IRREGULAR WAVE RUNUP ON BEACHES

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Irregular Wave Runup on Beaches

Description

This application provides an approach to calculate runup statistical parameters for wave runup on smooth slope linear beaches. To account for permeable and rough slope natural beaches, the present approach needs to be modified by multiplying the results for the smooth slope linear beaches by a reduction factor. However, there is no guidance for such a reduction due to the sparcity of good field data on wave runup. The approach used in this ACES application is based on existing laboratory data on irregular wave runup (Mase and Iwagaki, 1984; Mase, 1989).

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		
Deepwater significant wave height	H_{so}	ft, m	0.1	to	100.0
Peak energy wave period	T_p	sec	0.1	to	100.0
Cotangent of foreshore slope	$\cot\theta$		0.1	to	100.0

Output

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

Item	Symbol	English Units	Metric Units
Runup			
Maximum runup	R_{max}	ft	m
Runup exceeded by 2 percent of the runups	R_2	ft	m

Average of the highest one-tenth of the runups	$R_{1/10}$	ft	m
Average of the highest one-third of the runups	$R_{1/3}$	ft	m
Average runup	$\overline{R}$	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 [F5] on the Functional Area Menu to select Wave Runup, Transmission, and Overtopping.

° Press [F1] on the Wave Runup, Transmission, and Overtopping Application Menu to select Irregular Wave Runup on Beaches.

1. Fill in the highlighted input fields on the Irregular Wave Runup on Beaches 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 <u>one</u> 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 Runup, Transmission, and Overtopping 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 F5 on the Functional Area Menu to select Wave Runup, Transmission, and Overtopping.
- Press F1 on the Wave Runup, Transmission, and Overtopping Application Menu to select Irregular Wave Runup on Beaches.

1. Move the cursor to select a variable on the Irregular Wave Runup on Beaches 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 Runup, Transmission, and Overtopping Menu.

Example Problem

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
Deepwater significant wave height	H_{so}	4.60	ft
Peak energy wave period	T_p	9.50	sec
Cotangent of foreshore slope	$\cot\theta$	13.00	

Output

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

Item	Symbol	Value	Units
Maximum runup	R_{max}	8.74	ft
Runup exceeded by 2 percent of the runups	R_2	7.11	ft
Average of the highest one-tenth of the runups	$R_{1/10}$	6.50	ft
Average of the highest one-third of the runups	$R_{1/3}$	5.29	ft
Average runup	$\overline{R}$	3.38	ft

REFERENCES AND BIBLIOGRAPHY

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Wave Runup and Overtopping on Impermeable Structures

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WAVE RUNUP AND OVERTOPPING ON IMPERMEABLE STRUCTURES

DESCRIPTION

This application provides estimates of wave runup and overtopping on rough and smooth slope structures that are assumed to be impermeable. Run-up heights and overtopping rates are estimated independently or jointly for monochromatic or irregular waves specified at the toe of the structure. The empirical equations suggested by Ahrens and McCartney (1975), Ahrens and Titus (1985), and Ahrens and Burke (1987) are used to predict runup, and Weggel (1976) to predict overtopping. Irregular waves are represented by a significant wave height and are assumed to conform to a Rayleigh distribution (Ahrens, 1977). The overtopping rate is estimated by summing the overtopping contributions from individual runups in the distribution.

INPUT

The terminology used to define wave runup is shown in Figure 5-2-1.

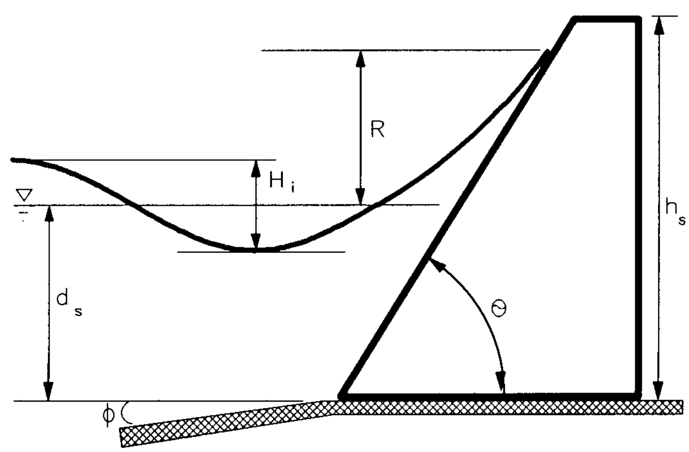

Figure 5-2-1. Wave Runup and Overtopping

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:

