Diyala Journal of Engineering Sciences

Journal homepage: https://en.enginmag.uodiyala.edu.iq/

ISSN: 1999-8716 (Print); 2616-6909 (Online)

Dynamic Response of Single Pile Subjected to Different Frequencies in Gypseous Soil

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ARTICLE INFO

Article history:
Received 29 July 2020
Accepted 3 September 2020

Keywords:

Gypseous soil; Piles; Dynamic load; Model test; Vibration

ABSTRACT

This paper exhibits an experimental study on dynamic response of a single pile under dynamic load which comes from motor placed on cap pile called a vibration source. This study used the effect of the dynamic movement of vibration on one pile, collapsible soil (gypseous soil) used in this study with 30% gypsum content. The experiment is performed in a dry and soak state. A solid steel pile with a slenderness ratio of 27 was inserted into the soil after preparing it in layers in a steel container (30 * 30 * 60) cm. The test was performed under a dynamic response to the different frequencies 10, 15, 20, and 25 Hz. The results showed that the speed, acceleration and displacement increase with increasing frequency of the vibration source in addition to that the values of speed, acceleration and displacement amplitude are less in the case of soaking compared to their values in the dry state.

1. Introduction

Gypseous soil cover broad areas of the earth's surface, especially in southern Africa and some parts of Asia and southwestern United States of America [1]. As the gypseous soil is considered a collapsible soil, then collapsing soils can be defined as unsaturated soils if they rearrange their particles and their size decreases dramatically when soaked with the addition of loads or without addition [2,3].

As the cause of the collapse is due to the materials included in the composition of gypseous soil, which are sand, clay, or other materials [4,5]. This soil covers about 31.7% of the regions of Iraq with different gypsum ratios ranging from 10-70% as the buildings on which they are facing face many problems as a result of the high percentage of gypsum that decomposes, which causes the loss of bonds between soil particles when there is water [6-7].

Pile foundations are used to support various structures on a large scale in weak and collapsible soils that are subject to static loads and also dynamic loads. The dynamic load can be defining that load different in mount and direction and it generated from the machine, ocean waves, traffic, and earthquakes. So, the study of the dynamic response received great attention (Manna and Baidya, 2009) [8]. There are several studies that support of exposure. Fattah et al. (2017) found that the deep foundation that is based on Impregnated sand, supporting machine and exposed to high frequency will be more likely to be liquefied [9].

Ghosh et al. (2012) provides a comprehensive review of two important topics it faces earthquake engineer design piles in these areas. First design methodologies from

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DOI: 10.24237/djes.2020.13407

simplified to complex models and a comparison of the selected methodologies is shown in order to illustrate the advantages more rigorous approach also discusses the implications for national and international second-heap performance standards, guidance documents, and specific requirements for heap design are reviewed and performance. An overview of this aspect of seismic foundation design for practicing engineers. over there. There are many symbols for providing piling design in liquefaction soils such as Eurocode 8 (EN1998-5: 2004) provisions, JRA provisions, ASCE 7-10, AASHTO (2010) and ISO-23469 (2005). Kinetics was discussed in all symbols and effects of inertial interaction clearly demonstrated what engineers needed to assess these effects when designing stacks, the liquefied land [10].

Prakash and Puri (2010) stated that piles were used as the basis for loading low strains such as those caused by machine foundations and in some cases usually for loading high strains such as those caused by earthquake. To determine the heap response when exposed to dynamic loads, a simplified model of the spring mass was adopted, Soil spring coefficient, either as a soil shear motor or as a sub-degree reaction coefficient, therefore these conditions must be observed [11].

Elkasabgy et al. (2010) Studied Foundations Supported on Helical Piles, Evaluation of Damping Solidity involves looking at interactive. The forces between the soil and the pile along the pile and at the shaft Spirals thus this work requires the correct understanding of the analysis. The transmission mechanism during dynamic loading. Snails have not been fully investigated for the dynamic behavior of large capacity helix piles with one or more [12].

Puri and Prakash (2008) achieved dynamic loading tests on a wide reinforced concrete pile with dimensions of length (17) and (450) mm in diameter, which were driven into a soil layer of uniform clay sand. Horizontal and anchored excitation was applied to the tip of the pile, and the amplitude response of the pile was observed across the frequency of the pile. Field and laboratory tests were also performed to predict soil properties [13].

