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Laboratory Studies of Bamboo Dendrocalamus Asper on Peat Soil Settlement by Continuous Loading

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ABSTRACT

Organic soil such as peat soil has a high organic content, compared with cohesive and cohesionless soil. The percentage of fiber content in peat soil shows the level degree of humification which is fibrous, hemic, and sapric. Organic and fibre content are two component properties that affect peat settlement due to its leading to extreme settlement issues for the foundation in long-terms. The purpose of this research is to identify the physical and mechanical properties of peat soil, as well as identify the displacement of bamboo Denrocalamus asper on peat settlement by applying continuous loading in physical modelling. Sample of peat from Kampung Parit Puteri Menangis, Benut, Johor. Sample preparations were divided into three parts which are physical properties (part 1), undisturbed samples were collected for moisture content, specific gravity, organic content, and fibre content. While mechanical properties (part 2), disturbed samples were collected for consolidation. As well as physical modelling (part 3) disturbed samples were collected for the displacement of settlement bamboo Dendrocalamus asper on peat soil. The outcomes of this research identified that the moisture content is 672%, specific gravity is 1.23, organic content is 88.34 – 96.19%, and fiber content is 38.1%. As well as the peat soil is categorized as H4 to H6 (Hemic). The outcomes for compressibility properties (C_c, C_v, and C_α) were determined as 0.13 to 1.54, 0.62 to 4.925, and 0.02 to 0.048 respectively. While for the outcome's settlement bamboo Dendrocalamus asper on peat soil, the displacement decreased by 48 to 50% after applying a maximum load of 4 kg/cm^2 in 2 hours. It can be concluded that the original peat soil needs to be treated to improve the settlement. The load applied on the peat soil affected the displacement of the foundation before collapse. The replacement with bamboo reinforcement on the peat reduces the displacement of settlement. The maximum settlement was decreased in a short period of 1 hour and 2 hours.

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1. Introduction

Soil can be categorized as cohesive, cohesionless, and organic. Cohesive soil is fine-grained soil such as clay, while cohesionless is any free-running type of soil such as sand [1]. Organic soil comes from natural ingredients. It is unique because it has environmental matter content or organic content. According to Yusof *et al*., [2] if the clay is cohesive soil, sand is cohesionless soil, while organic soil is peat. For agricultural purposes, peat soil is organic soil if the organic content is more than 35%. Meanwhile, for engineering purposes, the soil that has organic material content above 20% is organic soil, as well as peat above 75%. The contents of 75% include the different organic matter in the formation of the peat and make its different characteristics from other soil can be seen in review papers by several authors [3,4]. Mostly, the range of organic contents for Malaysian peat soil is from 70% to 98%. But it depends on the fibre content characterization system. The squeeze test was also conducted by Kamaruidzaman *et al*., [5] used to determine the differentiation between types of peat, as well as dividing peat into fibric, hemic, and sapric humification levels.

The visual texture of peat soil that was seen during the site visit shows that the peat has a very high-water content, but it can be categorized into fibrous, hemic, and sapric. Physically, peat soil holds the water content because of the organic component leading to overestimation of water content compared with other mineral soil such as sand and clay [6]. Yusof & Zain [7] also stated that it is an important parameter, as well as density, because peat has a slightly higher unit weight than water with the amorphous peat density being higher than fibrous peat. Higher water content, low shear strength, and high compressibility are the characteristics of peat soil [8]. Because of these, it has been known that peat famous with categorized as problematic soil. The composition of peat is generated from the incomplete decomposition of deceased by animal and plant matter with low temperatures, as well as the decomposition of peat develops a brown colour and soft. The texture of peat soil is very soft, making it not suitable for construction due to its tendency to fail if a heavy load is applied to it can be seen in review papers by several authors [9,10].

Thus, it is very challenging to construct on peat, especially for the maintenance and infrastructure because it has very soft and problematic soil due to its inadequate drainage. As an alternative, Mohamad [11] also mentioned that to fulfil the demands of construction requirements, peat soil needs underground reinforcement or improvement. The demand of the population increases every year is equivalent to the growing land demand. Faster design and construction for the construction development on peatland is needed to solve this problem. Unfortunately, the failure of design to avoid the failure of underground peat soil is still ongoing. For solution, the design of peat soil was settled and deformation in different conditions. This is because the high excessive settlement affects durability and smoothness, the most common causes of foundation structure can be seen in review papers by several authors [12,13]. Construction on peat soil exhibits distinct compression characteristics compared to clay soil, with initial compression occurring rapidly and subsequent primary and secondary loads not time-dependent [14]. Therefore, many researchers' studies on the settlement of peat. The famous method to improve the settlement of peat such as geotextiles, geogrids, timber, and bamboo [15]. The settlement of peat soil was also solved by reinforcement for many years, the concept of peat soil reinforcement is to develop the reinforcement elements in a soil mass that increase the shear resistance of the soil matrix. Suitable peat soil reinforcement that can make soil strong and more resistant such as bamboo, that is has durable and elastic properties [16,17].

