

Centrifuge investigation comparing the rocking response of two soil-structure systems

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ABSTRACT

In earthquake prone areas, stakeholders are asking for low damage systems that can be easily repaired, even following catastrophic earthquakes [1]. Seismic protection of structures by means of rocking isolation is becoming increasingly popular, since allowing uplift is an inexpensive way to reduce structural damage demand. However, understanding the role of soil–structure interaction in the response of rocking systems is important to define what type of rocking system might be most effective.

To address this challenge, a campaign based on centrifuge modelling and testing is currently ongoing. The primary objective is to assess the force demand that rocking systems experience during their motion, which results directly from the earthquake excitation and the characteristics of their excited rocking mechanisms.

Flexible structures that rock while stepping on discrete footings (structural rocking) and flexible structures with discrete footings rocking on soil (foundation rocking) are both considered. Following this distinction, two building models were designed with the only difference being the connectivity of the columns to the footings. For structural rocking, columns were designed to detach and step on their footings, while for foundation rocking the footing-column connection was designed to be rigid. The two building models were tested side-by-side in a centrifuge. A second test was also conducted, where thin steel “fuses” were installed in the interface of structural rocking, to study the allocation of energy dissipation between structural elements and fuses, and soil medium.

The building models rested on the surface of dense sand and then tested using sinusoidal ground motions. Overall, the responses of the different rocking systems were compared to each other, and the base isolation effect of each was quantified compared to the response of typical elastic oscillators. Larger rocking response was observed when the ground motion frequency was lower than the resonant frequency before uplift, enabling the so-called uplifted mode to be observed more readily. Ground motions at the initial resonant frequency caused, higher amplitude steady state rocking at the driving frequency. Results also include a direct comparison of the member forces, and clarify the role of the structural fuses, enabling general observations on the demand placed on the different types of rocking systems under the same excitation.

References

- [1] F. Marquis, J.J. Kim, K.J. Elwood, S.E. Chang, Understanding post-earthquake decisions on multi-storey concrete buildings in Christchurch, New Zealand, Bull. Earthq. Eng. (2015).