Coastal Processes and Longshore Sediment Transport along Krui Coast, Pesisir Barat of Lampung

Trika Agnestasia Tarigan [1], **Nanda Nurisman** [1]

[1] Ocean Engineering Department, Institut Teknologi Sumatera, Lampung Selatan, Lampung

Abstract. Longshore sediment transport is one of the main factors influencing coastal geomorphology along the Krui Coast, Pesisir Barat of Lampung. Longshore sediment transport is closely related to the longshore current that is generated when waves break obliquely to the coast. The growth of waves depends upon wind velocity, the duration of the wind, and the distance over which the wind blow called fetch. The daily data of wind speed and direction are forecast from European Centre for Medium-Range Weather Forecasts (ECMWF). This study examines for predicting longshore sediment transport rate using empirical method. The wave height and period were calculated using Shore Protection Manual (SPM) 1984 method and the longshore sediment transport estimation based on the CERC formula, which also includes the wave period, beach slope, sediment grain size, and breaking waves type. Based on the use CERC formula it is known that from the Southeast direction ($Q_{lst(1)}$) the sediment transport discharge is 2.394 m^3/s, in 1 (one) year the amount of sediment transport reaches 75,495,718 m^3/s. Whereas from the northwest direction of ($Q_{lst(2))}$ the sediment transport debit is 2.472 m^3/s, in 1 (one) year the amount of sediment transport reaches 77,951,925 m3/s.

1. Introduction

The geographical condition of Krui Coast which is directly adjacent to the Indian Ocean makes this area get a direct influence from the physical parameters of the sea, which is the wave. That coastal areas are dynamic systems, constanly altered by wind and waves. Wind is most often not perfectly perpendicular to the shoreline, wind generated waves usually run up the beach at an oblique angle, with a portion of energy parallel to the shoreline. At the maximum wave run-up, gravity takes over and pulls the water downslope in a parabolic pattern. This component of longshore transport is located within the swash zone with sediments transported directly by wave action. Longshore currents mobilize sediments in what is known as longshore sediment transport. The prediction of longshore sediment transport is importance in coastal engineering. Longshore sediment transport is the most commonly required quantities in coastal engineering and the morphodynamic response of coastal areas. Predicting coastal shoreline evolution typically requires reliable calculations of longshore sediment transport. The main objective of the present study is calculate for the total sediment transport along Krui Coast, Pesisir Barat of Lampung. Longshore sediment transport calculated using Coastal Engineering Research Center (CERC) formula, which is based on quantitative field studies.

2. Method

2.1. Study Area

The selected area for study is Krui Coast, Pesisir Barat of Lampung, geographically located at 5°11’30.04” LS dan 103°55’49.43” BT (fig.1).

Figure 1. Area for study.

2.2. Hindcasting of Wind Generated Waves

The research were occurred in Krui Coast, Pesisir Barat of Lampung is used main material which is wind data in January 2008 until December 2017 and obtained from European Centre for Medium-Range Weather Forecasts (ECMWF). The daily data of wind speed and from is converted to significant wave height and significant wave period using Shore Protection Manual (SPM) 1984 method. SPM 1984 have obtained relationships for the growth and decay of waves by considering the energy transfer from the wind to waves during growth and reverse transfer from wave to atmosphere during decay. The basic data required for sea and swell forecast are wind velocity and duration, fetch, and decay distance. In the hindcast of wave parameters, the required variabels can be determined as wind speed, fetch length, and wind duration [3]. The daily wind data records taken from ECMWF do not coincide with the standard 10 m reference level. It must be converted to the 10 m reference level to predict the waves. An equation is given adjust wind speed (U_{10}) measured at elevation z to 10 m height that is appropriate for use in wave hindcast equations [1].

2.3. Fetch Length

Wind fetch length was defined as the unobstructed distance that wind can travel over water in constant direction. The concept of effective fetch assumes that: waves are generated over 45^0 range either side of the wind direction and energy transfer from wind to wave is proportiobal to the cosine of the angle between the wind and wave directions, and wave growth is proportional to fetch length and the formula given by [2]:

$$F_{eff} = \frac{\sum F_i cos^2 \alpha_i}{\sum cos\alpha_i} \qquad (1)$$

where F_{eff} is the effective fetch and is the length to be used.

2.4. Parametric Wave Hindcast Methods

Significant wave height (H_s) and peak period (T_p) which is the period at the peak of the wave energy density spectrum are associated the wind speed, duration, and fetch length.

