The Suitable Utilization of Extractive Tuff as Building Materials Based on Mineral Composition and Rock Strength

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Abstract

Rocks that exist in this world can be used for various things such as building foundations, building material mixture, Industry, and others. Rock samples are taken from the village Ciawitali, Sumedang regency, West Java. Examined rocks which are pyroclastic rock in the form of lithic tuff and crystal tuff is quaternary volcanic sediment. Rock samples were petrographic analyzed to determine the mineral composition and point load strength tested to determine the strength of the rock. Lithic tuff dominated by the rock fragments with igneous rock types as much as 63.75% and has a compressive strength of 0.441 MPa. Crystal tuff dominated by plagioclase and chlorite minerals with a total of 85% and amounted to 0.6119 MPa compressive strength. Rock strength is influenced by mineral composition, grain density and the existing cavity. This study was conducted to look at the suitability of the use of extractive tuff and inform the general public about it.

Keywords: Sumedang, tuff, petrographic, point load test

1. Introduction

Research Area lies in the area Ciawitali, Sumedang, West Java, Indonesia located at latitude 6°40 '18 "- 6°34'55" S and longitude 107° 51' 51 "- 107o 57 '17" E. This area is located in the western part of Java Island. Rock samples in the form of lithic tuff and tuff crystals derived from quaternary volcanic sediment. Residents in the Ciawitali area often take the rock to be used as building materials.

1.1 Background

In the research area, there are many sites of excavation, whether conducted by the community using traditional tools or using heavy equipment such as excavators. Many rocks mined in the area of research is the result of volcanic products.

Most of the mined rock used for building materials, either for material mix or for building foundations.

The rocks of volcanic products usually have a

Fig. 1 Location of Research Area

loose characteristic, because it has not compacted optimally and have a lot of cavities.

Point load strength test performed on tuff samples that exist in the research area to determine the strength of the rock. In addition, texture and mineral composition which compose this tuff also have an important role in determining the usability of this tuff.

1.2 Problems

Society in the research area often used the tuff material as a building material. However, tuff is a result material of a volcanic explosive eruption that usually composed of fragments, lithic, glass, and crystal. This rock is easily separated and unconsolidated. If the utilization of the tuff material for building material is, it will cause crumbly and collapsed buildings when there is a disaster.

This study is intended to determine the most appropriate use of tuff as a building material and to inform the general public about the most suitable utilization of tuff as a building material.

1.3 Objectives

- Determining the mineral composition and texture tuff in the research area
- Determine the strength of tuff by compressive strength test point load
- Determine the usefulness of tuff as extractive to be utilized as a building material.
- To provide knowledge to the general public about the suitable utilization of tuff as an extractive.

2. Literature Review

2.1 Geology of Research Area

In physiographic, research areas included in the Basin Bogor, on Zone Bogor (Martodjojo, 1984). Bogor zone is a zone that extends east-west trending, has a maximum width of 40 km with intensive folding and reverse fault to the north. Constituent rocks consist of Tertiary sedimentary rocks and igneous rock either intrusive or extrusive.

This zone has the morphological that shows hilly appearance indicating that this zone has been folded strong. Morphology of steep hills was formed by intrusive igneous rock. In the Pliocene-Pleistocene epoch, Bogor Basin lifted into the mainland and become a magmatic track volcanic activity, and it creates deposits of Quaternary Volcanoes (Martodjodjo, 1984). Van Bemmelen (1949), named this morphology as strong antiklinorium accompanied by faulting.

Pyroclastic rocks composed of fragments of explosive volcanic eruptions (Williams, Turner, Gilbert, 1954). These rocks consist of pyroclastic material in the form of glass fragments, crystal, and lithic / volcanic rocks. Pyroclastic rocks are classified by its grain size.

Table 1 Schmidt Classification of Pyroclastic Rocks Grain Size

Clast size	Pyroclast	Manily unconsolidated: Tephra	Manily consolidated: Pyroclastic rock
> 64 mm	Block, bomb	Agglomerate	Agglomerate, pyroclastic breccia
< 64 mm	Lapillus	Layer, lapilli tephra	Lapilli tuff, lapillistone
< 2 mm	Coarse ash	Coarse ash	Coarse (ash) tuff
< 0.063 mm	Fine ash	Fine ash	Fine (ash) tuff

2.2 Keywords Explanation

Tuff is included in pyroclastic rock types. Pyroclastic rocks is a rocks that consist of reworked material that is erupted from an explosive volcanic, transported by air as well as cloud incandescent material, then deposited on the ground in dry conditions or in the body of water. (Fisher, 1961 & Vide Carozi, 1975).

Based on lithological variations, Schmidt (1981) distinguishes tuff into three types: vitric tuff, lithic tuff and crystal tuff. In the research area, there are two types of tuff that are lithic tuff and crystal tuff. Lithic tuff is a pyroclastic rock which is dominated by rock fragments. Rock fragments which usually become tuff constituent are andesite, porphyry, diorite and others. This fragment that determines how well the quality of this tuff as a building material because each type of fragment has a predominance of different mineral composition.

