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Deviation of Position of Piles Foundation from Its Original Designed Location

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Abstract

The aim of this preliminary research is to study the precision of pile foundation position compared to its original predetermined location. The deviations of pile foundations (precast piles), which is defined as the lateral displacement of the pile head, were collected from as-built drawing documents that were prepared after the piling activity at each project has completed. The precision of the pile foundation position is evaluated using available Standards such as British Standard, Canadian Standard, and Indian Standard. Those three standards employing maximum pile head movement of 75 mm, except for Canadian standard that allows lateral dislocation up to 150mm, when the measurement were taken after the entire piling activity of a project has been done. The results of 19 projects that employing pile foundations with dimension ranging from 250 mm to 600 mm, show that about 40% pile with diameter of 600 mm and about 60% pile with diameter 500 mm deviated lateraly less than 75 mm. While for pile with diameter ranging from 250 mm to 450 mm, between 65% to 70% were driven in the tolerance of 75 mm from its original design location. In other words, it can be concluded that the deviation of pile location influenced by pile dimension. The bigger the dimension of piles the smaller the percentage of piles driven in the 75 mm tolerance from its designed location

Keywords: deviation of piles, tolerance of piles, piles

Abstrak

Penelitian awal ini bertujuan untuk mempelajari ketepatan titik pemancangan pondasi tiang dibandingkan dengan rencana awal. Besarnya penyimpangan tiang pancang (*precast piles*) ditentukan dari hasil perpindahan kepala tiang secara lateral dari posisi awal, yang diperoleh berdasarkan as-*built drawing* setelah aktivitas pemancangan selesai. Penyimpangan titik pondasi tiang yang terpancang tersebut kemudian dievalusi berdasarkan batasan atau toleransi dari standar-standar yang ada, yang meliputi *British Standard*, *Canadian Standard*, dan *Indian Standard*. Ketiga standar tersebut menggunakan toleransi penyimpangan tiang pancang maksimum sebesar 75mm dan 150mm. Hasil penelitian awal terhadap 19 proyek yang menggunakan pondasi tiang *precast* dengan dimensi mulai dari 250mm sampai 600mm menunjukan bahwa sekitar 40% tiang dengan diameter 600mm berada dalam batas toleransi penyimpangan kurang dari 75mm; sekitar 60% tiang diameter 500mm berada dalam toleransi 75mm, dan sekitar 65% tiang dengan diameter antara 250mm sampai dengan 450mm berada dalam toleransi 75mm. Dengan kata lain dapat disimpulkan bahwa ketepatan titik pondasi dipengaruhi oleh dimensi tiang pondasi.

Kata kunci: penyimpangan tiang, pergeseran tiang, pondasi tiang

Introduction

Installation of pile foundation using injection method is getting popular in the past 5 years. This installation method is selected due to its advantages, such as the absence of vibration and noise. It also provides information regarding mobilized resistance of piles during driving. However, the installation of pile generates large of pressure to the upper layer of soil due to the weight of the machine and its counterweight required to push down the pile. Total weight of the machine is about 210

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percent of the designed working load of the pile. According to the specification, pressure generated by 700 ton capacity and 900 ton capacity injection machines is about the same, that is 21 ton/m^2 [1] . This large pressure that works on the surface layer might affect the surrounding piles that have been previously installed. Besides, it also requires relatively thick engineered fill to withstand the developed pressure.

Installation of piles using jacked-in method also generates lateral pressure to surrounding soil and existing piles. According to Poulos [2], the pressure generated by installation of piles could affect surrounding soil up to 7 diameter of pile. In other words, the position of existing piles within this range could be shifted by installation of new subsequent piles. The closer the location of existing piles to the pile being installed, the larger the displacement of the existing piles will be.

Factors that might affect the final position or deviation of piles from its original designed location include inaccuracy measurement of position point of piles that caused by human error, pile head displacement due to the vertical pressure generated by the weight of the jacked-in machine used to install the piles, and the lateral pressure developed by the installation of subsequent piles.

The objective of this preliminary research is to study the final deviation of installed piles from its original designed location after all piling activities has completed. The deviation of the installed piles was then compared to the tolerance allowed by available standards, such as British Standards, Indian Standards, and Canadian Standards.

The research was performed solely on the deviation of piles, which were installed by means of hydraulically jacked-in machine. All data were collected from nineteen projects that employed circular and square precast-prestressed concrete piles. The dimension of piles was ranging from 250 mm up to 600 mm.

