DRP-5-08
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Dredging Research Technical Notes

Berm Crest Width Considerations, Interim Design Guidance Update for Nearshore Berm Construction

Purpose

This note updates berm crest width considerations presented in *Dredging Research Technical Notes* DRP-5-02, "Interim Design Guidance for Nearshore Berm Construction" (McLellan, Kraus, and Burke 1990). Presented are preliminary results of a numerical analysis applied to generic berm configurations, which highlight berm effects on the local wave climate. Minimum berm widths for maximum wave height reduction benefits are presented. Dredging Research Program (DRP) monitoring and modeling work units will continue to update this guidance as the database and predictive techniques are improved.

Background

Nearshore berms are being used to enhance coastal shorelines. Placing clean dredged material in shallow water in the form of shore-parallel subaqueous relief features benefits the nearshore zone by providing material to the littoral system and reducing erosive wave action on the beach landward of the berm. Design guidance for these engineered structures is being developed as part of the DRP Technical Area 5 work unit entitled "Open Water Disposal Site Planning, Design, and Operation."

Technical Notes DRP-5-01 (McLellan 1990) summarized 10 ongoing and completed nearshore berm projects, and discussed planning and construction of nearshore berms. Burke, McLellan, and Clausner (1991) provided updated information on five nearshore berms in the United States. *Dredging Research Technical Notes* DRP-5-02 (McLellan, Kraus, and Burke 1990) provided interim guidance for siting and designing fine-to-medium sand nearshore berms constructed with dredged material. They cited empirical observations and preliminary analytical work to aid in design. *Technical Notes* DRP-5-06 (Burke and Allison 1992) updated the design guidance for nearshore berm end slope and crest length.

This technical note evaluates crest width considerations for shallow-water nearshore berms. It contains a description of the numerical model used for the analysis, the numerical test berm geometries and tested conditions, preliminary study results, and design guidance.

Additional Information

Contact the authors, Ms. Cheryl Burke Pollock, (601) 634-4029, and Ms. Mary C. Allison (601) 634-3088, or the manager of the Dredging Research Program, Mr. E. Clark McNair, Jr., (601) 634-2070, for additional information.

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Numerical Model Test of Varied Nearshore Berm Widths

Numerical Model

Some of the questions that need to be answered for designing a nearshore berm are "How wide is wide enough?" and "What percent increase in wave attenuation is achieved for increases in crest width?" By fine-tuning the berm geometry to break the steep erosive waves and allowing the longer period (less steep) accretionary waves to pass unhindered, benefits to the nearshore can be increased. Preliminary analysis of a numerical model simulation of several berm widths provides some general guidance for nearshore berm width design.

The numerical model study used a version of the Numerical Model of the LONGshore current (NMLONG) that had been modified to calculate only wave transformation (personal communication, 1992, J. M. Smith, U.S. Army Engineer Waterways Experiment Station). Wave transformation by NMLONG includes shoaling, refraction, breaking with energy dissipation, and wave reformation (Smith and Kraus 1991). The results are presented as a trace of the wave crest as it propagates toward shore. For detailed information on NMLONG, see Kraus and Larson (1991).

Berm Geometries

The nearshore profile used in this study was developed using Dean's (1990) expression for beach and nearshore profiles, and is the same profile used in Burke and Allison (1992). Figure 1 shows the nearshore profile, with an example of nearshore berms of the same height and various widths superimposed on the profile. The 100-ft-wide (30.5-m-wide) berm crest was centered at the 18-ft (5.5-m) depth. Other berms are built by adding or removing a parallelogram section of the appropriate width from the seaward edge of the berm. Berm crest widths of 0, 25, 50, 75, 100,

