Module 5 : Design of Deep Foundations

Lecture 24 : Under Reamed Pile [Section 24.1 : Introduction]

Objectives

In this section you will learn the following

- Introduction

Under Reamed Pile

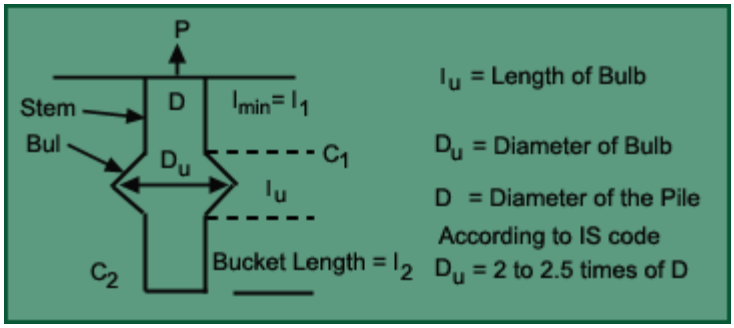

Fig 5.39 Single Under Reamed Pile

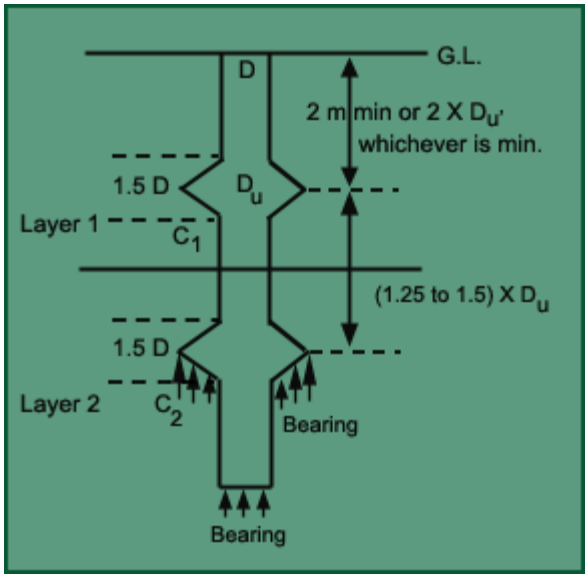

Fig 5.40 Multiple Under Reamed Pile

Module 5 : Design of Deep Foundations

Lecture 24 : Under Reamed Pile [Section 24.1 : Introduction]

Under reamed piles are bored cast-in-situ concrete piles having **one or more** number of **bulbs formed** by enlarging the pile stem. These piles are best suited in soils where considerable **ground** movements occur due to seasonal variations, filled up grounds or in soft soil strata. Provision of under reamed bulbs has the advantage of increasing the bearing and uplift capacities. It also provides better anchorage at greater depths. These piles are efficiently used in machine foundations, over bridges, electrical transmission tower foundation sand water tanks. Indian Standard IS 2911 (Part III) - 1980 covers the design and construction of under reamed piles having one or more bulbs. According to the code the diameter of under reamed bulbs may vary from 2 to 3 times the stem diameter depending upon the feasibility of construction and design requirements. The code suggests a spacing of 1.25 to 1.5 times the bulb diameter for the bulbs. An angle of 45 0 with horizontal is recommended for all under reamed bulbs. This code also gives Mathematical expressions for calculating the bearing and uplift capacities.

From the review of the studies pertaining to under reamed piles, it can be seen that ultimate bearing capacity of piles increases considerably on provision of under- reamed bulbs (Neumann and P&g, 1955, Subash Chandra and Kheppar, 1964, Patnakar, 1970 etc.). Pile load capacity was found to vary with the number of bulbs and with the spacing ratio S / D_u or S/d adopted (where S = distance between the piles, D_u = diameter of under reamed bulbs and d = diameter of piles). Table summarizes the various recommendations made for the selection of S / D_u and S/d for the optimum pile load capacity. It can be seen that some of these recommendations differ from those given in IS 2911 (Part III), 1980.