Manna and Baidya (2008) introduced FE analysis using the PLAXIS software, version 8, to see the dynamic response of a single pile under vertical vibration. Where the Mohr-Coulomb model was used for soil modeling, the field test results were for the two complete aggregates to confirm the results obtained from the FE analysis of the piles themselves. The FE analysis included three stages of calculations. Initially the plastic calculation was used to create the pile and in the second stage, the fixed load was attached to the top of the pile by inserting the steel plate so that the last stage involved the use of this model, where the vertical vibration amplitude of the vertical harmonic load that was applied was measured with different capacities (10 and 20) 30 KN/ m2) and at varying frequencies (10 to 60 Hz), for modeling vibrations transmitted by the oscillator. As the test results showed that the natural frequency and amplitude of displacement were overstated [14].

Hussain Abid Awn (2010), studied the effect of acidity on the collapsibility of gypsiferous soil, the laboratory models were included 350mm diameter and 400mm hight thick plastic container and three layers and 18.4KN gypsum content. The stress at 47 KPa was applied over diameter 50mm circular footing [15].

Abdul sattar Zakaria (2013) studied the effect of collapsibility on the general behavior of the soil the well graded sand was maxied with pure gypsum in gypsm content 10,20,30,50,70% [16].

2. Materials and methods

2.1. Soil

Gypseous soil used in the current study is taken from Tikrit city center Salah al-Din Governorate, north of Baghdad (Iraq), by 30%, as shown in Figure 1. This soil is used to study the dynamic response of single piles exposed to a dynamic load. The physical and chemical engineering properties have been implemented for gypsum soils as shown in Tables 1 and 2. Moreover, as Figures 2 and 3 revealed the results of the laboratory tests conducted on the soil used in the current study. In addition, the relative density test does not apply to this soil (ASTM D4254-00). Moreover, a preliminary water content test is obtained at a temperature below (40-50) ° C to avoid loss of gypsum soil crystal [16]. Two samples of gypsum soil were classified from Soil (percentage of GC30%) as moderate, (ASTM D5533-2003) as shown in Fig. 2.

