COMPARISON OF NUMERICAL AND EMPIRICAL ESTIMATES OF WAVE CONDITIONS IN THE LEE OF A DETACHED BREAKWATER

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ABSTRACT
This paper presents a comparison of numerical and empirical methods routinely applied by practitioners to examine wave penetration in the lee of a breakwater, using a case study of a breakwater which is planned for Entrance Point, Broome in the northwest of Australia.

Wave conditions representative of ambient and extreme conditions were determined from measured data captured directly offshore of the site, and an extreme cyclone metocean study (Baird, 2020). For ambient and extreme tropical cyclone conditions, waves are typically short crested at a peak period of between 4 seconds to 8 seconds.

To examine the effectiveness of the offshore breakwater, empirical methods (Goda, 2000), a phase-averaged model (SWAN) and two phase-resolving model systems– the 2D Boussinesq wave model (MIKE21BW) and 3D non-hydrostatic model (MIKE3-Wave FM) - were applied. MIKE21BW is a 2D hydrodynamic model that applies the Boussinesq approximation to account for the vertical gradient in flows. The MIKE3-WaveFM model is a 3D hydrodynamic model which adopts the non-hydrostatic (NHS) assumption and solves the propagation of nonlinear waves with the enhancement of an explicit solution of vertical acceleration and velocity gradients. Both phase-resolving models can account for the complex wave propagation processes at the site where diffraction, refraction and reflection from surrounding structures are important processes. An example of the output from the MIKE21BW model at the site is presented in Figure 1.

Figure 1 – Example of model output from MIKE21BW phase resolving model at the site (water surface elevation)

The performance of the various methods including the establishment of the model grid, model simulation time and validation to measured wave conditions within the model domain and benchmark physical model data are presented. A discussion of the model limitations and challenges of the application of each method and model type is presented. A key factor which influences the practical application of Boussinesq and 3D non-hydrostatic wave models at the site is the relatively large water depths compared to wavelength (wave period) for the short period sea conditions that dominate ambient and extreme conditions at the site.

Analysis of diffraction around the offshore breakwater comparing analytical wave diffraction solutions for random seas (Goda, 2000) against the spectral model showed the model performs relatively well up to the point where reflection from landside structures, refraction and shoaling influence outcomes in the lee (Figure 2).

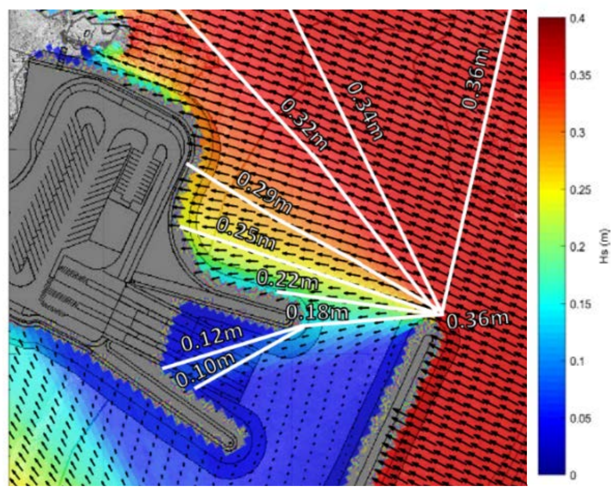

Figure 2 – Spectral model vs Empirical diffraction (Hs,m)

Comparison between the phase resolving models and the spectral model showed close agreement at concurrent locations in the lee of the breakwater with phase resolving models showing larger wave height during the extreme condition due to the inclusion of diffraction. The spectral model produces more wave energy through the gap between the offshore breakwater and landside structures in part due to wind growth being included.

REFERENCES
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