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Soft Soil Improvement by Using Bamboo Reinforcement

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Abstract: For supporting structures such as houses, bridges, highways, and dams, the current soil at a construction site may not always be fully suitable. The top layers of soil are often undesirable and need to be removed and replaced by better soil. In such a situation, to increase its unit weight and hence the shear strength and load bearing power, the soil needs to be improved. Peat soil can cause difficulties such as large settlement, failure of pre- and post-construction, and long-term effects in various ways. This paper gives brief introduction about practicality of bamboo by applying 3 different layer of bamboo reinforcement in peat soil. Settlement Testing under static load test had been done in this report. The constant load of 2kPa were used for low load testing. The bamboo used in this research is Buluh Madu/Buluh Semantan or the scientific name is Gigantochloa Scortechinii that were obtained at Muar, Johor. The container size is 1.0m × 0.50m × 0.53m and were filled with disturbed Peat Soil that were obtained at Parit Nipah, Batu Pahat, Johor. The initial soil level is 39cm high with total peat weight around 200kg. The testing had been done with interval 24hours for 3 days data. For the first layer to second layer the bamboo the settlement value decrease till 172% while for the third layer, the settlement value decreased till 900%. This increase meaning that the burden can be borne by the foundation on peat soil can increased up to 900% on the same load. When the settlement value decreased, the bearing capacity of soil is increased. Meaning that the bamboo reinforcement was able to improve the peat soil in construction.

Keywords: Peat, Settlement Testing, Bamboo

1. Introduction

Soft Soil is type of soil that does not fulfill the requirement for construction because have size particle less than 0.063mm. Soft soil is usually defined as problematic soil to geotechnical sector. It has to be treated and improved in order to gain the standard strength for construction. It this report, type of soft soil that being used is Peat Soil. Peat soil is obtained at Parit Nipah, Batu Pahat, Johor. Peat soil is type of poor soil in engineering term because of low shear strength, high water content, high compression and has low bearing capacity when act as foundation construction. Peat soil also has higher water content compared to inorganic soil. Peat soil behavior is determined using concept method developed

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for inorganic soil. Peat soil can differentiate as dark brown spongy amorphous peat and spongy fibrous peat and formed under both topogeneous and ombrogenous conditions. Peat soils also defined as soil with an organic content greater than anywhere from 20%70% of total weight. Peat soil need to be improved to support the structures such as buildings, bridges, highways, and dams by increase its unit weight and also the shear strength and load bearing capacity. One of the affordable techniques is by using bamboo reinforcement.

Bamboo is recognized as a potential natural reinforcing material for improvement and stabilization of soil. Bamboo can be obtained easily, trunk strong, resilient, cheap and eco-friendly to the nature compared to geosynthetic materials. Bamboo reinforcement having diameter of 1-3cm, weight in range of 0.10 – 0.20kg. The bamboo length is 49-50cm for horizontal position and 45-46cm for vertical position. Studies have shown that bamboo possess high tensile and compressive strength and have been used as reinforcement in concrete.

In order to do soil improvement, we can analyze by analyze the settlement value after applied specific load on top of the bamboo. When settlement value decrease, meaning that bearing capacity value of soil will increase. Settlement is dividing the load applied with distributed load. Soil should be able to support the super imposed load without excessive settlement or any failure.

2. Literature Review

Peat soil is classified as problematic soil as it is poorly because of it low shear strength, high water content, high compression and low bearing capacity [2]. As mention in [4] peat is known for its high natural moisture content, compressibility, and water-holding capacity, as well as its low specific gravity, low bearing capacity, and medium-to-low permeability. To build any form of infrastructure on peat, it must first be characterized and improved the soil. Because peat soils have lower geotechnical qualities than mineral soils, this is a serious issue for infrastructure development. Peat soil contained of occurrence of a mixture of fragments of organic material in wetlands under appropriate climatic and topographic conditions and it derived from vegetation that had been chemically changed and fossilized (Dhowian et al, 1980 as cited in [12]). It is important to improve the peat soil to avoid any problem such building collapse, landslide and settlement issues.