Mandatory 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
Cotan of nearshore slope	$cot\ \phi$		5.0	to	10000.0
Water depth at structure toe	d_s	ft, m	0.1	to	200.0
Cotan of structure slope	$cot\ \Theta$		0.0	to	30.0

NOTE: For vertical walls, specify 0.0.

Structure height above toe	h_s	ft, m	0.0	to	200.0

The above input variables are mandatory. In addition, the following input variables are required under the specified circumstances:

Item	Symbol	Source
Rough slope runup		
Empirical coefficient	a	See Table A-3 of Appendix A
Empirical coefficient	b	for suggested values.
Overtopping		
Empirical coefficient	α	See Figures 7-24 to 7-34 in the
Empirical coefficient	Q^*_0	SPM (1984).

Item	Symbol	Units	Data Range		
Onshore wind velocity	U	kn, ft/sec mph, m/sec, kph	0.0	to	200.0
Wave runup (if known)	R	ft, m	0.0	to	100.0

NOTE: For irregular waves, substitute the following:

Incident significant wave height	(H_s)	for	H_i
Peak wave period	(T_p)	for	T

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 (monochromatic waves)	Symbol (irregular waves)	English Units	Metric Units
Deepwater				
Wave height	H_0	H_{s0}	ft	m
Relative height	d_s/H_0	d_s/H_{s0}		
Wave steepness	H_0/gT^2	H_{s0}/gT^2		
Runup	R(if requested)	R_s	ft	m
Overtopping rate	Q(if requested)	Q	ft^3/sec-ft	m^3/sec-m

The deepwater wave parameters are provided as an aid to determining the empirical overtopping coefficients from the referenced figures in the SPM (1984).

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 F5 on the Functional Area Menu to select Wave Runup, Transmission, and Overtopping.
- Press F2 on the Wave Runup, Transmission, and Overtopping Application Menu to select Wave Runup and Overtopping on Impermeable Structures.
- On the Wave Runup and Overtopping on Impermeable Structures Menu, press one of the following:

Selections for Monochromatic Waves

- F1 Estimate runup on rough slope structures.
- F2 Estimate runup on smooth slope structures.
- F3 or F4 Estimate overtopping rate with a known run-up value.
- F5 Estimate both runup and overtopping rate on rough slope structures.
- F6 Estimate both runup and overtopping rate on smooth slope structures.

Selections for Irregular Waves

- F7 or F8 Estimate overtopping rate with a known run-up value.

1. Fill in the highlighted input fields on the Wave Runup and Overtopping on Impermeable Structures screen. Respond to any corrective instructions appearing at the bottom of the screen. Press F1 when all data on this screen are correct.

   NOTE: If the selected case involved the computation of rough slope runup, F10 may be pressed to provide access to the additional following options (choose one):

   - F1 Return to the input screen.
   - F2 Display a table of suggested rough slope run-up empirical coefficients (a and b). If this option is selected, these coefficients must be entered in the designated fields of the display screen. The data thus given will be transferred back to (and displayed on) the main input screen when F1 is pressed.
   - F10 Exit the application.

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 Runup, Transmission, and Overtopping Menu.

Multiple Case Mode

Run-up values are provided in this operational mode, but overtopping rates are excluded because of possible functional dependencies between incident wave conditions, structure slope, and the empirical overtopping coefficients. Single Case or Batch Modes may be used to process cases providing overtopping rates.

- 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 F5 on the Functional Area Menu to select Wave Runup, Transmission, and Overtopping.
- Press F2 on the Wave Runup, Transmission, and Overtopping Application Menu to select Wave Runup and Overtopping on Impermeable Structures.
- On the Wave Runup and Overtopping on Impermeable Structures Menu, press <u>one</u> of the following:

  F1 Estimate runup on rough slope structures.

