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ANALYSIS OF BRITTLE DACITE ROCK PARAMETERS BY USING THE HOEK – BROWN FAILURE CRITERION

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ANALYSIS OF BRITTLE DACITE ROCK PARAMETERS BY USING THE HOEK – BROWN FAILURE CRITERION

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ABSTRACT

The strength of rock and soil is one of the important things on a slope. This study used the weathered dacite rock type which affected the strength of the rock. By using the Hoek-Brown calculation analysis method and also supported by the Rocsience (Roclab) software application, the parameter results obtained, γ = 2.6 t/m^3, m_i = 25, Disturbance Factor (D) = 1.0, m_b = 0.118, s = 3.73e^{-6}, a = 0.531. The rock mass strength of the sample was brittle so that it can easily collapse. The purpose of this analysis is to do further study to overcome the problems that occur in most rocks, especially those related to transportation routes next to the slope.

Keywords: *Rock Classification, Rock Parameters, Roclab.*

1. INTRODUCTION

Rock is one of the materials on a slope. There are so many facilities such as road surfaces around the slope, so landslides can occur on slopes where the rock material has weathered, causing the road users and public facilities around them to experience landslides disaster. As the result of a series of landslides, several rock samples were taken on the Ponorogo - Pacitan road, precisely at KM 226 to analyze the strength of the rock mass. The rock mass is required for more detailed data on a repair or early stage of project construction (Hoek, et al, 1995) that will be included in the design. (Hoek and Brown 1980) made a "method" to obtain an assessment of rock mass [1], which can be seen directly and uses several parameters (Hoek, E., Carranza-Torres, C., & Corkum, B. 2002) [2]. In this analysis, further research is required regarding the problems that occur.

Dacite igneous rocks have influential components such as intermediates between andesitic igneous rocks and rhyolite igneous rocks which have an aphanitic-porphyritic texture [3] (Flett, John Smith, 1911).

2. RESEARCH METHOD

2.1 Research Object

In **Figure 1**. In the study, it can be seen the structure of near rock forms is arranged, and **Figure 2** it can be seen the structure of open rock forms is arranged. Rock samples taken on the slope is dacite rock type. If you look at it with the naked eye, you can see that the rock has undergone quite intense weathering so that when touched by hand or using a geological hammer it can easily be crushed. In this study, the rocks used namely dacite rock used the Hoek-Brown calculation method by finding the required parameters.

Figure 1 Structure of Near Rock Form

Figure 2 Structure of Open Rock Form

2.2 Analysis Based on Hoek and Brown

In rock analysis, according to failure based on Hoek and Brown, there are several determined parameters to get the value of the safety factor. In determining the Hoek and Brown failure analysis, several parameters are required, namely the GSI value, rock compressive strength (σ_{ci}) from the results of the compressive strength test, rock mass constant (m_i) based on rock type, and disturbance factor value (D) based on stress relaxation.

3. RESEARCH METHOD

3.1 Estimation of Laboratory Test Results

The rock to be tested has been taken for the sample, **Figure 3** by cutting it into a block shape with a predetermined size. Rock compressive strength testing was carried out in the concrete laboratory of the Civil Engineering Department, Brawijaya University, Malang, which was carried out using whole rock samples that had been cut into cubes. Samples on rocks using dacite rocks with data obtained in **Table 1**.

Figure 3 Samples of Rock Cut in Cube Shape

Table 1. Rock Test Sample Data

Date : 20 – 08 - 2019	
Location : KM 226	
Sample	1
Test Piece Size (cm)	9 x 9 x 9
Area (cm^2)	81
Test Piece Weight (Kg)	1.66

3.2 Intact Rock Strength

The compressive strength of intact rock (σ_{ci}) was carried out using a laboratory test, namely the Uniaxial Compressive Strength (UCS) test. This measurement aims to estimate the rock's compressive strength. The rock sample tested is highly weathered Dacite Rock so a UCS value of 2.5 MPa was obtained. **Figure 4**. And from field observations based on the GSI standard of rock assessment, which is a data processing technique to determine the properties of the rock samples. [4]

Figure 4 Sample Condition After Compressive Strength Test

In testing rock samples, a value of 2.5 can be input in the Roclab Software Program, seen in **Table 2** below.

