Characteristics of Shallow Foundation Carrying Capacity Geotextile Reinforcement Interaction and Soil Density Level

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Abstract:- Geosynthetics use in earthworks has been widely accepted as an additional material to strengthen unstable soil-structures. Geosynthetics are a promising alternative to be used for repairs, accelerations, savings in construction related to soil, as if geosynthetics are a "magic pill" that can solve all geotechnical problems instantly. One form of geosynthetic is geotextile as a reinforcement and holding the ground. This study aims to analyze the effect of length (Bq), depth (d) and distance configuration (h) of each geotextile layer on variations in loading (q) and density variations that provide maximum carrying capacity. The research was testing the physical model in the laboratory, this test was carried out with and without geotextile reinforcement on soil media. Examin[ation and characteristic checks are carried out in the Soil Mechanics Laboratory of the Civil Engineering Department. The results show that the placement of geotextile layers can contribute to changing the mechanical characteristics of the reinforced soil, more optimal L/B distance and closer h/B distance, this increases the carrying capacity of the soil under shallow foundations and reduces the settlement that occurs (higher carrying capacity.

***Keywords**:- Carrying capacity, geotextile, shallow foundation.*

I. INTRODUCTION

Soil is a constructions support that always plays a big role in every civil work, therefore a foundation that can carry and continue the load of the building must be planned according to condition of the subgrade without deformation [1]

The need for land for development continues to increase causing the building is forced to be carried out on land that does not meet the requirements, or in other words with less carrying capacity, namely on soft soil, on granular soil, and on soils that are less stable when there is vibration. These soils must be repaired before being used as foundation. In addition, contractor are often forced to use the land around the project site. So the soil that is not good has to be repaired first. One way to improve the carrying capacity is by reinforcement. [2]

In Indonesia, the most common way to reinforcement is by using natural fibers. Until now, efforts to increase the carrying capacity of foundations with reinforcement have become an interesting research topic. The use of geosynthetics in earthworks has been widely accepted as an additional material to strengthen unstable soil-structures. Geosynthetics are a promising alternative to be used for repairs, accelerators, and savers in construction related to soil, as if geosynthetics are a "magic pill" that can solve all geotechnical problems instantly. [3]

In its development, various forms of geosynthetics emerged according to their function and use. One of them is geotextile, which is shaped like a textile material, which one of its functions is as reinforcement and holding the ground.

Several studies are the results of experiments through physical model tests that show the beneficial effect of soil reinforcement on the carrying capacity of the foundation. Soil reinforcement materials that have been studied using geosynthetics include: aluminum strips, natural bamboo fibers, rope fibers, metal bars, and geogrids. [4]

The geotextile reinforcement method is more widely used in geotechnical work, one of the applications on shallow foundations to increase the carrying capacity under the foundation base. [5]

This study compares and analyzes the caarying capacity characteristics of a shallow foundation without geotextile reinforcement and with reinforcement on embankment soil media.

Seeing that there is still little information related to this, it is necessary to conduct intensive research both in the laboratory (physical models) and mathematical models, as well as in the field (full-scale models). This study was made to test physical models in the laboratory to analyze the behavior and carrying capacity of shallow foundations with geotextile reinforcement with various experimental design configurations for loading. [6]

II. METHODS

Testing the physical model of the foundation using a 20 mm plate measuring 20 cm x 20 cm. Carrying capacity testing is carried out in a box sized 1.00 m long x 2.40 m wide x 1.00 m deep. The inner walls of the side boxes are stiffened to resist lateral forces that may arise. Testing of loading and density variations both without reinforcement and with geotextile reinforcement with various configurations. The goal is to obtain a configuration effect that can reduce deformation and provide maximum carrying capacity. Density testing directly in the test tank with DCP test equipment, in addition to testing characteristics in the laboratory to obtain soil parameter values: volume weight (γ), soil cohesion (c), shear angle φ' and density to the embankment soil media.