  NOTE: Selection of this option will display the table of suggested rough slope run-up empirical coefficients (*a* and *b*). Fill in the highlighted input fields with the values for these items, and press F1 to resume input on the main input screen, or press F10 to exit the application.

  F2 Estimate runup on smooth slope structures.

1. Move the cursor to select a variable on the Wave Runup and Overtopping on Impermeable Structures 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 (<u>one</u> 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 <u>one</u> 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 Runup, Transmission, and Overtopping Menu.

EXAMPLE PROBLEMS

Example 1 - Monochromatic Wave - Rough Slope Runup (Riprap)

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	12.50	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	20.00	ft
Rough slope run-up item			
Empirical coefficient	a	0.956	
Empirical coefficient	b	0.398	

Output

Item	Symbol	Value	Units
Deep water			
Wave height	H_0	6.386	ft
Relative height	d_s/H_0	1.957	
Wave steepness	H_0/gT^2	0.002	
Runup	R	9.421	ft

Example 2 - Monochromatic Wave - Smooth Slope Runup

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	12.50	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	20.00	ft

Output

Item	Symbol	Value	Units
Deep water			
Wave height	H_0	6.386	ft
Relative height	d_s/H_0	1.957	
Wave steepness	H_0/gT^2	0.002	
Runup	R	21.366	ft

Example 3 - Monochromatic Wave - Rough Slope Overtopping

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	12.50	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	20.00	ft
Overtopping item			
Empirical coefficient (computed)	α	0.076463	
Empirical coefficient	Q^*_0	0.025	
Onshore wind velocity	U	35.000	kn
Wave runup (if known)	R	15.000	ft

Output

Item	Symbol	Value	Units
Deep water			
Wave height	H_0	6.386	ft
Relative height	d_s/H_0	1.957	
Wave steepness	H_0/gT^2	0.001985	
Overtopping rate	Q	3.565	ft^3/sec-ft

Example 4 - Monochromatic Wave - Smooth Slope Overtopping

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	12.50	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	20.00	ft
Overtopping item			
Empirical coefficient (computed)	α	0.076463	
Empirical coefficient	Q^*_0	0.025	
Onshore wind velocity	U	35.000	kn
Wave runup (if known)	R	20.000	ft

Output

Item	Symbol	Value	Units
Deep water			
Wave height	H_0	6.386	ft
Relative height	d_s/H_0	1.957	
Wave steepness	H_0/gT^2	0.001985	
Overtopping rate	Q	5.368	ft^3/sec-ft

Example 5 - Monochromatic Wave - Rough Slope Runup and Overtopping (Riprap)

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	12.50	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	20.00	ft
Rough slope run-up item			
Empirical coefficient	a	0.956	
Empirical coefficient	b	0.398	
Overtopping item			
Empirical coefficient (computed)	α	0.076463	
Empirical coefficient	Q^*_0	0.025	
Onshore wind velocity	U	35.000	kn

Output

Item	Symbol	Value	Units
Deep water			
Wave height	H_0	6.386	ft
Relative height	d_s/H_0	1.957	
Wave steepness	H_0/gT^2	0.001985	
Runup	R	9.421	ft
Overtopping rate	Q	0.829	ft^3/sec-ft

Example 6 - Monochromatic Wave - Smooth Slope Runup and Overtopping

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	12.50	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	20.00	ft
Overtopping item			
Empirical coefficient (computed)	α	0.076463	
Empirical coefficient	Q^*_0	0.025	
Onshore wind velocity	U	35.000	kn

Output

Item	Symbol	Value	Units
Deep water			
Wave height	H_0	6.386	ft
Relative height	d_s/H_0	1.957	
Wave steepness	H_0/gT^2	0.001985	
Runup	R	21.366	ft
Overtopping rate	Q	5.771	ft^3/sec-ft

Example 7 - Irregular Wave - Rough Slope Runup and Overtopping (Riprap)

