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The Chemical and Mineral Composition Effect on Rock Mass Strength in Kaliwadas Limestone Hills, Karangsembung, Kebumen, Central Java

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Abstract. The Kaliwadas Hills, Karangsembung, Kebumen, Central Java are composed of limestone lithology, which has been deformed in the form of cracks. The chemical and mineral rock composition is related to the adsorbed water content and rock strength. This paper will analyze the correlation between the chemical composition of rocks and adsorbed water content with rock strength of Kaliwadas Hills. Rock sample was soak in an acid solution that represent rainwater. It was known that if the crack exposed to rainwater (acid water) continually, it will change the chemical composition of rocks and water content adsorbed. It is resulting the decrease of rock mass strength that can lead to aftershocks landslide.

Keyword : Kaliwadas Hill, limestone, rock strength

1. Introduction

Rocks have various types of minerals, for example calcite, quartz, kaolin, chromite [1] and other minerals that can be used as natural resources for the synthesis of inorganic materials [2]. Synthesis of inorganic materials can be done by various methods, for example, sol-gel, solid state, and hydrothermal method [3]. Synthesized inorganic materials can be used as adsorbent [3] or photocatalyst [4] depends on their properties. For example, zeolite that has a high active surface area can be used as supporting material on photocatalyst TiO₂ [5] and calcite which usually found in limestone rock is used as building material because it has cementation effect [6].

Kaliwadas Hill is a type of limestone hill located in north of Karangsembung Village, Kebumen, Central Java. This limestone hill is located in a densely populated area. In 2016 this hill had already suffered a landslide. Hundreds of people were rescued. In 2017, some researchers found a fracture in this hill that is getting wider and deeper over the time [7]. This fracture if left unchecked is feared to caused another landslide. To find out the possibility of this happening, it is necessary to analyze the rock strength of the hill.

This study discusses the effect of rainwater on the strength of Kaliwadas Limestone Hill. Analysis of the hill's chemical composition was carried out using X-Ray Fluorescence (XRF) and X-Ray Diffractometer (XRD). To determine the impact of rainwater on the strength of the slope, modeling was carried out by soaking rock samples from the slope with acid water representing rainwater. The strength of the hill was measured with Point Load Index.



2. Methods

Determination of rock's chemical content effect on the rock strength can be done by a simple method. Rock sampling was done in 4 different locations in Kaliwadas Limestone Hill, Karangsembung, Kebumen, Central Java that represented by point I, A, B, and C. Rock sample was soak in an acid solution (pH 6) in a various amount of time. In this research acid solution is representing rain water, because rain water is containing a small amount of acid. The decrement of chemical content was characterized using XRF and XRD. The correlation between rock's porosity and chemical content with rock strength was determined using point load index.

3. Result and Discussion

3.1. X-Ray Diffraction (XRD) Analysis

X-Ray Diffraction (XRD) analysis was done to determine crystal phase of the rock sample. Sample from 4 different sampling location was characterized using XRD. To make the analysis process easier, 3 greatest peak were chosen. After being match with XRD data from ICDD (International Centre for Diffraction Data) it was known that the rock sample is consist of 3 minerals, Calcium Carbonate (calcite) with scale factor 0.874, Alumunium Calcium Silicon Oxide ($\text{CaAl}_2\text{Si}_2\text{O}_8$) with scale factor 0.063 and Calcium Iron Oxide ($\text{Ca}_4\text{Fe}_9\text{O}_{17}$) with scale factor 0.063. Because the scale factor of calcite is way higher than the other minerals, it can concludes that rock sample is mainly consist of calcite, while trace amount of the other minerals is impurities.

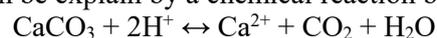
Table 1. XRD data obtained from rock samples

Sample	Chemical Formula	Mineral Name	Crystal	Content (%)
I	CaCO_3	Calcite	Rhombohedral	100%
A	CaCO_3	Calcite	Rhombohedral	100%
B	CaCO_3	Calcite	Rhombohedral	100%
C	CaCO_3	Calcite	Rhombohedral	100%

3.2. X-Ray Fluorescence (XRF) Analysis

X-Ray Fluorescence (XRF) analysis was done to determine the elemental composition of rock sample. XRF analyzer can not identify the sources of element detected, it can detect the element as it's oxide form [8]. Before testing using XRF, rock sample is pre-treated by soaking in an acid water (pH 6) with variation of soaking time. This treatment is carried out to find out the effect of rain water, represented as an acid water in this research, on the decrease of chemical content in rock sample.

