A NEW APPROACH TO NEARSHORE BREAKWATERS: A CASE STUDY FOR UNDULATING CRESTS

Taylor Nordstrom, AECOM, taylor.nordstrom@aecom.com
Chris Levitz, AECOM, chris.levitz@aecom.com

BACKGROUND

Traditionally, stone nearshore breakwaters are designed and constructed using standard parameters based on a series of existing equations and calculations (frequently those specified in the Coastal Engineering Manual for the U.S.). These include a calculated crest elevation based on design wave heights, along with computationally derived side slopes and crest widths chosen to either eliminate or reduce wave energy transmission by a desired amount. Another design decision is how frequent and how large to make gaps between the breakwaters, which is more standard for sandy scenarios, but less so when dealing with marsh and bluff shorelines. Additionally, the breakwaters are designed to be constructed within a range of design distances from the shoreline, with parameters chosen to define desired post-construction scenarios such as tombolo or spit formation. There are significant data and existing research allowing for these calculations in sandy environments. For marsh or bluff based shorelines, the offshore distance is often developed based on constructability or a desired marsh restoration template.

The concept of an undulating crest, a crest that varies in elevation along a single structure for nearshore breakwaters, was originated through collaboration between the design engineer, AECOM, and the Virginia Point site owner, Scenic Galveston. Rapid shoreline erosion for a two-mile stretch of Galveston Bay, and associated marsh loss, was the driver of the protection project at the Virginia Point site, for which breakwaters, in coordination with planting and marsh establishment, were identified as the optimal solution. While the solution could have been achieved through a straight forward approach, as described above, conversations between AECOM and Scenic Galveston led the design down a unique path.

BREAKWATER DESIGN

Beyond shoreline protection, the site is home to multiple vital ecosystems, including both oysters and key bird populations. While a standard breakwater design based on the Coastal Engineering Manual would be expected to accomplish the primary goals at hand for the Virginia Point site, it was recognized that with a one-time project such as this, it would be worthwhile to assess possible enhancements to the breakwater design to maximize the effectiveness of the structures themselves while accounting for the unique ecosystems.

The revised design included multiple standard characteristics, such as frequent breakwater gaps to promote circulation and placing low stone sills across the gaps to promote siltation landward of the structures. Rather than using a traditionally-derived design height, however, the concept of undulating crests, or crests that vary between a typical high and a typical low crest elevation, was incorporated. The concept of varying the crest in this manner was multi-purposeful. The first purpose of the undulating crests was to provide shoreline protection while retaining some of the shoreline aesthetics. Scenic Galveston viewed the shoreline and the uplands at the site as largely untouched native coastal habitat in a notably developed region of Galveston Bay; therefore, they looked to maintain this aesthetic for any construction. Other design constraints selected for this intent included utilizing native limestone for the structures, and creating a breakwater layout that mimics the natural formation of cells of oyster reef in the area, with varying breakwater distances from the shoreline based on the local wave climate.

The second purpose of the crest undulation was largely experimental, to determine if a) breakwaters with non-uniform crest heights could provide the same manner of shoreline protection as breakwaters with uniform crests and b) undulating crests were able to provide better shorebird habitat. Using standard practices, design waves typically expected of the site were analyzed to estimate a breakwater crest elevation for optimal wave energy reduction; these elevations were then used as the maximum crest elevations. Then, at regular spacing there were intermittent decreases in crest elevation by 1.5 feet, thus forming an undulating crest (Figure 1).

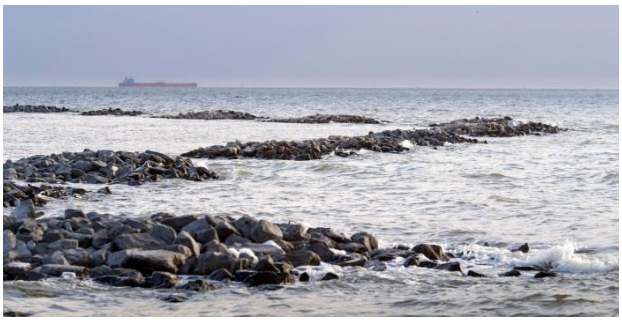

Figure 1 - Virginia Point Breakwaters

CONSTRUCTION, MONITORING, and NEXT STEPS

Construction of a unique structure such as this requires working side-by-side with the construction contractor to ensure proper understanding of the concept is in place. In the case of Virginia Point, multiple construction approaches were taken before finding an optimal method that was efficient while achieving the prescribed slopes along the crest parallel to the shoreline.

During and upon completion of construction, observations from the field during high tide with notable wave action indicated that the breakwaters provided the desired level of wave energy dissipation. These observations will be further tracked through a multi-year monitoring program to track sediment deposition and whether there is any residual erosion of the shoreline. Once sufficient sedimentation has occurred onshore of the breakwaters, *Spartina alterniflora* will be planted. Ultimately, the breakwaters are intended to only be a portion of a multifaceted system that will include restored marsh grasses and coastal prairie all working with the breakwaters to ensure a diverse coastal ecosystem that is resilient to future changes to the environment.