Crystal tuff is a pyroclastic rock that is dominated by crystal fragments. Fragments of crystal in the form of minerals such as of plagioclase, pyroxene, amphibole, biotite and others. The dominance of this crystal will also affect how well the rock quality based on existing mineral characteristics. Vitric tuff is dominated by glass fragments.

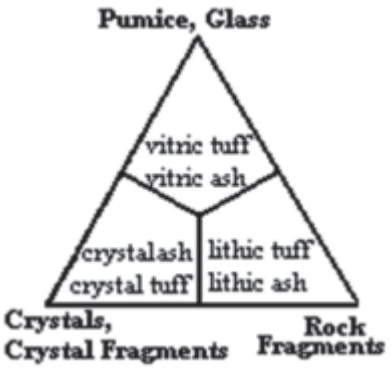

Fig. 2 Schmidt Classification of

Petrography is petrology that focuses on detailed descriptions of rocks. It relies heavily on observations made with the petrographic microscope. A petrographic description of a rock first involves identification of the minerals and, where possible, determination of their compositions. The mineral content and the textural relationships within the rock are described in detail. Petrographic descriptions start with the field notes at the outcrop and include megascopic description of hand specimens. The detailed analysis of minerals by optical mineralogy in thin section and the micro-texture and structure are critical to understanding the origin of the rock.

The point load test is intended as an index test for the strength classification of rock materials. It may also be used to predict other strength parameters with which it is correlated

3. Methodology

The object of this research is the lithic and crystal tuff in the area Ciawitali, Sumedang, West Java, Indonesia. In the area there are two types of lithic tuff, which is coarse grained lithic tuff with code sample C, fine grained lithic tuff with code sample B, and code samples A for crystal tuff.

The research methods used are petrographic analysis and point load strength test on rock samples. In petrographic analysis, samples of rocks made of thin slice thickness 0,03 mm and then analyzed under a refraction polarizing microscope. Petrographic analysis aims to determine the mineral content and the textural relationships within the rock are described in detail. The detailed analysis of minerals by optical mineralogy in thin section and the micro-texture and structure are critical to understanding the origin of the rock.

Compressive strength analysis aims to determine the strength of rock samples. The tools used for this test is a press machine equipped with a pressure gauge. Before using the tool, specify a point load of rock samples and then calculate the geometry according to ISRM suggested methods for determining point load strength. If the conditions are not fulfilled, then the rock will not split perfectly when the point load test performed.

After conducting such analyzes will be known suitability utilization of tuff on Ciawitali area as a building material.

4. Result and Discussion

4.1 Petrography Analysis

Crystal tuff with sample code A has these following characteristics: color without analyzers is colorless, color with analyzers is black, and texture is very smooth, angular grain shape, close fabric, and well sorted. These rocks are dominated by crystalline in the form of plagioclase 40%, chlorite 25%, 15% glass, and other minerals as much as 20%. There are not too many voids.

Fig.3a Megascopic Appearance of Crystal Tuff Sample Code A

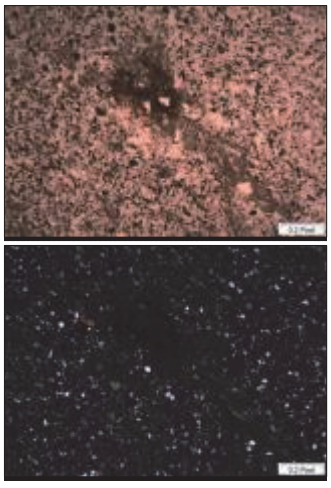

Fig.3b Microscopic Appearance of Crystal Tuff Sample Code A

Fine grained lithic tuff with sample code B has these following characteristics: color without analyzers is colorless, the color after using analyzers is blackish gray, fine texture, sub angular - angular grains shape, closed fabric, and moderately-well sorted. The composition of these rocks is dominated by lithic fragments as much as 55.5%. The lithic fragments are volcanic rocks that dominated by plagioclase and have sub angular shape. There are also crystal fragments as much as 32% in the form of plagioclase, alkali feldspar, quartz, pyroxene, biotite, and opaque minerals and also contained fragments of glass as much as 12.5%. In these rocks there are not too many voids.

Fig.4a Megascopic Appearance of Fine Grained Lithic Tuff Sample

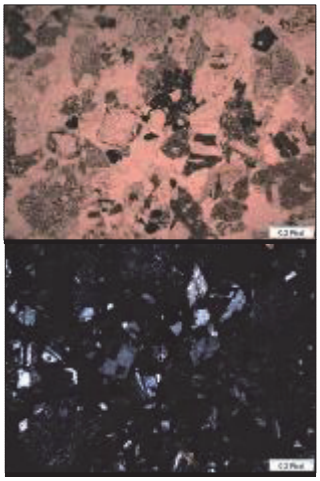

Fig.4b Microscopic Appearance of Fine Grained Lithic Tuff Sample

Coarse grained lithic tuff with sample code C has no color when not using analyzers and black with analyzers, the texture is coarse, moderately sorted with open – closed fabric, and the shape of grains are sub angular - angular. This rock composed by 63.75% lithic fragments which are volcanic rocks that dominated by plagioclase and have sub angular shape. There are 21.25% crystal fragments which is of plagioclase, alkali feldspar, quartz, opaque minerals, pyroxene, amphibole, and oxides minerals, as well as fragments of glass are 13.75%.

