COMPARISON STUDY ON SHAKING TABLE TESTS OF SSI SYSTEM WITH DIFFERENT PILE LENGTH IN LIQUEFIABLE SITE

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Introduction

Shaking table model tests on SSI system considering soil liquefaction were carried out in State Key Laboratory of Disaster Reduction in Civil Engineering at Tongji University. Through the comparative study of SSI system tests with longer pile (PS10L test) and shorter pile (PS10S test), the interaction laws between different pile length are discussed in this study.

Shaking Table Model Tests

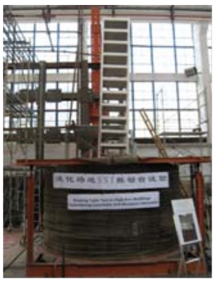

Fig.1 Photo of test

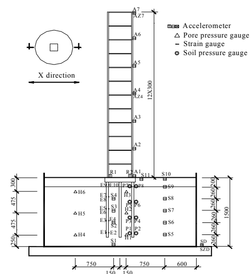

Fig.2 Sketch of the measuring points arrangement

Similitude factors of all physical quantities were induced from Bockingham π theorem. Non-gravity model with similitude rules controlled materials was adopted. A 12-story cast-in-place R.C. frame was used as prototype superstructure. The scale of models was 1/10. The similitude factor of mass density was 1, and the similitude factor of elasticity modulus for structure was 1/2.668. To reduce the boundary effect, a flexible container was designed for the model test. The cylindrical container was 3000 mm in diameter, and its lateral rubber membrane was 5 mm thick. Saturated sand covered by silt clay was used for the soil model. The top layer was silt clay, 0.2m in depth; while the bottom layer was sand, 1.30m in depth. For the foundation of the frame, 3 by 3 pile foundations with the length of 1.2m and 0.8m were used, respectively. The frame and the foundation were made of micro-concrete and fine zinc-coated steel bar.

Accelerometers, displacement meter and strain gauges were used to measure the dynamic response of the frame, foundation and soil. Pore pressure gauges were embedded in soil to measure the change of pore pressure. Pressure gauges were used to measure the contact pressure between piles and the surrounding soil. Fig.1 shows the photo of the test. Fig.2 shows the arrangement of measuring points of tests.

Ground shaking was simulated as unidirectional (x direction of the shaking table). The records selected for the study included El Centro wave (EL) and Shanghai Bedrock wave (SJ). From level 1 to level 5 the values for peak accelerations were, 0.131g, 0.375g, 0.75g, 1.125g and 1.5g, respectively. Before and after the altering of each acceleration level, the White Noise with small amplitude was input to observe the change of dynamic characteristics of the system. The time interval for the tests was 0.003266 s.

Results and Rules

Experimental Phenomena

Fig.3 Experimental phenomena

Obvious settlement and inclination of the frame occur in two tests. The inclination and settlement in PS10S test are larger than that in PS10L test.

Dynamic Characteristics

Under small excitation, the frequency of the system in PS10L test is larger than that in PS10S test, but under the latter stronger excitation, the degeneration of the system frequency in PS10L test is larger.

Tab. 1 Frequency and damping ratio of the soil and the system

Test	No.	Excitation code	Points on the soil surface		Points on the top of the frame	
			Freq. (Hz)	Damping ratio (%)	Freq. (Hz)	Damping ratio (%)
PS10L test	1	1WN	8.337	11.82	2.977	7.01
	4	4WN	8.337	11.62	2.977	8.08
	7	7WN	8.337	14.07	2.680	8.33
	10	10WN	7.741	10.50	2.084	9.10
	13	13WN	4.764	17.52	1.786	16.53
	16	16WN	5.657	20.18	1.786	11.19
PS10S test	1	1WN	7.443	12.97	2.680	10.16
	4	4WN	7.146	10.67	2.680	11.01
	7	7WN	7.443	13.64	2.382	10.14
	10	10WN	7.443	12.75	2.380	9.26
	13	13WN	6.550	18.74	2.382	8.45
	16	16WN	7.443	13.27	2.382	8.93

Amplification Factors of Acceleration

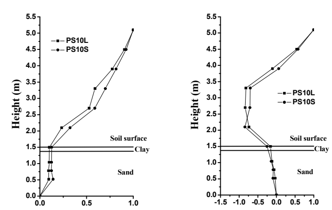

Fig.4 Mode shape curves of the model

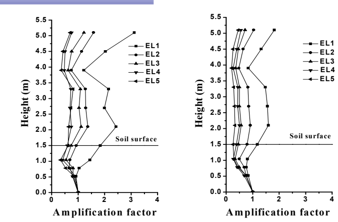

Fig.5 Amplification factors of the acceleration

There are obvious translation and rotation on the foundation. Distribution laws in two tests are similar, but the structural response of each story in PS10S test is smaller.

Pore Pressure Ratio

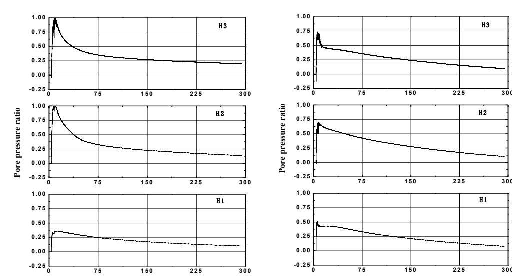

Fig. 6 Pore pressure ratio time histories of PS10L and PS10S tests under excitation of EL3

Pile Strain and Contact Pressure

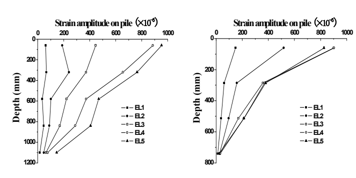

Fig. 7 Distribution of the strain under excitation of EL3

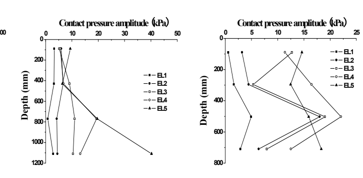

Fig. 8 Distribution of the contact pressure under excitation of EL3

Distribution of the strain is large at the top of piles and small at the tip. The strain in PS10S test is obviously larger than that in PS10L test at the same height. Distribution of the contact pressure on the interface is related to the amplitude of the input excitation.

Conclusions

(1) The inclination and settlement of the frame in PS10S test are larger while the crack on the pile in PS10L test is larger. (2) Under small excitation, the frequency of the system in PS10L test is larger than that in PS10S test, but under the latter stronger excitation, the degeneration of the system frequency in PS10L test is larger than that in PS10S test. (3) The acceleration, pore pressure ratio in the soil and strain response of the superstructure in PS10L test are larger than that in PS10S test, while the displacement is smaller than that in PS10S test. (4) Distribution of the strain is large at the top of piles and small at the tip. The strain in PS10S test is obviously larger than that in PS10L test at the same height. Distribution of the contact pressure on the interface in the tests is different and it is related to the amplitude of the input excitation.

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