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Compression Behavior of Fibrous Peat Stabilized with Admixtures of Lime CaCO3+Rice Husk Ash and Lime CaCO3+Fly Ash

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***Abstract*— Compression behavior of stabilized fibrous peat has similar behavior with the initial one. Therefore, one step loading consolidation test is still applicable for the stabilized fibrous peat to predict its compression. The stabilized fibrous peat behavior, however, still depends on the type of the admixture used and stabilization age or curing period. Based on that reason, this study was carried out to study the change of compression behavior of the stabilized peat and to know whether the correction curves developed for laboratory compression parameters are still applicable to predict the settlement of the stabilized peat in the field. For this purpose, two types of stabilizing material adopted, admixtures lime CaCO3+Rice Husk Ash (admix-1) and lime CaCO3+Fly Ash (admix-2). The stabilized peats were cured and tested at different curing periods 20, 30, 45, 60 and 90 days to check their behavior changes. Besides, laboratory models of peat stabilized at different layer thicknesses 1/3H, 2/3H, and H (H=peat sample thickness) were carried out to monitor their settlement under 50kPa load at different curing periods. This settlement is then compared with the predicted settlement. The results show that the fibrous peat stabilized with admixture-2 gives better behavior improvement than the one stabilized with admix-1; it is, however, then slightly decreases after 60 days of curing periods due to the fiber decomposition. Peat stabilized with admix-2 also give first settlement prediction when it is compared to the settlement of stabilized peat in the laboratory model.**

***Keywords*— admixture; compression; fibrous peat; fly ash; laboratory model; lime CaCO3; rice husk ash; stabilization**

I. INTRODUCTION

Peat is a soil which has very high organic content (≥75%) as a product of organic materials decomposition [1]. For fibrous peat which has a fiber content of more than 20% [2], the fibers dominantly influence its characteristics especially its compression behavior [3], [4]. The e vs. log σ curve of fibrous peat has two straight lines, and ΔH vs. log t curve has four components of compressions [4]. In this case, the Terzaghi consolidation method [5] is not applicable to fibrous peat soil.

In 1979, Gibson Lo model was adopted to evaluate the compression behavior of the fibrous peat [7]. For this method, it is used one step loading consolidation test in the laboratory and the load applied is the same as the load in the field. Parameters obtained from the laboratory test are primary compression factor (a), secondary compression factor (b), and rate factor for secondary compression (λ/b). To predict the field settlement, the laboratory parameters are corrected using the correction curves [8]. This method had been successfully applied for Palangkaraya fibrous peat [9].

To improve the compression behavior of the fibrous peat, stabilization method using admixture materials was adopted [10]-[12]. They figured out what type of admixture used and its curing period affects the stabilization results. Their effect on the stabilized fibrous peat compression will be discussed in this paper. Besides, the prediction of stabilized peat settlement using the correction curve [8] is also be presented.

II. MATERIAL AND METHOD

The research reported herein was carried out in the Soil Mechanics laboratory. Materials used were fibrous peat, lime CaCo3, rice husk ash (RHA), and fly ash (FA). The fibrous peat was taken from Barengbengkel, Palangkaraya, Central Kalimantan. In Fig. 1, Scanning Electron Microscope (SEM) of the peat studied is presented, and its parameters are given in Table 1. Peat parameters were determined based on Peat Testing Manual [13]. From those parameter values, the peat studied was classified as "Hemic Peat soil with Medium Ash Content and Highly Acid" (Standard Classification of Peat Samples by Laboratory Testing ASTM D4427-92 [14]).

There were two types of admixture used in this study; those were an admixture of 30% lime CaCO3+70% RHA (admix-1) and admixture of 30% lime CaCO3+70% FA (admix-2). For fibrous peat stabilization, the amount of admixture used in this study was 10% of the wet weight of peat stabilized[10], [12].

