BREAKWATER DESIGN USING HUDSON AND RELATED EQUATIONS

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BREAKWATER DESIGN USING HUDSON AND RELATED EQUATIONS

DESCRIPTION

This application provides estimates for the armor weight, minimum crest width, armor thickness, and the number of armor units per unit area of a breakwater using Hudson and related equations.

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
Armor unit weight	w_r	lb/ft^3, N/m^3	1.0 to 99999.0
Wave height	H_i	ft, m	0.1 to 100.0
Stability coefficient	K_D		See Table A-1, Appendix A.
Layer coefficient	k_Δ		See Table A-2, Appendix A.
Average porosity of armor layer	P	%	See Table A-2, Appendix A.
Cotangent of structure slope	$\cot\theta$		1.0 to 6.0
Number of armor units comprising the thickness of the armor layer	n		1 to 3

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
Weight of an individual armor unit	W	lb	N
Crest width of breakwater	B	ft	m
Average cover layer thickness	r	ft	m
Number of single armor units per unit surface area	N_r		

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 [F4] on the Functional Area Menu to select Wave - Structure Interaction.
- Press [F1] on the Structural Design Menu to select Breakwater Design Using Hudson and Related Equations.

1. Fill in the highlighted input fields on the screen. Respond to any corrective instructions appearing at the bottom of the screens. Press [F1] when all data on this screen are correct or [F10] to provide access to the additional following options (choose one):

   [F1] Return to the input screen.

   [F3] Display tables of suggested K_D values.

   [F4] Display a table of suggested values for P and k_Δ

   [F10] Exit application.

2. All output data and selected input 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 Structural Design 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 [F4] on the Functional Area Menu to select Structural Design.
- Press [F1] on the Structural Design Menu to select Breakwater Design Using Hudson and Related Equations.

1. Move the cursor to select a variable on the Breakwater Design Using Hudson and Related Equations 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 Structural Design 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.

Type of Armor Unit: Tribar, nonbreaking wave on structure trunk [Optional Input]

Item	Symbol	Value	Units
Armor unit weight	w_r	165.00	lb/ft^3
Wave height	H_i	11.50	ft
Stability coefficient	K_D	10.00	
Layer coefficient	k_Δ	1.02	
Average porosity of armor layer	P	54.00	%
Cotangent of structure slope	$\cot\theta$	2.00	
Number of armor units comprising the thickness of the armor layer	n	2	

Output

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

Item	Symbol	Value	Units
Weight of an individual armor unit	W	1.59	tons
Crest width of breakwater	B	8.21	ft
Average cover layer thickness	r	5.47	ft
Number of single armor units per unit surface area	N_r	130.30	

REFERENCES AND BIBLIOGRAPHY

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Hudson, R. Y. 1953. "Wave Forces on Breakwaters," *Transactions of the American Society of Civil Engineers*, American Society of Civil Engineers, Vol. 118, p. 653.

Hudson, R. Y. 1959. "Laboratory Investigations of Rubble-Mound Breakwaters," *Proceedings of the American Society of Civil Engineers*, American Society of Civil Engineers, Waterways and Harbors Division, Vol. 85, NO. WW3, Paper No. 2171.

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Smith, O. P. 1986. "Cost-Effective Optimization of Rubble-Mound Breakwater Cross Sections," Technical Report CERC-86-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS, p. 48.

Zwamborn, J. A., and Van Niekerk, M. 1982. *Additional Model Tests--Dolos Packing Density and Effect of Relative Block Density*, CSIR Research Report 554, Council for Scientific and Industrial Research, National Research Institute for Oceanology, Coastal Engineering and Hydraulics Division, Stellenbosch, South Africa.

TOE PROTECTION DESIGN

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TOE PROTECTION DESIGN

DESCRIPTION

Toe protection consists of armor for the beach or bottom material fronting a structure to prevent wave scour. This application determines armor stone size and width of a toe protection apron for *vertical* faced structures such as seawalls, bulkheads, quay walls, breakwaters, and groins. Apron width is determined by the geotechnical and hydraulic guidelines specified in Engineer Manual 1110-2-1614. Stone size is determined by a method (Tanimoto, Yagyu, and Goda, 1982) whereby a stability equation is applied to a single rubble unit placed at a position equal to the width of the toe apron and subjected to standing waves.

