

Redesign of Coastal Protection Structures at Santolo Beach, Garut District, West Java

Soctya Sinarawadhi^{1*}, Odih Supratman¹

¹Civil Engineering Study Program, Indonesia University of Education

*Corresponding Author: Soctya Sinarawadhi. Email: soctyasinarawadhi@gmail.com

Abstract

Santolo Beach in Garut Regency is a coastal area that experiences abrasion due to high sea waves from the south. The coastal protection building in the form of a jetty that has been built previously has a length of 185 m at the end of the river mouth experiencing sediment deposits that cover the flow of ship traffic is considered no longer effective in resisting the rate of sedimentation and abrasion that occurs around the mouth of the Cilauteureun River. The methods used include data analysis of wind, waves, tides, and modeling of shoreline changes with the support of software such as MIKE 21. The results of this study include processing of the last 10 years of ECMWF wind data (2014-2024) and tidal data. The main data is the wave height which is done through numerical approach, the highest wave height is obtained from 2.83 meters and the wave period is 8.8 seconds. The results of the jetty analysis show $DWL = 1.49$ meters, the peak height of the building is 4.2 meters. The protective layer used is tetrapod and crushed stone, the weight of the head and body protective layer = 2 tons, the layer thickness is 2 meters. The number of stone grains of the body protection layer = 20 grains per 10m^2 . With tetrapod volume = 0.83 m^3 .

Keywords: Jetty, hydrodynamic modeling, sedimentation, re-planning, Santolo Beach.

1. Introduction

Santolo Beach is one of the beaches in Garut Regency, West Java, located in the southern region of Java Island and directly facing the Indian Ocean. This beach has tourism and fisheries potential, but also faces abrasion and sedimentation problems, especially around the mouth of the Cilauteureun River. A coastal protection building in the form of a jetty has been built at the location, but its effectiveness in the long term is questionable. Therefore, this research focused on re-planning an adaptive and sustainable coastal protection structure. This study seeks to adapt the jetty design to marine dynamics and sedimentation processes based on technical and numerical approaches that are appropriate to the existing conditions in the field.

2. Research Methods

The research method used consists of several important stages including, collection of wind and wave data obtained from hindcasting results in 2014, which reflect seasonal conditions in the southern coastal region of West Java, Tidal Analysis: Using data from NOAA, the tidal type was determined based on the admiralty method. This analysis is important for determining the elevation of the jetty plan. Wave Calculation: Breaking wave characteristics and run-up were calculated using the approach of SNI 2834:2008. The calculation is used to determine the plan height of the protective building. Jetty Length Calculation: Based on the method of Triatmodjo (1999), and the Coastal Engineering Manual (CEM) the jetty length is determined from the safe distance of estuary protection and the influence of sedimentation along the shoreline. Shoreline Change Modeling: Using MIKE21 software to simulate the influence of seasonal waves on changes in coastal morphology and the effectiveness of the new jetty design.

3. Results and Discussion

From the wind speed data for the last 10 years based on the standard *word meteorological organization* classified by interval < 3 m / sec to obtain a sharper and clearer distribution value. Then a table is made in the form of frequency percentage of wind speed events, as follows.

Table 1. Recapitulation of Wind Direction Distribution

Wind direction	Wind Speed (m/sec)						Number of data	Average Speed (m/s)	%
	0 - 2.1	2.1 - 3.6	3.6 - 5.7	5.7 - 8.8	8.8 - 11.1	≥ 11.1			
NORTH	2194	963	106	0	0	0	3263	1,755	3,4%
WEST SEA	3288	5273	10214	7154	4	0	25933	4,410	26,9%
WEST	3489	6638	19257	6253	2	0	35639	4,324	37,0%
WEST POWER	1048	75	6	0	0	0	1129	1,098	1,2%
SOUTH	710	21	0	0	0	0	731	0,911	0,8%
SOUTHWEST	2191	1849	2009	1194	30	2	7275	3,508	7,5%
EAST	3610	5440	6896	2997	74	6	19023	3,827	19,7%
EAST SEA	2391	949	98	1	0	0	3439	1,716	3,6%
Total	18921	21208	38586	17599	110	8	96432		100%

From the results of these calculations, the dominant wind direction is obtained, namely from the West at 37% as many as 35639 wind events. After the calculation, a wind rose diagram was made using WRPLOT software as a simulation.