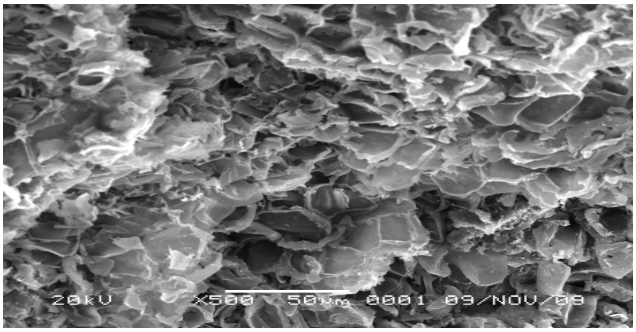


Fig. 1 Scanning Electron Microscope (SEM) of peat studied

TABLE I
PARAMETERS OF FIBROUS PEAT STUDIED

Parameters		**Fibrous Peat Studied**	**Others Researchers**
Wet Unit Weight	t/m3	1.06	0.9-1.25
Specific Gravity	-	1.78	1.4 – 1.7
Water Content	%	712.04	750-1500
Void ratio	-	12.67	6 - 15
Organic Content	%	94,56	62 – 98
Ash Content	%	5.44	2 – 37.5
pH	-	3.1	4-7
Fiber Content	%	39,48	39 - 62
Coarse Size Fiber	%	56.25	-
Medium Size Fiber	%	29.38	-
Fine Size Fiber	%	14.37	-
Shear Strength	kPa	0.87	
Total Compression	mm	5,5	-

In this study, there were two sizes of boxes used to place the stabilized peat; those were small boxes 30x30x40cm (Fig. 2) and big boxes 70x60x100cm (Fig. 3). The samples in small boxes were used to determine the physical and compression parameters of the stabilized peat at a different age or curing period 20, 30, 45, 60 and 90 days. The big boxes were used as laboratory model; samples in these models were stabilized in different thickness, those were 1/3H, 2/3H, and H; H was the sample thickness of 30 cm. After curing period of the stabilized samples reach 20 days, the samples were loaded step by step until it reached 50 kPa. The compression caused by the load applied was monitored in 20, 30, 45, 60 and 90 days.

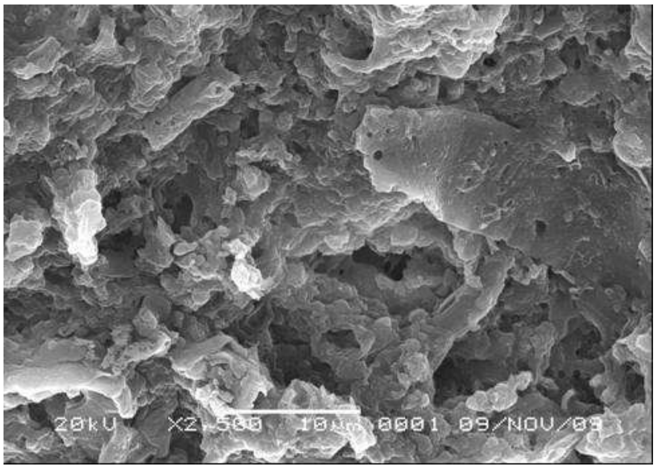
Fig. 2 Stabilized peat in small box 30x30x40 cm

Fig. 3 A laboratory model of stabilized fibrous peat

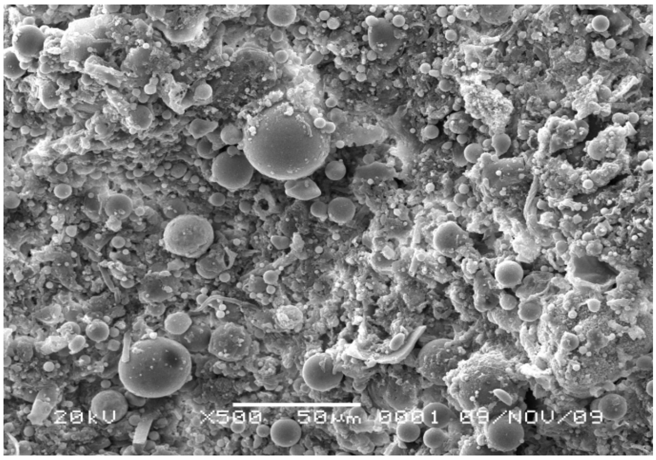
III. RESULT AND DISCUSSION

A. The Stabilized Fibrous Peat

Figs. 4a and 4b are the results of Scanning Electron Microscope (SEM) of the fibrous peat stabilized with admix-1 and admix-2, respectively. Fig. 4a shows clearly the burned fiber of rice husk ash; the granular of fly ash can also be seen in Fig. 4b. From those two figures, it can be seen that grains formed by admix-2 could fill the pores. As a result, fibrous peat stabilized with admix-2 has better density than the one stabilized with admix-1.



