LINEAR WAVE THEORY WITH SNELL'S LAW

TABLE OF CONTENTS

Description 3-1-1
Input 3-1-1
Output 3-1-2
Procedure 3-1-3
  Single Case Mode 3-1-3
  Multiple Case Mode 3-1-3
Example Problem 3-1-5
  Input 3-1-5
  Output 3-1-5
References and Bibliography 3-1-6

LINEAR WAVE THEORY WITH SNELL'S LAW

DESCRIPTION

This application provides a simple estimate for wave shoaling and refraction using Snell's law with wave properties predicted by linear wave theory. Given wave properties and a crest angle at a known depth, it predicts the values in deep water and at a subject location specified by a new water depth. An important assumption for this application is that all depth contours are assumed to be straight and parallel. The criteria of Singamsetti and Wind (1980) and Weggel (1972) are employed to provide an estimate for breaker parameters.

INPUT

The coordinate system and terminology used to define wave motion and Snell's law are shown in Figures 3-1-1 and 3-1-2.

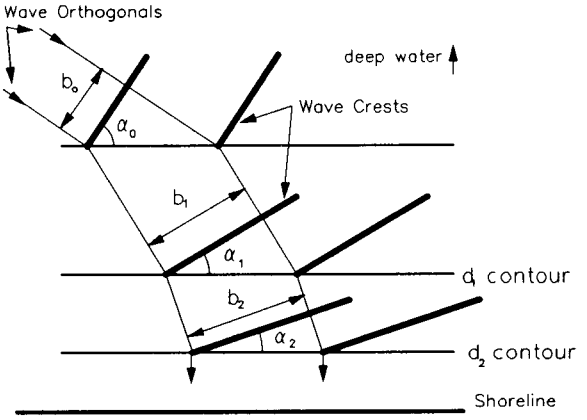

Figure 3-1-1. Snell's Law and Wave Refraction

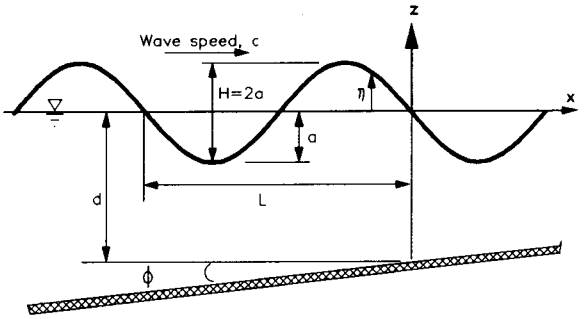

Figure 3-1-2. Progressive Wave on a Nearshore Slope

All data input for this application is done on one screen. The following list describes the necessary input parameters with their corresponding units and range of data recognized by this application:

Location	Item	Symbol	Units	Data Range
Known	Wave height	H_1	ft, m	0.1 to 200.0
	Wave period	T	sec	1.0 to 1000.0
	Water depth	d_1	ft, m	0.1 to 5000.0
	Wave crest angle	α_1	deg	0.0 to 90.0
	Cotan of nearshore slope	$\cot\phi$		5.0 to 1000.0
Subject	Water depth	d_2	ft, m	0.1 to 5000.0

OUTPUT

Results from this application are displayed on one screen. Those data include the original input values (in final units) and the following parameters:

	Wave Location				
Item	Known	Deep Water	Subject	English Units	Metric Units
Wave height	H_1	H_0	H_2	ft	m
Wave crest angle	α_1	α_0	α_2	deg	deg
Wavelength	L_1	L_0	L_2	ft	m
Wave celerity	c_1	c_0	c_2	ft/sec	m/sec
Group velocity	C_{g1}	C_{g0}	C_{g2}	ft/sec	m/sec
Energy density	E_1	E_0	E_2	ft-lb/ft^2	N-m/m^2
Energy flux	P_1	P_0	P_2	ft-lb/sec-ft	N-m/sec-m
Deepwater wave steepness		H_0/L_0			
Ursell number	$\frac{H_1 L_1^2}{d_1^3}$		$\frac{H_2 L_2^2}{d_2^3}$		

Breaker parameters

Item	Symbol	English Units	Metric Units
Height	H_b	ft	m
Depth	d_b	ft	m

PROCEDURE

The bulleted items in the following lists indicate potentially optional instruction steps. Any application in ACES may be executed in a given session without quitting the program. The bulleted items provide instructions for accessing the application from various menu areas of the ACES program. Ignore bulleted instruction steps that are not applicable.

Single Case Mode

- Press [F1] on the Main Menu to select Single Case Mode.
- Fill in the highlighted input fields on the General Specifications screen (or leave the default values). Press [F1] when all data on this screen are correct.
- Press [F3] on the Functional Area Menu to select Wave Transformation.
- Press [F1] on the Wave Transformation Application Menu to select Linear Wave Theory with Snell's Law.

1. Fill in the highlighted input fields on the Linear Wave Theory with Snell's Law screen. Respond to any corrective instructions appearing at the bottom of the screen. Press [F1] when all data on this screen are correct.
2. All input and output data are displayed on the screen in the final system of units.
3. Press one of the following keys to select the appropriate action:

   [F1] Return to Step 1 for a new case.

   [F3] Send a summary of this case to the print file or device.

   [F10] Exit this application and return to the Wave Transformation Application Menu.

Multiple Case Mode

- Press [F2] on the Main Menu to select Multi Case Mode.
- Fill in the highlighted input fields on the General Specifications screen (or leave the default values). Press [F1] when all data on this screen are correct.
- Press [F3] on the Functional Area Menu to select Wave Transformation.
- Press [F1] on the Wave Transformation Application Menu to select Linear Wave Theory with Snell's Law.

