Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

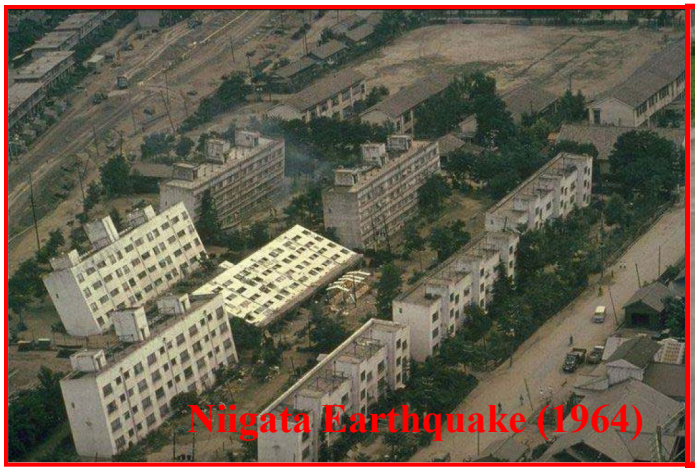
Responses of reinforced concrete pile group in two-layered liquefied soils: shake-table investigations

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Seismic Damage of Pile Foundations due to Sand Liquefaction

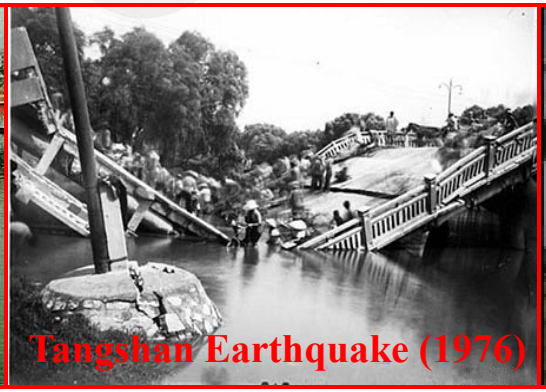






Sand liquefaction → Damage of pile foundations