Input

Item	Symbol	Value	Units
Incident wave height	H_s	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	12.50	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	20.00	ft
Rough slope run-up item			
Empirical coefficient	a	0.956	
Empirical coefficient	b	0.398	
Overtopping item			
Empirical coefficient (computed)	α	0.076463	
Empirical coefficient	Q^*_0	0.025	
Onshore wind velocity	U	35.000	kn

Output

Item	Symbol	Value	Units
Deep water			
Wave height	H_{s0}	6.386	ft
Relative height	d_s/H_{s0}	1.957	
Wave steepness	H_{s0}/gT^2	0.001985	
Runup	R_s	9.421	ft
Overtopping rate	Q	0.287	ft^3/sec-ft

Example 8 - Irregular Wave - Smooth Slope Runup and Overtopping

Input

Item	Symbol	Value	Units
Incident wave height	H_s	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	12.50	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	20.00	ft
Overtopping item			
Empirical coefficient (computed)	α	0.076463	
Empirical coefficient	Q^*_0	0.025	
Onshore wind velocity	U	35.000	kn

Output

Item	Symbol	Value	Units
Deep water			
Wave height	H_{s0}	6.386	ft
Relative height	d_s/H_0	1.957	
Wave steepness	H_{s0}/gT^2	0.001985	
Runup	R_s	21.366	ft
Overtopping rate	Q	2.728	ft^3/s-ft

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Wave Transmission on Impermeable Structures

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WAVE TRANSMISSION ON IMPERMEABLE STRUCTURES

DESCRIPTION

This application provides estimates of wave runup and transmission on rough and smooth slope structures. It also addresses wave transmission over impermeable vertical walls and composite structures. In all cases, monochromatic waves are specified at the toe of a structure that is assumed to be impermeable. For sloped structures, a method suggested by Ahrens and Titus (1985) and Ahrens and Burke (1987) is used to predict runup, while the method of Cross and Sollitt (1971) as modified by Seelig (1980) is used to predict overtopping. For vertical wall and composite structures, a method proposed by Goda, Takeda, and Moriya (1967) and Goda (1969) is used to predict wave transmission.

INPUT

The terminology used to define wave transmission on impermeable structures is shown in Figures 5-3-1 and 5-3-2.

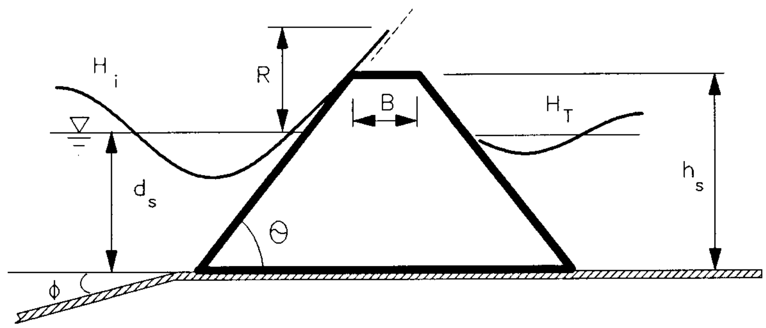

Figure 5-3-1. Wave Runup and Overtopping

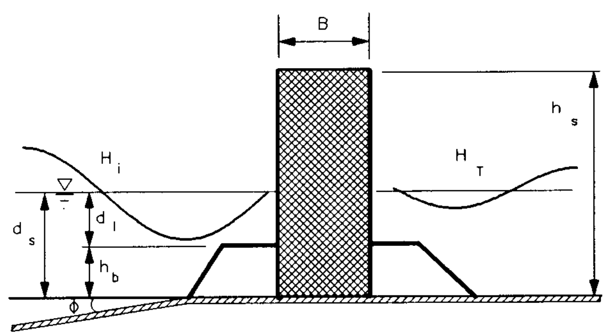

Figure 5-3-2. Composite Structure with Vertical Wall

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:

Mandatory 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
Cotan of nearshore slope	$cot\ \phi$		5.0	to	10000.0
Water depth at structure toe	d_s	ft, m	0.1	to	200.0
Structure height above toe	h_s	ft, m	0.0	to	200.0
Structure crest width	B	ft, m	0.0	to	200.0

The above input variables are mandatory. In addition, the following input variables are required under the specified circumstances:

Item	Symbol	Units	Data Range		
Rough and smooth slope					
Cotan of structure slope	$cot\ \Theta$		0.0	to	30.0
Runup (if known)	R	ft, m	0.0	to	100.0

Item	Symbol	Source
Rough slope runup		
Empirical coefficient	a	See Table A-3 of Appendix A
Empirical coefficient	b	for suggested values.

