MULTIDISCIPLINARY APPLIED RESEARCH AND INNOVATION
e-ISSN: 2773-4773

MARI

Vol. 5 No. 2 (2024) 67-73
https://publisher.uthm.edu.my/periodicals/index.php/mari

The Influence of Different Size of Filler in Peat Consolidation Study

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DOI: https://doi.org/10.30880/mari.2024.05.02.010

Article Info

Received: 01 December 2023
Accepted: 30 April 2024
Available online: 30 June 2024

Keywords

Consolidation, Different filler size, Peat, Sand

Abstract

The uniques properties of peat make it unsuitable for use as a foundation for infrastructure projects. High water content, high settlement, and low shear strength are the major concern when dealing with the peat soil. Thus, the purpose of the study is to understand the settlement behaviour of peat in its originais state and the influence of different sizes of sand as fillers on the consolidation of peat. The consolidation tests were conducted on original peat, peat with sand size of 0.425 mm and 0.150 mm. These sample were formed at optimum moisture content and maximum density that obtained from the proctor test. The result shows that the settlement for original peat, peat with 0.425 mm sand and peat with 0.150 mm sand are 4.199 mm, 3.816 mm and 3.549 mm respectively. The original peat experienced the highest settlement compared to the sample with sand. It is because of the sand that acts as a filling between the voids. The smaller sized of sand particles are corporated into peat as a filler, created a denser pack arrangement and providing a better compaction and at the same time helps in reduced the settlement.

1. Introduction

Peat soils are seen as having minimal economic value in Malaysia, other from being used for agricultural purposes. The entire global covering of peat soil is around thirty million hectares, with Canada and Russia having the most peat soil dispersion [1]. South-East Asia contains more than 60% of the world's tropical peat lands [2]. The largest peat land areas are in the Indonesian, Malaysian, and Bruneian islands of Borneo and Sumatra (Indonesia). However, large cases have been reported in other parts of Indonesia, Malaysia, Vietnam, Thailand, and the Philippines. The key engineering disciplines that peat soil contributes to, and benefits include hydrology, agriculture, social-economics, biodiversity habitats, and carbon sequestration. Peat was utilised as a fuel to create power and heat in temperate climes (particularly in Finland, Ireland, Sweden, and the United Kingdom). As a result, while peat can be considered a green energy source, it will be extremely harmful to the market for actual renewables. Malaysia's western coastal lowlands (such as Kukup) are mangroves that indicate the beginning of peat soil formation. These are the natural habitats of mangrove forests. It also removes more carbon from the atmosphere than it emits and accounts for around one-quarter of carbon stored in land plants and soils. Peat, on the other hand, is a troublesome or difficult foundation soil of poor quality because of its high-water content, compressibility, and low shear strength. Peat is made up of disintegrated plant pieces, and the unfavourable properties of peat soil deposits make it unsuitable for developing sustainable infrastructure for

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various engineering projects. As a result, this paper provides an outline of the pros and cons argument around sustainability, as well as the challenges it poses to Malaysian infrastructure development [3].

In this Study, sand is used as a filler. Sand is defined as loose, gritty particles of worn or dissolved rock that are typically deposited along the coastlines of bodies of water, in riverbeds, or in desert dunes. Sand is defined by geologists as a natural loose, granular material composed of distinct mineral or rock particles ranging in size from 0.0625 to 2.00 mm. Granules, pebbles, cobbles, or boulders (>256 mm) are larger particles, while silt (0.0625-0.00 mm) or clay (0.004 mm) are smaller grains. Particle size is determined by passing samples through a succession of screens with varying opening widths. Sand is a product of preexisting rock weathering and transport. Sand and its cemented counterpart, sandstone, are both very important geologic products that have received a lot of attention [4]. Publications aimed towards the general audience, such as Sand, have also garnered positive feedback. Because the forces that form sand and sand parent materials occur all over the Earth, sand can be found everywhere. Soil contains fine-grained, pliable clay minerals, organic compounds, oxide minerals, and poorly defined mineraloids in addition to sand grains [5]. In this experiment, two different sizes of sand 0.425mm and 0.150mm are used for the filler.

Consolidation settlements are frequently significant and perhaps structurally destructive. Many civil engineering projects rely on estimating their magnitudes and the speeds at which they will occur, Settlement magnitudes and rates were critical design considerations. It is critical to understand what factors influence the precision with which settlement magnitudes and settlement rates can be estimated in these and comparable circumstances. Accurate estimations of peat compressibility and pre-consolidation pressure are required for accurate prediction of settlement magnitudes [6].