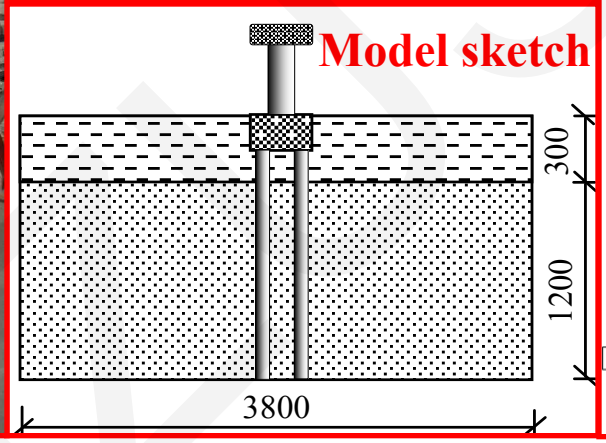


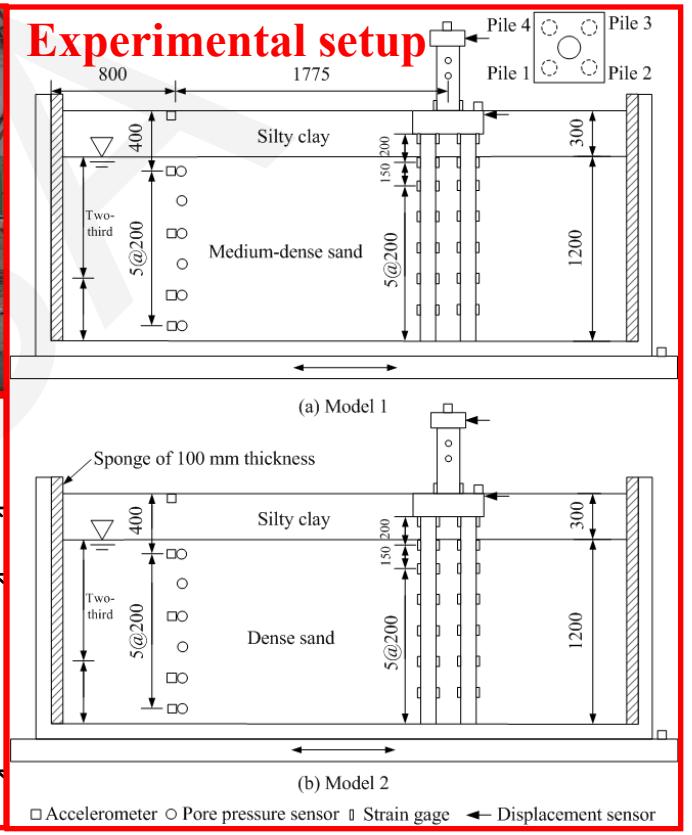


Shake-table Experiment



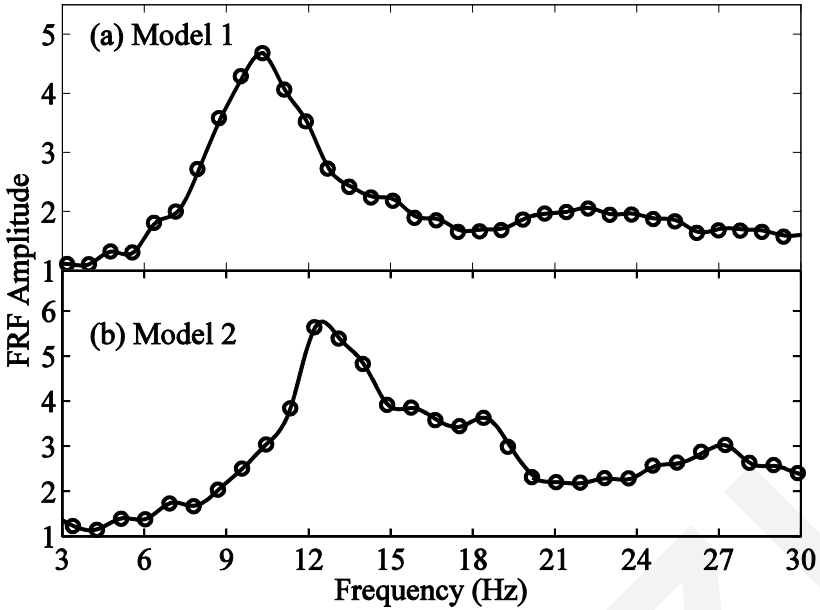






- **Sinusoidal base motion**
- **Measure the acceleration, excess pore pressure, displacement, and strain**

Assessment of Modal Parameters



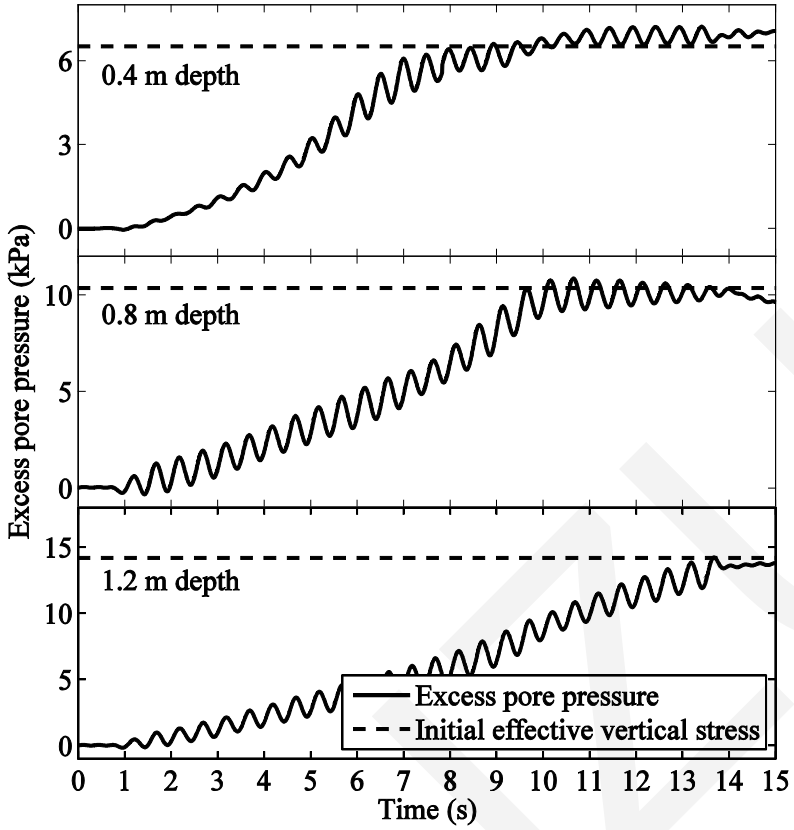
Frequency response function before liquefaction

