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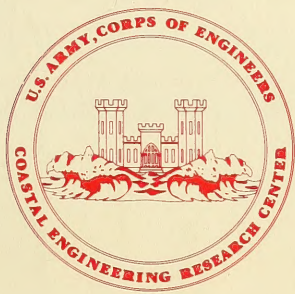
Two-Dimensional Tests of Wave Transmission and Reflection Characteristics of Laboratory Breakwaters

by

William N. Seelig

TECHNICAL REPORT NO. 80-1

JUNE 1980



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Monochromatic and irregular wave transmission and reflection measurements were made for various subaerial and submerged breakwater cross sections. These two-dimensional laboratory tests included smooth impermeable breakwaters, rubble-mound breakwaters, and breakwaters armored with dolos units. Wave transmission by overtopping was found to be related to breakwater freeboard wave runup, and breakwater crest width; a method of estimating transmission by overtopping coefficients is presented. The Madsen and White (1976) numerical (continued)		

procedure was found to be an important tool for predicting the amount of transmission through permeable breakwaters. Suggested procedures for estimating transmission coefficients have been incorporated into the computer programs OVER and MADSEN (included as appendixes) and these programs may be used to predict wave transmission coefficients for nonbreaking, breaking, monochromatic, and irregular wave conditions:

PREFACE

This report presents the results of research conducted to develop methods for estimating wave transmission past submerged, subaerial, permeable, and impermeable breakwaters. The final prediction techniques are given in the form of computer programs, and the laboratory data used to develop and test the methods are included in appendixes to this report. These methods supplement Section 7.23 of the Shore Protection Manual (SPM). The work was carried out under the offshore breakwaters for shore stabilization program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was prepared by William N. Seelig, Hydraulic Engineer, under the general supervision of Dr. R.M. Sorensen, Chief, Coastal Processes and Structures Branch. J. Ahrens and M. Titus provided a significant contribution to this report by their many useful suggestions and valuable laboratory assistance.

Comments on this publication are invited.

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TED E. BISHOP

Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins ¹

¹To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9) (F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9) (F - 32) + 273.15$.

SYMBOLS AND DEFINITIONS

A	material identifier
A_1	spectral coefficients
A_2	spectral coefficients
a	empirical rough-slope runup coefficient
a_I	incident wave amplitude at a spectral line
a_R	reflected wave amplitude at a spectral line
B	breakwater top width
B_1	spectral coefficients
B_2	spectral coefficients
b	empirical rough-slope runup coefficient
C	transmission by overtopping coefficient
C_1	empirical wave runup on smooth-slope coefficients
C_2	empirical wave runup on smooth-slope coefficients
C_3	empirical wave runup on smooth-slope coefficients
CF	physical model correction factor = (K_{Tt}) prototype / (K_{Tt}) model
d	water depth
d_s	water depth at toe of a structure
d_{50}	median material diameter
F	breakwater freeboard = $h - d_s$
f	wave frequency = $1/T$
g	acceleration due to gravity
H or H_I	incident wave height
H_R	reflected wave height
H_{rms}	root-mean-square (rms) wave height
H_s	significant wave height
H_T	transmitted wave height
\bar{H}	mean wave height
ID	a 10-digit identification code (year, month, day, hour, minute) assigned to each data collection run
j	spectral line number

SYMBOLS AND DEFINITIONS--Continued

K_R	reflection coefficient
K_T	transmission coefficient = $\sqrt{K_{T0}^2 + K_{Tt}^2}$
K_{T0}	wave transmission by overtopping coefficient
K_{Tt}	coefficient of wave transmission through a permeable breakwater
k	wave number = $2\pi/L$
L	wavelength
L_0	deepwater wavelength
P	material porosity
p	probability
Q_p	spectral-peakedness parameter
Q_{pi}	incident spectral-peakedness parameter
Q_{pr}	reflected spectral-peakedness parameter
Q_{pt}	transmitted spectral-peakedness parameter
R	wave runup
$r(H, H + 1)$	autocorrelation of wave heights
$r(H, T)$	correlation of wave heights and periods
T	wave period
T_p	period of peak energy density
W_{50}	median weight of material
γ	specific weight
Δf	band width
$\Delta \ell$	gage spacing
η_{rms}	root-mean-square water level
θ	angle of seaward face of a breakwater
ν	kinematic viscosity of water
ξ	surf parameter = $(\tan \theta / \sqrt{H/L_0})$
ρ	autocorrelation of zero up-crossing wave heights <ul style="list-style-type: none"> ● for incident waves ● for transmitted waves

TWO-DIMENSIONAL TESTS OF WAVE TRANSMISSION AND REFLECTION CHARACTERISTICS OF LABORATORY BREAKWATERS

by
William N. Seelig

I. INTRODUCTION

The primary function of a breakwater is to reduce wave heights in an area being sheltered. Breakwaters are primarily used to protect harbors from excessive wave action, to prevent beach erosion, and to trap sediment for mechanical bypassing at an inlet or harbor entrance. A secondary use of breakwater design is to reduce the wave reflection from the structure. Reflected waves combined with incident waves can produce undesirable water motions that may be a nuisance to navigation or encourage scour at the toe of a structure.

Since the cost of building breakwaters is generally high, methods are needed to estimate transmitted and reflected wave heights to enable comparison of alternative structure designs. This report presents suggested methods for predicting transmission and reflection characteristics of breakwaters based on laboratory experiments, including the work of previous investigators. These methods supplement Section 7.23 of the Shore Protection Manual (SPM) (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977). The basic types of breakwaters considered are permeable and impermeable structures with crest elevations above the stillwater level (subaerial) and below the stillwater level (submerged). The other factors investigated include wave height, period, breakwater cross-section design, and material characteristics. Both monochromatic and irregular waves were tested.

Section II of this report presents a brief review of research conducted by previous investigators. Section III describes the laboratory setup and procedures; Sections IV, V, and VI present data analysis methods and definitions. The conditions tested are summarized in Section VII. Detailed descriptions of the breakwaters tested and materials used are given in Appendixes A and B; summary tables and figures of laboratory results are presented in Appendixes C, D, and E.

Laboratory results are used in this study to develop a method for predicting wave transmission by overtopping coefficients using the ratio of breakwater freeboard to wave runup (suggested by Cross and Sollitt, 1971) and the breakwater crest width (suggested by Saville, 1963). The wave transmission by overtopping prediction method is then combined with the model of wave transmission through permeable structures of Madsen and White (1976) and this combination package is verified with the laboratory results over a wide range of conditions. Prediction methods are summarized in the computer programs OVER and MADSEN (Apps. F and G). An example breakwater design is worked with the aid of the two computer programs to illustrate how the prediction methods can be used to compare alternative breakwater designs, and to illustrate the importance of various design parameters.

II. LITERATURE REVIEW

Some of the important sources of ideas and data used in preparing this report are summarized below in chronological order.

Saville (1963) tested a large number of similar rough structures with a 1 on 2 front-face slope for a proposed breakwater at Point Loma, California. Most of Saville's breakwater models had a crest elevation near the stillwater level, so wave transmission in most of the tests was primarily due to overtopping. Some of the breakwaters tested were first modeled in the large wave tank at the Coastal Engineering Research Center (CERC), then re-tested at a smaller scale to examine scale effects. Some tests were repeated with otherwise identical permeable and impermeable breakwaters to assess the influence of wave transmission through the permeable breakwaters and wave transmission by overtopping. The breakwater crest width was also varied over a wide range of values to determine the influence of width on the wave transmission coefficient. Since wave reflection coefficients were not measured, the burst method was used during testing to avoid laboratory effects caused by re-reflection of waves from the generator blade.

Lamarre (1967) measured wave transmission by overtopping for a structure with a comparatively narrow crest width and 1 on 1.5 structure slopes. Wave conditions and the height of the structure were varied.

Goda (1969) tested vertical, smooth impermeable structures for wave transmission by overtopping. The breakwater crest width was varied and a wide range of submerged and subaerial structure heights and a number of wave conditions were tested. Wave reflection coefficients were measured to determine the incident wave height acting on the structure. A nonlinear empirical equation was developed for predicting wave transmission coefficients. In this formula the transmission coefficient is a function of the ratio of the breakwater freeboard to the incident wave height and two empirical coefficients, where the coefficients are related to structure geometry and the relative water depth.

Davidson (1969) tested a 1 on 40 scale model of a breakwater proposed for Monterey Harbor, California. The breakwater had tribar armor units and experienced a combination of wave transmission over and through the structure.

Cross and Sollitt (1971) developed a semiempirical model for wave transmission by overtopping of subaerial breakwaters. The model was compared to Lamarre's (1967) data for a smooth impermeable structure with a 1 on 1.5 front-face slope. Cross and Sollitt's model suggests that wave transmission by overtopping is a nonlinear function of the ratio of breakwater freeboard to runup. Examination of Saville's (1963) data suggests that a linear model would form an upper envelope for wave transmission over rough structures.

Keulegan (1973) measured wave transmission through a number of vertical-faced permeable breakwaters using a wide variety of materials and wave conditions. Comparison of results led to development of a method for designing scale models that consider scale effects.

Sollitt and Cross (1976) tested wave transmission through a permeable rubble-mound breakwater and used this information to develop an analytical-empirical model.

Bottin, Chatham, and Carver (1976) tested 1 on 22 rubble-mound scale and concrete armor unit breakwaters proposed for Waianae Harbor, Hawaii. Wave transmission consisted of a combination of wave transmission by overtopping

and wave transmission through the structures. Wave reflection coefficients were not measured. Wave runoff on dolos was observed.

Madsen and White (1976) developed a analytical-empirical model for the prediction of wave transmission and reflection coefficients for wave transmission through subaerial rubble-mound breakwaters. The model employs the long wave assumption, so predictions using their model are expected to be most reliable for shallow-water waves. Comparison of the Madsen and White model with physical model tests by Keulegan (1973) and Cross and Sollitt (1976) shows that the wave transmission coefficient can be predicted more reliably than the reflection coefficient.

The data from independent tests of wave transmission by overtopping conducted in this study, together with the results of Saville (1963), Lamarre (1967), Goda (1969), and Cross and Sollitt (1971), are used to develop a wave transmission by overtopping equation similar to one proposed by Cross and Sollitt (1971). The equation is then combined with the model of wave transmission through permeable breakwaters of Madsen and White (1976) to form a generalized model of wave transmission for breakwaters. This model is verified by comparing numerical and physical model results for a wide range of conditions.

III. LABORATORY TESTING

1. Laboratory Test Setup.

Laboratory tests were performed at CERC in a wave tank 4.57 meters wide, 42.7 meters long, and 1.22 meters deep. A part of the tank was divided by four walls to form two interior test flumes, each 61 centimeters wide; the remaining tank width contained a 1 on 12 absorber beach made of crushed stone with a median diameter of 2.9 centimeters (Fig. 1). This arrangement allowed two experiments to be performed simultaneously, and energy reflecting off of the test structures diffracts out of the test flume to minimize re-reflection of waves off of the generator blade.

The laboratory breakwaters were located between stations 5 and 10 meters along the flume and parallel-wire resistance gages were used to measure wave conditions in the flume. Gages placed at stations 1.40, 2.35, and 2.70 meters along the test flumes were used to document incident and reflected wave conditions. One or two gages placed landward were used to measure transmitted waves (Fig. 1).

A wave absorber consisting of a crushed gravel slope covered with a 0.6-meter-thick layer of hogshair was placed at the end of the test flume to absorb a majority of the transmitted wave energy. The test flume was terminated 3 meters before the end of the wave tank to allow water overtopping the test structure to escape from the flume through the absorber gravel. This arrangement prevented the buildup of water on the landward side of the test structure.

2. Methods of Generating Waves.

Waves in this facility were generated by a programable piston-type generator with a mean blade position 19 meters seaward of the entrance to the test flumes. A minicomputer was used to produce monochromatic waves of a specified wave height and period by moving the blade with a sinusoidal motion. Irregular waves

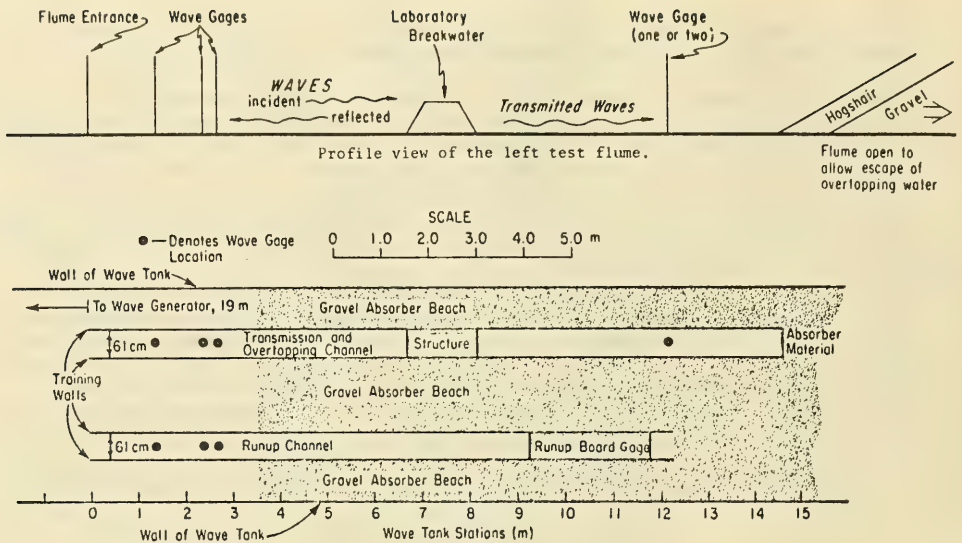


Figure 1. Plan view of wave tank setup.

were produced by using the CERC Data Acquisition System (DAS) to create a signal to move the blade. Irregular waves were made by summing 50 components of varying amplitude, period, and random phase to produce a wide variety of spectral shapes.

3. Data Collection.

The laboratory data collection scheme was designed after the CERC field wave data monitoring program. Data collection was performed automatically by the DAS in the following sequence:

(a) Wave gages were calibrated.

(b) Waves were produced for several minutes to allow tank startup transient conditions to die out.

(c) Wave gages collected data at a sampling rate of 16 times a second over a 256-second sampling interval.

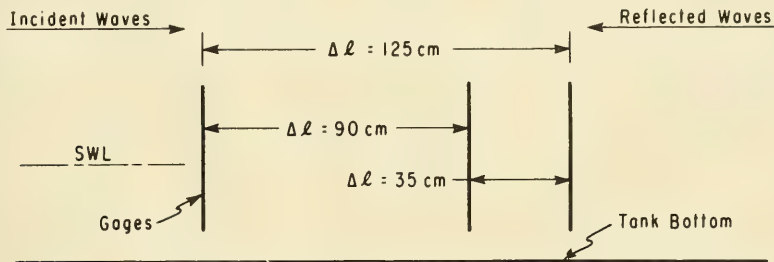
(d) The 4,096 data points from each gage were then stored on magnetic tape for analysis.

(e) A 10-digit identification code consisting of the year, month, day, hour, and minute of the data run was assigned (e.g., ID 7804260916 is a run made 1978, April, 26th day at 09:16).

4. Data Reduction Methods.

Laboratory data sorted on magnetic tape were analyzed on a CDC 6600 computer using a variety of data reduction schemes. The mean water level and the least squares, best-fit linear trend in the data was first removed from each gage record. A Fourier analysis was then performed on each gage record using a fast Fourier transform (FFT) routine and cosine bell function that is part of the CERC wave analysis package.

Incident and reflected waves, which are mixed together in each of the gage records, were separated using the method of Goda and Suzuki (1976) shown in Figure 2. This technique gives an estimate of the incident and reflected wave amplitudes, a_I and a_R , at each spectral line for each gage pair. Using three gages in front of the structure gives three estimates of the incident and reflected wave amplitude spectra. Calculations show that in this study the three estimates of wave amplitudes seldom differed by more than 5 percent, so the average incident and reflected wave amplitudes at each spectral line, j , were taken as representative; i.e., $(a_I)_j$ is the average incident wave amplitude at spectral line, j . The wave amplitude at each of the spectral lines was also determined for transmitted wave conditions; i.e., $(a_T)_j$ is the average transmitted wave amplitude at spectral line, j .



$$a_I = \frac{1}{2|\sin k\Delta\ell|} \sqrt{(A_2 - A_1 \cos k\Delta\ell - B_1 \sin k\Delta\ell)^2 + (B_2 + A_1 \sin k\Delta\ell - B_1 \cos k\Delta\ell)^2}$$

$$a_R = \frac{1}{2|\sin k\Delta\ell|} \sqrt{(A_2 - A_1 \cos k\Delta\ell + B_1 \sin k\Delta\ell)^2 + (B_2 - A_1 \sin k\Delta\ell - B_1 \cos k\Delta\ell)^2}$$

A, B = spectral coefficients

k = wave number = $\frac{2\pi}{L}$

$\Delta\ell$ = gage spacing

where

$$0.05 \leq \frac{\Delta\ell}{L} \leq 0.45$$

and

$$L = \frac{gT^2}{2\pi} \tanh\left(\frac{2\pi d}{L}\right)$$

where g equals acceleration due to gravity; d equals water depth; and T equals wave period.

Figure 2. Determination of incident and reflected waves using the method of Goda and Suzuki (1976).

Incident, reflected, and transmitted wave heights (H_I , H_R , H_T) are defined as

$$H_I = 2 \sqrt{\sum_{j=12}^{411} (a_I)^2_j} \quad (1)$$

$$H_R = 2 \sqrt{\sum_{j=12}^{411} (a_R)^2_j} \quad (2)$$

$$H_T = 2 \sqrt{\sum_{j=12}^{411} (a_T)^2_j} \quad (3)$$

where H_I is the height of the wave moving landward toward the breakwater, H_R the height of the wave reflecting from the breakwater and moving seaward, and H_T the height of the wave transmitted past and in the lea of the breakwater.

Wave reflection and transmission coefficients, K_R and K_T , are defined as

$$K_R = \frac{H_R}{H_I} \quad (4)$$

and

$$K_T = \frac{H_T}{H_I} \quad (5)$$

Wave transmission by overtopping has a transmission coefficient defined as K_{TO} ; wave transmission through porous structures is given by a transmission coefficient K_{Tt} . The coefficient for total wave transmission over and through a structure, K_T , is

$$K_T = \sqrt{K_{Tt}^2 + K_{TO}^2} \quad (6)$$

In the case of irregular waves the significant wave height, H_S (average of the highest one-third of the waves), is typically used to describe the wave conditions. To include the effects of wave reflection from the structure, significant height is defined as (Goda and Suzuki, 1976)

$$H_S = \frac{4 \eta_{rms}}{\sqrt{1 + K_R^2}} \quad (7)$$

where η_{rms} is the average root-mean-square (rms) water level from the three seaward gages. The mean wave height, \bar{H} , is defined as

$$\bar{H} = 0.625 H_B = \frac{2.5 \eta_{rms}}{\sqrt{1 + K_R^2}} \quad (8)$$

The wave period used to describe irregular wave conditions is the period of peak energy density, T_p . The spectral-peakedness parameter, Q_p (Goda, 1970), is used to characterize the spectral width for irregular wave conditions,

$$Q_p = \frac{1}{\Delta f} \frac{\sum_{j=1}^{36} f_j a_j^4}{\left(\frac{\sum_{j=1}^{36} a_j^2}{36} \right)^2} \quad (9)$$

where j is the band number (11 spectral lines are used to make each band), f_j the frequency midpoint of the band, and Δf the bandwidth frequency. a_j may be the incident, reflected, or transmitted wave amplitude associated with band, j , so that three values of Q_p (incident, reflected, and transmitted) are determined for each irregular wave run. Q_p was selected as the parameter to describe the spectral peakedness because it is an especially stable parameter not strongly influenced by the spectral techniques used to determine its value (Rye, 1977). The higher the value of Q_p , the more peaked a spectrum. For example, white noise has a Q_p value of 1.0, a Pierson-Moskowitz spectrum a value of 2.0, and JONSWAP values of Q_p vary between 3.0 and 9.0 with a value of 3.15 for the mean JONSWAP spectrum (Fig. 3). Values of Q_p associated with several incident wave spectra used in this study are illustrated in Figure 4.

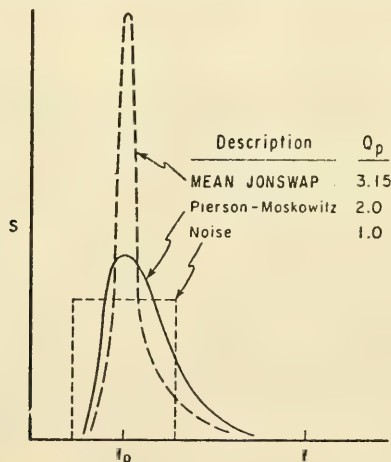


Figure 3. The spectral peakedness, Q_p , for various spectral shapes.

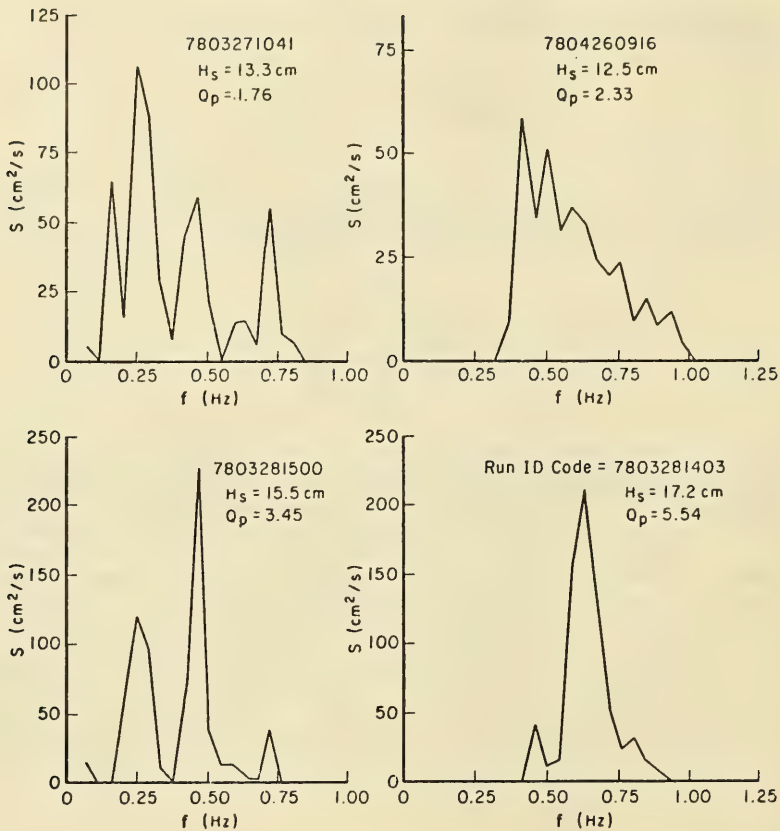


Figure 4. Sample incident laboratory wave spectra.

The zero up-crossing method was also used to analyze wave records. In this method the height of an individual wave is defined as the difference in extreme water elevations (maximum level minus minimum level) between two successive points in time where the water level up-crosses the mean water level. The period associated with that wave is the time between up-crossings. This type of analysis is useful for examining wave characteristics such as wave height, period, or joint wave height-period distributions. Zero up-crossing results may also be used to describe wave grouping (Rye, 1974). A high level of wave grouping means that there is a strong probability that a wave of approximately the same height will follow the previous wave (i.e., large waves are followed by large waves and small waves are followed by small waves). In this study the autocorrelation of zero up-crossing wave heights is used to quantify the amount of wave grouping. The wave gage records seaward of the test structure are somewhat contaminated by reflected waves, depending on the amount of reflection, so the autocorrelation of incident wave heights, ρ_I , is taken as the average wave height autocorrelation of the three gage records seaward of the structure.

Autocorrelation of transmitted waves, ρ_T , is taken as the average autocorrelation of any gage measuring transmitted waves. (Note that ρ may vary between 1.0 and -1.0.) A large positive value of ρ means that waves are strongly grouped. Values of ρ near zero mean that there is little relation between successive wave heights. A negative value of the autocorrelation implies that small waves follow large waves and vice versa. Several wave records measured in this study with various values of ρ are shown in Figure 5. Note that in all cases the water levels have been normalized by the significant wave height.

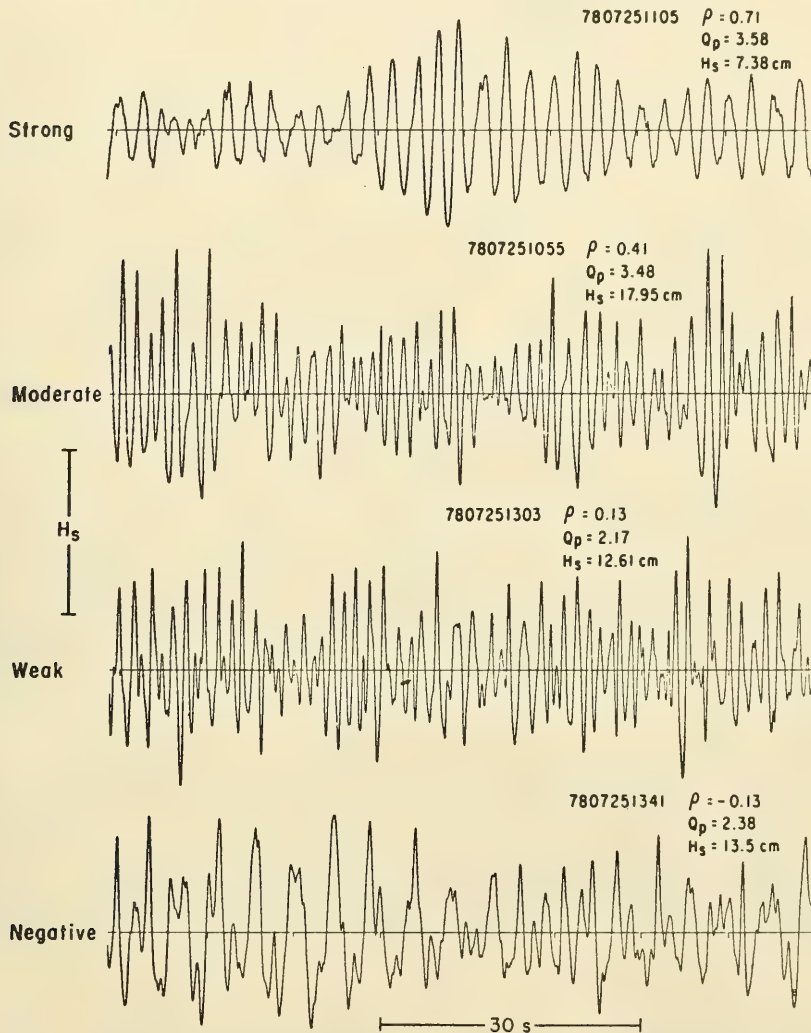


Figure 5. Sample laboratory wave records showing various levels of wave grouping.

For monochromatic wave tests, wave period, T , is defined as the period of wave generator blade motion. For most of the monochromatic wave conditions tested, 90 percent or more of the incident wave energy was found to be in the spectral band containing the blade frequency (Fig. 6). At a given value of wave steepness the amount of wave energy at higher harmonics of the blade frequency increases as the relative depth, d/gT^2 , decreases. This energy shift occurs because the waveform becomes more cnoidal and less sinusoidal in shape as d/gT^2 decreases and H/d increases.

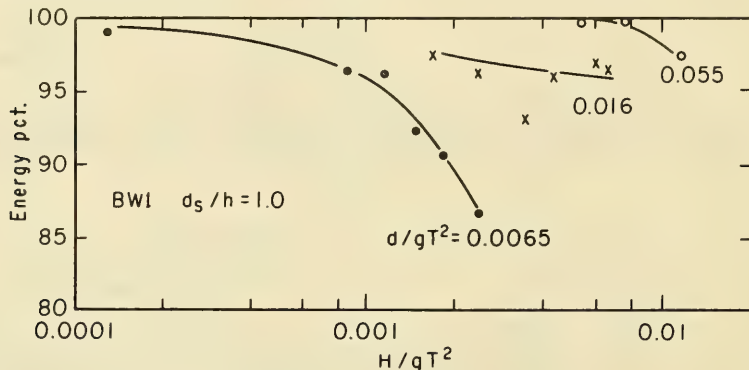


Figure 6. Percent of incident wave energy at the period of wave generator blade motion for sinusoidal wave generator blade motion.

5. Breakwaters Tested.

Cross sections for 17 breakwaters were tested for wave transmission and reflection; the cross-section geometries are illustrated in Appendix A. Each of the structures was assigned the letters BW and a number to identify the structure. Breakwaters BW1 to BW12 were built and tested on the flat bottom of the flume. However, BW13 to BW17 were constructed with a 1 on 15 fronting slope 25 centimeters high and 3.75 meters long. The fronting slope was used to simulate a sloping bottom and allow higher waves to break on the structure being tested.

Most of the breakwaters tested were of rubble-mound construction, because this is the most common type built. However, BW1 and BW14 were smooth and impermeable. BW2 had an impermeable core, and BW8 and BW9 had dolos armor units and an impermeable cap. BW3, BW4, and BW15 were tested with and without a vertical, thin impermeable plate placed in the center of the structure to prevent transmission through the lower section of the breakwater. The symbol W is used to indicate tests where the impermeable plate was used; e.g., BW3 tested with a plate is designated as BW3W. Materials used to construct the breakwaters are described in Appendix B.

6. Test Conditions.

Each breakwater was built with a fixed geometry, then tested at various water depths and wave periods. A number of wave heights were generally examined for each wave period. Most of the experiments were run with monochromatic waves

produced by sinusoidal motion of the piston-type generator blade. The ranges of dimensionless water depths (water depth at the toe of the structure divided by structure height, d_g/h) tested with monochromatic waves are given in Table 1. Major emphasis was placed on $d/gT^2 = 0.016$ because laboratory waves at this value of relative depth are comparatively free from secondary and Benjamin-Fier waves.

Table 1. Range of conditions tested with monochromatic and irregular waves.

Breakwater	Monochromatic waves		Irregular wave testing ¹
	$\frac{d_g}{h}$	$\frac{d}{gT^2}$	
	(range)	(range)	
BW1	0.6 to 1.2	0.0065 to 0.055	L
BW2	0.87	0.013 to 0.079	N
BW3	0.69 to 1.4	0.0038 to 0.037	N
BW3W	0.69 to 1.3	0.0065 to 0.08	N
BW4	0.68 to 1.3	0.0065 to 0.055	L
BW4W	0.76 to 1.3	0.0065 to 0.055	L
BW5	0.92 to 2.3	0.0065 to 0.055	L
BW6	0.75 to 1.3	0.0056 to 0.055	L
BW7	0.98 to 1.63	0.0065 to 0.055	N
BW8	0.64 to 0.86	0.016	N
BW9	0.64 to 1.1	0.0065 to 0.055	L
BW10	0.68 to 1.1	0.0065 to 0.055	L
BW11	0.51 to 0.75	0.0065 to 0.055	N
BW12	0.64 to 1.1	0.0065 to 0.055	N
BW13	1.1 to 1.8	0.0038 to 0.055	L
BW14	0.91 to 2.0	0.0038 to 0.055	L
BW15	0.61 to 1.4	0.0039 to 0.055	L
BW15W	0.91 to 1.5	0.0038 to 0.055	L
BW16	0.61 to 1.8	0.002 to 0.055	E
BW17	0.58 to 0.83	0.001 to 0.022	E

¹Testing: E = extensive; L = limited; N = none.

Breakwaters BW16 and BW17 were tested extensively with a wide variety of irregular wave conditions. A limited number of irregular wave runs were also made for several other breakwaters (Table 1).

7. Test Results.

Test results for monochromatic and irregular wave conditions are presented in tabular form in Appendixes C and D; monochromatic results are presented in graphical form in Appendix E.

IV. ANALYSIS OF TEST RESULTS

This section provides an analysis of the wave transmission and reflection results of the model tests. Impermeable and permeable breakwaters were investigated, and a separate discussion is devoted to each type breakwater. The first part of this section describes observed trends in the values of the transmission and reflection coefficients as a function of the parameters varied in this study. The second part includes development, description, and evaluation of methods for predicting wave transmission coefficients. The third part discusses the effect of a breakwater on other wave characteristics, such as the wave height distribution and shape of the transmitted wave spectra. Since good models are not available for predicting wave reflection coefficients for breakwaters, it is recommended that the model tests be used directly to estimate breakwater wave reflection coefficients.

1. Wave Transmission and Reflection for Impermeable Breakwaters.

a. Observed Trends in Transmission and Reflection Coefficients. As a wave approaches an impermeable breakwater some of the wave energy is supplied to wave runup, some of the energy is dissipated, and the remaining wave energy moves seaward in the form of a reflected wave. If the runup exceeds the crest elevation of the breakwater, waves will be regenerated on the landward side of the structure. Figure 7 shows aspects of this process and defines some of the terms used in wave transmission by overtopping.

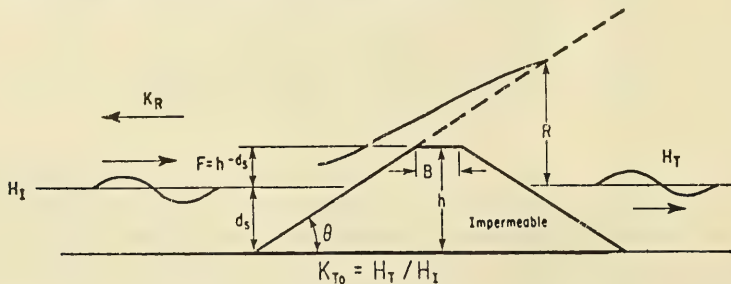


Figure 7. Definition of terms for wave transmission by overtopping.

Madsen and White (1976) found that low reflection coefficients and correspondingly large amounts of wave energy are dissipated on smooth nonovertopping structures. This observation has been verified using the data of Ahrens (1979) for breaking and nonbreaking waves. The data show that for the case of no overtopping the reflection coefficient decreases and a larger fraction of the wave energy is dissipated as the wave steepness increases (Fig. 8). More than 80 percent of the wave energy is dissipated by the smooth slope of 1 on 1.5 for the steepest waves tested. Note that the magnitude of the wave reflection coefficient is approximately the same for monochromatic and irregular waves, for a given value of wave steepness.

As the height of the breakwater is reduced the magnitude of the wave reflection coefficient decreases because much of the wave energy is transmitted by overtopping. For example, with a freeboard of zero (water level at the breakwater crest) BWL has reflection coefficients that are less than 20 percent of the reflection coefficient for a structure that is not overtopped for the steeper waves tested (Fig. 9). At values of small wave steepness the size of

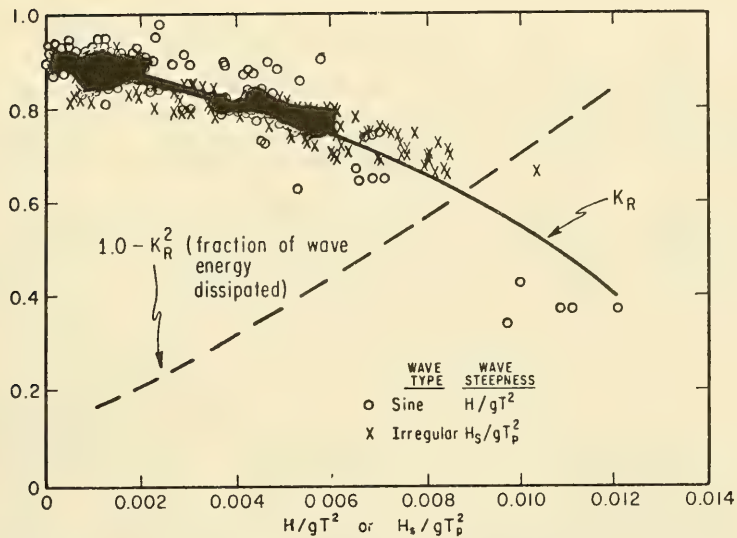


Figure 8. Wave reflection coefficients and fraction of wave energy dissipated for a 1 on 1.5 smooth slope with no wave transmission (data from Ahrens, 1979).

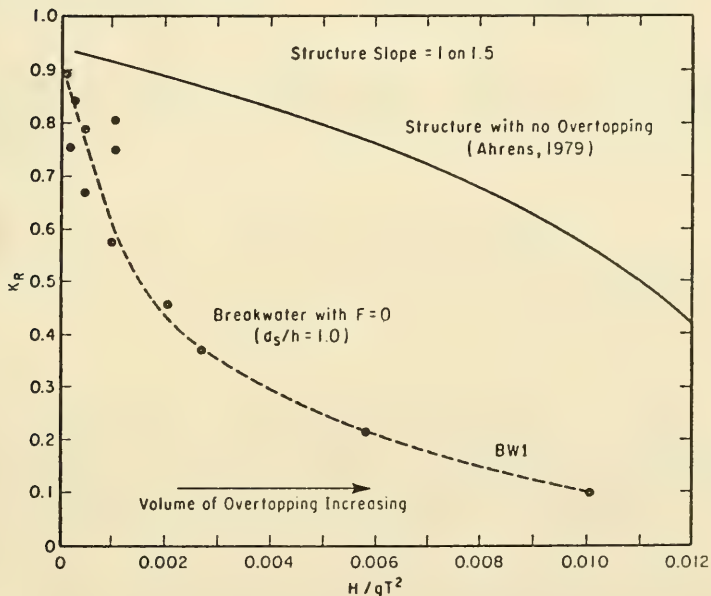


Figure 9. Wave reflection coefficients for a breakwater with zero freeboard compared to a similar structure with no overtopping.

the reflection coefficients for the breakwater and smooth impermeable slope is approximately the same because breakwater overtopping is small.

The wave reflection coefficient decreases as the wave height or steepness increases for a subaerial breakwater, but shows the opposite trend for a submerged breakwater (Fig. 10). There is a slight increase in the reflection coefficient as the wave height increases for the conditions tested.

The variation of the wave transmission coefficient for a smooth impermeable breakwater is the reverse of that found for the reflection coefficient. If the wave runup is less than the breakwater freeboard there is no wave transmission. As soon as the runup exceeds the crest of the breakwater, wave transmission by overtopping occurs. All other factors being fixed, as the wave height increases the size of the runup and the transmission by overtopping coefficient increase (Fig. 10); as the ratio of the water depth to structure height, d_g/h , approaches 1.0 the transmission coefficient increases. Even with zero freeboard ($d_g/h = 1$) there is some increase in the wave transmission coefficient as wave steepness increases (Fig. 10). However, for a submerged breakwater of fixed geometry the wave transmission coefficient declines as wave height or steepness increases (Fig. 10).

b. Estimating Wave Transmission by Overtopping Coefficients. Wave transmission by overtopping is closely related to wave runup and overtopping of a breakwater. Weggel (1976) found that overtopping rates are a function of the ratio of the structure freeboard, F , to the runup, R , on a similar structure high enough to prevent overtopping (Fig. 7). Cross and Sollitt (1971) also recommend the dimensionless parameter, F/R , for predicting wave transmission by overtopping coefficients.

Several methods are available for estimating wave runup on smooth impermeable slopes; some of these methods are summarized in Stoa (1978). The runup prediction equation developed by Franzius (1965) gives the best estimate of wave runup for predicting wave transmission coefficients. The runup is given by

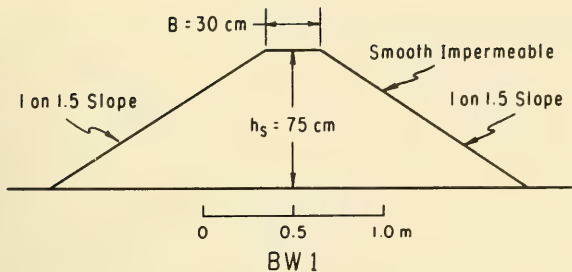
$$R = HC_1 \left(0.123 \frac{L}{H} \right) (C_2 \sqrt{H/d} + C_3) \quad (10)$$

where L is the local wavelength determined from linear theory using

$$L = \frac{gT^2}{2\pi} \tanh \left(\frac{2\pi d}{L} \right) \quad (11)$$

and C_1 , C_2 , and C_3 are empirical coefficients. Franzius suggests values for the coefficients, but improved coefficients were obtained in this study using the data of Saville (1955) and Savage (1959) with a nonlinear error minimization computer routine. The recommended values of the empirical coefficients are given in Table 2. These values are linearly interpolated to estimate values of the coefficients for other slopes. An advantage of using equation (10) is that it includes effects of wave height, structure slope, wave steepness, and the ratio of water depth to wave height on wave runup.

The runup on rough slopes is also a complex function of many factors (Stoa, 1978). Madsen and White (1976) give an analytical-empirical model for estimating



	d_s/gT^2	
○	1.20	Submerged Breakwater
△	1.13	
+	1.07	
×	1.00	
◇	0.93	Subaerial Breakwater
↑	0.87	
×	0.80	
Z	0.73	
Y	0.67	
×	0.60	

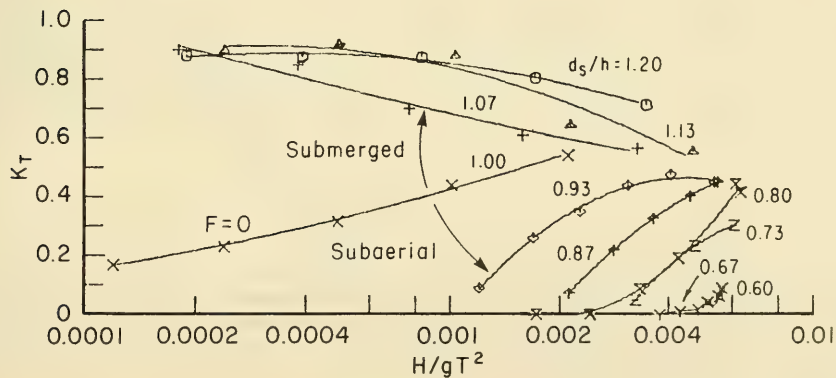
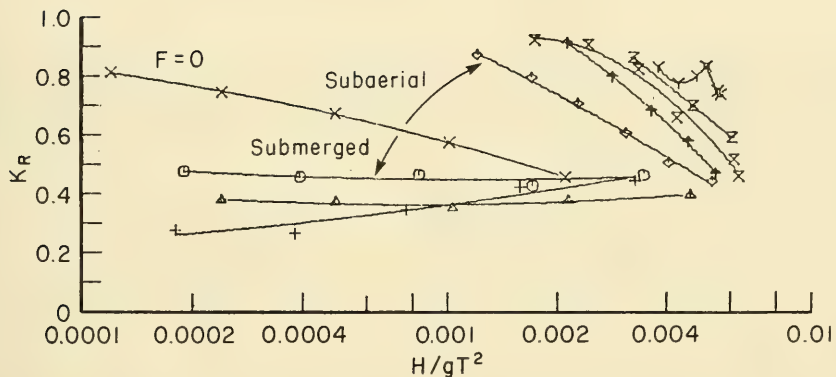


Figure 10. Wave transmission and reflection coefficients for a smooth impermeable breakwater (BW1, $d_s/gT^2 = 0.016$, monochromatic waves).

Table 2. Empirical wave runup prediction coefficients for smooth impermeable slopes.

Front-face slope of breakwater	C_1	C_2	C_3
Vertical	0.958	0.228	0.0578
1 on 0.5	1.280	0.390	-0.091
1 on 1.0	1.469	0.346	-0.105
1 on 1.5	1.991	0.498	-0.185
1 on 2.25	1.811	0.469	-0.080
1 on 3.0	1.366	0.512	0.040

runup on an impermeable rough slope armored with one layer of stone. Ahrens and McCartney (1975) present an empirical method for estimating the runup on two layers of riprap overlying a 0.2-meter thick underlayer (Fig. 11). In their method the runup is predicted as a nonlinear function of the surf parameter, ξ ,

$$\frac{R}{H} = \frac{a\xi}{1 + b\xi} \quad ; \quad \xi = \frac{\tan \theta}{\sqrt{\frac{H}{L_0}}} \quad (12)$$

where a and b are empirical coefficients with values of $a = 0.956$ and $b = 0.398$.

Both the Madsen and White and Ahrens and McCartney prediction methods tend to give high or conservative estimates of wave runup for predicting wave transmission coefficients. However, Hudson (1958) made numerous observations of runup over a wide range of breakwater conditions; the Ahrens and McCartney empirical curve (eq. 1) was fitted to the Hudson data to give the recommended runup coefficients of $a = 0.692$ and $b = 0.504$ (Table 3). These coefficients gave a lower prediction of runup than that given for riprap (Fig. 12). The equation

$$\frac{R}{H} = \frac{0.692 \xi}{1 + 0.504 \xi} \quad (13)$$

is recommended for predicting runup on stable permeable and impermeable stone breakwaters until a more comprehensive model becomes available. Coefficients for dolos were also estimated using Bottin, Chatham, and Carper's (1976) data for breaking and nonbreaking waves (Table 3). Stoa (1978) provides additional information on runup; runup data for nonbreaking waves on breakwaters are provided in Jackson (1968):

Runup predictions were made for the conditions tested, and observed wave transmission by overtopping coefficients, K_{T0} , were plotted as a function of F/R (Fig. 13). This figure shows the case of breakwaters with a slope of 1 on 1.5. The upper part of Figure 13 shows results from BW1 for tests that had a

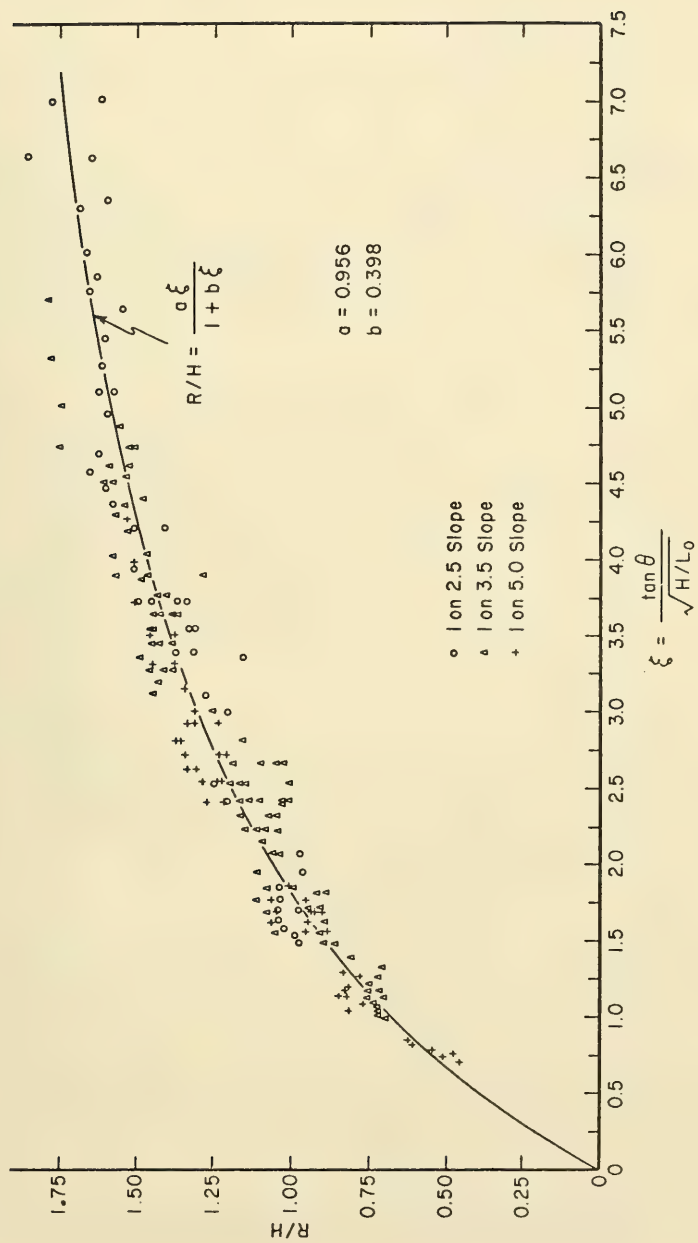


Figure 11. Wave runup on riprap (after Ahrens and McCartney 1975).

Table 3. Wave runoff prediction coefficients using the Ahrens and McCartney (1975) method.

Armor unit	No. of layers	Permeability ¹	2		$\frac{d}{gT^2}$ (range)	$\frac{H}{gT^2}$ (range)	Cot θ (range)	Source
			a	b				
Rubble	2	I	0.956	0.398	0.0036 to 0.059	0.0004 to 0.013	2.5 to 5.0	Ahrens and McCartney (1975) ³ (large-scale tests)
Rubble	0	P	0.692	0.504	0.0088 to 0.08	0.0004 to 0.02	1.25 to 5.0	Hudson (1958) ⁴
Rubble	2	I	0.775	0.361	----- ⁵	-----	2.5	Gunbak (1979) ⁶
Dolos	2	I	0.988	0.703	0.009 to 0.002	0.0002 to 0.006	2.0	Bottin, Chatham, and Carver (1976)

¹P = permeable; I = impermeable.

⁴Means of observations.

² $R/H = a\xi/(1+b\xi)$; $\xi = \tan \theta / \sqrt{H/L_0}$.

⁵Conditions unknown.

³Revised a and b.

⁶ $1.2 < \xi < 4.8$.

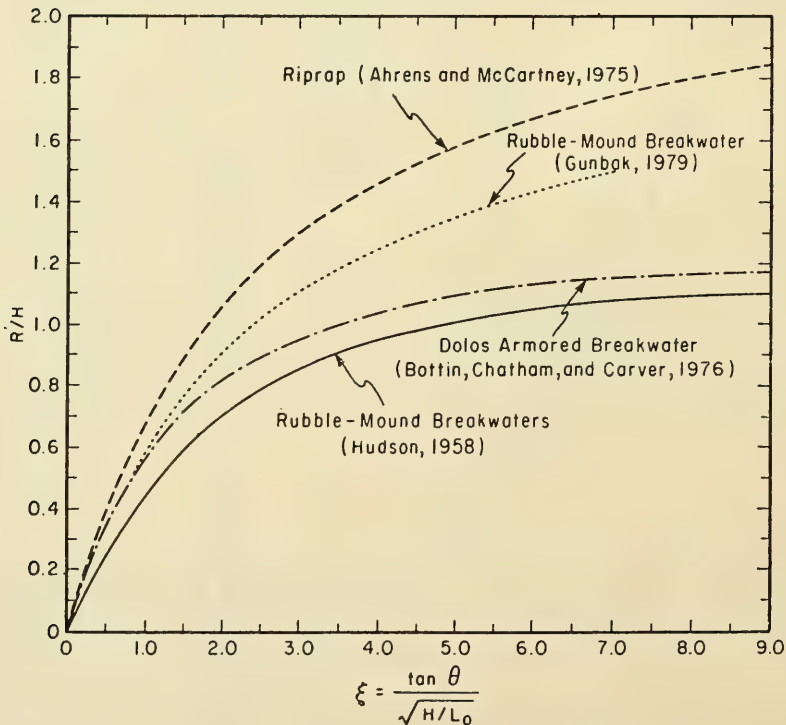


Figure 12. Wave runoff prediction for rough structures using the Ahrens and McCartney (1975) method.

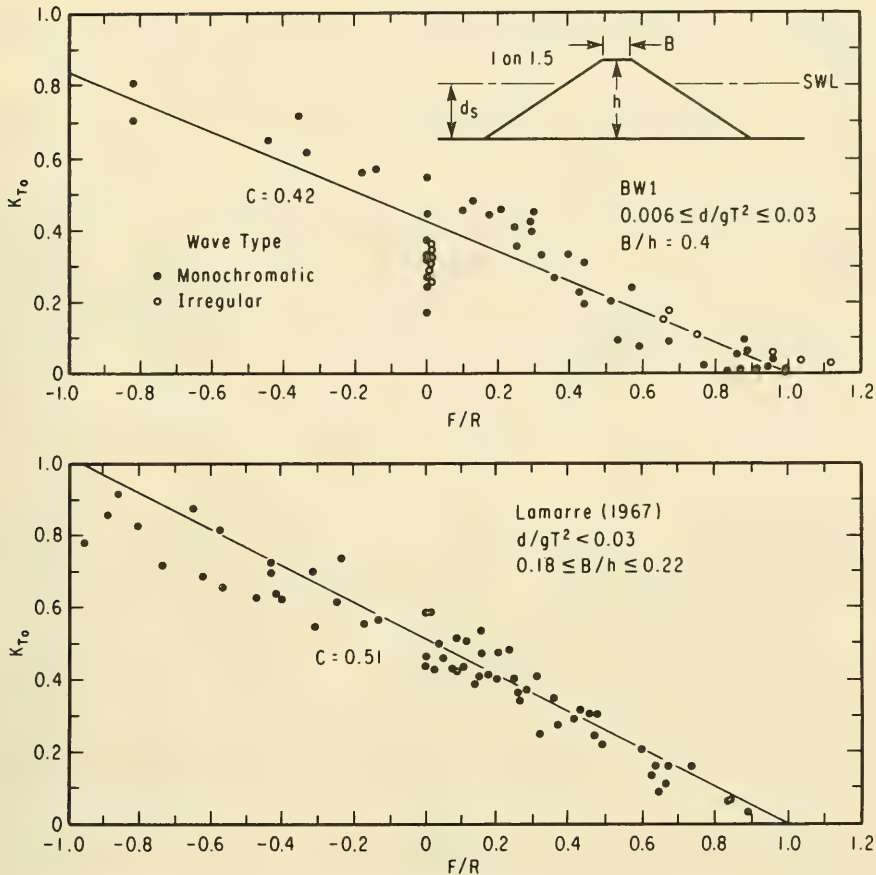


Figure 13. Wave transmission coefficients for smooth impermeable breakwaters with 1 on 1.5 slopes.

breakwater crest width-to-structure height ratio of $B/h = 0.4$. The lower part of the figure gives test results from Lamarre (1967), who tested structures with smaller values of B/h . Although there is some scatter in these data sets, it appears that the wave transmission coefficient decreases approximately linearly as F/R increases and that this linear trend is found for submerged as well as subaerial breakwaters. Most of the scatter occurs where the crest elevation is at the stillwater level ($F/R = 0$) for BW1, with small waves having significantly lower wave transmission coefficients than are present in the linear trend. Fortunately, small waves are generally not of interest for design purposes. The few irregular waves tested with BW1 suggest that wave transmission coefficients for irregular waves follow the same trend as for monochromatic waves. The mean wave height, taken as 63 percent of the significant wave height, should be used in equation (12) to determine the effective runup for predicting wave transmission coefficients for irregular wave conditions.

Comparison of the upper and lower parts of Figure 13 suggests that the structure tested by Lamarre (1967) with a smaller relative crest width has slightly higher wave transmission coefficients than found for BW1.

Results from laboratory tests by Goda (1969) for breakwaters with vertical faces (Fig. 14) have the same trends as observed for breakwaters with 1 on 1.5 slopes.

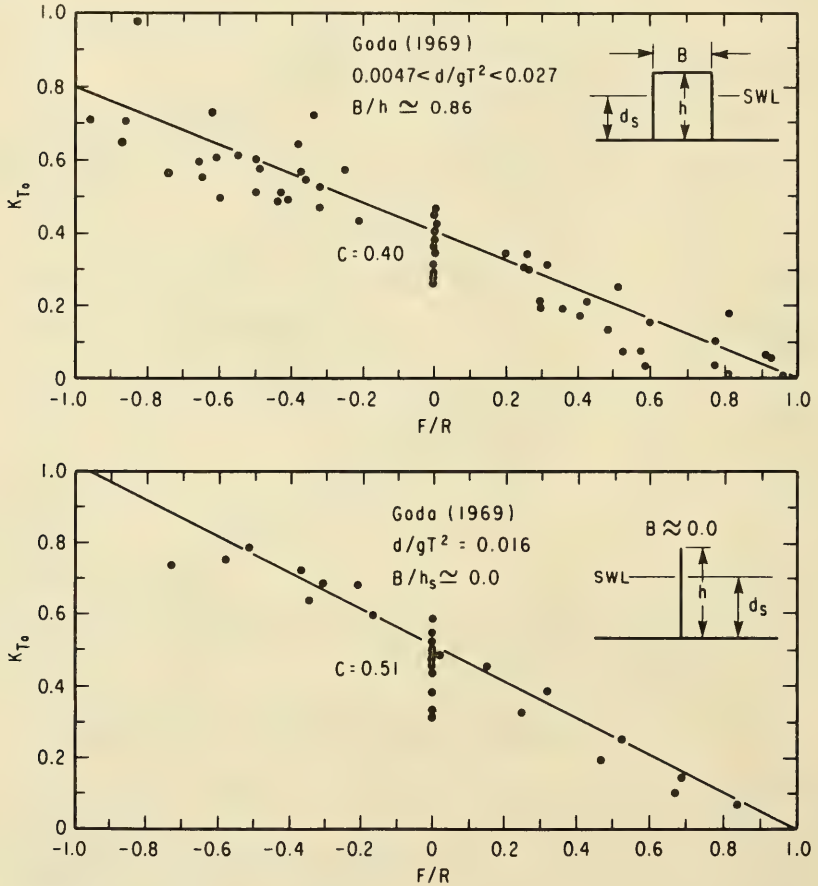


Figure 14. Wave transmission coefficients for vertical, smooth impermeable breakwaters using Goda's (1969) data.

The recommended formula for predicting the wave transmission by overtopping coefficient for the range $0.006 \leq d/gT^2 \leq 0.03$ is

$$K_{T0} = C \left(1 - \frac{F}{R} \right) \quad (14)$$

where C is an empirical coefficient and the minimum and maximum values of K_{T0} are 0.0 and 1.0, respectively. The recommended value of C is given by

$$C = 0.51 - \frac{0.11 B}{h} ; \quad 0 \leq \frac{B}{h} \leq 3.2 \quad (15)$$

for smooth impermeable structures tested over the range $0 \leq B/h \leq 0.86$ and rough impermeable breakwaters tested over the range $0.88 \leq B/h \leq 3.2$ (Fig. 15). However, for submerged breakwaters tested with 1 on 15 fronting slopes, equation (14) underestimates the wave transmission coefficient. For example, equation (14) underestimates the wave transmission coefficient for BW14 when submerged and the error increases as the breakwater becomes relatively more submerged (Fig. 16). The data from BW14 and from Saville (1963) show that for submerged breakwaters with $0.88 \leq B/h \leq 3.2$ and with a 1 on 15 fronting slope equation (14) should be adjusted to

$$K_{T0} = C \left(1 - \frac{F}{R} \right) - (1 - 2C) \frac{F}{R} ; \quad \frac{F}{R} < 0 \quad \text{and 1 on 15 fronting slope} \quad (16)$$

Figures 17 and 18 illustrate the observed and predicted wave transmission coefficients for two of the rough impermeable breakwaters tested by Saville (1963) for two values of crest width. Figure 17 shows the case of a structure with a crest width-to-structure height ratio of 0.88; Figure 18 shows the same information for a much wider structure with a width-to-height ratio of 3.2. A scatter plot of observed and predicted transmission coefficients using Saville's (1963) data indicates the level of ability to predict K_{T0} (Fig. 19).

The above discussion shows that the breakwater freeboard and wave runup have a major influence on the magnitude of the wave transmission by overtopping coefficient. Breakwater crest width has a much smaller effect and only large changes in breakwater crest width could be used to reduce the size of the transmission coefficient for a given design situation.

Wave transmission by overtopping coefficients may be predicted for impermeable structures using the computer program OVER (App. F) which applies methods described in this section.

c. Influence of a Breakwater on Other Wave Characteristics. The magnitude of the wave transmission by overtopping coefficient, K_{T0} , is generally the most important parameter to determine for the design of an impermeable breakwater used to reduce wave height. However, in addition to reducing the average wave height, the breakwater may also alter other characteristics of the waves, such as spectral shape or wave height distributions. Since these additional wave characteristics may be considered in some design problems, they are briefly discussed below.

The case of monochromatic waves incident on the structure is the condition most often used to test wave transmission of laboratory breakwaters in previous studies. This type of wave is similar to swell wave conditions in the prototype where the incident wave height and period are approximately constant. Spectral analysis of water level records for gages landward of the breakwater indicates that a significant part of the wave energy of transmitted waves may be at harmonic frequencies of the forcing wave (Saville, 1963; Goda, 1969). The fraction of wave energy at the forcing period (Fig. 20) shows the same trend

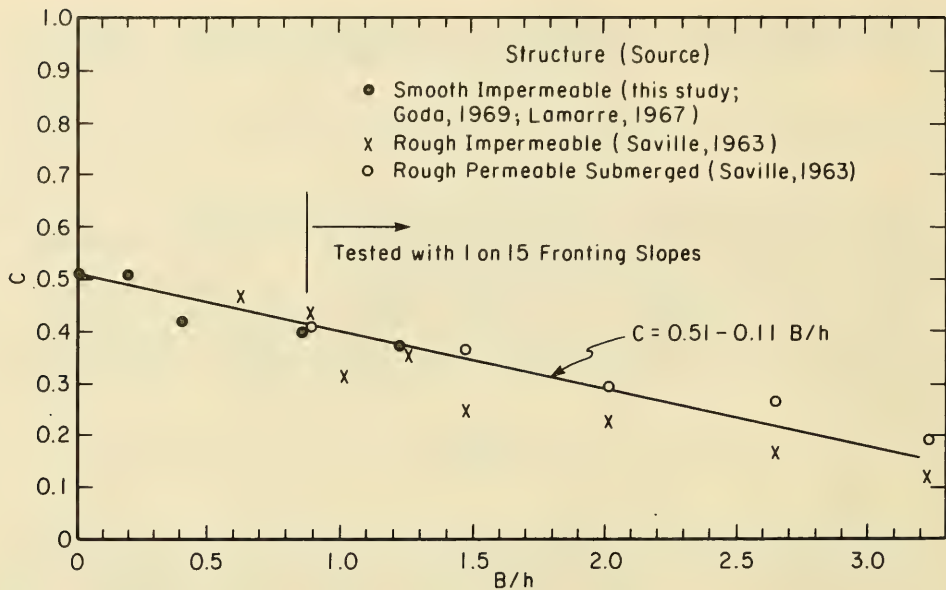


Figure 15. The effect of the relative structure width on wave transmission of impermeable breakwaters.

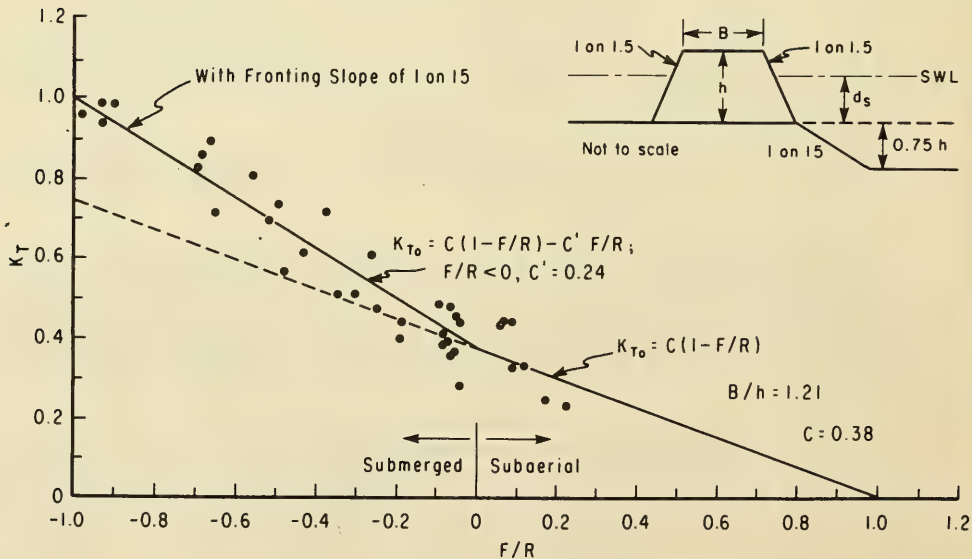


Figure 16. Wave transmission coefficients for BW14.

