Resiliency of MSE Wall Subjected to Surge and Wave Loading
(pending approval)

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Geotechnical Research In Progress (GRIP)

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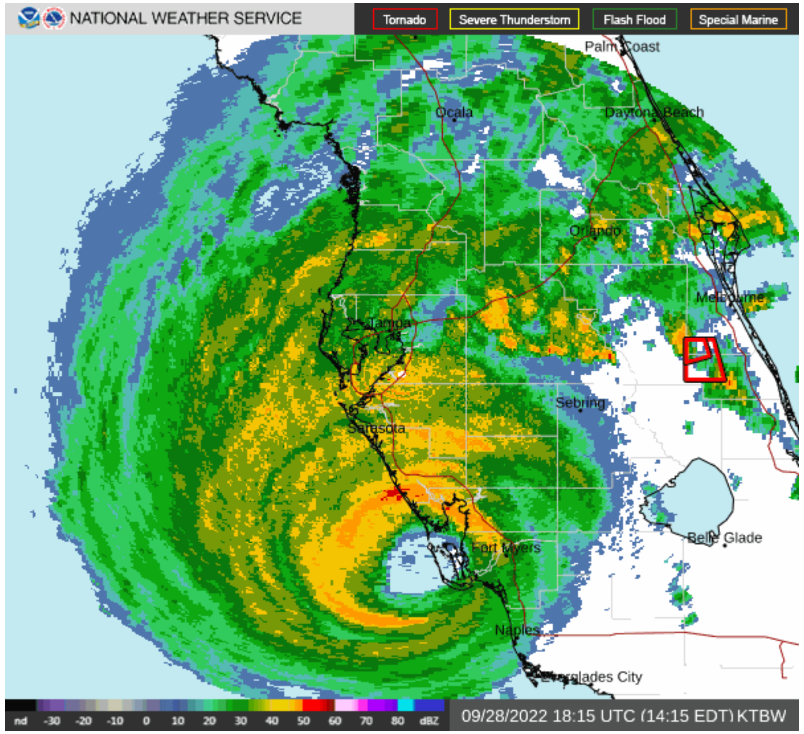
Presentation Outline

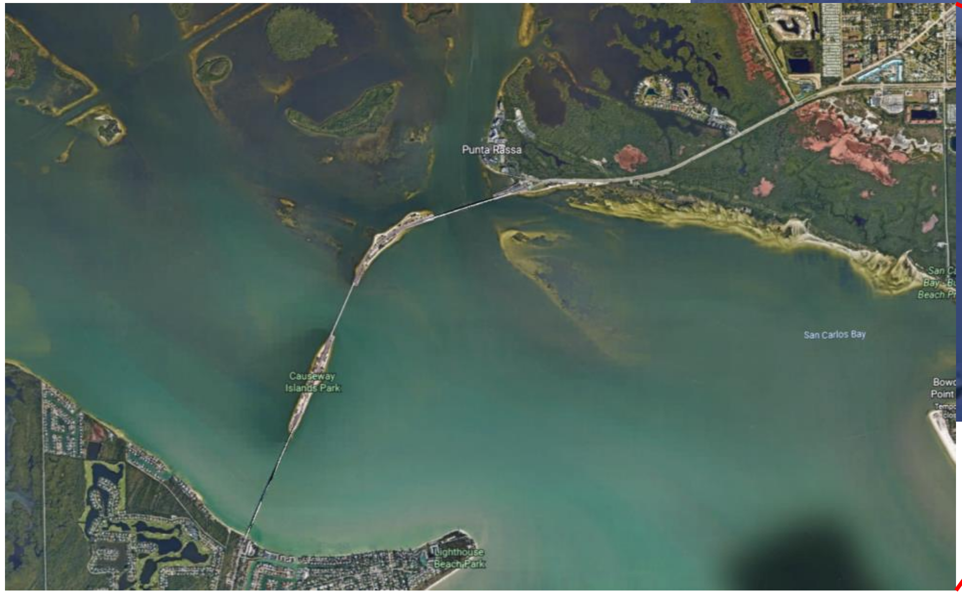
- Introduction
- Research Motivation
- Project Objectives
- Project Tasks