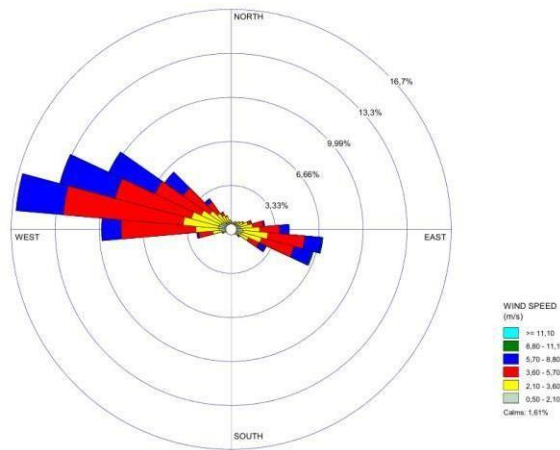


Figure 1. Santolo beach wind rose 2014 - 2024

Furthermore, the distribution of wave height events was simulated with WRPLOT, so the following results were obtained.

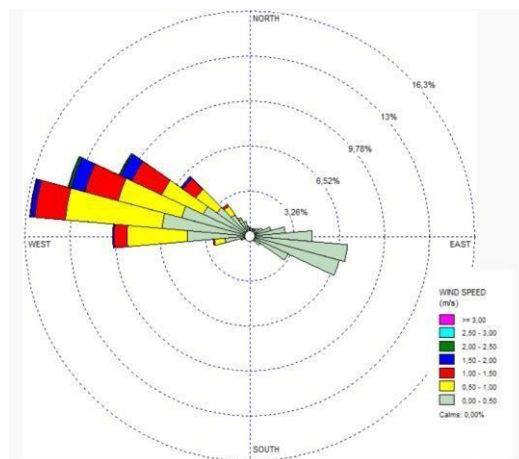


Figure 2. Wave rose of Santolo beach 2014 - 2024

The wave analysis results show that the maximum significant wave height (H_s) occurring at Santolo Beach is 2.83 meters, with a peak period of 8.8 seconds.

Table 2. Recapitulation of wave height at return period of FT-1 method

Recurrence Period (year)	Hsr South (m)	Southwest Hsr (m)	West Hsr (m)	Northwest Hsr (m)
2	0,10	0,21	2,31	2,42
5	0,14	0,36	2,52	2,59
10	0,18	0,46	2,66	2,70
25	0,22	0,59	2,83	2,83
50	0,24	0,69	2,96	2,93
100	0,27	0,78	3,09	3,03

From the tidal analysis, it is known that the tidal pattern is double daily (*semi diurnal*), with an MSL value of 0.23 meters. Based on the simulation results of shoreline changes, it is found that the existing jetty structure is less able to overcome the abrasion phenomenon that occurs on the west side of the estuary and abrasion on the east side of the Cilauteureun River estuary.

In the parameter analysis in the deep sea, it is obtained that the wave direction is from the west, the return period is 25 years, the wave height is 2.83, with the value of $UA = 10.68$ m/s, the significant wave height $T0 = 8.86$ s, the wavelength $L0 = 122.42$ meters, and the wave propagation rate $C0 = 13.82$ m/s.

Table 3. Westward wave parameter analysis

Tr (yr)	H0	UA	T0	L0	C0
(1)	(2)	(3)	(4)	(5)	(6)
2	2,31	9,65	8,01	99,98	12,49
5	2,52	10,08	8,36	108,96	13,04
10	2,66	10,35	8,58	114,90	13,39
25	2,83	10,68	8,86	122,42	13,82
50	2,96	10,92	9,06	127,99	14,13
100	3,09	11,16	9,25	133,52	14,43

Based on Figure 3, for a beach with a slope of $m = 0.02$, the H_b/H_0 coefficient is between 1.23 and 1.5. With a breaking wave height of 3.984 m, the breaking depth is estimated to occur in the range between 4.9 m and 5.9 m. Therefore, the jetties at Santolo Beach will be subject to breaking wave attack if built within this depth range.

