Civil and Environmental Research
ISSN 2222-1719 (Paper) ISSN 2222-2863 (Online)
Vol 2, No.3, 2012

www.iiste.org

Influence of Material Variability on the Seismic Response of Pile Foundation

Satarupa Sengupta*, Dr. Sima Ghosh
Civil Engg. Department, National Institute of Technology.
Agartala, PIN – 799055, E-mail ID: satarupas@yahoo.com

Abstract

Pile foundation response during earthquakes is strongly affected by the type of material used in pile construction. In the present study three different types of materials viz. concrete, wood and bamboo are used to construct pile foundation. Specimens of clean sand and clay soil are used to prepare the soil for test and the physical properties of that soil are evaluated. Next, earthquake response analyses are conducted to clarify the effect of the nonlinear soil-pile foundation system on the performance of pile foundation. The input shaking included sinusoidal earthquake accelerations. Pile displacement, acceleration, strain and earth pressure are found out using PULSE and MICRON software. Performance evaluation of the pile foundation is discussed on the basis of pile curvature.

Keywords: Soil-pile interaction, pile material, shake table test, curvature, PULSE, MICRON.

1. INTRODUCTION

Use of piles to resist earthquake loading has attracted a lot of attention from geotechnical engineers in the past decade. However, the response of a laterally loaded pile is a complicated soil–structure interaction problem. Many researchers have given their fruitful solutions in this field. Using two forms of varying modulus with depth, Matlock and Reese (1960) had given a generalized iterative solution for rigid and flexible piles subjected to lateral loads. For short piles, based on earth pressure theory, Hansen (1961) had developed the method to estimate the ultimate lateral resistance of rigid piles. For layered soil system, using different constant modulii of subgrade reaction, Davisson and Gill (1963) studied the case of a laterally loaded pile. Using earth pressure theory, Broms (1964a, b) proposed the solutions for pile deflections for both short and long piles. Broms (1964a, b) method for computing ground surface deflections of rigid and flexible, with fixed and free head piles was based on Terzaghi's (1955) modulus of subgrade reaction approach. Generalized solutions for laterally loaded pile in elasto-plastic soil have been proposed by Reddy and Valsangkar (1970). An elasto-platic model was used by Madhav et al. (1971) for obtaining the response of laterally loaded piles. Meyerhof and Ranjan (1972) conducted model tests on rigid single pile and pile groups under central inclined loads in homogeneous sand and developed a semi-empirical interaction relationship assuming elliptical variation of ultimate capacity under axial to lateral load.

A lot of experimental works has been done to evaluate the behavior of pile foundation. T.S. Ueng(2010) conducted a study on pile foundation with aluminum and steel pipe and evaluated the pore water pressure and settlement behavior. Similar studies for the comparison of the behavior of pile foundation made up of different material are really scarce. An attempt is made in this paper to study the effect of different pile material.

2. SAND SPECIMEN

The backfilling material was collected from local side and it was spread over the floor for air drying. That air dried sample was first sieved through 1.18mm sieve and then 70% 0f the sample was mixed with 30% pure sand sieved through 1.18mm sieve used in the experiments for backfilling. The grain shape of sample is mainly granular. The sample contains a wide range of fines. The representative grain size distribution is shown in the Fig.1. The specific gravity of the soil sample is 2.73. Liquid limit of the sample is 30.5, plastic limit is 25.03 and the shrinkage limit is 16.51. Cohesion 1.76 kg/cm2 and angle of friction is 31 and the density of soil in the soil box lies between 12.8-17.2 KN/m3.

3. MODEL PILES

The model piles were made of concrete, wood and timber, having 25 cm length, with diameter of 4 cm (Fig.2.).

Concrete pile. The concrete pile was of strength M25. For mix design sand confirming grading zone IV and coarse aggregate of 10 mm nominal size is used.

Wooden pile. The density of wooden pile is 0.432 gm/cm^3.