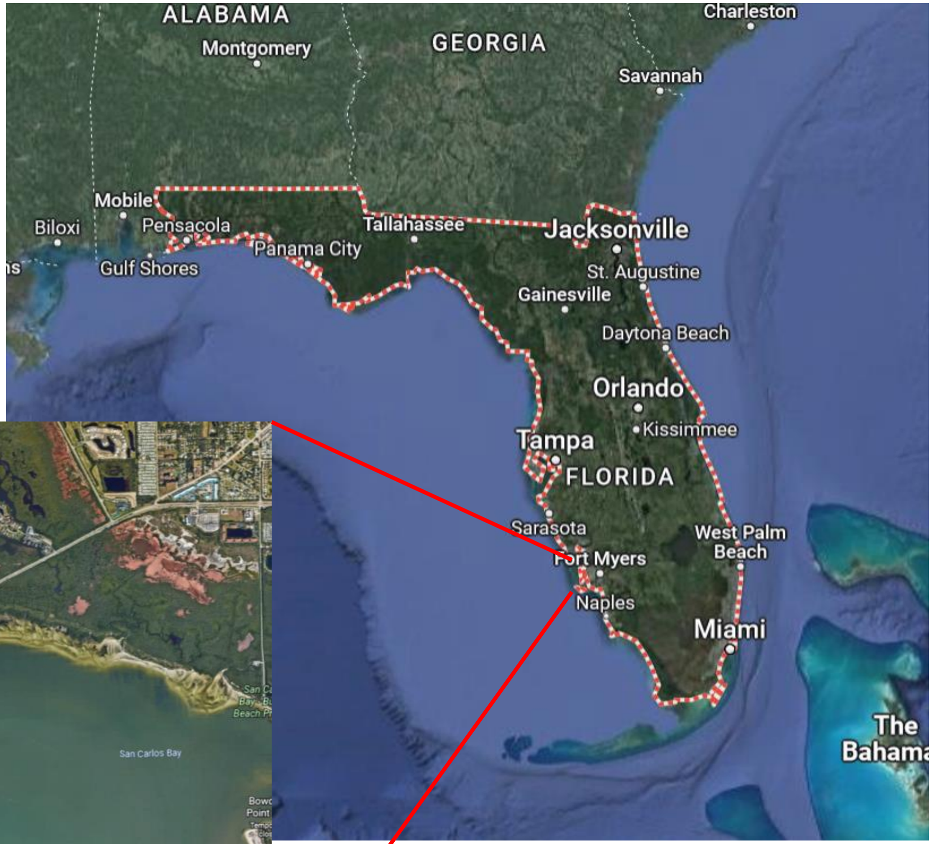
Introduction

- Many barrier island communities are served by bridges.
- In most places, the causeway bridges are the only emergency access (evacuation and post event aid).
- In Florida, many of these bridges have MSE wall approaches and abutments.
- Coastal MSE walls are much more likely to experience the storm tide associated with extreme tropical hydrodynamics.
- Storm tide is the storm surge + short waves + tide.
- The west coast and panhandle of Florida is prone to large surge (shallow offshore slope)
- MSE wall stability is susceptible to hydrodynamic forcing

Research Motivation – Hurricane Ian







Research Motivation – Western Abutment

Research Motivation – Mainland Abutment

Research Motivation – Storm Characteristics

- Hurricane Ian:
  - Sustained winds of 150 mph.
  - Storm surge of 12 – 18 ft near the coast (NOAA) and approximately 8 ft (recorded) in downtown Fort Myers.
  - Maximum wave heights of 6 – 13 ft (USGS).
  - The storm struck shortly after high tide (+2.5 ft) and included up to 15 inches of rain.

Research Motivation – Design Guidelines

- **AASHTO Guide Specifications for Bridge Vulnerable to Coastal Storms** provide recommended deign equations for both wave loading and surge affects that result in both horizontal and vertical loading.
- The hydrodynamic loading is based on 100-year storm event (those that have a likelihood of occurrence 1/100 years), and it may not capture the current observed extreme events at higher frequencies events impacting coastal communities.
- Predictions of the loading based on geomorphological factors, and atmospheric conditions, the forecasted loading should be modeled, in particular, for the abutments and MSE walls as well.