In the fetch limited condition, the significant wave height (H_s) and period (T_s) are expressed as [4]:

$$T_s = 8.61 \frac{U_{10}}{g} \left[1 - \left[1 + 0.008 \left(\frac{gF}{U_{10}^2} \right)^{1/3} \right]^5 \right] \qquad (2)$$

$$H_s = 0.30\frac{U_{10}^2}{g}\left[1-\left[1+0.004\left(\frac{gF}{U_{10}^2}\right)^{0.5}\right]^2\right] \quad (3)$$

2.5. Transport Sediment
The used formula for the Longshore Sediment Transport (LST) rate is the CERC formula. The formula is based on the principle that volume of sand in transport is proportional to the longshore wave power per unit length of the beach and the formula given by [4]:

$$Q_{lst} = \frac{\rho K\sqrt{\frac{g}{\gamma_b}}}{16(\rho_s-\rho)(1-a)} {H_b}^{2.5}\sin(2\theta_b) \quad (4)$$
$$H_b = \Omega_b {H_0}' \quad (5)$$
$$\Omega_b = 0.3(\frac{H_o}{L_0})^{-1/3} \quad (6)$$
$$H_0' = H_o Kr Ks, \text{ where } H_o = H_s \quad (7)$$
$$L_o = 1.56\, T^2 \quad (8)$$

Where Q_{lst} is the longshore transport rate in volume per unit time, K is an empirical coefficient (K = 0.39), ρ is the density of water, ρ_s is density of sediment, g is acceleration due to gravity, a us the porosity index ($a \cong 0.4$), H_b is the significant wave height at breaking, γ_b is the breaker index, and θ_b is the wave angle at breaking, T is calculate from relation of Hs and Ts.

3. Results

3.1. Wave Characteristic
Based on Hs and Ts graph, we could get the wave modelling from 2008 to 2017 is linear with the equation Ts = 5.264 $Hs^{0.5.}$ Wave distribution for 10 years were made with WRPLOT Software, the results for biggest distributive percentage of wave current in 10 years (2008-2017) in each month (fig 2).

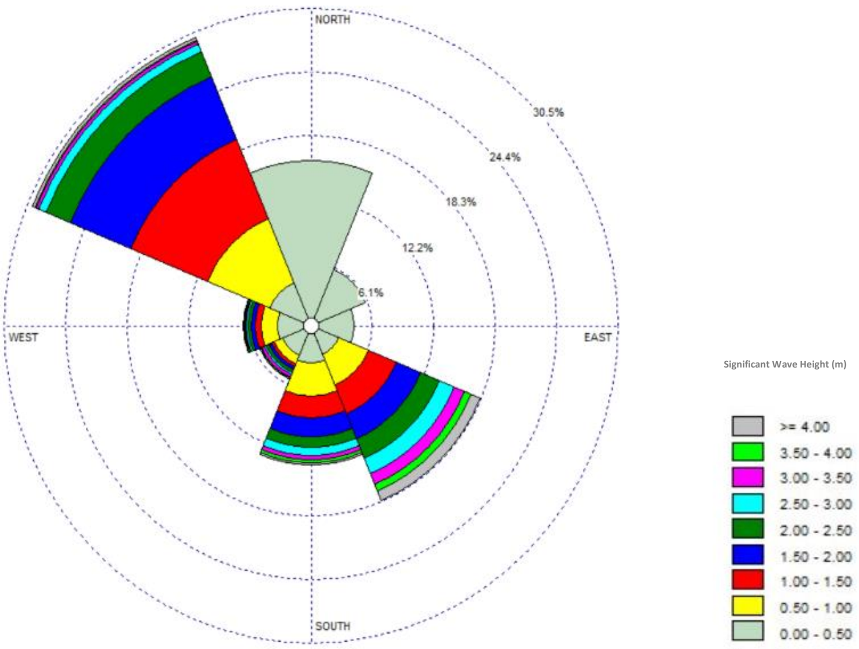

Figure 2. Wave height for 10 years (2008-2017)

Based on distribution of significant wave height, the maximum significant wave height is 0.5 m and mostly came from north side, for 1 - 2.5 m significant wave height is mostly came from northwest and for 3 - 4 m significant wave height is from south east.

3.2. Longshore Sediment Transport

Longshore sediment analysis was calculated using a wave distribution table which was divided into 8 (eight) wind directions and 9 (nine) wave height classes with 0.5 meter intervals. Illustration of the direction of wave arrival assuming in $\alpha_b=0^0$ terletak pada $\alpha_b=225^0$ (fig 3).