(a)



(b)

Fig. 4 SEM of peat stabilized with: (a).10% admix-1 (lime $CaCO_3$+ RHA), (b).10% admix-2 (lime $CaCO_3$+ fly ash), (Mochtar, N.E., et al [15])

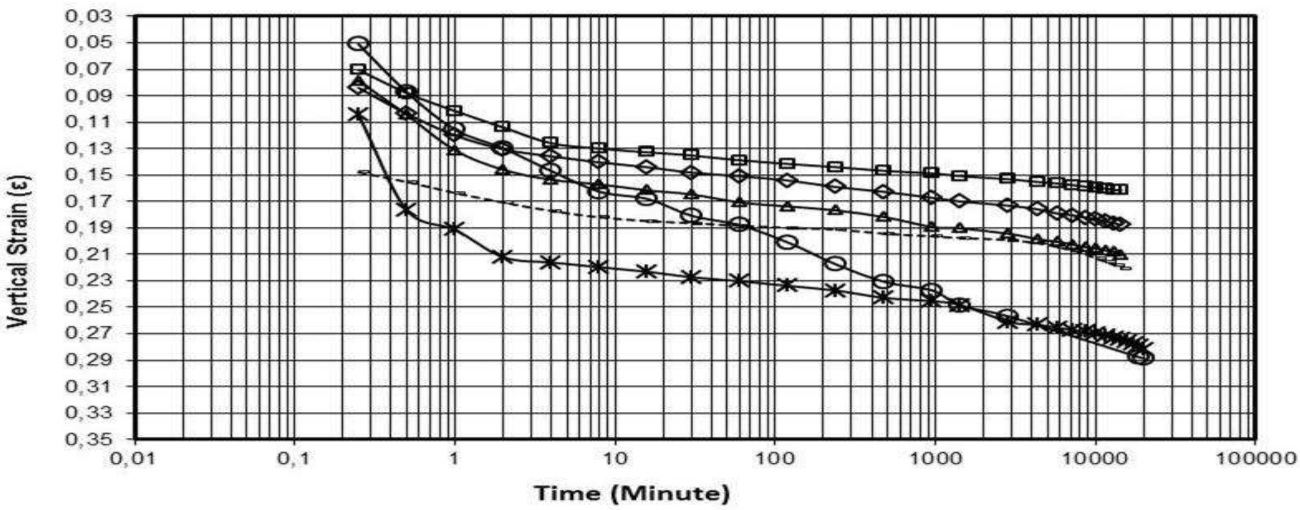


Fig. 5 Compression curves of one step loading consolidation test of fibrous peat stabilized with 10% admix-1 (Lime + RHA) at different curing period: 20, 30, 45, 60, and 90 days

B. Compression Rate of The Stabilized Fibrous Peat

Compression curves of the fibrous peat stabilized with 10% admix-1 and 10% admix-2 are given in Figs. 5 and 6, respectively. For samples with 20 and 30 days of the curing period, their curves are parallel to the curve of the initial peat. It means that the compression rates of the stabilized peat are similar to the one of the first peat. Their compressions, however, are smaller as shown where the compression curves of the stabilized peat are plotted above the initial ones. It can be stated that process of the $CaSiO_3$ gel formation still takes place because water in the pores is still available [16], [17].

When the curing period of the stabilized peat reaches 45 days, both stabilized peats show similar compression rates but they are slightly higher than the one of the first peat. Besides, the compression curve of peat stabilized with admix-1 (Fig. 5) is plotted above the initial one but peat stabilized with admix-2 (Fig. 6) is plotted underneath. It means that peat stabilized with admix-2 has more significant compression than the initial one. It could be due to there is not enough water available in the pores to produce a $CaSiO_3$ gel or the gel itself undergone volume decrement due to the gel is in the process to be crystal [18] - [21].

The highest compression rate of the stabilized peat takes place when the curing period reach 60 days, as shown in Figs. 5 and 6. Afterward, the compression rate decreases until the curing period reaches 90 days. The compression rate of peat stabilized with admix-1 at 60 days of curing period, however, is much higher than peat stabilized with admix-2. It is because the decomposition process starts taking place at peat stabilized with admix-1; besides, admix-2 can fill the pores perfectly as shown in Fig. 4b [11], [17].