Project Motivation – Bed Response to Hydrodynamic Loading

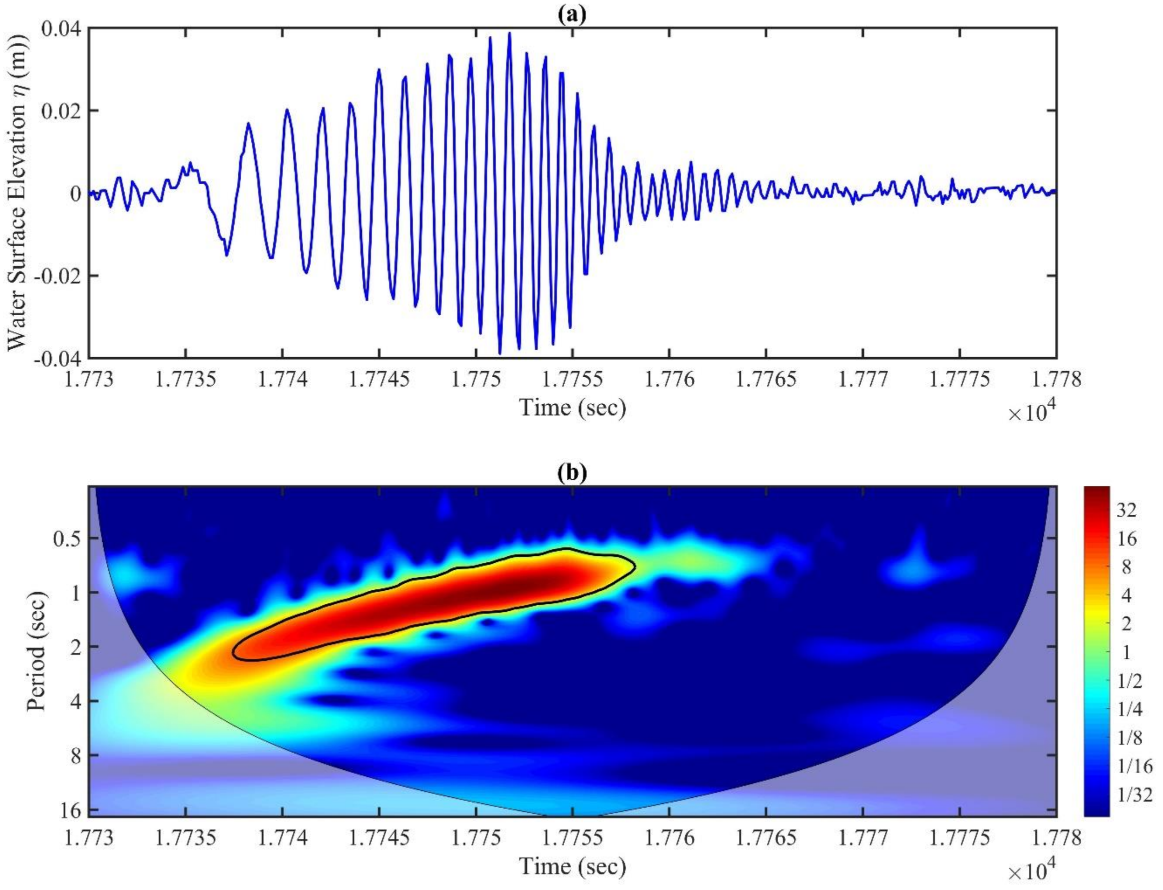


Figure 3. Water surface level time series and its energy distribution for wake 8 (a) Water surface level time series (b) Wavelet power spectrum of measured water level

