Revitalizing the Batu Mejan Beach with Geotextile Breakwater

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Abstract. The erosion that occurred at Batu Mejan Beach was handled by the government by building a revetment. The protection of the revetment serves to keep the coastline from regressing again. However, at present the condition of the revetment has failed, therefore this research was conducted to investigate the failure of the structure. The results of wave analysis indicate that the wave energy that occurs needs to be reduced by building submerged breakwaters, in addition to strengthening the toe protection of the revetment. There are several types of material to make submerged breakwater, in this study selected breakwater made from geotextile called geotube. Geotextile material is chosen because it is environmentally friendly besides its implementation method is relatively easy but has a relatively short construction life. The breakwater dimension plan made from this geotube is 60 m long with 7.8 m width and 40 m wide gap. The first section in your paper

1. Introduction

Batu Mejan Beach is one of the beaches in Badung Regency precisely in the Canggu area which serves as an area of tourism for domestic and foreign tourists to surf, parasailing, and to relax on beach chairs facing the sea to enjoy the sunset. In the coastal area there is Batu Mejan Temple which is purified by Hindus in Bali to carry out the ceremony. The current condition of Batu Mejan Beach has been a very severe coastline decline due to erosion [6]. The coastline has approached Batu Mejan Temple. To stop the retreat of the coastline the government has built a revetment. But the revetment that was built has failed, especially destroyed at the toe of the revetement. Pujianiki [8] have tried to reduce the wave energy that approaches the coastline by planning submerged breakwaters made from tetrapod. In this study we try to plan alternative submerged breakwaters using materials made of geotextile shaped like tubes called geotubes. The advantages of this material are environmentally friendly, available in various sizes, response to flexible waves and relatively easier and cheaper methods of implementation. But the weakness of the geotube is that the construction life is relatively short because the geotextile material is not resistant to UV light.

Sulaiman [10] has conducted research on coastal rehabilitation with low threshold breakwater from geotube at Tanjung Kait beach, Tangerang. The results of this study are that after six months of building installation, the new beach profile behind the advanced structure is about 6-10 m and the volume of sand deposited in the land form arises around 4000 m3. Sulaiman [11] also stated that Suhendra, et al. (2012) examined the application of geotube as an alternative construction of erosion control due to bono tidal
waves. The results of the analysis of this study can be concluded that the use of the geotube system provides satisfactory results and can be relied upon as an alternative construction of erosion problems. The use of geotube as a low threshold breakwater structure is also used by Widhianto et al. (2014) as a beach safety structure on Sigandu beach. On this occasion we tried to apply the breakwater on the Batu Mejan beach because it is suitable to be used on the beach that serves as a tourist area.

2. Method
The research method used in this study begins with a field survey. Site investigations were carried out to determine the existing conditions on the Batu Mejan coast (Figure 1). Aerial photography is also done to see the current coastline profile. In addition to physical observations, sediment sampling is also carried out at several points along the coastline to find out the current movement profile. Other supporting data used are secondary data obtained from government agencies such as wind data, tides, bathymetry and images of the island of Bali (https://www.google.com/maps). The results of the data collection were then analyzed to determine the wave characteristics and sediment at the study site. In addition to using primary and secondary data, we also conducted interviews with local communities to obtain additional data such as coastal use, wave conditions during highs and lows and the retreat of the coastline history.

3. Results and Discussion
3.1. Analysis of Wind and Wave
Research conducted by [7] states that good wind data is used for coastal building planning using at least wind data for 10 years. In this plan, wind data from 2007 - 2016 (BMKG Ngurah Rai Station, Tuban Bali) was presented in the form of Windrose with the help of WRPLOT View v. 8.0.0 as in Figure 2 (a). The dominant wind direction comes from the West with a percentage of 38.33% with wind speed dominant in 15-20 knots interval.

Figure 1. Existing Batu Mejan Beach [2].

Figure 2. (a) Windrose 2007 – 2017, (b) fetch at location.
The fetch calculation from the West direction as in Figure 2 (b) obtained fetch effective is 70.17 km. With graphical wave forecasting (Triatmojo B, 1999) obtained $H_s = 2.2$ m with a period of 6.5 seconds. According to [3] the life time of geotube max plan is 25 years, therefore the return period used in this plan is 25 years with the Gumbel method, so that a significant wave height of 2.5 m is obtained with a period of 6.7 seconds. The results of the calculation of wave height in the work location that is at a depth of 3 m is obtained at $H = 2.23$ m after shoaling and refraction processes, while into the breaking wave occurs at $db = 2.5$ m with $Hb = 2.3$ m.

To determine the planned water level, the sum of several parameters is needed, but in this plan the parameters taken are tides, global warming (SLR), wave sea level rise (wave set-up), and water depth ($d$). Based on tidal data obtained from [1], sea level elevation HWL (+3.10), MSL (+1.55), LWL (±0.00). The sea level elevation used in this planning is an elevation of ±0.00 as an MSL condition so that the elevation of seawater is based on MWL as in Figure 3. The water level plan or design water level (DWL) can be searched by calculating the water level rise due to waves and sea level rise (SLR) with the equation $DWL = LWL + Sw + SLR = -1.55 + 0.35 + 0.3 = -0.90$.

