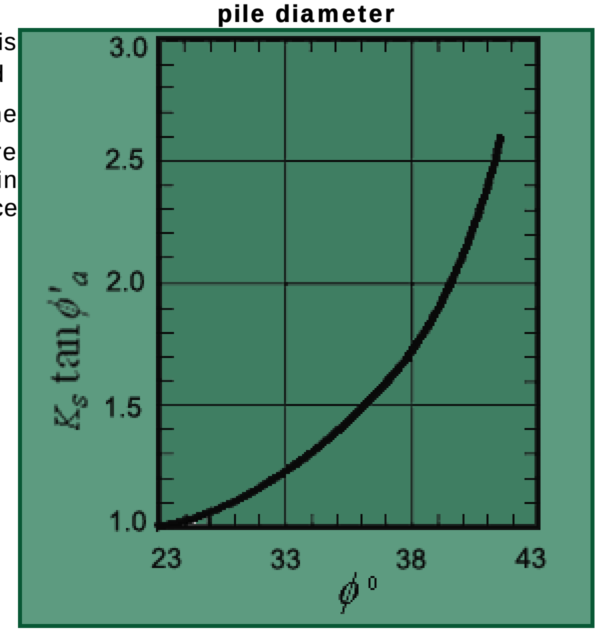


Fig. 5.38 Values of K_s tan ϕ'

Problem : Calculate the pile capacity for a concrete pile by following data.
Given data

d = 250 mm, L = 9 meter, γ_d = 19.5 KN/ m^3, γ_{sat} = 20 KN/ m^3, $\phi = 38^0$, F.O.S. = 2.0, K_s =0.95, $\tan\delta$= 0.45, N_q = (for 38^0) = 50.

1. Ground water table at very large depth.
2. Ground water table at 3 m below ground level.

Solution

1. Ground water table at very large depth.

- Since in our data $\frac{L}{d} > \frac{1}{2}\times\frac{L_c}{d}$ So select N_q^* according ϕ From Upper Curve Given By Mayerhaff.

  Since For $\phi = 38^0$ $\frac{Z_c}{d} = 16\cdot$

  The Critical depth (Z_c) at which Tip resistance become constant is

  $$Z_c = 16 \times d = 16 \times 0.25 = 4.0 \text{ meter.}$$

- Tip Resistance

$$q_p = \sigma_{vb}.N_q^*$$

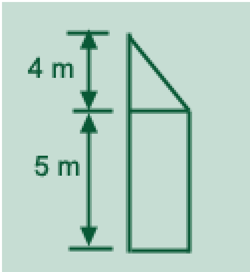
$$\sigma_{vb} = \gamma.Lc = 19.5\times 4 = 78 \quad KN/m^2$$

$$q_p = 78\times 50 = 3900 \quad KN/m^2$$

$$q_l = 50\times N_q^*.\tan\phi$$

$$q_l = 50\times 50\times \tan 38^o$$

$$q_l = 1953.21 \quad KN/m^2 < q_p$$



- Skin Resistance

$$f_s = K_s.\tan\phi_a^{'}.\sigma_v^{'}$$

$$\sigma_v^{'} = \left[\frac{(\frac{1}{2}\times 7.8\times 4)+(7.8\times 5)}{9}\right]$$

$$\sigma_v^{'} = 60.667 \quad KN/m^2$$

$$f_s = 0.95\times 0.45\times 60.667$$

$$f_s = 25.93 \quad KN/m^2 < f_l(100 \quad KN/m^2)$$

$$\text{here} \quad f_l > f_s$$

$$f_s = 25.93 \quad KN/m^2$$

- Total Load & Allowable load

$$P_U = q_p.A_p + f_s.A_s$$

$$P_U = 1953.2(\tfrac{\pi}{4}.d^2) + 25.93\times\pi.d.l$$

$$P_U = 1953.2(\tfrac{\pi}{4}.0.25^2) + 25.93\times\pi\times d\times l$$

$$P_U = 279.2$$

$$P_{allow} = \frac{279.2}{F.O.S.} = \frac{279.2}{2} = 139.6 \quad KN$$

2. When ground table below 3 m.

- Since For $\phi = 38^0$ $\frac{Z_c}{d} = 16\cdot$

  The Critical depth (Z_c) at which Tip resistance become constant is

  $$Z_c = 16 \times d = 16 \times 0.25 = 4.0 \text{ meter.}$$

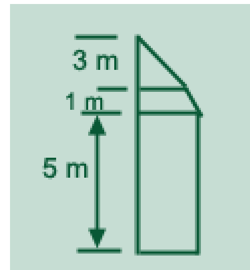
- $$\sigma_{vb} = \gamma.Lc = 19.5 \times 3 + (20 - 9.81) \times 1$$