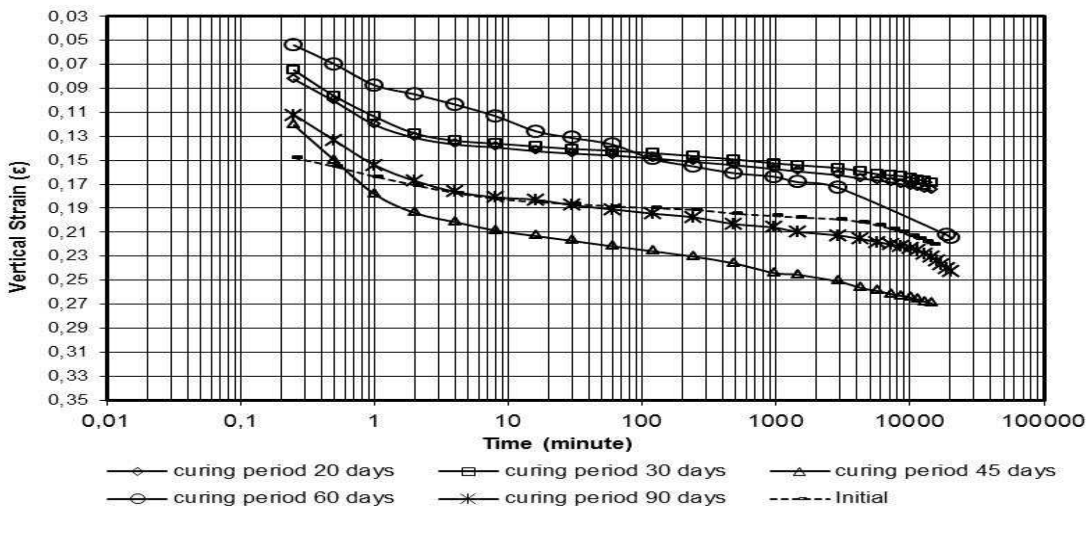


Fig. 6 Compression curves of one step loading consolidation test of fibrous peat stabilized with 10% admix-2 (Lime + FA) at different curing period: 20, 30, 45, 60, and 90 days

C. The Effect of Curing Period on The Total Compression of the Stabilized Peat

The effect of curing period to the total compression of the stabilized peat can be seen in Fig. 7. The total compression decreases until the curing period reach 30 days; when the curing periods are more extended than 45 days, the total stabilized peat compression increases. It is as mentioned previously that the CaSiO3 gel formation process is still taking place due to pore water is still available; when there is not enough water available in the pores to produce CaSiO3 gel, the gel itself undergone volume decrement due to the change of the gel to be CaSiO3 crystal [18], [19], [22]. This total compression continues to increase with the increment of the curing period when peat decomposition is taking place [7], [20], [21].

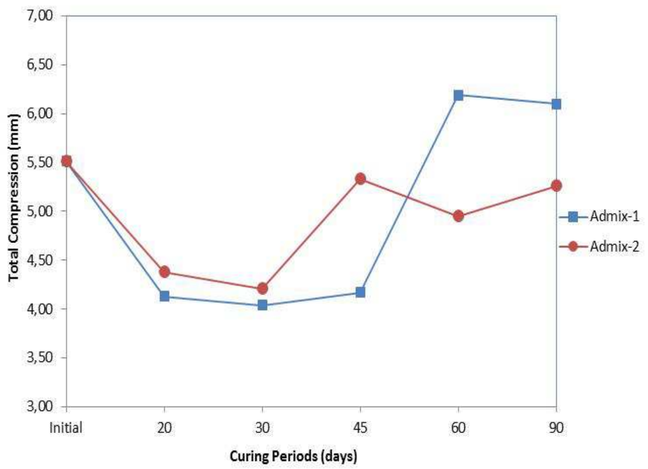


Fig. 7 Total compression of peat .stabilized with admix-1 (lime CaCO3+RHA) and admix-2 (lime CaCO3+FA)

From those two curves in Fig. Seven also can be seen the effect of the admixture type used for stabilization to the total compression. Admix-2 (lime CaCO3+FA) gives better result than admix-1 (lime CaCO3+ RHA). It is because rice husk ash absorbs more water than fly ash, and fly ash has finer granular than rice husk ash so that grains of admix-2 can easily fulfill the peat pores (as shown in Fig. 4b). Besides, mixing process of admix-2 and peat is easier than the one with admix-1 [20].

D. Compression Parameters

Since the Terzaghi consolidation method is not applicable for peat soil, therefore, the compression parameters determined in this study are Gibson and Lo compression parameters. Those parameters are primary compression factor (a-parameter), secondary compression factor (b-parameter), and rate factor for secondary compression (λ/b-parameter).

