Investigation of vertical stress behavior for reinforced model

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ABSTRACT: In this study, it was investigated the additional vertical stress behavior and load-settlement curve behaviors of two different conditions whose reinforced zone depths are same. Geotextile is the reinforcement and the strip conditions for unpaved road was used in the laboratory model tests. Measurements were compared with literature theories and with each other. As a result, it was noticed that each additional reinforcement layer affects the stress behavior in soil and different parameters can affect the values of stress. When the stress values were compared with the loading and settlement behavior of model, there is a good correlation between them.

Keywords: stress behavior, load-settlement, same reinforced zone

1 INTRODUCTION

It is well known that reinforcement works together with soil to provide an improved composite performance during compressive loading and change the differential settlement. For many years, a number of researchers have conducted studies to determine the effect of the reinforcements (Zhu et al. 2001, Ferroti et al. 2011, Cicek et al. 2011, Perkins et al. 2012, Han and Thakur 2014, Shafabakhsh et al. 2014, Abu-Farsakh et al. 2014, Wu et al. 2015, Chandtachot et al. 2016, Kadela 2016). However, pressure was studied by some researchers for unreinforced soil such as Boussinesq (1985) and Westergaard (1998), but their theories have limitations, also. Additionally, the limited studies have been done to express the behavior of reinforced models (Chen 2007, Lovisa et al. 2010, Cicek 2011). Therefore, different soil conditions and their effects with stress and loading-settlement behaviors are not known totally. Therefore, the laboratory model tests conducted in this study have importance to add critical information to literature.

The compaction of a road is an improving technique, but reinforced soil is also an improving way of a pavement. The effect of reinforcement should be learned without other improving techniques. Furthermore, the importance of the reinforcement condition for same reinforced zone depth has an importance. The property of different number of reinforcements is a critical factor for same depth of reinforced zone (d). Therefore, in this study two different condition for same reinforced zone depth were studied and their results were compared. It was investigated the additional vertical stress behavior occurring for geotextile reinforced soil under the strip conditions for unpaved road. The laboratory model tests were conducted and the results were compared. Two main test results for same reinforced zone depth were chosen and the additional stress behavior was tried to determine for different points in soil. Stress and load-settlement behaviors of two different models were compared with literature theories.

2 MATERIALS AND TEST METHOD

In all model tests, the average unit weight and relative density of the sand were kept constant as 15 kN/m^3 and 46%, respectively. The friction angle of the sand was 38° and woven geotextiles were used as reinforcements. Their tensile strength was 60 kN/m and were made of polypropylene. The test tank was a steel tank measuring 1000 mm x 500 mm x 1000 mm. The static load was applied on a steel plate. Its width was100 mm (B). The loading was thought as traffic loads, so the plate was on the surface of the sand bed to symbolize the traffic loads. A load cell with the help of a data logger was used to determine the load levels. Additional vertical soil stress values (Δσ) were measured by using miniature pressure sensors. Their diameter was 2.667 mm and they evaluated the pressures directly with the help of quarter bridges and a connector block (Cicek 2011). These devices were placed below the center line of the plate within different depths such as z=0.35B, 0.55B, 0.75B and 2.1B. The uniform static vertical loads were applied to the center of the model plate.

The first reinforcement depth, reinforcement length and reinforced zone were taken constantly as u=0.35B, L=3B and d=0.95B. In same reinforced zone conditions different number of reinforcement layers (N) and vertical spacing between reinforcement layers (h) were taken differently. Two different model results were compared in the study. For first model, number of reinforcement layers was chosen as N=2, and then for second model this value was N=4. These two different conditions can be more clearly in Figure 1.

The loading was made for plane strain conditions such as strip conditions and for each model new pressure sensors were used via controlled their calibrations. Tests were made in two series and controlled the results by repeating. Unreinforced model test for load-settlement behavior were conducted, and results were compared with reinforced models in results part for load-settlement behaviors.

