

# Soil-structure Interaction & Its Effects on Damped Structures

## experimental investigation in the centrifuge

### Background

- ❑ The effect of soil-structure interaction (SSI) on the response of structures is a heavily researched subject
- ❑ It is not clear how SSI affects the behaviour of buildings equipped with supplemental viscous dampers
- ❑ Experimental efforts on the subject have failed to consider ground flexibility and SSI



Fig.1 17-story steel structure in Taiwan equipped with 60 fluid viscous dampers (Taylor Devices India, 2016)

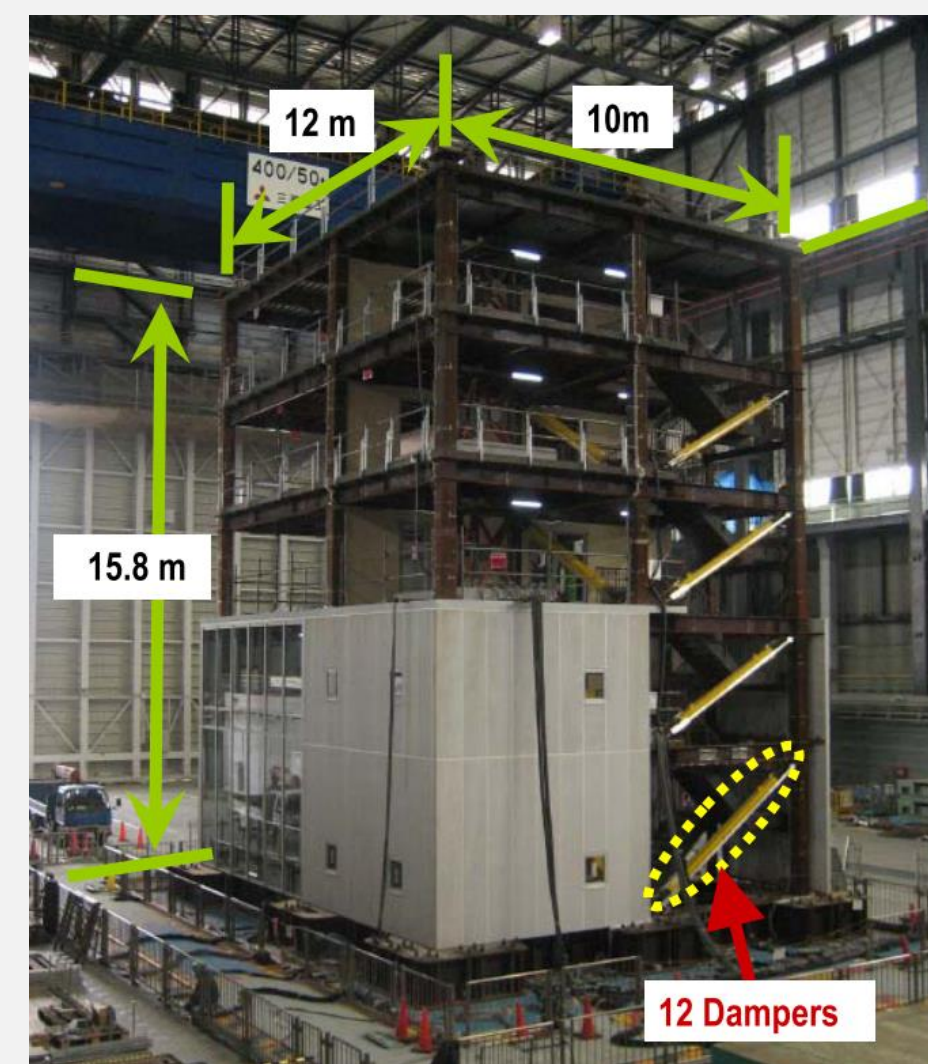


Fig.2 full-scale frame with viscous dampers erected on large shaking table, E-defence facility, Japan (Kasai et al. 2010)

