HALAMAN PENGESAHAN

1	a. Judul	: The Effectiveness of Using Models of Cylinder and Cube in the Clay Soil Compaction Test
	b. Bidang Ilmu	: Teknik Sipil
2	Identitas Pelaksana	
	a. Nama Tim	: Lusmeilia Afriani, Syahri Abdul Rahman, Yan Juansyah
	b. Nama Pengusul	: Dr. Ir. Lusmeilia Afriani, D.E.A.
	c. NIP	: 0010056505
	d. Pangkat/Golongan	: Pembina Tk I/IVB
	e. Jabatan Fungsional	: Lektor Kepala
	f. Fakultas/Program Study	: Teknik Sipil
	g. Bidang Keahlian	: Geoteknik
	h. No HP/Email	: 08127203960/lusmeilia.afriani@yahoo.com
3	Publikasi	
	a. Nama Publikasi	: International Journal of Sciences: Basic and Applied Research (IJSBAR)
	b. ISSN	: P & E-ISSN: 2307-4531
	c. Vol/No./Tggl/Hal.	: Vol 55 No 2 (2021) 116-127
	d. Tautan	: http://gssrr.org/index.php/JournalOfBasicAndApplied/article/view/12269
	e. DOI	: -
	f. Repository	: http://gssrr.org/index.php/JournalOfBasicAndApplied/index
4	Penerbit	: ISRRA

Bandar Lampung, 7 September 2021

Penulis

Mengetahui
Dekan Fakultas Teknik
Universitas Lampung

Prof. Dr. Drs. Suharno, M.Sc.
NIP. 196207171987031002

Dr. Ir. Lusmeilia Afriani, D.E.A.
NIP. 196505101993032008

Menyetujui
Ketua LP2M
Universitas Lampung

Dr. Ir. Lusmeilia Afriani, D.E.A.
NIP. 196505101993032008

International Journal of Sciences: Basic and Applied Research (IJSBAR)

Published: 2021-02-04

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Current Issue

International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

The Effectiveness of Using Models of Cylinder and Cube in the Clay Soil Compaction Test

Lusmeilia Afriani[a]*, Syahri Abdul Rahman[b], Yan Juansyah[c]

[a,b]*Universitas Lampung, Jl. Prof. Dr. Ir. Sumantri Brojonegoro No. 1, Lampung 35141, Indonesia*

[c]*Universitas Malahayati, Jl. Pramuka No. 27, Lampung 35152, Indonesia*

[a]*Email: afriani_L@eng.unila.ac.id,* [b]*Email: Syahriabdulrahman@gmail.com,* [c]*Email: juansyah1@yahoo.com*

Abstract

Soil is any uncemented or weakly cemented accumulation of mineral particles formed by the weathering of rocks, the void space between the particles containing water and/or air. According to SNI 03- 1743- 1989, soil compaction test with laboratory compaction method, using four methods with four molds which is different diameter. The formulation of this research problem is whether the test result of soil compaction is same if the mold that usually use cylindrical shape turned into cube shape. This research includes comparison of standard proctor and modified proctor soil compaction result either using manual rammers or a modified compactor. Two type of mold are used, which is cylindrical mold with 101,60 mm diameter, and cube mold with a size of 10 x 10 cm. it is known that the standard proctor soil compaction of the collision method, the moisture content correction is 100%. Meanwhile, the correction of dry volume weight is 99,58%. In modified proctor soil compaction of collision method, the moisture content correction is 93,2882%. Meanwhile, the correction of dry volume weight is 98,8082%. In standard proctor soil compaction of the pressure method, the moisture content correction is 99,03%. Meanwhile the correction of dry volume weight is 99,27%. In modified proctor soil compaction of the pressure method, the moisture content correction is 96,07%. Meanwhile the correction dry volume weight is 98,60%.

Keywords: Soil compaction; standard proctor; modified proctor; pressure method; comparison.

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* Corresponding author.