1. Move the cursor to select a variable on the Linear Wave Theory with Snell's Law screen (the selected variable name blinks). The current set of values for the variable is displayed on the right portion of the screen. When all variable sets are correct, go to Step 3.

2. Enter a set of values for the subject variable by following one of the input methods:

   a. Press [R] to select random method. Enter up to 20 values constituting a set for this variable (one in each field) on the right side of the screen. The set of 20 values originally displayed (first execution) in these fields contains the "delimiting" value, which "delimits" or "ends" the set. The "delimiting" value is *not* included as a member in the set unless it is the sole member.

   b. Press [I] to select incremental method. Fill in the fields for minimum, maximum, and increment values for this variable on the right side of the screen. In this method, the members of the set include all values from the minimum to the maximum (both inclusive) at the specified increment.

   The units field should also be specified for the variable regardless of input method. All members of a set of values for a subject variable are assigned the specified units. When all data are correct for the subject variable, press [F10] to return to Step 1. Errors are reported at the bottom of the screen and are corrected by pressing [F1] to allow respecification of the data for the subject variable.

3. Press [F1] to process the cases resulting from the combinations of the sets of data for all variables. The summary of each case will be sent to the print file or device. The screen will display the total number of cases to be processed as well as report progress. Errors are reported at the bottom of the screen and are corrected by pressing [F1] to allow respecification of variable sets.

4. Press one of the following keys to select the appropriate action:

   [F1] Return to Step 1 to specify new sets.

   [F10] Exit this application and return to the Wave Transformation Application Menu.

EXAMPLE PROBLEM

Input

All data input for this application is done on one screen. The values and corresponding units selected for this example problem are shown below.

Location	Item	Symbol	Value	Units
Known	Wave height	H_1	10.00	ft
	Wave period	T	7.50	sec
	Water depth	d_1	25.00	ft
	Wave crest angle	α_1	10.00	deg
	Cotan of nearshore slope	$\cot\phi$	100.00	
Subject	Water depth	d_2	20.00	ft

Output

Results from this application are displayed on one screen. Those data include the original input values and the following parameters (see Figure 3-1-3 for location of calculated parameters):

	Wave Location			
Item	Known	Deep Water	Subject	Units
Wave height	10.00	10.68	10.27	ft
Wave crest angle	10.00	15.00	9.12	deg
Wavelength	193.27	288.00	176.34	ft
Wave celerity	25.77	38.40	23.51	ft/sec
Group velocity	21.46	19.20	20.31	ft/sec
Energy density	799.83	911.50	843.04	ft-lb/ft^2
Energy flux	17165.59	17500.84	17121.06	ft-lb/sec-ft
Ursell number	23.91		39.91	
Deepwater wave steepness		0.04		

Breaker parameters

Item	Symbol	Value	Units
Height	H_b	12.29	ft
Depth	d_b	15.25	ft

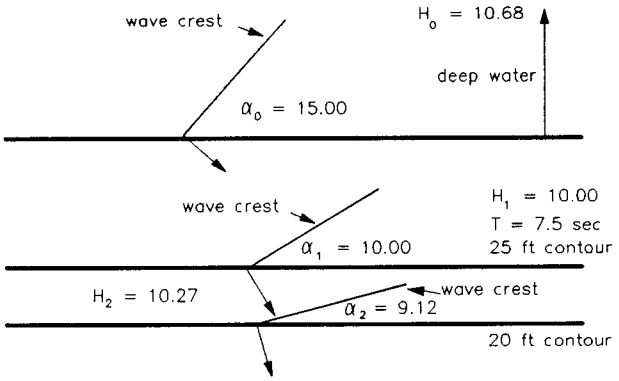

Figure 3-1-3. Snell's Law Example Output

REFERENCES AND BIBLIOGRAPHY

Airy, G. B. 1845. "Tides and Waves," *Encyclopaedia Metropolitana*, Vol. 192, pp. 241-396.

Dean, R. G., and Dalrymple, R. A. 1984. *Water Wave Mechanics for Engineers and Scientists*, Prentice-Hall, Englewood Cliffs, NJ, pp. 41-86, 104-105.

Hunt, J. N. 1979. "Direct Solution of Dispersion Equation," *Journal of Waterway, Port, Coastal and Ocean Division*, American Society of Civil Engineers, Vol. 107, No. WW4, pp. 457-459.

Le Mehaute, B. 1976. *An Introduction to Hydrodynamics and Water Waves*, Springer-Verlag, New York, pp. 228-232.

O'Brien, M. P. 1942. "A Summary of the Theory of Oscillatory Waves," Technical Report No. 2, US Army Corps of Engineers, Beach Erosion Board, Washington, DC.

Sarpkaya, T., and Isaacson, M. 1981. *Mechanics of Wave Forces on Offshore Structures*, Van Nostrand Reinhold, New York, pp. 150-168, 237-242.

Shore Protection Manual. 1984. 4th ed., 2 Vols., US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, US Government Printing Office, Washington, DC, Chapter 2, pp. 6-33, 60-66.

Singamsetti, S. R., and Wind, H. G. 1980. "Characteristics of Shoaling and Breaking Periodic Waves Normally Incident to Plane Beaches of Constant Slope," Breaking Waves Publication No. M1371, Waterstaat, The Netherlands, pp. 23-27.

Weggel, J. R. 1972. "Maximum Breaker Height," *Journal of Waterways, Harbors and Coastal Engineering Division*, American Society of Civil Engineers, Vol. 98, No. WW4, pp. 529-548.