INPUT

The terminology and symbols used in this application are shown in Figures 4-2-1 and 4-2-2.

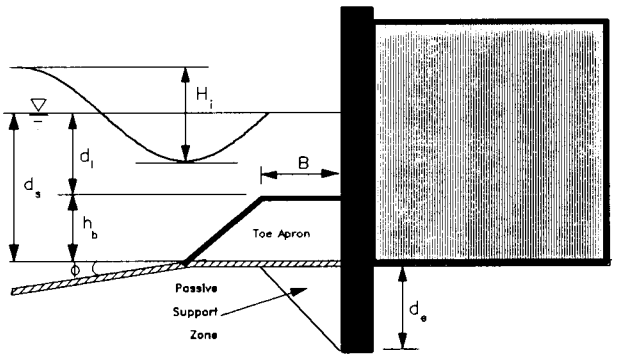

Figure 4-2-1. Typical Toe Apron for Sheet-Pile Walls

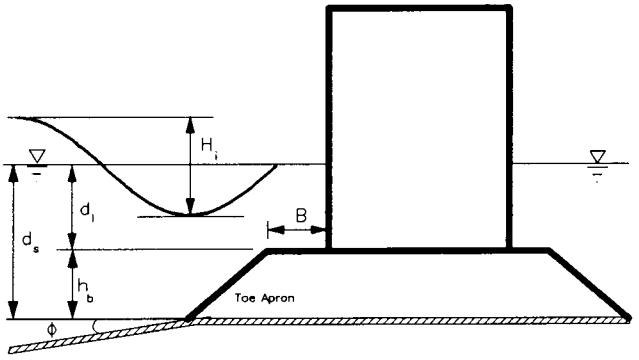

Figure 4-2-2. Typical Apron for Breakwaters

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
Incident wave height	H_i	ft, m	0.1 to 100.0
Wave period	T	sec	1.0 to 1000.0
Water depth at structure	d_s	ft, m	0.1 to 200.0
Cotangent of nearshore slope	$\cot\phi$		5.0 to 10000.0
Passive earth pressure coefficient	K_p		0.0 to 50.0
Sheet-pile penetration depth	d_e	ft, m	0.0 to 200.0
NOTE: For structures without sheet piles, the values of K_p and d_e should be set to 0.0.			
Height of toe protection layer above mudline	h_b	ft, m	0.1 to 200.0
Unit weight of rock	w_r	lb/ft^3, N/m^3	1.0 to 99999.0

OUTPUT

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

Item	Symbol	English Units	Metric Units
Width of toe protection apron	B	ft	m
Weight of individual armor unit	W	lb	N
Water depth at top of toe protection layer	d_l	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 [F4] on the Functional Area Menu to select Structural Design.
- Press [F2] on the Structural Design Menu to select Toe Protection Design.

1. Fill in the highlighted input fields on the screen. Respond to any corrective instructions appearing at the bottom of the screens. Press [F1] when all data on this screen are correct.
2. All output data and selected input 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 Structural Design 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 [F4] on the Functional Area Menu to select Structural Design.
- Press [F2] on the Structural Design Menu to select Toe Protection Design.

1. Move the cursor to select a variable on the Toe Protection Design 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 Structural Design Menu.

EXAMPLE PROBLEMS

Example 1 - Toe Protection for a Bulkhead

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	5.00	ft
Wave period	T	12.00	sec
Water depth at structure	d_s	20.00	ft
Cotangent of nearshore slope	$\cot\phi$	100.00	
Passive earth pressure coefficient	K_p	1.50	
Sheet-pile penetration depth	d_e	10.00	ft
Height of toe protection layer above mudline	h_b	4.50	ft
Unit weight of rock	w_r	165.00	lb/ft^3

Output

Results from this application are displayed on one screen. Those data include the original input values and the following parameters (see Figure 4-2-3 for location of parameters):

Item	Symbol	Value	Units
Width of toe protection apron	B	15.00	ft
Weight of individual armor unit	W	12.99	lb
Water depth at top of toe protection layer	d_l	15.50	ft