Allowable tolerance

Three standards used to analyze the deviation of piles. The standards include British, Indian, and Canadian standards. The tolerance of pile deviation stated by those three standards is presented briefly as follows:

British Standard [3] states that for vertical piles, the maximum deviation of pile is 1 in 75 (or 1.3%). At the working level of piling rig, the maximum deviation of pile is 75 mm from the designed position. Greater tolerance may be prescribed for piles driven over water and for raking piles.

Indian standard [4] prescribes more details tolerance to control the deviation of pile deviation. The maximum angular deviation for vertical piles is 1.5 percent, while the maximum deviation of raker piles is 4 percent. The permissible tolerances for piles is presented in Table 1

Table 1 Permissible tolerance of piles

Type of piles	Dimension of piles (D) mm	Tolerance
Vertical piles	D < 600	75mm or *D*/6, whichever is less
	D > 600	75mm or *D*/10, whichever is more
Single pile under column	D < 600	50 mm or *D*/6, whichever is less
	D > 600	100 mm
Raking piles and piles cast over water		Greater tolerance may prescribed

Where D : diameter of piles

Canadian Standard [5] states that at cut-off elevation, the maximum deviation of pile measured immediatley after termination of initial driving is within 75 mm, and 150 mm when the measurement taken after all piles have been driven.

Data of piles

Table 2 shows the information of the piles collected from 19 projects that was used in this research. Dimension of the piles was ranging from 250 mm to 600 mm. Almost all the spacing between piles in one group (pile cap) were about 3 times of pile diameter, and about 42 percent of the project employed pre-boring prior to installation of piles

Table 2 Information of piles used in the research

Project	D (mm)	Type of pile cap	S (mm)	Pre-boring
1	C-600	PC2;PC3;PC4;PC5;PC6;PC7;PC27	1800	No
	C-500	PC2;PC3	1500	No
	C-250	PC2;PC3;PC4	750	No
2	C-400	PC2;PC3;PC4;PC6;PC8;PC10;PC12	1200	No
		PC7	1250	No
3	C-400	PC2;PC3;PC4;PC5;PC6;PC7	1200	Yes
		PC20	1500	Yes
4	C-500	PC2;PC3;PC4;PC5;PC6;PC8	1500	Yes
5	C-250	PC2;PC4;PC6;PC10;PC25	750	Yes
6	C-500	PC2;PC3;PC4;PC5;PC6;PC8;PC9;PC12;PC14	1500	Yes
		PC42	1700	Yes
7	C-600	Raft	1800	Yes
8	C-500	PC2	1600	Yes
		PC3;PC5;PC6;PC7;PC123;PC320;PC495	1500	Yes
9	C-500	PC2;PC3;PC4;PC5;PC6;PC7;PC22;PC25;PC61	1500	No
10	C-400	PC2;PC3;PC4;PC5;PC6;PC9;PC10;PC11;PC12	1200	No
11	C-250	PC2;PC3;PC4;PC5;PC6;PC7;PC8;PC9;PC10;PC11;PC12;PC30;PC34;PC36;PC38	750	No
12	S-300	PC3;PC4;PC5	900	No
13	C-450	PC2;PC3;PC4	1350	No
14	C-300	PC2;PC3;PC4;PC5;PC6;PC24	900	No
15	C-400	PC2;PC4;PC25;PC28	1400	Yes
		PC6;PC11;PC13	1200	Yes
16	C-500	PC2;PC5;PC6;PC7	1500	Yes
17	S-450	Raft	1400	No
18	C-400	PC2;PC3;PC4;PC5;PC6;PC7;PC8;PC10;PC15;PC28	1200	No
19	S-250	PC2;PC3	750	No

Note:
D : dimension of piles
PC :Pile Cap
n : number of piles in a Pile Cap.

Deviation of piles with regard to its original designed position was measured after all piling activities have completed. Therefore, the deviation of installed piles might be caused by the inaccuracy of setting out of pile position, lateral pressure due to installation of subsequent neighboring piles, lateral pressure generated by the weight of jack-in machine, or by the combination of them. The deviation of all piles measured from 19 projects is presented in Table 3