The effect of curing period to the a-parameter can be seen in Fig. 8. It shows that at curing period of 20 and 30 days, the value of a-parameter is about the same. At curing period longer than 30 days, the a-parameter of peat stabilized with admix-1 is getting bigger until it reaches curing 90 days. It shows that RHA absorbs almost all water in micro and macro pores; besides, some of the gel is in the process to become crystal. Peat stabilized with admix-2, however, shows slightly different behavior; the a-parameter increases until at curing 45 days and then decreases again at curing period 60 days; afterward, it is slightly increasing. It shows that admix-2 is not absorbing water as much as admix-1 so that only water in macropores is absorbed. When curing period longer than 45 days (until it reaches 60 days), the CaSiO3 gel formation takes place by using water in micropores. At curing period longer than 60 days, the gel formation is slowing down because water in micropores decreases and some of the CaSiO3 gel are in the process to become crystal.

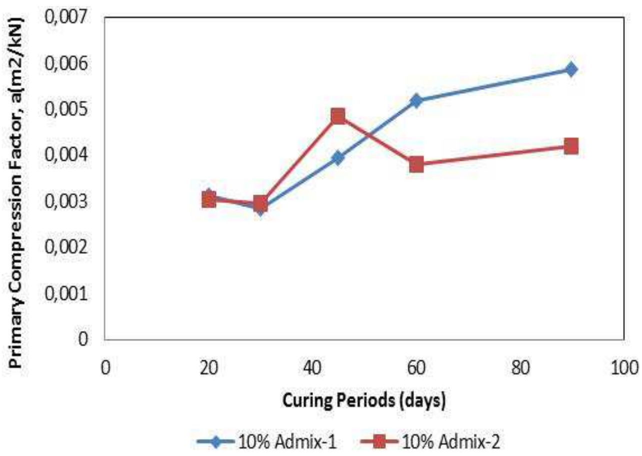


Fig. 8 The effect of curing period of peat stabilized with 10% admix-1 and 10% admix-2 to the "a" parameter

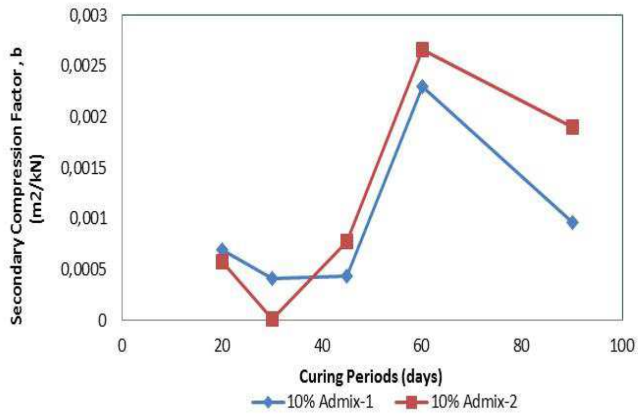


Fig. 9 The effect of curing period of peat stabilized with 10% admix-1 and 10% admix-2 to the b-parameter