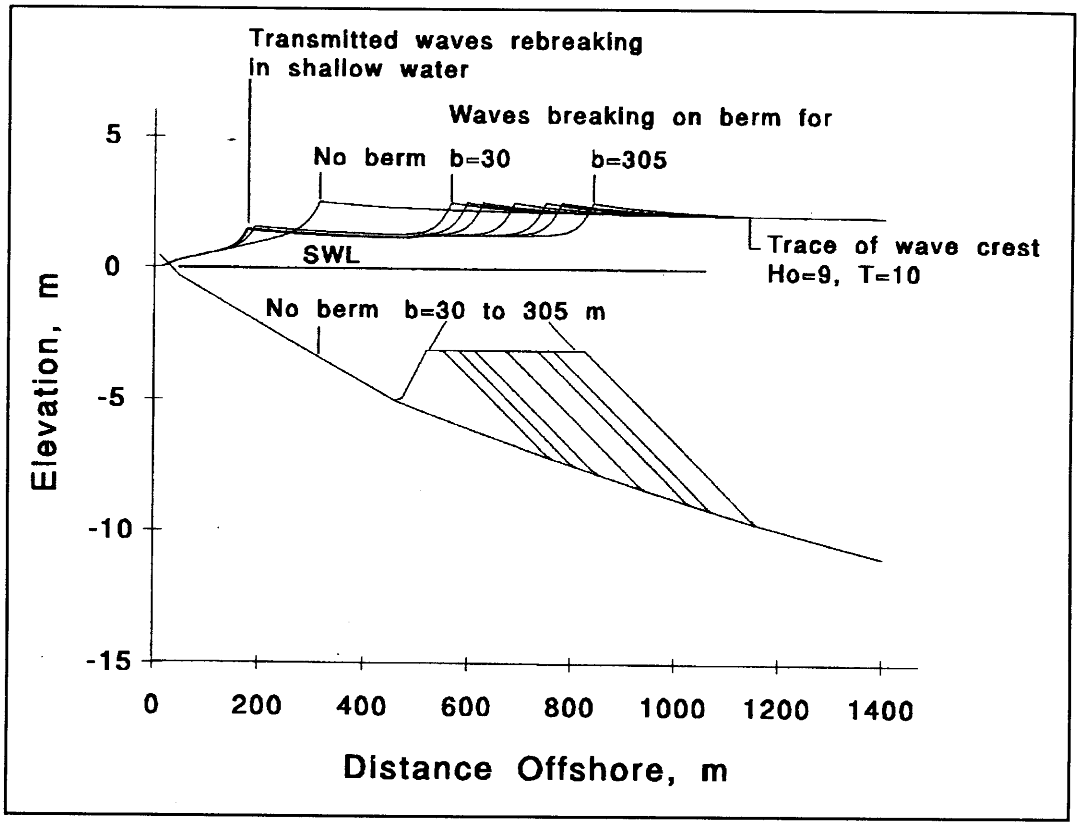

Figure 1. Diagram of nearshore berm profile and NMLONG-predicted water surface elevations corresponding to the profiles

150, 200, 300, 375, 425, 500, 700, 800, and 1,000 ft (0, 8, 15, 23, 30, 46, 61, 91, 114, 130, 152, 213, 244, and 305 m) were tested. Still-water depths above the berm crest were 7, 10, 12, and 15 ft (2.1, 3.0, 3.7, and 4.6 m).

Tested Conditions

The suite of waves used in this study was selected using the SINEWAVES program (Burke 1986). To determine which wave heights and wave periods would be used for input to the numerical model, depths of breaking for a range of wave heights and periods were tested. Waves were eliminated from testing if during the shoaling process the wave exceeded wave-breaking criteria prior to the -18-ft (-5.5-m) contour. Input waves were selected from waves with heights of 1, 3, 6, 9, 12, 15, and 18 ft (0.3, 0.9, 1.8, 2.7, 3.7, 4.6, and 5.5 m), and wave periods of 4, 6, 8, 10, 12, 14, 16, and 20 sec. All wave heights greater than 12 ft were eliminated because all broke before reaching the -18-ft contour. For the 12-ft wave height, only the 8- and 10-sec waves met the criteria for further testing. The 4-sec wave period would not support the 9- or 12-ft wave, and all 12-ft waves with wave periods above 10 sec broke before the -18-ft depth was reached. For the 9-ft input wave, all remaining wave periods met the criteria.

Study Results

The upper lines of Figure 1 exhibit NMLONG output of the maximum water surface elevation for the 9-ft input wave, 10-sec wave period, as the wave propagates toward the shore. From left to right, the water-surface peaks correspond with, first, the no-berm condition, and then sequentially with the incremental increases in berm crest width. As the berm crest width increases, NMLONG predicts an increase in wave attenuation for waves that break. Because NMLONG is based on linear wave theory, for waves that do not break, no wave attenuation is predicted; therefore, this study addresses only breaking waves. (Physical model testing of non-breaking waves indicates that they become less steep after passing over the submerged barrier; hence, neglecting them in this study should yield conservative results.)