2. Material and Methods

The objective of this study is to investigate the effects of different sizes of sand as fillers in aiding peat soil to reduce settlement. The materials utilized in this research include peat soil and three different sizes of sand fillers. To conduct the investigation, four tests were performed: moisture content test, sieve test, proctor test, and oedometer test.

2.1 Materials

In this research, the materials under investigation include peat soil and sand. The peat soil samples were collected from Parit Nipah. A specific location previously marked for sampling purposes in Fig. 1(a). The sampling process involved digging approximately 1 meter deep at the designated locations after removed the topsoil as in Fig. 1(b). The obtained soil samples were carefully stored in plastic bags during transportation (Fig. 1(c)). Upon arrival, the samples were promptly transferred to containers within a specially designated room to preserve their moisture content.

In addition to the peat soil, the study incorporated three different sizes of sand fillers: 0.425 mm and 0.150 mm. These sand sizes were selected to examine their impact on the behavior of the peat soil and its potential for settlement reduction. By employing proper collection techniques and meticulous preservation measures, the study ensures the integrity and representativeness of the soil samples from Parit Nipah. The inclusion of varying sand sizes enables a comprehensive investigation into the effects of different fillers on the behavior of the peat soil, contributing valuable insights to the field of geotechnical engineering.

(a) (b) (c)

Fig. 1 *Sampling (a) Marking the location; (b) Removed the topsoil; (c) Sample collected*

2.2 Method

The methodology employed in this study encompassed several techniques, including moisture content test, sieving, proctor test, and oedometer test, to analyze the properties of the materials.

2.2.1 Moisture Content Test

The peat soil samples, obtained meticulously from Parit Nipah, were skillfully transferred into separate, designated small containers. The process involved the careful allocation of the collected soil into a total of five small containers, ensuring individual representation. Before filling each container with the peat soil, its initial weight was precisely measured and recorded for accurate analysis. Subsequently, the containers, containing the soil samples, were cautiously placed within an oven, which had been preheated to a specific temperature of 105°C. Maintaining the required temperature consistently, the containers with the soil samples were left undisturbed for a period of 24 hours, allowing for the complete drying of the peat soil.

After the designated drying period, the containers, now holding the dried soil samples, were carefully retrieved from the oven. To determine the precise weight of the dried soil sample and its container, accurate measurements were taken. The final weight, inclusive of both the container and the dried soil sample, was recorded for subsequent calculations. Utilizing the recorded final weight and the initial weight of each container, the moisture content of the peat soil sample was meticulously calculated. This calculation allows for a comprehensive understanding of the moisture content within the soil, a vital parameter to assess its behavior and characteristics. By following this procedure, the research team ensures the accuracy and reliability of the moisture content measurements in the peat soil samples. These measurements form a crucial foundation for further analysis and insights into the behavior of the peat soil in relation to its moisture content.

2.2.2 Sieve Analysis Test

Sand was specifically chosen as the sand material for this test. To align with the research objectives, the sand underwent a meticulous sieving process to obtain the desired particle sizes. The study focused on sizes of 0.425 mm and 0.150 mm. A precisely measured quantity of 500 grams of dry sand was placed into the sieve, and with manual shaking by hand, the sand particles were effectively separated. Only the sand that met the predetermined size criteria and successfully passed through the sieve was carefully preserved for future use in the oedometer test. By implementing this rigorous procedure, the research ensures the consistency and reliability of the selected sand samples, enabling a thorough investigation into their impact on the oedometer behavior.

2.2.3 Proctor Test

The Proctor Test is performed to assess the compaction characteristics of peat soil. Wet peat soil is dried in an oven at 105°C for 24 hours. The dried soil is crushed to pass through a 4.25 mm sieve and small branches and root are removed. Dry peat soil weighing 3kg is measured, and the mould's weight is recorded for accurate measurements. To achieve the desired moisture content, 300 mL of water (10% of soil weight) is added to the soil in a cylindrical beaker. The water is mixed with the soil to provide moisture. Oil is applied to the mould's inner surface to prevent soil sticking during extraction. The soil is then compacted in layers using a rammer with 27 strokes as in Fig. 2.

After compaction, the soil and mould weight are measured to calculate the dry unit weight. Samples are collected from the top and bottom of the specimen to assess soil homogeneity, revealing moisture and density distribution. The process is repeated with varying water content until a decrease in weight indicates optimal compaction. The compacted sample is dried in an oven for 24 hours, and its weight is measured to determine moisture content. The average moisture content and dry density values are used to generate a graph, identifying the optimum moisture content and maximum dry density for the oedometer test. The procedures were done following the British Standard, BS 1377-4-1990.

