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The Relation of Micropile Diameters In Case Of Pressure Casting And Non-Pressure Casting

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Abstract**:** *The aim of this paper is to discuss the effect of pressure casting to Micropile on the strength of Micropile and to compare it with the normal way of casting (casting with gravity). With inference of finding a diameter equivalent to the Micropile casting with non-pressure gives the same strength to Micropile that casting with pressure. Preliminary studies have been made in Sudan in specific area, then an experimental works done for a number of Micropiles with different diameters and different techniques of placing concrete with various amount of pressure to find the relationship between diameters in the two cases (casting with pressure, casting with non pressure) these relation were presented graphically. It was concluded that the Micropile casting with pressure gives strength equivalent to Micropile with larger diameter that casting with non-pressure.*

Keywords: Micropiles, casting with pressure, experimental work diameter effect.

1. Introduction

Micropiles were conceived in Italy early 1950s, in response to the demand for innovative techniques for underpinning historic building and monuments that has sustained damage with time, and especially during World War II. A reliable underpinning system was required to support structural loads with minimal movement and for installation in access-restrictive environments with minimal disturbance to the existing structure. An Italian specialty contractor called Fondedile, for whom Dr. Fernando Lizzi was the technical director, developed the palo radice, or root pile, for underpinning application. The palo radice is small-diameter, drilled, cast-in-place, lightly reinforced, grouted pile.

2. Micropile Classification

Micropiles are categorized into broad groups based on their fundamental means of carrying the load. If each element is designed to directly some load, whether vertical or lateral, single element or in a group, then called these case1 micropiles. Should they be designs as a piece of composite mass that will itself become a unit that carries the load, called these case2 micropiles. The second element of classification system is a letter designation A-E. This designation is based on the method are use to grout the pile. The classification is shown schematically in Figure 1. Grout is always placed by tremie methods from the bottom of the hole up. This ensures complete filling, eliminates the risk of contaminating the grout or trapping air with the pile. Type A micropiles are done after the hole is filled and although can be used on soil, are more seen in piles socketed into rock. In type B, C, and D the grout is pressurized after initial filling. The method of pressurization vary between micropiles but the pressurization is intended to provide some repair to the ground and increase the bond strength around the micropile. Type B is pressurized from the top of the micropile to about 75 to 100 psi. Type D has some form of regrout tube installed in the micropile to allow higher pressure grouting to be done once the initial grout has set similar to a regrouted soil anchor. Type C is more common in some European countries. Type E was recently added to the classification system these are micropiles that are installed using hollow bar drilling methods where grout is used as the flushing media this accelerates the speed at which the micropiles can be installed because it eliminates several of the construction steps.

3. Experimental work for Micropiles constructed in Sudan.

3.1 Description:

The area of (20×20 m2) in the land of Building and Road Research Institute, University of Khartoum (B.R.R.I, U OF K) located in Soba, south of Khartoum was used for carry the experiments. The soil is identified and classified according to the British Standard BS 1377 with the Unified System for Classifying Soils (USCS). Micropiles for field work were divided into five groups (G1, G2, G3, G4, and G5). Each group was containing (4) piles with different diameters (D10=10cm, D15=15cm, D20=20cm and D25=25cm). The total number of Micropiles is (20). A general plan procedure for the field works was planned. Each of the above groups was casting with different technique. The first group was casted by normal way (casting concrete by gravity) and the second group to the fifth group casted the concrete with pressure of different amount from one group to another. This has been done after executed studies work such as excavations, laboratory tests of soil and the initial design.

