VOL. 12, NO. 17, SEPTEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

BEHAVIOUR CHANGE IN PEAT STABILIZED WITH FLY ASH AND LIME $CaCO_3$DUE TO WATER INFILTRATION

Noor Endah Mochtar[1] and Faisal Estu Yulianto[2]
[1]Department of Civil Engineering, Institut Teknologi Sepuluh, ITS, Surabaya, Indonesia
[2]Department of Civil Engineering, Madura University, Pamekasan, Indonesia
E-Mail: noormochtar@gmail.com

ABSTRACT

Stabilization method for fibrous peat is more beneficial than other soil improvement methods; it is cheaper and environmental friendly. Therefore, it has been developed continuously to obtain the optimum results. The previous study shows that 10% of admixture (lime $CaCO_3$+fly ash) causes bearing capacity of the stabilized peat increases and its compression decreases. However, the study was carried out without considering the field condition where the area of stabilized peat was only as wide as the area that will be built. It means that the surrounding of the stabilized peat is still the original peat with very high water content. Consequently, water from the original peat will infiltrate into the stabilized peat area which has smaller voids and lower water content. Based on this consideration, the study was carried out to check the effect of water infiltration to the behaviour of stabilized peat. This field condition was imitated in the laboratory model by putting the stabilized peat in the middle of the original peat. The admixture (lime $CaCO_3$+fly ash) used was 10% and the stabilized peat parameter was observed until 180 days. The results show that behaviour of stabilized peat w/o-infilt improve rapidly because formation of $CaSiO_3$ gel is faster; however, in short curing period (90 days), its shear strength drops drastically and its compression becomes bigger. On the other hand, $CaSiO_3$ gel formation of stabilized peat w-infilt is slow due to $CaSiO_3$ gel formation is disturbed by water infiltration. As a result, its behaviour improves slowly and the optimum results of the stabilized peat w-infilt reaches when the curing periods longer than 120 days. It also figures out that water infiltration gives a good effect to the behaviour of stabilized peat.

Keywords: CaS_iO_3 gel, curing period, fibrous peat, fly ash,rice husk ash, stabilization.

INTRODUCTION

Stabilization method for fibrous peat soil is more beneficial compared to the other soil improvement methods [1, 2,3] so that this stabilization method is continuously developed to obtain the optimum result. Harwadi and Mochtar, N.E.[4] proposed new admixture material as a mixture of side product of fertilizer industry (lime $CaCO_3$) and side product of steam power electric generator (fly ash). By using 10% of admixture (lime $CaCO_3$+fly ash), the bearing capacity of the stabilized peat increases and its compression decreases significantly [4]. It is due to the $CaSiO_3$ gel (formed by lime $CaCO_3$+fly ash) fills the pores and wraps the peat fibres. Afterwards, however, these physical and engineering behaviour of the stabilized peat drop almost to the initial condition. It is due to the decomposition process [5, 3, 6] and by the $CaSiO_3$ gel shrinkage due to pore water decrement [7, 8, 9].

The amount of admixture used for peat stabilization is also influenced by availability of water in the pores [10, 11]. Because of that, it needs special attention when carrying out peat stabilization in the field. It is because water from the original peat will infiltrate and will influence the stabilized peat behaviour. Based on that hypothesis, this research has been carried out and the results are reported in this paper.

PEAT STUDIED AND RESEARCH METHODOLOGY

The fibrous peat studied was taken from Bareng Bengkel, Palangkaraya, Central Kalimantan. Its physical and engineering behaviour were determined as explained in Peat Testing Manual [12]. According to ASTM [13] and Von Post [14] the fibrous peat studied is classified as "peat soil (hemic)with low ash content and high acidity"[2, 3, 4].

In order to figure out the effect of water infiltration from the original peat into the stabilized peat, as the real field condition, physical model was carried out in the laboratory. As shown in Figure 1, the stabilized peat was placed between the original peat where its water content was kept constant (630%). In this experiment, water from the original peat was allowed to infiltrate into the stabilized peat continuously.

