Centrifuge testing and computational modelling of buildings rocking on loose sand

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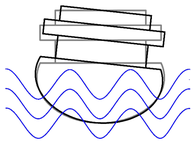
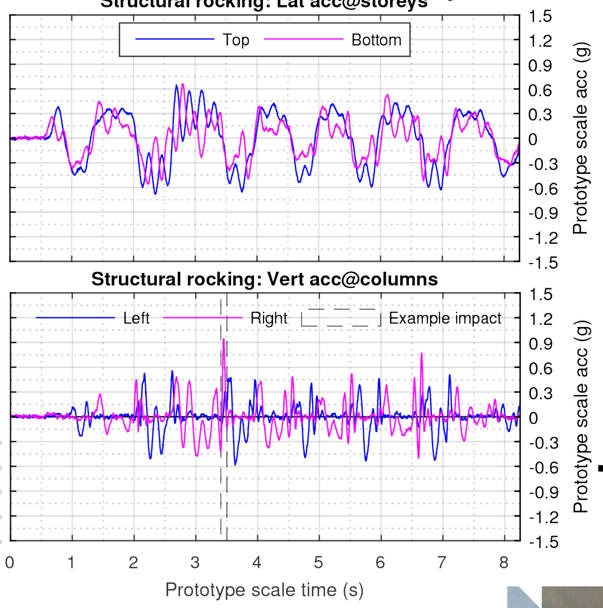
1. Introduction

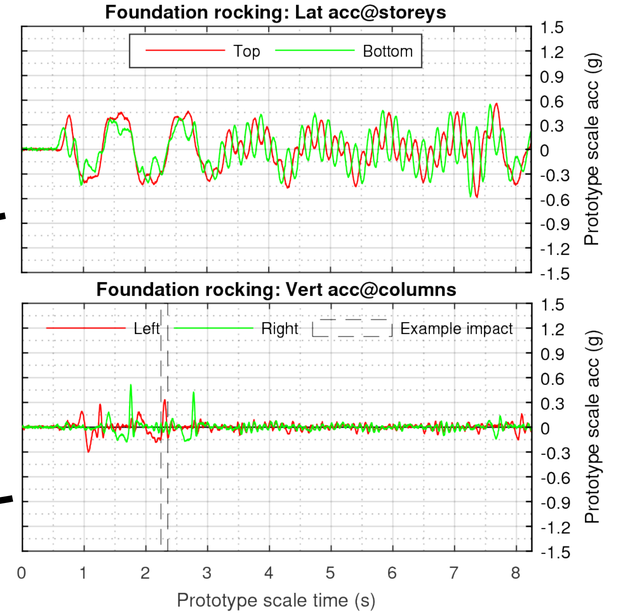


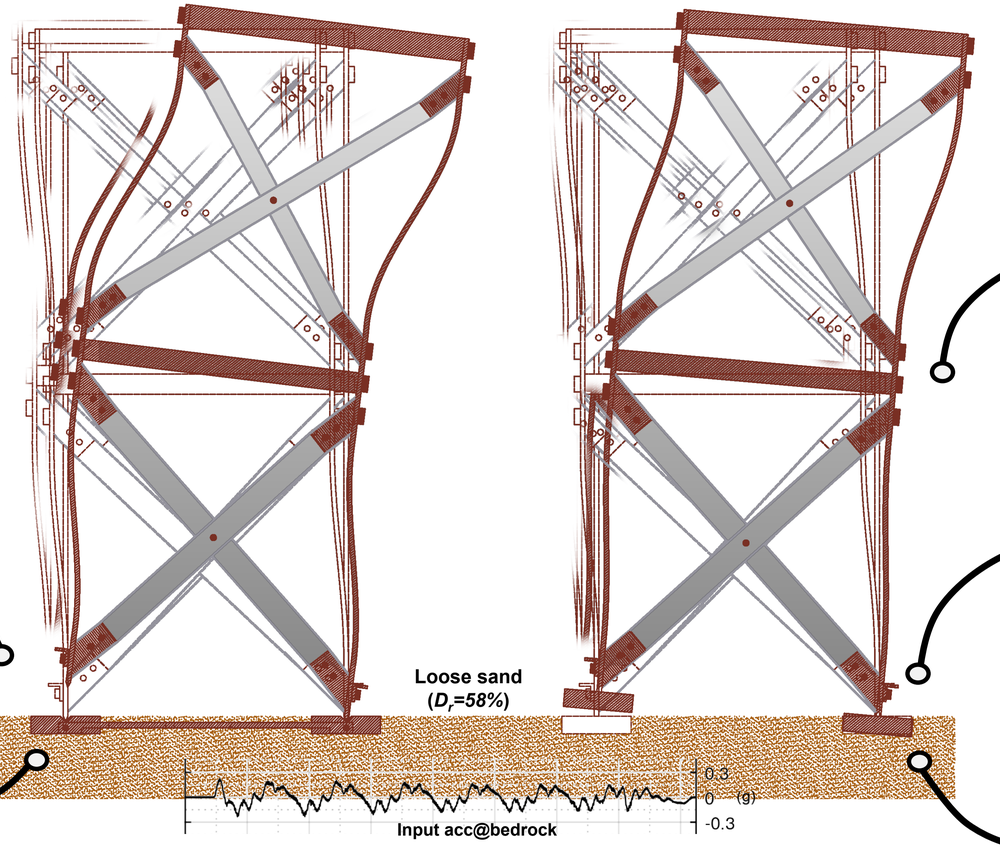
Earthquake Engineering is transitioning from ductile buildings with large foundations to rocking systems which essentially behave as floating vessels. This transition enables improved seismic performance and minimizes costs of repairing and disruption.

