Sustainable Civil Building Management and Engineering Journal Vol: 1, No 4, 2024, Page: 1-7

Tetrapod Placement Structure for River Estuary Stability on Luk Ulo Jetty

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DOI:
https://doi.org/10.47134/scbmej.v1i4.2778
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Received: 01-08-2024
Accepted: 15-09-2024
Published: 31-10-2024

Abstract: The meeting between the river and the sea is called the estuary which is a vital environment for the reproduction of marine life, especially fish. The estuary is preferred for industrial and commercial activities, including the construction of a lucrative port due to easy access to sea transport. However, estuaries face challenges such as sediment deposition that leads to shallow channels and river estuary closures. The mouth of the Luk Ulo River in Kebumen Regency, Indonesia, is particularly affected by sediment transport from the coast and changing the flow of the river to shrimp farming areas. To overcome this problem, the construction of a jetty is planned to stabilize the estuary. The study focused on the Luk Ulo River Estuary, utilizing wave, tidal, and bathymetric data to plan jetties effectively, emphasizing on the proper arrangement of tetrapods to prevent estuaries from becoming unstable. The research, which uses a quantitative descriptive approach, aims to determine the needs of tetrapods, porosity values, and the protective arrangement of jetties. The findings show that the Luk Ulo River estuary, which has a wave-dominated morphological characteristic, is susceptible to estuary closure due to sediment transport dynamics. Data analysis provides insights into tides, sediment transport, tetrapod placement and tetrapod needs that are highly beneficial for future projects, facilitating the design of effective jetty construction measures. This research contributes valuable information to coastal planning, especially in the regular arrangement of tetrapods and the need for tetrapods.

Keywords: *Estuary, Trasnpor Sedimen, Jetty Construction, Tetrapod Arrangement.*

Introduction

The mouth of the Luk Ulo River is part of the South Coast of Java which is included in open waters because it faces directly with the Indian Ocean. This position causes high waves and affects the magnitude of sediment transport along the coast that enters the river estuary. In facing the problem of siltation and closure of the river estuary, the Jetty building is used to hold coastal sediment and the stability of the river estuary. To plan the Jetty building, wave height rebalancing data, tidal data and bathymetric data are required. The stability of the Jetty building is greatly influenced by the dimensions, size of the tetrapod and the placement of the tetrapod.

Jetty building failures often occur due to improper placement of tetrapods, such as tetrapods only arranged in one layer, too large porosity of tetrapods and the arrangement of tetrapods not interlocking. Therefore, this study will use a case study of the Luk Ulo River Estuary, Kebumen Regency by using wave data, tidal data and bathimetric data on Kebumen Beach. It is hoped that this research can be used as a reference in planning Jetties, especially the placement of tetrapods with appropriate porosity. Considering that in some coastal building planning manuals there is no mention of the porosity value of tetrapods with a regular placement system and only the porosity value of tetrapods with a random placement system is mentioned, namely P = 50%. While in reality in the field, the placement of tetrapods on the Jetty section above sea level is arranged in an orderly, neat, interlocking with each other and at least two layers.

Methodology

The method used in this study is a quantitative descriptive about the porosity value, the value of the coefficient of the arrangement layer, the weight of the tetrapod, and the need for tetrapods as well as the arrangement of the neat and interlocking tetrapod placement in the context of securing the Luk Ulo River Estuary with the Jetty building. This research was carried out by collecting data in the form of Bathimetri Map data, wind data to wave height from ECMWF, tidal data and data on the number of tetrapods installed at the location. The location of this research was carried out at the mouth of the Luk Ulo River and the surrounding beaches located in Kebumen Regency, Central Java. To support this research, Microsoft excel and matlab software and world tide were used for tidal data processing

Result and Discussion

This research is located in Luk Ulo Beach, Kebumen Regency. The Bathimetri map is used to measure the area of wet cross-section at the mouth of the river mouth according to Figure 1 where there are important factors to determine the formation of the mouth of the river are the tidal prism and sediment transport along the coast. From the results of the calculation, a stable river estuary was obtained because the estuary channel could still break through the sand or sediment piles.

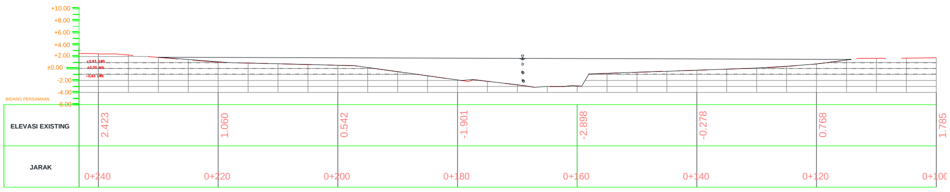

Figure 1. Section of the Luk Ulo River Estuary
Source: Bathimetri, 2023

The tides are used to determine the position of the lowest absolute sea level, and the tidal pattern is assisted by the worldtides program run with matlab 2011. This software is used to analyze the amplitude and phase of each harmonic component and then can determine the type of tide, namely the type of mixed tides inclined to semi-diurnal. Furthermore, the analysis of wind data to wave height using wind data for a minimum of 10 years for the Luk Ulo Beach. The use of annual wind data is treated to calculate wave heights at locations where coastal safety structures will be built. The results of the analysis that have been carried out then calculate the porosity value and the coefficient value of the tetrapod arrangement layer in each cross secrtion by combining the tetrapod analysis at Bogowonto Beach and Luk Ulo Beach so that the results of the porosity value and coefficient value can be more compatible according to table 1 below obtained a porosity value of 36% and a coefficient value of 1.04.