The soils depth that is arranged at each loading test, this is done to avoid distortion of the carrying capacity of the soil. The geotextile used in this research is a woven geotextile product HRX 250 (Geo-Reinfox), which has sufficient thickness, mass, tensile strength, elongation. The material used in this test is embankment soil.

Before the loading test is carried out, soil material is loaded in the test basin for each depth, the initial test is carried out without hits with variations in the length of the geotextile (L/B) = 1.5 x B ; 2.5 x B with a variation of the distance h/B 5 cm, 10 cm then a gradual loading-settlement test was carried out. Subsequent tests were carried out successively for variations in density (collison) 50, 100 and 200 for variations in geotextile length (L/B) = 1.5 x B ; 2.5 x B with a variation of the distance h/B 5 cm, 10 cm, then a uniform loading-settlement test was carried out for all tests. Therefore, to obtain a uniform density for all loading tests, when the soil material has been loaded into the box, the drop height of the load is kept constant at a certain height. This reinforcement layer is placed below the soil surface under the foundation according to the geometry of their respective placement, according to the experimental design.

The foundation model is placed on the soil surface, then the loading is carried out continuously until the desired collapse is produced. The magnitude of the working load and the amount of settlement that occurs are observed and read using a dial gauge.

A complete sketch of the variation and configuration of the reinforcement layer of the model can be seen in Fig 1.

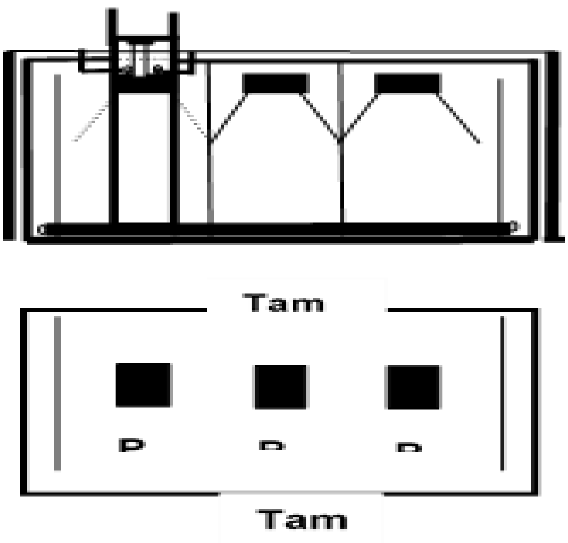

Fig. 1: Without Geotextile Reinforcement Skecth Test

Fig. 2: The Test Tub and Its Accessories

A. Model Test Design

The data taken is the settlement reading every 15 minutes for each increase in loading until a collapse occurs.

The test material is made without reinforcement – with reinforcement against density variations:

- No hits
- 50 Hits
- 100 hits
- 200 Hits

Research on soil deformation due to loading on unreinforced soil with geotextile reinforcement with various configurations in the laboratory (test basin) is carried out with the following stages:

- Prepare test materials
- Soil Properties Test, carried out by mechanical tests, namely: DCP Test, Direct Shear Test, Direct Shear Test, Uncofined Compression Test.
- Model Testing, with stages:
  - Unreinforced foundation soil loading with geotextile reinforcement with various L/B and h/B configurations (without impact) in the test basin
  - Unreinforced foundation soil loading with geotextile reinforcement with various L/B and h/B configurations (50 impacts in the test bath
  - Unreinforced foundation soil loading with geotextile reinforcement with various L/B and h/B configurations (100 impacts) in the test basin
  - Unreinforced foundation soil loading with geotextile reinforcement with various L/B and h/B configurations (200 impacts) in the test basin [7]

B. Analysis Method

Setting the vertical distance between geotextile layers is h. The topmost layer of geotextile is located at a depth u measured from the base of the foundation. The width of the geotextile reinforcement under the foundation is b. The depth of reinforcement, d, under the base of the foundation is obtained as [8]

$$d = u + (N - 1)h. \quad (1)$$

Reinforcement effect to increase the ultimate carrying capacity is usually expressed in a nondimensional quantity called the Carrying capacity Ratio, BCR or

$$BCR = \frac{q_{u(R)}}{q_u} \quad (2)$$

Where qu(R) and qu, are the ultimate carrying capacity of the reinforced and unreinforced embankment. [9]