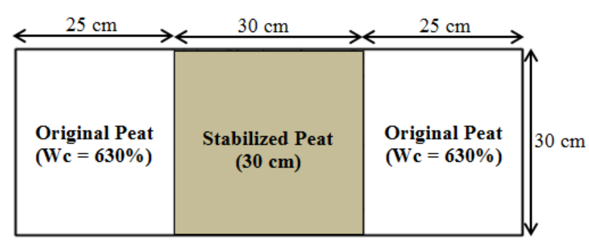


Figure-1. Physical model in laboratory.

FORMATION OF $CaSiO_3$ GEL

Lime $CaCO_3$ is very good material for filler [7], especially for fibrous peat which dominated by pores as shown in Figure-2. For stabilization material, however, lime is not able to give good results like the one used for clay soil;it is because peat has no silica content so that $CaSiO_3$ gel is not developed [4].

When the $CaCO_3$ is mixed with fly ash which has silica (SiO_2) content, the $CaSiO_3$ gel will develop and it

ARPN Journal of Engineering and Applied Sciences

will fulfill pores of the peat as shown in Figure-3. As a result, peat stabilized with admixture of $CaCO_3$ + SiO_2 will have smaller pores and will reduce the peat compressibility and increase its strength.

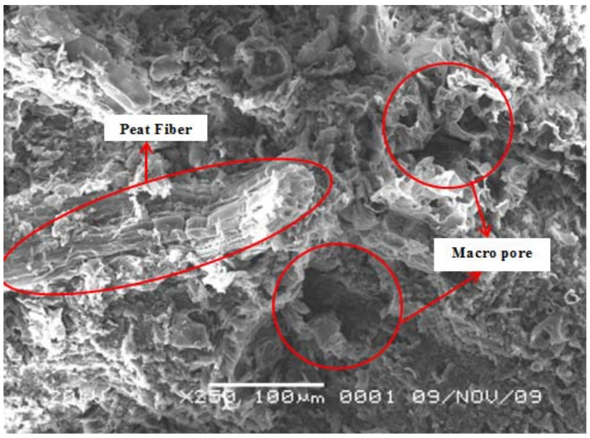


Figure-2. SEM of initial peat (Yulianto and Mochtar, NE., 2012).

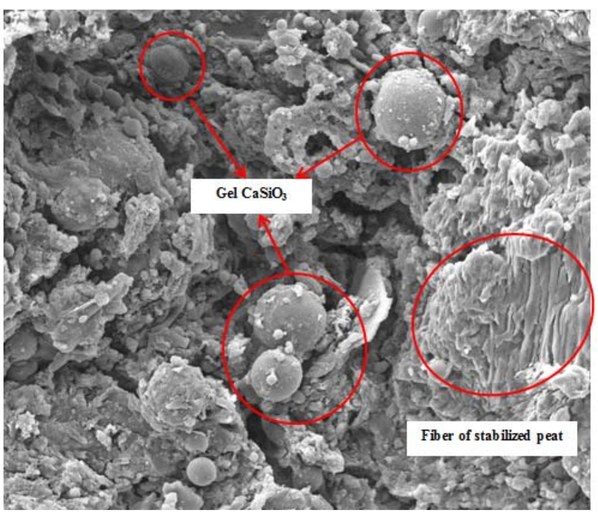


Figure-3. SEM of the stabilized peat where $CaSiO_3$ gel fulfil the pores of the fibrous peat (Yulianto and Mochtar, NE., 2012).

