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***Review Article***

# BEARING CAPACITY OF CIRCULAR FOUNDATION LOCATED ON REINFORCED SOIL

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**ABSTRACT**
Today use of circular foundation become widely practiced, sources and foundation engineering machinery may be circular. Under development of engineering sciences and creation of geo-synthetic, construct of foundation on reinforced soil has been increased thus study of behavior of a circular foundation on the reinforced soil is an important matter. Among evaluated parameters such as pre-stress factor it can help to optimize designing of reinforcing systems through geo-synthetics. Purpose of the present study is to do 2D analysis of circular foundation located on the soil surface reinforced with geo-synthetic layers and study of pre-stressing effects through PLAXIS software.

***Keywords:*** *Geo-Synthetic, Circular Foundation, Pre-Stressing*

## INTRODUCTION
Use of reinforced soil is one of the common methods of improving the soil strength properties, which in the past three decades many studies have been done in this regard. Today geo-synthetic should be used as one of factors of soil reinforcement in order to improve the soil strength properties; and because of its indestructibility, ease of implementation and cost-effectiveness compared with the other reinforcement materials has been considered by Engineers more. Evaluation of parameters such as pre-stress factors can help to optimize designing of reinforcement system by the use of geo-synthetic so that reinforcing of surface soil in different civil projects by the use of geo-synthetic has been improved around the world and needs to be improved in our country. Investigation of effective parameters can help to optimize their design. The purpose of the present study is to do 2D analysis of circular foundation located on the soil surface with geo-synthetic layers and study effects of pre-stressing through PLAXIS software.

### *An Overview of the Technical Literature*
Geogrids due to high tensile strength increase the strength of the soil and increase the loading capacity. These polymeric grids break off the failure surfaces in weak soils and can increase the strength of soil through tolerance of tensile force and reinforce the soil; it depends on different factors; and several experimental and numerical analysis should be done in this regard (Aubeny and Murff, 2005).
It can be seen that difference in the tensile modulus of geo-synthetic membranes cannot influence on response of subsidence system of granular soft soil based on studied parameters. Pre-tension of geo-synthetic membrane has effect on the response of subsidence significantly and then rate of subsidence under the point of loading would be decreased, although there was no significant change in the system (Bransby and Randolph, 1998). Pre-tensile force is effective on reducing the discrepancy subsidence. Increase of thickness of granular bed cause to reduce rate of subsidence. If shearing module of granular bed is increased, then rate of subsidence would be decreased under the point of loading. But rate of subsidence would be increased in center and at the tip of beam. It was observed that intensity of shear module is preferable in order to reduce differential subsidence (Shivashankar and Jayaraj, 2012).
Lovisa *et al.,* (2009) has carried out many studies in the field of experimental models and finite element analysis on a circular foundation located on reinforced sand through geotextile. Improvement of loading capacity due to reinforcer pre-stressing has been studied. It was observed that increase of pre-stressing has improved the loading capacity and would reduce the rate of subsidence.
Sharma *et al.,* (2000) have studied the available analysis methods to assess the loading capacity of reinforced foundations. They have carried out a lot of tests and field tests on reinforced foundation

located at sandy and silt soil. They also carried out theoretical analysis of the failure mechanism to determine some equations in order to calculate the loading capacity and taking into account the progress of tension in the reinforcer.

Vinod *et al.,* 2009 have carried out tests of models in laboratories to determine improvements of loading capacity and reduce subsidence in weal (loose) sand caused by increase of fiber-tape rope of reinforcer. Test results show that loading capacity can be increased up to 6 times and subsidence can be reduced to 90% through the fiber-tape reinforced rope.

***Plaxis Software***

PLAXIS software is based on finite element method with 2D and 3D analysis of deformation and stability of soil-structures, such as groundwater and surface flow analysis, and is used in geotechnical engineering applications, such as excavation, foundations, embankments and tunnels.

To obtain geotechnical applications of Software, some advanced behavioral models to simulate nonlinear and time-dependent behavior of soils are required.

