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POTENTIAL OF BAMBOO PILE AS REINFORCEMENT OF PEAT SOIL UNDER EMBANKMENT

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ABSTRACT

Implementation of preloading and reinforcing of bamboo grids on peat is expected to reduce compression and increase and bearing capacity of peat soils. Preloading can be applied by using a embankment material that can speed up compression, while to increase the bearingcapacity due to embankment load can use a combination of reinforcement of bamboo grids and piles. Modeling wasconducted in the laboratory by using peat soil media. The preloading model wasconducted with embankment model using iron scrap on peat soil, which were supported by bamboo grid and pile with diameter of 2 cm with length of 20 cm, and spacing of 20 cm and 10 cm. The increase of bearing capacity due to reinforcement can be seen from the settlement and deflection behavior of both peat with bamboo piles and without piles will be discussed in this paper.

Keywords: peat, preloading, bamboo pile, settlement, deflection, emulsion asphalt, erosion rate, rain simulation, sandy clay, stabilization.

1. INTRODUCTION

According to Mesri and Ajlouni [1], preloading and surcharging are effective methods of peat soil improvement. Ref. [2] using a combination of electroosmosis and vacuum-overlying water preloading methods to prevent deficiencies, increase bearing capacity and reduce compression on soil, making design more effective. While Ref. [3], using the vacuum preloading method to estimate the degree of consolidation on the ground. The behavior of soft soil deposits is improved by vertical drainage and preloading [4].

Preloading can be applied with embankments on peat soil. Ref. [5] applies preloading with fill of silty were compacted as high as 3 m above clay peaty soil. Between soft soil and embankment deposited geotextiles and sand as reinforcement and drainage. As a result of preloading, SPT values and compressive strength increased, indicating that preloading is effective in improving soft peat soils. Ref [6] states by preloading the form of sand deposits on peat soils, the bearing capacity may increase by 101-242% with a height of 13 cm fill. For small-scale test models in the laboratory can use a model of embankment of iron scrap [7]. The load test of this model shows a significant decrease for the laboratory scale model test.

In order for the embankment to remain stable above the peat soil surface, a reinforcement system is required. Ref. [8] suggest that the failure of embankment on peat soil is generally caused by excessive shear deformation of the fill rather than a particular surface shift. Reinforced can contribute to increase the stability of the pile, where reinforcement and shear strength of peat soil will withstand lateral forces.

Various types of reinforcement are commonly used as reinforced. Bamboo is better than geotextiles as a soil reinforcement, this can be seen from the research of [9], soft clay soil reinforced with a combination of bamboo and geotextiles as a separator between soft soil with embankment material, has a much better final settlement than reinforced with geotextiles, even from high tensile geotextiles. Square bamboo takes the load from the accumulation of matter, thus reducing the settlement much better than other models that do not use bamboo. On the other hand, square bamboo shapes form an interlock to resist horizontal shear stress and increase bamboo stiffness, hence the vertical spread of pressure is evenly distributed. As a result, lateral movement is observed low. Another factor is due to the void part of the bamboo, where air trapped inside the bamboo can provide a buoyant effect and because it distributes small embankment loads to soft soil soft layers.

A review by Anusha and Kindo [10] states that the use of bamboo as a soil reinforcement can increase the value of unconfined compressive strength, due to the friction between the ground and the rough surface of the bamboo. In addition to the increased compressive strength value, reduced decrease and non-uniform decrease. The use of bamboo grids on peat soils shows an increase in bearing capacity. The bamboo grid has been used as a reinforcement on a shallow foundation [11 and 12]. The bearing capacity of shallow foundations can be increased by the use of bamboo grids.

The use of bamboo grids as a reinforcement can be combined with bamboo piles. The bamboo pile with bamboo pile raft system (known as "cerucuk") has been proven to provide advantages for increased soil bearing capacity such as peat and can reduce the decline of pile [13].

Construction stages and controls are needed for embankment over peat, as the addition of rapid deposits can lead to large deformations along with tension cracks and heave [14]. Major deformations disrupt the stability of embankments on peat soils. To keep the embankment in a stable state, peat soil reinforcement is required. The reinforcement used in this study is a combination of bamboo grids with bamboo piles. This research is expected to reduce the settlement and deflection of bamboo grid due to the load of embankment and in the end can increase the bearing capacity of peat soil.

