HURRICANE MARIE AND THE PORT OF LONG BEACH, CALIFORNIA, USA

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INTRODUCTION

This paper describes the performance of the Middle Breakwater at the Port of Long Beach, California, USA. On 27 August 2014, swell waves generated by Hurricane Marie, a category 5 storm, severely damaged the breakwater (Figure 1). This paper evaluates general breakwater characteristics, incident wave conditions, and a wave transformation analysis that identifies uniquely contributing factors to the structure damages.

HURRICANE MARIE DAMAGE

Damages to the breakwater consisted of 103 individual damage areas with near and/or complete breaching in 11 locations. The armor layer was completely removed from the seaward side, thru the central trunk section, to the harbor side. A majority of the underlayer was completely displaced exposing the core stone. Additional damages consisted of extensive slumping, settlement, and loss of armor stone interlocking on the seaward slope.

Post-damage field data collection efforts included an estimation of the water level and wave climate, a topographic and bathymetric survey of the structure, visual observations of the structure above water, and compilation of the as-built construction drawings dating back to the 1920's. Emergency repairs entailed the placement of approximately 35,000 tons of 20 ton armor stone. Maximum wave conditions at the breakwater location were approximately H = 22 ft (6.7 m), Tp =15 sec, and Dp = 165°. Analysis of historical conditions show a similar pattern during a storm in 1930, when a southern swell (origin unknown) from the same direction caused damages to the breakwater. Since that time, the middle breakwater has remained relatively unchanged and undamaged.

CMS-WAVE AND WAVE RAYS

A wave transformation analysis was conducted using CMS-Wave, a two-dimensional spectral wave model, to compare the incident wave conditions with a historical wave ray refraction analysis conducted by M.P. O'Brien in 1947. CMS-Wave models reflection, refraction, diffraction, wave transformation, run-up and wave-current interaction (Lin, 2008); although the complexity in this case was not required. This analysis identified the wave conditions which caused similar damages to the same breakwater in 1930. The input wave was forced at a known offshore buoy location and the natural transformation was allowed to progress over the existing bathymetry. The original wave ray analysis suggested that an offshore wave as small as 2 ft (0.6 m) could produce a wave on the order of 12 ft (3.5 m) at the structure because of a lensing effect caused by offshore bathymetry.

CONCLUSION

The current analysis concurs with and confirms the 1947 analysis and shows the accuracy of the simplified wave ray tracing performed more than 50 years ago. The breakwater structure is uniquely affected by the swell wave characteristics (height, period, direction) that occurred in 1930 and 2014.

Figure 1. Breakwater Damage

REFERENCES

O'Brien, M. P., & University of California, Berkeley. (1947). *Wave refraction at Long Beach and Santa Barbara, California*. Berkeley, Calif: University of California, Dept. of Engineering.

Lin, L., Z. Demirbilek, H. Mase, J. Zheng, and F. Yamada. 2008. CMS-Wave: A near-shore spectral wave processes model for coastal inlets and navigation projects. Coastal and Hydraulics Laboratory Technical Report ERDC/CHL-TR-08-13. Vicksburg, MS: U.S. Army Engineer Research and Development Center.