Bamboo pile. The density of bamboo pile is 0.895 gm/cm3. Water absorption of bamboo is 103.85%.It is a hollow pile and thickness of the pile is 5 mm.

Table.1. is showing the properties of different pile foundation.

4. INSTRUMENTATION

1.0m ×1.0 m square plate of thickness 10 mm steel plate is fitted with symmetrically placed 4 (four) numbers ball bearings below the plate in such a way that the plate can run through the base channels which are firmly fixed with the foundation through nuts and bolts. The surfaces of the base channel are made smooth. One end of the crank shaft is fitted with the shake table and the other end is fitted with reciprocating shaft. The reciprocating shaft with the help of slotted disk is fitted with 7.5 H.P. reciprocating motor. A 12 mm thick Perspex box of size 80 cm x 58 cm x 45 cm (l x b x h) is prepared to conduct the test on model retaining wall using that shake table. For uniform filling of the soil in the Perspex box, a hopper system is also prepared. Strain gauges and accelerometers were placed at different locations top, middle and bottom respectively to measure bending strains, accelerations and displacement response at top, middle and bottom along the pile (Fig.3). The pile was placed above 5 cm soil bed. The overall depth of soil was 30 cm. Earth pressure cells are placed at a distance of 15cm from the pile foundation at the top, middle and bottom of soil depth. The model pile inside the soil sample was shaken with the frequency of 0.5 Hz, 1 Hz, 2 Hz and 3 Hz.

5. SHAKING TABLE TESTS

At first a layer of 5 cm soil is laid in the soil box. Backfilling operation was conducted by raining method by using sand pouring container in order to obtain a backfill of uniform density. Then the pile is kept in the box and again soil up to a depth of 25 cm i.e. up to the height of pile is laid (Fig.4). A series of shake table tests were performed to observe the strain, earth pressure generations and deflection characteristics of different pile foundations (Fig.5). Fig.6 is showing the variation of displacement in time and frequency domain by PULSE software and Fig.7 is showing the variation of strain with time by MICRON software.

6. TEST OBSERVATIONS

i. Fig.8. is showing the variation of concrete pile displacement with depth of pile for various frequencies. At 0.5 Hz and 1 Hz frequency, the values of displacement at the top of concrete pile are 11.64 and 11.89 mm respectively. At the middle of the pile the value of displacement is more or less same for 2 and 3 Hz frequency.

ii. Fig.9. is showing the variation of wooden pile displacement with depth of pile for various frequencies. At 0.5 and 1 Hz frequency at the bottom of wooden pile the values of displacement are 9.636 and 11.394 mm respectively.

iii. Fig.10. is showing the variation of bamboo pile displacement with depth of pile for various frequencies. At 1 and 2 Hz frequency at the middle of bamboo pile the values of displacement are 12.604 and 14.856 mm.

7. COMPARISON

i. Fig.11. shows the variation of displacement of different pile foundation at pile top, middle and bottom at 0.5 Hz frequency. At the top of concrete, wooden and bamboo pile the value of displacement are 11.636, 12.689 and 15.313 mm respectively. Displacement is the lowest for concrete pile, it acquires the highest value for bamboo and the wooden pile obtains the intermediate value.

ii. Fig.12. shows the variation of displacement of different pile foundation at pile top, middle and bottom at 1 Hz frequency. At the middle of concrete, wooden and bamboo pile the value of displacement are 10.208, 11.685 and 12.604 mm respectively.

iii. Fig.13. shows the variation of displacement of different pile foundation at pile top, middle and bottom at 2 Hz frequency. At the bottom of concrete, wooden and bamboo pile the value of displacement are 12.89, 13.213 and 14.137 mm respectively.

iv. Fig.14. shows the variation of displacement of different pile foundation at pile top, middle and bottom at 3 Hz frequency.

