ARGILLACEOUS ROCK PROPERTIES CHANGES DUE TO THE WEATHERING PROCESS

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ABSTRACT : Argillaceous rock is a clay rock in fresh condition has a very high shear and crushing strength. This is because the index properties of argillaceous rock are included in the soft rock category. However, if weathering occurs due to contact with atmosphere and hydrosfere, then argillaceous rock will quickly reduce its strength. In this paper, wetting-drying cycle process and drying process were done on argillaceous rock in laboratory were reported. Changes in the indes and physical properties of argillaceous rock show a complete adverse behavior due to wetting-drying cycle process and drying process. Due to wetting-drying cycles, from disintegration ratio parameter (D_R) of Semarang-Bawen argillaceous rock appears to have completely weathered on 24^{th} days and completely non-durable. While due to the drying process until the 80^{th} day, the physical properties of argillaceous rock seems to be reliable and completely durable.

Keywords : argillaceous rock, index properties, physical properties, wetting drying cycle, drying process

I. INTRODUCTION

Argillaceous rock is a formation of sedimentary rocks from clay deposits ("https://www. thefreedictionary.com " 2008), or in other terms referred to as clay stone and more specifically with the term clay shale. By adding the word "shale" which describes the specific behavior of this type of clay rock that is easily weathered. This is due to contact with atmosfere or hydrosfere. During the argillaceous rock weathering process through the drying process and wetting drying cycles there is a changes in the physical and index properties, which eventually changes in the index and physical properties.

These properties have been observed during the weathering process of up to 80 days. The incdex properties of the observed indices are changes in water content, bulk density and void ratio. The physical properties observed are changes in disintegration ratio and also shrinkaging-swelling behavior. The behavioral changes of these properties are illustrated from drying time and wet-dry cycle times (Alatas 2015 c, 2015 d; Irsyam M 2007).

II. PROPERTIES OF HAMBALANG AND SEMARANG BAWEN ARGILLACEOUS ROCK

Preliminary testing on the field and laboratory was also conducted to obtain the index, physical and mechanical properties of argillaceous rock. Test pit was performed to ensure that argillaceous rock to be tested in the laboratory is fresh and has not been weathered. Samples of undisturbed and disturbed argillaceous rock were brought to the laboratory for index, physical and mechanical properties. In this study, an undistubed argillaceous rock samples in sufficient numbers with initial properties of the overall sample were relatively the same.

In **Figure 1**, more than 130 argillaceous rock undisturbed samples from Hambalang West Java and Semarang-Bawen Central Java are placed in the drying room to be tested for shear strength on a predetermined schedule up to the 80th day. In **Figure 2** shows a measurement of undistubed sample change during the weathering process due to the drying process . While in **Figure 3** shows the wetting drying cycle process using the same device. However, it can be seen that its swelling behavior though filling the chamber with water, and drying it in order to obrserve the shrinkage in the sample in 3 dimension. In **Figure 4** shown that schematic for drying room process and 3D volume change device.

In **Figure 5, Figure 6, Figure 7 and Figure 8** shown the initial index properties parameter of argillaceous rock from Semarang-Bawen and Hambalang before weathering process been done.

Figure 1. More than 130 argillaceous rock undisturbed sample fro two different location in P. Jawa, have been prepared for this reseach (Alatas I. M. 2017).

Figure 2. Three dimension (3D) of undisturbed sample volume changes device in drying process (Alatas I. M. 2017).

Figure 3. Three dimension (3D) of undisturbed sample volume changes device in wetting-drying process (Alatas I. M. 2017).