Malaysian peat is oligotrophic, meaning it has a low mineral content and is acidic in action, with a pH of less than 4 in its natural condition, usually between 3.5 and 3.8 [10]. These peats, which contain less than 10% ash, are formed from forest detritus and are made up of a mass of semi-decomposed woody material with a dark brown peaty substrate. The water- holding capacity of peat soil is very high which is can vary from 15-20 times its own dry weight. Excessive drainage might cause "irreversible drying" of peat. Peat shrinks significantly as a result of consolidation and oxidation when it is drained. The exposed peat will shrink and the soil will subside if the water is drained too quickly or to a great depth at first [10].

Soil settlement means the soil is moving in vertical direction (downward movement) because of change in stress within the earth. Embankment of peat settles in 2 stage which is primary and secondary consolidate. The primary consolidation stage occurs as the pore water in the peat mass is squeezed out. The weight of the embankment and the thickness of the peat deposit depends on the magnitude of primary consolidation, while for secondary compression stage occurs as the internal peat matrix gradually absorbs an increasing share of the embankment load as its strength increases [1]. The secondary compression with a substantially slower settlement rate. The secondary phase is thought to be the result of the peat mass sliding and reorganizing its fibers, resulting in a considerably denser medium. It has been emphasized that peat should be loaded slowly enough to solidify and build strength. (Munro, 2004 as cited in [1]).

Bamboo is a group of woody perennial grasses in true grass family Poaceae and has large family with over 10,000 species. Bamboo size are varying from small annuals to timber bamboo. Bamboo Plant is one of the fastest growing plants in the world and have more than 1400 species that are

distributed worldwide. According to research, bamboo can grow over 30inches in a single 24-hour period and can offer a variety of functions. Most bamboo species show a strong development and colonization ability. Although part of bamboo stems is hollow, it is still very strong and useful. Many studies have proved that use of bamboo grid reinforcement could increase the bearing capacity of the peat soil. According to [5], bamboo can be regarded as the best alternative for replacing timber because bamboo has high strength and is fast-growing.

Despite the fact that bamboo is a fast-growing, high-yielding, and easily renewable natural resource, research need to be conduct before applying bamboo in construction site. From much previous research had proven that bamboo has a highly strong fiber as a construction material. The compressive strength of bamboo is two times stronger than concrete, but the tensile strength is close to steel. Bamboo fiber has a higher shear stress than wood. Bamboo has a greater span than wood. Bamboo can also be bent without breaking [6]. Bamboo thrives in many parts of the world, particularly in tropical and subtropical climates. Increased usage of bamboo in building results in energy savings, conservation of the world's limited resources, and pollution reduction. [6]

According to [5] bamboo can be used to construct scaffolding, bridges, dwellings, and other structures. Bamboo has a similar strength to weight ratio to timber, and its strength is comparable to that of a robust softwood or hardwood. Bamboos, with to a unique rhizome-dependent structure, are among the world's fastest-growing plants. Due to a lack of natural toxins and its relatively thin walls, bamboo is more prone to decay than timber, which means that even a tiny quantity of deterioration can result in a substantial percentage change in capacity. Beetle attack, termite attack, and fungal attack are the three main causes of deterioration (rot). Internally, untreated bamboo can last 2-6 years, and if exposed to water, it can live less than a year.

With some treatments, combination, and improvement for the bamboo, it can have ability to compete with steel or timber based on architectural structure to fulfill structural requirement. The technical requirement needed is still doable and relatively low for example by integrate the bamboo with soil, mixing with concrete, knotted using wire already can help to increase the structural strength. The joint strength between structure components of the building determines the stiffness, strength, and stability of nodes. When a result, as connecting structure improves, more contributions to the diversification of bamboo architecture are made [10]

2. Materials and Methods

Plate Load Test is a method for assessing the ground's ultimate bearing capacity and the likelihood of settling under a given load. This test is usually carried out in-situ and accordance with BS 1377 Part 9:1990. This test is particularly common for shallow foundation selection and design. The peat soil is obtained from Parit Nipah, Batu Pahat, Johor. The moisture content is 605%, organic content is 66%, liquid limit is 203%, specific gravity is 1.4, the pH value is 3.75 (acidic) and von post humification is H5 [1]