THE EFFECT OF WATER INFILTRATION AND CURING PERIOD TO THE WEIGHT OF SUBSTANCES OF THE STABILIZED PEAT

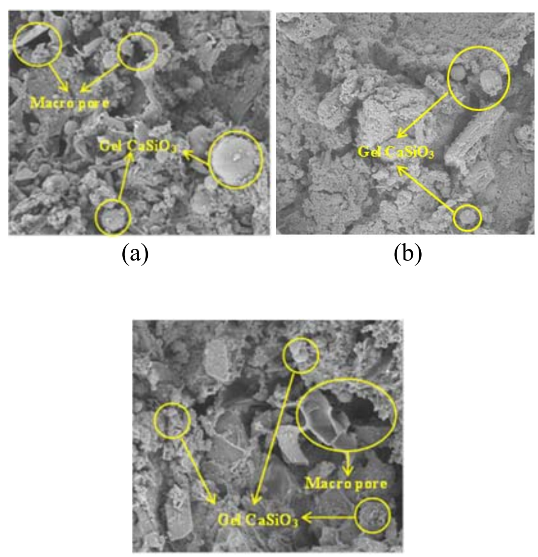
By performing SEM EDX test, the weight of substances of the stabilized peat undergone water infiltration can be determined as shown in Table-1. From these results, it is known that substances of silica (Si), lime (Ca), and oxygen (O) increase from the initial value as results of introducing admixture into peat soil; however, carbon (C) substances decreases. These are in line with the one studied by Fung, *et al*. [15] in which the water content decrement during the $CaSiO_3$ gel formation causes the CO_2 is released from the stabilized peat. The decrement of CO_2,

Table-1. Substance of stabilized peat soil.

No.	Substance		Initial	Curing periods (Days)		
				30	120	180
1	C	%	71.87	54.2	34.36	36.72
2	O	%	27.32	30	37.03	29.28
3	Si	%	0.36	3.88	4.27	1.92
4	Ca	%	0	3.12	2.95	6.44

however, is very small compared to the one caused by drastic water content decrement [16].

The SEM EDX images of the stabilized peat at different curing periods are given in Figure-4. Figure-4a shows the $CaSiO_3$ gel fulfilled only parts of the peat pores; it is because the limitation of the $CaSiO_3$ gel formed during 30 days of curing periods or it is due to the admixture is not enough to form gel to fulfilled the entire pores. At 120 days of curing period (Figure 4b), the pores are still not entirely fulfilled by the gels; it confirms that more admixture is needed in order to fulfilled all pores. At 180 days of curing periods, pores of stabilized peat become bigger (Figure-4c); it is suspected that the $CaSiO_3$ gel changes to be crystal [9].



(a) (b)

(c)

Figure-4. Image SEM EDX of stabilized peat cured at (a) 30 days,(b) 120 days, and (c) 180 days.

The effect of curing period to the weight of Si, O, and Ca substances can be seen in Figures, 5, 6, and 7, respectively. The Si substance (Figure-5) increases when the curing period reach 30 days and then it is about constant until 120 days of the curing period; it shows that more admixture is needed to form silica. After 120 days of curing periods, however, the weight of Si substance

ARPN Journal of Engineering and Applied Sciences

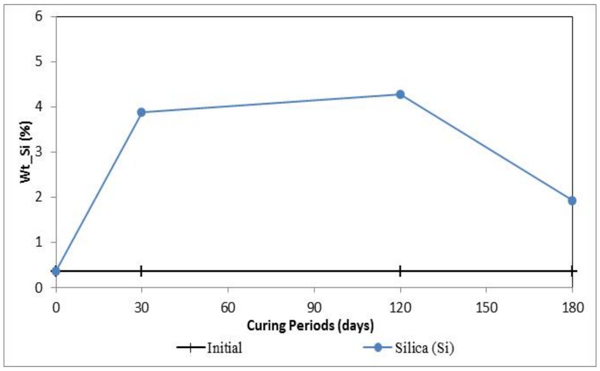


Figure-5. The effect of curing period to the weight of silica substance (Wt_Si) in stabilized peat.

decreases. It shows that disturbance process of $CaSiO_3$ gel by water infiltration takes place.

As shown in Figure-6, the effect of curing period to the weight of calcium substance (Wt_Ca), until curing period reach 120 days, is similar to the one of silica substance. When curing period longer than 120 days, however, the Wt_Ca increases drastically. It could be because the admixture is not mixed thoroughly so that sample tested contains more Ca than Si. It is as explained by Jelisic and Lappanen [1] and Mochtar, NE., *et al.* [3] that it is difficult to mix admixture and peat during peat stabilization process.

