LAST HURDLES FOR IMPLEMENTATION OF ROCKING FOUNDATIONS FOR BRIDGES

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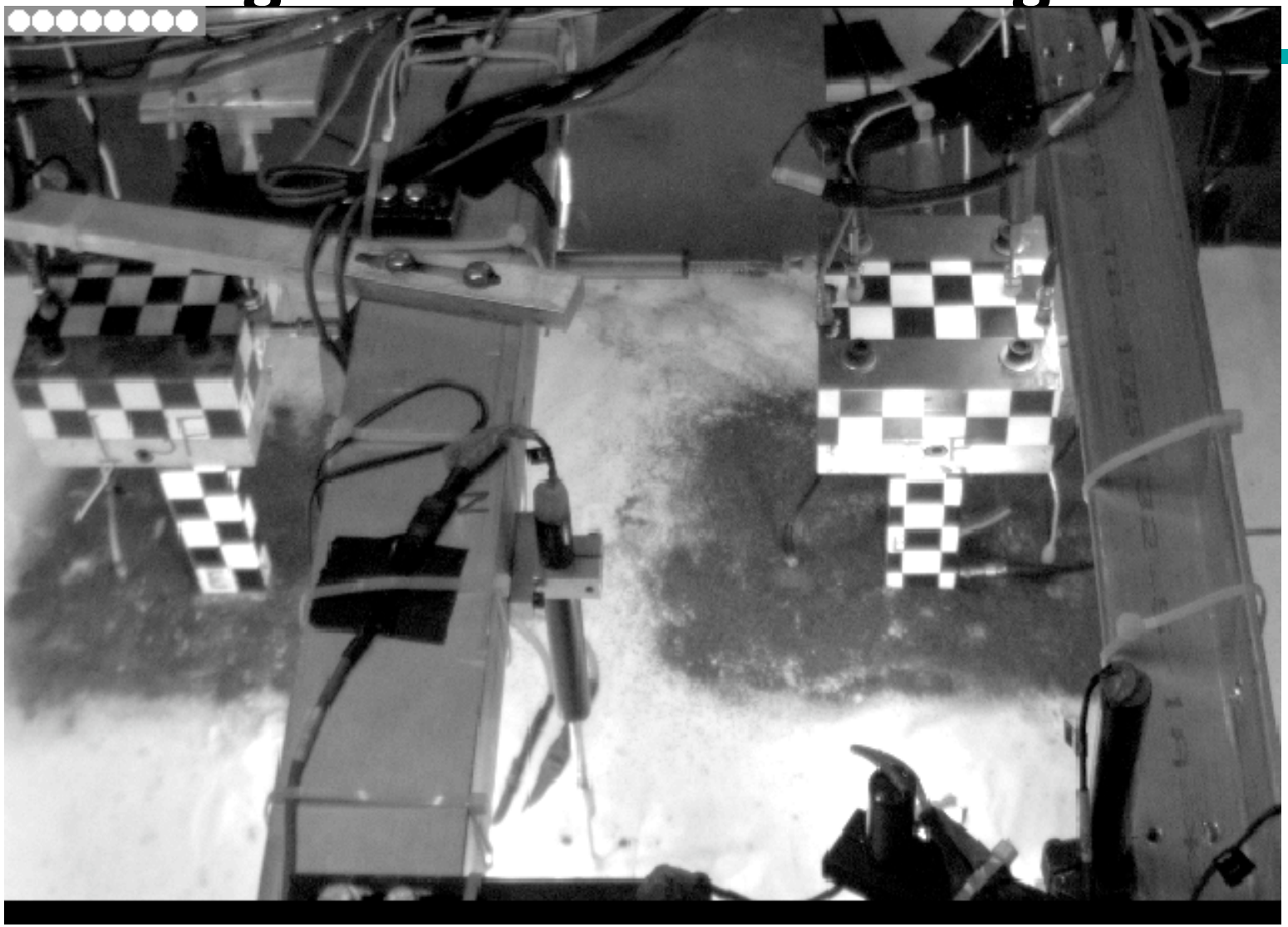
PEER TSRP coordination meeting

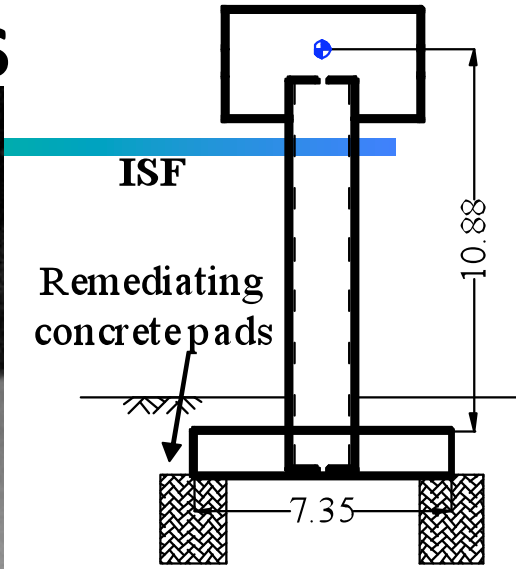
August 11, 2010

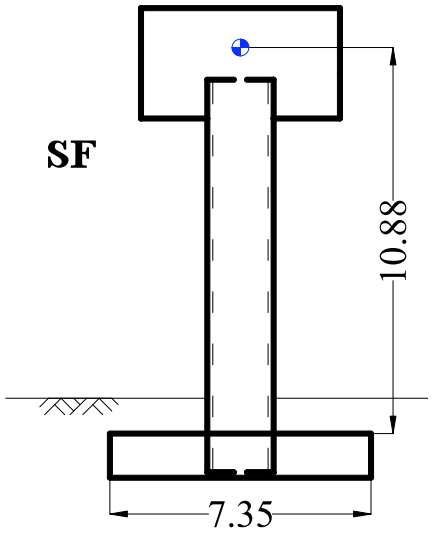
Outline of last hurdles project

- Background
  - Centrifuge model tests on collapse mechanisms
- Progress of project
- Test observations
- Ongoing & Future work
  - Continued collaboration with Caltrans engineers
  - Data processing and analysis
  - Ongoing IDA parametric studies
  - 2nd centrifuge test
- Budget issues