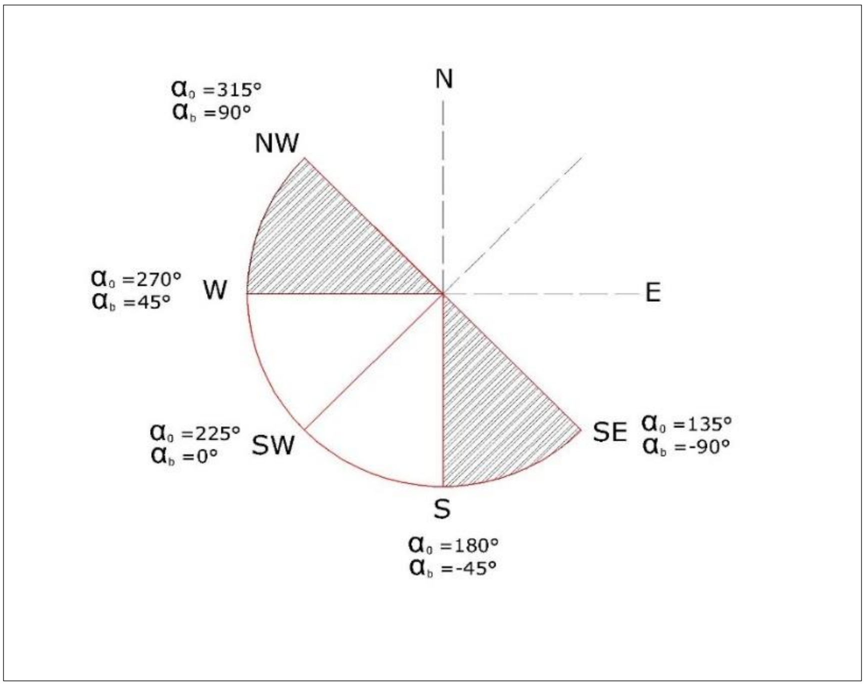

Figure 3. Ilustration of wave direction.

So that the percentage data of the required wave height distribution is obtained to be:

Table 1. Wave Height Distribution for Sediment Transport Calculation

Dir	Range		αb (deg)	αb (rad)	Wave Height (m)								
					0.5	1	1.5	2	2.5	3	3.5	4	4.5
SE	112.5	157.5	90	1.57079633	0.0301716	0.0318154	0.0298976	0.026119	0.0195436	0.0161646	0.0108106	0.0064841	0.0105366
S	157.5	202.5	45	0.78539816	0.035731	0.0315643	0.021119	0.0177742	0.0108791	0.0073631	0.0044407	0.0025	0.0025229
SW	202.5	247.5	center (αb=0o)										
W	247.5	292.5	45	0.78539816	0.0335049	0.015902	0.0068836	0.0040069	0.002774	0.0015982	0.0010617	0.0009589	0.0008904
NW	292.5	337.5	90	1.57079633	0.0450918	0.0669186	0.0817247	0.0643044	0.0264387	0.0072033	0.002911	0.0017694	0.0024772

Q_{lst} calculation result in each direction and significant wave height class:

Table 2. Q_{lst} Calculation Result

Dir	Range		αb (deg)	αb (rad)	Wave Height (m)				
					0.5	1	1.5	2	2.5
SE	112.5	157.5	90	1.570796327	7.63268E-20	4.55293E-19	1.17901E-18	2.11439E-18	2.76381E-18
S	157.5	202.5	45	0.785398163	0.001030184	0.005148026	0.009491745	0.016398708	0.017534265
SW	202.5	247.5	center (αb=0o)						
W	247.5	292.5	45	0.785398163	0.001069793	0.002872224	0.003426181	0.00409402	0.004951342
NW	292.5	337.5	90	1.570796327	1.43201E-19	1.20219E-18	4.04582E-18	6.53492E-18	4.6937E-18

Dir	Range		αb (deg)	αb (rad)	Wave Height (m)				Total (m3/s)	Total (m3/year)
					3	3.5	4	4.5		
SE	112.5	157.5	90	1.570796327	3.60597E-18	3.54547E-18	2.96929E-18	6.47717E-18	2.394	75,495,718
S	157.5	202.5	45	0.785398163	0.01872011	0.016598396	0.013047718	0.01767567		
SW	202.5	247.5	center (αb=0o)							
W	247.5	292.5	45	0.785398163	0.004499878	0.004394793	0.005542297	0.006908487	2.472	77,951,925
NW	292.5	337.5	90	1.570796327	2.01725E-18	1.1985E-18	1.01719E-18	1.91169E-18		

