Research Project Highlight

Tsunami Debris: Simulating Hazard and Loads

Project # 1140-NCTRLY

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Start-End Dates:
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Abstract
Port facilities are among the most vulnerable to tsunami hazards. Even a relatively small tsunami causing limited or no inundation locally could greatly impact port operations through strong currents. Large vessels, when pulled from their berths by the tsunami currents, become "extraordinary debris," causing severe damage to any structure they might impact. With a reasonable handle on tsunami-induced current modeling in ports, it becomes feasible to accurately predict both the generation and transport of debris. It is the main goal of this proposed project to develop, validate, and apply transport models for various types of debris inside ports, such that both the probability of debris impact as well as the magnitude of debris loading can be quantified. For this research area, we divide the debris transport modeling studies into two categories: (1) detailed 3D simulation of the flow around a single large object; and (2) two-horizontal-dimension (2HD) simulation of a large volume of debris through port-sized domains. These two approaches represent a means to answer research questions on two different scales. The 3D simulation permits the quantification of the detailed pressure distribution around an object or structure, which then allows for a proper design in response to these loads. In the 2HD study, we aim to understand the combined and coupled dynamics of a tsunami churning through a port with a temporally increasing debris field. The debris field includes objects with length scales typical of cargo shipping containers, small boats, and vehicles to understand the impact of the debris on the flow field and the potential to impart loads on structures.

Deliverables
A PEER report and several conference and journal papers describing the simulation methodology and results will be provided. The PEER report will also include a summary of the workshop outcomes.

Research Impact
Advances in this area are greatly in need, as existing approaches for debris loading (e.g. Chapter 6 of ASCE7-16) are shockingly crude and often highly conservative. Indeed, as the ASCE7 tsunami subcommittee begins to organize for ASCE7-22 revisions, early discussions indicate that the debris loading section will undergo significant revision. The research proposed here would likely be the main guide for determining how to change the section. In the short term, the ability to predict debris transport

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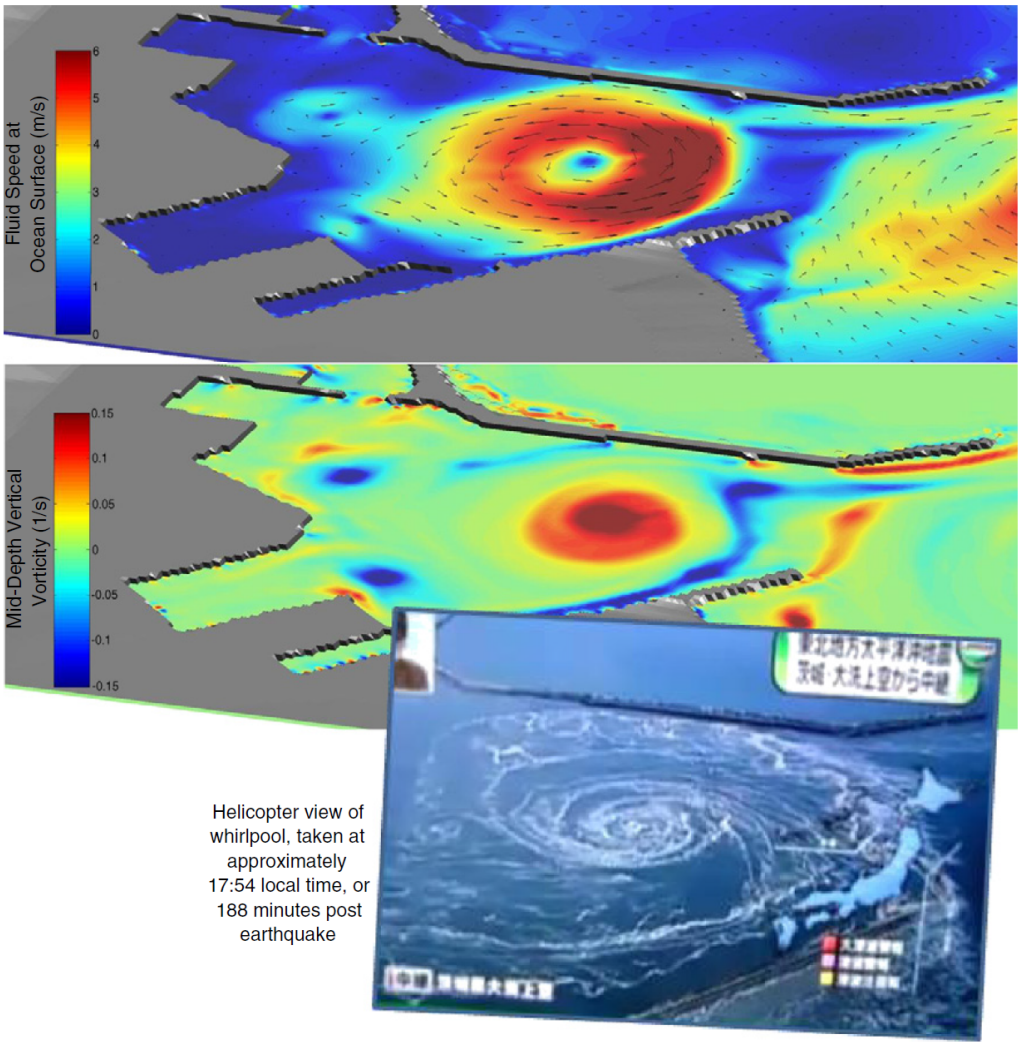
in ports, and the detachment and drifting of large vessels has immediate application. Scenario simulations will be performed at major ports along the U.S. West Coast (i.e., San Diego, LA/LB, Oakland/Richmond, and Seattle/Tacoma) to both visualize and quantify debris effects. Finally, a workshop will be organized to demonstrate the need to recognize the tsunami debris hazard, and to show stakeholders how to use the developed tools to estimate local impacts. Industry in the energy and cargo sectors, as well as the Navy, Coast Guard, and port/harbor commissions will be brought together in the workshop, and will be shown the potential of these hazards in their local ports.



Numerical model results of the Tohoku tsunami in the Port of Oarai. Snapshots are from 188 minutes after the earthquake: (top) fluid speed, (middle) vertical vorticity at mid-depth, and (bottom) aerial image of the rotational feature at approximately the same time.

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