Stage	Model 1		Model 2	
	Frequency (Hz)	Damping ratio	Frequency (Hz)	Damping ratio
Before liquefaction	10.2	0.178	12.5	0.172
Partial liquefaction*	7.7	0.214	9.4	0.206
Full liquefaction*	4.1	0.267	5.0	0.258

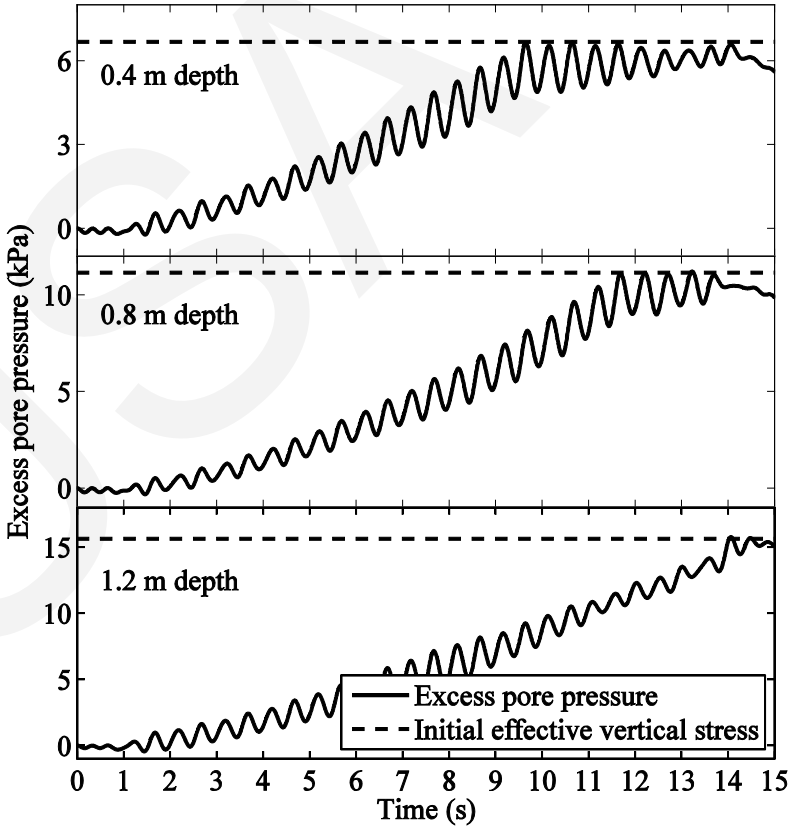
Frequency and damping ratio of pile-superstructure in different stages of liquefaction

- Natural frequency of the pile-superstructure was 10.2 Hz and 12.5 Hz for Models 1 and 2.
- Natural frequency reduced by 20-25% and 50-60%, and the damping ratio increased by 20% and 50% at partial and full liquefaction (Lombardi, 2014).

