FAMU-FSU
College of Engineering

DEPARTMENT OF
CIVIL & ENVIRONMENTAL
ENGINEERING

Resiliency of MSE Wall to Surge and Wave Loading (BED30 977-15)

Principal Investigator: Scott Wasman, PhD

Project Manager: Rodrigo Herrera, P.E.

GRIP Meeting

August 16th, 2024

Presentation Outline

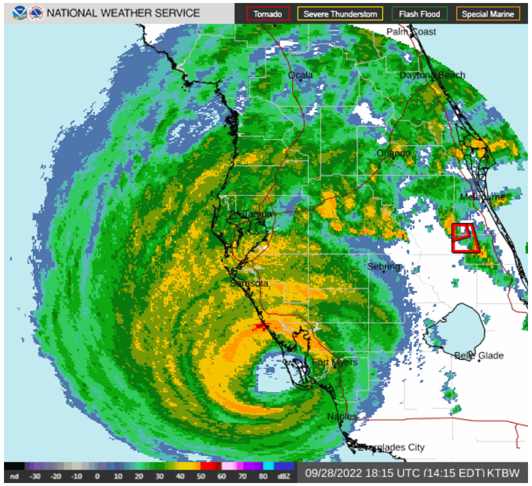
- Introduction
- Background
- Project Tasks
- Project Timeline

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

Project Background

- Hurricane Ian struck Florida’s southwest coast 9/28/22:
  - 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).
  - Struck shortly after high tide (+2.5 ft) and with 15 in. of rain.



Background

- **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 (1/100 likelihood of occurrence in any given year), and it may not capture the current observed frequencies of extreme 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.

Background

- 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 has been 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 Objectives

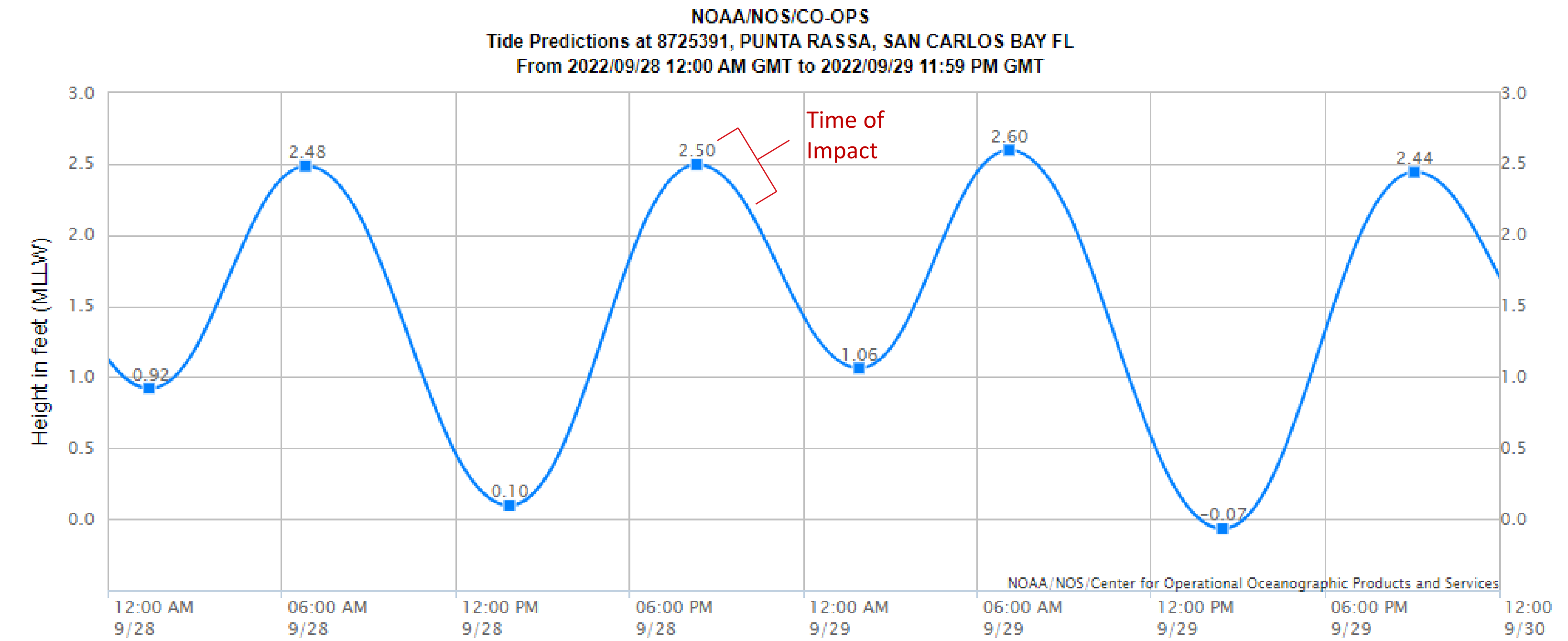
- Review of literature, reports, AASHTO and USACE design guidelines
- Collect hydrodynamic data and shoreline bathymetry
- Collect MSE wall information for those that failed during Hurricane Ian
- Identify the mode of failure of the MSE walls under hydrodynamic storm surge and wave loading
- Study effective remediation measures to increase their reliability (reduce probability of failure)