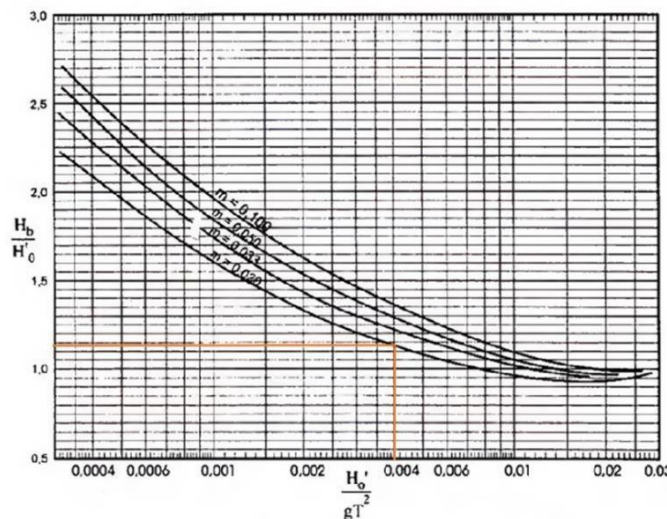


Figure 3. H_b/H_0 relationship graph Source: Triatmodjo, 1SSS

The re-planning of the jetty building was carried out with several adjustments, namely: The Jetty length was designed to be 208 meters from the shoreline based on the calculation of shoreline changes and the need for protection against estuary sedimentation. The Jetty Peak Elevation was set at +7.07 m from MSL to avoid overtopping during extreme conditions. The Jetty Slope was designed with a slope of 1:2 in order to efficiently break down wave energy and stabilize against wave forces. Protective Materials, the main layer uses tetrapods and crushed stone, with woven-nonwoven geotextile as a filtration layer according to the provisions in SNI 8460: 2017. The modeling results also show that the newly designed jetty structure is able to divert sediment flow away from the estuary, as well as provide better

protection against abrasion on the east side. The addition of geotextiles improves foundation stability and prevents scouring of the lower layers of the structure.

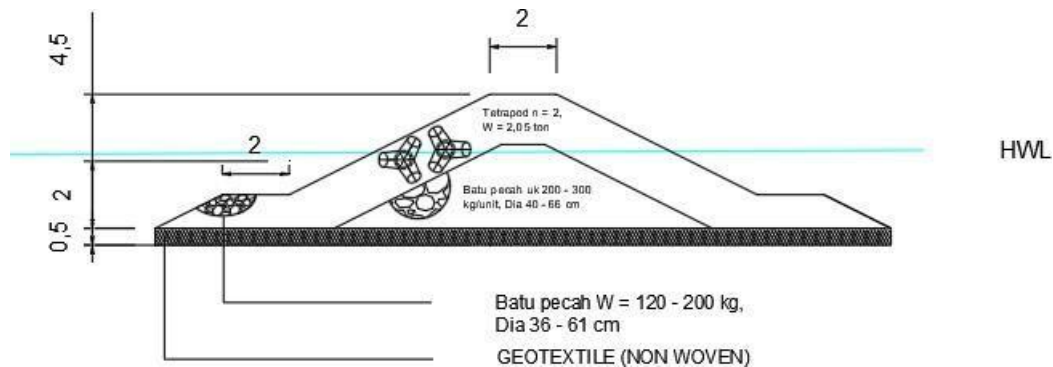


Figure 4. Layout jetty

4. Conclusion

The re-planning of coastal protection buildings in the form of jetties in the Santolo Beach area is a strategic step to overcome abrasion and sedimentation problems that interfere with fisheries and tourism activities in the region. Based on the analysis of hydrodynamic data, tides, and numerical simulation of the shoreline, it was found that a jetty design with a length of 110 m, a peak elevation of +5.5 m against MSL, and a slope of 1:2, can provide more effective protection. The use of a combination of crushed stone layers, tetrapods, and geotextiles according to SNI standards is proven to improve the performance of the building against wave forces and long-term stability. It is expected that the results of this planning can be a reference in the development of sustainable coastal infrastructure in the southern coastal area of West Java.

Bibliography

- [1] National Standardization Agency. SNI 8460:2017 - Procedures for planning coastal protection buildings. Jakarta: BSN, 2017.
- [2] National Standardization Agency. SNI 2834:2008 - Wave calculation procedure for port planning. Jakarta: BSN, 2008.
- [3] National Standardization Agency. SNI 7974:2013 - Procedure for port planning. Jakarta: BSN, 2013.
- [4] DHI Water & Environment. MIKE 21 Shoreline Morphology User Manual. Denmark: DHI, 2021.
- [5] SPM, Shore Portection Manual. 1984.
- [6] Triatmodjo, B. Beach Engineering. Yogyakarta: Beta Offset, 1999.