Table: 5.6 of recommendations for S / D_u and S/d for the optimum pile load capacity

Recommendations of S/ D_u & S/d values for under reamed piles			
s.no.	Reference	No. of Bulbs	Spacing
1.	Patnakar (1970)	Pile capacity for one bulb increases25 percent, for two bulbs 600 percent, and for three bulbs700 percent over simple pile.	For optimum capacity two bulbs S / D_u = 6 or S/d = 15, far three bulbs, S / D_u = 5 or S/d = 12.
2	Agarwal and Jain (1971)	-	For optimum capacity S / D_u = 1.25 to 1.5
3	Sonapal and Thakkar (1977)	-	For optimum capacity S / D_u = 2.5
4	IS 2911(Part III 1980)	More than two bulbs are not advisable	S / D_u = 1.25 to 1.5
5	Ray and Raymond (1983)	-	Maximum value of S / D_u = 1.24 to 1.5

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Lecture 24 : Under Reamed Pile [Section 24.1 : Introduction]

The choice of an under-reamed pile in unstable or water-bearing ground is generally to be avoided. There is a danger of collapse of the under-ream, either when personnel are down the hole, or during concreting.

Important Notes: On the basis of limited experimental studies conducted on model under reamed piles in cohesion less soil the following conclusions are drawn.

1. By providing under reamed bulbs the ultimate load capacities of piles increases significantly.
2. The ultimate load bearing capacities of the under reamed piles with angle of under reamed bulbs of 45^0 and zero are almost same.
3. Three or more under reamed bulbs are advantageous only when the spacing ratio (S / D_u) is two or less, and when (S / D_u) is greater than two, multi-under reamed piles do not have specific advantages.
4. The ultimate load bearing capacities of piles are maximum when the spacing between two under reamed bulb is 2.5 times the diameter of the under reamed bulb. It appears that the spacing between two under reamed bulbs suggested in (1.25 to 1.5 times) IS 2911(1980) is not the optimum,
5. The expression suggested in IS 2911(1980) can be used for predicting the ultimate load carrying capacity of under reamed piles with spacing ratio (S / D_u) less than 2.5.

Module 5 : Design of Deep Foundations

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

Recap

In this section you have learnt the following.

- Introduction

Module 5 : Design of Deep Foundations

Lecture 24 : Under Reamed Pile [Section 24.2 : Bearing Capacity of Under Reamed Pile in Clay]

Objectives

In this section you will learn the following

- Introduction

Bearing Capacity of Under Reamed Pile in Clay

$$P_U = P_{bu} + P_{su}$$

Tip Resistance

1 For Single Under Reamed Pile for Clay

$$P_{bu} = n\left[\tfrac{\pi}{4}\times\left(D_u^2 - D^2\right)\times C_1 \times N_c\right] + \left[\tfrac{\pi}{4}\times D^2 \times C_c \times N_c\right] \quad \text{---------(42)}$$

Here n = No. Of Bulbs

2 For Single Under Reamed Pile for $C-\Phi$ Soil

$$P_{bu} = n\left[\tfrac{\pi}{4}\times\left(D_u^2 - D^2\right)\times\left(C_1.N_c + \sigma_1^{'}.N_q\right)\right] + \left[\tfrac{\pi}{4}D^2 \times\left[C_2.N_c + \sigma_2^{'}.N_q\right]\right] \quad \text{----------(43)}$$

Here $\sigma_1^{'}$ is effective vertical stress at bulb base.

$\sigma_2^{'}$ is effective vertical stress at stem base.

Skin Resistance

$$P_{su} = \left(\pi.\Delta l_1.C_1.\alpha_1\right) + \left(\pi\times(D_u - D)\times l_2 \times C_2 \times \alpha_2\right) + \pi \times \Delta l_2 \times C_2 \times \alpha_3 \quad \text{---------(44)}$$

$\left(\pi.\Delta l_1.C_1.\alpha_1\right)$ This term will absent in compressive Under Reamed pile.

($\pi \times \Delta l_2 \times C_2 \times \alpha_3$) This Term will absent in Tension under Reamed pile.

Recap

In this section you have learnt the following.

- Introduction

Congratulations, you have finished Lecture 24. To view the next lecture select it from the left hand side menu of the page