2.1 Material Preparation

The container size is 1.0m × 0.50m × 0.53m with initial soil level is 39 cm. The peat shall be looked wet and have buoyancy of water, therefore water is added until it reached desired condition. For bamboo preparations, the bamboo used is Buluh Madu. The average weight of bamboo is about 0.10kg till 0.2kg with diameter range 1-3cm. length of bamboo used for horizontal position is 49-50cm and for vertical position is 45-46cm. After the bamboo is mark and cut off, it is being placed at open air for air-dried process to remove the water and glucose inside the bamboo. Then the bamboo is knotted using cable tie to fixed the position likes a raft. Then the bamboo was placed on top of the soil with load on top of it. The reading was taken using metal ruler that were placed in front of the glass to ease process of taking settlement reading.

Next, a constant load which is 2kPa being placed on top of bamboo to test the reinforcement. The load placed on the middle to get precise and evenly reading of settlement. The reading was taken after 24hours of settlement by using the ruler that was placed at the glass window.

Figure 1: First Layer bamboo

Figure 2: First Layer Testing

For second and third layer of reinforcement, after finish taking reading for 72hours, the load and bamboo is taken out because the soil need to be setup again to get fair reading. The soil is being tilted to get nearly same condition as the first layer. Then the process is repeated until finish all three layer of bamboo reinforcement.

Figure 3: Second Layer of bamboo

Figure 4: Third Layer of bamboo

2.1 Schematic Drawing of Bamboo Arrangement

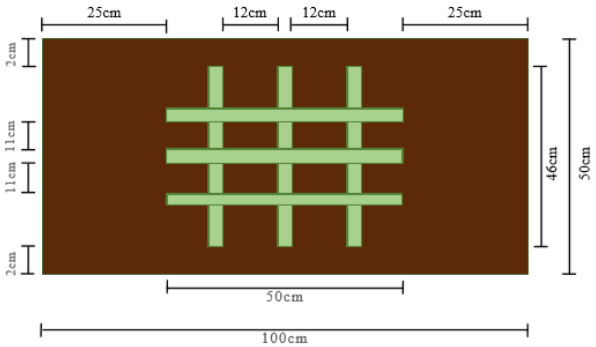

Figure 5: Top view of bamboo arrangement

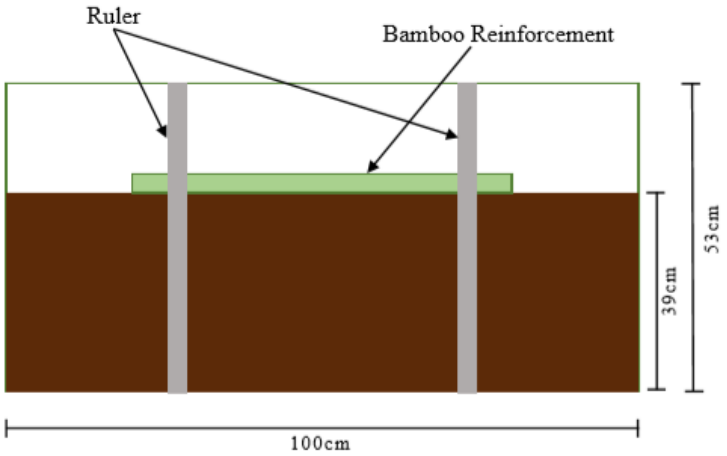

Figure 6: Front view of bamboo arrangement

3. Results and Discussion

To estimate the settlement value, settlement testing was done by placing static load on top of bamboo reinforcement. Results of the study consisted of the different layer of bamboo with constant load which is 2 kPa for each layer. Based on the data obtained, different layer of bamboo surely can help to reduce settlement of soil and increase the soil bearing capacity. The experiment was done for 72 hours/3 days and until the reading of soil settlement is constant. Result value from the experiment was recorded then plotted in a graph to analyze their settlement for different layer.

