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Investigation of the Size Effect at Different Geometries on Stress Distribution of Sandy Soils

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ABSTRACT

In this study, the induced vertical soil stress values occuring along with horizontal surfaces at predetermined depths of the shallow foundations on sandy soils were investigated by model tests. In the model tests pressure transducer was used to measure the stresses. Circular foundations at different size were used in the model tests and the sizeeffect were investigated. As a result of this study, the size effect at circular foundations wasn't found to be an important factor on stress distribution of sandy soils.

Keywords:*Size effect, Soil transducers, Vertical stress*

INTRODUCTION

During the past decades, increasing interest has been shown in the development of a satisfactory formulation for the stress–strain relationships of engineering soils that incorporates a concise statement of nonlinearity,inelasticity and stress dependency based on a set of assumptions and proposed failure criteria[1].

It is very significant to know the real distribution of stresses and the relationship of stress–strain behaviour for solution of the problem and the design of many projects. Thus, this real distribution of stresses and relationship of stress–strain behaviour, due to the additional loads in the soils, should be found experimentally.

LITERATURE REVIEW

Horizontal and vertical stresses which caused by vertical loads at sand and clay samples are measured by Terzaghi[2].As a result of the experiments, K_0=0.42 value was obtained from Donathsolution ($K_0= \sigma_v/\sigma_h$) for coarse sand [3].Effects of compaction on the values of K_0 was first investigated by Terzaghi and he reported that Ko values are variyingbetween 0.6–0.7[4].Additional vertical stress values by loading sand fill that occur on a horizontal planes of particular specified depths, have been measured by ScheidigveKögler[5].Kjellman measured stresses in the sandy soils with a device which is similiar to triaxial compression tests and he reported that K_0 values are in between 0.5 and 1.5 [6].Bayliss developed an instrument to measure lateral soil pressure and he indicated that K_0 value is 0.5 for sand and medium-plasticity organic clay [7].Hendron[8] used an oedometer that can measure lateral pressures by strain gauge that was mounted on a metal ring that is sensitive to the lateral stresses[9]. Then, Brooker and Ireland[10] used the data obtained from Hendron's study and they investigated the variation of earth–pressure coefficient at rest dependent on the over consolidation ratio and plasticity index[9].Sağlamer investigated the effect of relative density (Dr), shape of soil, particle size, stress history to K_0 in coarse-grained soils. In an odometer that was improved for this purpose, loading tests were carried out on four different air-dried sand. In his tests, 3 pressure transducers have been used in order to measure high stress values(Figure.1). It was found that at loading condition $K_0$was mostly dependent on relative density of soil. He indicated that K_0 values in dense sand were lower than the values in loose sands[11].

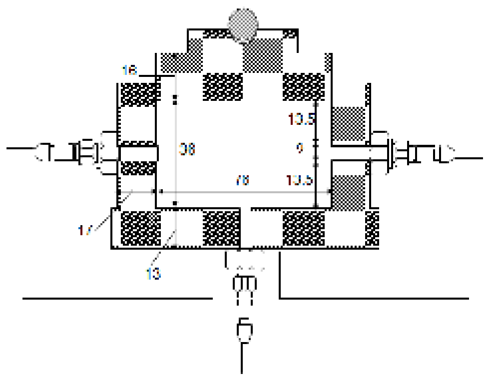

Figure 1.Sağlamer, 1972 Test Equipment, (Dimensions = mm)

The test equipment that can directly measure the horizontal stresses on clay soils was used by Abdelhamid andKrizek[12]. The variations of the horizontal stress and K_0 values due to applied vertical stresses were investigated. It was concluded that the K_0 values were remain stable for the vertical stresses higher than the pre consolidation pressure, but this value risedin unloading status[12].The time dependent behaviour of horizontal stresses was investigated by using K_0 test tube by Edil and Dhowian[13]. Pore water pressures were measured by means of pressure transducer. It was concluded that the relationship between vertical and horizontal effective pressures was nearly linear in loading stage on the turba soils at high water contents[13].K_0 values are 0.60 for loose sands and 0.35 for dense sands. Furthermore, it varies from 0.50 to 0.60 for normally consolidated soils and it can be bigger than 1 for over consolidated soils[14].The thin-walled oedometer was used to investigate the relationship between K_0 and OCR for loading, unloading and reloading status byBedişkan[15]. It was determined that as the OCR rises K_0 values also rises and K_0 values in the unloading status is lower than in the loading status. Moreover, K_0 and time dependent behaviour of the horizontal stresses were investigated and it is concluded that K_0 values decrease under the static vertical stress [15]. Soil pressure transducers were used to determine the stress distribution in the backfill in a soil box by Cho veVipulanandan[16]. A self loading steel soil box was designed for simulating earth pressure with a width of 61.0 cm, breath of 51.0 cm, and a height of 91.4 cm. The specially developed soil pressure transducers were diaphragm strain gage types with 8.9 cm in diameter and 2.54 cm thick. The sand was deposited uniformly into the soil box by achieving a relative density of %70. The surface load was applied using a rigid plate and the load was measured using load cells.The theoretical solution (Van Horn, 1963)[17] for vertical stress at a depth z below the surface in a box of width b and breath l, interface friction angle between backfill and walls of f, subjected to an applied surface pressure of q, can be estimated by following equation[16].