IRREGULAR WAVE TRANSFORMATION (GODA'S METHOD)

TABLE OF CONTENTS

Description 3-2-1
Input 3-2-1
Output 3-2-2
  Screen Output 3-2-2
  Plot Output File 1 3-2-2
  Screen Plots 3-2-3
Procedure 3-2-3
  Single Case Mode 3-2-3
  Multiple Case Mode 3-2-4
Example Problem 3-2-5
  Input 3-2-5
  Output 3-2-5
    Screen Output 3-2-6
    Plot Output File 1 3-2-7
    Screen Plots 3-2-8
References and Bibliography 3-2-9

IRREGULAR WAVE TRANSFORMATION (GODA'S METHOD)

DESCRIPTION

This application yields cumulative probability distributions of wave heights as a field of irregular waves propagate from deep water through the surf zone. The application is based on two random-wave theories by Yoshimi Goda (1975 and 1984). The 1975 paper concerns transformation of random waves shoaling over a plane bottom with straight parallel contours. This analysis treated breaking and broken waves and resulted in cumulative probability distributions for wave heights given a water depth. It did not include refraction, however. The 1984 book details a refraction procedure for random waves propagating over a plane bottom with straight parallel contours assuming a particular incident spectrum. This ACES application combines the two approaches by treating directional random waves propagating over a plane bottom with straight parallel contours. This application also uses the theory of Shuto (1974) for the shoaling calculation. The theories assume a Rayleigh distribution of wave heights in the nearshore zone and a Bretschneider-Mitsuyasu incident directional spectrum.

INPUT

All data input for this application is done on one screen. The following list describes the necessary input parameters with their corresponding units and range of data recognized by this application:

Item	Symbol	Units	Data Range
Significant deepwater wave height	H_o	ft m	2.00 to 20.0 0.61 to 6.09
Water depth	d	ft, m	10.00 to 5000.0
Significant wave period	T_s	sec	4.00 to 16.0
Cotan of nearshore slope	$\cot\phi$		30.00 to 100.0
Principal direction of incident wave spectrum	Θ	deg	-75.00 to 75.0

OUTPUT

Results from this application are displayed on one screen. In addition, there is an option (available in the Single Case Mode only) to send data to plot output file 1 (default name **PLOTDAT1.OUT**). This application also generates two screen plots. Each of these outputs is described below.

Screen Output

Results from this application are displayed on one screen. Those data include the original input values (in final units) and the following parameters:

Item	Symbol	English Units	Metric Units
Significant wave height	H_s	ft	m
Mean wave height	H	ft	m
Root-mean-square wave height	H_{rms}	ft	m
Average of highest 10 percent of all waves	H_{10}	ft	m
Average of highest 2 percent of all waves	H_2	ft	m
Maximum wave height	H_{max}	ft	m
Shoaling coefficient	K_s		
Root-mean-square surf beat	ζ	ft	m
Wave setup	S_w	ft	m
Deepwater wave steepness	H_o/L_o		
Effective refraction coefficient	K_r		
Ratio of water depth to deepwater wave height	d/H_o		
Relative water depth	d/L_o		

Plot Output File 1

Plot output file 1 contains wave heights with their cumulative probability distribution of exceedance for both deep water and the specified depth and is available in Single Case Mode only. The data are written to plot output file 1 in the following format (refer to the **Example Problem** section for a paradigm):

Field	Columns	Format	Data
1	1-10	F10.3	Wave height in deep water
2	11-20	F10.3	Cumulative probability distribution of exceedance (CDF)
3	21-30	F10.3	Wave height in water depth of interest
4	31-40	F10.3	Cumulative probability distribution of exceedance (CDF2)

Screen Plots

This application generates two plots. These plots may be accessed by selecting the **Plot Data** option (F2) from the **Options** menu on the data output screen. The plots generated are shown in Figures 3-2-1 and 3-2-2 in the example problem below. The first plot displayed is the cumulative probability distribution of exceedance (CDF) versus wave height in deep water. The second plot is the CDF versus wave height in water depth of interest.

PROCEDURE

The bulleted items in the following lists indicate potentially optional instruction steps. Any application in ACES may be executed in a given session without quitting the program. The bulleted items provide instructions for accessing the application from various menu areas of the ACES program. Ignore bulleted instruction steps that are not applicable.

Single Case Mode

- Press F1 on the Main Menu to select Single Case Mode.
- Fill in the highlighted input fields on the General Specifications screen (or leave the default values). Press F1 when all data on this screen are correct.
- Press F3 on the Functional Area Menu to select Wave Transformation.
- Press F2 on the Wave Transformation Application Menu to select Goda's Wave Transformation.

1. Fill in the highlighted input fields on the Goda's Wave Transformation screen. Respond to any corrective instructions appearing at the bottom of the screen. Press F1 when all data on this screen are correct.
2. All input and output data are displayed on the screen in the final system of units.
3. Press one of the following keys to select the appropriate action:

F1 Return to Step 1 for a new case.

F2 Plot the data.

F3 Send a summary of this case to the print file or device.

F4 Generate a file containing plot data (cumulative probability versus wave height).

F10 Exit this application and return to the Wave Transformation Application Menu.

Multiple Case Mode

- Press F2 on the Main Menu to select Multi Case Mode.
- Fill in the highlighted input fields on the General Specifications screen (or leave the default values). Press F1 when all data on this screen are correct.
- Press F3 on the Functional Area Menu to select Wave Transformation.
- Press F2 on the Wave Transformation Application Menu to select Goda's Wave Transformation.