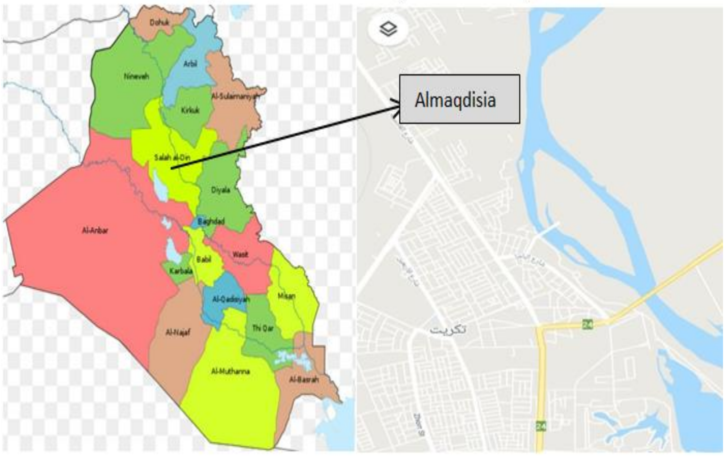


Fig1. The location of the soil samples

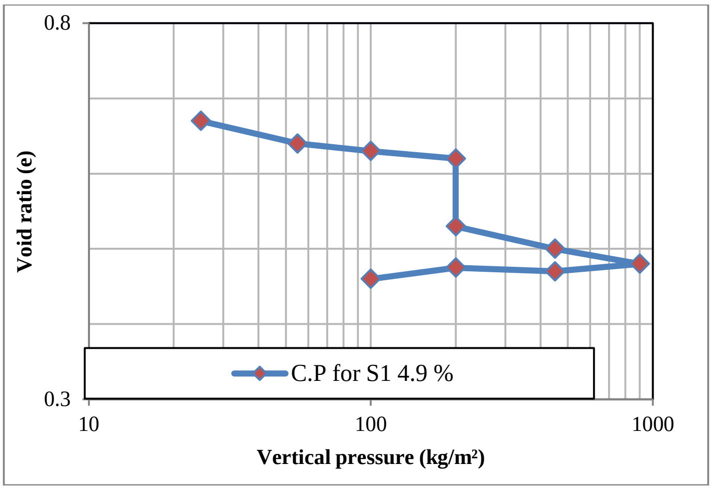


Fig 2. Collapse test (odometer test) in G.C 30%

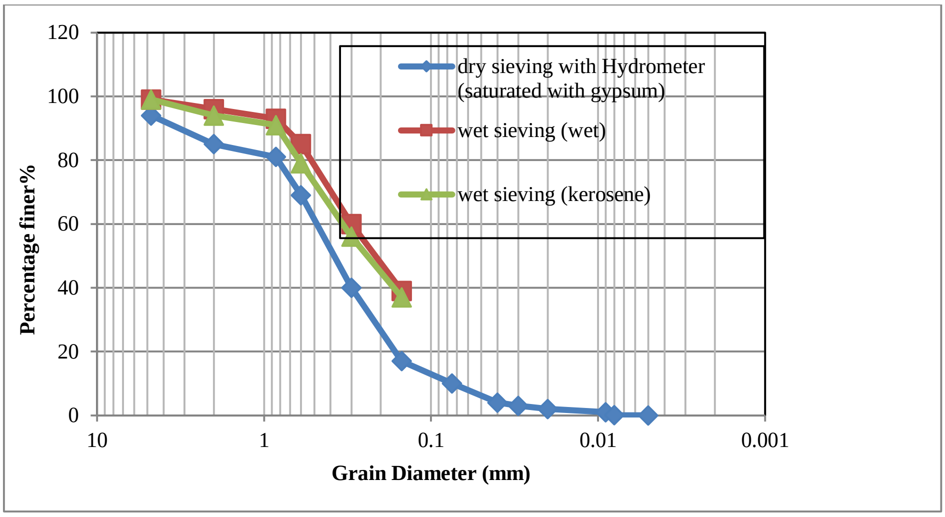


Fig 3. Grain size distribution of soil 30% G.C

Table 1 Results of chemical properties of Gypseous soil used for testing (BS 1377:1990, Part 3)

Composition	**Value %**
Total soluble salts (T.S.S.) %	32.7
Sulphate content (SO3) %	13.8
Gypsum content %	30
Organic matters (O.M) %	0.35
Chloride content (CL) %	0.06
pH value	7

Table 2 Physical properties of Gypseous soil used for testing

Property		Sample (G.C 30%)	specification
Grain size analysis	D30 (mm)	0.07	ASTM D22-02
	D60 (mm)	0.19	
	Coefficient of uniformity, Cu	3.02	
	Coefficient of curvature, Cc	0.4	
	passing sieve No.200% (using kerosene)	38	
	Classification of soil based on (USCS)	SM	
Specific gravity, Gs		2.48	ASTM854(2006)
Atterberg limits	Plastic limit (P.L) %	N.P	ASTM 316-84
	Liquid limit (L.L)%	23	
	Plasticity index (P.I)	___	
Angle of Internal Friction (Ø) in dry for γ test		34	ASTM D3080-98
Angle of Internal Friction (Ø) in soaked for γ test		30	
Soil Cohesion (C) (kN/m2) in dry		8	
Soil Cohesion (C) (kN/m2) in soaked		5	
Dry unit weight	Maximum, γd (max) KN/m3	16.9	
	Minimum, γd (min) KN/m3	12.8	
	Relative density, Dr%	70	
	Test unit weight (kN/m3), γd test	15.12	
Field density ((kN/m3), γfield by (Tikrit university)		15	ASTM D1556-07
Initial void ratio, etest		0.63	
Initial water content %		0.72	ASTM D2216-02
Compaction characteristics	Max. Dry unit weight(KN/m³)	17.4	STM 689-00
	Optimum Moisture content (%)	14.8	
Collapse Potential %		4.9	ASTM D5533-2003

2.2 Apparatuses of model

Figure 4. show the model with apparatuses.