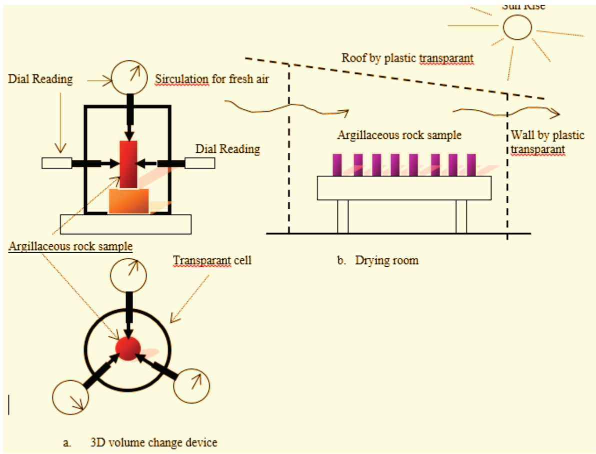

Figure 4. Schematic for drying room and 3D volume change device

The research program has been prepared in accordance with the objectives of the study illustrated in **Figure 9**. This study requires a considerable amount of undisturbed samples. From each observation location it takes approximately 70 undistubed argillaceous rock samples having the same initial properties. Therefore, sampling is not possible through depth boring. One of the solution is to obtain the sample through Test Pit. Generally in a soil investigation, the sample is obtained from a thin walled sample through drilling. Sample from test pit is usually onbtained from the cor box sample. Samples from thin-walled samples or cast boxes were brought to the laboratory and undisturbed sampling was undertaken with standard sizes determined (Alatas I. M. 2017).

Preliminary investigation was conducted to develop an argillaceous rock undisturbed sampling methodology. Methodology wa developed undistubed samples in large quantities, this is because argillaceous rock is rapidly weathered when reacted with hydrosphere and atmosfere. In this case dry drilling becomes the right solution. Rotational speed drilling machine becomes an important equipment to minimize disturbance effect. The solution of using cast drilling machine which usually used for concerete sampling was modified. Single core barrels have been developed as a split single core barrel to facilitate operators to obtained an argillaceous rock sample from inside the core barrel. The sample preparation for laboratory testing is done on site after the sample is successfully removed from the split ingle core barrel (Alatas I. M. 2017). Schematic sampling of argillaceous rock samples on the pit test as illustrated in **Figure 10** below. By using new sampling methodology, it has been successfully obtain undisturbed sample or argillaceous rock. The comparison of standard sampling methods compared with the new developed methodology can be seen in **Table 1** below.

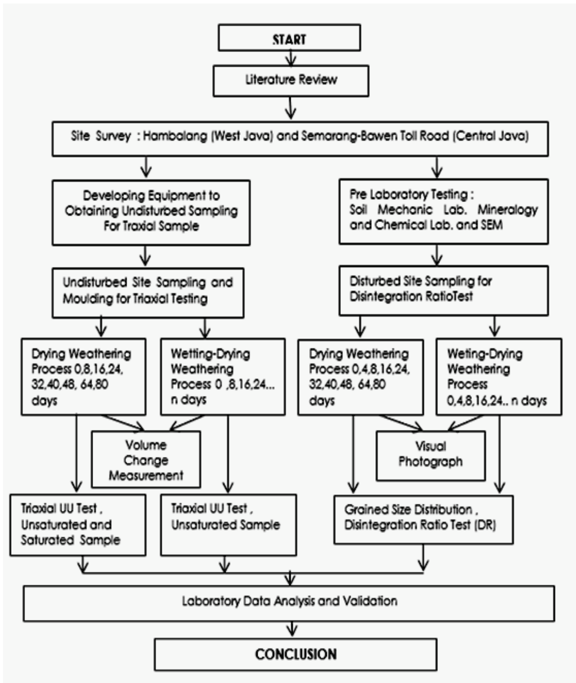

Figure 9. Flow chart for reaserch programe

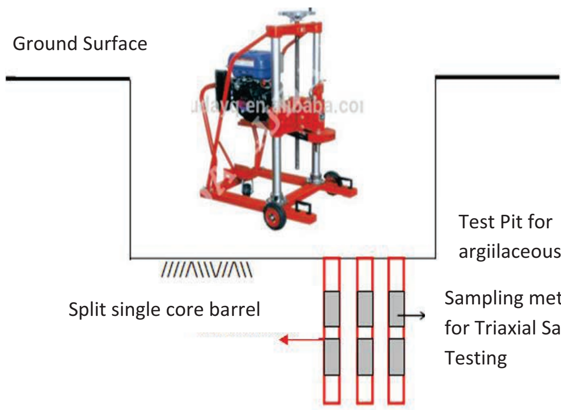

Figure 10. An argillaceous rock sampling methodology developed.