1. Introduction

Soil is any uncemented or weakly cemented accumulation of mineral particles formed by the weathering of rocks, the void space between the particles containing water and/or air [1]. Soil is a group of mineral, organic matter, and relative loose deposits which located above bedrock [1]. Soil is a fundamental material which very influential from a structure nor construction in civil engineering work [2]. There are also biochemical effects on soil such as CEC, Ph value, and nitrogen becoming the substances exposed [3,4,5]. According to SNI 03- 1743-1989, soil compaction test with laboratory compaction method, using four methods with four molds which is different diameter. The mold used have a diameter of 102 mm, 152 mm, and 152 mm. whereas soil compaction test using the laboratory compaction method divided in to 4 methods with 2 molds that have different diameters, namely 101,6 mm and 152,4 mm [6]. The formulation of this research problem is whether the test result of soil compaction is same if the mold that usually use cylindrical shape turned into cube shape. Due to different soil properties, it is necessary to have same type of soil by conducting a soil physical properties test or atteberg test in order to obtain soil physical properties so as to ensure that the soil used is of the same type. It has a mechanism by cropping its wide spread to be linked with heavy traffic machinery based on field [7]. The impacts of soil compaction have become attention in 1960s [8,9]10]. It covers both an area as the subject and depth [10]. The management of soil compaction consist of improvements on productivity factors and range of biophysical properties in soil [11,12,13,14]. Due to laboratory compaction is divided in two ways, Standard Proctor and Modified Proctor, it is very necessary to do soil compaction using these two methods by using two tools, a manual pulveriser and a modified pressure tool. This research includes comparison of standard proctor and modified proctor soil compaction result either using manual hammers or a modified compactor using soil from Way Urang Village, Padang Cermin district, Pesawaran regency. Using two type of mold are used, which is cylindrical mold with 101,60 mm diameter, and cube mold with a size of 10 x 10 cm. this study uses two types of tools, manual pounder and a modified compactor. The data for comparison is the result of the optimum moisture content (wopt) and also the maximum dry volume weight (γ_{dmax}) obtained at the time of the research. Examining the above problems, this study aims to find out the procedure soil compaction standard proctor & modified proctor using manual pounder, and modified compactor then find out the difference between the use of cylindrical mold and cube mold in compaction process and can be reference for standard formulation for compaction process using cube mold. Soil is described as a material consisting of aggregates (grains), solid minerals that are not sedimented from each other and of decomposed solid particle organic matter accompanied by liquids and gases that fill the empty space or gap between these solid particles [15]. Soil is formed from main material that as undergone weathering or modification due to the dynamics of climatic factors, relief of the earth's surface (topography) and organisms over time [16]. Compaction is a mechanical effort to bring the soil grains together. As a result, the soil volume will decrease because the pore volume decreases but the grain volume does not change [16]. This can be done by crushing or grinding. The principle of the soil compaction process is an effort to reduce the distance between the soil grains (solid) by reducing the volume of air in the soil pores [17]. Basically, soil compaction aims to increase soil stability, increase bearing capacity, reduce soil compressibility, reduce water seepage, control changes in soil volume and prevent erosion. Soil compaction is carried out in two ways, the soil compaction standard proctor and modified proctor. Soil compaction standard proctor using mold with 10 cm (4inch) diameter and 943,3 cm3 (1/30 ft3) volume, which is equipped with a

base and collar. The rammer with weight 5,5 Lbs (2,5 Kg). while soil compaction modified proctor using mold with 10 cm (4inch) diameter or 15 cm (6 inch) and 943,3 cm3 (1/30 ft3) and 2124 cm3 (3/40ft3) volume, which is equipped with a base and collar. The rammer with weight 10 Lbs (4,5 Kg). The compaction test is carried out by collision method, there are 2 collision tools , the hand pounding tool (manual rammer) wich is accordance with the applicable soil compaction standards (SNI, ASTM, AASTHO) and modification compactor which is equipped with a free fall height control device 305 mm ± 2 mm above the ground level to be compacted and can spread the impact evenly over the ground surface. The crusher must have a mass of 2,495 kg ± 0,009 kg and have a round and flat surface of impact, with a diameter of 50,80 mm ± 0,25 mm.