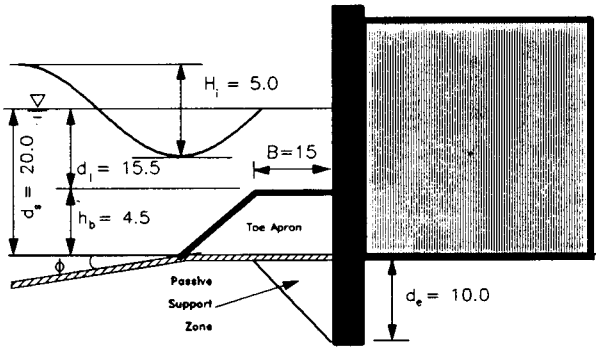

Figure 4-2-3. Toe Protection for Bulkhead Example Output

Example 2 - Toe Protection for a Vertical Breakwater

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
Incident wave height	H_i	5.00	ft
Wave period	T	12.00	sec
Water depth at structure	d_s	20.00	ft
Cotangent of nearshore slope	$\cot\phi$	100.00	
Passive earth pressure coefficient	K_p	0.00	
Sheet-pile penetration depth	d_e	0.00	
Height of toe protection layer above mudline	h_b	4.50	ft
Unit weight of rock	w_r	165.00	lb/ft^3

Output

Results from this application are displayed on one screen. Those data include the original input values and the following parameters (see Figure 4-2-4 for location of parameters):

Item	Symbol	Value	Units
Width of toe protection apron	B	10.00	ft
Weight of individual armor unit	W	4.836	lb
Water depth at top of toe protection layer	d_l	15.50	ft

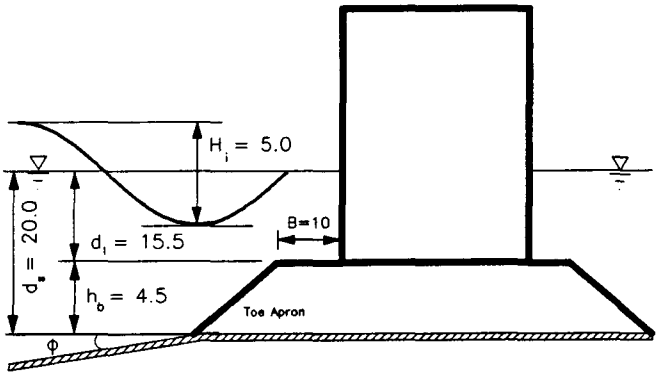

Figure 4-2-4. Toe Protection for Vertical Breakwater Example Output

REFERENCES AND BIBLIOGRAPHY

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Eckert, J. W., and Callendar, G. 1987. "Geotechnical Engineering in the Coastal Zone," Instructional Report CERC-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS, Chapter 8, pp. 36-38.

Headquarters, Department of the Army. 1985. "Design of Coastal Revetments, Seawalls, and Bulkheads," Engineer Manual 1110-2-1614, Washington, DC, Chapter 2, pp. 15-19.

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NONBREAKING WAVE FORCES AT VERTICAL WALLS

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NONBREAKING WAVE FORCES AT VERTICAL WALLS

DESCRIPTION

This application provides the pressure distribution and resultant force and moment loading on a vertical wall caused by normally incident, *nonbreaking*, regular waves as proposed by Sainflou (1928), Miche (1944), and Rundgren (1958). The results can be used to design vertical structures in protected or fetch-limited regions when the water depth at the structure is greater than about 1.5 times the maximum expected wave height. Both the Sainflou and Miche-Rundgren theories are used by this application to determine wave-induced pressure distribution on a vertical wall. Sainflou's theory is more appropriate for measuring results of long, nonbreaking waves of low steepness, but it overpredicts as the waves become steeper. The Miche-Rundgren theory provides more accurate results for steep, nonbreaking waves, but the theory begins to overpredict as the wavelength is increased. Given wave properties and a wave reflection coefficient, this application presents results of each theory with a recommendation of using results from the theory giving lower values for force and moment. This application provides the same results as found using the design curves given in Chapter 7 of the SPM (1984).