1. Steel tank with dimension (600*300*300) mm
2. Water tank
3. Steel frame
4. Circular weight
5. Mechanical oscillator
6. Single pile
7. Dial gage
8. Cap pile
9. Ac automatic voltage regulator
10. Computer device
11. Digital tachometer
12. Variable frequency drive
13. Vibration meter

2.3 Test setup

In this study, a single pile made of solid steel has a thin ratio of 27. There is also a pile cover with dimensions (120×60×30) mm where the mechanical oscillator connects in the middle of the pile cover. The mechanical oscillator composed of rotating disc with a thickness of 1 mm and a radius of 35 mm to generate the movement. The cap pile weight with the mechanical oscillator weighs 300g. A circular weight used for loading pile statically determine after measuring the bearing capacity. The piezoelectric accelerometer that connects directly to the computerized digital vibration scale model (6063).

It connects to a calculator to see dynamic response like and speed or the acceleration and amplitude are set before the test. To ensure no change in frequency, a digital tachometer model (DT-2234A +) is used. The dial gage used to determine the settlement of pile by place him on cap pile.

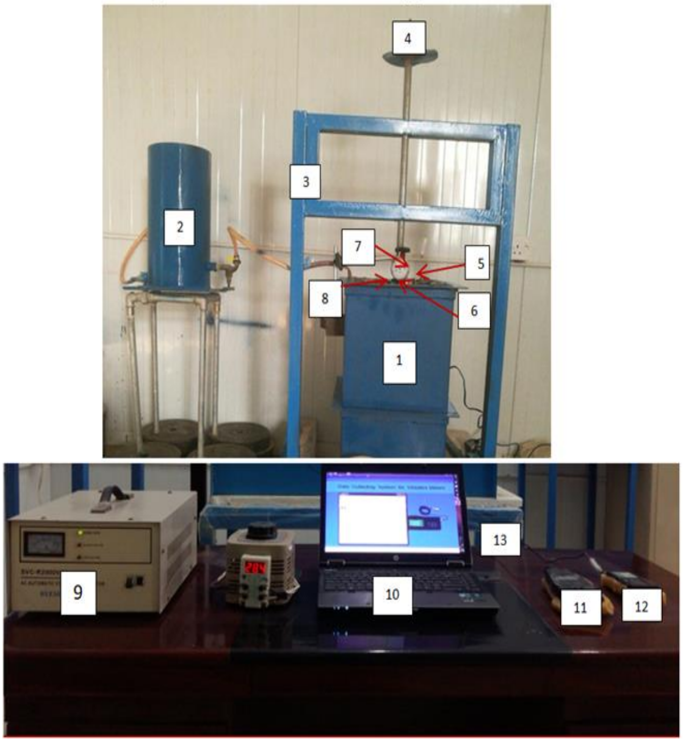


Fig 4. The model with apparatuses

Fig 5. Devices used for measuring vibration response

Fig 6. Digital tachometer

3.Test procedure

3.1 Soil bed preparation

Gypseous soil is prepared to fill the test box with a size (600×300×300) mm and divided into 6 layers. And that each layer has dimensions (100×300× 300) mm. The weight of the total volume of soil is calculated based on the weight of the dry soil unit in its place (15.12 kN /m³ (of gypsum soil with gypsum content) GC (30% that pressed the soil layer with a steel plate to avoid crushing the soil particle and to obtain a uniform density of all layers.

3.2 Installation of model pile and test

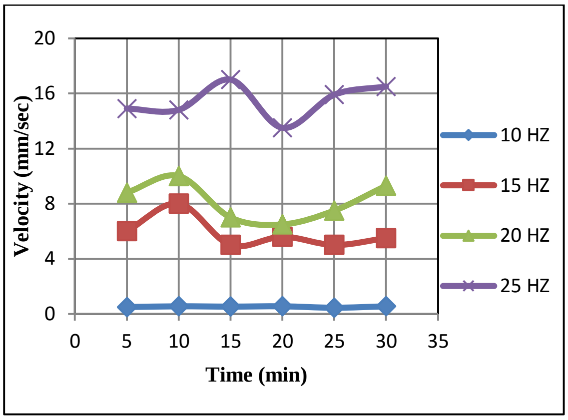
After the process of preparing the soil, the pile is inserted through the mechanical jacking device, since the steel tank is placed inside the frame of the device, as the pile forms in the space below the cell, and then the pile is pushed through a mechanical piston and as the force is determined to be pushed if it should not exceed the depth of the pile entering the soil 2 - 2.5 mm / min. After completing the insertion of the pile, the steel tank is placed in the inspection frame and a static load is attached to it. The dynamic response (displacement amplitude, Velocity, and acceleration) is measured for pile recorded at the same time using a piezoelectric accelerometer and a disk gauge, pre-positioned on the cap-pile and to obtain the settlement for the pile, the operating frequency (600,900,1200,1500) rpm is equivalent to (10, 15, 20, 25) Hz is considered in this study, response parameters were recorded every 5 minutes for 30 minutes.

