

Rock Slope Stability Analysis in Melasti Beach Area: Ungasan, Bali

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Abstract: Melasti Beach is one of the main tourist attractions developed by Bali Government. This beach is located in the southern area of Bali, precisely in Ungasan village, Badung Regency, Bali. At the moment, the region administrator is constructing a tourism facility by excavating a rock mass near the beach. Therefore, to avoid damage to nearby shops and beach facilities, a study is needed to be conducted about the safety of the rock mass that being excavated. Direct observation on the rock mass and rock mass classification is conducted to obtain the physic and mechanic characteristic of the rock. To do the stability analysis of the slope, Geo-Studio 2012 software is used by inputted the data obtained from the field and laboratory data. The result of this study are mass rock in the Melasti beach is classified as limestone that has Fair rock classification and factor of the safety of the rock slope / cliff is 1.631 which means the cliff is safe and no need to build an extra reinforcement on the slope/ cliff.

1 INTRODUCTION

Melasti Beach is one of the main tourist attractions which is currently developed by Bali Government. This beach is located in the southern of Bali, precisely in Ungasan Village, Badung Regency, Bali. The number of tourists is increasing every year because of its beautiful scenery and supported by a complete tourism facility.

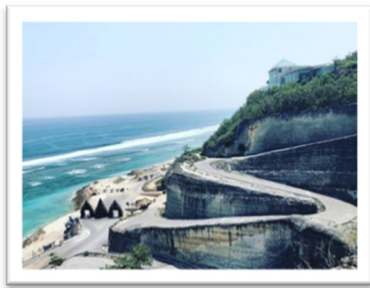


Figure 1: Melasti beach area.

Slope which is resulted from excavation activities can be unstable because of activating moment of the rock mass is greater than resisting moment. Therefore, to avoid damage to nearby area due to excavation activity, a study is needed to be conducted about the rock mass that being excavated.



Figure 2: Excavation process in Melasti Beach.

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At this moment, to develop the area, the region administrator is constructing a tourism facility by excavating a rock mass near the beach. The rock

In order to do the slope stability analysis, firstly, the rock mass classification analysis is conducted to obtain physical and mechanical characteristic of the rock mass. Those characteristics determine the rock mass's shear strength. Shear strength is internal resistance per unit area that the rock mass can offer to

resist failure and sliding along any plane inside it.

To determine the rock mass characteristic in Melasti Beach Area, in this study uses RMR (Rock Mass Rating) method by Bieniawski (1989). In RMR method, field and laboratory test is performed. Field test consist of: direct observation of the rock mass condition, observation of cracks (discontinuities) that occur in the rock mass, rock coring, observation of the water table. Laboratory tests consist of: Uniaxial Compression Test and Unit Weight Test.

Study about rock mass characteristic have been conducted previously by some other researcher. Ardana and Aribudiman (2017) have studied rock mass in Pecatu Area, which is nearby the Melasti Area and have a similar geological condition. Therefore, the result of the previous study can be used for controlling and comparison of the result in this study.

2 METHODOLOGY

2.1 Location and Time of the Study

This study is located in Melasti Beach Area in southern of Bali Province. Field observation and sampling is done on April 17, 2020. Laboratory test is conducted on April 20 – 30, 2020. The location of this study is shown in figure below:



Figure 3: Location of Study.

2.2 Type of Data and Data Collection Technique

Data obtained in this study consist of primary and secondary data. Primary data in this study are field observation result, laboratory test and discontinuity measurement. Secondary data are previous study and literatures.

2.3 Data Analysis and Calculation Technique

This study is quantitative and applied studies because it can solve a problem that can occurs in the field (Yusuf, 2016). This study consists of field test of the rock mass, rock core sampling, laboratory test, and slope stability analysis. This study is conducted as follows:

1. Direct observation of the rock mass, analyze and measure the crack discontinuities which occur on the rock mass.
2. Rock core sampling. This sampling is used to obtained undisturbed sample of the rock core and the RQD (Rock Quality Designation) value of the rock mass. Sampling is performed is 4 different point to obtain the representative result.
3. Unit weight and Uniaxial Compression Test (UCT). The rock core obtained from the field is tested with Unit weight and UCS test. Both of those tests are done in laboratory.
4. Rock mass classification analysis. The data obtained from previous step is used to determine the characteristic of the rock mass. The RMR method is used in this study. RMR method gives rating from 1 to 100; according to some rock mass properties such as: RQD value, UCS value, crack spacing, condition of crack, water condition.
5. Rock slope stability analysis. The slope stability analysis is done by using GeoStudio 2012. The rock's physical and mechanical properties is obtained from previous analysis. The geometry of the slope are right angle slope with height of 100 m. This height is the highest excavation plan on the Melasti Area.