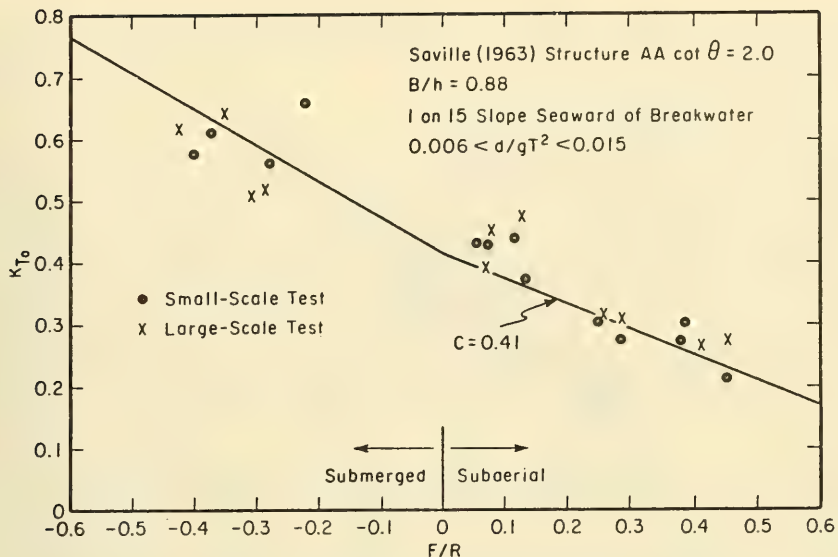


Figure 17. Wave transmission coefficients for a breakwater tested by Saville (1963) with $B/h = 0.88$.

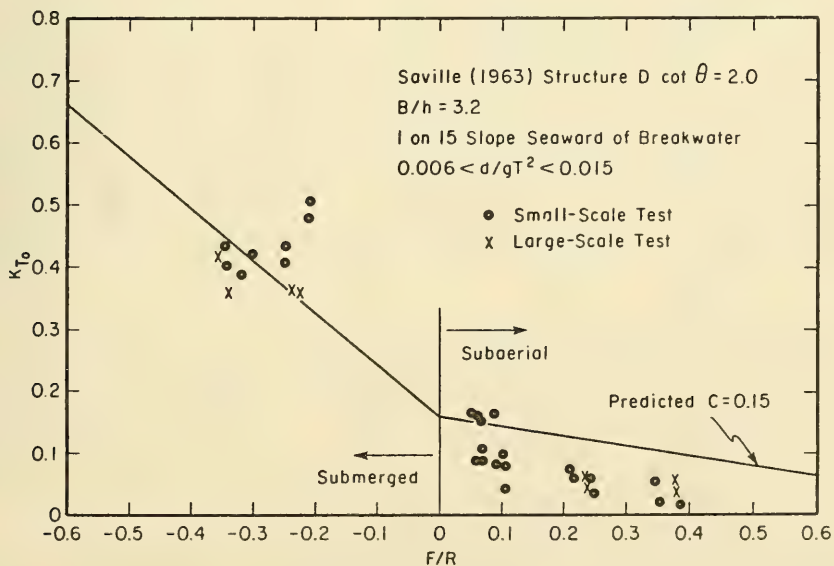


Figure 18. Wave transmission coefficients for a breakwater tested by Saville (1963) with $B/h = 3.2$.

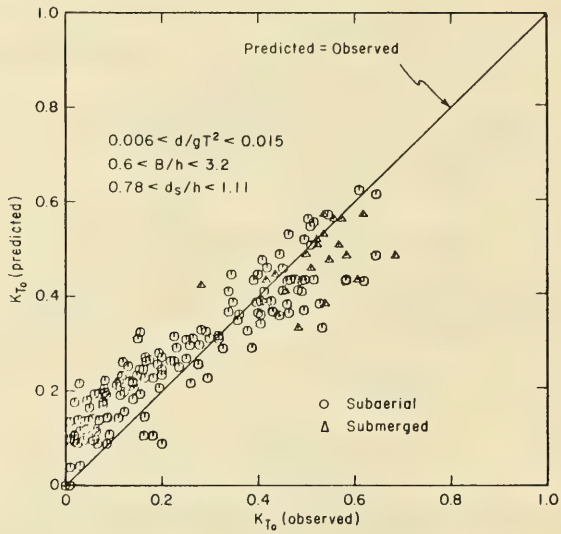


Figure 19. Observed and predicted coefficients of wave transmission by overtopping (Saville, 1963; impermeable breakwaters).

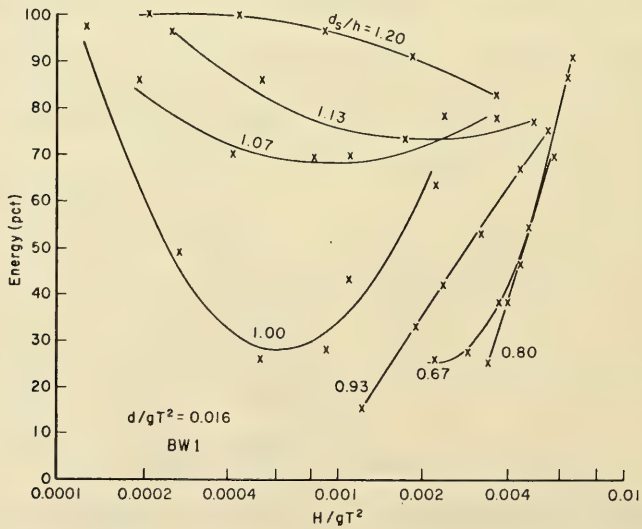


Figure 20. Percent of wave energy at the forcing wave period for wave transmission by overtopping of a smooth impermeable structure (monochromatic waves).

as was found for the transmission coefficient, K_{T0} (lower half of Fig. 10). Comparison of Figures 10 and 20 suggests that the amount of wave energy found at the forcing period will increase as the transmission by overtopping coefficient increases.

The case of irregular waves is where the incident wave energy is distributed over a range of wave frequencies (several measured incident laboratory wave records and computed wave spectra are shown in Figs. 4 and 5). Tests with irregular waves indicate that the shapes of the incident and reflected wave spectra are approximately the same (two examples are given in Fig. 21). The approximately constant spectral shape is shown by the spectral-peakedness parameter, Q_p , where the value for the reflected waves, Q_{pr} , is approximately equal to the incident spectral peakedness, Q_{pi} (Fig. 22). The shape of the transmitted spectrum may be approximately equal to or sharper than the incident spectrum (Fig. 22) with the spectral-peakedness parameter of the transmitted waves, Q_{pt} , greater than or equal to Q_{pi} (Fig. 22). Secondary waves may appear in the transmitted wave spectrum at harmonics of the period of peak energy density, T_p , (Fig. 21).

A zero up-crossing analysis (Fig. 23) was performed on the wave records to allow statistical examination of individual wave heights and periods. Since reflected waves contaminate the incident wave conditions, an analysis was performed for the record from each gage, then results averaged to minimize the influence of reflection. Cumulative height distributions were then prepared for incident and transmitted waves. The cumulative curves were put into dimensionless form by dividing by the observed rms wave height, H_{rms} , and the dimensionless heights at various probability levels, p , determined ($p = 0.01, 0.02, 0.05, \dots, 0.60$). A plot of these dimensionless heights for transmitted versus incident waves indicates the shape of the transmitted wave height distribution as a function of the incident wave height distribution. For the case of a breakwater with the water depth at the crest level ($d_g/h = 1.0$ or $F = 0$) the transmitted wave height distribution is approximately the same as the incident height distribution (Fig. 24). If the water level is below the crest elevation ($d_g/h = 0.80$, positive freeboard), the transmitted wave height distribution is skewed toward larger waves (Fig. 25). This means that the larger transmitted waves are bigger than predicted by the transmission coefficient, K_{T0} . For example, at the 5-percent level, transmitted waves are 30 percent larger than expected from the overall transmission coefficient and at the 1-percent level 100 percent larger.

The above observations are consistent with the wave transmission by overtopping model given by equation (14). At zero freeboard the transmission coefficient is approximately constant, so all waves in a distribution will transmit the same amount and the distribution will remain unchanged. However, for subaerial breakwaters the larger waves will have smaller F/R ratios and transmit more efficiently than small waves, so that the transmitted wave distribution is skewed toward large waves.

The joint distributions of wave heights and periods observed in the laboratory illustrate the same overall trends found in the field. Larger waves have a mean period approximately equal to the period of peak energy density in the spectrum, T_p (Goda, 1978), with the average wave period decreasing for smaller wave heights (Fig. 26). The correlation between

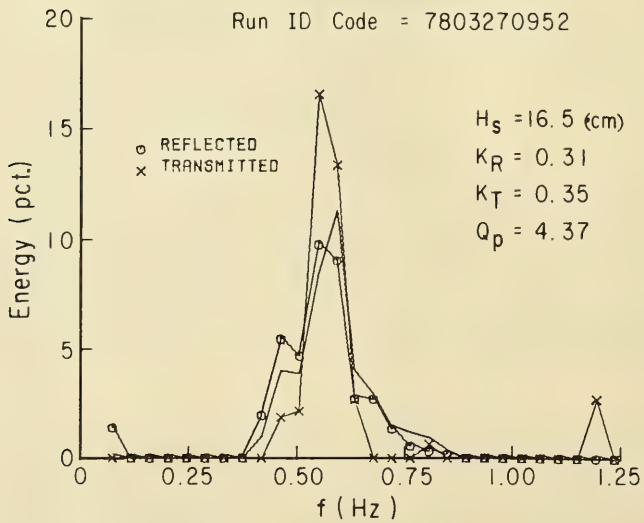
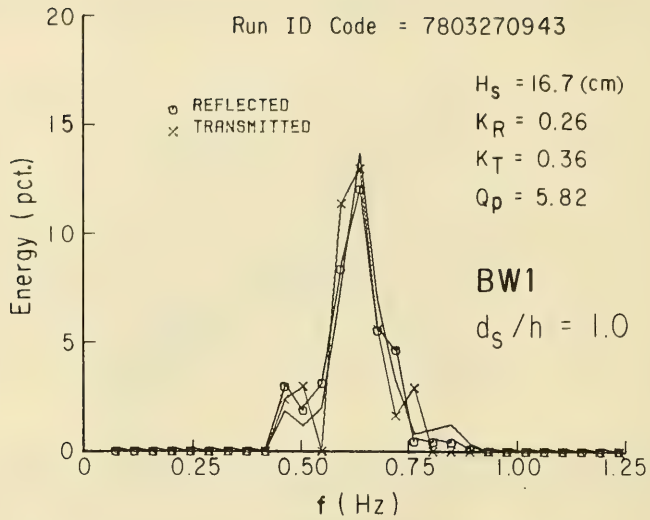


Figure 21. Sample incident, reflected, and transmitted wave spectra.

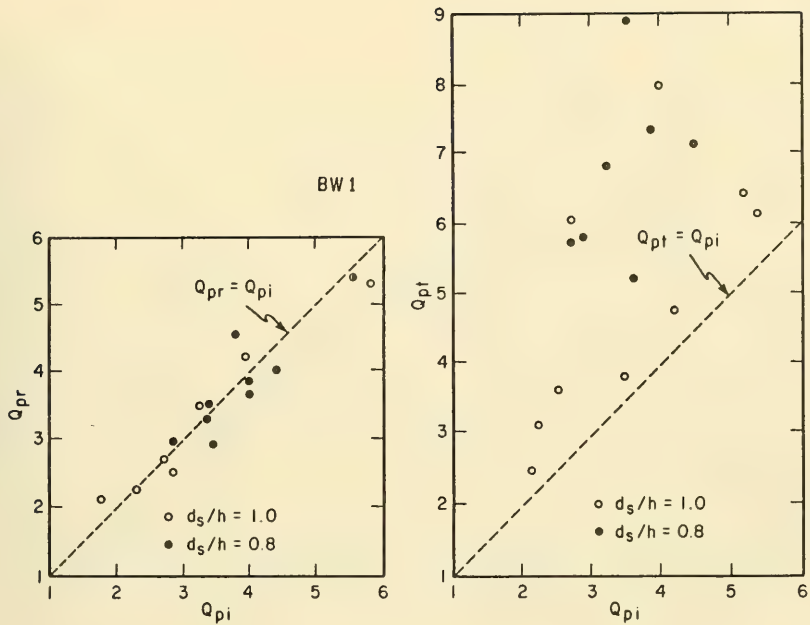


Figure 22. Spectral peakedness of incident, reflected, and transmitted wave spectra.

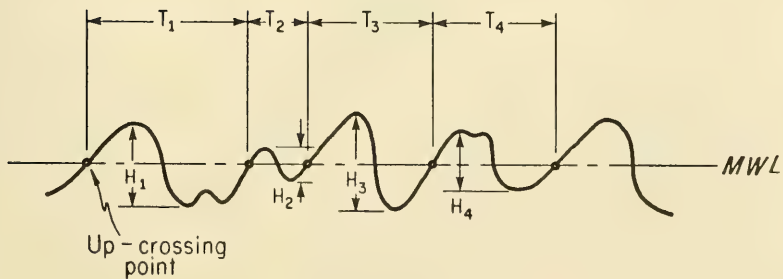


Figure 23. Zero up-crossing analysis.

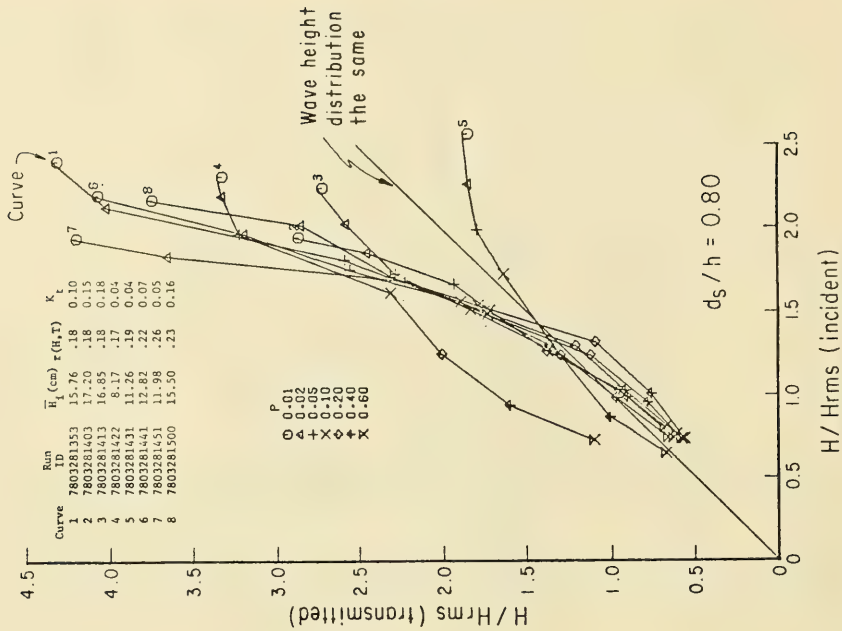


Figure 25. Transmitted versus incident wave height distributions for a breakwater with $d_5/h = 1.0$.

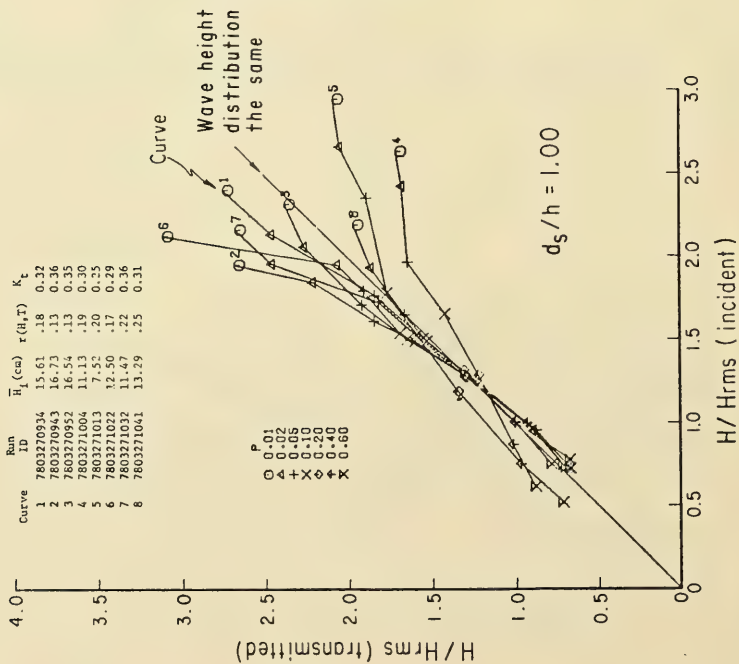


Figure 24. Transmitted versus incident wave height distributions for a breakwater with $d_5/h = 0.8$.

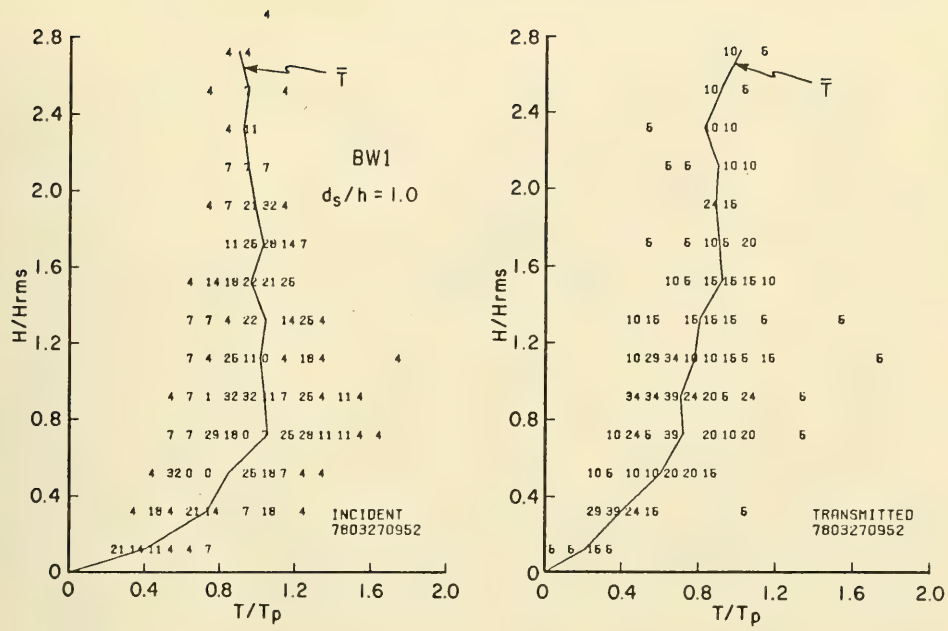
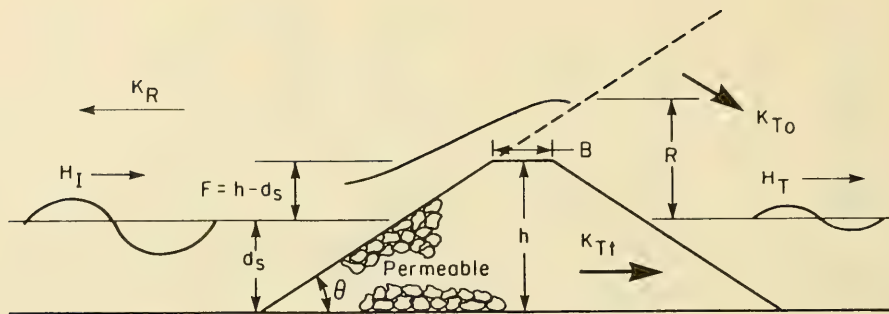


Figure 26. Sample incident and transmitted joint distributions of wave height and period.

heights and periods (Goda, 1978) was observed to be $0.13 \leq r(H,T) \leq 0.26$ for the incident wave conditions tested with approximately the same values for transmitted waves. The major difference between observed and transmitted joint distributions of height and periods is that the mean period of smaller waves is lower for the transmitted waves (Fig. 26) than for the incident waves.

2. Wave Transmission and Reflection for Permeable Breakwaters.

a. Observed Trends in Transmission and Reflection Coefficients. As a wave approaches and interacts with a rough permeable breakwater the sequence of action is similar to that for an impermeable breakwater, but with important differences. First, some of the wave energy moves through the permeable breakwater and this flow through the porous medium may dissipate a significant amount of wave energy. Second, because the breakwater absorbs some of the wave energy and water, the runup and reflection coefficients on a rough permeable breakwater are less than for the same wave condition on a similar smooth impermeable structure. If the runup level exceeds the height of the structure, wave transmission by both overtopping and transmission through the structure will contribute to the overall transmission coefficient, K_T (Fig. 27).



$$K_T = \sqrt{(K_{T0})^2 + (K_{Tt})^2} = H_T/H_I$$

Figure 27. Definition of terms for wave transmission for permeable breakwaters.

The relative water depth, d/gT^2 , is one of the most important parameters controlling the reflection coefficient, K_R (Fig. 28), with the reflection coefficient increasing as d/gT^2 decreases. The wave steepness, H/gT^2 , and the ratio of water depth to structure height, d_s/h , have less influence. In general, the reflection coefficients for rough permeable breakwaters are much less than for similar smooth impermeable breakwaters (Fig. 10). Since no comprehensive model is currently available for predicting reflection coefficients, laboratory model results should be used to estimate K_R . A rough estimate of the reflection coefficient for permeable subaerial breakwaters may be obtained using the method of Madsen and White (1976) (computer program MADSEN in App. G). Typical comparisons between predictions and laboratory measurements are shown in Figure 29.

The wave transmission coefficient, K_T , is primarily a function of wave steepness for a given permeable breakwater design and hydraulic conditions where there is no transmission by overtopping (Fig. 28). Since the wave steepness increases the amount of energy dissipated on the face and inside the breakwater increases (Madsen and White, 1976), the transmission coefficient decreases. However, as soon as the wave runup level exceeds the breakwater crest, wave transmission by overtopping occurs and the transmission coefficient increases with increasing steepness. Figure 30 (lower part) shows the case where no overtopping occurs and K_T decreases (low steepness waves), then K_T increases with increasing steepness where transmission by overtopping and transmission through a breakwater occur simultaneously. In the case of a submerged breakwater the wave transmission coefficient decreases as the wave steepness increases (upper part of Fig. 30).

b. Estimation of the Coefficient of Wave Transmission Through Permeable Breakwaters Using the Madsen and White Model. The advantages of the Madsen and White (1976) model for predicting transmission coefficients are that the model is completely self-contained and it can be used to predict coefficients over a wide range of conditions. Parameters that can be varied include the breakwater height, breakwater width, breakwater slope, the size and relative location of various layers in the breakwater, and the size and porosity of materials used in the breakwater. Another advantage of the model is that it can be used to

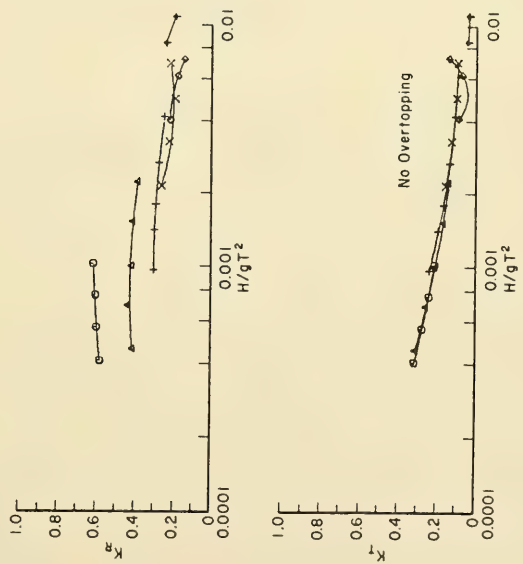
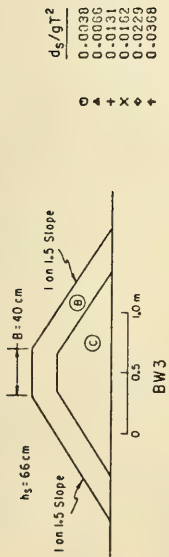


Figure 28. Wave transmission and reflection coefficients for BW3 ($d_g/h = 0.69$).

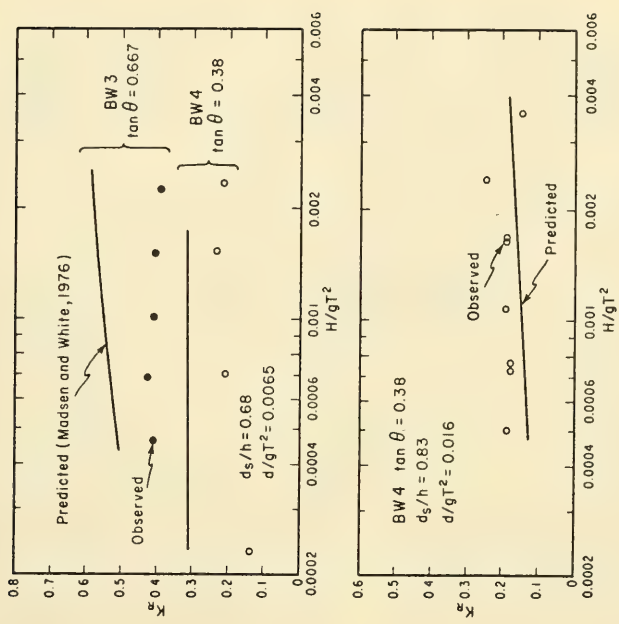


Figure 29. Sample observed and predicted reflection coefficients for permeable subaerial breakwaters.

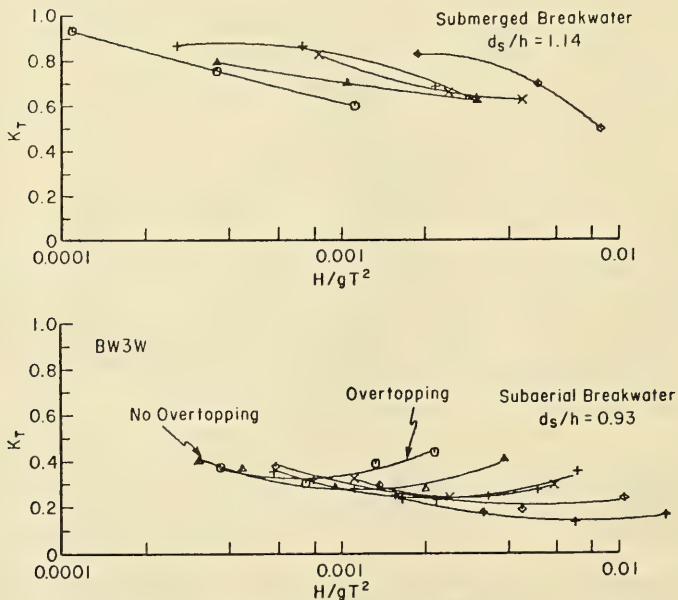
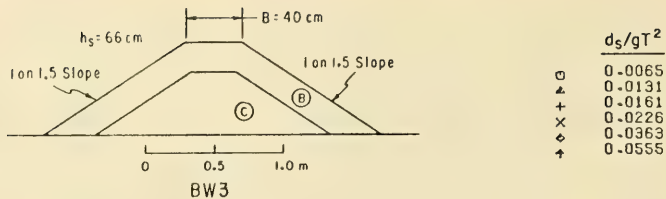


Figure 30. Wave transmission coefficients for a subaerial and a submerged breakwater.

predict coefficients for any size breakwater, useful when designing or assessing scale effects in small-scale physical models (see Sec. V).

The Madsen and White model was designed for manual use, but because of the many calculations and iterations necessary, manual calculation is tedious. The model was automated as a part of this study in a FORTRAN computer program, MADSEN (App. G) to simplify use of the model. Advantages of the computer program are that only a few input cards are required to model even a breakwater with complex geometry and the program computer cost is very low. The program includes all the generality in the original model, and the wave transmission by overtopping model developed in Section IV,1 is also incorporated. Since the Madsen and White (1976) technique is complex, reference is made to their publication for details of the model. A brief summary of the major steps in the model and computer program is given below; additional information on the computer program is given in Appendix G.

(1) Determine the breakwater cross-sectional geometry and material characteristics of diameter and porosity.

(2) Estimate the energy dissipation on the seaward face of the breakwater assuming it is rough and impermeable. This is done by solving Madsen and White's equation (127) implicitly using their Figures 15, 16, and 17 and applying a correction factor from their Table 2.

(3) Assume as a first approximation that the head across the breakwater is equal to runup determined from step 2 above.

(4) Transform the trapezoidal breakwater into a hydraulically equivalent rectangular breakwater (see Sec. 4.2 of Madsen and White).

(5) Estimate the coefficient of transmission through the structure, K_{Tt} , using Madsen and White's Figures 2 and 3 and implicitly solving their equation (57).

(6) Obtain a revised estimate of the head across the breakwater using Madsen and White's equation (161). (Repeat steps 4, 5, and 6 until a converged solution is obtained.)

(7) Estimate wave runup on the breakwater using the method of Ahrens and McCartney (1975) and the coefficients given in Table 3 of this study.

(8) Calculate the transmission by overtopping coefficient, K_{TO} , using equations (14) and (15) in this study.

(9) Calculate the transmission coefficient, K_T , using K_{Tt} from step 5 and K_{TO} from step 8 and

$$K_T = \sqrt{K_{Tt}^2 + K_{TO}^2}$$

Madsen and White compared the model predictions to physical model results from Keulegan (1973) for rectangular breakwaters composed of one rock type, and from Sollitt and Cross (1976) for a multilayered trapezoidal breakwater made of riprap. There was good agreement between analytical and physical model results for predicting the wave transmission coefficient for long nonbreaking waves. However, the following questions need to be answered to determine the range of usefulness of the Madsen and White model:

(1) How useful is the model for predicting transmission coefficients for relatively short waves?

(2) Can the model be used if waves are breaking?

(3) Can the model be used for breakwaters with concrete armor units?

(4) Can the model be used for irregular waves?

(5) How sensitive is the model to porosity of the materials?

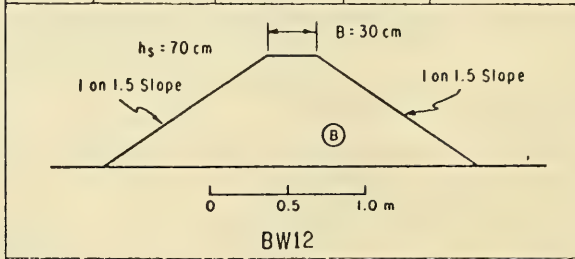
(Porosity is an input parameter and although it probably does not vary over a very wide range, its value will probably not be known accurately in a design situation.)

Each of these areas is discussed below.

(1) The case of the relative wavelength. In many of the laboratory tests the wave period was varied to cover the range from shallow-water long waves to deepwater short waves. Comparison of laboratory data and MADSEN computer program predictions shows excellent correspondence for shallow-water waves; e.g., at $d/gT^2 = 0.0065$ (Table 4). As the relative depth becomes larger (the wavelength becomes shorter), the computer program slightly overpredicts the observed transmission coefficient (Fig. 31). This means that the prediction method is conservative. Although the absolute value of the overprediction is small, the percent overprediction may be large (Table 4).

Table 4. Effect of relative depth on prediction of K_{Tt} .

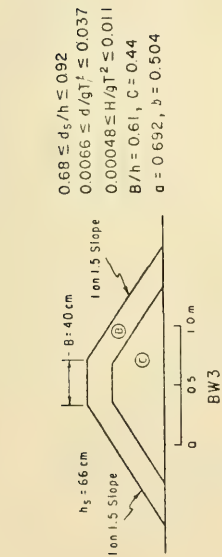
$\frac{d}{gT^2}$	K_{Tt}^1		Pct. error	Relative depth
	Observed	Predicted		
0.0065	0.34	0.33	-3	Shallow
0.016	0.46	0.44	-4	Transitional
0.055	0.13	0.21	+60	Deep



¹BW12, $d_0/h = 0.64$, $H/gT^2 \approx 0.0015$.

The ability of the model to predict wave transmission coefficients for a breakwater constructed entirely of armor stone is shown in Figure 32; wave transmission coefficients for a breakwater with a front-face slope of 1 on 2.6 are shown in Figure 33.

(2) The case of waves breaking on the breakwater. It was difficult in the laboratory to generate long waves that would break on a rough permeable structure without any overtopping. However, several tests that met these conditions were run using nonsurging, breaking waves (Galvin, 1968). These laboratory tests show that for breaking and nonbreaking waves the coefficient of transmission decreases gradually as the incident steepness increases (Fig. 34); no difference was evident between K_{Tt} for breaking and nonbreaking waves. The same trend is observed in Bottin, Chatham, and Carver's (1976) data for a breakwater with dolos armor units. Comparison of observed and predicted coefficients of transmission through the structure shows good agreement for the few breaking wave conditions tested (Fig. 34). These few tests suggest that the Madsen and White (1976) model can be used for breaking as well as nonbreaking waves.



$0.69 \leq d_s/h \leq 0.92$
 $0.0066 \leq d/gT^2 \leq 0.037$
 $0.00048 \leq H/gT^2 \leq 0.011$
 $B/h = 0.61, C = 0.44$
 $a = 0.692, b = 0.504$

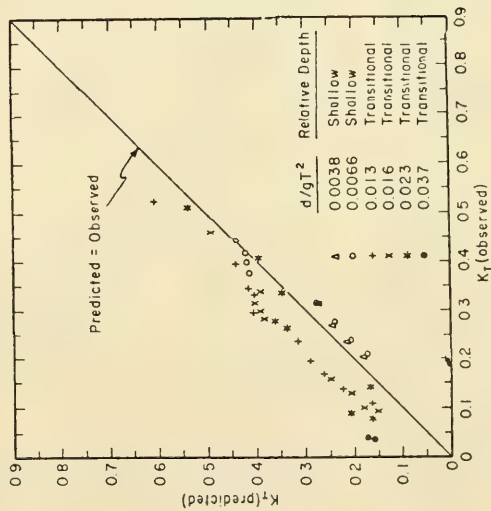
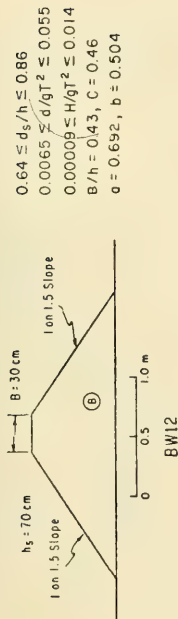


Figure 31. Observed and predicted transmission coefficients for BW3.



$0.64 \leq d_s/h \leq 0.86$
 $0.0065 \leq d/gT^2 \leq 0.055$
 $0.00009 \leq H/gT^2 \leq 0.014$
 $B/h = 0.43, C = 0.46$
 $a = 0.692, b = 0.504$

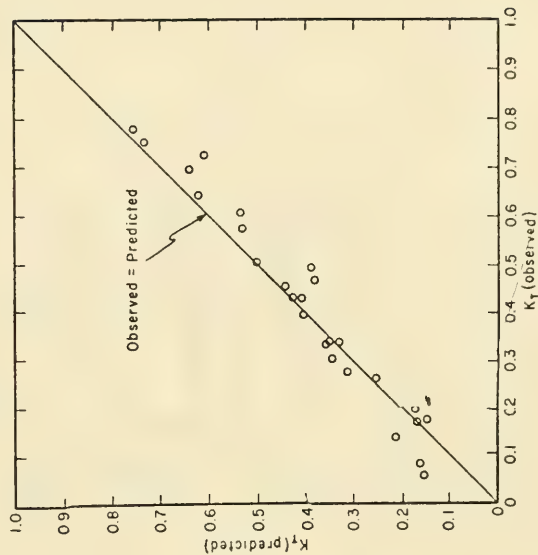


Figure 32. Observed and predicted transmission coefficients for BW12.

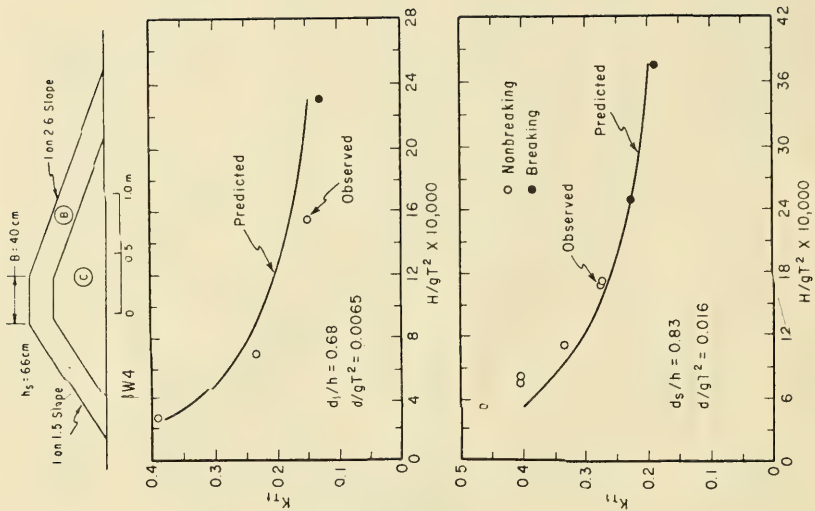


Figure 34. Observed and predicted transmission coefficients for breaking and non-breaking conditions (BW4).

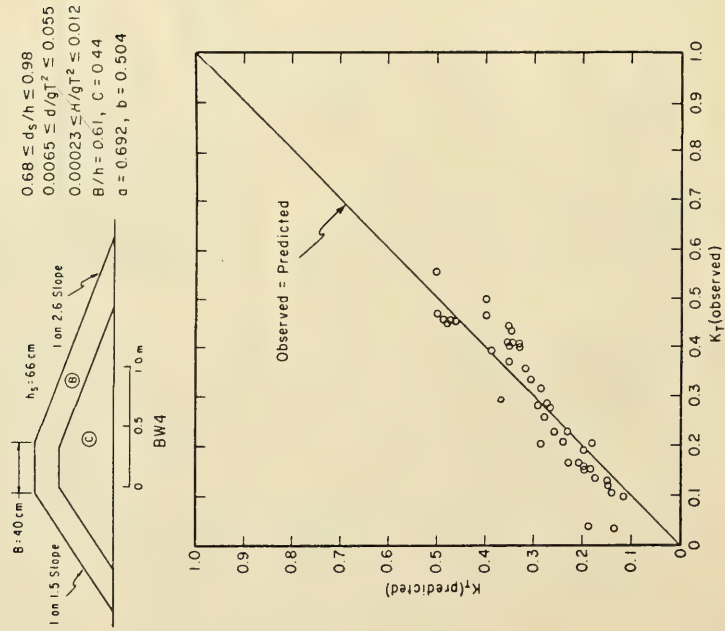


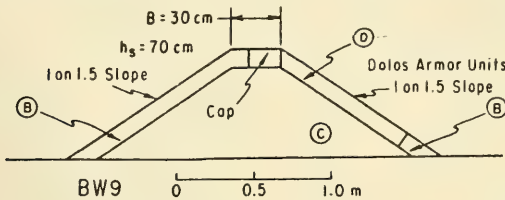
Figure 33. Observed and predicted transmission coefficients for BW4.

$0.68 \leq d_s/h \leq 0.98$
 $0.0065 \leq d_1/gT^2 \leq 0.055$
 $0.00023 \leq H/gT^2 \leq 0.012$
 $B/h = 0.61, C = 0.44$
 $a = 0.692, b = 0.504$

(3) The case of breakwaters with concrete armor units. The friction factor and porous media flow factors for concrete armor units are unknown, but they are assumed to be similar to the properties of stone with an effective median diameter, d_{50} , of

$$d_{50} = \left(\frac{W_{50}}{\gamma} \right)^{1/3} \quad (17)$$

Figure 35 shows observed and predicted transmission coefficients for a breakwater with two layers of dolos armor units. There is excellent prediction of transmission coefficients for long shallow-water waves with the Madsen and White (1976) model overpredicting transmission coefficients for waves with greater relative depth. This is the same trend found in prediction of transmission coefficients for rubble-mound breakwaters.



$0.64 \leq d_s/h \leq 0.86$
 $0.0065 \leq d/gT^2 \leq 0.055$
 $0.0001 \leq H/gT^2 \leq 0.012$
 $B/h = 0.43, C = 0.46$
 $a = 0.692, b = 0.504$

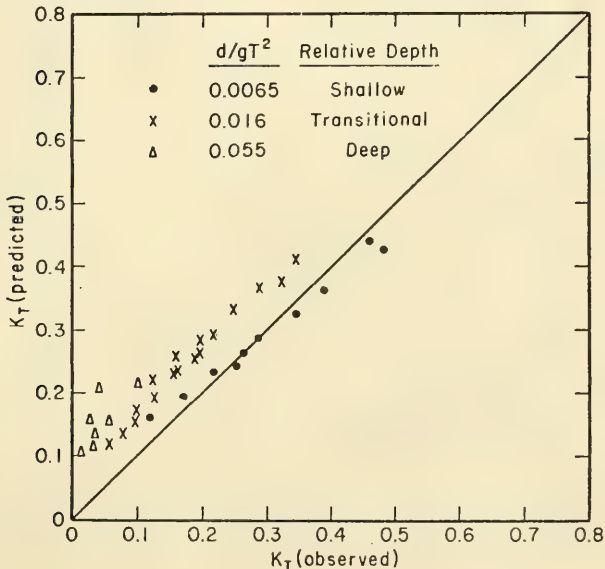


Figure 35. Observed and predicted transmission coefficients for a breakwater with dolos armor units (BW9).

The model also does a good job of predicting the coefficient of transmission through a permeable breakwater armored with tribars tested by Davidson (1969) (Fig. 36). However, the effective transmission by overtopping coefficient, C , is larger than would be expected from Figure 15 for $B/h = 0.30$. Fortunately, the observed transmission coefficient appears to be approaching a value of approximately 0.48, the limiting value of the overtopping wave transmission coefficient for this breakwater predicted from equations (14) and (15). The relatively high porosity of artificial armor units apparently increases the size of the wave transmission by overtopping coefficient over a limited range of wave heights for this case where the stillwater level is above the core and close to the breakwater crest (D. Davidson, Chief, Wave Research Branch, U.S. Army Waterways Experiment Station, personal communication, 1979).

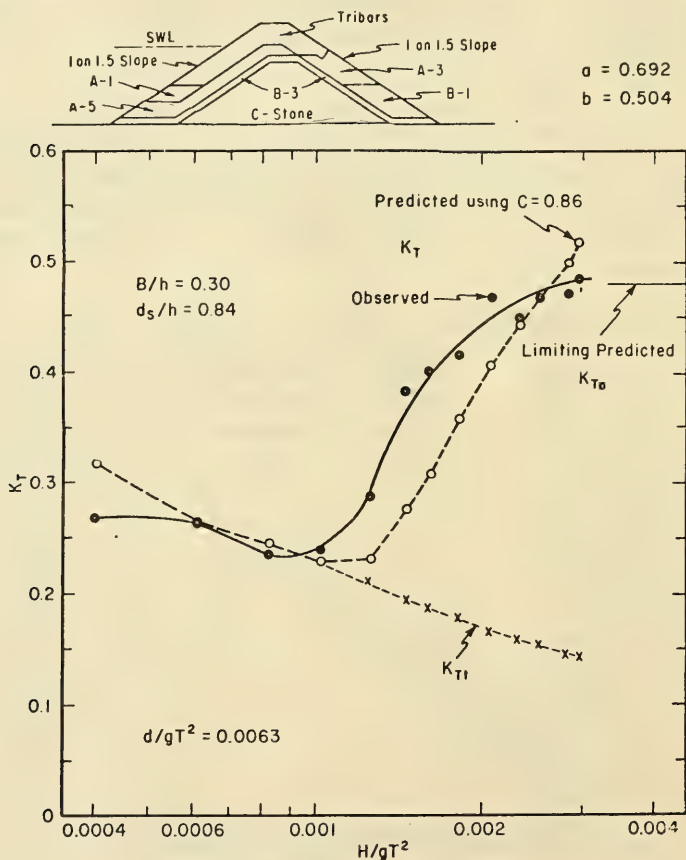


Figure 36. Wave transmission past a heavily overtopped breakwater with tribar armor units (laboratory data from Davidson, 1969).

(4) The case of irregular waves. Laboratory tests with a wide variety of spectral shapes suggest that there is little difference in the transmission coefficient from one spectral type to another. The overall transmission coefficient, K_T , is approximately the same for a monochromatic test as for an equivalent irregular wave test with the period of peak energy density, T_p , and mean incident wave height, \bar{H} , used to characterize the irregular wave conditions. Figure 37 shows observed and predicted transmission coefficients for a rubble-mound breakwater tested with monochromatic and irregular waves. The ability of the computer program MADSEN to predict transmission coefficients for irregular waves is at the same level as for monochromatic waves for the conditions tested.

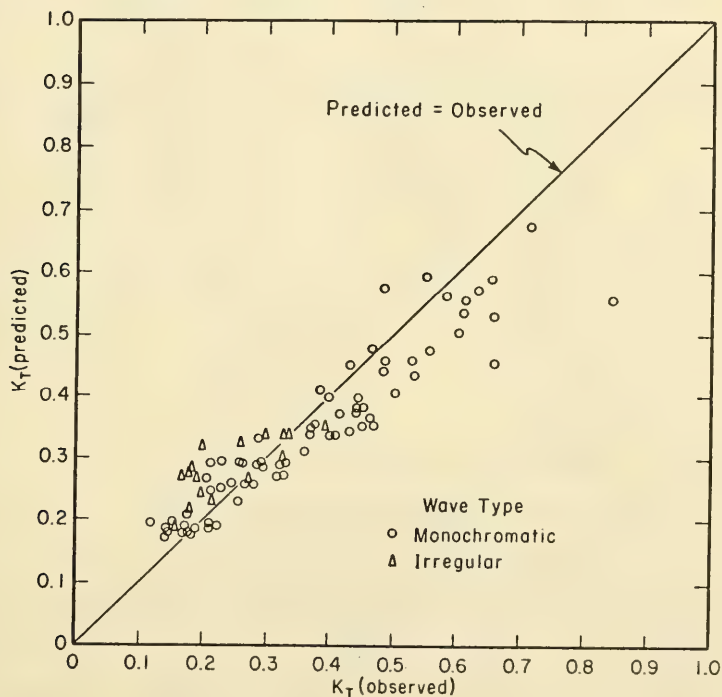
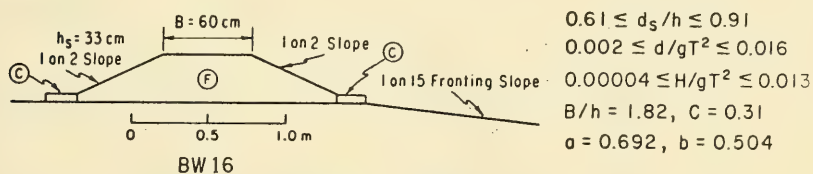


Figure 37. Observed and predicted transmission coefficients for BW16.

(5) The case of porosity of the breakwater. Porosity of each of the materials must be known in order to use the computer program MADSEN. However, in many design situations the value of porosity may be poorly known. Typical values of porosity, P, are given in Table 5. The recommended method of determining the influence of porosity on the predicted transmission coefficient is to run the program MADSEN at various values of porosity keeping all other parameters fixed. Figure 38 shows predicted transmission coefficients over a range of wave steepnesses for three different values of porosity. For this example, the absolute change in K_{Tt} produced by a given change in P is largest for waves of small steepness. The largest percent change in K_{Tt} for a given change in P occurs for the steepest waves tested. In general, the same trend will be observed for any breakwater; the value of K_{Tt} will increase as porosity increases for a given set of conditions. However, the magnitude of change of K_{Tt} is a complex function of all of the parameters in a design (breakwater geometry, water depth, wave height and period, etc.). A sensitivity analysis with the use of the program MADSEN, similar to the analysis shown in Figure 38, is recommended if the porosity of proposed materials is poorly known.

Table 5. Porosity of various armor units (from U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977).

Armor unit	No. of layers	Placement	Porosity (P)
Quarrystone (smooth)	2	Random	0.38
Quarrystone (rough)	2	Random	0.37
Quarrystone (rough)	>3	Random	0.40
Cube (modified)	2	Random	0.47
Tetrapod	2	Random	0.50
Quadripod	2	Random	0.49
Hexapod	2	Random	0.47
Tribar	2	Random	0.54
Dolos	2	Random	0.63
Tribar	1	Uniform	0.47
Quarrystone	Graded	Random	0.37

c. Wave Transmission for Submerged Permeable Breakwaters. The coefficient of wave transmission over a submerged permeable breakwater, K_{TO} , may be estimated by the methods given in Section IV,2. However, no generalized model is currently available for determining the coefficient of wave transmission through the structure, K_{Tt} . Saville's (1963) data for similar permeable and impermeable structures show that the total coefficient, K_T , approaches the transmission by overtopping coefficient, K_{TO} , and transmission through the breakwater becomes less important as the structure becomes more submerged and the incident wave height increases (Fig. 39). At $d_s/h \geq 1.2$, the data from breakwaters BW3, BW3W, BW4, and BW4W show that the coefficients of transmission through the structure are approximately zero, so that $K_{TO}/K_T = 1.0$. An upper estimate of the coefficient of transmission through the structure, K_{Tt} , for a submerged breakwater

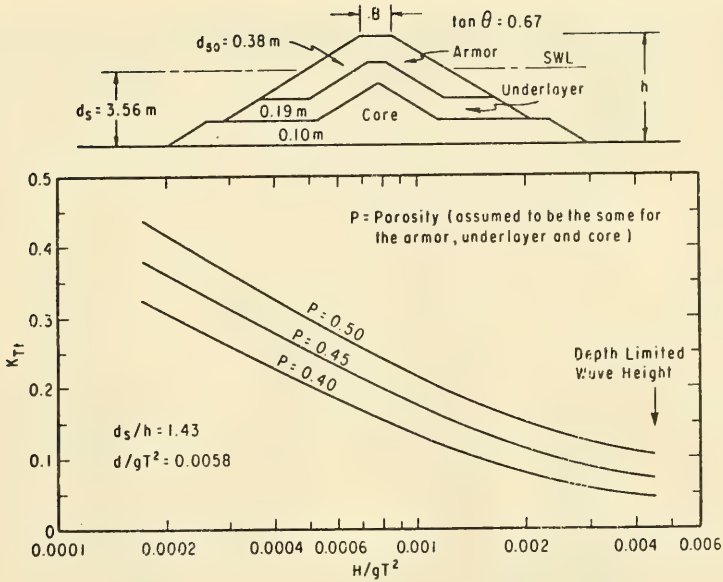


Figure 38. Example of the influence of porosity on the predicted coefficient of transmission for a rubble-mound breakwater.

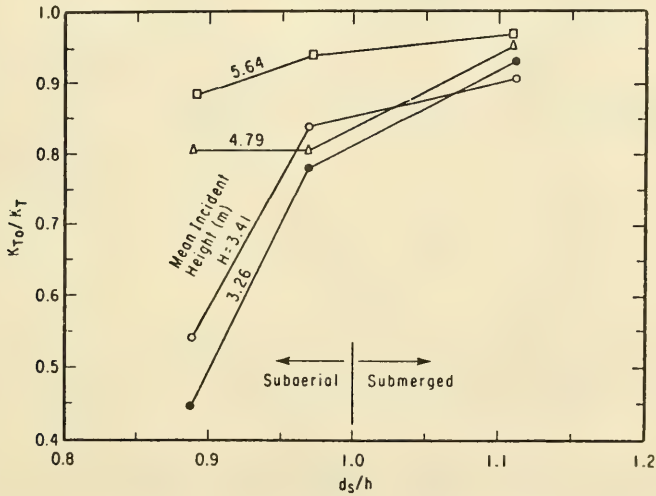


Figure 39. The relative importance of transmission by overtopping as a function of the incident wave height and the water depth-to-structure height ratio (after Saville, 1963).

can be made using the program MADSEN with $d_g/h = 1.0$. As a lower estimate, $K_{Tt} = 0.0$ can be assumed. Laboratory results from BW13, BW15, BW15W, and BW16 show that even using $K_{Tt} = 0$, methods in Section IV.1,b tend to give conservative estimates of the transmission coefficient for submerged permeable breakwaters (Fig. 40).

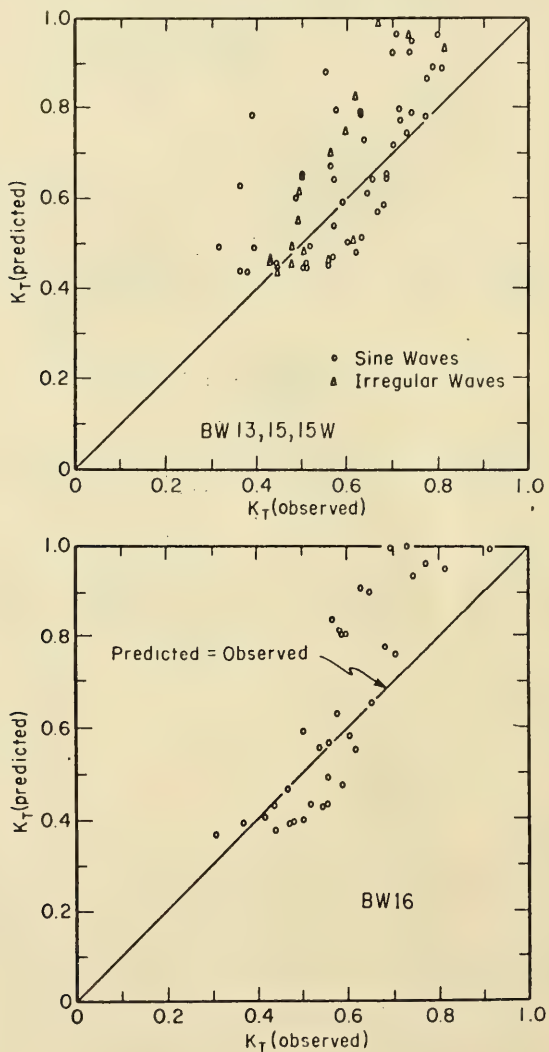


Figure 40. Observed and predicted transmission coefficients for submerged permeable structures assuming $K_{Tt} = 0$.

d. Influence of a Permeable Breakwater on Other Wave Characteristics. Wave energy shifts to higher harmonics are found in the transmitted wave records for monochromatic wave tests, as determined for overtopped impermeable breakwaters (Fig. 41). The energy shift is primarily a function of incident wave steepness and the ratio of the water depth to structure height. The largest shifts of energy to higher harmonics occur for steep waves where the structure crest is near to the stillwater level (Fig. 41).

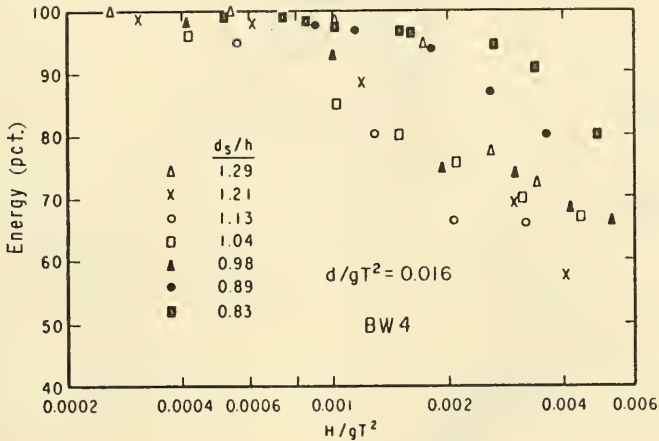


Figure 41. Percent of wave energy at the forcing period for waves transmitted past a permeable breakwater (monochromatic waves).

In the case of irregular waves the higher frequency parts of the reflected and transmitted spectra tend to be dampened out, so relatively more wave energy is found at lower frequencies than in the incident spectrum (Fig. 42). This means that on the average the spectral peakedness, Q_p , of reflected and transmitted spectra is greater than or equal to the spectral peakedness of incident spectra (Fig. 43).

A zero up-crossing analysis of wave records shows that on the average the wave height distribution shape is approximately the same for incident and transmitted waves for the irregular conditions tested for a permeable breakwater (Fig. 44).

The amount of wave grouping or the tendency of large waves to follow large waves and small waves to follow small waves is characterized by the autocorrelation of zero up-crossing wave heights, ρ (see Sec. III,4). Results from BW16 show that the autocorrelation transmitted waves is less than or equal to that for incident waves in the case of irregular waves incident on a permeable breakwater (Fig. 45).

The joint distribution of transmitted wave heights and periods for an irregular wave condition is similar to that found for smooth impermeable breakwaters. There is a tendency for lower transmitted waves to have average periods less than found in the incident joint height-period distribution (Fig. 46). Both the incident and transmitted larger wave heights have average periods approximately equal to the period of peak energy density.

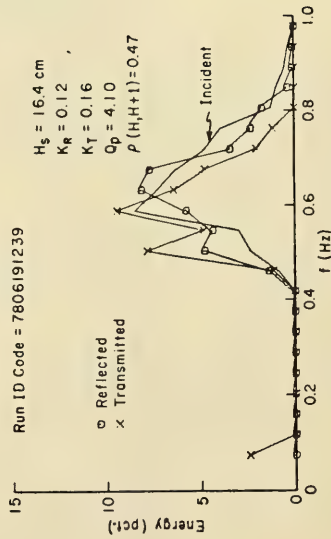
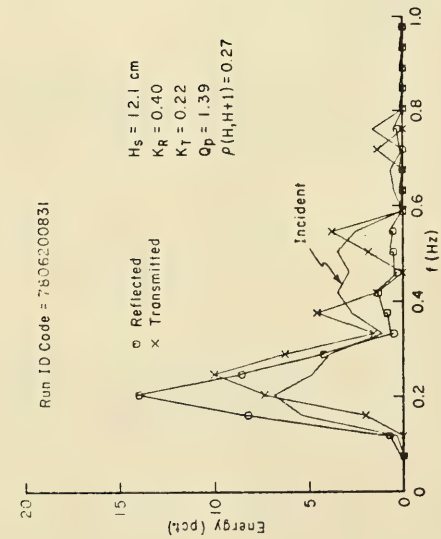


Figure 42. Sample incident, reflected, and transmitted wave spectra for BW16 ($d_g/h = 0.76$).

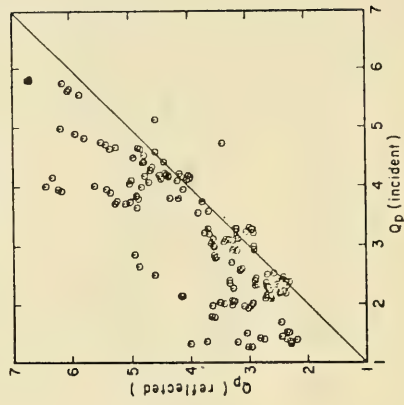
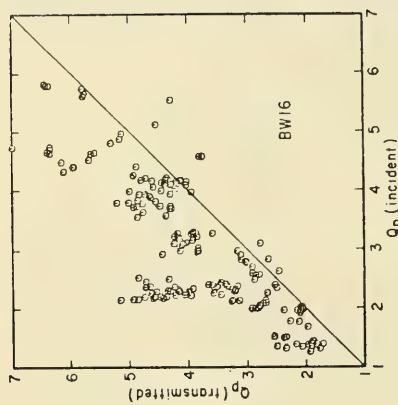


Figure 43. Spectral peakedness of transmitted and reflected wave spectra versus incident spectral peakedness for a permeable breakwater.

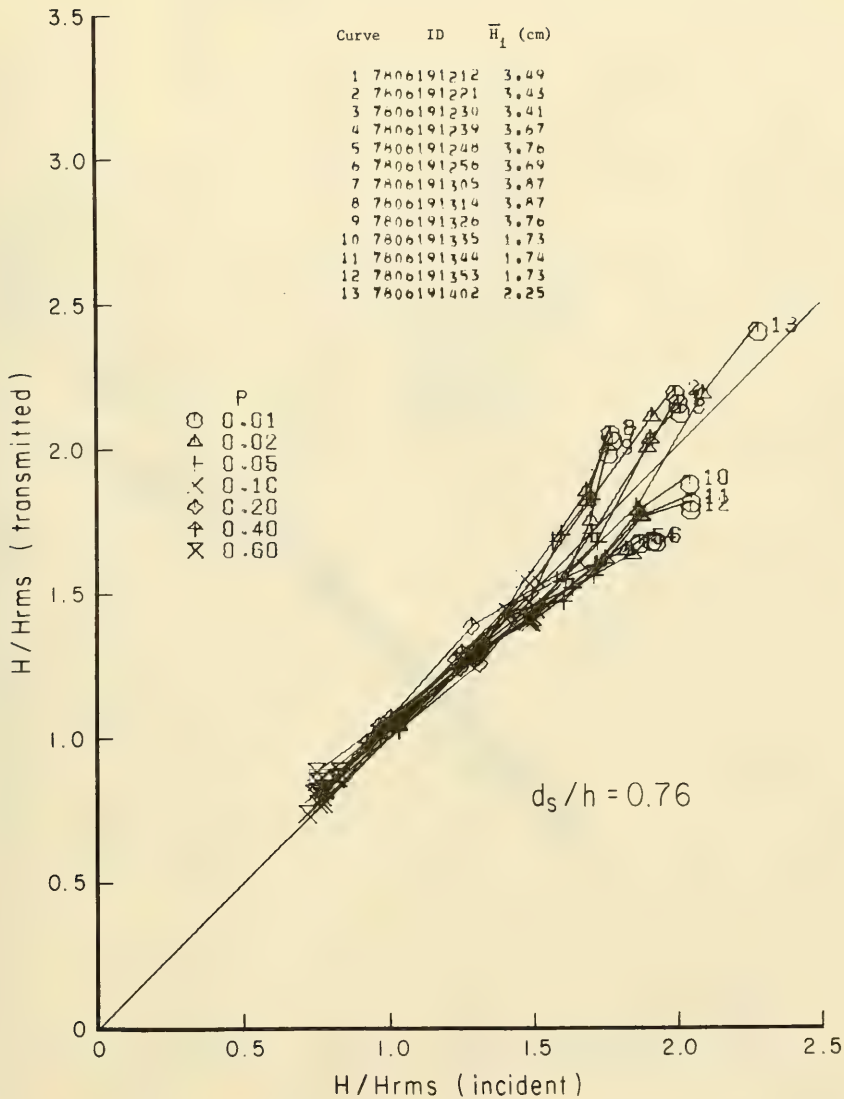


Figure 44. Comparison between incident and transmitted wave height distribution for a permeable breakwater (BW16).

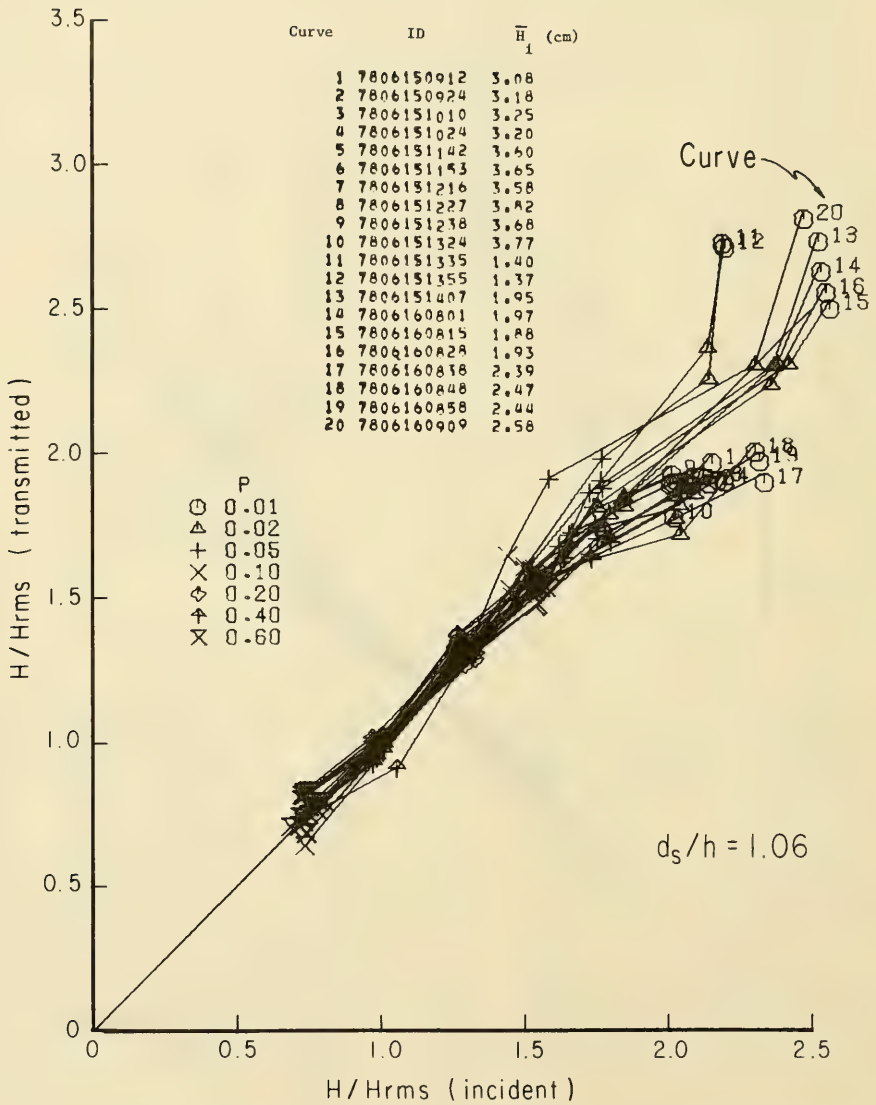


Figure 44. Comparison between incident and transmitted wave height distribution for a permeable breakwater (BW16).--Continued

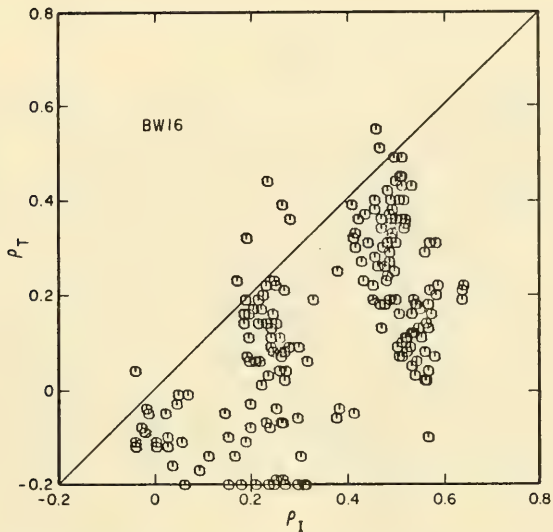


Figure 45. Autocorrelation of zero up-crossing wave heights for transmitted and incident wave records for a permeable breakwater.