Fig. 2 *Compaction process*

2.2.4 Consolidation Test

The oedometer test was conducted to evaluate the settlement characteristics of each sample. The samples, consisting of original peat, peat mixed with sand of sizes 0.425 mm and 0.150 mm were prepared (Fig. 3), and weighed using the prescribed calculation method. For optimal consolidation, a calculated weight of 46g was determined to fill the space within the consolidation ring. The sand content was set at 10% of the sample weight.

To begin the test, 500 g of peat was prepared and mixed to achieve the desired moisture content of 50%. The peat and sand were then weighed and combined according to their respective weights, as determined by the calculation. The weight of the consolidation ring was recorded prior to inserting the sample.

Subsequently, the sample, along with the consolidation ring, was re-weighed and placed into the consolidation cell of the oedometer. Water was carefully added to each sample until it reached maximum capacity. The gauge was positioned on the cover, and incremental loads of 5 kPa, 10 kPa, 20 kPa, 40 kPa, 80 kPa, 160 kPa, and 320 kPa were applied, representing the desired loading conditions. After a period of 7 days, the test data was collected to analyze the settlement behavior of each sample.

(a) **(b)** **(c)**

Fig. 3 *Peat sample (a) Original peat; (b) Peat + 0.425 mm sand; (c) Peat + 0.150 mm sand*

3. Results and Discussion

This data from three conducted experiments: the moisture content test, the proctor test, and the consolidation test. The research undertaken in this study adheres to the research methodology outlined in the previous chapter. The obtained results from the research analysis will reveal the state of peat soil quality in Parit Nipah area and assess the quality after incorporating sand into the peat soil. Based on the available data, the optimal percentage of sand required to enhance the characteristics of the peat soil can be calculated.

3.1 Proctor

Based on Fig. 4, data shows moisture content at the x-axis and dry density at the y-axis. The graph shows that the optimum moisture content is 99% and the maximum dry density is 0.516 g/m3. The data outcomes from previous researchers show that untreated peat soil has a maximum dry density. The data outcomes from previous researchers show that untreated peat soil has a maximum dry density of 6.1×10-7 kg/m3 and an optimum moisture content of 63.5%. As a result, the values for maximum dry density and optimum moisture content for this test are not the same as those from the previous study because the peat sample was taken at different places.

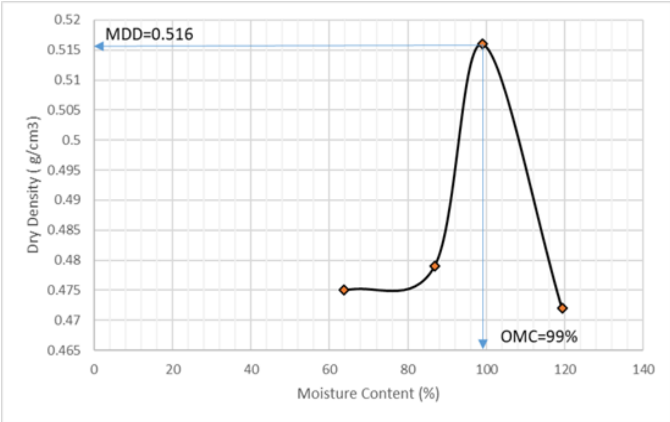
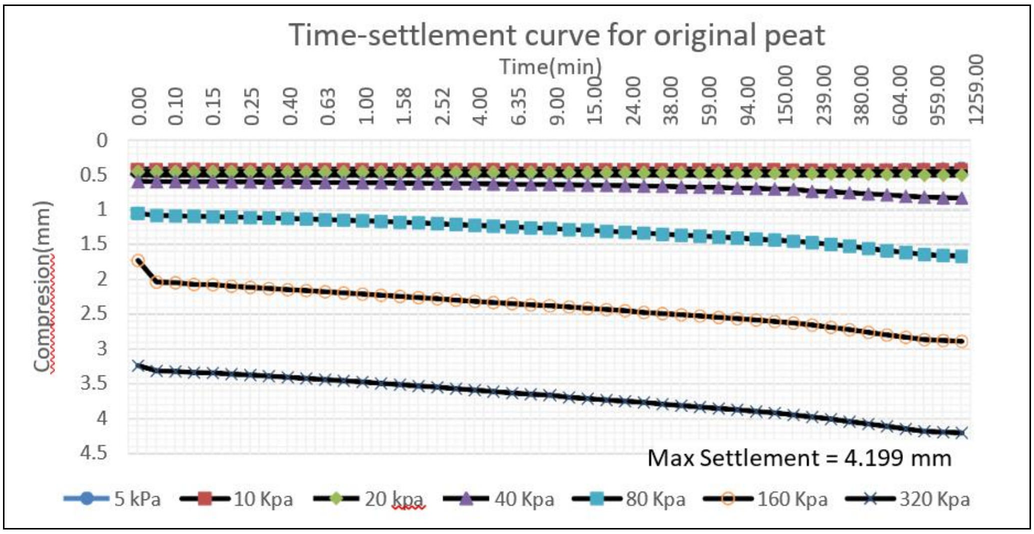