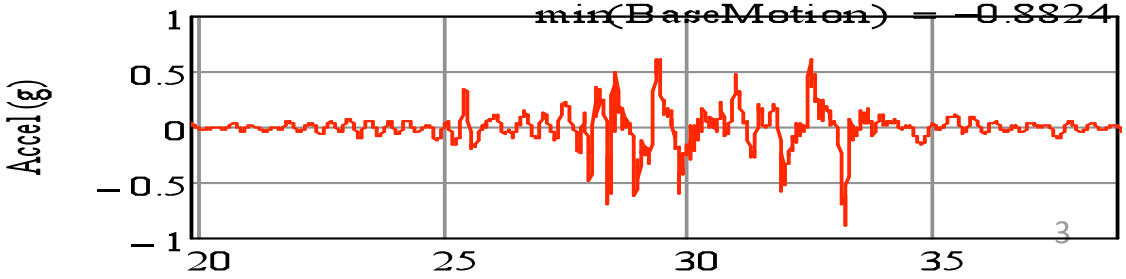
Rocking Foundation Centrifuge Tests



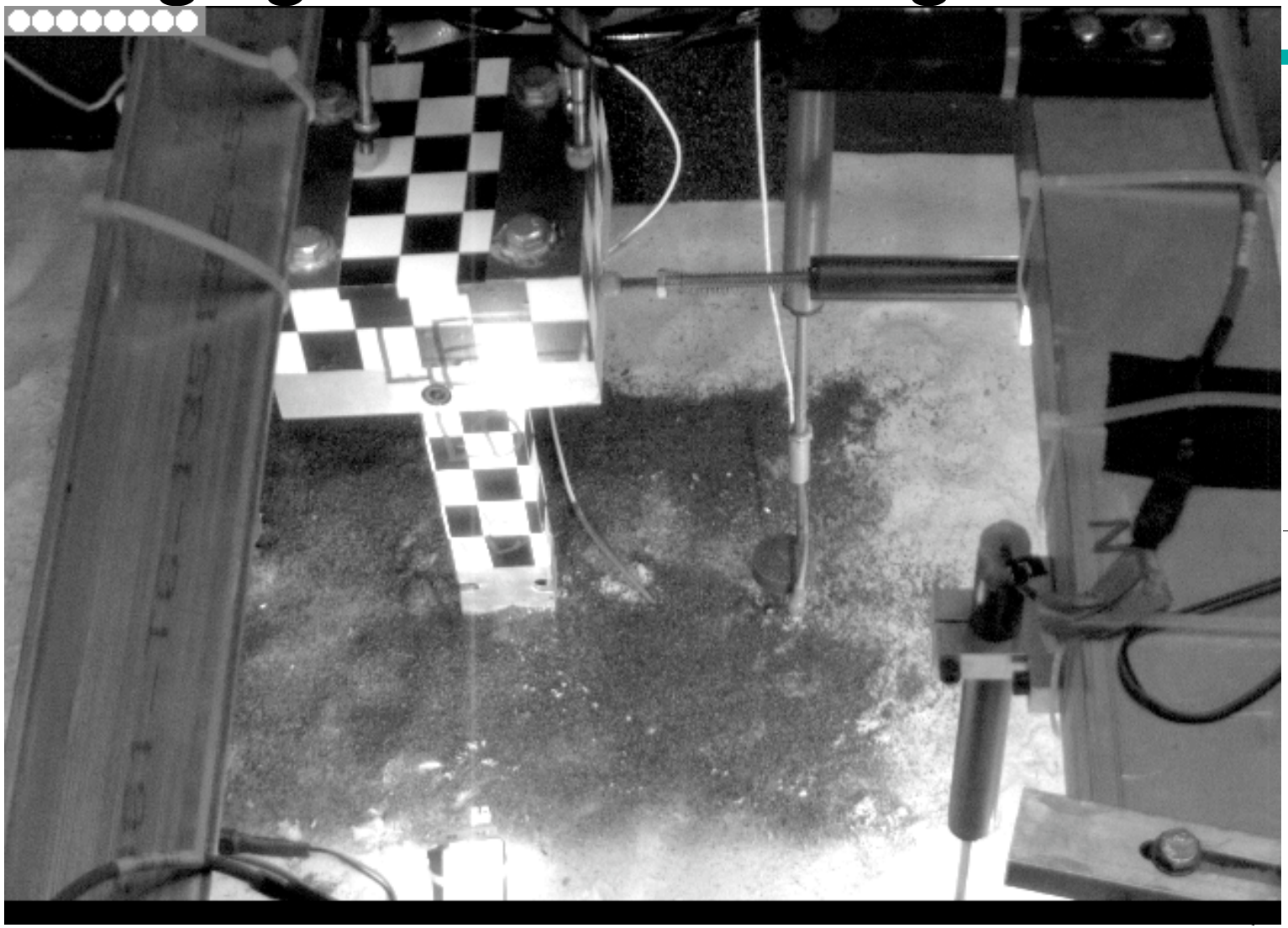


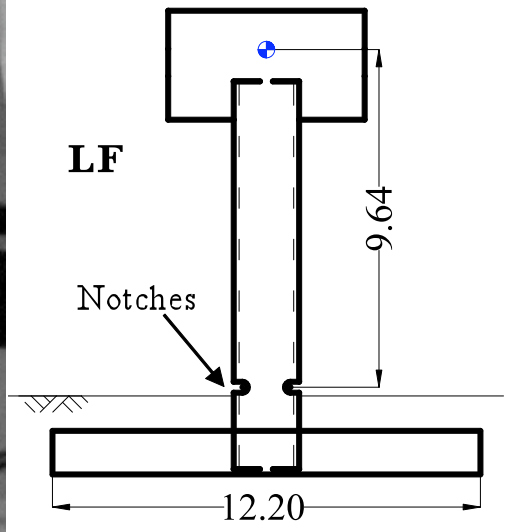


Gazli earthquake,
pga= 0.88 g