1.1 Use of mold in soil compaction

According to SNI 1742-2008, the molds used in laboratory soil compaction must be of solid-walled metal and made according to the appropriate size and capacity. The mold must be equipped with an attachment neck of the same material as the mold, with a height of approximately 60 mm. the mold and the attachment neck must be securely attached to the base plate which is of the same material and can be removed. On soil compaction standard proctor and modified proctor using a mold diameter of 101,60 mm has a capacity of 943 cm3 ± 8 cm3 and height 116,43 mm ± 0,13 mm. For cubes molds, sized molds are used 1000 cm3 volume with dimensions of 10 cm x 10 cm x 10 cm. The use of molds in the form of cylinders and cubes in this research using the laboratory soil compaction method is intended to determine the value of the maximum dry weight (γ_{dmax} and optimum moisture content. Research using cylindrical tubes has also been carried out whose results state that using a compactor using the Test Machine by Using Control System on Compaction Energy is more effective and gets a compaction value that is close to field compaction [18,19]. soil compaction results in the laboratory by using a new modification compression strength test machine with an energy compaction control system can be an option for selecting heavy equipment that can be used in the field to compact the soil [20,21,22,23].

2. Methodology

Research materials used is a soil sample at Way Urang village, Padang Cermin district, Pesawaran regency, Lampung, Indonesia. Undisturbed soil sample taken using a tube used for water content test, volume weight test, specific gravity test. Disturbed sample taken using hoe then put in the sack which will be used for Atterberg limit test, sieve analysis test, hydrometric analysis test, soil compaction standard proctor and modified proctor, and soil compaction using modification compactor (pressure method). The execution of testing for this research was conducted at Soil Mechanic Laboratory, Engineering Faculty, Lampung University Indonesia tests carried out are as follows:

1) Soil Properties test;
2) Name the sample to be tested;
3) Testing samples with the standard proctor compaction method and modified proctor. In this test, 20 samples will be used consisting of 10 samples with a cylinder mold and 10 samples with a cube mold. Then 3 layers will be used in the standard proctor compaction method and 5 layers of soil in the modified proctor compaction method.

4) Testing sample with the soil pressure method compaction. In this test, 18 cylindrical mold samples and 18 cube molds were used with 3 variations of pressure, 5MPa, 10 MPa, & 15 MPa with 3 samples at each pressure.

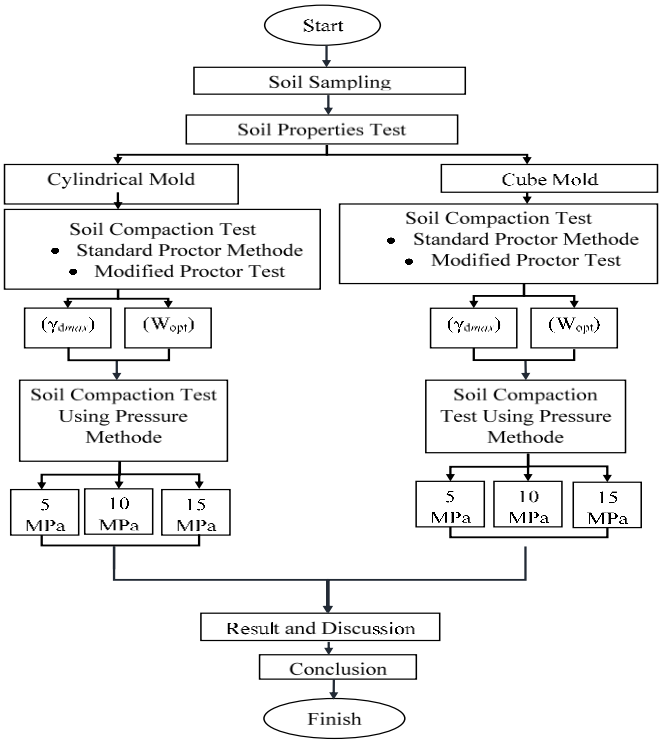

Figure 1: Research Flow Diagram.

3. Results

Soil is formed due to natural weathering of rocks and it takes millions of years for soil formation. Clay minerals are the essential component of a soil in controlling its engineering characteristics and are essential for supporting the plant growth on soils. Soils are used for the manufacture of construction materials such as burnt clay bricks, which are consumed in bulk quantities. Also, it is used in the form of stabilized soil for the manufacture of blocks (stabilized soil blocks and stabilized adobe) and in-situ construction (rammed earth). Stabilized soils have been successfully used for the construction of road subbases. From all laboratory test results regarding the physical and mechanical properties of the soil, it will be explained full in table 1.