INPUT

The terminology used to define wave forces at vertical walls is shown in Figure 4-3-1.

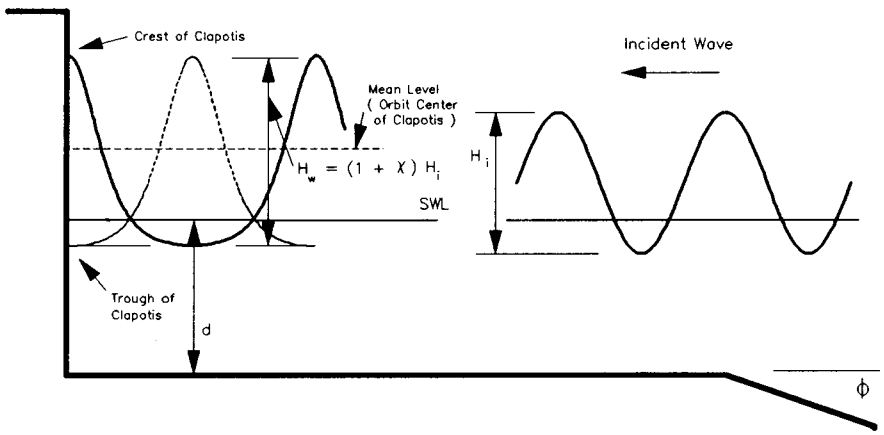

Figure 4-3-1. Nonbreaking Waves at Vertical Walls

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		
Depth for SWL	d	ft, m	0.1	to	200.0
Incident wave height	H_i	ft, m	0.1	to	100.0
Wave period	T	sec	1.0	to	100.0
Wave reflection coefficient	χ		0.9	to	1.0
Cotangent of nearshore slope	$\cot\phi$		5.0	to	10000.0

OUTPUT

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

Screen Output

Results from this application are displayed on one screen. Those data includes the original input values (in final units) and the following parameters at the wave *crest* and *trough* for both the *Miche-Rundgren* and *Sainflou* methods:

Item	Symbol	English Units	Metric Units
Wave crest and trough positions at wall (measured from the bottom)		ft	m
Integrated wave force		lb/ft	n/m
Integrated moment about base		lb-ft/ft	n-m/m

Also displayed on the screen is a recommendation to use results from the method yielding the lower values for force and moment.

Plot Output File 1

Plot output file 1 contains the Miche-Rundgren and Sainflou pressure distribution for both the wave crest and trough at the wall and is written in the following format (see Table 4-3-1 in the example problem):

Field	Columns	Format	Data
1	1-3	I3	Point Counter
2	5-14	F10.2	Elevation
3	19-28	F10.2	Wave Pressure
4	33-42	F10.2	Hydrostatic Pressure
5	50-59	F10.2	Wave and Hydrostatic Pressure

Screen Plots

This application generates four plots showing pressure distribution for both the Miche-Rundgren and Sainflou methods with the wave crest and trough at the wall. Three curves per plot are plotted including the individual wave and hydrostatic pressure and the sum of the wave and hydrostatic pressure (see Figures 4-3-2 through 4-3-5 in the example problem).

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 [F4] on the Functional Area Menu to select Structural Design.

- Press [F3] on the Structural Design Menu to select Nonbreaking Wave Forces at Vertical Walls.

1. Fill in the highlighted input fields on the Nonbreaking Wave Forces at Vertical Walls 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 pressure data.

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

   [F4] Generate a file containing the plot data (Plot Output File 1).

   [F10] Exit this application and return to the Structural Design 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 [F4] on the Functional Area Menu to select Structural Design.
- Press [F3] on the Structural Design Menu to select Nonbreaking Wave Forces at Vertical Walls.

1. Press [F1] to enter Multi Case data entry mode.
2. Move the cursor to select a variable on the Nonbreaking Wave Forces at Vertical Walls 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.
3. 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.

4. 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.

