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Analysis of Pile Capacity of In-Situ Piles In Homogeneous Sandy Soil Using Empirical and Analytical Approaches

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I. Introduction

The determination of the load bearing capacity of piles entails a variety of procedures which can be either analytical or empirical. The former entails an evaluation of soil-pile interaction with several underlying assumptions while the latter is based on the use of results of in-situ tests and procedures. Dewi and Tjie-Liong as well as Basack (2008), Shoda et al (2007) and Moayed and Rabe (2008) have all given various approaches to analysis of bearing capacity based on the evaluation of soil properties viz their interaction with the piles.

Evaluation of bearing capacity of piles using data obtained from in-situ tests and procedures have been highlighted by Shariatnadari et al (2008). Sahedja (2011) used in-situ field test results, specifically penetration tests to estimate pile capacity.

This work attempts to compare the differences between bearing capacity of piles in homogenous, non-cohesuve soils evaluated by in-situ and analytic technique.

II. General Description Of The Study Area

The data used for this work were from deep soils investigations (DSI) conducted at a proposed 4-apan bridge along a dualisation road project traversing North west to North east Nigeria. The area lies within the region covered by extensive sedimentary formation. Specifically, it is made up of the keri-keri formation. This comprises of grits, sands and clays. The particular materials observed at the project location were primarily sands and silts up to the maximum depth explored (25 - 35m).

The road lies along latitude 10 – 11^{0}E and around longitude 11^{0}N

III. Materials And Methods

a) Field works

Field works was facilitated by drilling of five (5 Nos) boreholes between 25 – 35m depths along the proposed bridge axis. This was done with the use of hydraulic rotary drilling rig with the provision for conducting standard penetration tests (SPT). Sample, predominantly disturbed, were collected at 1.5m interval for index and strength property tests.

All field works were in accordance with ASTM D 2488, D420, D1586,-08a and BS 1377.

b) Laboratory Tests

Index and strength properties test were conducted on recovered samples from all the drilled holes. The specific tests include particle size distribution (PSD), atterberge limits, direct shear and consolidation. Laboratory test were conducted according to ASTM D 2488, and BS 1377.

c) Method of Pile Capacity Analysis

For the purpose of this work, two distinct methods have been adopted to analysed the bearing capacity of piles. These are static analysis method which entails the use of soil parameter deduced from laboratory test and insitu test result methods respectively there are five approaches to determine nature of bearing capacity of piles as reported by shariat madari et al (2008) viz:

1. Use of pile loading test data;
2. Dynamic analysis method based on wave equation analysis;
3. Pile during analysis (PDA);
4. Static analysis by the use of soil parameters
5. Use of insitu test results

Specifically the static analysis method used for this work is based on the analysis of the skin friction

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resistance of bored and cast in hole plate (BCIH) or replacement pile which is esto method from the relationship as given by Tomlison (2001) and Bowles (1997).

$$Q_s = K_s tan\emptyset \dots\dots\dots 1$$

Where

$Q_s - skin\ frictional\ resistance\ in\ kN/m^2$
$K_s - coefficient\ of lateral\ resistance$
$\emptyset - angle\ of\ frictional\ resistance$
$\gamma - unit\ weight\ of\ soil\ in\ kN/m^3$

The total frictional resistance in kN is deduced by multiplying the result of equation 1 by the total shaft area.

The end resistance is given by

$$Q_b = CN_q \dots\dots\dots 2$$

Where $Q_b - base\ resistance\ at\ pile\ tip$
$C - undrained\ shear\ strength$

The total end bearing is also deduced by multiplying equation 2 by the cross sectional area of the pile base.

A typical analysis of pile capacity using this method is given in Table 1 while the summary for all the tested points are given in Table 2.