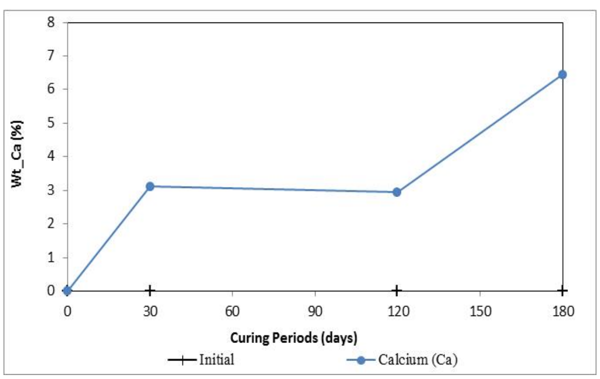


Figure-6. The effect of curing period to the weight of calcium (Wt_Ca) in stabilized peat.

The weight of oxygen (Wt_O) increases with the increase of curing period until it reaches 120 days, as shown in Figure-7. When the curing period longer than 120 days where the disturbance process of $CaSiO_3$ gel by water infiltration takes place, however, the weight of oxygen decreases. It shows similar behaviour with the weight of Si (Wt_Si).

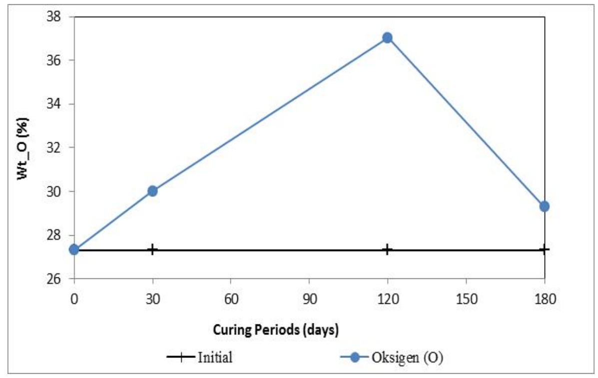


Figure-7. The effect of curing period to the weight of oxygen (Wt_O) of stabilized peat.

Formation process of $CaSiO_3$ gel is also able to be detected from decrement of the organic content (Oc) of the stabilized peat (Figure-8). At the beginning of the stabilization process where pore water is still available, the organic content (Oc) drops drastically; it means that the admixture using the pore water to form $CaSiO_3$ gel [6, 10, 11]. Afterwards, decrement process of the organic content becomes slower until the curing periods reaches 120 days; it means that the $CaSiO_3$ gel formation isstill taking place but the availability of pore water is limited. When the

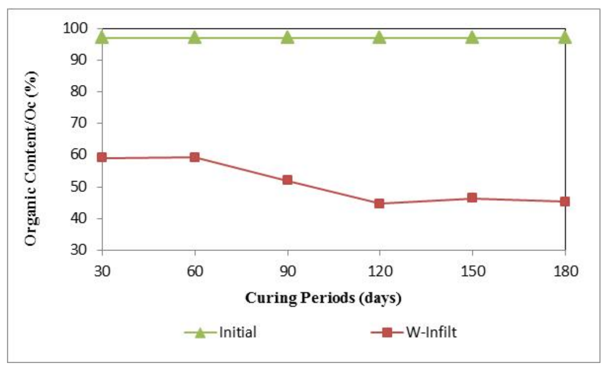


Figure-8. The effect of curing period to the organic content (Oc) of stabilized peat.

curing periods longer than 120 days, the organic content is about constant. This condition can be because no more $CaSiO_3$ gel formation do to the disturbance process of $CaSiO_3$ gel by water infiltration takes place [8, 9].

THE EFFECT OF WATER FILTRATION TO THE BEHAVIOUR OF STABILIZED PEAT

Figure-9 shows the value of unit weight of the stabilized peat with infiltration (w-infilt) and without infiltration (w/o-infilt). Due to addition of admixture as the stabilization material, its unit weight (γt) of stabilized peat w/o-infilt increases significantly. However, the unit weight increment of the stabilized peat w-infilt is not that high due to the disturbance of CaSiO3 gel formation by water infiltration. It is the same with the one found by Mullin, [8] and Toyukura, [9].