III. RESULTS AND DISCUSSION

A. Characteristics of subgrade foundation layer

Based on the results of testing in the laboratory and density test in the test tank with the DCP Test, it was obtained that the CBR for no hits, variations in hits of 50, 100, and 200 = 1.40, 2.50, 2.80 and 3.00 with carrying capacity values (DDT) respectively = 2.40, 3.40, 3.60 and 3.80. From the results above, several relationships can be drawn: the variation of the hits with the shear angle is directly proportional, the variation of the hits with the compressive strength is also directly proportional, but at 100 hits a large compressive strength is obtained, the variation of the hits with CBR and the variation of the hits with DDT is directly proportional, the more the number of hits, the higher the CBR value and the carrying capacity of the soil.

Based on equations 2.1 and 2.2. variation of geotextile length (L/B) 1.5 x B and variation of distance h/B 5 cm, 10 cm obtained the ratio of BCR carrying capacity for 1 layer, 2 layers and 3 layers respectively 1.07, 1.14, and 1.27 and 1,071, 1,143 and 1,193. This shows an increase as well. Likewise, the variation of geotextile length (W/B) 2.5 x B and the variation of the distance h/B 5 cm, 10 cm experienced a greater increase than the previous variation.

From the above results, the presence of geotextile material in the soil mass contributes to changing the mechanical characteristics of the reinforced soil (higher carrying capacity).

B. Loading and Deformation Relationship

a) Variation of geotextile width (L/B): 1.5 B and 2.5 B (B = foundation base)

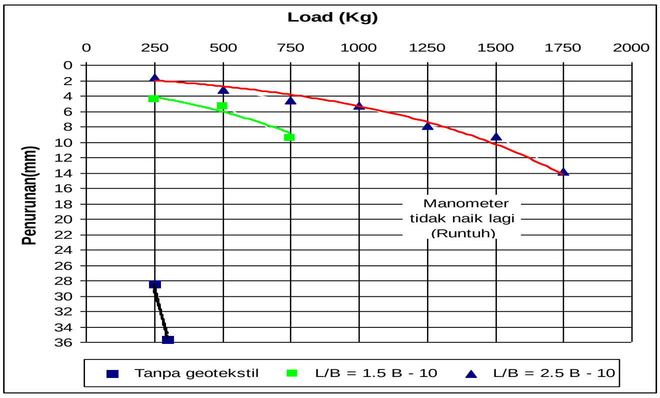

Fig. 3: Graph of Load-Deformation geotextile width conditions 1.5 B and 2.5 B (No Hits)

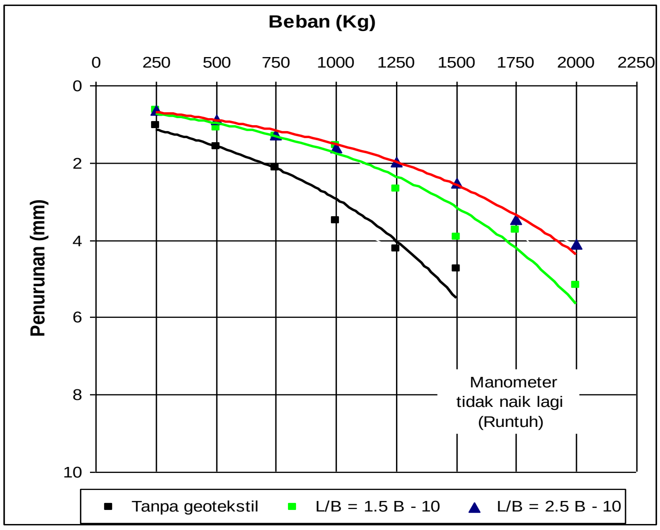

Fig. 4: Graph of Load-Deformation geotextile width conditions 1.5 B and 2.5 B (No Hits)

