Benchmark Problem 6: Laboratory. Solitary Waves on a Conical Island.

The goal of this Benchmark Problem (BP) is to compare computed model results with laboratory measurements obtained during a physical modeling experiment conducted at the Coastal and Hydraulic Laboratory, Engineer Research and Development Center of the U.S. Army Corps of Engineers. The laboratory physical model was constructed as an idealized representation of Babi Island, in the Flores Sea, Indonesia, to compare with Babi Island runup measured shortly after the 12 December1992 Flores Island tsunami (Yeh, et al., 1994).

Several descriptions of the physical model have been published (see the references, below) and the associated laboratory data files can be downloaded from http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Projects;35 or http://nctr.pmel.noaa.gov/benchmark/Laboratory/Laboratory_ConicalIsland/index.html . This document and the accompanying data files draw on these sources and on personal communication with Michael Briggs, USACE, to resolve questions encountered during simulations of this benchmark problem for validation of the GeoClaw model. Except for some added information and the differences noted, what follows is primarily based on the documentation and figures found at the USACE benchmark problem website http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Projects;35 and the reader is referred to this site as the primary site for additional details.

Physical Model

Figure 1 was developed through discussions with Mike Briggs. The basin wall dimensions were 29.3 x 30 m, and absorbing material was installed to form the smaller, 25 x 28.2 m wave basin. The absorbing material was synthetic horsehair about 2 inches thick, rolled into cylinders approximately 0.9 m in diameter, and characterized by a reflection coefficient that varied somewhat with wave frequency, but was of the order of 12 %. The length of the wavemaker was 27.4 m. A few differences between Figure 1 and previously published figures of the wave basin stem primarily from the fact that (a) the wavemaker face extended about 2 m into the wave basin, and (b) a gap of approximately 0.38 m was present between each end of the wavemaker and the bottom and top walls.

The island had the shape of a truncated, right circular cone with diameters of 7.2 m at the toe and 2.2 m at the crest. The vertical height of the island was approximately 62.5 cm, with 1V on 4H beach face (i.e. ß=14°). The water depth was set at 32 cm in the basin.

Laboratory Data Files

fdbk2abc.txt : Wave-paddle trajectories, i.e., the displacement in centimeters of the paddle from the rest position, y = 0, for time t = 22 to 32 seconds. The first column provides "Time" values and the next three columns correspond to wave paddle motion for "Case A," "Case B," and "Case C," intended to generate target wave heights Htgt = 0.05, 0.10, and 0.20 cm. Actual measured wave heights Hmeas were approximately 90 percent of these target values. See Figure 2 (a).

ts2a.txt, ts2b.txt, ts2cnew1.txt: time series of surface displacement in centimeters, for gages 1-4, 6, 9, 16, and 22 for cases A, B, and C, respectively, for t = 20 – 80 seconds. See Figure 2 (b). Note that original files on the USACE website contain erroneous entries of "M" instead of a numerical value, and these were replaced with linearly interpolated or extrapolated values.

run2a.txt, run2b.txt, run2c.txt: Runup heights around the island for Cases A, B and C, respectively. Each file consists of four data columns labeled "Rad", "Deg", "Max Vert Runup, cm" (Average of 2 runs), and "R/d" (runup normalized by water depth). Note that for plotting purposes, simple trigonometric relationships can be derived to transform gage position coordinates from the Deg-Runup coordinate system of the island data to the x-y coordinate system of the wave basin, based on the water depth, the description of the island geometry and the position of the island center. See Figure 2 (c).

Table 1. Laboratory Gage Positions. For convenience, the positions of gages to be compared with model computations are given in the following table. Note that the x-coordinate of gages 1-4 are different for each of the cases A, B and C (Briggs, et al., 1996).