Most of the information on bamboo properties is very lacking, making it neglected in the application in construction. A further advantage of bamboo is its effectiveness in lowering groundwater levels and preventing lateral movement by isolating the original muddy soil like peat

[18]. Waruwu [19] also stated that the Geotextile cannot be used independently directly on the peat area without the roll sinking into the extremely soft material. However, a geotextile placed over a bamboo fascine was found to be the most effective method of overcoming the said problems.

The giant bamboo Dendrocalamus Asper is always used as construction materials especially as soil reinforcement because these materials are suitable for the application of flexible structures to increase the unconfined compressive strength and reduce the displacement [20]. As a sustainable green building construction material, bamboo has shown a better performance compared with other products such as timber [21]. Manandhar *et al.*, [22] also stated that a common application in construction uses bamboo as grids to reinforce the settlement of shallow foundations and increase the bearing capacity. These findings highlight that bamboo can be cost-effective and the potential of using bamboo as a reinforcement material for peat soil and provide insights into its effectiveness in improving soil strength and stability.

Therefore, the laboratory studies in this research specifically focus on the influence of peat compression on loading settlement and the depth of settlement. The compressibility of reinforced or unreinforced single-layer bamboo laminated beams within the peat soil was used to mitigate settling problems caused by the peat soil's compressibility.

Among the states in Peninsular Malaysia, Johor has the largest area of peatland as mentioned by Sapar *et al*., [23]. For the study, peat soil samples would be collected from an oil palm plantation area in Kampung Parit Puteri Menangis, Benut, Johor, which is conveniently located near the University Tun Hussein Onn Malaysia (UTHM) and facilitates the sample collection process. The objective of this paper is to identify the physical and mechanical properties of peat soil, as well as identify the displacement of bamboo Dendrocalamus Asper on peat settlement by applying continuous loading in physical modelling.

2. Methodology

2.1 Collecting Peat Soil and Bamboo Dendrocalamus Asper Sample for the Research

The peat samples were collected from Kampung Parit Puteri Menangis, Benut, Johor. The activity clearance on the soil surface was conducted to remove the unwanted materials such as dead leaves, wood limbs, and grass to make such it was not collected with the original peat soil sample. The top surface was cleared at a depth of around 0 to 0.1 metres. The depth from 0.1 to 0.3 metres of soil layer is not the original level of peat soil. Therefore, this level was removed to make sure it was not mixed with the original layer of peat soil from the topsoil after clearance until the level of 0.3 metres before gathering the true peat soil sample. On visual site view, the level of water is around 0.4 metres depth due to the site location being near the river. It is proof that the peatland water level is approximately 0.4 metres from the groundwater surface. It is very difficult to collect undisturbed samples of peat. Therefore, a collection of peat soil samples needs to be careful to make sure that sampling for undisturbed is properly collected. While the disturbed sample was taken randomly. All samples were placed in a container that was labelled and wrapped properly. The transportation of the sample had to be immediate to the laboratory to maintain the original condition of the peat soil sample.

The bamboo Dendrocalamus Asper was collected from Felda Nitar, Mersing, Johor. For bamboo Dendrolamus Asper, the sample was collected originally from the tree (giant bamboo). The bamboo was cut smaller and more carefully because it was sharp. Dimensions of bamboo for physical modelling are already measured to make cutting work easier.

2.2 Physical Properties Methods

The physical properties of the original soil are very important to determine. It is compulsory to determine the physical properties of the original soil. For this research, the physical properties of peat soil need to be determined such as specific gravity (G_s), water content (*w*), organic content (OC), fiber content (FC), and the degree of humification.

2.2.1 Specific gravity (G_s)

According to the British Standard (BS) 1377: Part 2: 1990 in Johari *et al*., [24] the specific gravity was determined using a small pycnometer. All the procedures followed the guidelines as stipulated in the standard. According to these standards, the preparation of the sample is oven-dried at 105 °C temperature to prepare the dry soil in a 425 mm mesh sieve. The sample that was prepared had to be free-of-lumps soil samples including unoccupied, dry peat soil, finely ground particulate, and the distilled water used a pycnometer's mass in grams and weight for determining the specific gravity.

2.2.2 Water content (w)

The water content of peat soil in this research was determined according to the procedure as stipulated in the British Standard (BS) 1377: Part 2: 1990 and ASTM D 2216 – 98 (2004). The standard recommended that microwave ovens are not suitable for organic soil such as peat. While following the procedure from the standard, the empty cans were used, and determined the weight, as well as filling with the peat soil. The water content was calculated using percentages.

2.2.3 Organic content (OC)

Soil organic matter percentage, measuring moisture, ash, and organic matter in soil relative to dry solids was determined according to ASTM D 2974 Standard in Mohd Zain *et al*., [25], and the organic content was determined by percentage. Following the procedure in the standards, the weight of the sample was dried for 24 hours at a temperature of 105 °C. The sample continued with the drying process in a furnace set at a temperature of 440 °C for a duration of two hours. The sample was weighed once more a room temperature.