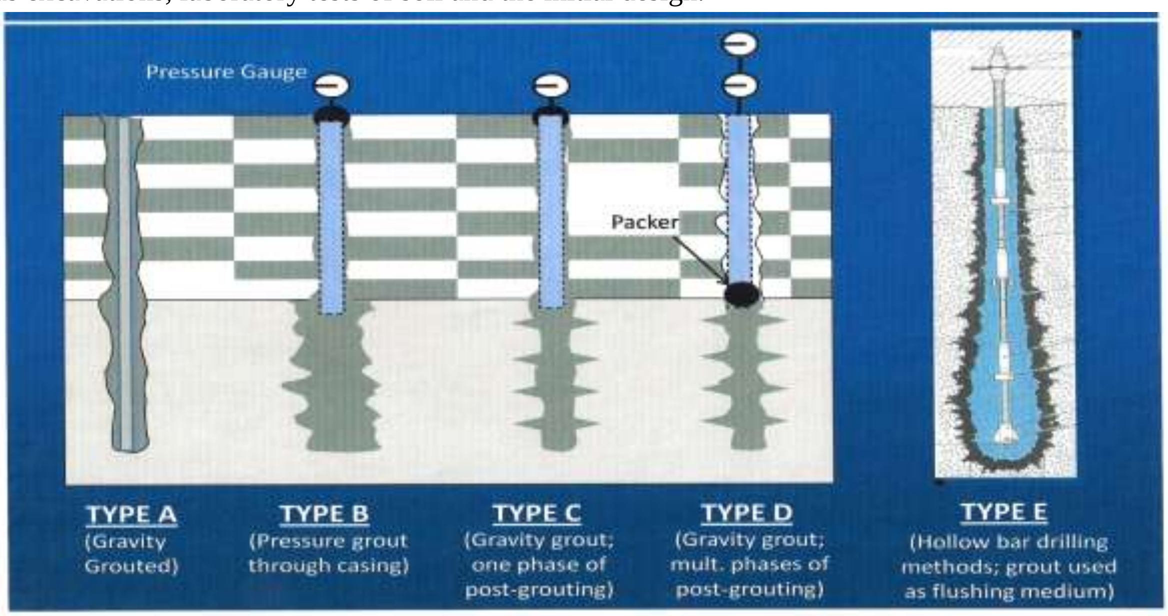

Fig. 1. Micropiles Classification based on Grouting Method. The international Association of foundation Drilling (ADSC).

3.2. Pouring concrete

The concrete mix used for Micropiles is (4:2:1) as normal common mix in Sudan (fcu = 30N/mm2).

Pouring concrete for (G1) by gravity as normal (accordingly the classifications type 1A) but for (G2 ……G5) pressures of (2…..8 Bar (1 bar=0.1 MPa)) were used (accordingly the classifications type 1B).

From FHWA Guide Line:

1A → Micropile case 1 (Directly loaded), type A (concrete placed under gravity)

1B → Micropile case 1 (Directly loaded), type B (concrete placed under pressure = [5 – 10] bar)

A pressure machine (comperson) 25 bars was used.

Pressures of 2 bar, 4 bar, 6 bar and 8 bar were applied in pouring concrete in the holes for G2, G3, G4, and G5 respectively.

3.3. Testing Programs of Micropiles:

3.3.1 Preliminary Design:

Preliminary design of micropile was made for testing program. The data used for the design:

fcu = 30 N/mm2, fy = 420 N/mm2. The description of the soil through which the bond length will be calculated→ Hard, Light brown, dry, silty CLAY of low plasticity with calcareous material. From the summary of typical ∂bond (grout to ground bond) for preliminary micropile design and feasibility evaluation for micropile type 1A (50----120KPa), for micropile type 1B (70----190KPa). Accordingly the soil test result will be ∂bond = 120 KPa.

Design of Micropile type (1A):

The allowable compression load for the uncased length of a micropile according to FHWA Design Guide Line is given as:

Pc-allowable = [0.4f'c-grout*Agrout + 0.47*Fy-bar*Abar]... where Abar = area of steel, Ag = gross section area of micropile, Pc = allowable compression load on micropile.

We have (4) different diameters of piles :(10, 15, 20 and 25 cm).

Pc10-allowable =[0.4*30*(7857.14-235.71)*0.25 + 0.47*420*235.17*0.5] = 46.129 KN

Pc15-allowable = 83.112 KN

Pc20-allowable = 137.596 KN

Pc25-allowable = 201.46 KN

Calculation of bond length:

Accordingly ASD (Allowable stress design- AASHTO 1998)

PG-allowable = (∂bond/FS) ×π × Db × Lb

Where:

∂ Bond = grout to ground ultimate bond strength, FS = factor of safety applied to the ultimate bond strength, Db = diameter of drill hole, Lb = bond length, PG-allowable = Micropile Geotechnical Capacity.

Lb10 = (46.129 × 2) / (3.14 ×0.1×120) = 2.4 m

Lb15 = 2.9 m

Lb20 = 3.65 m

Lb25 = 4.3 m

3.3.2 Load structural capacity:

From FHWA Design Guide Line: Pult-compresion = [(0.85f'c-grout × Agrout) + (fy-bar × Abar)] where: Pult= the ultimate load compression on micropile.

Pult10-compresion = 94 KN, Pult15-compresion = 160 KN, Pult20-compresion = 274 KN, Pult25-compresion = 402 KN.

3.3.3 Field Compression Load Test procedure

For this compression test using reaction frame or kentledge system is undertaken on a test concurrent with construction of the Micropiling works. The test is used to validate the Micropile design. In this case the Micropile is loaded to 3 times the design working load. Controlled-stress method has been used with quick maintained load test (QML). In this procedure, 15% of design load is added at a time and held for 5 minutes. The maximum load is equal to 3 times the design load. When the load is reached, unloading is then done with four equal decrements allowing 5 minutes between each two decrements. Typical time of load test can be between 3 to 5 hours. This method has advantage of being fast but it cannot be used where the pile is installed in strata with significant creep properties because load may be shed from the sides to the base without changes in the applied load (O'Neill and Hawkins, 1982).