Teble 1. Comparison of standard sampling with the developed methodology for taking argillaceous rock

STANDARD UNDISTURBED SAMPLING METHODS				
SITE INVESTIGATION		LABORATORY TEST		
From BORING TEST or TEST PIT as Thin Walled Tube Sampling Core/ Barrel Sampling/ Box Sampling	Mobilization to Laboratory	Triaxial UD Sampling Using Moulding, Extruder, Triming	Weathering Process	Triaxial Testing
ARGILLACEOUS SAMPLING DEVELOPMENT METHODS				
Undistubed Sampling using Split Single Core Barrel	Mobilization to Laboratory	→		Triaxial Testing

With this new improvised developed method, then undisturbed sample in the laboratory can be eliminated and only done in the field.

IV. CHANGES ARGILLACEOUS ROCK PROPERTIES DUE TO WEATHERING PROCESS

Changes in the properties of argillaceous rock due to drying process as shown in **Figure 11** for wetting-drying process include changes in index properties such as moisture content, bulk density, dry density, saturation density, void ratio.

process. The change in volume and moisture content of the argillaceous rock samples results also changes in other properties index (Alatas I. M. 2017).

Initial Hambalang argillaceous rock water content between 4.1% and 5.3%, during the 80 days drying process it reduces to 2.1%. While the initial water content in Semarang-Bawen between 15.9% to 17.6% in 80 days drying time it reduces to 8.9%. Both samples have shown similar behavior to water-level reduction, where significant water content reduction occurred early in the drying process (Alatas I. M. 2017).

Changes in soil properties of argillaceous rock due to wetting-drying cycles show a very