Hinging Column Centrifuge Test





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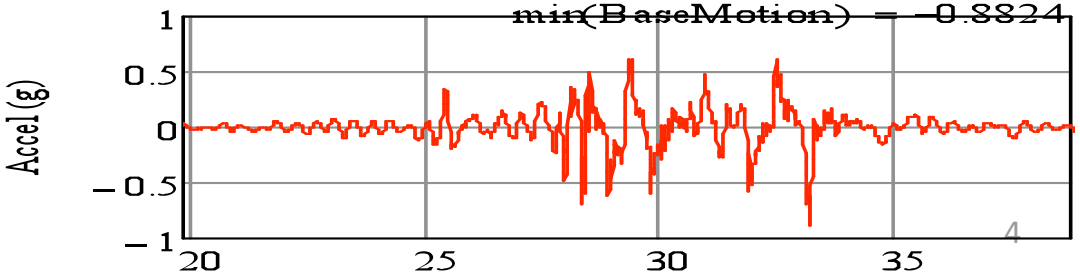
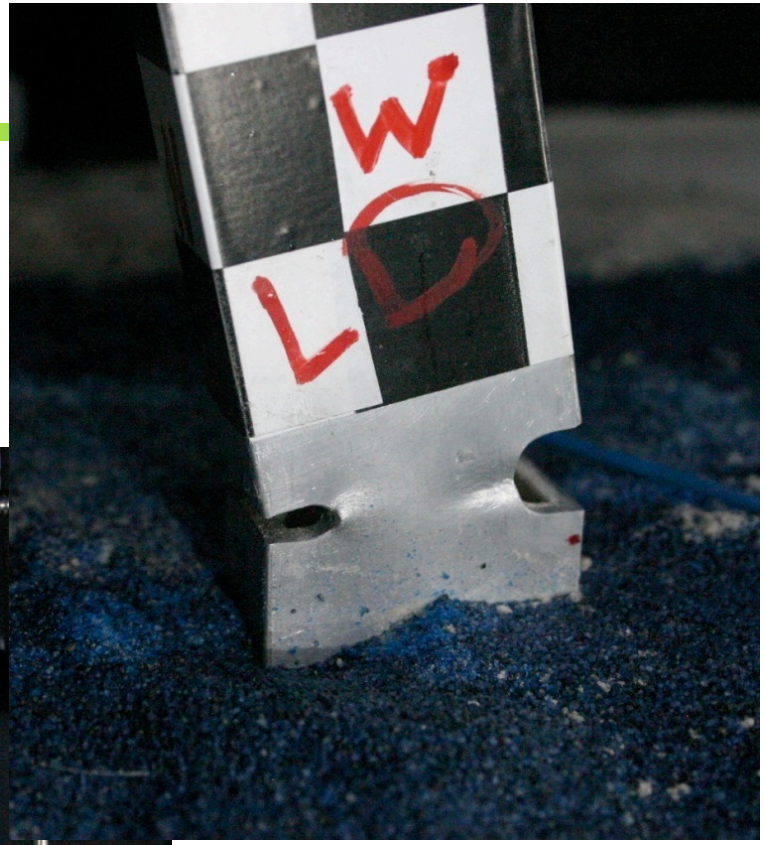
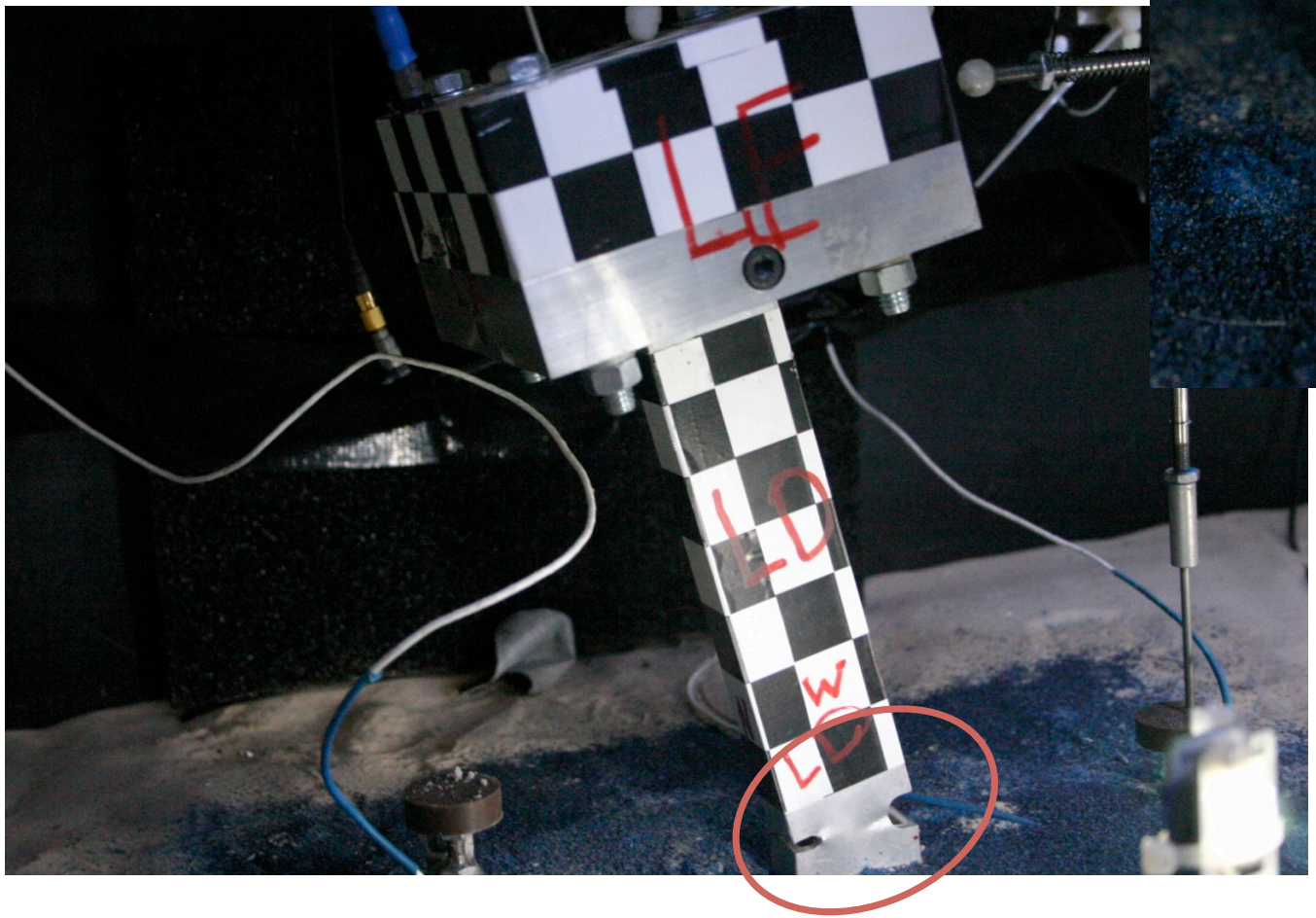