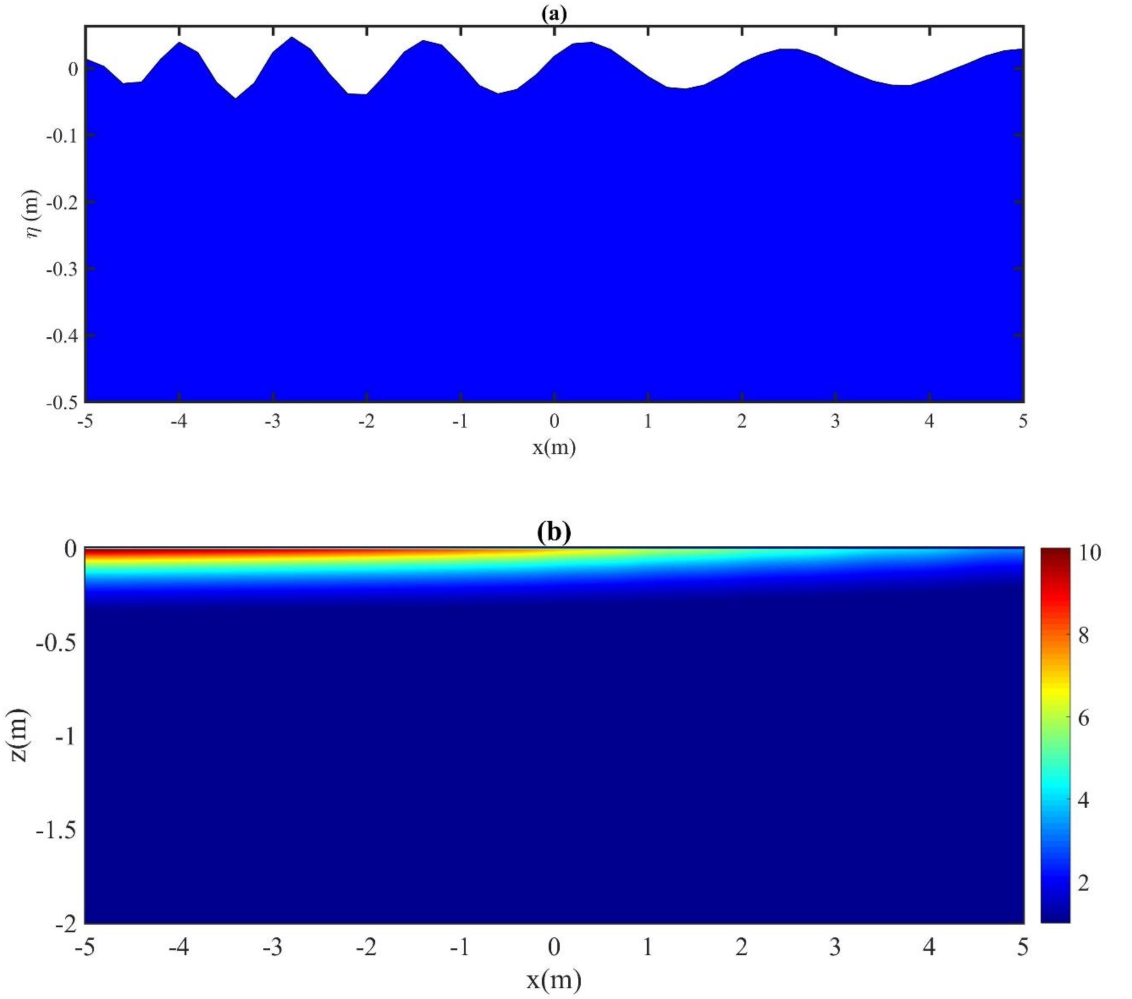


Figure 12. A plot of residual pore water pressure normalized by initial effective vertical stress with depth at time, t=50.125 seconds (liquefaction if ratio >1) (a) Water surface (b) Normalized residual pore water pressure

Project Motivation – Wave Tank Bed Response to Hydrodynamic Loading

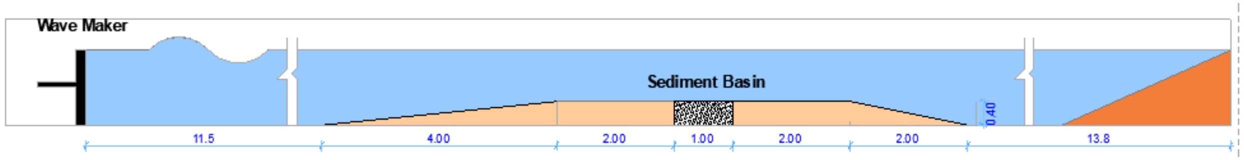


Figure 1. A layout showing locations of the Pore pressure sensor (*Dimensions are in m. Not to Scale*)

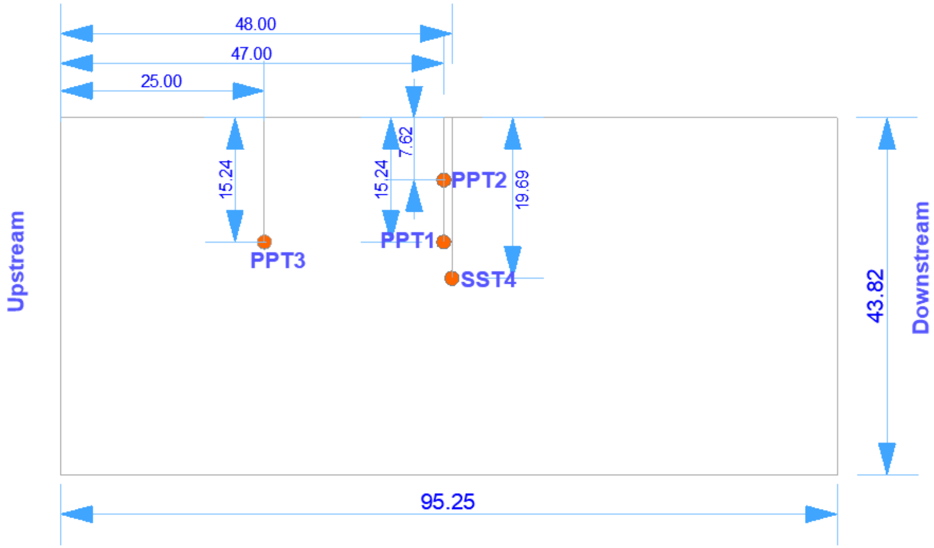


Figure 2. A layout showing locations of the Pore pressure sensor (*Dimensions are in cm. Not to Scale*)

