INCORPORATING CLIMATE CHANGE RESILIENCE INTO A BREAKWATER REPAIR: A CASE STUDY AT HILO, HAWAII

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BACKGROUND

Hilo Harbor is located on the northeast coast of the island of Hawaii (the "Big Island"), the state's eastern and southernmost island. Hilo Harbor is one of only two commercial ports serving the entire island of Hawaii. Hilo Harbor is the primary location of commercial waterborne traffic for the eastern half of the island. It averages more than 2 million tons of waterborne commerce each year, provides a wide range of maritime facilities and services, and is the major distribution center for the island. It also has the only pier on-island large enough to accommodate cruise ships.

The original breakwater at Hilo Harbor was completed in 1930 and consisted of a 10,080-foot-long rubble-mound breakwater built over Blonde Reef, protecting a 35-foot-deep basin. Recent repairs were completed in 1973, 1975, and 1981. The 1981 repair consisted of a layer of 7.5-ton tribar armor units along 900 feet of the breakwater along the trunk of the structure.

USACE CLIMATE CHANGE PREPAREDNESS AND RESILIENCE

The US Army Corps of Engineers (USACE) is committed to reducing potential vulnerabilities to the United States' water infrastructure resulting from climate change and variability, through design of resilient systems as well as adaptation of existing assets. USACE has incorporated climate preparedness and resilience into its Civil Works planning process and is working toward integrating climate adaptation into the operation and maintenance of its existing projects, which include over 900 coastal and inland harbors. To maintain the stability and performance of existing navigation structures in the changing climate, engineers must move from an expectation that the future will be similar to the past – a stationarity paradigm – to one that more explicitly accounts for the dynamic nature of a changing climate and rising seas.

RESILIENT REPAIR FOR HILO HARBOR BREAKWATER

The USACE Honolulu District intends to conduct repairs to the Hilo Harbor breakwater within the next 5 to 10 years. A multifaceted analysis has been conducted to optimize future repair design from both an economic investment standpoint, as well as to incorporate evaluation of risk of failure and reliability-based design under projected future forcing conditions. The results of this analysis will be presented including the following: 1) evaluation of breakwater damage using both visual inspection and remote sensing data; 2) an in-depth analysis of present and future breakwater overtopping rates due to extreme waves and sea level rise through the use of spectral phase-averaged wave modeling, Boussinesq phase-resolving models, and high fidelity, fully three-dimensional Computational Fluid Dynamics (CFD) wave modeling; and 3) initial results of reliability-based design to assess past and present performance and damage modes.

Based on present and future wave climate as affected by sea level rise, a quantitative comparison of simulated breakwater overtopping flow rates between Boussinesq (XBeach) and CFD (OpenFOAM) wave models is investigated at high resolution, utilizing spectral output at discrete reporting stations embedded within larger 2D Boussinesq model domains to generate the forcing wave boundary conditions used for both overtopping models. Additional 3D CFD modeling at even higher fidelity will attempt to model narrow segments of the breakwater at scales sufficient to resolve individual armor stones within the armor layer profile to investigate hydrodynamic forces on these units from wave impacts.

Figure 1 – Wave overtopping at Hilo Breakwater

SUMMARY

Federal investment of limited maintenance funds toward aging navigation structures that will continue to be subjected to increased loading due to climate change will require careful analysis and strategic repairs including adaptive designs. This case study will outline some of the advanced tools being used to conduct such an analysis, including lessons learned and applicability to other efforts to increase coastal structure resiliency to future climate changes.