Fig. 4 *Result of Proctor test*

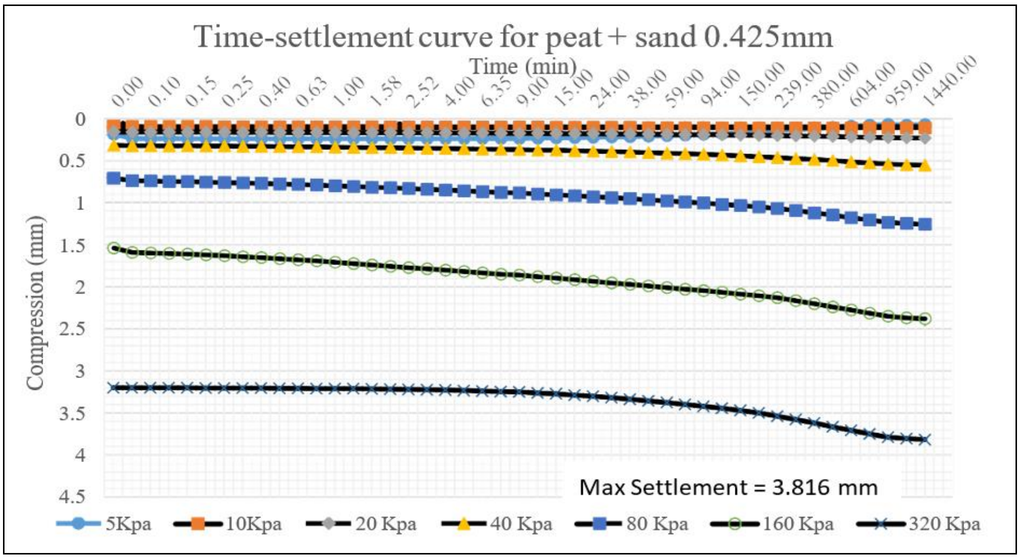
3.2 Consolidation Test

In the consolidation testing, three different samples were prepared, including the original peat and two variations with the addition of sand. Each sample was carefully weighed to ensure proper compaction within the consolidation ring and to achieve optimal peat conditions. The original peat sample had a weight of 45.6g, while the other two samples consisted of 41.4g of peat and 4.6g of sand, which corresponded to 10% of the weight of the original peat. The weight ratios were chosen to maintain consistency and allow for comparative analysis.

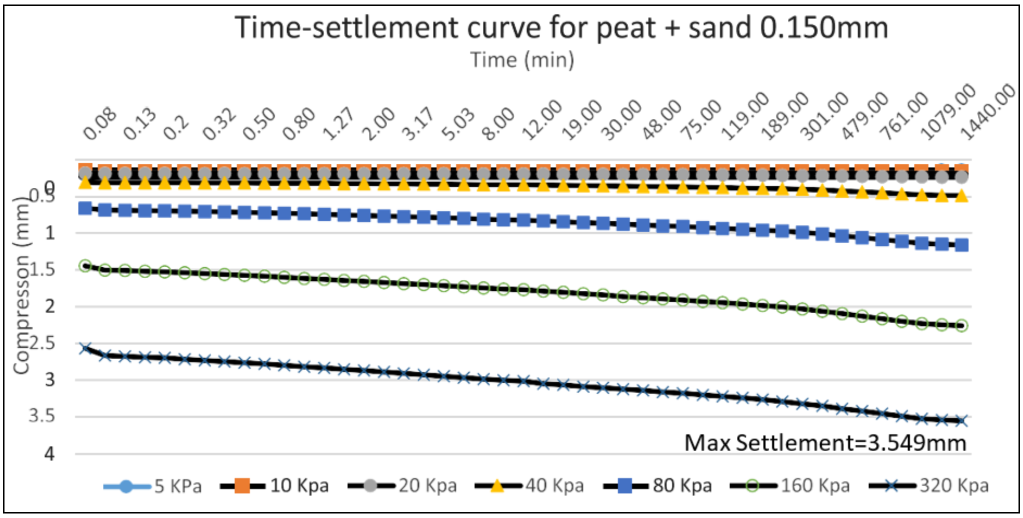
The experimental setup included monitoring settlement over time for each sample. Fig. 5 (a) presents the time-settlement behavior of the original peat sample, while Fig. 5(b) displays the corresponding data for the peat mixed with sand size 0.425mm. Furthermore, Fig. 5(c) illustrates the time-settlement relationship for the peat mixed with sand size 0.150mm. These figures serve as visual representations of the consolidation behavior and provide valuable insights into the effects of sand inclusion on settlement characteristics.