1. Move the cursor to select a variable on the Goda's Wave Transformation screen (the selected variable name blinks). The current set of values for the variable is displayed on the right portion of the screen. When all variable sets are correct, go to Step 3.
2. Enter a set of values for the subject variable by following one of the input methods:

   a. Press R to select random method. Enter up to 20 values constituting a set for this variable (one in each field) on the right side of the screen. The set of 20 values originally displayed (first execution) in these fields contains the "delimiting" value, which "delimits" or "ends" the set. The "delimiting" value is *not* included as a member in the set unless it is the sole member.

   b. Press I to select incremental method. Fill in the fields for minimum, maximum, and increment values for this variable on the right side of the screen. In this method, the members of the set include all values from the minimum to the maximum (both inclusive) at the specified increment.

   The units field should also be specified for the variable regardless of input method. All members of a set of values for a subject variable are assigned the specified units. When all data are correct for the subject variable, press F10 to return to Step 1. Errors are reported at the bottom of the screen and are corrected by pressing F1 to allow respecification of the data for the subject variable.

3. Press [F1] to process the cases resulting from the combinations of the sets of data for all variables. The summary of each case will be sent to the print file or device. The screen will display the total number of cases to be processed as well as report progress. Errors are reported at the bottom of the screen and are corrected by pressing [F1] to allow respecification of variable sets.
4. Press one of the following keys to select the appropriate action:

   [F1] Return to Step 1 to specify new sets.

   [F10] Exit this application and return to the Wave Transformation Application Menu.

NOTE: Multiple Case Mode does not generate any plot output files or plots.

EXAMPLE PROBLEM

Input

All data input for this application is done on one screen. The values and corresponding units selected for this example problem are shown below.

Item	Symbol	Value	Units
Significant deepwater wave height	H_o	20.00	ft
Water depth	d	50.00	ft
Significant wave period	T_s	8.00	sec
Cotan of nearshore slope	$\cot\phi$	100.00	
Principal direction of incident wave spectrum	Θ	10.00	deg

Output

Results from this application are displayed on one screen and, if requested, written to plot output file 1 (default name **PLOTDAT1.OUT**). In addition, two plots are generated. Each of these outputs for the example problem is presented below.

Screen Output

Results from this application are displayed on one screen. Those data include the original input values and the following parameters:

Item	Symbol	Subject	Deep Water	Units
Significant wave height	H_s	17.7	20.1	ft
Mean wave height	H	11.2	12.5	ft
Root-mean-square wave height	H_{rms}	12.5	14.1	ft
Average of highest 10 percent of all waves	H_{10}	22.5	27.0	ft
Average of highest 2 percent of all waves	H_2	26.7	32.1	ft
Maximum wave height	H_{max}	30.1	37.6	ft
Shoaling coefficient	K_s	0.9133	1.0000	
Root-mean-square surf beat	ζ	0.4350	0.1766	ft
Wave setup	S_w	-0.0763	-0.0218	ft
Deepwater wave steepness	H_o/L_o	0.0611	0.0611	
Effective refraction coefficient	K_r	0.9638		
Ratio of water depth to deepwater wave height	d/H_o	2.4655	20.0000	
Relative water depth	d/L_o	0.1505	1.2212	

Plot Output File 1

Table 3-2-1 below is a partial listing of plot output file 1 generated by this application.

Table 3-2-1
Wave Height versus Cumulative Probability
Distribution of Exceedance

Deep Water		Water Depth = 50 ft	
H (ft)	CDF	H (ft)	CDF2
0.328	0.001	0.328	0.001
0.656	0.004	0.656	0.003
0.984	0.007	0.984	0.007
1.312	0.011	1.312	0.012
1.640	0.017	1.640	0.018
1.968	0.023	1.968	0.026
2.296	0.030	2.296	0.034
2.624	0.039	2.624	0.044
2.952	0.048	2.952	0.055
3.280	0.058	3.280	0.067
⇓	⇓	⇓	⇓
26.240	0.970	26.240	0.995
26.568	0.972	26.568	0.996
26.896	0.975	26.896	0.997
27.224	0.977	27.224	0.998
27.552	0.979	27.552	0.998
27.880	0.981	27.880	0.999
28.208	0.982		
28.536	0.984		
28.864	0.985		
29.192	0.987		
⇓	⇓		
33.784	0.997		
34.112	0.997		
34.440	0.998		
34.768	0.998		
35.096	0.998		
35.424	0.998		
35.752	0.998		
36.080	0.999		
36.408	0.999		
36.736	0.999		

Screen Plots

This application generates two plots. These plots may be accessed by selecting the **Plot Data** option (F2) from the **Options** menu on the data output screen. The plots generated for the example problem are shown in Figures 3-2-1 and 3-2-2 below. The first plot displayed is the cumulative probability distribution of exceedance (CDF) versus wave height in deep water. The second plot is the CDF versus wave height in water depth of interest. After viewing the first plot, the second plot may be displayed by selecting the **NEXT** option in the graphics package (see Appendix C).

