CHAPTER 127

POTENTIAL USES FOR THE RAPIDLY INSTALLED BREAKWATER SYSTEM

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Abstract

Engineers and scientists at the U.S. Army Engineer Waterways Experiment Station (WES) are developing a Rapidly Installed Breakwater (RIB) System specifically designed to address problems associated with the military's efforts to off-load ships during Logistics Over The Shore (LOTS) operations. Problems arise with these operations when seas become energetic and limit capabilities of crane operators and stevedore crews. The RIB System is designed to solve this problem by creating a 'pool' of calmer water where these operations occur so that crews can continue to function. A series of small-scale laboratory experiments conducted in 1995 and 1996 at WES's facilities in Vicksburg, Miss., and at the O. H. Hinsdale Wave Research Laboratory at Oregon State University in Corvallis, laid the groundwork for the RIB System development and yielded an optimum RIB System configuration known as the "Double Delta". Laboratory results, obtained with the Double Delta configuration, showed that wave heights could be reduced by more than 80 percent. During the spring and summer of 1996, a mid-scale RIB System successfully demonstrated its capabilities during a field deployment, with wave height reduction on the order of 75 percent. Based on these results, it is believed that the RIB System will be integrated into the Army's LOTS asset inventory and become a key part of the solution to the military's LOTS problems.

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Introduction

For many years, the US Army Engineer Waterways Experiment Station (WES) has been involved with the design and deployment of floating breakwaters, primarily for application within bays or estuaries which are semi-protected from large waves. Such structures typically are intended to attenuate waves with heights not exceeding 4 ft and periods not exceeding 4 sec. Extrapolation to an open ocean environment is at least an order of magnitude greater in difficulty. In an oceanic environment, waves with heights and periods up to 10 ft and 10 seconds respectively, are common during storm conditions. Previous experiments have shown that to be effective, floating breakwaters must have widths on the order of 1/4 of the wavelength being attenuated, and hence, must be very massive to be effective. Such structures are simply not feasible for most temporary and rapidly installed floating breakwater applications, since it would be necessary to transport large volumes of construction materials to the site being sheltered. As described below, this problem was the driving force behind recent floating breakwater developments at the WES.

During energetic seas, the primary problem occurs in key offshore areas (anchorages) where containerships and roll-on/roll-off (RO/RO) vessels discharge cargo and unit equipment onto much smaller vessels, collectively termed lighterage. Hence, WES efforts were directed towards creating sheltered areas in which these anchorages could be located and operated more effectively. A Tactical Auxilliary Crane Ship (TACS) anchorage for offloading containerships offshore is shown in Figure 1 while a Roll On/Roll Off anchorage for offloading rolling stock, such as

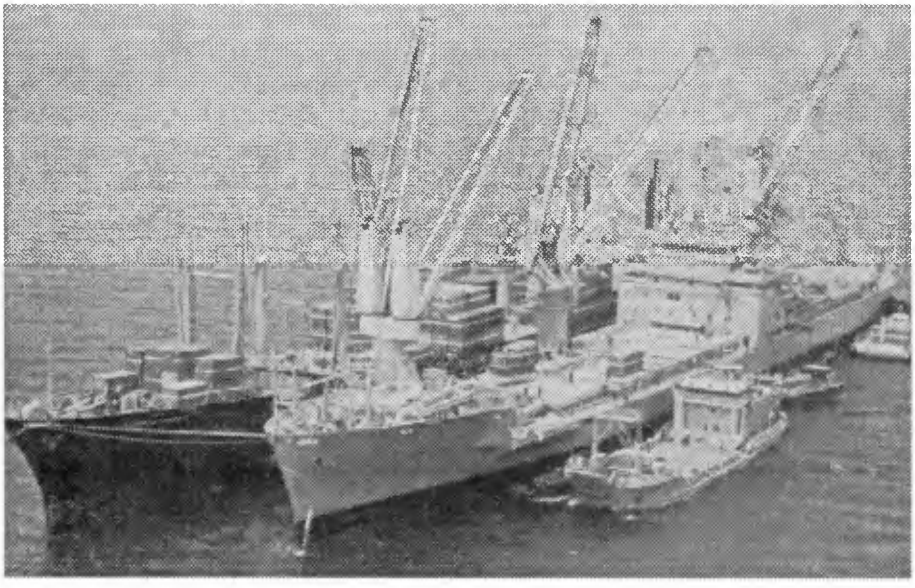

Figure 1. Example of Crane Ship (TACS) Anchorage.

