CHAPTER 59

SCALE EFFECTS IN WAVE ACTION THROUGH POROUS STRUCTURES

by

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ABSTRACT

The energy in waves which impinge on a porous structure, such as a rubblemound breakwater, is divided into reflected energy, transmitted energy, and the energy dissipated by turbulence within the structure. To obtain information on the reliability of using models to predict the transmission of wave energy through a rubble medium, a series of three models were constructed and tested in the 1 ft. by 3 ft. by 106 ft. wave channel at the University of California. The models consisted of rectangular, vertical-faced, wire baskets (constructed of expanded metal lath) which were filled with crushed stone. The three models were 0.5, 1.0, and 2.0 ft. in length, respectively. All models were 1 ft. wide and 3 ft. high. Each structure was installed in turn in the wave channel and subjected to wave action with the wave height being measured both seaward (H_1) and leeward (H_2) by resistance-type wave gages. Using the Froude law for scaling and considering the largest basket to be the prototype which the smaller baskets are to model, the following conditions were used in the tests of the three structures:

Structure	Structure Length, B (ft)	Water Depth, d (ft)	Stone Size, D (in)	Porosity of Structure (%)	Wave Period (sec)
Prototype	2	2	1.3	45	1.4
1:2 Model	1	1	0.56	49	0.99
1:4 Model	0.5	0.5	0.36	50	0.70

With a particular structure in place and the water depth and wave period set as indicated in the above table, the seaward wave height was progressively varied. From the experimental data, the transmission coefficient (H_2/H_1) was calculated and plotted against the wave steepness for each structure as shown in Figure 1.

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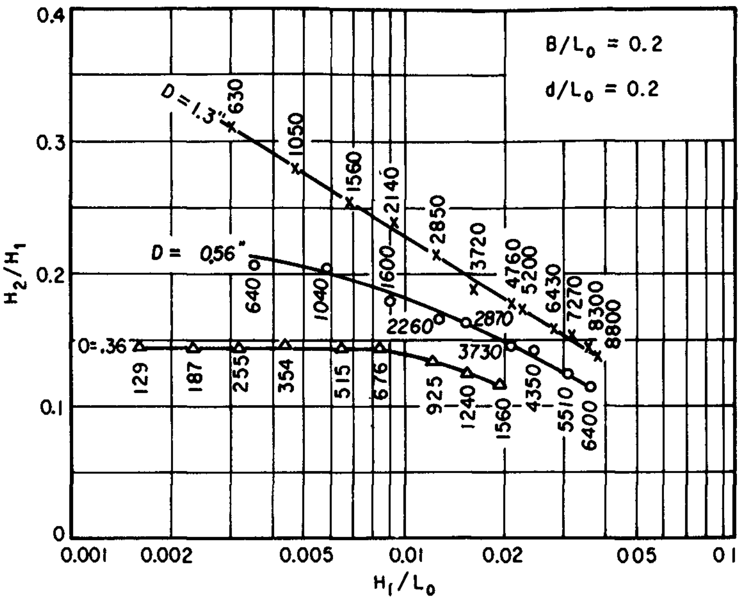

Fig. 1. Transmission ratio vs wave steepness.

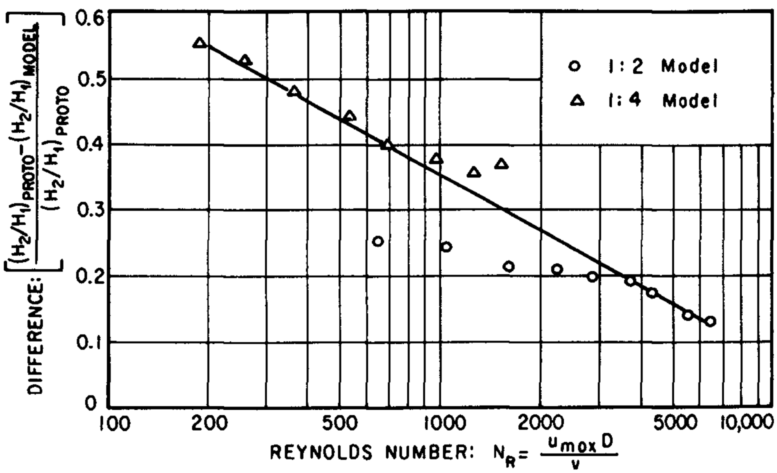

Fig. 2. % difference vs Reynolds number.

It is evident from a comparison of the dimensionless plots for the three structures that the Froude law is not the only factor involved. Whereas the reflected energy is probably a function of the Froude number as well as the porosity of the structure, the energy dissipated by turbulence within the structure is probably a function of a Reynolds number. Other factors affecting the model tests were:

(a) the stone sizes were not exactly scaled;
(b) the porosities for the three structures varied;
(c) the amount of energy absorbed by the metal lath baskets was unknown;
(d) experimental errors probably affected the results of the smallest model (1:4).

To determine whether or not there appears to be a consistent Reynolds effect a modified Reynolds number was computed by the following relationship

$$N_R = \frac{u'_{max} D}{\nu} \qquad (1)$$

where

u'_{max} = maximum horizontal component of particle velocity at the position of the swl, ft/sec

D = median diameter of stone, ft

ν = kinematic viscosity of water

= 1.2×10^{-5} ft^2/sec

The above velocity was computed by the following formula:

$$u'_{max} = \frac{\pi H}{T} \; \frac{\mathrm{Cosh}\; 2\pi d/L}{\mathrm{Sinh}\; 2\pi d/L} \qquad (2)$$

The Reynolds number as computed by Equation 1 for each run is shown in Figure 1 for each model experimental point. A cross plot to show the percentage difference between model and prototype transmission coefficients for various values of Reynolds number is shown in Figure 2. From an examination of this figure, it is evident that as the Reynolds number increases, the comparison between "model" and "prototype" becomes much better. Obviously, additional and more controlled experiments are required to completely define the limits in which scale models can be used to predict the transmission of wave energy through rubble structures.