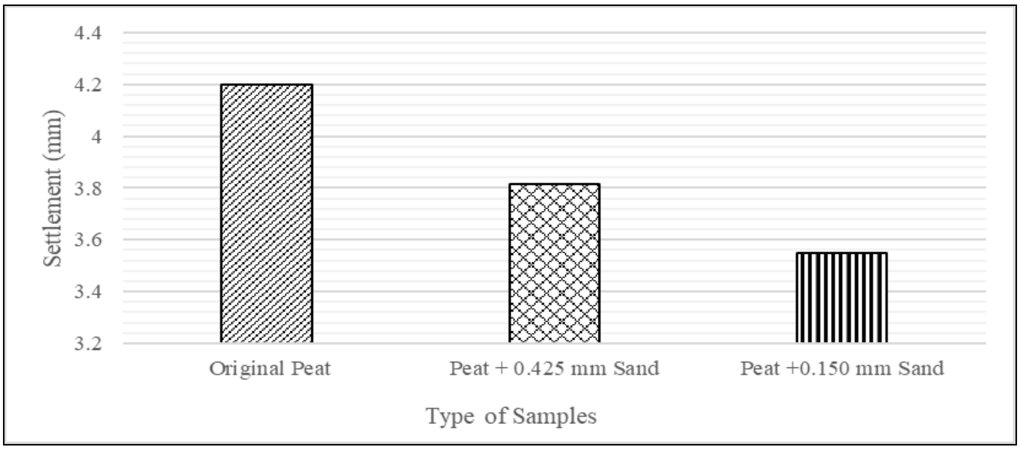
(a)



(b)



(c)



(d)

Fig. 5 *(a)Settlement of original peat; (b)Settlement of peat + 0.425 mm sand; (c)Settlement of peat + 0.150 mm sand; (d)Maximum settlement for each sample*

By precisely weighing the samples and monitoring settlement trends, the study ensured accurate data collection and enabled meaningful comparisons between the original peat and the peat-sand mixtures of different particle sizes. The details of settlement of each sample are as in Fig. 5(d).

Smaller sand particles showed greater reductions in settlement, reinforcing peat soil. This suggests that sand fillers offer a practical and cost-effective solution to improve load-bearing capacity and stability in peatland areas. However, environmental considerations and further research on influencing factors are important for sustainable implementation. Overall, sand fillers present valuable potential for more resilient and durable infrastructure development in regions with peat soil.

4. Conclusions

In conclusion, based on the data obtained from the consolidation tests, it was found that the maximum settlement observed in the consolidation of the original peat alone was 4.199 mm. However, when sand with a particle size of 0.425 mm was added to the peat, the settlement decreased significantly to 0.3816 mm. Similarly, the addition of sand with a particle size of 0.150 mm resulted in a reduced settlement of 3.5488 mm. These findings demonstrate that the inclusion of sand fillers can effectively mitigate settlement in peat soil, with smaller sand sizes leading to a greater reduction in settlement. These results highlight the potential for using sand fillers as a practical approach to address consolidation issues in peatland areas.

Acknowledgement

The authors would like to thank the Centre for Diploma Studies (CeDS), Universiti Tun Hussein Onn Malaysia for their support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: Study literature and method: Nik Abdul Muhaimin Nik Azran and Nik Ahmad Hakim Nik Azman. Lab test and data: Nik Abdul Muhaimin Nik Azran and Nik Ahmad Hakim Nik Azman. Data analysis: Nik Abdul Muhaimin Nik Azran, Nik Ahmad Hakim Nik Azman and Siti Nooraiin Mohd Razali. Draft manuscript preparation: Nik Abdul Muhaimin Nik Azran and Nik Ahmad Hakim Nik Azman. Finalized the manuscript: Siti Nooraiin Mohd Razali.

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