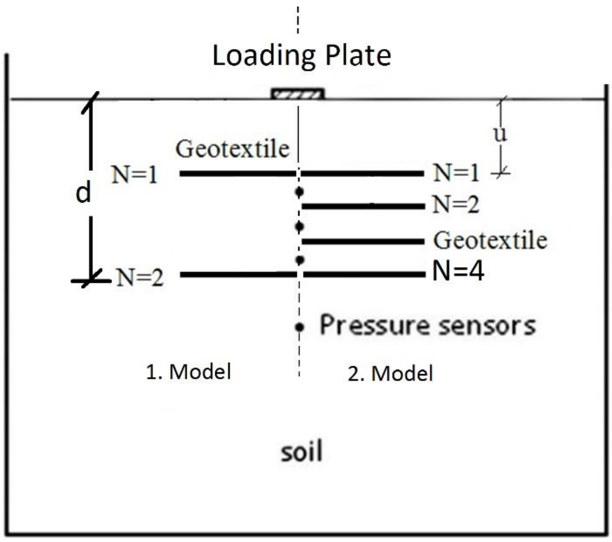

Figure 1. Test models for two different conditions.

3 RESULTS

The measurement results were compared with calculations of Boussinesq and Westergaard theories. As it can be known, both of these theories assume the curve between additional vertical stress and loading values behave linearly. However, the results show that the behavior of medium dense type of subgrade of a road is not linear and additional stress values (Δσ) decreases by loading. They are different for small and bigger loading values, and generally for bigger loading values the stress measurements in the tests are smaller than Boussinesq and Westergaard theories, despite the fact that small loadings show similar values in some cases (Figure 2 and Figure 3).

Number of reinforcement layers affect the stress distribution in same reinforced zone depth. For small loading values Westergaard theory calculation results may be more suitable to estimate the stress changings, but for big loads such as 200 kPa or more they have smaller results.

When the Figure 2 and Figure 3 compare it can be clearly seen that not only different models but also different points behave differently. Generally, for less reinforcement layers, (Model 1) the behavior of the additional vertical stress is similar with Boussinesq for upper soil points. However, as the load increases the behave starts to come to be close the Westergaard theory. But, when the number of reinforcement layers are increased the stress behavior is smaller (Model 2). For model 1, for reinforced layers the stress behavior is similar with Boussinesq and as loading increases the stress values decrease (z=0.35 and 0.95). However, in reinforced zone the stress values are smaller than the theories, because the medium dense soil start to be stiffer in this part and there is a big distance between reinforcement layers. As for Model 2, for reinforcement layers the stress behavior smaller than Model 1, but in this model there is a reinforcement in point z=0.55B, so behavior of the stress is bigger, because reinforcements behave a modular blocks and divide the part into categories. By this was the soil behave stiffer and stress behave changes.