Item	Symbol	Units	Data Range		
Vertical wall					
Toe protection or composite breakwater berm height above structure toe (if present)	h_b	ft, m	0.0	to	200.0

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
Wave runup (if requested)	R	ft	m
Transmitted wave height	H_T	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 F5 on the Functional Area Menu to select Wave Runup, Transmission, and Overtopping.
- Press F3 on the Wave Runup, Transmission, and Overtopping Application Menu to select Wave Transmission on Impermeable Structures.
- On the Wave Transmission on Impermeable Structures Menu, press one of the following:

  F1 Estimate wave transmission over a sloped structure (with a known run-up value).

  F2 Estimate wave transmission over a vertical wall or composite breakwater.

  F3 Estimate both runup and wave transmission on rough slope structures.

  F4 Estimate both runup and wave transmission on smooth slope structures.

1. Fill in the highlighted input fields on the Wave Transmission on Impermeable Structures screen. Respond to any corrective instructions appearing at the bottom of the screen. Press F1 when all data on this screen are correct.

   NOTE: If the selected case involved the computation of rough slope runup, F10 may be pressed to provide access to the additional following options (choose one):

   F1 Return to the input screen.

F2 Display a table of suggested rough slope run-up empirical coefficients (*a* and *b*). If this option is selected, these coefficients must be entered in the designated fields of the display screen. The data thus given will be transferred back to (and displayed on) the main input screen when F1 is pressed.

F10 Exit the application.

2. All input and output data are displayed on the screen in the final system of units.
3. Press <u>one</u> 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 Runup, Transmission, and Overtopping Menu.

Multiple Case Mode

Run-up values and the associated transmitted wave heights over sloped structures are provided in this operational mode. Also, wave transmission over vertical walls and composite structures is handled. Wave transmission with known run-up values on sloped structures is excluded because of possible functional dependencies between given incident wave conditions, structure slope, and run-up values. Single Case or Batch Modes may be used to process cases providing wave transmission with known run-up values.

- 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 F5 on the Functional Area Menu to select Wave Runup, Transmission, and Overtopping.
- Press F3 on the Wave Runup, Transmission, and Overtopping Application Menu to select Wave Transmission on Impermeable Structures.
- On the Wave Transmission on Impermeable Structures Menu, press <u>one</u> of the following:

F2 Estimate wave transmission over vertical walls or composite structures.

F3 Estimate runup and wave transmission on rough slope structures.

NOTE: Selection of this option will display the table of suggested rough slope run-up empirical coefficients (*a* and *b*). Fill in the highlighted input fields with the values for these items, and press F1 to resume input on the main input screen, or press F10 to exit the application.

F4 Estimate runup and wave transmission on smooth slope structures.

1. Move the cursor to select a variable on the Wave Transmission on Impermeable Structures 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 Runup, Transmission, and Overtopping Menu.

Example Problems

Example 1 - Sloped Structure - Known Runup - Transmission Only

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	10.00	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	15.00	ft
Structure crest width	B	7.50	ft
Known runup	R	15.00	ft

Output

Item	Symbol	Value	Units
Transmitted wave height	H_T	2.275	ft

Example 2 - Vertical Wall with Berm (Submerged) - Transmission Only

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	4.50	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	20.00	ft
Structure height above toe	h_s	17.50	ft
Structure crest width	B	12.00	ft
Structure berm height above toe	h_b	6.00	ft

Output

Item	Symbol	Value	Units
Transmitted wave height	H_T	3.798	ft

Example 3 - Rough Slope - Runup and Transmission (Riprap)

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	10.00	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	15.00	ft
Structure crest width	B	7.50	ft
Empirical coefficient	a	0.956	
Empirical coefficient	b	0.398	

