Large-Scale Shake Table Test on a Shallow Foundation in Liquefied Soils

Principal Investigator: Ramin Motamed, Associate Professor, University of Nevada Reno
Student Investigators: Milad Jahed Orang, Graduate Student, University of Nevada Reno
Athul Parayancode, Muhammad Zayed, Graduate Students & Ahmed Elgamal, Professor, UC San Diego

Introduction

In this study, the effects of input ground motion as well as the level of ground water table on the liquefaction-induced settlement were evaluated. Previously, Bray and Dashti (2014) conducted Centrifuge tests to study the amount and contributing mechanisms in liquefaction-induced settlements of shallow foundations. In the present work, the shake table facility at the University of California San Diego was utilized to generate three different combination of PGAs and ground water levels to examine the magnitude of liquefaction-induced settlement. Uniform cyclic input motion with target PGAs 0.15g and 0.3g for 18 seconds with a constant frequency equal to 2 Hz was applied during the experiment. The main objective is to capture sand boils and their contribution to the amount of liquefaction-induced settlement and to create a benchmark standpoint for the second phase of our large scale testing which will be carried out using helical piles beneath shallow foundation.

Fig.1- Field Reconnaissance and Observation after Tohoku Earthquake (March 11, 2011) (after Ashford et al. 2011)

Large-Scale Shake Table Test Results

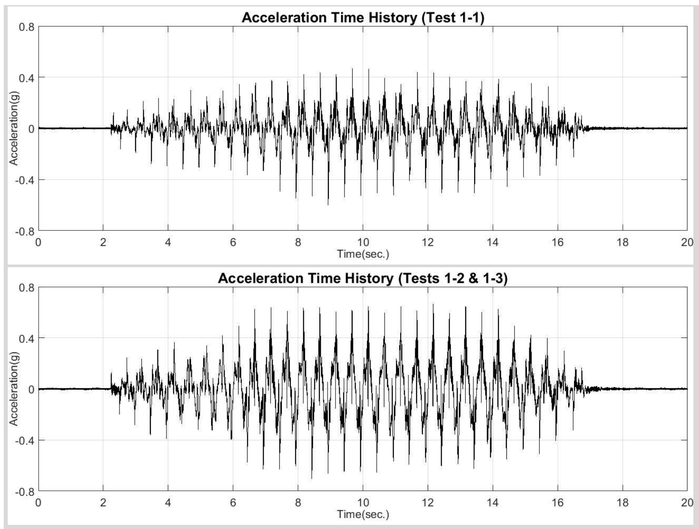

Fig. 6- Acceleration Time Histories for Tests 1-1, 1-2 & 1-3

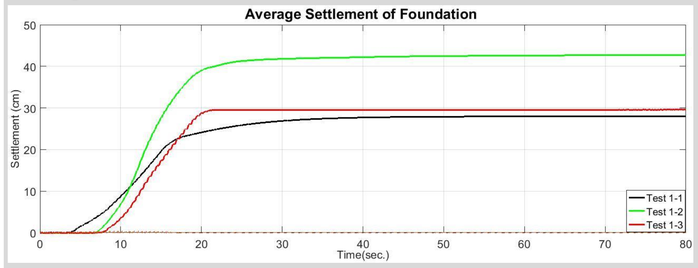

Fig. 7- Avg. Foundation Settlement in Three Motion Sequences

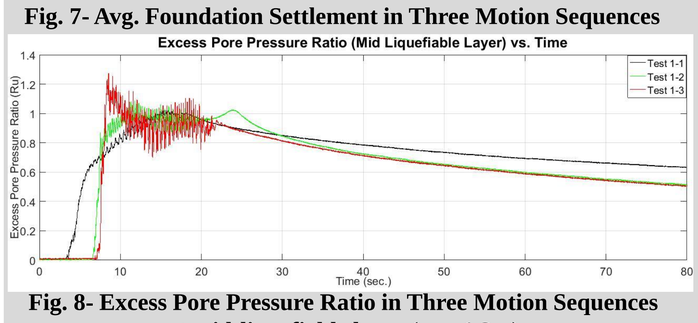

Fig. 8- Excess Pore Pressure Ratio in Three Motion Sequences at mid-liquefiable layer (z = -1.3m)

Fig. 9- Photo After Test #1 (Test 1-1)

Fig. 10- Photo After Test #2 (Test 1-2)

Fig. 11- Observed Sand Ejecta at the End of Test 1-3

Experimental Procedure

Soil Properties and Test Program:

- Ottawa F-65 Sand (SP)

Property	C_u	C_c	G_S	e_{max}	e_{min}	$\rho_{d,max}$ (gr/cm^3)	$\rho_{d,min}$ (gr/cm^3)
Value	1.61	0.96	2.65	0.83	0.48	1.78	1.44

- Three test sequence with varying PGAs and GW level:

Test #	Relative Density(%)			Foundation Dimensions (L*W*H) (cm)	Target PGA(g)	GW Level below Ground (m)
	Dense layer	Liquefiable layer	Crust Layer			
1-1	87	41	53	1.3*0.6*0.4	0.15	-0.6
1-2					0.30	-0.6
1-3					0.30	0.0

- Types & number of instrumentation:

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

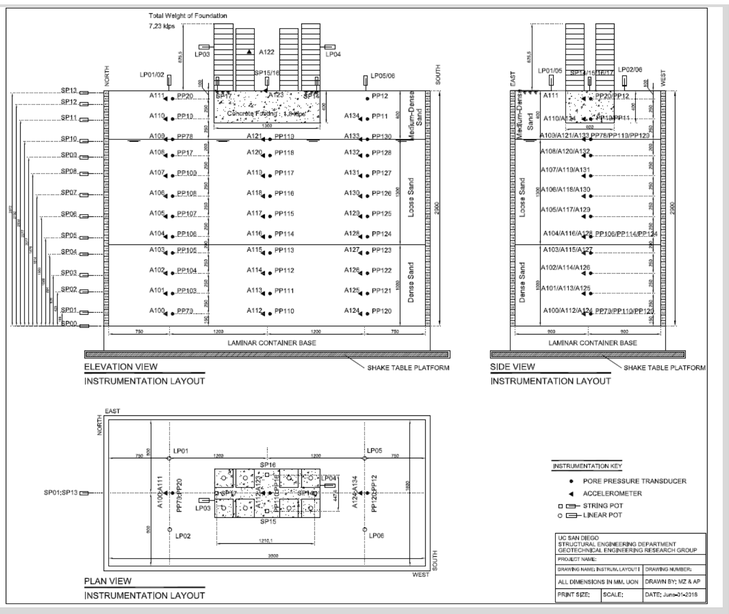

Fig.2- Instrumentation Plan

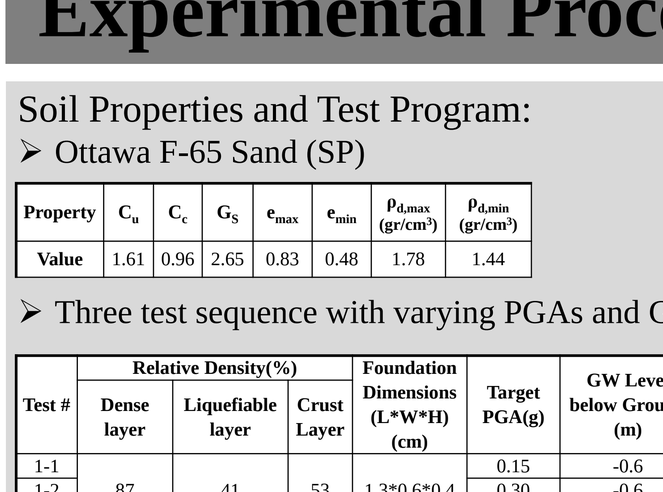

Fig. 3- Laminar Box at UCSD's Powell Lab

Fig.4- Model Prior to Shake

Fig.5- Model Foundation

Conclusions

- The effects of ground motion intensity and ground water level were evaluated.
- As PGA increased, the amount of accumulated liquefaction-induced settlement increased.
- The absolute magnitude of liquefaction-induced settlement decreased in Test no. 1-3 due to the densification of soil layers in previous motions.
- The amount of excess pwp indicates the occurrence of liquefaction in all three motion sequences regardless of soil layers densification.
- The foundation bearing capacity failure also occurred during liquefaction as a result of reduced soil effective stress due to liquefaction.
- Settlement below the foundation resulted in heave on both side of the foundation due to bearing capacity failure.

References

1. Ashford S, Boulanger R, Donahue J, Stewart J. "Geotechnical quick report on the Kanto Plain region during the March 11, 2011, Off Pacific Coast of Tohoku earthquake, Japan". GEER quick report, April 5; 2011.
2. Bray JD & Dashti S 2014. "Liquefaction-Induced Building Movements", Bull Earthquake eng., pp. 1129-1156.

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