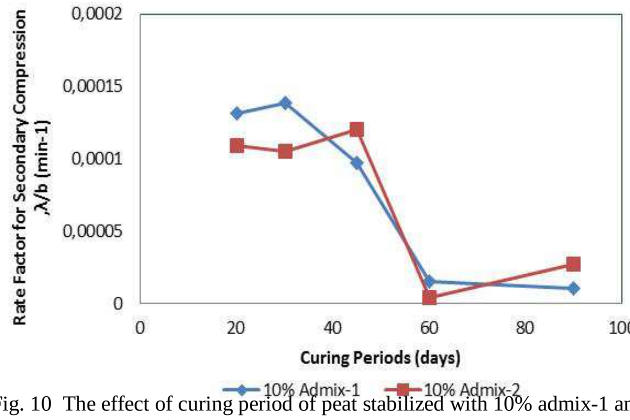
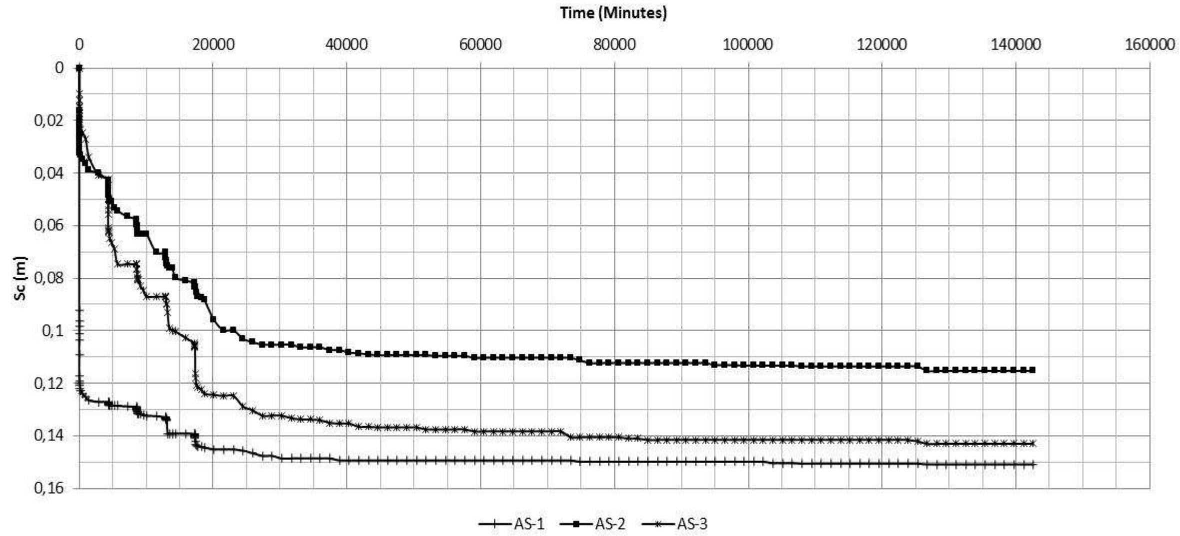
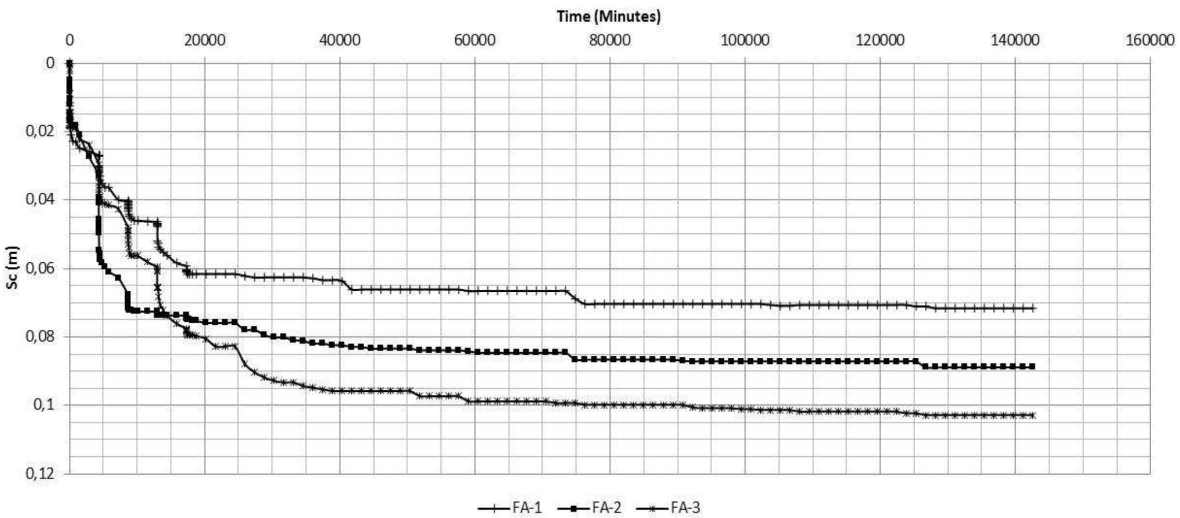


Fig. 10 The effect of curing period of peat stabilized with 10% admix-1 and 10% admix-2 to the λ/b-parameter



(a)



(b)

Fig. 11 Settlement of peat stabilized at different thickness 1/3H, 2/3H, and H (H is peat thickness) from the laboratory model loaded 50 kPa: a). Peat stabilized with admix-1 (lime + RHA); b). Peat stabilized with admix-2 (lime + FA). (Yulianto, F.E. and Mochtar, N.E [16])

The effect of curing period to the b-parameter is shown in Fig. 9. Peat stabilized with admix-1 and admix-2 show similar behavior except for peat stabilized with admix-2 show bigger b-parameter when the curing period longer than 45 days especially when curing period longer than 60 days. Based on the a-parameter discussed above, it is known that no more water available in the pores so that fiber decomposition dominantly causes the b-parameter for stabilized peat. Therefore, the curves of b-parameters shown in Fig. 9 are in line with the a-parameter where decomposition process for peat stabilized with admix-1 take place earlier than the peat stabilized with admix-2 so that the b-parameter of peat stabilized with admix-1 is still dominantly caused by the decomposition process.

The λ/b-parameter of peat stabilized with admix-1 and admix-2 that plotted in Fig. 10 shows similar behavior. The λ/b-parameter drops drastically when the curing period between 45 to 60 days. This result is in line with the b-parameter discussed above.

