Coastal Engineering Technical Note

ESTIMATING IRREGULAR WAVE RUNUP HEIGHTS ON ROUGH SLOPES COMPUTER PROGRAM: WAVRUNUP (MACE-14)

PROGRAM PURPOSE: This program applies the significant wave height at the site, the peak spectral period, the cotangent of the structure's seaward slope and a choice of slope material to estimate runup heights on rough slopes corresponding to the 50 percent, 13.5 percent, 10 percent, 1 percent, and other optional probabilities of exceedance.

PROGRAM APPLICATION: Prediction of wave runup heights on structures with rough slopes, such as breakwaters or revetments, is necessary to evaluate their level of functional performance. The program WAVRUNUP applies the relation of runup to the surf similarity parameter developed by Ahrens and McCartney (1976) and adapted for application with irregular waves by Seelig (1980):

$$R/H = a\xi/(1 + b\xi)$$

where

R = runup height above still water level

H = incident wave height at toe of structure

ξ = surf similarity parameter

$= \tan\theta / \sqrt{H/L_o}$

L_o = equivalent deep water wavelength = $gT^2/2\pi$

g = acceleration of gravity

T = wave period

a & b = empirical runup coefficients for particular slope materials, as indicated in Table 1

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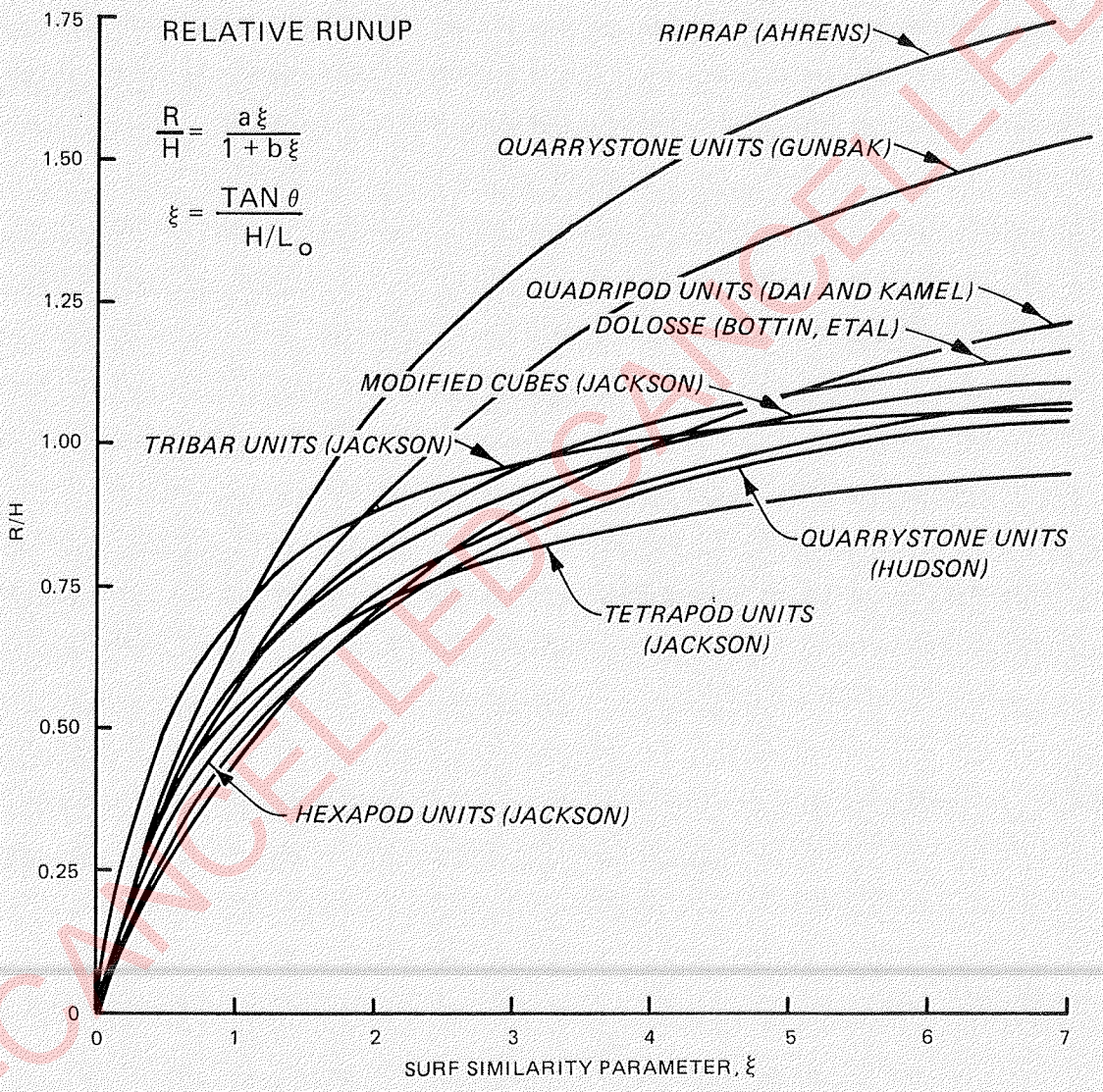
Table 1 - Runup Coefficients Applied by the Program RUNUP