5. 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 Structural Design 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
Depth for SWL	d	15.0	ft
Incident wave height	H_i	8.0	ft
Wave period	T	10.0	sec
Wave reflection coefficient	χ	1.0	
Cotangent of nearshore slope	$\cot\phi$	100.0	

Output

Results from this application are displayed on one screen and, if requested (in Single Case only), written to plot output file 1. In addition, four 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:

Wave Position at Wall	MICHE-RUNDGREN		SAINFLOU		
	Crest	Trough	Crest	Trough	Units
Hgt above Bottom	32.95	16.95	32.95	16.95	ft
Integrated Force	28683.39	7121.92	17724.17	2323.04	lb/ft
Integrated Moment about Base	306958.40	38825.47	148008.60	7214.73	lb-ft/ft

NOTE: Sainflou results are recommended for this case.

Plot Output File 1

Table 4-3-1 below is a partial listing of plot output file 1 (default name **PLOTDAT1.OUT**) generated by this application for the example problem.

Table 4-3-1
Partial Listing of Plot Output File 1 for Example Problem

Miche-Rundgren Pressure Distribution
Crest at Wall (Figure 4-3-2)

	Elevation (ft)	Wave Pressure (lb/ft^2)	Hydrostatic Pressure (lb/ft^2)	Wave & Hydrostatic Pressure (lb/ft^2)
1	-15.00	871.49	959.79	1831.28
2	-14.65	871.52	937.40	1808.92
3	-14.30	871.62	915.00	1786.62
4	-13.95	871.78	892.60	1764.38
5	-13.60	872.01	870.20	1742.21
6	-13.25	872.30	847.79	1720.09
7	-12.90	872.65	825.39	1698.04
8	-12.55	873.07	802.97	1676.05
9	-12.20	873.56	780.56	1654.12
⇓	⇓	⇓	⇓	⇓
83	14.79	152.88	0.00	152.88
84	15.18	133.71	0.00	133.71
85	15.57	114.56	0.00	114.56
86	15.96	95.43	0.00	95.43
87	16.36	76.31	0.00	76.31
88	16.75	57.21	0.00	57.21
89	17.15	38.13	0.00	38.13
90	17.55	19.06	0.00	19.06
91	17.95	0.00	0.00	0.00

(Table 4-3-1 Continued on the Next Page)

(Table 4-3-1 Continued)

Miche-Rundgren Pressure Distribution

Trough at Wall (Figure 4-3-3)

	Elevation (ft)	Wave Pressure (lb/ft^2)	Hydrostatic Pressure (lb/ft^2)	Wave & Hydrostatic Pressure (lb/ft^2)
1	-15.00	-465.53	959.79	494.26
2	-14.82	-459.31	948.41	489.10
3	-14.64	-453.10	937.02	483.92
4	-14.47	-446.90	925.64	478.74
5	-14.29	-440.71	914.25	473.54
6	-14.11	-434.53	902.86	468.33
7	-13.93	-428.35	891.47	463.11
8	-13.75	-422.19	880.07	457.89
9	-13.58	-416.03	868.68	452.65
⇓	⇓	⇓	⇓	⇓
83	0.29	45.25	0.00	45.25
84	0.50	39.59	0.00	39.59
85	0.70	33.94	0.00	33.94
86	0.91	28.28	0.00	28.28
87	1.11	22.63	0.00	22.63
88	1.32	16.97	0.00	16.97
89	1.53	11.31	0.00	11.31
90	1.74	5.66	0.00	5.66
91	1.95	0.00	0.00	0.00

Sainflou Pressure Distribution

Crest at Wall (Figure 4-3-4)

	Elevation (ft)	Wave Pressure (lb/ft^2)	Hydrostatic Pressure (lb/ft^2)	Wave & Hydrostatic Pressure (lb/ft^2)
1	-15.00	465.53	959.79	1425.32
2	-14.73	466.96	942.20	1409.16

(Table 4-3-1 Continued on the Next Page)

(Table 4-3-1 Continued)

3	-14.45	468.40	924.61	1393.00
4	-14.18	469.85	907.02	1376.86
5	-13.90	471.31	889.42	1360.73
6	-13.63	472.78	871.83	1344.61
7	-13.35	474.27	854.23	1328.50
8	-13.08	475.76	836.63	1312.40
9	-12.80	477.27	819.03	1296.31
⇓	⇓	⇓	⇓	⇓
83	7.94	125.38	0.00	125.38
84	8.23	109.71	0.00	109.71
85	8.52	94.03	0.00	94.03
86	8.81	78.36	0.00	78.36
87	9.10	62.69	0.00	62.69
88	9.39	47.02	0.00	47.02
89	9.69	31.34	0.00	31.34
90	9.98	15.67	0.00	15.67
91	17.95	0.00	0.00	0.00

