Determination of Wave Transmission Coefficients for Oyster Shell Bag Breakwaters

Richard J. Allen[1] and Bret M. Webb[2]

Introduction

At the present time problems are inevitable in the use of oyster shell bag breakwaters. Oyster shell bag breakwaters have been used in many locations throughout the USA to quantify their ecological benefits, but little research has been conducted regarding their wave attenuating properties. Quantitative information has been produced for traditional structures, but nothing has been published to describe the attenuating properties of an oyster shell bag breakwater. Currently, projects employing oyster shell bag breakwaters would need to adapt published methodologies for determining the transmissive properties of traditional materials or conduct individualized experimentation for their project to determine the adequate dimensions necessary to handle the hydrodynamic loads applied to them. Projects using this methodology could be over or under designing the oyster shell bag breakwaters. The remainder of this report will attempt to resolve this issue by conducting laboratory experiments in a controlled setting and comparing those results to existing methodologies available in the published literature.

Methodology

The tests performed in this study were conducted in the University of South Alabama's wave basin. The wave basin is 6.09 m (20 ft) wide and 9.14 m (30 ft) long. Waves are generated in the basin by a uni-directional bulkhead capable of producing monochromatic waves, which propagate across the basin to a sloping sand beach. For the tests conducted in this study, a wall was built 0.76 m (2.5 ft) from the side of the basin, 4.88 m (16 ft) in length, beginning 0.61 m (2 ft) from the bulkhead's maximum stroke. The wall built within the basin served to minimize the effects of refraction around the oyster shell bag breakwater being tested, see Figure 1. The wall was constructed from timber and held in place using high-density armor stone. The upright portion of the wall was supported by triangular stanchions which were placed 0.61 m (2 ft) on center along the outboard side.

The composite breakwater structure is made up of oyster shell bags 0.76 m (2.5 ft) in length having a nominal diameter of 0.076 m (3 in). The bags were constructed using a 0.76 m (2.5 ft) section of 0.10 m (4 in) PVC pipe. An empty bag was placed in the pipe and tied on one end. Oyster shell was then scooped into the assemblage and shaken/compacted until full, then the open end was closed using a cable tie, Figure 2 shows a completed bag.

The wave height measurements obtained during the testing were determined using a two-wire capacitance gage. The gage was placed on the leeward side of the testing area and calibrated using the incident wave height prior to the placement of any material in the testing area. The sampling rate of the gage was set at 10 Hz; the data was digitally recorded using a program created by National Instruments called LabView.

[1]Student, University of South Alabama, Department of Civil Engineering, 6021 USA Drive South, Mobile, Alabama 36688. rja801@jaguar1.usouthal.edu
[2]Assistant Professor, University of South Alabama, Department of Civil Engineering, 6021 USA Drive South, Suite 280, Mobile, Alabama 36688. bwebb@usouthal.edu

The testing performed in this study did not follow any specific scale since the results are dimensionless and only a function of the wave height and the structure size. The only portion of the testing that could be scaled is the size of the oyster shell. Scaling the oyster shell is not possible since the scaling would need to be controlled by both Froude and Reynolds scaling which are not compatible. Reducing the size of the shell, either by obtaining smaller shell, which is difficult to find, or by mechanical means, may introduce a strong bias in the results due to a corresponding decrease in structure porosity.

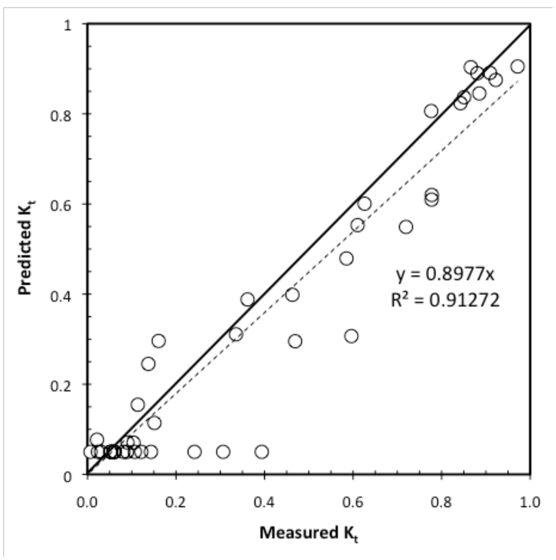
A testing matrix was constructed to produce a range of values, which would be adequate to describe the attenuation of wave height and period of bagged oyster shell. The matrix contained 36 unique combinations of structure height and crest width. Seven additional tests were conducted using different wave characteristics, resulting in a total of 43 unique experiments. The height of the structure was varied from 1 bag high to 6 bags high, which yielded a structure height 1.5 times greater than the depth. The crest width was also varied for each structure height. Structure crest widths varied from 4 bags to 19 bags, yielding a total of six unique crest widths. The largest crest width was proportional to the incident wavelength.

A structure side slope of 1:1.5 (H:V) was kept constant throughout testing. The water depth remained constant throughout the experiment as well. For selected experiments where the freeboard was greater than zero, three additional trials were run using a larger wave height and longer wave period to produce overtopping. The larger wave provided additional data of the variation between wave heights for a similar structure. To reduce the contamination of reflection of the wave energy from the shoreline, the trials were conducted in "bursts." An average root-mean-square transmitted wave height, H_t, was obtained for each experiment by averaging the RMS wave height in each burst. This wave height is then used to determine the transmission coefficient for the given test conducted.

The results obtained in this report are a substantial finding in terms of constructing oyster shell bag breakwaters. The resulting data obtained from testing was compared to published methodologies for measuring the wave transmission coefficient for low crested breakwaters (Van der Meer et al., 2005), which produced a distinguishable resemblance based on the 43 tests conducted during this study, see Figure 3. Furthermore, the wave transmission coefficient was associated to the non-dimensional aspects of the breakwater and incident wave height to produce the preliminary graph shown in Figure 4.

Figure 1: View of the University of South Alabama wave basin after the installation of the partition wall.

Figure 2: Completed oyster shell bag before testing.



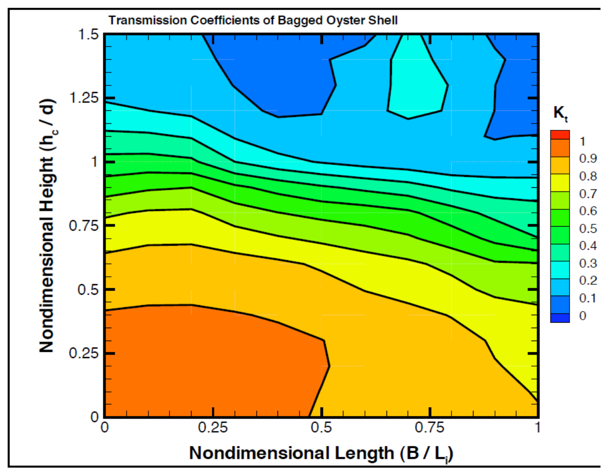


Figure 3: A comparison of measured and predicted transmission coefficients using the predictive equations of Van der Meer et al. (2005). Open symbols (o) represent measured data, the dashed line is a linear regression with a zero intercept, and the dark solid line represents perfect agreement.

Figure 4: Non-dimensional relationships of the structure and the incident wave height to the wave transmission coefficient.

References

Van der Meer, J. W., Briganti, R., Zanuttigh, B., & Wang, B. (2005). Wave Transmission and Reflection at Low-Crested Structures: Design Formulae, Oblique Wave Attack, and Spectral Change. *Coastal Engineering* 52: 915 - 929.