<table>
<tr><th>Gage ID</th><th>X, m</th><th>Y, m</th><th>Z, cm</th><th>Comment</th></tr>
<tr><td>1</td><td rowspan="4">A: 5.76
B: 6.82
C: 7.56</td><td>16.05</td><td>32.0</td><td rowspan="4">Incident gage</td></tr>
<tr><td>2</td><td>14.55</td><td>32.0</td></tr>
<tr><td>3</td><td>13.05</td><td>32.0</td></tr>
<tr><td>4</td><td>11.55</td><td>32.0</td></tr>
<tr><td>6</td><td>9.36</td><td>13.80</td><td>31.7</td><td rowspan="2">270 deg transect</td></tr>
<tr><td>9</td><td>10.36</td><td>13.80</td><td>8.2</td></tr>
<tr><td>16</td><td>12.96</td><td>11.22</td><td>7.9</td><td>0 deg transect</td></tr>
<tr><td>22</td><td>15.56</td><td>13.80</td><td>8.3</td><td>90 deg transect</td></tr>
</table>

To accomplish this benchmark, it is suggested that, for

CASE A: Water Depth, d = 32.0 cm, Target H = 0.05, Measured H = 0.045
CASE C: Water Depth, d = 32.0 cm, Target H = 0.20, Measured H = 0.181
(*OPTIONAL* CASE B: Water Depth, d = 32.0 cm, Target H = 0.10, Measured H = 0.096)

model simulations be conducted to address the following

Objectives/Checklist:

1. Demonstrate that two wave fronts split in front of the island and collide behind it

2. Compare computed water level with laboratory data at gauges 1, 2, 3, 4, 6, 9, 16, and 22 (files ts2a.txt, ts2b.txt, ts2cnew1.txt)

3. Compare computed island runup with laboratory gage data (files run2a.txt, run2c.txt)

References

Briggs, M.J., Synolakis, C.E., Harkins, G.S. (1994): Tsunami runup on a conical island. Proc. of Waves — Physical and Numerical Modelling, 21-24 August 1994, Vancouver, Canada, V1, 446-455.

Briggs, M.J., C.E. Synolakis, G.S. Harkins, and D. Green (1995): Laboratory experiments of tsunami runup on a circular island. *Pure Appl. Geophys., 144*, 569-593.

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Fujima, K, M.J. Briggs and D. Yuliadi (2000): Runup of tsunamis with transient wave profiles incident on a conical island, Coastal Engineering Journal, V42, 175-195.

Liu, P.L.-F., Y.-S. Cho, K. Fujima (1994): Numerical Solutions of Three-Dimensional Run-up on a Circular Island, 21-24 August 1994, Vancouver, Canada, V2, 1031-1040.

Liu, P.L.-F., Y.-S. Cho, M.J. Briggs, U. Kânoglu, and C.E. Synolakis (1995): Runup of solitary waves on a circular island. *J. Fluid Mech., 302*, 259-285.

Yeh, H., P. Liu, M. Briggs, C. Synolakis, (1994): Propagation and amplification of tsunamis at coastal boundaries, Nature 372, 353-355.