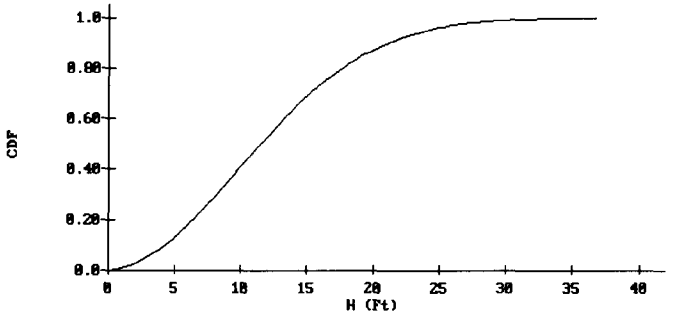

Figure 3-2-1. Wave Height versus Cumulative Probability Distribution of Exceedance (Deep Water)

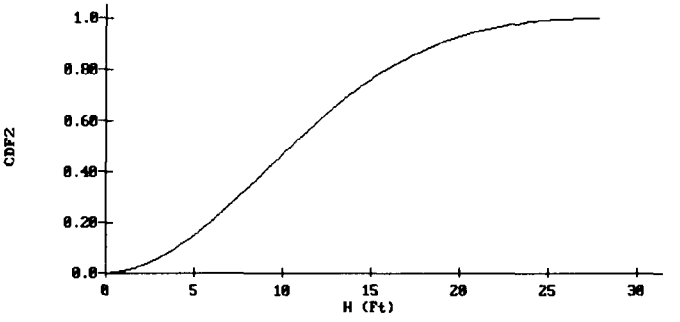

Figure 3-2-2. Wave Height versus Cumulative Probability Distribution of Exceedance (Water Depth = 50 ft)

REFERENCES AND BIBLIOGRAPHY

Goda, Y. 1975. "Irregular Wave Deformation in the Surf Zone," *Coastal Engineering in Japan*, Vol. 18, pp. 13-26.

Goda, Y. 1984. *Random Seas and Design of Maritime Structures*, University of Tokyo Press, Tokyo, Japan, pp. 41-46.

Mitsuyasu, H. 1975. "Observation of the Directional Spectrum of Ocean Waves Using a Cloverleaf Buoy," *Journal of Physical Oceanography*, Vol. 5, No. 4, pp. 750-760.

Shuto, N. 1974. "Nonlinear Long Waves in a Channel of Variable Section," *Coastal Engineering in Japan*, Vol. 17, pp. 1-12.

COMBINED DIFFRACTION AND REFLECTION BY A VERTICAL WEDGE

TABLE OF CONTENTS

Description 3-3-1
Coordinate System 3-3-1
Procedure 3-3-2
  Single Case Mode 3-3-2
    Evaluate at a Single Location 3-3-2
    Evaluate Upon a Uniform Grid 3-3-4
      Plot Output File 1 3-3-5
  Multiple Case Mode 3-3-5
Example Problems 3-3-7
  Example 1 - Semi-Infinite Breakwater (Single Point) 3-3-7
    Input 3-3-7
    Output 3-3-7
  Example 2 - 90-Deg Wedge (Single Point) 3-3-8
    Input 3-3-8
    Output 3-3-8
  Example 3 - Semi-Infinite Breakwater (Uniform Grid) 3-3-9
    Input 3-3-9
    Output 3-3-10
      Print File or Device 3-3-10
      Plot Output File 1 3-3-11
References and Bibliography 3-3-12

Combined Diffraction and Reflection by a Vertical Wedge

Description

This application estimates wave height modification due to combined diffraction and reflection near jettied harbor entrances, quay walls, and other such structures. Jetties and breakwaters are approximated as a single straight, semi-infinite breakwater by setting the wedge angle to zero. Corners of docks and quay walls may be represented by setting the wedge angle equal to 90 deg. Additionally, such natural diffracting and reflecting obstacles as rocky headlands can be approximated by setting a particular value for the wedge angle. Assumptions include monochromatic, linear waves, and constant water depth.

Coordinate System

The coordinate system and terminology used in the diffraction and reflection by a vertical wedge is shown in Figure 3-3-1.

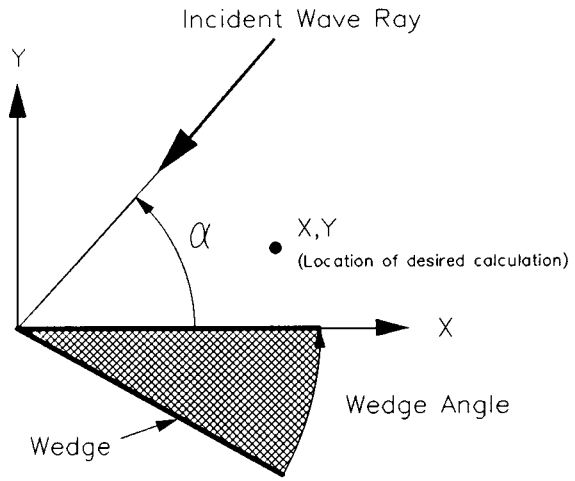

Figure 3-3-1. Diffraction/Reflection by Vertical Wedge System

PROCEDURE

This section provides instructions for running this application in the **Single Case** and **Multiple Case** modes.

Single Case Mode

- Press [F1] on the Main Menu to select Single Case Mode.
- Fill in the highlighted input fields on the General Specifications screen (or leave the default values). Press [F1] when all data on this screen are correct.
- Press [F3] on the Functional Area Menu to select Wave Transformation.
- Press [F3] on the Wave Transformation Application Area Menu to select Combined Diffraction and Reflection by a Vertical Wedge.

In Single Case mode, this application allows two options for calculating a modification factor and modified wave height.

- At a single location.
- Upon a uniform grid.

From the Activity Menu, select either the Single Location or Uniform Grid option. These two options are described below.