Fig.5a Megascopic Appearance of Coarse Grained Lithic Tuff Sample

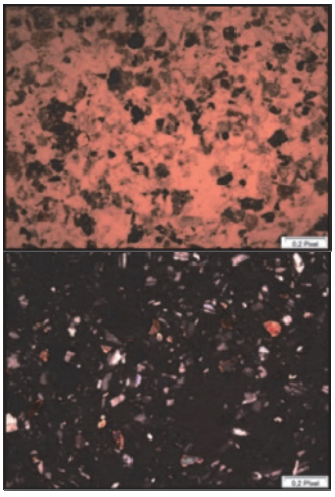

Fig.5b Microscopic Appearance of Coarse Grained Lithic Tuff Sample

4.2 Point Load Test

- Tuff with sample code A that will be tested has geometric size as follows: W (width) 4.5 cm; D (thickness) of 4.2 cm; L (length) of 5.6 cm. Based on the geometric correction we obtained value of compressive strength is 0.6119 MPa.
- Tuff with sample code B has geometric size as follows: W 5.925 cm; D 5.5 cm; L 7.6 cm. Based on the geometric correction we obtained value of compressive strength is 0.3604 MPa.
- Tuff with sample code C has geometric size as follows: W 6.175 cm; D 4.25 cm; L 6.8 cm. And based on the geometric correction, we obtained value of compressive strength is 0.441 MPa.

4.3 Discussion

Judging from the rock's characteristic by microscopic it can be seen that the crystalline form dominated by angular shape but has a fine grain size which indicates that this tuff transported through the medium of air and not too far from the source of the eruption.

From the mineral composition of the rock, it can be seen that the rocks dominantly composed of plagioclase and alkali feldspar. Plagioclase and alkali feldspar is included in the subclass of tectosilicate. Minerals that have tectosilicate structure tend to be stronger than the other structures.

Tectosilicate subclass is often called the "framework silicates" because its structure is composed of interconnected tetrahedrons going outward in all directions, forming an intricate framework analogous to the framework of large building. In addition, when exposed to the pressure of this structure will not change because it has a structure that forms the skeleton.

However, when viewed from the compressive strength of the rock, it is included in extremely low strength (ISRM, 1978). This is happen because tuff itself is not consolidated and compacted.

Table 2 Classification of the Uniaxial Compressive Strength of Rocks (ISRM,1978)

Soil	$\sigma_c < 0.25$ MPa
Extremely low strength	$\sigma_c = 0.25$ - 1 MPa
Very low strength	$\sigma_c = 1$ - 5 MPa
Low strength	$\sigma_c = 5$ - 25 MPa
Medium strength	$\sigma_c = 25$ - 50 MPa
High strength	$\sigma_c = 50$ - 100 MPa
Very high strength	$\sigma_c = 100$ - 250 MPa
Extremely high strength	$\sigma_c > 250$ MPa

Table 3 Standard of natural rocks for building materials SNI.

No.	Characteristics	Rock Usability					
		Building Foundation			Prop and Curbstone	Pavements	Ornamental Stone
		Heavy	Medium	Light			
1	Minimum average of compressive strength (kg/cm^2)	1500	1000	800	500	600	200
2	Rudellof Broken Tenacity	~	~	~	~	~	~
	a.Minimum Index (%)	~	~	~	~	~	~
	b.Maximum piercing 2 mm (%)	~	~	~	~	~	~
3	Los Angeles Shear Resistance, maximum piercing 1,7 mm (%)	27	40	50	~	~	~
4	Maximum Aus Friction Resistance with Bauschinger, mm/min	~	~	~	~	0,16	~
5	Maximum water absorption	5	5	8	5	5	5* 12**
6	Permanent form with Na_2SO_4						
	a.	12	12	12	12	12	12
	b.Crack, Rupture, Defect	No crack and defect					

From the compressive strength values obtained, if seen from the table of natural rock quality standards for building materials, the strength of tuff in the research area is very far from the standards as a foundation of the building. So this tuff is more suitable for use as an adhesive material or a mixture of building materials than used as a building foundation.

5. Conclusions

The results obtained from the research that has been conducted are the characteristics of rocks, mineral composition and compressive strength which indicates that these rocks are not suitable used as a building foundation as it is more appropriately used

as material mixture or adhesive mixture. Then the society in research area will understand more about the usability of tuff as extractive.

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