8. CONCLUSION

Based on the observed data during the tests on a single pile, and the results of analysis, the following conclusions may be made.

i. The displacement at the top of different piles is the highest and it gradually decreases towards their bottom.

ii. The values of displacement increases with the increase in the frequency of shaking.
iii. For a constant value of frequency the displacement is the lowest for concrete pile and then it acquires higher value for wooden pile and lastly the bamboo pile.

9. REFERENCES

[1] Broms, B. (1964a).The Lateral Resistance of piles in cohesive soils. Journal of Soil Mechanics and Foundation Division, ASCE, 90 (SM2), 27-63.
[2] Broms, B. (1964b).The lateral resistance of piles in cohesive soils Journal of Soil Mechanics and Foundation Division,ASCE, 90 (SM3), 123-56.
[3] Davisson, M.T. and Gill, H.L. (1963). Laterally loaded piles in a layered soil system. Journal of Soil Mechanics and Foundation Engineering, ASCE, 89(3), pp 63-94.
[4] Hansen, J.B. (1961). The ultimate resistance of rigid piles against transversal forces. Danish Geotechnical Institute, Bulletin no.12, Copenhagen, 5-9.
[5] Madhav, M.R., Rao, N.S.V.K., and Madhavan, K. (1971). Laterally loaded piles in elasto-plastic soil. Soils and Foundations, 11(2), 1-15.
[6] Matlock, H. and Reese, L. C. (1960). Generalized solutions for laterally loaded piles. Journal of Soil Mechanics and Foundations Division, ASCE, 86, 63-91.
[7] Ueng, T.S. (2010). Shaking Table Tests for Studies of Soil Liquefaction and Soil-Pile Interaction. Geotechnical Engineering Journal of the SEAGS &AGSSEA Vol 41 No.1 March 2010 ISSN 0046-5828.

