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Effect of Micropile on Foundation Settlement

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Abstract - *Micropiles are smaller diameter piles which are used around the foundation to reduce settlement and increase the bearing capacity of soil.Two soil samples are prepared ,one with micropile and the other without micropile. Pure clay is used as soil. A tank of dimensions 300*300mm and height 600mm is filled with soil and a steel plate of dimensions 80*80mm is used as footing. The micropiles are placed around the footing and load is applied. The corresponding settlement is noted using dial gauges. Another sample tank without micropiles around the footing is also tested. The settlement values are compared. This will be an economical solution in challenging sites like kuttanad, Ernakulam etc. The focus of this paper is to study the effect of micropile on foundation settlement using simple load tests.*

Key Words: **Micropile, dial gauges, kuttanad clay, triaxial shear apparatus, digital loading cell.**

1.INTRODUCTION

Micropiles are small diameter drilled piles typically between 5-12 inches in diameter which can have a depth of 200 feet and can achieve a working load of 200 tons. They are highly performing and having high capacity drilled deep foundations. Micropiles are having a high strength casing made of steel, rebars and grout. They transfer the loads from the foundation to competent soils through soil layers. The loads from the foundation will be dissipated to the soil or rock through the steel and micropile grout. Micropiles are generally used when there are difficult ground conditions, such as natural or man-made obstructions, sensitive ground with adjacent structures, limited access/low headroom and/or karstic geology**.**

These micropiles are used when there occur deteriorating foundation systems, renovation of buildings, to support structures from adjacent construction, to support buildings situated in earthquake prone areas or from landslides stabilization. Nowadays, hollow core bars widely used in the construction of micropiles. The main advantage of these bars are faster installation and ground improvement. Micropile is an effective solution for conventional piles and carry heavier loads. Micropile applications include underpinning for existing foundations, in-situ soil reinforcement, seismic retrofitting and as foundations for new constructions.

2.DESIGN OF MICROPILES

The design of micropile is an extremely lengthy process. The design steps for the micropile are discussed below. These includes geotechnical strength requirement, other structural considerations, corrosion protection and some seismic considerations.

Review available project information.

a. Requirements of specified job, loading pile requirements, layout constraints of pile.

b. Special conditions like environmental stability, access available, presence of hazardous materials, presence of overhead clearance constraints.

c. Stipulations defined in a contract's terms and conditions, statement of work, and other documents.

Review geotechnical data.

d. Obtain geotechnical/geological subsurface profile.

e. Estimate geotechnical design parameters.

f. Obtain soil properties that determine corrosion protection requirements.

g. Identify problem areas if any.

Complete initial soil investigation and geotechnical pile design.

h. Examine load transfer factors and grout-to-ground bond for the different soil layers and decide the pile bond length needed to support the loading.

i. Check the spacing of the pile needed.

The various structural design components of the pile are

j. cased length of the pile (bar reinforcement including grout).

k. Uncased length of the pile (bar reinforcement including grout).

l. Check the bond between reinforcement and grout (concrete).

m. Transition between cased to uncased section.

n. Ductility should be checked between the pile components.

o. The bar or pipe reinforcement splice connections.

p. The connection between pile and footing.

Complete combined structural and geotechnical design considerations.

q. Analyze the stiffness needed and the expected settlement.

r. side capacity/ side displacement and combined stresses (axial + bending) due to lateral loading conditions.

s. The Bending of the pile/soil should be checked.

Check the other micropile system considerations.

t. Requirements for corrosion protection.

u. Determine quality control program and construction load testing requirements.

v. Check the cost effectiveness and constructability of the design.

3.INSTALLATION OF MICROPILE

The installation of micropile includes mainly three steps;

(a) Drilling- The suitable drilling method is chosen on the basis of causing minimal disturbance to the ground and nearby structures which is sensitive or challenging and able to achieve the required drilling performance. In all those methods, the drilling fluid is used as a coolant for the drilling and to remove the cuttings from drilling, it acts as a medium to flush all those waste materials. Water is used as most common drilling fluid. Apart from water, drill slurry, polymer, foam and bentonite are used as industrial drilling fluids. Compressed air is another type of flushing medium which is commonly used in Malaysia.

Fig-1 drilling

b) Grouting – The special characteristics of the equipment used for pile grouting have a minimum of a high colloidal speed, high shear mixer, grout pump with reaching pressures of 300 psi, qa/qc equipment, log books, pressure gauges and recirculation lines. The colloidal mixer is a plant which helps in quickly mixing neat cement-based grout in a few minutes, with a neat wetting of the individual grains of cement. A thorough wetting of cement grains helps to pump grout through the grout lines which is having a low water-cement ratio easily from plant to micropile. The absence of a colloidal plant results in the clinging of cement clumps, clogging injection lines, and ultimately results in a lower strength grout, because most of the cement not get hydrated. After a neat mixing, an agitation tank stores the grout with blades that constantly agitates the mixed grout, and prolongs the separation of the cement from the mix water. Addition of proper admixtures increases the life of the grout up to a working time of 6 hours and in some cases, may be suspended for indefinitely till the reaction is re-initiated .

