ISSN: 0128-7680
Pertanika J. Sci. & Technol. Supplement **9(1)**:81 - 86 (2001)

Coastal Hazard Modeling from Radar Data

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ABSTRACT

The effects of wave force or the effects of the coastal engineering structures induce coastal hazards such as erosion. Coastal engineering structures such as jetties could trap a sediment transport along the coastline. This could induce erosion in the downstream. The aim of this study is to model the effects of shoreline changes to jetties located along coastal water of Chendering, Malaysia. The numerical model will be based on the change of wave spectra extracted from ERS-1 data. For this purpose, two-dimensional Fourier Transform was applied on window size of 200 × 200. The quasi-linear model was used to model significant wave height. The significant wave height was used to model the volume of sediment transport and shoreline evaluation along jetties.

The result shows that the erosion occurred in the south of Chendering with rate of change of 4 m/month. The prediction shows that the rate of erosion would increase within 10 years. This study shows the location of jetty decreases the rate of sediment transport along the south of Chendering. It can be said that ERS-1 data are able to predict shoreline evaluation along the coastal structures. The jetty induced an equilibrium beach profile along jetty. This is due to that jetties-trap sediment in the north of Chendering, which lead to erosion in the south of Chendering.

Keywords: erosion, sediment transports

INTRODUCTION

Coastal erosion occurs due to the effects of the coastal construction such as jetties, which is an interesting topic between scientists. Kraus *et al.* (1984) and Hanson *et al.* (1990) used a numerical model of waves in order to predict shoreline change due to the present of breakwater. Kraus *et al.* (1984) found that the accumulation of the sand was began to take place as the breakwater progressed and by the time the latter were completed, nearly 370,000 cu. yds. of sand were found deposited in the harbor. Up to now, there are few studies on wave effects on coastal structures, which were conducted on the East Coast of Malaysia. Stanely *et al.* (1985) reported that erosion along the shoreline of Chendering port due to the jetty traps the sediment and causes erosion at the down of littoral drift and accretion to the upper littoral drift. However, this study could not model the shoreline rate changes between seasons. Moreover, this study could not answer question such as what the breakwater effects in terms of short time and long time. Recently, Maged and Shattri (1997) used radar data (ERS-1) to predict the shoreline changes along port of Chendering. They found that the rate of erosion was 4 m/yr. Maged and Shattri (1997) could not identify the location of erosion and sedimentation. Some other studies such as Salleh *et al.* (1991) used numerical model to investigate the effect of tidal current on nearshore sediment transport. However, the nearshore sediment transport does not induce by tidal current but induces by the wave effects. The aim of this study is to model the effects of shoreline changes to the jetties located along coastal water of Chendering, Malaysia.

METHODOLOGY

Study Area

The study area is located in the South China Sea between 5° 14' N to 5° 18' N and 103° 10' E to 103° 12' E. This area lies in an equatorial region dominated by two monsoon seasons (Rosnan 1987 and Maged 1994). The southwest monsoon lasts from May to September while the northeast monsoon lasts from October to March. The monsoon winds affect the direction and magnitude of the waves. Strong waves are prevalent during the northeast monsoon when the prevailing wave direction is from the north from December to February, while during the southwest monsoon (May to September), the wave direction from the south (Wong 1981). The rate of longshore drift based on wave effects is about 40,000 to 50,000 cubic meters per year (Stanely *et al.* 1985).

Wave Spectra Model

Wave spectra are derived from the C-band ERS-1 by applying two-dimensional Fourier Transform from PCI's EASI/PACE image-processing system this. The wave spectra derived from C-band ERS-1 were mapped into the real wave spectra by using quasi-linear model. This model was simplified by Vachon *et al.* (1994) as follows

$$S(Q) = H(Kx; Kc)\, S(L)\, S(k) \quad (1)$$

where S (Q) is a quasi- linear transform function, Kx is wave number azimuth direction; Kc is the cut-off wave number, which function of wind speed. S (k) is an ERS-1 wave spectrum while S (L) is real wave spectra measured in situ.

Equation 1 used to model significant wave height (Hs) along the jetty as

$$Hs(Kc) = F(Kc, U) \quad (2)$$

where U is wind speed m/s.

The modulation spectra were used to model the wave diffraction feature along the jetty located on Chendering port. The method of Huygen was used to plot wave ray diffraction.