2.2.4 Fiber content (FC)

Fiber content was measured according to the procedure stipulated in the standards of BS 1377 - 2: 1990 and ASTM D 2216 - 91. According to the procedure, a solution containing 5% sodium hexametaphosphate as a dispersing agent was used to subject a dry mass of a peat sample. This process needs a total immersion time of approximately 15 hours. The material follows the washing process via a 100 (or 150 microns) mesh size sieve, utilizing a gentle stream of tap water. The sieve is subjected to a drying process in an oven that is maintained at a temperature of 105 °C until it achieves a homogeneous consistency.

2.2.5 Degree of humification

The Von Post Scale was used as the guideline to determine the range of degree of humification of peat after determining the fibre content of peat soil. The site visual (used squeeze test) was also used as the indicator to determine the types of peat soil either fibrous, hemic, or sapric. From H1 to H10, the scale of the ranges determines the fibrous peat in a scale from H1 to H4, while hemic and sapric peat has scaled from H5 to H7 and H8 to H10 respectively.

2.3 Mechanical Properties Methods

In this research, a conventional 1-D oedometer consolidation was used to determine the compressibility of the peat soil. As stipulated in ASTM D2435, the procedure was to apply the load (5, 10, 20, 40, and 80 kPa) to test the peat soil sample. The peat sample with a size of 75 mm diameter and 20 mm height was used is sustained for a duration of 24 hours and the data was recorded. The outcomes for compressibility properties (C_c, c_v, and C_α) were determined for this research.

2.4 Physical Modelling (Load Settlement) Method

The disturbed sample of peat soil was used as the primary material, and the bamboo Dendrocalamus Asper (giant bamboo) as the secondary material in the physical modelling testing. Original peat soil without roots and debris was excavated and collected from 0.3 to 1 meter. The peat sample was placed in the container as shown in Figure 1, the schematic drawing of physical modelling. The laminated bamboo with the size 41 cm x 41 cm and a height of 1 cm (Figure 2 and Figure 3) was prepared early with the true measurement and placed properly. It is to make sure the dimensions of the bamboo are suitable and not too fixed with the size of the container (50 cm x 50 cm x 70 cm).

The original peat sample was prepared in wet conditions collected from the site and added into the box in a slow and careful manner, reaching a height of 50 cm. A square plate base made of polystyrene was placed on it. The loads were applied to the foundation (base made of polystyrene) which is a square plate with sizes 10 cm x 15 cm.

This foundation was placed above a bamboo layer the bamboo layer was placed in the container together with peat soil before the displacement of the settlement was observed. This method ensures that the structure is well-supported by a stable foundation. The bamboo laminated beam model has been installed at a specific depth to ensure optimal soil conservation.

The displacement of the settlement without bamboo was observed, as well as the load was added. The data was recorded for loads of 1 kg for 1 and 2 hours, followed by loads of 2 kg, 3 kg, and 4 kg. The displacement of the settlement shows that the soil was compressed 10 cm times using a small hoe.

Following with, as mentioned by Rahim *et al.*, [26] the load was applied by repeating loading on the foundation of the peat soil with bamboo. The loading was applied such as 2kg, 3kg, and 4kg to the uppermost section of the bamboo. Two different types of time, which are 1 hour, and 2 hours were also selected to measure the settlement performance. The measurement displacement of the settlement was taken using the dial gauge at the centre of the container. The bottom of the box was started with the first layer of the laminated bamboo beam. The height of the peat soil is approximately 40 cm. The laminated bamboo beam was then placed on top of the soil, followed by an additional layer of 10 cm of soil at the top (which is a 10 cm gap between each laminated bamboo beam).

The process was followed with the second and third layers. The first layer involved covering the peat soil with a layer of approximately 30 cm in height and placing a 20 cm layer at the bottom.