The use of insitu test entails the application of the following relationship to evaluate pile capacity as given by Meyerhof (1956, 1976).

$$Q_b = P_b(40N)\,L_b/D \dots\dots\dots 3$$
$$Q_s = 2N \dots\dots\dots\dots\dots\dots\dots\dots 4$$
$$Q_u = Q_b + Q_s \dots\dots\dots\dots\dots 5$$

$Where\ N -$
$average\ SPT\ N_{30}\ values\ over\ the\ pile\ critical\ length$
$D - Pile\ width\ or\ diameter$

$L_b - Pile\ penetration\ depth\ into\ bearing\ stratum$
$A_b - Area\ of\ thepile\ cross\ section$

IV. Discussions

Varition of pile capacity with pile diameter, are shown in figs. 1-2, for static analysis method. These were deduced for various pile depth for 600 – 1300m pile diameters. These shows that pile capacity increases with increasing pile diameter for the different pile length. Obviously there was an observed increase in pile capacity with increase in pile length (viz25,30 and 35m).

These increase were observed for both pile capacity deduced by static analysis and for insitu methods. The variation in pile capacity for insitu analysis is also shown in Fig 3-7.

Comparative Analysis of in-situ and Static Analysis method shows that values from static analysis were considerably higher than the values deduced by in-situ techniques. These are depicted in Tables 2 and 3 and figs 8- 10.The values of pile capacity by static analysis ranges between 2829 – 12,147kN while for in-situ analysis the values are between 2454-6009kN.

The values of pile capacity by both static and insitu methods are closer at lower diameter and the difference increases with increase in pile diameter as depicted in figures 8 - 10. The difference also increases with increasing depth of boring as shown in the plots for various depths of boring.

V. Conclusion

The analysis of the capacity of pile for a proposed five span concrete bridge along a road dualization project in North east Nigeria. The piles were for the abutment and the piers of the proposed bridge. The capacity of piles were analysed by static analysis by using derived geotechnical parameters as well as insitu test results .The following conclusion were drawn there from:

1. The capacity of piles deducted by static analysis were higher than the values deduced by insitu test results;
2. The capacity of piles increase with pile length and diameter of piles
3. The capacity of piles range from 2829-12,147KN and 2454 – 6009KN for static analysis and in-situ test results method respectively.

The higher values of the piles capacity computed from static analysis are due to the values of laboratory parameters used. These are subject to errors and assumption as compared to the parameters applied in the in- situ technique.

The latter values (in-situ procedures) agrees with the results deduced by Shariatmadari et al for which it was demonstrated the pile capacity deduced by SPT N-value show more accuracy and less scatter than other methods.

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Boring No.	Pile Diameter (mm)	Total Pile Capacity (kN)		
		Pile Length (m)		
		35	30	25
BH1	600	5564.66	4163.14	2974.24
	900	8205.99	6103.71	4324.85
	1300	11,727.77	8691.13	6121.68
BH2	600	5510.54	4123.38	2949.62
	900	8124.81	6044.06	4283.43
	1300	11,610.50	8604.98	6061.85
BH3	600	5758.60	4305.63	3076.18
	900	8496.90	6317.44	4473.28
	1300	12147.97	8999.86	6336.07
BH4	600	5725.29	4281.15	3059.19
	900	8446.93	6280.73	4447.78
	1300	12075.79	8946.83	6299.24
BH5	600	5270.70	3950.10	2829.29
	900	7771.04	5784.15	4102.94
	1300	11095.51	8229.56	5801.14

Table 1: Total pile capacity for varying pile diameters (Static analysis)

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Boring No.	Pile Diameter (mm)	Total Pile Capacity (kN)		
		Pile Length (m)		
		35	30	25
BH1	600	2850	2912	2912
	900	4148	4237	4237
	1300	5716	6009	6009
BH2	600	2454	2558	2642
	900	2571	3723	3844
	1300	5046	5280	5451
BH3	600	2683	2787	2829
	900	3904	4056	4116
	1300	5537	5752	5838
BH4	600	2621	2704	2746
	900	3814	3935	3995
	1300	5292	5580	5666
BH5	600	2704	2746	2787
	900	3935	3995	4036
	1300	5460	5666	5752

Table 2 : Total pile capacity for varying pile diameters (In situ analysis)