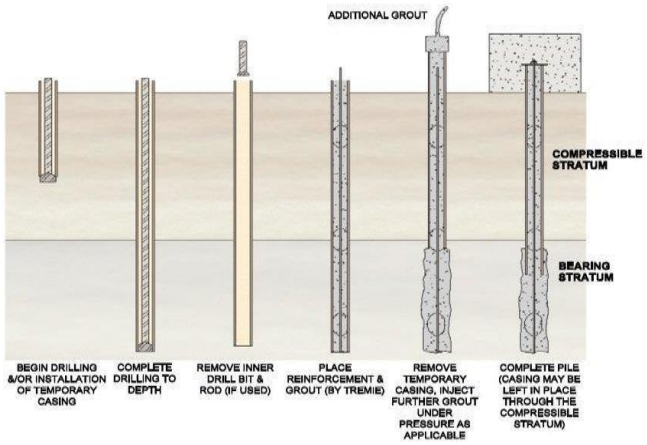

Fig-2 construction procedure

c) Installation- The contractor installing micropiles must keep exact and contemporaneous logs showing detailed information about installation. For planning the pile installation, boring logs are used. In rocky conditions, rock head may vary greatly within each feet of the boring. Each pile head will be unique in sequencing of bearing stratum, depth to rock head, un-bonded length and overall length in hilly areas or areas having variable topographical conditions. The pile installation log is the only record of the verification of the pile design dimensions and compositions having been achieved. The pile installation log also generates the pay items such as drilled footage in soil, rock and amount of grout consumed for the project.

Fig-3 Installation of micropile

4. EXPERIMENTAL WORK AND METHODOLOGY

Experimental work is done on Kuttanad soil and the different index and engineering properties of the soil are done in the laboratory.

The materials used for the experiment are Kuttanad clay, Steel reinforcement(as micropile), Dial gauges ,Digital load cell, Steel plate(as footing), LVDT, Triaxial test apparatus Two clay samples are made one with reinforcement and the other without reinforcement. Loading is applied and the corresponding dial gauge readings are noted. The readings are compared.

Soft clay bed is made by filling the soil sample in three layers. The clay bed for the tests was prepared in a tank of plan dimensions 300*300 mm and depth 600mm.Clay was thoroughly mixed and filled in three layers. Each layer is tamped twenty five times. The surface of each layer was provided with a uniform compaction.

For determining load settlement behavior of clay samples, triaxial shear apparatus is used. Settlements corresponding to 0.5kg ,1.5kg, 2.5kg, 3.5kg and 4 kg were determined.

Table 4.1: Load test results of a clay sample without micropile

Sl.No.	Load(kg)	Settlement(mm)
1	0.5	0.320
2	1.5	0.425
3	2.5	0.900
4	3.5	3.370
5	4.0	3.480

Table 4.2: Load test results of a clay sample with group micropile of dia 12mm

Sl. No.	Load (kg)	Settlement
1	0.5	0.013
2	1.5	0.218
3	2.5	0.364
4	3.5	0.760
5	4.5	0.980

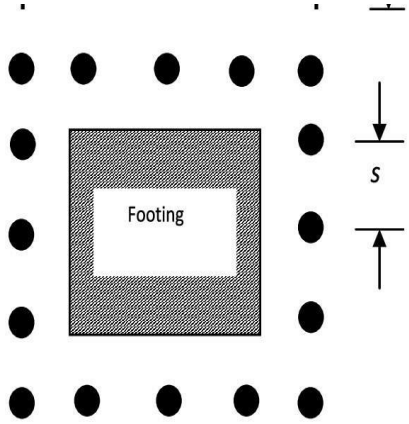

Fig 4- clay sample with micropiles

Fig 5- Kuttanad clay

Table 4.3- Various index and engineering properties of clayey soil

Sl. No.	Property	Value
1	Optimum moisture content	11.76%
2	Dry Density	1.33g/cc
3	Liquid limit	49.99%
4	Plastic limit	40.72%
5	Shrinkage limit	38.83%
6	Water content	64%
7	Specific gravity	2.54
8	Plasticity index	9.27%
9	Liquidity index	2.51%

5. CONCLUSION

Experimental study of micropiles on foundation settlement on clay samples with and without micropiles are carried out.

- Settlement of soil bed is more when load is applied on the plate directly before placing the micropile.
- For group micropile of 12mm diameter around the steel plate, the load is applied and the settlement decreases with increase in number of micropile.
- By increasing the depth of micropile and reducing the spacing between the micropile, the settlement reduces considerably.

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