Table 1: Soil Sample Testing Result

No	Testing	Result (%)
1	Water Content (w)	41.05
2	Spesic Gravity (Gs)	2.22
3	Atterberg Limit: a. Liquid Limit (LL) b. plastic Limit (PL) c. Plasticity Index (PI)	 47.41 28.45 18.95
4	Sieve Analysis a. Passing Sieve No. 4 b. Passing Sieve No. 200	 92.27 2.37

The results obtained from the filter analysis test No. 200 which is passed by 2,37%. According to the AASTHO classification system, soils from Way Urang Village, Padang Cermin District, Pesawaran Regency, Lampung Province are classified as soil group A-2-7 (silty sand). According to the USCS classification system, based on the USCS classification table, it shows that soil samples from Way Urang Village, Padang Cermin District, Pesawaran Regency, Lampung Province are classified into the SP group, which is poorly graded sand. Figure 2 shows the soil samples for this study.

Figure 2: Soil sample from Way Urang Village, Padang Cermin District, Pesawaran Regency, Lampung Province, Indonesia.

3.1 Soil Compaction Using Cylindrical Mold

From the results of soil compaction experiments using cylindrical tubes can be seen in Figure 3 and table 1. The experiment was carried out with 5 repetitions with 5 different water content values, in order to get the maximum dry density and optimum water content.

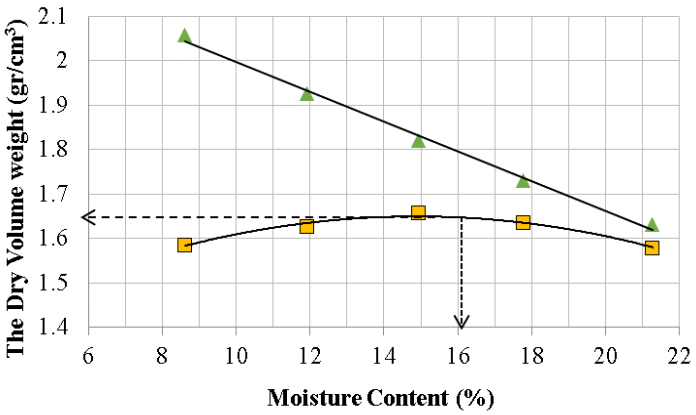

Figure 3: The Relationship of dry volume weight and moisture content of soil compaction standard proctor

According to figure 3. It can be seen that maximum dry volume weight is 1.64 gr/cm^3 and the optimum moisture content value is 16.24%. Based on the result of the soil compaction test using the standard proctor pressure method, the dry volume weight value and the moisture content is obtained as in the table 1. below.

Table 2: The Relationship Between Dry volume weight and Moisture content of soil compaction standard proctor

Pressure (MPa)	5.0	10.0	15.0
Dry Volume weight (gr/cm³)	1.47	1.48	1.51
Moisture content (%)	19.46	19.79	19.88

Based on the result of the soil compaction test using the modified proctor pressure method, the dry volume weight value and the moisture content is obtained as in the table 2. Below

Table 3: The Relationship Between Dry Volume Weight and Moisture Content of Soil Compaction with Modified Proctor

Pressure (MPa)	5.0	10.0	15.0
Dry Volume weight (gr/cm³)	1.65	1.67	1.68
Water content (%)	16.89	16.96	17.08

3.2 Soil Compaction Using Cube Mold

The soil compaction experiment also uses a cube mold which will later compare the results with the mold cylinder, shown in Figure 4 and table 2. The experiment was carried out with 5 repetitions with 5 different water content values, in order to get the same maximum dry density and optimum water content. like how to test with a cylinder mold.

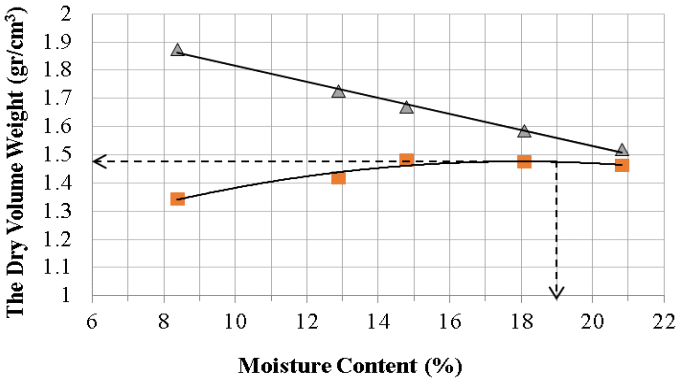

Figure 4: The Relationship of Dry Volume Weight and Moisture Content of Soil Compaction with Standard Proctor

Based on the figure 4, it can be seen that the maximum dry volume weight is 1,48 gr/cm^3 and the optimum moisture content value is 19.00%.