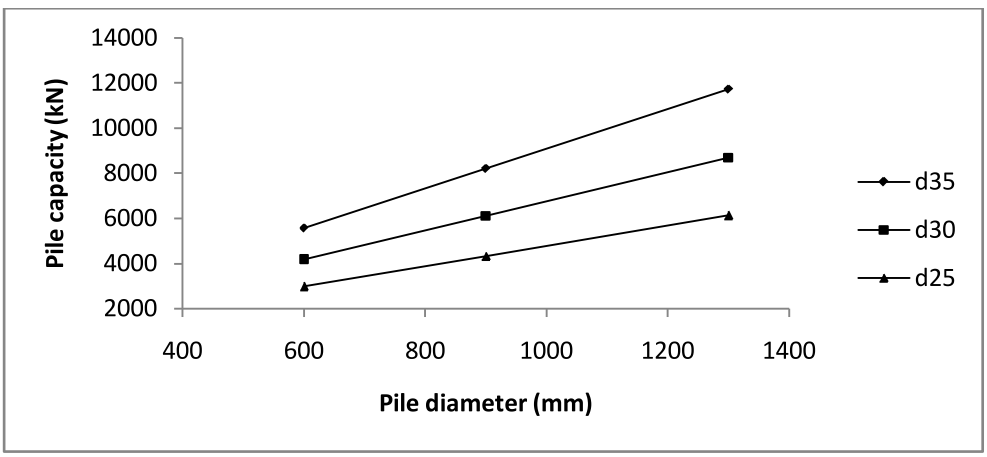

Fig. 1: Variation of Pile Capacity with Pile diameter for different pile depths – Static Analysis (BH1 –Abutment)

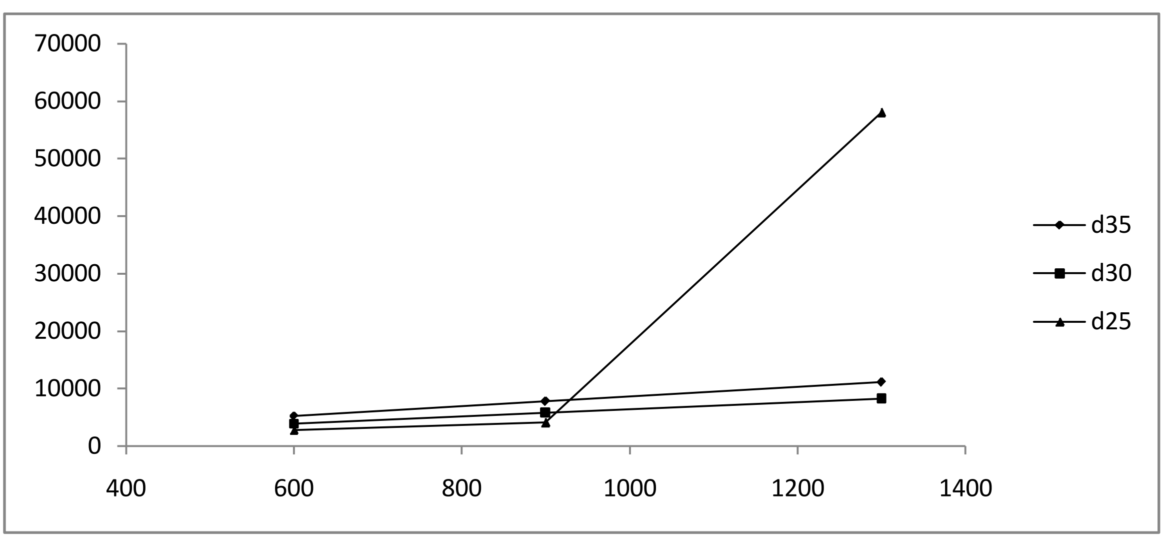

Fig. 2 : Variation of Pile Capacity with Pile diameter for different pile depths– Static Analysis (BH5 –Abutment)

