NUMERICAL MODELING OF TSUNAMI GENERATED BY SUBMARINE AND SUBAERIAL LANDSLIDES

Arturo Jimenez, Moffatt & Nichol, ajimenez@moffattnichol.com
Oleg Mouraenko, Moffatt & Nichol, omouraenko@moffattnichol.com
Cheng-Feng Tsai, Moffatt & Nichol, ctsai@moffattnichol.com

INTRODUCTION

Tsunami triggered by landslides have proven to be greatly destructive to the coast (e.g. 1998 Papua New Guinea) and, in many coastal areas, to be crucial in the design of infrastructure and tsunami hazard mapping. Numerical models are the most widely used tool to study this type of tsunami. Some commercial coastal modeling software have added the ability to incorporate time- and spatial-varying ground elevations to model landslides. However, the evolution of the landslide must still be predefined in a way that is consistent with the physics of landslide motion.

Following published analytical methods, an approach was developed to generate time- and spatial-varying ground surface elevations that define subaerial and submarine landslide motion. The elevations can be used as input into a hydrodynamic model for tsunami generation.

METHODOLOGY

The primary component of the methodology is the description of the landslide parameters. The primary input parameters include the following:

- Landslide length, width, and thickness;
- Horizontal travel distances, direction, and slopes along subaerial and submarine paths;
- Parameters of friction between moving landslide and ground

The methodology assumes that the landslide has a semi-elliptical shape, which is preserved during movement.

For the subaerial landslide, the work of Heller (2009) was adopted to relate the impulse wave characteristics upon impact to the landslide parameters. The impact velocity at the water surface is:

$$V_S = \sqrt{2g\Delta z_{SC}(1 - \tan\delta \cot\alpha)} \qquad (1)$$

Where g is the gravitational acceleration, Δz_{sc} is the drop height of the center of gravity of the slide, δ is the dynamic bed friction angle, and α is the downslope subaerial angle.

For the submarine movement, the work of Watts (1998) was adopted assuming the landslide translates down a plain slope as a continuous mass of predefined shape. The landslide motion is defined by initial acceleration (a_0) and a terminal velocity (u_t):

$$a_0 = \frac{\gamma-1}{\gamma+C_m} g \sin\alpha_m \qquad (2)$$

$$u_t = \frac{\sqrt{\pi g B(\gamma-1)\sin\alpha_m}}{2C_d} \qquad (3)$$

Where γ is the landslide specific gravity, α_m is the average bed slope, C_m is the added-mass coefficient, B is the slide length, and C_d is the drag coefficient.

Figures 1 and 2 present examples of generation of submarine and subaerial/submarine landslides, respectively, used as input into MIKE 21 hydrodynamic model.

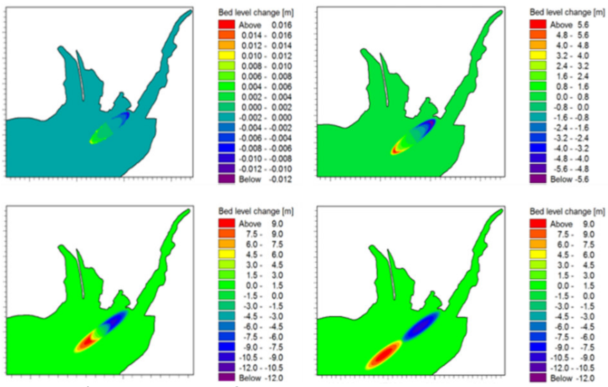

Figure 1 - Example of submarine landslide generation

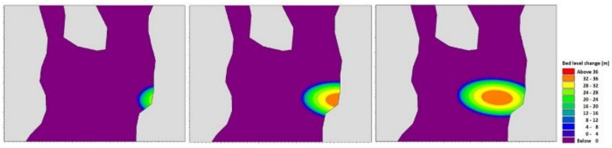

Figure 2 - Example of subaerial/submarine landslide generation

APPLICATIONS

The developed approach is used to model subaerial and submarine landslide-generated tsunami in a practical way suitable for coastal engineering projects. Sample applications of the approach for modeling of historic events and recent projects will be shown. In addition, a sensitivity analysis of the landslide parameters will be presented to illustrate their effect on tsunami generation.

REFERENCES

Heller, Hager, and Minor (2009): Landslide Generated Impulse Waves in Reservoirs - Basics and Computation, Zürich, Switzerland.

Watts (1998): Wavemaker Curves for Tsunamis Generated by Underwater Landslides, Journal of Waterway, Port, Coastal, and Ocean Engineering, vol. 124, Issue 3.