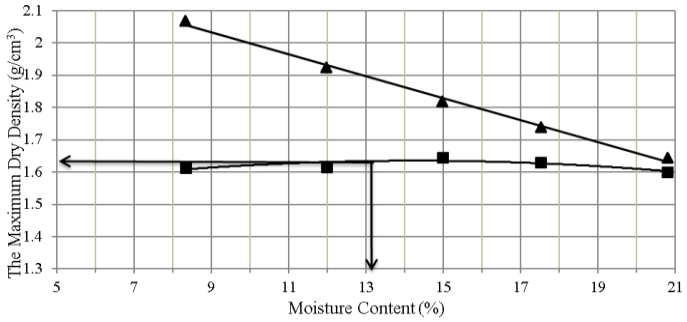

Figure 5: The Relationship of Dry Volume Weight and Moisture Content of Soil Compaction Modified Proctor

According to figure 5. It can be seen that maximum dry volume weight is 1.635 gr/cm^3 and the optimum moisture content value is 15.15%. Based on the result of the soil compaction test using the standard proctor pressure method, the dry volume weight value and the moisture content is obtained as in the table 4 below.

Table 4: The Relationship Between Dry volume weight and Moisture content of soil compaction with standard Proctor method

Pressure (MPa)	5.0	10.0	15.0
Dry Volume Weight (gr/cm^3)	1.48	1.49	1.51
Moisture Content (%)	19.39	19.51	19.65

Based on the result of the soil compaction test using the modified proctor pressure method, the dry volume weight value and the moisture content is obtained as in the table 4. Below.

Table 5: The Relationship Between Dry Volume Weight and Moisture Content of Soil Compaction with Modified Proctor Method.

Pressure (MPa)	5.0	10.0	15.0
Dry Volume Weight (gr/cm³)	1.64	1.69	1.72
Moisture Content (%)	15.83	16.30	16.54

3.3 Comparison of Soil Compaction Test Results Using Cylindrical and Cube Molds

The test results will be evaluated after the soil testing using cylindrical molds and cube molds with various soil compaction test methods are completed. The results are corrected to see how accurate the effect of the soil compaction test using cube molds is.

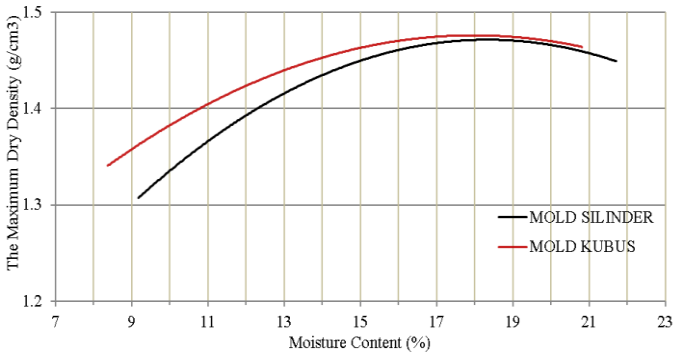

Figure 6: The Comparison Soil Compaction Standard Proctor Collision Method Using Cylindrical and Cube Mold

According from the figure 6. it can be seen that optimum moisture content value for cylindrical mold is 19.00% and form cube mold is 19.00%, with the correction value 100%. Whereas maximum dry volume weight for cylindrical mold is 1.457 gr/cm³ and for cube mold is 1.463 gr/cm³ with the correction value is 99.58%.