Because soil is a multi-phase material, there are needed some special processes to consider the hydrostatic and non hydrostatic pore pressure in the soil. Although modeling of soil is an important issue, but many geotechnical engineering projects involve the modeling of structures and interactions between structures and soil requirements.

PLAXIS software with features and special capabilities could be involved and deal with the numerical aspects of complex geotechnical structures. It is known for its high quality and robustness. In order to preserve these high standards, the company has a chain of quality assurance processes that are supported by proper tools.

***Analysis of Plane Strain and Axial Symmetry***

Plaxis can be used for analysis of plane strain and axial symmetry. Plane strain model can be used for the structures with cross-section and with constant stress and loading in a high length perpendicular to the section.

Axial symmetry model can be used for the structures with radial section and uniform loading around the central axis in which deformations and stresses are assumed equal in every radial direction.

Moher-Columb Model is a non-linear, robust and simple model that can truly be considered as a first estimate of the actual behavior of soil or rock.

Moher-Columb model can be used to calculate the actual final loads and reliability coefficient. This elastic perfectly plastic model composed of five basic input parameters include Young's modulus E, Poisson's ratio v, angle of internal friction φ, cohesion C, angle of stretch ψ. Moher-Columb model includes a yielding function that represents a yielding level in stresses surfaces in which behavior of soil is elastic and follows Hooke 's law of elasticity through E and v.

When stress reaches to yielding level, plastic deformations begin (it should be noted that the angle of stretch is required to model the irreversible increase of size of shearing).

Full conditions of yielding can be defined in terms of the principal stresses through three yielding functions.

$$Sin\phi - C\cos\phi \leq 0\, f_z = \frac{1}{2}|\sigma_2' - \sigma_3'| + \frac{1}{2}\left(\sigma_2' + \sigma_3'\right)$$

$$f_z = \frac{1}{2}(\sigma_2' + \sigma_1')Sin\phi - C\cos\phi \leq 0$$

$$f_z = \frac{1}{2}\left(\sigma_2' + \sigma 1'\right)Sin\phi - C\cos\phi \leq 0$$

These yielding functions create a hexagonal irregular pyramid among the main stresses (4-7). $\sigma_{1,2,3}{}'$ is main stresses in directions X, Y, Z.

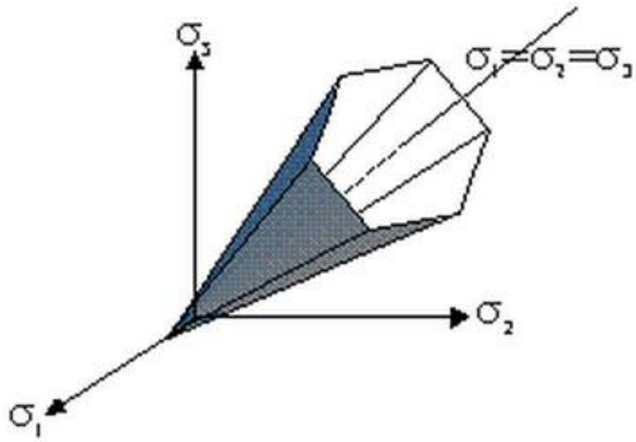


**Figure 1: Yielding level of Moher-Columb**

Failure function of Moher-Columb generally leads to estimate of stretch. Therefore a potential function is considered that the rate of plastic strains is proportional to derivative of potential function of stresses; and therefore according to Orthogonal Rule, the plastic strain is perpendicular to the potential function. For simplicity we assume that this function is similar to Moher-Columb criteria, but ψ is used instead of φ. In fact, this parameter is used to model the plastic volumetric strain for compacted soils; therefore, three potential plastic functions can be defined for Moher-Columb model:

$$g_z = \frac{1}{2}(\sigma_2' - \sigma_3')Sin\psi$$

$$g_z = \frac{1}{2}(\sigma_2' - \sigma_1')Sin\psi$$

$$g_z = \frac{1}{2}|\sigma_2' - \sigma_1'| + \frac{1}{2}(\sigma_1' - \sigma_2')Sin\psi$$

***Modeling***

Here it is assumed that there is a plane circular foundation with radius 6m which analyzed through an axial symmetry analysis, because circle has axial-symmetry property because of its geometrical shape.