4. Results and discussion

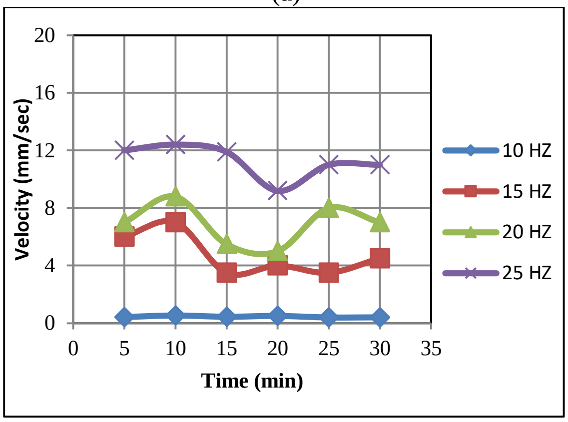
In this study, the dynamic response of the single pile was investigated under a dynamic exciting force created as the basis of the machine. After the pile was pushed into the soil and the static load projected, the dynamic pile analysis with the vertical load created by the machine. velocity, acceleration and displacement amplitude at the slenderness ratio (L/D) 27 pile of gypsum soils to each state (dry and soaking), dynamic excitation applied to the pile of 10, 15, 20, and 25 Hz.

4.1 Velocity

Figure (7) explains the relationship between velocity and time during machine operation, in a dry and soak state at the slenderness ratio 27 and gypsum content 30% for different frequencies 10, 15, 20, and 25 Hz. As the velocity increases when increasing the frequency for both state, in addition to that the velocity in the dry state is greater than its value in the sunken state due to the decrease in vibration energy due to the presence of water in the soil (works as a wave inhibitor), which in turn led to decrease the velocity of vibration for all tests.



(a)

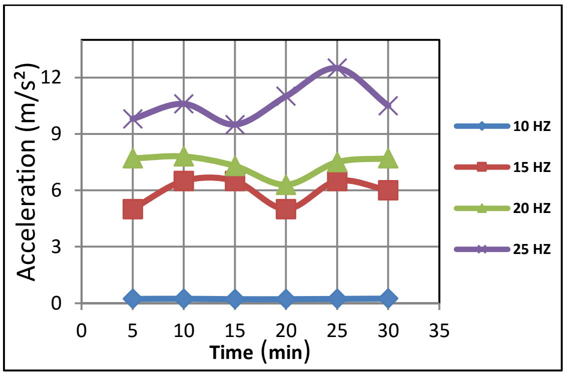


(b)

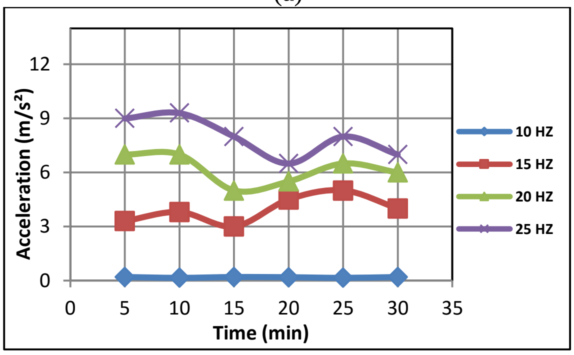
Fig 7. Variation velocity with time for four values of frequency at single steel solid pile (L/D) 27 (a) Dry state (b) Soak state

4.2 Acceleration

Figure (8) explain the relationship between acceleration and time, which is recorded for a solid steel pile with a slenderness ratio of 27 and different frequencies 10, 15, 20 and 25 HZ in a dry and sunken state. The acceleration increases as the frequency increases, the volume of the acceleration increases increases in the dry state compared to the volume in the soaked state in all tests because the water acts as a wave inhibitor (previously mentioned).