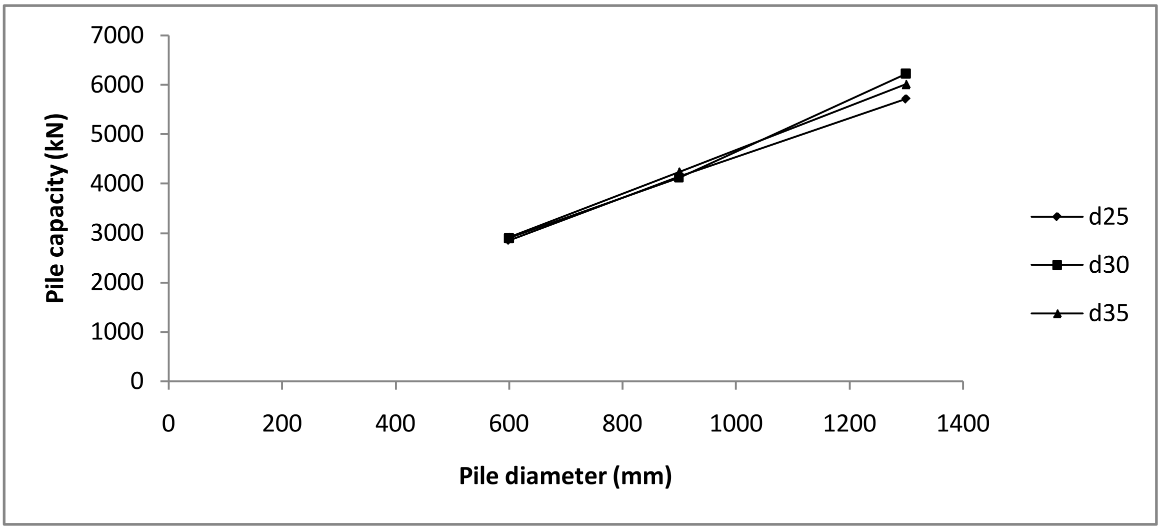

Fig. 3 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH1–Abutment)

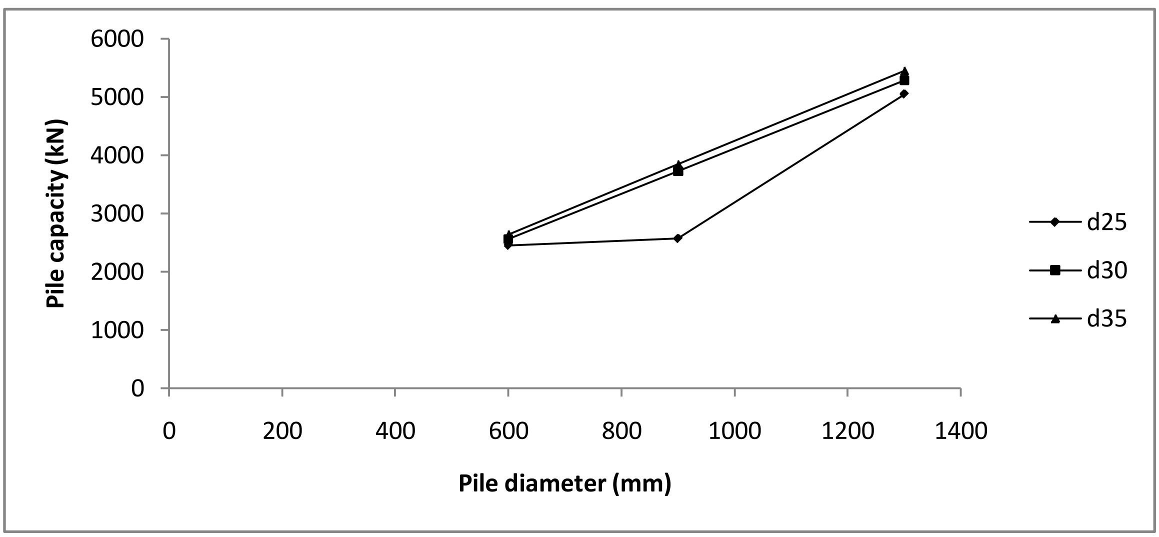

Fig. 4 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH2–Pier)