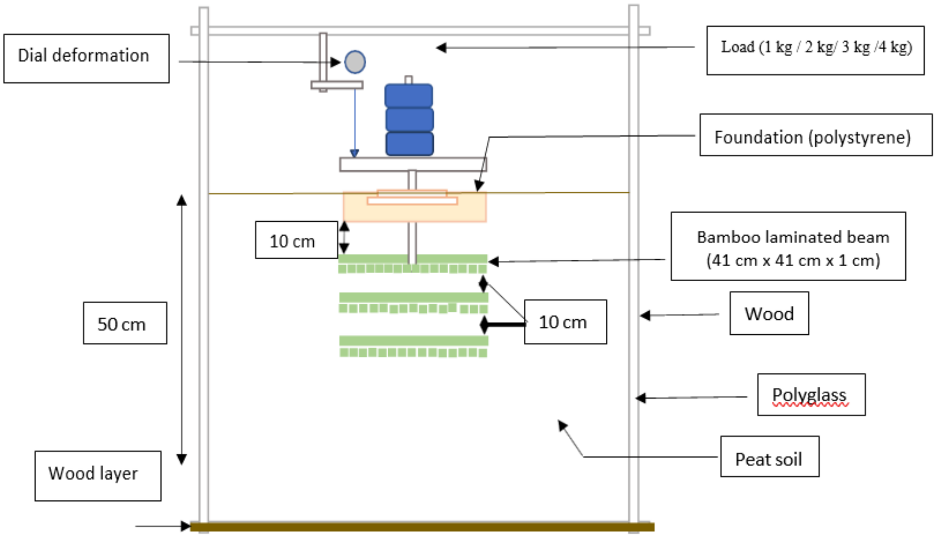

Fig. 1. Schematic drawing of physical modelling

Fig. 2. Laminated Bamboo

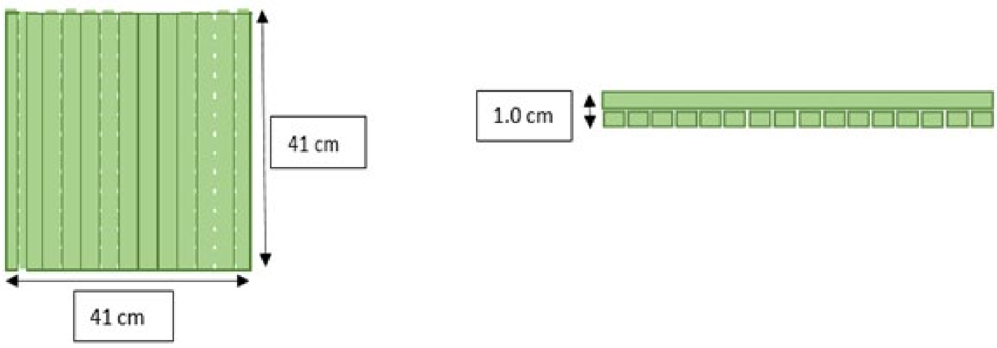

Fig. 3. Dimensions of the bamboo

3. Results and Discussion

3.1 Physical Properties Results and Discussion

For the physical properties of peat soil in this research, it was determined that the value of specific gravity (G_s) is measured as 1.23. It is shown that the Johore Hemic Peat as mentioned by Razali *et al*., [27] ranges from 1.07 to 1.63. The value of the water content (w) is 672%. Research by Zainorabidin *et al.,* [28] stated that characteristics of peat like spongy make it absorb more water and hold the water content in a percentage of 652.1% to 898.91%. While, the value of organic content (OC), and fibre content (FC) respectively 88.34 – 96.19% and 38.1%. According to Karthigeyan & Ramachandran [29], the organic content of peat soil in Malaysia is between 70% to 98% because the presence of organic matter in soil is higher, while fibre content for this research was identified as 38.1%, making it in categories hemic range and as mentioned by Johari *et al*., [30] hemic has a degree of humification H4 to H6, which is equal 33% to 66%.

Thus, peat soil is classified as pseudo-fibrous peat (hemic) based on the degree of peat decomposition (H4-H6), hemic has fibre content in between fabric and sapric. Von Post classification test at Kampung Parit Puteri Menangis, Benut, Johor found moderate decay in fresh peat. Peat soil with organic content of organic content >75% and hemic to fibrous peat, peat soil with fiber content >20% (33% - 66%).

3.2 Mechanical Properties Results and Discussion

In this research, the mechanical properties were observed through the oedometer test. The conventional oedometer test was used to determine the consolidation parameters which are compression index (C_c), consolidation coefficient (C_v), and coefficient of secondary compression (C_α). The C_c, C_v, and C_α were determined as in the range 0.13 to 1.54, 0.62 to 4.925, and 0.02 to 0.048 respectively within the consolidation pressure from 5 kPa to 80 kPa. C_c values for Hemic peat soil range from 1.3 to 2.78 as stated by Duraisamy *et al*., [31]. The C_v values for the conventional 1 - Dimensional consolidation were in the range of 0.696 to 17.379 as stated by [24] in their study. The C_α values for hemic peat soil in Duraisamy *et al*., [31] studies also were in the range of 0.0225 to 0.0881.

3.3 Physical Modelling Results and Discussion

The displacement of the settlement of this research is the outcome of the effect of the settlement on the compressibility of repeating loading.

3.3.1 Displacement of the settlement without bamboo

Figure 4 shows the movement of the displacement without bamboo. The displacement of settlements increases with different loads applied, such as 1 kg, 2 kg, 3 kg, and 4 kg. At 0 hours, the displacement starts to move, followed by 1 hour and as well as at 2 hours. At 1 kg load, the displacement was increased by 52%, following at load 3 kg the displacement moves to 27%, and as well as 20% at a load of 4 kg.