Figure 3-4, shows that the loading of the embankment soil without reinforcement – with reinforcement has increased by 25% - 85.71% and is able to reduce the decrease by 0.36% - 94.59%. For variations in the length of geotextile (L/B) 2.5B (B=width of the foundation) it shows that the carrying capacity is greater than the variation of 1.5B for the same distance h/B, as well as the decrease. This means that variations in the optimal length of geotextiles (L/B) will further increase the carrying capacity and reduce settlement. Variation in the number of layers, 3 layers are more capable of reducing settlement than 1 layer of geotextile.

b) Geotextile distance variation (h/B): 5 cm and 10 cm

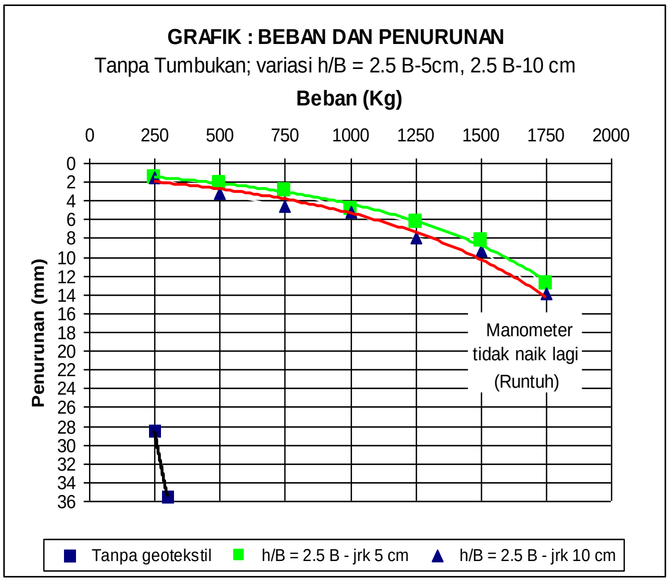

Fig. 5: Graph of Load-Deformation geotextile distance conditions 5 cm and 10 cm (No Hits)

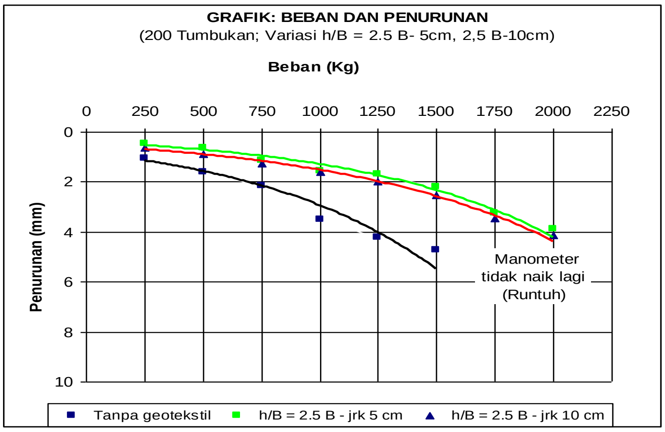

Fig. 6: Graph of Load-Deformation geotextile width conditions 1.5 B and 2.5 B (200 Hits)

Based on Figure 5-6. shows that the loading applied without reinforcement with reinforcement is the same as the previous analysis, as well as the carrying capacity when viewed from the same variation of geotextile length (L/B). This is more specifically the variation of h/B is that the geotextile distance of 5 cm is more able to reduce the decrease by 3.13%, - 94.59% when compared to the geotextile distance of 10 cm sequentially by 1.78% - 94.35%. This means that variations in the geotextile distance h/B which are denser will increase the carrying capacity and reduce the settlement more.

c) Hits Variation (No, 50, 100, 200 hits)

