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Experimental Investigation into the Behavior of Piled-Footing in Clayey Soil

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Abstract : This paper presents the comparative results of the investigation is of the various affecting parameters of the proposed pile foundations like L/D ratio, length of piles & number of piles. These parameters are studied for straight, bored concrete piles of 50 mm diameter. The corresponding settlements for various pile footing models were investigated. The load-settlement observations are presented in the form of tables & graphs. The experimental results of the piled footing model cases are compared by carrying out theoretical analysis by means of Computer Programming. The load-settlement curves of the investigation, reveals the nature of the various piled footing model cases. The settlements of piled footings are much lesser than unpiled footing. By increasing the L/D ratio & number of piles below the footing; settlement reduces, thus proving the Piled footing as an efficient foundation system.

Keywords : Soil-structure interaction, Pile footing, clayey soil, sandy soil, settlement, Pile Load carrying capacity.

1. Introduction :

The basic elastic response of the soil from which the solutions for elastic piles in elastic soil can be derived is given by Mindlin's set of equations for the stresses and displacements throughout an elastic half space resulting from horizontal or vertical point load applied at a point beneath the surface. Alternatively, the elastic response can be assumed to be that of a series of unconnected springs, i.e. Winkler medium or subgrade reaction assumption. Previous studies such as [Gandhi S.R. and Maharaj D.K. (1996)], [Poulos and Davis (1972)], [Butterfield and Banerjee (1971)], [Chandrashekhara K., Antony S.J. and Reddy J.M. (1994)], [Nayak, Sitaram and Ansari M.M (2002)], [Agrawal R (2005)] have revealed about the significant behaviour of soil-structure interaction.

The aim of this paper is to design, analyse, experimentally investigate and conduct a comparative study on the settlement behaviour of Piled-footing in clayey soil. The experimental work was performed in clayey soil, comparing the different cases on the basis of loads, L/D ratios, number of piles, length of piles, etc. This experimental investigation was carried out in a tank of size 1.0 m x 1.0 m area and 1.0 m height, fabricated by 4-ply 12 mm thick waterproof shuttering plywood, whose vertical faces were stiffened by ISA (45X45X5).

2. Objectives :

1) Experimental determination of maximum settlement of pile footings on scaled models in various configurations.
2) Theoretical assessment of maximum settlement of pile footings in various configurations.
3) Comparison of the experimental results with analytical results.

3. Methods :

3.1 Experimental Method :

Pile model used was of reinforced cast-in-situ bored concrete of M-20 grade having 50 mm diameter, reinforced with single 8 mm rebar. L/D ratio was 10 & 12.5 for 1, 2 & 4 pile groups. Clayey soil was used.

3.1.1 Experimental Set-up :

Mild Steel Plate of size (0.5m x 0.5) & 20 mm thickness was used as footing model. Experimental Tank comprised of 1m x 1m x 1m depth fabricated by 4-ply 12 mm thick waterproof shuttering plywood, whose vertical faces were by stiffened by ISA (45x45x5) through 3mm diameter screws & nuts. The loading frame over the tank is fabricated with M.S. welded channel sections of ISMC-150 @ 16.72 kg/m for taking the maximum reaction loading of 5T as per design. Hydraulic Screw Jack Pump of 10 T capacity was used for reaction loading. Load cell of 5 T capacity were used to measure load and corresponding settlements were measured by dial gauges of 0.01 mm least count.

Figure No. 1. Experimental Tank

3.1.2 Test Procedure :

The tank was filled with clayey soil in 3 layers of 0.3 m each. Each layer was thoroughly compacted by 25 kg rammer followed by light sprinkling of water for its consolidation. The tank with compacted soil was kept undisturbed for three days.

The fourth day, the top surface of the soil was scraped with the trowel & a fine layer of sand was spread, for acquiring a plane levelled surface of 0.5m x 0.5m. Then the footing model i.e. plate, was placed over the plane levelled surface. The plate level was again checked by bubble tube. Then, the H-shaped arrangements made by bolting of three angle section pieces were placed over the tank for supporting the dial gauges.

The hydraulic jack was placed over the centre of the plate in vertical alignment with c.g. of loading frame. Then 5T load cell was placed over the jack by means of spacers. The dial gauges were set on H-shaped arrangement by means of magnetic base & set for their initial reading of the experimental set-up. The initial readings of the dial gauges at the corners & near the centre of plates, with respect to the initial load applied were recorded. Then, the load was applied by means of hydraulic jack pump.

During the load testing, each load increment of 0.5T was kept constant for 30 min until the settlement became constant. Corresponding settlements of the plate were recorded up to the final reaction load of 5T. The applied load was maintained constant with help of Digital Load Indicator. For the piled-footing cases, the model piles used were of bored cast-in-situ type. The bore holes of the required depths were made by means of 50mm diameter pile augers.