For each wave condition, the wave was numerically propagated across the profile without the nearshore berm, and with each of the berm configurations listed above in place. Wave height data used in this study were collected just inshore of the berm crest. The sampling location was 1,503 ft (458.1 m) offshore of origin of the profile. The wave height was labeled H_n without a nearshore berm in place and H_i with a nearshore berm in place.

Input waves less than 9 ft did not break over the berm when $d - h = 10$ ft (3.1 m) (d is the still-water depth in the absence of the berm, h is the height of the berm, and $d - h$ is the still-water depth over the berm). The 6-sec, 9-ft input wave also did not break. Periods longer than 6 sec broke for all remaining tests. No wave breaking was predicted for the $d - h = 15$-ft berm, and only the 8- and 10-sec, 12-ft input waves broke on the $d - h = 12$-ft berm. For $d - h = 7$ ft (2.1 m), all waves longer than 6 sec on the 6-ft input wave broke. However, $d - h = 7$ ft (2.1 m) is difficult to achieve using normal hopper dredge disposal methods.

Figure 2 shows the berm crest width versus the relative wave height, H_i/H_n, for the 9-ft input wave propagating over the $d - h = 10$-ft crest elevation. The 16-sec wave period values are omitted on this graph because they are very close to the 14-sec wave period values. This figure indicates that the increases in wave attenuation as berm crest width increases are greater for shorter period waves (steeper waves) than for long-period waves. It also indicates that as the crest widths become larger, the amount of additional wave attenuation diminishes. For these crest elevations, significant increases in wave attenuation are achieved for crest widths up to 200 ft (61 m). Only a slight increase in wave attenuation occurs for crest width increases from 200 to 300 ft (91 m), almost no increase for crest widths between 300 and 500 ft (152 m), and no increase for crest widths wider than 500 ft (not shown on the figure).

H_n was plotted against H_i for the suite of input waves. For a given H_n and nearshore berm crest width, as the wave period increases, the wave height in the lee of the berm decreases. Figure 3 is an example of the