E. Settlement Prediction of Stabilized Peat

As mentioned previously that laboratory model was carried out in this study; thickness of the layer stabilized was 1/3H, 2/3H, H, where H was the sample thickness in the box = 30 cm. For peat stabilized with admix-1, the samples were called as AS-1, AS-2, and AS-3 for peat which thickness of the stabilized layer was 1/3H, 2/3H, and H, respectively. When admix-2 used for stabilization material, the samples were called as FA-1, FA-2, and FA-3, for the thickness of the stabilized layer was 1/3H, 2/3H, and H, respectively. The load was applied step by step until it reaches 50 kPa; each step was ten kPa, and it was maintained for three days so that the total loading process was 12 days. The settlement caused by 50 kPa load applied was monitored in 20, 30, 45, 60 and 90 days, and then plotted as shown in Figs. 11a., and 11b.

The settlement of stabilized peat shown in Fig. 11 had been published [17]. They figured out that the settlement is about constant after 20.000 minutes (14 days) of load application. They stated that the thicker the layer stabilized, the higher the compression takes place. They also explained that strange settlement behavior of sample AS-1 at the beginning of loading was due to bearing capacity failure of the fragile stabilized layer (1/3 H) or due to the CaSiO3 gel has not developed correctly.

In this paper, the total settlement obtained from the laboratory model is compared with the settlement predicted using a, b, and λ/b-parameters (from Figs. 8, 9, and 10) that were corrected using the correction factor curves [8]. The results are plotted in Figs. 12, 13, and 14 for samples stabilized with admix-1 and Figs. 15, 16, and 17 for samples stabilized with admix-2.

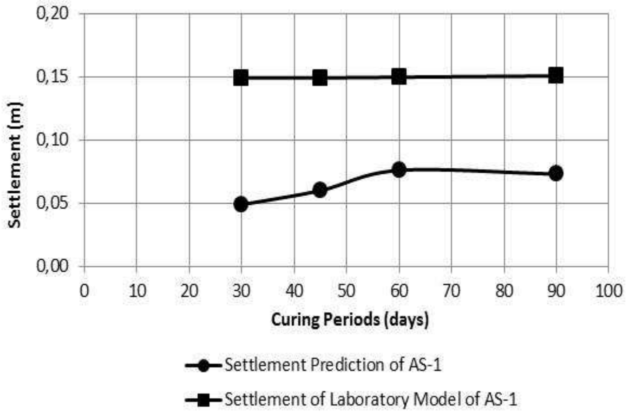


Fig. 12 Total settlement obtained from laboratory model and prediction of fibrous peat stabilized with admix-1 at 1/3 of sample thickness and loaded with 50 kPa

Fig. 12 shows that predicted settlement is much smaller than that the one from laboratory model. As mention before, it is because the sample from laboratory model undergoes bearing capacity failure at the beginning of the loading period. For samples AS-2 and AS-3 (Figs. 13 and 14), they have similar settlement behavior where the settlement that occurs after 60 days caused by peat decomposition.

Predicted settlement for samples stabilized with admix-2 (Figs. 14, 15, and 16) show better results than the one stabilized with admix-1. The predicted settlement is very close to the settlement of the laboratory model. The results also show that the decomposition process starts when the curing periods reach 60 days that means decomposition process only causes the settlement.

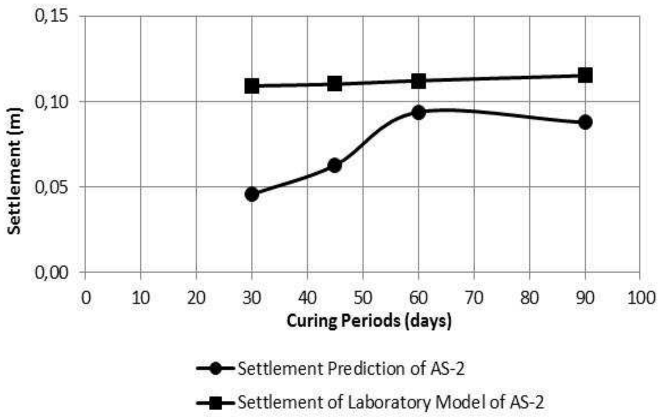


Fig. 13 Total settlement obtained from laboratory model and prediction of fibrous peat stabilized with admix-1 at 2/3 of sample thickness and loaded with 50 kPa