VOL. 12, NO. 17, SEPTEMBER 2017 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

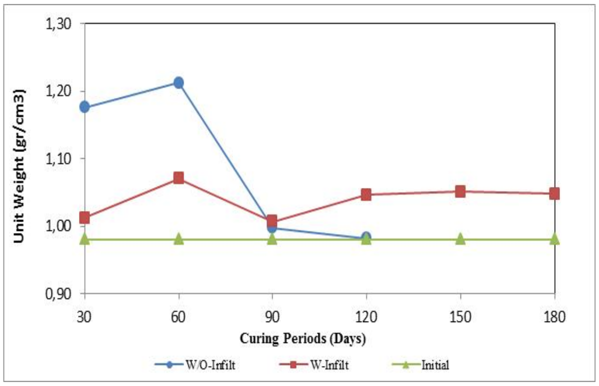


Figure-9. Influence of the water infiltration to the value of unit weight of the stabilized peat w-infilt and w/o-infilt.

When the curing periods reaches 90 days, the unit weight of stabilized peat with and without infiltration decreases. Afterword, the unit weight of stabilized peat w/o-infilt continue decreases until it reaches the initial unit weight; it shows that there is no more water available in the pores to form the gel so that decomposition process starts taking place [3, 5, 6, 7, 9]. On the other hand, the unit weight of the stabilized peat w-infilt increases and then becomes constant. It shows that the stabilized peatw-infilt has enough water in the pores to form the $CaSiO_3$ gel; after 120 days of curing periods, its unit weight is about constant because the gel formation about finishes.

The condition above is also can be seen from the value of water content (wc) that plotted in Figure-10. Water content of the stabilized peat w/o-infilt decreases more significant than the one of stabilized peat w-infilt. It is because the stabilized peat w/o-infilt has no water supply from water infiltration during the $CaSiO_3$ gel formation. After 120 days of curing periods, the water content of stabilized peat w-infilt increases slightly; it is because the gel formation about finishes and at the same time, the water infiltration continues taking place.

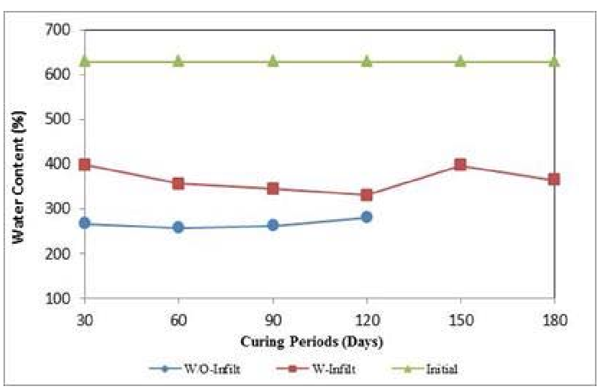


Figure-10. Influence of the water infiltration to the value of water content of stabilized peat w-infilt and w/o-infilt.

The admixture introduced in peat as stabilization material also influences the value of its specific gravity; it is because the admixture increases the mineral content of the stabilized peat [3 and 17]. This condition is also experienced by the peat studied herein (Figure-11), where the Gs value of the stabilized peat increases significantly.

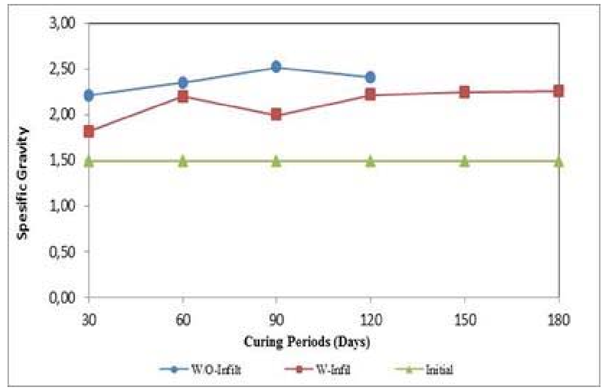


Figure-11. Influence of the water infiltration to the value of Gs of stabilized peat w-infilt and w/o-infilt.