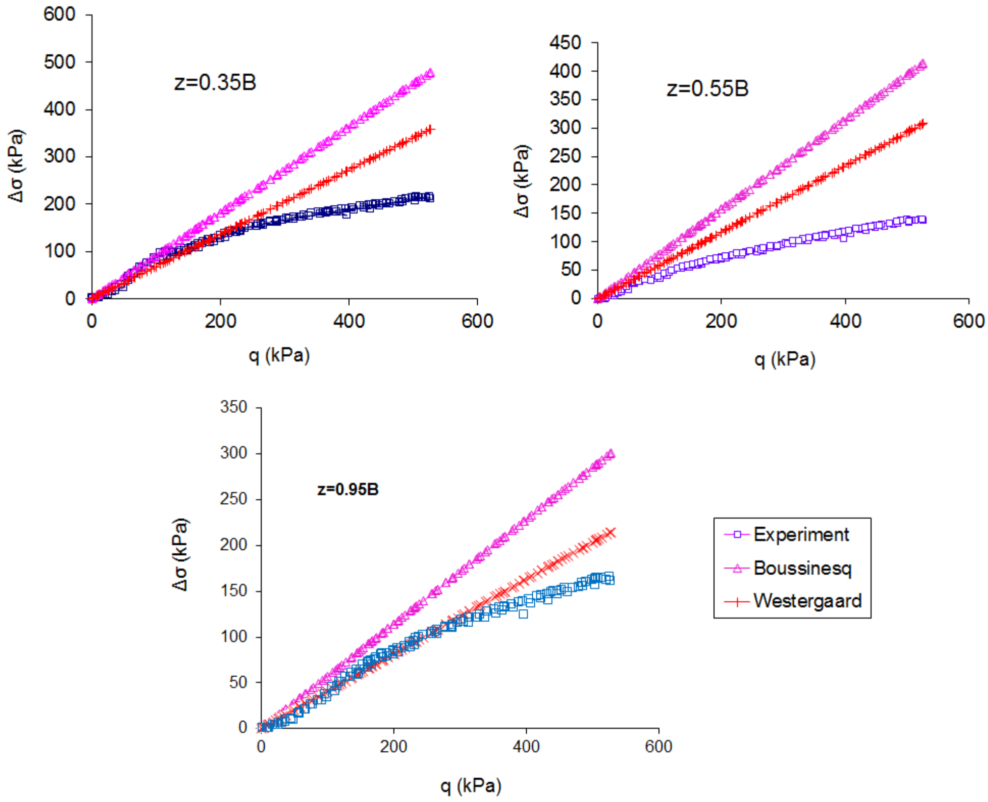

Figure 2. Additional vertical stress behaviors for different points in reinforced subgrade (First Model).

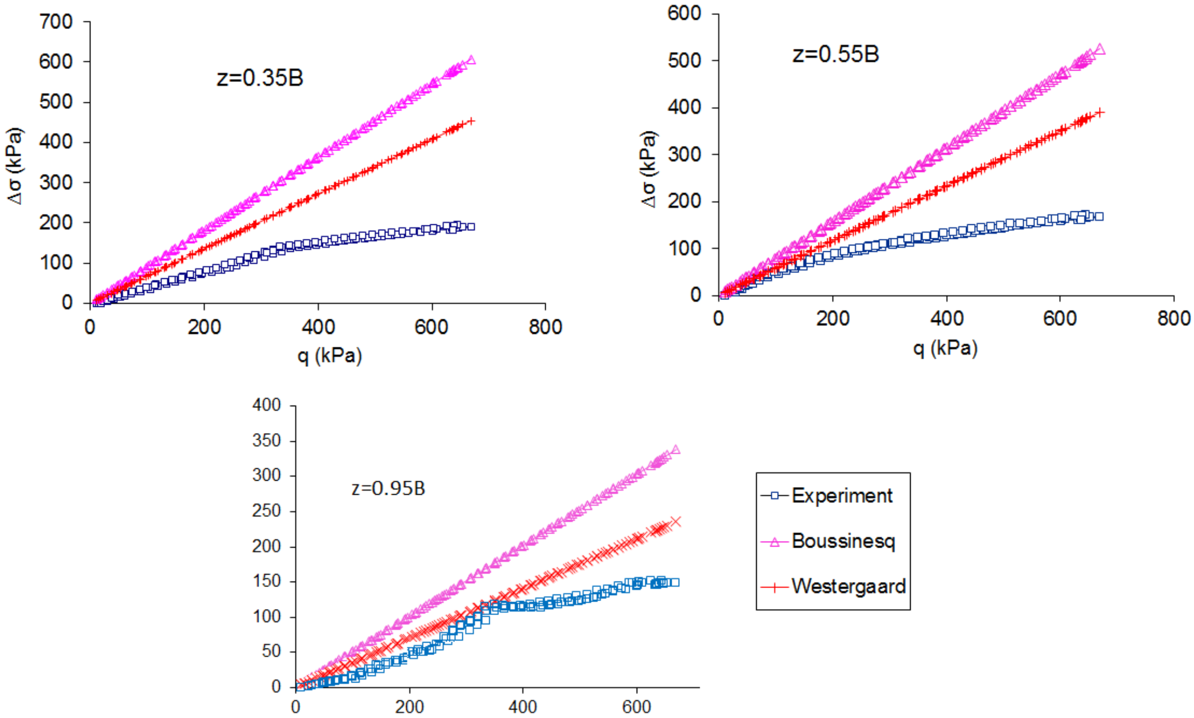

Figure 3. Additional vertical stress behaviors for different points in reinforced subgrade (Second Model).

