Impact of tsunami waves on structures

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Introduction

The word tsunami comes from the Japanese words “tsu” and “nami” which translates directly to “harbour wave”. A tsunami is a series of waves that are created by the displacement of a large volume of water. This displacement is usually caused by an earthquake that occurs offshore, beneath the surface of the ocean seafloor.

Most Recent Tsunami Disasters

• 2004 Indian Ocean Tsunami
• 2010 Chile Tsunami
• 2011 Japan Tsunami

In order to accurately represent the effects of a tsunami, a large scale experiment would require massive additional costs. These costs can be avoided through the use of a numerical model. The scope of this work is to focus on smoothed particle hydrodynamics (SPH) to numerically model and reproduce several physical experiments.

Methodology

Traditionally, numerical wave modelling is done using the Eulerian approach in which a mesh or grid is involved. These methods however have computational drawbacks. SPH is a Lagrangian based approach that represents a fluid through individual particles each having their own specific properties.

SPHysics Model

SPH is a mesh-free method that avoids computational deficiencies prevalent in grid-based methods.

Mesh Method SPH Method

The physical experiment considered for this research was conducted by Ramsden in 1996. Ramsden’s experiment focused on the impact of a hydraulic bore on a vertical surface. The bore was created by the breaking of a solitary wave that was generated using a piston-type wave maker. After the model is run, a comparison of results is made to the physical experiment in order to determine the model’s accuracy.

Results

In this stage of the experiment the wave is just starting to form and the wave height ratio (h_b/h_a) at the point indicated by the yellow arrow in Figure 1 is 0.288. The wave-height ratio is a means to measure a wave by relating the water depth to the amplitude of the wave. Breaking of the wave will commence when this ratio exceeds a value of 1. The value obtained in Ramsden’s physical experiment was 0.283.

Conclusions

The SPH numerical model was used to represent the Ramsden’s (1996) physical experiment. The model was shown to be fairly accurate however it still requires some minor “tweaking”. By improving the numerical model, this work can contribute to the development of design guidelines and building codes for tsunami-resistant infrastructure. Future work could include reproducing the experiment on a larger scale which would be more applicable to a real-world tsunami scenario.

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