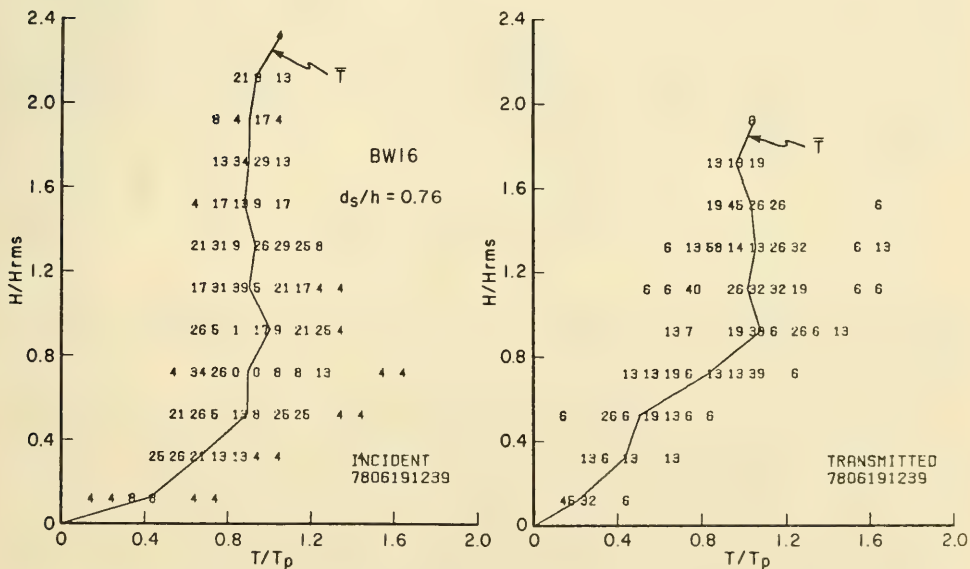


Figure 46. Sample joint distributions of wave height and period for an irregular wave condition and a permeable breakwater.

1. Causes of Physical Model Scale Effects.

Wave energy dissipation and resulting reduction of wave height produced by a breakwater are due to a combination of laminar and turbulent energy loss as well as wave modification. Little information is available on scale effects of wave transmission by overtopping, but scale effects are probably small. This is illustrated by Saville (1963) who tested wave transmission by overtopping for similar breakwaters that differed by a scale of 10. There was little systematic difference between the results of tests run at the two scales, with the small-scale tests being slightly conservative.

Wave transmission through permeable breakwaters is controlled primarily by laminar and turbulent energy loss of flow through the structure (Wilson and Cross, 1972; Keulegan, 1973; Madsen and White, 1976). In the prototype the wave height reduction is due largely to turbulent effects, but in a model laminar and turbulent losses may be important so that a model underpredicts the coefficient of transmission through a breakwater. The size of the scale effect is a complex function of model design, water depth, and wave height and period.

2. Interpreting and Applying Laboratory Results to Prototype Conditions.

The recommended method of estimating scale effects of transmission through permeable breakwaters is to use the computer program MADSEN to predict transmission coefficients for the model and prototype. The physical model correction factor, CF, is defined as the expected coefficient of wave transmission through the structure in the prototype divided by the coefficient of wave transmission through the structure at the model scale. CF is determined by first running the program MADSEN with prototype conditions to determine K_{Tt} (MADSEN prototype). The program is then run at the model scale to determine K_{Tt} (MADSEN scale model). CF is defined as

$$CF = \frac{K_{Tt} \text{ (MADSEN prototype)}}{K_{Tt} \text{ (MADSEN scale model)}} \quad (18)$$

The coefficient for wave transmission through the structure measured in the physical scale model should then be multiplied by CF to estimate the prototype coefficient.

For example, assume that the laboratory breakwater tested by Sollitt and Cross (1976) is a 1 on 10-scale Froude model of a prototype structure (Fig. 47). There was no transmission by overtopping. The program MADSEN was run at both model and prototype scales and the results together with the physical model measurements are shown in Figure 48. The MADSEN program output shows that the physical model was probably underpredicting the prototype coefficient because the scale model has proportionally more laminar energy loss than the prototype. Even in this large 1 on 10-scale Froude physical model, the prototype K_{Tt} is expected to be as much as 20 percent higher than in the scale model over the range of conditions tested.

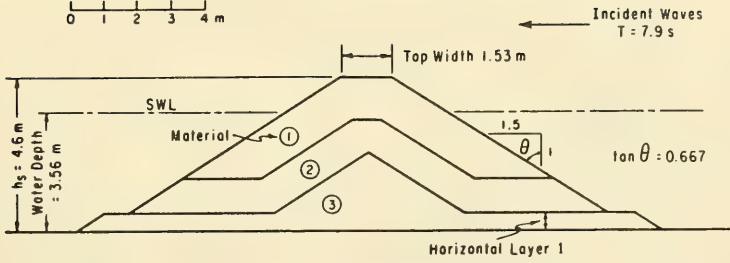


Figure 47. Trapezoidal multilayered breakwater tested by Sollitt and Cross (1976) (prototype).

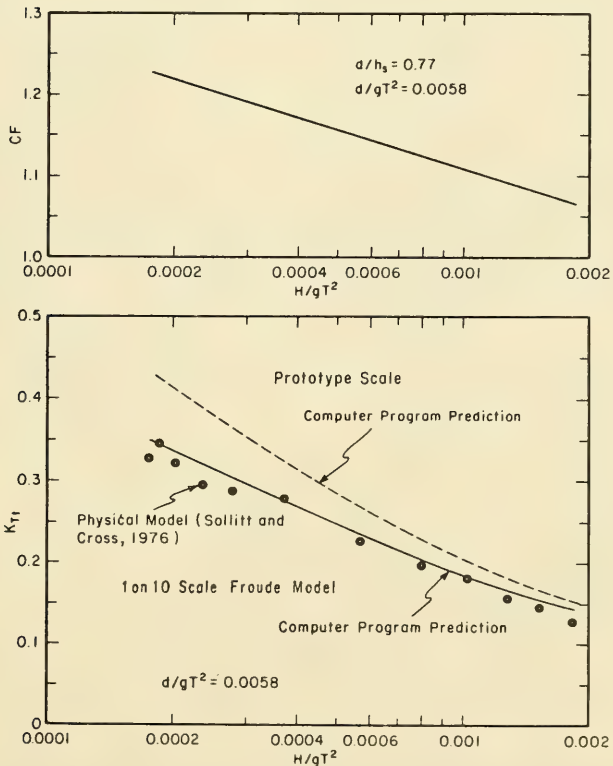


Figure 48. Physical model results and correction factors determined from the analytical model of Madsen and White (1976).

VI. EXAMPLE OF ESTIMATING WAVE TRANSMISSION COEFFICIENTS

***** EXAMPLE PROBLEM *****

GIVEN: T = 7.9 seconds

$d_s = 3.56$ meters

Breakwater top width, B = 1.53 meters

Breakwater seaward slope, $\tan \theta = 0.667$ (1 on 1.5)

FIND: The influence of incident wave height and structure height on the transmission coefficient for the permeable breakwater shown in the upper part of Figure 49 (change the structure height by varying the thickness of horizontal layer 1). Also, compare the predicted transmitted wave heights to heights for a similar smooth impermeable structure (lower part of Fig. 49).

SOLUTION: The computer program MADSEN (App. G) is used to predict wave transmission coefficients for the permeable structure and the program OVER (App. F) is used to predict coefficients for the smooth impermeable breakwater. The transmission coefficient for the permeable structure decreases as wave steepness increases, until overtopping occurs when the transmission coefficient increases with steepness (Fig. 50). The transmission coefficient decreases as structure height increases and the initiation of overtopping occurs at a larger value of the incident wave height as the structure height increases. The similar shaped smooth impermeable breakwater has larger values of the transmission coefficient for the steeper waves examined (Fig. 50) because the runup is higher on the smooth structure. However, there is no transmission for the impermeable structure for the small waves where the runup does not reach the breakwater crest. The predicted transmitted wave height as a function of breakwater crest height is given in Figure 51 for two values of the incident wave height.

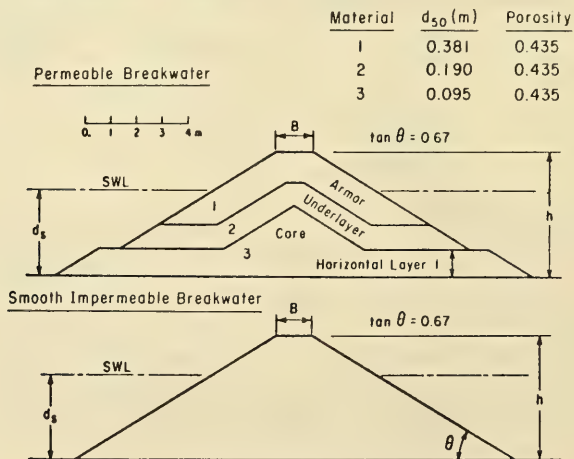


Figure 49. Breakwater cross sections used in the example for estimating wave transmission coefficients.

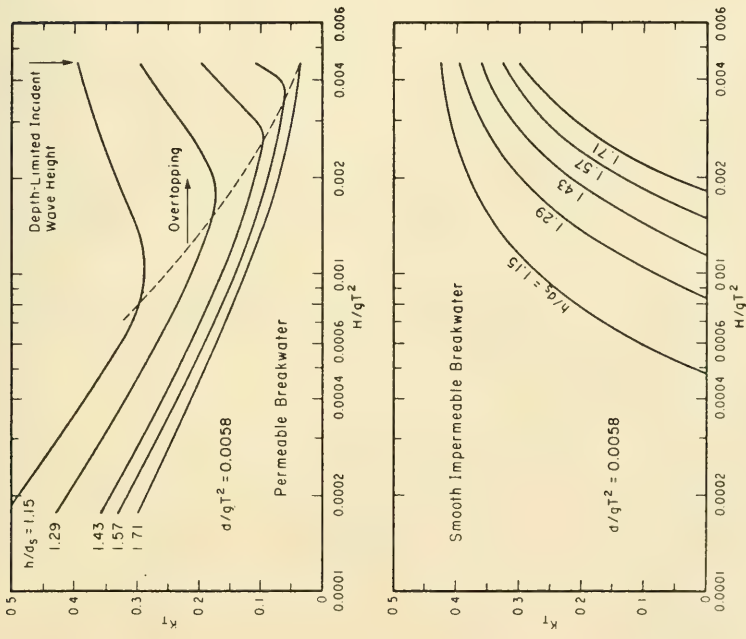


Figure 50. Predicted wave transmission coefficients.

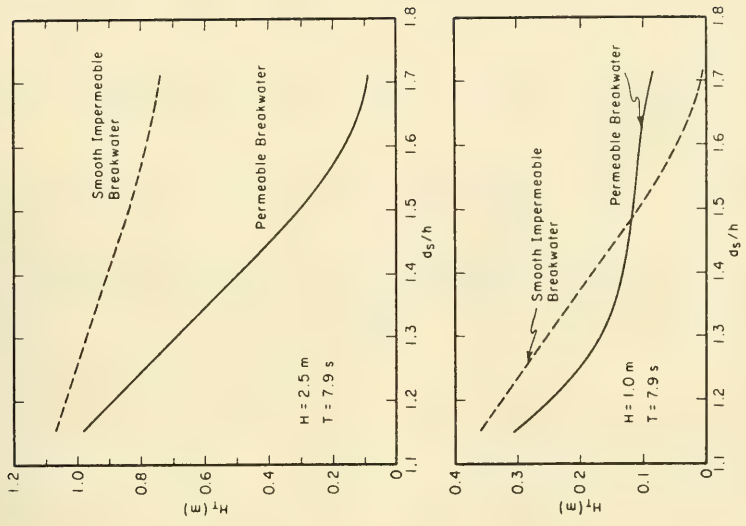


Figure 51. Predicted transmitted wave height as a function of breakwater crest height.

VII. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The primary conclusions from the tests of wave transmission and reflection of laboratory breakwaters conducted for this study are:

1. A simple formula for predicting wave transmission by overtopping coefficients together with the model of Madsen and White (1976) for transmission through permeable structures can be used to obtain estimates of wave transmission coefficients.
2. Limited tests with breaking waves suggest that the methods can be used for breaking or nonbreaking conditions.
3. Tests with irregular waves show that the transmission coefficient for irregular waves is approximately the same as for a similar monochromatic wave test. The mean wave height and period of peak energy density are the parameters recommended to describe irregular waves.
4. Irregular wave tests indicate that for permeable or submerged breakwaters the incident and transmitted wave height distributions have similar shape. However, smooth impermeable subaerial breakwaters have height distributions biased toward the larger heights for irregular waves because large waves transmit more efficiently than small waves.
5. Transmitted and reflected spectra for irregular waves generally have equal or higher spectral peakedness than incident spectra.
6. Joint wave height-period distributions have similar dimensionless shapes for incident and transmitted wave records.
7. There is a tendency for wave heights to be less grouped after they have transmitted past a breakwater.
8. Transmitted wave energy may appear at higher order harmonics of the incident waves for monochromatic wave tests. However, the tendency for energy shifts decreases as the wave transmission coefficient increases.
9. Additional work is necessary to develop generalized models for predicting wave reflection coefficients and wave transmission through the crests of breakwaters armored with relatively porous materials, such as concrete armor units.

The recommended steps for design of a breakwater for wave transmission are:

1. Use the computer programs MADSEN and OVER to estimate transmission coefficients for preliminary breakwater design. Alternative designs can be tested by varying parameters such as:

- (a) structure height
- (b) crest width
- (c) seaward and landward breakwater slopes
- (d) water depth
- (e) number, thickness, location, and diameter of materials
- (f) porosity
- (g) permeability
- (h) wave height
- (i) wave period

2. A sensitivity analysis is recommended on those input parameters that are poorly known. For example, if there is some uncertainty in the value of the design water level, predictions should be made over the range of expected water levels keeping all other factors fixed. Comparison between the predictions at different levels will indicate the importance of water level.

3. Estimate reflection coefficients from model results.

4. If possible, final breakwater design should be made with the use of physical models. The program MADSEN can be used to assist in designing and interpreting physical laboratory models and results for permeable breakwaters.

Copies of the program decks for the program MADSEN and OVER described in Appendixes F and G may be obtained from the Automatic Data Processing Coordinator, Coastal Engineering Research Center, Fort Belvoir, Virginia 22060.

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APPENDIX A

BREAKWATER GEOMETRIES

Each of the breakwaters tested is assigned an identifying code (e.g., BW1). This appendix includes a cross-section drawing and a brief description of each of the breakwaters. Note that breakwaters 1 to 12 (Figs. A-1 to A-14) were tested on a flat tank bottom; breakwaters 13 to 17 (Figs. A-15 to A-19) had a 1 on 15 fronting slope 3.75 meters long. Materials used in construction of the structures are identified by a circled letter; material characteristics are discussed in Appendix B.

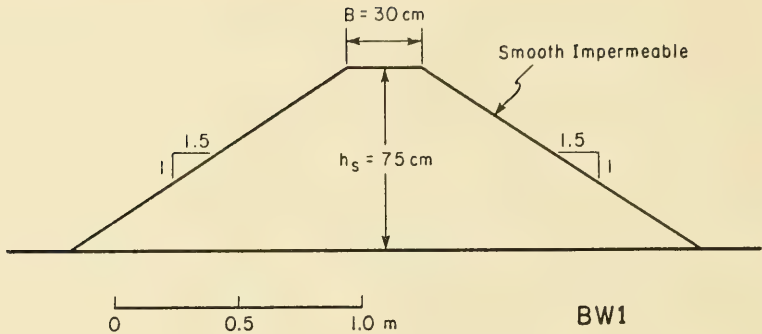


Figure A-1. Breakwater 1 cross section.

BW1 is a smooth impermeable structure tested for wave transmission by overtopping and reflection. Note that simultaneous measurements of wave runup were being made on a smooth 1 on 1.5 slope in an adjacent flume by Ahrens (1978) while the breakwater tests were underway (see Fig. 1).

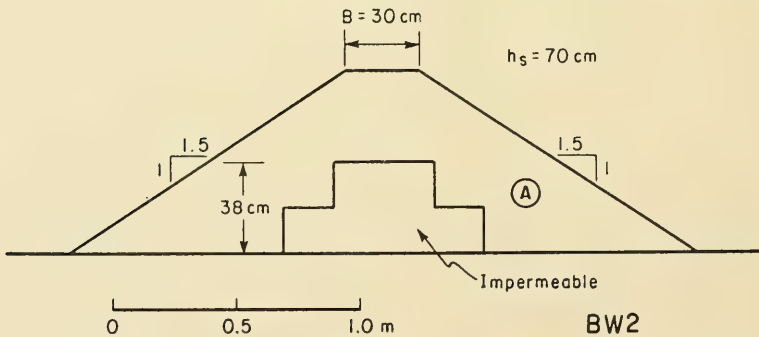


Figure A-2. Breakwater 2 cross section.

BW2 is similar to a caisson breakwater that has been rehabilitated by adding rock armor units. The major emphasis of these tests was to examine the effects of wave period and height on transmission and reflection. Armor material was randomly placed.

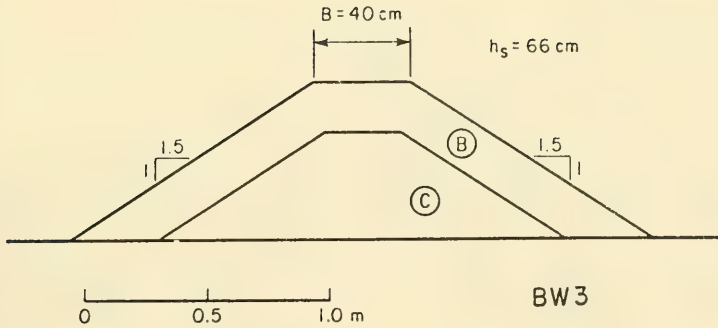


Figure A-3. Breakwater 3 cross section.

BW3 has an armor two units thick of angular stone. A moderate amount of fitting was used in placing the armor, especially near the crest. Core material was placed by dumping.

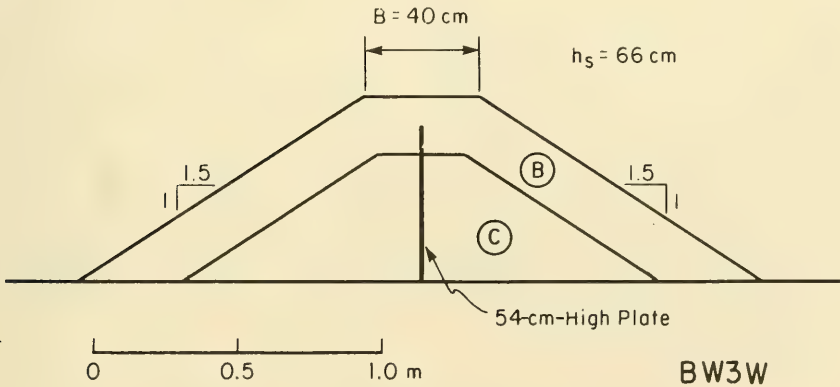


Figure A-4. Breakwater 3W cross section.

BW3W is similar to BW3, except that a 5-millimeter-thick metal plate was installed in the center of the structure. The caulked plate extended from the bottom to within one armor unit of the crest (54 centimeters high).

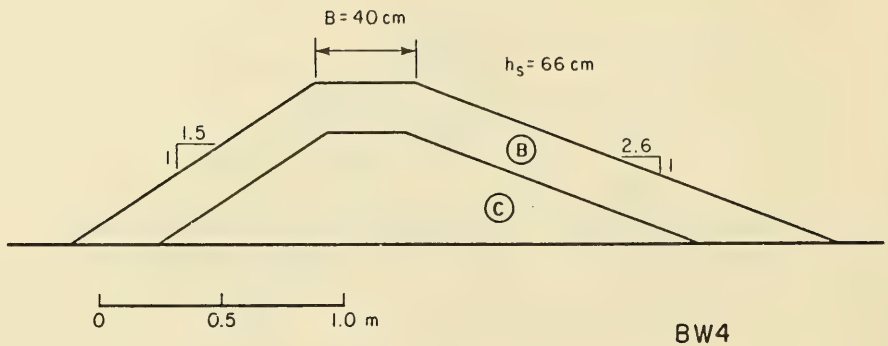


Figure A-5. Breakwater 4 cross section.

BW4 is similar to BW3, except with a 1 on 2.6 front-face slope.

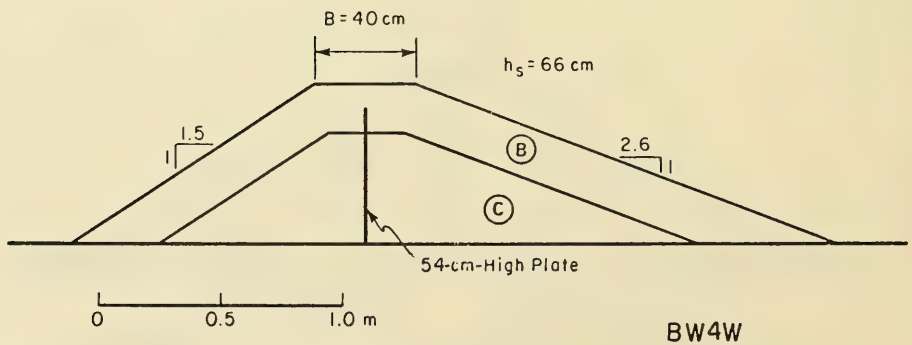


Figure A-6. Breakwater 4W cross section.

BW4W is similar to BW4, but includes a 54-centimeter-high impermeable plate in the center of the structure.

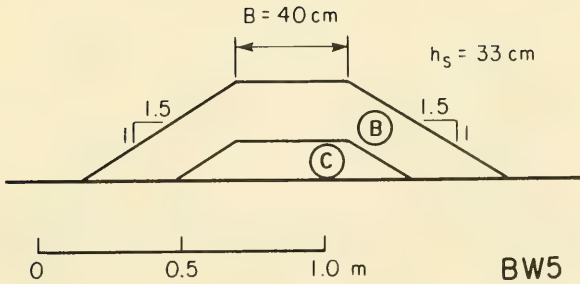


Figure A-7. Breakwater 5 cross section.

BW5, geometrically similar to the upper part of BW3, is typical of a breakwater built in relatively shallow water. The armor unit size is large compared to the structure height and the core size relatively small.

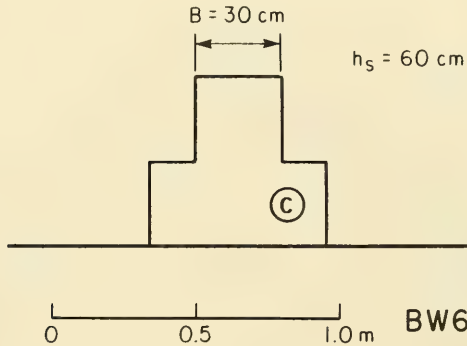


Figure A-8. Breakwater 6 cross section.

BW6 was made of three triangular, fine wire containers filled with core material.

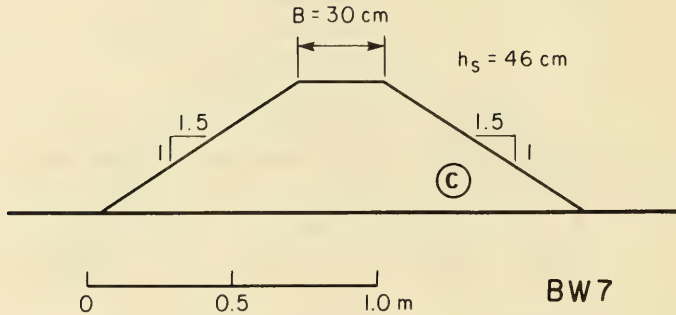


Figure A-9. Breakwater 7 cross section.

BW7 is geometrically similar to the core of BW3. The material was held in a fine wire structure to prevent motion of the stone.

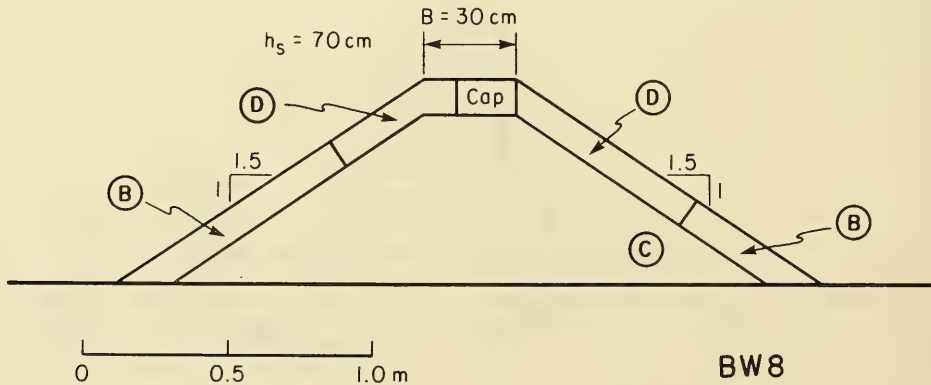


Figure A-10. Breakwater 8 cross section.

BW8 uses dolos artificial units as part of the armor material on both the front and back of the structure near the crest. Stone was used in the lower parts of the armor. A moderate amount of fitting was used in placing the armor units. An impermeable cap was installed toward the seaward side of the crest.

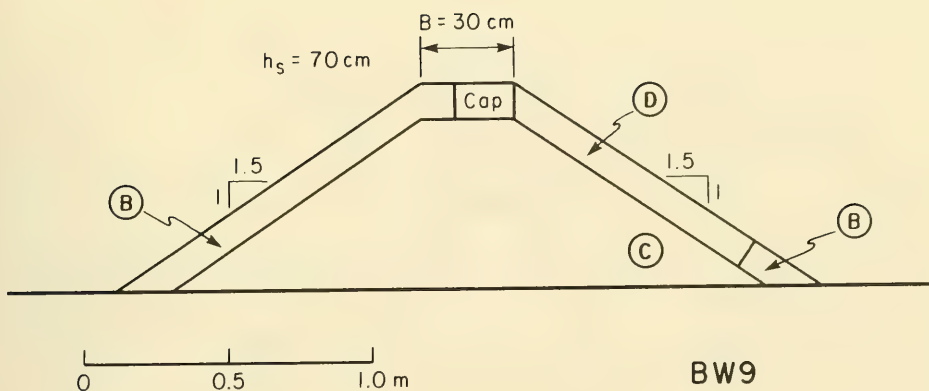


Figure A-11. Breakwater 9 cross section.

BW9 is similar to BW8, except that armor units have been arranged so that all of the dolos units are on the seaward side of the structure.

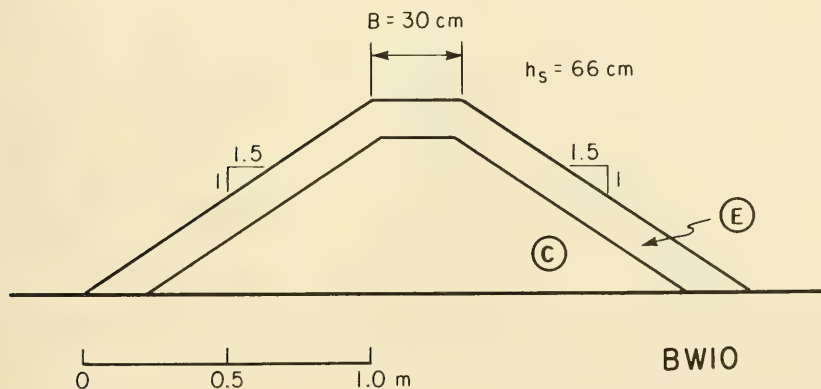


Figure A-12. Breakwater 10 cross section.

BW10 was made with an armor one unit thick of well-fitted rectangular rock. The material was placed with one surface parallel to the structure face.

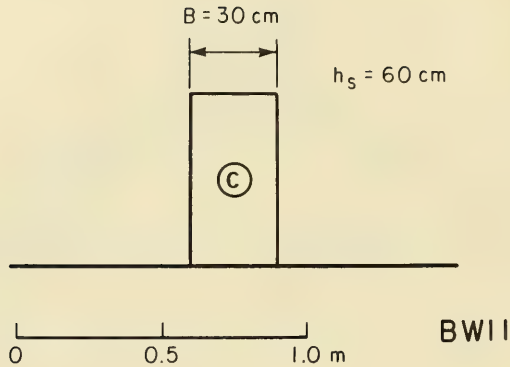


Figure A-13. Breakwater 11 cross section.

BW11 was made of two fine-wire rectangular baskets that enclosed core-type stone. The primary purpose of this structure was to examine the wave transmission and reflection characteristics of permeable material.

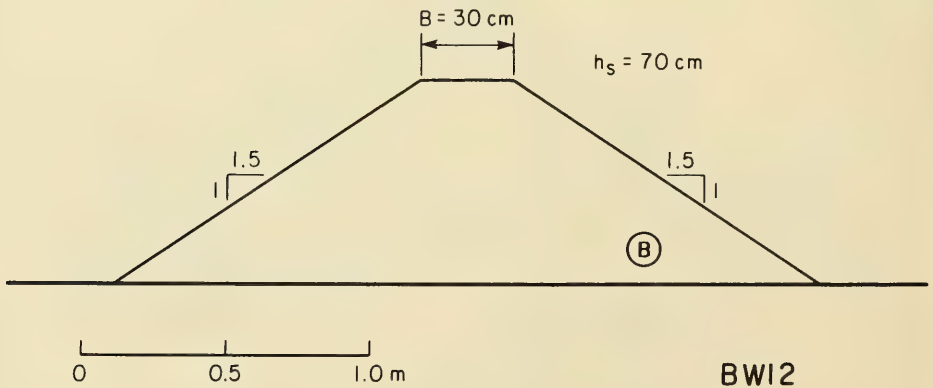


Figure A-14. Breakwater 12 cross section.

BW12 is a structure with no core similar in geometry to breakwaters 8 and 9.

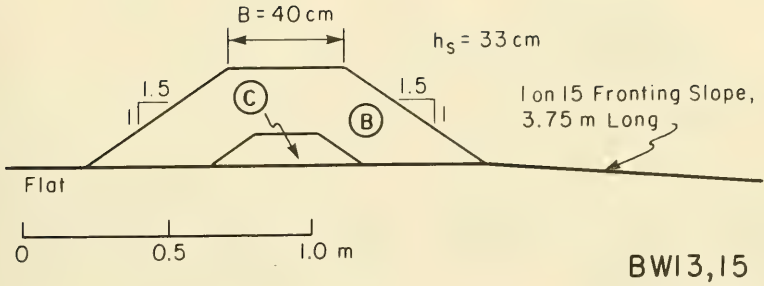


Figure A-15. Breakwaters 13 and 15 cross section.

BW13 and BW15 were tested with a 1 on 15 fronting slope 3.75 meters. Note that these structures are the same geometry as BW5 (built on a flat tank bottom).

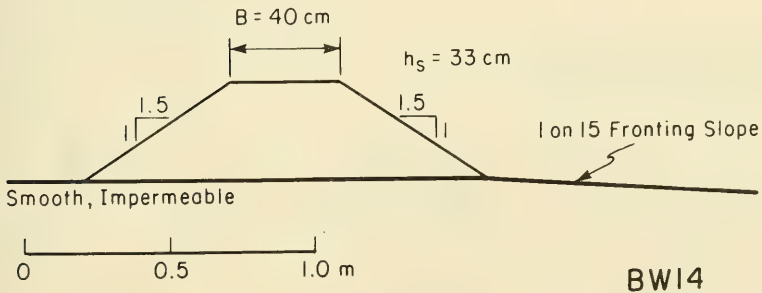


Figure A-16. Breakwater 14 cross section.

BW14, a smooth impermeable structure, has the same outside dimensions as permeable breakwaters BW5, BW13, and BW15.

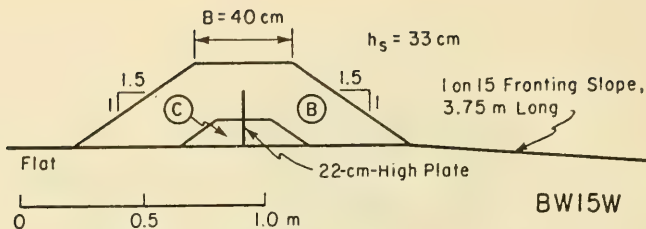


Figure A-17. Breakwater 15W cross section.

BW15W has the same dimensions and materials as BW13 and BW15, except that a 22-centimeter-high metal plate 5 millimeters thick has been installed in the center of the structure. This plate prevents transmission through the lower part of the structure.

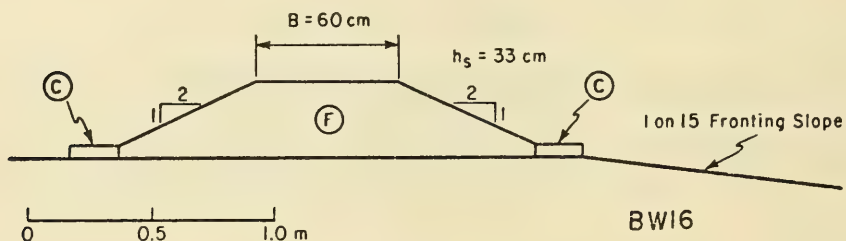


Figure A-18. Breakwater 16 cross section.

BW16 is a one-ninth scale Froude model of a proposed submerged breakwater for Imperial Beach, California.

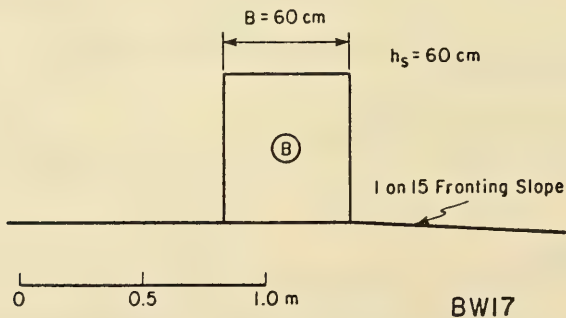


Figure A-19. Breakwater 17 cross section.

BW17 is a vertical permeable structure, similar to BW11, with the rock retained by a thin wire mesh.

APPENDIX B

MATERIAL CHARACTERISTICS

Materials used to construct permeable breakwaters are discussed in this appendix. Each material is identified by a circled letter and shown on the breakwaters where it was used in Appendix A. Figure B-1 includes photos of samples of the various materials (material F, not shown, is similar to A and B). Some basic parameters, such as weights, diameters, and porosities, are shown in Table B-1. The weight distribution of each of the materials is given in Figure B-2.



(B)



(E)



(A)



(C)



(D)

Figure B-1. Photos of construction materials.

Table B-1. Material characteristics.

Material	Description	W_{85}^1 (g)	W_{50}^2 (g)	W_{15}^3 (g)	d_{50}^4 (cm)
A	Angular stone	2,520	1,530	990	8.3
B	Angular stone	4,680	3,690	2,900	11.1
C	Angular stone	180	63	31	2.9
D	Dolos	405	390	390	----
E	Flat stone	13,200	11,200	8,100	16.1
F	Angular stone	7,600	4,900	2,500	12.2

¹Weight at which 85 percent by weight of the material is heavier than.

²Weight at which 50 percent by weight of the material is heavier than.

³Weight at which 15 percent by weight of the material is heavier than.

⁴Representative diameter corresponding to W_{50} .

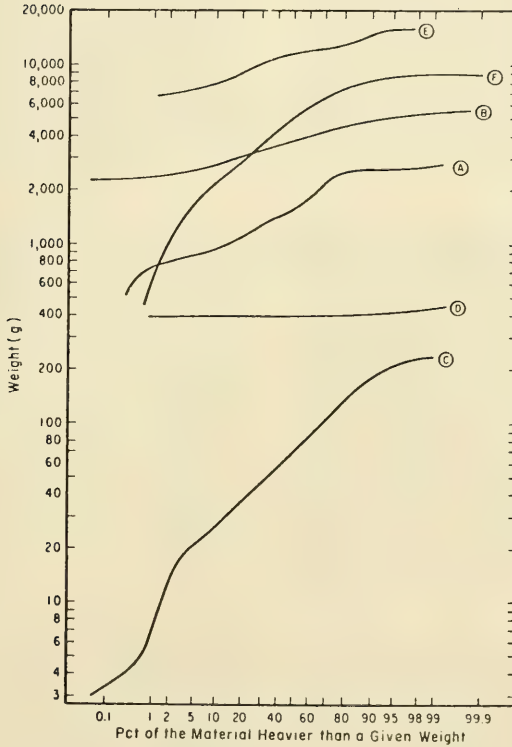


Figure B-2. Weight distribution of the construction materials.

APPENDIX C

TEST RESULTS (SINUSOIDAL BLADE MOTION)

SINE BLADE MOTION															
ID	D(CM)	T(S)	H(CM)	KV	KH	D/GT2	H/GT2	ID	D(CM)	T(S)	H(CM)	KV	KR	D/GT2	H/GT2
BREAKWATER 1															
7803240A31.	90.	2.39	1.1	.888	.880	.016	.0002	7803240A40.	90.	2.39	2.2	.876	.876	.016	.0004
7803240A49.	90.	2.39	4.7	.876	.876	.016	.0008	7803240A5A.	90.	2.39	9.6	.806	.806	.016	.0017
7803240914.	90.	2.39	19.3	.714	.714	.016	.0034	7803240915.	90.	2.32	1.3	.898	.898	.016	.0002
7803240954.	85.	2.32	2.6	.91A	.918	.016	.0005	7803241003.	85.	2.32	5.4	.881	.881	.016	.0010
7803241012.	85.	2.32	11.3	.666	.666	.016	.0021	7803241020.	85.	2.32	24.5	.555	.555	.016	.0046
7803241055.	80.	2.25	.9	.899	.899	.016	.0002	7803241105.	80.	2.25	1.9	.848	.848	.016	.0004
7803241113.	80.	2.25	3.8	.700	.700	.016	.0008	7803241122.	80.	2.25	7.8	.611	.611	.016	.0016
7803241130.	80.	2.25	16.2	.564	.564	.016	.0033	7803271119.	75.	3.42	1.4	.240	.240	.007	.0001
7803271112.	75.	3.42	2.9	.264	.264	.007	.0003	7803271104.	75.	3.42	6.1	.332	.332	.007	.0005
7803271055.	75.	3.42	13.0	.367	.367	.007	.0011	7803241152.	75.	2.18	.6	.168	.168	.016	.0001
7803241202.	75.	2.18	1.1	.231	.231	.016	.0002	7803241212.	75.	2.18	2.3	.315	.315	.016	.0005
7803241222.	75.	2.18	4.7	.441	.441	.016	.0010	7803241239.	75.	2.18	9.8	.543	.543	.016	.0021
7803271143.	75.	1.14	3.6	.275	.275	.055	.0026	7803271136.	75.	1.18	8.0	.369	.369	.055	.0059
7803271129.	75.	1.14	13.8	.373	.373	.055	.0101	7803271335.	70.	2.11	5.3	.089	.089	.016	.0012
7803271325.	70.	2.11	7.4	.259	.259	.016	.0017	7803271104.	70.	2.11	9.9	.349	.349	.016	.0023
7803271311.	70.	2.11	13.4	.041	.041	.016	.0031	7803271303.	70.	2.11	17.6	.478	.478	.016	.0040
7803271256.	70.	2.11	23.2	.452	.452	.016	.0053	7803271436.	65.	2.03	8.6	.073	.073	.016	.0021
7803271429.	65.	2.03	11.4	.220	.220	.016	.0028	7803271421.	65.	2.03	14.6	.328	.328	.016	.0036
7803271413.	65.	2.03	18.5	.065	.065	.016	.0046	7803271405.	65.	2.03	22.0	.452	.452	.016	.0054
7803241132.	60.	3.06	8.1	.016	.016	.007	.0009	7803281142.	60.	3.06	10.7	.087	.087	.007	.0012
7803241150.	60.	3.06	13.4	.202	.202	.007	.0015	7803281234.	60.	3.06	16.8	.331	.331	.007	.0018
7803241244.	60.	3.06	22.0	.394	.394	.007	.0024	7803281122.	60.	1.95	6.5	.001	.001	.016	.0017
7803241114.	60.	1.95	9.0	.001	.001	.016	.0024	7803281107.	60.	1.95	12.4	.088	.088	.016	.0033
7803241059.	60.	1.95	15.8	.193	.193	.016	.0042	7803281914.	60.	1.95	22.7	.444	.444	.016	.0061
7803241522.	60.	1.95	23.5	.417	.417	.016	.0065	7803281314.	60.	1.05	5.9	.003	.003	.056	.0055
7803241307.	60.	1.05	8.2	.084	.084	.050	.0076	7803281300.	60.	1.05	12.4	.145	.145	.056	.0115
7803241253.	60.	1.05	14.0	.122	.122	.050	.0130	7803281608.	55.	1.87	11.1	.051	.051	.016	.0032
7803241600.	55.	1.87	16.2	.234	.234	.016	.0047	7803281552.	55.	1.87	20.7	.304	.304	.016	.0060
7803290958.	50.	1.78	11.8	.001	.001	.016	.0038	7803290958.	50.	1.78	13.3	.011	.011	.016	.0043
7803290930.	50.	1.78	15.0	.018	.018	.016	.0048	7803291331.	45.	2.65	13.3	.009	.009	.007	.0019
7803291259.	45.	2.65	14.4	.012	.012	.007	.0021	7803291435.	45.	1.69	14.4	.043	.043	.016	.0051
7803291142.	45.	1.69	15.9	.062	.062	.016	.0055	7803291134.	45.	1.69	15.7	.089	.089	.016	.0056
BREAKWATER 2															
7711021130.	61.	2.14	4.4	.387	.397	.013	.0009	7711021155.	61.	2.18	9.1	.276	.276	.013	.0020
7711021147.	61.	2.18	9.2	.274	.278	.013	.0020	7711021204.	61.	2.18	16.9	.239	.239	.013	.0036
7711021211.	61.	2.18	17.1	.204	.240	.013	.0037	7711081000.	61.	1.97	1.9	.689	.689	.016	.0002
7711081009.	61.	1.97	1.3	.622	.622	.016	.0003	7711081021.	61.	1.97	1.8	.567	.567	.016	.0005
7711021018.	61.	1.97	2.5	.480	.480	.016	.0007	7711080952.	61.	1.97	2.6	.489	.489	.016	.0007
7711080902.	61.	1.97	3.7	.421	.420	.016	.0010	7711021026.	61.	1.97	5.2	.350	.350	.016	.0014
7711080911.	61.	1.97	5.2	.353	.353	.016	.0014	7711080920.	61.	1.97	7.5	.300	.300	.016	.0020
7711021044.	61.	1.97	10.3	.253	.253	.016	.0027	7711021030.	61.	1.97	10.4	.255	.255	.016	.0027
7711080929.	61.	1.97	10.5	.250	.250	.016	.0028	7711080930.	61.	1.97	13.9	.236	.236	.016	.0037
7711080948.	61.	1.97	18.4	.260	.260	.016	.0048	7711021103.	61.	1.97	18.6	.253	.253	.016	.0049
7711021056.	61.	1.97	18.8	.206	.246	.016	.0049	7711021223.	61.	1.66	2.3	.469	.469	.023	.0009
7711021230.	61.	1.66	2.3	.476	.476	.023	.0009	7711021242.	61.	1.66	4.6	.349	.349	.023	.0017
7711021238.	61.	1.66	4.7	.309	.349	.023	.0036	7711021244.	61.	1.66	9.6	.241	.241	.023	.0036
7711021252.	61.	1.66	9.8	.244	.244	.023	.0036	7711081029.	61.	1.31	2.2	.336	.336	.036	.0013
7711081037.	61.	1.31	3.1	.293	.293	.036	.0018	7711081046.	61.	1.31	4.2	.256	.256	.036	.0025
7711081054.	61.	1.31	5.3	.228	.228	.036	.0032	7711081033.	61.	1.31	5.7	.220	.220	.036	.0034
7711081111.	61.	1.31	6.0	.227	.227	.036	.0036	7711081119.	61.	1.31	6.3	.191	.191	.036	.0049
7711081127.	61.	1.31	14.8	.145	.145	.036	.0088	7711081135.	61.	1.31	18.2	.164	.164	.036	.0108
7711021318.	61.	1.06	7.6	.196	.196	.056	.0069	7711021316.	61.	1.06	9.0	.194	.194	.056	.0082
7711021332.	61.	1.06	16.6	.081	.081	.056	.0151	7711021326.	61.	1.06	17.3	.104	.104	.056	.0157
7711081145.	61.	.89	2.3	.216	.216	.079	.0030	7711081153.	61.	.89	4.1	.166	.166	.079	.0053
7711081201.	61.	.89	5.1	.154	.154	.079	.0066	7711081209.	61.	.89	6.1	.148	.148	.079	.0079
7711081217.	61.	.89	8.4	.134	.134	.079	.0108								
BREAKWATER 3															
7712231340.	95.	2.46	8.4	.826	.826	.016	.0014	7712231347.	95.	2.46	12.0	.809	.809	.016	.0020
7712231359.	95.	2.46	16.9	.801	.801	.016	.0028	7712231405.	95.	2.46	23.7	.854	.854	.016	.0040
7712231129.	91.	3.77	2.0	.817	.817	.007	.0001	7712231122.	91.	3.77	4.2	.804	.804	.007	.0003
7712231115.	91.	3.77	8.5	.785	.785	.007	.0006	7712231134.	91.	2.67	4.0	.830	.830	.013	.0006
7712231147.	91.	2.67	12.4	.827	.827	.013	.0018	7712231200.	91.	2.40	3.0	.851	.851	.016	.0005
7712231201.	91.	2.40	6.3	.843	.843	.016	.0011	7712431530.	91.	2.40	13.7	.838	.838	.016	.0024
7712231239.	91.	2.40	19.7	.805	.805	.016	.0035	7712231215.	91.	2.02	6.1	.838	.838	.023	.0015
7712231226.	91.	2.02	11.6	.830	.830	.023	.0029	7712231233.	91.	2.02	16.4	.846	.846	.023	.0041
7712231253.	91.	2.02	22.0	.787	.787	.023	.0055	7712231300.	91.	1.60	24.0	.715	.715	.036	.0096
7712230726.	85.	3.65	1.5	.832	.832	.007	.0001	7712230733.	85.	3.65	3.2	.793	.793	.007	.0002

SINE BLADE MOTION

ID D(CM) T(S) H(CM) KT KR D/GT2 H/GT2 ID D(CM) T(S) H(CM) KT KR D/GT2 H/GT2

BREAKWATER 3

Table with 15 columns: ID, D(CM), T(S), H(CM), KT, KR, D/GT2, H/GT2, ID, D(CM), T(S), H(CM), KT, KR, D/GT2, H/GT2. Contains two columns of data for Breakwater 3.

BREAKWATER 3M

Table with 15 columns: ID, D(CM), T(S), H(CM), KT, KR, D/GT2, H/GT2, ID, D(CM), T(S), H(CM), KT, KR, D/GT2, H/GT2. Contains two columns of data for Breakwater 3M.

		SINE BLADE MOTION															
ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2			ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2
BREAKWATER 4																	
7801181430	85	3.65	1.6	913	913	0.07	0.000			7801181426	85	3.65	1.4	878	878	0.07	0.001
7801181414	85	3.65	3.0	842	842	0.07	0.002			7801181406	85	3.65	6.4	801	801	0.07	0.005
7801181359	85	3.65	9.4	783	783	0.07	0.007			7801181350	85	3.65	13.6	782	782	0.07	0.010
7801181303	85	2.32	1.4	904	904	0.16	0.003			7801181056	85	2.32	2.9	861	861	0.16	0.005
7801181450	85	2.32	6.1	804	804	0.16	0.012			7801181444	85	2.32	12.9	782	782	0.16	0.024
7801181037	85	2.32	10.1	659	659	0.16	0.038			7801181510	85	2.32	19.8	888	888	0.16	0.112
7801181515	85	2.32	15.3	920	920	0.16	0.030			7801191240	85	2.32	1.8	812	812	0.16	0.007
7801191108	80	2.25	1.5	880	880	0.16	0.003			7801191135	80	2.25	3.0	885	885	0.16	0.006
7801191128	80	2.25	8.3	776	776	0.16	0.013			7801191336	80	2.25	13.5	855	855	0.16	0.027
7801191145	80	2.25	19.9	610	610	0.16	0.040			7801201156	75	2.18	1.3	853	853	0.16	0.003
7801201149	75	2.18	2.7	792	792	0.16	0.006			7801201140	75	2.18	5.4	758	758	0.16	0.012
7801201133	75	2.18	11.3	683	683	0.16	0.024			7801201107	75	2.18	15.6	608	608	0.16	0.034
7801191241	74	3.42	9.9	888	888	0.06	0.001			7801191244	74	3.42	4.5	752	752	0.06	0.004
7801191255	74	3.42	14.3	588	588	0.06	0.012			7801191331	74	2.18	1.3	787	787	0.16	0.003
7801191324	74	2.18	2.6	736	736	0.16	0.006			7801191317	74	2.18	5.4	707	707	0.16	0.012
7801191310	74	2.18	11.1	642	642	0.16	0.024			7801191303	74	2.18	15.5	559	559	0.16	0.033
7801191439	72	1.18	2.3	762	762	0.53	0.017			7801191633	72	1.18	5.0	631	631	0.53	0.037
7801191427	72	1.18	9.1	562	562	0.53	0.067			7801191416	72	1.18	13.2	462	462	0.53	0.097
7801200959	70	2.11	1.7	728	728	0.16	0.004			7801201006	70	2.11	4.9	607	607	0.16	0.011
7801200133	70	2.11	6.8	589	589	0.16	0.016			7801201023	70	2.11	9.4	560	560	0.16	0.022
7801201030	70	2.11	13.4	524	524	0.16	0.031			7801201036	70	2.11	19.4	487	487	0.16	0.044
7801201215	65	2.03	1.9	553	553	0.16	0.005			7801201221	65	2.03	3.9	468	468	0.16	0.010
7801201227	65	2.03	7.9	457	457	0.16	0.020			7801201233	65	2.03	11.3	448	448	0.16	0.028
7801201239	65	2.03	15.9	455	455	0.16	0.039			7801201245	65	2.03	22.1	452	452	0.16	0.055
7801201311	60	3.06	6.1	444	444	0.07	0.007			7801201317	60	3.06	8.5	404	404	0.07	0.009
7801201323	60	3.06	11.7	402	402	0.07	0.013			7801201330	60	3.06	16.1	433	433	0.07	0.018
7801201344	60	1.95	3.3	407	407	0.16	0.009			7801201350	60	1.95	4.6	356	356	0.16	0.012
7801201357	60	1.95	6.5	315	315	0.16	0.017			7801201404	60	1.95	9.6	284	284	0.16	0.026
7801201411	60	1.95	14.0	281	281	0.16	0.038			7801201450	60	1.05	2.0	293	293	0.55	0.019
7801201444	60	1.65	4.2	204	204	0.55	0.039			7801201458	60	1.05	7.3	164	164	0.55	0.068
7801201431	60	1.65	11.5	153	153	0.55	0.106			7801201425	60	1.05	13.5	153	153	0.55	0.125
7801211357	55	1.88	1.7	465	465	0.16	0.005			7801211403	55	1.87	2.9	402	402	0.16	0.007
7801211514	55	1.87	2.6	405	405	0.16	0.008			7801211009	55	1.87	3.7	335	335	0.16	0.011
7801211415	55	1.87	5.6	275	275	0.16	0.016			7801211521	55	1.87	5.7	276	276	0.16	0.017
7801211421	55	1.87	8.3	224	224	0.16	0.024			7801211028	55	1.87	12.5	190	190	0.16	0.036
7801211528	55	1.87	12.5	194	194	0.16	0.036			7801211035	55	1.87	18.4	204	204	0.16	0.054
7801211554	49	1.85	1.9	371	371	0.15	0.006			7801211544	49	1.85	3.8	257	257	0.15	0.011
7801211520	49	1.85	5.6	207	207	0.15	0.017			7801211000	49	1.85	8.2	165	165	0.15	0.024
7801211606	49	1.85	12.3	136	136	0.15	0.037			7801211612	49	1.85	17.8	120	120	0.15	0.052
7801211631	45	2.65	1.6	393	393	0.07	0.002			7801211638	45	2.65	4.6	227	227	0.07	0.007
7801211644	45	2.65	10.7	151	151	0.07	0.016			7801211651	45	2.65	15.9	130	130	0.07	0.023
7801211659	45	1.69	2.0	278	278	0.16	0.007			7801211705	45	1.69	6.3	149	149	0.16	0.023
7801211715	45	1.69	4.5	105	105	0.16	0.008			7801211717	45	1.69	19.1	106	106	0.16	0.068
7801211723	45	1.65	9.3	037	037	0.55	0.057			7801211729	45	1.91	9.7	033	033	0.55	0.120

BREAKWATER 4W

7801181155	85	3.65	1.6	886	886	0.07	0.000			7801181148	85	3.65	1.3	857	857	0.07	0.001
7801181140	85	3.65	2.9	834	834	0.07	0.002			7801181132	85	3.65	6.1	804	804	0.07	0.005
7801181126	85	3.65	9.4	784	784	0.07	0.007			7801181118	85	3.65	13.3	776	776	0.07	0.010
7801181272	85	2.32	1.3	894	894	0.16	0.002			7801181220	85	2.32	2.8	860	860	0.16	0.005
7801181214	85	2.32	5.9	827	827	0.16	0.011			7801181208	85	2.32	12.6	790	790	0.16	0.024
7801181201	85	2.32	10.2	744	744	0.16	0.035			7801181233	85	1.26	1.9	885	885	0.55	0.012
7801181259	85	1.26	3.9	924	924	0.55	0.028			7801181245	85	1.26	6.0	925	925	0.55	0.039
7801181258	85	1.28	11.9	832	832	0.55	0.076			7801181041	80	2.25	1.3	909	909	0.16	0.003
7801181034	80	2.24	2.8	836	836	0.16	0.006			7801181270	80	2.25	6.0	783	783	0.16	0.012
7801181020	80	2.25	13.0	661	661	0.16	0.026			7801181013	80	2.25	18.5	591	591	0.16	0.037
7801180803	76	3.42	1.9	974	974	0.07	0.001			7801180809	76	3.42	4.0	727	727	0.07	0.003
7801180815	76	3.42	13.4	556	556	0.07	0.012			7801180850	76	2.18	1.3	846	846	0.16	0.003
7801180842	76	2.18	2.6	779	779	0.16	0.006			7801180836	76	2.18	5.4	736	736	0.16	0.012
7801180823	74	2.18	16.0	877	877	0.16	0.034			7801180854	76	1.18	2.2	848	848	0.55	0.016
7801180902	76	1.18	4.4	766	766	0.55	0.032			7801180904	76	1.18	10.2	614	614	0.55	0.075
7801180914	76	1.18	15.0	492	492	0.55	0.110			7801171318	70	2.11	1.9	658	658	0.16	0.004
7801171324	70	2.11	5.1	571	571	0.16	0.012			7801171330	70	2.11	7.3	526	526	0.16	0.017
7801171336	70	2.11	9.7	490	490	0.16	0.022			7801171342	70	2.11	13.3	477	477	0.16	0.030
7801171349	70	2.11	19.2	453	453	0.16	0.044			7801171235	65	2.03	2.3	387	387	0.16	0.006
7801171242	65	2.03	4.6	333	333	0.16	0.011			7801171249	65	2.03	8.3	369	369	0.16	0.021
7801171255	65	2.03	11.8	388	388	0.16	0.029			7801171301	65	2.03	15.8	385	385	0.16	0.039
7801171307	65	2.03	19.6	403	403	0.16	0.049			7801171018	60	3.06	2.1	385	385	0.07	0.002
7801171424	60	3.06	4.														