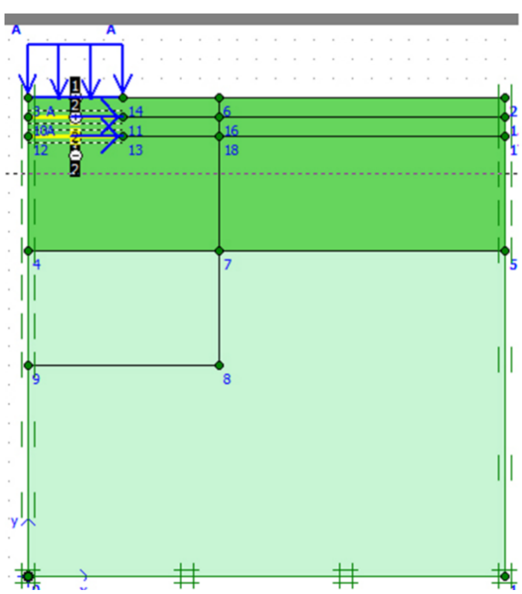

**Figure 2: Schematic Geometric Model**

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In this study, some parameters include model geometry, density ($\gamma$), Poisson's ratio (v), modulus of elasticity (E), cohesion (C) and friction angle ($\phi$), length of geogrid, number of geogrid, angle of stretch ($\psi$ (, the geometric boundary conditions, the number of layers of reinforcement, loading and fixed mesh and parameters including distance between jeogrids, axial stiffness, and pre-stressing force are assumed as variables.

**Table 1: Soil bed properties**

| $\varphi$ | $v$ | $\psi$ | $\gamma$ |
|---|---|---|---|
| 12 | 0.3 | 15 | 17 |

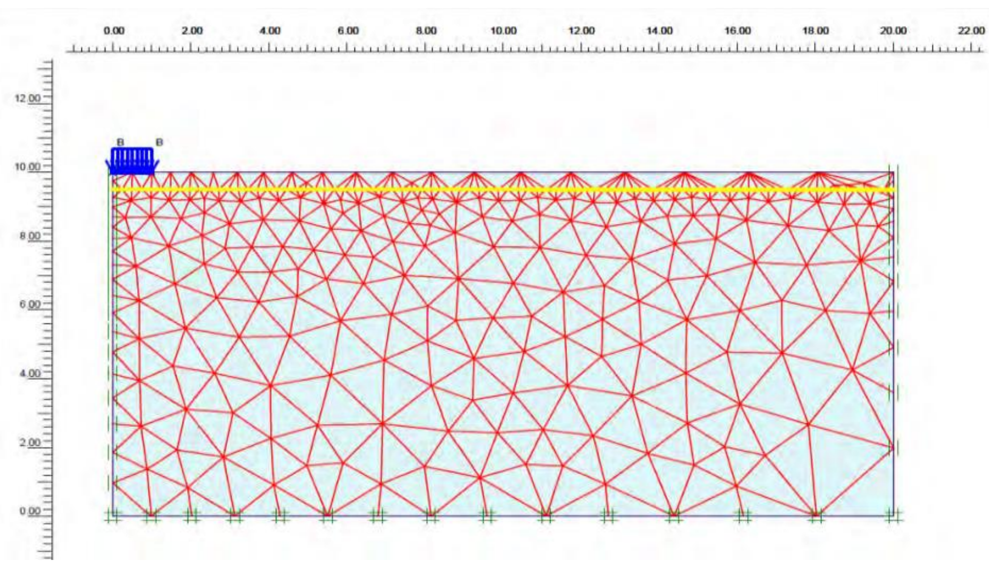


**Figure 3: Numerical mesh**

In loadings, point A in the left corner and point B in the right corner are located.
Geometric boundary conditions should be applied so that rounds of geometric boundary must be created (except the upper boundary of the surface) and the lower boundary of the model is blockage (no motion in the x and y directions) and the vertical borders around the foundation is hooped (a movement in the Y direction), and standard mapping is used for this option.