Photos of hinging column after 0.88g Gazli shake





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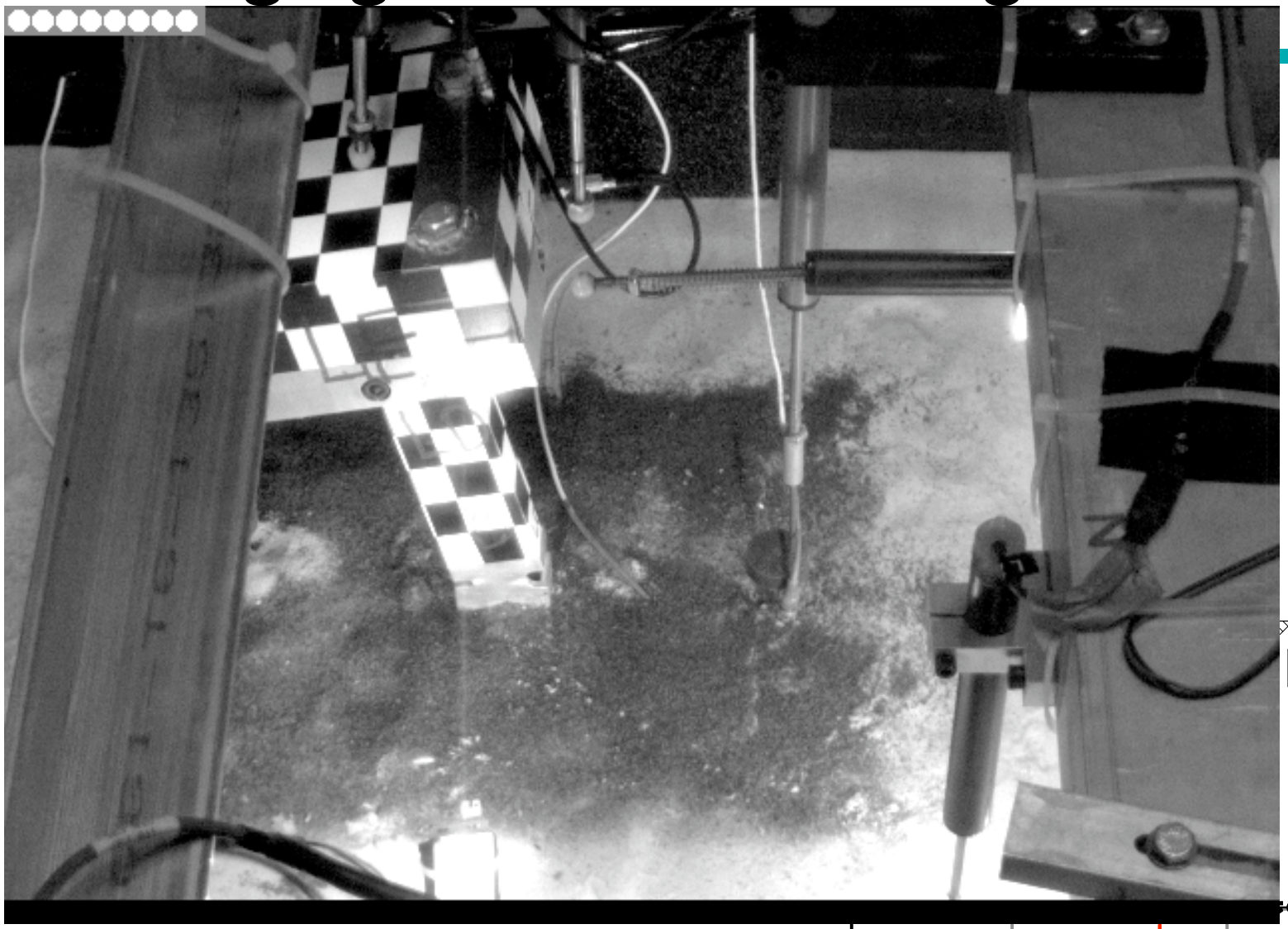
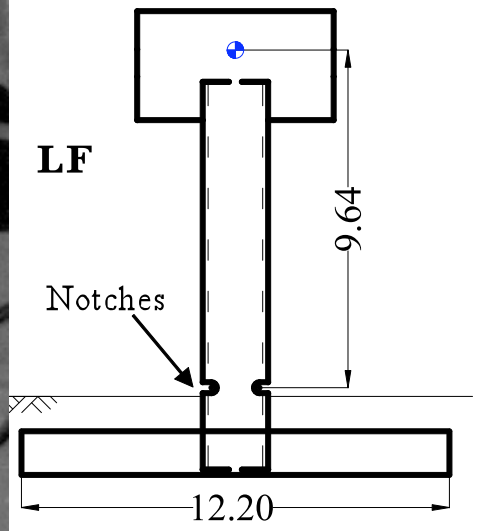
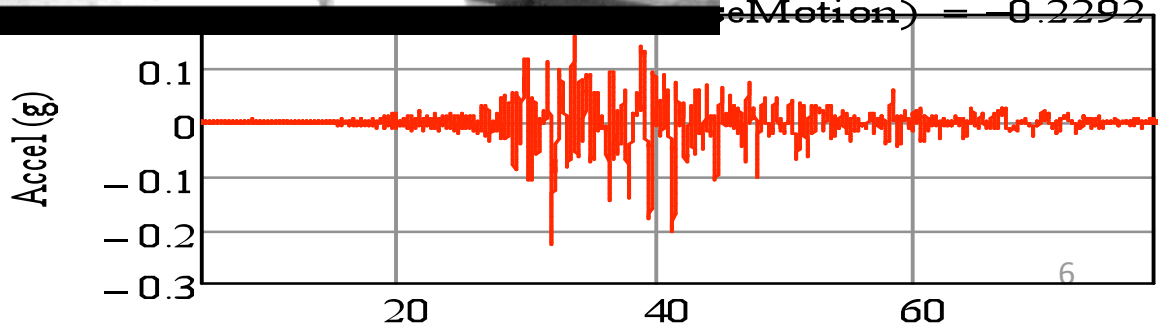
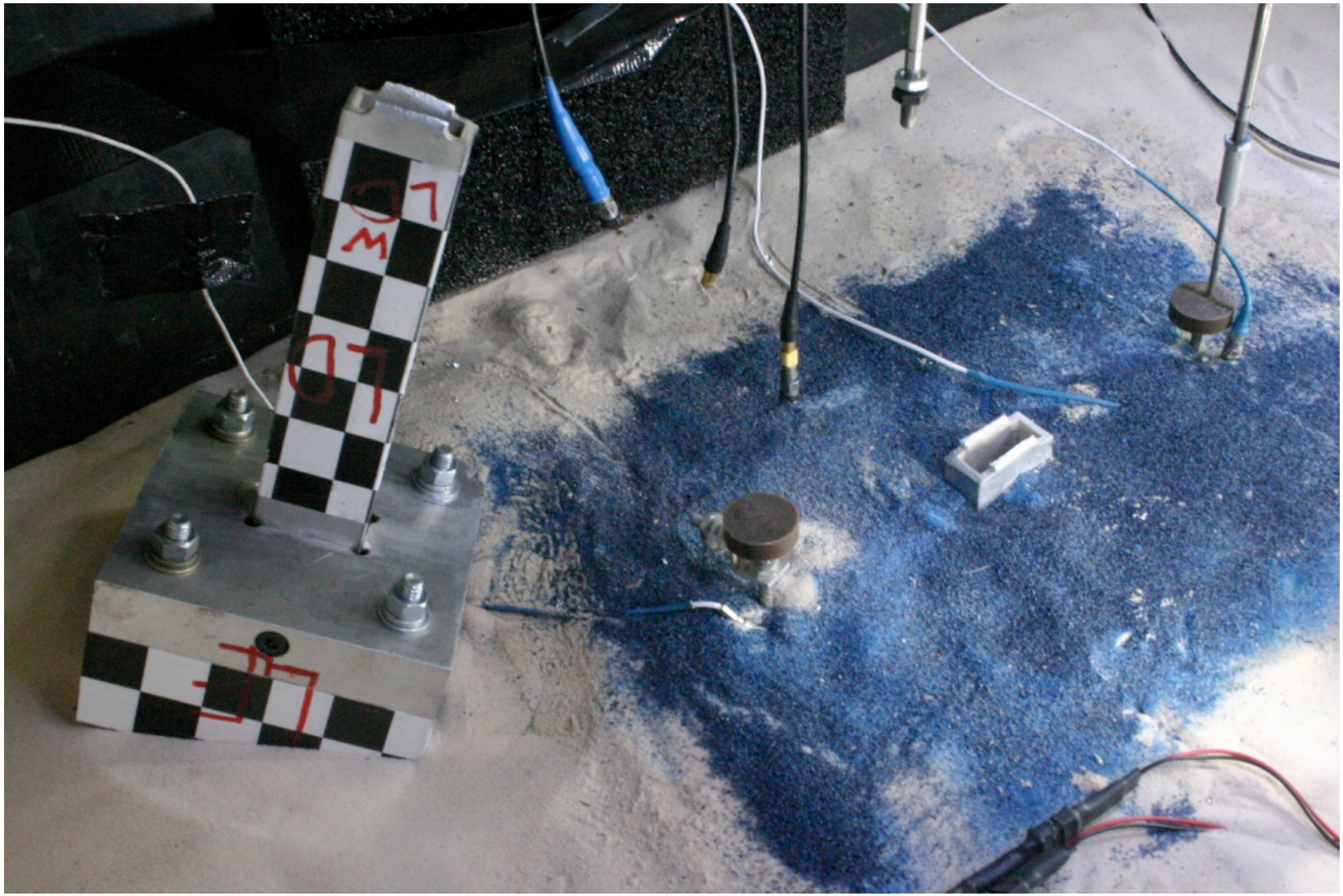