Until 120 days of curing periods, the Gs value of stabilized peat w/o-infilt is still higher than the one of stabilized peat w-infilt. This could be because of the disturbance of $CaSiO_3$ gel formation by water infiltration so that its formation becomes slower. As a result, the Gs value of the stabilized peat w-infilt is lower than the one of the stabilized peat w/o-infilt. When the curing periods is longer than 120 days, the Gs value is about constant; it is in line with other parameters (γt and wc) discussed previously.

Shear strength of the stabilized peat w-infilt dan w/o-infilt (Figure-12) show similar behaviour with the other parameters (γt, wc, and Gs). At the beginning of the stabilization process, the stabilized peat w/o-infilt has higher shear strength than the one w-infilt. This condition confirms that the $CaSiO_3$ gel formation is faster for stabilized peat w/o-infilt because no water disturbance by infiltration. At 90 days of curing period, however, shear strength of the stabilized peat w/o-infilt drops drastically until it reaches less than the initial shear strength. This condition is in line with the γt value that due to peat fibre decomposition. On the other hand, shear strength of the stabilized peat w-infilt increases very slowly and it reaches the highest value at 120 days curing period. It shows that the water infiltration causes the gel formation occur very slowly, so that, the shear strength increment is slowly too.

ARPN Journal of Engineering and Applied Sciences

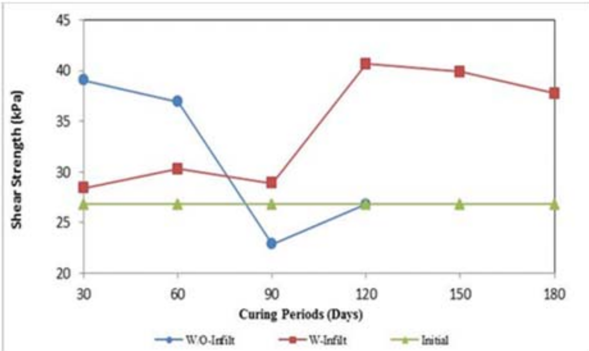


Figure-12. Influence of the water infiltration to the shear strength of stabilized peat w-infilt and w/o-infilt.

As mention previously that pores of stabilized peat are filled by $CaSiO_3$gels so that peat compression of the stabilized peat has to be reduced significantly. The result shown in Figure-13, however, the compression curve is inconsistent; it can be due to fibre decomposition or due to the admixture materials is not mixed thoroughly with peat. When the curing period longer than 120 days, the compression curve of the stabilized peat w-infilt shows different behaviour where its total compression keeps reducing. It shows that the gel keeps filling the pores so that the stabilized peat becomes less compressible. As a result, the compression keeps reducing slowly.

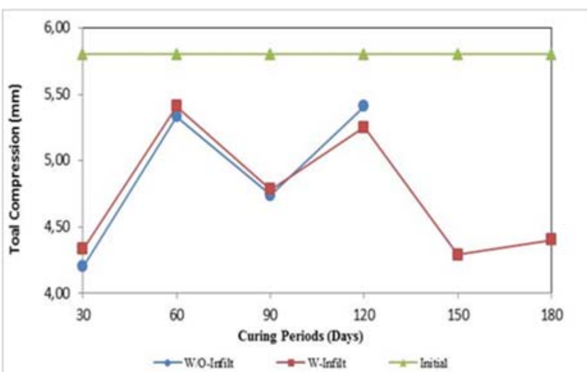


Figure-13. Influence of the water infiltration to the compression behaviour of stabilized peat w-infilt and w/o-infilt.

CONCLUSIONS

Based on the analysis given above, it can be concluded as follows:

a) Weight of Si, O, and Ca substances are affected by curing period and by water infiltration. They increase with the increase of curing period (until 120 days); when curing period longer than 120 days, they decrease except weight of Ca.
b) Behaviour of the stabilized peat w/o-infilt improves rapidly because formation of $CaSiO_3$ gel is faster; in short curing period (90 days), its shear strength drops drastically and its compression becomes bigger.
c) Behaviour of the stabilized peat w-infilt improves slowly due to water infiltration disturbance during $CaSiO_3$ gel formation; the optimum results of the stabilized peat w-infilt are obtained after the curing period reaches 120 days.
d) Water infiltration gives a good effect to the behaviour of the stabilized peat because the infiltrated water retards the decomposition process of peat fibres.