3.1 First Layer Reinforcement

After finish set the peat soil and finish knot the bamboo, test for first layer reinforcement had begun. For the first layer, the initial soil level is 39 cm and after 24 hours the bamboo went till 30 cm level. It is shown that the bamboo had sink for 9 cm. while for 48hours, the soil level is 29 cm and the 24 hour is 28 cm.

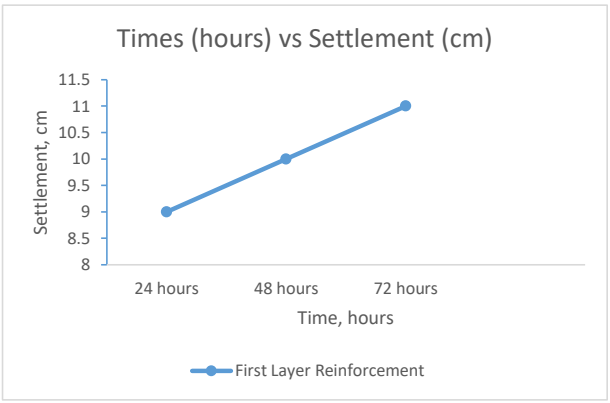

Figure 6: First Layer Reinforcement

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3.2 Second Layer Reinforcement

For the second layer, the soil level is 37cm and with the load of 2kPa, after 24 hours the soil level went to 34cm (3cm settlement). For 2-day record, the soil level is 33 cm and remains constant for the next day.

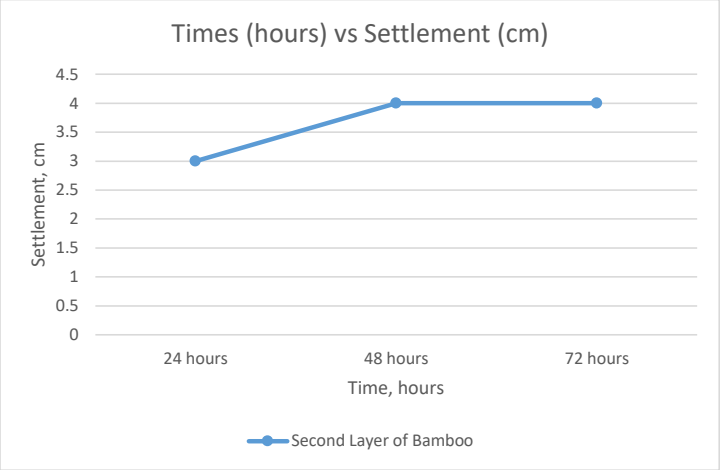

Figure 7: Second Layer Reinforcement

3.3 Third Layer Reinforcement

For the third layer, the initial soil level is 37cm. After a day having load on the bamboo reinforcement, the soil level went to 36cm (1cm settle) and it is remains constant for next 24hours and 48hours.

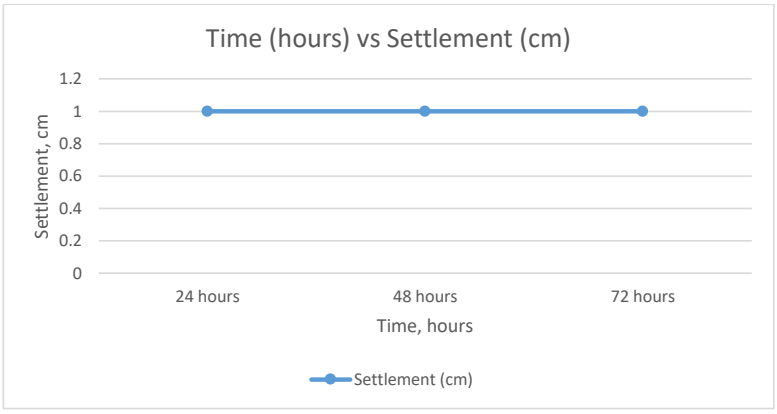

Figure 8: Third Layer Reinforcement

Figure 9: Tilting of bamboo

As the Figure 9, the bamboo seems to experience failure and tilted to the side. The particular reason for the circumstances is the unstable peat in the horizontal direction and resulted in the building tilted and not last longer. This phenomenon is called tipping settlement failure. For example, in real construction situation, an external lateral or "sideways" force applied to some component of the wall causes horizontal displacement in construction foundations or walls. A force applied to a foundation wall might cause it to move in one of several ways, depending on the building materials used and the strength of the wall, which we explain in depth in horizontal movement in foundations.