CHY024,
pga=0.23 g



Collapse of hinging column



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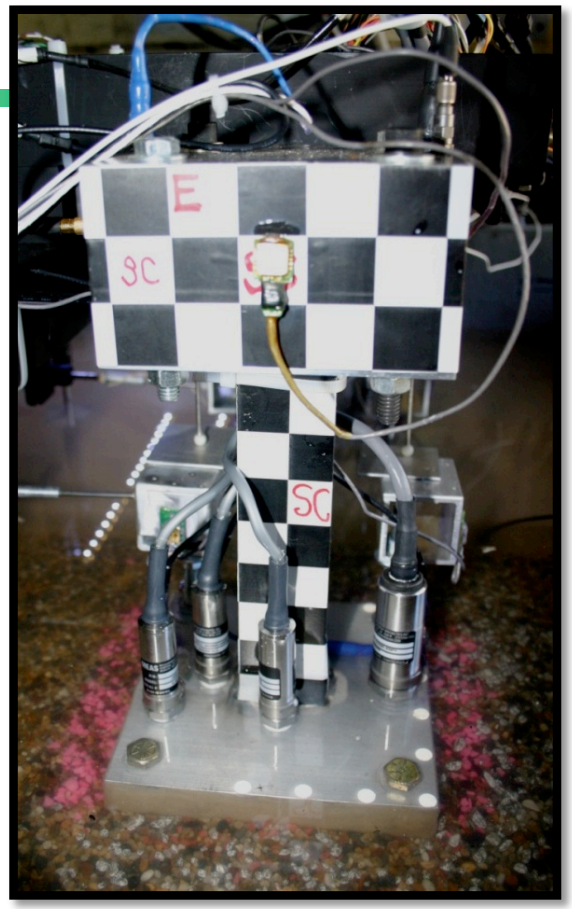
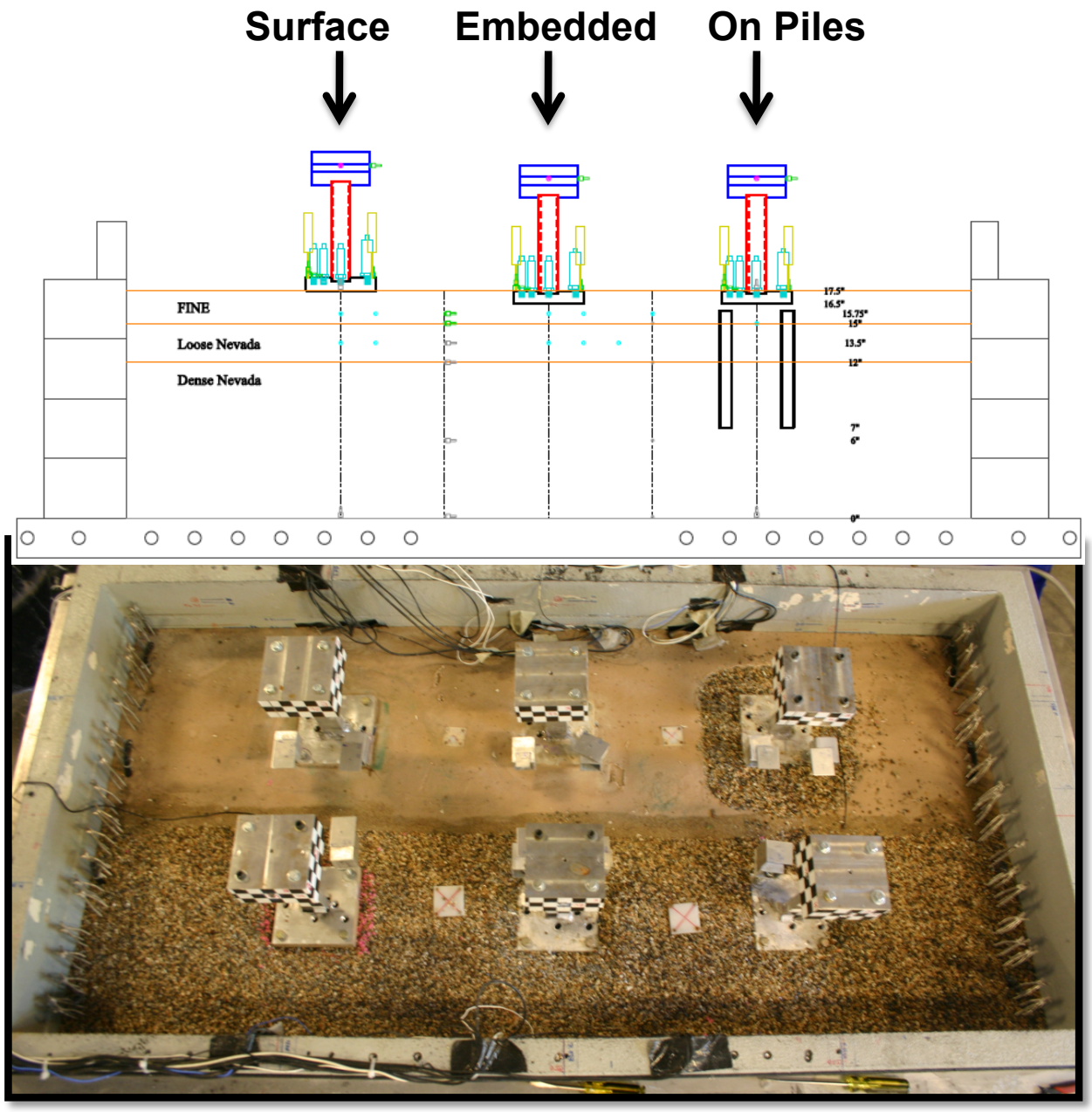
JDA01 – Shallow Rocking Foundations on Saturated/Liquefiable Soil

