

University of Nevada, Reno

Shake Table Tests on Shallow Foundations in Liquefied Soils Supported on Helical Piles

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- Pacific Earthquake Engineering Research Center (PEER)
- Staff and a group of graduate students at UCSD
- Ram Jack



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Presentation Outline

- Background and Motivation
- Experimental Program
- Test Series #1
- Future Testing Program

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Field Reconnaissance and Observations (March 11, 2011 Tohoku Earthquake M_w 9.0)

- Widespread Liquefaction
 - 27,000 buildings damaged
 - Similar to Christchurch, NZ
- Building foundation performance varied
 - Deep foundations => good performance
 - Shallow foundations => extensive damage
 - $0\text{ cm} < 30\text{ cm} < 70\text{ cm}$
 - Factor of 2.3



Building (Pile Supported)
-No Settlement

Free field
-30cm Settlement

Building (Mat Foundation)
-70cm Settlement

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Research Approaches

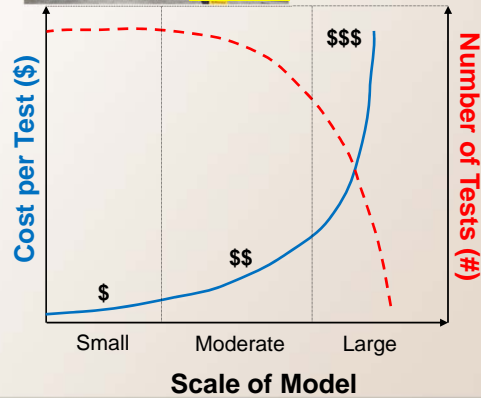
- Field case histories
- Centrifuge tests
- 1-g shaking table tests
- Field tests



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Shake Table Experiments

- Model size vs. cost

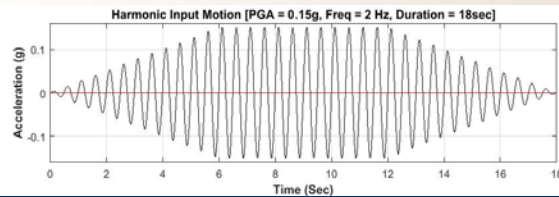


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Testing Program of Study

- Two series of tests
 1. Without any mitigation (benchmark test) – Completed June 2018
 2. With helical piles as a countermeasure
- Multiple shakings including white noises during each test

Test #	PGA (g)	GWT (m)
1-1	0.15 g	0.6
1-2	0.3 g	0.6
1-3	0.3 g	0



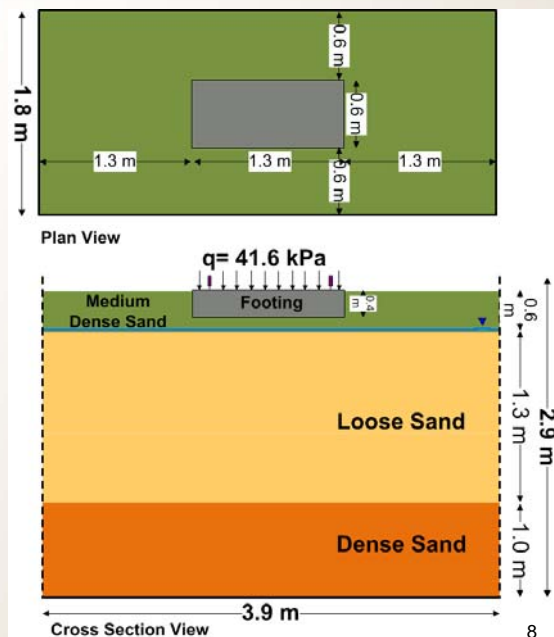
Target Input Motion

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Benchmark Test Layout

Test Series#1:

- Isolated footing,
- GWT @ 0.6m
- Uniform liquefiable layer w/o mitigations
- 41.6kPa contact pressure was meant to reproduce a low-story building foundation
- Extensive instrumentation



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Laminar Box at UCSD's Powell Lab



- Height= 2.9m (9.5 ft), Width= 1.8m (5.9 ft), Length= 3.9m (12.8 ft)