REFERENCES

[1] Jelisic N., Leppänen M. 2001.Mass Stabilization of Peat in Road and Railway construction.Swedish Road Administration, SCC-Viatek Finlandia.

[2] Yulianto F.E. and Mochtar, N.E. 2010.Mixing of Rice Husk Ash (RHA) and Lime for Peat Stabilization.Proceedings of the First Makassar International Conference on Civil Engineering (MICCE2010), March 9-10.

[3] Mochtar N.E, Yulianto F.E., Satria T.R. 2014. Pengaruh Usia Stabilisasi pada Tanah Gambut Berserat yang Distabilisasi dengan Campuran $CaCO_3$ dan Pozolan.Jurnal Teknik Sipil ITB (Civil Engineering Journal ITB). 21(1): Hal 57-64.

[4] Harwadi F. and Mochtar N.E. 2010. Compression Behaviour of Peat Soil Stabilized with Environmentally Friendly Stabilizer.Proceedings of the First Makassar International Conference on Civil Engineering (MICCE2010), March 9-10.

[5] Huttunen E. and Kujala K. 1999. On the stabilization of organic soils. Proceedings of the 2nd International Conference on Ground Improvement Geosystem, IS-Tokyo 96. 1: 411-414.

[6] Mochtar N.E and Yulianto FE. 2016. The Effect of Curing Period and Thickness of Stabilized Peat Layer to The Bearing Capacity and Compression Behaviour of Fibrous Peat. ARPN Journal of Engineering and Apllied Science. 11(19): 2150-2153.

[7] Ingles, O. G and Metcalf, J. B. 1979. Soil Stabilization. Principles and Practise. Butterworths, Sydney Australia.

[8] Mullin J. W. 1972.Crystallization, Butterworths, London.

[9] Toyukara Ken *et al.*1982.CrystallizationVolume I & II, JACE Design Manual Series, Tokyo.

ARPN Journal of Engineering and Applied Sciences

[10] Kusumawardani M & Mochtar N.E. 2012. Experiment on Fibrous Peat Subjected to Reduction of Water Content, Proceeding of 8^{th} International Symposium on Lowland Technology.

[11] Yulianto F.E., Ma'ruf A.M., Mochtar N.E. 2014.Pengaruh filtrasi Air pada Tanah Gambut yang Distabilisasi dengan Campuran Kapur+Abu Sekam Padi,Prosiding Konferensi Teknik Sipil_8 (KONTEKS_8), 16-18 October, Bandung.

[12] Canada National Research Council (CNRC) 1979, Muskeg Subcommittee 1979; Peat Testing Manual; Technical memorandum 125, 193p.

[13] ASTM Annual Book. 1992. Standard Classification of Peat Samples by Laboratory Testing (D4427-92), ASTM, Section 4, Volume 04.08 Soil and Rock, Philadelphia.

[14] Von Post, L. 1992. Sveriges Geologiska Undersoknings Torvinventering Och Nagre av Dess Hittills Vunna Resultat, *Sv*. Mosskulturfor. Tidskr. 1:1-27.

[15] Fung I Jhon, *et al*. 1991. Global Budget if Atmospheric Methane: Result from Three Dimensional Global Model Syntesis.Journal of Geophysical Research. 6: 13033-13065.

[16] Sabiham S. 2010. Properties of Indonesian Peat in relation to The Chemistry of Carbon Emission. Proceeding of International Workshop on Evaluation and Sustainable Management of Soil Carbon Sequestration in Asian Countries, Bogor, Indonesia.

[17] MacFarlane, I.C. dan Radforth, N.W. 1965. A Study of Physical Behaviour of Peat Derivatives Under Compression. Proceeding of The Tenth Muskeg Research Conference. National Research Council of Canada, Technical Memorandun No. 85.