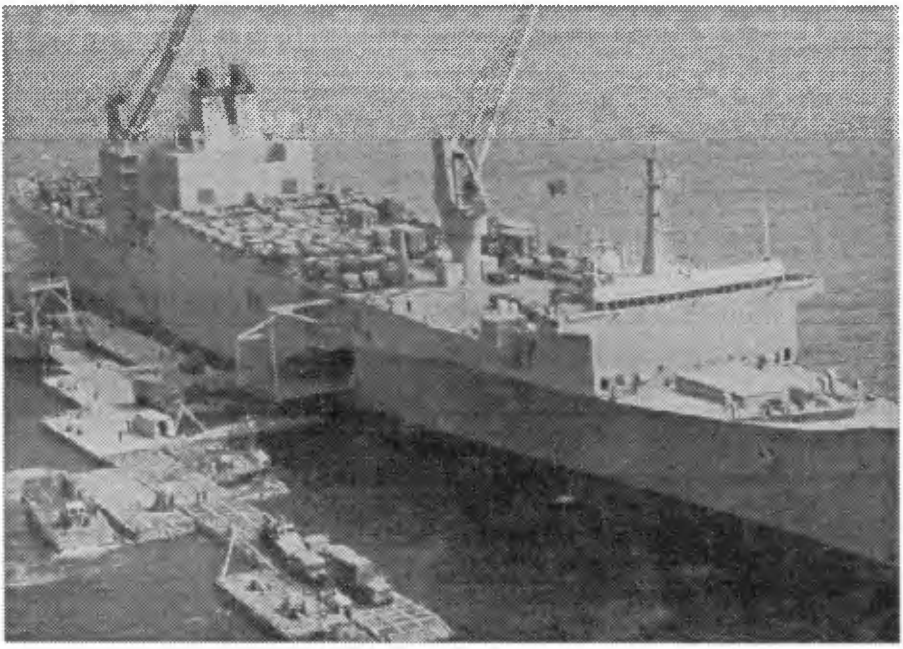

Figure 2. Example of Roll On/Roll Off Anchorage.

tracked and wheeled vehicles, is shown in Figure 2. The ability to move vehicles, equipment, and supplies from ship to shore in a rapid manner is considered vital to existing military force deployment operations such as humanitarian relief efforts or supporting a war-fighting effort. Therefore, a key feature of the RIB System is the ability to use existing assets to transport and deploy the system within acceptable time constraints. In light of this, the RIB System will very likely be stockpiled at various pre-positioned locations around the world in fairly large modular components. When exercises or real-world events require its use, the RIB System would then be loaded from the nearest pre-positioned site and transported via sealift to the LOTS site, where it would be assembled with the assistance of either Fast Sealift Ships or TACS in combination with Army and/or Navy tugs.

Operational Requirements of the RIB System.

The main problem to be overcome during these operations is the demonstrated inability to effectively conduct LOTS offloading operations when wave climate conditions exceed what is commonly termed "sea state 2", as given by the Pierson-Moskowitz scale for characterizing energetic seas. The Army uses the period of maximum energy associated with a given significant wave height as found in the Pierson-Moskowitz scale to characterize sea state, which has categories ranging between zero and nine. Figure 3 is provided to demonstrate the relationship between sea state, significant wave height, and period as found in the Pierson-Moskowitz scale. The problematic condition described above is commonly known as the "sea

state 3 problem" and exists when significant wave height is between 3 to 5 feet and periods range from about 3 to 7 seconds. The military considers the sea state 3 problem to be critical since these conditions exist a significant percent of the time worldwide, and in fact is considered to be a potential "war stopper" for present force projection plans and technology.

