Benchmark 2: Analytical. Solitary Wave on a Composite Beach

A composite beach simulating geometrical dimensions of the Revere Beach was constructed in a water tank by the U.S. Army Corps of Engineers at the Coastal Engineering Research Center in Vicksburg, Mississippi. The constructed beach consists of three piece-wise linear segments, and a vertical wall, against which the maximum runup was measured. The schematics of the beach is shown in Figure 1. Locations of the water gauges are marked by dotted lines. Gauge G4 was used to measure an incident wave that propagated towards the vertical wall. The laboratory equipment and the beach profile are described in great detail by Yeh et al. (1996), and can be found at the web-site http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Projects;36 of the Coastal & Hydraulics Laboratory, or at the web-site http://nctr.pmel.noaa.gov/benchmark/Solitary_wave/ of the NOAA Center for Tsunami Research.

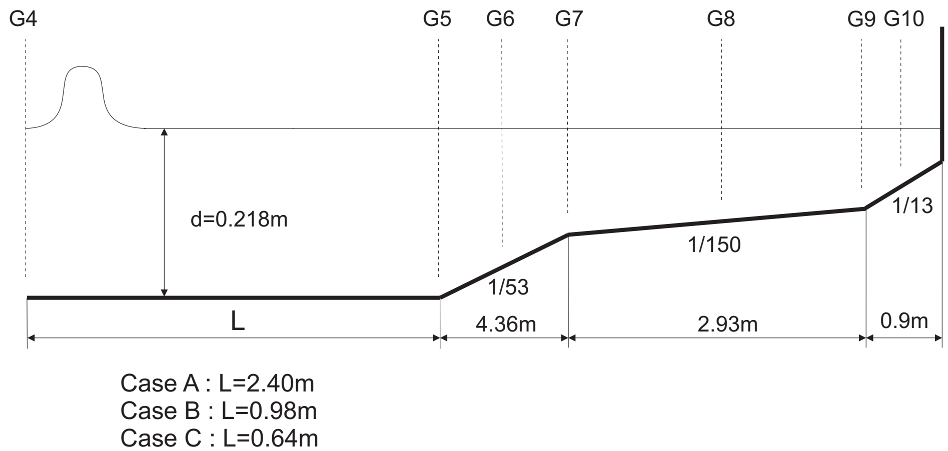

Figure 1: Schematics of the composite beach and locations of water gauges. Distance between the gauges and the vertical wall are given in Table 1.

Kânoğlu and Synolakis (1998) developed an exact analytical solution to the linear shallow water equations to predict propagation and run-up of an incident solitary wave over the piece-wise linear bathymetry. This analytical solution was proposed to be used as a benchmark problem by Synolakis et al. (2007). In the presented benchmark problem, an analytical solution is developed, using the mathematical apparatus developed by Kânoğlu and Synolakis (1998), in the case when the incident wave is specified by the actual water level recordings at gauge G4.

In the laboratory experiments, the water level at gauges G4 through G10 was measured from 165 to 195 seconds. It is suggested to use the measured water level at gauge G4 from 165 to 175 seconds to specify the Dirichlet boundary condition at gauge G4, the left side of the computational domain. The water level at gauge G4 for all three cases A, B, and C can be found in files ts3a.txt, ts3b.txt, and ts3c.txt, respectively. For the remainder of the numerical experiment, it is suggested to specify a non-reflective boundary condition at the left boundary.

To accomplish this benchmark, it is suggested to:

1. Model propagation of the incident and reflective wave according to the above-specified boundary condition.
   Note that the numerical model must be run in appropriate (i.e. linear, non-dispersive, no friction) mode for the comparison and verification purposes.

2. Record the water level $\eta_n(t)$ at all gauges and at the wall over the time period of $t \in [165, 195]$ seconds,

3. Compare numerical solution $\eta_n(t)$ to the analytical solution $\eta_a(t)$ at all gauges and the vertical wall.

Description of the data files

The analytically computed water levels at gages G4...G10 and at the wall for cases A, B, and C are provided in files ts3a_analytical.txt, ts3b_analytical.txt, and ts3c_analytical.txt, respectively. The nine columns are labeled "Time", "G4", "G5", ..., "G10", "Wall".

Files ts3a.txt, ts3b.txt, and ts3c.txt contain the measured surface elevation time series for gauges G4...G10 for cases A, B, and C, respectively, and are a part of the laboratory data for Benchmark Problem 5.

Attention: Since gauge G4 in Case C was not calibrated properly, it is suggested to subtract 0.001524 meters from the water level recordings at G4 (the second column in file ts3c.txt) and then use the obtained time series to set the boundary condition.

Table 1: Distance to gauges G4 through G10 from the vertical wall.

Gauge	Distance, meters
G10	0.43
G9	0.9
G8	2.37
G7	3.83
G6	6.01
G5	8.19
G4, Case A	10.59
G4, Case B	9.17
G4, Case C	8.83

References

Kânoğlu, U., Synolakis, C., (1998). Long wave runup on piecewise linear topographies. Journal of Fluid Mechanics 374, 1–28.

Synolakis, C., Bernard, E., Titov, V., Kânoğlu, U., González, F., 2007. Standards, criteria, and procedures for NOAA evaluation of tsunami numerical models. OAR PMEL-135 Special Report, NOAA/OAR/PMEL, Seattle, Washington, 55 pp..

Yeh H., Liu P.L.-F., Synolakis C. (1996) Long-Wave Runup Models. World Scientific, 403 pp.