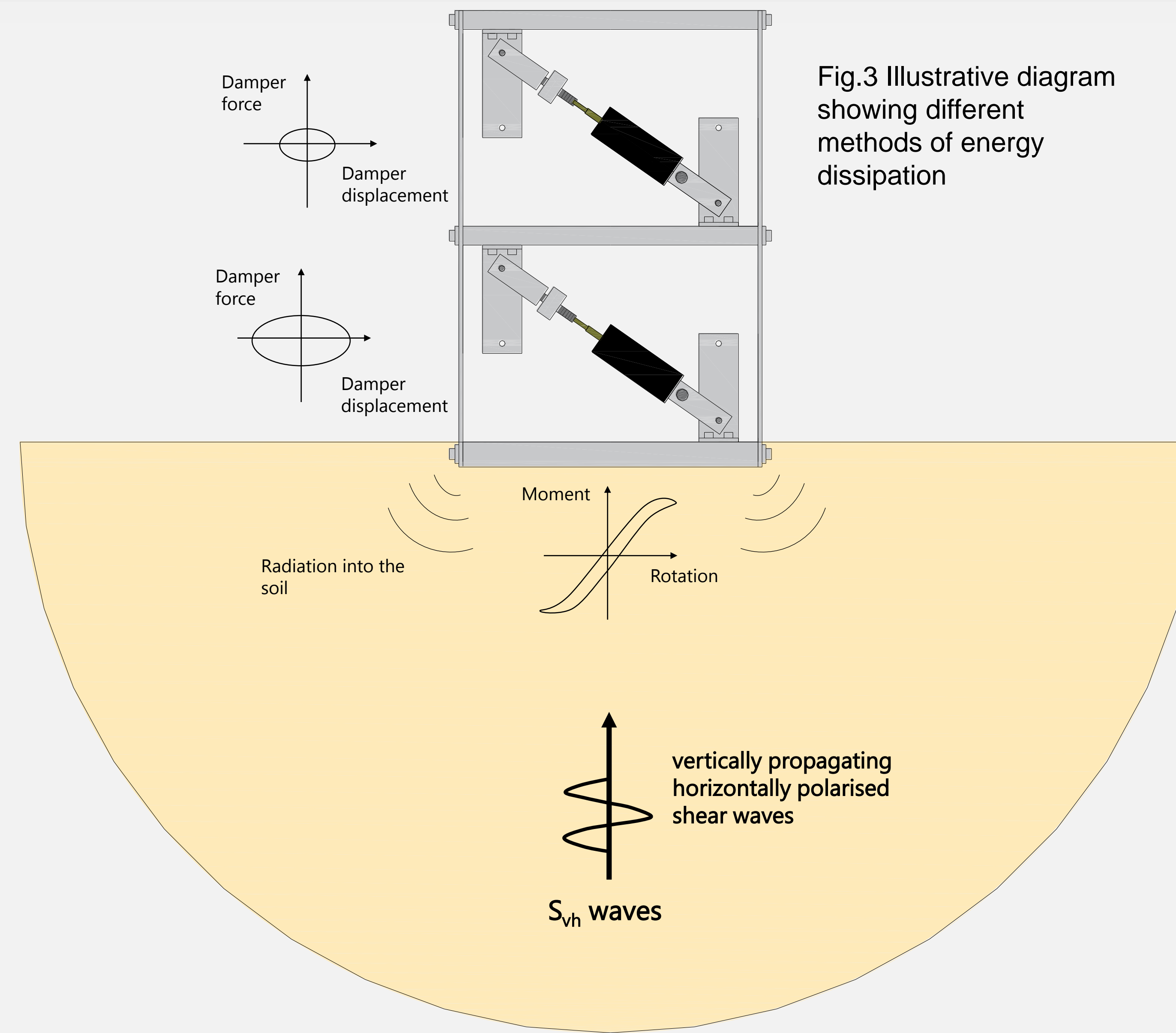


Fig.3 Illustrative diagram showing different methods of energy dissipation