Output

Item	Symbol	Value	Units
Wave runup	R	9.421	ft
Transmitted wave height	H_T	1.601	ft

Example 4 - Smooth Slope - Runup and Transmission

Input

Item	Symbol	Value	Units
Incident wave height	H_i	7.50	ft
Wave period	T	10.00	sec
Cotan of nearshore slope	$cot\ \phi$	100.00	
Water depth at structure toe	d_s	10.00	ft
Cotan of structure slope	$cot\ \Theta$	3.00	
Structure height above toe	h_s	15.00	ft
Structure crest width	B	7.50	ft

Output

Item	Symbol	Value	Units
Wave runup	R	22.436	ft
Transmitted wave height	H_T	2.652	ft

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Wave Transmission Through Permeable Structures

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WAVE TRANSMISSION THROUGH PERMEABLE STRUCTURES

DESCRIPTION

Porous rubble-mound structures consisting of quarry stones of various sizes often offer an attractive solution to the problem of protecting a harbor against wave action. It is important to assess the effectiveness of a given breakwater design by predicting the amount of wave energy transmitted by the structure. This application determines wave transmission coefficients and transmitted wave heights for permeable breakwaters with crest elevations at or above the still-water level. This application can be used with breakwaters armored with stone or artificial armor units. The application uses a method developed for predicting wave transmission by overtopping coefficients using the ratio of breakwater freeboard to wave runup (suggested by Cross and Sollitt, 1971). The wave transmission by overtopping prediction method is then combined with the model of wave reflection and wave transmission through permeable structures of Madsen and White (1976). Seelig (1979,1980) had developed a similar version for mainframe processors.

INPUT

All data input for this application is done on two screens. For each screen the necessary input parameters with their corresponding units and range of data recognized by this application are given below.

First Screen

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
Number of materials comprising the breakwater	NM		1	to	4

Mean diameter of each material	d_{50}	ft, m	0.05	to	99.0

NOTE: Determine the mean diameter of a given material using the following relation:

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

where: W_{50} = median weight
γ = specific weight

Porosity of each material	P	%	See Table A-2, Appendix A

Second Screen (Breakwater Geometry Input)

Item	Symbol	Units	Data Range		
Units		ft, m			
Structure height above toe	h_s	ft, m	0.1	to	200.0
Cotangent of structure slope	$\cot\theta$		1.0	to	5.0
Structure crest width	B	ft, m	0.1	to	200.0
Number of horizontal layers in the breakwater	NL		1	to	4

NOTE: Divide the breakwater into horizontal layers. A new layer occurs any time there is a change vertically in any material type. Make the layer next to the seabed *layer number 1* and proceed upward.

Thickness of each horizontal layer	TH	ft, m	0.1	to	200.0
Horizontal length of each material in each layer	LL	ft, m	0.0	to	200.0

NOTE: Determine an *average* horizontal length of each material in each layer. This average length is measured at the *midpoint* of each layer. Remove the outer layer of armor from the seaward face of the breakwater before making length calculations, because the energy dissipation on the front face is determined separately.

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
Wave reflection coefficient	K_R		
Wave transmission coefficients			
Through	K_{Tt}		
Overtopping	K_{To}		
Total	K_T		
Transmitted wave height	H_T	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 F5 on the Functional Area Menu to select Wave Runup, Transmission, and Overtopping.
- Press F4 on the Wave Runup, Transmission, and Overtopping Menu to select Wave Transmission Through Permeable Structures.

1. Fill in the highlighted input fields on the first screen; then press F1 to obtain the second screen in this application, and fill in the input fields. Respond to any corrective instructions appearing at the bottom of the screens. Press F1 when all data on this second 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 Wave Runup, Transmission, and Overtopping 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 F5 on the Functional Area Menu to select Wave Runup, Transmission, and Overtopping.
- Press F4 on the Wave Runup, Transmission, and Overtopping Menu to select Wave Transmission Through Permeable Structures.

1. Fill in the highlighted input fields on the first screen; then press F1 to obtain the second screen in this application, and fill in the input fields. Respond to any corrective instructions appearing at the bottom of the screen. Press F1 when all data on this second screen are correct to obtain the third data input screen.

