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

Marissa J. Torres¹, Matt Malej², Michael-Angelo Y. Lam²

¹Cold Regions Research & Engineering Laboratory, U.S. Army Engineering Research & Development Center, Hanover, NH 03766
²Coastal & Hydraulics Laboratory, U.S. Army Engineering Research & Development Center, Vicksburg, MS 39180

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- Existing guidance is outdated and limited in range of applicability in modern applications.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

<table>
<thead>
<tr>
<th>Height (freeboard)</th>
<th>Surface</th>
<th>Porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent</td>
<td>Smooth</td>
<td>Permeable</td>
</tr>
<tr>
<td>Submerged</td>
<td>Rough</td>
<td>Impermeable</td>
</tr>
</tbody>
</table>

Wave Climate Properties

<table>
<thead>
<tr>
<th>Wave Type</th>
<th>Dimension</th>
<th>Wave Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td>1D</td>
<td>Short</td>
</tr>
<tr>
<td>Irregular (TMA Spectra)</td>
<td>2D normal</td>
<td>Long</td>
</tr>
</tbody>
</table>

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