Six Identical SDOF Structures

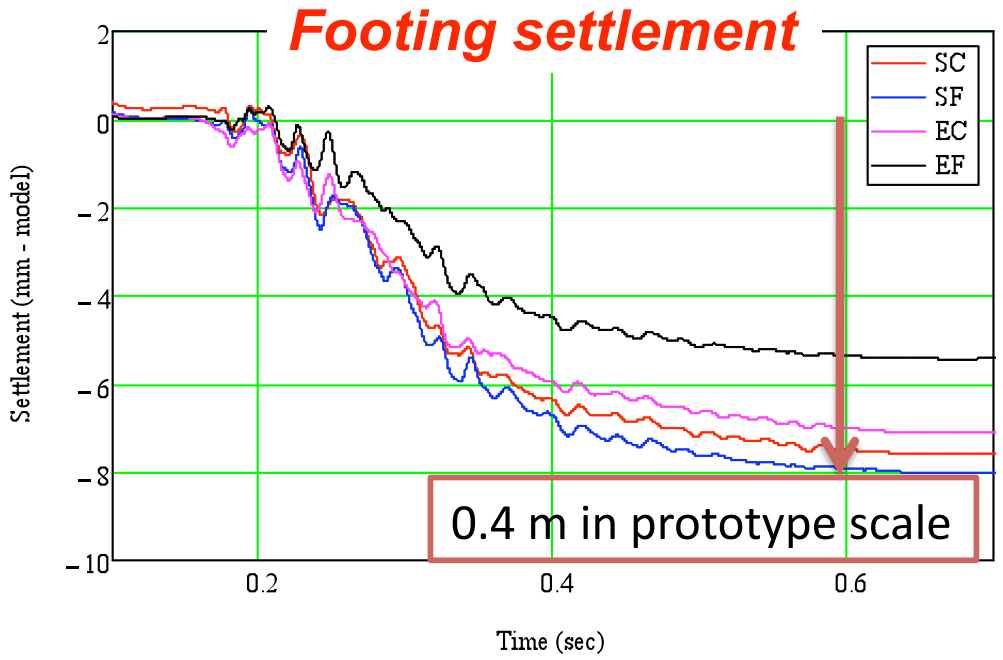




← **Fine (Nevada Sand)**

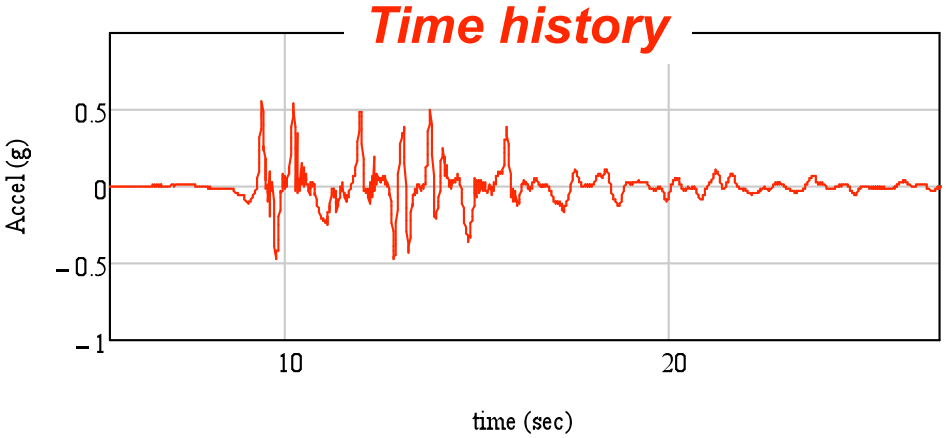
← **Coarse (Medium Aquarium Gravel)**

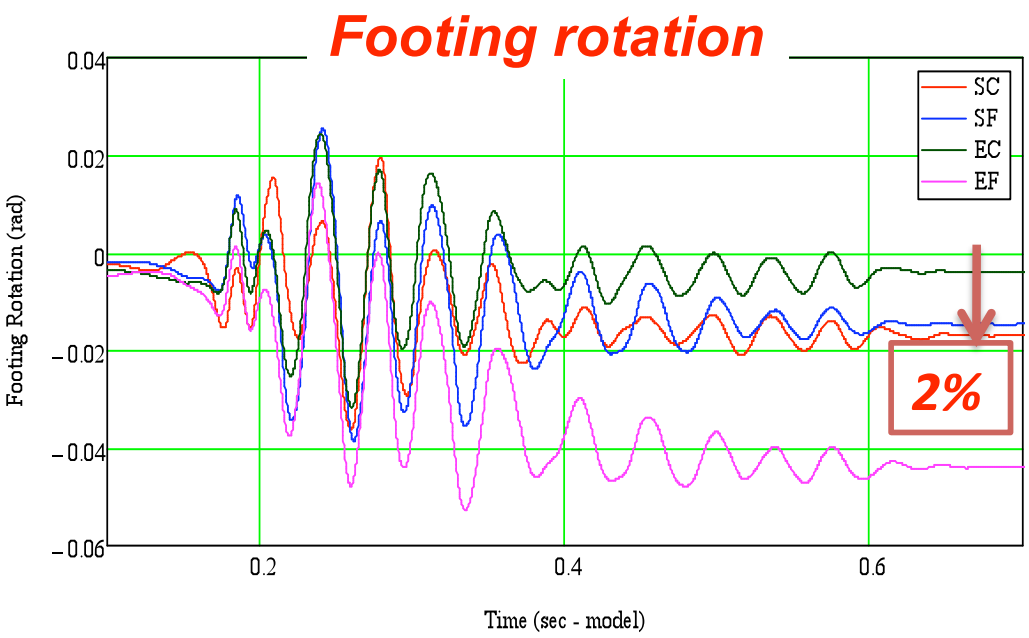
Preliminary Results

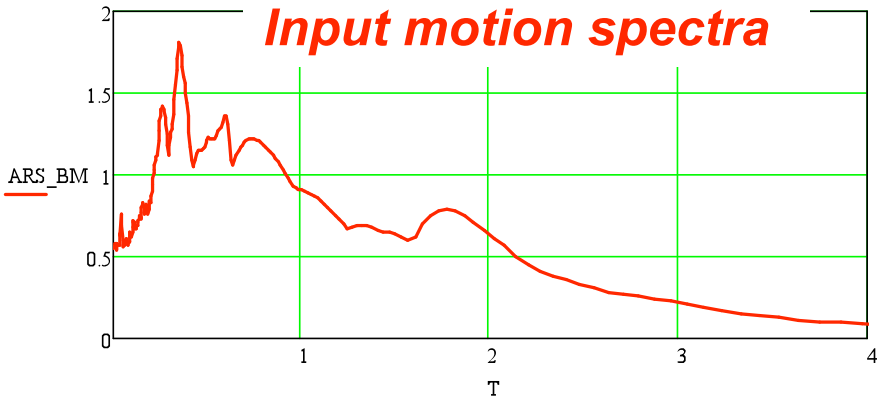


KOBE0807

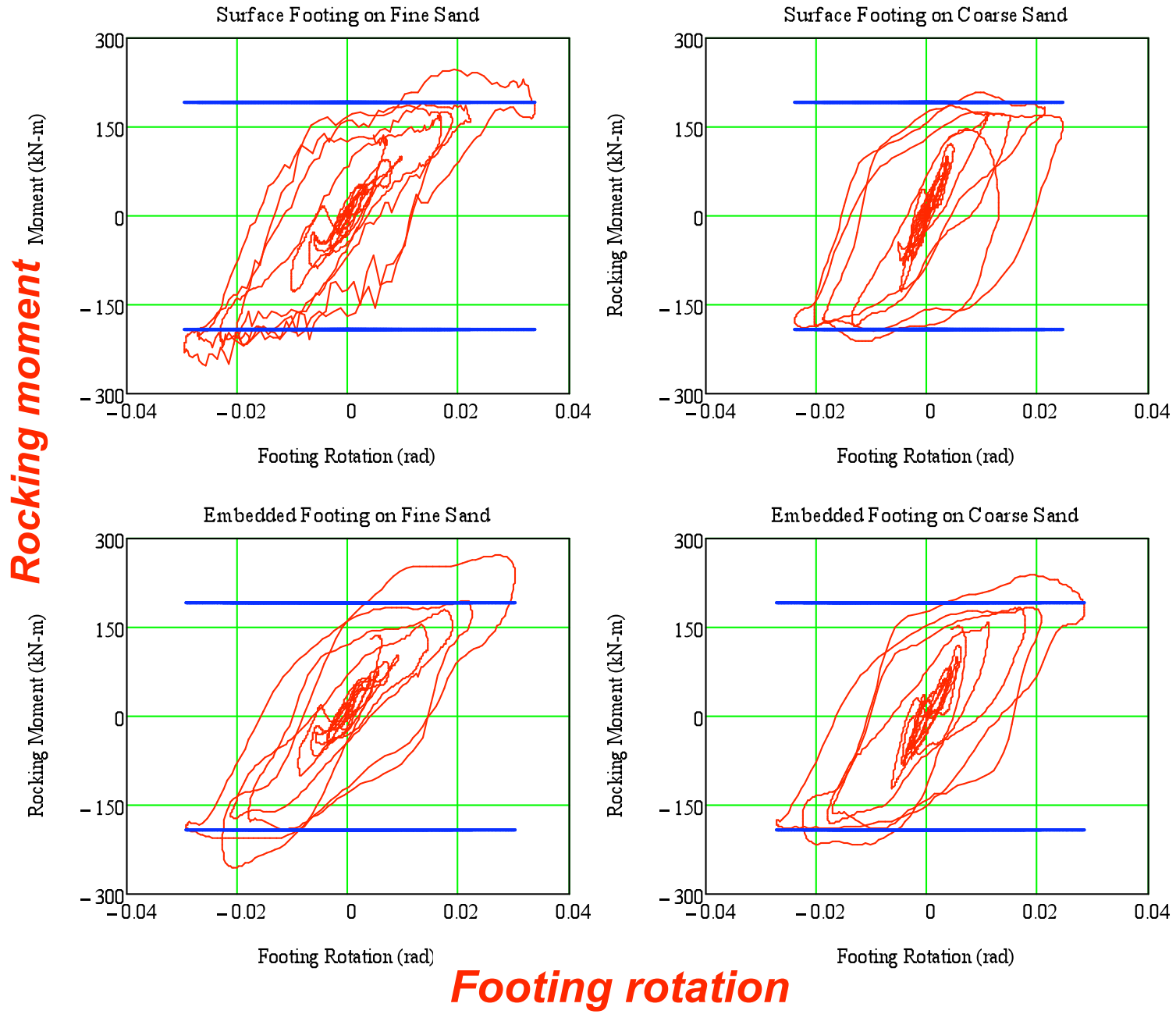
PGA = 0.57g







Preliminary Results: rocking moment vs. rotation

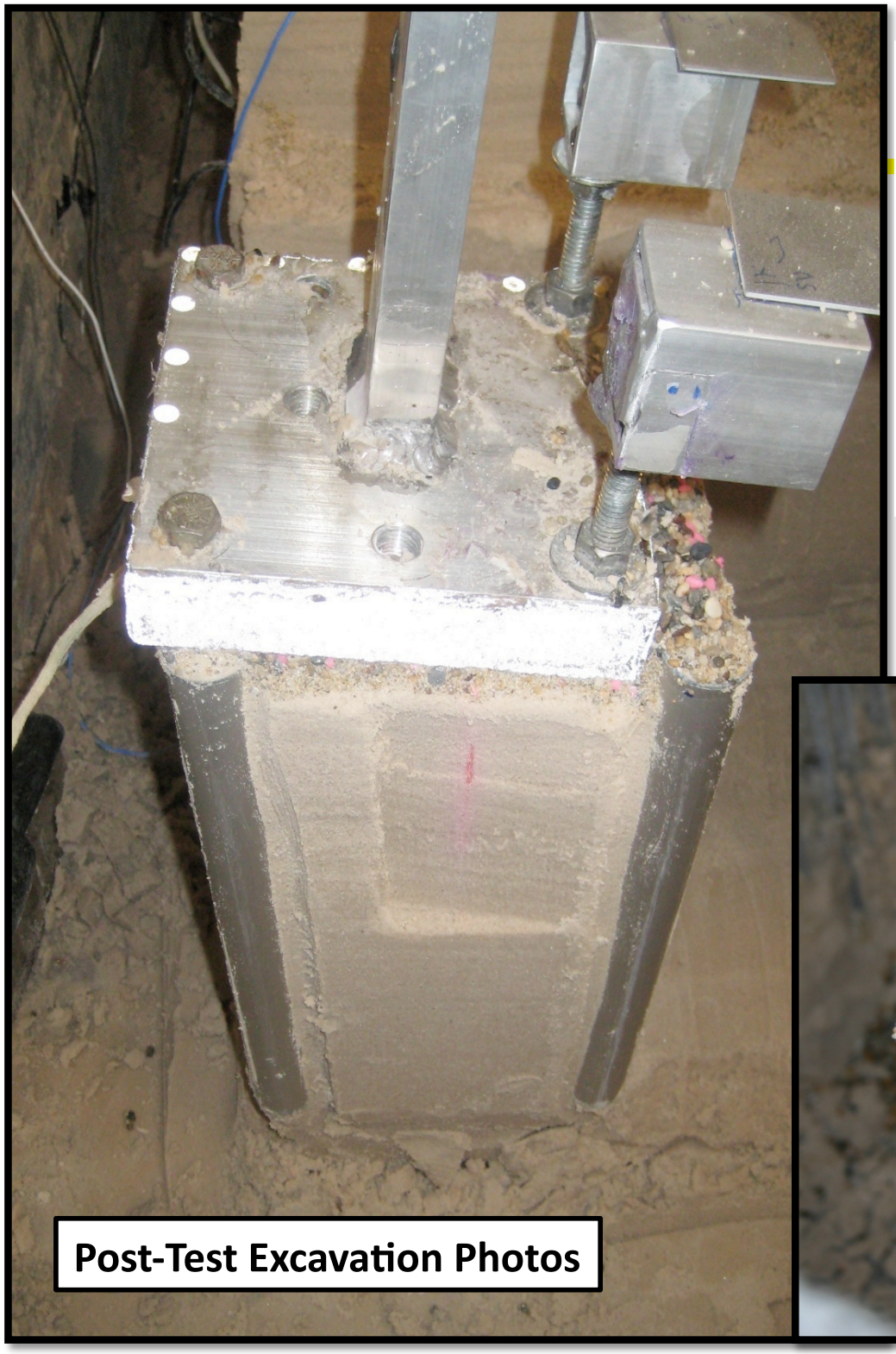


KOBE080
7PGA = 0.57g

Test Observations

- Experiments show that moment capacity of rocking foundations is reasonably certain.
- Column with rocking footing is more stable than bending column.
- Rocking foundations provide recentering effect that limits the accumulation of P-Δ demand.

- Settlement is still an issue for rocking foundations in liquefiable soil. Residual rotations however may be acceptable.