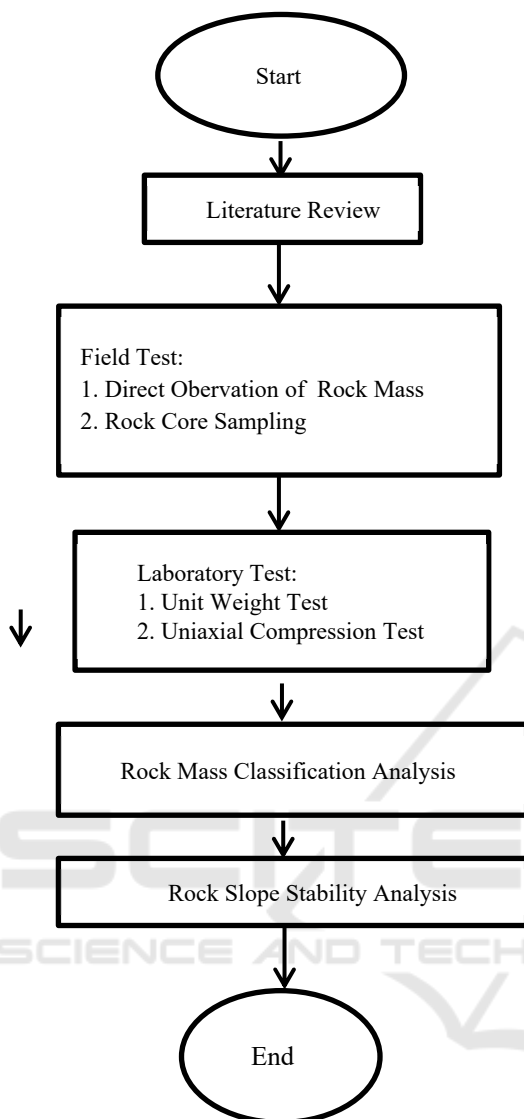


Figure 4: Rock Slope Stability Analysis Flowchart.

3 RESULT AND DISSCUSION

3.1 Rock Mass Observation

Observation of rock mass type is conducted by using direct visual observation and measure the crack on the rock mass. The result of rock mass observation are: rock mass is formed by million years-sedimentation of sea organism; has a rough surface and spacing between crack (discontinuities) is 6 cm – 20 cm.



Figure 5: Crack or discontinuities condition on the rock mass in Melasti Beach area.

3.2 Rock Core Sampling

Rock core sampling is done to obtain undisturbed sample of the rock core and determine the RQD value of the rock mass. Coring is done in 4 point; 2 in the top of the slope and 2 on the bottom of the slope. RQD value is determine by:

$$RQD = \frac{\text{length of the obtained rock core}}{\text{total coring length}} \times 100\% \quad (1)$$

The result of the rock core sampling is shown in table as follows:

Table 1: Rock Core Sampling Result.

Number	Total Length (cm)	Rock Core Length (cm)
1	35	20
2	26	7
3	30	28
4	27	26

$$RQD = \frac{20 + 7 + 28 + 26}{35 + 26 + 30 + 27} \times 100\%$$

$$RQD = 68 \%$$

Thus, the RQD of the rock mass in melasti beach area is 68%.

3.3 Laboratory Test

The sample obtained from rock core sampling is tested in laboratory. The result of the laboratory test is shown in table below:

Table 2: Laboratory Test Result.

No Sample	Specific Gravity	Unit Weight (kg/m3)	UCS (MPa)
1	2.67	2140	16
2	2.68	2396	31
3	2.69	2512	59
Average	2.68	2349	35

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In this study, rock mass classification is determined by the RMR method. RMR method gives rating from 1 to 100; according to some rock mass properties such as: RQD value, UCS value, crack spacing, condition of crack, water condition. The data result from field and laboratory test is used to give the rock mass its rating. RMR value of rock mass in Melasti Beach area is shown in table below:

Table 3: Rock Mass Rating Result.