Figure 4 also shows that as the load increases, the settlements also increase over time. It shows that the displacement at 1 hour when applied 1 kg load increased from 2.509 mm to 5.201 mm after applying load 2 kg. The displacement increased to 7.166 mm in load 3 kg before slightly changing to 8.919 mm after applying load 4 kg. However, for the displacement at 2 hours when applied 1 kg load it increased from 3.728 mm to 6.014 mm after applying load 2 kg. The displacement increased to 7.864 mm in load 3 kg before the slight change increased to 9.543 mm after applying load 4 kg.

It also identified that in Figure 4, the difference in the displacement at 1 hour was 6.41 mm, while at 2 hours the difference in displacement movement was 5.815 mm. It is shown that without bamboo reduces the displacement of the settlement by 0.595 mm within one hour, and as load increases, settlements gradually increase. The soil settled gradually as the load was applied until the reading remained constant [32].

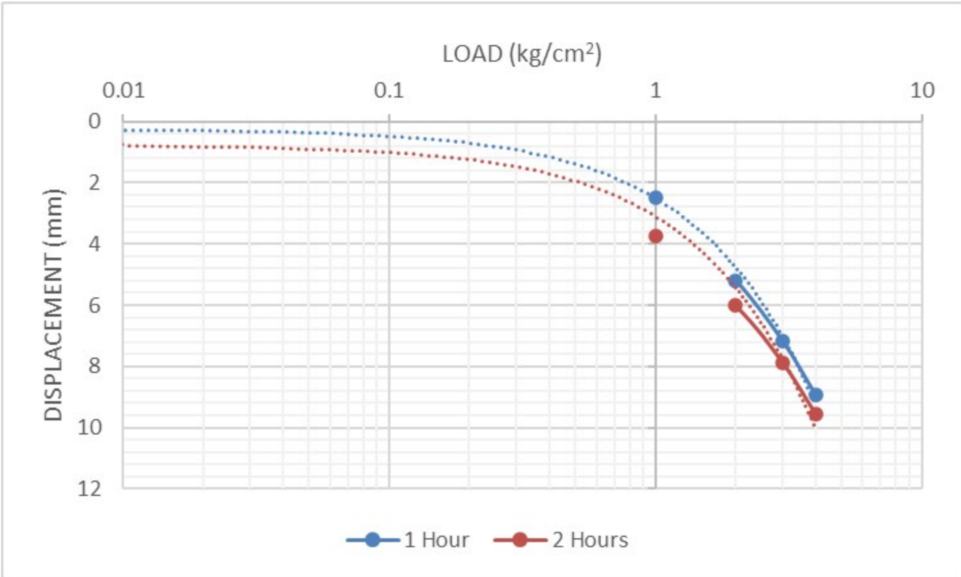

Fig. 4. Without Bamboo

3.3.2 Displacement of the settlement with bamboo

Figure 5 shows the movement of the displacement of a settlement with one layer of bamboo reinforcement. The movement of the displacement starts at 0 hours and persists until 2 hours. The loads include 1 kg, 2 kg, 3 kg, and 4 kg. The displacement increases with load, with 1 kg causing 1.258 mm displacement, 2 kg causing 57.7%, 3 kg causing 24%, and 4 kg causing 11%.

Figure 5 also shows that the displacement at 1 hour when applied 1 kg load increased from 1.258 mm to slightly increased 2.98 mm after applying load 2 kg. The displacement increased slightly to 3.929 mm in load 3 kg before slightly changing to 4.432 mm after applying load 4 kg. However, for the displacement at 2 hours when applied 1 kg load it increased slightly from 2.129 mm to 3.571 mm after applying load 2 kg. The displacement increased slightly to 4.264 mm in load 3 kg before the slight change increased to 4.993 mm after applying load 4 kg.

It also identified that in Figure 5 the difference in the displacement at 1 hour was 3.174 mm, while at 2 hours the difference in displacement movement was 2.864 mm. It is shown that single-layer bamboo reduces the displacement of the settlement by 0.31 mm within one hour, and as load increases, settlements gradually increase. The soil settled gradually as the load was applied, and a higher applied load reduced compression in peat soil was also conducted by several authors [18,32].

Figure 6 shows the movement of the displacement of a settlement with two layers of bamboo reinforcement. The movement of the displacement starts at 0 hours and persists until 2 hours. Loads include 1 kg, 2 kg, 3 kg, and 4 kg. The displacement measurement starts at hour 0 and lasts until hour 2. The settling rate of a solitary bamboo layer is 36.37%. The soil experiences a 37% increase in settlements after a 120-minute period, with a 14% increase after 2 hours.