Sainflou Pressure Distribution
Trough at Wall (Figure 4-3-5)

	Elevation (ft)	Wave Pressure (lb/ft^2)	Hydrostatic Pressure (lb/ft^2)	Wave & Hydrostatic Pressure (lb/ft^2)
1	-15.00	-465.53	959.79	494.26
2	-14.90	-464.11	953.21	489.10
3	-14.79	-462.71	946.63	483.92
4	-14.69	-461.32	940.05	478.74
5	-14.59	-459.93	933.47	473.54
6	-14.49	-458.56	926.89	468.33
7	-14.38	-457.20	920.31	463.11
8	-14.28	-455.85	913.73	457.89
9	-14.18	-454.51	907.15	452.65
⇓	⇓	⇓	⇓	⇓

(Table 4-3-1 Continued on the Next Page)

(Table 4-3-1 Concluded)

83	-6.56	-374.30	419.54	45.25
84	-6.45	-373.33	412.93	39.59
85	-6.35	-372.37	406.31	33.94
86	-6.25	-371.41	399.69	28.28
87	-6.14	-370.45	393.07	22.63
88	-6.04	-369.48	386.45	16.97
89	-5.94	-368.52	379.83	11.31
90	-5.83	-367.55	373.21	5.66
91	1.95	0.00	0.00	0.00

Screen Plot

This application generates four plots. The plots may be accessed from the **Nonbreaking Wave Forces on Vertical Walls Plot Selection Menu**, which appears when the **Plot Pressure Data** option (F2) from the input screen is requested. To access a plot, move the cursor (using the arrow keys) to the desired plot and press F1. (Appendix C describes options to customize plots.) The plots generated for this example problem are shown below.

