# Development of Performance Based Tsunami Engineering, PBTE

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## Summary

In 2005, the US National Science Foundation funded a project through the Network for Earthquake Engineering Simulation to develop Performance Based Tsunami Engineering, PBTE. The primary objective of this study is the development of design guidelines and computational tools that can be used by engineers to design coastal structures to resist tsunami loads. This involves improved inundation and scour modelling, as well as determination of structural loading time histories and loading expressions for use in structural design. This paper presents preliminary results for some of the laboratory experiments performed to determine tsunami bore loading on structural components. In particular, results are presented for the effects of multiple column arrangements that are typical for the ground floor layout of a multi-storey coastal building.

**Keywords:** Tsunami inundation, tsunami bore, wave loading, building design.

## 1. Introduction

Coastal buildings, bridges, highways, and harbour facilities that are at risk of tsunami inundation may suffer significant damage if the structures are not adequately designed for the fluid loading. Ref. [1, 2] document damage from scour and fluid loading from the 2004 Great Indian Ocean Tsunami. The structural damage is strikingly similar to what can happen from hurricane storm surge and waves [3, 4]. Damage to structural floors from fluid forces as a result of Hurricane Katrina is shown in Figure 1. Although there are some clear differences between the damage mechanisms of tsunami and hurricane surge/waves, there are also clear similarities in the damage.

The quantification of wave impact forces on structures has received significant attention over the years. The work can be categorized into three areas. Probably one of the most studied is the issue of storm wave impact on offshore platforms. A sampling of work, spanning experimental and numerical attempts to develop design formulas for the loads, can be found in [5, 6]. The second area is storm wave breaking on coastal structures, especially seawalls and breakwaters [7-10]. Much less studied are the forces resulting from tsunami bores/surges hitting coastal structures [11-14].

Tsunami engineering, the focus of a 2007 special issue of the ASCE *Journal of Waterway, Port, Coastal and Ocean Engineering*, was defined therein as ‘those activities that are significant for the engineering goal of designing and protecting the built environment and the people that dwell therein, with regard to potential tsunami hazards’ [15]. While this has received more attention recently, designers of onshore facilities typically have very little experience and receive very little guidance in tsunami induced loads that should be considered for bridge and building design [16, 17]. In addition, the simulation of these loads is very complex and it pushes the state-of-the-art in computational fluid dynamics (CFD).

The US National Science Foundation (NSF) has initiated a program to improve the understanding of tsunamis and their threat to the built environment. One aspect of this initiative is the funding of the NSF Network for Earthquake Engineering Simulation (NEES), which includes Oregon State University’s (OSU) Tsunami Wave Basin, shown in Figure 2. The rectangular basin is 48.8 m x 26.5 m x 2.1 m. The maximum water depth is 1.3 m, resulting in a freeboard of 0.8 m. The wave

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