ANALYSIS OF PHYSICAL AND MECHANICAL PROPERTIES OF ANDESITE LAVA GEULIS MOUNTAIN AREA, JATINANGOR, WEST JAVA

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ABSTRACT

Jatinangor is an area composed of material from volcanic activity, one of the results of volcanic activity is andesite rock. The purpose of this research is to provide information related to the physical and mechanical properties of the lava rock in the Gunung Geulis area so that if there is construction work or rock utilization there is already information about the characteristics of the rock. The method used in this study is a laboratory experiment by conducting tests on 9 selected rock samples. The results of laboratory testing can be concluded the rock in the research area is andesite rocks and have rock physical properties namely Natural density (1.5 – 1.6 gr/cc), Saturated density (1.6 – 1.7 g/cc), Dry Density (1.5 – 1.6 g/cc), Bulk Saturated Surface Dry (SSD) Specific Gravity (2.3 – 2.4), Apparent Specific Gravity (2.5 – 2.7), absorption (3 – 5.9%), Natural moisture content (0.6 – 2.3%), Porosity (4.9 – 9.4%) and the mechanical properties of the rock, namely the compressive strength of the rock, ranged from 33,099 – 85,096 Mpa. Based on the results and analysis, the mechanical properties of rocks, namely the compressive strength of rocks in the study area, have varying values and varied physical properties of rocks. Physical and mechanical properties of rocks that are correlated based on linear correlation are the compressive strength of rocks with absorption, Natural moisture content, and porosity. These parameters will show the relationship that can affect the compressive strength of rocks. So that when using rock in construction work, mining, the use of rock needs to pay attention to the compressive strength or mechanical properties and physical properties of the rock.

Keyword: Andesite, Lava, Mechanical Properties, Physical Properties

INTRODUCTION

The research area is located in Jatinangor, Tanjungsari Regency, West Java. Jatinangor is an area composed of material from volcanic activity originating from Mount Tangkubanparahu and Mount Tampomas (Silitonga, 1973). Andesite is a rock formed by volcanic activity. According to Raymond (2000), andesite rocks are composed of primary minerals, namely plagioclase, pyroxene, and amphibole, and the texture of andesite is porphyritic to aphanitic with holocrystalline degrees of crystallinity.

Rock physical properties are quantitative descriptions of rocks tested through laboratory analysis with reference to ASTM D6473-15 (anonymous, 2015). The analysis is in the form of density (in condition Natural, saturated, and dry), Apparent specific gravity, Bulk Saturated Surface Dry (SSD) Specific gravity, porosity, absorption, natural moisture content.

The engineering property is the compressive strength of the rock. Compressive strength was carried out using the UCS (Uniaxial Compressive Strength) system which was classified according to Bieniawski in 1979 and ISRM in 1981.

The purpose of this research is to identify the physical and mechanical properties of rocks as an initial stage in further research, especially in the world of mining or infrastructure.