  $$\sigma_{vb} = 58.5 + 10.19$$

  $$\sigma_{vb} = 68.69 \quad KN/m^2$$

  $$q_p = \sigma_{vb}.N_q^* = 68.69 \times 50$$

  $$q_p = 3434.5 \quad KN/m^2$$



- $$q_l = 50 \times N_q^*.\tan\phi$$

  $$q_l = 50 \times 50 \times \tan 38^o$$

  $$q_l = 1953.21 \quad KN/m^2 < q_p$$

  $$f_s = K_s.\tan\phi_a^{'}.\sigma_v^{'}$$

  $$\sigma_v^{'} = \left[\frac{(\frac{1}{2} \times 58.3 \times 3) + \frac{(58.5+68.69)}{2} \times 1 + (5 \times 68.69)}{9}\right]$$

  $$\sigma_v^{'} = 54.977 \quad KN/m^2$$

$$\sigma_v^{'} = \left[\frac{(\frac{1}{2}\times 58.3\times 3)+\frac{(58.5+68.69)}{2}\times 1+(5\times 68.69)}{9} \right]$$

$$\sigma_v^{'} = 54.977 \quad KN/m^2$$

$$f_s = 0.95\times 0.45\times 54.977$$

$$f_s = 23.50 \quad KN/m^2 < f_l(100 \quad KN/m^2)$$

$$\text{here} \quad f_l > f_s$$

$$f_s = 23.50 \quad KN/m^2$$

$$P_U = q_p.A_p + f_s.A_s$$

$$P_U = 1953.2(\tfrac{\pi}{4}.d^2) + 23.5\times \pi.d.l$$

$$P_U = 1953.2(\tfrac{\pi}{4}.0.25^2) + 25.93\times \pi \times 0.25\times 5$$

$$P_U = 261.99KN$$

$$P_{allow} = \frac{261.99}{F.O.S.} = \frac{261.99}{2} = 130.99KN$$

Recap

In this section you have learnt the following.

- Vesic's method
- Limited depth method – Vesic
- Problem

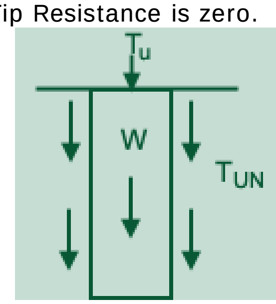
Objectives

In this section you will learn the following

- Computation of the Pull out resistance of pile

Computation of the Pull out resistance of pile

Structures such as tall chimneys, transmission towers and jetties can be subject to large overturning moments and so piles are often used to resist the resulting uplift forces at the foundations. In such cases the resulting forces are transmitted to the soil along the embedded length of the pile. The resisting force can be increased in the case of bored piles by under-reaming. In the design of tension piles the effect of radial contraction of the pile must be taken into account as this can cause about a 10% - 20% reduction in shaft resistance Only Skin friction guided the pullout of pile. No Bearing is there, so Tip Resistance is zero.



$$P_{bu} = 0$$

$$\text{So} \quad P_U = P_{Su}$$

$$T_U = T_{UN} + W$$

$$T_{UN} = L.P.\alpha^{'}.C_U$$

----------(40)

Here P = Perimeter,

For Cast In- Situ Concrete Pile.

$$\alpha^{'} = 0.9 \text{ to } 0.00625 \ \& \ C_u < 80 Kpa$$

In Sands Pullout Resistance

$$T_{UN} = \int_0^L f_n.P.dz \qquad (P = \text{Perimeter})$$

$$f_n = K_U.\sigma_V^{'}.\tan\delta$$

----------(41)

$$F.S. = 2 \text{ to } 3$$

Recap

In this section you have learnt the following.

- Computation of the Pull out resistance of pile

Congratulations, you have finished Lecture 23. To view the next lecture select it from the left hand side menu of the page