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Impact of a Proposed Pier on Tidal Currents: Koa Kood Island, Thailand

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***Abstract*—**The impact of a proposed pier on tidal current alteration was evaluated. The proposed pier location was in Salad Bay on Koa Kood Island, Trat province, Thailand, and was designed to accommodate passenger ships with a draft of less than 2 m. The study began with collecting necessary data, including bathymetric, water elevation and tidal current characteristics. The impact was assessed using a software package (MIKE21). Although the results showed that the pier would affect the existing current pattern, the change was determined to be insignificant, as the design of the piles for the pier provided sufficient spacing to let the current flow as freely as possible. Consequences of the altered current, such as seabed erosion, water stagnation, sediment deposition and navigational risk were assessed. Environmental mitigation measures might be necessary if the impacts were considered unacceptable.

***Keywords*—**Environmental impact assessment, pier, tidal current change, coastal engineering and management

I. Introduction

KOA Kood is a remote island located in the Gulf of Thailand, in Trat Province, Thailand. The size of the island is approximately 105 km^2, with a width of about 12 km and a length of roughly 25 km. There are a number of coastal piers that accommodate tourists and commuters, situated on the western side of the island (Fig. 1). Ships visiting the island during the southwest monsoon (May to September) when there are high waves coming from a west and southwesterly direction, face difficulties, since the existing piers are not able to operate. Therefore, a new pier has been proposed to be constructed in Salad Bay on the northeastern part of the island (Fig. 1).

The proposed pier must be subjected to an environmental impact assessment (EIA). In Thailand, an EIA is mandatory for 34 types of project that are likely to cause significant impacts on the environment. An approved EIA report is required prior to construction of any port or pier project that: a) accommodates ships larger than 500 gross tonnage; b) has a total berthing length longer than 100 m; or c) has a total land size bigger than 1,000 m^2.

Since 1997, the laws of Thailand have required that stakeholders be involved and their concerns be considered in development projects [1]. The environmental impacts of a project must be forecasted and the foreseen negative impacts must be addressed by appropriate environmental measures.

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The impact of any alteration of tidal currents is usually considered when carrying out an EIA for any coastal project in Thailand. Prime objectives of this study were to evaluate the change in tidal currents and associated consequences due to the construction of the pier. Readers should be able to use knowledge gained of the process to assess the impact of seawater current alterations caused by any coastal development. The methodology is presented in Section 2, followed by the study results in Section 3. Sections 4 and 5 provide discussion and the conclusion, respectively.

Fig. 1 Koa Kood Island, existing piers and the proposed pier site at Salad Bay

A. Site Conditions and Characteristics of the Proposed Pier

At the proposed location, the coast is rocky with a small fraction of sand (Fig. 1). A tidal gauge operated by the Harbor Department at Laem Ngope station, the nearest tidal station, indicated that the local mean water level was approximately -0.07 m below the national mean sea level (MSL). The mean low water at the site was -0.77 m MSL. The tidal range during spring tide was 2.3 m, while during the neap tide it was 0.5 m. A feasibility study carried out earlier suggested that the new

pier would be used for the transportation of people. The biggest ship expected to visit the pier in the future would have an overall length of 30 m, a width of 5.50 m and a draft of 2.0 m. In order to accommodate ships having a draft of less than 2 m, the safe depth in front of the berth should be deeper than -3.50 m MSL. The engineering design of the new L-shaped pier in Salad Bay specified the pier's length be 210 m and the width 10 m. The berth would be 55 m long, enough to accommodate at least three ships visiting the pier at the same time. The pier structure would be pile-supported in order not to interrupt natural current flows and sediment transportation. The piles would be circular with a diameter of 0.4 m, with a spacing of 5 m in a transverse direction, and 15 m in a longitudinal direction (Fig. 2).