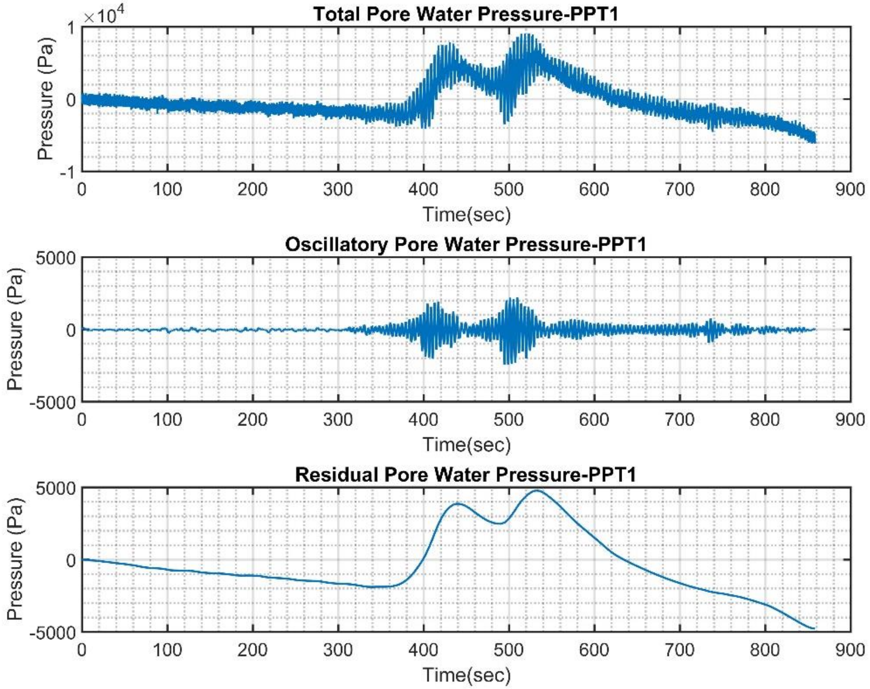


Figure 7. Measured pore water pressure time series at a depth of 0.15 m *(Test 1: Measured by PPT1)*

Project Motivation – Scale Modeling of MSE Wall Response to Hydrodynamic Loading

- Previous MSE Wall Stability Modeling (BDK75 977-22).
  - Centrifuge tests able to model MSE wall stability at 1/40th scale
  - Internal miniature sensors for total stress demonstrated
- Wave loading on bed demonstrated in centrifuge tests at similar scales.
- Incorporation of miniature pore pressure sensors and fiber optic to capture backfill and bearing bed stresses and high resolution strains (mm).

Project Tasks

- Task 1: Background and Case History Review
  - Collect design and forensic data on coastal MSE wall failures from tropical storms
  - Collect hydrodynamic data pre, during, and post storms
    - NOAA-NDBC and IOOS HF Radar wave data
    - FL agencies and universities
  - Collect bathymetry data

- Task 2: Predictions of MSE wall stability
  - Use models (WAVEWATCH/FUNWAVE or SCHISM, FLAC3D)
  - Hydrodynamic loading per model and AASHTO guidelines (Level I and III)
  - Account for oscillatory and residual pore pressure effects on backfill and bearing soil contact stress

Project Tasks

- Task 3: Centrifuge Test Program
  - 2-3 model MSE wall configurations exposed to:
    - Surge of varying velocity and depths
    - Waves of different periods and heights
    - Combined surge and waves expected to introduce instability
  - 2-3 MSE walls with wave attenuation facades under hydrodynamic loading
    - Test depth and porosity of facades (e.g., gabions) and measure incident, reflected, and transmitted waves
    - Test use of new backfill materials to resist hydrodynamic loading, pore pressure build up, as well as internal and external stability

- Task 4: Analysis of Experimental Results, Comparisons, and Recommendations for Design

Thank You!