US Army Corps of Engineers®
Engineer Research and Development Center

Coastal Inlets Research Program

Engineering Design Calculations for Navigation Structures in Wave Models

Description

Methods for USACE design practice for navigation structures are described in the Coastal Engineering Manual (CEM). The design calculations use a storm of selected return periods from 10 to 100 years, associated wave heights and wave periods, storm surge, and wave setup. The combination of these design parameters is used in the calculation of rock size, crest width and elevation of structure, stable armor stone size, seaside and leeside stability for waves approaching the structure, wave runup and overtopping on a rubble-mound structure (Figure 1). No procedures are available in existing USACE wave models to determine the requisite design parameters and methods for calculating structural design estimates. Such calculations are presently done manually after modeling and other engineering studies have been completed. In the CEM approach, the design is not examined for future storms which could exceed the return-period based storm, wave parameters, and increased water level due to sea level rise. These concerns will be investigated in this research from a perspective of a developing a better understanding and quantifying a relationship between design and functionality of rubble-mound structures. An integrated approach is required that couples engineering design calculations with life-cycle functional performance and Operation & Maintenance (O&M) requirements. The intent in the first phase of this research is to implement design calculations for rubble-mound structures in wave models to provide Districts an automated procedure. The results of this research will be modularized products which will implemented in subsequent years using a practice-oriented toolbox called Engineering Design for Navigation Structures (ED4NS).

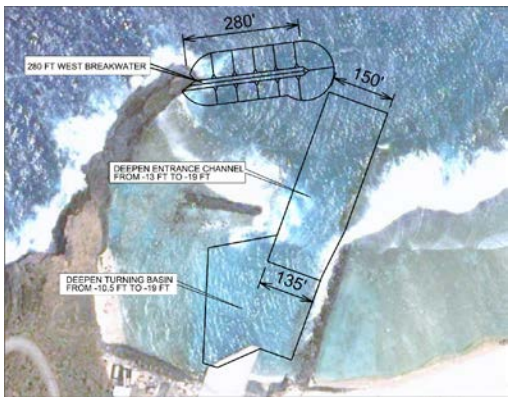

Figure 1. Breakwater design at Faleasao Harbor, American Samoa

Issue Addressed

The purpose of this research is to address a basic need of the USACE for an integrated asset management capability that couples advanced modeling estimates with the functionality requirements for coastal navigation structures in planning, design, and O&M. The methodologies will apply to existing, potentially degraded rubble-mound structures, options for rehabilitation of these structures, and new structural design. The ultimate goal is to provide a tool with the capability to evaluate effects of changes on design and O&M functional requirements while minimizing complexities, assumptions and uncertainties in the asset management process (Figure 2). To effectively address these inter-twined issues, a modularized design system is required. This decision-support system will provide estimates and their impacts calculated by advanced numerical wave models using metocean databases for coastal navigation systems, and project-specific structural data from various GIS sources.

Specifically, the ED4NS will account for the impacts of water levels, winds, waves, and currents on navigation structures at coastal inlets and ports/harbors. This tool will facilitate the USACE mission for asset management by coupling results from numerical capabilities with the CEM-based design method. In addition, it will offer USACE other worldwide accepted rubble-mound structural design methods, including the Eurotop and Japanese practices, for comparison of cost, risk and consequences of changes in design options. The tool will provide tabular and graphical information for project planning, engineering design and O&M support activities, and inputs for budget preparation.

Products

The ultimate end product is ED4NS, a modularized engineering design tool that utilizes results from advanced numerical wave models, and structural parameters from project design documents and GIS databases, to perform estimates for navigation structures. Calculations are based on coupling models to the data from web-based GUIs which provide users with a GIS mapping tool to query and select data sources according to the desired geographic region using the Google Map interface to display data from different sources.

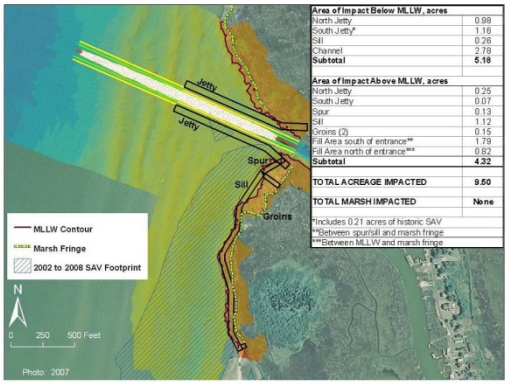

Figure 2. Jetty design for Rhodes Point entrance channel, MD

Application of Products

Recent project applications using output from wave models and preliminary ED4NS like estimates include: Kikiaola Harbor, HI; Faleasao Harbor, Guam; Hilo Harbor, HI; Tangier Island, VA; Braddock Bay, NY; Dana Point Harbor, CA; Tillamook Bay, OR; Grays Harbor, WA; Rhodes Point, MD; Duluth Harbor, MN; Ambrose Entrance Channel and Buffalo Harbor, NY.

Projected Benefits

The ED4NS will support USACE coastal navigation and storm damage reduction mission areas using science-based wave models to develop engineering estimates for design, planning and O&M requirements. It will be coupled to models and databases to facilitate access, process and analysis of winds, water levels, waves and currents affecting system design and functions. It will include a combination of design methods, analysis and graphical tools to minimize the complexity and uncertainty in application of design methods and data processing in project applications. Scientifically defensible calculations will be developed for improved design and O&M for existing and new navigation structures, and impacts of engineering activities affecting the safety of coastal navigation in port and harbor studies.

Documentation

The first series of publications will describe the design methods implemented in numerical wave models with example applications. Additional documentation will follow as the methods are advanced and new capabilities and modules are added to the tool.

Points of Contact

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CIRP Website

- Please see the CIRP website to download documentation about the wave models to be utilized in ED4NS: http://www.erdc.usace.army.mil/Missions/WaterResources/CIRP/Publications.aspx
- View archived webinars: http://www.erdc.usace.army.mil/Missions/WaterResources/CIRP/TechTransfer.aspx
- Review guidance documented on the CIRP wiki: http://cirpwiki.info/wiki/Main_Page