Each pile model was reinforced with single 8 mm diameter steel bar. Then, the concrete was poured into the bore hole & compacted by another steel bar. The pile was remained to set in the soil for three days & the test was carried out the fourth day.

The same testing procedure was repeated for the footing with different pile configurations.

3.2 Analytical Method :

In this, a hybrid approach is used by treating the footing pad as a system of interconnected beam supported on springs and friction pile as a stiff spring. The soil behaviour has been defined using the "Winkler Model". This concept is being opted for the analysis of soil and pile supported footing. Winkler model is used to get the 'spring constant' for modelling the soil and pile footing.

3.2.1 Descretized Footing Model :

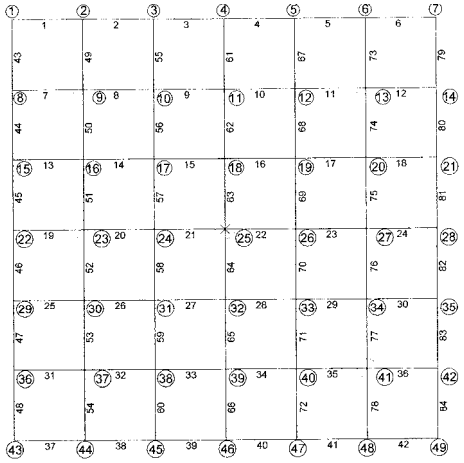

Figure No. 2Descretized Footing Model

The analytical programme will consist of the input data required for the Computer programming based on finite element method, to analyse the settlement behaviour, which would be collected from the Experimental method such as :-

- Safe bearing capacity of soil (SBC)
- Modulus of Elasticity (E)
- Modulus of Rigidity (G)
- Soil spring constant (SK)
- Pile spring constant (SP)
- Poisson's Ratio (υ)
- No. of Rows (M)
- No. of Columns (N)
- No. of Members (NM)
- No of Beams (NBEAM)

➢ Other Modeling data such as :

- Width of beam in XX-direction (WL1)
- Width of beam in YY-direction (WL2)
- Length of Beam in XX-direction (DL1)
- Length of Beam in YY-direction (DL2)
- No. of piles (NP)
- Node no. of piles PL(I)
- No. of nodes (NNOD)
- No of free displacements (ND)
- Thickness of footing pad (THIK)
- No. of loaded joints (NLJ)
- Node no. of loaded joints (KLD)
- Load P, Moments Mx, My. B(KLD)

Thus, using the above input data in the Computer program, we can expect the required output in terms of maximum, minimum and differential settlement at all nodes.

4. Results and Discussion :

4.1 Results :

The gist of this investigation is documented in a tabular format, explaining clearly the settlement behaviour of piled-footings in clayey soil & thereby enumerating the contribution of pile/piles in reducing the settlement.

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ase No.	Cases of Piled footing Model	/D ratio	Maximum Settlement by Experiment (mm)	Maximum Settlement by Analysis (mm)
	Footing only		11	9.7
	Footing + One 0.5m Pile	0	9.7	8.9
	Footing + Two 0.5m Piles	0	6.9	8.4
	Footing + Four 0.5m Piles	0	4.5	7.5
	Footing + One 0.625m Pile	2.5	8.7	8.5
	Footing + Two 0.625m Piles	2.5	5.5	8.10
	Footing + Four 0.625m Piles	2.5	3.9	7

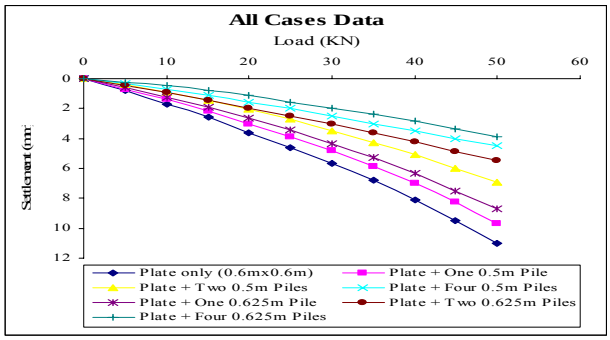

Fig. No. 2. Load Vs deformation (all cases)

4.2 Discussion :

By comparing the experimental and analytical results, we observe that :

- The maximum settlement of the various piled footing model cases ranges from 3.9 mm - 11 mm by experiments & 7.0 mm – 9.7 mm by analysis.
- By increasing the L/D ratio of piles ; settlement reduces.
- By increasing the number of piles; settlement reduces.

5. Conclusion :

- By reducing the size of the footing model, maximum settlement increases for the same final reaction load.
- The maximum settlements of the Piled Footing models are much lesser when compared with the Unpiled Footing model.
- By increasing the L/D ratio of the piles, settlement reduces.
- By increasing the number of piles below the footing, settlement reduces.

6. Acknowledgement :

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