Shoreline Change Model

The governing equation for shoreline position y is given by

$$\partial Y / \partial t + 1/D(\partial Q / \partial x \pm q) = 0 \quad (3)$$

where x is the longshore coordinate, t is the time, D is the depth of closure (beyond which the profile is assumed not to be move), and Q is the longshore sand transport rate. The predictive expression for the longshore transport rate is taken as

$$Q = H_b^{\,2} C_{gb} / 16(\rho_s / \rho - 1)(1 - p) * (K_1 \sin 2\theta_{bs} - 2k_2 \partial H_b / \partial x \cot\beta \cos\theta_{bs}) \quad (4)$$

where C_{gb} is the wave group velocity at the jetty line, $(\rho_s(\rho)$ is the sand water density, p is the sand porosity, θ_{bs} is the angle of the breaking wave crests to the shoreline and tan β is the beach slope. The coefficient K_1 and K_2 are treated as the parameters in the calibration of the model (Kraus *et al.* 1984).

RESULTS AND DISCUSSION

Fig. 1a shows that the wave peaks propagated from southeast direction. When the wave spectra approached the jetties, the wave spectra turn to propagate toward the southwest

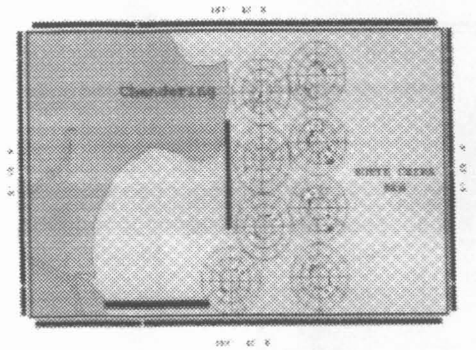


Fig. 1. (a) Wave spectra model from Ers-1 data

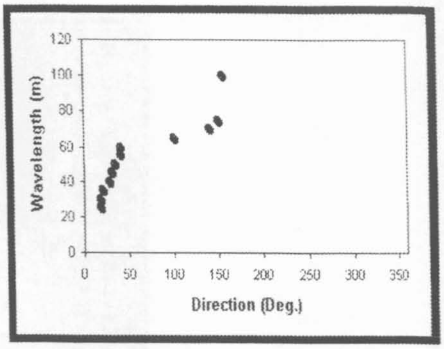


Fig. 1. (b) Wave spectra direction and length

direction and tend to curve along the jetties (Fig. 1a). The wavelength along the jetties ranged from 25 m to 100 m (Figure 1b). It obvious that the wavelength decreased when the wave spectra changed their directions (Figure 1b). Figure 2 shows that the wave orthogonal tended to curve along the jetties. The wavelength decreased near the jetties and inside the port. This indicates that the wave diffraction patterns. A similar finding is in Fig. 1. Figure 3 shows that the longshore current vectors moved with velocity ranged from 0.3 m/s to 1.3 m/s towards the northwest direction. The maximum velocity was observed in the south jetty while the minimum velocity was observed in the north jetty. This means that the jetty could reduce the longshore current velocity. The longshore current curved inside the port and moved out the port with minimum velocity towards the north of Chendering. Figure 4 shows that the erosion occurred in the south of Chendering and north of Chendering with approximately 4 m/month. The sedimentation occurred near to the south jetty with -2.3 m/ month.