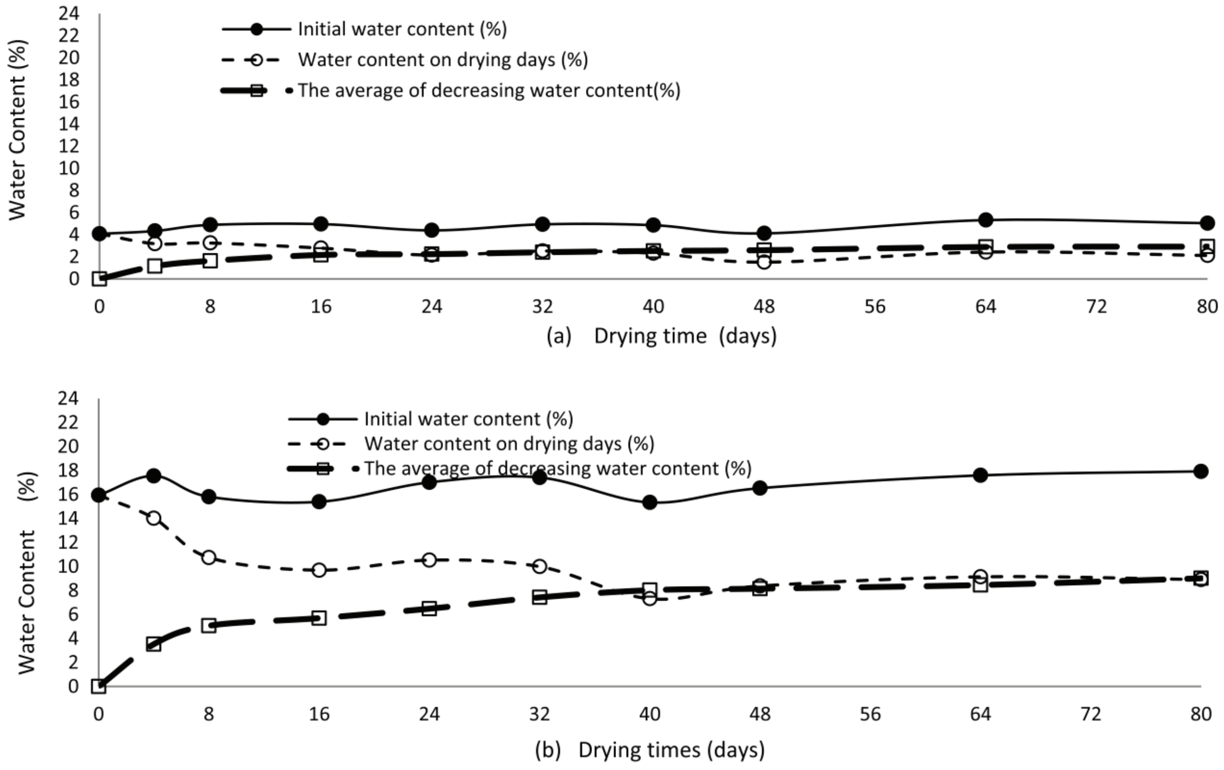

Figure 11. Changes in water content on argillaceous rock where (a) Hambalang (b) Semarang-Bawen due to drying process up to 80 days.

Changes in physical properties include changes in GSD are measured by determining the disintegration ratio (Dr). In general, due to weathering process decreases from disintegration ratio (Alatas 2015 c; Erguler Z A 2009; Shakoor A 2011; Shakoor A 2015). Changes in sample volume such as swelling and shrinkage occur due to wetting and drying

significant difference when compared to weathering by drying process. This can be seen in **Figure 12**, where argillaceous rock Hambalang and Semarang-Bawen day on 40th day already full weathered (completelly non durable). Changes in the index properties due to the swelling process due to wetting and shrinkage due to drying. If wetting-drying cycles occur more frequently within a certain time, it will cause a faster weathering process. Wetting process is done 1 soaking, 2 soaking and 3 soaking every 8 days and only 5 minutes soaking (Pineda J.A 2014; Alatas I. M. 2017). Measurements of vertical and horizontal deformations of the Hambalang and Semarang-Bawen argillaceous rocks were performed with free swells, without pressure.

From the results of the above properties change research, argillaceous rock from Semarang-Bawen has a slightly larger vertical strain and horizontal strain compared to the argillaceous rock of Hambalang. This is due to a dominant clay mineral element that is different from the two argillaceous rocks. Argillaceous rock Hambalang contained kaolinite and chloride. While Semarang-Bawen is dominated by smectite.