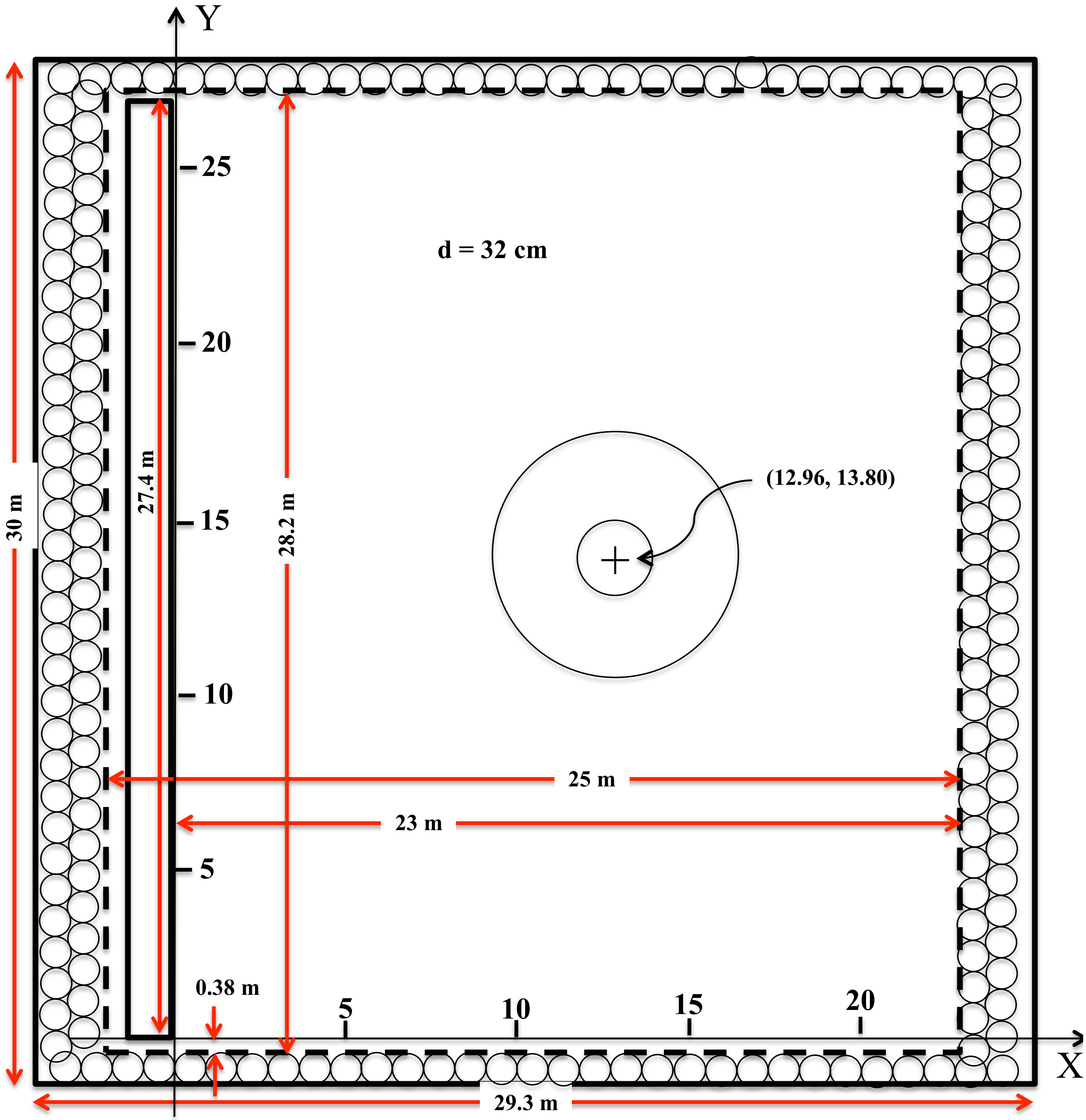
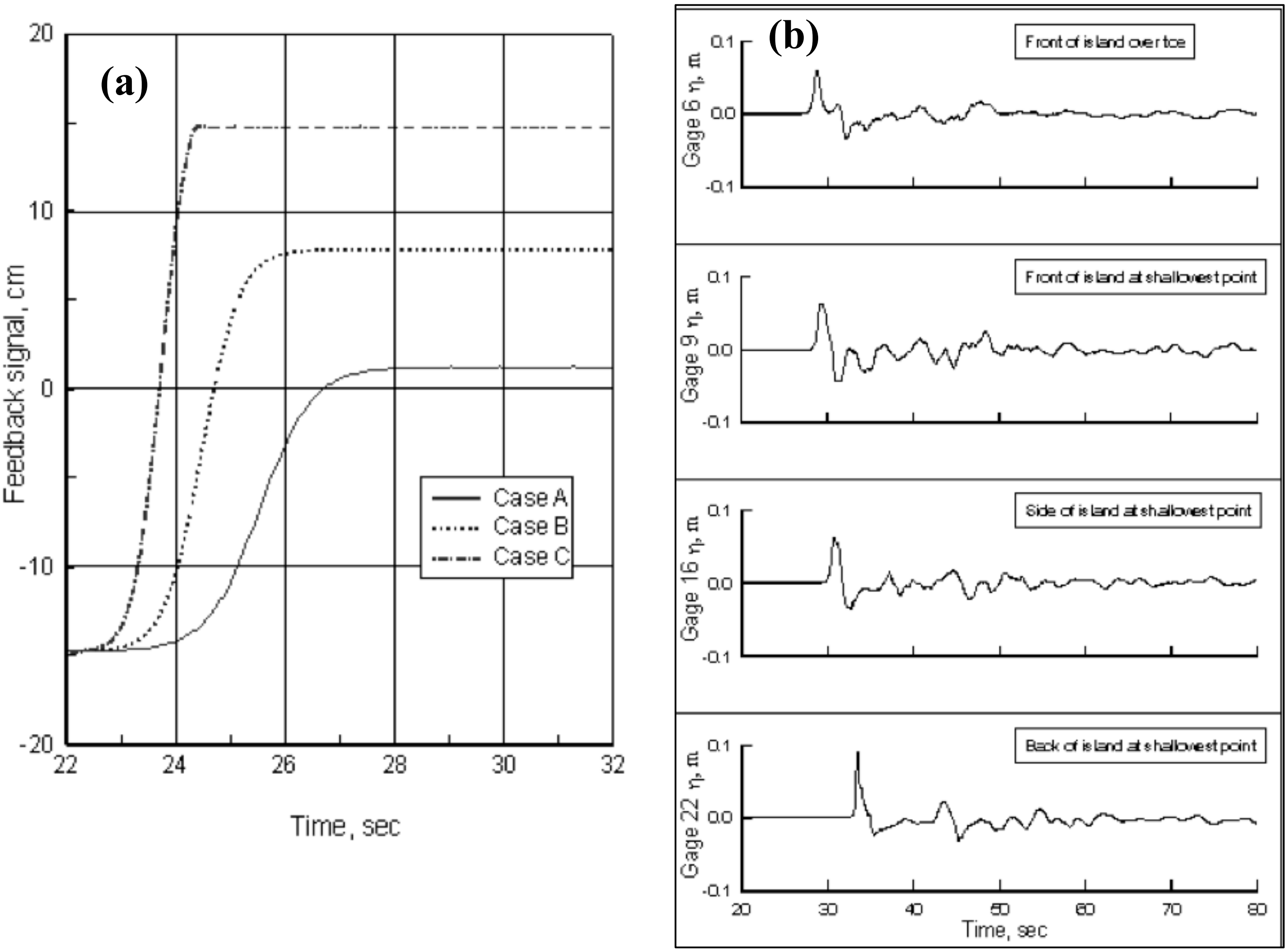


