

REINFORCEMENT MODELING USING GEOTEXTILE FOR BEARING CAPACITY OF SHALLOW FOUNDATION ON PEAT SOIL

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Article History

Received: 07.06.2025

Accepted: 21.07.2025

Published: 02.08.2025

Abstract: This research aims to determine the effect of woven geotextile reinforcement on increasing the bearing capacity of shallow foundations on peat soil. The peat soil sample from Sukadamai Village, Pedamaran District, Ogan Komering Ilir Regency, South Sumatra, with characteristics of water content (ω , 357.361%), specific gravity (G_s) 1.534, organic content 67.087%, and pH 5.75. The testing method was carried out in the laboratory using foundation modeling with variations in depth and number of layers of geotextile reinforcement. Testing was carried out using the direct loading method and analysis of load graphs against settlement. Results showed that woven geotextile reinforcement significantly increased the bearing capacity of shallow foundations. The maximum bearing capacity value was recorded at 12.81 kPa or increased by 3.03% at a variation in reinforcement depth $d = 0.25B$ with 3 layers of geotextile and a reinforcement width of 60 cm $\times$ 60 cm. The highest Bearing Capacity Ratio (BCR) value of 3.09 was also achieved in this configuration. The more layers and the more optimal the depth of reinforcement, the greater the bearing capacity produced. This research concludes that the use of woven geotextiles is effective in improving the characteristics of peat soil for shallow foundation construction purposes, and opens up opportunities for further development for implementation in the field.

Keywords: Peat Soil, Reinforcement, Woven Geotextile, Shallow Foundation, Bearing Capacity (BCR).

Cite this article:

Sari, W. K., Sutejo, Y., and Hadinata, F., (2025). REINFORCEMENT MODELING USING GEOTEXTILE FOR BEARING CAPACITY OF SHALLOW FOUNDATION ON PEAT SOIL. *ISAR Journal of Science and Technology*, 3(8), 1-7.

1. Introduction

Peat soil is widespread in Indonesia, especially in Sumatra, Kalimantan, and Papua. This type of soil has poor geotechnical properties for civil engineering construction, such as low bearing capacity, large and long-term settlement, and high acidity levels. This problem results in high costs for infrastructure development on peatlands. South Sumatra Province has a peat soil distribution of around 16.3%, which is found in several districts such as OKI (500,000 Ha), Muba (250,000 Ha), Banyuasin (200,000 Ha), Muara Enim (45,000 Ha), and Musi Rawas (35,000 Ha).

Peat soil is a type of soil with very poor geotechnical characteristics, namely having low bearing capacity, high compressibility, and high organic content. This condition causes the structure of buildings built on it to be susceptible to differential settlement and even structural failure. Therefore, an effective and economical soil reinforcement method is needed to increase the

stability and bearing capacity of shallow foundations on this type of soil. One method that is widely researched and used is the use of geotextiles as soil reinforcement materials. Geotextiles can increase the bearing capacity of the soil by strengthening the interaction between the soil layer and the foundation, as well as inhibiting lateral movement of the soil under load. Various studies have shown that the addition of a geotextile layer significantly increases the bearing capacity of peat soil.

Research by (Martini, 2016) shows that the use of geotextiles with variations in the number and width of layers can increase the bearing capacity by up to 232.3%. Similar results were found by (Riyadi et al., 2011), which recorded an increase of up to 336.09% with a combination of geotextile and bamboo reinforcement. Meanwhile, classical research by (Guido et al., 1985) proved that reinforcement with geotextiles can increase the bearing capacity of the soil more than threefold on soft soils.

Based on the background that has been described then this research aims to determine the effect of the use of woven and nonwoven geotextiles on increasing the bearing capacity of shallow foundations on peat soils, through a series of laboratory tests using a physical foundation model approach with variations in the number of layers and depth of geotextile

2. Literature Review

Peat soil is a type of organic soil formed from the accumulation of incompletely decayed plant material under water-saturated conditions. This soil has a very high organic matter content, high water content, and very low density and shear strength. Other characteristics of peat soil include high compressibility and very low soil bearing capacity, making it very challenging in geotechnical engineering (Huat et al., 2014). One of the peat soil improvement techniques is physical improvement, namely by using geotextile material. Holtz et al. (2009) present a complete and comprehensive guide to geosynthetics for soil reinforcement, covering material characterization, interaction mechanisms, major applications (embankments, slopes, walls), and mandatory design and construction procedures. Effective design is only achieved if laboratory and field support are well integrated.