SINE BLADE MOTION

ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2
BREAKWATER 4W							
7801171209.	60.	1.05	5.0	.147	.147	.056	.0050
7801171157.	60.	1.05	11.7	.119	.119	.056	.0108
7801170922.	56.	1.08	1.8	.327	.327	-.016	.0005
7801170935.	56.	1.88	3.6	.221	.221	.016	.0010
7801170947.	56.	1.88	8.0	.141	.141	.016	.0023
7801171800.	56.	1.88	17.6	.149	.149	.016	.0051
7801170848.	50.	1.78	8.5	.051	.051	.016	.0027
7801170901.	50.	1.78	18.1	.065	.065	.016	.0058

ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2
7801171203.	60.	1.05	6.9	.125	.125	.056	.0064
7801171151.	60.	1.05	12.9	.124	.124	.056	.0119
7801170929.	56.	1.88	2.6	.267	.267	.016	.0008
7801170941.	56.	1.88	5.4	.177	.177	.016	.0016
7801170955.	56.	1.88	12.4	.119	.119	.016	.0036
7801170841.	50.	1.78	5.6	.022	.022	.016	.0018
7801170855.	50.	1.78	12.8	.058	.058	.016	.0041

BREAKWATER 5

7802011154.	75.	3.42	3.1	.879	.879	.007	.0003
7802011222.	75.	3.42	13.4	.818	.818	.007	.0012
7802011124.	75.	2.18	5.3	.974	.974	.016	.0011
7802011250.	75.	2.18	19.5	***	***	.016	.0042
7802011243.	75.	1.10	9.3	.970	.970	.055	.0068
7801311339.	60.	3.09	5.6	.855	.855	.006	.0006
7801311220.	60.	1.97	.8	***	***	.016	.0002
7801311252.	60.	1.97	3.6	***	***	.016	.0009
7802021213.	45.	8.01	3.8	.960	.960	.011	.0010
7802021231.	45.	2.01	14.8	.811	.811	.011	.0037
7802021117.	45.	1.69	3.0	***	***	.016	.0011
7802021137.	45.	1.69	6.4	.965	.965	.016	.0023
7802021158.	45.	1.69	13.9	.799	.799	.016	.0050
7802021033.	45.	1.18	4.1	.901	.901	.033	.0030
7802021050.	45.	1.18	8.4	.839	.839	.033	.0062
7802021006.	45.	.91	5.5	.920	.920	.055	.0068
7802021337.	31.	1.39	1.4	.530	.530	.016	.0007
7802021355.	31.	1.39	3.8	.469	.469	.016	.0020
7802021414.	31.	1.39	8.5	.375	.375	.016	.0045

7802011205.	75.	3.42	6.5	.846	.846	.007	.0006
7802011120.	75.	2.18	2.7	.979	.979	.016	.0006
7802011138.	75.	2.18	10.6	***	***	.016	.0023
7802011236.	75.	1.18	3.9	.972	.972	.055	.0029
7801311328.	60.	3.09	2.5	.879	.879	.006	.0003
7801311344.	60.	3.09	11.5	.873	.873	.006	.0012
7801311242.	60.	1.97	1.7	***	***	.016	.0004
7801311320.	60.	1.97	7.4	.991	.991	.016	.0019
7802021219.	45.	2.01	5.5	.949	.949	.011	.0014
7802021106.	45.	1.69	1.0	***	***	.016	.0004
7802021124.	45.	1.69	4.3	.989	.989	.016	.0015
7802021145.	45.	1.69	9.6	.928	.928	.016	.0034
7802021225.	45.	1.18	2.8	.911	.911	.033	.0021
7802021044.	45.	1.18	6.5	.867	.867	.033	.0048
7802020914.	45.	.91	2.1	.866	.866	.055	.0026
7802021018.	45.	.91	9.3	.744	.744	.055	.0115
7802021346.	31.	1.39	2.8	.838	.838	.016	.0015
7802021404.	31.	1.39	5.9	.372	.372	.016	.0031
7802021425.	31.	1.39	9.8	.359	.359	.016	.0052

BREAKWATER 6

7802071045.	75.	3.42	.9	.792	.792	.007	.0001
7802071102.	75.	3.42	6.2	.689	.689	.007	.0005
7802071220.	75.	2.60	2.2	.805	.805	.011	.0003
7802071235.	75.	2.60	9.2	.716	.716	.011	.0014
7802070946.	75.	2.18	1.3	.851	.851	.016	.0003
7802071000.	75.	2.18	3.5	.799	.799	.016	.0008
7802071019.	75.	2.18	7.1	.737	.737	.016	.0015
7802071035.	75.	2.18	14.2	.683	.683	.016	.0030
7802071156.	75.	1.40	10.9	.755	.755	.039	.0057
7802071117.	75.	1.18	2.2	.821	.821	.055	.0016
7802071129.	75.	1.18	14.2	.711	.711	.055	.0104
7802061147.	60.	3.06	3.3	.525	.525	.007	.0004
7802061055.	60.	2.32	5.3	.463	.463	.011	.0010
7802061014.	60.	1.95	3.8	.498	.498	.016	.0010
7802061032.	60.	1.95	14.9	.467	.467	.016	.0040
7802061218.	60.	1.25	2.5	.365	.365	.039	.0016
7802061250.	60.	1.25	6.6	.391	.391	.039	.0043
7802061051.	60.	1.05	2.1	.280	.280	.056	.0019
7802061118.	60.	1.05	7.4	.297	.297	.056	.0068
7802061204.	45.	2.66	1.6	.550	.550	.006	.0002
7802061217.	45.	2.66	3.3	.378	.378	.006	.0008
7802061032.	45.	2.65	1.0	.604	.604	.007	.0001
7802061045.	45.	2.65	4.4	.403	.403	.007	.0006
7802071451.	45.	2.65	13.9	.234	.234	.007	.0020
7802070852.	45.	1.64	3.5	.426	.426	.017	.0013
7802071422.	45.	1.69	14.7	.237	.237	.016	.0055
7802081059.	45.	.91	5.8	.167	.167	.055	.0071

7802071054.	75.	3.42	2.9	.732	.732	.007	.0003
7802071109.	75.	3.42	13.2	.687	.687	.007	.0012
7802071227.	75.	2.60	4.5	.760	.760	.011	.0007
7802071309.	75.	2.60	17.8	.998	.998	.011	.0027
7802070952.	75.	2.18	2.5	.835	.835	.016	.0005
7802071010.	75.	2.18	5.1	.748	.748	.016	.0011
7802071027.	75.	2.18	10.0	.717	.717	.016	.0021
7802071145.	75.	1.40	5.7	.788	.788	.039	.0030
7802071205.	75.	1.40	14.8	.747	.747	.039	.0077
7802071123.	75.	1.18	6.4	.712	.712	.055	.0047
7802061152.	60.	3.06	.9	.735	.735	.007	.0001
7802061158.	60.	3.06	10.3	.487	.487	.007	.0011
7802060204.	60.	2.32	11.4	.400	.400	.011	.0022
7802061021.	60.	1.95	7.5	.474	.474	.016	.0020
7802061040.	60.	1.95	19.8	.439	.439	.016	.0053
7802061229.	60.	1.25	5.2	.389	.389	.039	.0034
7802061323.	60.	1.25	11.3	.361	.361	.039	.0074
7802061459.	60.	1.05	3.8	.266	.266	.056	.0035
7802061119.	60.	1.05	14.3	.386	.386	.056	.0132
7802081213.	45.	2.86	3.1	.469	.469	.006	.0004
7802081226.	45.	2.86	8.9	.328	.328	.006	.0011
7802081039.	45.	2.65	2.0	.534	.534	.007	.0003
7802071435.	45.	2.65	10.0	.271	.271	.007	.0015
7802081024.	45.	1.64	1.8	.499	.499	.017	.0007
7802071501.	45.	1.69	7.3	.334	.334	.016	.0026
7802081052.	45.	.91	1.6	.259	.259	.055	.0020
7802081107.	45.	.91	8.3	.137	.137	.055	.0102

BREAKWATER 7

7802121422.	45.	2.65	.7	.559	.559	.007	.0001
7802121414.	45.	2.65	2.9	.408	.408	.007	.0004
7802121447.	45.	2.65	13.8	.378	.378	.007	.0020
7802121355.	45.	1.69	2.3	.367	.367	.016	.0008
7802121408.	45.	1.69	9.9	.293	.293	.016	.0035
7802121455.	45.	.91	1.7	.132	.132	.055	.0021
7802121506.	45.	.91	9.4	.091	.091	.055	.0116
7802121618.	60.	3.06	8.0	.767	.767	.007	.0009
7802121545.	60.	1.95	1.2	.865	.865	.016	.0003
7802121557.	60.	1.95	9.5	.811	.811	.016	.0025
7802121632.	60.	1.05	1.9	.911	.911	.056	.0018
7802121845.	60.	1.05	10.9	.708	.708	.056	.0101
7802131012.	75.	3.42	2.8	.807	.807	.007	.0002
7802131030.	75.	3.42	12.7	.743	.743	.007	.0011

7802121428.	45.	2.65	1.4	.499	.499	.007	.0002
7802121440.	45.	2.65	6.4	.334	.334	.007	.0009
7802121349.	45.	1.69	1.1	.457	.457	.016	.0004
7802121401.	45.	1.69	4.6	.277	.277	.016	.0016
7802121414.	45.	1.69	14.1	.326	.326	.016	.0050
7802121501.	45.	.91	4.4	.085	.085	.055	.0054
7802121612.	60.	3.06	1.6	.864	.864	.007	.0002
7802121625.	60.	3.06	15.8	.780	.780	.007	.0017
7802121551.	60.	1.95	4.3	.791	.791	.016	.0012
7802121603.	60.	1.95	19.6	.641	.641	.016	.0053
7802121639.	60.	1.05	5.7	.755	.755	.056	.0053
7802131003.	75.	3.42	1.3	.800	.800	.007	.0001
7802131021.	75.	3.42	5.9	.799	.799	.007	.0005
7802130914.	7						

ID	D(CM)	T(S)	H(CM)	KT	SINE BLADE MOTION	
					KR D/GT2	H/GT2
BREAKWATER 7						
7802130922	75	2.18	2.6	.914	.914	.016 .0006
7802130943	75	2.18	10.5	.845	.845	.016 .0023
7802131041	75	1.18	2.2	.855	.855	.055 .0016
7802131056	75	1.18	14.9	.894	.894	.055 .0109

ID	D(CM)	T(S)	H(CM)	KT	SINE BLADE MOTION	
					KR D/GT2	H/GT2
7802130932	75	2.18	5.2	.867	.867	.016 .0011
7802130954	75	2.18	14.3	.870	.870	.016 .0031
7802131048	75	1.18	5.7	.861	.861	.055 .0042

BREAKWATER 8						
7802141416	45	1.69	1.5	.270	.270	.016 .0005
7802141438	45	1.69	6.7	.181	.121	.016 .0024
7802141459	45	1.69	13.8	.071	.071	.016 .0049
7802151043	60	1.95	3.8	.251	.251	.016 .0010
7802151051	60	1.95	15.8	.159	.159	.016 .0042

BREAKWATER 8						
7802141429	45	1.69	3.1	.193	.193	.016 .0011
7802141447	45	1.69	9.7	.094	.094	.016 .0035
7802151024	60	1.95	1.9	.334	.334	.016 .0005
7802151033	60	1.95	8.0	.188	.188	.016 .0021
7802151058	60	1.95	20.9	.205	.205	.016 .0056

BREAKWATER 9						
7802161313	45	2.65	.7	.464	.460	.007 .0001
7802161329	45	2.65	3.1	.285	.285	.007 .0005
7802161346	45	2.65	11.8	.117	.117	.007 .0017
7802160906	45	1.69	1.4	.784	.284	.016 .0005
7802281017	45	1.69	4.0	.196	.196	.016 .0014
7802160922	45	1.69	6.6	.122	.122	.016 .0024
7802281448	45	1.69	12.6	.096	.096	.016 .0045
7802281513	45	1.69	24.6	.057	.057	.016 .0088
7802161503	45	.91	2.0	.024	.028	.055 .0025
7802211014	60	3.06	1.5	.480	.480	.007 .0002
7802211029	60	3.06	7.9	.250	.250	.007 .0009
7802211044	60	3.06	15.2	.261	.261	.007 .0017
7802210924	60	1.95	3.7	.247	.247	.016 .0010
7802210939	60	1.95	7.7	.182	.182	.016 .0021
7802211006	60	1.95	15.8	.154	.154	.016 .0042
7802211059	60	1.95	4.6	.054	.054	.056 .0043
7802211114	60	1.05	12.1	.030	.030	.056 .0112
7802220954	75	3.42	2.9	.650	.630	.007 .0003
7802221009	75	3.42	13.7	.487	.487	.007 .0012
7802220916	75	2.18	2.6	.741	.741	.016 .0006
7802220931	75	2.18	10.7	.583	.583	.016 .0023
7802221017	75	1.18	3.1	.633	.633	.055 .0023
7802221034	75	1.18	14.0	.413	.413	.055 .0103

BREAKWATER 9						
7802161321	45	2.65	1.5	.391	.391	.007 .0002
7802161337	45	2.65	7.2	.169	.169	.007 .0010
7802281407	45	1.69	1.3	.322	.322	.016 .0005
7802160914	45	1.69	3.1	.197	.197	.016 .0011
7802281427	45	1.69	5.7	.159	.159	.016 .0027
7802281438	45	1.69	8.4	.125	.125	.016 .0030
7802281458	45	1.69	17.8	.075	.075	.016 .0064
7802161353	45	.91	7.7	.040	.040	.055 .0009
7802161138	45	.91	9.5	.007	.007	.055 .0117
7802211021	60	3.06	3.5	.345	.345	.007 .0004
7802211036	60	3.06	11.2	.216	.216	.007 .0012
7802210916	60	1.95	1.8	.349	.349	.016 .0005
7802210931	60	1.95	5.3	.214	.214	.016 .0014
7802210946	60	1.95	11.1	.157	.157	.016 .0030
7802211051	60	1.05	1.5	.113	.113	.056 .0014
7802211107	60	1.05	7.6	.032	.032	.056 .0070
7802210976	75	3.42	1.4	.624	.624	.007 .0001
7802221001	75	3.42	6.3	.528	.528	.007 .0005
7802220909	75	2.18	1.3	.775	.775	.016 .0003
7802220924	75	2.18	5.3	.660	.660	.016 .0011
7802220938	75	2.18	15.7	.555	.555	.016 .0034
7802221024	75	1.18	7.3	.526	.526	.055 .0053

BREAKWATER 10						
7803061141	75	3.42	1.3	.643	.643	.007 .0001
7803061157	75	3.42	6.2	.584	.584	.007 .0005
7803061273	75	3.42	20.4	.475	.475	.007 .0018
7803061106	75	2.18	2.7	.785	.785	.016 .0006
7803061110	75	2.18	11.5	.675	.675	.016 .0025
7803061126	75	2.18	22.8	.535	.535	.016 .0049
7803061231	75	1.18	7.9	.642	.642	.055 .0058
7803031322	60	3.06	3.8	.361	.361	.007 .0001
7803031340	60	3.06	19.5	.435	.435	.007 .0024
7803031016	60	1.95	4.2	.302	.302	.016 .0011
7803031032	60	1.95	16.0	.304	.304	.016 .0043
7803031225	60	1.05	2.1	.184	.184	.056 .0019
7803031248	60	1.05	8.1	.115	.115	.056 .0075
7803031250	45	2.65	.7	.393	.393	.007 .0001
7803021106	45	2.65	3.2	.253	.253	.007 .0005
7803021224	45	2.65	14.6	.106	.106	.007 .0021
7803021124	45	1.69	4.3	.165	.165	.016 .0015
7803021140	45	1.69	13.8	.074	.074	.016 .0049

BREAKWATER 10						
7803061149	75	3.42	2.9	.630	.630	.007 .0003
7803061205	75	3.42	13.6	.498	.498	.007 .0012
7803061047	75	2.18	1.3	.630	.630	.016 .0003
7803061103	75	2.18	5.5	.733	.733	.016 .0012
7803061118	75	2.18	17.1	.632	.632	.016 .0037
7803061222	75	1.18	3.1	.726	.726	.055 .0023
7803031308	60	3.06	1.1	.498	.498	.007 .0001
7803031330	60	3.06	11.1	.340	.340	.007 .0012
7803031348	60	3.06	24.9	.451	.451	.007 .0027
7803031025	60	1.95	8.3	.249	.249	.016 .0022
7803031208	60	1.95	21.8	.406	.406	.016 .0059
7803031241	60	1.05	3.6	.145	.145	.056 .0031
7803031255	60	1.05	14.1	.181	.181	.056 .0151
7803021203	45	2.65	1.5	.343	.343	.007 .0002
7803021217	45	2.65	7.2	.157	.157	.007 .0010
7803021059	45	1.69	1.0	.337	.337	.016 .0004
7803021133	45	1.69	9.6	.100	.100	.016 .0034
7803021147	45	1.69	17.0	.060	.060	.016 .0061

BREAKWATER 11						
7803131303	45	2.65	.8	.676	.676	.007 .0001
7803131319	45	2.65	3.2	.506	.506	.007 .0005
7803131334	45	2.65	13.3	.297	.297	.007 .0019
7803131153	45	1.69	5.1	.429	.429	.016 .0018
7803131247	45	1.69	14.1	.324	.324	.016 .0050
7803131427	45	.91	1.7	.286	.286	.055 .0021
7803131356	45	.91	7.8	.153	.153	.055 .0096
7803131440	31	1.94	.8	.707	.088	.002
7803131453	31	1.94	3.8	.493	.493	.008 .0010
7803131510	31	1.93	1.1	.472	.472	.013 .0005
7803131724	31	1.53	5.2	.345	.345	.013 .0023
7803141428	31	1.41	.8	.387	.387	.016 .0004
7803141405	31	1.41	3.1	.338	.338	.016 .0016
7803141104	31	1.16	6.6	.375	.375	.023 .0005

BREAKWATER 11						
7803131311	45	2.65	1.5	.607	.607	.007 .0002
7803131327	45	2.65	6.8	.398	.398	.007 .0010
7803131146	45	1.69	2.4	.499	.499	.016 .0009
7803131239	45	1.69	10.9	.336	.336	.016 .0039
7803131254	45	1.69	15.7	.309	.309	.016 .0056
7803131349	45	.91	5.0	.182	.182	.055 .0062
7803131404	45	.91	8.6	.145	.145	.055 .0106
7803131448	31	1.94	1.7	.605	.605	.008 .0005
7803131503	31	1.94	10.5	.315	.315	.008 .0028
7803131517	31	1.53	2.4	.400	.400	.013 .0010
7803141021	31	1.53	13.1	.228	.228	.013 .0057
7803141038	31	1.41	1.6	.367	.367	.016 .0008
7803141052	31	1.41	7.0	.273	.273	.016 .0036
7803141107	31	1.16	1.4	.317	.317	.023 .0011

					SINE BLADE MOTION			
ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2	
BREAKWATER 11								
7803141114	31.	1.16	3.0	.274	.278	.023	.0023	
7803141130	31.	1.00	.6	.284	.284	.031	.0006	
7803141144	31.	1.00	3.6	.205	.205	.031	.0037	
BREAKWATER 12								
7803171001	75.	3.42	1.3	.751	.751	.007	.0001	
7803170910	75.	3.42	2.8	.738	.738	.007	.0002	
7803170927	75.	3.42	13.5	.569	.569	.007	.0012	
7803170932	75.	2.18	2.7	.864	.864	.016	.0006	
7803170947	75.	2.18	11.4	.712	.712	.016	.0024	
7803170937	75.	1.18	3.5	.732	.732	.055	.0026	
7803170951	75.	1.18	14.4	.509	.509	.055	.0106	
7803171255	60.	3.06	9.7	.430	.430	.007	.0011	
7803171311	60.	3.06	25.2	.493	.493	.007	.0027	
7803171335	60.	1.95	3.9	.507	.507	.016	.0010	
7803171049	60.	1.95	10.6	.341	.341	.016	.0045	
7803171106	60.	1.05	.9	.266	.266	.056	.0008	
7803170913	60.	1.05	7.4	.170	.170	.056	.0068	
7803160923	45.	2.65	.6	.753	.753	.007	.0001	
7803160945	45.	2.65	6.0	.433	.433	.007	.0009	
7803160842	45.	1.69	.9	.727	.727	.016	.0003	
7803160858	45.	1.69	3.7	.455	.455	.016	.0013	
7803160913	45.	1.69	10.6	.280	.280	.016	.0038	
7803161010	45.	.91	3.1	.079	.079	.055	.0038	

ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2	
BREAKWATER 13								
7804211154	60.	3.06	.9	.932	.932	.007	.0001	
7804211138	60.	3.06	4.2	.870	.870	.007	.0005	
7804211120	60.	3.06	13.6	.885	.885	.007	.0015	
7804211052	60.	1.95	3.2	.947	.947	.016	.0009	
7804211100	60.	1.95	13.8	.859	.859	.016	.0036	
7804211203	60.	1.05	1.6	.884	.884	.056	.0015	
7804211219	60.	1.05	6.4	.898	.898	.056	.0059	
7804201436	45.	3.31	2.5	.866	.866	.004	.0002	
7804201357	45.	3.31	11.1	.704	.704	.004	.0010	
7804210403	45.	2.65	4.5	.915	.915	.007	.0007	
7804210900	45.	2.65	18.8	.769	.769	.007	.0027	
7804210320	45.	2.11	4.5	.849	.849	.010	.0010	
7804210341	45.	2.11	11.8	.836	.836	.010	.0027	
7804210504	45.	1.69	2.9	.844	.844	.016	.0010	
7804210320	45.	1.69	12.8	.705	.705	.016	.0046	
7804210336	45.	1.14	1.5	.805	.805	.035	.0012	
7804210927	45.	.91	2.1	.881	.881	.055	.0026	
7804210909	45.	.91	7.8	.687	.687	.055	.0096	
7804201957	35.	3.06	1.5	.737	.737	.004	.0002	
7804201130	35.	3.06	8.0	.569	.569	.004	.0009	
7804200934	35.	1.95	1.1	.791	.791	.009	.0003	
7804201015	35.	1.95	4.8	.655	.655	.009	.0013	
7804201034	35.	1.95	19.8	.444	.444	.009	.0053	
7804201149	35.	1.25	4.6	.697	.697	.023	.0030	
7804201149	35.	1.25	11.5	.360	.360	.023	.0075	
7804201224	35.	1.05	5.1	.358	.358	.032	.0047	

BREAKWATER 14								
7804240907	65.	2.03	2.7	.964	.960	.016	.0007	
7804240825	65.	2.03	8.3	.987	.987	.016	.0021	
7804241007	60.	3.06	.9	.946	.940	.007	.0001	
7804241024	60.	3.06	8.9	.900	.900	.007	.0010	
7804240909	60.	1.95	1.1	.961	.961	.016	.0003	
7804240926	60.	1.95	4.6	.974	.974	.016	.0012	
7804240902	60.	1.95	9.4	.991	.991	.016	.0025	
7804240958	60.	1.95	18.9	.992	.992	.016	.0051	
7804241051	60.	1.05	4.0	.939	.939	.056	.0037	
7804241145	55.	1.87	1.3	.889	.889	.016	.0004	
7804241252	55.	1.87	5.4	.934	.934	.016	.0016	
7804250802	55.	1.87	15.0	.860	.860	.016	.0044	
7804250846	50.	1.78	.7	.861	.861	.016	.0002	
7804250940	50.	1.78	3.5	.954	.950	.016	.0007	
7804250926	50.	1.78	11.6	.826	.826	.016	.0037	
7804251122	45.	2.65	4.9	.922	.922	.007	.0007	
7804251141	45.	2.65	14.1	.713	.713	.007	.0020	
7804251311	45.	1.69	1.0	.934	.934	.016	.0004	
7804251030	45.	1.69	4.4	.981	.981	.016	.0016	
7804251048	45.	1.69	12.9	.869	.869	.016	.0048	

7803141121	31.	1.16	7.8	.225	.225	.023	.0059	
7803141137	31.	1.00	1.8	.213	.213	.031	.0018	
7803141152	31.	1.00	5.4	.195	.195	.031	.0055	
BREAKWATER 15								
7803170902	75.	3.42	1.3	.762	.762	.007	.0001	
7803170919	75.	3.42	6.2	.659	.659	.007	.0005	
7803170824	75.	2.18	1.4	.890	.890	.016	.0003	
7803170839	75.	2.18	5.6	.793	.793	.016	.0012	
7803170854	75.	2.18	16.3	.684	.684	.016	.0035	
7803170944	75.	1.18	7.5	.656	.656	.055	.0055	
7803171240	60.	3.06	8.	.779	.779	.007	.0001	
7803171303	60.	3.06	19.2	.468	.468	.007	.0021	
7803171028	60.	1.95	1.3	.863	.863	.016	.0003	
7803171042	60.	1.95	8.2	.398	.398	.016	.0022	
7803171057	60.	1.95	22.4	.335	.335	.016	.0030	
7803170005	60.	1.05	4.1	.192	.192	.056	.0030	
7803171153	60.	1.05	14.8	.164	.164	.056	.0137	
7803160930	45.	2.65	1.3	.697	.697	.007	.0002	
7803160954	45.	2.65	11.7	.340	.340	.007	.0017	
7803160849	45.	1.69	1.8	.608	.608	.016	.0008	
7803160906	45.	1.69	8.2	.306	.306	.016	.0029	
7803161003	45.	.91	1.1	.134	.134	.055	.0014	
7803161017	45.	.91	8.0	.057	.057	.055	.0099	

7804240816	65.	2.03	5.8	.979	.979	.016	.0014	
7804240835	65.	2.03	11.8	.997	.997	.016	.0029	
7804241015	60.	3.06	2.8	.900	.900	.007	.0003	
7804241030	60.	3.06	13.4	.939	.939	.007	.0015	
7804240918	60.	1.95	2.3	.964	.964	.016	.0006	
7804240930	60.	1.95	6.5	.984	.984	.016	.0017	
7804240951	60.	1.95	15.7	.968	.968	.016	.0037	
7804241004	60.	1.05	1.5	.921	.921	.056	.0014	
7804241059	60.	1.05	9.7	.888	.888	.056	.0090	
7804241240	55.	1.87	2.7	.927	.927	.016	.0008	
7804241304	55.	1.87	10.8	.961	.961	.016	.0032	
7804250812	55.	1.87	20.5	.732	.732	.016	.0060	
7804250855	50.	1.78	1.6	.913	.913	.016	.0005	
7804250917	50.	1.78	7.4	.869	.869	.016	.0024	
7804250935	55.	1.78	15.2	.693	.693	.016	.0049	
7804251132	45.	2.65	10.0	.806	.806	.007	.0015	
7804251120	45.	2.65	19.7	.652	.652	.007	.0029	
7804251302	45.	1.69	2.1	.952	.952	.016	.0008	
7804251039	45.	1.69	8.9	.713	.713	.016	.0032	
7804251058	45.	1.69	18.3	.510	.510	.016	.0065	

SINE BLADE MOTION

TD	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2
7804251236.	45.	.91	1.9	.879	.879	.055	.0023
7804251254.	45.	.91	5.6	.729	.729	.055	.0069
7804251316.	45.	.91	8.9	.530	.530	.055	.0110
7804251350.	40.	1.39	4.0	.670	.670	.016	.0016
7804251407.	40.	1.39	9.6	.509	.509	.016	.0039
7804251505.	35.	1.49	11.7	.419	.419	.016	.0054
7804251577.	35.	1.49	17.2	.363	.363	.016	.0079
7804261031.	35.	3.06	12.2	.339	.339	.004	.0013
7804261049.	35.	3.06	21.2	.437	.437	.004	.0023
7804261005.	35.	1.95	14.1	.477	.477	.009	.0038
7804261111.	35.	1.49	8.3	.397	.397	.016	.0024
7804261022.	35.	1.30	14.3	.354	.354	.021	.0069
7804261229.	30.	2.17	13.7	.439	.439	.007	.0030
7804261213.	30.	2.17	20.1	.429	.429	.007	.0044
7804261158.	30.	1.38	11.2	.330	.330	.016	.0060

BREAKWATER 14

7805021015.	45.	2.80	4.7	.903	.903	.006	.0006
7805021036.	45.	2.80	10.3	.833	.833	.006	.0013
7805021058.	45.	2.80	19.4	.739	.739	.006	.0024
7805021116.	45.	1.69	2.1	.908	.908	.016	.0008
7805021136.	45.	1.69	6.0	.858	.858	.016	.0021
7805021155.	45.	1.69	12.9	.795	.795	.016	.0046
7805021311.	45.	.91	1.8	.865	.865	.055	.0022
7805021330.	45.	.91	3.1	.851	.851	.055	.0038
7805021247.	45.	.91	8.2	.594	.594	.055	.0101
7805021337.	40.	2.80	8.6	.785	.785	.005	.0011
7805021358.	40.	2.80	16.6	.685	.685	.005	.0022
7805030854.	40.	2.50	.7	.931	.931	.007	.0001
7805030930.	40.	2.50	3.1	.826	.826	.007	.0005
7805030947.	40.	2.50	9.0	.772	.772	.007	.0015
7805031007.	40.	2.50	19.1	.641	.641	.007	.0031
7805030827.	40.	1.59	2.8	.813	.813	.016	.0011
7805030756.	40.	1.59	10.8	.627	.627	.016	.0044
7805030740.	40.	1.59	20.0	.484	.484	.016	.0081
7805031052.	40.	.86	3.2	.755	.755	.055	.0044
7805031037.	40.	.86	5.6	.730	.730	.055	.0077
7805031018.	40.	.86	7.4	.516	.516	.055	.0102
7805030945.	35.	2.80	3.0	.713	.713	.005	.0004
7805041002.	35.	2.80	12.6	.619	.619	.005	.0016
7805041027.	35.	2.80	20.6	.561	.561	.005	.0027
7805041206.	35.	2.34	1.1	.819	.819	.007	.0002
7805041226.	35.	2.34	3.2	.714	.714	.007	.0006
7805040109.	35.	2.34	6.6	.664	.665	.007	.0012
7805040129.	35.	2.34	14.3	.567	.567	.007	.0027
7805041149.	35.	1.49	1.1	.767	.796	.016	.0005
7805041114.	35.	1.49	4.8	.569	.569	.016	.0022
7805041053.	35.	1.49	10.7	.441	.440	.016	.0077
7805041042.	35.	1.49	23.0	.374	.374	.016	.0106
7805040211.	30.	2.80	5.1	.480	.480	.004	.0007
7805051228.	30.	2.17	1.6	.673	.673	.007	.0003
7805051215.	30.	2.17	3.3	.602	.602	.007	.0007
7805051003.	30.	2.17	12.1	.551	.551	.007	.0026
7805050933.	30.	2.17	21.0	.436	.436	.007	.0046
7805050848.	30.	1.38	2.2	.501	.501	.016	.0012
7805050906.	30.	1.38	9.6	.408	.408	.016	.0051
7805050924.	30.	1.38	16.9	.303	.303	.016	.0091
7805041040.	25.	1.98	1.4	.692	.692	.007	.0004
7805041024.	25.	1.98	0.5	.437	.437	.007	.0017
7805041004.	25.	1.98	13.6	.366	.366	.007	.0035
7805080907.	25.	1.26	3.0	.464	.464	.016	.0019
7805080928.	25.	1.26	9.3	.311	.311	.016	.0060
7805080956.	25.	1.26	14.9	.256	.256	.016	.0096
7805091036.	20.	1.77	8.0	.341	.341	.007	.0026
7805090845.	20.	1.13	.7	.371	.371	.016	.0006
7805090855.	20.	1.13	2.7	.271	.271	.016	.0022
7805090913.	20.	1.13	5.6	.198	.198	.016	.0045

BREAKWATER 15

7804270921.	50.	2.18	.9	****	****	.011	.0002
7804270942.	50.	2.18	3.6	.918	.918	.011	.0008
7804271003.	50.	2.18	10.7	.877	.877	.011	.0023
7804271055.	50.	1.78	1.1	.868	.868	.016	.0004
7804271040.	50.	1.78	5.6	.824	.824	.016	.0018

TD D(CM) T(S) H(CM) KT KR D/GT2 H/GT2

7804251246.	45.	.91	4.3	.820	.820	.055	.0053
7804251305.	45.	.91	7.8	.684	.684	.055	.0096
7804251349.	40.	1.59	2.1	.852	.852	.016	.0008
7804251352.	40.	1.59	7.1	.564	.564	.016	.0029
7804251415.	40.	1.59	13.1	.473	.473	.016	.0053
7804251426.	40.	1.59	17.6	.438	.438	.016	.0071
7804251448.	35.	1.49	23.9	.280	.280	.016	.0110
7804261040.	35.	3.06	17.0	.452	.452	.004	.0019
7804260956.	35.	1.95	9.9	.483	.483	.009	.0027
7804261103.	35.	1.49	1.8	.417	.417	.016	.0008
7804261133.	35.	1.30	11.5	.382	.382	.021	.0069
7804261206.	30.	2.17	7.7	.246	.246	.007	.0017
7804261221.	30.	2.17	17.5	.440	.440	.007	.0038
7804261150.	30.	1.38	6.3	.229	.229	.016	.0034
7804261205.	30.	1.38	14.8	.326	.326	.016	.0079

7805021026.	45.	2.80	7.1	.663	.663	.006	.0009
7805021045.	45.	2.80	14.8	.605	.605	.006	.0019
7805021108.	45.	1.69	1.0	.908	.908	.016	.0004
7805021128.	45.	1.69	4.2	.890	.890	.016	.0015
7805021145.	45.	1.69	8.7	.821	.821	.016	.0031
7805021204.	45.	1.69	18.3	.627	.627	.016	.0065
7805021321.	45.	.91	2.4	.850	.850	.055	.0030
7805021339.	45.	.91	3.9	.866	.866	.055	.0048
7805021329.	40.	2.80	5.9	.788	.788	.005	.0008
7805021348.	40.	2.80	12.1	.727	.729	.005	.0016
7805030732.	40.	2.80	20.8	.588	.588	.005	.0027
7805030905.	40.	2.50	1.5	.864	.864	.007	.0002
7805030939.	40.	2.50	6.3	.810	.810	.007	.0010
7805030956.	40.	2.50	13.0	.700	.700	.007	.0021
7805030845.	40.	1.59	1.3	.861	.861	.016	.0005
7805030816.	40.	1.59	5.6	.718	.718	.016	.0023
7805030744.	40.	1.59	15.0	.561	.561	.016	.0061
7805031143.	40.	.86	2.2	.772	.772	.055	.0030
7805031044.	40.	.86	4.2	.726	.726	.055	.0058
7805031026.	40.	.86	6.0	.521	.521	.055	.0083
7805040935.	35.	2.80	1.5	.789	.789	.005	.0002
7805040953.	35.	2.80	6.1	.679	.679	.005	.0008
7805041012.	35.	2.80	17.7	.557	.557	.005	.0023
7805041157.	35.	2.34	5.5	.889	.889	.007	.0001
7805041215.	35.	2.34	2.2	.739	.719	.007	.0004
7805040135.	35.	2.34	4.6	.685	.685	.007	.0009
7805040120.	35.	2.34	9.6	.630	.630	.007	.0018
7805040137.	35.	2.34	20.3	.506	.506	.007	.0038
7805041138.	35.	1.49	2.3	.696	.696	.016	.0011
7805041102.	35.	1.49	11.1	.516	.516	.016	.0051
7805040146.	35.	1.49	22.3	.359	.359	.016	.0102
7805040203.	30.	2.80	2.6	.538	.538	.004	.0003
7805040219.	30.	2.80	10.6	.537	.537	.004	.0014
7805051222.	30.	2.17	1.7	.674	.674	.007	.0004
7805051155.	30.	2.17	6.3	.543	.543	.007	.0014
7805050944.	30.	2.17	15.9	.510	.510	.007	.0034
7805050840.	30.	1.38	1.1	.566	.566	.016	.0006
7805050857.	30.	1.38	4.9	.425	.425	.016	.0026
7805050916.	30.	1.38	12.0	.362	.362	.016	.0064
7805081048.	25.	1.98	.7	.767	.767	.007	.0002
7805081032.	25.	1.98	3.1	.573	.573	.007	.0008
7805081012.	25.	1.98	9.5	.417	.417	.007	.0025
7805080958.	25.	1.26	1.4	.609	.609	.016	.0009
7805080919.	25.	1.26	6.3	.346	.346	.016	.0040
7805080941.	25.	1.26	13.7	.297	.297	.016	.0088
7805091028.	20.	1.77	5.5	.405	.405	.007	.0018
7805091044.	20.	1.77	11.9	.309	.309	.007	.0039
7805090837.	20.	1.13	1.2	.335	.335	.016	.0010
7805090903.	20.	1.13	3.8	.233	.233	.016	.0030
7805090923.	20.	1.13	7.8	.176	.176	.016	.0062

7804270921.	50.	2.18	1.8	.955	.955	.011	.0004
7804270945.	50.	2.18	7.5	.897	.897	.011	.0016
7804271105.	50.	2.18	15.7	.856	.856	.011	.0034
7804271048.	50.	1.78	2.3	.868	.868	.016	.0007
7804271102.	50.	1.78	11.8	.851	.851	.016	.0038

				SINE BLADE MOTION			
ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2
BREAKWATER 15W							
7804271023.	50.	1.7A	14.7	.783	.783	.016	.0047
7804271210.	45.	2.03	4.5	.860	.860	.007	.0007
7804271227.	45.	2.03	13.6	.811	.811	.007	.0020
7804271119.	45.	1.69	3.0	.859	.859	.016	.0011
7804271135.	45.	1.69	8.9	.802	.802	.016	.0032
7804271151.	45.	1.69	16.9	.815	.815	.016	.0060
7804271252.	45.	.91	3.3	.859	.859	.055	.0043
7804281251.	40.	1.59	1.9	.835	.835	.016	.0008
7804281327.	40.	1.59	7.2	.864	.864	.016	.0029
7804281304.	40.	1.59	10.7	.891	.891	.016	.0075
7804281256.	35.	3.06	17.6	.776	.776	.004	.0019
7804281425.	35.	1.93	14.9	.558	.558	.009	.0040
7804281230.	35.	1.49	3.4	.594	.594	.016	.0016
7804281247.	35.	1.49	16.7	.430	.430	.016	.0077
7804281125.	35.	1.30	15.0	.428	.428	.021	.0091
7804271417.	30.	2.17	4.4	.464	.464	.007	.0010
7804271432.	30.	2.17	16.2	.478	.478	.007	.0035
7804271324.	30.	1.38	1.4	.453	.453	.016	.0008
7804271341.	30.	1.38	7.1	.332	.332	.016	.0038
7804271357.	30.	1.38	13.0	.318	.318	.016	.0070

BREAKWATER 16

7805110706.	60.	4.83	.8	.826	.826	.003	.0000
7805110723.	60.	4.83	6.0	.766	.766	.003	.0003
7805110746.	60.	4.83	17.8	.793	.793	.003	.0008
7805110831.	60.	3.06	2.8	.917	.917	.007	.0003
7805110811.	60.	3.06	8.9	.908	.908	.007	.0010
7805110856.	60.	1.95	1.7	.959	.959	.016	.0005
7805110924.	60.	1.95	6.7	.915	.915	.016	.0018
7805111010.	60.	1.95	26.4	.766	.766	.016	.0071
7805111201.	60.	1.05	4.1	.953	.953	.058	.0038
7805111038.	60.	1.05	9.3	.869	.869	.058	.0086
7805111232.	55.	4.69	1.2	.786	.786	.003	.0001
7805111252.	55.	4.69	8.3	.764	.764	.003	.0004
7805111313.	55.	4.69	21.5	.824	.824	.003	.0010
7805120822.	55.	2.93	3.5	.972	.972	.007	.0004
7805111318.	55.	2.93	11.1	.949	.949	.007	.0013
7805111326.	55.	2.93	22.2	.909	.909	.007	.0026
7805120857.	55.	1.87	3.3	.860	.860	.016	.0010
7805120955.	55.	1.87	13.6	.823	.823	.016	.0040
7805120955.	55.	1.87	25.7	.643	.643	.016	.0075
7805121023.	55.	1.01	3.8	.900	.900	.055	.0038
7805121014.	55.	1.01	4.0	.897	.897	.055	.0048
7805121205.	50.	4.54	4.0	.715	.715	.002	.0002
7805121225.	50.	4.54	11.2	.762	.762	.002	.0006
7805121247.	50.	4.54	23.7	.591	.591	.002	.0012
7805121319.	50.	2.80	9.5	.908	.908	.007	.0012
7805121259.	50.	2.80	16.1	.923	.923	.007	.0021
7805140942.	50.	1.78	2.4	.886	.886	.016	.0008
7805141015.	50.	1.78	8.5	.869	.869	.016	.0027
7805141042.	50.	1.78	17.1	.688	.688	.016	.0055
7805141241.	45.	4.38	1.3	.694	.694	.002	.0001
7805141306.	45.	4.38	6.1	.671	.671	.002	.0003
7805141329.	45.	4.38	12.7	.788	.788	.002	.0007
7805141411.	45.	2.85	12.9	.818	.818	.007	.0019
7805141350.	45.	2.85	25.7	.574	.574	.007	.0037
7805170830.	35.	4.06	5.4	.555	.555	.002	.0003
7805170857.	35.	4.06	15.4	.499	.499	.002	.0010
7805220937.	35.	3.10	.9	.871	.871	.004	.0001
7805221003.	35.	3.10	5.1	.601	.601	.004	.0005
7805221022.	35.	3.10	11.1	.516	.516	.004	.0012
7805170921.	35.	2.34	1.0	.799	.799	.007	.0002
7805170939.	35.	2.34	4.0	.650	.650	.007	.0007
7805170957.	35.	2.34	8.3	.587	.587	.007	.0015
7805171022.	35.	2.34	16.9	.468	.468	.007	.0031
7805221049.	35.	1.65	1.4	.673	.673	.013	.0005
7805221145.	35.	1.65	5.6	.534	.534	.013	.0021
7805221203.	35.	1.65	14.4	.414	.414	.013	.0054
7805171043.	35.	1.49	2.3	.624	.624	.016	.0011
7805171154.	35.	1.49	11.5	.438	.438	.016	.0053
7805171214.	35.	1.49	23.2	.305	.305	.016	.0107
7805171243.	30.	3.89	3.0	.468	.468	.002	.0002
7805171303.	30.	3.89	10.3	.417	.417	.002	.0007
7805180937.	30.	2.87	1.8	.616	.616	.004	.0002
7805180959.	30.	2.87	7.2	.484	.484	.004	.0009
7805181241.	30.	2.87	14.7	.483	.483	.004	.0018

				SINE BLADE MOTION			
ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2
BREAKWATER 15W							
7804271207.	45.	2.65	.9	.975	.975	.007	.0001
7804271219.	45.	2.65	9.7	.871	.871	.007	.0014
7804271111.	45.	1.69	1.4	.880	.880	.016	.0005
7804271127.	45.	1.69	6.2	.810	.810	.016	.0022
7804271143.	45.	1.69	12.9	.732	.732	.016	.0046
7804271259.	45.	.91	1.9	.937	.937	.055	.0023
7804271244.	45.	.91	8.1	.600	.600	.055	.0100
7804281259.	40.	1.59	3.8	.754	.754	.016	.0015
7804281316.	40.	1.59	13.7	.561	.561	.016	.0055
7804281151.	35.	3.06	12.5	.502	.502	.004	.0014
7804281305.	35.	3.06	22.5	.444	.444	.004	.0025
7804281222.	35.	1.49	1.6	.675	.675	.016	.0007
7804281239.	35.	1.49	7.4	.489	.489	.016	.0034
7804281116.	35.	1.30	11.3	.478	.478	.016	.0068
7804271409.	30.	2.17	2.2	.555	.555	.007	.0005
7804271425.	30.	2.17	6.6	.463	.463	.007	.0019
7804271442.	30.	2.17	20.7	.438	.438	.007	.0045
7804271332.	30.	1.38	3.1	.355	.355	.016	.0017
7804271349.	30.	1.38	9.6	.342	.342	.016	.0051

7805110715.	60.	4.83	2.8	.794	.794	.003	.0001
7805110735.	60.	4.83	12.6	.758	.758	.003	.0006
7805110840.	60.	3.06	.9	.956	.956	.007	.0001
7805110820.	60.	3.06	6.1	.902	.902	.007	.0007
7805110802.	60.	3.06	13.5	.939	.939	.007	.0015
7805110933.	60.	1.95	3.4	.947	.947	.016	.0009
7805110937.	60.	1.95	13.7	.871	.871	.016	.0037
7805111208.	60.	1.05	2.8	.947	.947	.056	.0026
7805111046.	60.	1.05	6.5	.952	.952	.056	.0060
7805111022.	60.	1.05	11.8	.780	.780	.056	.0109
7805111242.	55.	4.69	4.0	.760	.760	.003	.0002
7805111304.	55.	4.69	10.1	.822	.822	.003	.0007
7805120832.	55.	2.93	1.1	.979	.979	.007	.0001
7805120810.	55.	2.93	7.7	.949	.949	.007	.0009
7805111339.	55.	2.93	15.9	.981	.981	.007	.0019
7805120843.	55.	1.87	1.6	.869	.869	.016	.0005
7805120913.	55.	1.87	6.5	.852	.852	.016	.0019
7805120946.	55.	1.87	19.2	.754	.754	.016	.0056
7805121031.	55.	1.01	1.3	.927	.927	.055	.0013
7805121005.	55.	1.01	4.3	.893	.893	.055	.0043
7805121152.	50.	4.54	2.0	.714	.714	.002	.0001
7805121215.	50.	4.54	7.9	.734	.734	.002	.0004
7805121235.	50.	4.54	16.4	.731	.731	.002	.0008
7805140836.	50.	2.80	4.2	.954	.954	.007	.0005
7805121510.	50.	2.80	13.6	.916	.916	.007	.0018
7805140921.	50.	1.78	1.0	.820	.820	.016	.0004
7805140959.	50.	1.78	5.0	.852	.852	.016	.0016
7805141029.	50.	1.78	12.4	.828	.828	.016	.0040
7805141144.	50.	1.78	23.3	.578	.578	.016	.0075
7805141253.	45.	4.58	2.8	.688	.688	.002	.0001
7805141318.	45.	4.58	6.9	.695	.695	.002	.0005
7805141340.	45.	4.58	17.7	.678	.678	.002	.0009
7805141400.	45.	2.65	18.3	.702	.702	.007	.0027
7805170815.	35.	4.06	2.6	.562	.562	.002	.0002
7805170847.	35.	4.06	11.1	.552	.552	.002	.0007
7805170911.	35.	4.06	20.9	.437	.437	.002	.0013
7805220955.	35.	3.10	2.2	.739	.739	.004	.0002
7805221013.	35.	3.10	7.6	.554	.554	.004	.0008
7805221032.	35.	3.10	16.1	.478	.478	.004	.0017
7805170930.	35.	2.34	2.0	.725	.725	.007	.0004
7805170948.	35.	2.34	5.7	.615	.615	.007	.0011
7805171005.	35.	2.34	11.6	.542	.542	.007	.0022
7805221041.	35.	1.65	.7	.750	.750	.013	.0003
7805221137.	35.	1.65	2.8	.583	.583	.013	.0010
7805221154.	35.	1.65	8.8	.464	.464	.013	.0033
7805171134.	35.	1.49	1.1	.703	.703	.016	.0005
7805171152.	35.	1.49	4.9	.498	.498	.016	.0025
7805171203.	35.	1.49	16.5	.366	.366	.016	.0076
7805171233.	30.	3.89	1.0	.553	.553	.002	.0001
7805171253.	30.	3.89	6.5	.401	.401	.002	.0004
7805171313.	30.	3.89	14.8	.373	.373	.002	.0010
7805180846.	30.	2.87	3.5	.531	.531	.004	.0004
7805181004.	30.	2.87	10.2	.465	.465	.004	.0013
7805181252.	30.	2.87	21.3	.403	.403	.004	.0026

SINE BLADE MOTION

ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2	ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2
BREAKWATER 16															
7805171321.	30.	2.17	2.0	.660	.660	.007	.0004	7805171330.	30.	2.17	4.1	.536	.536	.007	.0009
7805171330.	30.	2.17	8.1	.444	.444	.007	.0018	7805171340.	30.	2.17	14.9	.434	.434	.007	.0032
7805171355.	30.	2.17	19.1	.411	.411	.007	.0041	7805180832.	30.	1.53	.7	.636	.636	.013	.0003
7805180902.	30.	1.53	4.5	.762	.762	.013	.0020	7805180910.	30.	1.53	12.4	.330	.330	.013	.0054
7805180920.	30.	1.53	18.2	.264	.264	.013	.0079	7805180928.	30.	1.53	24.1	.213	.213	.013	.0105
7805180733.	30.	1.38	1.3	.490	.490	.016	.0007	7805180741.	30.	1.38	2.7	.377	.377	.016	.0014
7805180750.	30.	1.38	5.9	.292	.292	.016	.0032	7805180759.	30.	1.38	8.3	.298	.298	.016	.0044
7805180907.	30.	1.38	10.7	.288	.288	.016	.0057	7805180815.	30.	1.38	15.0	.261	.261	.016	.0080
7805180923.	30.	1.38	18.6	.228	.228	.016	.0100	7805190910.	25.	3.70	1.1	.487	.487	.002	.0001
7805190916.	25.	3.70	2.4	.434	.434	.002	.0002	7805190945.	25.	3.70	3.1	.387	.387	.002	.0002
7805191111.	25.	3.70	12.7	.245	.245	.002	.0009	7805191021.	25.	3.70	18.6	.267	.267	.002	.0014
7805191315.	25.	2.62	1.2	.585	.585	.004	.0002	7805181323.	25.	2.62	2.7	.487	.487	.004	.0004
7805191351.	25.	2.62	5.6	.371	.371	.004	.0008	7805181340.	25.	2.62	8.0	.324	.324	.004	.0012
7805191348.	25.	2.62	11.6	.282	.282	.004	.0017	7805181357.	25.	2.62	16.7	.283	.283	.004	.0025
780519147.	25.	1.40	2.6	.288	.288	.013	.0014	7805190801.	25.	1.40	5.3	.211	.211	.013	.0028
7805190909.	25.	1.40	9.8	.171	.171	.013	.0051	7805190818.	25.	1.40	18.1	.144	.144	.013	.0094
7805190926.	25.	1.26	4.4	.206	.206	.016	.0028	7805190934.	25.	1.26	9.9	.150	.150	.016	.0064
7805190943.	25.	1.26	13.9	.147	.147	.016	.0089	7805190851.	25.	1.26	17.5	.140	.140	.016	.0112
7805190950.	25.	1.26	20.4	.118	.118	.016	.0131	7805191225.	20.	3.51	4	.717	.717	.002	.0000
7805191234.	20.	3.51	.7	.658	.658	.002	.0001	7805191251.	20.	3.51	10	.612	.612	.002	.0001
7805191301.	20.	3.51	1.5	.559	.559	.002	.0001	7805191311.	20.	3.51	3.0	.444	.444	.002	.0002
7805191322.	20.	3.51	6.3	.328	.328	.002	.0005	7805191331.	20.	3.51	13.5	.225	.225	.002	.0011
7805191340.	20.	3.51	20.0	.187	.187	.002	.0017	7805220820.	20.	2.34	.9	.845	.845	.004	.0002
7805220812.	20.	2.34	1.8	.662	.662	.004	.0003	7805220831.	20.	2.34	3.6	.472	.472	.004	.0007
7805191405.	20.	2.34	7.0	.317	.317	.004	.0013	7805220754.	20.	2.34	7.1	.316	.316	.004	.0013
7805220766.	20.	2.34	9.9	.257	.257	.004	.0018	7805191356.	20.	2.34	13.5	.209	.209	.004	.0025
7805220736.	20.	2.34	14.3	.210	.210	.004	.0027	7805191349.	20.	2.34	20.7	.169	.169	.004	.0039
7805220727.	20.	2.34	19.9	.180	.180	.004	.0037	7805220829.	20.	1.77	1.2	.605	.605	.007	.0004
7805220938.	20.	1.77	2.5	.447	.447	.007	.0008	7805220846.	20.	1.77	5.4	.293	.293	.007	.0018
7805220855.	20.	1.77	8.1	.229	.229	.007	.0026	7805220904.	20.	1.77	12.4	.175	.175	.007	.0040
7805220912.	20.	1.77	18.1	.138	.138	.007	.0059								
BREAKWATER 17															
7807070834.	50.	6.99	2.1	.780	.780	.001	.0000	7807070844.	50.	6.99	4.3	.692	.692	.001	.0001
7807070854.	50.	6.99	8.5	.586	.586	.001	.0002	7807070904.	50.	6.99	8.5	.559	.559	.001	.0002
7807070937.	50.	6.99	16.4	.457	.457	.001	.0003	7808010135.	50.	6.34	4.4	.934	.934	.001	.0000
7808151017.	50.	6.34	1.5	.742	.742	.001	.0000	7808151025.	50.	6.34	2.8	.671	.671	.001	.0001
7808151033.	50.	6.34	3.9	.649	.649	.001	.0001	7808010206.	50.	6.34	4.1	.682	.682	.001	.0001
7808151049.	50.	6.34	8.9	.529	.529	.001	.0002	7808010155.	50.	6.34	9.1	.561	.561	.001	.0002
7808151057.	50.	6.34	14.8	.435	.435	.001	.0004	7808010145.	50.	6.34	14.9	.458	.458	.001	.0004
7807070923.	50.	5.17	1.0	.709	.709	.002	.0000	7807070814.	50.	5.17	2.0	.670	.670	.002	.0001
7807070964.	50.	5.17	4.0	.598	.598	.002	.0002	7807070755.	50.	5.17	5.9	.543	.543	.002	.0002
7807070976.	50.	5.17	8.8	.491	.491	.002	.0003	7808151133.	50.	4.54	2.3	.546	.546	.002	.0001
7807071027.	50.	4.54	7.1	.427	.427	.002	.0004	7808151119.	50.	4.54	10.5	.377	.377	.002	.0005
7807071114.	50.	4.54	15.7	.330	.330	.002	.0008	7808151105.	50.	4.54	23.3	.296	.296	.002	.0012
7807071124.	50.	3.70	2.8	.565	.565	.004	.0002	7807071105.	50.	3.70	5.7	.501	.501	.004	.0004
7807070956.	50.	3.70	11.0	.419	.419	.004	.0008	7807070947.	50.	3.70	14.8	.397	.397	.004	.0011
7807071040.	50.	2.80	1.6	.767	.767	.007	.0002	7807071031.	50.	2.80	3.4	.689	.689	.007	.0004
7808020709.	50.	1.87	2.3	.508	.508	.015	.0007	7808020719.	50.	1.87	4.7	.467	.467	.015	.0014
7808020727.	50.	1.87	6.7	.433	.433	.015	.0020	7808020735.	50.	1.87	9.7	.409	.409	.015	.0028
7808151151.	50.	1.87	14.0	.339	.339	.015	.0041	7808151145.	50.	1.87	18.8	.311	.311	.015	.0055
7808151139.	50.	1.87	26.4	.245	.245	.015	.0077	7807071129.	50.	1.78	6.0	.472	.472	.016	.0019
7807071122.	50.	1.78	12.7	.370	.370	.016	.0041	7807071047.	50.	1.78	23.2	.294	.294	.016	.0075
7807071144.	50.	1.50	8.8	.437	.437	.023	.0031	7807071136.	50.	1.50	11.7	.352	.352	.023	.0053
7807081508.	45.	6.90	2.8	.760	.760	.001	.0001	7807051458.	45.	6.90	5.8	.660	.660	.001	.0001
7807081509.	45.	6.90	8.6	.586	.586	.001	.0002	7807051441.	45.	6.90	13.7	.475	.475	.001	.0003
7807081308.	45.	4.91	2.1	.579	.579	.002	.0001	7807051116.	45.	4.91	3.1	.553	.553	.002	.0001
7807081326.	45.	4.91	4.7	.519	.519	.002	.0002	7807051334.	45.	4.91	6.9	.471	.471	.002	.0003
7807081342.	45.	4.91	10.3	.426	.426	.002	.0004	7807051354.	45.	4.91	15.1	.364	.364	.002	.0006
7807081358.	45.	3.51	1.4	.689	.689	.004	.0001	7807051405.	45.	3.51	2.9	.624	.624	.004	.0002
7807081416.	45.	3.51	6.0	.534	.534	.004	.0005	7807051424.	45.	3.51	12.4	.443	.443	.004	.0010
7807081432.	45.	3.51	18.2	.386	.386	.004	.0015	7807051515.	45.	2.65	1.2	.734	.734	.007	.0002
7807081521.	45.	2.65	2.7	.664	.664	.007	.0004	7807051528.	45.	2.65	6.2	.553	.553	.007	.0009
7807081536.	45.	2.65	13.6	.424	.424	.007	.0020	7807051544.	45.	2.65	18.5	.361	.361	.007	.0027
7807081608.	45.	1.88	2.8	.544	.544	.013	.0008	7807051601.	45.	1.88	5.4	.492	.492	.013	.0016
7807081555.	45.	1.88	10.6	.407	.407	.013	.0031	7807051549.	45.	1.88	21.0	.317	.317	.013	.0061
7807081614.	45.	1.69	.6	.552	.552	.016	.0002	7807051620.	45.	1.69	1.5	.551	.551	.016	.0005
7807081626.	45.	1.69	2.8	.523	.523	.016	.0010	7807051632.	45.	1.69	6.2	.453	.453	.016	.0022
7807071450.	35.	6.09	1.6	.836	.836	.001	.0000	7807071437.	35.	6.09	3.3	.728	.728	.001	.0001
7807071444.	35.	6.09	6.9	.589	.589	.001	.0002	7807071453.	35.	6.09	10.1	.523	.523	.001	.0003
7807071218.	35.	4.33	3.0	.471	.471	.002	.0002	7807071226.	35.	4.33	8.7	.370	.370	.002	.0005
7807071244.	35.	4.33	14.8	.345	.345	.002	.0008	7807071315.	35.	3.10	1.2	.707	.707	.004	.0001
7807071308.	35.	3.10	3.9	.706	.706	.004	.0004	7807071300.	35.	3.10	5.6	.596	.596	.004	.0006
7807071252.	35.	3.10	8.5	.501	.501	.004	.0009	7807071322.	35.	2.34	1.5	.637	.637	.007	.0003
7807071350.	35.	2.34	4.4	.557	.557	.007	.0008	7807071338.							

APPENDIX D
TEST RESULTS (IRREGULAR WAVES)

IRREGULAR WAVES				IRREGULAR WAVES													
ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2	QP	ID	D(CM)	T(S)	H(CM)	KT	KR	D/GT2	H/GT2	QP
BREAKWATER 1																	
78032A1353.	60.	1.60	15.8	145	103	.024	.0063	3.33	78032A1403.	60.	1.46	17.2	151	151	.029	.0082	5.54
78032A1413.	60.	1.62	16.9	176	176	.023	.0066	4.01	78032A1422.	60.	3.08	8.2	135	135	.006	.0009	3.97
78032A1431.	60.	3.32	11.3	039	019	.006	.0010	3.38	78032A1441.	60.	2.05	12.8	108	108	.015	.0031	3.77
78032A1451.	60.	3.32	12.0	045	045	.006	.0011	2.84	78032A1500.	60.	2.02	15.8	160	160	.015	.0039	3.45
78032Z0934.	75.	1.34	15.6	319	319	.043	.0069	2.28	78032Z0934.	75.	1.45	16.7	355	355	.036	.0081	5.82
78032Z0952.	75.	1.56	16.5	347	347	.031	.0069	4.37	78032Z1004.	75.	3.32	11.1	303	303	.007	.0101	3.94
78032Z1032.	75.	3.28	7.5	253	253	.007	.0007	3.24	78032Z1022.	75.	1.33	12.5	291	291	.043	.0072	2.69
78032Z1032.	75.	2.00	11.5	356	356	.019	.0029	2.85	78032Z1041.	75.	1.34	13.3	305	305	.043	.0076	1.76
BREAKWATER 4																	
7801191338.	74.	2.12	13.3	543	543	.017	.0030	5.11	7801191346.	74.	1.97	15.6	488	488	.080	.0169	5.39
7801191354.	74.	2.03	16.1	495	495	.018	.0040	4.56	7801191404.	74.	1.53	15.6	484	484	.032	.0068	6.03
7801191410.	74.	1.44	14.6	501	501	.036	.0072	7.54	7801240808.	60.	2.12	14.7	226	226	.014	.0053	5.14
7801240817.	60.	2.23	15.0	231	231	.012	.0031	4.98	7801240825.	60.	1.38	17.4	237	237	.032	.0093	4.59
7801240834.	60.	1.53	15.0	193	193	.026	.0065	5.62	7801240834.	60.	1.44	14.6	187	187	.030	.0072	7.26
7801213121.	60.	2.12	14.6	229	229	.014	.0033	5.15	7801213120.	60.	2.23	14.8	228	228	.012	.0030	4.42
7801213127.	60.	2.03	17.0	233	233	.015	.0042	4.37	7801211122.	60.	1.38	15.4	209	209	.032	.0063	6.22
7801213339.	60.	1.44	14.6	188	188	.029	.0072	7.42	7801211735.	45.	2.12	12.1	113	113	.010	.0027	4.46
7801211749.	45.	2.35	16.4	113	113	.008	.0030	3.62	7801211755.	45.	1.53	14.9	108	108	.020	.0065	8.30
7801211820.	45.	1.30	12.4	071	071	.027	.0075	6.53	7801211830.	45.	1.70	12.4	109	109	.016	.0040	9.99
BREAKWATER 4W																	
7801181004.	80.	1.38	17.4	658	658	.043	.0093	4.49	7801191004.	85.	1.53	16.7	755	755	.037	.0073	6.30
7801191019.	85.	1.82	17.0	765	765	.026	.0052	4.62	7801191026.	85.	1.94	15.3	768	768	.023	.0041	4.62
7801191041.	85.	1.44	15.2	786	786	.042	.0075	9.85	7801180938.	76.	1.30	15.7	518	518	.046	.0095	5.24
7801180945.	76.	1.02	16.4	551	551	.074	.0161	5.35									
BREAKWATER 5																	
7802010849.	75.	1.88	15.1	769	769	.022	.0044	2.13	7802010901.	75.	1.19	16.8	844	844	.054	.0121	2.14
7802010912.	75.	1.19	16.7	845	845	.054	.0120	7.12	7802010924.	75.	2.06	9.9	843	843	.013	.0017	2.50
7802010935.	75.	2.44	9.8	803	803	.013	.0017	2.54	7802010947.	75.	1.45	9.6	825	825	.036	.0047	2.03
7802010957.	75.	1.45	9.5	807	807	.036	.0046	2.90	7802011010.	75.	1.34	17.7	885	885	.043	.0101	6.31
7802011421.	75.	1.34	17.8	898	898	.043	.0101	6.20	7802011034.	75.	1.26	17.3	922	922	.048	.0111	8.90
7802011457.	75.	1.88	15.3	823	823	.022	.0044	2.23	7802011107.	75.	1.88	15.3	826	826	.022	.0044	2.24
7801310957.	60.	2.64	12.5	777	777	.009	.0018	2.15	7801311011.	60.	1.26	15.8	792	792	.039	.0102	2.70
7801311023.	60.	1.55	15.2	815	815	.025	.0065	3.87	7801311034.	60.	1.97	17.0	814	814	.016	.0045	2.76
7801311049.	60.	1.16	13.4	663	663	.045	.0102	1.59	7801311058.	60.	2.64	13.1	713	713	.008	.0017	1.91
7801311109.	60.	2.84	12.6	804	804	.009	.0018	2.19	7801311119.	60.	1.26	16.0	791	791	.039	.0103	2.85
7801311131.	60.	1.55	15.3	815	815	.025	.0065	3.75	7801311142.	60.	1.97	17.1	810	810	.016	.0045	2.74
7801311154.	60.	1.16	13.4	662	662	.045	.0102	1.63	7802020832.	45.	2.12	12.3	842	842	.010	.0028	4.96
7802020832.	45.	2.12	12.2	798	798	.010	.0028	4.77	7802020840.	45.	2.23	14.4	735	735	.009	.0030	4.59
7802020847.	45.	2.35	15.8	688	688	.008	.0029	3.53	7802020857.	45.	1.53	14.8	662	662	.020	.0065	5.71
7802020904.	45.	1.30	12.2	710	710	.027	.0074	6.51	7802020952.	45.	1.91	8.0	708	708	.055	.0099	2.58
BREAKWATER 6																	
7802071316.	75.	.91	13.3	677	677	.092	.0164	5.86	7802071324.	75.	1.30	16.1	648	648	.045	.0097	5.23
7802071332.	75.	1.82	16.2	643	643	.023	.0030	4.69	7802071339.	75.	1.53	17.5	934	934	.033	.0076	5.29
7802071348.	75.	1.44	14.6	840	840	.036	.0072	6.31	7802080216.	60.	1.62	14.0	380	380	.023	.0054	5.42
7802080225.	60.	1.30	15.1	403	403	.036	.0091	5.38	7802080232.	60.	2.03	18.3	405	405	.015	.0045	4.87
7802080239.	60.	1.53	15.3	364	364	.026	.0067	6.02	7802080246.	60.	1.30	15.0	342	342	.036	.0091	8.01
7802081135.	45.	2.12	12.3	288	288	.010	.0028	4.54	7802081125.	45.	2.23	16.2	276	276	.009	.0033	5.86
7802081134.	45.	1.37	15.6	268	268	.024	.0085	4.85	7802081144.	45.	1.53	14.4	223	223	.020	.0063	5.05
7802081154.	45.	1.30	12.6	239	239	.027	.0076	6.61									
BREAKWATER 9																	
7802221044.	75.	1.23	13.4	428	428	.051	.0090	5.46	7802221333.	75.	1.30	15.9	404	404	.045	.0096	4.91
7802221341.	75.	2.03	16.3	451	451	.019	.0040	4.46	7802221349.	75.	1.53	16.6	401	401	.033	.0072	5.96
7802221357.	75.	1.44	14.3	394	394	.037	.0070	6.74	7802231016.	75.	1.34	15.8	364	364	.043	.0090	2.11
7802231026.	75.	1.45	16.0	393	393	.036	.0078	6.02	7802231035.	75.	1.63	17.3	372	372	.029	.0066	3.52
7802231055.	75.	3.24	7.1	055	055	.007	.0007	4.53	7802240953.	75.	1.33	12.3	361	361	.043	.0071	2.40
7802241003.	75.	2.00	11.0	421	421	.019	.0028	1.56	7802241013.	75.	1.54	13.3	417	417	.043	.0076	1.45
7802271156.	60.	2.75	15.9	151	151	.008	.0021	2.09	7802271205.	60.	1.46	16.6	120	120	.029	.0079	6.11
7802271214.	60.	1.63	17.2	136	136	.023	.0066	3.37	7802281243.	45.	1.60	19.0	104	104	.018	.0076	2.10
7802281301.	45.	1.86	21.7	081	081	.017	.0080	4.46	7802281310.	45.	3.12	9.0	217	217	.005	.0009	2.96
7802281322.	45.	3.32	14.3	167	167	.004	.0013	2.98	7802281332.	45.	2.05	16.2	098	098	.011	.0039	2.41
7802281342.	45.	3.56	16.3	187	187	.004	.0013	3.03									
BREAKWATER 10																	
7803060930.	75.	1.34	16.0	408	408	.043	.0091	2.15	7803060939.	75.	1.45	16.2	447	447	.036	.0079	6.25
7803060948.	75.	1.77	17.0	418	418	.026	.0059	4.15	7803060957.	75.	2.64	10.3	552	552	.011	.0015	4.58
7803061006.	75.	2.81	6.7	625	625	.011	.0010	3.67	7803061016.	75.	1.33	12.5	405	405	.043	.0072	2.37
7803061025.	75.	2.90	11.0	475	475	.019	.0028	1.79	7803061035.	75.	1.34	13.0	458	458	.043	.0074	1.46

		IRREGULAR WAVES															
ID	D(CM)	T(S)	H(CM)	KT	NR D/GT2	H/GT2	DP	ID	D(CM)	T(S)	H(CM)	KT	NR L:GT2	H/GT2	DP		
BREAKWATER 10																	
7803031003.	60.	1.95	2.1	.381	.381	.016	.0006	9.99	7803031051.	60.	1.54	14.6	.229	.229	.026	.0053	2.56
7803031101.	60.	1.51	16.2	.191	.191	.027	.0072	4.44	7803031110.	60.	1.64	16.9	.215	.215	.023	.0064	3.64
7803031120.	60.	3.12	7.4	.305	.305	.006	.0008	3.24	7803031129.	60.	3.32	11.2	.268	.268	.006	.0010	2.44
7803031139.	60.	1.14	12.2	.190	.190	.047	.0096	2.35	7803031148.	60.	3.66	11.3	.232	.232	.005	.0009	2.12
7803031158.	60.	3.24	14.4	.286	.286	.006	.0014	2.69	7803020211.	45.	2.21	15.4	.099	.099	.009	.0032	4.18
7803021413.	45.	1.36	15.8	.062	.062	.025	.0087	4.61	7803021422.	45.	1.67	16.1	.082	.082	.016	.0059	2.37
7803021431.	45.	3.12	6.7	.213	.213	.005	.0007	2.41	7803021449.	45.	3.28	10.9	.155	.155	.004	.0010	4.03
7803021450.	45.	2.21	12.5	.088	.088	.009	.0026	2.50	7803021459.	45.	3.46	12.3	.126	.126	.004	.0010	2.64

BREAKWATER 13																	
7804211247.	60.	1.95	17.8	.724	.724	.016	.0048	2.50	7804211256.	60.	1.52	19.2	.773	.773	.026	.0085	3.98
7804211305.	60.	1.83	20.0	.755	.755	.018	.0061	3.46	7804211315.	60.	2.84	7.8	.767	.767	.008	.0010	3.23
7804211334.	60.	1.82	14.0	.713	.713	.018	.0043	2.70	7804211343.	60.	4.20	16.2	.608	.608	.003	.0009	1.76
7804211353.	60.	4.34	20.4	.666	.666	.003	.0011	1.83									

BREAKWATER 14																	
7804260816.	35.	2.10	15.6	.361	.361	.008	.0036	2.49	7804260829.	35.	1.55	16.6	.261	.261	.015	.0071	3.73
7804260852.	35.	2.84	6.8	.357	.357	.004	.0009	5.67	7804260904.	35.	2.78	9.9	.352	.352	.005	.0013	4.66
7804260916.	35.	2.10	12.5	.266	.266	.008	.0029	2.33	7804260928.	35.	4.20	14.0	.330	.330	.002	.0008	1.81
7804260940.	35.	4.00	18.4	.297	.297	.002	.0012	2.03									

BREAKWATER 15																	
7805011009.	50.	1.23	16.3	.594	.594	.034	.0110	2.00	7805011030.	50.	1.45	17.2	.652	.652	.024	.0083	3.93
7805011044.	50.	1.57	17.8	.653	.653	.021	.0070	3.24	7805011228.	35.	1.55	17.1	.370	.370	.015	.0073	3.72
7805011237.	35.	1.63	18.2	.444	.444	.013	.0074	3.25	7805011247.	35.	2.81	6.4	.510	.510	.005	.0008	3.06
7805011286.	35.	2.61	9.7	.476	.476	.005	.0015	4.19	7805011305.	35.	2.08	12.3	.383	.383	.008	.0029	2.10
7805011315.	35.	4.49	12.5	.362	.362	.002	.0004	1.37	7805011326.	35.	4.74	17.3	.361	.361	.002	.0004	1.99
7805011334.	35.	2.10	16.3	.355	.355	.008	.0038	2.29	7805081115.	20.	2.29	14.6	.169	.169	.004	.0028	2.26
7805081126.	20.	1.40	16.3	.154	.154	.010	.0085	4.17	7805081134.	20.	1.65	16.3	.157	.157	.007	.0061	3.89
7805081143.	20.	3.12	6.7	.280	.280	.002	.0007	2.86	7805081153.	20.	3.24	10.4	.240	.240	.002	.0010	2.94
7805081204.	20.	2.29	12.3	.182	.182	.004	.0024	2.32	7805081215.	20.	3.56	11.7	.196	.196	.002	.0009	1.69

