ANALYSES OF HYDRODYNAMIC AND TYPHOON WAVE LOADINGS FOR THE SUBSTRUCTURE SCOUR PROTECTION DESIGN OF PANGUIL BAY BRIDGE PROJECT

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INTRODUCTION

Panguil Bay Bridge is a national coastal bridge infrastructure project of the Department of Public Works and Highways (DPWH), Philippines national roads and infrastructure agency, that will connect via road transport the towns of Tubod, Lanao del Norte and Tangub, Misamis Occidental. The bridge project consists of 320m length of the main bridge, 1,920m of approach bridge, 861m of approach road section, yielding a total length of 3,101m which surpasses the previously longest 2.1-km-long San Juanico Bridge. The bridge superstructure is supported by 32 piers consisting of 2 main pylon piers for navigation passage, 2 supporting piers, and 28 single piers distributed on both sides of the Panguil Bay Channel.

The objective of this paper is to present a methodology and the results of its application to the determination of the hydrodynamic and storm wave loadings required in the design of the marine scour protection of this coastal bridge's substructure.

METHODOLOGY

The project site is located in Mindanao, which is frequented by relatively fewer tropical cyclones yearly than the rest of the Philippines. In recent years, however, more and stronger typhoons frequented the island. In order to adequately design the piers and the substructure scour protection against the typhoon hazard loadings, it is necessary to determine the design loads induced by historical typhoons that tracked the project bay itself.

Numerical simulations were carried out to determine the storm hydrodynamics around the bridge substructure and abutments generated by typhoons. A depth-adaptive unstructured local mesh was used to discretize the marine domain of computation, and a pan-Philippine regional model was used to provide the tide levels and currents along the interface of the nested model.

HAZARD LOADING ANALYSIS

Preliminary design adopted clustered piles for the main bridge piers and single 3-m-diameter single piles for shallower supporting piers. As these substructures are not small relative to the bay morphometry, the piers were also modeled as part of the coastal boundaries (Figure 1). The hydrodynamics and storm wave fields due to the strongest south- and north-tracking typhoons were simulated using Mike21 HD and spectral wave model SW. Atmospheric boundary conditions were modeled and interpolated via Holland's (1980) single-vortex cyclone model and utilized the meteorological data from Japan Meteorological Agency (JMA) tropical cyclone database to characterize the typhoons at every 6-hour intervals. Different hazard loading scenarios were used to design various elements of the bridge. For the substructure, a 100-year Return Period Scenario, instead of the historically critical hazard, was adopted.

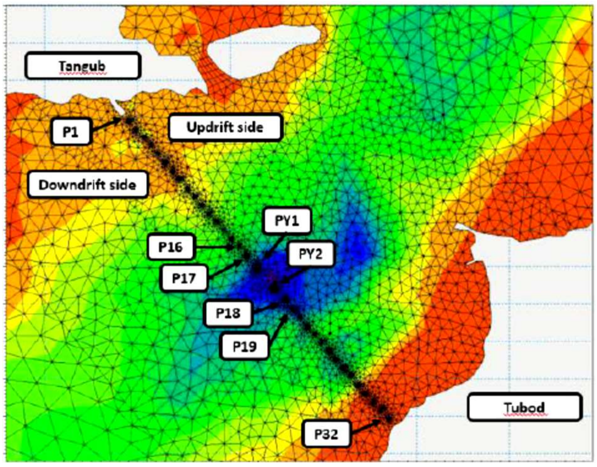

Figure 1. Pier-accounting unstructured mesh (partial view)

RESULTS

Among other findings, it was found that the inclusion of the clustered and single piers affects both the storm surge and typhoon wave loadings, regardless of which hazard scenario is chosen for design. The differences with the no-pier model's results depend on the pile dimensions, pile count, the track of the typhoons, and the pier depth. For the analysis of typhoon currents' intensities for the substructures' protection against marine scour, it was found that the storm currents varied between with-pier and no-pier coupled hydrodynamics-wave models, with with-pier hazard loadings materially higher.

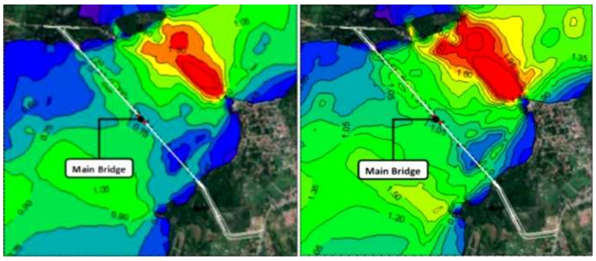

Figure 2. Typhoon currents using no-pier (left) and with-pier (right) local models

REFERENCES

Holland (1980). An analytic model of the wind and pressure profiles in hurricanes. Monthly weather review, Volume 108, pp. 1212-1218.

Japan Meteorological Agency. Kitamoto Asanobu National Institute of Informatic (NII). Digital Typhoon: Typhoon Images and Information.