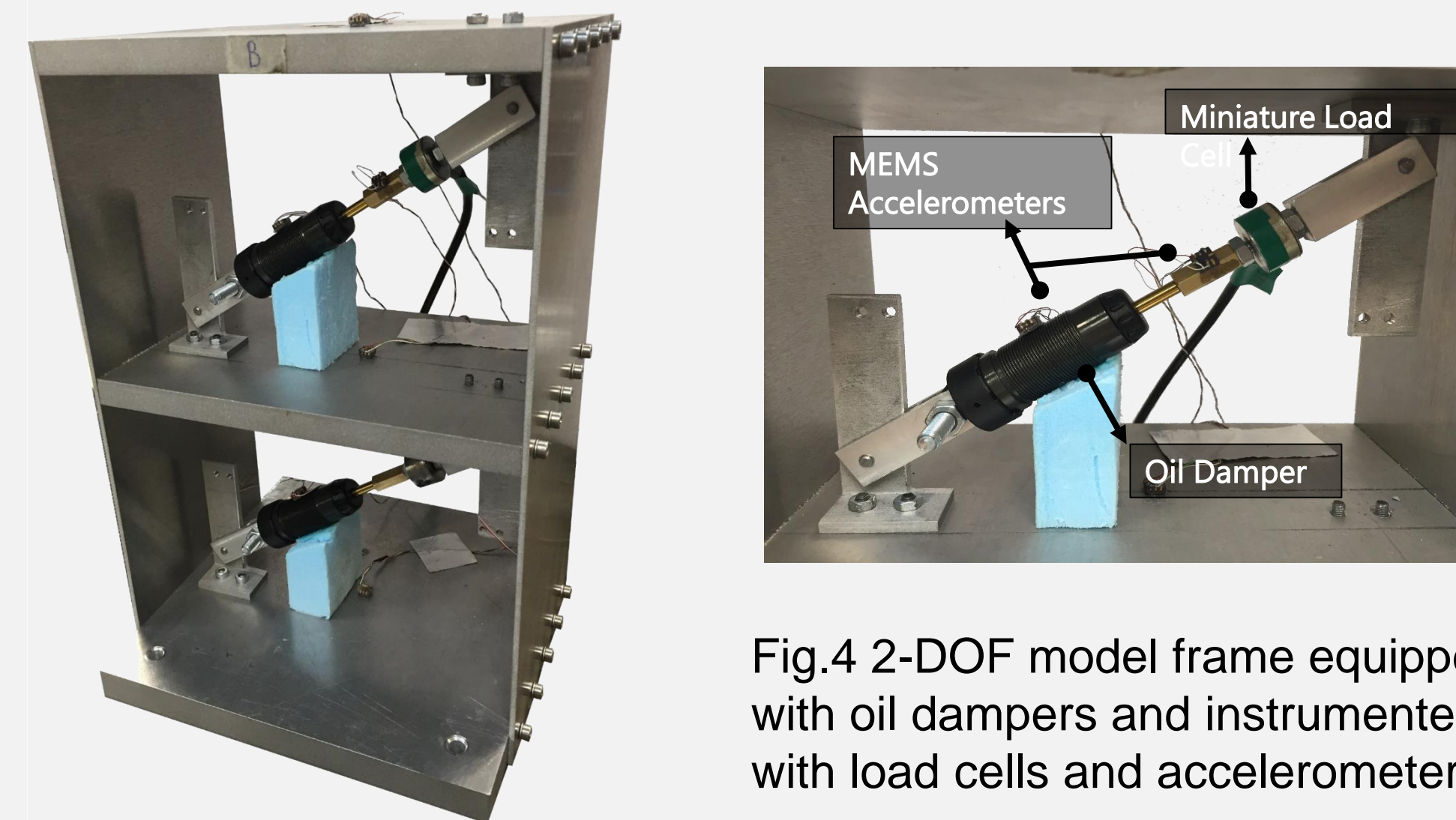


Fig.4 2-DOF model frame equipped with oil dampers and instrumented with load cells and accelerometers