Parameter	Description	Rating
Nilai UCS	35 MPa	4
RQD	68 %	13
<u>Discontinuity Spacing</u>	0.06 – 0.2 m	10
<u>Discontinuity condition</u>	Rough Surface, weathered, separation 1 – 5 mm	10
<u>Water condition</u>	dry	15
Total Rating		52

Rock mass in Melasti Beach area obtained total rating of 52 and categorized as fair rock. Mechanical parameter suitable for fair rock are: (ϕ) : 25° - 35° and cohesion : 200 KPa – 300 KPa.

3.4 Slope Stability Analysis

Rock slope stability analysis in this study use GeoStudio 2012 software and use Morgenstren – Prince calculation method. The height of the slope is 100 m, which is the highest excavation plan on Melasti beach area. Input geometry on Geostudio is shown in figure below:

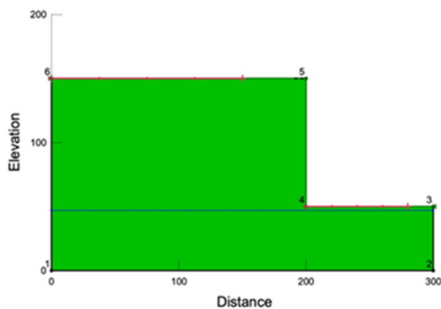


Figure 6: Geometry input on GeoStudio.

The input of the rock mechanical and physical properties is obtained from previous analysis on this study. Input parameter is shown in table and figure below:

Table 4: Rock Parameter.

Parameter	Description
Unit Weight	2349 kg/m3
Phi	30
Cohesion	250 KPa

The selection of phi and cohesion value is based on range value that correspond with the type of rock in Melasti Beach area.

Result of calculation shows that slope has factor safety (FS) of 1.63. FS >1 value means that the slope resulted from excavation of the rock mass is stable and don't need any stabilization or external support. The results of the calculation are shown in figure 8.

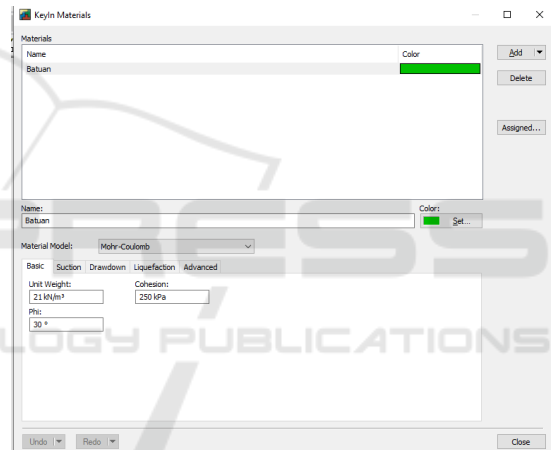
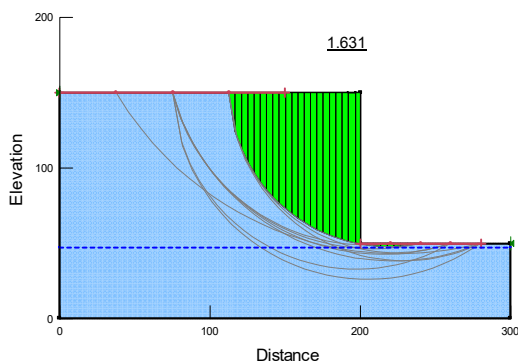


Figure 7: Rock Parameter Input On Geoslope.

Table 5: Tabulation of slope stability calculation.

Item	Data
Slip Surface	90
Factor of Safety	1.63
Volume	6,571 m ³
Weight	137,997kN
Resisting Moment	12,254 kN-m
Activating Moment	7,515,343. kN-m
Resisting Force	91,282 kN
Activating Force	a. 55,980 kN
Exit	b. (240.144, 50) m
Entry	(112.5, 150) m
Radius	106.38839 m
Center	c. (218.80441, 154.22625) m



Abbas, S. M dan Konietzky. H.H. (2015). *Rock Mass Classification Systems*.

Figure 8: Slope stability analysis output on GeoStudio.

4 SUMMARY

From field test, laboratory test and analysis that have been conducted in this study, can be summarized as follows:

- A. The type of rock in Melasti Beach area is sedimentary rock formed by sea organism with classification of fair rock.
- B. The physical and mechanical properties of rock mass are:
 - Internal angle of friction (ϕ): 30
 - Cohesion (c): 250 Kpa
 - Unit Weight (γ): 2349 kg/m³
- C. Factor of safety of the excavation plan is 1.63 (FS = 1.631)
- D. The rock slope doesn't need any stabilization or external support.

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