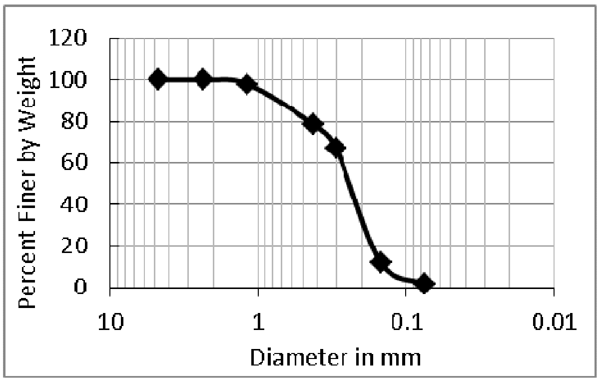


Figure.1. Grain Size Distribution of Sample

Figure.2. Pictorial View Concrete, Wooden and Bamboo pile

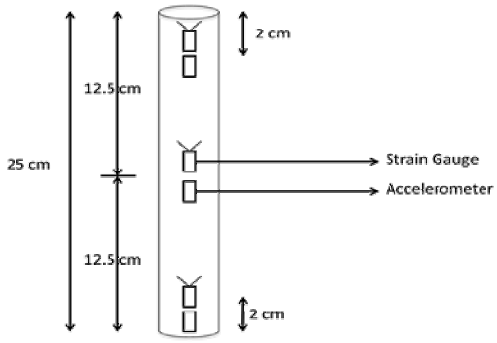


Figure.3. Placement of Strain Gauge and Accelerometer

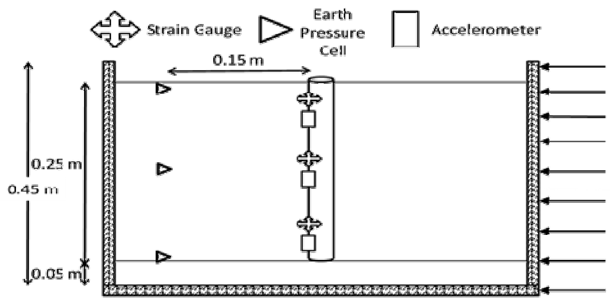


Figure.4. Outline of Test Setup

Figure.5. Pictorial View of Pile Foundation during Test

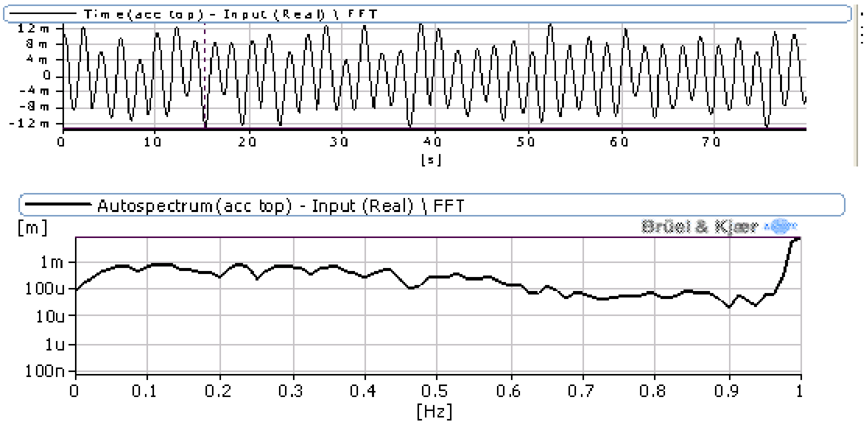


Figure.6. Displacement Graphs in Time and Frequency Domains

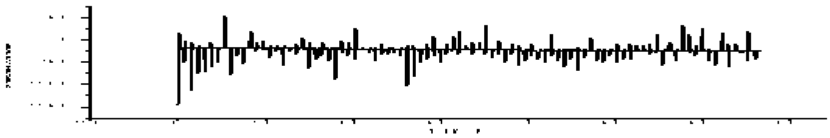


Figure.7. Variation of Bending Strain With Respect to Time

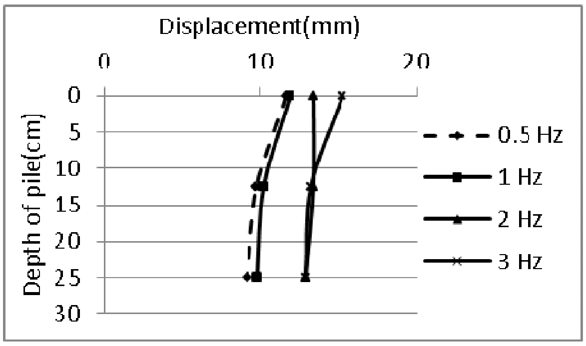


Figure.8.Displacement of Concrete Pile for Various Frequencies.

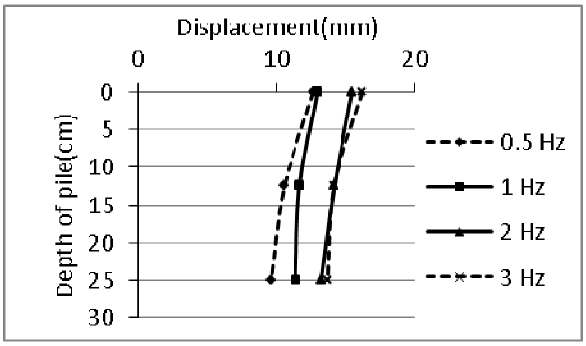
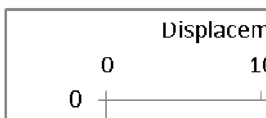