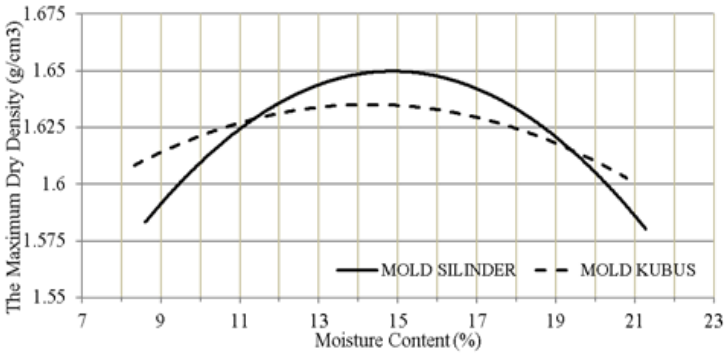

Figure 7: The Comparison Soil Compaction Modified Proctor

3.4 Method Using Cylindrical and Cube Mold

According from the figure 7. it can be seen that optimum moisture content value for cylindrical mold is 19.00% and form cube mold is 19.00%, with the correction value 100%. Whereas maximum dry volume weight for cylindrical mold is 1,46 gr/cm³ and for cube mold is 1.46 gr/cm³ with the correction value is 99.58%. It is known that the results of the comparison of the results of the standard proctor soil compaction test using pressure method are as follows:

Table 6: The Comparison Soil Compaction Standard Proctor with Pressure Method

Mold Type	Cylindrical			Cube		
Pressure, (MPa)	5.0	10.0	15.0	5.0	10.0	15.0
Dry Volume Weight (gr/cm³)	1.47	1.48	1.51	1.48	1.49	1.51
Water Content (%)	19.46	19.79	19.88	19.39	19.51	19.65

Table 7: The Correction Result of Soil Compaction Standard Proctor with Pressure Method

Pressure, (Mpa)	5.0	10.0	15.0
Dry Volume Weight Correction (%)	99.45	98.84	99.51
Moisture Content Correction (%)	99.63	98.62	98.83
Average Dry Volume Weight Correction (%)	99.27		
Average Moisture Content Correction (%)	99.03		

Whereas for comparison of the results of the soil compaction modified proctor test pressure method is as follows:

Table 8: The Comparison Soil Compaction Modified Proctor with Pressure Method

Mold Type	Cylindrical			Cube		
Pressure (MPa)	5.0	10.0	15.0	5.0	10.0	15.0
Dry Volume Weight (gr/cm³)	1.65	1.66	1.51	1.48	1.49	1.51
Water Content (%)	16.89	16.89	19.88	19.4	19.51	19.65

Table 9: The Correction Result of Soil Compaction Modified Proctor with Pressure Method

Pressure (MPa)	5.0	10.0	15.0
Dry Volume Weight Correction (%)	99.27	98.82	97.72
Moisture Content Correction (%)	93.74	96.52	97.96
Average Dry Volume Weight Correction (%)	98.60		
Average Moisture Content Correction (%)	96.07		

4. Conclusion

The soil sample used in this research based on the AASHTO classification system were classified in A-2-7 (silty sand) and classified into the SP group, poorly graded sand based on the USCS classification system. It is more effective to use a cylindrical mold for soil compaction than a cube mold from the point of view of tool use. Due to the use of a more compact tool using a cylindrical mold. Not only that, but also the availability of the cylindrical mold is more alleviable in the field than the cube mold. But the cube mold research can be continued with further research, namely the falling head permeability system. The use of cylindrical mold and cube mold in soil compaction has similar result. Due to the correction value of the maximum dry volume weight value is 99,58% and the optimum moisture content correction value is 100% in soil compaction standard proctor. In the soil compaction modified proctor, the maximum dry volume weight correction value is 98,81% and the optimum moisture content correction value is 93,29%. The use of cylindrical mold and cube mold also have similar result after did a soil compaction pressure method using modification compactor with the correction dry volume weigh value is 99,27%, and for optimum moisture content value is 99,03%. In soil compaction standard proctor. In soil compaction modified proctor, the dry volume weight correction value is 98,60% and for the moisture content value is 96,70%.

5. Limitation

This study is focused on the clay soil compaction which are cemented materials and when exposed to normal weathering process will take a long time (may be several decades) to disintegrate into smaller particles. In order to examine the stabilized soil compacts for the presence of clay minerals the samples have to be crushed to a powder form.

6. Recommendation

It is recommended for the researchers and affiliated stakeholders to have further investigations to reveal that it is possible to retrieve a large percentage of natural clay minerals in cement stabilized soil products when subjected to either accelerated or natural weathering process. Whereas in lime-stabilized soil products only a small fraction of the clay minerals which were present in the soil can be retrieved.

Acknowledgement

The authors would like to say huge thankfulness for the real support and courage to finish this research to paper as the output both in supervision and financial perspective.

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