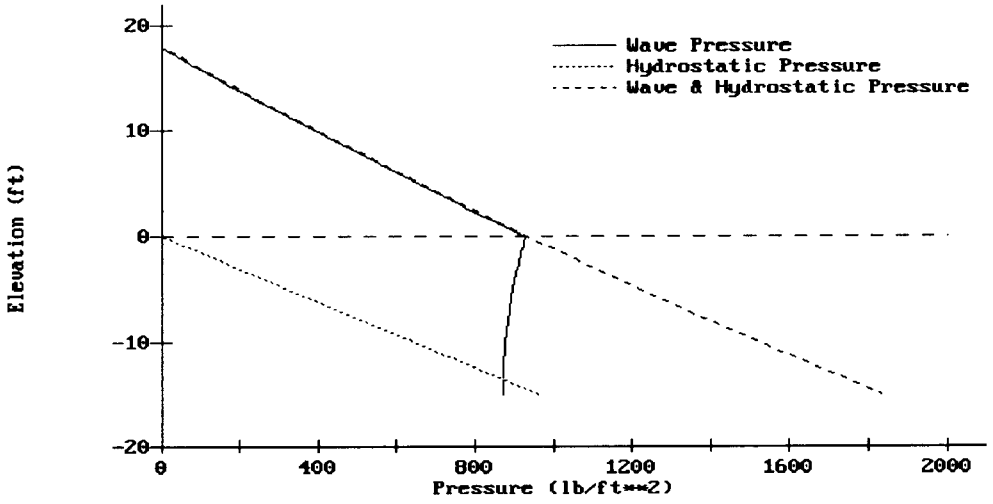

Figure 4-3-2. Miche-Rundgren Pressure Distribution - Crest at Wall

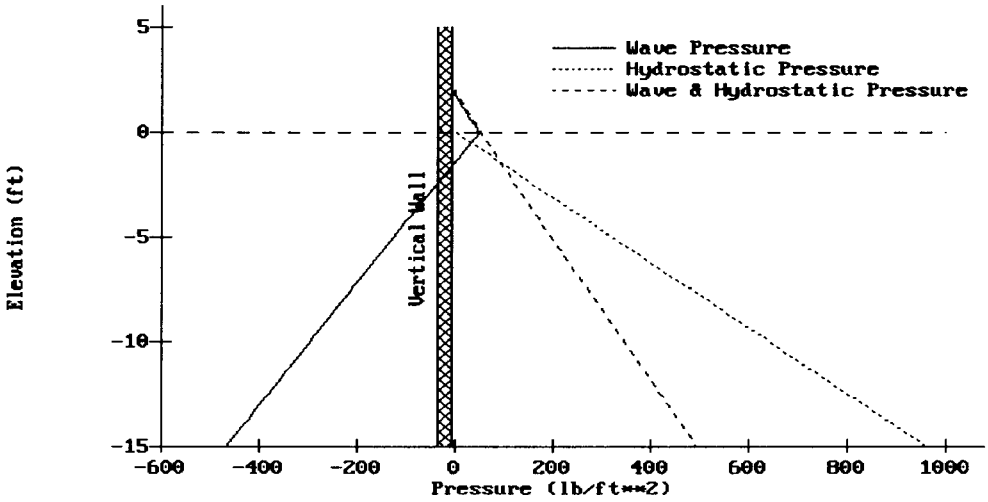

Figure 4-3-3. Miche-Rundgren Pressure Distribution - Trough at Wall

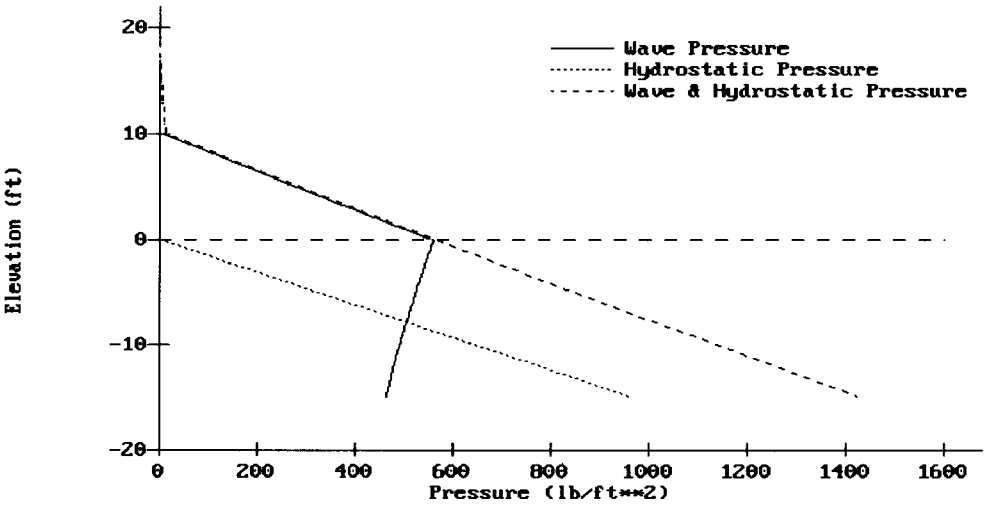

Figure 4-3-4. Sainflou Pressure Distribution - Crest at Wall

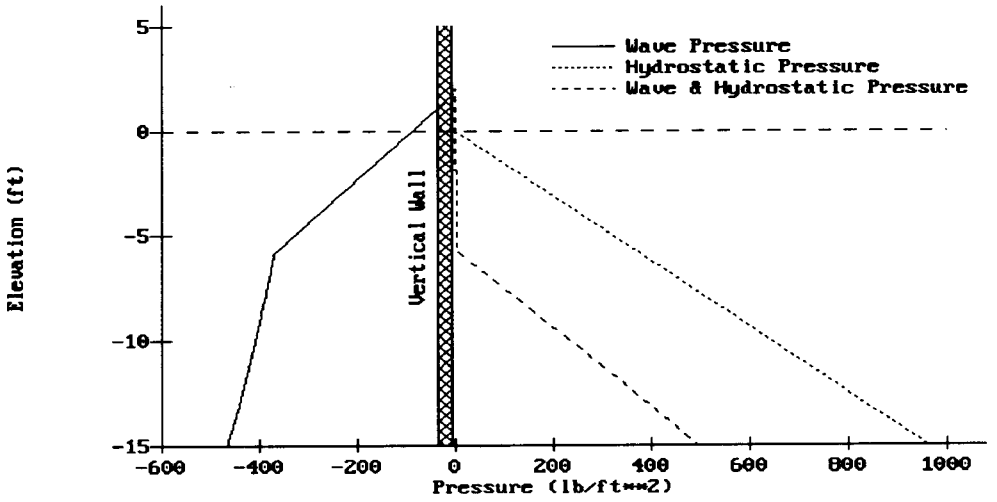

Figure 4-3-5. Sainflou Pressure Distribution - Trough at Wall

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RUBBLE-MOUND REVETMENT DESIGN

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RUBBLE-MOUND REVETMENT DESIGN

DESCRIPTION

Quarrystone is the most commonly used material for protecting earth embankments from wave attack because, where available, high-quality stone provides a stable and unusually durable revetment armor material at relatively low cost. This ACES application provides estimates for revetment armor and bedding layer stone sizes, thicknesses, and gradation characteristics. Also calculated are two values of runup on the revetment, an expected extreme and a conservative runup value.

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 wave height	H_s	ft, m	0.1	to	100.0
Significant wave period	T_s	sec	1.0	to	1000.0
Cotangent nearshore slope	$\cot\phi$		5.0	to	10000.0
Water depth at toe of revetment	d_s	ft, m	0.1	to	200.0
Cotangent of structure slope	$\cot\theta$		2.0	to	6.0
Unit weight of rock	w_r	lb/ft^3, N/m^3	1.0	to	99999.0
Permeability coefficient	P		0.05	to	0.6
Damage level	S		2	to	17

OUTPUT

Results from this application are displayed on one screen. The results include the armor and filter layer thicknesses, stone size gradations (weight and size), and an expected extreme and conservative runup on the riprap revetment.

Item	Symbol	English Units	Metric Units
Weight of individual armor and filter stone	W	lb	N
Armor/filter layer thickness	r	ft	m