3.4 The result of the experimental work

The results of the experimental work is presented in Table 1.

Table 1. The results of the experimental work

D(diameter) mm	F (failure load) KN when p(pressure)= 0	F KN When P = 2 bar	F KN When P = 4 bar	F KN When P = 6 bar	F KN When P = 8 bar
10	129.3	134.3	142.3	153.5	185.4
15	235	262.5	292	298	345
20	265	293	385	468	497.5
25	445	534.5	553.3	557.3	565

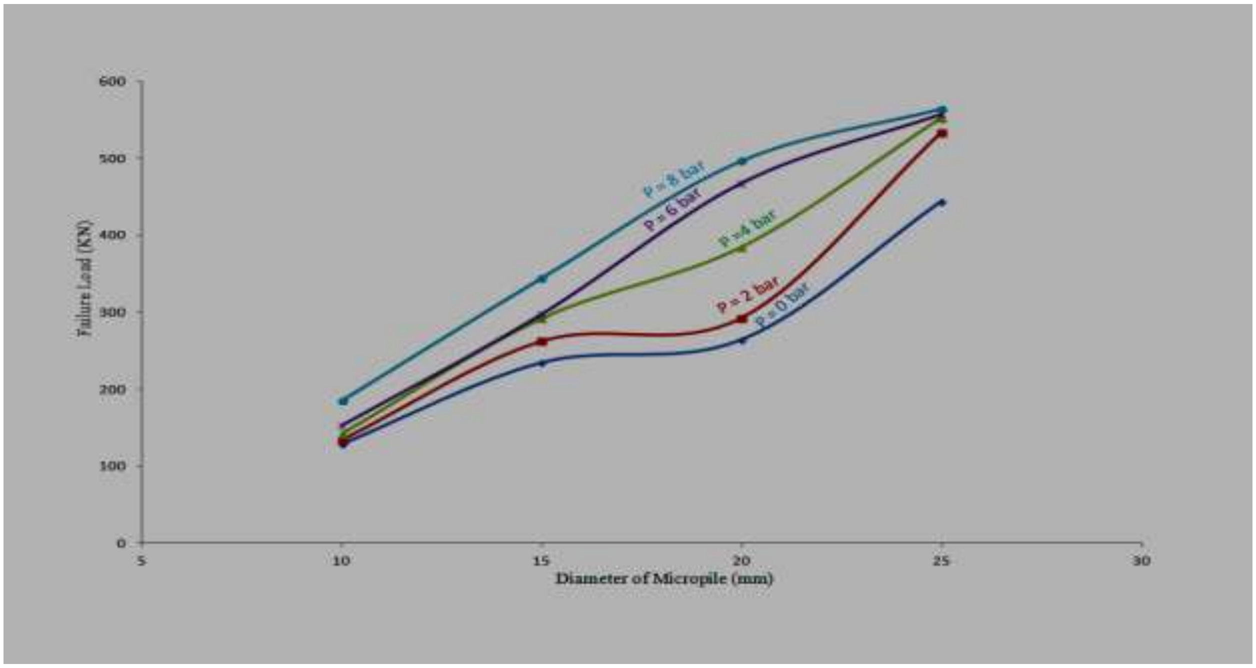

Fig. 2. (Micropile diameter vs. Load) Curves, (In the case of different amount of pressures).

4.0 Discussions

From the results of field test, Fig. 2, and the comparison between the values of failure load of G1 which casting with gravity, and other four groups which casting with pressure, it can be seen that the diameter of Micropile gives failure load in case of casting with pressure act as a diameter of a bigger size than the diameter of Micropile gives the same failure load in case of casting without pressure.
Table 2. shows the equivalent diameters of Micropile in case of casting without pressure that give the same failure load in case of casting with pressure.

Table 2. Equivalent diameter of micropiles at failure.

The diameter (mm)	The equivalent diameter give the same failure load in case of non-pressure(mm)			
	P=2 bar	P=4 bar	P=6 bar	P=8bar
10	10	11	12	14
15	20	22	23	25
20	22	29	35	38
25	32	33	33	34

For example:
The Micropile diameter → D = 10mm can work as 14mm in the normal case (casting with gravity), if this Micropile casted with amount of pressure equal 8 bars.

5. Conclusions

A micropile is a small-diameter (typically less than 300 mm), drilled and grouted replacement pile that is typically reinforced. A micropile is constructed by drilling a borehole, placing reinforcement, and grouting the hole. The capacity of Micropile cast with pressure equivalent the capacity of Micropile of larger diameter cast without pressure. Micropile casted with pressure can reduce construction materials compared with normal piles.

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