There are two types of geotextiles that are often found in Indonesia, namely: Woven geotextiles and non-woven geotextiles. Woven geotextiles are geotextile sheets made of woven synthetic fiber materials with additional anti-ultraviolet protection that has a fairly high tensile strength. Woven geotextiles are made as an effort to improve the soil, especially those related to the construction sector efficiently and effectively. The function of woven geotextiles includes overcoming or overcoming the problem of making roads and embankments on soft soil bases, swampy soil. The raw materials for this material are Polypropylene Polymer (PP) and there are also Polyester (PET) which are supported by test results and research results in the laboratory, following ASTM (American Standard Testing and Material) standards including tensile strength, strength against punctures, tears, and resistance to microorganisms, bacteria, fungi and chemicals.

On the other hand, non-woven geotextiles are produced by a bonding process or embroidery method, not weaving. The yarn bonding is done using the punch needle method. However, there are also those who use chemicals and/or heat to make non-woven geotextiles. Non-woven geotextile fabrics are usually made of synthetic materials and are widely used in separation and filtration projects. Unlike woven geotextile materials, non-woven geotextile materials are not suitable for reinforcement and stabilization projects, although this type of geotextile is actually a better choice for special uses such as protecting geomembrane lining systems, both against exterior and interior penetration. In projects involving waterlogging, non-woven geotextiles are a much better option. The reason is none other than because the permeability level of non-woven geotextiles is higher when compared to woven geotextiles. It should also be noted that non-woven geotextile fabrics still offer good durability and strength, especially for drainage functions, making them ideal for a variety of applications. Figure 1 shows the types of Woven and Non-woven Geotextiles.



Figure 1: The types of Woven and Non-Woven Geotextiles

3. Methods and Materials

This research is an experimental researches conducted to determine the modeling of reinforcement using geotextiles for the bearing capacity of shallow foundations on peat soil. The research was conducted at the Soil Mechanics Laboratory, Civil Engineering Department, Faculty of Engineering, Universitas Sriwijaya, Indralaya, Indonesia and CV Global Engineering, Palembang, Indonesia. In this study is the use of geotextiles and the properties of peat soil, namely soil bearing capacity, soil settlement, and the number of soil reinforcement layers. Figure 1 shows the flow diagram of this research.

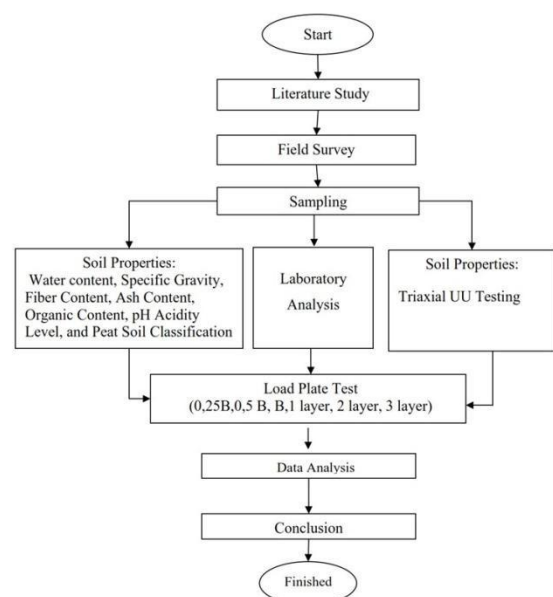


Figure 2: Research Flowchart

The soil samples used were located in Sukadamai Village, Pedamaran District, Ogan Komering Ilir Regency, South Sumatra. The soil material to be used was disturbed soil and undisturbed soil which was taken by digging 1 m deep. Before taking the soil, the land was first cleaned from the disturbance of plants above it. Research location and woven geotextile reinforcement shown in Figure 2.



Figure 2: Research Location and Woven Geotextile Reinforcement

Peat soil properties testing was carried out to determine the physical properties of the peat soil classification used. This testing includes testing water content, specific gravity, ash content, organic content, fiber content, and acidity (pH). The soil has been included in the peat soil classification and then continued with mechanical testing. Mechanical testing of peat soil is a test carried out to determine the nature of the soil mass structure when pressure is applied. Mechanical testing on peat soil includes Triaxial UU testing.

The testing is carried out after the peat soil is soaked until saturated and the water content approaches the original value in the field. Testing is carried out on modeling with variations in the width of reinforcement (2B, 3B, 4B) for single reinforcement (1 layer) (2 layers) and (3 layers) reinforcement at each reinforcement width (2B, 3B, 4B), with a distance between reinforcements of 0.5B with B being the width.

Foundation model and sand as its embankment. For testing with variations in the width of reinforcement against the number of reinforcement layers, one test is carried out for each test variation, the soil in the test tank is excavated to a depth of 0.5B (7.5 cm) with a width according to the variation that has been determined in each test.

