



## **Run-up generated by three-dimensional sliding masses**

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This investigation is directed to a better understanding of the water waves generated by partially aerial and submarine landslides. It has become apparent in recent years that there may be a serious threat due to tsunamis generated near the shoreline by massive underwater landslides. For example, in Skagway, Alaska in 1994 a large underwater landslide generated waves that caused several million dollars damage to harbor facilities and killed one person. This took place during construction of a new cruise ship wharf. If it had occurred when a ship had been moored and unloading passengers the results could have been catastrophic. A more recent event, which was indeed catastrophic, occurred in July 1998 in Papua New Guinea. More than 2000 lives were lost due to a tsunami associated with a relatively small (for tsunamis) earthquake of magnitude seven. Upon further investigation it appeared that the tsunami, which some estimate to be 7 m to 8 m high at the shoreline, may have been generated by a massive underwater slump caused by the earthquake, see Kawata et. al. (1999). Southern California is especially susceptible to such events due to the combination of offshore faults and near-shore submarine canyons with stored sediment as well as bottom material on relatively steep slopes that may fail due to earthquake shaking. The resulting waves generated by the submarine landslides may generate sizeable onshore and offshore propagating waves; the former leading to significant danger of coastal inundation with little warning time.

There have been several investigations dealing with waves generated by underwater landslides, e.g., Watts (1996), to mention one. In that case two dimensional experiments of submarine landslides were conducted at a small scale using both solid body motions and sediment masses. In work by Grilli, Watts, and Dias (2001) three-dimensional underwater bodies of irregular shapes moving by gravity were used to

confirm a numerical model, but these experiments also were conducted at a small scale. In both cases the experiments were directed at investigating the wave characteristics in the generation region and not the local run-up associated with such waves.

Large scale experiments have been conducted in a wave tank with a length 104 m, width 3.7 m, depth 4.6 m and with a plane slope (1:2) located at one end of the tank. Three shapes have been used to represent the landslide: a wedge, a hemisphere, and a rectangular parallelepiped. (For the wedge two configurations on the slope are used: (1) the front face of the wedge is vertical and (2) the wedge is turned “end-for-end” so that for this orientation each face is neither horizontal nor vertical.) The triangular shaped wedge had a horizontal length of 91 cm, a vertical face 46 cm high and a width of 65.3 cm. The radius of the hemisphere was 45.72 cm. The rectangular parallelepiped initially had a width and length of 66 cm and a height of 45.72 cm. In later experiments the length of the parallelepiped was increased to 96.52cm. The bodies were connected to a position indicator to independently determine the velocity and position-time histories and traveled down the slope under the effect of gravity rolling on specially designed wheels with low friction bearings. These wheels rode in shallow grooves on the slope. A sufficient number of wave gages were used to determine the seaward propagating waves, the waves propagating to either side of the bodies, and for the submerged case, the water surface-time history above the bodies. In addition, the time history of the run-up on the slope was accurately measured using wave gages mounted parallel to the slope for the wedge experiments and embedded in the slope for the experiments with the hemisphere and the rectangular parallelepiped. In addition for all experiments video images of the runup process were obtained, and for several experiments high speed videos were obtained. For a given initial body position the mass was varied to vary the initial acceleration. Their initial position was varied from totally aerial to fully submerged.

These experiments involve both small and finite amplitude waves and the concomitant run-up that depends on the initial position and acceleration of the bodies. The results using these well defined shapes and a range of initial locations relative to the still water level and initial accelerations (masses) provide a carefully obtained set of data on this very important tsunami problem conducted at a scale which minimizes viscous and capillary effects. A greater understanding of the mechanisms affecting runup from both subaerial and submerged landslides can be gained from these results. If we postulate that submarine material landslides behave in a manner similar to solid body slides, the obvious conclusion drawn from these and other experiments is that the runup and the rundown would be controlled by size, submergence and initial motion time history.

References

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