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Response of Coastal Structures against Seismic and Tsunami Forces

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ABSTRACT

In the event of a major submarine earthquake, not only severe ground shaking but also high tsunami waves are expected posing a significant threat to coastal community and structures. Apart from having a sound warning system, it is necessary to design and construct Earthquake and Tsunami-Resistant (ETR) shelters for the evacuees as a part of civil protection measures during such mega events. In this paper three typical structures are chosen and forces against different types of earthquakes and tsunamis are calculated. From the investigations, a useful guideline is evaluated for determining the depth of inundation where both the forces will be of equal magnitude.

KEY WORDS: Earthquake; tsunami; shelter; time period; base shear; inundation depth; and hydrodynamic force.

INTRODUCTION

Past history and geological evidences reveal that great earthquakes are considered to occur at tectonic plate boundaries, particularly along the coastal belts that rim the Pacific and Cross Southern Asia. On 26th December, 2004, Indonesian submarine earthquake generated catastrophic tsunamis killing more than two lakh people and created a major economic impact on the countries surrounding the Indian ocean. Such mega events reminded the coastal community alert on the preparedness against initial ground shaking and subsequent effects followed by tsunamis. As most of the tsunamis are earthquake induced tsunamis, it is necessary that coastal structures should be designed against both earthquake and tsunami loads. Seismic and Tsunami resistant analyses are complicated as the motion is transient and the forces are time dependent. Though there are no well established design procedures for tsunami resilient buildings, FEMA CCM provided some guidelines based on the considerations of tsunami forces. A review by Harry Yeh, Ian Robertson and Jane Preuss(2005) suggested that fluid forces exerted on a structure can be evaluated in terms of hydrodynamic and impact forces for a given depth of inundation and the velocity of the approaching tsunami. Okada et al. (2005) have proposed an empirical method for estimating the forces exerted on structures by tsunami overland flow assuming that seaward face of the building will be loaded by a hydrostatic pressure based on an immersion depth of three times the design inundation depth, with no load on the landward face of the structure. Thio.H.K, Ichinose.G. and Somerville.P.(2005) described a method of probabilistic tsunami hazard analysis.

Tsunami forces reportedly altered the topography in certain regions and strongly warned the community particularly along the Indian coast and Andaman and Nicobar (A&N) Islands. Even though tsunamis can not be averted, their after effects could be mitigated with Early Warning Systems.

Apart from having a sound warning system, important protection measures like providing ETR shelters, overhead water tanks for supply of drinking water to the evacuees and preparedness for such disastrous events play a vital role.

The process of long-term planning and Civil Engineering research activity should raise to the occasion so that protection measures against earthquakes and tsunamis become ingrained in the designs.

CHARACTERISTIC FEATURES OF TSUNAMI

Tsunami events trigger a series of fast moving long waves, initially with low amplitude that radiate outwards in a manner resembling the waves radiating when a stone is dropped in a pond. Tsunamis are characterized with the following parameters:

i. Wavelength, the horizontal distance between crests or peaks
ii. Period, the time it takes successive peaks to pass a fixed point
iii. Height, the vertical distance from the wave trough to its crest.

In general, waves are considered as deep water waves if their wavelength is relatively small compared to the water depth through which they travel. Most of the wind waves are deep water waves. Shallow Water (SW) waves are those with long wave length relative to depth. The depth and nature of the sea floor strongly influence how SW waves propagate. Because tsunamis have such long wave lengths, even when traveling in deep water, they are considered as SW waves.

Tectonic Tsunamis tend to have longer wave lengths, longer periods