Application of a new distributed fiber optic pressure sensor on hydraulic wave experiments

Student

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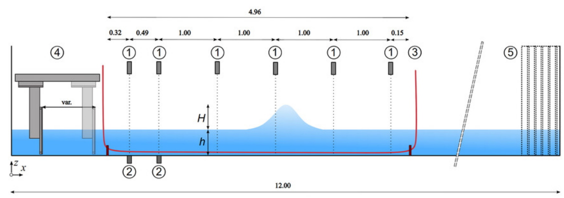
Initial Situation: Natural hazards are extremely difficult to predict or even prevent entirely. Therefore, it is of particular importance to monitor endangered zones as precisely and reliably as possible. One of the most dan-gerous and destructive natural hazards are tsunamis, but water waves in general can also lead to ero-sion of shores or dams due to climate-induced sea level rise. These disasters decimate the habitat on land substantially.

Approach: For the investigation of such shallow water waves or tsunamis, solitary waves are particularly suitable for laboratory experiments. In the Laboratory of Hydraulics, Hydrology and Glaciology (VAW) at ETH Zürich (ETHZ), different geometries of solitary waves were investigated using the wave channel with the study of three different types of sensors. An attempt was made to reconstruct the shape and dimension of the waves as realistically as possible using ultrasonic distance sensors (US), punctual pressure sensors (PS) and a distributed fiber optics sensor (DFO) newly developed at Eastern Switzerland University of Applied Science (OST).

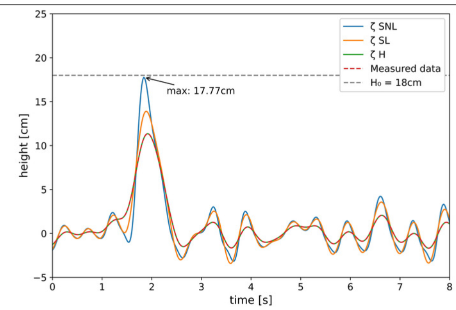
Result: US can reliably measure data of solitary waves in a wave channel, requiring minimal effort for both data registration and post-processing. Since PS only measures the hydrostatic pressure of the water wave, the hydrodynamic part of the solitary wave must be taken into account subsequently by a nonlinear weakly dispersive method to reconstruct the wave shape. Through this recalculation the pressure sensor generated results, which are directly comparable with the US.
The newly developed DFO sensor can reliably register even small sized water waves. With experiments of two different water depths and various wave geometries, it could be proven that the DFO sensor can reliably measure small sized waves as well as waves near to the breaking point. Since the fiber cable works as a pressure sensor, it needs the same back calculation as the PS to compare the DFO directly with the other sensors considered. Based on data from various wave heights, it can be assumed that DFO sensors can more precisely reconstruct solitary waves as water pressures increases.
According to first tests, a direct comparison of all three sensor types showed that none of the sensors had a deviation of more than 3% from the known wave height generated by the wave channel.

In conclusion, it can be said that further research in the application of the DFO sensor in case of large-scale waves and calibration can create a monitoring system with only one sensor, which is able to measure pressure changes over long distances in real time. This minimizes the effort in post-processing enormously and simultaneously increases the efficiency of such a system. With the great potential of this fiber optic cable, another step can be made towards a safer handling of natural hazards and thus reliably protecting people and the environment.

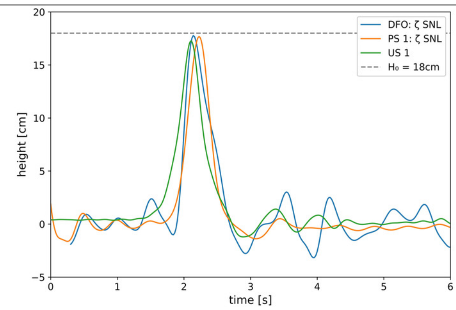
Schematic representation of the wave channel (All dimensions in meter [m])
Own presentment



Recalculation of the DFO measurement data according to Benneton et al.
Own presentment



Sensor comparison (Wave height = 18cm, still water depth = 30cm)
Own presentment



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Subject Area
Civil Engineering