Table 2 Giving UCS Values to the Roclab Program

Field Estimate of Strength	Examples	Strength (MPa)
Specimen can only be chipped with a geological hammer.	Fresh basalt, chert, diabase, gneiss, granite, quartzite.	>250
Specimen requires many blows of a geological hammer to fracture it.	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, limestone, marble, rhyolite, tuff.	100-250
Specimen requires more than one blow of a geological hammer to fracture it.	Limestone, marble, phyllite, sandstone, schist, shale.	50-100
Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow from a geological hammer.	Claystone, coal, concrete, schist, shale, siltstone.	25-50
Can be peeled with a pocket knife with difficulty, shallow indentation made by firm blow with point of a geological hammer.	Chalk, rocksalt, potash.	5-25
Crumbles under firm blows with point of a geological hammer, can be peeled by a pocket knife.	Highly weathered or altered rock.	1-5
Indented by thumbnail.	Stiff fault gouge.	0.25-1

Uniaxial Compressive Strength (sigci): 2.5 MPa OK Cancel

If it is seen in the table options, it can be explained and concluded that rocks that have a value of 1-5 are brittle so they can be easily destroyed if hit using a geological hammer or using a pocket knife. It has been explained that the rock is very weathered or has undergone alteration. On the rocks where the sample was taken in the field, the rock's color is bright so that it supports a fairly intense alteration process.

3.3 Rock Mass Constant

In determining the rock constant (m_i) with dacite rock type, a m_i value of 25 is obtained according to **Table 3**, so obtained value:

$$\mathbf{m_i = 25}$$

In the table it can be concluded that this dacite type rock is a rock that is included in the igneous rock type or igneous rock type originating from magma, namely a liquid containing concentrated silicate [5] whose temperature is cooling so that the rock can harden, this rock type does not experience crystallization process either inside or above the soil surface (earth) [6].

Table 3 Values for Intact Rock (values in parenthesis are estimates)

Rock type	Class	Group	Texture: Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerates (21±3) Breccias (19±5)	Sandstones 17±4	Siltstones 7±2 Greywackes (18±3)	Claystones 4±2 Shales (6±2) Marls (7±2)
	Non-Clastic	Carbonates	Crystalline Limestone (12±3)	Sparitic Limestones (10±2)	Micritic Limestones (9±2)	Dolomites (9±3)
		Evaporites		Gypsum 8±2	Anhydrite 12±2	
		Organic				Chalk 7±2
METAMORPHIC	Non foliated		Marble 9±3	Hornfels (19±4) Metasandstone (19±3)	Quartzites 20±3	
	Slightly foliated		Migmatite (29±3)	Amphibolites 26±6	Gneiss 28±5	
	Foliated*			Schists 12±3	Phyllites (7±3)	Slates 7±4
IGNEOUS	Plutonic	Light	Granite 32±3 Granodiorite (29±3)	Diorite 25±5		
		Dark	Gabbro 27±3 Norite 20±5	Dolerite (16±5)		
	Hypabyssal		Porphyries (20±5)		Diabase (15±5)	Peridotite (25±5)
	Volcanic	Lava		Rhyolite (25±5) Andesite 25±5	Dacite (25±3) Basalt (25±5)	Obsidian (19±3)
		Pyroclastic	Agglomerate (19±3)	Breccia (19±5)	Tuff (13±5)	

Source: Duncan and Christopher (2004)

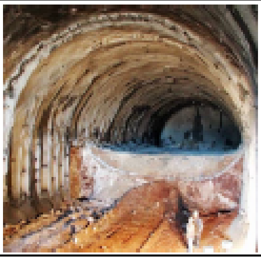
3.4 Disturbance Factor (D) and Parameters

Disturbance factor determination can determine the good or bad of rock be analyzed. So obtained rock description as bad rock (Poor Blasting) which is the rock mass damage on a slope which can be seen in the table. Getting the Disturbance Factor (D) value can be done with the guideline for the factor value (D) in **Table 4** according to Hoek and Brown. So obtained value:

D = 1.0 (Poor Blasting)

While some other parameter calculations are required, namely the Hoek-Brown Criterion which is known from the values obtained, namely Mb, s and a based on the values obtained from the GSI and the disturbance factor (D) by using the formula proposed by Hoek & Brown (2002). The m_b value calculation is an intact rock that has a reduction in the constant value. Obtained with the following equation.

