Rapid screening of partially submerged coastal structure designs using Boussinesq numerical modeling

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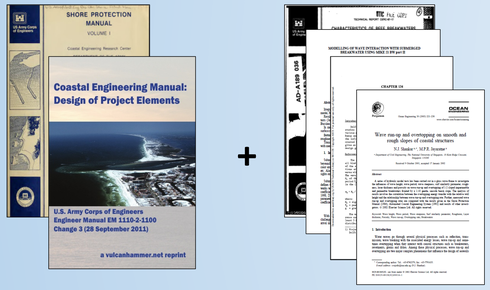
Problem

- Coastal structures are vital for navigation, shore protection, and beach stabilization.
- There is rarely enough time, money, and resources to execute screening of structure design alternatives or robust assessment of wave-structure interactions
- Existing guidance is outdated and limited in range of applicability in modern applications



Objective

To enhance the transition of structure design materials and their respective porosity (transmission), reflection, and absorption properties directly and seamlessly into a phase-resolving nearshore wave modeling framework

Impact

- Connect planning and design strategies with high-fidelity numerical modeling practices to:
  - Improve management and design
  - Increase reliability of actions
  - Reduce or minimize maintenance, rehabilitation, and operating costs

Approach

- Focus on single, trapezoidal breakwater
- Evaluate the following wave responses:
  - Wave reflection and absorption
  - Wave run-up and overtopping
  - Wave transmission
- Simulate permutations of structure design and wave climate characteristics
- Verify responses with existing literature
- Three methods for incorporating coastal structures in FUNWAVE numerical domain
  - Modify existing bathymetry
  - Add partially absorbing/reflecting 'sponge' layer
  - Combination of both (layering)

Structure Design Properties

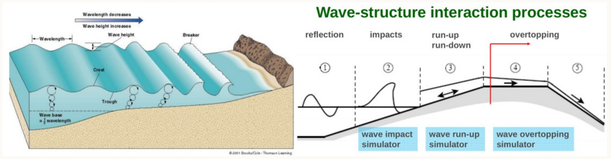
Height (freeboard)	Surface	Porosity
Emergent	Smooth	Permeable
Submerged	Rough	Impermeable

Wave Climate Properties

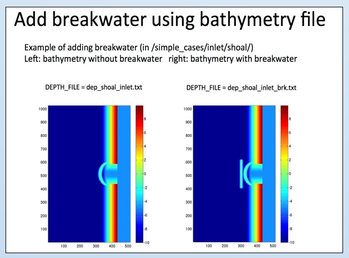
Wave Type	Dimension	Wave Period
Regular (Monochromatic)	1D	Short
Irregular (TMA Spectra)	2D normal 2D oblique	Long

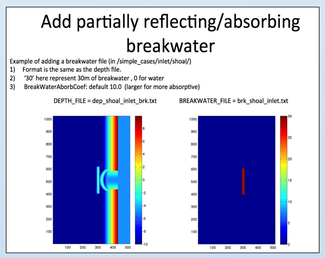
FUNWAVE

- Fully nonlinear Boussinesq phase-resolving numerical wave model in intermediate and shallow water



- Can resolve wave-induced nearshore processes:
  - Breaking
  - Shoaling
  - Reflection
  - Diffraction
  - Refraction
  - Run-up
  - Overtopping
  - Infragravity waves
  - Nonlinear interactions





Next Steps

- Prepare, execute, and troubleshoot simulations
- Provide deterministic guidance on:
  - Amount of wave energy dissipation provided by the structure
  - Wave run-up exceedance probability
  - Wave overtopping rate in extreme scenarios
- Provide modeling guidance on FUNWAVE Wiki
- Future considerations include:
  - Alternate structure configuration (multiple structures)
  - Validation with physical models (NNBF materials)
  - Expansion of FUNWAVE DoD Portal Application

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