XRF analysis result of the rock sample is shown in figure 1. From this image, it is known that the rock sample is mostly content of Ca and trace amount of Si and Fe that detected by the instrument as it's oxide form. After acid treatment, it is known that Ca content is decreased with increasing amount of acid soaking time. This result can be explain by a chemical reaction below :



From XRD data, it's already known that Ca as the biggest constituent of the rock sample is exist as calcite. Calcite will react with rain water (in this research is represented by acid water) and form a water soluble Calcium [9]. Before XRF test, all water is separated from the solid. This affect the amount of Ca content in the rock after acid soaking treatment.

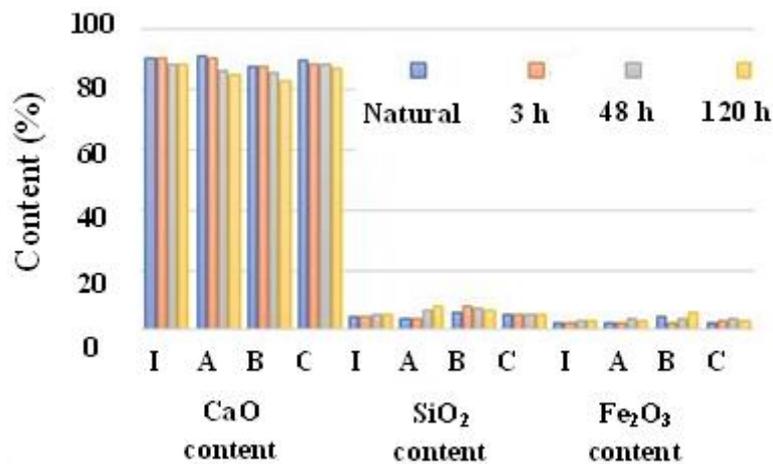


Figure 1. The decrement of rock samples’ chemical content obtained by XRF analysis

3.3. Correlation between the decrement of CaO content, water adsorbed content, and porosity of rock sample

Figure 2 shows the correlation between the decrement of CaO content, water adsorbed content, and rock sample porosity. From this data it is known that the decrement of CaO content leads to the higher rock porosity, that makes water adsorbed content is increased.

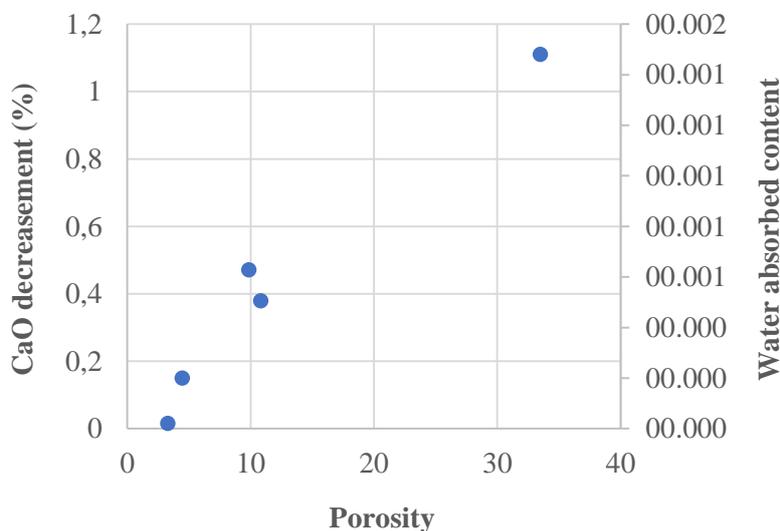


Figure 2. Correlation between CaO decrement, porosity and water adsorbed content

3.4. Correlation between Soaking Time, CaO content and Point Load Index

Figure 3 shows the correlation between acid soaking time, CaO content, and Point Load Index of the rock sample. Acid soaking time is varied to determine its effect on rock strength. The variation made is 3 hours, 48 hours (2days), and 120 hours (5days). From this data, the longer acid soaking time is

done, the higher CaO decreased from the rock sample, the lower CaO content remains on the rock sample, lead to a lower point load index. It means the strength of rock sample is low.

