DEPARTMENT of CIVIL & ENVIRONMENTAL ENGINEERING
GEOTECHNICAL ENGINEERING RESEARCH GROUP
GW SCHOOL of ENGINEERING & APPLIED SCIENCE

Laboratory Characterization of a Liquefiable Soil

M. ElGhoraiby[a], M. T. Manzari[b]

Introduction

- Statistics reported by the United States Geological Survey (USGS) show that earthquakes have increased in their rate of occurrence over time and in their intensity in the past decade. The Chile, New Zealand and Japan Earthquakes in 2010 and 2011 resulted in wide spread damages to civil infrastructure due to soil liquefaction, shedding light on the understanding of this phenomenon.
- With the motivation of improving the current understanding of soil liquefaction and assessing the predictive capabilities of state-of-the-art computational tools, a consortium of research institutes across the globe have started a series of Liquefaction Experiments and Analysis Projects (LEAP).
- Under the LEAP umbrella, the research presented here intends to develop a database of laboratory experiments which characterizes the liquefaction strength of the project's designated soil at the element level.

Scope of Research

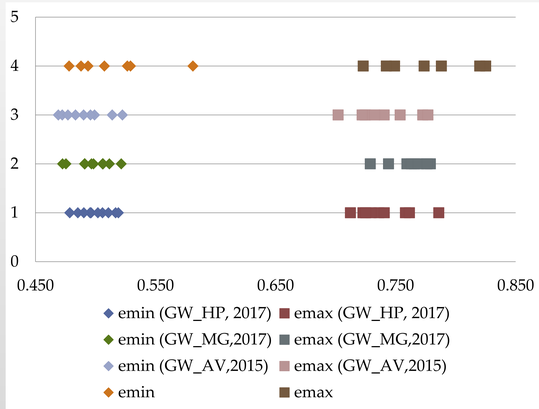
A laboratory testing program for the characterization of Ottawa F65 is carried out. The program includes:

- Specific gravity tests for samples obtained from different sand patches to evaluate the consistency of the soil.
- Particle size distribution for different samples to validate the soil designation as SP on the USCS classification system.
- Permeability tests to obtain the soil's permeability at different soil densities.
- Maximum and minimum void ratio tests performed on different samples.
- Cyclic triaxial stress-controlled tests on different soil densities to obtain the soil's liquefaction strength

Ottawa-F65 Properties

Maximum and Minimum Void Ratio:

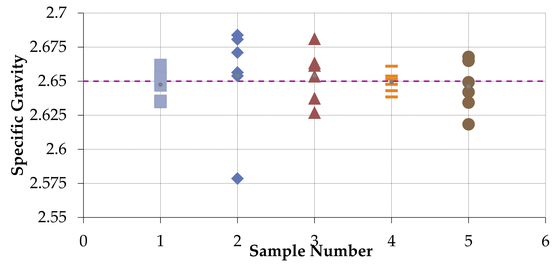
- Maximum void ratio: mean = 0.75; COV = 2.5%
- Minimum void ratio: mean = 0.5; COV = 2.7%



Ottawa-F65 Properties

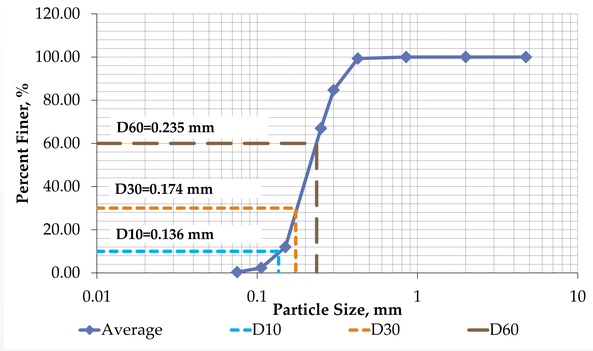
Specific Gravity:

- ASTM D854 - standard test method for specific gravity of soil solids by water pycnometer were followed
- Soil samples were obtained from five different patches.
- Six tests were performed for each patch
- Specific Gravity, mean = 2.65; COV = 0.88%



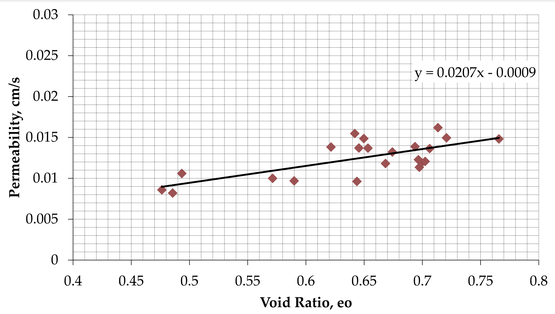
Particle Size Distribution:

- ASTM D422-63 – standard tests method for particle-size analysis of soils were followed
- USCS Classification:
  - Cu= 1.728; Cc=0.947
  - SP (Poorly Graded Sand);



Soil Permeability:

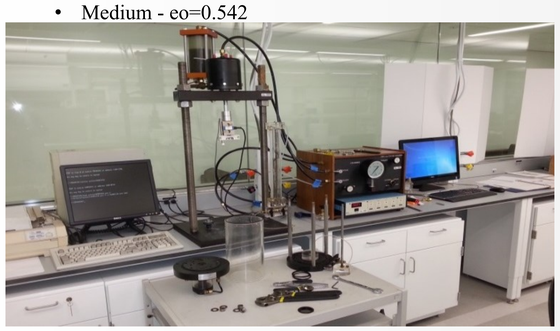
- A series of constant head permeability tests were performed at different densities.
- Dry-pluviation method was used to prepare the soil specimen in a similar fashion as in the cyclic triaxial tests.



Cyclic Triaxial Experiment

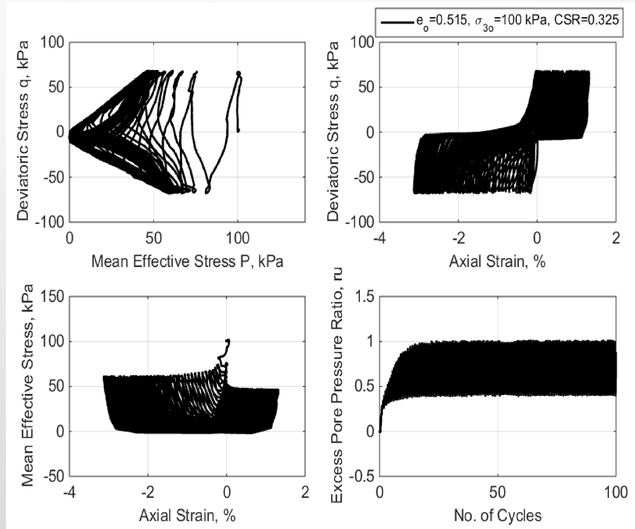
Cyclic Stress-Controlled Triaxial Tests:

- Constant Drop Height Dry Pluviation Technique used for sample preparation.
- Three test Densities:
  - Dense - eo=0.515
  - Loose - eo=0.585
  - Medium - eo=0.542



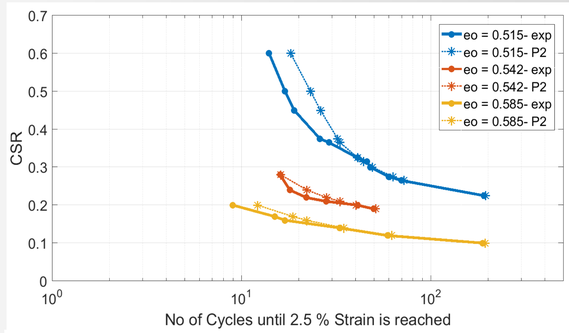
Constant Drop Height Dry Pluviation Device:

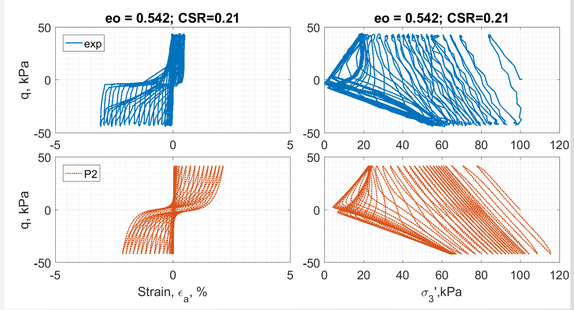
Typical Triaxial Experiment Results:



Liquefaction Strength

- Liquefaction Strength is defined as the number of cycles it takes the soil to reach 2.5% single amplitude of strain.
- The database generated was provided in the LEAP 2017 prediction exercise. It was used for calibration of the constitutive model parameters before the simulation of the centrifuge experiments.
- One example of the simulation compared to the experiment is shown below.





Concluding Remarks

- Under the LEAP project a database of laboratory experiments is developed for the characterization of Ottawa F65 Sand.
- The database included:
  - Lab Tests: (emin/emax, specific gravity, particle size distribution and permeability)
  - Cyclic Stress-Controlled Triaxial Tests on three different densities
- Additional Testing:
  - Undrained triaxial monotonic tests to obtain the failure envelope
  - Cyclic direct simple shear tests

Acknowledgement

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Research Team:
a) PhD candidate, CEE Department, GWU
b) Professor, CEE Department, GWU