2. RESEARCH METHODS

The research was carried out using peat samples taken from Riau area, bamboo used is bamboo species taken from Deli Serdang area of North Sumatra.

In this research, the modeling of embankment using pieces of iron size 4 cm x 1.9 cm x 1.9 cm based on [7]. This piece of iron was arranged to form a trapezoid over a bamboo grid and a bamboo pile as a reinforcement of peat soil. The use of embankment model with iron scraps like this refers to the research of [7].

The embankment were conducted gradually with the addition of a fill load, 1 layer each day until the compressing peat soil is close to zero. The embankment model is expected to be close to the conditions in the field, thus accelerating the compression of peat soil. While bamboo grids and piles can be used as a reinforcement of peat with the aim that the compression is smaller and the carrying capacity of peat can be increased so that the stability of the embankment can be maintained.

The embankment model was placed on top of the peat layer which is inserted into a model box of 90 cm in width, 120 in length, and 90 cm in height, at which the embankment was graded with bamboo grids and bamboo poles (Figure-1). The bamboo grid was placed between a heap with a surface of peat with an area of 60 cm x 30 cm. Strengthening of bamboo grid combined with bamboo pole diameter (d) 2 cm with length 20 cm. Spacing (s) of bamboo pole are varied 10 cm (ratio s/d = 5) and 20 cm (ratio s/d = 10).

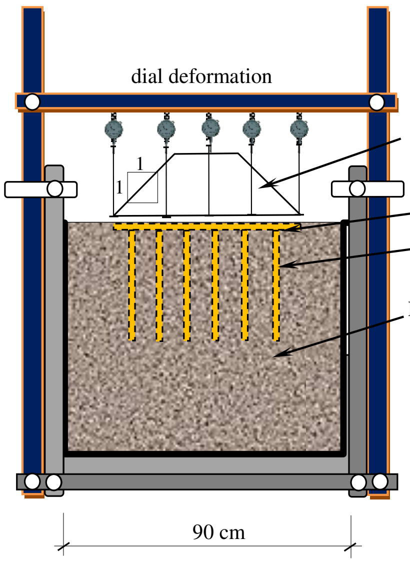

Figure-1. Testing scheme in the laboratory.

3. RESULTS AND DISCUSSIONS

The reinforcement used to improve peat soil's capability is the bamboo grid on the surface with and without reinforcement of bamboo piles. To produce a significant decrease, the embankment load model is taken from a piece of iron material with a volume weight above 79 kN/m^3. The embankment load is given gradually each load embankment reaches a pressure of about 1.52 kPa. These loads are given gradually every day until the fifth day. On the sixth day there is reduced load from the fifth to the first layer.

3.1 Measurement result of settlement in center of the embankment

The observed decrease in the center of the embankment on peat without reinforcement piles can be seen in Figure-2, while in peat with reinforcement of 20 cm and 10 cm spacing can be seen in Figure-3 and Figure-4.

All three types of testing result in smaller decreasing changes in line with the increase in fill rate, which means that peat soil is compounded due to the consolidation process in peat soil. In addition to the height factor of the embankment, the time factor of loading appears to have an effect on the compression of the peat.

Load reduction results in the development of peat soil surface. Significant development occurs in peat without bamboo pile reinforcement. Bamboo piles contribute to reducing the development of soil after load reduction. The bamboo piles also support the development of the soil.

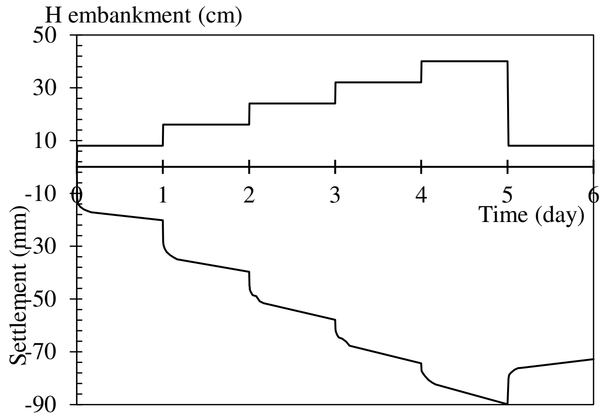

Figure-2. Settlement in center of embankment on peat without reinforcement of bamboo pile.