After excavation, the reinforcement variation is inserted into the excavation with a woven geotextile arrangement first. The excavation is filled with sand. After preparing the test object, the load retainer is then installed. Then the foundation modeling is installed in the form of a plate measuring 15cm x 15cm x 2cm, load cell, data logger, and LVDT. Modeling for this test will be carried out in 9 variations tested as many as 3 samples of reinforcement layers and variations in height difference d (d is the distance between the ground surface to the first soil reinforcement layer (ASTM D-1196-93., 1993). The number of test objects is summarized in Table 1. From the tests carried out, data on the bearing capacity of shallow foundations on peat soil without reinforcement and with woven geotextile reinforcement were obtained. Then an analysis of the bearing capacity of the peat soil obtained after being reinforced was carried out.

Table 1: Variations of Load Plate Test

Test	Variation d	Number of Reinforcement Layers
1	D = 0 B	1
2	D = 0 B	2
3	D = 0 B	3
4	D = 0,25 B	1
5	D = 0,25 B	2
6	D = 0,25 B	3
7	D = 0,5 B	1
8	D = 0,5 B	2
9	D = 0,5 B	3

4. Results and Discussion

Results of Soil Properties and Mechanical Properties of Peat Soil

The soil and mechanical properties of the soil were tested to determine the characteristics of the peat soil used in this study. The test results showed that the peat soil from Sukadamai Village has a water content of 357.361%, a specific gravity of 1.5340, an organic content of 67.087%, a fiber content of 24.962%, a volumetric weight of 1.293 g/cm³, and a pH of 5.75. Based on these values, the soil is categorized as peat soil with moderate acidity and high organic content. The data from the test results of the physical properties of the original soil can be seen in Table 2 below.

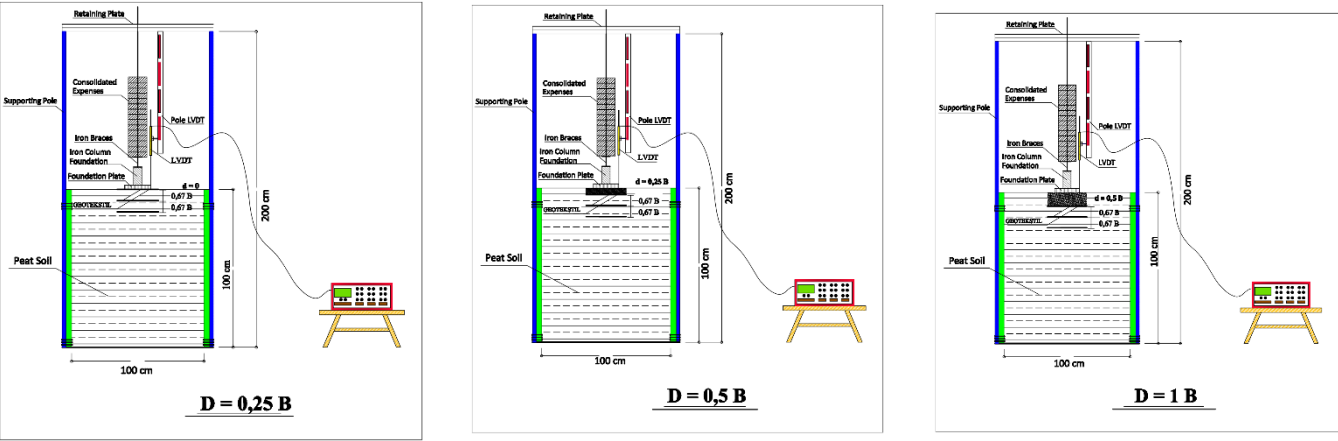


Figure 3: Sketch of the Testing Model for Plate Load Test on Peat Soil

Tabel 2: Soil and Mechanical Properties

No.	Parameter	Symbol	Results
1	Water Content	ω , %	357.361
2	Specific Gravity	G_s	1.534
3	Ash Content	AC, %	32.913
4	Organic Content	OC, %	67.087
5	Fiber Content	FC, %	24.962
6	Unit Weight	γ , kN/m ²	1.293
7	Acidity	-	5,750
8	Triaxial UU (Cohesion)	c , kg/cm ²	0,0050
9	Triaxial UU (Angle of Internal Friction)	ϕ , °	1,350

Results of Reinforcement Testing

Analysis of the ultimate bearing capacity calculation without reinforcement was carried out using LVDT and data logger. This analysis uses the method proposed by Adams and Collins with data obtained from laboratory testing. The test results show the maximum load value that occurs at a load of 9.50 kg and the cumulative load data obtained is 17,600 kg and the ultimate foundation bearing capacity (Q) from this test is 4.14 kPa.

Meanwhile, the test results of peat soil with woven geotextile reinforcement which is reinforced using variations in layer depth $d = 0.25 B$; $d = 0.5 B$; $d = 1 B$. The addition of layer depth shows an increase in soil bearing capacity. In general, based on the test results, it can be said that the increase in layer depth as a whole provides an increase in effective bearing capacity. But in reality, the most effective addition of layer depth is at a depth of $d = 0.25B$. In sequence, the order of the most effective layer depth to the least effective is $d = 0.25 B$; $d = 0.5 B$; $d = 0 B$. The magnitude of the ultimate bearing capacity value due to variations in layer depth and number of layers in peat soil reinforcement is explained in Table 3. And Figure 4 explains the graph of the increase in the ultimate bearing capacity value in woven reinforcement.