***Loading***

Loading of a geometric model is that a default displacement as well as load on a building with weight 16 (KN/M) per story, and total 96 (KN/M) were applied. Thus default value of displacement was 5 cm and y = - 0/05 m at two points A (0,25) and B 25,5) B is applied. In loadings point A is in the left corner of foundation and point B is in the right corner.

Geogrid used in the study, with the axial stiffness EA = $10^5 \frac{KN}{M^2}$ equal to the default value of software library and the mass of the geogrid is 730 $\frac{g}{m^2}$ and its general characteristics presented in Table 2.

**Table 2: Properties of reinforcer**

| Thickness mm | Mass $gm^{-2}$ | Area $M^2$ | Tensile strength KN | Deformation of max.tensile strength |
|---|---|---|---|---|
| 37 | 730 | 72 | 1000 | 12.5 |

Geogrid length of 6 m is used in geometric modeling

**Table 3: Properties of models**

| **Vertical distance of geogrids** | **Axial stiffness of georids** | **Pre-stress forece (KN/M)** | **Model No.** |
|---|---|---|---|
| 3.5 | 1E+05 | 0.1 | Model no. 16 |
| 3.5 | 1E+05 | 0.2 | Model no. 32 |
| 3.5 | 1E+05 | 0.3 | Model no. 48 |
| 3.5 | 1E+05 | 0.4 | Model no. 64 |

Figure 4 shows the comparison of the two graphs is defined as the stress-strain models 16 and 32 and the two graphs 16 and 32 are chosen because of changing of pre-stressing force in both models and stability of both parameters e.g. axial stiffness and geogrid EA (KN / M) and the distance between the geogrids (M) of 1E + 05 and 3.5 respectively.
Then you can choose both models and evaluste effect of pre-stressing force (KN/M) on the output of models. As a comparison chart of both models, it is clear that the curves 16 and 32 have approximately equal stress and model no. 32 has a less strain compared with model no. l6 and show that the if pre-stressing force is increased from 0.1 to 0.2 (100 percent increase of pre-stressing force), an decrease in horizontal strain by the models will be seen.

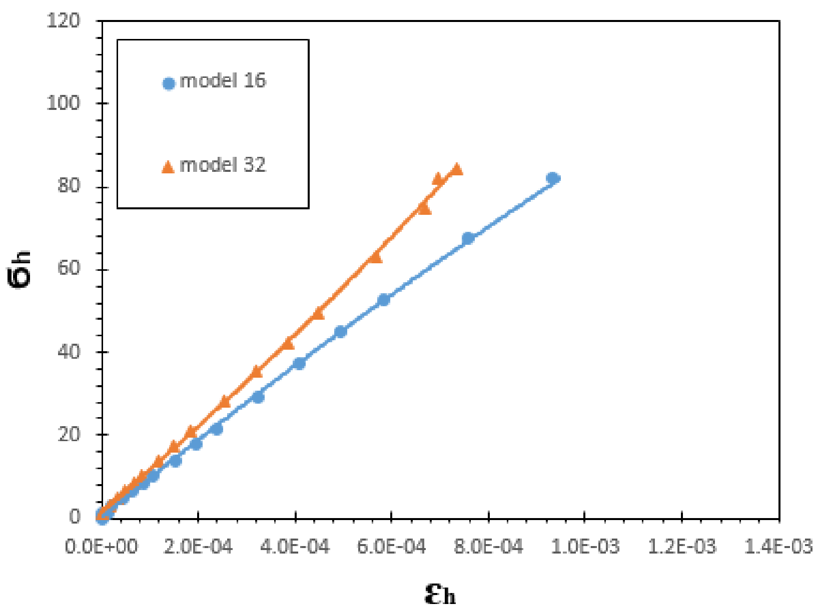


**Figure 4: Compare of strain-stress graph of models no. 16 and 32**

Figure 5 shows the comparison of stress-strain graph for models no. 48 and 64. Model no. 64 has less strain compared to model no. 48. We have same stress in model no. 48 with model no. 64. By comparing of both models no. 48 and 64, we will understand that the model with re-stressing force of 0.4 has less horizontal strain in comparison of model with pre-stressing force of 0.3.
Figure 6 shows the comparison of four graphs is defined as horizontal stress-strain models 16, 32, 48 and 64. Comparing the four graphs of models no. 16, 32, 48 and 64, we know that models with pre-stressing force of 0.4, 0.3, 0.2 and 0.1 has less horizontal strain. So, model no. 64 is the most optimal model.