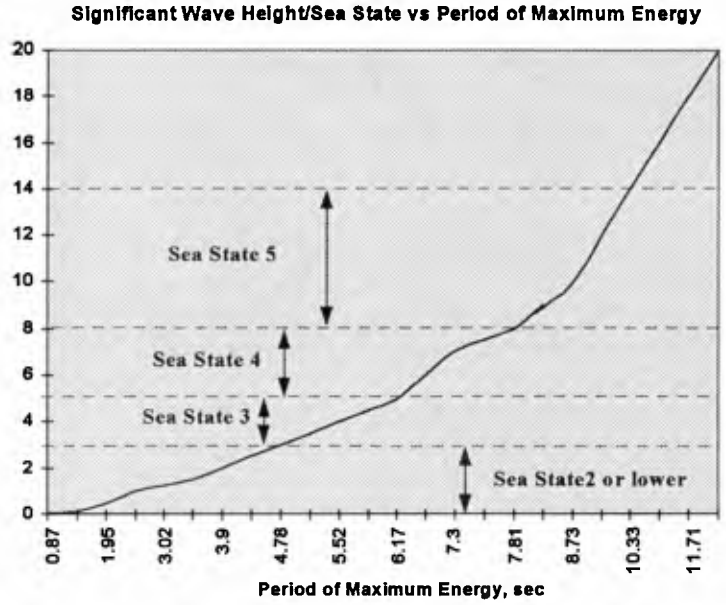

Figure 3. Relationship Between Sea State, Significant Wave Height and Period.

In light of the above, for the RIB System to be effective, it should be deployable during sea state 3 conditions and should reduce incident waves to create a "pool" of calmer water in the immediate vicinity of these anchorages which is below the sea state 3 threshold. With this scenario, crane operators and stevedore crews could continue to function during sea state 3 and even greater, since existing lighters can operate effectively in sea state 3, once safely loaded. An efficiently performing RIB System would cause the limiting sea state condition to be determined by capabilities of the various lighterage and equipment being used during the LOTS operation.

WES-Developed Rapidly Installed Breakwater System.

The RIB System is presently being developed and evaluated by research coastal engineers at WES. The RIB System consists of a V-shaped structure in plan view, with vertical barrier curtains extending from the surface of the water toward the bottom for a distance sufficient to preclude excessive wave energy from penetrating beneath the structure (see Figure 4). The RIB system concept was initially developed to address specific problems encountered by military personnel during LOTS operations, primarily those affected by sea state conditions characterized by relatively short period waves.

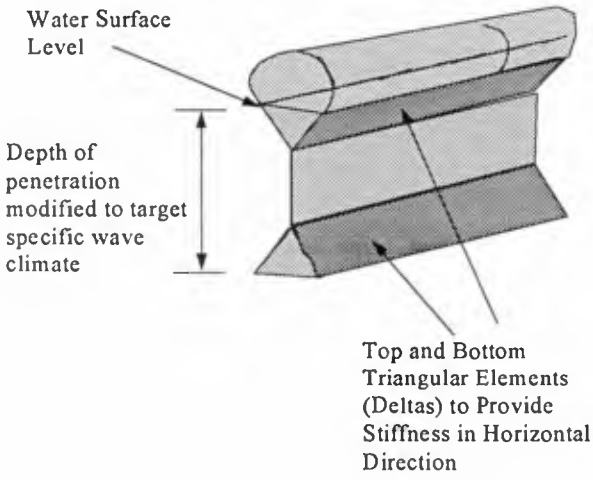

Figure 4. Double Delta Version of the RIB System

When deployed, the tip of the V-shape is oriented into approaching waves and spreads wave fronts apart based on geometric spreading and coupled deflections of wave motion. Ships and lighterage are moored in the lee of the V-shape for offloading. Depending on the specific location where the RIB System is to be employed, the legs of the "V" will vary, but for maximum effectiveness, each leg should be at least three wavelengths in length. The legs are joined at the front of the RIB System and supported with braces to insure structural stiffness. Wave-related mooring loads are relatively small due to two factors. First, the structure is designed to deflect waves rather than absorb them. Second, since the structure is oriented at an angle and is several wavelengths long, the oscillatory nature of the wave forces associated with the crest are simultaneously reduced by the force associated with the trough, which acts in the opposite direction.

Small Scale Laboratory Model Experiments.