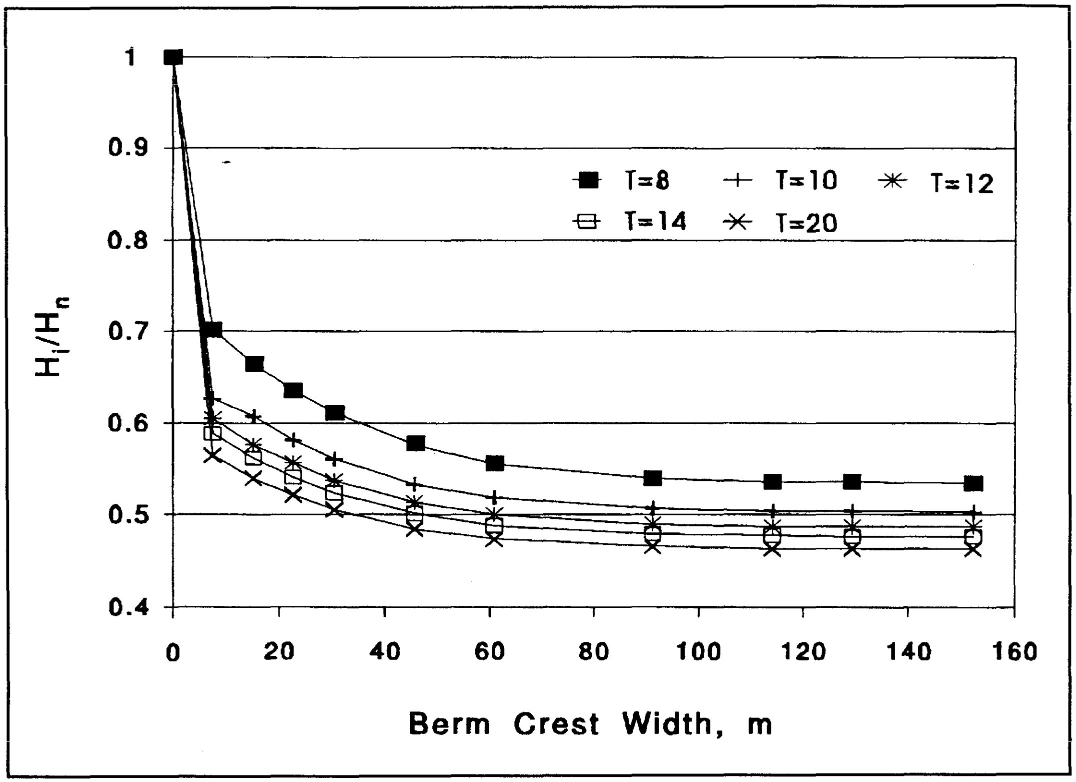

Figure 2. Berm crest width versus NMLONG-predicted (H_i/H_n) for 9-ft (2.7-m) input wave, $d - h$ = 10 ft (3.1 m)

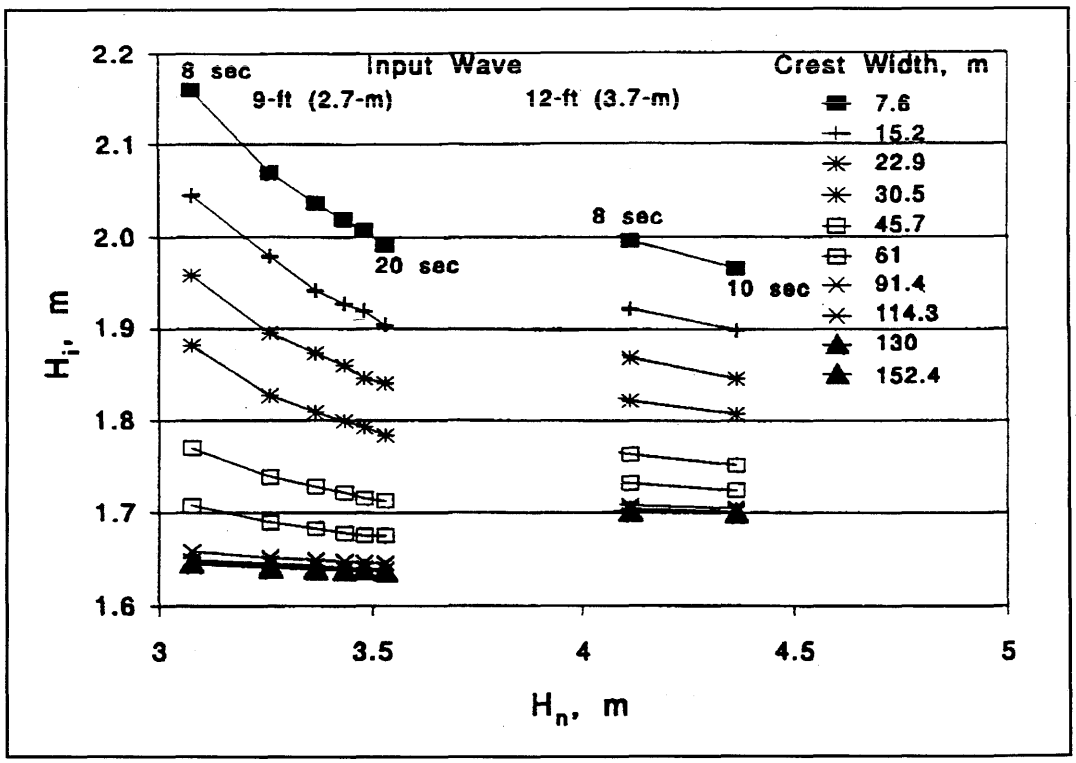

Figure 3. H_n versus H_i predicted by NMLONG for all berm crest widths, 10-ft (3.1-m) water column over crest, 9- and 12-ft (2.7- and 3.7-m) input waves

9- and 12-ft input waves over the $d - h$ = 10-ft crest elevation for wave periods tested. Wave periods, from left to right, are 8, 10, 12, 14, 16, and 20 sec for the 9-ft input wave and 8 and 10 sec for the 12-ft input wave for each crest width.

The amount of wave reduction that can be expected from a 9- and a 12-ft wave propagating across the various berm crest widths, for a $d - h$ = 10-ft water depth over the crest, was calculated. From these calculations it is clear that, for all wave periods, greater wave attenuation is achieved for the wider crests, but the amount of additional wave height reduction is very small for berms in this depth of water with crest widths over 200 ft. Figure 4 shows the average wave reduction that can be expected for the 9- and 12-ft wave heights (all periods) averaged for various berm crest widths.