2. Move the cursor to select the wave height or wave period variable on this 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 4.

3. 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 (<u>one</u> 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 <u>one</u> 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 Runup, Transmission, and Overtopping Menu.

Example Problems

Example 1 - Breakwater (3 Materials and 3 Layers)

Input

All data input for this application is done on two screens. For each screen the values and corresponding units selected for this first example problem are shown below.

First Screen

Item	Symbol	Value	Units
Wave Characteristics			
Incident wave height	H_i	6.56	ft
Wave period	T	20.00	sec
Water depth at structure	d_s	15.75	ft

Item	Symbol	Value
Material Characteristics		
Number of materials comprising the breakwater	NM	3
Units		ft
Mean diameter of material 1-Armor	d_{50}	2.39
Mean diameter of material 2-Underlayer		1.11
Mean diameter of material 3-Core		0.30
Porosity of material 1	P	37%
Porosity of material 2		37%
Porosity of material 3		37%

Second Screen (Breakwater Geometry Input)

See Figure 5-4-1 for the breakwater dimensions used in this first example.

Item	Symbol	Value
Units		ft
Structure height above toe	h_s	19.69
Cotangent of structure slope	$\cot\theta$	1.5
Structure crest width	B	8.27
Number of horizontal layers in the breakwater	NL	3

Thickness of layer 1	TH_1	11.65
Thickness of layer 2	TH_2	2.56
Thickness of layer 3	TH_3	1.54
Note: Sum of the layer thicknesses must = the water depth.		
Length of material 1 in layer 1	$LL_{1,1}$	14.76 (9.84+4.92)
Length of material 1 in layer 2	$LL_{1,2}$	14.76 (9.84+4.92)
Length of material 1 in layer 3	$LL_{1,3}$	17.39
Length of material 2 in layer 1	$LL_{2,1}$	12.46 (6.23+6.23)
Length of material 2 in layer 2	$LL_{2,2}$	8.20
Length of material 2 in layer 3	$LL_{2,3}$	0.0
Length of material 3 in layer 1	$LL_{3,1}$	21.00
Length of material 3 in layer 2	$LL_{3,2}$	0.0
Length of material 3 in layer 3	$LL_{3,3}$	0.0

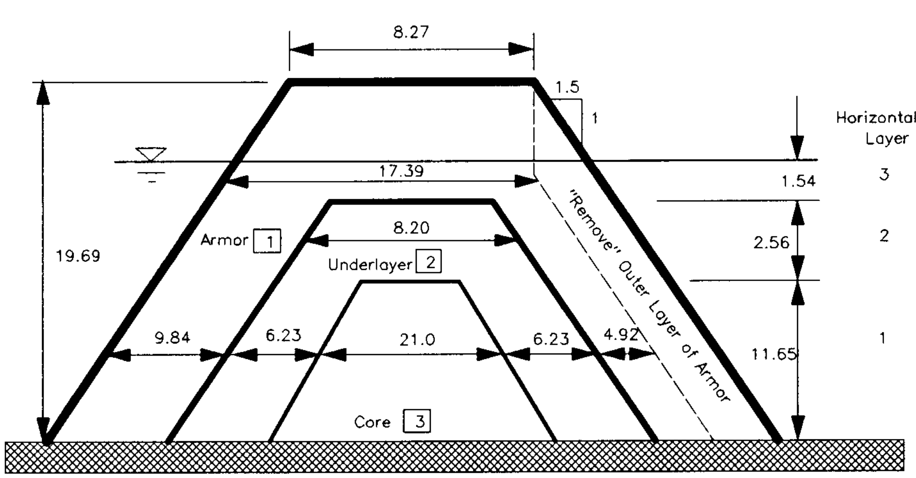

Figure 5-4-1. Sample Problem 1 - Breakwater Geometry

Output

Item	Symbol	Value	Units
Wave reflection coefficient	K_R	0.719	
Wave transmission coefficients			
Through	K_{Tt}	0.077	
Overtopping	K_{To}	0.227	
Total	K_T	0.239	
Transmitted wave height	H_T	1.570	ft

Example 2 - Breakwater (3 Materials and 4 Layers)

Input

All data input for this application is done on two screens. For each screen the values and corresponding units selected for this second example problem are shown below.