During the early stages of the RIB System development, scale model studies were conducted at WES and Oregon State University (OSU) to test the concept , refine the initial design, and subsequently to test enhancements and various modifications. Results indicated that a significant "offshore" area could be effectively reduced from sea state 3 to sea state 1 by the RIB system. The objective of this effort was to obtain data relating to wave transmission in the lee of the RIB system, by evaluating multidirectional waves with both frequency and directional spreading. Wave heights were recorded at 15 locations throughout the sheltered region to ascertain diffraction effects around the ends of the RIB System. Laboratory experiments evaluating the Double Delta configuration which yielded the favorable results are depicted in Figure 5, with each plotted line representing a different wave period. Results are presented as the ratio of recorded wave height in the lee of the system divided by measured incident wave height approaching the RIB System versus distance from the leading edge of the RIB system. As shown below, it was possible to obtain up to 83 percent attenuation (19 percent transmitted height ratio) for some of the wave conditions, for the Double Delta configuration RIB system arrangement.

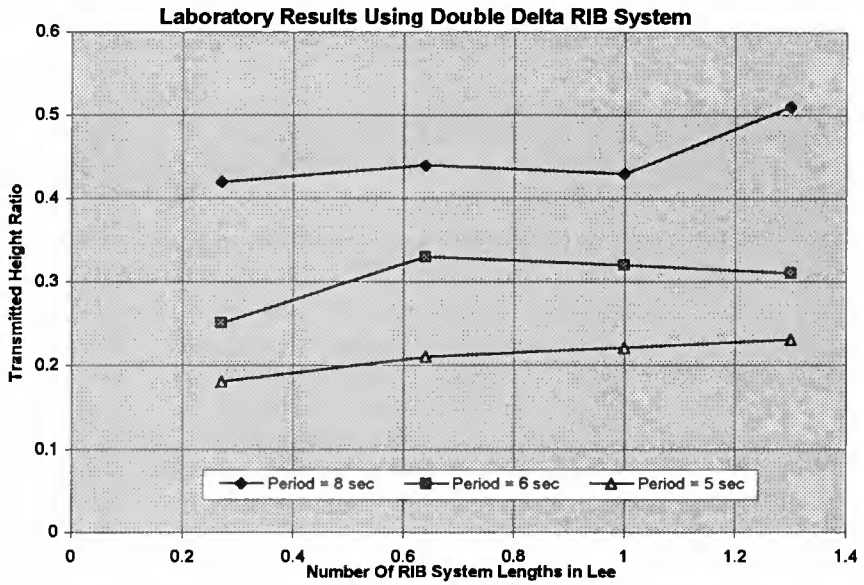

Figure 5. Laboratory Results Using Double Delta RIB System.

Figure 6 is a photograph which shows the wave basin setup and wave reduction achieved by the RIB System during one of the Double Delta experiments conducted at the OSU facilities. Based on the successes achieved in laboratory environments, a mid-scale field experiment was designed and subsequently conducted in the Currituck Sound during May 20 - 14 June 1996.

Figure 6. Laboratory Experiment Conducted at OSU Using the Double Delta Version of RIB System with Significant Height = 5 ft, Period = 6 sec..

RIB System Field Experiment

The field study was performed at WES's Field Research Facility, located on the Outer Banks in Duck, North Carolina. Since the model was constructed at a 1 to 4 scale, open ocean deployment was not suitable, and the somewhat milder wave climate of the Currituck Sound was selected. The RIB System deployed at Duck consisted of a combination of welded steel structure and closed cell foam floatation. The model was designed as a modular system capable of being assembled using simple hand tools on the beach at Currituck Sound. The deployment featured two 150-ft long RIB System legs, which were assembled from 30 RIB System modules and a nose buoy which was designed and constructed to expedite connecting the two legs. Each leg was assembled on the beach and subsequently towed into deeper water,

where they were joined to the previously positioned nose buoy as shown in the photo in Figure 7. Following attachment to the nose buoy, the trailing ends of each leg were attached to prepositioned anchors to achieve the desired "V" configuration. Instrumentation to measure wave height and weather conditions along with video recordings were used to document the effectiveness of the model used during the field investigation. During the two week period, the RIB System was successfully deployed, and data were collected to document wave reduction capabilities and allow comparison to the laboratory data. The comparison indicated that the mid-scale field deployment performed quite similar to the laboratory version, again reducing incoming wave heights by about 75 percent. Figure 8 is a photograph of the RIB System as it was functioning during the field deployment. Incident waves in the photograph scaled to mid- to upper sea state 3, while the wave climate in the lee of the RIB System scaled to sea state 1.