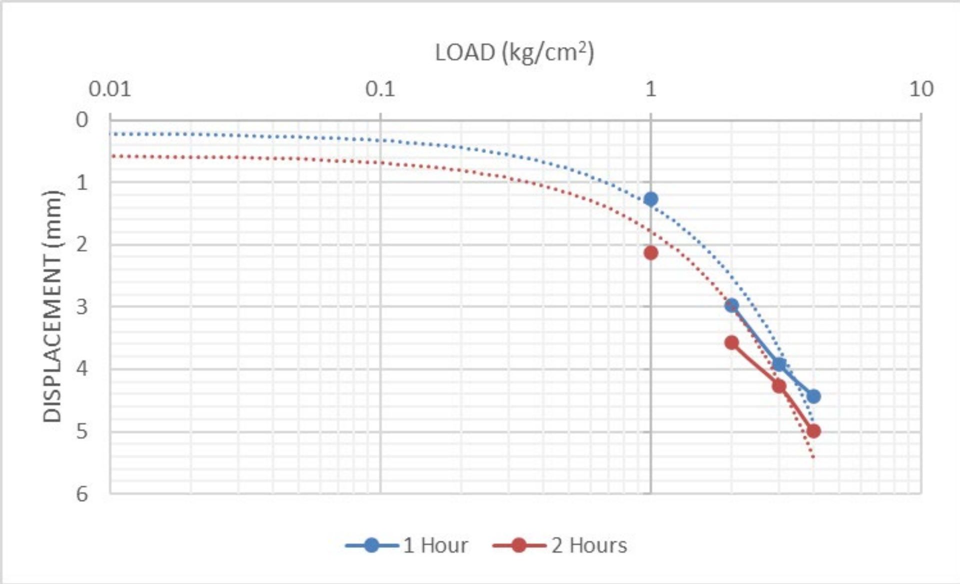

Fig. 5. With 1 Layer Bamboo

Figure 6 also shows that the displacement increases with load, with 1 kg causing 1.089 mm displacement, 2 kg causing 57.7%, 3 kg causing 24%, and 4 kg causing 11%. It shows that the displacement at 1 hour when applied 1 kg load increased from 1.089 mm to slightly increased 1.99 mm after applying load 2 kg. The displacement increased slightly to 2.888 mm in load 3 kg before slightly changing to 3.54 mm after applying load 4 kg. However, for the displacement at 2 hours when applied 1 kg load it increased slightly from 1.429 mm to 2.261 mm after applying load 2 kg. The displacement increased slightly to 3.121 mm in load 3 kg before the slight change increased to 3.77 mm after applying load 4 kg.

It also identified that in Figure 6, the difference in the displacement at 1 hour was 2.451 mm, while at 2 hours the difference in displacement movement was 2.341 mm. It is shown that double-layer bamboo reduces the displacement of the settlement by 0.11 mm within one hour, and as load increases, settlements gradually increase. The soil demonstrates gradual settlement as the load is applied, eventually reaching equilibrium. Waruwu & Susanti [18] also mentioned that an increase in applied load leads to a significant decrease in peat soil compression.

Figure 7 shows the movement of the displacement of a settlement with three layers of bamboo reinforcement. The movement of the displacement starts at 0 hours and persists until 2 hours. Loads include 1 kg, 2 kg, 3 kg, and 4 kg. The displacement measurement starts at hour 0 and lasts until hour 2. The displacement of a settlement is affected by adding one more layer of bamboo reinforcement.

Figure 7 also shows that the displacement at 1 hour when applied 1 kg load increased from 1.089 mm to slightly increased 1.99 mm after applying load 2 kg. The displacement increased slightly to 2.888 mm in load 3 kg before slightly changing to 3.54 mm after applying load 4 kg. However, for the displacement at 2 hours when applied 1 kg load it increased slightly from 1.429 mm to 2.261 mm after applying load 2 kg.

In Figure 7, the displacement increased slightly to 3.121 mm in load 3 kg before the slight change increased to 3.77 mm after applying load 4 kg. It also identified that in Figure 7, the difference in the displacement at 1 hour was 2.451 mm, while at 2 hours the difference in displacement movement was 2.341 mm. It is shown that triple-layer bamboo reduces the displacement of the settlement by 0.11 mm within one hour, and as load increases, settlements gradually increase. The displacement increases with the load applied, with one kilogram causing 1.487 mm and 2 kg causing 2.63 mm. A single bamboo layer settling was 36.37% [17,33]. Other researchers found that a load of 3 kg for an hour resulted in a displacement of 3.626 mm, a 27% increase, and a 19% increase under a 4 kg weight. The soil levelled out gradually with the load applied, and increasing the load on peat soil would result in less compression was also conducted by several authors [18,32].

The research has shown that the movement of the displacement as shown in Figure 8 demonstrates that the displacement of settlements increased by 72% without bamboo reinforcement and 71.6% with bamboo reinforcement in 1 hour.