First Screen

Item	Symbol	Value	Units
Wave Characteristics			
Incident wave height	H_i	10	ft
Wave period	T	15.00	sec
Water depth at structure	d_s	25.00	ft

Item	Symbol	Value
Material Characteristics		
Number of materials comprising the breakwater	NM	3
Units		ft
Mean diameter of material 1	d_{50}	3.61
Armor-16,000 lb units (170 lb/ft^3)		
Mean diameter of material 2		2.07
Underlayer-3,000 lb stone (170 lb/ft^3)		
Mean diameter of material 3		1.05
Core-400 lb stone (170 lb/ft^3)		
Porosity of material 1	P	37%
Porosity of material 2		37%
Porosity of material 3		37%

Second Screen (Breakwater Geometry Input)

See Figure 5-4-2 for the breakwater dimensions used in this second example.

Item	Symbol	Value
Units		ft
Structure height above toe	h_s	38.00
Cotangent of structure slope	$\cot\theta$	1.75
Structure crest width	B	18.00
Number of horizontal layers in the breakwater	NL	4

Thickness of layer 1	TH_1	4.00
Thickness of layer 2	TH_2	8.00
Thickness of layer 3	TH_3	7.00
Thickness of layer 4	TH_4	6.00

Note: Sum of the layer thicknesses must = the water depth.

Length of material 1 in layer 1	$LL_{1,1}$	0
Length of material 1 in layer 2	$LL_{1,2}$	0
Length of material 1 in layer 3	$LL_{1,3}$	10
Length of material 1 in layer 4	$LL_{1,4}$	28 (10+18)
Length of material 2 in layer 1	$LL_{2,1}$	14
Length of material 2 in layer 2	$LL_{2,2}$	36
Length of material 2 in layer 3	$LL_{2,3}$	46 (16+30)
Length of material 2 in layer 4	$LL_{2,4}$	32
Length of material 3 in layer 1	$LL_{3,1}$	128
Length of material 3 in layer 2	$LL_{3,2}$	75
Length of material 3 in layer 3	$LL_{3,3}$	22
Length of material 3 in layer 4	$LL_{3,4}$	0

NOTE: Length of a particular material is measured at the *midpoint* of the layer.

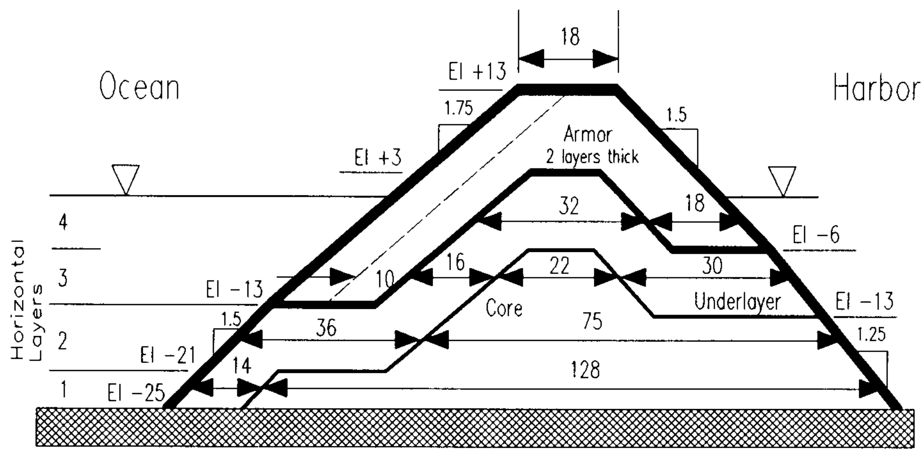

Figure 5-4-2. Sample Problem 2 - Breakwater Geometry

Output

Item	Symbol	Value	Units
Wave reflection coefficient	K_R	0.662	
Wave transmission coefficients			
Through	K_{Tt}	0.055	
Overtopping	K_{To}	0	
Total	K_T	0.055	
Transmitted wave height	H_T	0.550	ft

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