Project Objectives

- Conduct model tests of representative MSE wall cases subjected to storm surge and loading using numerical models and centrifuge model experiments
- In centrifuge experiments, measure: hydrodynamics (wave heights and currents), hydrodynamic loading on the model MSE walls, wall displacements and pore pressure in soil
- Test remediation measures that include larger mean particle size of the backfill and test external porous protection elements
- Based on experimental findings make recommendations for design revisions and remediation measures of existing MSE walls

Task 1: Review of Prototype MSE Wall Design, Hydrodynamic Data, and Literature

Hurricane Ian – Predicted Tide

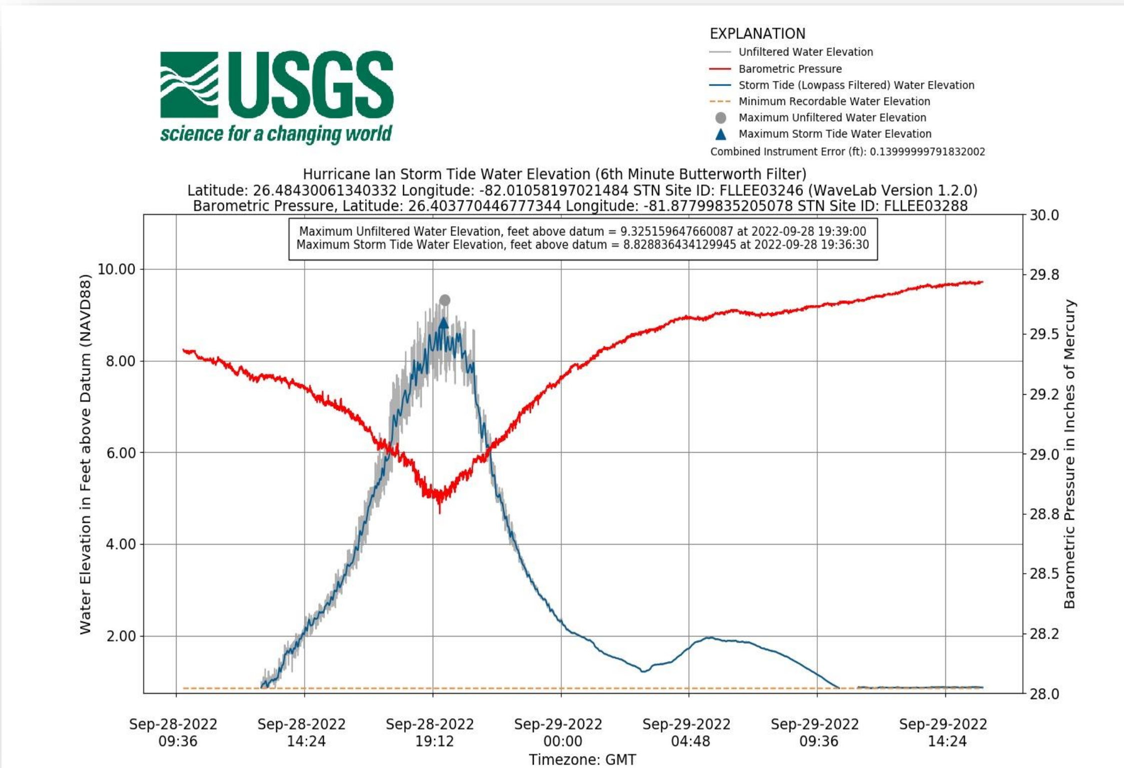


Note: The interval is High/Low, the solid blue line depicts a curve fit between the high and low values and approximates the segments between.
Disclaimer: These data are based upon the latest information available as of the date of your request, and may differ from the published tide tables.

By: Kisan Patel, P.E. and Andrew Newman, P.E.
FDOT Districts 1 and 7 Materials Office

Task 1: Review of Prototype MSE Wall Design, Hydrodynamic Data, and Literature

Hurricane Ian – Measured Storm Surge



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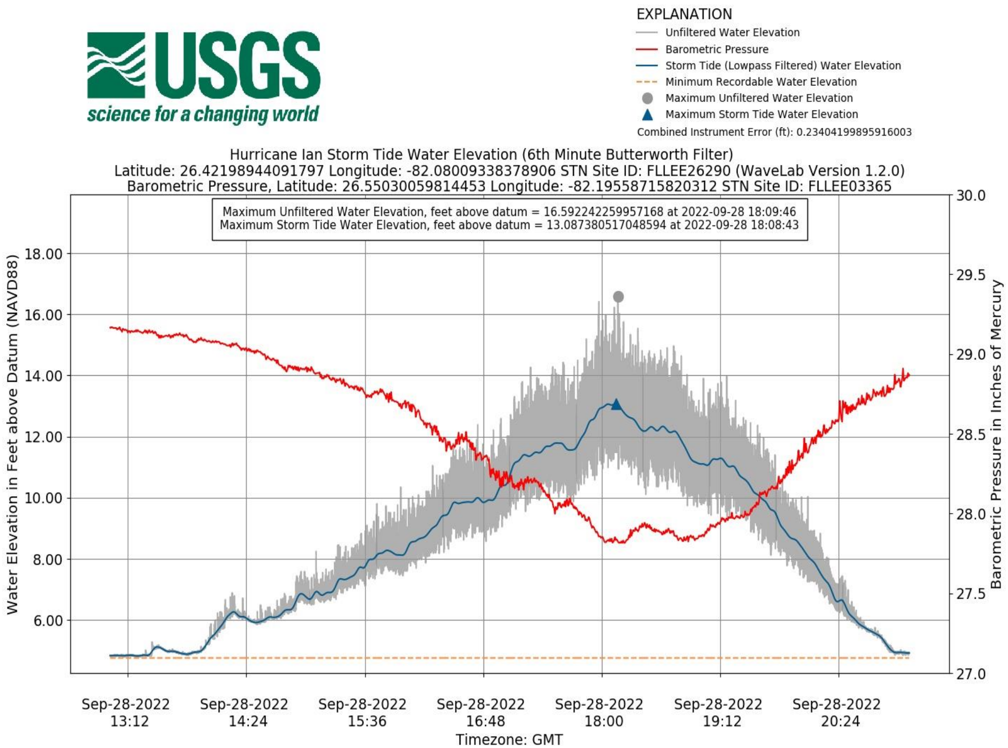