Table 4. Determination of the Disturbance Factor (D) value of Hoek and Brown 2002

Appearance of rock mass	Description of rock mass	Suggested value of D
	Excellent quality controlled blasting or excavation by Tunnel Boring Machine results in minimal disturbance to the confined rock mass surrounding a tunnel.	$D = 0$
	Mechanical or hand excavation in poor quality rock masses (no blasting) results in minimal disturbance to the surrounding rock mass. Where squeezing problems result in significant floor heave, disturbance can be severe unless a temporary invert, as shown in the photograph, is placed.	$D = 0$ $D = 0.5$ No invert
	Very poor quality blasting in a hard rock tunnel results in severe local damage, extending 2 or 3 m, in the surrounding rock mass.	$D = 0.8$
	Small scale blasting in civil engineering slopes results in modest rock mass damage, particularly if controlled blasting is used as shown on the left hand side of the photograph. However, stress relief results in some disturbance.	$D = 0.7$ Good blasting $D = 1.0$ Poor blasting
	Very large open pit mine slopes suffer significant disturbance due to heavy production blasting and also due to stress relief from overburden removal. In some softer rocks excavation can be carried out by ripping and dozing and the degree of damage to the slopes is less.	$D = 1.0$ Production blasting $D = 0.7$ Mechanical excavation

Obtained with the following equation:

$$\mathrm{m_b} = \mathrm{m_i} \exp\left(\frac{GSI - 100}{28 - 14D}\right)$$

$$\mathrm{m_b} = 25 \times \exp\left(\frac{25 - 100}{28 - 14(1)}\right) = 0.118$$

$$\mathrm{m_b} = 0.118$$

To obtain the value of the rock mass constant which includes the value of s and a with the following calculation:

$$s = \exp\left(\frac{GSI - 100}{9 - 3D}\right)$$

$$s = \exp\left(\frac{25 - 100}{9 - 3(1)}\right) = 3.73e^{-6}$$

$$s = 3.73e^{-6}$$

And the calculation of a value is as follows:

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{-\frac{GSI}{15}} - e^{-\frac{20}{3}}\right)$$

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{-\frac{25}{15}} - e^{-\frac{20}{3}}\right) = 0.531$$

$$a = 0.531$$

the uniaxial compressive strength of the rock mass was adjusted with the calculation σ'3 = 0 with the following results:

$$\sigma_c = \sigma_{ci} \, . s^a$$

$$\sigma_c = 2.5 \; . \; (3.73e^{-6})^{0.531}$$

$$\sigma_c = 0.00326483 \text{ Mpa}$$

and, tensile strength with the following equation:

$$\sigma_t = -\frac{s\sigma_{ci}}{m_b}$$

$$\sigma_t = -\frac{3.73e^{-6}(2.5)}{0.118}$$

$$\sigma_t = -7.9049\text{e}^{-005} \text{ Mpa}$$

The calculation results of the deformation modulus on the rock mass according to Hoek and Brown criteria by inputting the disturbance factor (D) value as follows:

$$E_m = \left(1 - \frac{D}{2}\right)\sqrt{\frac{\sigma_{ci}}{100}}\; 10^{\left(\frac{(GSI-10)}{40}\right)}$$

$$E_m = \left(1 - \frac{1.0}{2}\right)\sqrt{\frac{2.5}{100}}\; 10^{\left(\frac{(25-10)}{40}\right)}$$

$$E_m = 187.474 \text{ MPa}$$

The analysis of the Roclab program obtained similar values according to the calculations above. The data input is in **Figure 4** and parameter values can be seen in **Figure 5**.

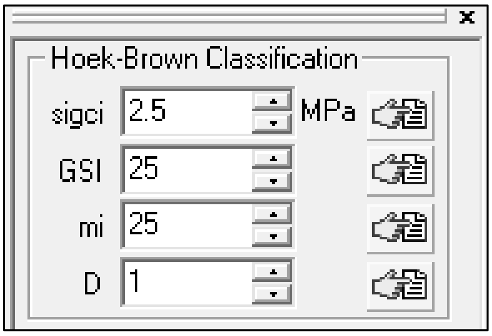


Figure 4 Data Input for Hoek & Brown Classification in the Roclab program

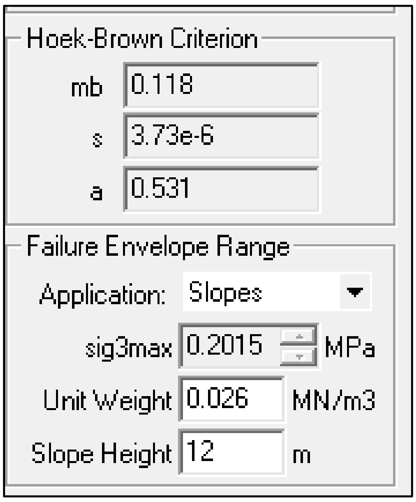


Figure 5 Data Input Results for Hoek & Brown Classification in the Roclab Program

From the data input results in the Roclab program, images in the form of major and minor graphs are obtained according to the input data through the Hoek and Brown parameter criteria in **Figure 6** below.