Figure.9.Displacement of Wooden Pile for Various Frequencies



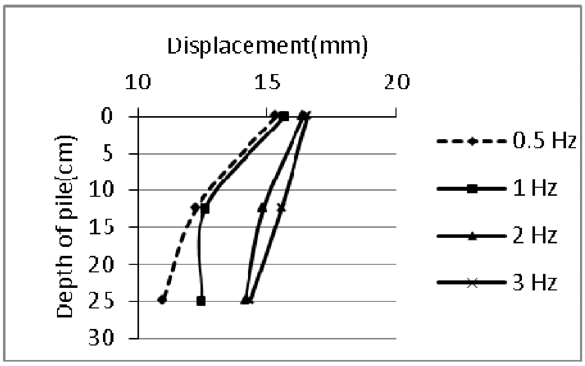


Figure.10.Displacement of Bamboo Pile for Various Frequencies

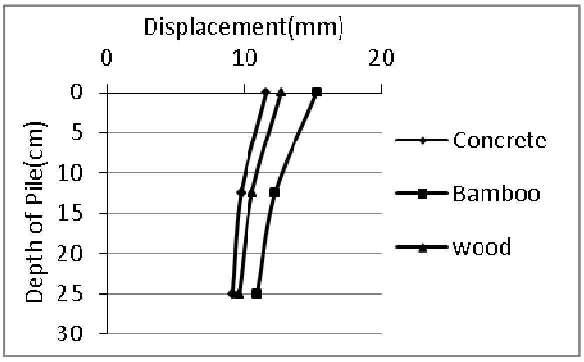


Figure.11.Variation of displacement of different pile at 0.5 Hz

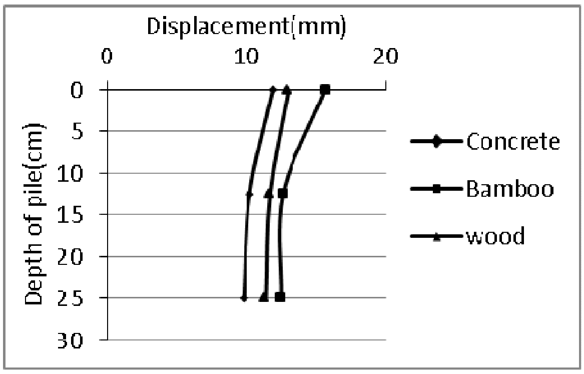


Figure.12.Variation of displacement of different pile at 1 Hz

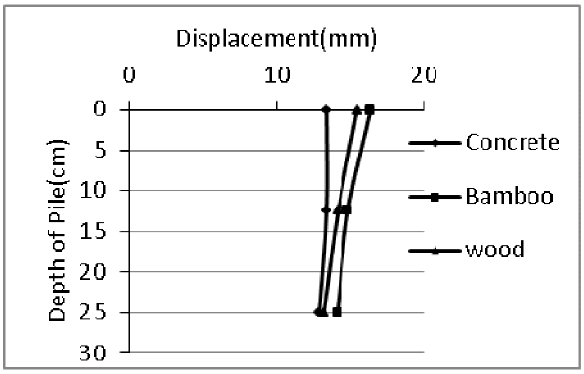


Figure.13.Variation of displacement of different pile at 2 Hz

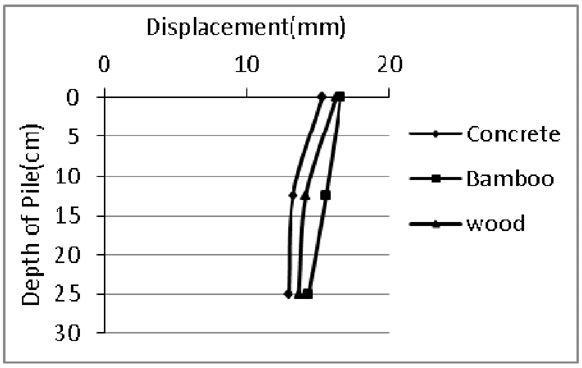


Figure.14.Variation of displacement of different pile at 3 Hz

Table.1. Properties of Pile Foundation

Pile Material	**Concrete Pile**	**Wooden Pile**	**Bamboo Pile**
Shape	Circular	Circular	Circular
Cross Section	Solid	Solid	Hollow
Diameter(cm)	4	4	4
Length(cm)	25	25	25