Fig. 2 Artist impressions of the proposed pier at Salad Bay

II. Materials And Methods

An assessment of tidal currents began with a collection of data on the existing physical conditions, including bathymetric and topographic surveying, tidal elevation recording and measurements of current speed and direction at specified points, among others. A computer software package, MIKE21, developed by the Danish Hydraulic Institute [2] was used to assess any impacts of the pier design on the currents.

Current speed and direction were measured at three specified points within Salad Bay (Fig 3a). The measured current flow patterns were compared with the simulated ones, in order to calibrate and verify the MIKE21 model. The simulation of the whole bay covered 5.0 x 1.5 km^2, thus a grid size of 25 x 25 m was chosen (coarse model) (Fig. 3b). The time step in the coarse simulation was 10 sec, in order to keep the value of the maximum Courant number to less than 5. Since the diameter of the piles was only 0.4 m, simulation using a large grid size was very inappropriate. After calibrating and verifying the coarse model, a boundary transfer technique was implemented and a new bathymetric file with a grid size of 0.4 x 0.4 m was prepared (fine model) (Fig. 3c).The time step for the fine model was 0.25 second to keep the value of the maximum Courant number to less than 5. Finally, the current patterns of the "with pier" and the "without pier" cases were compared at eight arbitrary points around the pier (Fig. 3c).Possible consequences from an alteration of tidal currents include scouring and erosion, navigational difficulty, water stagnation, and sediment and pollutant deposition. Faster current speeds may induce bed sediment movements, creating bed scouring or coastal erosion if the shear velocity exceeds the critical value [3]. Low-speed ships sailing around the pier may encounter maneuvering difficulties if the current flows too strongly [4-5]. On the other hand, water stagnation may result in retarded circulation of oxygen, elevating levels of biological (BOD) and chemical oxygen (COD) demand. Land-based sediments, pollutants or nutrients may be deposited at a particular location, while sedimentation around the pier may increase the grounding risk for visiting vessels [6]. These effects were evaluated, based on site-specific conditions.

III. Results

The speed of currents flowing inside Salad Bay was moderate, being less than 0.3 m/s. Calibration and verification factors that provided satisfactory agreement were Manning's resistance of 30 $m^{1/3}/s$, and the value for the Smagorinsky flux-based eddy viscosity of 0.4. These values were used later for an evaluation of the pier's impact on the current circulation.

The current speed and direction at eight points (A to H) were compared. The proposed pier was found to have a negligible effect, because its piles were spaced wide enough to not impede the current flow. The flow speed around the berthing tip of the pier (points B, C, and D in Fig. 3c) would be reduced, and the flow direction would be altered. Other comparison points showed insignificant current alterations (Fig. 4).