BREAKWATER 15W																	
7804280947.	35.	2.10	15.2	.374	.374	.008	.0035	2.42	7804281003.	35.	1.45	16.1	.347	.347	.017	.0078	3.74
7804281014.	35.	1.58	17.2	.325	.325	.014	.0070	3.13	7804281023.	35.	2.84	6.3	.488	.488	.004	.0008	5.21
7804281033.	35.	2.78	9.5	.444	.444	.005	.0013	4.29	7804281043.	35.	4.10	11.7	.356	.356	.008	.0027	2.21
7804281053.	35.	4.20	13.1	.383	.383	.002	.0008	1.92	7804281104.	35.	4.00	16.9	.323	.323	.002	.0011	2.05

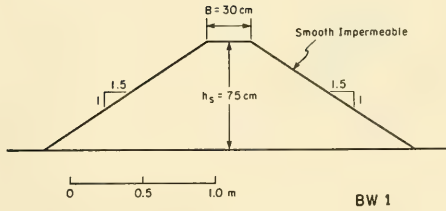
BREAKWATER 16																	
7806300028.	45.	2.03	16.2	.561	.561	.011	.0040	2.44	7806300038.	45.	2.03	16.5	.500	.500	.011	.0041	2.40
7806300047.	45.	1.55	17.3	.517	.517	.019	.0073	4.16	7806300057.	45.	1.55	17.7	.515	.515	.019	.0075	3.93
7806300066.	45.	1.55	17.3	.511	.511	.019	.0073	4.05	7806300076.	45.	1.58	18.4	.496	.496	.018	.0075	3.26
7806300097.	45.	1.58	18.4	.496	.496	.018	.0075	3.26	7806300096.	45.	1.64	18.6	.505	.505	.017	.0071	3.29
7806300098.	45.	3.05	6.3	.655	.655	.005	.0007	3.62	7806301001.	45.	3.05	6.3	.651	.651	.005	.0007	3.71
7806301010.	45.	3.05	6.3	.654	.654	.005	.0007	3.72	7806301020.	45.	2.72	9.8	.589	.589	.006	.0014	3.54
7806301029.	45.	2.75	9.8	.599	.599	.006	.0013	3.56	7806301039.	45.	2.75	9.8	.614	.614	.006	.0013	3.73
7806301048.	45.	1.43	12.9	.504	.504	.022	.0064	2.34	7806301057.	45.	1.43	13.2	.486	.486	.022	.0066	2.29
7806301120.	45.	4.27	12.8	.497	.497	.003	.0007	1.36	7806301130.	45.	1.72	17.9	.466	.466	.016	.0062	4.71
7806301140.	45.	4.27	13.0	.524	.524	.003	.0007	1.32	7806301152.	45.	4.20	13.2	.476	.476	.003	.0008	1.35
7806301202.	45.	3.88	18.1	.568	.568	.003	.0012	2.63	7806301211.	45.	3.88	18.0	.491	.491	.003	.0012	2.83
7806301221.	45.	4.00	18.7	.494	.494	.003	.0012	2.49	7806261248.	40.	2.75	15.4	.419	.419	.005	.0021	2.40
7806261300.	40.	2.75	15.3	.466	.466	.005	.0021	2.15	7806261310.	40.	2.75	15.6	.414	.414	.005	.0021	2.26
7806261321.	40.	1.44	16.3	.399	.399	.019	.0076	4.12	7806261330.	40.	1.40	16.5	.393	.393	.021	.0081	3.93
7806261339.	40.	1.44	16.4	.393	.393	.021	.0085	3.99	7806261349.	40.	1.58	17.6	.416	.416	.016	.0072	3.15
7806270809.	40.	1.54	17.9	.407	.407	.016	.0073	3.20	7806270827.	40.	2.68	6.2	.578	.578	.005	.0008	3.98
7806270845.	40.	2.88	6.2	.583	.583	.005	.0008	3.92	7806270854.	40.	2.88	6.3	.587	.587	.005	.0008	3.90
7806270904.	40.	3.16	9.4	.519	.519	.004	.0010	5.53	7806270913.	40.	2.75	9.5	.512	.512	.005	.0013	4.10
7806270922.	40.	2.75	9.5	.516	.516	.005	.0013	4.10	7806270931.	40.	1.14	12.9	.388	.388	.031	.0101	2.38
7806270940.	40.	1.14	12.8	.391	.391	.031	.0101	2.36	7806270949.	40.	1.14	12.8	.384	.384	.031	.0101	2.37
7806270959.	40.	4.20	14.1	.439	.439	.002	.0008	1.78	7806271007.	40.	4.20	14.3	.428	.428	.002	.0008	1.79
7806271016.	40.	4.13	14.2	.443	.443	.002	.0008	1.97	7806271026.	40.	4.00	17.7	.400	.400	.003	.0011	2.13
7806271035.	40.	4.00	17.9	.388	.388	.003	.0011	2.12	7806271043.	40.	4.00	17.9	.390	.390	.003	.0011	2.14
7806271041.	40.	2.75	14.3	.420	.420	.005	.0019	5.13	7806271150.	40.	2.75	14.5	.412	.412	.005	.0020	2.99
7806271150.	40.	2.75	14.5	.412	.412	.005	.0020	2.99	7806271208.	40.	1.40	15.6	.405	.405	.021	.0081	3.69
7806271216.	40.	1.40	15.6	.406	.406	.021	.0081	3.69	7806271225.	40.	1.40	15.5	.401	.401	.021	.0081	3.73
7806271236.	40.	1.58	16.4	.412	.412	.016	.0067	2.97	7806271245.	40.	1.58	16.5	.401	.401	.016	.0067	2.91
7806271254.	40.	1.58	16.8	.411	.411	.016	.0069	3.21	7806271304.	40.	2.69	14.3	.500	.500	.006	.0020	4.39
7806271311.	40.	2.84	8.7	.547	.547	.005	.0011	5.11	7806271322.	40.	2.75	8.3	.547	.547	.005	.0011	4.14
7806271332.	40.	2.72	5.6	.607	.607	.006	.0008	4.39	7806271341.	40.	2.72	5.6	.608	.608	.006	.0008	4.39
7806271349.	40.	2.72	5.6	.603	.603	.006	.0008	4.31	7806271359.	40.	1.43	11.4	.410	.410	.020	.0057	2.23
7806280037.	40.	1.20	11.6	.357	.357	.028	.0082	3.21	7806280049.	40.	1.14	11.7	.387	.387	.031	.0092	2.22
7806280115.	40.	3.51	12.6	.431	.431	.003	.0010	1.27	7806280129.	40.	3.51	11.9	.431	.431	.003	.0010	1.27
7806280132.	40.	3.51	12.6	.430	.430	.003	.0010	1.27	7806280142.	40.	4.27	15.7	.474	.474	.002	.0009</	

IRREGULAR WAVES										IRREGULAR WAVES																									
TD D(CM) T(S) H(CM) KT					KR D/GT2 H/GT2 GP					TD D(CM) T(S) H(CM) KT					KR D/GT2 H/GT2 GP																				
BREAKWATER 16																																			
7806260900.	35.	2.0A	17.1	.313	.313	.008	.0040	2.31	7806260910.	35.	1.54	17.3	.302	.302	.015	.0074	2.29	7806260920.	35.	1.55	17.9	.295	.295	.015	.0076	4.08	7806260930.	35.	1.55	17.9	.297	.297	.015	.0076	3.96
7806261004.	35.	1.59	19.2	.269	.269	.014	.0078	1.26	7806261013.	35.	1.58	19.2	.288	.288	.014	.0078	3.18	7806261023.	35.	2.80	7.2	.470	.470	.004	.0009	4.79	7806261032.	35.	1.84	7.1	.478	.478	.004	.0009	4.06
7806261040.	35.	2.80	7.2	.470	.470	.004	.0009	4.79	7806261050.	35.	2.84	10.2	.407	.407	.004	.0013	2.97	7806261059.	35.	2.84	10.2	.407	.407	.004	.0013	2.97	780626110A.	35.	2.84	10.2	.407	.407	.004	.0013	3.03
780626110A.	35.	2.84	10.2	.407	.407	.004	.0013	2.97	7806261126.	35.	1.25	13.5	.333	.333	.023	.0088	2.50	7806261147.	35.	4.20	13.9	.384	.384	.002	.0008	1.45	7806261206.	35.	4.20	13.8	.384	.384	.002	.0008	1.45
7806261135.	35.	1.73	13.5	.326	.326	.012	.0046	2.30	7806150924.	35.	2.10	15.1	.270	.270	.008	.0035	2.42	7806151024.	35.	2.10	15.2	.261	.261	.008	.0035	2.40									
7806261156.	35.	4.20	14.0	.36A	.36A	.002	.0008	1.69	7806151153.	35.	1.55	16.6	.235	.235	.015	.0071	3.78	7806151227.	35.	1.58	17.4	.242	.242	.014	.0071	3.10									
7806150912.	35.	2.80	14.0	.36A	.36A	.002	.0008	1.69	7806151324.	35.	1.58	17.4	.242	.242	.014	.0071	3.10	7806151355.	35.	2.84	6.2	.380	.380	.004	.0008	4.63									
7806151142.	35.	1.55	16.5	.235	.235	.015	.0070	3.78	7806230718.	35.	2.7A	8.1	.474	.474	.005	.0011	4.17	7806230737.	35.	2.7A	8.1	.474	.474	.005	.0011	4.21									
7806151216.	35.	1.55	16.5	.229	.229	.015	.0070	3.13	7806230755.	35.	2.7A	8.1	.474	.474	.005	.0011	4.17	7806230814.	35.	1.73	10.6	.336	.336	.020	.0061	2.51									
7806151216.	35.	1.55	16.5	.229	.229	.015	.0070	3.13	7806230831.	35.	1.25	10.6	.331	.331	.023	.0069	2.15	7806230932.	35.	4.27	14.6	.35A	.35A	.002	.0008	1.51									
7806151216.	35.	1.55	16.5	.229	.229	.015	.0070	3.13	7806230949.	35.	4.27	14.6	.350	.350	.002	.0008	1.51	7806231008.	35.	2.10	15.1	.335	.335	.004	.0035	2.38									
7806151315.	35.	2.80	6.2	.384	.384	.005	.0012	4.08	7806231026.	35.	1.55	16.1	.292	.292	.015	.0068	3.87	7806231043.	35.	1.55	16.4	.289	.289	.015	.0070	3.80									
7806230724.	35.	2.7A	8.1	.474	.474	.005	.0011	4.18	7806231110.	35.	1.58	17.2	.243	.243	.014	.0070	3.07	7806231132.	35.	2.84	6.1	.469	.469	.004	.0008	4.68									
7806230747.	35.	2.7A	8.4	.471	.471	.005	.0007	4.63	7806231150.	35.	2.7A	9.3	.453	.453	.005	.0012	4.57	7806231208.	35.	2.7A	9.3	.453	.453	.005	.0012	4.57									
7806230804.	35.	2.7A	8.4	.474	.474	.005	.0007	4.63	7806231226.	35.	2.7A	9.3	.453	.453	.005	.0012	4.57	7806231255.	35.	1.58	17.2	.298	.298	.014	.0070	3.05									
7806231022.	35.	1.33	10.6	.326	.326	.020	.0061	2.15	7806231314.	35.	1.58	17.2	.298	.298	.014	.0071	3.09	7806231347.	35.	2.10	11.8	.319	.319	.008	.0027	2.20									
7806230903.	35.	4.27	10.8	.38A	.38A	.002	.0005	1.32	7806231408.	35.	4.20	12.8	.370	.370	.002	.0007	1.98	7806160815.	35.	2.81	9.5	.355	.355	.005	.0012	4.14									
7806230949.	35.	4.27	14.6	.35A	.35A	.002	.0008	1.52	7806160848.	35.	2.10	12.1	.252	.252	.008	.0028	2.18	7806160909.	35.	4.20	13.0	.297	.297	.002	.0008	2.03									
7806230951.	35.	2.10	15.1	.324	.324	.008	.0035	2.26	7806160928.	35.	4.20	13.0	.299	.299	.002	.0008	2.02	7806160949.	35.	4.00	16.9	.247	.247	.002	.0011	2.04									
7806231017.	35.	2.10	15.1	.330	.330	.008	.0035	2.38	7806160958.	35.	2.10	16.9	.247	.247	.002	.0011	2.04	7806161352.	30.	4.05	16.1	.199	.199	.007	.0036	2.52									
7806231045.	35.	1.55	16.5	.291	.291	.015	.0070	3.77	7806161402.	30.	1.55	17.2	.199	.199	.013	.0072	2.37	7806161412.	30.	1.55	18.6	.166	.166	.013	.0071	4.17									
7806231054.	35.	1.58	17.1	.291	.291	.014	.0070	3.07	7806161430.	30.	1.58	18.3	.178	.178	.012	.0077	3.28	7806161440.	30.	1.58	18.3	.178	.178	.012	.0077	3.28									
7806231119.	35.	1.58	17.2	.295	.295	.014	.0070	3.08	7806190008.	30.	3.05	7.1	.393	.393	.003	.0008	5.83	7806191008.	30.	3.05	7.1	.393	.393	.003	.0008	5.82									
7806231141.	35.	2.84	6.1	.468	.468	.004	.0008	4.61	7806191022.	30.	2.84	9.9	.337	.337	.004	.0013	2.58	7806191046.	30.	2.84	10.0	.329	.329	.004	.0013	2.58									
7806231159.	35.	2.7A	9.3	.455	.455	.005	.0012	4.57	7806191104.	30.	2.13	13.0	.258	.258	.007	.0029	2.26	7806191123.	30.	4.20	12.8	.300	.300	.002	.0007	1.98									
7806231217.	35.	2.7A	9.3	.456	.456	.005	.0012	4.58	7806191141.	30.	4.20	12.9	.297	.297	.002	.0007	1.98	7806191221.	35.	1.49	15.3	.176	.176	.011	.0070	2.36									
7806231245.	35.	2.7A	9.3	.456	.456	.005	.0012	4.17	7806191239.	25.	1.55	16.4	.162	.162	.011	.0070	4.10	7806191256.	25.	1.55	16.4	.158	.158	.011	.0070	4.20									
7806231303.	35.	1.5A	17.0	.327	.327	.014	.0069	3.10	7806191344.	25.	2.23	17.1	.179	.179	.005	.0035	2.91	7806191355.	25.	3.05	6.7	.328	.328	.003	.0007	5.79									
7806231337.	35.	1.25	11.9	.303	.303	.023	.0078	2.19	7806191355.	25.	3.05	6.7	.328	.328	.003	.0007	5.79	7806200731.	25.	3.20	9.3	.274	.274	.002	.0009	2.80									
7806231356.	35.	2.10	11.9	.311	.311	.008	.0028	2.19	7806191408.	30.	3.05	7.1	.393	.393	.003	.0008	5.83	7806200752.	25.	3.20	9.3	.273	.273	.002	.0009	2.78									
7806160801.	35.	2.7A	9.5	.367	.367	.005	.0013	4.16	7806191022.	30.	2.84	9.9	.337	.337	.004	.0013	2.58	7806200811.	25.	2.21	11.9	.19A	.19A	.005	.0025	2.24									
7806160838.	35.	2.10	12.0	.259	.259	.008	.0028	2.20	7806191046.	30.	2.84	10.0	.329	.329	.004	.0013	2.58	7806200831.	25.	3.76	12.1	.219	.219	.002	.0009	1.39									
780616085A.	35.	2.10	12.1	.244	.244	.008	.0028	2.20	7806191066.	30.	2.84	10.0	.329	.329	.004	.0013	2.58																		
7806160919.	35.	4.20	12.9	.29A	.29A	.002	.0007	2.00	7806191104.	30.	2.13	13.0	.258	.258	.007	.0029	2.26																		
7806160939.	35.	4.00	16.9	.247	.247	.002	.0011	2.04	7806191123.	30.	4.20	12.8	.300	.300	.002	.0007	1.98																		
7806161000.	35.	4.00	16.9	.244	.244	.002	.0011	2.04	7806191141.	30.	4.20	12.9	.297	.297	.002	.0007	1.98																		
7806161342.	30.	1.5A	17.1	.196	.196	.013	.0074	2.46	7806191221.	35.	1.49	15.3	.176	.176	.011	.0070	2.36																		
7806161402.	30.	1.55	18.0	.166	.166	.013	.0076	4.25	7806191239.	25.	1.55	16.4	.162	.162	.011	.0070	4.10																		
7806161421.	30.	1.55	18.6	.166	.166	.013	.0076	4.26	7806191256.	25.	1.55	16.4	.158	.158	.011	.0070	4.20																		
7806161459.	30.	1.40	18.6	.166	.166	.013	.0071	3.27	7806191344.	25.	2.23	17.1	.179	.179	.005	.0035	2.91																		
7806190957.	30.	3.05	7.1	.392	.392	.003	.0008	5.80	7806191355.	25.	3.05	6.7	.328	.328	.003	.0007	5.77																		
7806191017.	30.	3.05	7.1	.394	.394	.003	.0008	5.72	7806200731.	25.	3.20	9.3	.274	.274	.002	.0009	2.80																		
7806191037.	30.	2.84	9.9	.334	.334	.004	.0013	2.57	7806200752.	25.	3.20	9.3	.273	.273	.002	.0009	2.78																		
7806191056.	30.	2.13	12.7	.267	.267	.007	.0029	2.26	7806200811.	25.	2.21	11.9	.19A	.19A	.005	.0025	2.24																		
7806191113.	30.	2.13	12.9	.267	.267	.007	.0029	2.26	7806200831.	25.	3.76	12.1	.219	.219	.002	.0009	1.39																		
7806191132.	30.	4.20	12.8	.297	.297	.002	.0007	1.94	7806200919.	25.	1.34	15.4	.305	.305	.028	.0088	1.95																		
7806191217.	25.	1.49	15.4	.175	.175	.011	.0071	2.32	78070610147.	35.	4.20	13.9	.384	.384	.002	.0008	1.45																		
7806191230.	25.	1.49	15.3	.175	.175	.011	.0070	2.36	78070610349.	50.	1.34	15.4	.305	.305	.028	.0088	1.91																		
7806191268.	25.	1.55	16.5	.159	.159	.011	.0070	4.15	78070610470.	50.	3.76	20.9	.36A	.36A	.004	.0015	2.18																		
7806191305.	25.	2.23	17.1	.179	.179	.005	.0035	2.98	7807211006.	40.	2.56	17.1	.329	.329	.006	.0027	2.88																		
7806191326.	25.	2.23	17.0	.179	.179	.005	.0035	2.98	7807211011.	40.	1.36	17.9	.315	.315	.022	.0009	4.44																		
7806191344.	25.	3.05	6.7	.328	.328	.003	.0007	5.77	7807211030.	40.	1.80	17.7	.317	.317	.016	.0071	3.45																		
7806191402.	25.	3.20	9.3	.274	.274	.002	.0009	2.81	7807211249.	40.	1.57	19.5	.312	.312	.017	.0081	3.31																		
7806200731.	25.	3.20	9.3	.273	.273	.002	.																												

IRREGULAR WAVES
KR D/G/T2 M/G/T2 GP

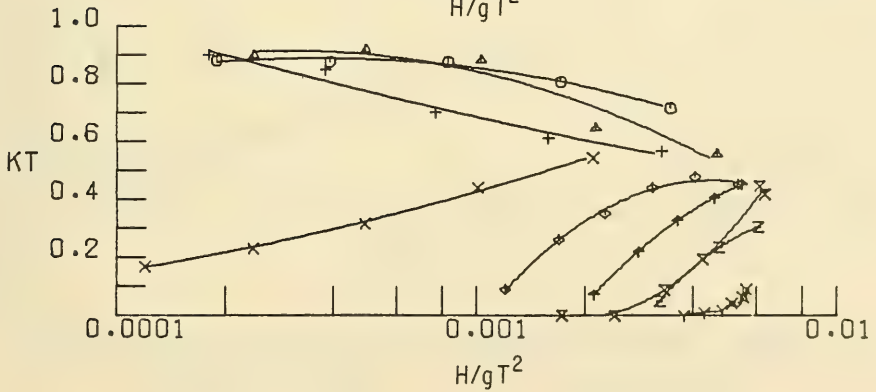
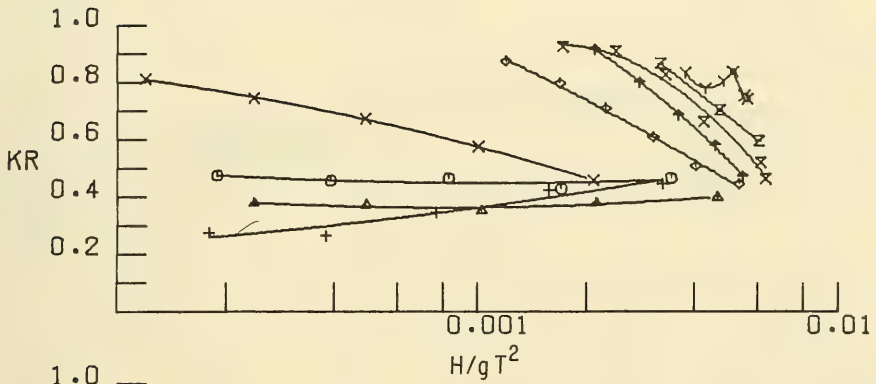
ID	D(CM)	T(S)	H(CM)	KT	IRREGULAR WAVES KR D/G/T2 M/G/T2 GP	ID	D(CM)	T(S)	H(CM)	KT	IRREGULAR WAVES KR D/G/T2 M/G/T2 GP						
BREAKWATER 17																	
780221211	40	1.97	15.6	317	317	011	0041	2,85	780221220	40	1.97	15.4	322	322	011	0040	2,88
780221229	40	4.20	17.7	336	330	002	0010	2,73	780221238	40	4.20	17.6	340	340	002	0010	2,78
780221240	40	4.20	17.7	343	343	002	0010	2,80	780221258	35	2.56	14.3	356	356	005	0022	2,66
780221260	35	2.00	14.1	353	353	009	0036	2,89	780221268	35	2.00	14.1	352	352	009	0036	2,86
780221273	35	1.60	15.1	322	322	018	0079	3,95	780221287	35	1.62	14.9	319	319	014	0058	3,89
780221286	35	1.62	15.1	317	317	014	0059	3,85	780221296	35	1.63	15.9	305	305	013	0061	3,44
780221295	35	1.63	15.6	307	307	013	0060	3,53	780221294	35	1.63	15.6	312	312	013	0060	3,46
780221303	35	2.78	7.6	431	431	005	0010	4,18	780221292	35	2.78	7.6	432	432	005	0010	4,06
780221309	35	2.78	7.6	433	433	005	0010	4,12	780221303	35	2.78	5.0	467	467	005	0007	5,09
780221311	35	2.61	4.9	458	458	005	0007	6,19	780221302	35	2.61	4.9	454	454	005	0007	6,28
780221312	35	1.97	10.6	341	341	009	0028	2,39	780221300	35	1.97	10.6	345	345	009	0028	2,40
780221314	35	1.97	10.6	338	338	009	0028	2,43	780221307	35	2.00	12.7	367	367	009	0032	2,02
780221316	35	2.00	12.5	368	368	009	0032	2,00	780221305	35	2.00	12.5	368	368	009	0032	2,03
780221318	35	4.27	16.8	319	319	002	0009	2,19	780221302	35	2.56	15.8	320	320	005	0025	2,09
780221320	35	4.27	16.8	319	319	002	0009	2,19	780221300	35	2.56	15.8	320	320	005	0025	2,09
780221321	35	2.56	15.7	319	319	005	0024	2,41	780221303	35	2.56	15.6	321	321	005	0024	2,92
780221322	35	1.63	17.5	302	302	013	0067	3,59	780221302	35	1.63	17.4	296	296	013	0067	3,57
780221323	35	1.63	17.6	300	300	013	0068	3,59	780221301	35	2.84	5.8	446	446	004	0007	3,73
780221324	35	2.84	8.9	380	380	005	0012	4,26	780221300	35	2.84	8.9	382	382	005	0012	4,17
780221325	30	2.06	17.8	280	280	007	0043	2,96	780221299	30	2.06	17.9	279	279	007	0043	2,94
780221326	30	2.06	17.7	278	278	007	0043	2,97	780221298	30	1.47	18.9	274	274	014	0089	4,44
780221327	30	1.47	18.9	275	275	014	0089	4,37	780221297	30	1.47	18.6	268	268	014	0088	4,45
780221328	30	1.66	19.7	280	280	011	0073	3,82	780221296	30	1.66	19.6	281	281	011	0073	3,81
780221329	30	1.66	19.8	282	282	011	0073	3,91	780221294	30	2.69	7.1	378	378	004	0010	4,14
780221330	30	2.84	9.8	337	337	004	0009	4,16	780221293	30	2.69	7.0	378	378	004	0010	4,24
780221331	30	2.84	9.8	337	337	004	0009	4,16	780221292	30	2.84	9.8	339	339	004	0009	4,12
780221332	30	2.84	9.8	350	350	007	0012	3,46	780221291	30	2.05	14.1	314	314	007	0034	2,56
780221333	30	2.05	14.6	292	292	007	0035	2,57	780221290	30	2.05	14.5	320	320	007	0035	2,48
780221334	30	4.20	15.5	291	291	002	0019	9,91	780221289	30	4.20	15.6	281	281	002	0019	2,06
780221335	30	4.20	15.5	288	288	002	0019	1,89	780221288	30	2.06	14.0	300	300	007	0034	2,74
780221336	30	2.06	14.1	303	303	007	0034	2,80	780221287	30	2.06	14.2	296	296	007	0034	2,71
780221337	30	1.47	15.0	283	283	014	0071	3,73	780221286	30	1.47	15.0	287	287	014	0071	3,74
780221338	30	1.47	14.8	285	285	014	0070	3,34	780221285	30	2.06	16.1	297	297	007	0039	3,35
780221339	30	2.06	16.1	295	295	007	0039	3,39	780221284	30	2.06	16.2	296	296	007	0039	3,38
780221340	30	2.91	7.8	304	304	004	0009	5,62	780221283	30	2.72	7.8	351	351	004	0011	4,60
780221341	30	2.69	7.8	352	352	004	0011	4,64	780221282	30	2.69	5.2	397	397	004	0007	4,62
780221342	30	1.47	15.7	295	295	014	0074	4,26	780221281	30	1.47	15.9	293	293	014	0075	2,40
780221343	30	1.96	17.0	304	304	011	0063	3,66	780221280	30	1.66	17.1	302	302	1	0063	3,61
780221344	30	1.66	17.4	300	300	011	0064	4,19	780221279	30	2.67	5.6	427	427	004	0008	4,05
780221345	30	2.91	5.7	422	422	004	0007	4,19	780221278	30	2.84	5.6	424	424	004	0007	4,12
780221346	30	2.91	5.7	422	422	004	0007	4,12	780221277	30	2.72	6.6	358	358	004	0012	4,66
780221347	30	2.72	8.6	357	357	004	0007	4,82	780221276	30	2.05	2.2	333	333	004	0030	2,22
780221348	30	4.05	12.5	309	309	007	0030	2,94	780221275	30	4.05	12.3	313	313	007	0030	2,79
780221349	30	1.97	14.1	305	305	008	0037	2,94	780221274	30	1.97	14.1	299	299	008	0037	2,96
780221350	30	4.20	14.0	302	302	002	0008	2,94	780221273	30	4.34	17.5	296	296	002	0009	2,94
780221351	30	4.34	17.5	300	300	002	0009	2,95	780221272	30	4.34	17.6	298	298	002	0010	2,93
780221352	30	1.47	16.1	292	292	014	0076	3,94	780221271	30	1.46	16.1	293	293	014	0077	4,13
780221353	30	1.46	16.1	293	293	014	0077	4,12	780221270	30	2.69	4.9	408	408	004	0007	6,71
780221354	30	2.69	5.0	410	410	004	0007	6,72	780221269	30	2.05	10.3	344	344	007	0025	2,39
780221355	30	2.05	10.2	352	352	007	0025	2,40	780221268	30	2.05	10.4	350	350	007	0025	2,37
780221356	30	4.57	11.6	328	328	001	0064	1,48	780221267	30	4.34	10.8	321	321	002	0006	1,50
780221357	30	4.27	15.3	301	301	002	0009	2,05	780221266	30	4.27	14.9	304	304	002	0008	2,12
780221358	30	4.27	15.2	300	300	002	0009	1,98	780221265	25	1.55	16.8	266	266	011	0071	4,16
780221359	25	2.23	17.6	269	269	005	0036	2,94	780221264	25	2.23	17.5	275	275	005	0036	3,02
780221360	25	4.49	13.2	293	293	001	0007	1,87	780221263	25	4.41	13.3	291	291	001	0007	1,84
780221361	25	2.75	13.0	294	294	003	0018	2,35	780221262	25	2.75	13.1	293	293	003	0018	2,28
780221362	25	2.75	13.1	293	293	003	0018	2,33	780221261	25	1.45	13.5	279	279	012	0066	3,90
780221363	25	1.45	13.4	294	294	012	0067	3,73	780221260	25	1.45	13.7	280	280	012	0066	3,85
780221364	25	1.45	14.2	300	300	012	0069	2,89	780221259	25	1.45	14.4	298	298	012	0070	2,88
780221365	25	2.23	14.3	299	299	005	0029	2,92	780221258	25	2.75	7.6	331	331	003	0010	4,78
780221366	25	2.75	7.5	333	333	003	0010	4,86	780221257	25	2.75	4.9	388	388	003	0007	5,12
780221367	25	2.75	10.5	378	378	003	0007	5,18	780221256	25	1.50	5.0	380	380	003	0007	5,10
780221368	25	2.75	7.5	335	335	003	0010	4,76	780221255	25	1.50	9.9	308	308	011	0045	2,50
780221369	25	1.50	10.1	318	318	011	0046	2,50	780221254	25	1.50	10.1	311	311	011	0046	2,50
780221370	25	4.57	10.3	304	304	001	0005	1,43	780221253	25	4.57	10.3	305	305	001	0005	1,43

APPENDIX E
TEST RESULTS (GRAPHICAL FORM)



SYMBOL DS/HS

○	1.20
△	1.13
+	1.07
×	1.00
◇	0.93
†	0.87
×	0.80
Z	0.73
Y	0.67
×	0.60



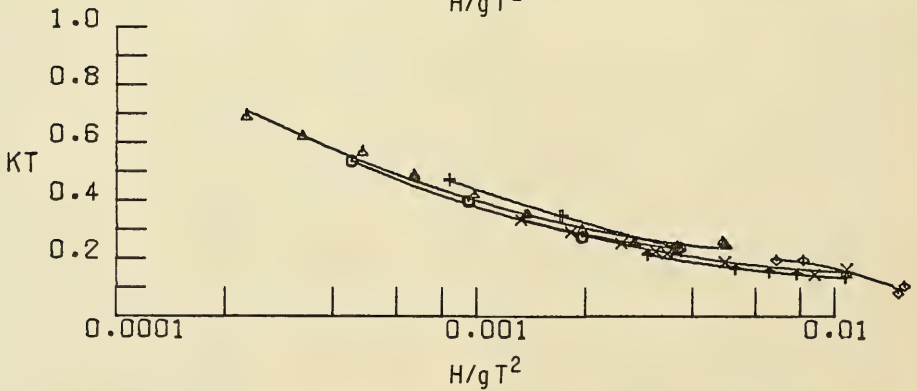
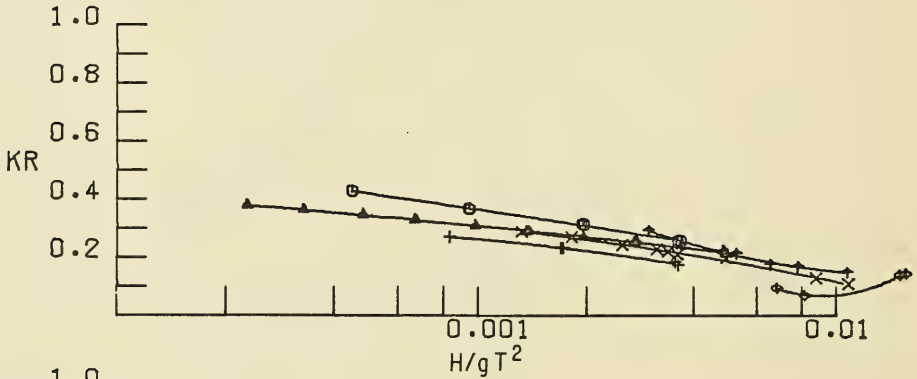
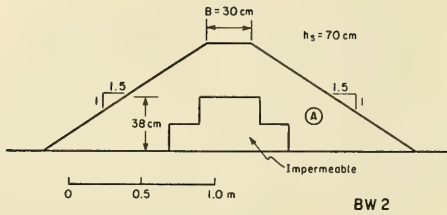
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 1

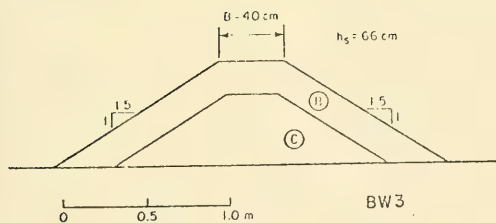
$D/(GT^2) = 0.016$

SYMBOL D/ST^2

- 0.0131
- △ 0.0161
- + 0.0227
- × 0.0364
- ◇ 0.0556
- † 0.0788

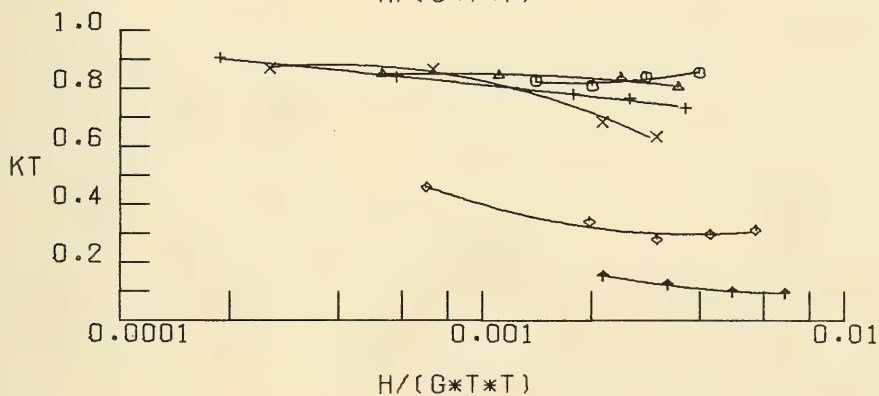
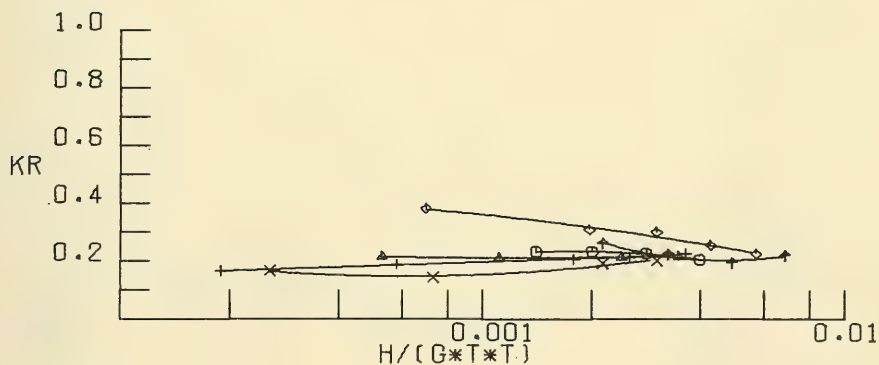


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
BREAKWATER 2 DS/HS= 0.87



SYMBOL DS/HS

□	1.44
△	1.38
+	1.29
×	1.14
◇	0.92
†	0.69



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

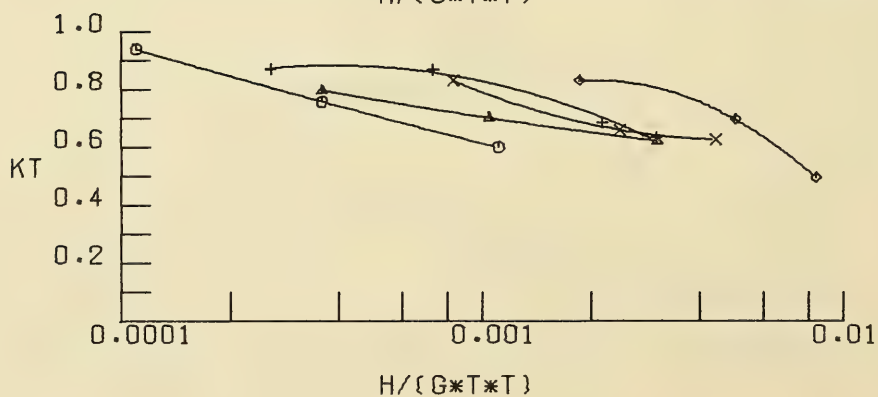
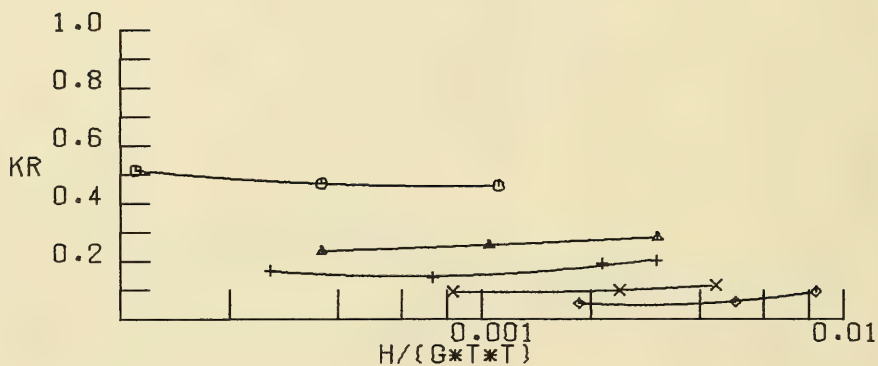
BREAKWATER

3

$D/((GT)^2)=0.016$

SYMBOL D/GT2

○ 0.0065
 ▲ 0.0131
 + 0.0161
 × 0.0226
 ◇ 0.0364

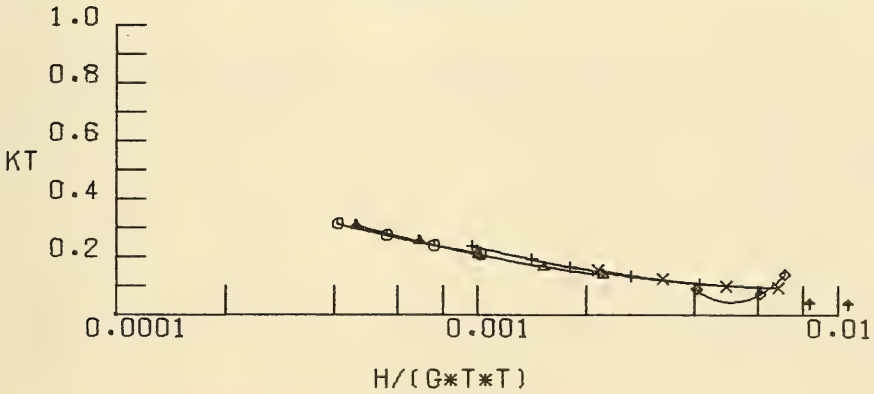
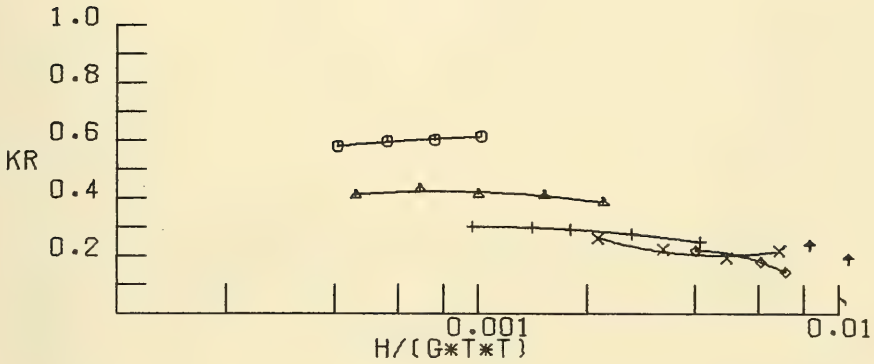


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 3 DS/HS= 1.14

SYMBOL D/GT²

○	0.0038
△	0.0066
+	0.0131
×	0.0162
◇	0.0229
†	0.0368



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

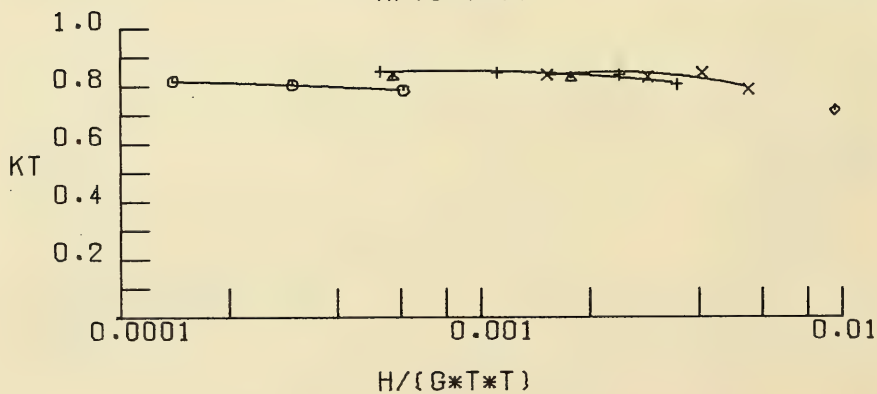
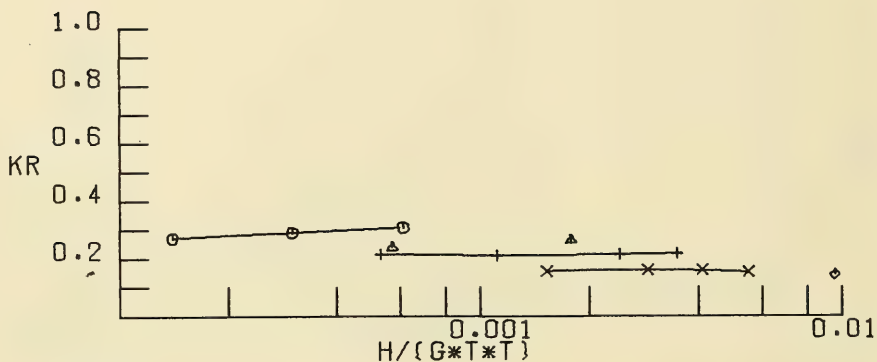
BREAKWATER

3

DS/HS= 0.69

SYMBOL D/GT²

- 0.0065
- △ 0.0130
- + 0.0161
- × 0.0227
- ◇ 0.0362



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

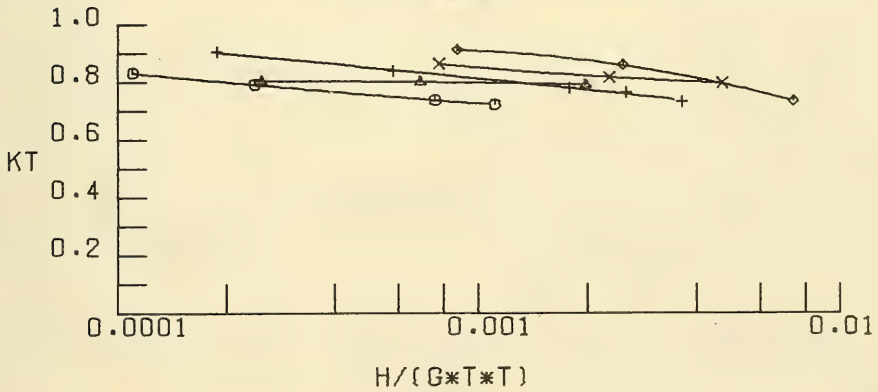
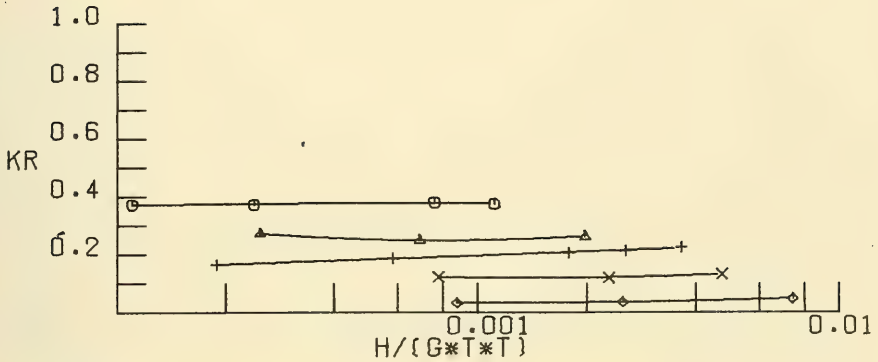
BREAKWATER 3

3

DS/HS= 1.38

SYMBOL D/GT2

□	0.0065
△	0.0130
+	0.0161
×	0.0226
◇	0.0366



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

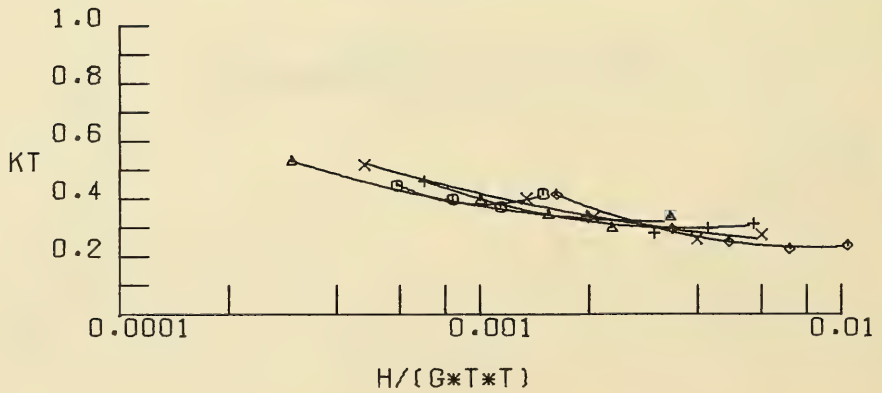
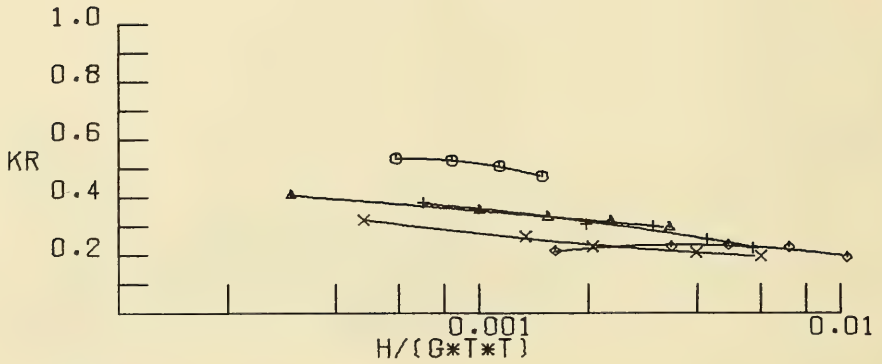
BREAKWATER 3

3

DS/HS= 1.29

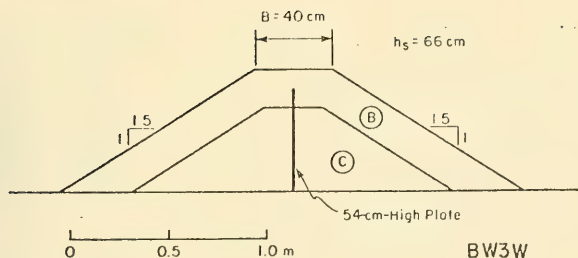
SYMBOL D/GT2

○	0.0066
△	0.0131
+	0.0162
×	0.0230
◇	0.0365



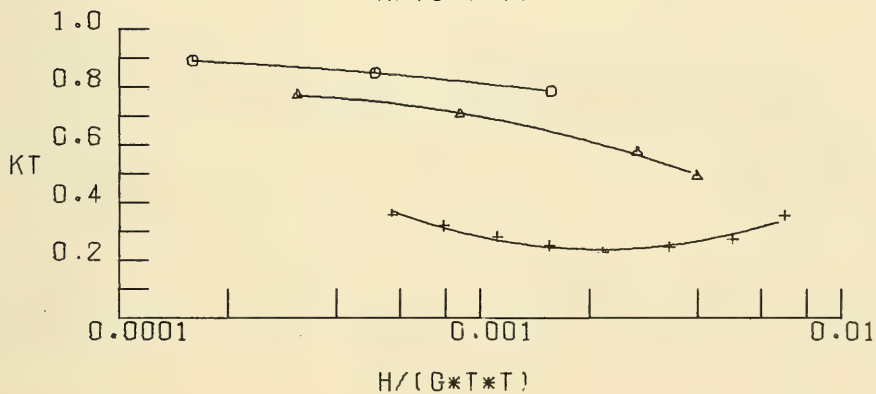
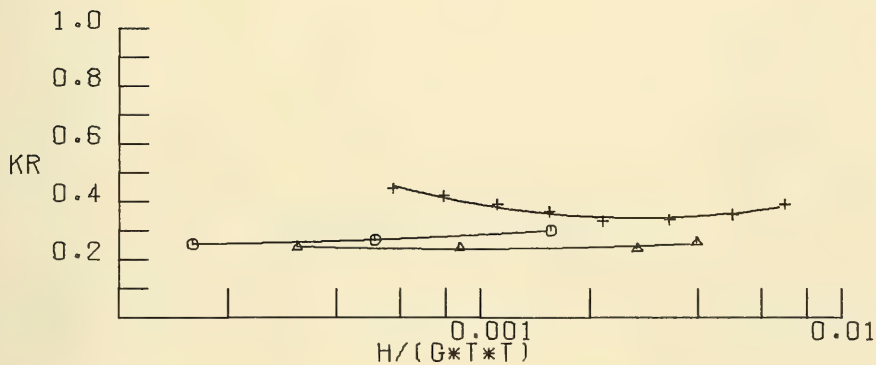
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 3 DS/HS= 0.92



SYMBOL D_s/H_s

○	1.29
△	1.15
+	0.93
×	0.69



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

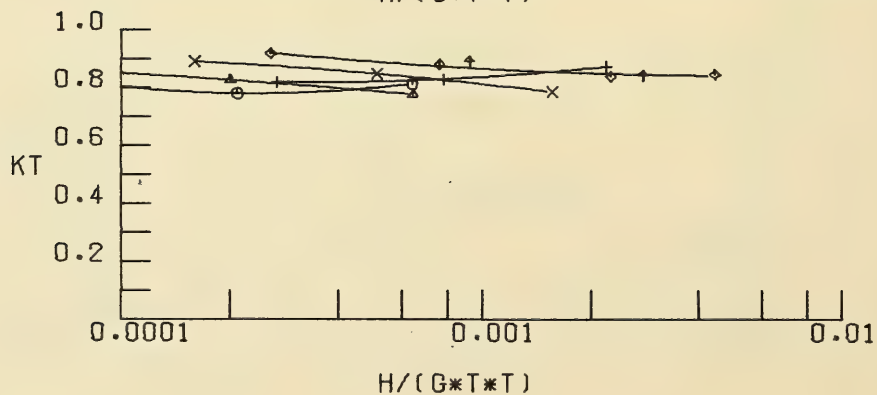
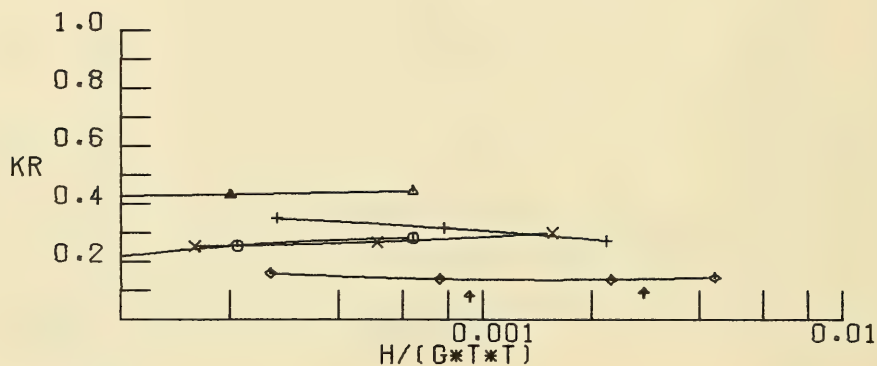
BREAKWATER

3W

$D/(GT^2) = 0.016$

SYMBOL D/GT2

○	0-0037
△	0-0065
+	0-0130
x	0-0161
◇	0-0226
†	0-0366

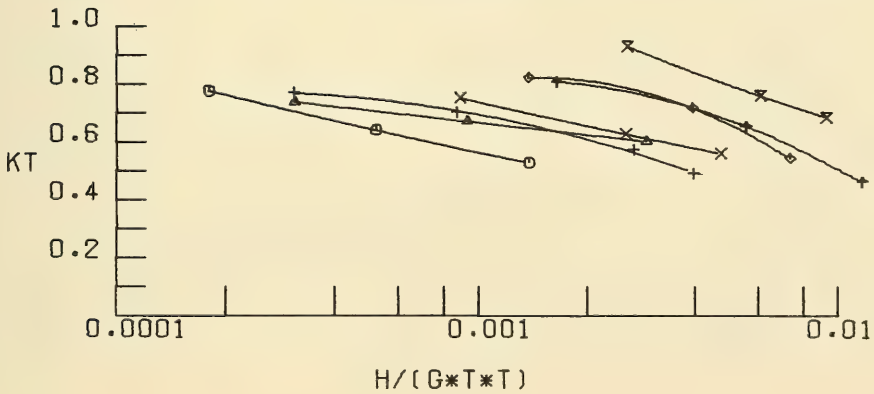
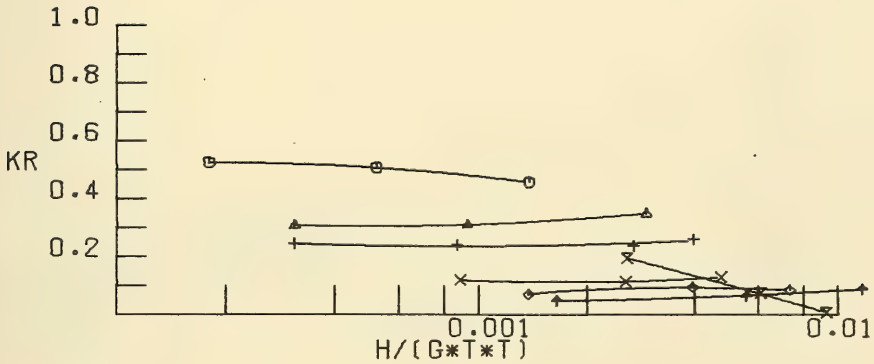


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 3W DS/HS= 1.29

SYMBOL D/GT²

□	0.0066
△	0.0132
+	0.0163
×	0.0228
◇	0.0368
†	0.0555
×	0.0805

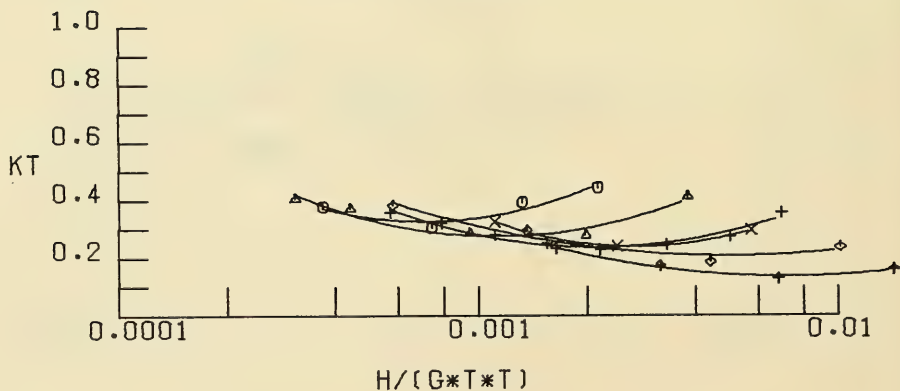
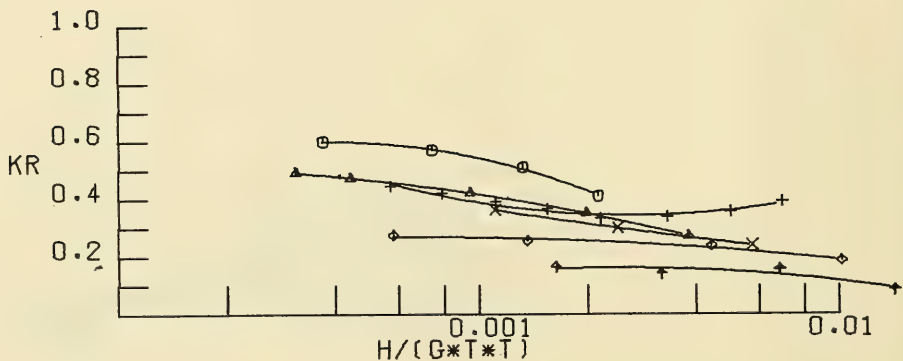


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 3W DS/HS= 1.15

SYMBOL D/GT2

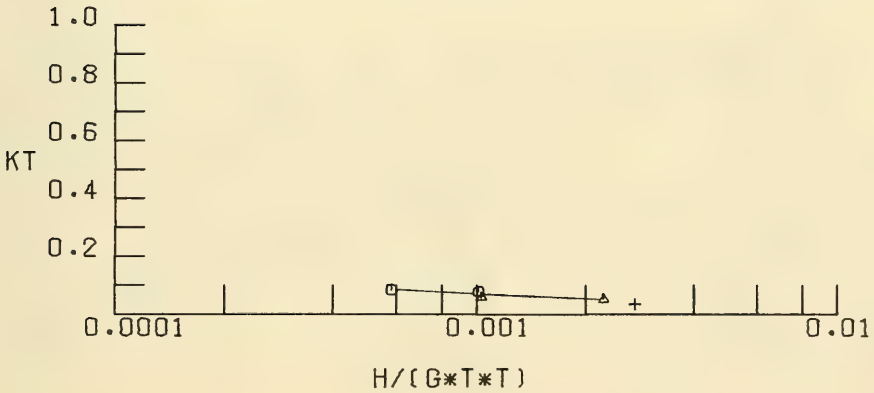
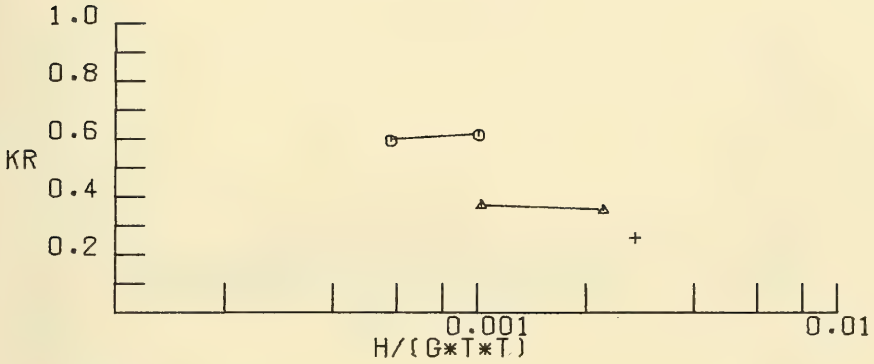
- 0.0065
- △ 0.0131
- + 0.0161
- × 0.0226
- ◇ 0.0363
- † 0.0555



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 3W DS/HS= 0.93

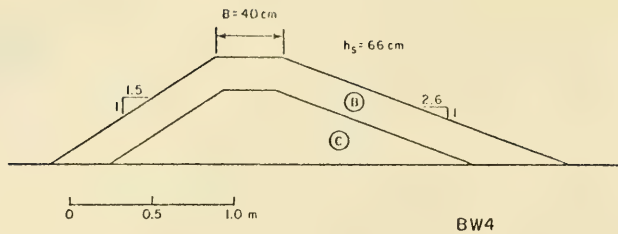
SYMBOL D/GT2

○ 0.0038
△ 0.0066
+ 0.0131



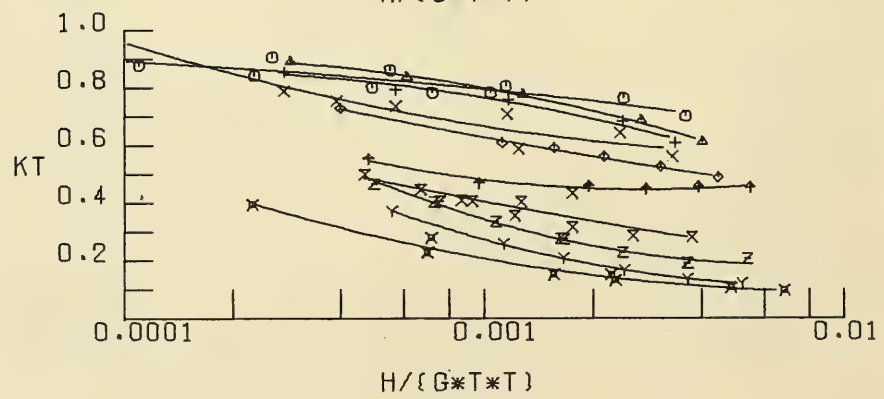
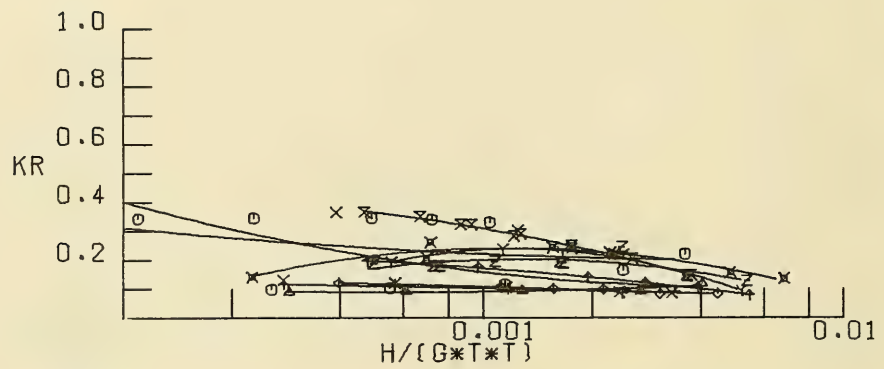
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 3W DS/HS= 0.69



SYMBOL DS/HS

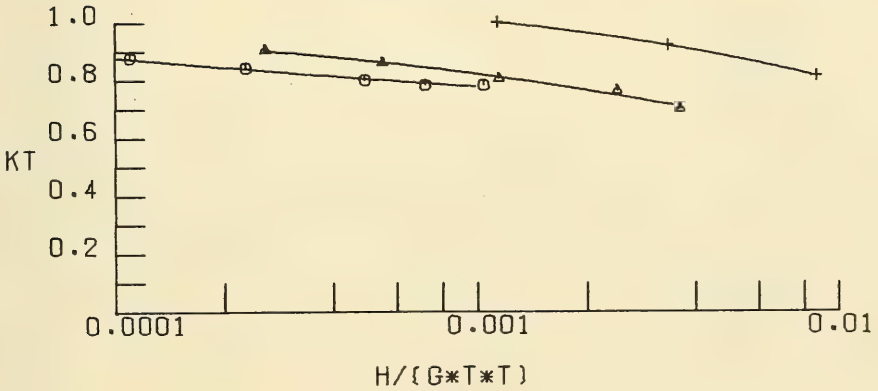
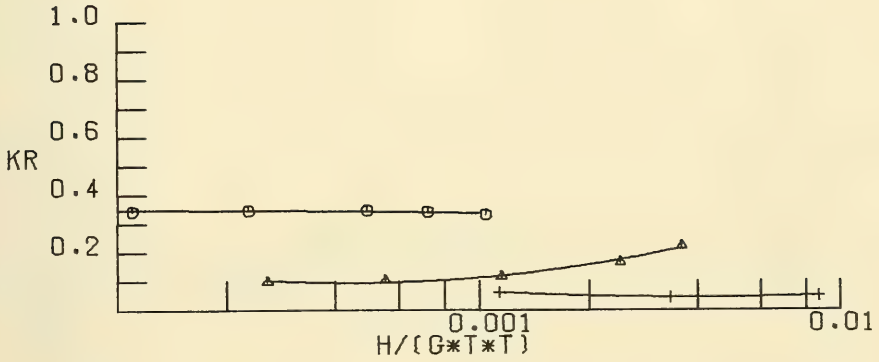
⊙	1.29
△	1.21
+	1.14
×	1.11
◇	1.09
†	0.98
×	0.90
Z	0.84
Y	0.74
X	0.68