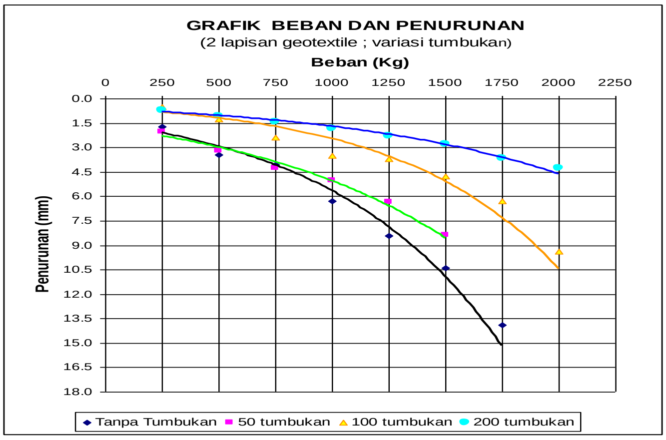

Fig. 7: Load-Deformation Graph, L/B = 2.5 B , h/B = 5 cm with respect to hits variation

Based on Figure 7 – Figure 10, it shows that with the reinforcement and the higher the number of hits, the denser the soil, the smaller the settlement. What is more typical shows the effect of the geotextile layer, namely in the treatment without hits the decrease that occurs is 28.5 mm, where at the same time the loading is the same as the geotextile reinforcement the decrease is 1.54 mm so that with the reinforcement layer it is able to reduce the decrease by 94 ,59%. This happens when the geotextile width (L/B) = 2.5 B and the geotextile distance (h/B) = 5 cm. Regarding the variation in the number of layers, 3 layers are more capable of reducing settlement than 1 layer of geotextile

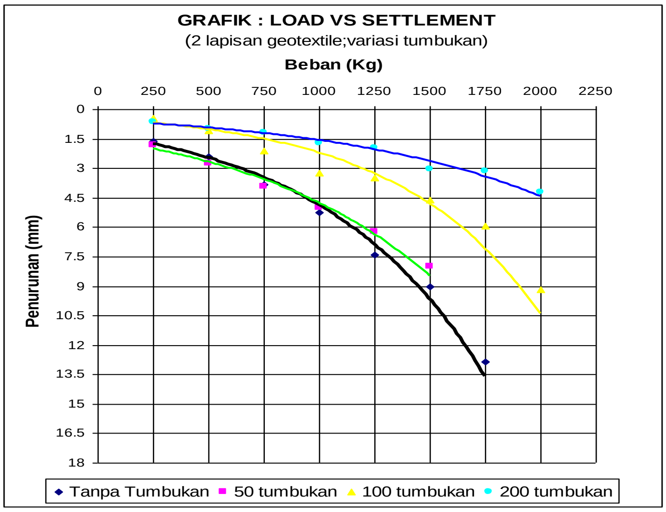

Fig. 8: Load-Deformation Graph, L/B = 2.5 B , h/B = 10 cm with respect to hits variation

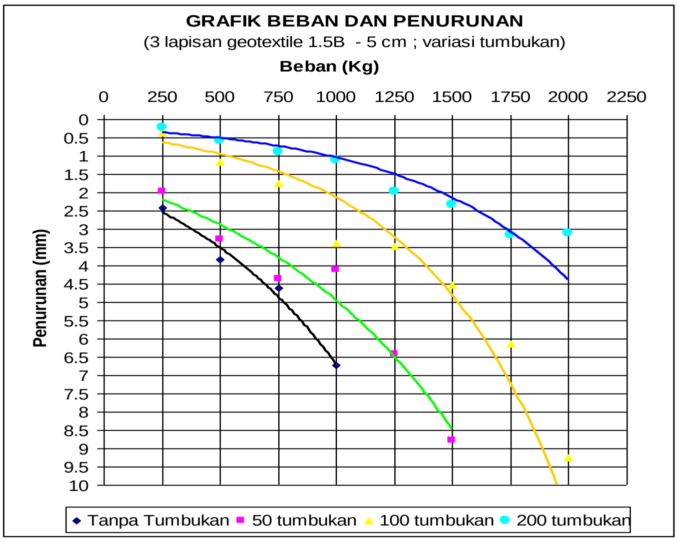

Fig. 9: Load-Deformation Graph, L/B = 1.5 B, h/B = 5 cm with respect to hits variation