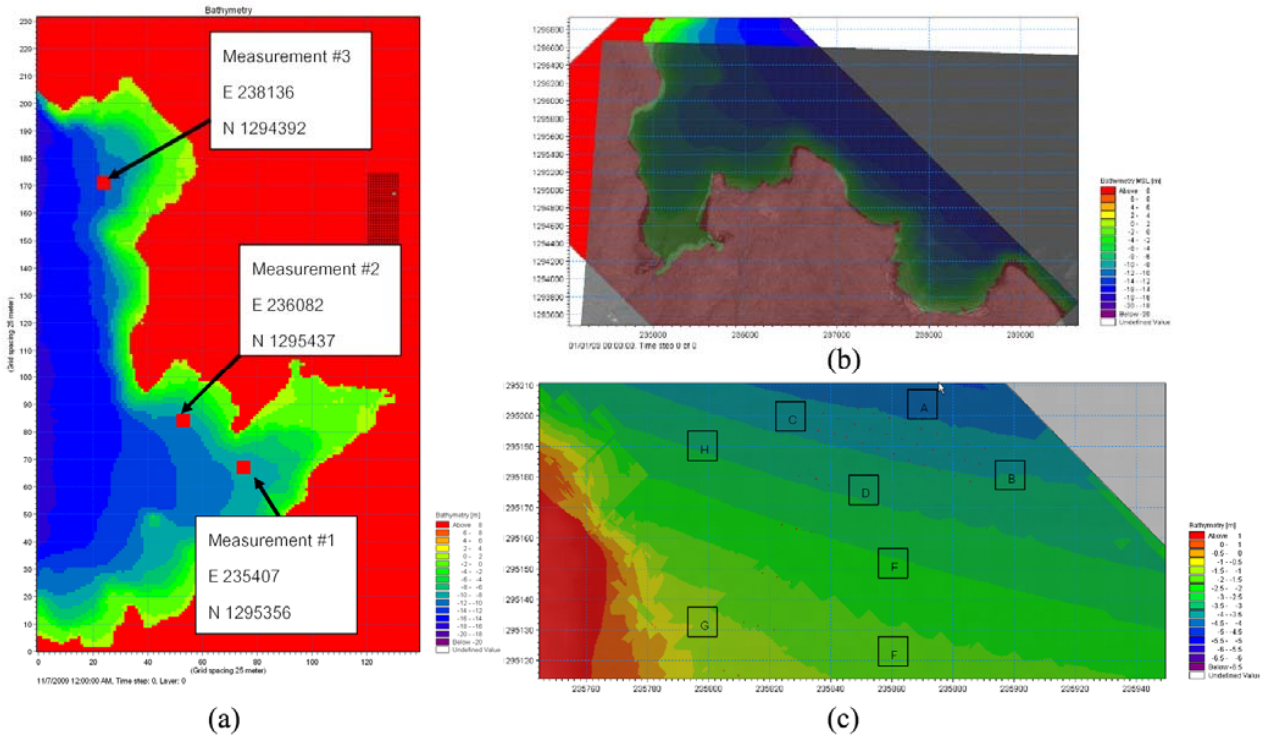

Fig. 3 (a) Current measurement points; (b) Bathymetry of Salad Bay; and (c) Piles of the proposed pier (represented by dots) and points for current comparison (A to H)

The changes in current flow were considered acceptable and would not create any impact. If the pier were constructed, the current speed would not exceed a value that could initially move bed sediment. Based on a Shield's diagram, the current speed that initiates movement of the sediment with a diameter of 0.3 mm is 0.50 m/s, while the speed to move the 1.0-mm sediment is 0.84 m/s. Since the sediment size (rock) at the proposed site was much bigger, no erosion was expected.

The current velocity around the pier would not create a difficulty for ships being maneuvered. US Army Corps of Engineers [7] suggests that care should be taken in controlling and turning ships if the current speed is stronger than 0.8 m/s. Therefore, the pier's influence on the current would not affect the ships, since the modified flow speed would be less than 0.8 m/s. Instead, the pier would decrease the current speed.

Water would not be stagnant inside Salad Bay, as simulation results indicated that currents would still circulate there. Although the pier would slow down the speed, any change would be very small and be localized around the berth.

Due to the reduced speed of the current, sediment deposition might be promoted around the berth, but to an insignificant level. Not much deposition was expected because: a) the natural concentration of total suspended solids in the water inside Salad Bay was only 6.6 mg/L; and b) there was no sediment source that provided a large quantity of sediment to the site.

IV. Discussion

Inevitably, coastal projects create environmental impacts [8]. In the past, coastal developers did not pay much attention to considering the effects on neighboring areas. In today's society, where public involvement is of the utmost importance, such practices are no longer acceptable. Foreseen impacts upon innocent people must be prevented, mitigated or compensated.

A proposed pier in Salad Bay would have small impacts on tidal currents. The pier design impedes current flow as little as possible by locating piles far apart, but even so, the flow speed around the pier would be reduced still. Such an effect would influence current circulation and sediment deposition, while being irrelevant to erosion activity and navigational safety.

Setting up monitoring programs for the foreseen impacts is vital for environmental management. Monitoring water quality (BOD, COD, dissolved oxygen, other land-based pollutants and nutrients) inside Salad Bay would be indispensable, because simulation results clearly indicated the altered circulation. A monitoring of the depth in front of the berth would be necessary also, since increased sedimentation was expected from the retarded current flow.