Post-Test Excavation Photos

- Footings unseated from piles
- Caused permanent rotation
- Portion of footing on piles experienced little settlement
- Future tests should have:
  - more piles
  - closer to center
  - larger diameter/surface area

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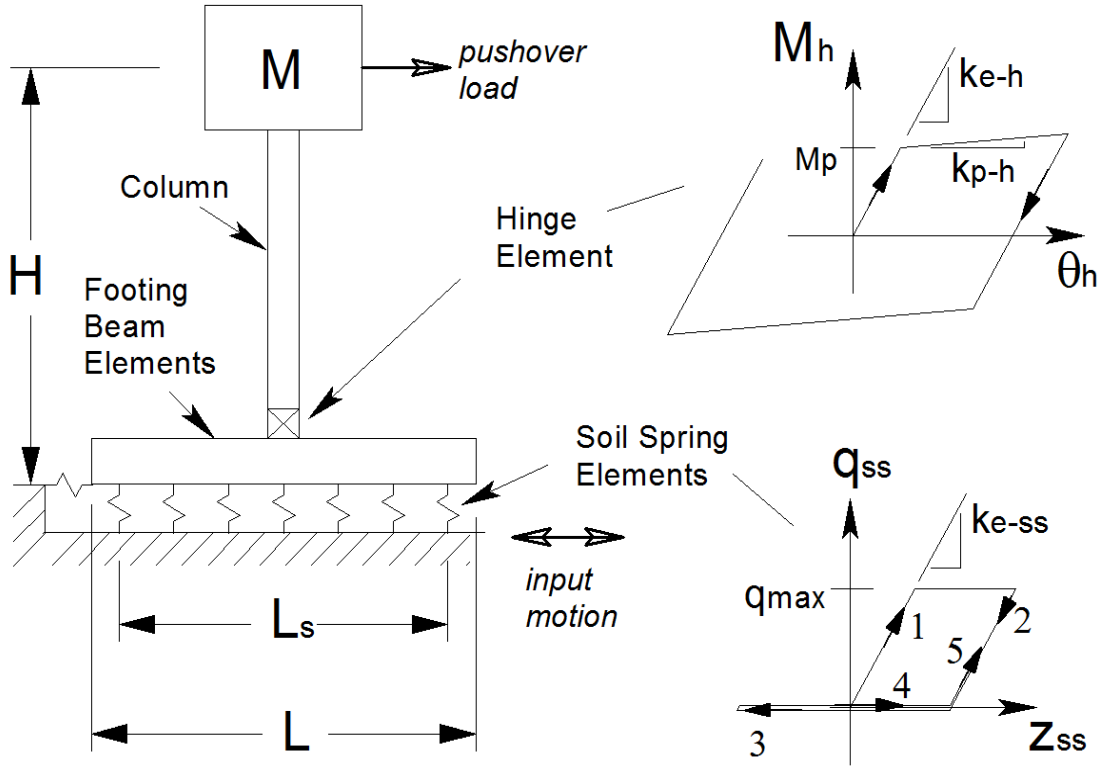
Ongoing parametric studies



Numerical models to be built in OpenSees for Incremental Dynamic Analysis

Rocking acceleration coefficient of footing:

$$C_r = \frac{L_f}{2 \cdot H_c} \cdot \left(1 - \frac{A_c}{A}\right) \cdot \left(1 + r_m\right)$$

Base shear coefficient of column:

$$C_y = \frac{M_{c_col}}{m_d \cdot g \cdot H}$$

Ongoing parametric studies

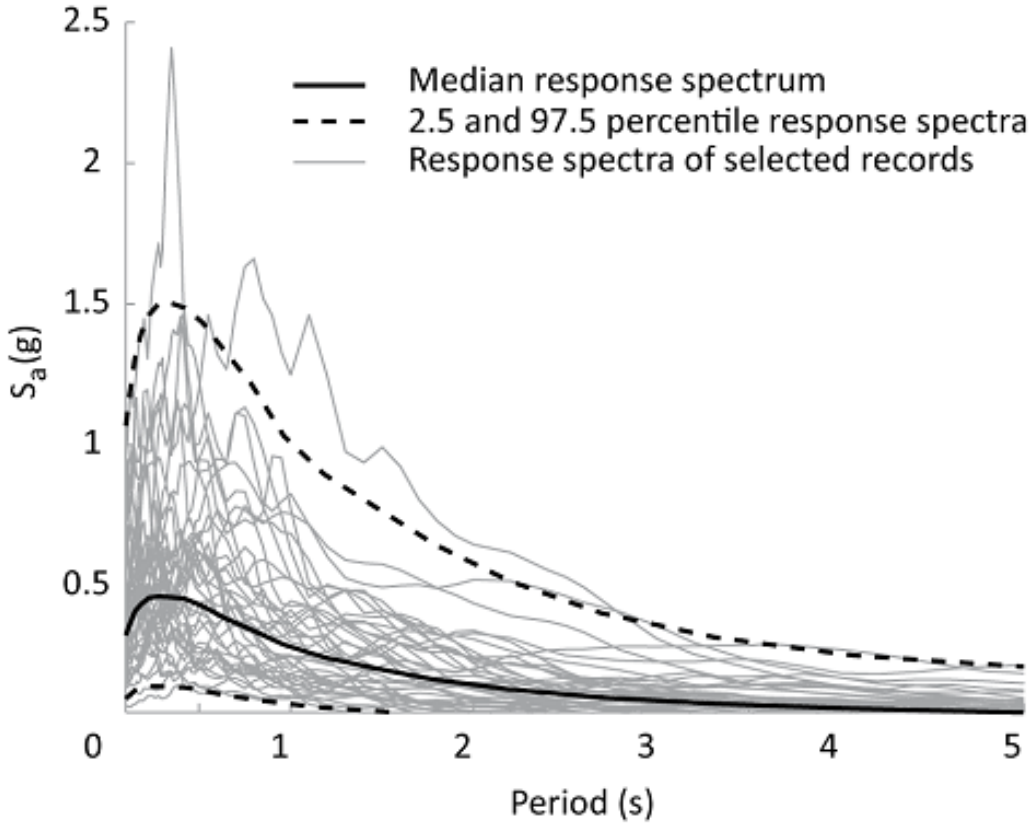
Two yielding mechanisms:
$C_r > C_y$ → Hinging column system
$C_y > C_r$ → Rocking foundation system
Incremental Dynamic Analysis (IDA) to be performed to identify the intensity measure for hinging column and rocking foundation systems.

Preliminary Intensity Measures: Sa(Tf), Sa(Tr), Sa(T_sys)

Cy/Cr	# SF	# Motions	# Periods	Total runs
0.5, 0.8, 1.0, 1.2, 2.5	10	40 broad-band soil site motions	0.2, 0.4, 0.5, 0.6, 0.7, 0.8, 1.0, 1.2, 1.5, 2.0	20000
0.5, 0.8, 1.0, 1.2, 2.5	10	40 Pulse-like motions	0.2, 0.4, 0.5, 0.6, 0.7, 0.8, 1.0, 1.2, 1.5, 2.0	20000

Ground motions from J. Baker

- Initial concept: 40 pulse like motions & 40 soil site motions



Response spectra of the selected ground motions for soil site (Baker et al. 2010)

Future Experiments

- 1st centrifuge test series done
- Configuration of 2nd TBD by analysis of 1st series has advanced: overall objective is to look at rocking foundations in poor and intermediate soils

Budget Issues

First series cost “somewhat more than expected”. We did not get NEES shared use status, so we had to pay about $40k to the NEES site for the 1st series. Not sure if we can afford this again. May apply for shared use status, but then access to the facility may be delayed due to backlog of NEES experiments at Davis.

Acknowledgements

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