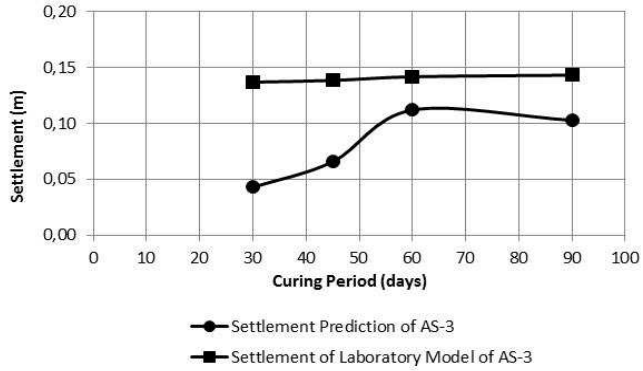


Fig. 14 Total settlement obtained from laboratory model and prediction of fibrous peat stabilized with admix-1 and loaded with 50 kPa

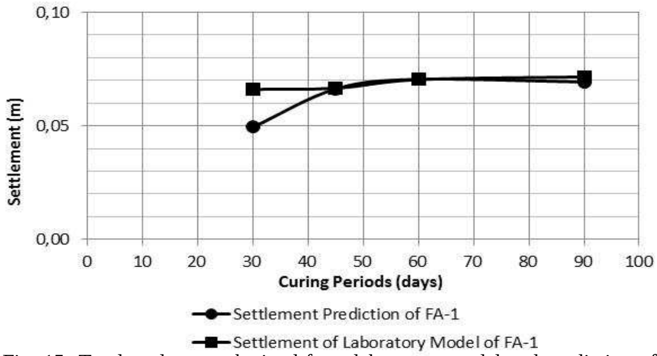


Fig. 15 Total settlement obtained from laboratory model and prediction of fibrous peat stabilized with admix-2 at 1/3 of sample thickness and loaded with 50 kPa

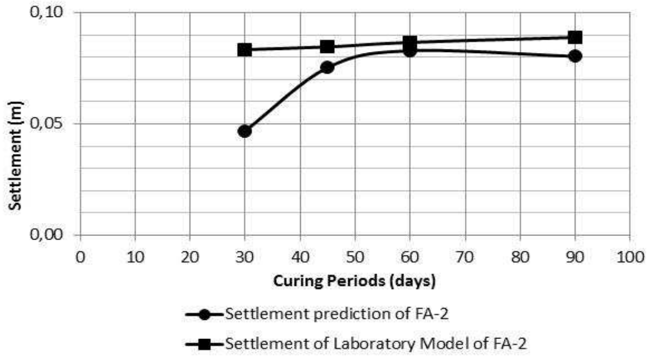


Fig. 16 Total settlement obtained from laboratory model and prediction of fibrous peat stabilized with admix-2 at 2/3 of sample thickness and loaded with 50 kPa

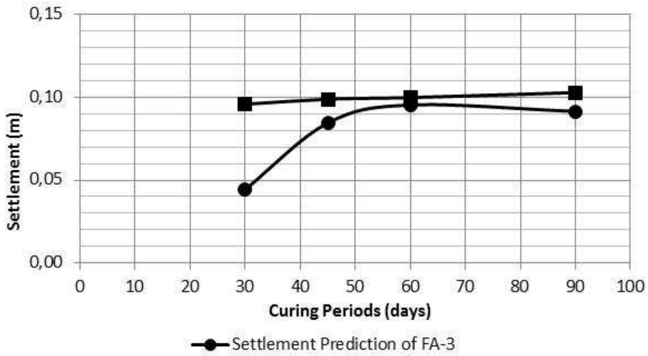


Fig. 17 Total settlement obtained from laboratory model and prediction of fibrous peat stabilized with admix-2 and loaded with 50 kPa

IV. CONCLUSIONS

From the test results and analysis given above, it can be concluded that: The peat studied can be classified as **"**Hemic Peat soil with Medium Ash Content and Highly Acid." Fibrous peat stabilized with 10% admix-2 (lime CaCO3 + RHA) has better density than the one stabilized with 10% admix-1 (lime CaCO3 + FA) because grains formed by admix-2 can fill the pores correctly. The compression rate of the stabilized peat is affected by the type of admixture and its curing period; peat stabilized with admix-1 has higher compression rate, and it occurs when the curing period reach 60 days; The total compression of the stabilized peat are affected by curing period and by admixture type. Type of admixture used for stabilization and curing periods affect the a-parameter, b-parameter, and λ/b-parameter. The correction curves are still applicable for the stabilized peat. The thickness of peat layer stabilized affects the total settlement of peat layer, the thicker the peat layer stabilized, the bigger the total compression.

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