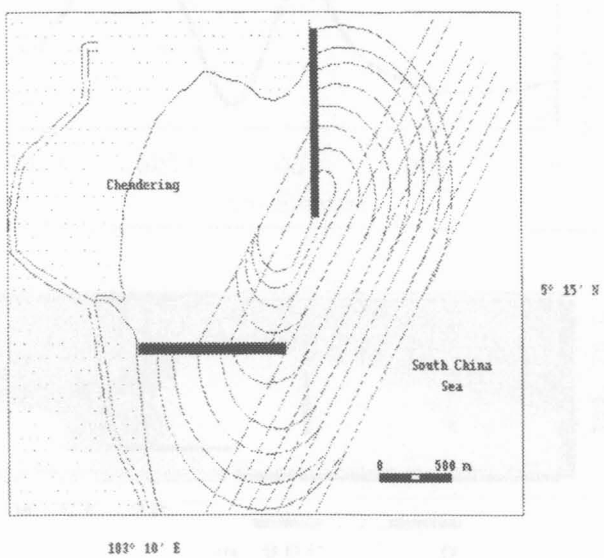


Fig. 2. Wave diffraction pattern along Port Chendering

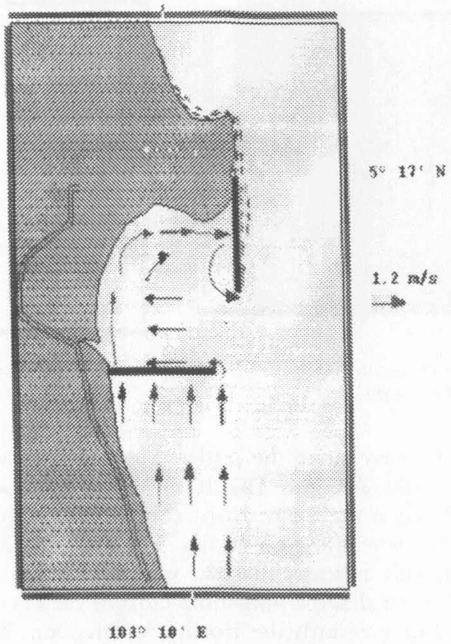
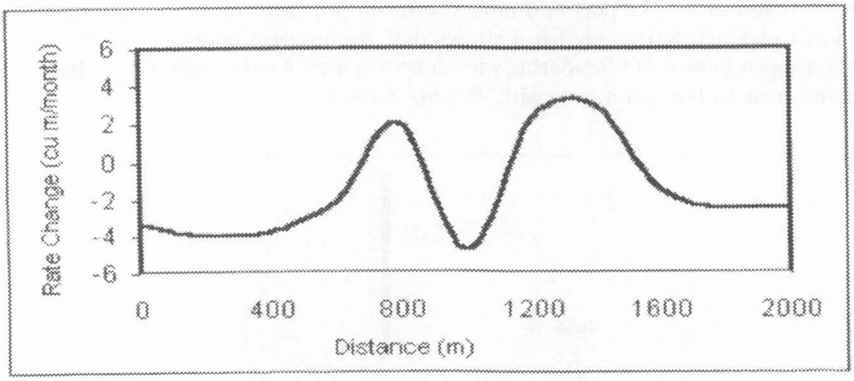


Fig. 3. Longshore current modeled from wave spectra



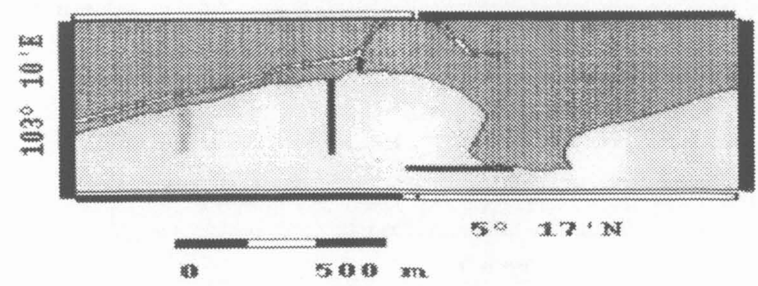


Fig. 4. Shoreline change modeled by quasi-linear transform

It can be explained that the mechanism of the shoreline change along the Chendering as: the southerly wave when approached the jetty diffracted and induced strong longshore current at the southerly jetty. This southerly jetty trapped all the sediment transport and deposited beside the jetty. This action caused erosion in the south of Chendering. Inside the Chendering port the current meander and carried the sediment out the port causing erosion inside the port. The sediment carried out from the Chendering deposited along the north jetty. Due to the weak littoral drift the shoreline extends along the north of Chendering exposed to erosion by less than 3 m/month. These results are not similar to study of Stenely *et al.* (1985). This is because that Stenely et al., 1985 did not use the diffraction as an index of erosion and sedimentation.

Fig. 5 shows that the rate of erosion could be exceeded to 5 m/year with 10 years. This finding suggested that the location of the jetty cause continuos erosion along the year. The ground data coincided with the quasi-linear model. This can be suggested that high accuracy involve with the model.

In spite of that, August represents a southwest monsoon season in which characterized by less wave energy in coastal water of Kuala Terengganu, erosion occurred along the Chendering shoreline. This suggests a future study, which includes the modeling of the shoreline change along the Chendering by using the integration of Kapas Island and jetty in shoreline configuration.

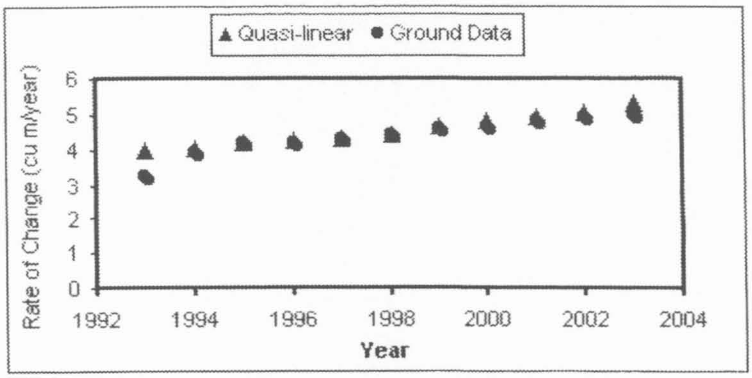


Fig. 5. Shoreline erosion rate in south of Chendering over 10 years

CONCLUSION

In conclusion, ERs-1 data could be used to derive the jetty effects in shoreline configuration. This is because that the ERS-1 data can be used to model wave information compare to classical methods. The shoreline change simulated from ERS-1 data suggested that jetty caused erosion along the coastal water of Chendering. With above study it was found that the rate of erosion could be increased with time.

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