Table 1. Recapitulation of Porosity Value (P%) and Layer Coefficient Value

Number	Sta. Installation	Tetrapod Size (ton)	Volume (unit)	Porosity (%)	Coefficient Value K$_\Delta$)	New Coefficient Value (K$_\Delta$)
1	Cross Section STA 0+050 S/D 0+075	4	140	41.2	1.04	0.95
2	Cross Section STA 0+075 S/D 0+100	4	221	37.0	1.04	1.02
3	Cross Section STA 0+100 S/D 0+125	4	298	37.5	1.04	1.02
4	Cross Section STA 0+050 S/D 0+075	4	173	41.4	1.04	0.95
5	Cross Section STA 0+075 S/D 0+100	4	238	35.6	1.04	1.05
6	Cross Section STA 0+100 S/D 0+125	4	312	37.2	1.04	1.02
7	Cross Section STA 0+125 S/D 0+150	7	256	35.6	1.04	1.05
8	Cross Section STA 0+150 S/D 0+175	7	299	34.3	1.04	1.07
9	Cross Section STA 0+175 S/D 0+200	7	311	34.9	1.04	1.06
10	Cross Section STA 0+125 S/D 0+150	7	269	34.2	1.04	1.07
11	Cross Section STA 0+150 S/D 0+175	7	301	35.6	1.04	1.05

Number	Sta. Installation	Tetrapod Size (ton)	Volume (unit)	Porosity (%)	Coefficient Value K_Δ)	New Coefficient Value (K_Δ)
12	Cross Section STA 0+175 S/D 0+200	7	313	35.0	1.04	1.06
13	Cross Section STA 0+200 S/D 0+225	11	232	35.0	1.04	1.06
14	Cross Section STA 0+225 S/D 0+250	11	257	34.8	1.04	1.06
15	Cross Section STA 0+200 S/D 0+225	11	235	34.9	1.04	1.06
16	Cross Section STA 0+225 S/D 0+250	11	258	34.7	1.04	1.06
17	Cross Section STA 0+250 S/D 0+275	13	247	35.0	1.04	1.06
18	Cross Section STA 0+275 S/D 0+300	13	256	37.7	1.04	1.05
19	Cross Section STA 0+300 S/D 0+306	13	71	34.9	1.04	1.06
20	Cross Section STA 0+250 S/D 0+275	13	243	35.3	1.04	1.05
21	Cross Section STA 0+275 S/D 0+300	13	267	34.8	1.04	1.10
22	Cross Section STA 0+300 S/D 0+306	13	71	34.7	1.04	1.06
23	Ujung Lingkar Kepala *Jetty*	13	903	33.1	1.04	1.09
24	Pangkal *Jetty*	2.5	840	35.1	1.04	1.06

Source: Calculation Analysis, 2024

Table 2. Comparison of Porosity Values Regularly and Randomly

Stone Protective	n	Placement	Coefficient Value	Porosity (P%)	Sources
Nature Stone (delicate)	2	random	1.02	38	triatmodjo,2008,Teknik Pantai
Nature Stone (rough)	2	random	1.15	37	triatmodjo,2008,Teknik Pantai
Nature Stone (rough)	>3	random	1.1	40	triatmodjo,2008,Teknik Pantai
Cube	2	random	1.1	47	triatmodjo,2008,Teknik Pantai
Tetrapod	2	random	1.04	50	triatmodjo,2008,Teknik Pantai
Tetrapod	**2**	**Interlocking**	**1.04**	**36**	**Research Result**
Quadripod	22	random	0.95	49	triatmodjo,2008,Teknik Pantai
Hexapod	2	random	1.15	47	triatmodjo,2008,Teknik Pantai
Tibard	2	random	1.02	54	triatmodjo,2008,Teknik Pantai
Dolos	2	random	1	63	triatmodjo,2008,Teknik Pantai
Tribar	1	neat	1.13	47	triatmodjo,2008,Teknik Pantai
Nature Stone		random		37	triatmodjo,2008,Teknik Pantai

Source: Triatmodjo, 2008, Teknik Pantai

The scenario of regular and interlocking installation of tetrapods is that in their arrangement, tetrapods can be arranged with two main positions. In the initial position, the tetrapod is placed in an upright state, where each corner protrudes outwards, providing stability and the ability to effectively withstand large waves. In the second position, the tetrapod is placed on its stomach, with one flat side attached to the ground or substrate surface. This arrangement allows the tetrapod to create a more solid and stable barrier, which reduces erosion and the impact of ocean waves on coastal or harbor structures. The combination of these two positions ensures optimal protection against damage caused by natural forces as shown in figure 2 below

Figure 2. Tetrapod Arrangement (interlocking)

Conclusion

The magnitude of the Porosity value is not related to the weight of the protective stone, but is related to the shape of the protective stone. From the results that have been analyzed, it is found that the porosity value is 36%. From these results, it can be seen that the smaller the porosity value, the tighter the arrangement of tetrapods in the field and can reduce the level of landslides in tetrapods.

The magnitude of the Structuring Layer Coefficient value is not related to the weight of the protective stone, but is related to the shape of the protective stone. From the results that have been analyzed, it is found that the value of the coefficient of the structuring layer is 1.04.

The method of installing interlocking tetrapods is that the installation of the first layer is carried out in a standing tetrapod position, then for the second layer it is carried out in a prone position. The estuary is said to be stable because it meets the requirements for comparison with the existing sediment transport, namely sand piles or sediment enlargement, but the estuary groove can still break through the sand or sediment piles.

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