3.4 Summary of Result

Table 1: Settlement Value

The Foundation layout on Peat	Settlement value, cm			Settlement value, cm average	Decreased %
1 Layer	9	10	11	10	0
2 Layer	3	4	4	3.67	172
3 Layer	1	1	1	1	900

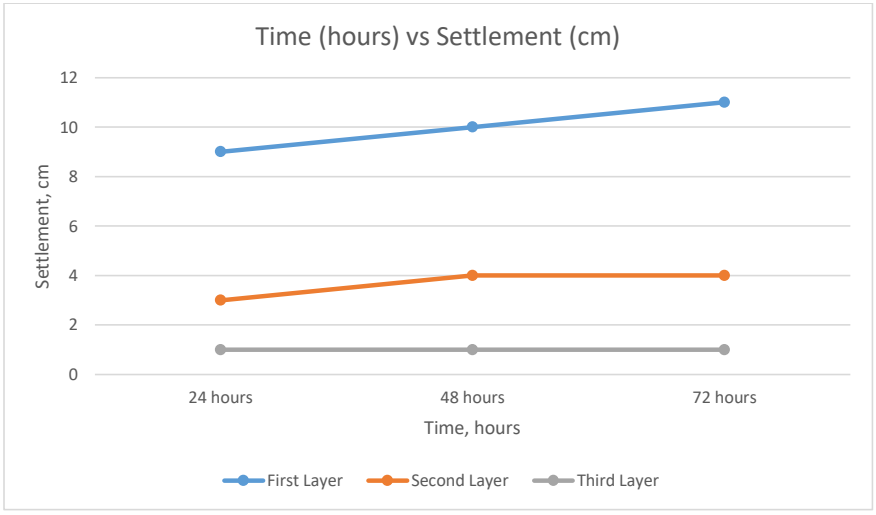

Figure 10: Summary of bamboo settlement

From the table above, it explained that utilization of bamboo reinforcement, the settlement value decreased till 172% for second layer and the settlement decreased drastically reach 900% after retrofitting of 3 layers of bamboo reinforcement. This increase gives the meaning that the burden can be borne by the foundation on peat soil can be increased up to 900% on the same load. The graph elucidates that more layer of bamboo can decrease the reading of soil settlement. Averagely after second days, the readings demand to stay constant except for the first layer. When the load applied, the soil began to settle slowly until the reading is remains constant. Reinforcement effect on the settlement of peat soil. The settlement that occurred in the first layer is different with third layer and can been analyse obviously.

4. Conclusion

For conclusion, by using buluh madu/buluh semantan that were knotted like a raft had contribute to act as an alternative for peat soil improvement method, the settlement value had decreased until 900% with 3 layer of bamboo and with 2kPa load on top. For the first layer, the bamboo had sink for 11cm in 72hours while for second layer, had sink for 4cm in 48hours then remains constant for the next 24 hours. lastly for the layer, the bamboo only sinks for 1 cm in 24hours then it is remains constant for next second and third days.

For material properties, bamboo used in this test is Buluh Madu/Buluh Semantan or the scientific name is Gigantochloa Scortechinii. Bamboo is stated as having a low cost, a wide range of local availability, and a high strength comparable to steel. This bamboo also having the thickest culm wall makes it suitable for parquet, furniture and building structures. The more the thickness of the wall, the more strengthen the bamboo. This is helpful information about using bamboo as a structural building material. In the event of a natural disaster, such as an earthquake or hurricane, it can prevent significant damage to structural members. Bamboo is widely regarded as a viable alternative to traditional building materials.

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