E-ISSN : 2579 – 3136

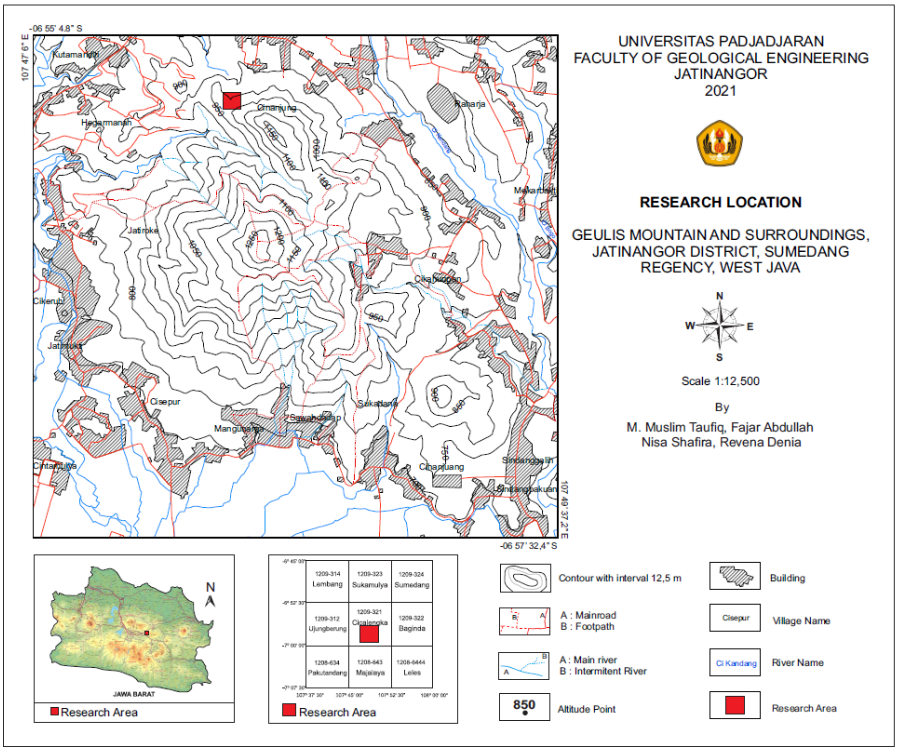

Figure 1. Research location

RESEARCH METHOD

This research is experimental research conducted in the laboratory. Laboratory tests were carried out to determine the physical and mechanical properties of rock samples taken from andesite lava outcrops in the Geulis mountain area, Jatinangor with 9 selected rock samples.

Testing of mechanical properties refers to ISRM (1981) (Table 1) which is rock preparation for compressive strength testing, rock samples are in the form of blocks with a height: width of the base of 2-2.5:1 (Figure 2). Then, the rock sample will be given a force until the rock sample is crushed and calculated by the formula (1).

$$\sigma_c = \frac{F}{A} \qquad \text{.................................... (1)}$$

Code:

σ_c = Compressive Strength of Rock

F = Force

A = Area

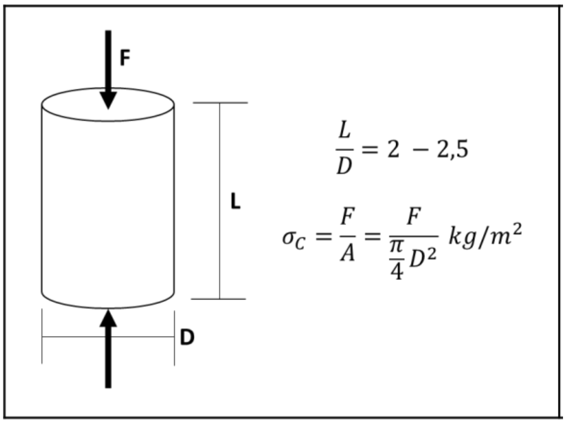

Figure 2. Uniaxial compressive strength test sketch and its calculation formula (Modification of Effendi et al, 1998)

Table 1. Classification of ISRM (1981)

Grade	Term	Field Identification	Compressive strength (Mpa)
R0	Extremely weak rock	Intended by thumbnail	0.25 – 1
R1	Very weak rock	Crumble under firm blows with point of geological hammer, can be peeled by a pocket knife	1 – 5

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R2	Weak Rock	Can be peeled by a pocket knife with difficulty, shallow identification made by firm blow with point of geological hammer	2 – 25
R3	Medium strong rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	25 – 50
R4	Strong rock	Specimen requires more than one blow of geological hammer to fracture it	50 – 100
R5	Very Strong rock	Specimen requires many blows of geological hammer to fracture it	100 – 250
R6	Extremely strong rock	Specimen can only be chipped with geological hammer	> 250

Research on the physical properties of rocks carried out are density (in condition Natural, saturated, and dry), Apparent specific gravity, Bulk Saturated Surface Dry (SSD) Specific gravity, porosity, absorption, natural moisture content. This study refers to ASTM D6473-15 (Anonymous, 2015).