$$\sigma_v = \frac{L\gamma}{2k_r \tan\phi}\left[1-\exp(-2k_r \tan\phi \frac{2z}{L})\right]+q\exp(-2k_r \tan\phi \frac{2z}{L}) \text{, where, } L=\frac{bl}{(b+l)} \quad (1)$$

γ = Unit weight of soil, k_r = the ratio between horizontal and vertical pressure

The vertical stress distribution obtained from the experimental results agreed with the theoretical prediction [16].The induced vertical and lateral soil stress values of the square shallow foundations on sandy soils were investigated by LamanandKeskin[18]. In the model tests pressure transducer was used to measure the stresses. The effect of density on the stresses was investigated. The experimental results were compared with theoretical and numerical results. It was determined that the stress values were decreased, when the depth of soil was increased. Furthermore, it was seemed that experimental results at three depth of soil were similiar to Boussinesq solutions.Keskin et al.,were investigated the effect of vertical effective stress and over-consolidation ratio to the coefficient earth pressure at rest[9].The vertical stress values occurred under the center line of the uniformly loaded square footings were investigated experimentally and numerically by Keskinet al.[19]. Tests were performed in a square shaped test box and pressure transducer was used to measure the stresses.The results of the study were compared with the results of Boussinesq method. In the numerical analysis, soil was modeled using finite element method with two dimensional axi-symmetric and three dimensional conditions as linear elastic and non-linear elastoplastic materials and the effect of these models on the vertical stress values was investigated. A general agreement was observed between the experimental, numerical and theoretical results for the values obtained for predetermined depths of sand and the obtained results are discussed[19].

In this study, additional vertical stresses, which occur in a soil as a result of uniformly loaded circularfoundations were investigated with laboratory model tests. Additional vertical stress values that occur on a horizontal planes of particular specified depth (1.0D), were measured. In the tests, pressure transducers were used to measure stress values. Furthermore, the sizeeffect were investigatedin the model tests.

MODEL GROUND AND TEST EQUIPMENT

Clean, uniform and fine sand supplied from the Çakıt River was used in present research.The physical properties of sandare summarized in Table 1 and the grain-size distribution curve is shown in Figure 2. The sand is classified as SP according to Unified Soil Classification System (USCS).

Table 1. Properties of sand(Bağrıaçık, 2010)[20]

Property	Unit	Value
Coarse sand fraction	(%)	0.00
Medium sand fraction	(%)	46.40
Fine sand fraction	(%)	53.60
D_{10}	mm	0.18
D_{30}	mm	0.30
D_{60}	mm	0.50
Uniformity coefficient,C_U	-	2.78
Coefficient of curvature,C_C	-	1.00
Classification (USCS)	-	SP

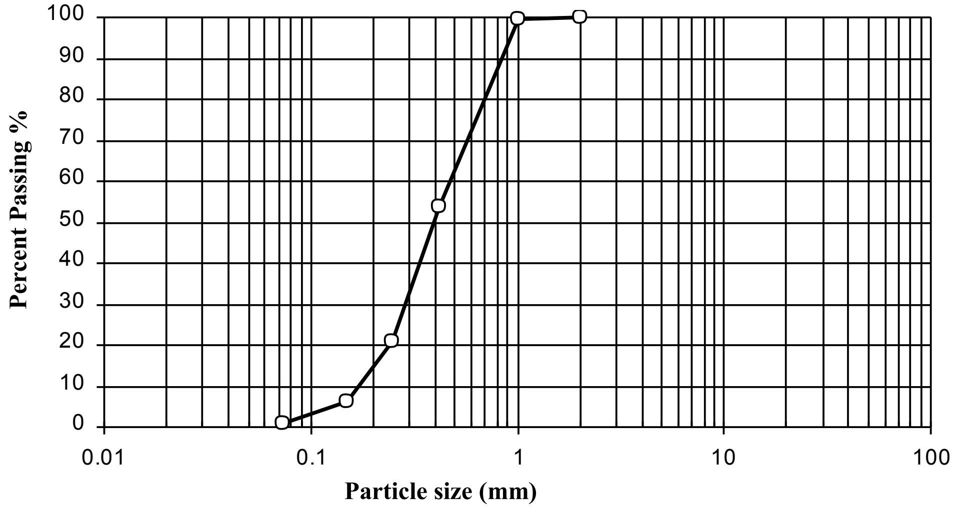

Figure 2 Grain-size distribution curve of sand

The laboratory tests were conducted in the Geotechnical Laboratory of the Civil Engineering Department of the CukurovaUniversity. The model tests were conducted inside a box which consists of wooden plate, glass surface and steel profile with dimensions of 50 cm (length) × 50cm (width) × 40cm (height)(Figure 3).