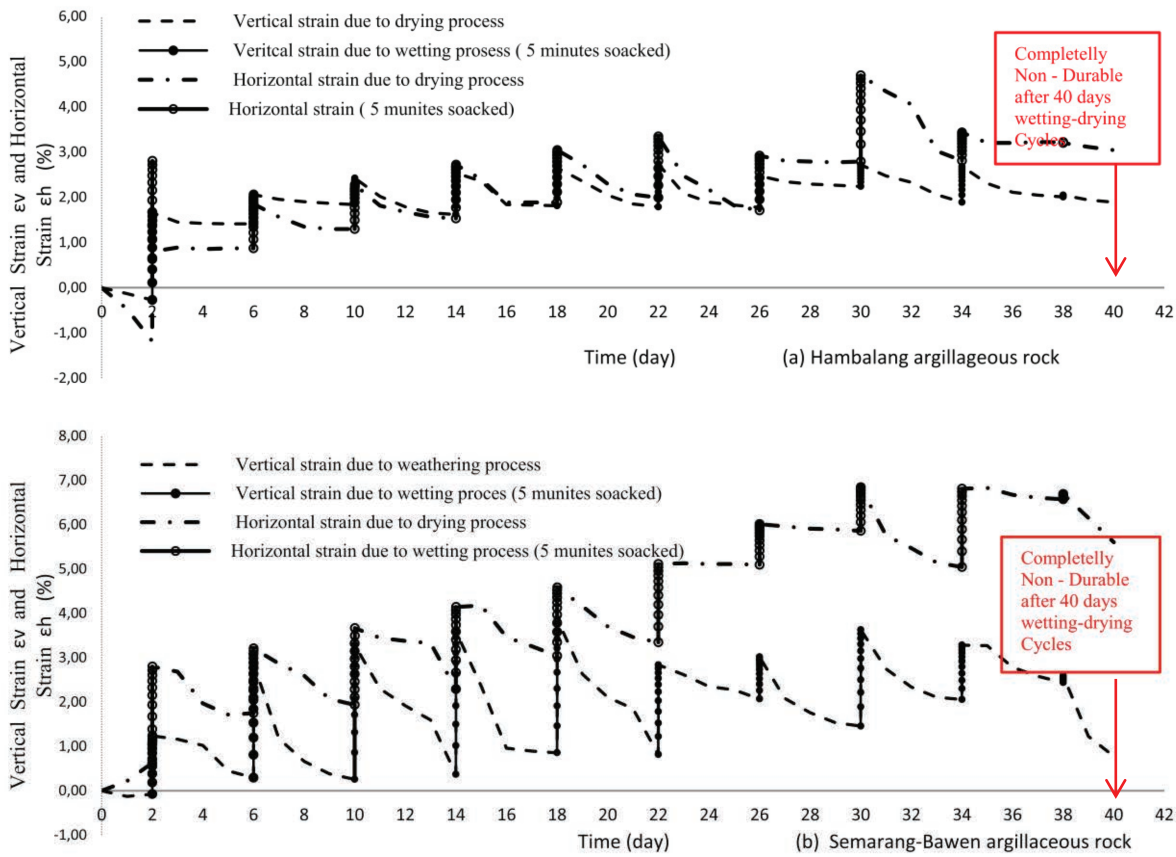

Figure 12. Swelling and shrinkage behavior of argillaceous rock due to wetting-drying cycle process (a) Hambalang, (b) (Semarang-Bawen)

The smectite mineral from the montmorillonite mineral family has a greater swelling effect when compared with other clay minerals (Mitchell J.K 2005).

Table 2. Mineralogy content for two types argillaceous rock (LEMIGAS 2015)

Location	CLAY MINERAL (%)				TOTAL (%)
	Smectite	Illite	Kaolinite	Chlorite	
Smg-Bwn	50	3	2	1	56
Hambalang	-	12	30	20	62
	CARBONATE MINERAL (%)				TOTAL (%)
	Calsite	Dolomite	Siderite	-	
Smg-Bwn	30	-	2	-	32
Hambalang	-	-	4	-	4
	OTHERS MINERAL (%)				TOTAL (%)
	Quarts	Feldspar	Plagioclase	Pyrite	
Smg-Bwn	8	-	2	1	12
Hambalang	30	-	4	-	34

Disintegration ratio is represented as an argillaceous rock weathering parameter though Grained Size Distribution testing with sieve shaker. By plotting between the cumulative percentage against the grained size as in **Figure 13**. The next process is to determines the disintegration ratio (D_R) by utilizing the graph in Figure 13. Changes in the physical properties of the argillaceous rock weather due to the wetting-drying cycle process is as shown in **Figure 14** below.

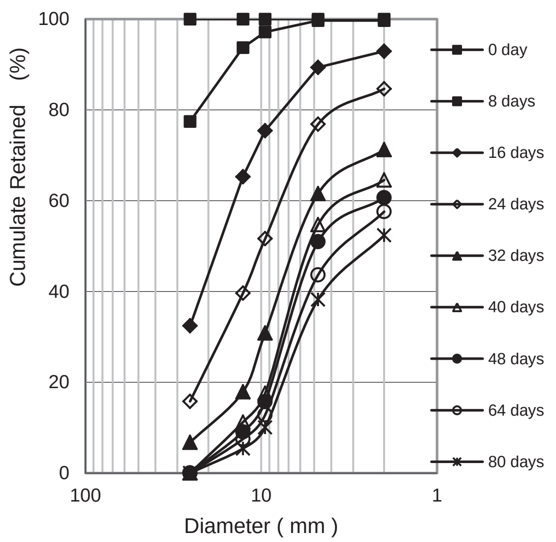

Figure 13. GSD Curve Hambalang argillaceous rock due to wetting-drying proses with 1 soaking every 8 days in 5 munites (Alatas I. M. 2017).