Density is the ratio between the weight and volume of rock. The density of the rocks depends on the weight and volume under test. in the calculation of 3 conditions, namely dry, saturated and natural conditions. Here's the formula for density:

- $Saturated\ Density\ \left(\frac{gr}{cc}\right)$

$$\gamma_s = \frac{w_w}{V} \quad \ldots\ldots (2)$$

- $Natural\ Density\ \left(\frac{gr}{cc}\right)$

$$\gamma = \frac{w_n}{V} \quad \ldots\ldots (3)$$

- $Dry\ Density\ \left(\frac{gr}{cc}\right)$

$$\gamma_d = \frac{w_d}{V} \quad \ldots\ldots (4)$$

Code:

- $Volume\ (gr) = w_w - w_s$

ww = saturated weight; wd = dry weight; ws = saturaterd weight in water; V = volume

Porosity is the ratio of the pore volume to the total volume. Porosity is divided into two, namely primary porosity and secondary porosity. Primary porosity is the porosity that is formed when the rock is formed, while secondary porosity is the porosity that is formed after the rock is formed. Factors that can affect the formation of porosity are uniformity of grain size, degree of cementation, compaction, and arrangement between grains. The formula porosity is:

$$Porosity\ (\%): \frac{(w_w - w_d)}{(w_w - w_s)} \times 100\% \quad \ldots\ldots (5)$$

Code:

ww = saturated weight; wd = dry weight; ws = saturaterd weight in water

Absorption and Natural moisture conten is a rock's ability to absorb water, the formula for calculating Absorption is as follows:

$$Absorption\ (\%): \frac{w_w - w_d}{w_d} \times 100\% \quad \ldots\ldots (6)$$

$$Natural\ moisture\ content\ (\%): \frac{w_n - w_d}{w_d} \times 100\% \quad \ldots\ldots (7)$$

Code:

wn = saturated weight; wd = dry weight;
wn= natural weight

Specific gravity is the ratio of the total weight of solid volume and weight of water volume Calculation of Specific gravity in the analysis was carried out in 2 conditions. The first situation is the measurement of specific gravity using the total weight which does not include the pores in the rock so that the value will be higher, the process name is Apparent Specific Gravity. The second condition is the measurement of specific gravity by taking into account the filled pores called Bulk Saturated Surface Dry (SSD) Specific Gravity. The formula specific gravity is:

- Bulk Saturated Surface Dry (SSD) Specific Gravity

$$SG_{SSD} = \frac{w_w}{(w_w - w_s)} \quad \ldots\ldots (8)$$

- Apparent Specific Gravity

$$SG_{apparent} = \frac{w_d}{(w_w - w_s)} \quad \ldots\ldots (9)$$

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Code:

ww = saturated weight; wd = dry weight; ws = saturaterd weight in water

RESULT AND DISCUSSION

1. Rock Condition

The lava Andesite of the research area is an extrusive rock. The megascopic, appearance shows a light gray color, in fresh and brownish gray, in weathered. The color index of this rock has a felsic mineral percentage of 55 - 66% and can be classified as mesocratic igneous rock (S.J Shans, 1943). The granularity of these rocks is porphyritic to aphanitic and the structure is massive. This rock megascopically shows the presence of minerals such as amphibole, plagioclase, and other minerals (Figure 3).

Figure 3. Megascopic appearance of andesite rocks

While microscopically this rock shows porphyritic-aphanitic, hypocrystalline, inequigranular, and hypidiomorphous granularity. Thin section of rock are composed of phenocrysts consisting of amphibole, plagioclase, K-feldspar, and pyroxene minerals, while the base mass of thin slices is plagioclase microlite, secondary quartz, chlorite, clay, opaque, oxide, glass, and volcanic. The percentage of phenocrysts was 29% and the base mass was 71%. Then the thin section found special textures, namely trachytic and glomeruloporphyritic, these textures indicate that the rock in the study area is the result of an effusive eruption.