Figure 3.Test Box(Bağrıaçık, 2010)[20]

The circular foundations with dimension of 6 cm, 9 cm, 12 cm and 15 cmwereused in the model tests(Figure 4).

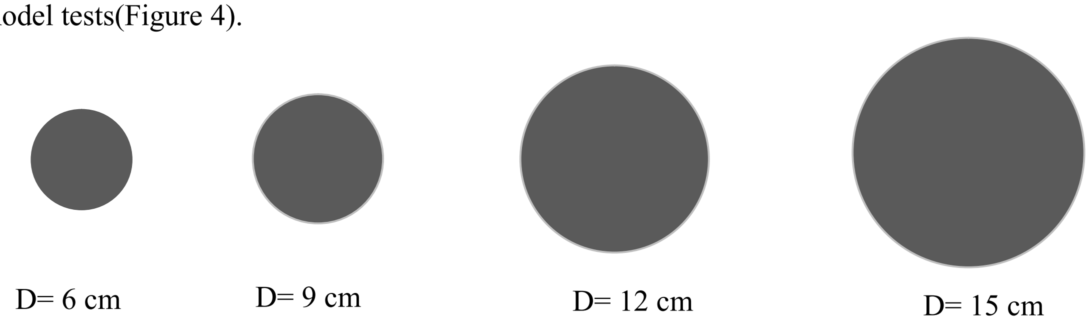

Figure 4.Model Foundations(Bağrıaçık, 2010)(D= dimension of foundation)[20]

Test equipmentusedfor model testingconsists of a tank, loadingandmeasurementsystems. Thefacilityandtypical model areshown in Figure 5.

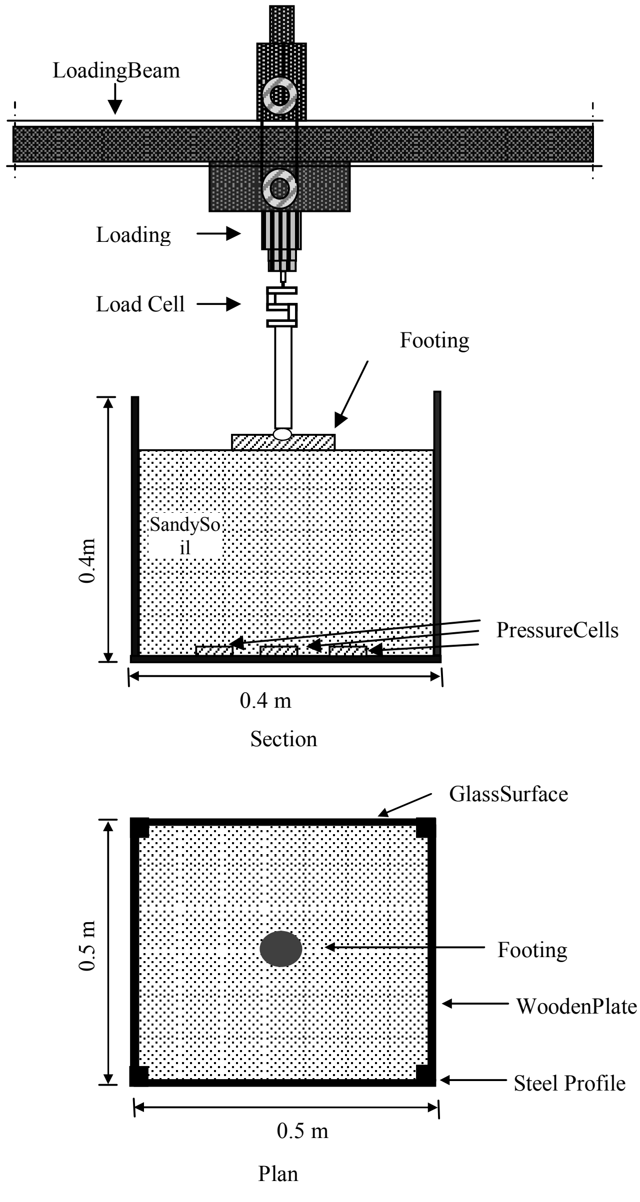

Figure5.Test Equipment (Bağrıaçık, 2010)[20]

TEST RESULTS

The aim of this study is to investigate of the size effect at different geometries on stress distribution of sandy soils. So that, aseries of laboratory model testswereconducted on thesandysoil at differentmodel sizesand the results were presented at Figure 6 and Figure 7.