(a)

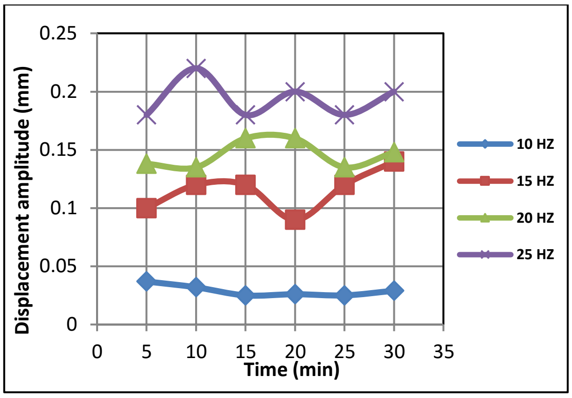


(b)

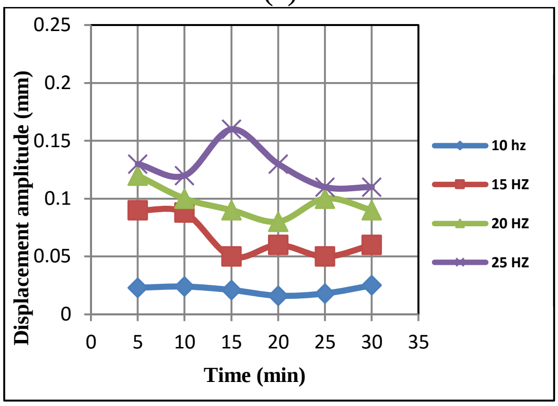
Fig 8. Variation acceleration with time for four values of frequency at single solid steel pile (L/D) 27 (a) Dry state (b) Soak state

4.3 Displacement amplitude

In Figure (9) shows the relationship between the magnitude of displacement amplitude in dry and soak state with time for solid steel pile (L/D) 27 and different frequencies10,15,20 and 25 Hz. The magnitude of displacement amplitude increases when increase the frequency of source, so that magnitude of displacement amplitude at frequency 25 is larger than other values. In soak state the magnitude of displacement amplitude decreases than magnitude in dry state because the present water lead to acting the energy of vibration.



(a)



(b)

Fig 9. Variation displacement amplitude with time for four values of frequency at single solid steel pile (L/D) 27 (a) Dry state (b) Soak state

5. Conclusions

1. The velocity value decreases in the soak state compared to the equivalent value in the dry state.
2. The velocity value increases with increase the frequency of source for same slenderness ration of pile (L/D) 27. The reduction in the value of velocity vibration of pile at soak state compared to the dry state at frequencies of 10 ,15, 20 and 25 HZ is 16.7 ,21.69 ,15.15 and 27.8 % respectively. When the frequency decreases from 25 to 10 at dry and soak state the value of velocity vibration decreased by 97, 96.15% respectively.
3. The acceleration value at dry state is greater than its value at soak state.
4. The acceleration values. of single solid steel pile which L/D 27. decreases when the operation frequency of vibration source decreased. The reduction in the acceleration value at soak state compared to the dry state at frequencies 10, 15, 20 and 25 HZ is

23,31.43 ,18.1 and 38.46% respectively. The acceleration value decreases when the operation frequency of vibration source decreased from 25 to 10 in dry and soak state by 98 and 97.8%. respectively.

5. The value of amplitude at soak state is lower than its value at dry state.
6. The amplitude value of single solid steel pile which L/D 27 decreases when the operation frequency of vibration source decreased. The amplitude value at soak state decreases compared to the dry state at frequencies 10, 15, 20 and 25 HZ is 22.8 ,40, 41.7 and 31.81% respectively. The reduction in the amplitude value when the operation frequency of vibration source decreased from 25 to 10 in dry and soak state is 84.1and 80% respectively.

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