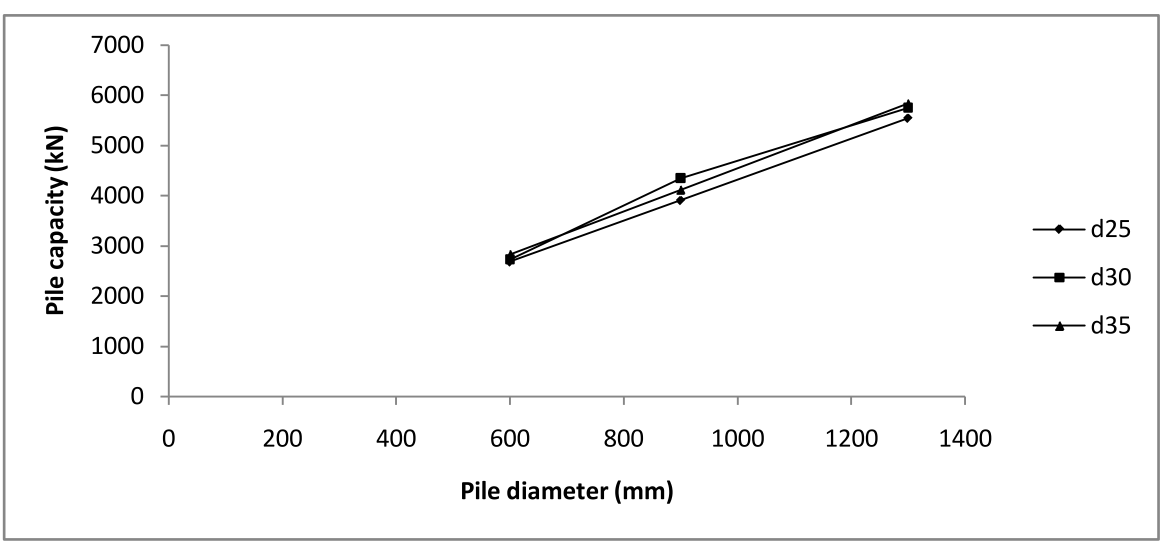

Fig. 5 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH3–Pier)

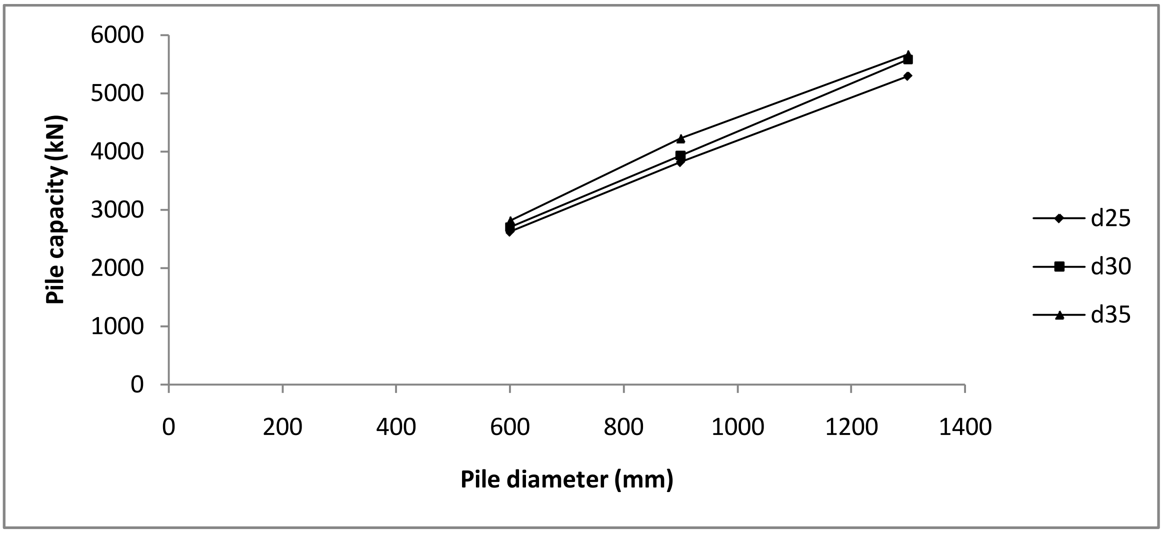

Fig. 6 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH4–Pier)