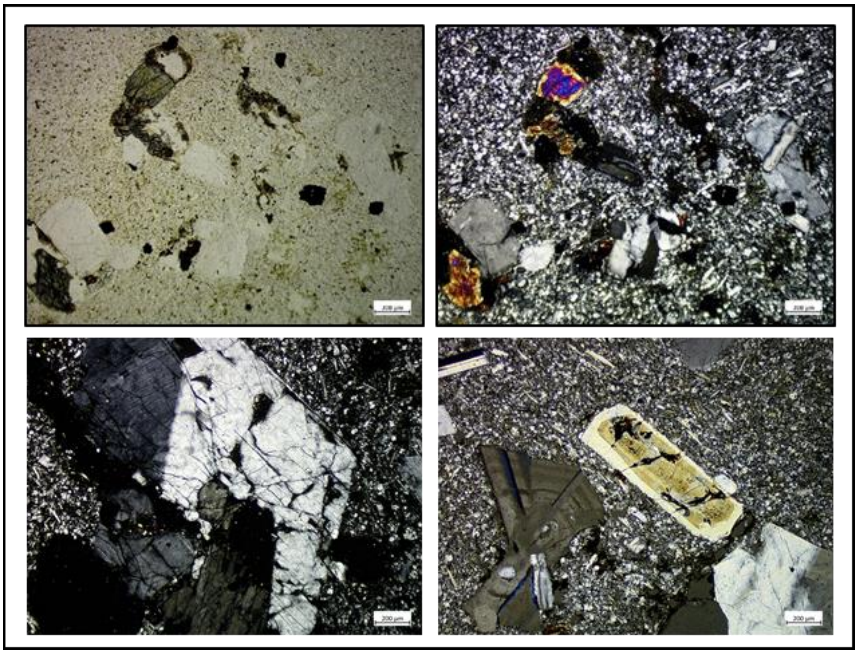

Figure 4. The appearance of andesite rocks in a thin section with a magnification of 40x

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2. Physical Properties

The results of testing physical properties in the laboratory are then calculated using formula 2 to 9 and produce rock physical properties, is density (in condition Natural, saturated, and dry), Apparent specific gravity, Bulk Saturated Surface Dry (SSD) Specific gravity, porosity, absorption, natural moisture content.

In the calculation of physical properties, the weight of rock in a state of sinking, saturated, normal, and dry is used. Then from the weight will be obtained the volume of rock. If you put the volume and weight of the rock into formulas 2 to 4, you will get the density of the rock.

The rock density is attached in Table 2, where the rock density value in the study area is below the average, ranging from 1.5 to 1.7 g/cc, which usually according to Sharma (1997), igneous rock has a density of 2.5 to 3.5 g/cc. This shows that the volume of rock in the study area is large, while the rock mass is low. This can happen because the low rock mass is thought to be because the rock constituents consist of other materials that make the rock density low, this material can occur due to certain conditions such as weathering or changes in the origin of the mineral.

Then, high volume can be indicated because the pores in the rock are quite high. If correlated between the linear density and porosity diagrams, the diagram shows that natural density and saturation density have a (+) or direct correlation, but dry density shows a (-) correlation or an inverse correlation. Although the R-value in the diagram shows a small value or is close to 0 (chart 1), the presence of porosity in the rock can be said to still affect the rock density even though the probability is small.

Table 2. Result analysis Density of rock sudy area

Sample	Natural density (gr/cc)	Saturated density (gr/cc)	Dry Density (gr/cc)	Average Density (gr/cc)
A	1,660	1,704	1,627	1,664
B	1,633	1,672	1,623	1,643
C	1,650	1,683	1,624	1,652
D	1,589	1,627	1,562	1,593
E	1,679	1,734	1,661	1,691
F	1,657	1,712	1,636	1,669
G	1,620	1,673	1,608	1,634
H	1,645	1,688	1,624	1,652
I	1,626	1,684	1,590	1,633

The result of analysis laboratory, porosity of the rock in study area have porosity 4.92 to 9.45% (table 3). According to Costa & Barker (1981), andesite porosity ranges from 0.1% to 11%. If the research andesite rock is compared with the porosity according to Costa & Barker (1981) which is 4.92% to 9.45%, this shows that the rock in the study Classified into andesite rock according to Costa & Barker (1981).