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 4 $D/(GT^2)=0.016$

SYMBOL D/GT2

□ 0.0065
 ▲ 0.0161
 + 0.0546



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

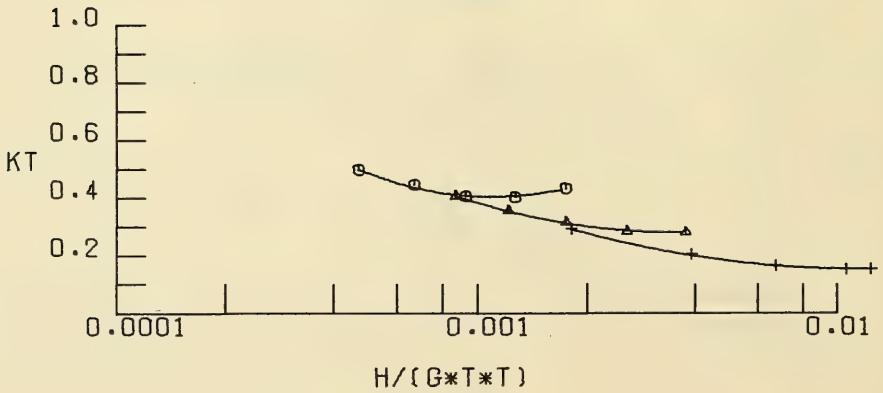
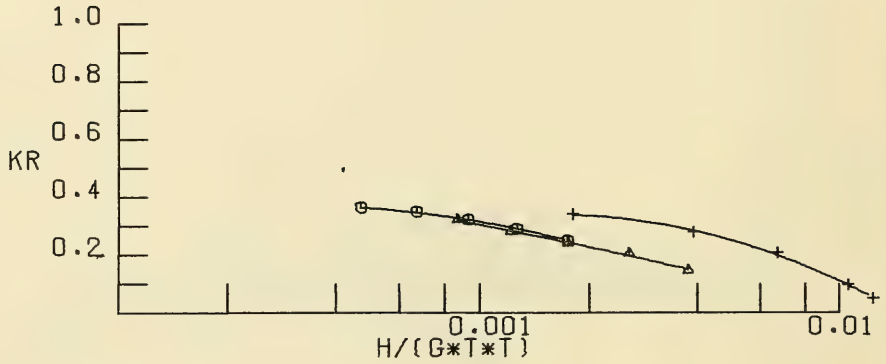
BREAKWATER

4

DS/HS= 1.29

SYMBOL D/GT²

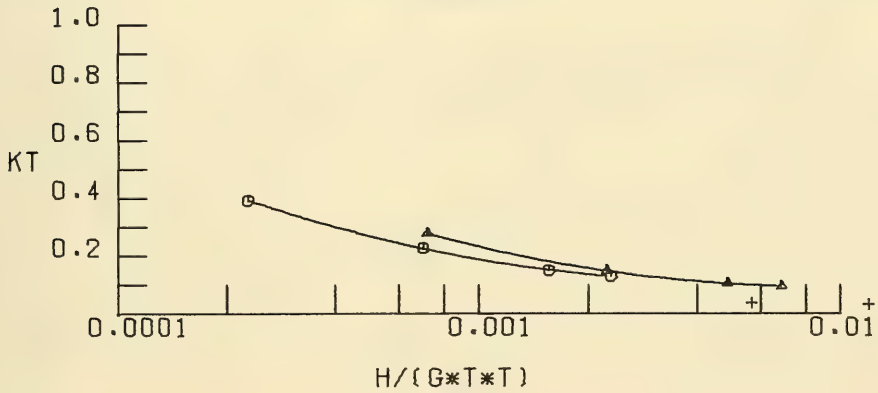
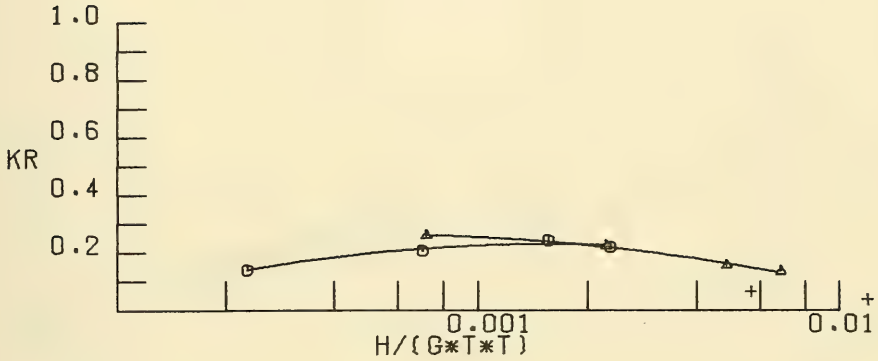
○ 0.0065
 △ 0.0160
 + 0.0553



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 4 DS/HS= 0.90

SYMBOL D/GT^2

○ 0.0065
 ▲ 0.0161
 + 0.0555

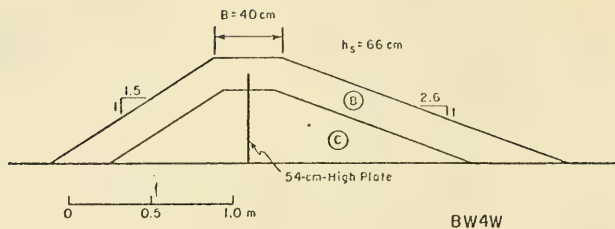


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER

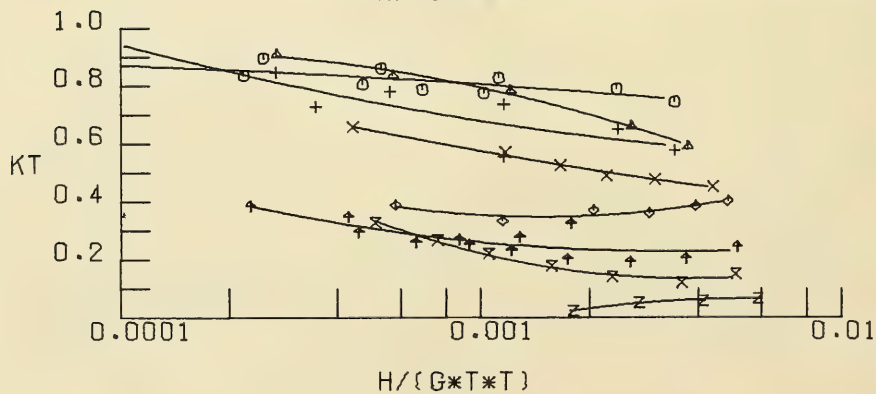
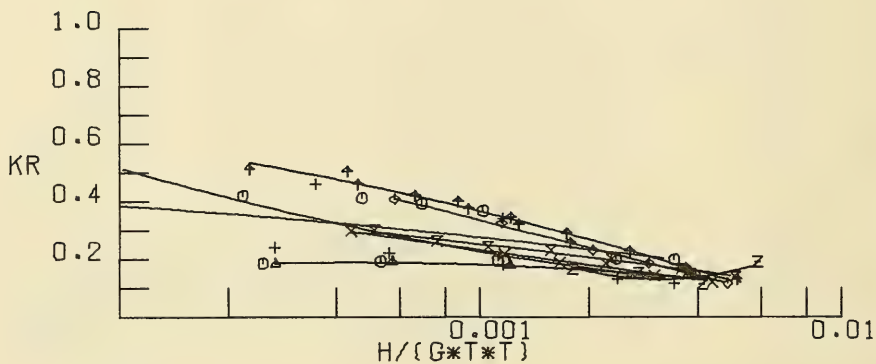
4

$DS/HS = 0.68$



SYMBOL DS/HS

□	1.29
△	1.21
+	1.14
×	1.06
◇	0.98
†	0.91
×	0.85
Z	0.76

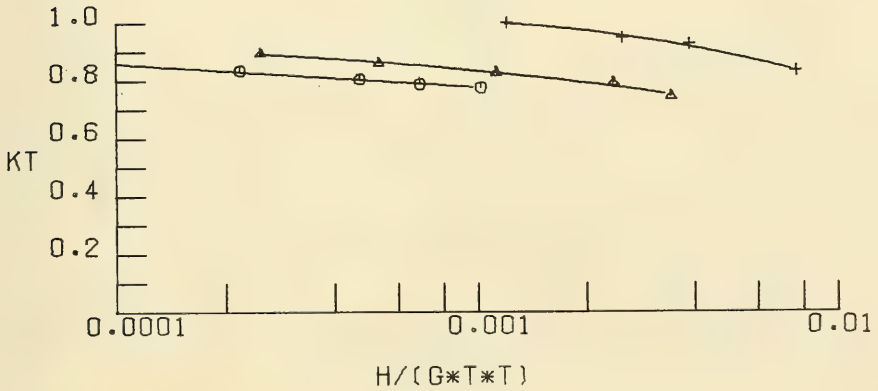
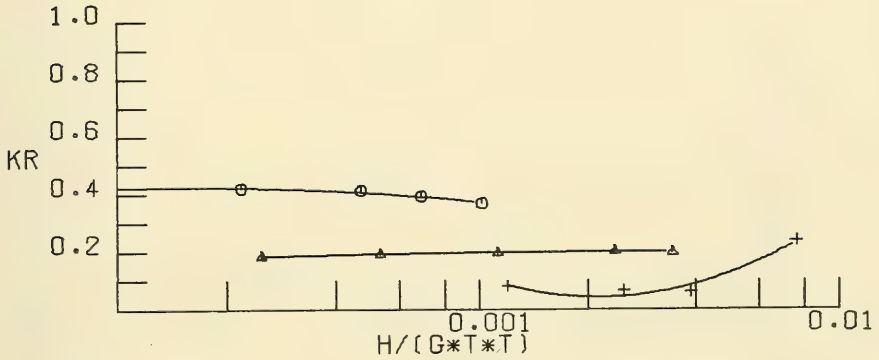


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 4W $D/((G T^2))=0.016$

SYMBOL D/GT²

○ 0.0065
 ▲ 0.0161
 + 0.0546

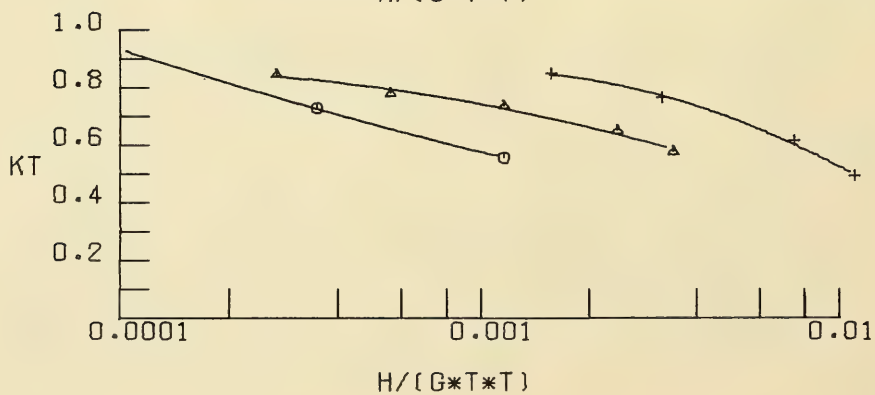
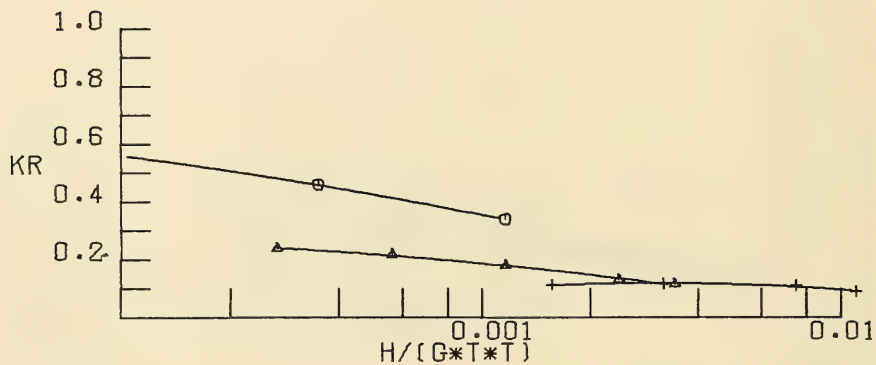


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 4W DS/HS= 1.29

SYMBOL D/GT2

○ 0.0066
 △ 0.0162
 + 0.0553

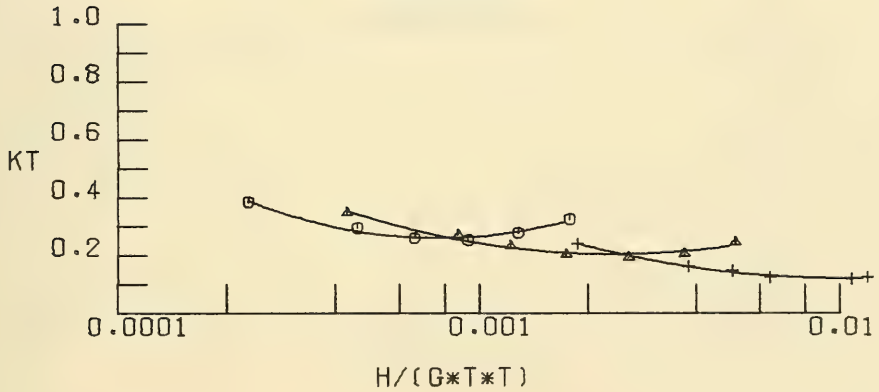
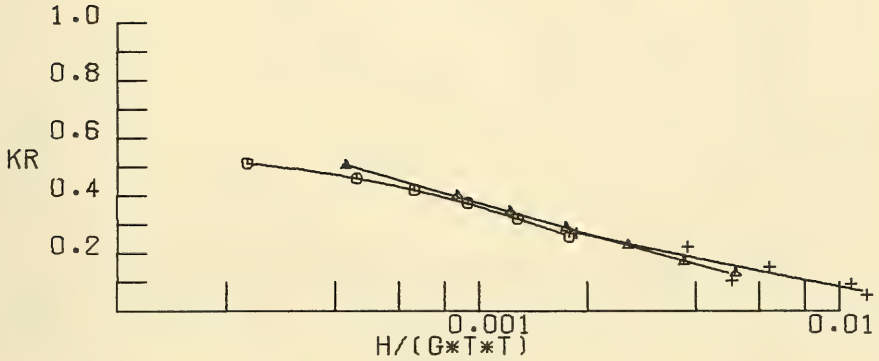


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 4W DS/HS= 1.14

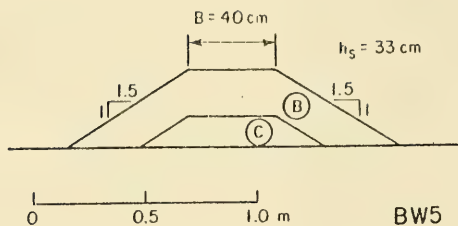
SYMBOL D/GT²

○ 0.0065
 △ 0.0161
 + 0.0555



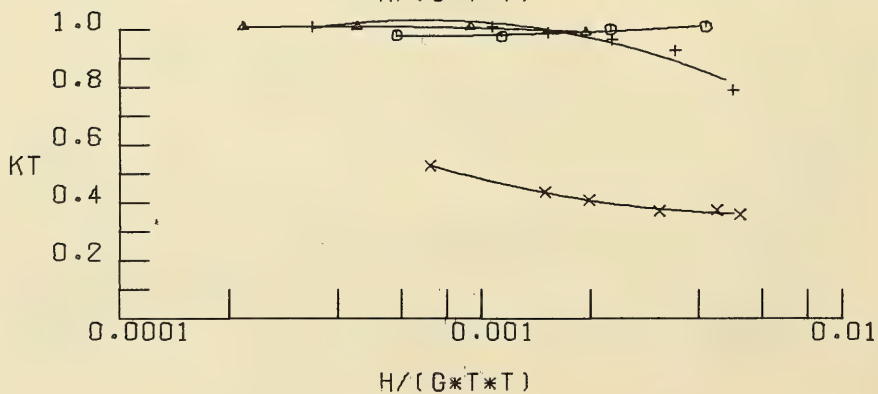
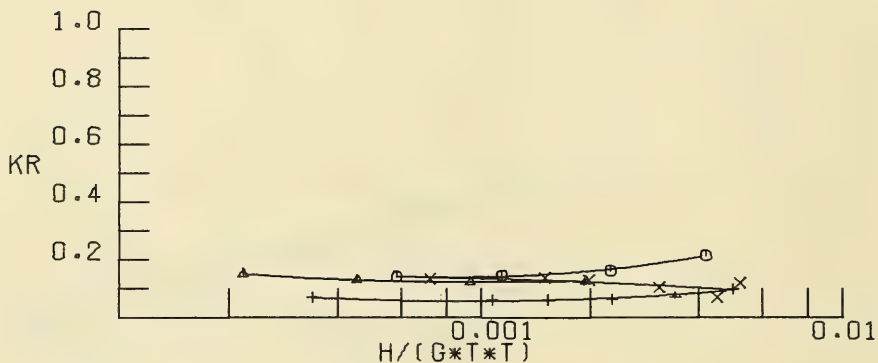
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 4W DS/HS= 0.91



SYMBOL DS/H_S

○	2.27
△	1.82
+	1.36
×	0.92



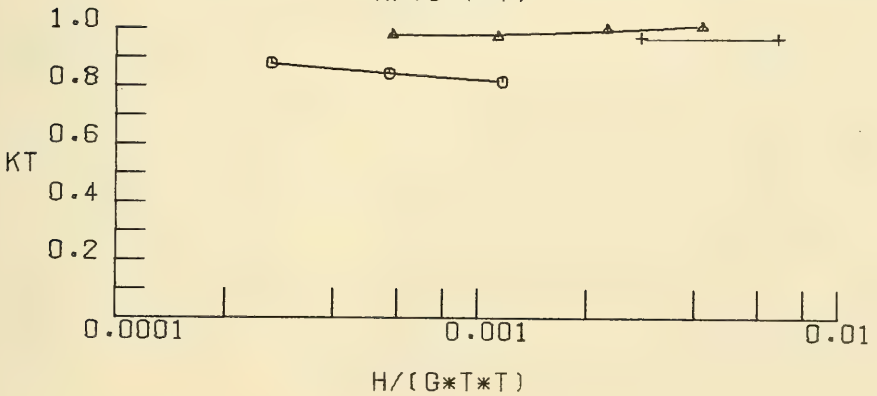
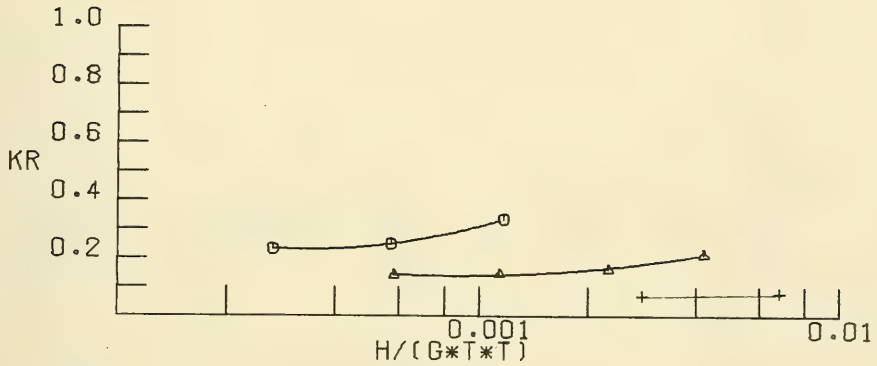
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 5

$D/((GT^2))=0.016$

SYMBOL D/GT2

○ 0.0065
 △ 0.0161
 + 0.0550



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

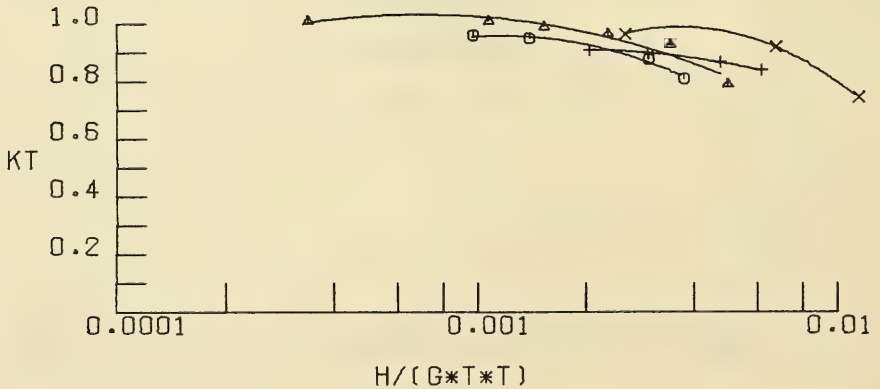
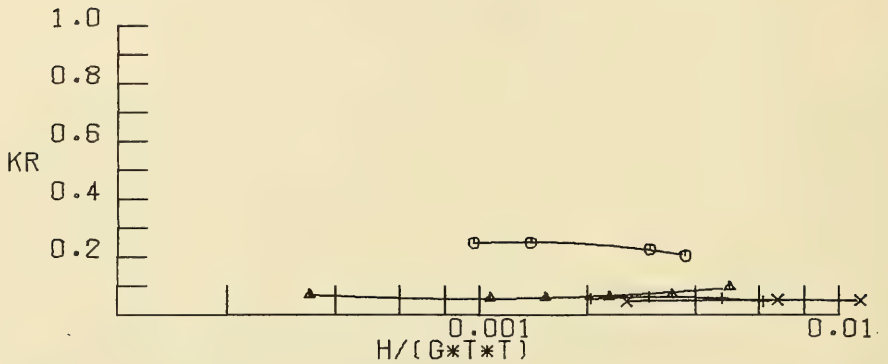
BREAKWATER

5

DS/HS= 2.27

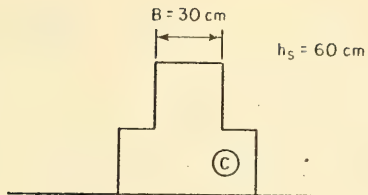
SYMBOL D/GT2

○	0.0114
△	0.0161
+	0.0330
x	0.0555



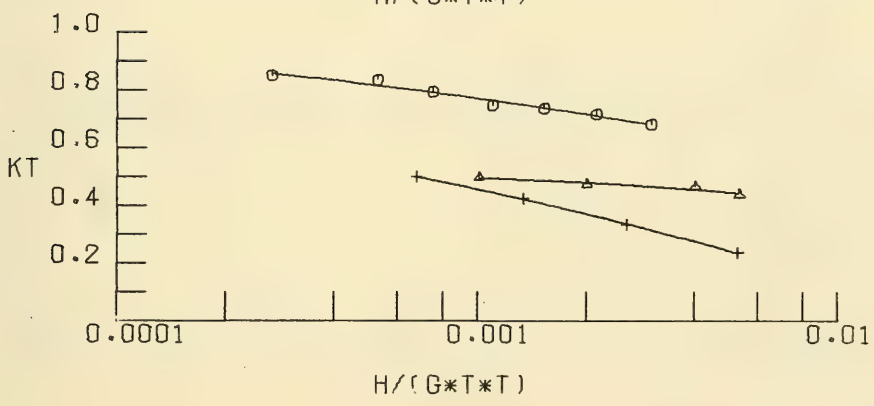
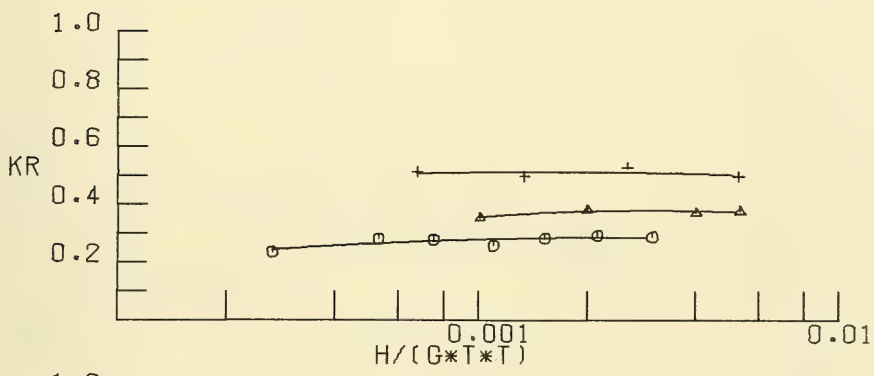
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 5 DS/HS= 1.36



SYMBOL	DS/HS
○	1.25
△	1.00
+	0.75

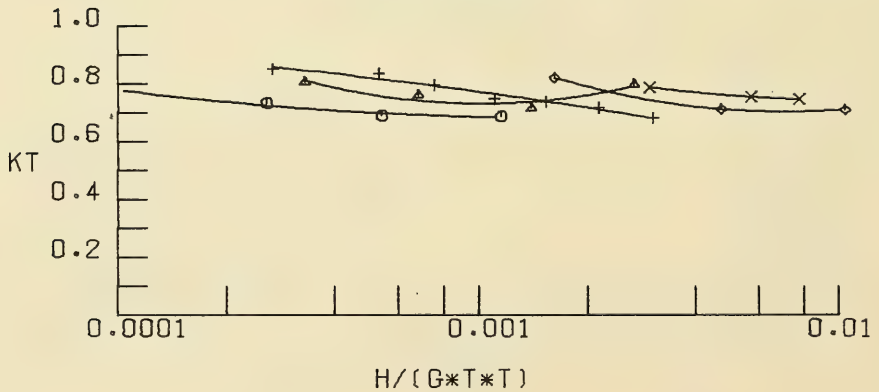
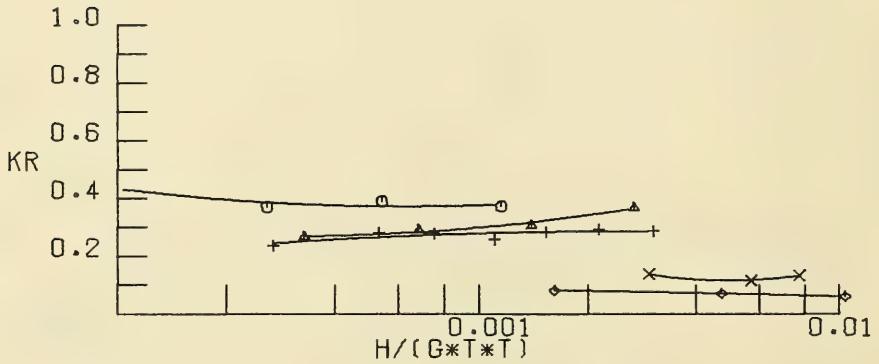
0 0.5 1.0 m BW6



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 6 D/(GT²)=0.016

SYMBOL D/GT2

○	0.0065
△	0.0113
+	0.0161
×	0.0390
◇	0.0549

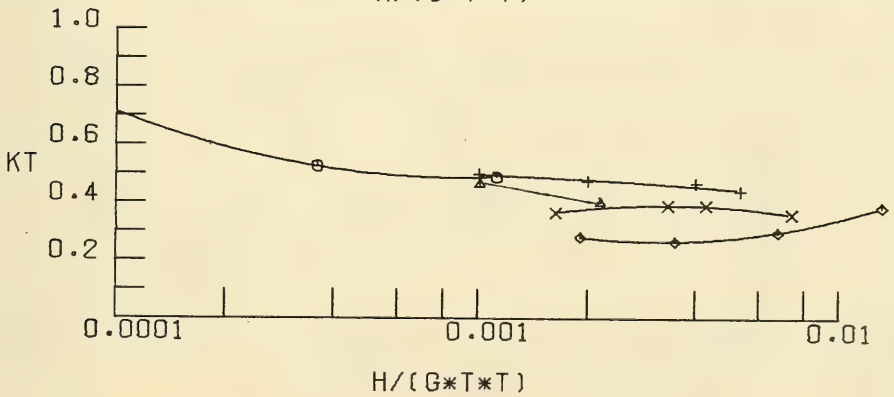
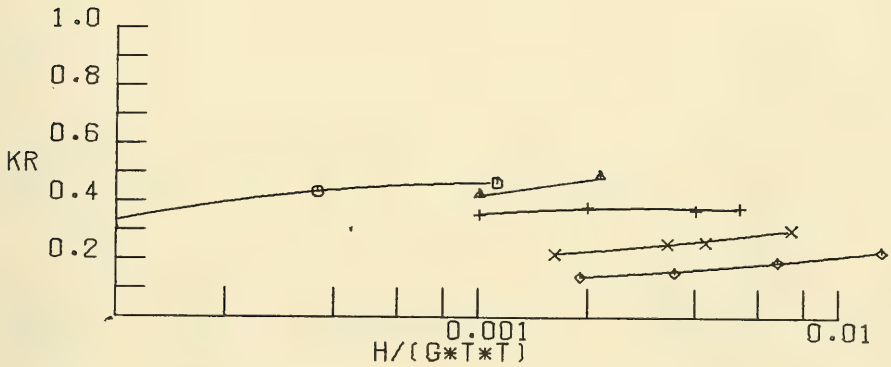


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 6 DS/HS= 1.25

SYMBOL D/GT2

○	0.0065
△	0.0114
+	0.0161
×	0.0392
◇	0.0555

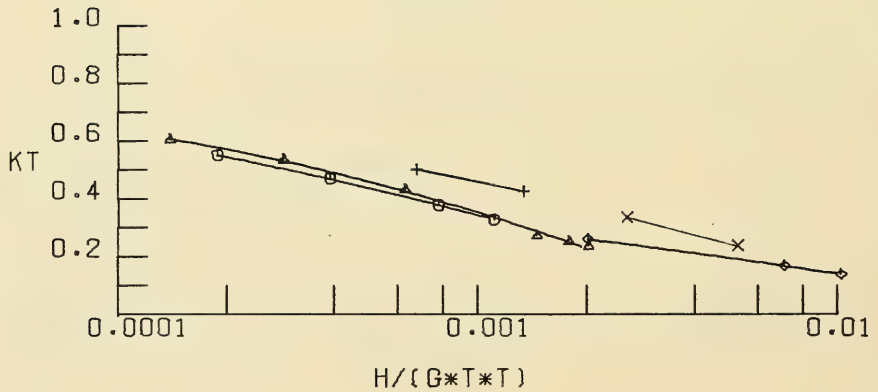
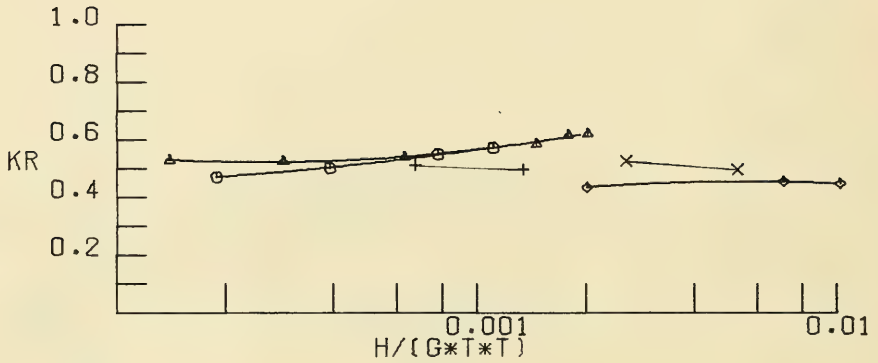


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 6 DS/HS= 1.00

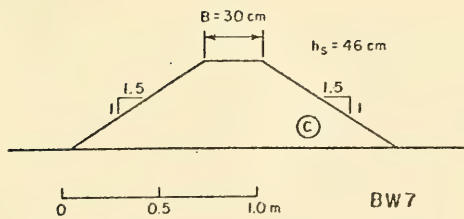
SYMBOL D/GT2

○	0.0056
△	0.0065
+	0.0171
×	0.0161
◇	0.0555



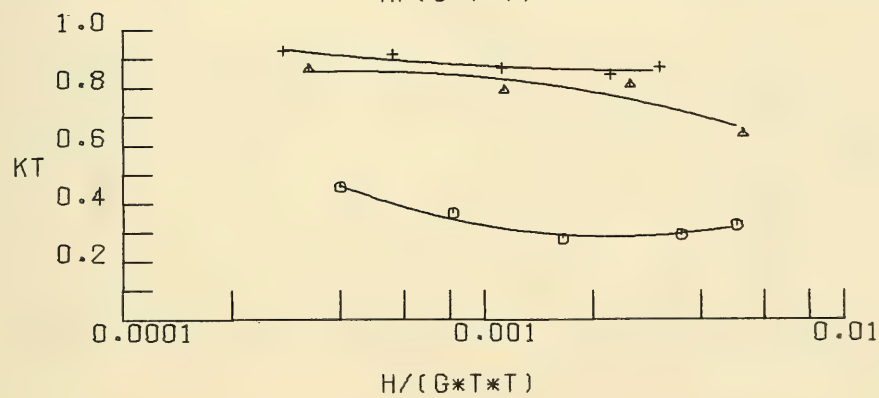
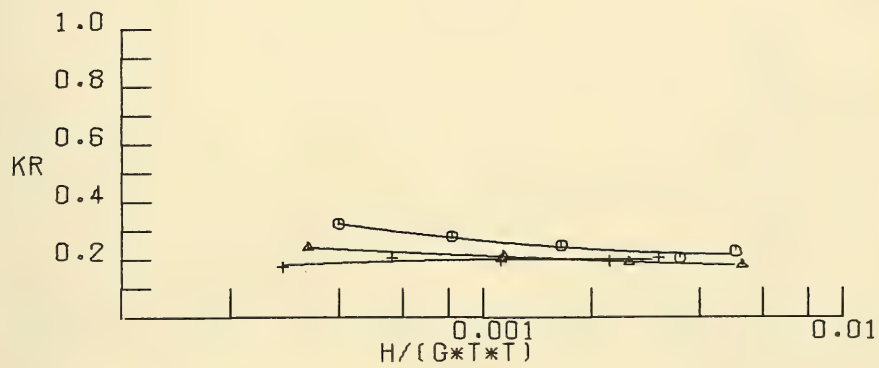
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 6 DS/HS= 0.75



SYMBOL DS/HS

- 0-98
- △ 1-30
- + 1-63

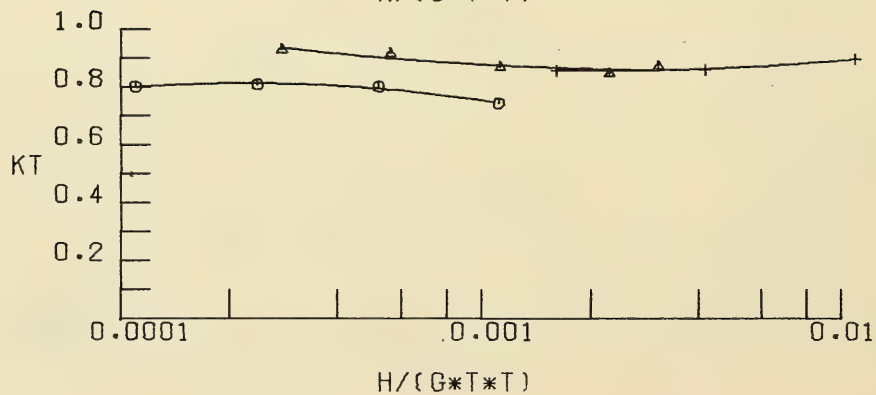
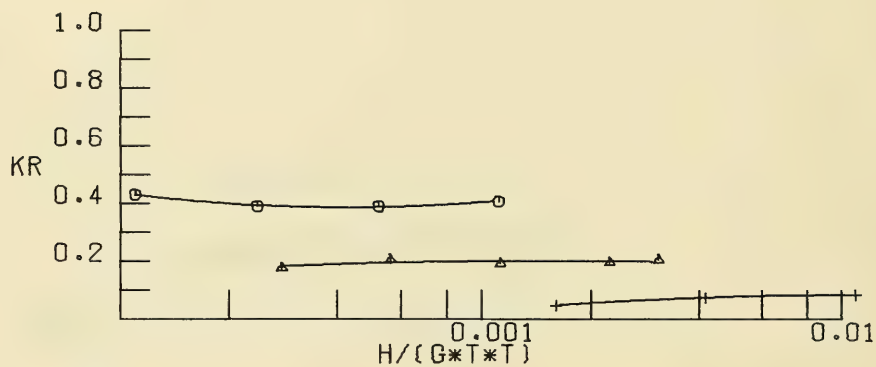


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 7 D/(GT²)=0.016

SYMBOL D/GT²

○ 0.0065
 ▲ 0.0161
 + 0.0550

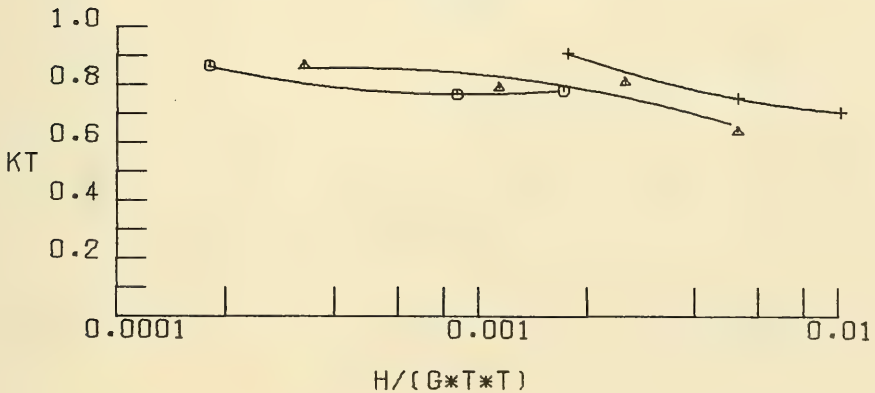
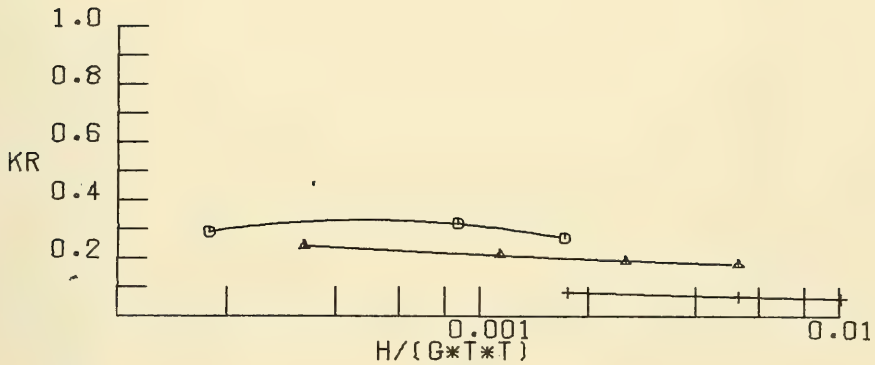


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 7 DS/HS= 1.63

SYMBOL D/OT2

□ 0.0065
 ▲ 0.0161
 + 0.0555



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

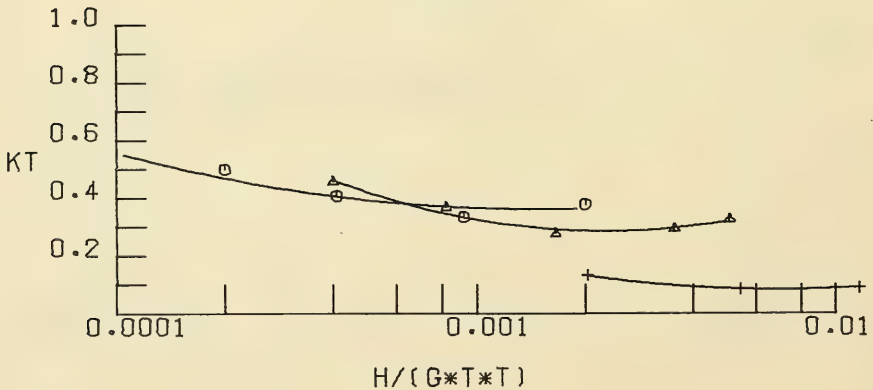
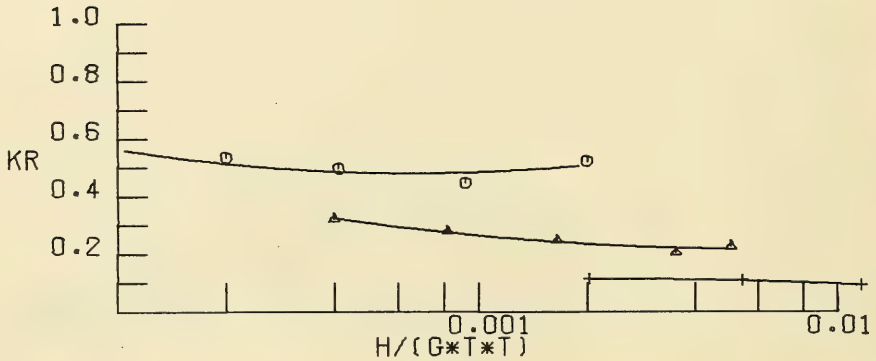
BREAKWATER

7

DS/HS= 1.30

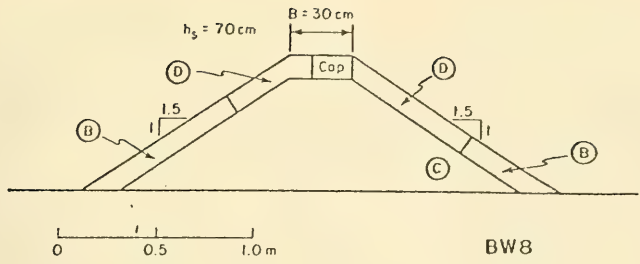
SYMBOL D/GT^2

○ 0.0065
 ▲ 0.0161
 + 0.0555

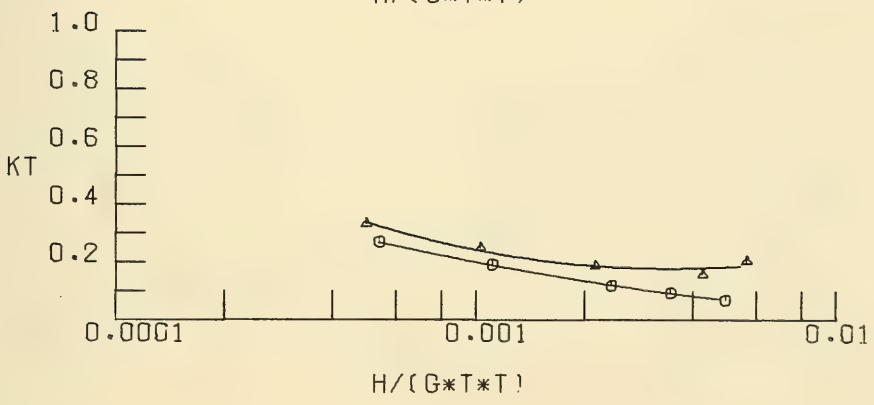
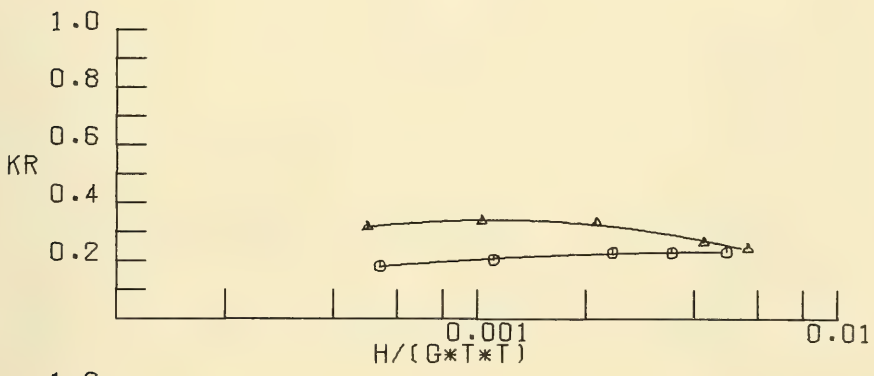


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

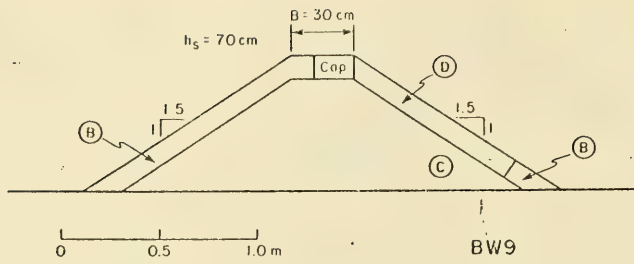
BREAKWATER 7 DS/HS= 0.98



SYMBOL DS/HS
 □ 0.64
 △ 0.86

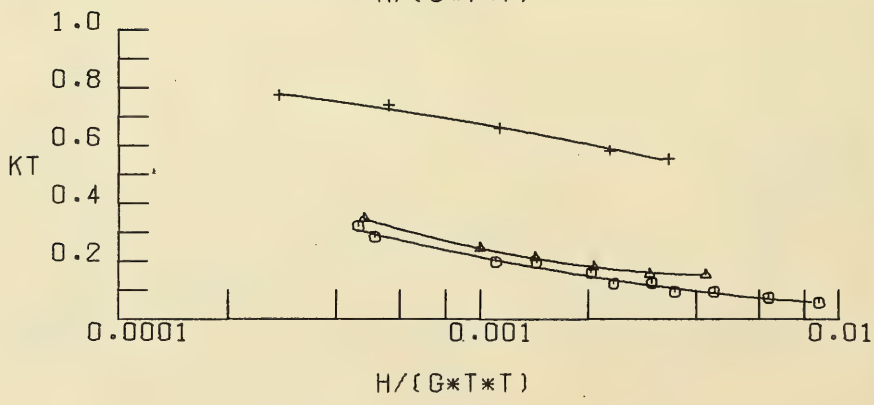
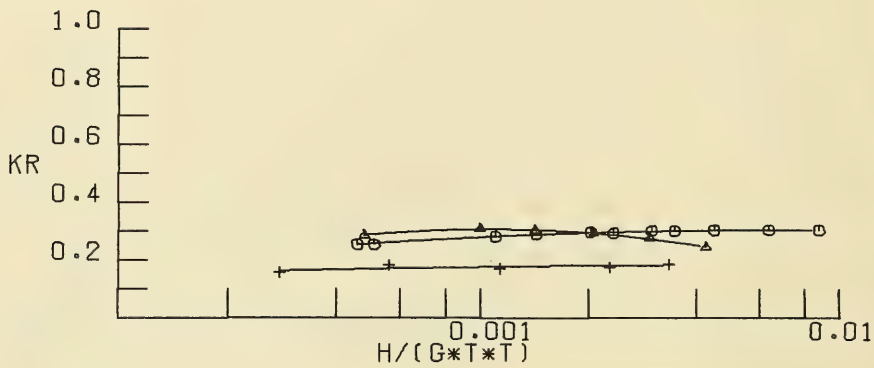


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 8 D/(GT²)=0.016



SYMBOL DS/HS

□	0.64
△	0.86
+	1.07

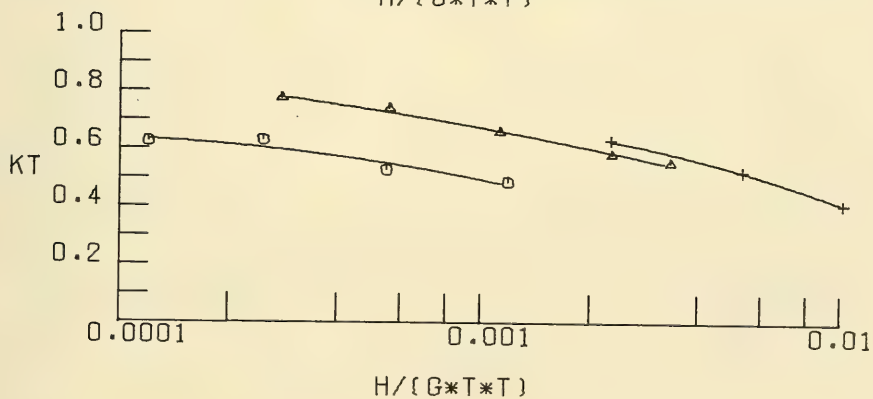
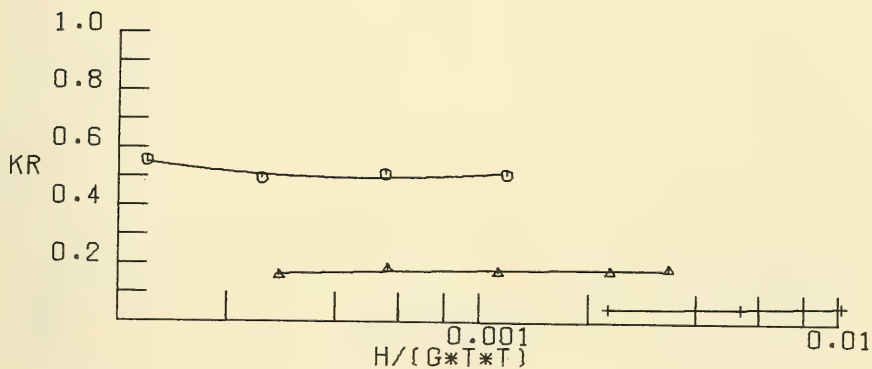


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 9 D/(GT²)=0.016

SYMBOL D/GT^2

○ 0.0065
 ▲ 0.0161
 + 0.0550



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

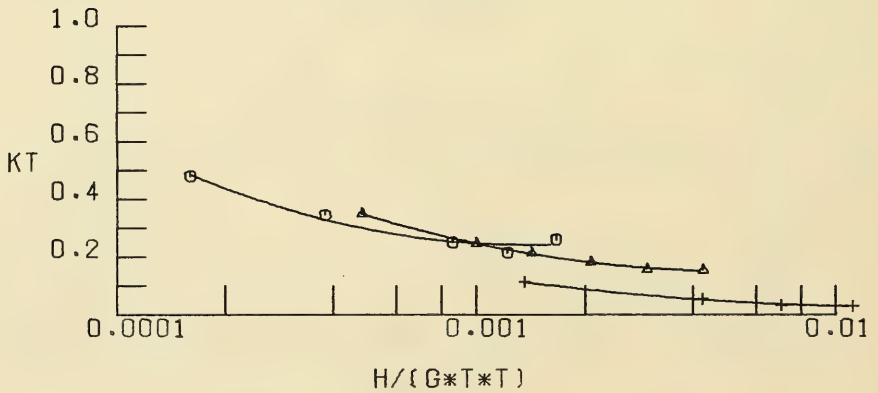
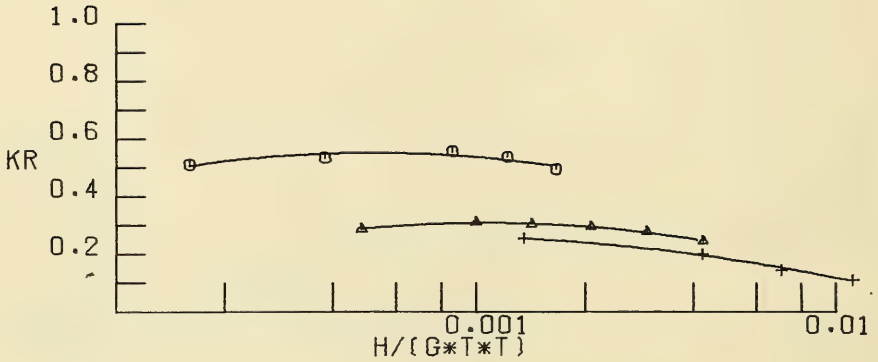
BREAKWATER

9

DS/HS= 1.07

SYMBOL D/GT2

□ 0.0065
 ▲ 0.0161
 + 0.0555

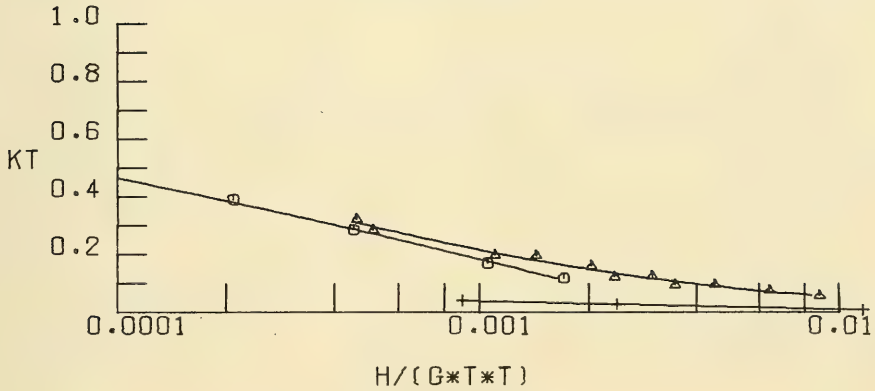
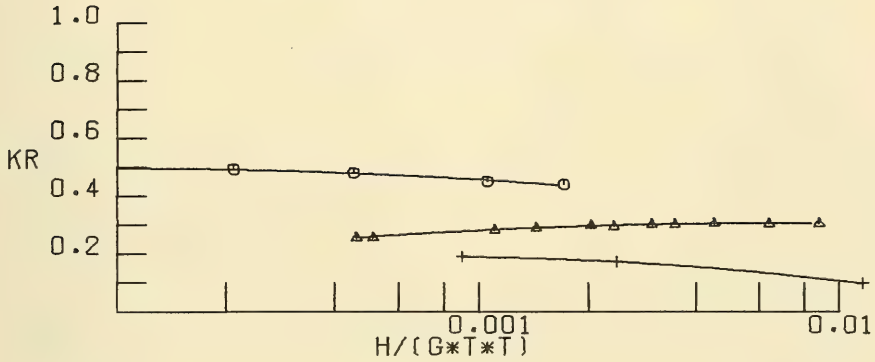


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

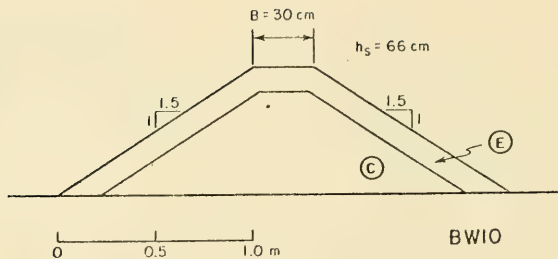
BREAKWATER 9 DS/HS= 0.86

SYMBOL D/GT²

□ 0.0065
 ▲ 0.0162
 + 0.0555

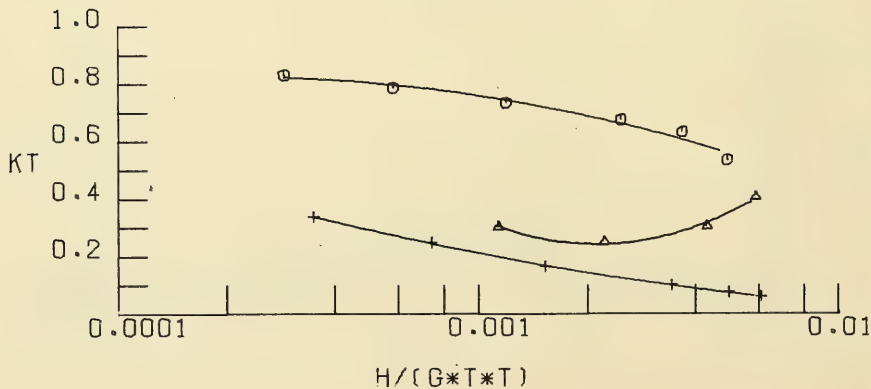
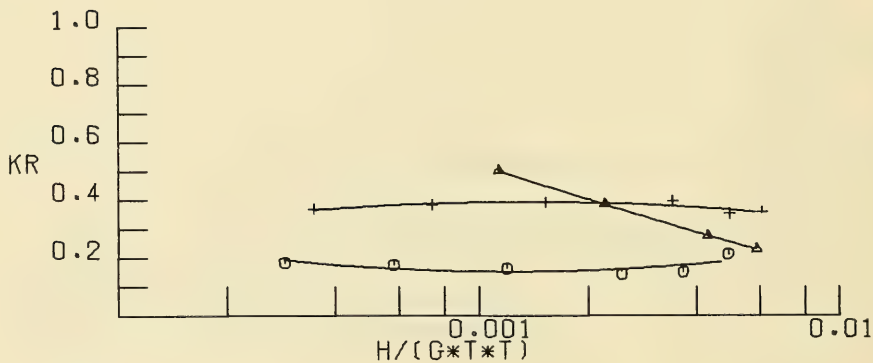


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 9 DS/HS= 0.64



SYMBOL DS/HS

○	1.14
△	0.91
+	0.6



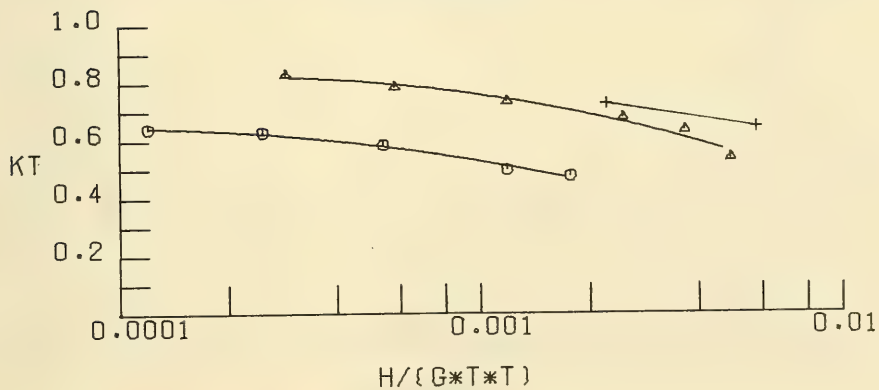
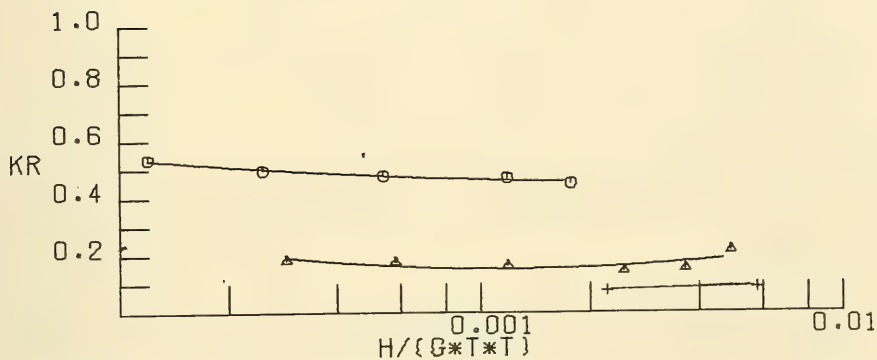
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 10

$D/(GT^2) = 0.016$

SYMBOL D/GT²

○ 0.0065
 △ 0.0161
 + 0.0550



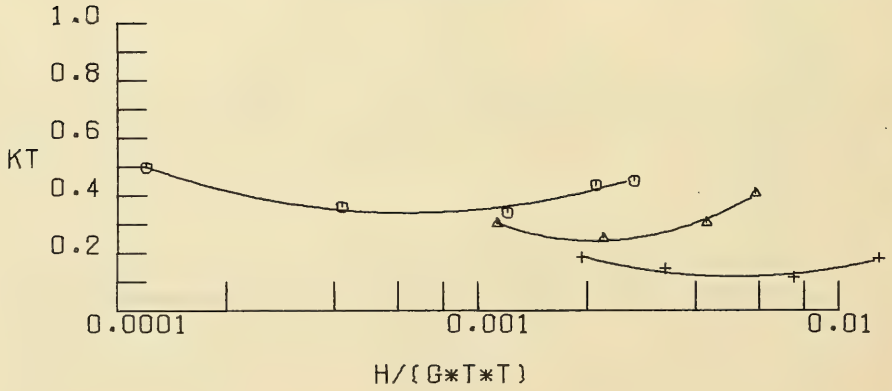
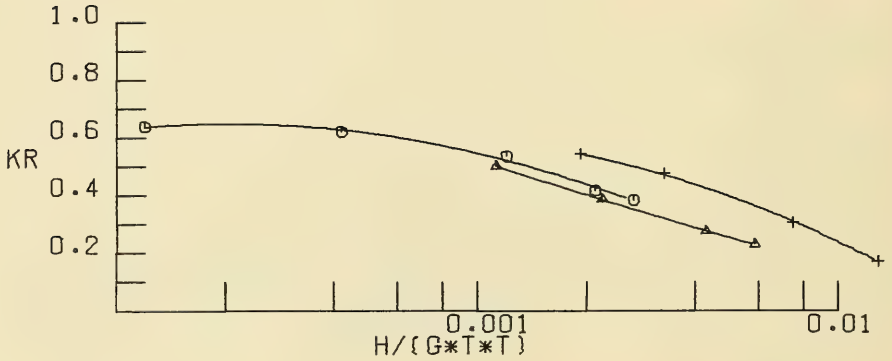
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 10

DS/HS= 1.14

SYMBOL D/GT^2

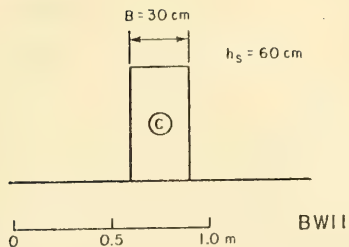
□ 0.0065
 △ 0.0161
 + 0.0555



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

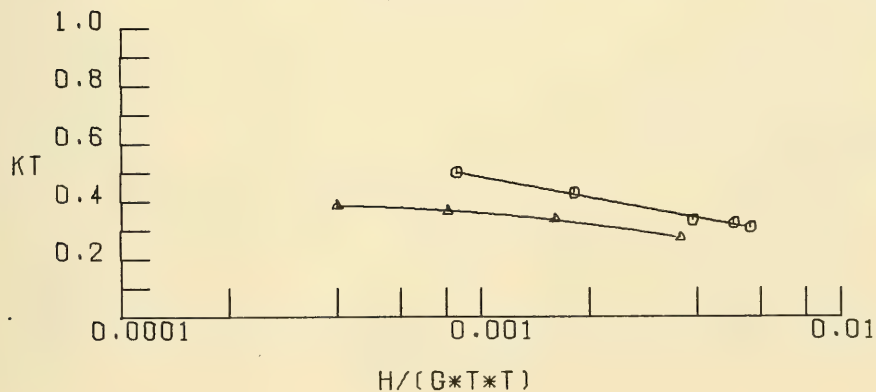
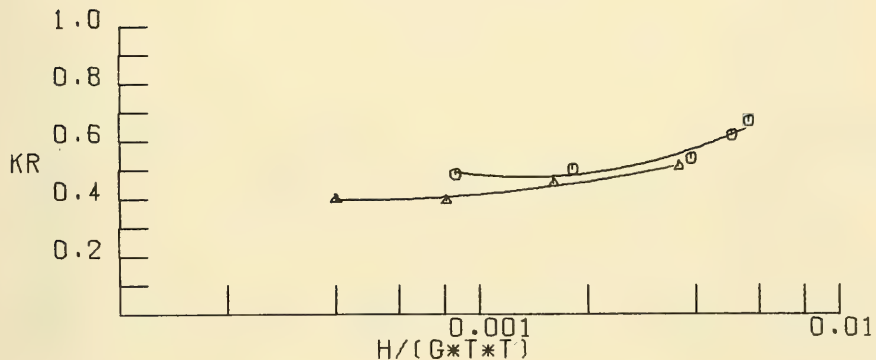
BREAKWATER 10