It is wise to emphasize that the environmental effects of a certain project are site-specific. The same project constructed

at different locations could create different types of impacts and different levels of severity. If the same pier were to be situated in a muddy bay, where there was a large sediment source, the effect on sedimentation might require considerable attention.

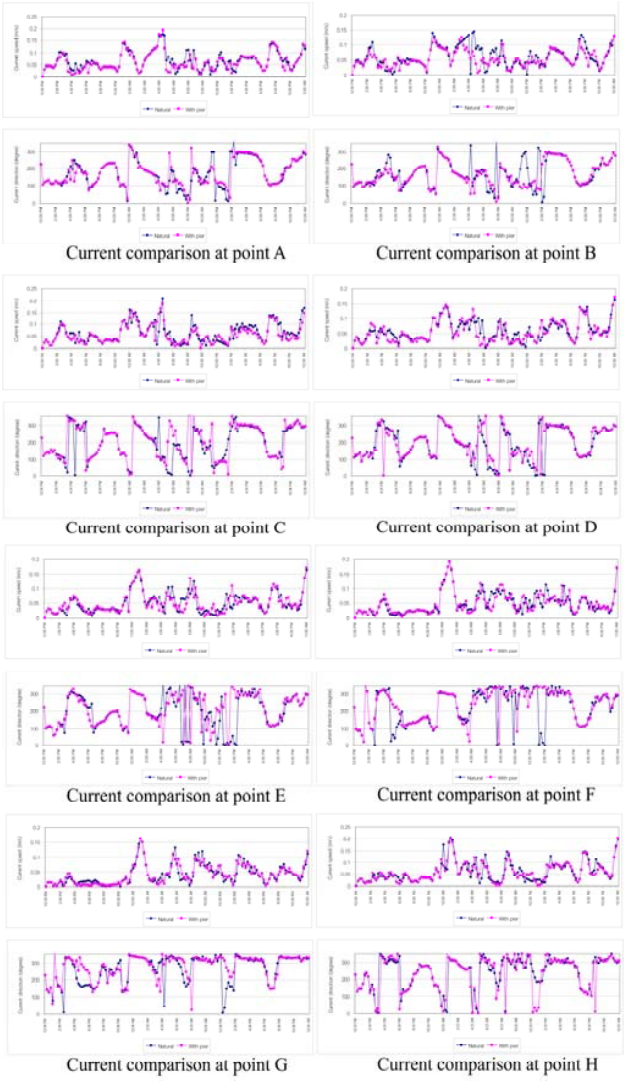

Fig. 4 Comparisons of current speed and direction at eight points

Methods to investigate environmental impacts may be different, depending on various factors. Technologically advanced or rich countries may apply other assessment methods, such as physical models that require higher budgets. In Thailand, the present evaluation of the environmental impacts is based on software simulations because of their cheap cost. Although the computer calculations must be calibrated and verified, accuracy of the calculations cannot always reach 100%. What is important for the environmental assessment is not to rely solely on the calculation results, but to establish plans for the foreseen negative impacts. Therefore, coastal managers must take the prediction results into consideration, and regard them as precautions in order to prepare for any eventuality that may arise.

V. Conclusion

This study illustrated the impact on alterations to seawater currents of a proposed pier on Koa Kood Island, Trat province, Thailand. The study began by gathering necessary site-specific information on bathymetry, topography, tidal elevation, and water current characteristics, among others. A computer software package (MIKE21) was used as an assessment tool. Results showed that the proposed pier would not create any drastic current alterations. The currents around the pier would flow more slowly due to obstruction by the pier's piles. The effects on erosion, water stagnation, sediment deposition and navigational risk were assessed. The evaluation results were expected to raise the awareness of coastal managers to consider any possible consequences and to urge them to prepare proper mitigation measures if the impacts exceeded an acceptable level

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