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Model Preparation

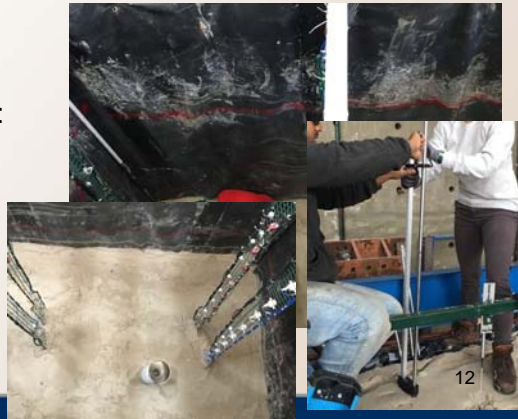




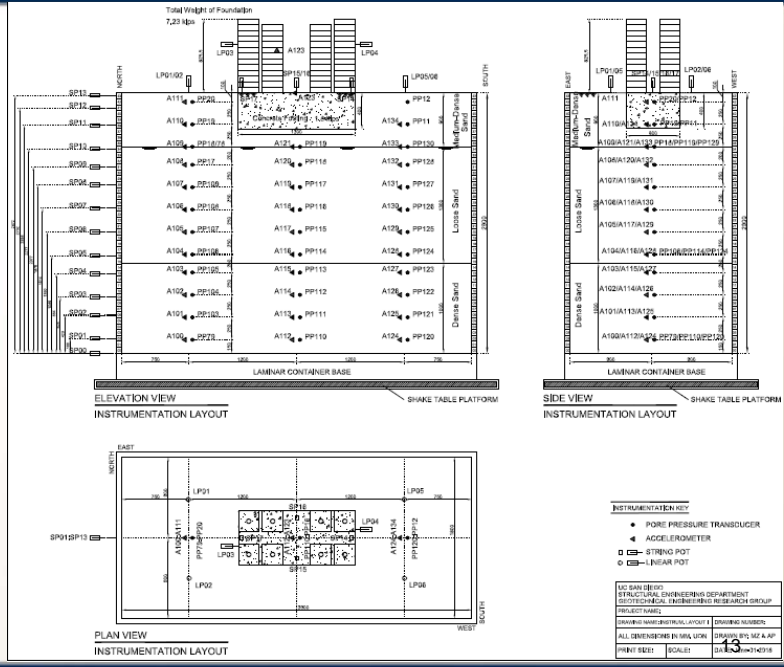
Characterization of Soil Layers

- Material: Ottawa F-65 Sand
- Three layers: (1) shallow crust, (2) thick loose, (3) dense
- Model preparation
- Three methods used for relative density calculations:
 - 1- Sand cone test
 - 2- Based on volume and weight of each layer
 - 3- Dynamic Cone Penetrometer (DCP) test

Layer	Dr % (Sand cone)	Dr % (Weight)	Dr % (DCP)
Dense	90	87	83
Loose	-	41	-
Crust	52	53	-



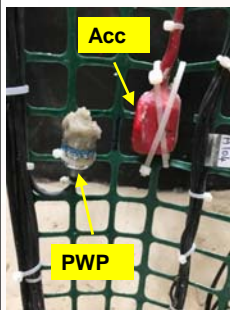
Instrumentation Plan



Instrumentation

Types and number of instrumentation

Type	Accelerometer	High Resolution Acc.	PWP	String Pot.	Linear Pot.	Total
#	35	28	47	18	6	134



Test #1-1: PGA= 0.15g, GWT= 0.6m



Observations and Conclusions

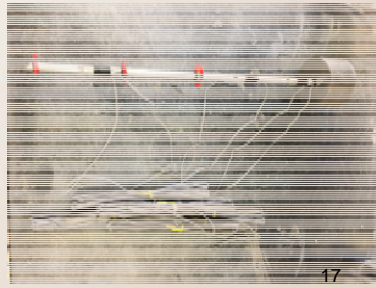
- Test series#1 (benchmark) results are being processed
- Extensive liquefaction and sand ejecta were achieved
- So far, very good agreement with published literature and prior 1-g scaled shake table tests at UNR
- Benchmark test is being evaluated for a potential blind prediction contest through PEER => information to follow



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Mitigation Measures

- Cost effective
- Applicable to new construction and existing buildings
- Helical piles
- 1-g shaking table testing on dry sands and liquefied soils



**Thank you and
questions**