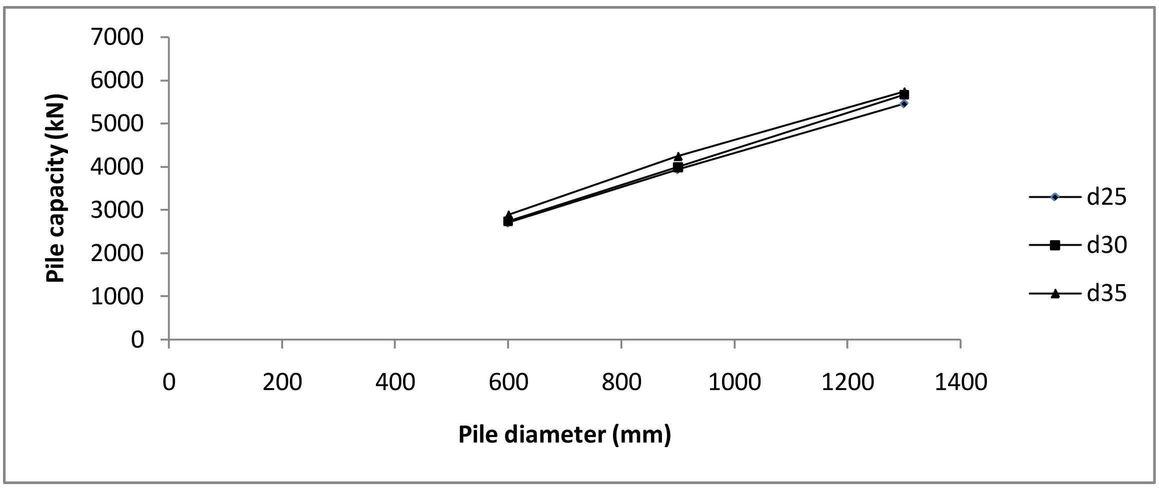

Fig. 7 : Variation of Pile Capacity with Pile diameter for different pile depths– In situ Analysis (BH5–Abutment)

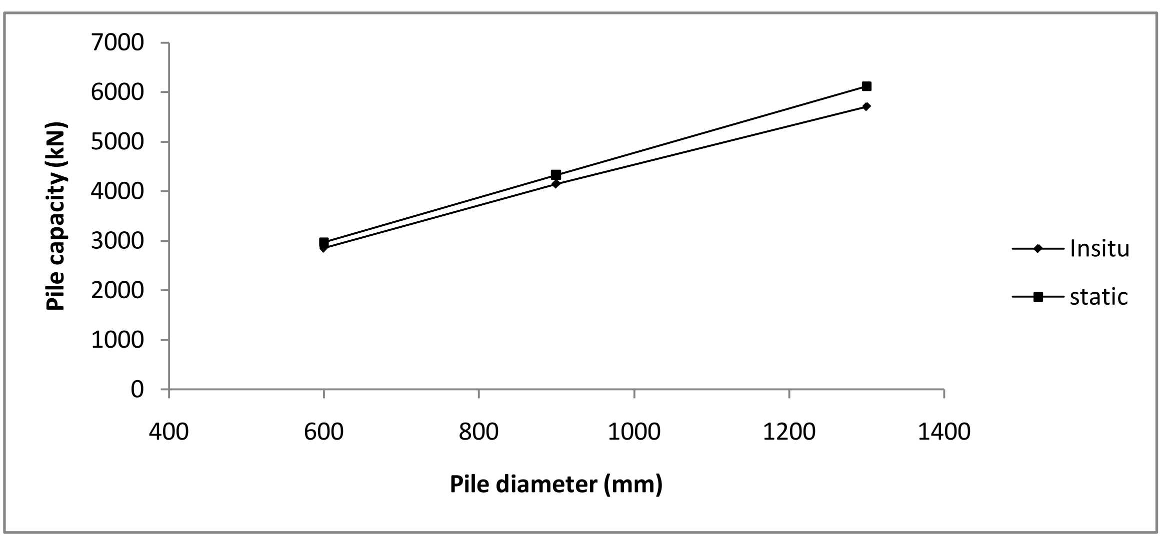

Fig. 8 : Plot of pile capacity by static analysis and In situ analysis for 25m depth

