COMPARISON ANALYSIS OF THE PILE DYNAMIC LOAD TESTS WITH DIESEL HAMMER AND HYDRAULIC HAMMER

Y. Ashkey[1], *R. Bazilov*[2], *U. Kimanov*[3]

[1, 2] Civil Engineering Department & Geotechnical Institute of ENU, Astana, Kazakhstan [3]Master Student, Civil Engineering Department, ENU, supervisor- Ashkey Ergen E-mails: [1]yergenashkey@mail.ru; [2]bruslank@mail.ru; [3]ulybek@gmail.com

ABSTRACT: In this paper presented comparison analysis of the bearing capacities of driven piles used for pile foundations buildings (campus) of the Nazarbayev University, which dynamic pile tests estimated with two types (diesel and hydraulic) hammer through requirements SNiP of RK 5.01-03-2002 and GOST 5686-94.

1. INTRODUCTION

For designing pile foundations of campus construction site was chosen for dynamic pile tests, rectangular precast driven pile type C10-30 with lengths 10 m, weight 2.28 tons and driven with diesel hammer type C-330 from original soil surface. After dynamic pile test results, the designers was chosen work piles rectangular precast driven pile type C8-30 with lengths 8 m, weight 1.83 tons for campus pile foundations. Work piles installation was driven with hydraulic hammer type HHK-5A.

Therefore, driving above work piles especially for pile foundations of Block #23 detected low bearing capacity's of piles (low than design load) at the time supervision of piling control. After this situation come to a conclusion dynamic testing whole pile foundations of campus and for safety pile installation in number two piles, vertically static load testing for pile foundations of Block #23.

2. ENGINEERING – GEOLOGICAL CONDITION OF SITE

On the basis of the visual description of grounds and to the data of the skilled field works confirmed with results of laboratory researchers, division of grounds (layers), researches composing the site on engineering-geological elements (EGE) in their sequences of bedding (Table 1):

EGE-1. Fill-up soil;

EGE-2. Loamy soil, water saturated; EGE-3. Gravelly sand;

EGE-4. Gravel soil;

EGE-5. Loamy soil with inclusion gruss and gravel.

Table 1 Soil properties

Soil description	**Physical & mechanical properties of soils**				
	ρ, g/cm³	**C, kPa**	**φ, angle**	**E, MPa**	**R, kPa**
EGE-1. Fill-up soil	1,87	21,0	29	8,0	-
EGE-2. Loamy soil, water saturated	2,03	28,0	22	9,0	-
EGE-3. Gravelly sand	1,92	2,0	35	17,0	-
EGE-4. Loamy soil with inclusion gravel soil	2,00	1,0	38	21,0	-
EGE-5. Gruss and gravel	2,05	-	-	-	350

According to design for bearing soil layer assumed EGE-4 and EGE-5 (abs. soil level about from 338 m to 336 m) and all test piles driven mentioned depth.

3. THE SPECIFICATIONS DIESEL AND HYDRAULIC HAMMERS

The specifications diesel and hydraulic hammers for determination of bearing capacity of driven piles displaying in the Table 2.

Table 2 Hammer specifications

Descriptions of specifications	Diesel hammer type C-330	Hydraulic hammer type HHK-5A
Weight of blowing part (drop) in tons	2.5	5.0
Total weight in tons (m_1)	4.2	8.755
Hammer blowing energy in t·m (E_d)	3.5	6.0
Max. height blowing part in meter (H)	2.0	1.2
Weight of pile cap in tons	0.150	0.835

4. THE DEFINITION OF BEARING CAPACITY OF THE TEST PILES BY STATIC (SLT) AND DYNAMIC (DLT) LOAD TEST

Bearing capacity of piles F_d, *kN* by static (SLT) and dynamic load tests (DLT) described below equation [1],

F_{dc} [redacted] $F_{u,n}$ / [redacted] (1)

where γ_c – safety factor; if compression load, then $\gamma_c = 1$;

$F_{u,n}$ – ultimate resistance of piles, kN;

γ_g – safety factor by soil ground, according to the [4]. For define γ_g:

- if the test piles quantity less than 6, then safety factor by soil ground assumed $\gamma_g = 1$ and $F_{u,n} = F_{u,min}$

- if the test piles quantity more than and equal to 6, then safety factor by soil ground (γ_g) defined according to the [4].

4.1. By DLT

For define bearing capacity of test piles (F_u) by dynamic load test during test pile driving described refusal (10cm/blows) and defined below equation[1],

$$F_u = \frac{M}{2}\left[\sqrt{1 + \frac{4E_d}{S_a}\cdot\frac{m_1 + \varepsilon^2 (m_2 + m_3)}{m_1 + m_2 + m_3}} - 1\right] \quad (2)$$

where $\eta=1500\ kN/m^2$ – nominal material pressure of the for concrete;
$A=0,09\ m^2$ – pile cross section area, m^2;
$M=1$ – hammer influence factor;
E_d – blowing energy of the drop parts hammer, kNm:
- for hydraulic hammers, $E_d=GH$;
- for diesel hammers, $E_d=(H-h)$

where $G=50\ kN$ – weight of drop parts of hydraulic hammers HHK-5A;
$G=25\ kN$ – weight of drop parts of diesel hammers C-330;
$H=0,4\ m$ – height of drop parts of hydraulic hammers HHK-5A;
$H=2\ m$ – height of drop parts of hydraulic hammers C-330;
$h=0.6\ m$ – diesel influence height of diesel hammers C-330;
S_a – refusal (10cm/blows), m;
$m_1=87.55\ kN$ – total weight of hydraulic hammers HHK-5A;
$m_1=42\ kN$ – total weight of diesel hammers C-330;
ε^2 – damping factor $\varepsilon^2 = 0,2;$
m_2 – weight of piles and pile cap;
$m_3 = 0$ – pile cushion.