$DS/HS = 0.91$



SYMBOL DS/HS

□ 0.75
 △ 0.51



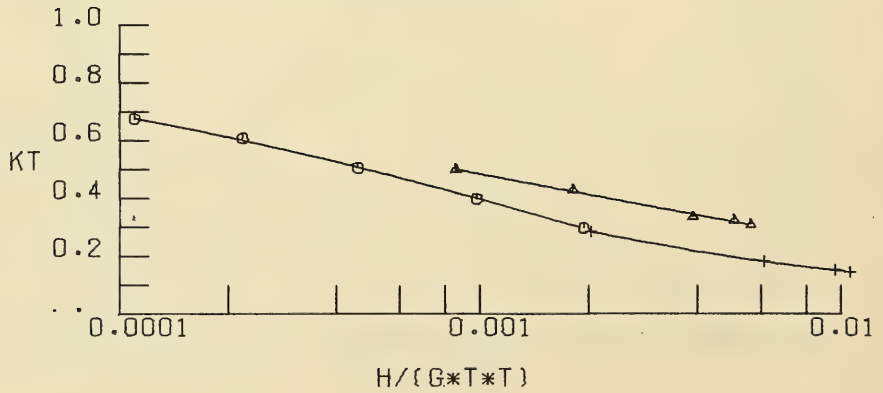
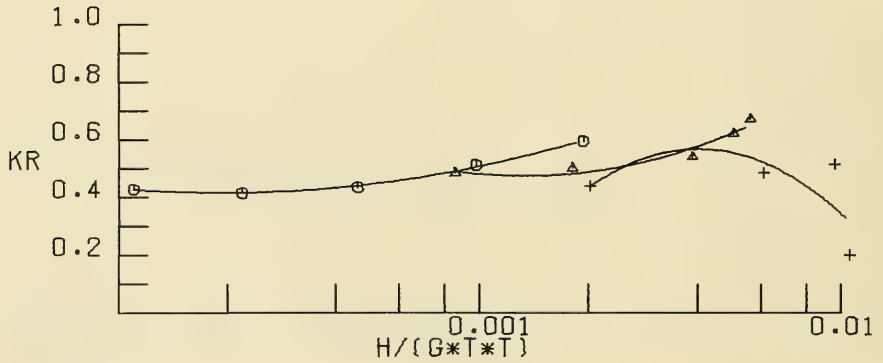
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 11

$D/(GT^2) = 0.016$

SYMBOL D/GT2

○ 0.0065
 △ 0.0161
 + 0.0555



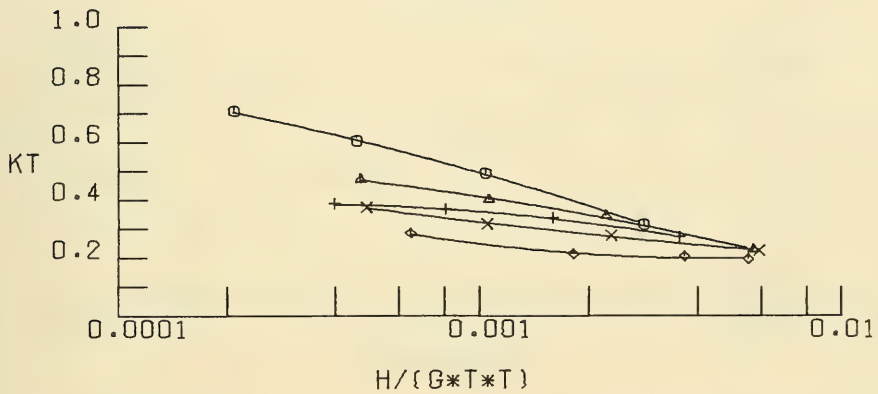
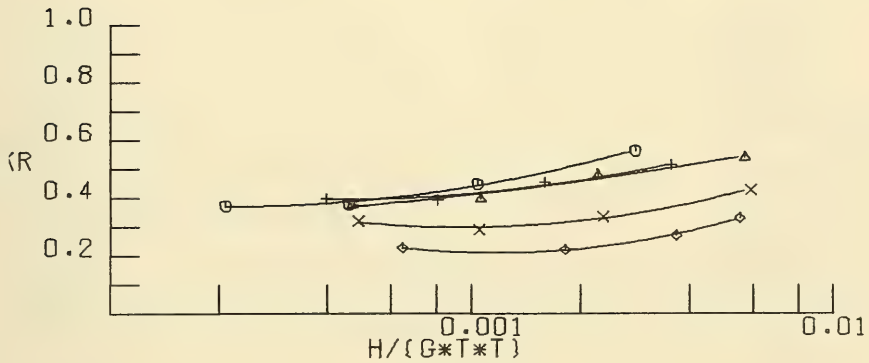
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 11

DS/HS= 0.75

SYMBOL D/GT2

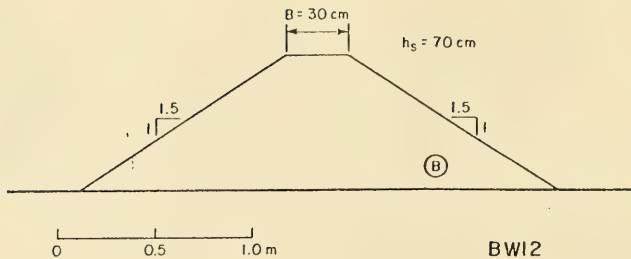
□ 0.0083
 ▲ 0.0133
 + 0.0157
 × 0.0231
 ◇ 0.0311



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

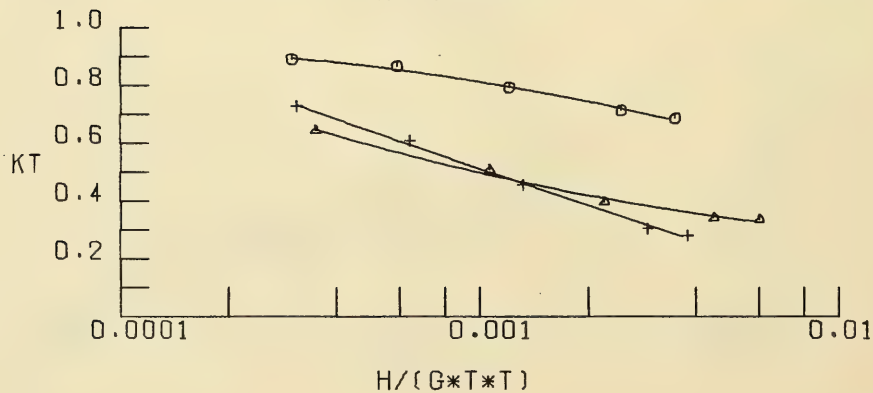
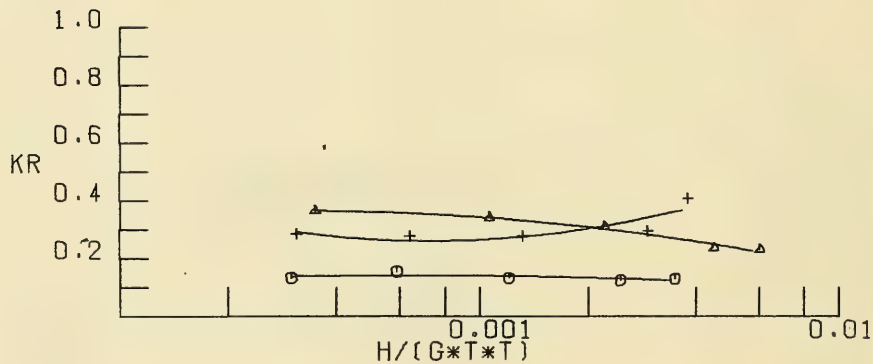
BREAKWATER 11

DS/HS= 0.51



SYMBOL DS/HS

○	1.07
△	0.86
+	0.64



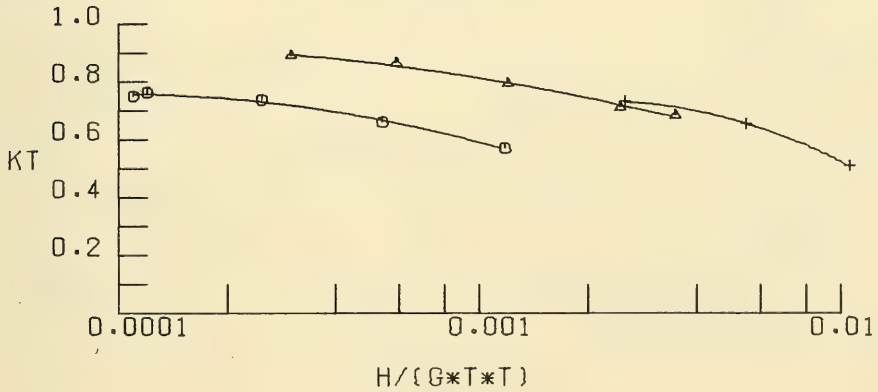
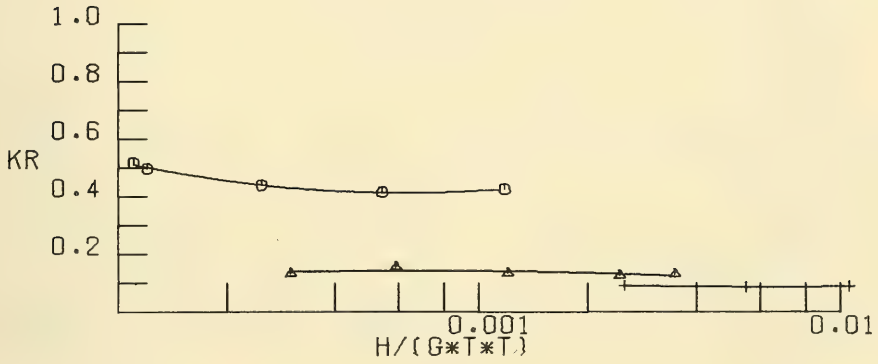
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 12

$D/(GT^2) = 0.016$

SYMBOL D/GT²

□ 0.0065
 ▲ 0.0161
 + 0.0550



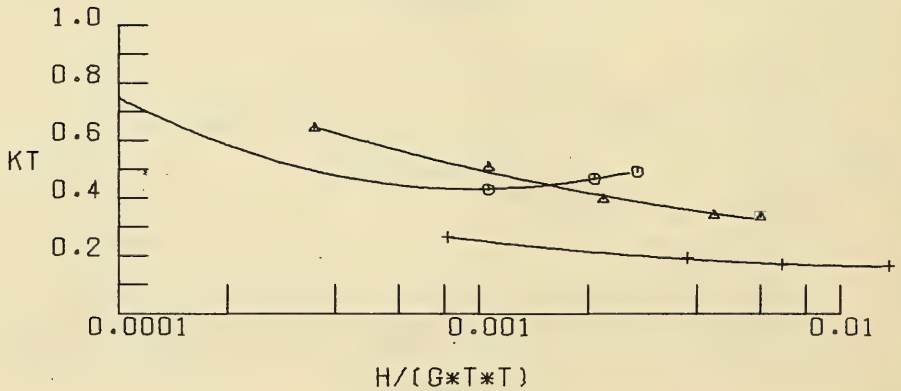
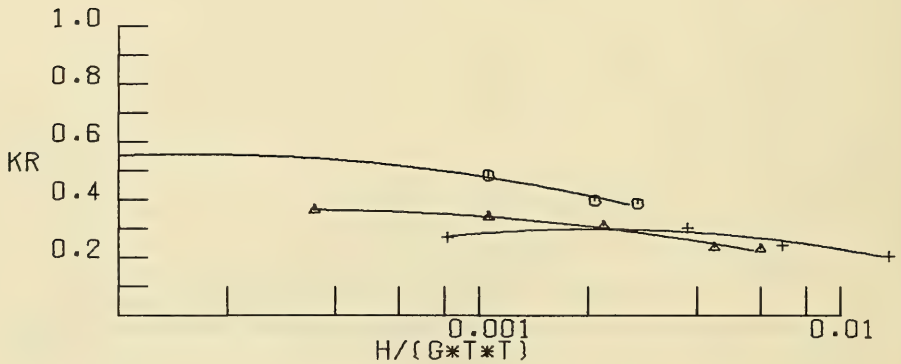
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 12

DS/HS= 1.07

SYMBOL D/GT2

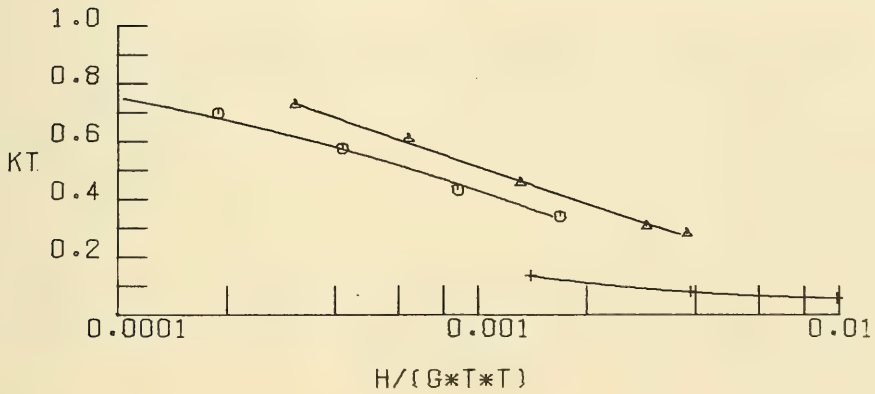
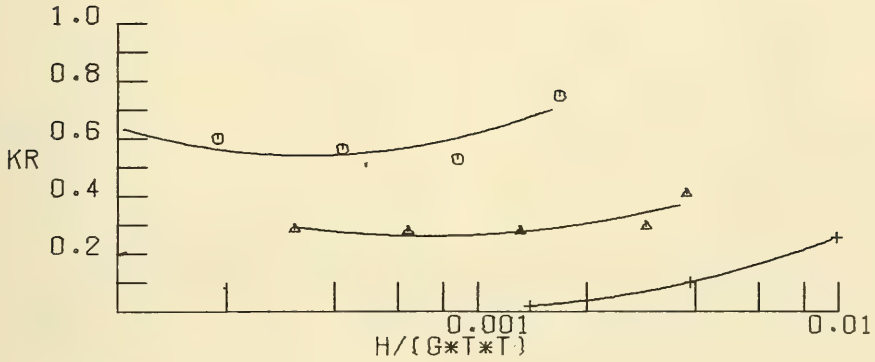
○ 0.0065
 ▲ 0.0161
 + 0.0555



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 12 DS/HS= 0.86

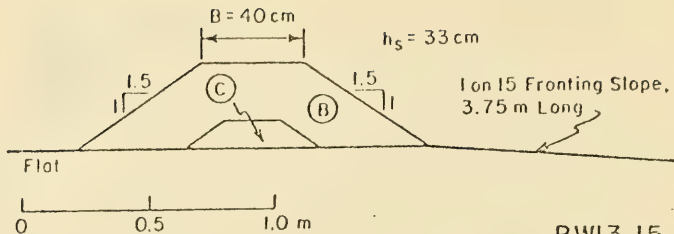
SYMBOL D/GT2

○ 0.0065
 ▲ 0.0161
 + 0.0555



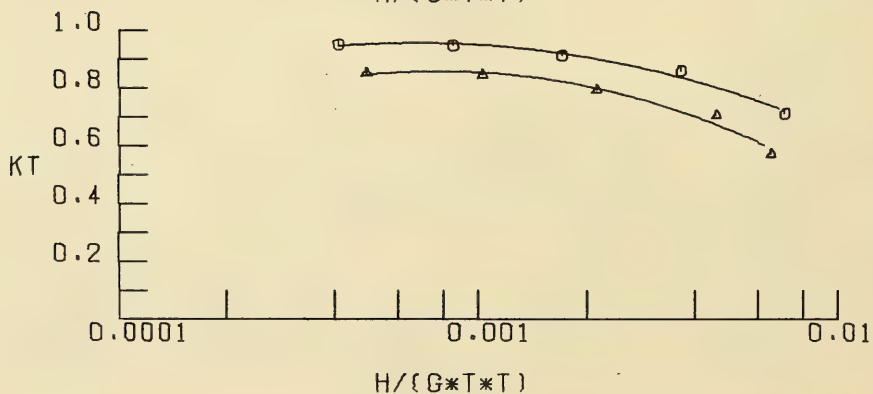
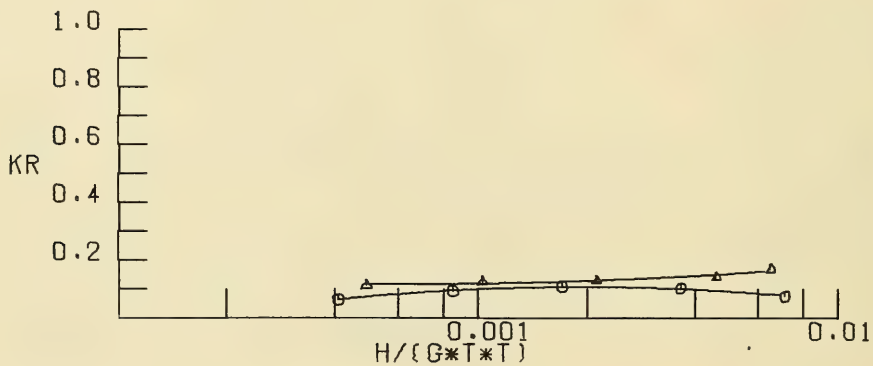
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 12 DS/HS= 0.64



SYMBOL DS/HS

\circ 1.82
 \triangle 1.36
 $+$ 1.06



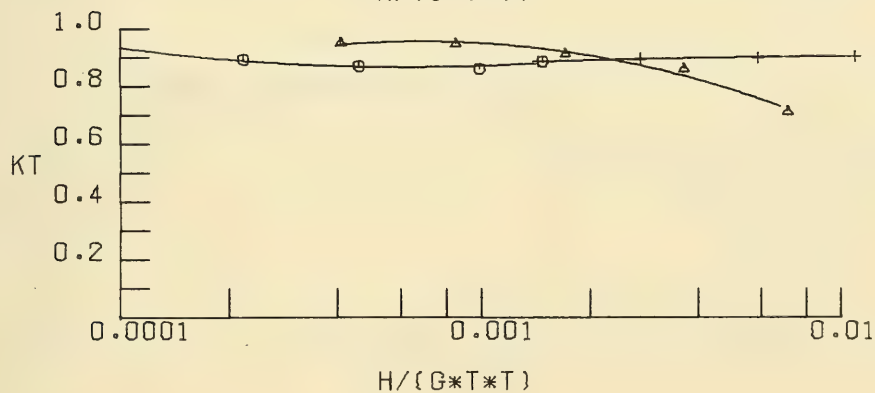
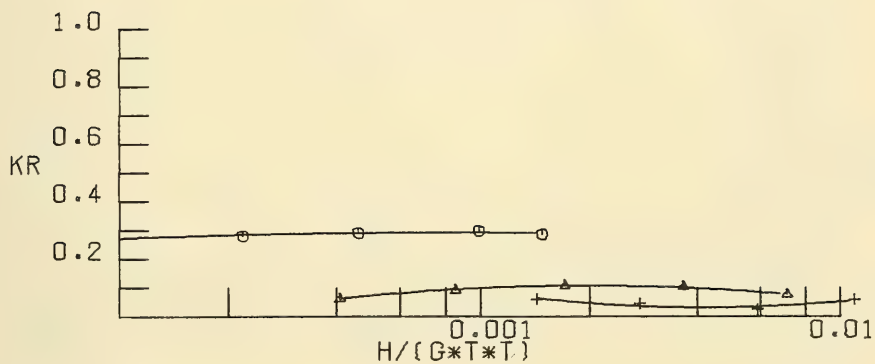
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 13

$D/(GT^2) = 0.016$

SYMBOL D/GT²

○ 0.0065
 △ 0.0161
 + 0.0555

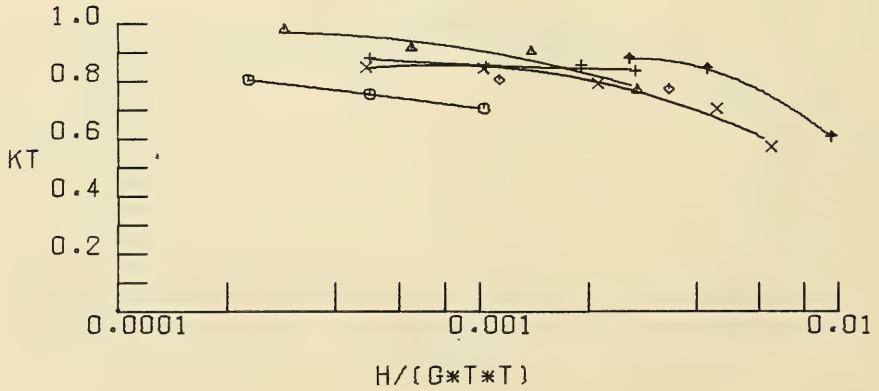
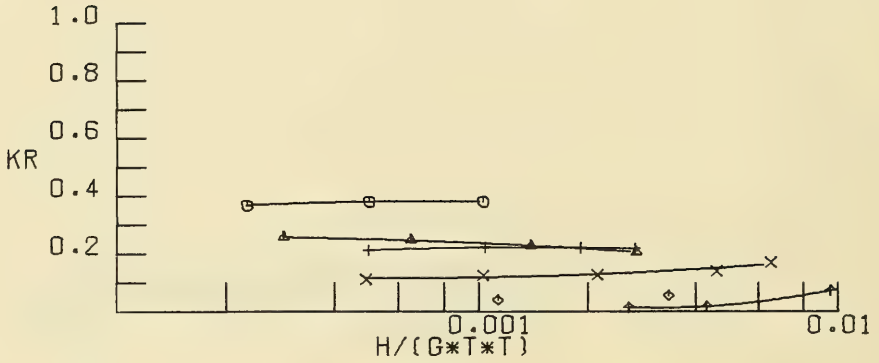


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 13 DS/HS= 1.82

SYMBOL D/GT2

□	0.0042
△	0.0065
+	0.0103
×	0.0161
◇	0.0353
†	0.0555

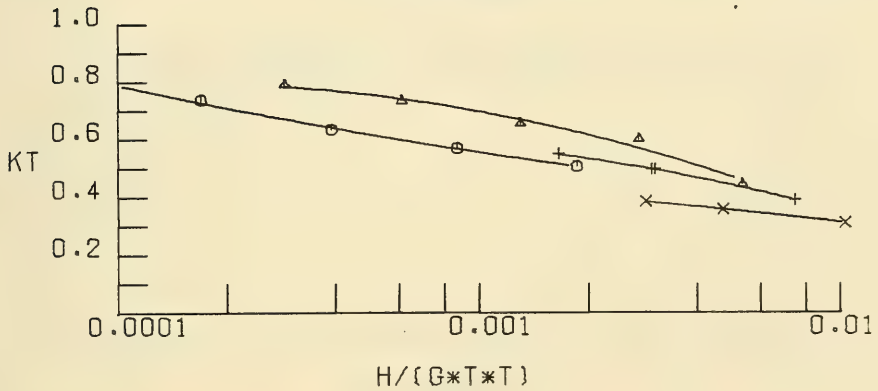
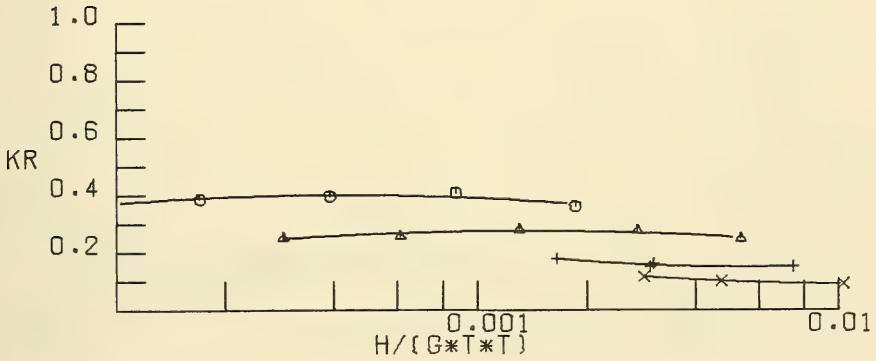


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 13 DS/HS= 1.36

SYMBOL D/GT^2

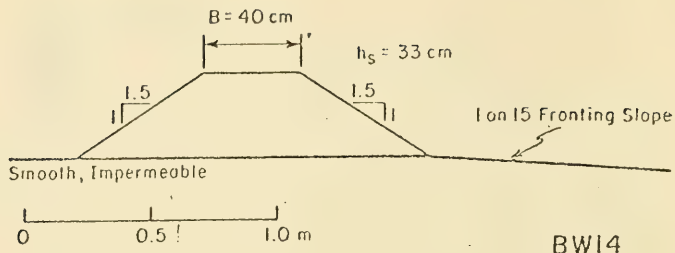
\square 0.0038
 \triangle 0.0094
 $+$ 0.0229
 \times 0.0324



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

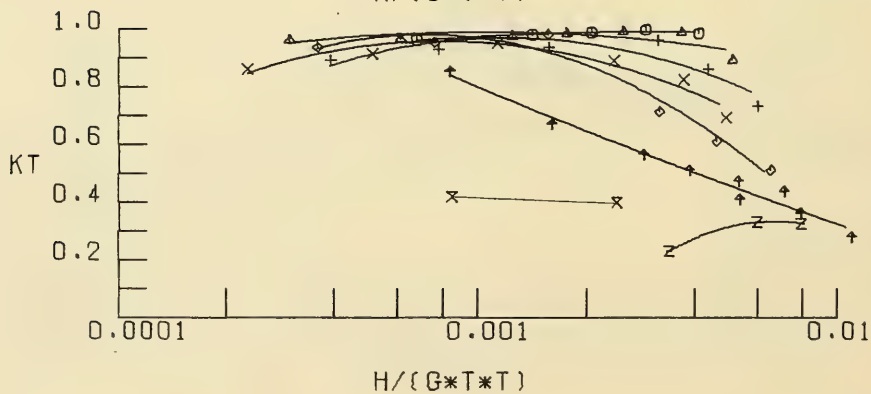
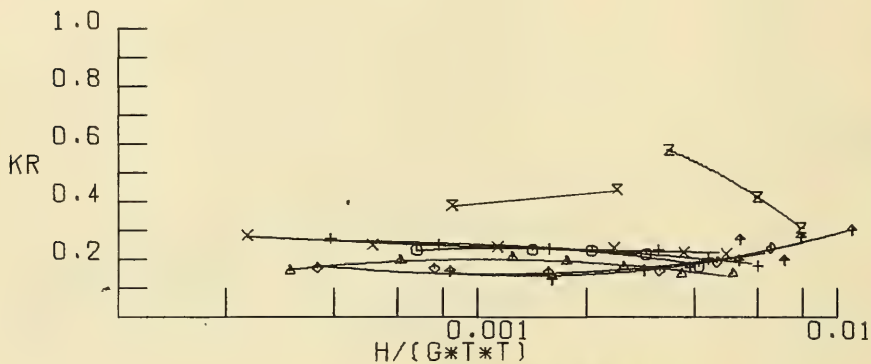
BREAKWATER 13

$DS/HS = 1.06$



SYMBOL DS/HS

○	1.97
△	1.82
+	1.67
×	1.52
◇	1.36
↑	1.21
×	1.06
Z	0.91



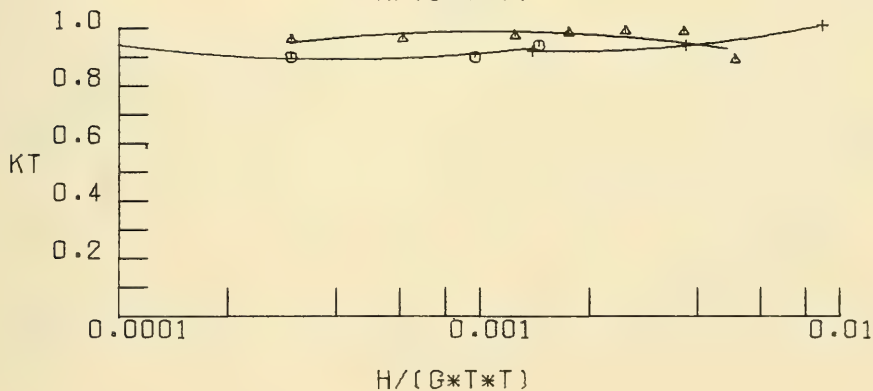
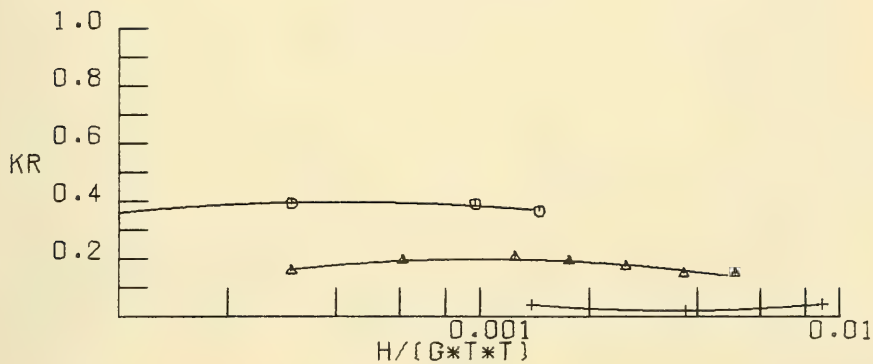
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 14

$D/(GT^2) = 0.016$

SYMBOL D/GT^2

○ 0.0065
 ▲ 0.0161
 + 0.0555

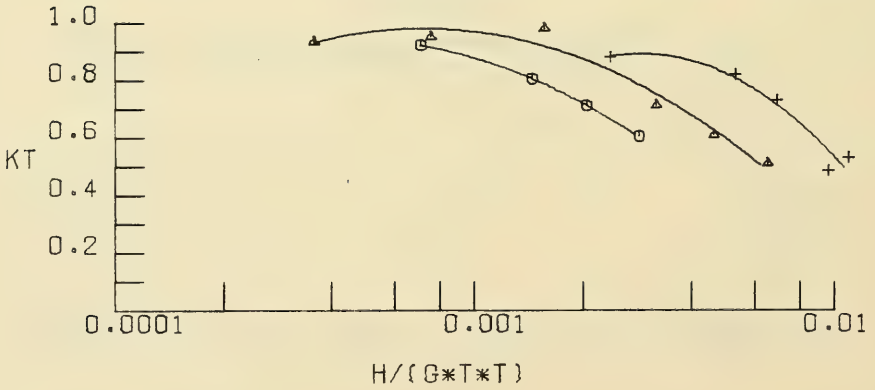
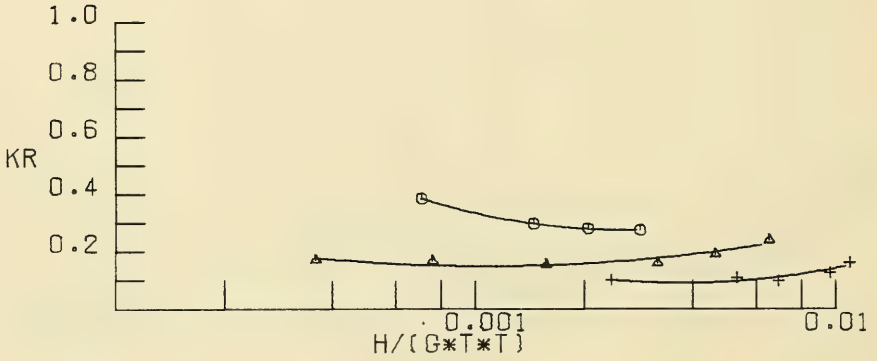


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 14 DS/HS= 1.82

SYMBOL D/GT2

○ 0.0065
 △ 0.0161
 + 0.0555



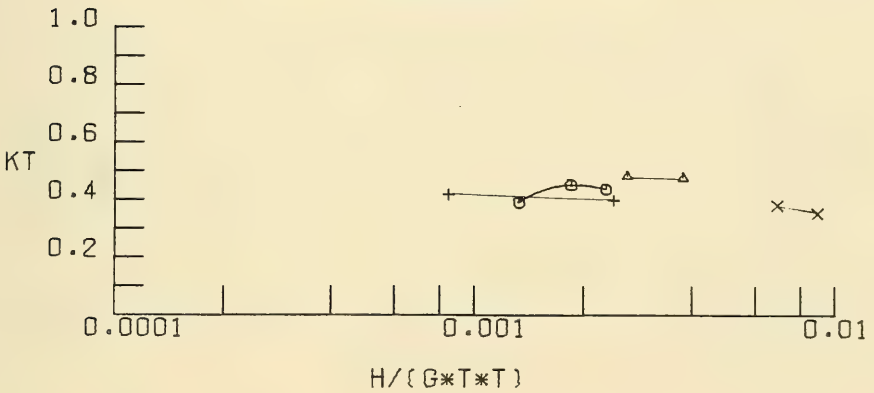
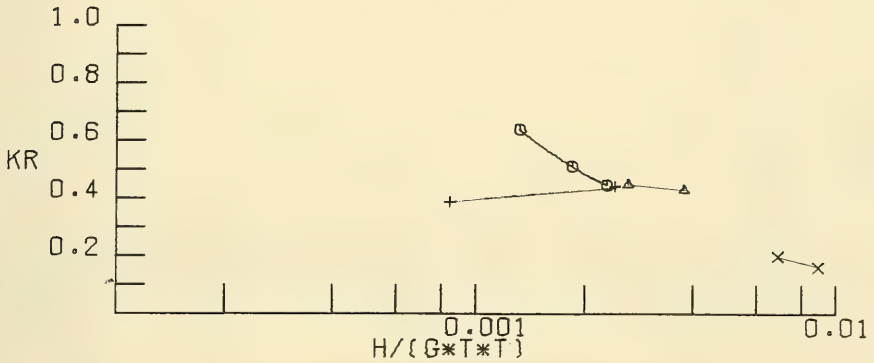
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 14

DS/HS= 1.36

SYMBOL D/GT2

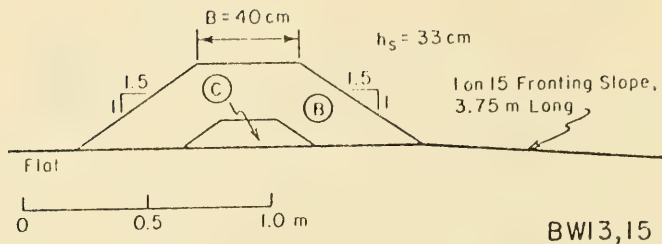
○	0.0038
△	0.0094
+	0.0161
x	0.0211



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

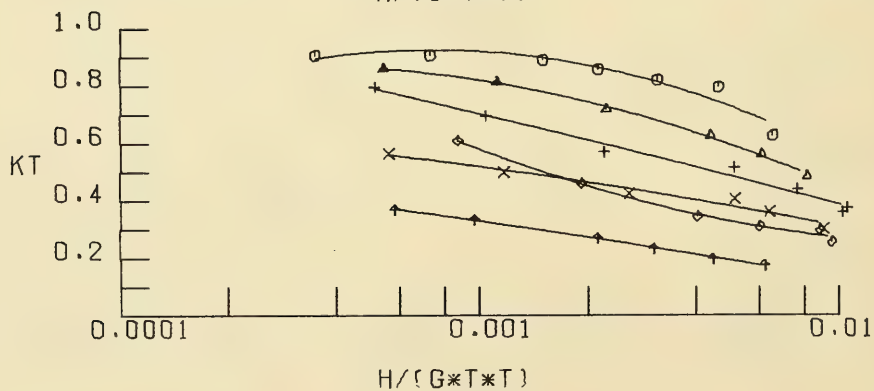
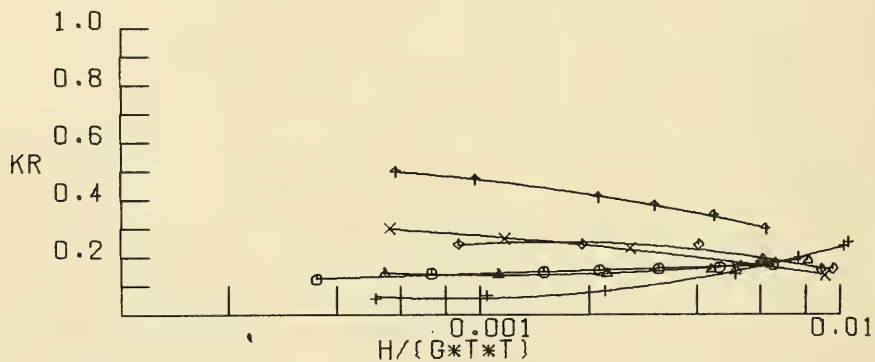
BREAKWATER 14

DS/HS= 1.06



SYMBOL D_S/H_S

○	1.36
△	1.21
+	1.06
×	0.91
◇	0.76
†	0.61



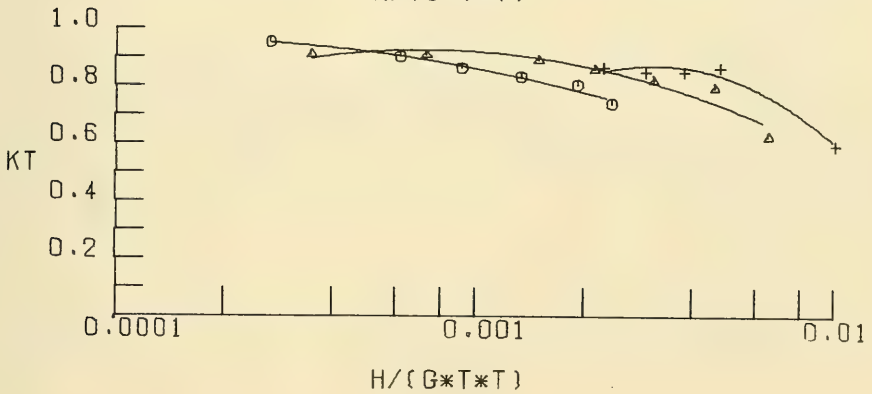
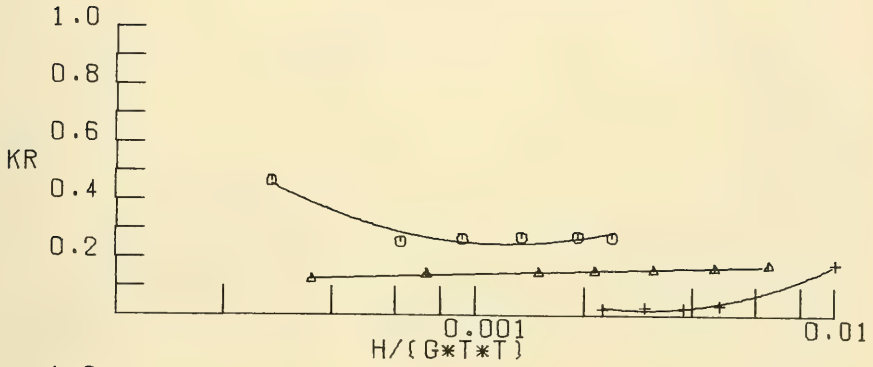
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 15

$D/(GT^2) = 0.016$

SYMBOL D/GT²

□	0.0059
△	0.0161
+	0.0555



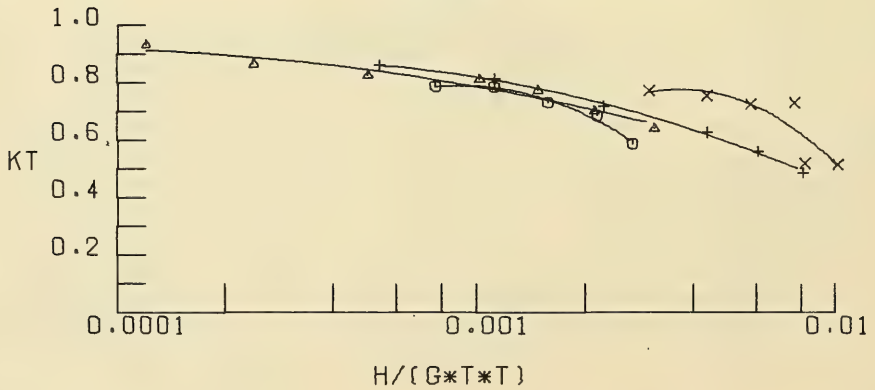
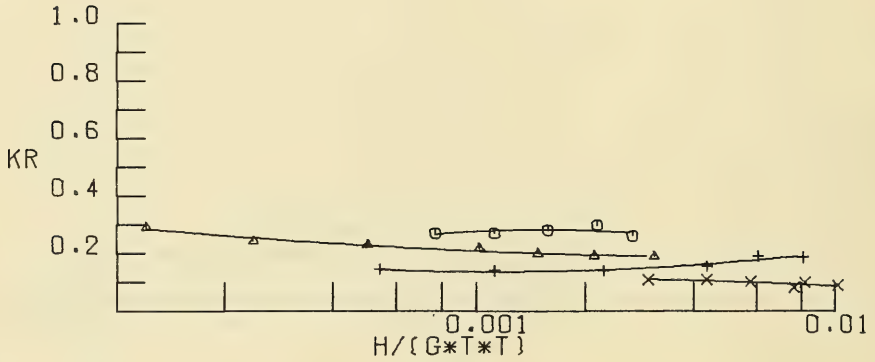
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 15

DS/HS= 1.36

SYMBOL D/GT2

○	0.0052
△	0.0065
+	0.0161
x	0.0552



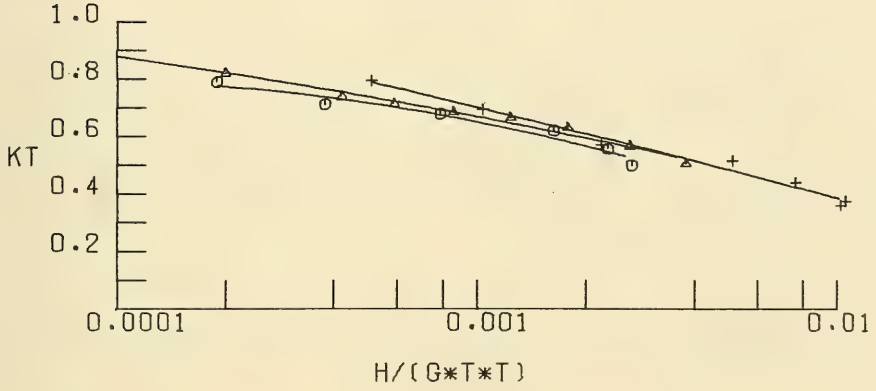
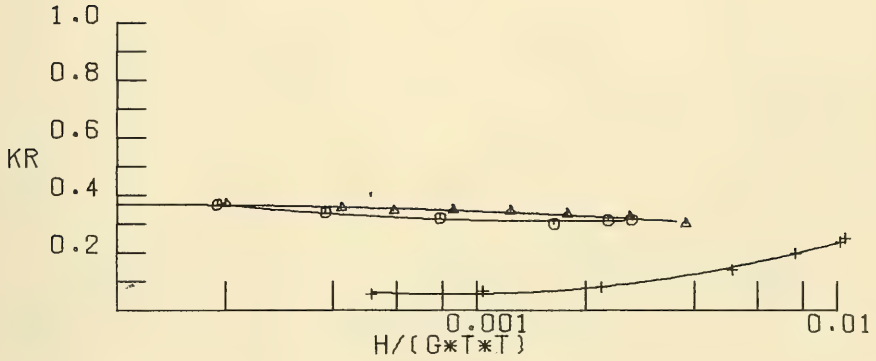
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 15

DS/HS= 1.21

SYMBOL D/GT²

○ 0.0046
 △ 0.0065
 + 0.0161

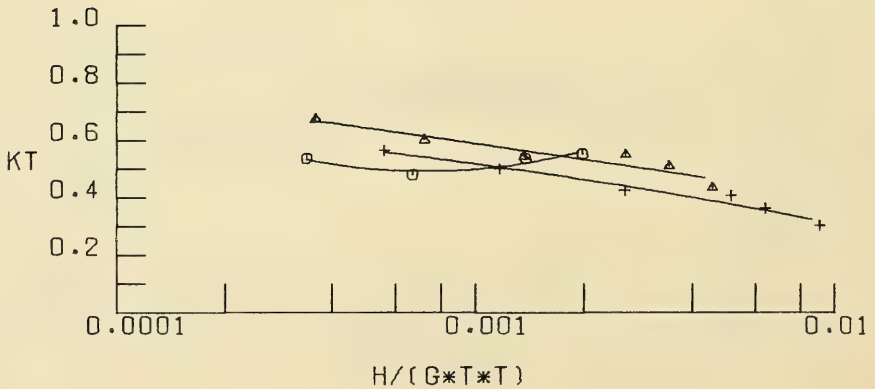
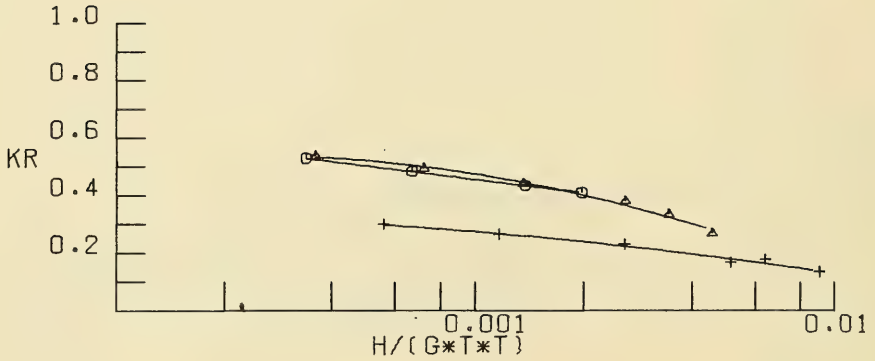


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 15 DS/HS= 1.06

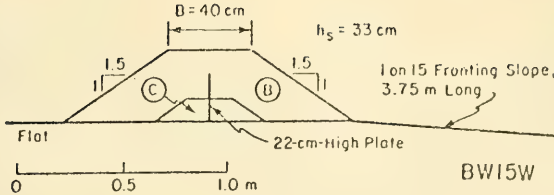
SYMBOL D/GT2

○ 0.0039
 ▲ 0.0065
 + 0.0161



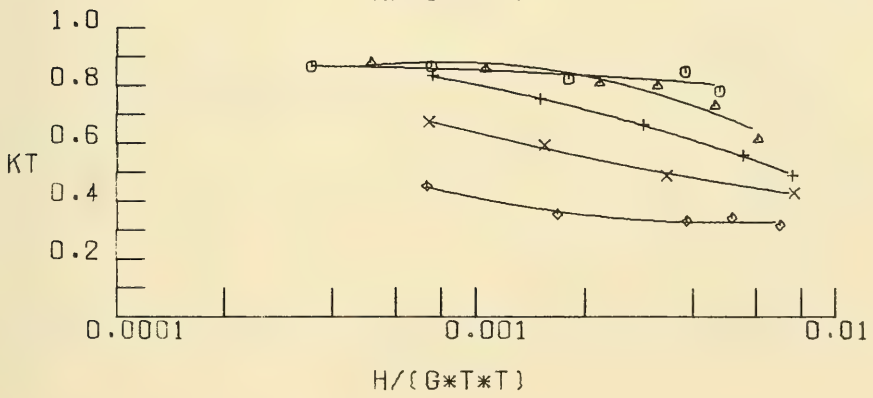
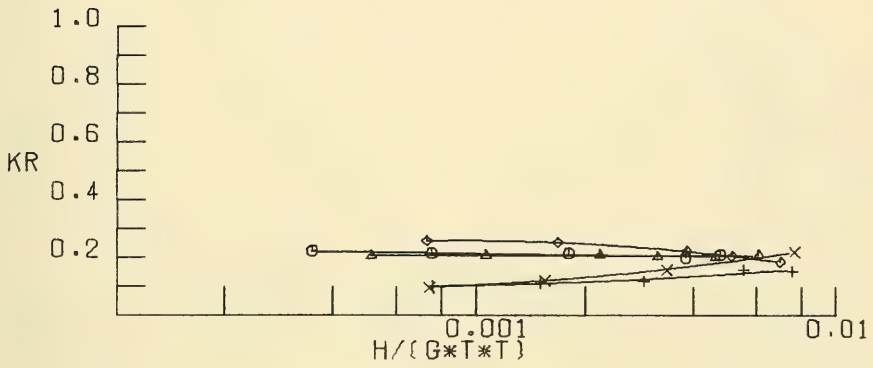
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 15 DS/HS= 0.91



SYMBOL DS/HS

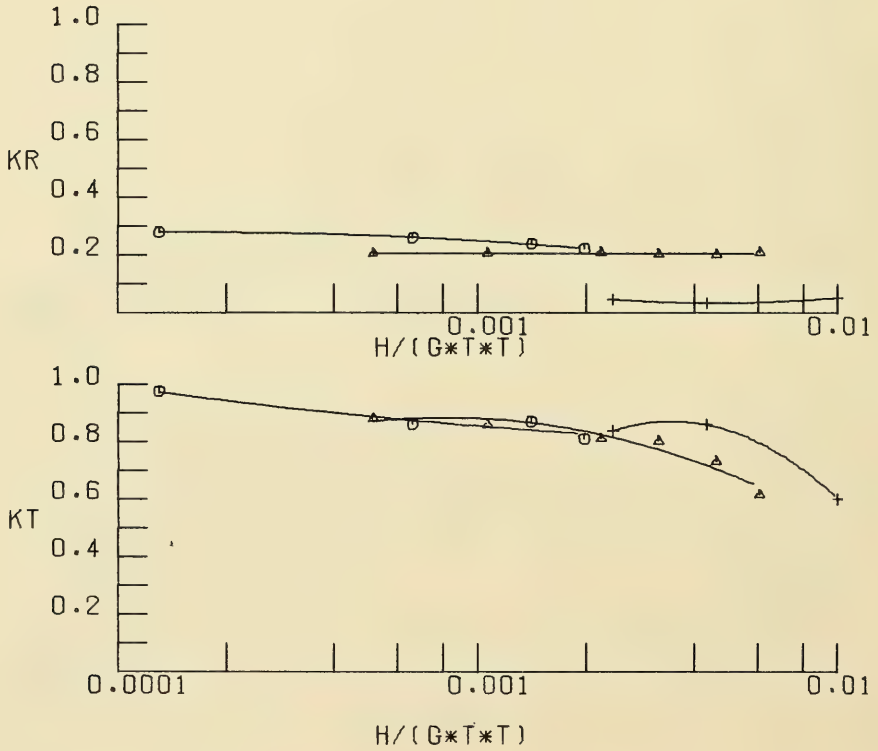
○	1.52
△	1.36
+	1.21
×	1.06
◇	0.91



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 15W $D/(GT^2)=0.016$

SYMBOL D/GT²

○ 0.0065
 ▲ 0.0161
 + 0.0555



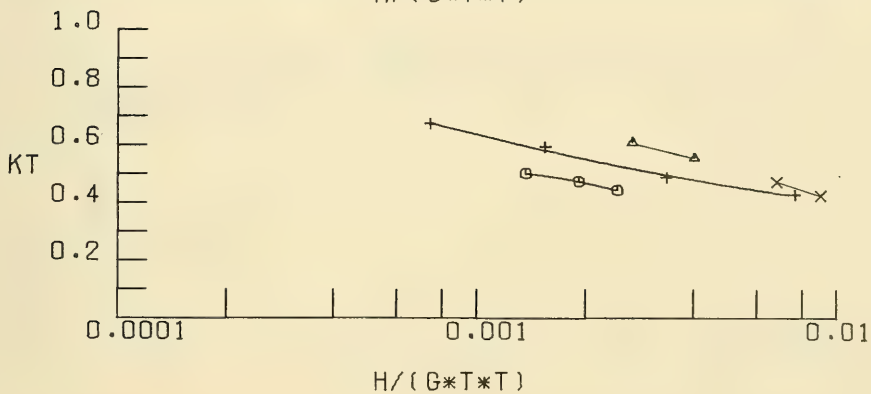
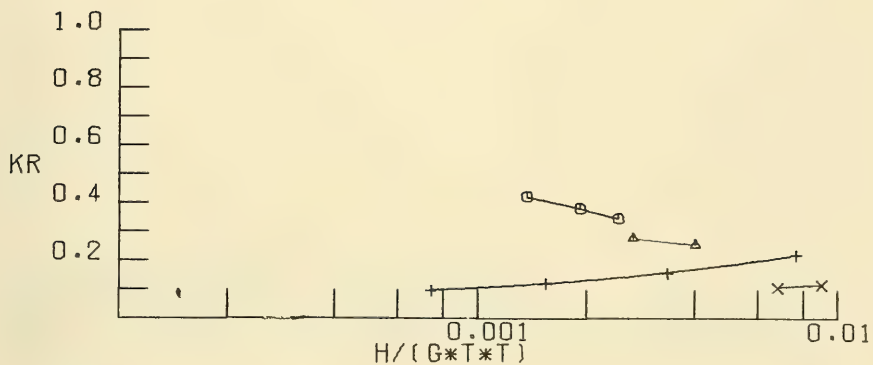
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 15W

DS/HS= 1.36

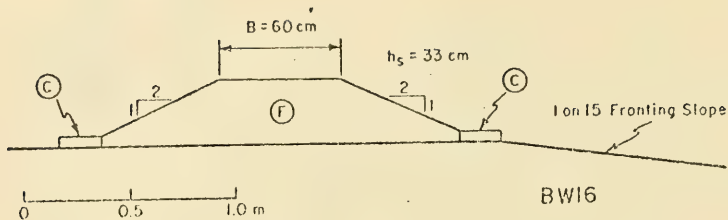
SYMBOL D/GT2

○	0.0038
△	0.0094
+	0.0161
×	0.0211



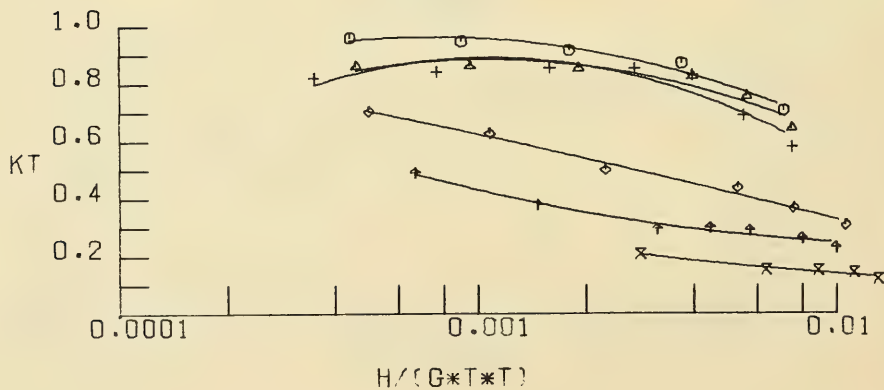
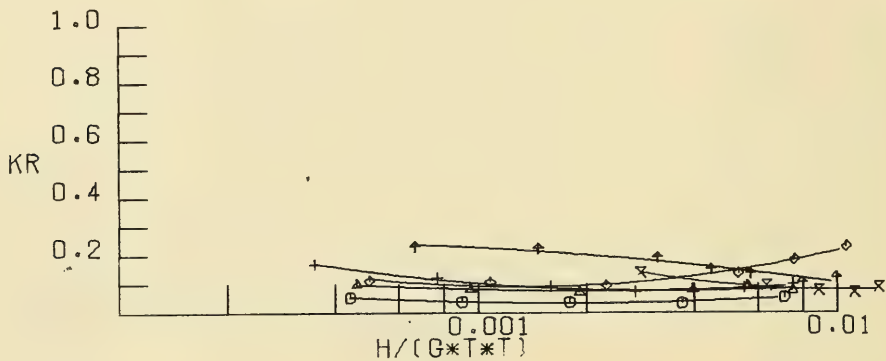
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 15W DS/HS= 1.06



SYMBOL DS/H_s

○	1.82
△	1.67
+	1.52
×	1.36
◇	1.06
†	0.91
×	0.76
z	0.61



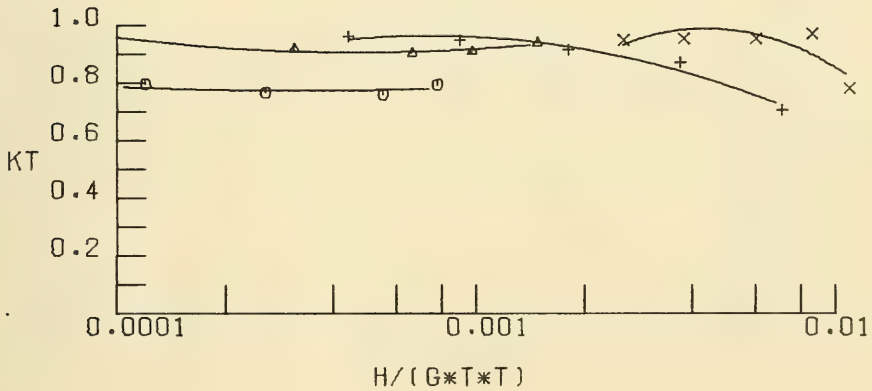
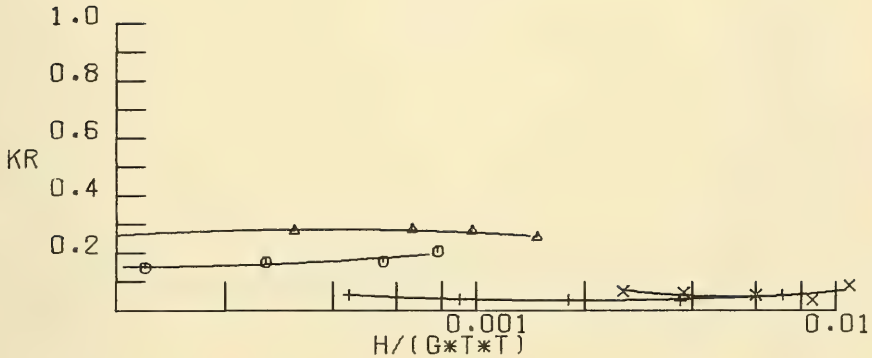
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 16

$D/(GT^2) = 0.016$

SYMBOL D/GT²

○ 0.0026
 ▲ 0.0065
 + 0.0161
 × 0.0555

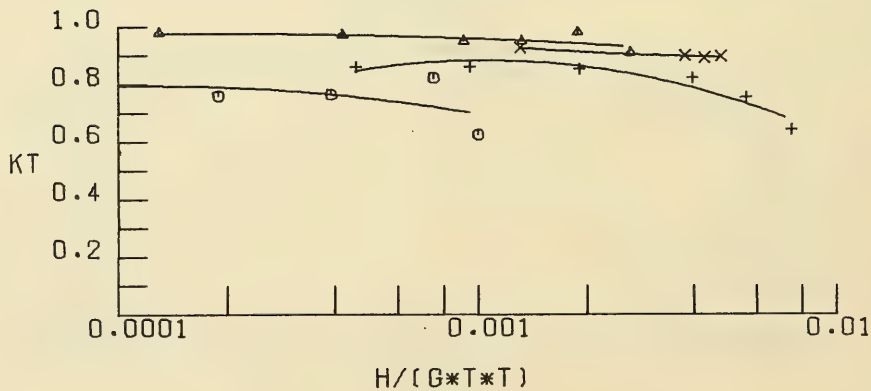
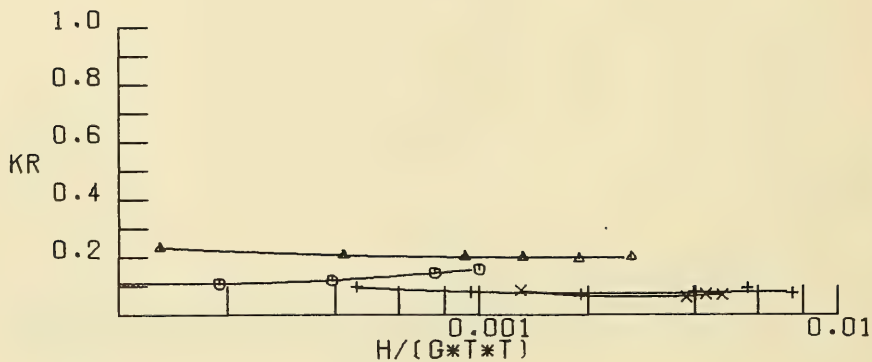


WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 16 DS/HS= 1.82

SYMBOL D/GT2

□	0.0026
△	0.0065
+	0.0160
x	0.0550



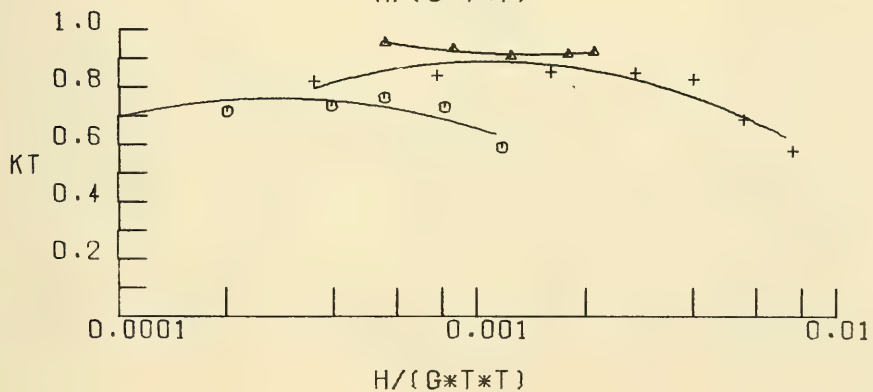
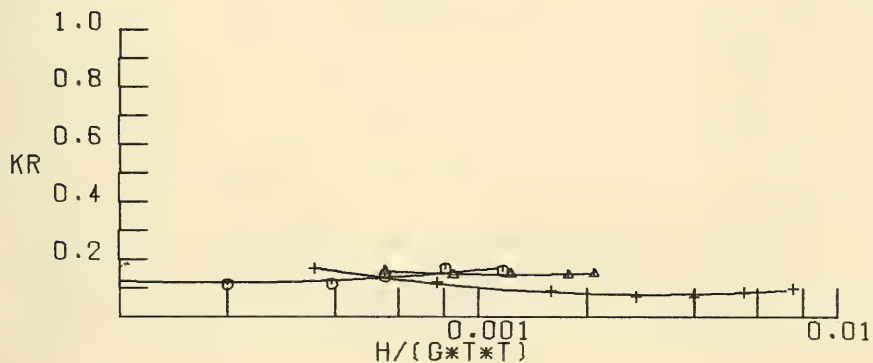
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 16

DS/HS= 1.67

SYMBOL D/GT²

○ 0.0025
 △ 0.0065
 + 0.0161



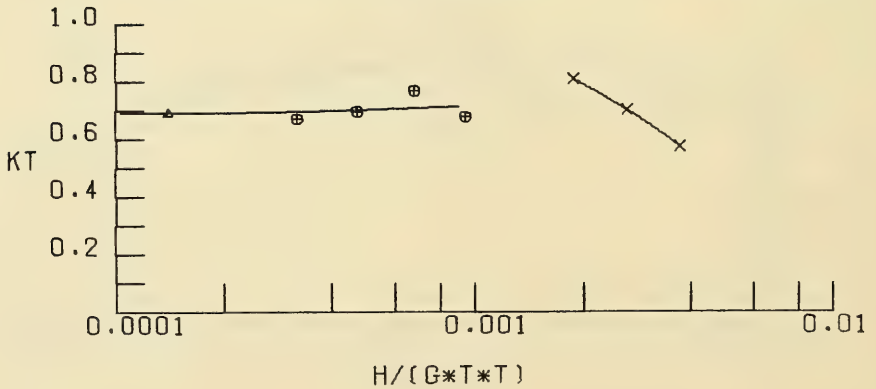
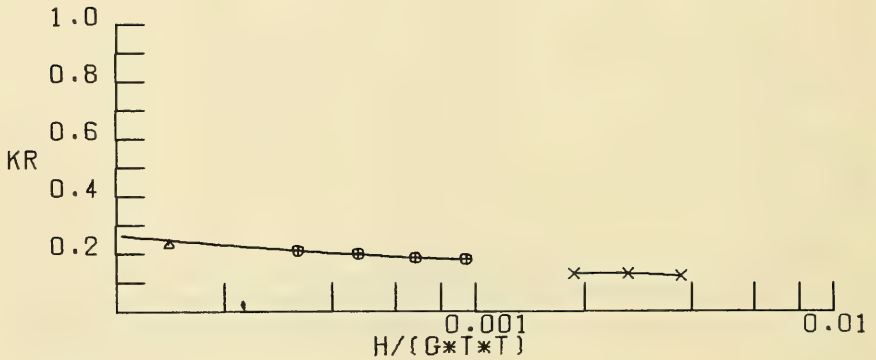
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 16