Material	a	b
Graded Riprap (impermeable base)	0.956	0.398
Quarrystone (permeable base)	0.775	0.361
Plain Cubes*	0.775	0.361
Modified Cubes	0.99	0.74
Tetrapods	1.04	0.95
Quadripods	0.60	0.35
Hexapods	0.80	0.60
Tribars	1.71	1.45
Toskanes*	0.988	0.703
Dolosse	0.988	0.703

*Coefficients for these units were assumed the same as the most similarly shaped units for which test data were available.

The distribution of wave heights in a sea state of irregular waves, even in shallow water (before breaking), is known to closely follow a Rayleigh probability distribution. Wave periods vary to a lesser degree, but a simplifying assumption can be made that all periods in a particular sea state equal the period of maximum energy density. This assumption has been shown by Andrew and Smith (1985) to be conservative when applied to runup predictions made with the above empirical formula. Previously suggested means to estimate irregular runup Shore Protection Manual (SPM, 1984) have applied a Rayleigh distribution to the runup computed by the above formula. This in effect assumes that the wave steepness, H/Lo, is constant. Assumption of constant period is a more accurate, but still conservative, method to address irregular runup given an incident significant wave height and period of peak spectral density. Both methods assume the "hypothesis of equivalence" which states that the effect of each individual wave in an irregular sea state is equivalent to that of a monochromatic wave of the same height and period and is independent of the effects of preceding or following waves. The alternatives to the approach proposed here and that of the SPM, which involve extensive computations dealing with both wave height and period as random variables, are considered at this time to be inappropriate for the MACE program (see CETN-VI-16, 11/84).



PROGRAM CAPABILITY: The program is written in Microsoft BASIC for the IBM PC and uses English or metric units.

PROGRAM AVAILABILITY: The program is available for the IBM PC on a 5 1/4-in. diskette or as a printed program listing and may be obtained from Ms. Gloria J. Naylor of the Engineering Computer Programs Library at 601-634-2151 or FTS 542-2151, US Army Engineer Waterways Experiment Station, P.O. Box 631, Vicksburg, Mississippi 39180-0631. Questions concerning the applications of WAVRUNUP can be directed to Mr. Orson P. Smith at 601-634-2013 (FTS 542-2013) or Mr. Doyle L. Jones at 601-634-2069 (FTS 542-2069) both of the Coastal Engineering Research Center, Coastal Design Branch.

INPUT:

1. Incident significant wave height (ft or m)

2. Incident peak spectral period (sec)

3. Cotangent of seaward structure slope

4. Choice of slope materials from Table 1 (presented by the program)

OUTPUT: A table of wave runup heights of various probabilities in both English and metric units, with the corresponding incident wave heights and surf similarity parameters.

SAMPLE PROBLEM: Given an incident significant wave height of 10 ft, a peak spectral period of 11 sec, a cotangent of the seaward slope of 1.5, and a slope material of uniform quarrystone (breakwater with sublayers and quarry run core), estimate the range of runup heights.