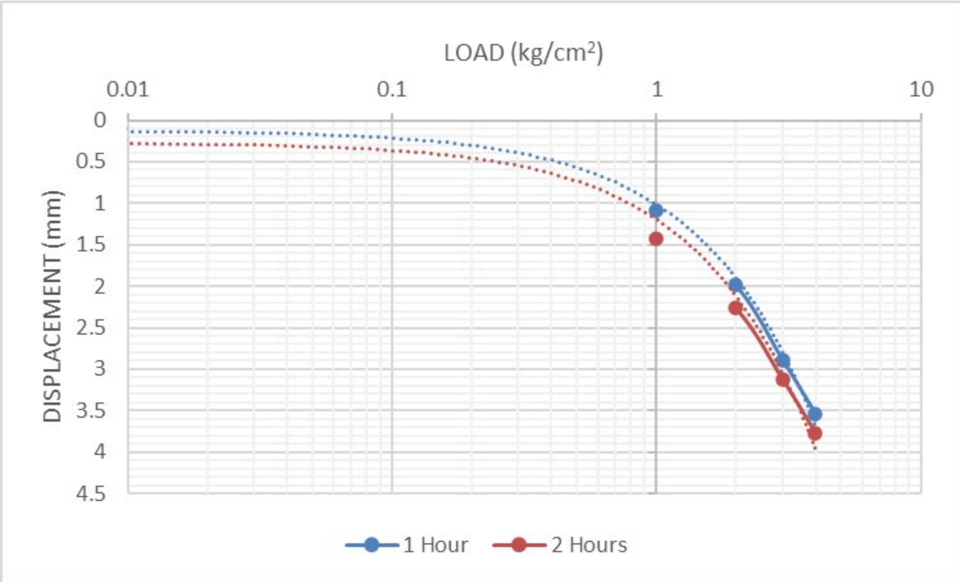

Fig. 6. With 2 Layer Bamboo

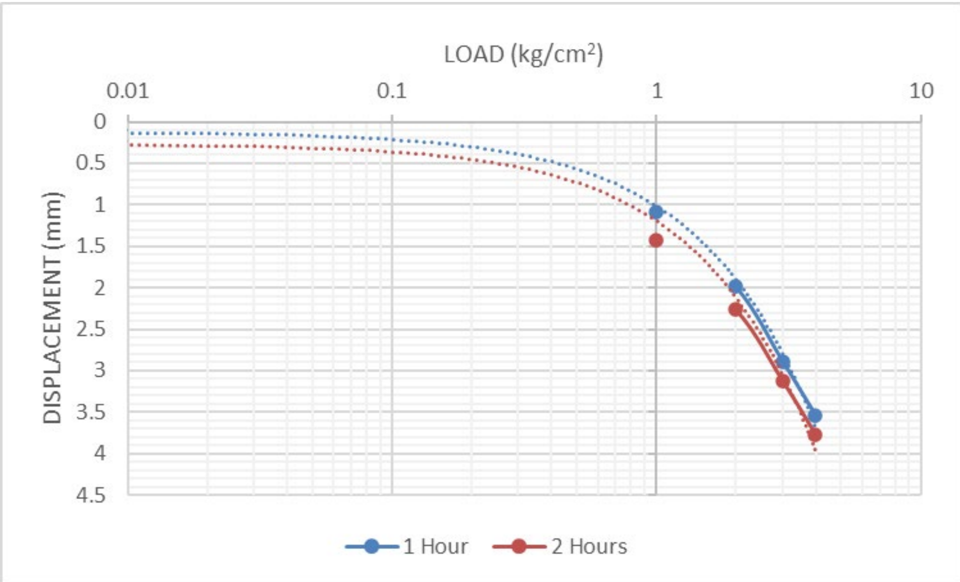

Fig. 7. With 3 Layer Bamboo

Figure 8 also presents that the application of a 1 kg load on peat soil resulted in a 50% decrease, while 2 kg load reduced settlements by 43%. Waruru *et al.*, [33] also stated that the without and with bamboo layers can enhance the load-bearing capacity of peat soil in construction. The reduction in displacement suggests that the foundation on peat soil can bear up to 50% more under the same load.

In Figure 8 also shows the movement of the displacement in 2 hours. It was presented that the investigation found that displacement of the settlement increased by 61% in the absence of bamboo reinforcement and 62% in the presence of two layers of bamboo reinforcement. The thickness of peat soil decreased by 62% when 1 kg of weight was applied to it. The settlements decreased slightly by 62.4% when subjected to a 2 kg load for 2 hours, and 61% under a 4 kg load for 2 hours. Therefore, based on the findings, it is suggested that the bamboo reinforcement can improve settlement speed and reduce displacement in peat.

Therefore, it can see in Figure 8 also shows the movement of the displacement of peat settlements with and without bamboo reinforcement. Over one hour, the thickness of peat decreased from 8.919 mm to 4.432 mm when a weight of 4 kg was applied. This means the difference in the displacement achieves 4.487 mm, reduced slightly. This represents a loss of almost 50%. A load of 4 kg was applied over two hours, resulting in a 48%-point drop in settlement displacement.