From Figure 14 it can be seen that Hambalang argillaceous rock is more resistant to weathering than Semarang-Bawen argillaceous rock. On the 24nd day it appears that argillaceous rock Semarang-Bawen has been completelly non durable with D_R approaching the number 0.00 with a frequent of 2 and 3 soaking in every 8 days until the undisturbed sample completely non durable on day 24th . However, for Hambalang argillaceous rock samples on day 24th , D_R was 0.67 on 1 soaking , 0.55 on 2 soaking and and 0.38 on 3 soaking. Soaking period 1, 2, 3 times every 8 days, and every soaking period only takes 5 minutes. (Shakoor A 2011; Alatas 2015 c). Until the end of day 80, Hambalang argillaceous rock has a D_R respectively of 0.15, 0.14 and 0.10 on the same soaking day as above. The difference between the argillaceous rocks from two samples is due to the different dominance of clay minerals. When due to drying process until day 80, D_R equal to 0.9162 show both sample still completelly durable.

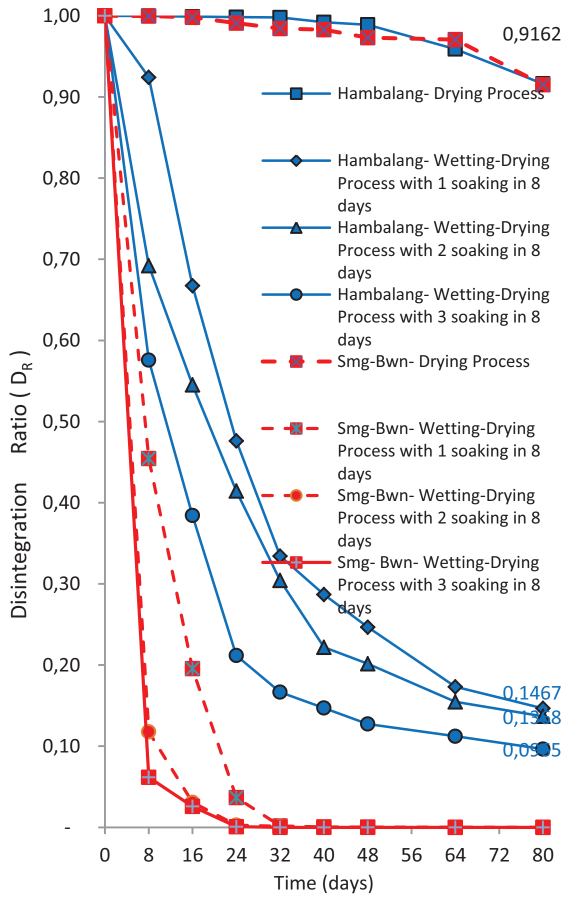

Figure 14. Changes disintegration ratio (D_R) Hambalang and Semarang-Bawen argillaceous rock. (Alatas I. M. 2017).

V. CONLUSSION

From the discussion about the behavior of argillaceous rock properties due to the weathering process, it can be concluded as follows:

1. The process of wetting and drying is more influential to accelerate weathering rather than the drying process on argillaceous rock.
2. When wetting-drying cycles occur more frequently in certain periods, it is more likely to accelerate the occurrence of weathering in argillaceous rock.
3. Acceleration of properties change during the weathering process is also highly

dependent on the main dominant clay minerals from argillaceous rock.

4. From shrinkage with a frequency of 2 soaking in 5 minutes per day for every 8 days on undisturbed sample, both samples from Hambalang and Semarang bawen argillaceous rock can still be measured by shrinkage until day 40. After 40 days both samples have collapsed, and the test is not can proceed.
5. from disintegration ratio testing using distubed sample, Semarang-Bawen argillacesous rock completelly non durable on day 24 with D_R approaching 0.00. While on Hambalang on the same day its D_R ranges from 0.38 to 0.67. So it can be concluded that Hambalang argillaceous rock is more resistant to weathering than Semarang-Bawen argillaceus rock.

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