[F1] Evaluate at a Single Location

All data input for this option is done on one screen. The following list describes the necessary input parameters with their corresponding units and range of data recognized by this application:

Item	Symbol	Units	Data Range		
Incident Wave Height	H_i	ft,m	0.1	to	200
Wave Period	T	sec	1	to	1000

Water Depth	d	ft,m	0.01	to	5000
Wave Angle	α	deg	0	to	180
Wedge Angle		deg	0	to	180
X Coordinate	X	ft,m	-5280	to	5280
Y Coordinate	Y	ft,m	-5280	to	5280

NOTE: In practice, the range for X and Y should be limited to plus or minus 10 wavelengths.

When all the data have been entered press, F1 to begin calculations. When calculations have been completed, all input and output data are displayed on the screen in the selected system of units. Output data include the following parameters:

Item	Symbol	English Units	Metric Units
Wave Length	L	ft	m
Modification Factor (ratio of calculated wave height to incident wave height)	ϕ		
Wave Phase	β	rad	rad
Modified Wave Height	H	ft	m

After data have been displayed, press one of the following keys to select the appropriate action:

F1 Return to Step 1 for a new case.

F3 Send a summary of this case to the print file or device.

F10 Exit this application and return to the Activity Menu.

(F2) Evaluate Upon a Uniform Grid

All data input for this option is done on one screen. The following list describes the necessary input parameters with their corresponding units and range of data recognized by this application:

Item	Symbol	Units	Data Range		
Incident Wave Height	H_i	ft,m	0.1	to	200
Wave Period	T	sec	1	to	1000
Water Depth	d	ft,m	0.01	to	5000
Wave Angle	α	deg	0	to	180
Wedge Angle		deg	0	to	180
X Start Coordinate	X_0	ft,m	-5280	to	5280
X End Coordinate	X_m	ft,m	-5280	to	5280
Spatial Increment (X-direction)	ΔX		0.1	to	5280
Y Start Coordinate	Y_0	ft,m	-5280	to	5280
Y End Coordinate	Y_m	ft,m	-5280	to	5280
Spatial Increment (Y-direction)	ΔY		0.1	to	5280

> **CAUTION:** For the application to function properly, the **Start Coordinate** for both the X- and Y-directions **must** be *less than* the corresponding End Coordinate.

When all the data have been entered, press (F1) to begin calculations. When calculations have been completed, all input and output data are sent to the print file or device and also to plot output file 1 (default name **PLOTDAT1.OUT**). See the section titled Plot Output File 1 for the description and format of the contents of plot output file 1.

After calculations have been completed, press one of the following keys to select the appropriate action:

(F1) Return to Step 1 for a new case.

(F10) Exit this application and return to the Activity Menu.

Plot Output File 1

Plot output file 1 (default name **PLOTDAT1.OUT**) contains the Modification Factors, Modified Wave Heights, and Wave Phase differences between the incident and the modified waves at the grid points defined by the X and Y start and end coordinates. Plot output file 1 is written in the following format (see Table 3-3-2 in Example Problem 3):

Field	Columns	Format	Data
1	1-10	G10.3	X-coordinate
2	11-20	G10.3	Y-coordinate
3	21-30	G10.3	Modified wave height
4	31-40	G10.3	Modification factor
5	41-50	G10.3	Wave phase difference

Multiple Case Mode

- Press [F2] on the Main Menu to select Multi Case Mode.
- Fill in the highlighted input fields on the General Specifications screen (or leave the default values). Press [F1] when all data on this screen are correct.
- Press [F3] on the Functional Area Menu to select Wave Transformation.
- Press [F3] on the Wave Transformation Application Menu to select Combined Diffraction and Reflection by a Vertical Wedge.

1. Move the cursor to select a variable on the Combined Diffraction and Reflection by a Vertical Wedge screen (the selected variable name blinks). The current set of values for the variable is displayed on the right portion of the screen. When all variable sets are correct, go to Step 3.

2. Enter a set of values for the subject variable by following <u>one</u> of the input methods:

a. Press [R] to select random method. Enter up to 20 values constituting a set for this variable (one in each field) on the right side of the screen. The set of 20 values originally displayed (first execution) in these fields contains the "delimiting" value, which "delimits" or "ends" the set. The "delimiting" value is *not* included as a member in the set unless it is the sole member.

b. Press [I] to select incremental method. Fill in the fields for minimum, maximum, and increment values for this variable on the right side of the screen. In this method, the members of the set include all values from the minimum to the maximum (both inclusive) at the specified increment.

The units field should also be specified for the variable regardless of input method. All members of a set of values for a subject variable are assigned the specified units. When all data are correct for the subject variable, press [F10] to return to Step 1. Errors are reported at the bottom of the screen and are corrected by pressing [F1] to allow respecification of the data for the subject variable.

3. Press [F1] to process the cases resulting from the combinations of the sets of data for all variables. The summary of each case will be sent to the print file or device. The screen will display the total number of cases to be processed as well as report progress. Errors are reported at the bottom of the screen and are corrected by pressing [F1] to allow respecification of variable sets.

4. Press one of the following keys to select the appropriate action:

   [F1] Return to Step 1 to specify new sets.

   [F10] Exit this application and return to the Wave Transformation Application Menu.

EXAMPLE PROBLEMS

Example 1 - Semi-Infinite Breakwater (Single Point)

Input
All data input for this application is done on one screen. The values and corresponding units selected for this first example problem are shown below.

