Probable Maximum Tsunami Along the Dutch Coastline

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ABSTRACT

A deterministic tsunami hazard assessment was conducted to estimate maximum water levels at a typical location on the Dutch coastline in the Province of Zeeland due to a tsunami event originating in the North Sea. Two source mechanisms were examined: earthquake-generated tsunamis and landslide-generated tsunamis.

Thirty-four tsunamigenic earthquakes located in or near the Sole Pit and the Viking Graben Basins were evaluated. The sea bottom deformation associated with the MCE, the 10,000 year return period earthquake based on the historical earthquake catalogue in the North Sea, was developed. The tsunami generation and propagation toward the Dutch coastline was estimated using a two-dimensional, depth averaged numerical model. For the simulation of the tsunami propagation, a coarse regional grid tsunami generation and propagation model was developed that covers the North Sea. Nested within this coarse domain is a high resolution local computational domain, developed to simulate flooding at the coastline.

The impact of a hypothetical landslide-generated tsunami wave of six meters at the northern boundary of the North Sea was also examined. The computed maximum water level caused by the hypothetical landslide-generated tsunami was higher than any of the computed maximum water levels due to earthquake-generated tsunamis.

KEY WORDS: Storegga Landslide; Sole Pit; Viking Graben; Delft3D

INTRODUCTION

Tsunamis are ocean waves generated either by large earthquakes, volcanic eruptions, or landslides that occur near or under the ocean (NOAA, 2007a). The maximum water level that is expected to affect a typical location along the Westerschelde Estuary in the Province of Zeeland, including tsunami wave run-up, due to any one of these phenomena is referred to as the PMT.

The design basis PMT includes adequate conservatism to ensure that critical infrastructure along the coast are protected against the potential effects of tsunami events. Hence in compliance with industry standards and regulations, the PMT water level accounts for the following components:

- Antecedent high water level;
- Increase in water level due to the tsunami waves;
- Wave setup generated by the two year return period wind speed occurring coincidently with the tsunami event; and
- Tsunami run-up on the shoreline or structure.

The design basis PMT could be determined using one of these two approaches: 1) a deterministic approach (i.e., numerical modeling and empirical equations) based on the physical characteristics of the fault area and/or the landslide; and 2) a probabilistic approach which is dependent on long representative record of tsunami events at the area of interest. Deterministic tsunami hazard studies, such as this paper, involve hydrodynamic modeling of tsunami propagation, run-up, and inland flood level from a particular source, usually defined as an earthquake, landslide, or another tsunami trigger. Risk assessment relies heavily on determining the probability that a tsunami of a certain size will be exceeded within a given time frame. Remote possibilities exist for a tsunami water level height to exceed the determined design tsunami height due to uncertainties regarding the tsunami phenomena (Sakai et al, 2006). These uncertainties could be evaluated by performing a PTHA, which also accounts for coincident storm effects (PG&CE, 2010). This combination may exceed the design basis tsunami. However, the beyond design basis tsunami is not part of the scope of this paper.

PTHA studies have been conducted on the western coastline of United States, including Alaska. However, probabilistic estimates of tsunami waves in the North Sea have not been conducted yet because of lack of tsunami run-up measurements. Deterministic estimates of tsunami waves have been conducted by leading British and German governmental agencies such as DEFRA and BSH.