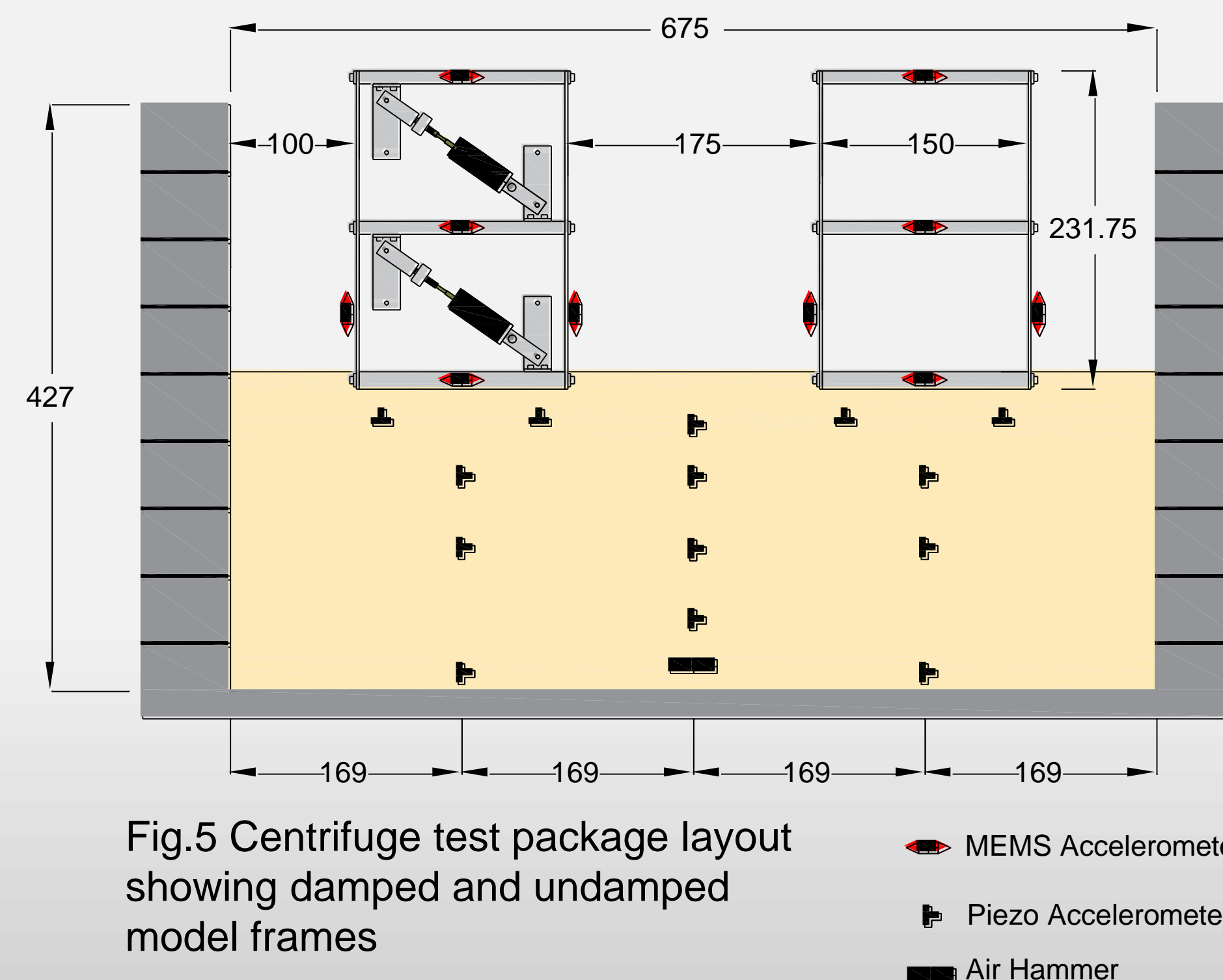


Fig.5 Centrifuge test package layout showing damped and undamped model frames

### Results

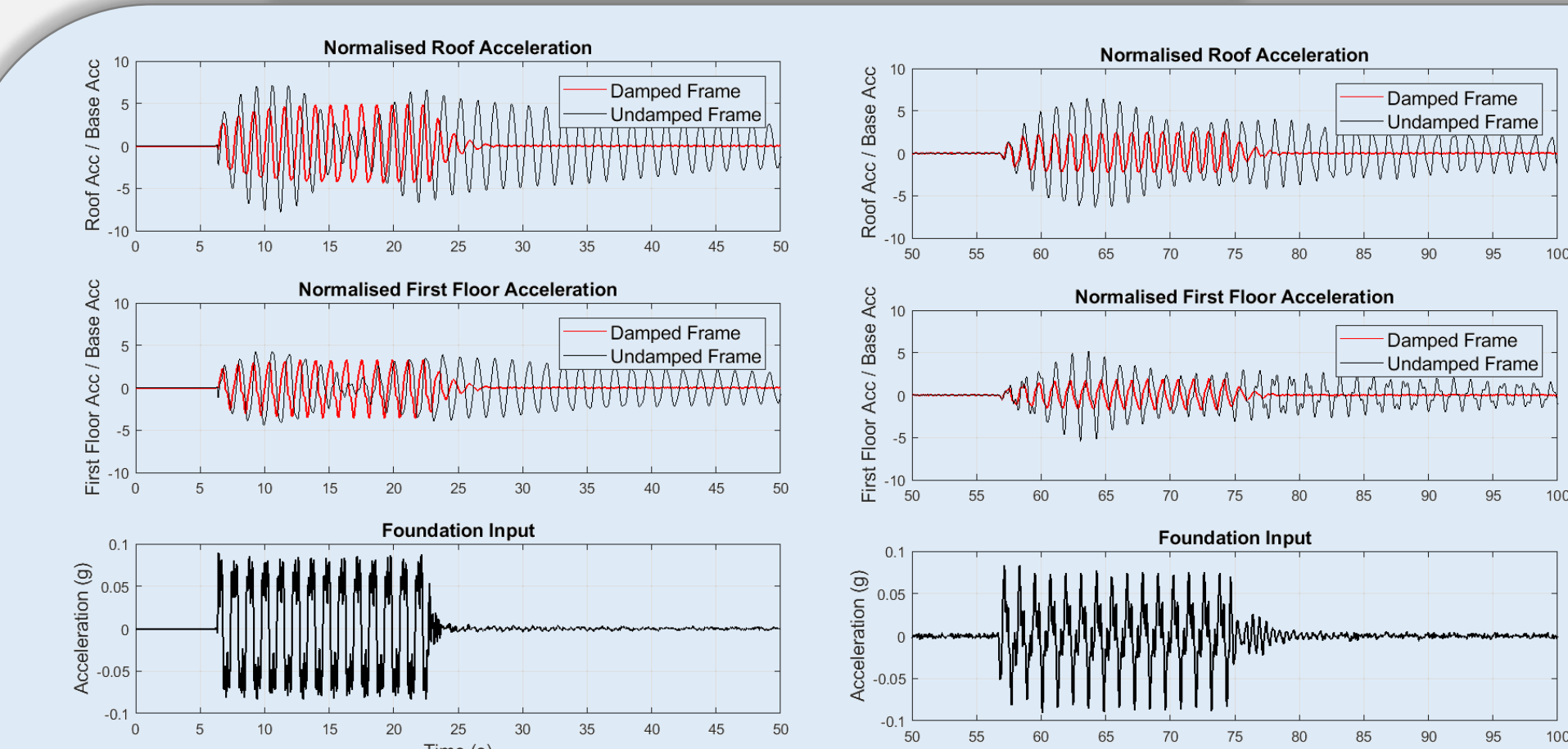


Fig.6 Comparing normalised roof and first floor accelerations for frames fixed at the base (left) and embedded in loose sand (right)