Table 3. Result analysis Porosity of rock study area

Sample	Porosity (%)
A	7,73
B	4,92
C	5,98
D	6,50
E	7,34
F	7,58
G	6,54
H	6,43
I	9,45

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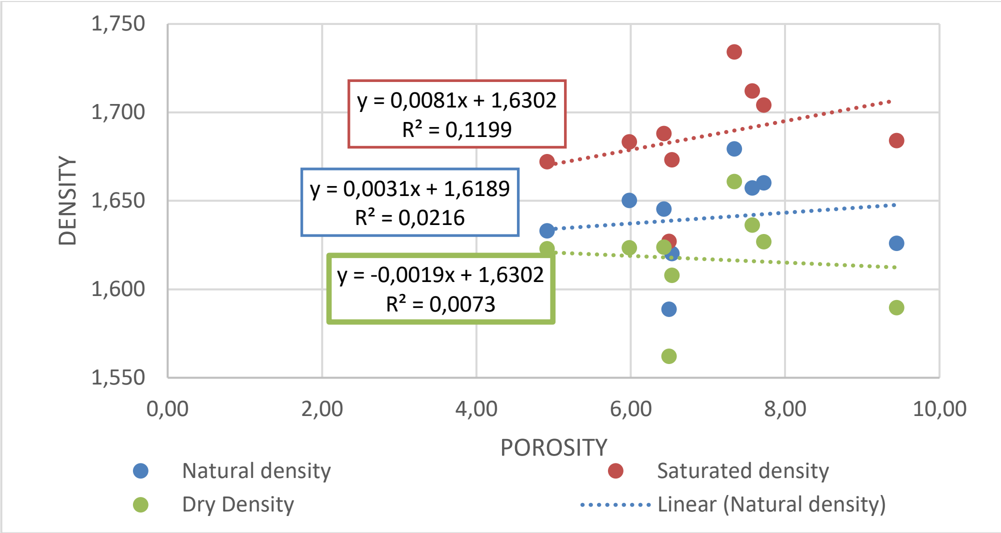

Chart 1. Relationship density and porosity

Then the results of the specific gravity of rocks in the study area have an SG of 2.4 to 2.7 (table 4). According to Krynine & Judd (1957, in Aghamelu et al, 2011), the specific gravity of igneous rocks ranges from 2.2 to 3. It shows that the calculation result of spesific gravity is classified into spesificgravity of igneous rock.

Table 4. Result analysis Specific gravity of rock study area

Sample	Apparent Specific Gravity	Bulk Specific Gravity (SSD)
A	2,6	2,4
B	2,6	2,5
C	2,6	2,5
D	2,7	2,6
E	2,5	2,4
F	2,6	2,4
G	2,6	2,5
H	2,6	2,4
I	2,7	2,5

Then, the results of the analysis of the maximum absorption capacity of the research rock ranged from 3 to 5.9% and the Natural moisture content ranged from 0.7 to 2.2%. Absorption and natural moisture content have differences, namely, the absorption capacity is the maximum ability of rocks to absorb water and natural moisture content is the water content in rocks under normal conditions, based on SNI 03-0394-1989, the good rocks have a maximum absorption below 12 %, it shows that the results of the calculation of the rock in the research area are good.

Table 5. Result analysis absorption and Natural moisture content of rock study area

Sample	Natural Moisture Content (%)	Absorption (%)
A	2,05	4,75
B	0,63	3,03
C	1,64	3,69
D	1,70	4,16
E	1,12	4,42
F	1,28	4,63
G	0,77	4,07
H	1,33	3,96
I	2,30	5,94

porosity with natural moisture content and absorption has a direct relationship, where the relationship is very strong indicated by the value of R^2 close to 1 (chart 2), it means that when the porosity value of the rock is low, the absorption and natural moisture content of the rock will be low too and applies otherwise. This can be explained because the pores in the rock can be filled with water, and it is clearly visible on absorption because the pores are filled to the maximum by water so that the R on the chart shows a higher value, in contrast to the natural moisture content the pores in the rock are still partially filled with air, so produce different values between natural moisture content and absorption.