Table 3 Deviation of Pile Location

Project	D (mm)	No of piles	Deviation of piles			Pre-boring
			0-75 mm	75-150 mm	>150 mm	
1	C-600	572	46%	41%	13%	No
	C-500	152	59%	30%	11%	No
	C-250	128	83%	16%	1%	No
2	C-400	265	84%	16%	0%	No
3	C-400	115	76%	23%	1%	Yes
4	C-500	614	73%	27%	0%	Yes
5	C-250	250	70%	28%	2%	Yes
6	C-500	193	51%	40%	9%	Yes
7	C-600	361	31%	34%	35%	Yes
8	C-500	153	97%	2%	1%	Yes
9	C-500	627	56%	42%	2%	No
10	C-400	255	88%	12%	0%	No
11	C-250	679	46%	45%	9%	No
12	S-300	550	65%	28%	7%	No
13	C-450	378	75%	25%	0%	No
14	C-300	335	68%	30%	2%	No
15	C-400	141	52%	40%	8%	Yes
16	C-500	96	53%	36%	11%	Yes
17	S-450	796	66%	29%	5%	No
18	C-400	248	75%	20%	5%	No
19	S-250	424	67%	29%	4%	No

Distribution of the deviation of installed piles with diameter of 250 mm to 600 mm taken from several projects is presented in Figure 1 to Figure 6
Complete and more details distribution of deviation of piles with diameter 250 mm to 600 mm had been prepared by Charles and Christianto [6]