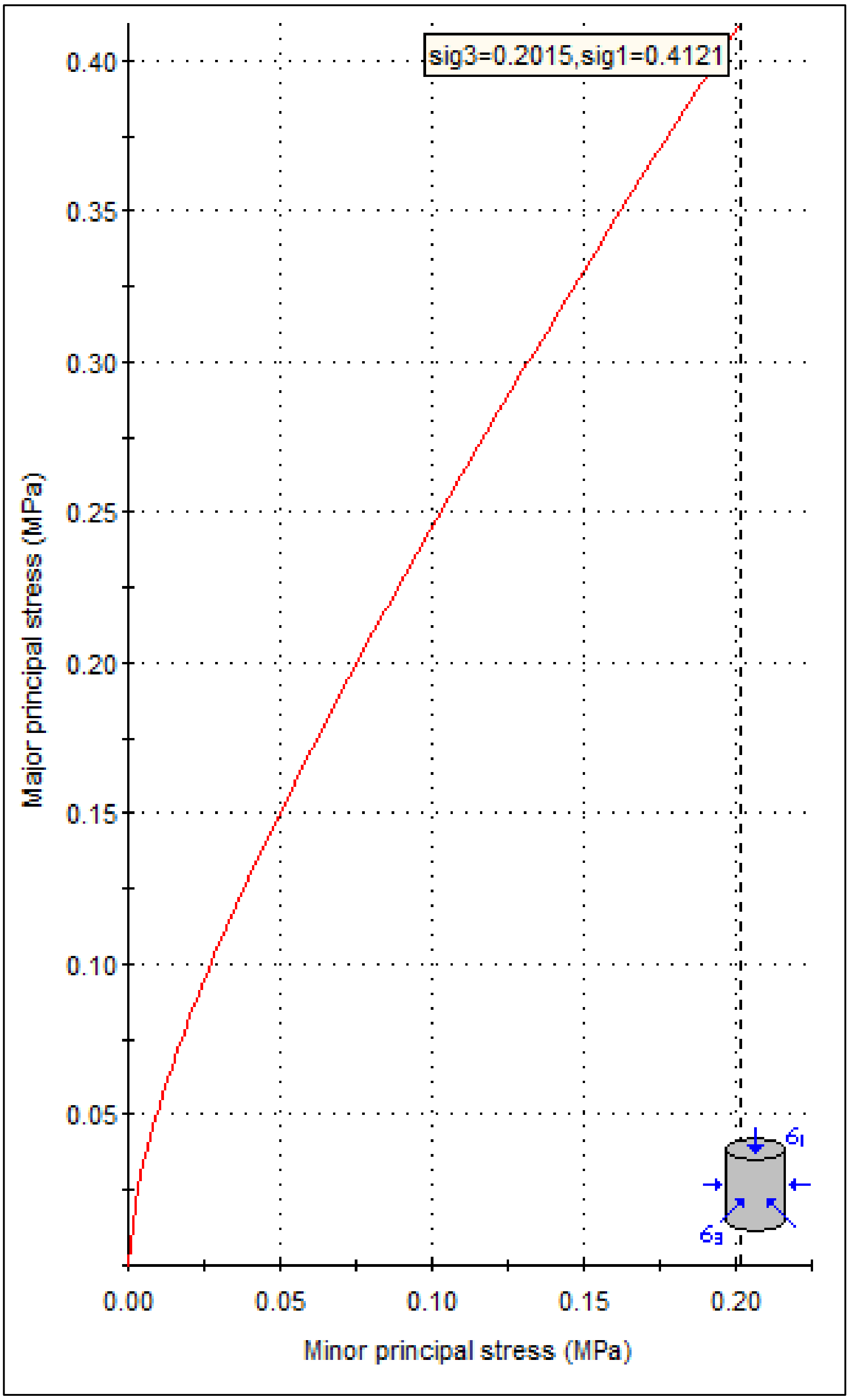


Figure 6 Major and Minor Graphs in the Roclab Program

4. CONCLUSION

The research analysis results on dacite rocks can be concluded that the rocks obtained are weathered/altered rocks. By using the Hoek-Brown method, it is mandatory to get the parameter values of the rocks. The parameter values obtained are γ = 2.6 t/m^3 ; UCS = 255 t/m^2 ; m_i = 25 ; D = 1.0; m_b = 0.118; s = 3.73e^{-6}; a = 0.531. So that further research can be carried out to get the value of the safety factor and can be used to overcome the problems that occur.

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