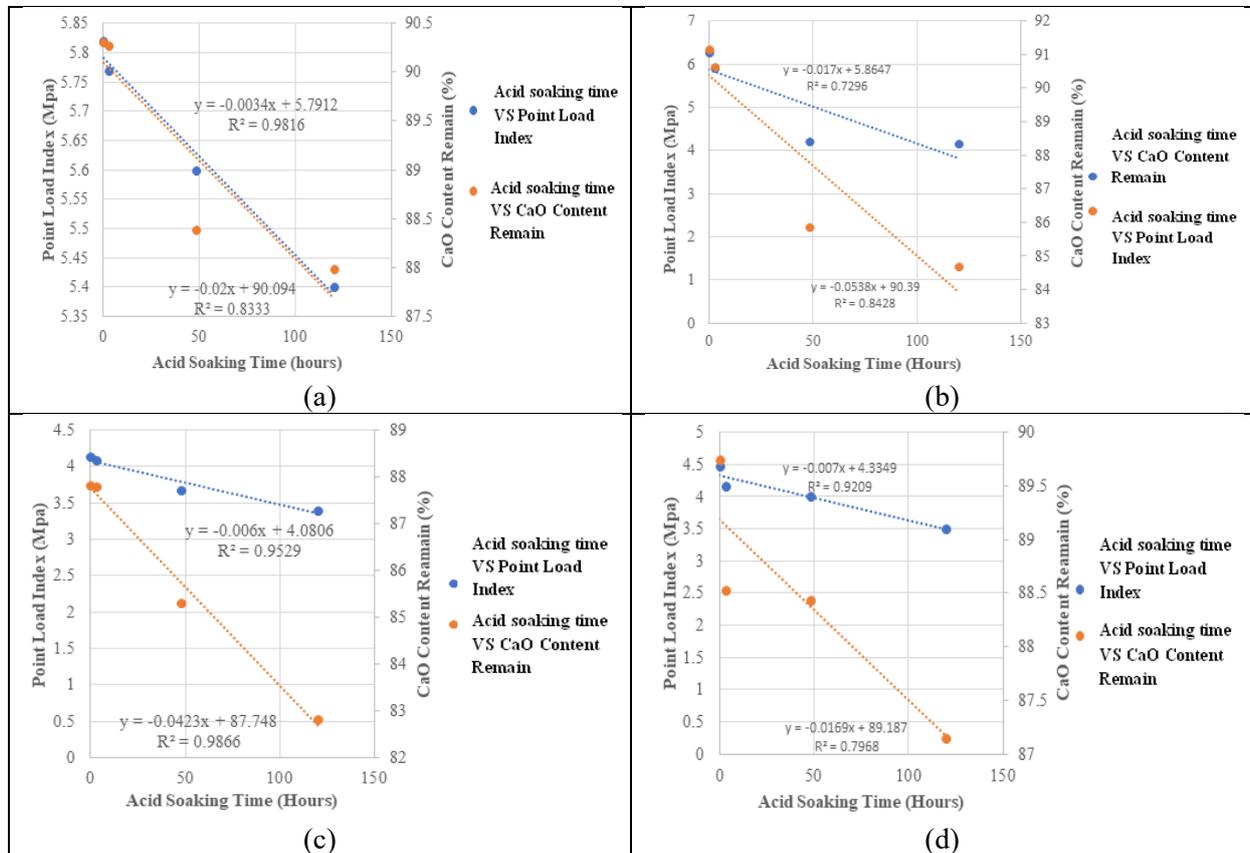


Figure 3. Correlation between acid soaking time, CaO content remain, and point load index in a) I point sampling location b) A point sampling location c) B point sampling location d) C point sampling location

The higher CaO content in the sample caused cementation force in the sample increased, so the more the strength of the rock caused by strong cement properties [6]. The strength of the rock in the sample is also affected by the iron content. Iron (Fe) as FeCO_3 is very reactive and stronger than CaCO_3 . If limestone (CaCO_3) is substituted with iron (Fe), the properties will be more stable than the ordinary limestone. But for rock sample from point B, the amount of iron is very high while the strength of the rock is very weak. This happen due to a number of corroded iron, indicated by the presence of brown cracks which are rust of iron (Fe).

4. Conclusion

Kaliwadas Limestone Hills in Karangsembung, Kebumen, Central Java is mainly consist of calcite (CaCO_3). Calcite is mineral that has sementation characteristic. Sementation is characteristic that strengthen the rock. By contact with water rain that in this study is represented by acid water, this calcite mineral will form a water soluble chemical that makes the amount of calcite decreased over the time. During calcite decrease process, bigger pore is formed in the rock. This lead to a higher aborbed water content that makes the rock has a lower load point index. It means that the rock that build the hill has a lower strength, that later can lead to landslide.

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