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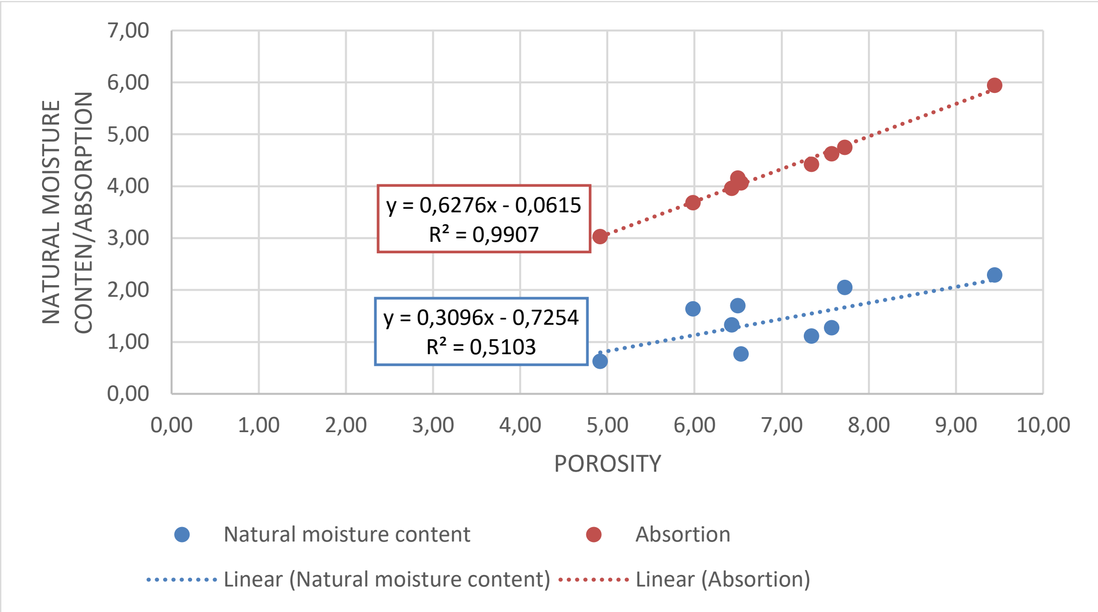

Chart 2. Relationship Absorption and porosity of the rock

3. Mechanical Properties

The results of testing the compressive strength of rocks with the Uniaxial Compressive Strength (UCS) system on 9 rock samples and show different compressive strength values. The UCS results show that the rock samples in the study area have compressive strength values ranging from 33,099 – 85,096 Mpa and an average rock compressive strength of 58,227 Mpa (Table 6).

Based on the weighting of Bieniawski (1979), andesite lava in the study area has a compressive strength value in the medium to a strong category and based on the ISRM classification (1981) the rocks in the study area are included in R3-R4. Based on Atteewell and Farmer (1976, in Rai et al., 2014) rocks in the research area is igneous rock have coarse-grained and low fill weight, because have compressive strength ranging from 40-80 Mpa.

Table 6. Results of Mechanical Properties Testing on selected rock samples

Sample Code	Rock Compressive Strength (Mpa)	Quantitative Description	GRADE (ISRM)
A	33,099	Medium	R3
B	85,096	Strong	R4
C	60,584	Strong	R4
D	44,083	Medium	R3
E	45,234	Medium	R3
F	68,280	Strong	R4
G	67,192	Strong	R4
H	68,636	Strong	R4
I	51,841	Strong	R4
average	58,227	Strong	R4

E-ISSN : 2579 – 3136

The relationship between physical and mechanical properties in rock experiments in the research area shows that when rock physical properties and rock mechanical properties are related, not all linear correlations show strong values. Chart 3 and Table 7 show that the compressive strength of rocks can be said to be influenced by porosity, absorption and natural moisture content with an R-value or coefficient of determination, namely Absorption R^2 = 0.32, natural moisture content R^2 = 0.50, and porosity R^2 = 0.32 with the three These parameters form a negative linear correlation, which means that when the compressive strength is high, the porosity, natural moisture content, and absorption will be low, and vice versa.