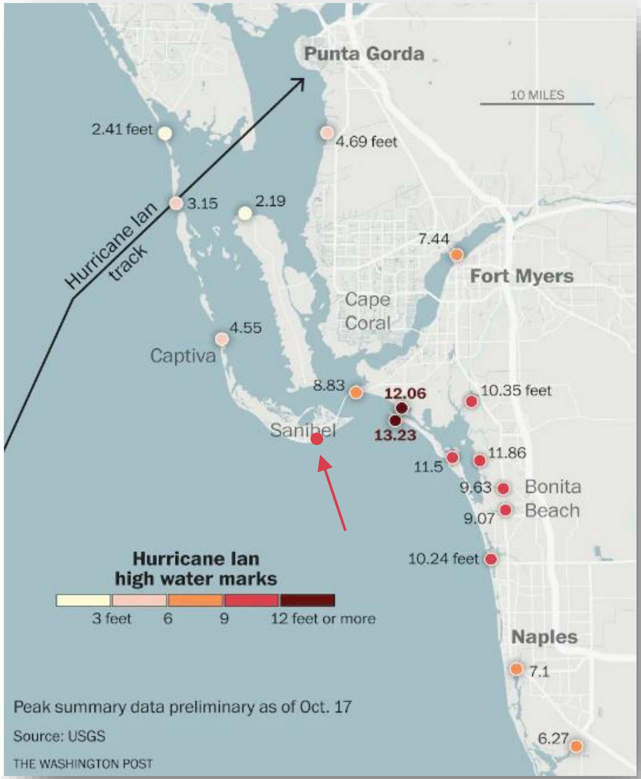

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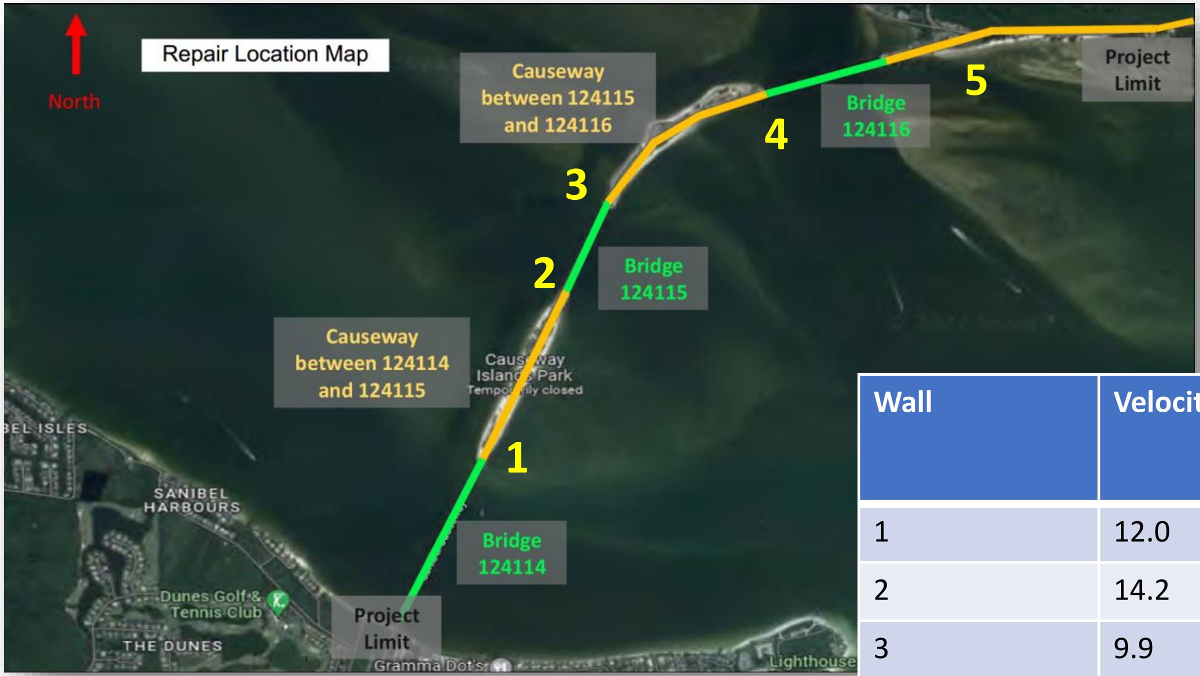
Task 1: Review of Prototype MSE Wall Design, Hydrodynamic Data, and Literature