Comparison of Excess Pore Pressure



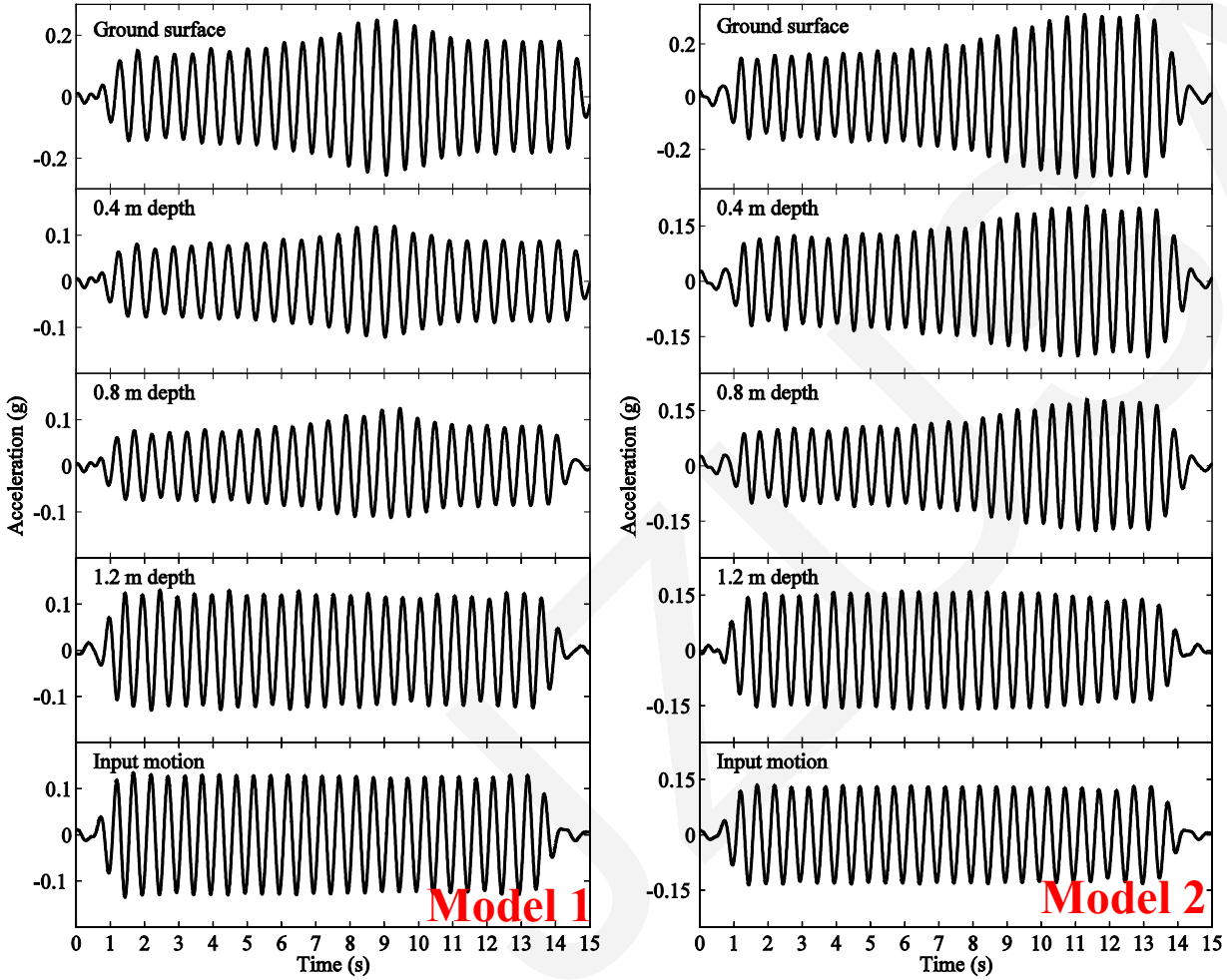
Model 1 with medium-dense



Model 2 with dense sand

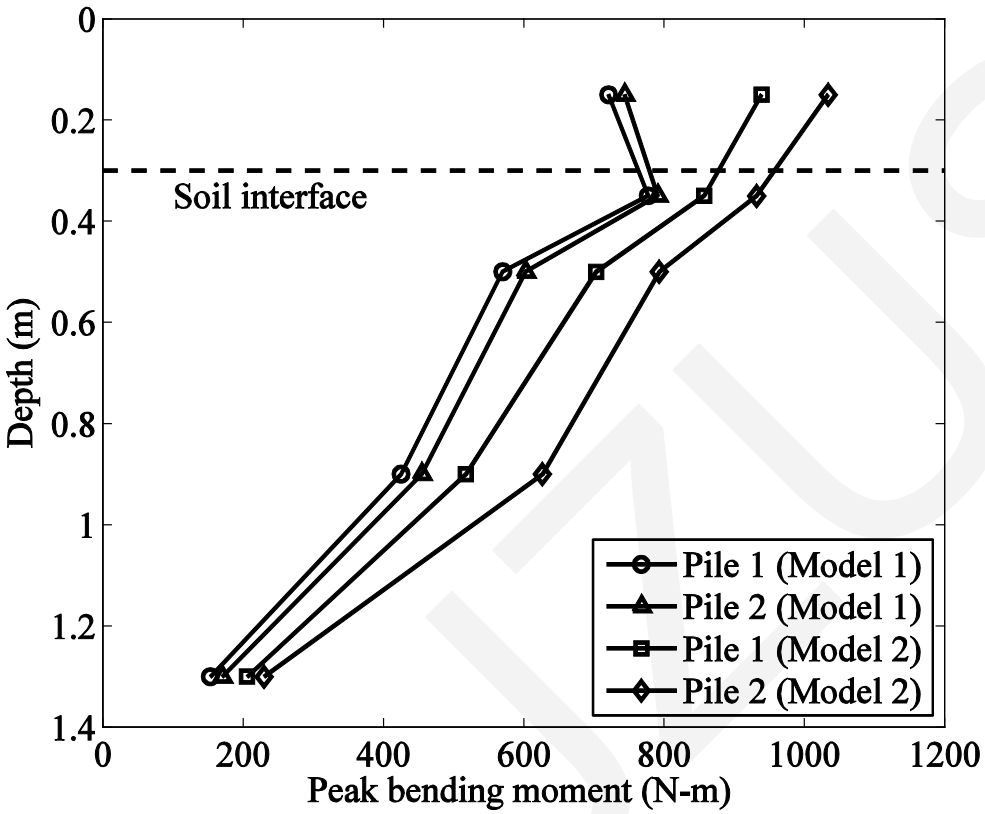
- Excess pore pressure buildup slightly lower in Model 2 than in Model 1

Comparison of Acceleration



- Acceleration exhibited the noticeable amplification effects on the base motion
- Strength and stiffness of the dense sand didn't weaken while sand was fully liquefied.

Comparison of Peak Bending Moment



- In liquefied medium-dense sand, the pile group effect on the pile bending moments may be negligible.
- In liquefied dense sand, the pile group effect is relatively significant and it noticeably affects the bending moment distributions on individual piles.

Conclusions

- It was important to consider the behavior of the ground, when evaluating the superstructure response in liquefied medium-dense sand.
- There was an overall stiffer response of liquefied dense sand than liquefied medium-dense sand.
- Maximum pile bending moment appeared near the soil interface in liquefied medium-dense sand, and it occurred at the pile head in liquefied dense sand.
- The obvious pile group effect was observed in liquefied dense sand stratum, but it was insignificant in liquefied medium-dense sand stratum.

Related Paper

- Su, L., Tang, L., Ling, X. Z., Zhang, X. Y., Gao, X., & Liu, C. H. (2013). Numerical Study on Dynamic Behavior of Pile Group in Liquefiable Soils. In International Efforts in Lifeline Earthquake Engineering (pp. 624-631). ASCE.
- Tang, L., Maula, B. H., Ling, X., & Su, L. (2014). Numerical simulations of shake-table experiment for dynamic soil-pile-structure interaction in liquefiable soils. Earthquake Engineering and Engineering Vibration, 13(1), 171-180.

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