Item	Symbol	Value	Units
Incident Wave Height	H_i	2.0	ft
Wave Period	T	6.0	sec
Water Depth	d	12.0	ft
Wave Angle	α	135.0	deg
Wedge Angle		0.0	deg
X Coordinate	X	35.0	ft
Y Coordinate	Y	-17.0	ft

Output
Results from this application are displayed on one screen. These data include the original input values and the following parameters (see Figure 3-3-2):

Item	Symbol	Value	Units
Wave Length	L	109.82	ft
Modification Factor (ratio of calculated wave height to incident wave height)	ϕ	0.58	
Wave Phase	β	-2.58	rad
Modified Wave Height	H	1.16	ft

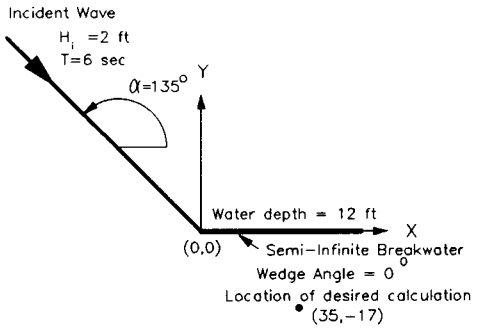

Figure 3-3-2. Semi-Infinite Breakwater Diffraction/Reflection Example Output

Example 2 - 90-Deg Wedge (Single Point)

Input

All data input for this application is done on one screen. The values and corresponding units selected for this second example problem are shown below.

Item	Symbol	Value	Units
Incident Wave Height	H_i	5	m
Wave Period	T	8	sec
Water Depth	d	10	m
Wave Angle	α	47	deg
Wedge Angle		90	deg
X Coordinate	X	-10	m
Y Coordinate	Y	-40	m

Output

Results from this application are displayed on one screen. These data include the original input values and the following parameters (see Figure 3-3-3):

Item	Symbol	Value	Units
Wave Length	L	70.88	m
Modification Factor (ratio of calculated wave height to incident wave height)	ϕ	0.60	
Wave Phase	β	2.12	rad
Modified Wave Height	H	3.01	m

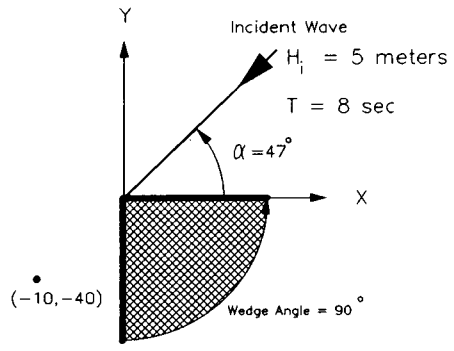

Figure 3-3-3. 90-Deg Wedge Diffraction/Reflection Example Output

Example 3 - Semi-Infinite Breakwater (Uniform Grid)

Input

All data input for this application is done on one screen. The values and corresponding units selected for this second example problem are shown below (see Figure 3-3-4).

Item	Symbol	Value	Units
Incident Wave Height	H_i	4	ft
Wave Period	T	12	sec
Water Depth	d	30	ft
Wave Angle	α	52	deg
Wedge Angle		0	deg
X Start Coordinate	X_0	-600	ft
X End Coordinate	X_m	200	ft
Spatial Increment (X-direction)	ΔX	200	ft
Y Start Coordinate	Y_0	-400	ft
Y End Coordinate	Y_m	200	ft
Spatial Increment (Y-direction)	ΔY	100	ft

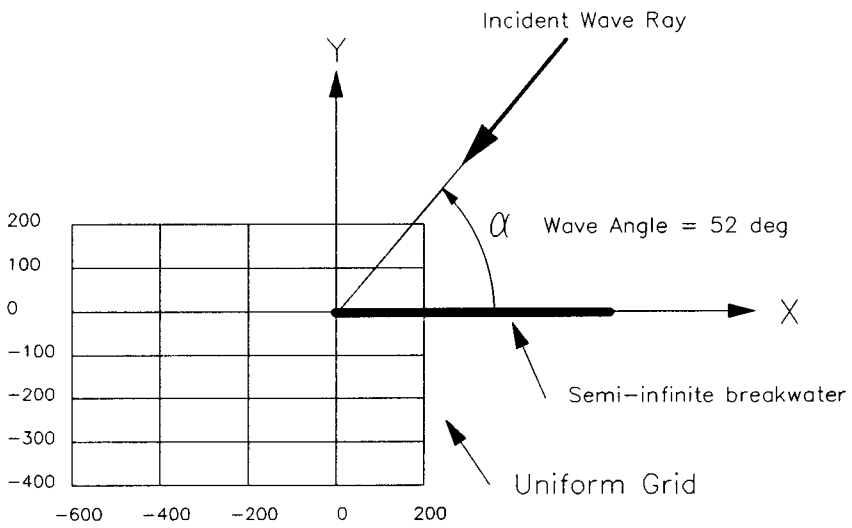

Figure 3-3-4. Semi-Infinite Breakwater Diffraction/Reflection (uniform grid)

Output

Results from this application are sent to the print file or device (see Table 3-3-1) and to plot output file 1 (default name **PLOTDAT1.OUT**) (see Table 3-3-2).