Impacted Area - Sanibel Causeway Bridges and Islands



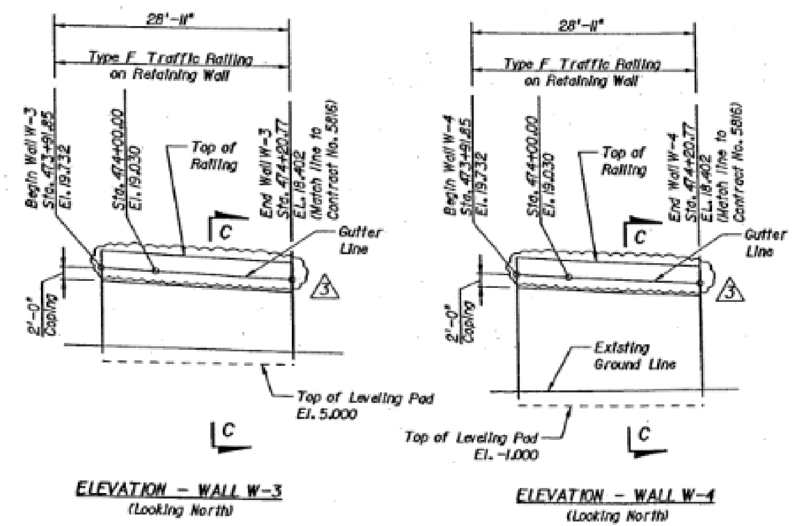
Wall	Velocity (ft/s)	Significant Wave Height (ft)	Peak Period (sec)
1	12.0	6.1	4.1
2	14.2	6.5	4.8
3	9.9	7.2	4.7
4	9.6	7.9	5.1
5	14.5	6.9	5.1

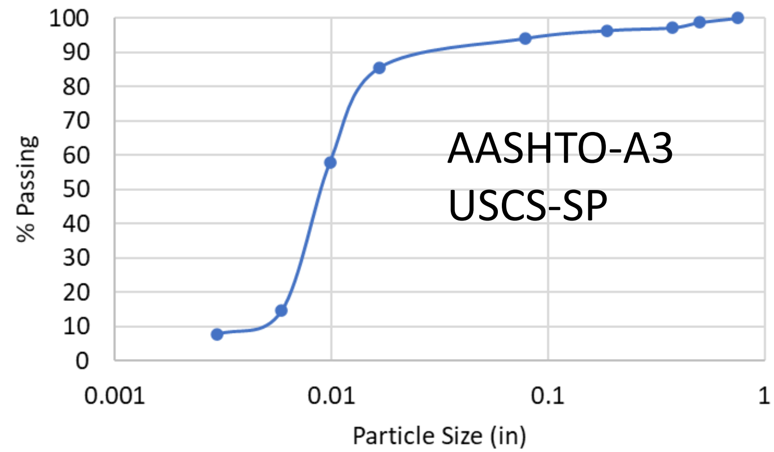
Task 1: Review of Prototype MSE Wall Design, Hydrodynamic Data, and Literature

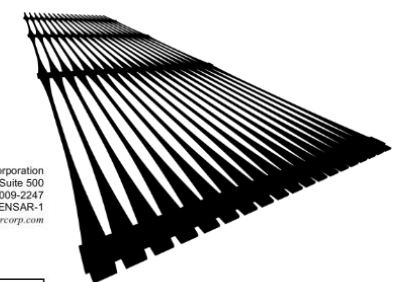
Impacted Area - Sanibel Causeway Bridges and Islands