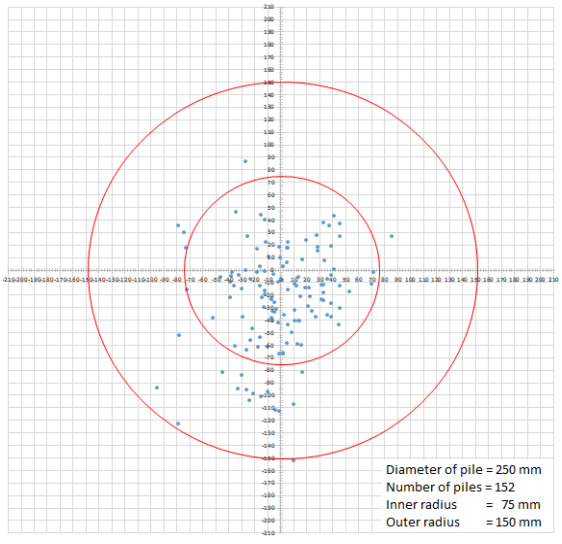

Figure 1 Deviation of piles with diameter of 250 mm

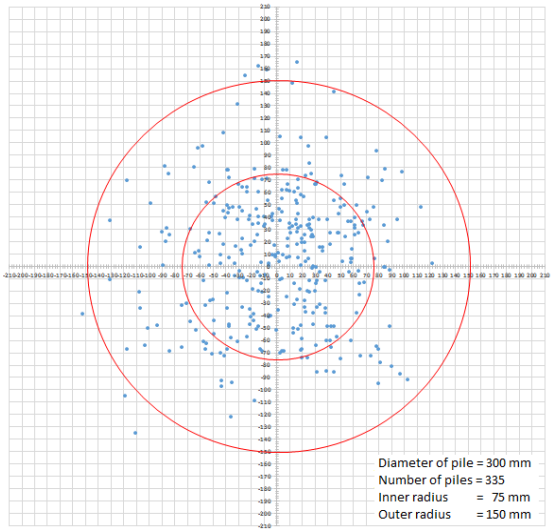

Figure 2 Deviation of piles with diameter of 300 mm

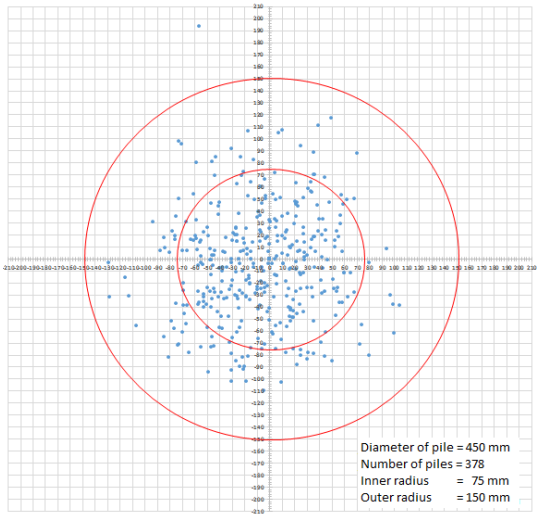

Figure 4 Deviation of piles with diameter of 450 mm

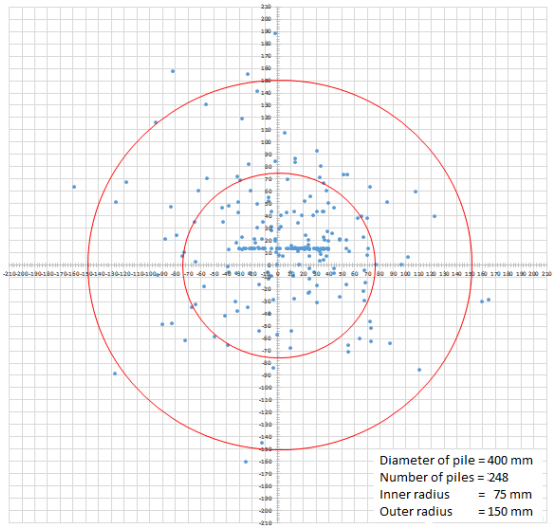

Figure 3 Deviation of piles with diameter of 400 mm

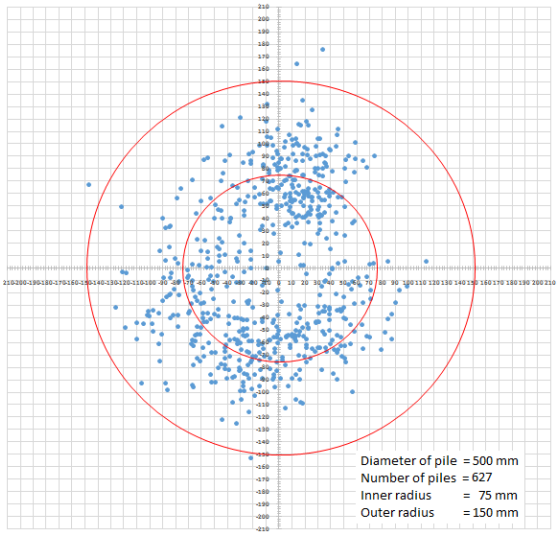

Figure 5 Deviation of piles with diameter of 500 mm

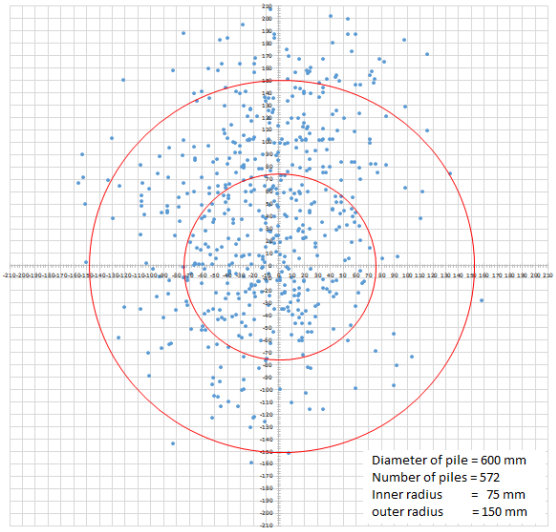

Figure 6 Deviation of piles with diameter of 600 mm

Table 4 presents the average deviation of piles from all projects categorized based on its diameter. It shows that about 39% of piles with diameter of 600 mm and about 60% of piles with diameter 500 mm were driven in the tolerance of 75 mm from its original design position. While for piles with diameter ranging from 250 mm to 450 mm, between 65% and 70% were installed in the tolerance less than 75 mm.

Table 4 also shows that, the bigger the diameter of piles the larger the number of piles that were driven beyond 150 mm tolerance

Table 4 Average deviation of piles categorized to its dimensions

D	Deviation of piles		
	0-75 mm	75-150 mm	>150 mm
C-600	39 %	38%	23 %
C-500	60 %	30 %	10 %
C-450	70 %	25 %	5 %
C-400	67 %	25 %	8 %
C-300	66 %	29 %	5 %
C-250	65 %	31 %	4 %

Conclusion

Based on piling records collected from 19 projects, it can be concluded that:

- The bigger the pile dimensions, the larger the deviation of piles from its original designed location
- The deviation of pile location with dimensions from 250 mm to 450 mm relatively the same; there was about 65% less than 75 mm tolerance and about 30% within 75 mm to 150 mm tolerance.
- Piles with dimension of 500 mm exhibits larger deviation; about 60 % and 30 % of piles installed less than 75 mm and between 75 mm to 150 mm tolerance, respectively. While 39% of piles with dimension of 600 mm installed less than 75 mm and between 40% installed between 75 mm to 150 mm.

Reference

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