![Figure 3. Water level.](image)

### 3.2. Analysis of Sediment and Current
Sand sampling is carried out at several points along the damaged revetment. The samples were taken from two points of each retrieval line as in Figure 4. Sediment analysis was carried out based on [9], to determine the direction of current based on the diameter of the granules shown in Table 1 and Figure 4.

![Figure 4. Sand sampling points and current direction.](image)

| No. | Sample | $D_{50}$ (mm) |
|-----|--------|--------------|
| 1   | S1_A   | 0.70         |
| 2   | S1_B   | 0.73         |
| 3   | S2_A   | 0.61         |
| 4   | S3_A   | 1.23         |
| 5   | S4_A   | 0.65         |
| 6   | S5_A   | 0.56         |
| 7   | S5_B   | 0.42         |
| 8   | S6_A   | 0.41         |
| 9   | S6_B   | 0.59         |
| 10  | S7_A   | 0.50         |
| 11  | S7_B   | 0.53         |
| **Average** |                  | **0.63**     |
3.3. Dimension of Breakwater

Based on the wave height that occurred at the building site with a coastal slope \( m = 0.033 \) it was determined that the geotube was placed perpendicular to the coastline at a distance of 107 m from the shore of the beach as shown in Figure 5. In order to form a silent behind the pheasant the length of the geotube was made 60 m long with gap of 40 m ([4] and [5]).

![Figure 5. Layout of breakwater at location.]

3.4. Transmission of Wave

The transmission wave is calculated using Equation \( K_t = \left( (aW - R_c) / (aW + d) \right)^{1/3} \) where \( aW \) is the incoming wave amplitude, \( R_c \) is the height of the water above the geotube to disgust the average sea water and \( d \) is the depth of the water. The wave transmission results on various mean sea levels are shown in Table 2 and Figure 7 below.

![Figure 6 Graphic of influence of fill-grade and Geotube dimension.]

| Sea Level | Transmission Wave |
|-----------|-------------------|
| HWL       | 2.03 m            |
| MSL       | 1.82 m            |
| DWL       | 1.54 m            |
| LWL       | 0.98 m            |
4. Conclusion
Low Threshold Breakwater on Batu Mejan beach from geotextile is planned with dimensions of peak height = 2.50 m, Width = 7.80 m, Length = 60.00 m, Slit width = 40.00 m.

5. References
[1] Bali Penida River Region Hall. 2011. S.I.D.D Works Jasri Beach in Karangasem Regency, Brawa Beach, and Geger Beach in Badung Regency, Bali. Ministry of Public Works Directorate of Water Resources Jendra Bali Penida River Region.
[2] Google Maps. 2017. Batu Mejan Beach. https://www.google.co.id/maps/place/Beach+STONE+MEJAN+STAKE (ECHO+BEACH). Retrieved 30/12/2017.
[3] Greenwood J. H., Schroeder H. F. and Voskamp W. 2012. Durability of Geosynthetics. Https://www.crcpress.com/Durability-of-Geosynthetics-Second-Edition/Greenwood-Schroeder-Voskamp/p/book/9789053675991. Retrieved 06/08/2018.
[4] Paotononan, C. 2012. Simple Method of Determining the Dimension of Geotextile Tube (Geotube) as a Protective Beach Structure. *Journal of Marine Research and Technology (JRTK)*, Marine Engineering Study Program Hasanuddin University, Vol. 10, No. 2, p. 236.
[5] Pilarczyk, K. W. 2011. Development in Design and Application of Geosynthetics and Geosystems in hydraulic and Coastal Engineering. Rijkswaterstaat, Road, and Hydraulic Engineering Institute Delft, The Netherlands.
[6] Prasetia, A. 2017. Beach Sender in Badung Rusak and Jebol, Abrasion Reaches 83.8 km. Tribune-Bali. January 15, 2017, p. 1.
[7] Pujianiki, NN (2015) The Effect of Time on Wind Data Measurement on Windrose Data Accuracy, *KontekS Proceedings 9*, Vol.1, pp. 305-310, UnHas.
[8] Pujianiki, NN., Astawa Diputra IG., and Widya Jayantari, M. (2018). Shore Protection Work for Batu Mejan Beach, Bali. ICanCEE 2018 Bali
[9] SNI 03-1968-1990. 1990. Test Methods About Fine and Coarse Aggregate Filter Analysis, p. 2-3.
[10] Sulaiman, D. M. 2012. Rehabilitation of Beaches with Low Threshold Breakers Made of Geotube. *Journal of Hydraulic Engineering. Hydraulic Engineering*, Vol. 3, No. 5, p. 129-142.
[11] Sulaiman, D. M. 2017. Pheasant Split with Protective Buildings and Beach Growers. Deepublish, Yogyakarta.

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