Runup (expected maximum and conservative)	R	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 [F4] on the Functional Area Menu to select Structural Design.
- Press [F4] on the Structural Design Menu to select Rubble-Mound Revetment Design.

1. Fill in the highlighted input fields on the screen. Respond to any corrective instructions appearing at the bottom of the screens. Press [F1] when all data on this screen are correct.
2. All 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 Structural Design 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 [F4] on the Functional Area Menu to select Structural Design.
- Press [F4] on the Structural Design Menu to select Rubble-Mound Revetment Design.

1. Move the cursor to select a variable on the Rubble-Mound Revetment Design 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 Structural Design 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.

Item	Symbol	Value	Units
Significant wave height	H_s	5.0	ft
Significant wave period	T_s	10.0	sec
Cotangent nearshore slope	$\cot\phi$	100.0	
Water depth at toe of revetment	d_s	9.0	ft
Cotangent of structure slope	$\cot\theta$	2.0	
Unit weight of rock	w_r	165.0	lb/ft^3
Permeability coefficient	P	0.1	
Damage level	S	2.0	

Output

Results from this application are displayed on one screen. The results include the armor and filter layer thicknesses, stone size gradations (weight and size), and an expected extreme and conservative runup on the riprap revetment.

ARMOR LAYER Thickness = 4.95 ft

PERCENT LESS THAN BY WEIGHT	WEIGHT (lbs)	DIMENSION (ft)
0.00	313.08	1.24
15.00	1001.84	1.82
50.00	2504.61	2.48
85.00	4909.04	3.10
100.00	10018.44	3.93

FILTER LAYER Thickness = 1.24 ft

PERCENT LESS THAN BY WEIGHT	WEIGHT (lbs)	DIMENSION (ft)
0.00	0.82	0.17
15.00	1.38	0.20
50.00	4.65	0.30
85.00	15.65	0.46
100.00	26.35	0.54

IRREGULAR WAVE RUNUP
EXPECTED MAXIMUM = 10.96 ft
CONSERVATIVE = 13.79 ft

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