Assessing and Mitigating Impacts of Shore Revetment on Neighboring Coastline

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Abstract. Coastal erosion is one of the most critical problems for Thailand. Revetments have been implemented as structures to mitigate the erosion. If the revetment is constructed in a way that does not interrupt alongshore sediment transport, it will not induce coastal erosion to adjacent beaches. This research uses a case study of the revetment design in Pranburi district, Prachuapkhirikhan Province, Thailand to demonstrate that environmental mitigation measures may be required when installing the revetment. A software package named LITPACK was applied to predict locations and severity of the revetment-induced coastal erosion. The research began with a gathering of physical data such as bathymetry, wave climate, sediment, and information on existing coastal structures. A LITPACK calibration was undertaken. The LITPACK simulations predicted that the revetment construction would create coastal erosion at nearby area. Mitigation measures as well as monitoring plans were suggested.

Keywords: coastal erosion, coastal protection, revetment, integrated coastal management, Thailand

1. Introduction

Coastal erosion is one of the most critical problems for most coastal countries [1-5]. In Pranburi district, Prachuapkhirikhan Province, Thailand (Fig. 1), coastal people have suffered from erosive waves during February to June. A lot of governmental departments (both local and national levels) have put a lot of efforts
and resources to mitigate the erosion. There was a revetment in place to protect the coastline along the study site, but the revetment was damaged by big waves.

A revetment is a form of cladding or protection placed on a sloping surface or a structure to stabilize and protect against erosion resulting from waves or currents [6]. It can be constructed from rocks, concrete blocks, or sand-filled geocontainers. The literature indicates that coastal structures that interrupt alongshore sediment transport or alter nearshore wave patterns can have influences on adjacent shorelines [7-9]. Often, one solution causes another problem. Protecting a certain coastal stretch may result in another coastal erosion occurring nearby. Coastal managers, engineers, and project owners must care for innocent coastal people whose properties and livelihoods may be affected. Most importantly, negative externalities must be evaluated and mitigated by appropriate measures. This article supports such a concept by utilizing a 2,800-meter revetment at Pranburi Beach, Prachuapkhirikhan Province, Thailand as a case study.

1.1. The designed revetment along Pranburi Beach

A revetment is a structure that is constructed along a coastline to combat high waves. Normally, the revetment is located along beach dune where swash waves during calm weathers rarely reach it. It therefore does not obstruct alongshore sediment movement. Along the Pranburi beach, there was a revetment in place but it was damaged (Fig 1b). A responsible governmental department planned to repair the damaged revetment by removing it and re-installing the new one. However, the new revetment in this case study was designed to protrude into the ocean (Fig. 2). The responsible governmental department insisted on a necessity of locating the revetment in such a manner. The new revetment construction might be seen as a reclamation project, interrupting the alongshore sediment transport to some extent. An impact of the new revetment on adjacent shorelines (coastal erosion/accretion) could be expected. If the negative impact was significant, environmental mitigation measures had to be established.

2. Methodology

2.1. Gathering of required physical data

The study began with collecting site-specific physical data indispensable for the research. Information on wind statistics (Fig. 3), bathymetry, and coastal sediment were gathered. Later on, wave climate was synthesized from the wind data by using a JONSWAP method. It was found that the waves mainly came from East and East-Southeast directions. The calculated maximum offshore significant wave height was 3.4 meters with the wave period of 8.5 seconds (Fig. 3).

Bathymetric data was acquired by echo sounding. The survey found that depth contours were more or less parallel to the coastline (Fig. 4). Beach profiles were extracted so that they could be used as inputs for computer simulations. Coastal sediment was sand with a D₅₀ of 0.22-0.30 millimetre, varying with depth.

2.2. LITPACK simulation
LITPACK is a software package that is capable of simulating morphological evolutions of sandy shoreline affected by coastal structures. This 1-Line model has been developed by Danish Hydraulics Institute and has been widely implemented in various countries [10].

A LITPACK calibration was vital for accurate shoreline predictions. Two high-resolution satellite images taken in January 2009 and December 2010 were utilized for the calibration. The coastline position in 2009 was used as a starting point. The calculated coastline in 2010 was compared with the actual digitized shoreline in 2010. Appropriate calibration parameters were (a) active depth = 2.5 meters, (b) active height = 3.0 meters, and (c) dune height = 3.0 meters. After successfully calibrating the LITPACK model, the author was able to forecast shoreline positions in the next 25 years. Two scenarios (with and without the new revetment installation) were carried out and a comparison between them was made. In this manner, an impact of the new revetment installation (if any) on adjacent shorelines could be predicted.

![Fig. 3: Yearly wind rose and wave rose](image)

![Fig. 4: high-resolution satellite images and the bathymetry](image)
3. Result

The LITPACK simulations clearly suggested that adjacent shorelines would be affected. The new revetment which protruded into the sea obstructed alongshore sediment transport. Since net sediment transport movement was from south to north, shoreline accretion was expected to happen at southern area next to where the revetment started, while coastal erosion was forecasted to occur at northern shoreline adjacent to where the new revetment ended (Fig. 5). The magnitude of the erosion was predicted to be 35 meters in 25 years (Fig. 5). Unfortunately, the location that is likely to experience the erosion has a lot of buildings as well as facilities for recreational activities. Therefore, mitigation measures to address the expected erosion must be established.

One of potential mitigation measures is to replenish the affected beach with sand every year. It is better to annually repair the beach. If the responsible governmental department allows the erosion to persist and chooses to repair the beach once in a few years, recreational activities along the beach will be heavily interrupted and the beach may not be suitable for tourism. Sand used for the beach nourishment needs to have characteristics similar to existing sand on the beach (e.g. color, gradation, chemical, and biological components). As a part of monitoring plans, beach profile surveys must be undertaken every year in order to assess whether the revetment-induced erosion is more/less severe than forecasted.
4. Discussion and conclusion

Coastal erosion is a problem that needs urgent solutions. A revetment is one of the most applied hard structures that can effectively protect properties along shoreline. However, great care should be taken when constructing the revetment that interferes with alongshore sediment transport. Often, one solution to a certain problem creates another problem at another location. If such incident happens, a trade-off between benefits received and losses occurred must be made.

This article presents a case study along Pranburi Beach, Prachuapkhirikhan Province, Thailand, where a 2,800-meter revetment will be constructed. The revetment will protect a long coastal stretch but it also has a potential to cause coastal erosion nearby. A computer simulation can be a useful tool to predict locations that are likely to be eroded/deposited as well as severity of the erosion/accretion. Such information is valuable and should be incorporated into a decision making. Coastal managers as well as developers (or in this case study, the responsible governmental department who proposes to construct the sea-protruding revetment) must take care of negative externalities originated from the construction. Appropriate mitigation measures must be established. Continuous monitoring plans are also required.

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6. References