The impact of bamboo reinforcement on peat settling is temporary by the time, as the population may grow again within a few hours. It is shown in a previous study by Zainorabidin *et al.*, [34] found that the reinforcing effect can impact peat soil settling over time.

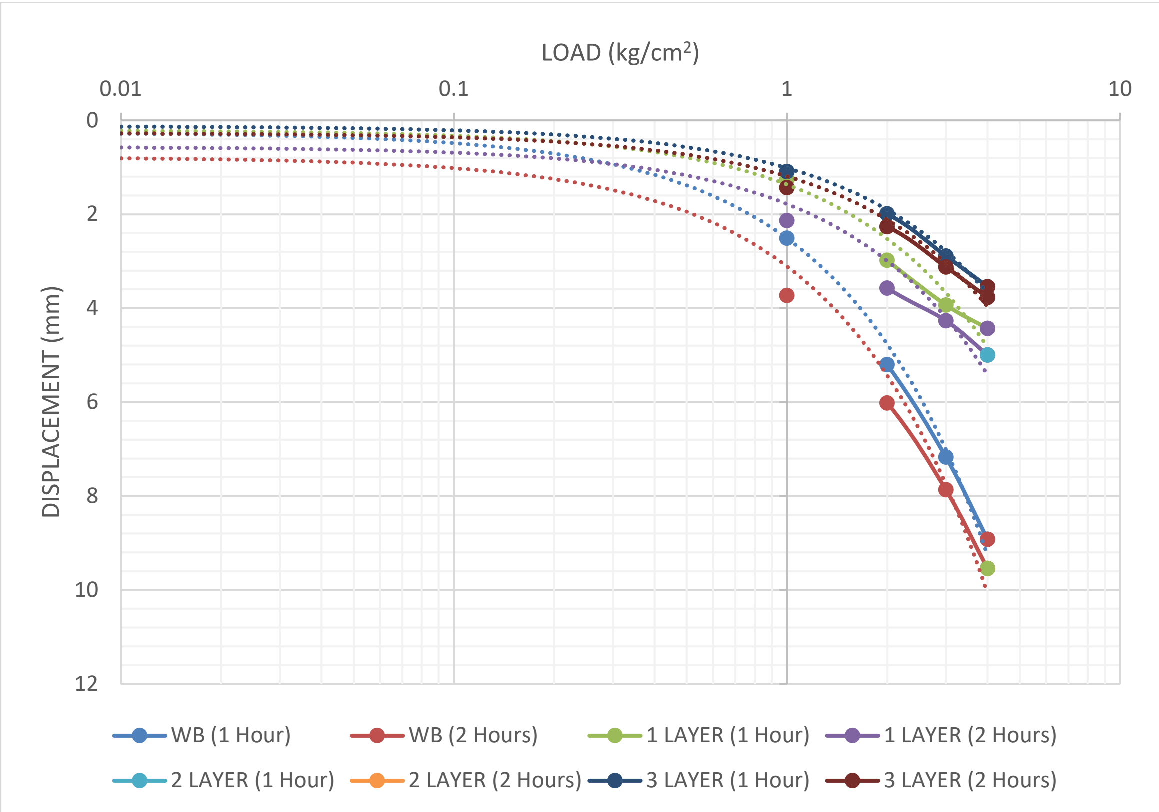

Fig. 8. Movement of the Displacement in 1 Hour and 2 Hours

4. Conclusions

The purpose of this research is to identify the physical and mechanical properties of peat soil, as well as identify the displacement of bamboo Denrocalamus asper on peat settlement by applying continuous loading in physical modeling. In this research, bamboo Dendrocalamus asper was used as reinforcement to observe the displacement of settlement of peat soil. For Kampung Parit Puteri Menangis, Benut, Johor, the physical properties were determined as follows: moisture content of 672%, specific gravity of 1.23, organic content of 88.34 – 96.19%, fiber content of 38.1%, and categories H4 to H6 (Hemic). All these physical properties give the different performances of the settlement.

The compressibility properties (C_c, C_v, and C_α) from the original peat soil were identified as 0.13 to 1.54, 0.62 to 4.925, and 0.02 to 0.048 respectively. In the physical modeling, settlement without bamboo reduces the displacement by 0.595 mm.

Meanwhile, the single-layer bamboo settlement reduces the displacement by 0.31 mm. For double-layer bamboo, the settlement reduces the displacement by 0.11 mm. The last layer which is the triple-layer bamboo settlement reduces the displacement of the settlement by 0.11 mm within one hour. As the load increases, settlements gradually increase.

The bamboo Denrocalamus Asper reinforcement decreased the movement of the settlement of peat. The movement of peat displacement depends on peat properties. The different locations show the different challenges in the displacement of settlements of peat for groundwork.

In the real world, peat soil has a large settlement and long-term effects in various ways. It is important for the practical application of the research finding that the use of bamboo in this research can keep the peat soil ground foundation settlement in a stable state.

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