Summary and Conclusions

Preliminary results of a numerical model test indicate several trends related to the effect on wave attenuation as a result of varying the crest width of submerged barriers. Included in these trends is greater wave attenuation achieved by increasing the crest width. The rate of increase in wave attenuation relative to barrier crest width diminishes as the barrier

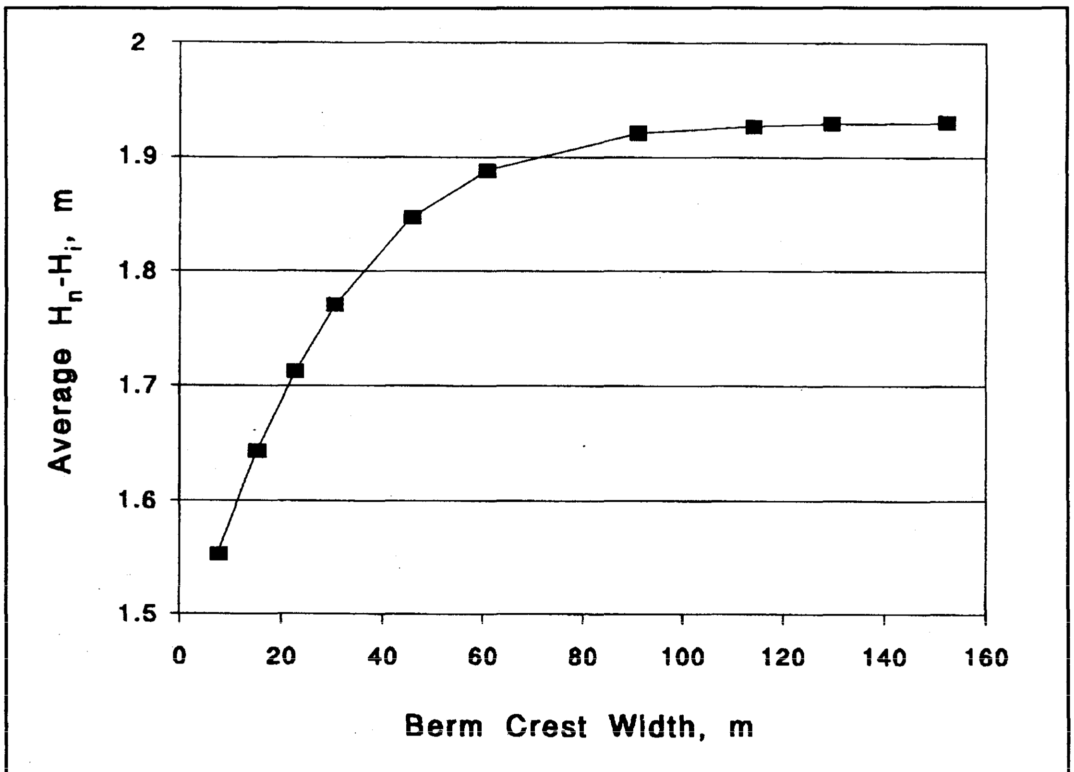

Figure 4. Average wave height reduction predicted by NMLONG for 9- and 12-ft (2.7- and 3.7-m) input wave heights for all periods versus the berm crest width

crest width increases. Steeper waves are affected more significantly by increases in crest widths than are less steep waves.

Using the numerical model NMLONG, wave attenuation values were predicted for a suite of wave conditions and various berm configurations placed in 18-ft water depths. From these results, reductions in wave height in the lee of the nearshore berm are associated with crest width increases. Additionally, for the test conditions of this study, significant wave height reductions in the lee of the berm were achieved by increasing the nearshore berm crest width up to 200 ft, but little or no change was realized for wider berm crests. Therefore, while berms with crest widths wider than 200 ft may be desirable from an operational, beach building, or volumetric viewpoint, they may not provide significant additional wave height reduction benefits. However, berms may need to be constructed to a crest width greater than 200 ft because wave activity will reform the berm and erode some of the material from the berm area. By constructing the berm to a greater crest width, or by maintaining the berm crest at or above 200 ft, maximum wave attenuation from the berm can be realized for a longer period of time.

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