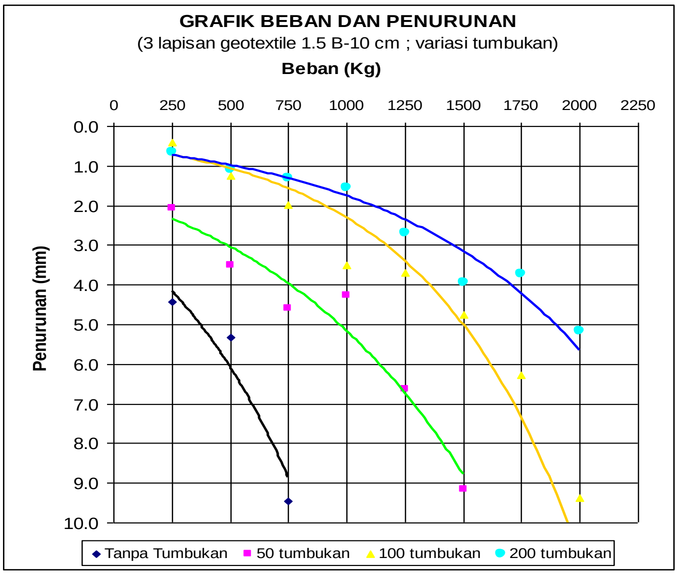

Fig. 10: Load-Deformation Graph, L/B = 1.5 B, h/B = 10 cm with respect to Hits Variation

C. Density Interaction – Deformation

The interaction of density – ratio (δ/δt), the condition of the width of the geotextile (L/B) = 2.5 B (B = width of the foundation base) can be seen in the following figure

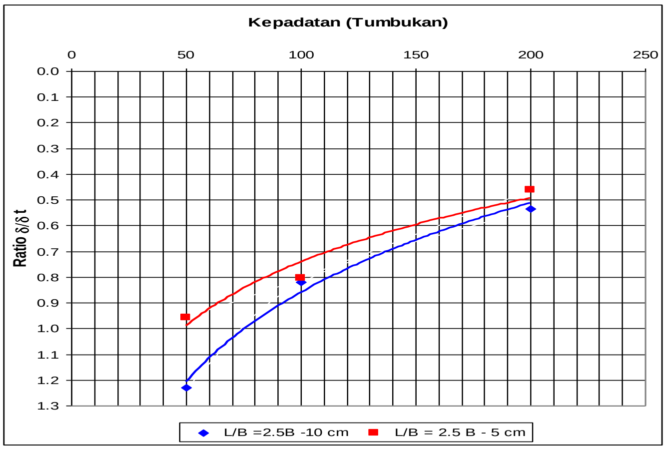

Fig. 11: Density interaction graph - ratio δ/δt condition 2.5B. (hits variation)

Based on Figure 11, shows the interaction ratio δ/δt (reinforced/Unreinforced) & h/B (5 cm & 10 cm) in terms of L/B = 2.5 B , the more the number of hits the smaller δ/δt (reinforced/Unreinforced), meaning a decrease what happened was small. And this is obtained in the condition of the width of the geotextile L/B = 2.5 B, the distance of the geotextile h/B = 5 cm, the number of hits is 200 and the geotextile reinforcement is 3 layers.