Figure 1. Basin geometry and coordinate system. Solid lines represent approximate basin and wavemaker surfaces. Circles along walls and dashed lines represent wave absorbing material. Note the gaps of approximately 0.38 m between each end of the wavemaker and the adjacent wall. Gage positions are given in Table 1.



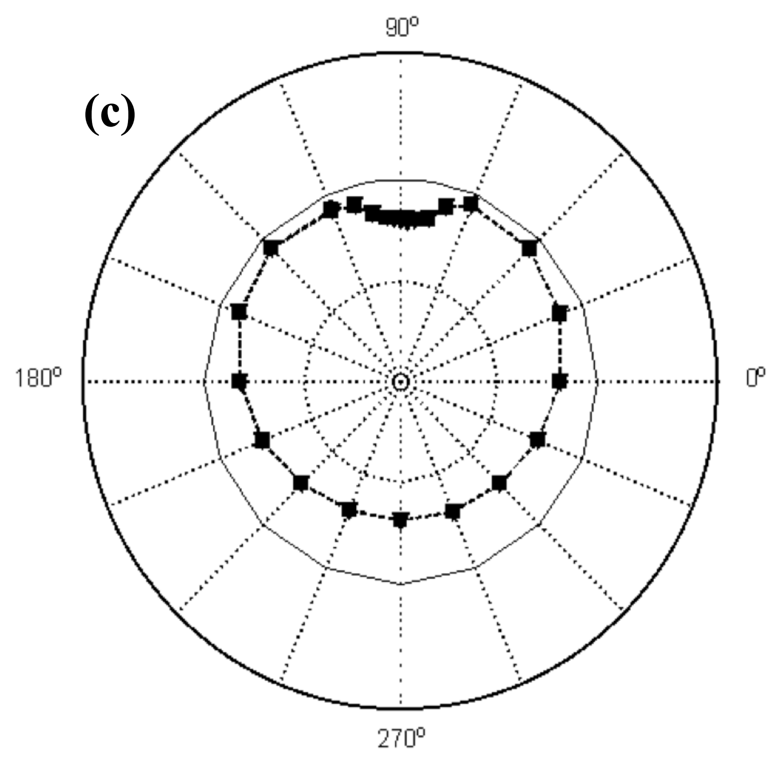


Figure 2. (a) Wavemaker paddle trajectories for Cases A, B and C (file fdbk2abc.txt), (b) Lab time series for Case C, at gages 6, 9, 16, 22, (c) island runup for Case C