2. Experimental details

Two flexible building models, inspired by Housner's rocking rigid block [1] with discrete footings were designed for structural & foundation rocking. They represent 4-storey buildings with a period of 0.7s. Their excitation was a low frequency cyclic acceleration.





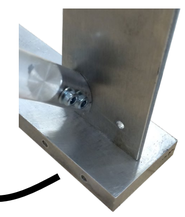


3. Structural rocking response

During shaking, impacts developed at the footing-column interface. They generated a strong rotational acceleration, causing excessive storey acceleration and force demand.

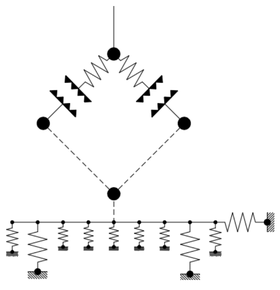
4. Foundation rocking response

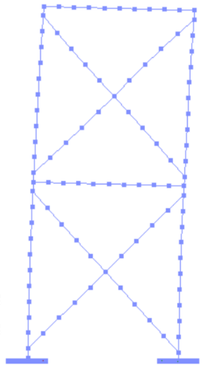
As the footing rotated on the soil, damping was activated leading to suppression of rocking. Marginally lower storey accelerations occurred after that.



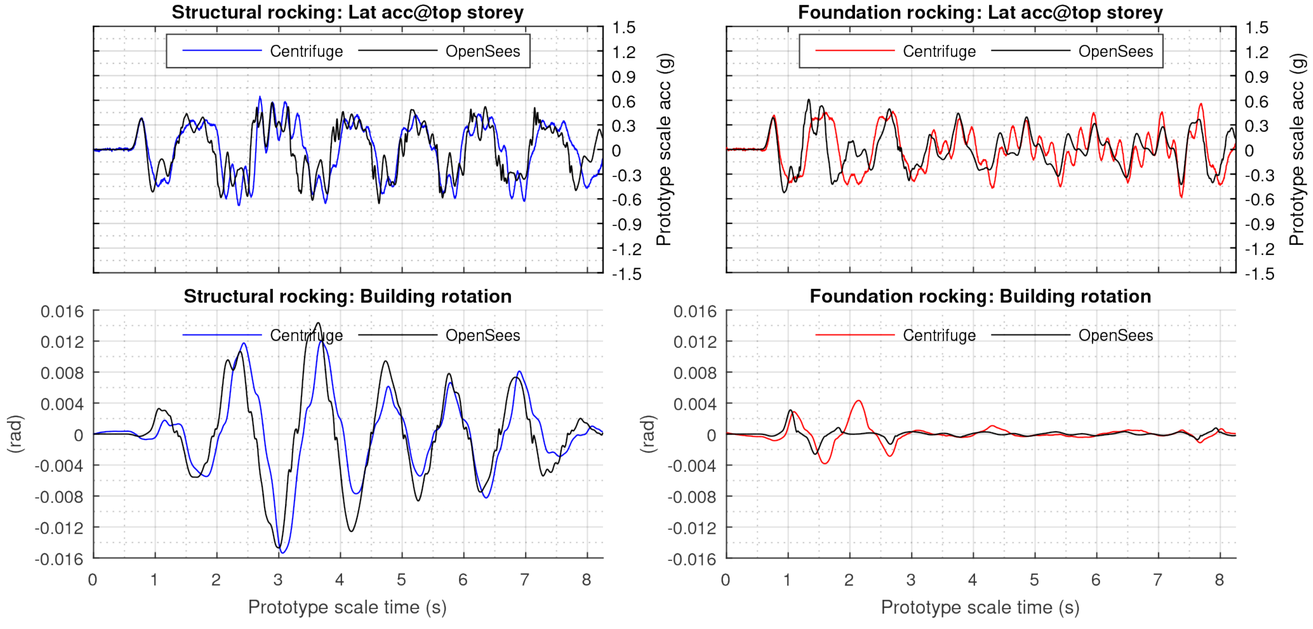
5. Rocking response with OpenSees

Inclined friction/gap elements were used for the contact interface in structural rocking. They were connected on a beam on non-linear Winkler foundation (BNWF, [2]). The BNWF is also used to simulate the uplift response of the footing directly for foundation rocking. In this case, more work is needed to capture the post-rocking response accurately.



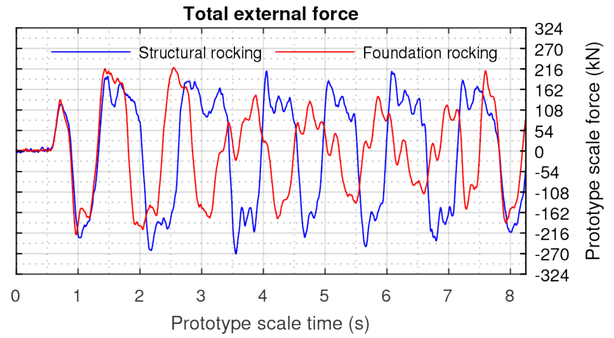


Inclined friction-gap elements on BNWF [2] and OpenSees finite element model



6. Conclusion

In structural rocking, soil cannot influence significantly the rocking amplitude. This can lead to additional excitation of a building. Consequently, the total external force in structural rocking can be larger than in foundation rocking.



References

[1] Housner, G.W., 1963. The behaviour of inverted pendulum structures during earthquakes.
[2] Raychowdhury P., Hutchinson T. C., Performance evaluation of a nonlinearWinkler-based shallow foundation model using centrifuge test results.

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