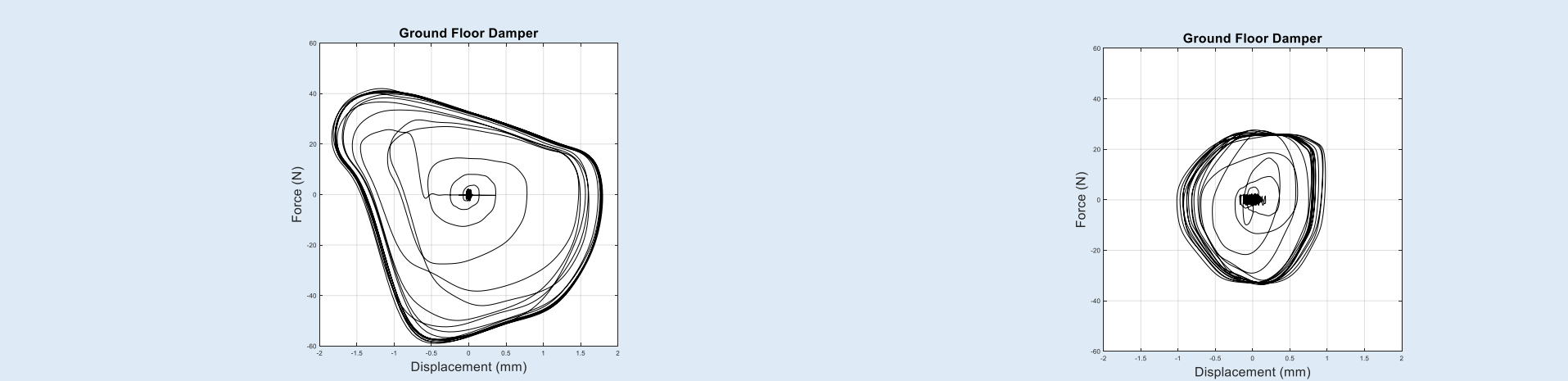


Fig.7 Ground floor damper force displacement loops for fixed base frame (left) and frame embedded in loose sand (right)