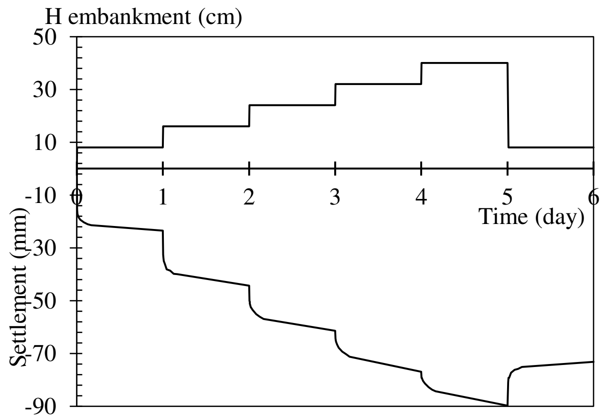

Figure-3. Settlement in center of embankment on peat with bamboo pile space of 20 cm.

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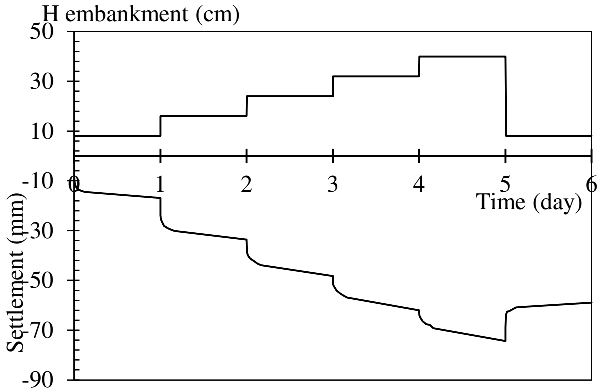

Figure-4. Settlement in center of embankment on peat with bamboo pile space of 10 cm.

3.2 Measurement of deflection results

The observation of the bamboo grid deflection in the cross section direction of the embankment is shown in Figure-5 to Figure-7. The deflection of the bamboo grids on peat without bamboo piles is shown in Fig. 5, while for peat with bamboo pile reinforcement is shown in Figures 6 and 7, each with a space of 20 cm and 10 cm.

The deflection in the peat without the pile reinforcement looks higher for each additional load of embankment. The deflection centers in the center of the embankment and further shrinks toward the outer pile. This can lead to the unstable construction of the embankment. It proves that peat has a decrease in excess and decrease is not uniform. To anticipate the problem, it needs bamboo piles as reinforcement on peat soil under the embankment.

The use of bamboo poles with spacing of 20 cm (s/d = 10) can reduce the resulting deflection and result in a more uniform decline than without reinforcing the bamboo pole (Figure-6). Although the settlement in the center of the pile is almost equal to the decrease in peat without reinforcement pole.

A more stable deflection is seen in the use of bamboo piles with a space of 10 cm (s/d = 5). As shown in Figure-7, the deflections occur more evenly at all points than on spaced piles.

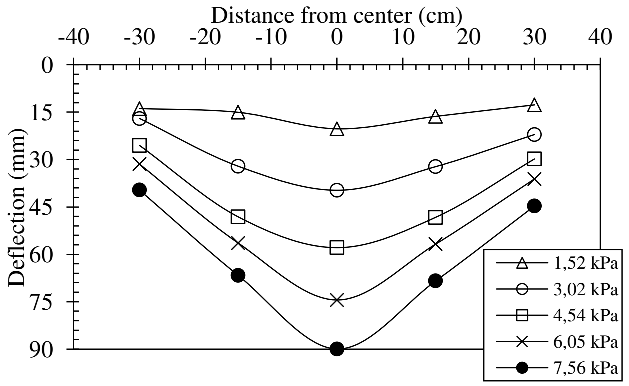

Figure-5. Deflection of bamboo grid on peat without reinforcement of bamboo pile.

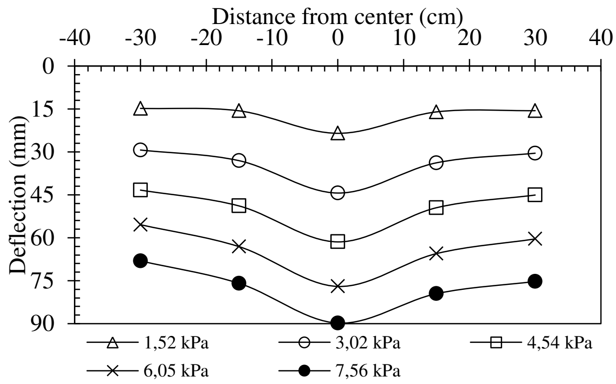

Figure-6. Deflection of bamboo grid on peat with bamboo pile space of 20 cm.