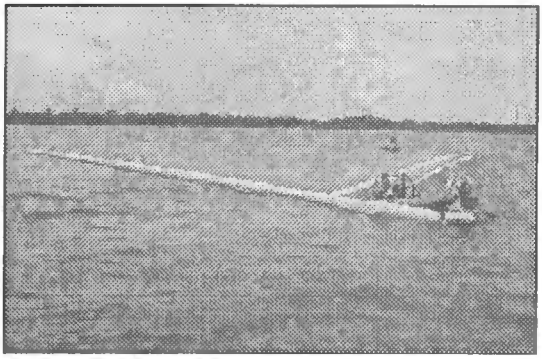

Figure 7. Joining of RIB System Legs.

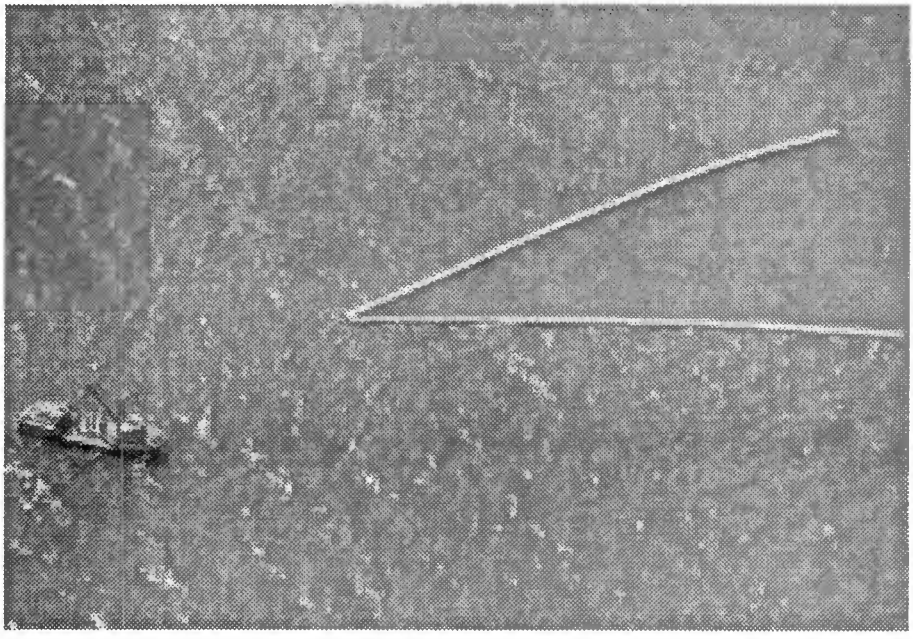

Figure 8. Aerial View of RIB System During 1996 Field Deployment.

Future Plans.

The next step in the development of the RIB System will be additional laboratory investigations to study deployment options, construction materials, and mooring requirements. These efforts will be followed by the construction, and field deployment of a larger, near full size version in 1997. This will in turn be followed by design, construction and deployment of a full-scale version during an actual LOTS operation exercise in the year 2000.

Conclusions

Based on results such as those obtained in the extensive laboratory studies and observations made during the field study in May-June 1996, the RIB System being developed at WES holds great promise for alleviating the military's ship offloading problems associated with higher sea states during LOTS operations. Additional laboratory investigations oriented towards mooring techniques and methods of deployment are scheduled for 1997. These studies will be designed to optimize present design and examine potential alternative uses for the RIB System. A second field deployment of the RIB System constructed at a 1 to 3 scale, will occur during the summer of 1997, primarily to evaluate mooring and deployment options developed during the laboratory studies. These efforts will be followed by a full-scale demonstration, and by research to evaluate other potential applications of the RIB system, including protection of shore--based offloading sites, protection of nearshore construction/repair sites such as for jettys or breakwaters, and temporary small boat harbors.

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