D. Geometric Geotextile Interaction – Deformation

a) Interaction (L/B) = 1.5 B & 2.5 B – ratio δ/δt, condition (h/B) 5 cm

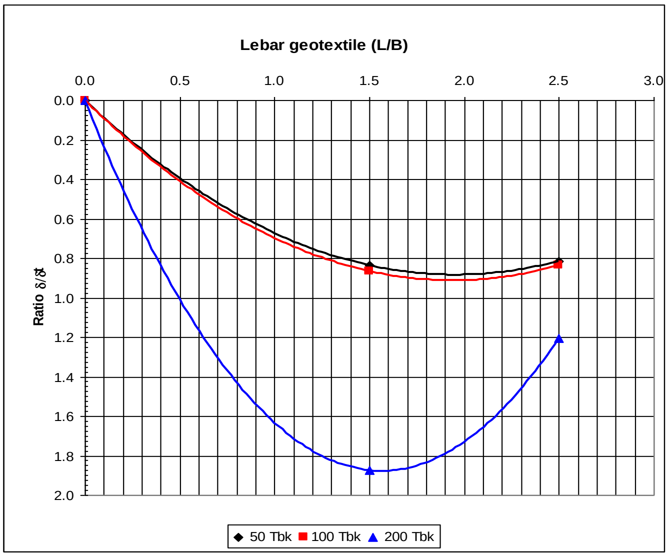

Fig. 12: Interaction Graph L/B = 1.5 B & 2.5 B - ratio δ/δt

Based on Figure 12 shows that the interaction δ/δt (reinforced/Unreinforced) & L/B (1.5 B & 2.5B) tends to be smaller in the variation of the width of the geotextile 2.5 B when compared to 1.5 B, this can be reviewed against all hits variations. And this tendency is more clearly seen in the non-hits condition.

b) Geotextile spatial interaction (h/B) = 5 cm & 10 cm – ratio δ/δt, condition (L/B) = 2.5 B

Based on Figure 13, it shows that the interaction ratio δ/δt (reinforced/Unreinforced) & h/B spacing (5 cm & 10 cm) in terms of L/B = 2.5 B, tends to be smaller in the variation of the geotextile distance of 5 cm B when compared to 10 B, this can be considered for all hits variations. So it can be concluded that the variation of geotextile distance h/B which is denser will increase the carrying capacity and reduce the settlement more.

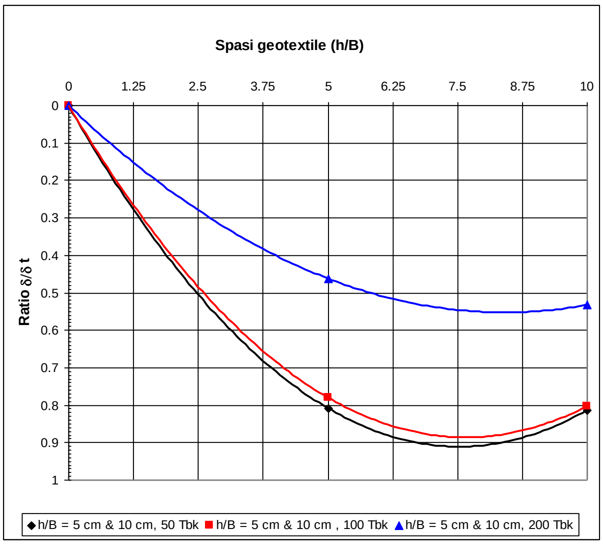

Fig. 13: Geotextile spacing interaction (h/B) = 5 cm & 10 cm–ratio δ/δt

IV. CONCLUSION AND SUGGESTION

A. Conclusion

- The placement of geotextile layers can increase the carrying capacity of the soil under shallow foundations and reduce the settlement that occurs.
- Based on the research, the optimal configuration of the geotextile length (L/B), will further increase the carrying capacity of the soil and the settlement will be smaller.
- The closer the geotextile distance variation (L/B), it tends to increase the carrying capacity of the soil and the smaller the settlement.
- In conditions with variations in density (50,100,200) hits, it does not really show a significant effect on unreinforced and reinforced soils. This can be seen from the relatively smaller decline.
- In general, the presence of geotextile material in the soil mass contributes to changing the mechanical characteristics of the reinforced soil (higher carrying capacity).

B. Suggestion

It is necessary to do further research, load-settlement testing on variations of L/B, h/L which is greater and the number of layers more.

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