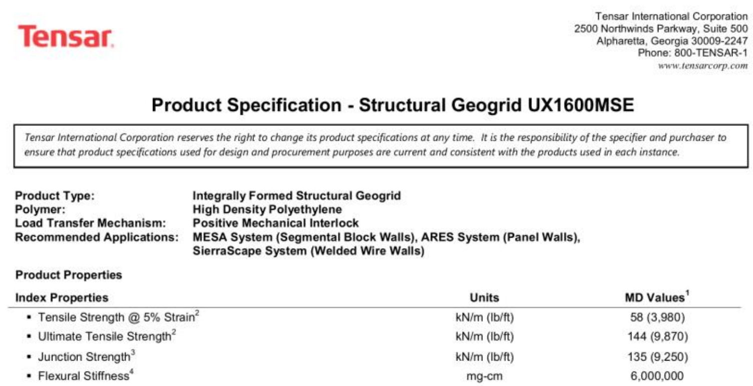
Task 1: Review of Prototype MSE Wall Design, Hydrodynamic Data, and Literature

- Prototype MSE wall parameters









Tensar

Tensar International Corporation
2500 Northwinds Parkway, Suite 500
Alpharetta, Georgia 30009-2247
Phone: 800-TENSAR-1
www.tensarcorp.com

Product Specification - Structural Geogrid UX1600MSE

Tensar International Corporation reserves the right to change its product specifications at any time. It is the responsibility of the specifier and purchaser to ensure that product specifications used for design and procurement purposes are current and consistent with the products used in each instance.

Product Type: Integrally Formed Structural Geogrid
Polymer: High Density Polyethylene
Load Transfer Mechanism: Positive Mechanical Interlock
Recommended Applications: MESA System (Segmental Block Walls), ARES System (Panel Walls), SierraScape System (Welded Wire Walls)

Product Properties

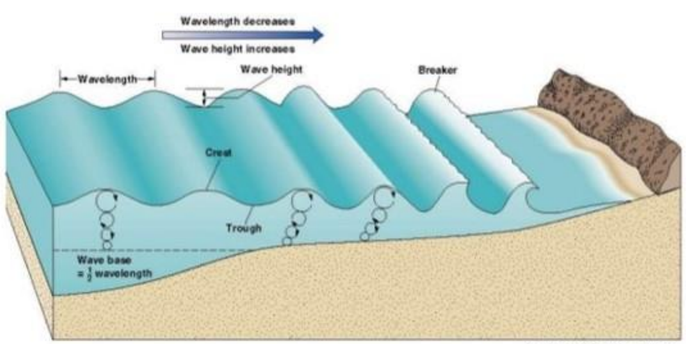
Index Properties	Units	MD Values[1]
• Tensile Strength @ 5% Strain[2]	kN/m (lb/ft)	58 (3,980)
• Ultimate Tensile Strength[2]	kN/m (lb/ft)	144 (9,870)
• Junction Strength[3]	kN/m (lb/ft)	135 (9,250)
• Flexural Stiffness[4]	mg-cm	6,000,000

Task 1: Review of Prototype MSE Wall Design, Hydrodynamic Data, and Literature

- Review design guidelines and previous events
  - AASHTO specifications for bridges vulnerable to coastal storms includes recommendations for estimating horizontal and vertical wave forces associated with intact and breaking waves and direct currents
  - USACE Coastal Structures manual includes methods and approaches for estimating non-linear hydrodynamics and scour
  - Post storm observation data collected through NSF program – data exists for about a dozen storms
  - Hydrodynamic data varies and only recently has the coastal environment storm observations started