Print File or Device

Table 3-3-1
Combined Reflection and Diffraction by a Vertical Wedge

Incident Wave Height	=	4.00	ft	Wave Period	=	12.00	sec
Water Depth	=	30.00	ft	Wavelength	=	356.85	ft
Wave Angle	=	52.00	deg	Wedge Angle	=	0.00	deg

***** Modification Factors:

	x=	-600.00	-400.00	-200.00	0.00	200.00
y=	200.00	1.00	1.15	1.27	1.67	1.88
y=	100.00	1.04	1.00	0.83	0.74	0.20
y=	0.00	1.00	1.00	1.00	1.00	1.77
y=	-100.00	1.04	1.03	0.86	0.46	0.23
y=	-200.00	1.06	0.93	0.66	0.37	0.22
y=	-300.00	1.00	0.80	0.53	0.32	0.21
y=	-400.00	0.90	0.67	0.44	0.28	0.20
	x=	-600.00	-400.00	-200.00	0.00	200.00

***** Modified Wave Heights (ft):

	x=	-600.00	-400.00	-200.00	0.00	200.00
y=	200.00	4.02	4.59	5.07	6.68	7.52
y=	100.00	4.17	4.00	3.33	2.96	0.81
y=	0.00	4.00	4.00	4.00	4.00	7.08
y=	-100.00	4.17	4.10	3.42	1.84	0.92
y=	-200.00	4.25	3.74	2.66	1.48	0.88
y=	-300.00	4.02	3.19	2.12	1.27	0.84
y=	-400.00	3.61	2.68	1.77	1.14	0.80
	x=	-600.00	-400.00	-200.00	0.00	200.00

***** Phase Angles (rad):

	x=	-600.00	-400.00	-200.00	0.00	200.00
y=	200.00	2.47	-1.60	0.79	-2.97	-1.09
y=	100.00	1.18	-2.87	-0.75	0.52	2.77
y=	0.00	-0.22	1.95	-2.17	0.00	2.18
y=	-100.00	-1.61	0.63	2.82	-2.22	1.64
y=	-200.00	-2.93	-0.68	1.34	2.22	0.60
y=	-300.00	2.04	-2.07	-0.27	0.42	-0.77
y=	-400.00	0.69	2.75	-1.94	-1.37	-2.30
	x=	-600.00	-400.00	-200.00	0.00	200.00

Plot Output File 1

Plot output file 1 (default name **PLOTDAT1.OUT**) contains at grid points defined by the X and Y start and end coordinates the Modified Wave Heights, Modification Factors, and Wave Phase differences between the incident and modified waves. Table 3-3-2 is a listing of plot output file 1 for Example 3.

Table 3-3-2
Listing of Plot Output File 1 for Example Problem 3

Combined Reflection and Diffraction by a Vertical Wedge
Wedge Angle: 0 Incident Wave Angle: 52

ft	ft	ft		rad
-600.	-400.	3.61	0.903	0.690
-400.	-400.	2.68	0.670	2.75
-200.	-400.	1.77	0.442	-1.94
0.000	-400.	1.14	0.285	-1.37
200.	-400.	0.804	0.201	-2.30
-600.	-300.	4.02	1.00	2.04
-400.	-300.	3.19	0.798	-2.07
-200.	-300.	2.12	0.531	-0.273
0.000	-300.	1.27	0.319	0.419
200.	-300.	0.843	0.211	-0.772
-600.	-200.	4.25	1.06	-2.93
-400.	-200.	3.74	0.934	-0.684
-200.	-200.	2.66	0.665	1.34
0.000	-200.	1.48	0.369	2.22
200.	-200.	0.882	0.221	0.599
-600.	-100.	4.17	1.04	-1.61
-400.	-100.	4.10	1.03	0.629
-200.	-100.	3.42	0.856	2.82
0.000	-100.	1.84	0.460	-2.22
200.	-100.	0.916	0.229	1.64
-600.	0.000	4.00	1.00	-0.221
-400.	0.000	4.00	1.00	1.95
-200.	0.000	4.00	1.00	-2.17
0.000	0.000	4.00	1.00	0.000
200.	0.000	7.08	1.77	2.18
-600.	100.	4.17	1.04	1.18
-400.	100.	4.00	1.00	-2.87
-200.	100.	3.33	0.833	-0.754

(Table 3-3-2 Continued on the Next Page)

(Table 3-3-2 Concluded)

0.000	100.	2.96	0.740	0.517
200.	100.	0.809	0.202	2.77
-600.	200.	4.02	1.00	2.47
-400.	200.	4.59	1.15	-1.60
-200.	200.	5.07	1.27	0.787
0.000	200.	6.68	1.67	-2.97
200.	200.	7.52	1.88	-1.09

REFERENCES AND BIBLIOGRAPHY

Chen, H. S. 1987. "Combined Reflection and Diffraction by a Vertical Wedge," Technical Report CERC-87-16, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Chen, H. S., and Thompson, E. F. 1985. "Iterative and Pade Solutions for the Water - Wave Dispersion Relation," Miscellaneous Paper CERC-85-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Kaihatu, J. A., and Chen, H. S. 1988. "Combined Diffraction and Reflection by a Vertical Wedge: PCDFRAC User's Manual," Technical Report CERC-88-9, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Morris, A. H., Jr. 1984. "NSWC Library of Mathematics Subroutines," NSWC TR 84 -143, Strategic Systems Department, Naval Surface Weapons Center, Dahlgren, Va.

Penny, W. G., and Price, A. T. 1952 "The Diffraction Theory of Sea Waves by Breakwaters, and the Shelter Afforded by Breakwaters", *Philosophical Transactions, Royal Society* (London), Series A, Vol. 244, pp. 236-253

Stoker, J. J. 1957. *Water Waves*, Interscience Publishers Inc., New York, pp. 109-133.

Shore Protection Manual. 1984. 4th ed., 2 Vols., US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, US Government Printing Office, Washington, DC, Chapter 2, pp. 75-109.

Wiegel, R. L. 1962. "Diffraction of Waves by a Semi-Infinite Breakwater," *Journal of the Hydraulics Division*, Vol. 88, No. HY1, pp. 27-44.