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RUN
WAVE RUNUP ON ROUGH SLOPES
WAVRUNUP
VERSION 9-85
USE UPPER CASE FOR ALL RESPONSES
PRESS ANY KEY TO CONTINUE

S = SCREEN OUTPUT OR P = PAPER OUTPUT ? S

WAVE HEIGHT UNITS
   F-FEET
   M-METERS

WHICH UNIT ? F

SIGNIFICANT WAVE HEIGHT AT SITE ? 10

PEAK SPECTRAL PERIOD (IN SECONDS) ? 11

COTANGENT OF SEAWARD SLOPE(E.G., 1.5 FOR 1.0 VERTICAL TO 1.5 HORIZONTAL) ? 1.5

SLOPE MATERIAL
1-QUARRYSTONE(UNIFORM)
2-QUARRYSTONE(GRADED RIPRAP)
3-PLAIN CUBES
4-MODIFIED CUBES
5-TETRAPODS
6-QUADRIPODS
7-HEXAPODS
8-TRIBARS
9-TOSKANES
10-DOLOSSE

ENTER INTEGER VALUES FROM 1 TO 10 ? 1
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RUNUP ON ROUGH SLOPES

SIGNIFICANT WAVE HEIGHT = 10.0 FT = 3.0 M
PEAK WAVE PERIOD = 11 SECONDS
SLOPE COTANGENT = 1.5
SLOPE MATERIAL = QUARRYSTONE(UNIFORM)
RUNUP COEFFICIENTS A = .775
B = .361

% EXCEEDANCE	RUNUP HEIGHT FT	RUNUP HEIGHT M	WAVE HEIGHT FT	WAVE HEIGHT M	SURF PARAMETER
1.0	19.7	6.0	15.2	4.6	4.3
10.0	14.9	4.5	10.7	3.3	5.1
13.5	14.1	4.3	10.0	3.0	5.2
50.0	9.0	2.7	5.9	1.8	6.8

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DO YOU WISH TO ESTIMATE RUNUP FOR ANOTHER EXCEEDANCE PROBABILITY (Y OR N) ? Y

WHAT IS THE EXCEEDANCE PROBABILITY (PER CENT) ? 25
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% EXCEEDANCE	RUNUP HEIGHT FT	RUNUP HEIGHT M	WAVE HEIGHT FT	WAVE HEIGHT M	SURF PARAMETER
25.0	12.1	3.7	8.3	2.5	5.8

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DO YOU WISH TO ESTIMATE RUNUP FOR ANOTHER EXCEEDANCE PROBABILITY (Y OR N) ? N

DO YOU WISH TO ESTIMATE PROBABILITY FOR A GIVEN RUNUP (Y OR N) ? Y
RUNUP UNITS
  F-FEET
  M-METERS

WHICH UNIT ? F

RUNUP HEIGHT ? 12

PROBABILITY OF A GIVEN RUNUP
-----------------------------------------------------------------
RUNUP                        = 12.0 FT =  3.7 M
SIGNIFICANT WAVE HEIGHT      = 10.0 FT =  3.0 M
PEAK WAVE PERIOD             = 11 SECONDS
SLOPE COTANGENT              =  1.5
PROBABILITY OF EXCEEDANCE    =  25.4  %
-----------------------------------------------------------------

ANOTHER RUNUP VALUE (Y OR N) ? N
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REFERENCES:

Ahrens, J. P. and McCartney, B.L. 1975. "Wave Period Effect on the Stability of Riprap," Proceedings, Civil Engineering in the Oceans/III, American Society of Civil Engineers, New York.

Andrew, M.E. and Smith, O.P. 1975. "Estimating Irregular Wave Runup on Rough Slopes," CERC MP (in preparation), US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Seelig, W.N. 1980. "Two-Dimensional Tests of Wave Transmission and Reflection Characteristics of Laboratory Breakwaters," CERC TR 80-1, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Shore Protection Manual. 1984. 4th ed., 2 vols, US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, US Government Printing Office, Washington, DC.