Task 2: Experimental Design and Numerical Model Predictions

- Numerical models will help to inform the centrifuge container and model designs
- Use models to study hydrodynamic loading (ADCIRC/WAVEWATCH and FUNWAVE and MSE wall system response (FLAC3D)



https://fengyanshi.github.io/build/html/index.html

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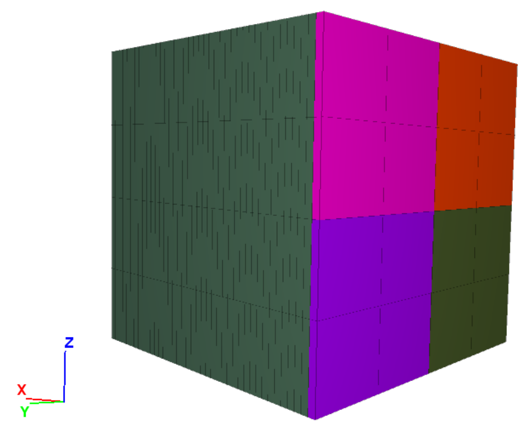
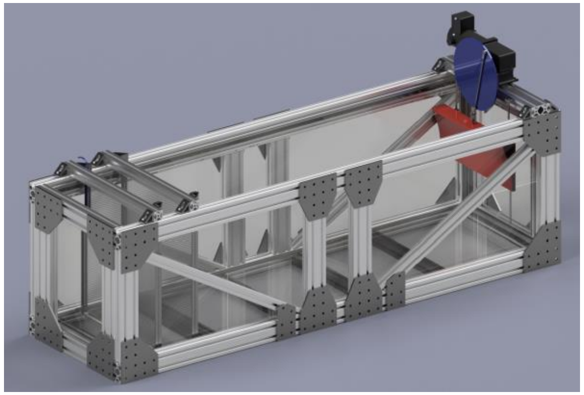


FUNWAVE-TVD Near shore wave and current model

FLAC 3D model of MSE Wall section

Task 3: Centrifuge Tests of Model MSE Walls Exposed to Hydrodynamics

- Centrifuge Test Program
  - 2-3 MSE wall pre-storm configurations
  - 2-3 MSE walls with new internal and external higher permeability and dissipative features
- ERDC GSL Centrifuge
  - 8.8 tons capacity
  - 10 – 350 Gs
  - 4.25 ft X 4.25 ft payload platform



Centrifuge model flume container (67 inches (L) x 16 inches (W) x 16 inches (H)) with wave maker (red plunger and DC gear motor)

Three meter radius centrifuge at the US ERDC GSL

Task 4: Comparison Analysis Between Experiments and Predictions with Recommendations for Mitigation and Design

- Measurements and results of the Task 3 work will be summarized and used to calibrate numerical models if necessary
- In particular the hydrodynamic conditions that induce instability in the MSE wall models will be identified and defined in terms of ultimate and factored limit states
- Comparisons to existing design guidelines (AASHTO and USACE) will be made followed by recommendations for revisions
- Recommendations for remediation measures of existing MSE walls will be made based on the Task 2 and 3 findings

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Project Timeline

Deliverable # / Description of Deliverable as provided in the scope (included associated task #)	Anticipated Date of Deliverable Submittal (month/year) Proposed start date:
Kickoff teleconference	June 2024
Task 1, Deliverable 1: Review of Prototype MSE Wall Design, Hydrodynamic Data, and Literature	Oct. 2024
Task 2, Deliverable 2: Experimental Design and Numerical Model Predictions	March 2025
Task 3, Deliverable 3: Centrifuge Tests of Model MSE Walls Exposed to Hydrodynamics	Nov. 2025
Task 4, Deliverable 4: Comparison Analysis between Experiments and Predictions with Recommendations for Mitigation and Design	March 2026
Task 5, Deliverable 5a: Draft Final Report	April 2026
Task 5, Deliverable 5b: Closeout Teleconference	May 2026
Task 6, Deliverable 6: Final Report	July 2026

Thank You!