4.1. By SLT

For define bearing capacity of test piles (F_u) by static load test assumed settlement (S) of the test piles from static loading and defined below equation[1],

$$S = \zeta S_{u,mt} \quad (3)$$

where $S_{u,mt}$ – ultimate settlement of designing buildings or structures (according to catagories) by requirments [2], cm;

ζ=0,2 – settlement factor (if settlement condition last 1 hour less than or equal to 0.1 mm).

The results of SLT are shown Figure 1.

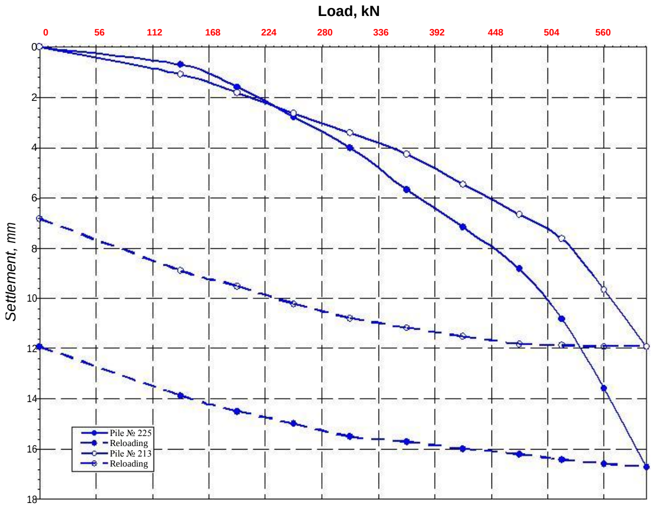

Figure 1. Diagram of Load-Settlement by the SLT

5. METHOD STATEMENT OF DLT

Testing of piles by DLT carried out with requirements of [3]. Before pile driving for test precast piles marked every 1 m and last meter (1 m) marked every 10 cm (Figure 2). After marking test piles driving soil ground with pile driving rigs and during driving count blow quantity with height of drop parts and writing report paper. Redriving carried out after ―rest time‖. Rest time give if bearing layer of building supported to gravel soils then 3 days, while clayey soils 6-10 days. For redriving after ―rest time‖ attached indication paper (marked by mm) and blowing 3 and 5 times, and settlement for refusal mentioned with leveling instrument [5]. Results of DLT with two types of hammer (hydraulic and diesel hammer) are shown Table 3.

Fifure 2. Test pile driving for DLT

Table 3 DLT bearing capacity comparisons

Type of hammer	*Type pile and cross section pile in cm*	*Level of soil surface in meter*	*Embedded depth of in soil ground in meter*	*Height blowing part during driving in meter*	*Refusal of during pile driving (initial) in cm*	*Height blowing part during redriving in meter*	*Refusal of during redriving (final) in cm*	*Bearing capacity of pile in kN*	*Bearing capacity of pile with an allowance of safety factors =1.4 in kN*	*Comparison results ofthepiledynamictests*
C-330	*C 10-30,30x30*	*34 4,80*	*7, 3-9,0*	*2, 00*	*0, 20-0,30*	*2, 0*	*0, 20*	***12 41***	***88 6***	***2,2***
HHK-5A	*C8-30, 30x30*	*345,10*	*7,0-7,3*	*0,30*	*0,77-3,33*	*0,40*	*0,20-1,10*	***562***	***401***	

6. METHOD STATEMENT OF SLT

Testing of piles by SLT carried out with requirements of [3]. SLT carried out for low bearing capacity two piles (design #213, 225) by DLT, above mentioned university campus's Blok#23. The static loads were made until 602 kN by load steps from 84 kN to 42 kN, by hydraulic jack DG100P150 with capacity 1000 kN supported to kentledge (Figure 3). The pressure in the jack was created with the help of manual oil pump station NRG-8080, load was controlled with the technical monometer MA100BU63. Every load steps controlled the settlement condition, when last 1 hour less than or equal to 0.1 mm (S≥0.1mm) and made next load. Pile head settlement controlled with dial gages 6PAO[6]. Results of SLT and comparison analysis with two types of hammer (hydraulic and diesel hammer) are shown Table 4.

Figure 3. SLT for pile foundations of Nazarbayev University campus

Table 4 SLT & DLT comparisons

Design marks of piles	*Pile type*	*Embedded depth of insoilgroundinmeter*	*Max. settlement ofpilesinmm*	*Bearing capacity of pile in kN*	*Bearing capacity ofpilewithandallowanceofsafetyfactors=1.2inkN*	Comparison results of the DLT and SLT	
						Hydraulichammertype HHK-5A	*Dieselhammertype C-330*
№ 213	C 8-30	7,0	11,93	**593**	**494**	**1,23**	**1,80**
№ 225	C 8-30	7,3	16,74				

7. CONCLUSION

The results of DLT for definition of bearing capacities of the test piles showed 2.2 times higher bearing capacity carried out with diesel (C-330) hammer than hydraulic (HHK-5A) hammer (See Table 3).

If the comparision results of SLT and DLT, then results of DLT 1.23 times higher bearing capacity carried out hydraulic (HHK-5A) hammer, while 1.8 times higher bearing capacity carried out diesel (C-330) hammer than SLT results(See Table 4).

Above mentioned results are problems of the pile foundations Astana soil ground, i.e for carried out DLT with diesel hammer (C-330) not enough hammer blowing energy for pile foundations Astana soil ground. If to conclude, pile driving with low energy of diesel hammers (C-330):

- not fully driven piles to required depth;
- false results of DLT;
- pile breaking and cracking many blowing.

8. REFERENCES

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