3.3 Effect of bamboo pile on settlement and deflection

Comparison of peat settlement without bamboo piles and peat with bamboo piles reinforcement can be seen in Figure-8. The bamboo pile with a distance of 20 cm or s/d = 10, gives a similar settlement to the decrease in peat without pile. While the use of bamboo piles with a distance of 10 cm or s/d = 5 shows a smaller settlement than both. The spacing of the bamboo pile is less effective at the ratio of s/d = 10, but in the ratio s/d = 5, it can show a significant effect on the settlement. Even the change in settlement after the third day looks smaller.

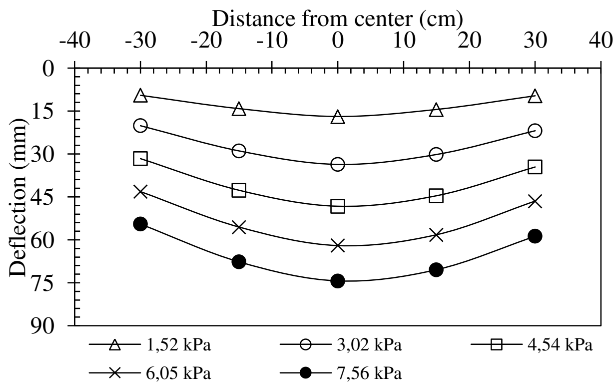

Figure-7. Deflection of bamboo grid on peat with bamboo pile space of 10 cm.

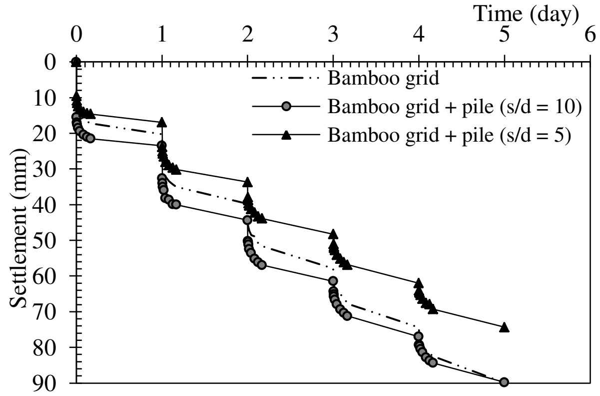

Figure-8. Relationships between time and settlement.

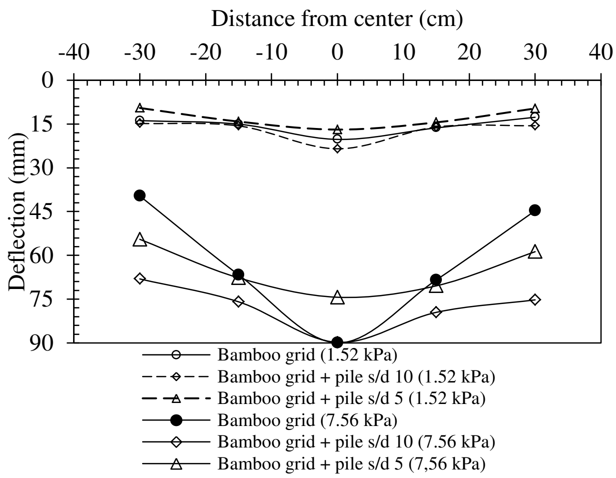

Figure-9. Deflection in the cross section direction of embankment.

In contrast to the settlement in the center of the embankment, the use of bamboo piles with any distance can minimize the deflection that occurs. This can be seen in the relation between the measurement point distance from the load center and the deflection in the transverse direction of the embankment (Figure-9). For small loads (1.52kPa) the influence of bamboo piles with a distance of 20 cm (s/d = 10) is not visible, but with a distance of 10 cm (s/d = 5) the influence of bamboo piles is clearly visible. However, on larger loads, the influence of bamboo piles on deflections is clearly visible. Due to the use of bamboo piles, the bamboo grid deflection under the embankment looks smaller as the bamboo pile spacing is used as a reinforcement. Thus the installation of bamboo piles combined with bamboo grids is able to reduce the settlement and the deflection of the bamboo grid and in the end can maintain the stability of the embankment as preloading which can improve the compressing behavior of peat soil which is known to have high compression, excessive and non-uniform settlement, and high moisture content.