DS/HS= 1.52

SYMBOL D/GT2

⊖	0.0024
△	0.0022
+	0.0024
×	0.0065



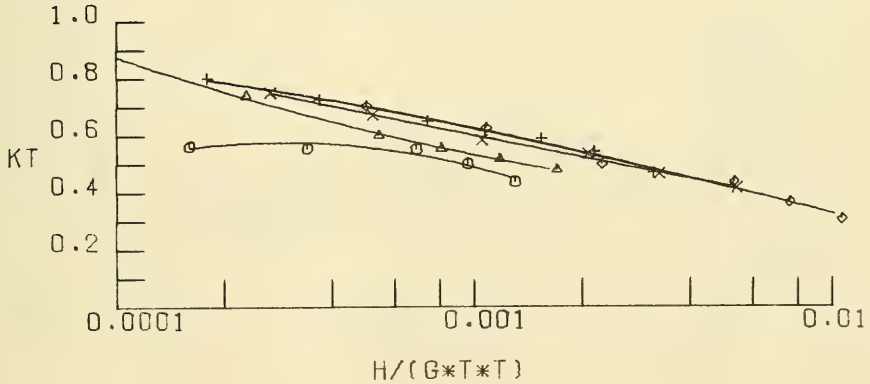
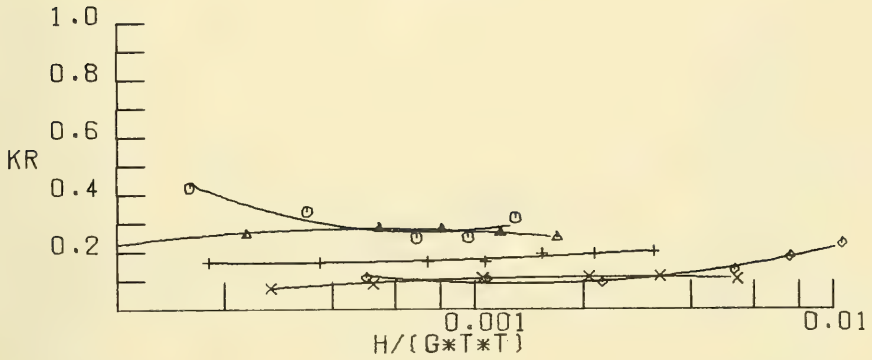
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 16

DS/HS= 1.36

SYMBOL D/GT^2

○	0.0022
△	0.0037
+	0.0065
×	0.0131
◇	0.0161



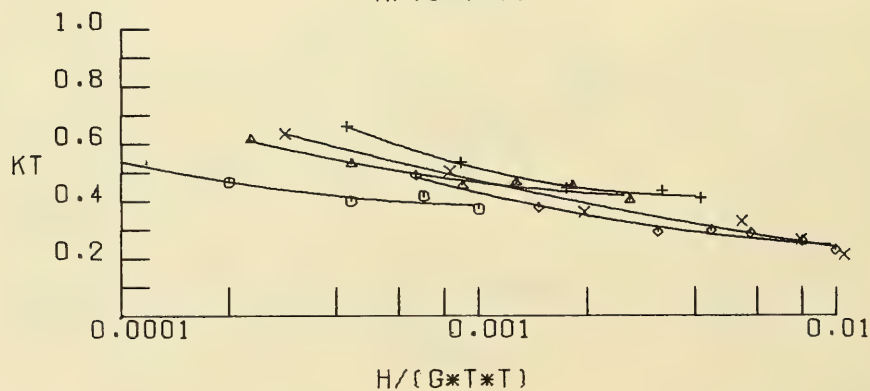
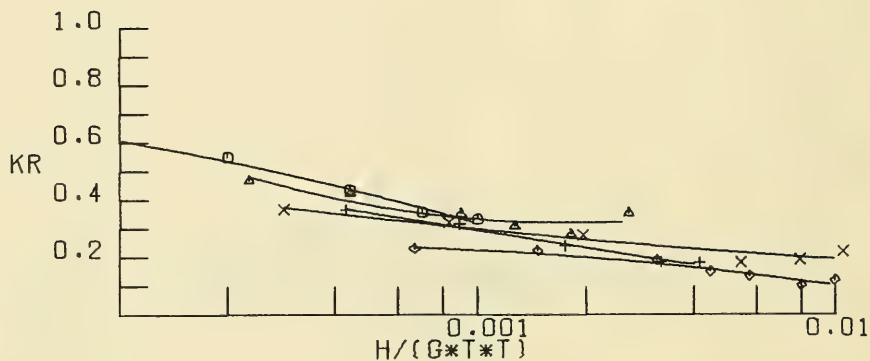
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 16

$DS/HS = 1.06$

SYMBOL D/GT^2

\square 0.0020
 \triangle 0.0037
 $+$ 0.0065
 \times 0.0131
 \diamond 0.0161



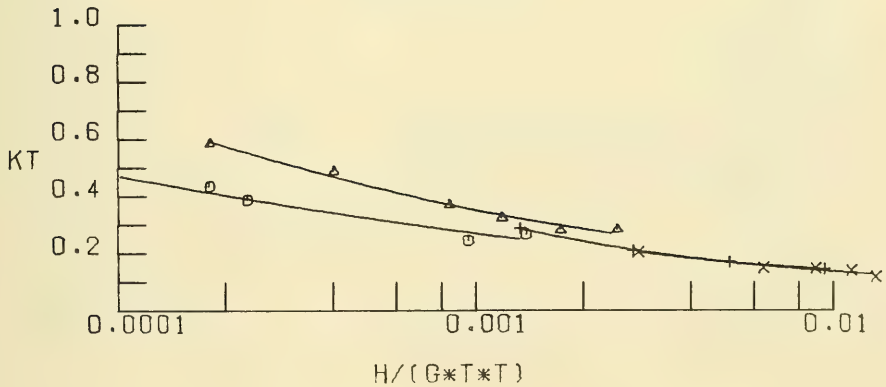
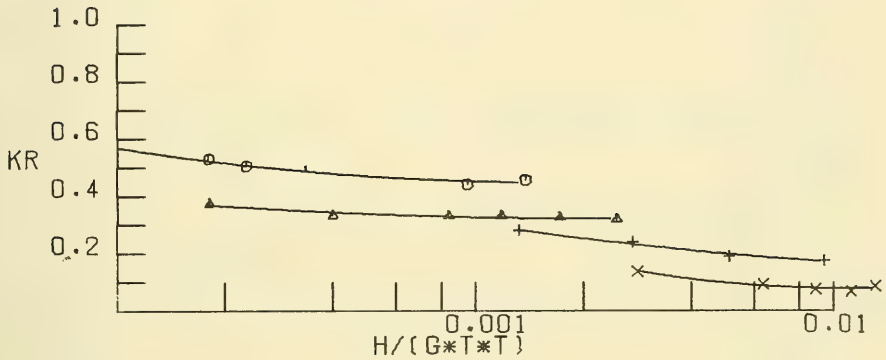
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 16

$DS/HS = 0.91$

SYMBOL D/GT2

○	0.0019
△	0.0037
+	0.0130
x	0.0161



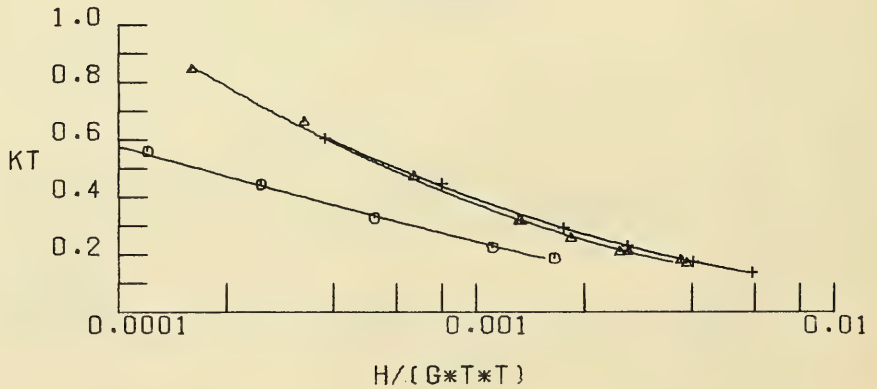
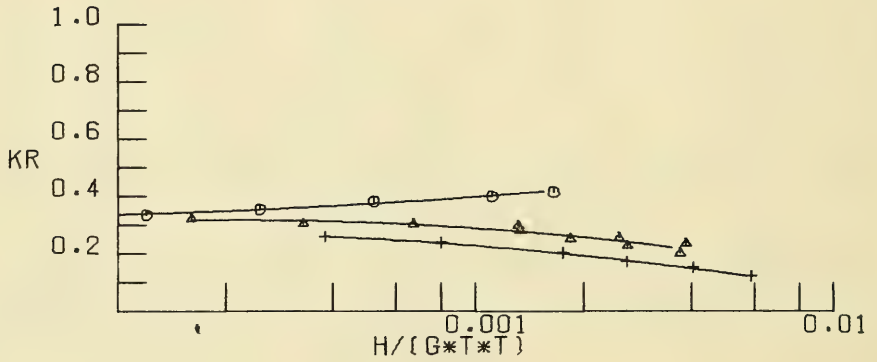
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 16

DS/HS= 0.76

SYMBOL D/QT2

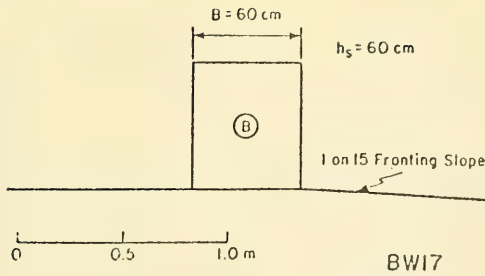
□ 0.0017
 ▲ 0.0037
 + 0.0065



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

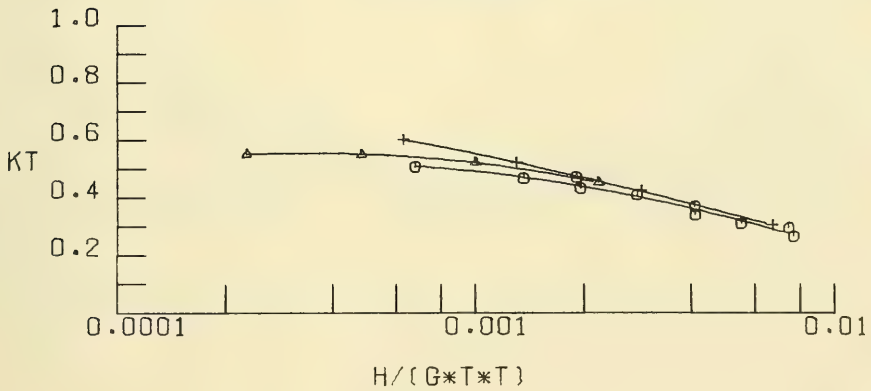
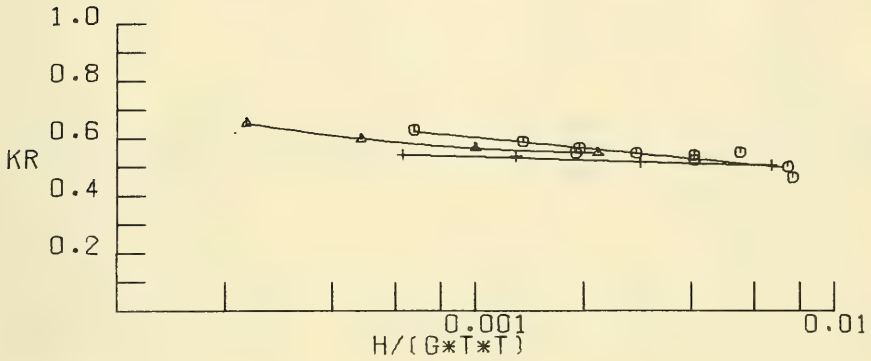
BREAKWATER 16

DS/HS= 0.61



SYMBOL DS/HS

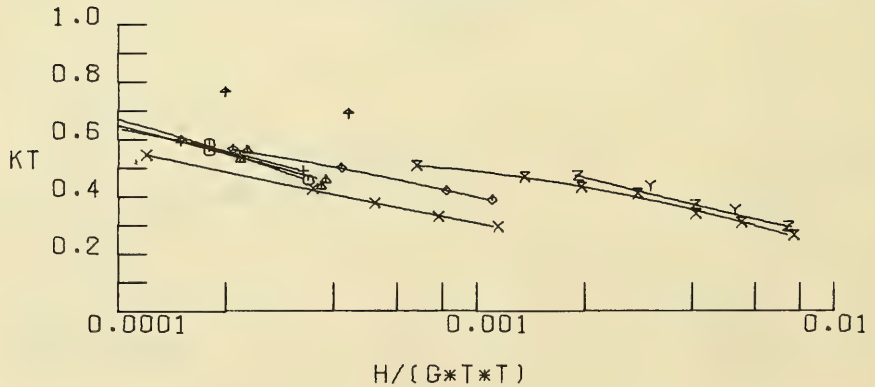
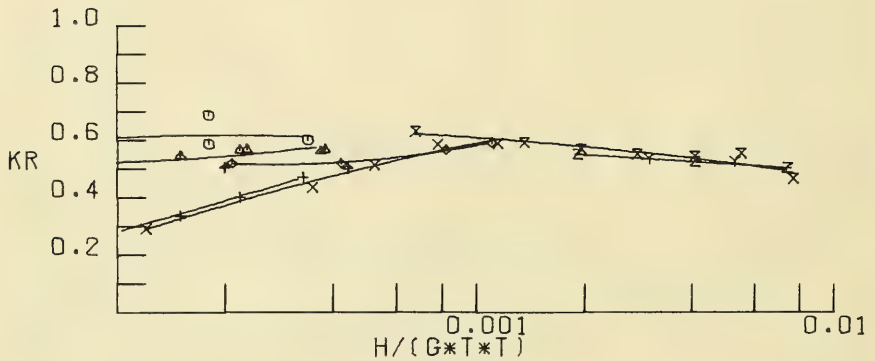
○ 0.83
 ▲ 0.75
 + 0.58



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS
 BREAKWATER 17 $D/(GT^2) = 0.016$

SYMBOL D/GT2

⊙	0.0010
△	0.0013
+	0.0019
×	0.0025
◇	0.0037
+	0.0065
×	0.0146
Z	0.0161
Y	0.0227



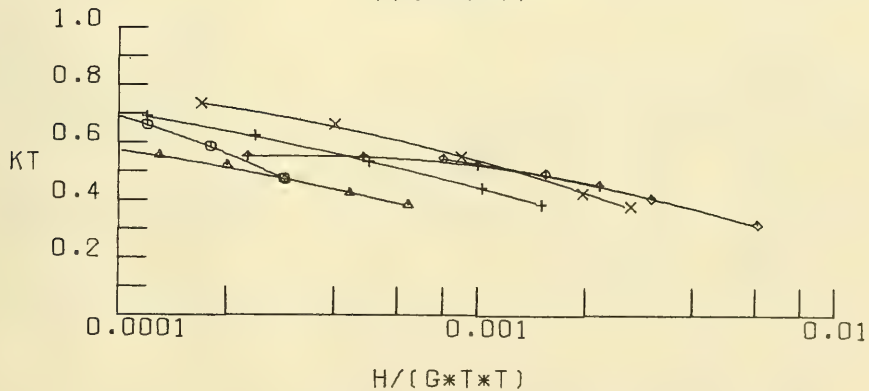
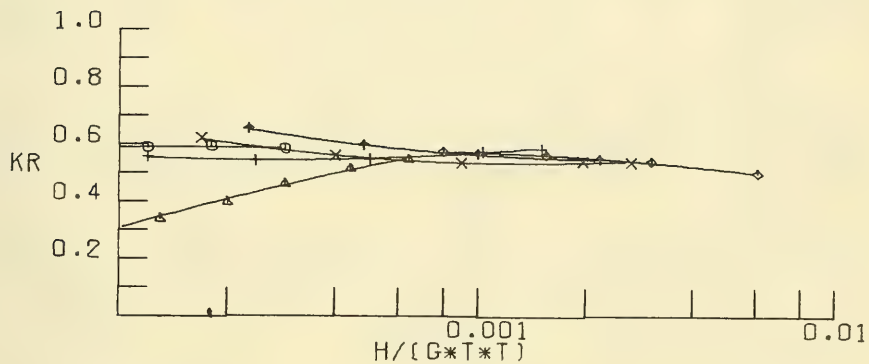
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 17

DS/HS= 0.83

SYMBOL D/GT²

○	0.0010
△	0.0019
+	0.0037
×	0.0065
◇	0.0130
†	0.0161



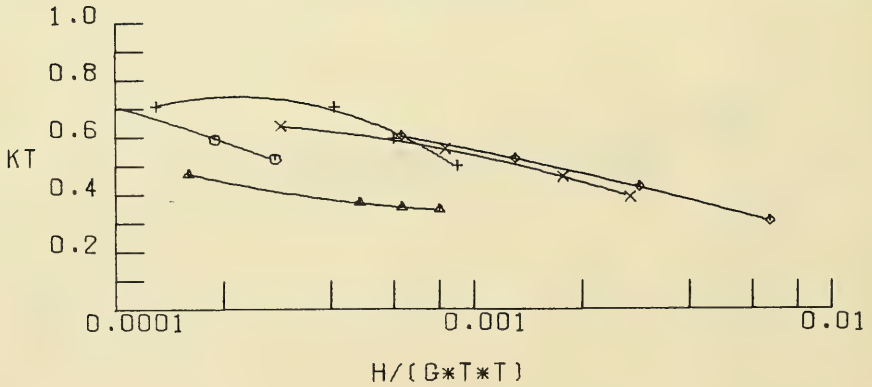
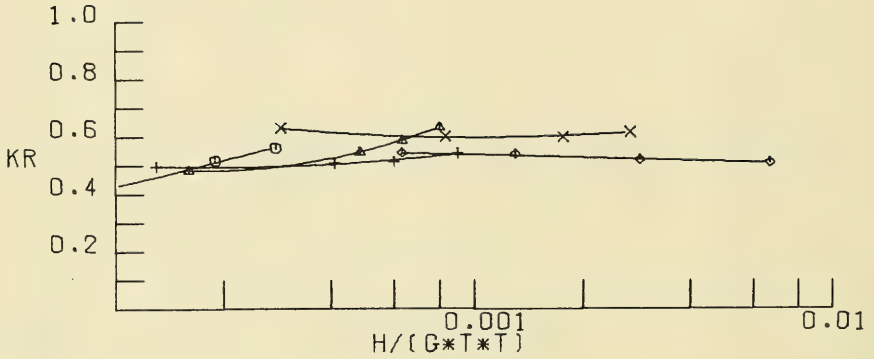
WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 17

DS/HS= 0.75

SYMBOL D/GT2

□	0.0010
△	0.0019
+	0.0037
×	0.0065
◇	0.0161



WAVE TRANSMISSION AND REFLECTION COEFFICIENTS

BREAKWATER 17

DS/HS= 0.58

APPENDIX F

DOCUMENTATION OF THE PROGRAM OVER (752X6R1CY0)

1. Purpose. This FORTRAN program estimates wave transmission by overtopping coefficients and transmitted wave heights for smooth impermeable breakwaters. The method can be used for subaerial and submerged breakwaters with structure seaward-face slopes from vertical to 1 on 3. It is recommended for values of $d_g/(gT^2) \leq 0.03$.

2. Mathematical Method and Procedure. The program uses the methods developed in this report. The procedure is to estimate wave runup on smooth impermeable slopes, R , using the equation

$$R = HC_1 \left(\frac{0.123 L}{H} \right) (C_2 \sqrt{H/d} + C_3)$$

where C_1 , C_2 , and C_3 are empirical coefficients related to the structure slope, H is incident wave height, d is water depth, and L is the local wavelength. Runup on rough slopes is estimated using

$$R = \frac{Ha\xi}{(1 + b\xi)}$$

where a and b are empirical coefficients and ξ is the surf parameter given by

$$\xi = \frac{\tan \theta}{\sqrt{\frac{H}{L_0}}}$$

where θ is the angle of the front face of the breakwater and L_0 is the deepwater wavelength.

A wave transmission by overtopping coefficient, C , is estimated from

$$C = 0.51 - \frac{0.11 B}{h}$$

where B is the breakwater crest width and h the structure height. The transmission by overtopping coefficient, K_{TO} , is determined from

$$K_{TO} = C \left(1 - \frac{F}{R} \right)$$

where F is the breakwater freeboard. For submerged breakwaters with a 1 on 15 fronting slope the equation

$$K_{TO} = C \left(1 - \frac{F}{R} \right) - (1 - 2C) \left(\frac{F}{R} \right)$$

is used.

The transmitted wave height, H_T , is given by

$$H_T = K_{TO} H$$

3. Program Variables. A description of all program variables is presented in Table F-1.

4. Input. A description and an example of the input parameters are given in Table F-2. Note that all measurements are in metric units.

5. Output. Program output includes a summary table of input information together with the predicted ratio of the breakwater freeboard to wave runup, the wave transmission by overtopping coefficient, and the predicted transmitted wave height. An example output corresponding to the input is shown in Table F-3.

6. Program Listing. A listing of the program is shown in Table F-4. The subroutine LENGTH finds the value of d/L given d/L_0 by using linear wave theory.

Table F-1. Variables used in the program OVER.

Variable	Description
AC	a; rough-slope runup coefficient
BC	b; rough-slope runup coefficient
B	breakwater crest width (meter)
BH	B/h
C	transmission by overtopping coefficient = $0.51 - 0.11 B/h$
CA, CB, CC	runup coefficient lookup tables
C1, C2, C3	smooth-slope runup coefficients (a function of slope) $R/H = C_1(0.123 L/H) (C_2 \sqrt{H/d} + C_2)$
DGT2	$d_g/(gT^2)$
DL	d_g/L
DLO	d_g/L_0
DS	structure water depth, d_g
F	breakwater freeboard = $h - d_g$
FR	F/R
H	incident wave height, H
HGT2	$H/(gT^2)$
HMAX	depth-limited maximum wave height = $0.78 d_g$
HS	structure height, h_g
HT	transmitted wave height
I	counter index
IFRONT	flag to indicate the presence of a fronting slope (IFRONT = 1 for fronting slope of 1 on 15)
KTO	wave transmission by overtopping coefficient
L	wavelength
N	number of wave conditions of interest
P	linear interpolation factor to find C1, C2, C3
R	predicted smooth-slope runup
RH	R/H
SURF	the surf parameter = $\tan \theta / \sqrt{H/L_0}$
T	wave period (second)
TANA	lookup table of structure slopes corresponding to CA, CB, CC
TANT	tangent of the seaward face of the breakwater = $\tan \theta$

Table F-2. Input to the program OVER.

Card	Format	Description
1	I2	number of breakwaters
2	I2	number of wave conditions of interest <ul style="list-style-type: none"> ● equals 1 if breakwater has a 1 on 15 fronting slope seaward of the structure
	4X	
	F10.5	tangent of breakwater seaward slope <ul style="list-style-type: none"> ● breakwater crest width (m) ● breakwater structure height (m) ● water depth at toe of the structure (m) ● rough-slope runoff parameter, a (a = 0 for smooth slopes) ● rough-slope runoff parameter, b
3	F10.5	wave period (s) <ul style="list-style-type: none"> ● incident wave height (in)
(one card per wave condition)		
(repeat card types 2 and 3 for each breakwater)		

Sample input

14.0	0.667	1.53	4.6	3.56	0.	0.
7.9	0.2					
7.9	0.4					
7.9	0.6					
7.9	0.8					
7.9	1.0					
7.9	1.2					
7.9	1.4					
7.9	1.6					
7.9	1.8					
7.9	2.0					
7.9	2.2					
7.9	2.4					
7.9	2.6					
7.9	2.8					

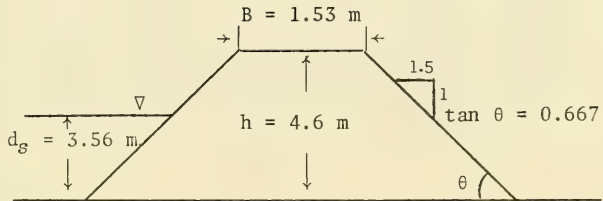


Table F-3. Sample output from the program OVER.

PREDICTION OF WAVE TRANSMISSION COEFFICIENTS FOR
AN IMPERMEABLE BREAKWATER

NUMBER OF WAVE CONDITIONS = 14
 IFRONT = 0
 TAN(SLOPE) = .667
 BREAKWATER TOP WIDTH(M) = 1.530
 STRUCTURE HEIGHT(M) = 4.600
 WATER DEPTH(M) = 3.560
 FREEBOARD(M) = 1.040
 COEFFICIENT OF OVERTOPPING C_o = .473

C₁ = 1.9910
 C₂ = .4980
 C₃ = .1850

T (SEC)	D/GT2	H (M)	H/GT2	H/H	F/R	K _{TU}	HT (M)
7.900	.0058	.200	.00033	1.594	3.261	0.000	0.000
7.900	.0058	.400	.00065	1.899	1.369	0.000	0.000
7.900	.0058	.600	.00098	2.079	.834	.079	.047
7.900	.0058	.800	.00131	2.197	.592	.193	.155
7.900	.0058	1.000	.00164	2.278	.456	.257	.257
7.900	.0058	1.200	.00196	2.334	.371	.298	.357
7.900	.0058	1.400	.00229	2.371	.313	.325	.455
7.900	.0058	1.600	.00262	2.394	.272	.345	.552
7.900	.0058	1.800	.00294	2.406	.240	.360	.648
7.900	.0058	2.000	.00327	2.410	.216	.371	.743
7.900	.0058	2.200	.00360	2.407	.196	.380	.837
7.900	.0058	2.400	.00392	2.399	.181	.388	.931
7.900	.0058	2.600	.00425	2.386	.168	.394	1.025
7.900	.0058	2.800	.00458	2.370	.157	.399	1.118

Table F-4. Listing of the program OVER.

```

1  PROGRAM OVER(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
   REAL L,KTO
   DIMENSION TANA(6),CA(6),CB(6),CC(6)
   DATA TANA/10.,0.2,1.,0.667,1.444,0.333/
5  DATA CA/0.958,1.280,1.469,1.991,1.811,1.366/
   DATA CB/.228,0.390,0.346,0.498,0.469,0.512/
   DATA CC/.0578,0.091,0.105,0.185,0.080,0.040/
   READ(5,1) NBW
   DO 100 IBW=1,NBW
10  READ(5,1) N,IFRONT,TANT,B,HS,DS,AC,BC
   I
   I  FUMMAT(212,0X,7F10.5)
   CN = NUMBER OF WAVE CONDITIONS
   C IFRONT = 1 FOR 1/16 FRONTING SLOPE
   C TANT = TANGENT OF FRONT BREAKWATER SLOPE ANGLE
15  C B = STRUCTURE WIDTH AT THE CREST (M)
   C HS = STRUCTURE HEIGHT (M)
   C DS = WATER DEPTH AT TOE OF STRUCTURE (M)
   C AC = AHRENS ROUGH SLOPE RUNUP COEFFICIENT (=0 FOR SMOOTH SLOPES)
   C BC = AHRENS ROUGH SLOPE RUNUP COEFFICIENT
20  FMS=DS
   BMR=HS
   C=0.51+0.11*BH
   WRITE(6,2) N,IFRONT,TANT,B,HS,DS,F,C
2  FOMMAT(1H1,2X,(PREDICTION OF WAVE TRANSMISSION COEFFICIENTS FOR{/
   *2X, [AN IMPERMEABLE BREAKWATER{/},1X,(NUMBER OF WAVE CONDIT
   *IONS ={/},13, /,1X,[IFRONT ={/},12,/,1X,[TAN(SLOPE) ={/},F6,3,/,1X,[BREAK
   *K WATER TOP WIDTH(M) ={/},F6,3,/,1X, [STRUCTURE HEIGHT(M) ={/},F6,3,/,1X
   * [WATER DEPTH(M) ={/},F6,3,/,1X,[FREEBOARD(M) ={/},F6,3,/,1X,
   * [COEFFICIENT OF OVERTIPPING C ={/},F6,3,//)
30  IF(AC.LT.0.001) GO TO 21
   WRITE(6,22) AC,BC
22  FOMMAT(1X,[RUNUP COEFFICIENTS FOR ROUGH SLOPE RUNUP AC ={/},F6,2,
   * [ BC ={/},F6,2)
   GO TO 23
35  21  DO 3 I=1,5
   IF(TANT.GT.TANA(I),OR,TANT.LT.TANA(I+1)) GO TO 3
   P=(TANA(I)-TANT)/(TANA(I)+TANA(I+1))
   C1=CA(I)=(CA(I)+CA(I+1))*P
   C2=CB(I)=(CB(I)+CB(I+1))*P
   C3=CC(I)=(CC(I)+CC(I+1))*P
40  3  CONTINUE
   IF(TANT.GT.10.) C1=CA(1)
   IF(TANT.GT.10.) C2=CB(1)
   IF(TANT.GT.10.) C3=CC(1)
45  IF(TANT.LT.0.333) C1=CA(6)
   IF(TANT.LT.0.333) C2=CB(6)
   IF(TANT.LT.0.333) C3=CC(6)
   WRITE(6,7) C1,C2,C3
7  FOMMAT(1X,[C1 ={/},F6,4,/,1X,[C2 ={/},F6,4,/,1X,[C3 ={/},F6,4,//)
50  23  WRITE(6,14)
14  FOMMAT(/,1X,[ T(SEC) D/GT2 H(M) H/GT2 R/H F/R KTO HT(M) {/
   */)
   DO 4 I=1,N
   READ(5,5) T,H
55  5  FOMMAT(2F10.5)
   DLO=US/(1.56*T*7)
   CALL LENGTH(DLO,DL)

```


Table F-4. Listing of the program OVER.--Continued

```

L=DS/DL
MGT2=H/(9.8*T*T)
60  DGT2=DS/(4.8*T*T)
    HM=C1*(0.123*L/H)**(C2*SQR(T(H/DS)+C3)
    SURF=TANT/SQRT(H/(1.56*T*T))
    IF (AC,GT,0.001) HM=AC*SURF/(1.+BC*SURF)
65  R=HM*H
    F=H/R
    KTO=C*(1.=FR)
    IF (IFRONT,EQ,1,AND,F,LT,0.) KTO=C*(1.=FR)=(1.=2.+C)*FR
    IF (FM,GT,1.) KTO=0.
    MT=H*KTO
70  *WRITE(6,12) T,DGT2,H,MGT2,HH,FR,KTO,MT
12  FORMAT(1X,F6.3,P7.4,F6.3,F7.5,4F6.3)
4   CONTINUE
100 CONTINUE
75  STOP
END

1   SUBROUTINE LENGTH(DLO,DL)
    REAL LD,LDNE#,LOD
    LD=1.0/DLO
5   LOD=1.0/DLO
    N=1
    PI=3.14159
1   ARG=2.0*PI/LD
    LDNE#=LOD*TANH(ARG)
    N=N+1
10  DIFF=ARS(LDNE#*LD)
    IF(N=200) 3,4,4
3   IF(DIFF=0.0005) 2,2,5
5   LD=(LDNE#*LD)/2.0
    GO TO 1
15  4   DL=1.0/LDNE#
    *WRITE(6,100) DLO,DL
100  FORMAT(44H SUBROUTINE LENGTH DID NOT CONVERGE, D/LO = ,F10.5,
1   1  BHD/L = ,F10.5)
20  2   DL=1.0/LDNE#
    RETURN
    END

```

APPENDIX G

DOCUMENTATION OF THE COMPUTER PROGRAM MADSEN

The computer program MADSEN (CERC program number 752X1R1CPO) is used to predict wave transmission through rubble-mound breakwaters using methods developed by Madsen and White (1976). (Note: Equations and figures referenced from that publication are identified by the symbol MW.) A wave transmission by overtopping model is also included as discussed in the text of this report. The program is organized as shown in Figure G-1. Whenever possible the variable names used are a close approximation to the symbols used by Madsen and White (1976). Table G-1 lists important variable names, corresponding symbols used in Madsen and White, and gives a description including references to defining equations in Madsen and White (1976). A description of each of the program subroutines is given below:

SUBROUTINE READI - This routine reads standard lookup tables corresponding to MW Figures 2, 3, 15, 16, and 17 from Madsen and White (1976). Lookup tables with a combination linear and logarithmic interpolation were selected to avoid having to use Bessel functions with complex arguments. The 53 standard lookup table cards are given in Table G-2.

SUBROUTINE REFL - This routine determines reflection coefficients from rough impermeable slopes to account for energy dissipation on the breakwater face (see Ch. III of Madsen and White, 1976). MW equation (127) is solved iteratively and the final result corrected by the corresponding correction factor from MW Table 2 (a linear fit to these points is used). Lookup tables from MW Figures 15, 16, and 17 are employed in this routine.

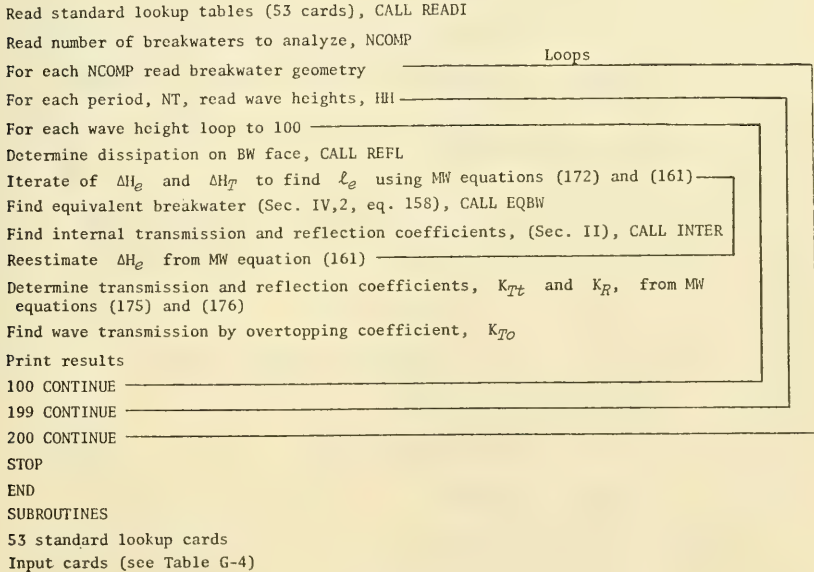


Figure G-1. General program organization.

Table G-1. Program variables.

Symbol (Madsen and White, 1976)	Variables	Description
a_i	A	incident wave amplitude
RII	RII	reflection coefficient (Sec. III)
ΔH_T	DHT	head (MW eq. 160)
ΔH_e	DHE	equivalent head (MW eq. 159)
d_r	DR	reference diameter
β_r	BETAR	reference beta
ν	NU	kinematic viscosity
d	D	diameter (cm)
a_I	AI	equals RII a_i (MW eq. 146)
RI	RI	internal reflection coefficient (Sec. II)
TI	TI	internal transmission coefficient (Sec. II)
T	KTT	coefficient of wave transmission for transmission through the structure (MW eq. 175)
	KTO	transmission by overtopping coefficient
	KT	total wave transmission coefficient equals $\sqrt{KTT^2 + KTO^2}$
R	KR	reflection coefficient (eq. 176)
η	N	porosity
S_*	SS	$(n/0.45)^2$
$\eta k_o \ell$	NKL	equivalent
ℓ_e	LE	equivalent BW width (eq. 158)
h_o	HO	water depth
T	T	wave period
f/S_*	FS	
λ	LAMBDA	
k_o	KO	$2\pi/L$
	TS	lookup tables

Table G-1. Program variables.--Continued

Symbol (Madsen and White, 1976)	Variables	Description
	RS	lookup tables
	FST	lookup tables
	RUT	lookup tables
	RT	lookup tables
	GSS	lookup tables
	FUS	lookup tables
	TX	lookup tables
	RX	lookup tables
F_s	FS	(Fig. 17)
l_s	LS	slope length
L	L	wavelength
	NM	number of materials (maximum of 10)
	NL	number of layers (maximum of 10)
Δh_j	TH	level thickness
$\frac{\Delta h_j}{h_0}$	DH	relative thickness
	NR	reference porosity = 0.45
$\frac{\Delta h_j}{h_0} \frac{1}{\left(\sum \frac{\beta_i}{P_r} l_i\right)^{1/2}}$	SUM2	
$\sum \frac{\beta_i}{\beta_r} l_i$	SUM1	
	TOPW	width of top of structure
l_n	LL	length of materials in horizontal layers
	F	breakwater freeboard
	R	wave runup

Table G-2. Standard lookup tables to be read by READ1.

1	.85	.83	.901	.502	.192	.333	.233	.463	.96
2	.85	.83	.901	.492	.192	.303	.193	.423	.90
3	.85	.83	.901	.492	.162	.293	.103	.283	.70
4	.85	.83	.901	.472	.102	.222	.943	.073	.40
5	.85	.83	.901	.462	.052	.142	.742	.803	.00
6	.85	.63	.901	.451	.982	.032	.502	.502	.60
7	.85	.83	.901	.441	.891	.922	.282	.222	.20
8	.85	.83	.901	.421	.801	.792	.021	.911	.83
9	.85	.83	.901	.401	.701	.681	.791	.631	.60
10	.85	.83	.901	.361	.611	.521	.571	.381	.24
11	.85	.83	.901	.301	.501	.401	.371	.171	.00
12	1.001	.242	.032	.492	.693	.283	.353	.744	.00
13	1.001	.231	.942	.322	.502	.682	.973	.203	.34
14	1.001	.221	.852	.162	.312	.562	.632	.732	.80
15	1.001	.201	.762	.032	.142	.282	.322	.342	.36
16	1.001	.191	.701	.901	.982	.042	.042	.021	.97
17	1.001	.191	.611	.781	.821	.821	.791	.731	.65
18	1.001	.181	.541	.681	.671	.651	.581	.491	.38
19	1.001	.181	.481	.571	.541	.471	.371	.271	.18
20	1.001	.171	.431	.481	.421	.321	.211	.08	.97
21	1.001	.161	.371	.381	.311	.181	.05	.93	.80
22	1.001	.161	.321	.291	.191	.06	.43	.80	.67
23	1.001	.001	.001	.001	.001	.001	.001	.001	.001
24	1.001	.00	.98	.96	.92	.87	.87	.88	.87
25	1.001	.00	.98	.93	.83	.75	.76	.78	.75
26	1.001	.00	.97	.90	.75	.65	.66	.69	.65
27	1.001	.00	.97	.87	.68	.55	.58	.62	.56
28	1.001	.00	.95	.83	.62	.46	.52	.55	.48
29	1.00	.99	.94	.79	.57	.40	.45	.50	.43
30	1.00	.99	.93	.75	.51	.34	.40	.45	.38
31	1.00	.99	.92	.72	.44	.28	.36	.42	.33
32	1.00	.99	.91	.70	.40	.23	.33	.38	.30
33	1.00	.98	.90	.67	.35	.18	.31	.35	.27
34	.80	.66	.57	.50	.46	.42	.38	.36	.34
35	.67	.50	.41	.34	.30	.26	.22	.18	.16
36	.58	.41	.32	.26	.21	.17	.13	.11	.08
37	.50	.33	.26	.19	.16	.12	.99	.07	.05
38	.45	.30	.22	.16	.12	.08	.07	.04	.03
39	.41	.26	.18	.13	.09	.07	.05	.03	.02
40	.37	.23	.16	.11	.08	.05	.03	.02	.02
41	.33	.21	.13	.09	.06	.04	.03	.02	.01
42	.31	.18	.12	.08	.05	.03	.03	.02	.01
43	.29	.17	.11	.07	.04	.03	.02	.01	.01
44	.25	.40	.49	.56	.58	.59	.58	.56	.53
45	.35	.52	.60	.65	.66	.65	.63	.62	.60
46	.44	.60	.68	.71	.71	.69	.67	.67	.66
47	.50	.67	.73	.74	.73	.72	.71	.70	.70
48	.57	.71	.75	.77	.76	.74	.73	.73	.73
49	.60	.73	.78	.78	.77	.76	.76	.76	.76
50	.63	.76	.80	.79	.78	.78	.77	.77	.77
51	.66	.78	.81	.80	.79	.79	.79	.79	.79
52	.68	.80	.82	.81	.80	.80	.80	.80	.80
53	.71	.81	.83	.82	.81	.81	.81	.81	.81

SUBROUTINE INTER - Internal wave transmission and reflection coefficients for the equivalent breakwater found in EQBW are solved in this routine. MW equations (57) and (37) are solved implicitly using $R_c = 170$ and interpolation of MW Figures 2 and 3, when nk_1 is greater than 0.1. If nk_1 is greater than 0.9 the coefficients cannot be solved, so another equivalent breakwater with smaller reference diameter stone is determined.

SUBROUTINE EQBW - This routine determines the rectangular breakwater corresponding to the multilayered trapezoidal breakwater using the methods described in MW Section IV,2. The initial reference diameter is taken as one-half the armor diameter and reference porosity is defined as 0.435.

SUBROUTINE LENGTH - Finds the relative depth given the ratio of water depth to deepwater wavelength.

1. Program Use. The following steps are required to use the program MADSEN:

(a) Assign each of the materials used in the various layers of the breakwater a consecutive number making the armor "material number 1." Determine the diameter of each material from

$$d_{50} = \left(\frac{W_{50}}{\gamma} \right)^{1/3}$$

where W_{50} is the median weight and γ the specific weight. Also estimate the material porosity.

(b) Divide the breakwater into horizontal layers. A new layer occurs any time there is a change vertically in any material type of slope (see Fig. G-2 for an example problem). Make the layer next to the seabed "layer number 1." Find the thickness of each layer and determine the average horizontal length of each material in each layer. Remove the outer layer of armor from the seaward face of the breakwater before making length calculations, because energy dissipation on the front face is determined separately in the program.

(c) Estimate the kinematic viscosity of water as a function of water temperature (Table G-3).

(d) Estimate breakwater water runup parameters, a and b . At the present time the values of $a = 0.692$ and $b = 0.504$ are recommended based on the laboratory data of Hudson (1958).

(e) Put the information into the required input format (Table G-4). Input cards for the example breakwater (Fig. G-2) are shown in Table G-5.

(f) Sample output for the example problem is shown in Table G-6.

2. Computer Program. A listing of the computer program MADSEN is given in Table G-7.

Table G-3. Kinematic viscosity of water.

Water temperature (C°)	Kinematic viscosity of water (m ² /s)
0	0.0000018
10	0.0000013
20	0.0000010
30	0.0000008

Table G-4. Format of input information.

Card type	Format	Description
standard		53 standard input cards (see Table G-3)
1	I2	number of breakwater configurations or water depths to test
2	20A4	title card
3	3I2, 4X, 7F10.5	number of wave conditions to test number of materials number of horizontal layers structure height (m) water depth (m) kinematic viscosity (m ² /s) width of top of breakwater (m) front slope of breakwater = tan (θ) wave runup parameter a = 0.692 wave runup parameter b = 0.504
4	10X, 2F10.5 (one card per material)	material diameter (m) (armor 1st) material porosity
5	10X, 7F10.5 (one card per horizontal layer)	layer thickness (m) mean length of each material type in the layer (put in consecutive order, material 1 (armor 1st), etc.)
6	2F10.5 (wave condition card; one card per wave condition)	wave period (s) wave heights (m)

NOTE.--Repeat card types 2 to 6 for each water depth or breakwater configuration to be tested.

Table G-5. Sample input to program MADSEN.

1	EXAMPLE PROBLEM				
18 3 3	6.0				
MAT 1	0.729				
MAT 2	0.538				
MAT 3	0.092				
LAY 1	3.55				
LAY 2	0.78	2.80	6.46		
LAY 3	0.47	2.50	0.0		
5.0	0.1	0.0	0.0		
5.0	0.5				
5.0	1.0				
5.0	1.5				
5.0	1.75				
5.0	2.0				
10.0	0.1				
10.0	0.5				
10.0	1.0				
10.0	1.5				
10.0	1.75				
10.0	2.0				
20.0	0.1				
20.0	0.5				
20.0	1.0				
20.0	1.5				
20.0	1.75				
20.0	2.0				
		0.0000093	2.52	0.667	0.592
					0.504

Table G-6. Sample output.

EXAMPLE PROBLEM

COMPUTATIONS OF WAVE TRANSMISSION THROUGH A POROUS BREAKWATER

NUM OF WAVE CONDITIONS 18
 NUM OF MATERIALS= 3
 NUM OF HORIZONTAL LAYERS= 3
 STRUCTURE HEIGHT (M)= 6.000
 WATER DEPTH (M)= 4.800
 KINEMATIC VISCOSITY (M2/SEC)= .00000930
 BW TOP WIDTH (M)= 2.520
 TANH OF FRONT SLOPE= .6670
 RUNUP COEFFICIENTS A= .692 B= .504
 MATERIAL CHARACTERISTICS (MAKE ARMOR MATERIAL NUMBER 1)

MATERIAL= 1 DIAMETER (M)= .729 POROSITY= .370
 MATERIAL= 2 DIAMETER (M)= .538 POROSITY= .370
 MATERIAL= 3 DIAMETER (M)= .092 POROSITY= .370

HORIZONTAL LAYER CHARACTERISTICS
 (MAKE LAYER NEXT TO SEAFED LAYER NUMBER 1)

			MATERIAL=	1	2	3
HORIZONTAL LAYER=	1 THICKNESS (M)=	3.550	LENGTHS (M)=	4.5	2.8	6.4
HORIZONTAL LAYER=	2 THICKNESS (M)=	.780	LENGTHS (M)=	4.5	2.5	0.0
HORIZONTAL LAYER=	3 THICKNESS (M)=	.470	LENGTHS (M)=	5.3	0.0	0.0

H(M)	T(SEC)	H/(G*T*T)	H/L	D/(G*T*T)	KTT	KTO	KT	KR	HT(M)
.100	5.00	.000408	.00335	.0196	.392	0.000	.392	.26	.039
.500	5.00	.002041	.01674	.0196	.213	0.000	.213	.28	.106
1.000	5.00	.004082	.03349	.0196	.151	0.000	.151	.27	.151
1.500	5.00	.006122	.05023	.0196	.131	0.000	.131	.27	.205
1.750	5.00	.007143	.05860	.0196	.122	.080	.149	.26	.262
2.000	5.00	.008163	.06697	.0196	.115	.125	.169	.26	.339
.100	10.00	.000162	.00151	.0049	.401	0.000	.401	.50	.040
.500	10.00	.000510	.00753	.0049	.202	0.000	.202	.59	.101
1.000	10.00	.001520	.01507	.0049	.135	0.000	.135	.62	.135
1.500	10.00	.002531	.02260	.0049	.100	.115	.152	.63	.229
1.750	10.00	.002786	.02637	.0049	.088	.159	.182	.64	.318
2.000	10.00	.002941	.03013	.0049	.080	.193	.209	.64	.413
.100	20.00	.000026	.00073	.0012	.381	0.000	.381	.53	.038
.500	20.00	.000128	.00367	.0012	.186	0.000	.186	.66	.093
1.000	20.00	.000255	.00735	.0012	.127	.010	.127	.70	.127
1.500	20.00	.000383	.01102	.0012	.098	.154	.182	.71	.214
1.750	20.00	.000440	.01286	.0012	.087	.196	.214	.72	.375
2.000	20.00	.000510	.01470	.0012	.081	.227	.241	.72	.482

KTT = WAVE TRANSMISSION THROUGH THE STRUCTURE
 KTO = WAVE TRANSMISSION BY OVERTOPPING COEFFICIENT
 KT = TOTAL WAVE TRANSMISSION COEFFICIENT
 KR = WAVE REFLECTION COEFFICIENT
 HT = TRANSMITTED WAVE HEIGHT

Table G-7. Listing of the computer program MADSEN.

```

1      PROGRAM MADSEN(INPUT,OUTPUT,TAPES=INPUT,TAPE6=OUTPUT,TAPE3)
COMMON/MADS1/NM,NL,D(1),N(1),LL(1,1),TH(1)
COMMON/SEEL/NKL,P8
2      REAL NKL
3      DIMENSION IBUF(1),TITLE(20),NUM(10)
4      REAL L,NU,KT,KR,N,LE,NR,LL,KTO,KTT
5      DATA NUM/1,2,3,4,5,6,7,8,9,10/
6      PI=3.14159
7      CALL READI
8      READ(5,590) NCOMP
9      590 FORMAT(3I2,4X,7F10,5)
10     DO 200 JJ=1,NCOMP
11     C READ INPUT INFORMATION
12     READ(5,171) (TITLE(JJM),JJM=1,20)
13     171 FORMAT(20A4)
14     WRITE(6,172) (TITLE(JJM),JJM=1,20)
15     172 FORMAT(1M1,10X,20A4)
16     READ(5,590) NT,NM,NL,HS,HO,NU,TOPW,TANB,RA,RB
17     F=HS*HO
18     IF(PA,LE,0.) RA=0.692
19     IF(OB,LE,0.) RB=0.504
20     WRITE(6,971) NT,NM,NL,HS,HO,NU,TOPW,TANB,RA,RB
21     971 FORMAT(/,10X,1COMPUTATIONS OF WAVE TRANSMISSION THROUGH A POROUS
22     * BRFAK*WATER,/,5X, INUM OF WAVE CONDITIONS(1,2X,I3,/,5X,
23     * INUM OF MATERIALS(1,17X,I3,/,5X,
24     * INUM OF HORIZONTAL LAYERS(1,6X,I5,/,5X,(STRUCTURE HEIGHT (M)
25     *=(1,4X,F10,3,/,5X, (WATER DEPTH (M)=1,11X,F10,3,/,5X,
26     * (KINEMATIC VISCOSITY (M2/SEC)=1,F11,9, /,5X, (BW TOP WIDTH (M)=1,
27     * 10X,F10,3,/,5X, (TANB OF FRONT SLOPE=1,9X,F3,4,/,5X, (RUNUP COEFFICI
28     * ENTS A=1,6,3,1 B=1,6,3)
29     DO 99 I=1,11
30     DO 98 J=1,11
31     LL(I,J)=0.
32     99 CONTINUE
33     WRITE(6,283)
34     283 FORMAT(5X, { MATERIAL CHARACTERISTICS (MAKE ARMOR MATERIAL NUMBER 1)
35     * (/,/ )
36     DO A J=1,NM
37     READ(5,7) D(I),N(I)
38     7 FORMAT(10X,7F10,5)
39     WRITE(6,177) I,D(I),N(I)
40     177 FORMAT(5X, { MATERIAL={,I3, ( DIAMETER (M)={,F 6,3, ( POROSITY={,F6,3)
41     6 CONTINUE
42     WRITE(6,284) (NUM(JM),JM=1,NM)
43     284 FORMAT(//,5X, { HORIZONTAL LAYER CHARACTERISTICS(/,5X,
44     * (MAKE LAYER NEXT TO SEABED LAYER NUMBER 1) (/,/ )
45     * 52X, { MATERIAL={,7(I1,5X),/,63X,6(I2,4X),/ )
46     DO 33 J=1,NL
47     READ(5,7) TH(J), (LL(I,J),I=1,NM)
48     WRITE(6,178) J,TH(J), (LL(I,J),I=1,NM)
49     178 FORMAT(5X, { HORIZONTAL LAYER={,I3, ( THICKNESS (M)={,F 6,3, ( LENGTH
50     * S (M)={,7F6,1,/,60X,7F6,1)
51     33 CONTINUE
52     NM=NM+1
53     D(NM)=D(1)
54     N(NM)=0.01
55     NL=NL+1
56     TH(NL)=10000000.
57     LL(NM,NL)=3.*D(1)
58     WRITE(6,942)
59     942 FORMAT(//, 6X, {H(M) T(SEC) H/(G*T*T) H/L D/(G*T*T/) KTT
60     * KTU KT KR HT(M)I)
61     DO 199 IK=1,NT
62     READ(5,8) T,H
63     8 FORMAT(2F10,5)
64     A=H*0.5
65     DR=D(1)*0.5

```

Table G-7. Listing of the computer program MADSEN.--Continued

```

IF(A,LT,0,00001) GO TO 100
IF(TANB,LE,0,) GO TO 37
CALL REFL(A,HS,D(1),HO,TANB,T,RII,RII,L)
70   AI=RII*A
22   DHT=2,*RU*A
      IFLAG=0
C ASSUME DMF=DHT AND ITERATE ON THE EQUIVANT B $\omega$ 
75   ICOUNT=0
      DHE=DHT
10   ICOUNT=ICOUNT+1
      CALL EQBW(DHE,DHT,LF,HO,HS,TANB,NR,DR,TOPW)
      CALL INTER(NR,T,LE,HO,AI,NU,DR,TI,RI,L,IFLAG)
80   IF(TFLAG,EQ,1) DR=DR*0,95
      IF(TFLAG,EQ,1) GO TO 22
      DHE=(1,+RI)*RII*A
      IF(TCOUNT,LT,4) GO TO 10
      KR=R1*RII
85   KTT=TI*RII
37   IF(TANB,LE,0,) CALL INTER(N(1),T,TOPW,HO,A,NU,D(1),KTT,KR,L,IFLAG)
      IF(TFLAG,EQ,1) DR=DR*0,5
      IF(TFLAG,EQ,1) GO TO 37
      SUMF=TANB/SQRT(W/(1,56*T*T))
90   HMF=A*SUMF/(1,+RB*SUMF)
      H=H*RH
      FR=F/R
      C=0,91-0,11*TOPW/HS
      KTO=C*(1,+FR)
95   IF((TOPW/HS),GT,0,8A,AND,F,LT,0,) KTO=C*(1,+FR)=(1,+2,0)*C*FR
      IF(KTO,GT,1,0) KTO=1,0
      IF(FM,GT,1,0) KTO=0,0
      HGT=A*2,0/(9,80*T*T)
100  HL=A/L
      DGT=HD/(9,80*T*T)
      FLAG=3H
      KT=SQRT(KTT**2+KTO**2)
      IF(KT,GT,1,0) KT=1,0
      HT=4*KT
105  WRITE(6,9R1) H,T,HGT,HL,DGT,KT,KTO,KT,KR,HT
9R1  FORMAT(5X,F6,3,F10,2,F10,6,F10,5,F10,4,3F6,3,F6,2,F7,3)
100  CONTINUE
199  CONTINUE
      WRITE(6,201)
110  201  FORMAT(//,2X,|KT| = WAVE TRANSMISSION THROUGH THE STRUCTURE|,/,
*2X,|KTO = WAVE TRANSMISSION BY OVERTOPPING COEFFICIENT|,/,
* 2X,|KT = TOTAL WAVE TRANSMISSION COEFFICIENT|,/,2X,
* |KR = WAVE REFLECTION COEFFICIENT|,
*/,2X,|HT = TRANSMITTED WAVE HEIGHT|)
115  200  CONTINUE
      STOP
      END
1   SUBROUTINE REFL(A,HS,D,HO,TANB,T,RII,RII,L)
      COMMON/MADS/FST(9,11),RUT(9,11),RT(17,11),TX(9,10),RX(9,10)
      DIMENSION FSS(11),RUS(11),HS(11)
      REAL I,LSL,LS
5   C CF = MODEL CORRECTION FACTOR TO ACCOUNT FOR MODEL SLOPE EFFECTS
      CF=1,28-0,578*TANB
      IF(TANB,LT,0,4) CF=1,02
      IF(TANB,GT,0,68) CF=0,89
10  C FIND WAVE LENGTH L
      HOLO=HO/(1,56*T*T)
      CALL LENGT(HOLO,HOL)
      L=HO/HOL
      LS=HU/TANB
      IF(HS,LT,HO) LS=HS/TANB
15  LSL=LS/L
      IF(LSL,LT,0,8) GO TO 105
      TMIN=SQRT(6,283*(LS/0,8)/(9,8*TANH(6,283*HO/(LS/0,8))))
      WRITE(6,101) TMIN
101  FORMAT(//,1X,|WARNING=THE MINIMUM WAVE PERIOD TO BE ANALYZED BY T

```

Table G-7. Listing of the computer program MADSEN.--Continued

```

20      *THIS PROGRAM IS (,F6,2,1 SEC FOR THIS CONDITION)
      LSL=0.799
105     I=(LSL*10,+1)
C INTERPOLATE INPUT TABLE FOR THIS LSL VALUE
      II=LSL*20,+1
25     DO 3 J=1,11
      FSS(J)=FST(I,J)+(PST(I+1,J)-FST(I,J))*(LSL-(I-1)*0.1)/0.1
      RUS(J)=RUT(I,J)+(RUT(I+1,J)-RUT(I,J))*(LSL-(I-1)*0.1)/0.1
3       RS(J)=RT(I,J)+(RT(II+1,J)-RT(II,J))*(LSL-(II+1)*0.05)/0.05
C GUESS PHI AND ITERATE
30     PHI=5.0
      M=0
6       J=PHI
      FAC=(ALOG(PHI+1.)=ALOG(J+1.))/(ALOG(J+2.)=ALOG(J+1.))
      FS=FSS(J+1)+ FAC*(FSS(J+2)-FSS(J+1))
35     RI=RUS(J+1)+ FAC*(RUS(J+2)-RUS(J+1))
      RI1=RS(J+1)+(RS(J+2)-RS(J+1))*FAC
      ARG=0.29*(D/HO)**0.2*(RU*2.**A/(HO*TANB))**0.3*FS
      PHIN=0.5*ATAN(ARG)*57.29578
      M=M+1
40     DEL=ARS(PHIN-PHI)
      IF (M.GT.20) GO TO 9
      PHI=PHIN
      IF (PHI.LT.0.01) PHI=0.01
      IF (PHI.GT.9.99) PHI=9.99
45     IF (DEL.GT.0.05) GO TO 6
9       HIL=PI*CF
      RETURN
      END
1       SUBROUTINE READI
      COMMON/MADS/FST(9,11),RUT(9,11),RT(17,11),TX(9,10),RX(9,10)
177     FORMAT(3X,17F4.2)
      DO 1 M=1,11
5         1 READ(5,177) (FST(N,M),N=1,9)
          DO 2 M=1,11
2           2 READ(5,177) (RUT(N,M),N=1,9)
              DO 3 M=1,11
3               3 READ(5,177) (RT(N,M),N=1,17)
                  DO 4 M=1,10
4                   4 READ(5,177) (TX(N,M),N=1,9)
                      DO 5 M=1,10
5                       5 READ(5,177) (RX(N,M),N=1,9)
                          RETURN
15                      END
1       SUBROUTINE EBRW(DHE,DHT,LE,HO,HS,TANB,NR,DR,TDPW)
      COMMON/MADS1/NM,NL,D(11),N(11), L(11,11),TH(11)
      DIMENSION BETA(11),DH(11)
      REAL N,L,LE,NR
5         NR=N.435
      BETAR=2.7*(1.=NR)/(NR**3*DR)
      DO 1 I=1,NM
21        BETA(I)=2.7*(1.=N(I))/(N(I)**3*D(I))
          TH1=0.
          TH2=0.
10         DO 4 J=1,NL
              TH1=TH1+TH(J)
              NYL=J
15         DH(J)=TH(J)/HO
              IF (TH1.GT.HO) DH(J)=(HO=TH2)/HO
              IF (TH1.GT.HO) GO TO 5
4           TH2=TH2+TH(J)
5           SUM2=0.
          DO 16 J=1,NYL
20            SUM1=0.
              DO 17 I=1,NM
17             SUM1=SUM1+BETA(I)/BETAR*L(I,J)
16            SUM2=SUM2+DH(J)/(SQRT(SUM1))
              LE=1./(SUM2**2)*DHE/DHT

```

Table G-7. Listing of the computer program MADSEN.--Continued

```

25      RETURN
      END
1      SUBROUTINE INTER(N,T,L,HU,A,NU,D,TI,RI,WL,IFLAG)
      COMMON/SEFL/NKL,FS
      COMMON/MADS/FAST(9,11),RUT(9,11),RT(17,11),TX(9,10),RX(9,10)
      DIMENSION TS(10),RS(10)
5      REAL NKL,L,NU,K0,LAMBDA,N
      SS=(N/0.45)**2
      K0=2.*3.14159/WL
      NKL=N*K0*L
      BETA=2.7*(1.+N)/(N**3*D)
      LAMBDA=1.
      F=0.
      RC=170.
      IC=0
      FNF
17      FNF
15      IC=IC+1
      U=A*SQRT(9.80/HN)/(1.+LAMBDA)
      RU=11*D/NU
      F=N*(K0*L)*(SQRT(1.+(1.+RC/RU)*(16.*BETA**4*L/(3.*3.14159*H0))))=1.
      LAMBDA=K0*L*F/(2.*N)
20      IF(TC.GT.10) GO TO 5
      IF(ABS(FN-F)/F).GT.0.02) GO TO 2
5      TI=1./(1.+LAMBDA)
      RT=LAMBDA/(1.+LAMBDA)
      FS=F/SS
25      C
      WRITE(6,397) F,FS,U,K0
397      FORMAT(PUX,(F,FS,U,RU=(1.4E13,5)
      IF(NKL.GT.0.9) IFLAG=1
      IF(NKL.GT.0.9) RETURN
      IF(NKL.LT.0.1) RETURN
30      IF(FS.GT.35.) FS=35.
      J=NKL*10.
      I=FS
      C INTERPOLATE MADSEN CURVES 2 AND 3
      DO 1 M=1,10
35      RS(M)=RX(J,M)+(RX(J+1,M)-RX(J,M))*(NKL=N,1*J)/0.1
      TS(M)=TX(J,M)+(TX(J+1,M)-TX(J,M))*(NKL=N,1*J)/0.1
      IF(FS.LF.1.0) TI=TS(1)+ALOG10(FS)*(TS(10)-TS(1))
      IF(FS.LF.1.0) RT=RS(1)+ALOG10(FS)*(RS(10)-RS(1))
      IF(FS.GF.10.) TI=TS(10)*(35.-FS)/25.
      IF(FS.GF.10.) RT=RS(10)+(1.-RS(10))*(FS-10.)/25.
40      IF(FS.LF.1.0.OR.FS.GE.10.0) RETURN
      HI=RS(I)+(RS(I+1)-RS(I))*(ALOG(FS)=ALOG(I*1.))/(ALOG(I+1.)=ALOG(I*
*1.))
      TI=TS(I)+(TS(I+1)-TS(I))*(ALOG(FS)=ALOG(I*1.))/(ALOG(I+1.)=ALOG(I*
*1.))
45      *1.)
      *1.)
      RETURN
      END
1      SUBROUTINE LENGT(DLO,DL)
      REAL LD,LDNEW,LOD
      LD=1.0/DLO
      LOD=1.0/DLO
5      N=1
      PI=3.14159
      ARG=2.0*PI/LOD
      LDNEW=LOD*TANH(ARG)
      N=N+1
10      DIFF=ABS(LDNEW-LD)
      IF(N=200) 3,4,4
      IF(DIFF=0.0005) 2,2,5
      LD=(LDNEW+LD)/2.0
      GO TO 1
15      4
      DL=1.0/LDNEW
      WRITE(6,100) DLO,DL
100  FORMAT(44H SUBROUTINE LENGTH DID NOT CONVERGE, D/LO = ,F10.5,
1 8WD/L = ,F10.5)
      DL=1.0/LDNEW
20      RETURN
      END

```


<p>Seelig, William N.</p> <p>Two-dimensional tests of wave transmission and reflection characteristics of laboratory breakwaters / by William N. Seelig - Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980. [187] p. : ill. : 27 cm. - (Technical report - U.S. Coastal Engineering Research Center ; no. 80-1)</p> <p>Includes bibliographical references.</p> <p>Appendixes.</p> <p>This report presents the results of research conducted to develop methods for estimating wave transmission past submerged, subaerial, permeable, and impermeable breakwaters. The final prediction techniques are given in the form of computer programs; laboratory data used to develop and test the methods are included as appendixes.</p> <ol style="list-style-type: none"> 1. Breakwaters. 2. Wave reflection. 3. Wave transmission. <p>I. Title. II. Series: U.S. Coastal Engineering Research Center. Technical report no. 80-1. .U581tr no. 80-1 627 TC203</p>	<p>Seelig, William N.</p> <p>Two-dimensional tests of wave transmission and reflection characteristics of laboratory breakwaters / by William N. Seelig - Fort Belvoir, Va. : U.S. Coastal Engineering Research Center ; Springfield, Va. : available from National Technical Information Service, 1980. [187] p. : ill. : 27 cm. - (Technical report - U.S. Coastal Engineering Research Center ; no. 80-1)</p> <p>Includes bibliographical references.</p> <p>Appendixes.</p> <p>This report presents the results of research conducted to develop methods for estimating wave transmission past submerged, subaerial, permeable, and impermeable breakwaters. The final prediction techniques are given in the form of computer programs; laboratory data used to develop and test the methods are included as appendixes.</p> <ol style="list-style-type: none"> 1. Breakwaters. 2. Wave reflection. 3. Wave transmission. <p>I. Title. II. Series: U.S. Coastal Engineering Research Center. Technical report no. 80-1. .U581tr no. 80-1 627 TC203</p>
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