SimCenter Community Roundtable
"High-Fidelity Modeling of Wave-Induced Forces and Structural Response"

November 25, 2024

This SimCenter Community Roundtable meeting was organized by the **Working Group on Wind and Water Simulation**. Invited speakers presented advances in high-fidelity modeling, and discussion with attendees followed.

Advances in regional scale modeling of tsunami and storm surge have provided interested stakeholders with tools to estimate flow conditions at critical locations. These tools have enabled engineers and community leaders to provide guidance to residents on the hazard risk and develop generalized approximations of the fluid and debris induced forces using fundamental principles of fluid statics and dynamics. For critical structures (e.g., evacuation towers), new advances in coastal hazard modeling allow designers to develop more comprehensive loading profiles and better understand the interactions between the flow and an individual structure or even individual structural components. As interest in these problems grows, fluid modelers are applying a number of disparate approaches to solving various components of the complex fluid-debris-structure interaction phenomena. In this community roundtable, invited speakers will present several different approaches to this problem and how engineers may be able to leverage these new capabilities for improved predictions for load and response, followed by community discussion of the associated challenges in extending these models for broader application.

Moderators: Mike Motley, University of Washington
Catherine Gorle, Stanford University

Presentations and Key Ideas

1. **"Loads and effects of Extreme Flow Condition Along Shore Lines and on the Built Environment"**
   Presenter: Nils Goseberg, Technische Universität Braunschweig, Germany.
   The presentation highlighted challenges of tsunami modeling in the lab and emphasized the need to accurately model what is seen in the field. These challenges are related to debris impact modeling and modeling uncertainties for elevated buildings.

2. **"When does Fluid-Structure Interaction Matter?"**
   Presenter: Barbara Simpson, Stanford University.
   Addressed the challenges associated with real-time hybrid simulation, particularly similitude conditions relevant to the impact of wind and wave forces on structures. The discussion emphasized the broader objective of scaling small-scale experimental facilities and accurately simulating complex systems governed by multiple physical phenomena.

3. **"Tsunami-like Wave impacts on Coastal Structures"**
   Presenter: Andrew Winter, University of Washington.
   The presentation highlighted several research projects undertaken by the team to simulate wave-structure interactions. These studies primarily focused on validation efforts utilizing computational fluid dynamics (CFD) to investigate fluid-structure interactions (FSI), with an emphasis on modeling tsunami impacts on coastal structures.

Discussion Highlights

- The coastal engineering community is looking to characterize two primary items:
  - (i) Characterizing the extremities of hazard events relative to building inventories. This includes characterizing building inventories not fully accounted for (e.g. Nils' mentioned unique foundation types for single-story wood buildings in Japan, Andrew talked about shielding effects in simulated ports). It

also includes the collapse of structures and production / advection of the debris into buildings and lifelines. Need adaptable twins.

- (ii) Understanding similitude laws. While scaling based on Reynolds and Froude numbers (i.e. gravity, inertial, and viscous forces) is well understood, we do not understand Cauchy / Mach, Weber, and Euler scaling as adequately (i.e. elastic forces / speed-of-sound, surface-tension forces, bulk pressure forces). These are critical in prototype events with huge impact forces (e.g. tsunamis, debris impacts) and flume model events with surface tension effects (i.e. flume tests done at < 1:50 Froude scale typically, especially when debris are present). Further, constitutive similitude is critical for the study of damage, collapse, and debris generation as it affects the scaling of nonlinear material laws present in wood, concrete, soils, etc., which MPM tackles.

More Information

Additional SimCenter Community Roundtable meetings can be found at https://simcenter.designsafe-ci.org/collaborate/scr/.

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