4. CONCLUSIONS

There are several conclusions obtained in this study, including:

a) The spacing of the bamboo pile is less effective at the ratio s/d = 10, but in the ratio s/d = 5, it can show a significant effect on the settlement. Even the change in settlement after the third day looks smaller

b) The use of bamboo piles with any distance can minimize deflection that occurs. For small loads (1.52 kPa) the influence of bamboo piles with a distance of 20 cm (s/d = 10) is not apparent, but with a distance of 10 cm (s/d = 5) the influence of bamboo piles is clearly visible. However, on larger loads, the influence of bamboo piles on deflections is clearly visible. Installation of bamboo piles combined with bamboo grids is able to reduce the settlement and reduce the deflection of the bamboo grid and ultimately can maintain the stability of the embankment.

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REFERENCES

[1] Mesri G. and Ajlouni M. 2007. Engineering Properties of Fibrous Peats. Journal of Geotechnical and Geoenvironmental Engineering © ASCE. 133(7): 850-866.

[2] Shen Y., Tao M., Liu H., Gao Y., and Cui Y. 2013. The Performance of Super Soft Foundation under Modified Vacuum Preloading Method. Forensic Engineering © ASCE. pp. 708-715.

[3] Chu J. and Yan S.W. 2005. Estimation of Degree of Consolidation for Vacuum Preloading Projects. International Journal of Geomechanics © ASCE. pp. 158-165.

[4] Azari B., Fatahi B., Khabbaz H. and Vincent P. 2014. Elastic Visco-Plastic Behaviour of Soft Soils Improved with Preloading and Vertical Drains. Pavement Performance Monitoring, Modeling, and Management 18 GSP 254 © ASCE. pp. 17-24.

[5] Hoque E., Islam M.S. and Munshi M.M.K. 2004. Performance of Preloading Applied on a Peaty Clay Deposit. Geotechnical Engineering for Transportation Projects, ASCE. pp. 1991-1999.

[6] Susanti R.D., Maulana A.R, WaruwuA. 2017. Bearing Capacity Improvement of Peat Soil by Preloading. ARPN Journal of Engineering and Applied Sciences, 12(1):121-124.

[7] Waruwu A., Hardiyatmo H.C. and Rifa'I A. 2016. Compressive Behavior of Bagansiapiapi-Riau Peat in Indonesia. Electronic Journal of Geotechnical Engineering. 21(16): 5217-5227.

[8] Rowe R.K., dan Li A.L. 2005. Geosynthetic-reinforced embankments over soft foundations. Geosynthetics International. 12(1): 50-85.

[9] Marto A. and Othman B.A. 2011. The Potential Use of Bamboo as Green Material for Soft Clay Reinforcement System. International Conference on

Environment Science and Engineering. 8, pp. 129-133.

[10] Anusha R. and Kindo E.C. 2011. Behaviour of Bamboo Reinforced Soils - State of Art. Proceedings of Indian Geotechnical Conference, December 2011, Kochi (Paper No. H-247).

[11] Waruwu A. 2014. Bamboo Reinforcement in Shallow Foundation on the Peat Soil. Journal of Civil Engineering Research. 4(3A): 96-102.

[12] Waruwu A. and Susanti R.D. 2015. Behavior of Soil Peat with Reinforcement of Bamboo Grid. IOSR Journal of Engineering. 5(11): 29-36.

[13] Rahardjo P. P. 2005. Chapter 31 The Use of Bamboo And Bakau Piles for Soil Improvements and Application of Pile Raft System for The Construction of Embankment on Peats and Soft Soils. Elsevier Geo-Engineering Book Series. 3: 899-921.

[14] Porbaha A., Hanzawa H. and Kishida T. 2000. Analysis of a Failed Embankment on Peaty Ground. Proceedings of sessions at Geo-Denver 2000August 2000, pp. 281-293, Colorado.