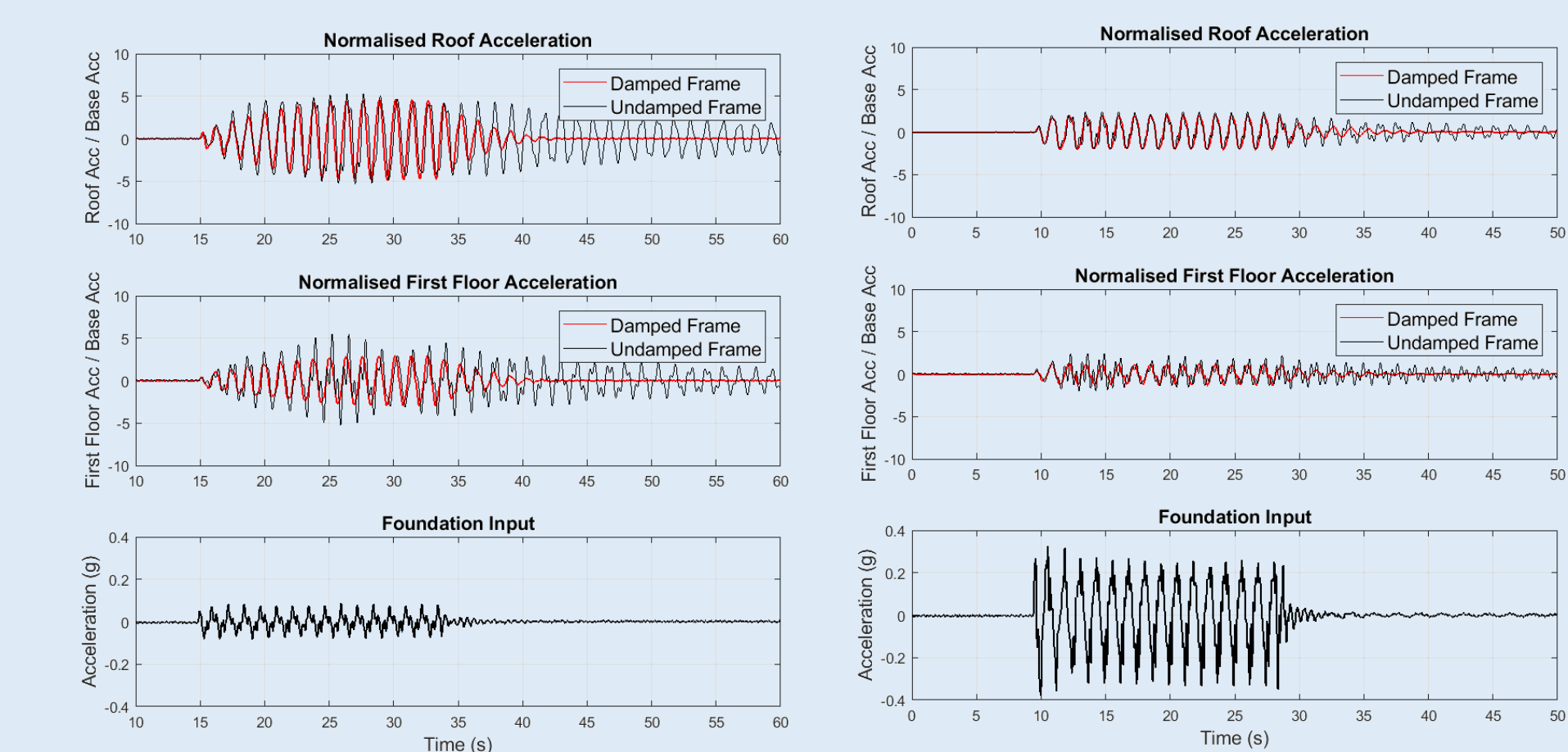


Fig.8 Comparing normalised roof and first floor accelerations of frames embedded in loose sand for moderate excitation (left) and strong excitation (right)

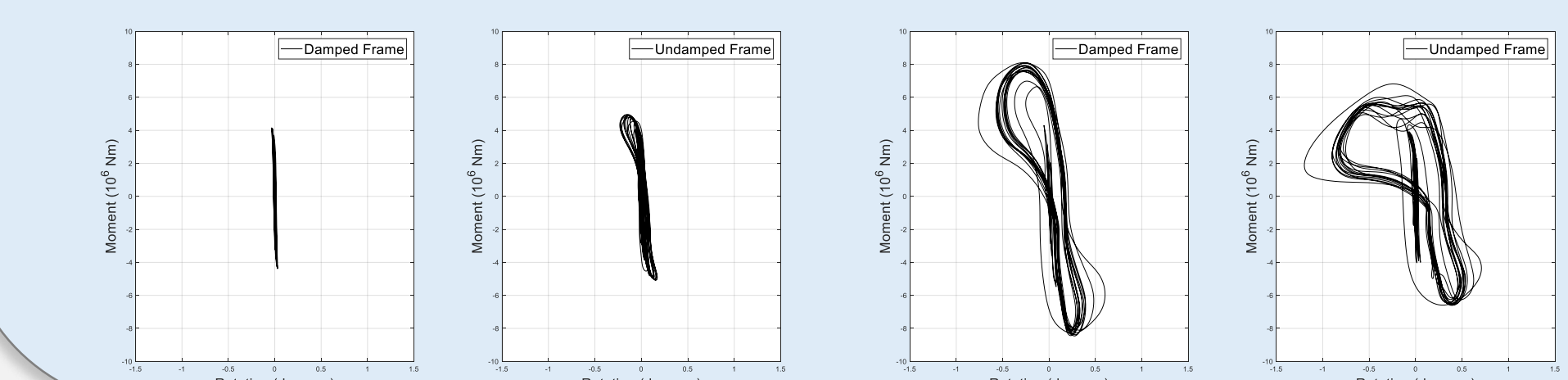


Fig.9 Moment-rotation hysteresis loops for base excitations of different magnitudes

### Energy Dissipation in SSI

- ❑ Total seismic input energy into the structure can be decomposed into:

$$E_I = E_k + E_s + E_h + E_d + E_{fd}$$

- ❑ Foundation soil damping and radiation damping due to inertial interaction of the structure with the supporting ground dissipates a component of the input energy
- ❑ Energy dissipation associated with SSI can reduce the energy transferred to the superstructure

### Research Framework

- ❑ Investigating dynamic SSI in the centrifuge to quantify deviation of damped building response from fixed base assumption
- ❑ Three control parameters will be varied (1) soil stiffness (2) structure aspect ratio (3) structure-to-soil stiffness ratio

### Observations

- ❑ Soil structure interaction modifies input to the dampers relative to the ideal case of a building fixed at its base
- ❑ The stronger the intensity of the base excitation, the greater the contribution of foundation soil damping, and the lower the contribution of the oil dampers

### Further work

- ❑ Investigate reduction in damper efficiency for building models of different aspect ratios and fundamental frequency
- ❑ Development of mass-spring-dashpot model capable of accounting for foundation soil damping as well as viscous damping in the superstructure