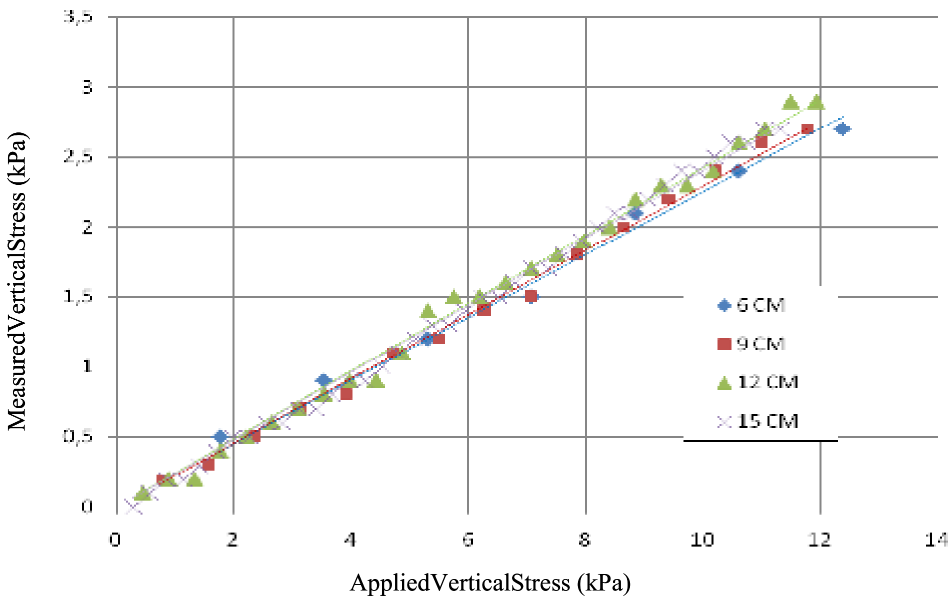

Figure 6. The Size Effect at the Center of Foundations

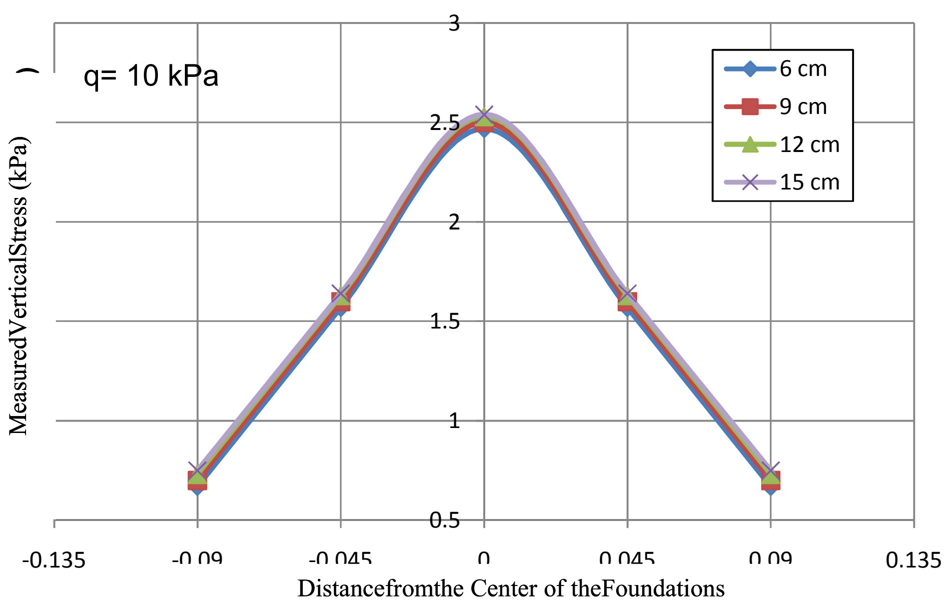

Figure 7. The Size Effect at Different Distance from the Foundation’s Center

As seen from the Figure 6 thatexperimental results show a linear increase in stresses for all different sizes and the size effect wasn't found to be an important factor on stress distribution of sandy soilsat circular foundations.From Figure 7, when distance from the center of the foundations is increased, the size effect wasn't found to be an important factor in any position such as at the center of the foundations.

CONCLUSION

Predicated on theresults of thestudy, thefollowingconclusions can be drawn:

Alinearincrease in stressesduetoappliedloadis shownforallsizes at experiments.

Whenthesize effect is evaluatedin terms ofstress distribution in sandy soilsforcircular foundations, it can be saidthatthe size effecthasn'tanyconsiderableeffect on circularfoundations.

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