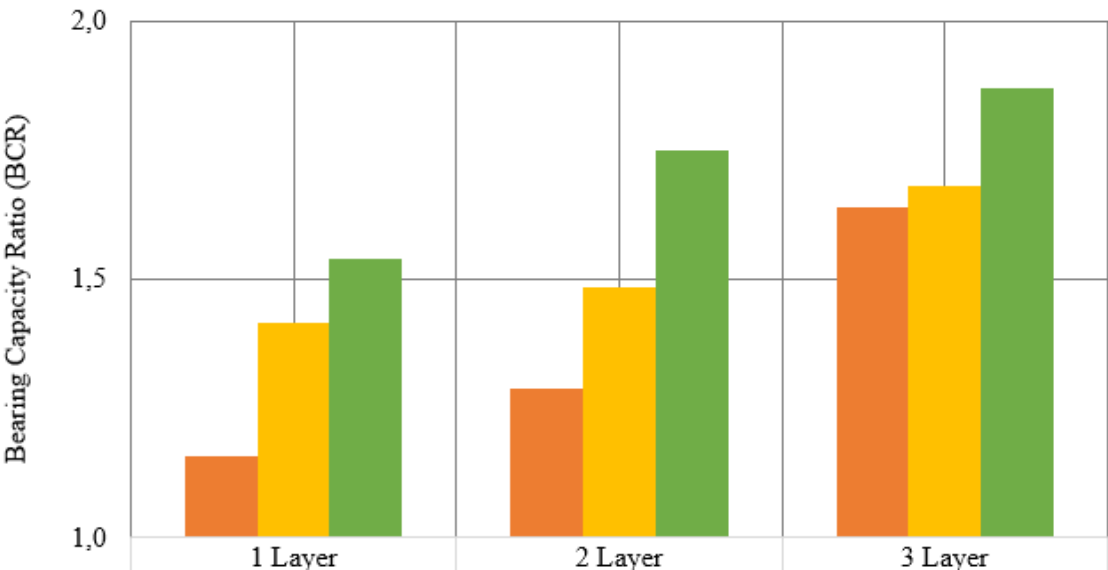


Figure 4: Graph of The Increase in The Ultimate Bearing Capacity Value in Woven Reinforcement

Table 3: Recapitulation of Ultimate Bearing Capacity Values of Peat Soil

Reinforcement	Depth	Layer	Q (Woven)
Reinforcement Width Variation (60 x 60)	d=0,25B	1	10,42
		2	11,55
		3	12,81
	d=0,5B	1	9,37
		2	10,33
		3	11,03
	d=1B	1	9,15
		2	9,85
		3	10,24
Reinforcement Width Variation (45 x 45)	d=0,25B	1	9,76
		2	10,98
		3	12,47
	d=0,5B	1	8,28
		2	9,46
		3	9,94
	d=1B	1	7,19
		2	7,58
		3	8,32
Reinforcement Width Variation (30 x 30)	d=0,25B	1	8,59
		2	10,98
		3	9,37
	d=0,5B	1	7,89
		2	9,46
		3	9,55
	d=1B	1	6,45
		2	7,58
		3	7,28

As explained in Figure 4 on the test sample with all variations of layer depth and variations in the number of reinforcements of 1 layer, 2 layers, and 3 layers provide an increase in the bearing capacity of each test sample. Based on the results of the bearing capacity, it can be said that at each layer depth with a greater number of reinforcement layers will provide greater bearing capacity. From the results of this study, it can be concluded that reinforcement, for woven geotextiles it is able to increase the bearing capacity of the peat soil due to the distribution of soil stress by the presence of the reinforcement.

5. Conclusion

Based on the data and discussion of the results of the loading test on each of the test objects in this research, the conclusion that can be obtained is that the bearing capacity of shallow foundations on peat soil gets a bearing capacity value of 414 kPa. The bearing capacity of shallow foundations on peat soil after being reinforced with woven geotextiles which provides maximum bearing capacity is at a depth ratio of $d = 0.25 B$ with 3 layers of reinforcement which gets a bearing capacity value of 12.81 kPa or 3.03% at a reinforcement width variation of 60 cmx 60cm.

The largest (BCR) value is possessed by reinforcement with a variation of 0.25 B with a total of 3 layers of reinforcement, which is 3.09 kPa. The results of this research indicate that woven geotextile reinforcement provides an increase in bearing capacity on peat soil, the more effective the layer depth and the more layers of reinforcement, the greater the bearing capacity ratio (BCR) of the soil.

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