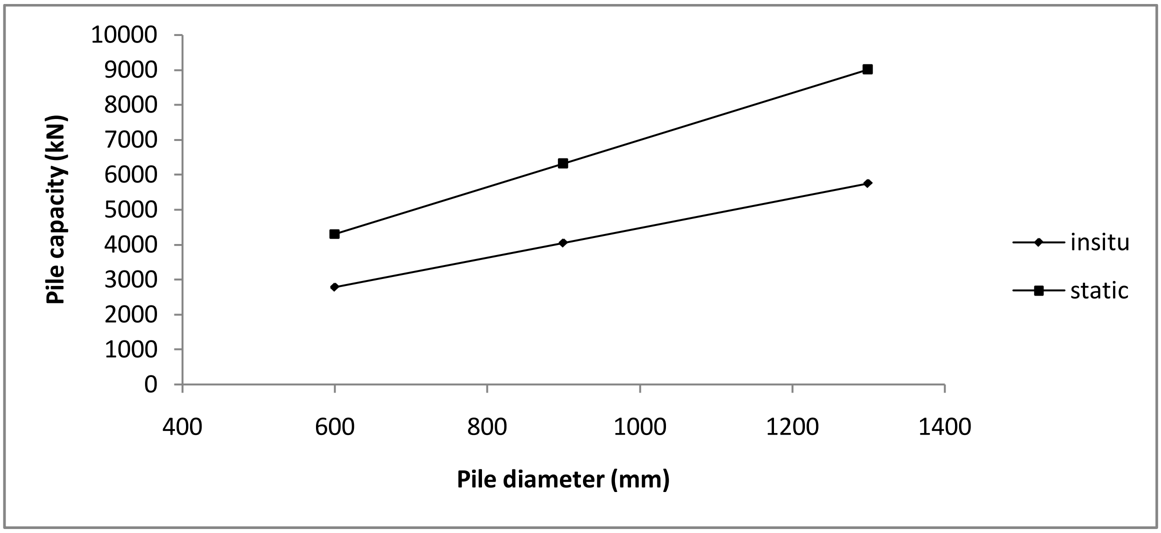

Fig. 9 : Plot of pile capacity by static analysis and In situ analysis for 30m depth

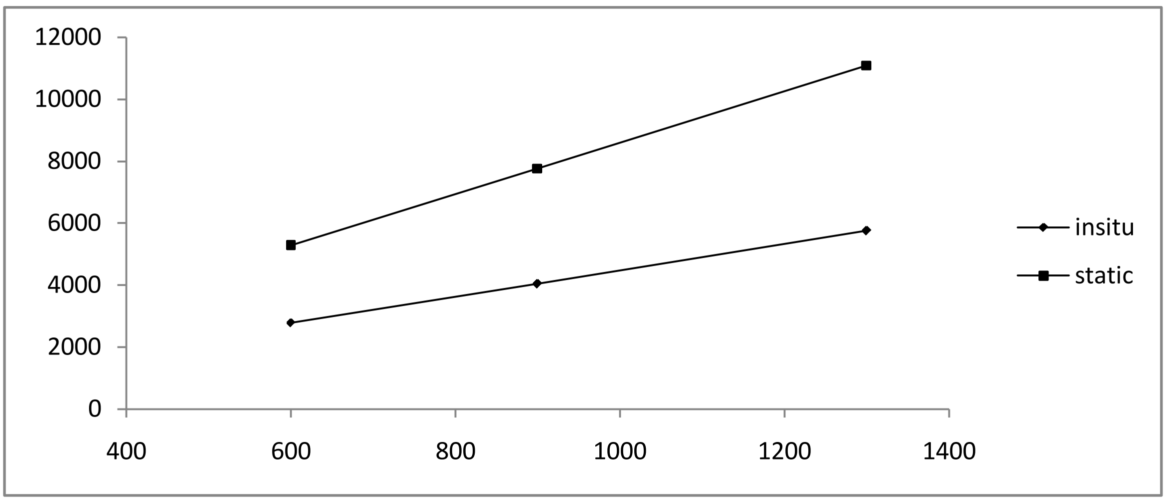

Fig. 10 : Plot of pile capacity by static analysis and In situ Analysis for 35m depth

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