Table 3. $Q_{lst(1)}$ dan $Q_{lst(2)}$ Calculation Result

Debit	Total (m3/s)	Total (m3/year)
Qlst (1)	2.394	75,495,718
Qlst (2)	2.472	77,951,925

4. Discussions and Conclusion

The formation of waves because of the wind is very influential on the dynamics of the beach krui, which is based on the results of wave forecasting analysis for 10 years (2008 - 2017) where in January, February, March, April, and December angina moves from the Southeast and South. Whereas in May, June, July, August, September, October and November angina moves from the Northwest direction. But overall the analysis of the direction of the dominant wave coming from the Northwest with the highest maximum wave height from the wave forecasting result is 5,655 meters. The waves direction comes at certain angle to shore line that influent the sediment transport movement across beaches, based analysis of empirical calculation using CERC formula, we can get the result that can be found in (fig 4). Based on formula, we can found that from southeast direction the sediment transport flow rate is 2.394 m^3/s and in 1 (one) year the cumulative sediment amount would reached 75,495,718 m^3/s. From northwest direction we could get the sediment transport flow rate is 2.472 m^3/s, and in 1 (one) year the cumulative sediment amount would reached 77,951,925 m^3/s.

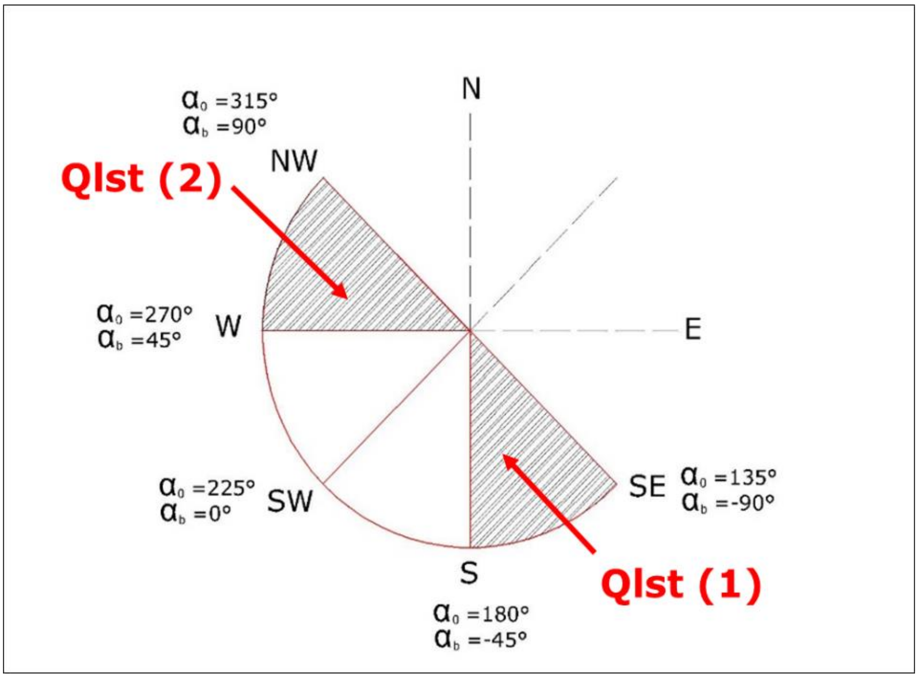

Figure 4. Ilustration of Sediment Transport Result

5. References

[1] Akpinar A, Mehmet O, Serkan B, and Murat I K 2014 Performance Evaluation of Parametric Models in the Hindcasting of Wave Parameters Along the South Coast of Black Sea *Indian Journal of Geo-Marine Sciences* vol **43** (6) p 905-920
[2] Bambang T 1999 *Teknik Pantai* Beta Offset Yogyakarta
[3] Goda Y 2003 Revisiting Wilson's Formula for Simplified Wind-Wave Prediction. *Journal of Waterway, Port, Coastal and Ocean Engineering ASCE* vol **129** p 93-95
[4] U.S. Army 1984 *Shore Protection Manual Fourth Edition* U.S.Army Engineer Waterways Experiment Station U.S. Goverment Printing Office Washington (DC) USA 20402