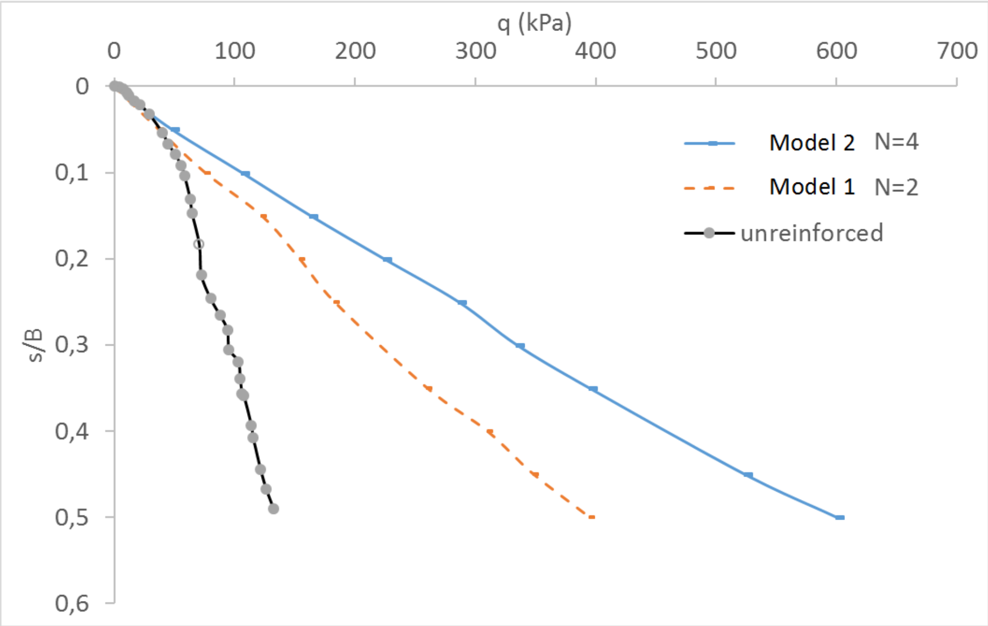

Figure 3. Additional vertical stress behavior for different conditions; a. h/B=0.2, N=4; b. h/B=0.6, N=2.

In order to see the effect to load-settlement behavior of the specimens, Figure 3 was prepared. As it can be seen, unreinforced model can load in small loading values, but when the reinforcement used more load can be applied. The curve of the load-settlement behaves more linearly. The model which has more reinforcement layers (Model 2) can be loaded more. In other words, although more loads can be applied, less settlements can be observed. When discussing with stress behavior, more reinforcement layers decrease the stress and models can carry more loads for same settlement conditions. So, it can be said that there is a good correlation between stress and load-settlement behaviors. Additionally, it can be added that reinforcement layers help to be stiffer for the medium dense sand conditions. For medium dense sand soil particle behaviors can affect the changings of the stress behavior. Therefore, for different type of medium dense conditions stress and loading behaviors can be changed. In the future researches different condions and different type of reinforcements should be studied to determine the stress behavior. Because Boussinesq and Westergaard theories can be inadequate to determine the behavior of different conditions and parameters for reinforced models.

4 CONCLUSIONS

In this study, it was investigated the additional vertical stress behavior for two different model tests. The laboratory model tests were conducted. Additional vertical stress and load-settlement behaviors of the models were discussed. As a conclusion, it can be interpreted that each additional reinforcement layer affects the stress behavior in soil and different parameters can affect the values of stress for same reinforced zone depth. There is a good correlation between the stress values and load-settlement curves. Boussinesq and Westergaard theories should be improved for different reinforcement conditions and different subgrade cases such as loose sand. For bigger loads new stress calculation theories are needed. Different soil conditions should be studied because different soil conditions and their settlement types can affect the stress behavior of the roads.

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