Then for other physical properties, the coefficient of determination (R^2) is low or close to 0, so the correlation between these parameters and the compressive strength does not apply.

Table 7. Determinations of coefisien (R^2)

Physical Property Parameters	**Determinations of coefisien**
Dry Density	0,0184
Average Density	0,0007
Natural Density	0,0085
Saturated Density	0,0136
Absorption	0,3278
Natural Moisture Content	0,5012
Porosity	0,327
SSD Specific Gravity	0,0111
Apparent Specific Graviy	0,0214

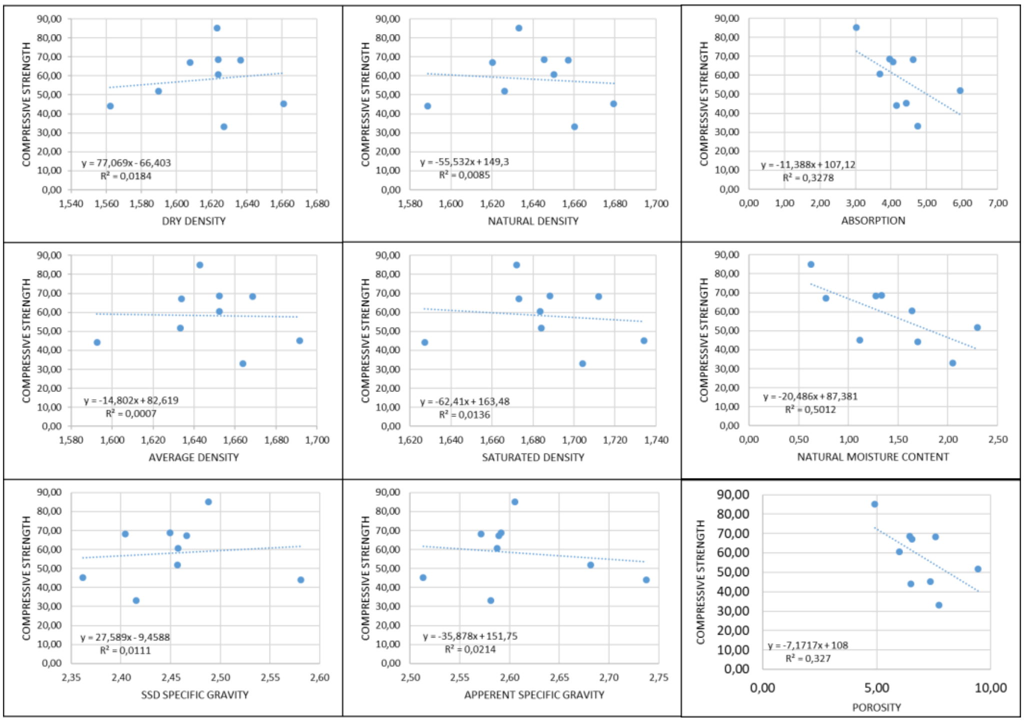

Chart 3. Relationship compressive strength with density of the rock

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CONCLUSION

Rocks in the study area are igneous rocks formed from volcanic activity, namely effusive eruptions. Rock-based on petrological analysis is andesite rock. Rocks in the study area are based on their physical properties, namely specific gravity including igneous rock, and rock types in the study area based on their porosity include andesite rock types. The mechanical properties of rocks in the study area are classified as moderate to strong rocks or included in R3-R4, the difference in compressive strength values is because these rocks have different physical properties. Physical properties that affect the value of compressive strength based on linear correlation are absorption, Natural moisture content, and porosity, the relationship shows an inverse relationship. where absorption, natural moisture content, and porosity have a linear correlation which shows a direct relationship. Therefore, if in further engineering analysis in mining or utilization that requires high compressive strength, then physical properties such as absorption, Natural moisture content, and porosity must be considered because they can affect the compressive strength of rocks.

ACKNOWLEDGEMENT

The author would like to thank all parties involved in this research. Especially the Jatinangor-Cimanggung Research Team. The author hopes that this research can be useful for those who read and need it.

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E-ISSN : 2579 – 3136