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Finally, the comparative compare of four models no. 16, 32, 48 and 64, we find that models no. 16, 32, 48 and 64 with pre-stressing force of 0.1, 0.2, 0.3 and 0.4 have less horizontal strain under corresponding loading. Also we can find that models no. 64, 48, 32 and 16 with pre-stressing force of 0.4, 0.3, 0.2 and 0.1 have same vertical strain according to Figure 7.

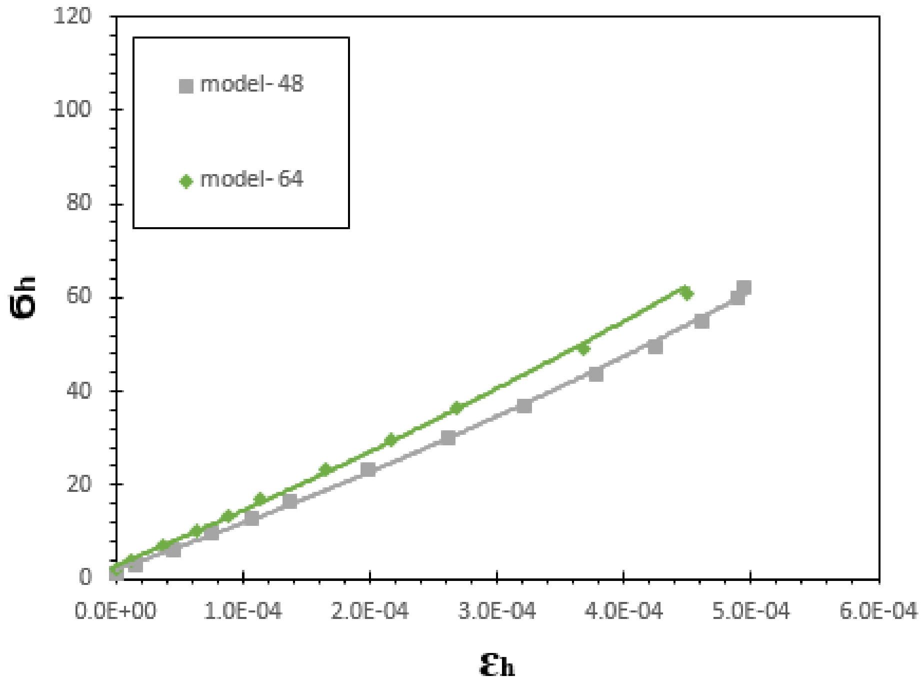


**Figure 5: Compare of horizental stress-strain models no. 48 and 64**

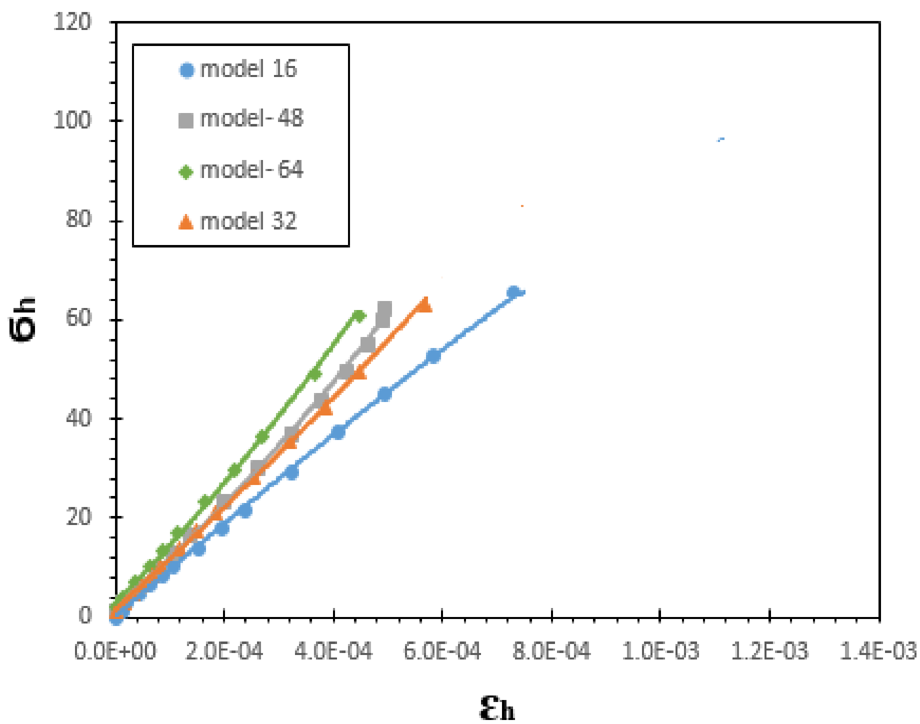


**Figure 6: Compare of horizental stress-strain models no. 16, 32, 48 and 64**

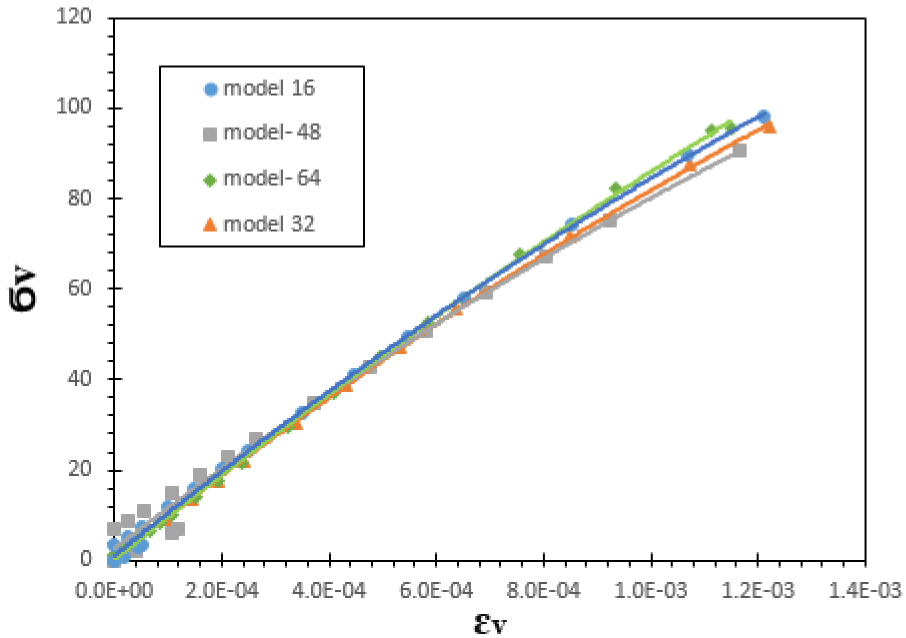


**Figure 7: Compare of vertical stress-strain models no. 16, 32, 48 and 64**

## CONCLUSION

With comparative compare of four graphs for models no. 16, 32, 48 and 64, we find that the models no. 16, 32, 48 and 64 with pre-stressing force have min. horizontal strain of 0.4, 0.3, 0.2 and 0.1 under corresponding loading. So, pre-stressing of 0.4 is the best value. Also we found that models no. 16, 32, 48 and 64 with pre-stressing force have same vertical stress- strain curves of 0.1, 0.2, 0.3 and 0.4 under loading.

## REFERENCES

**Aubeny C and Murff JD (2005).** Simplified limit solutions for the capacity of suction anchors under undrained conditions. *Ocean Engineering* **32** 864–877.

**Bransby MF and Randolph MF (1998).** Combined loading of skirted foundations. *Geotechnique* **48**(5) 637–655.

**Kurian C, Vinod P, Bhaskar AB and Sreehari S (2009).** Behaviour of a squaremodel footing on loose sand reinforced with braided coir rope. *Geotextiles and Geomembranes* **27** 464-474.

**Kurian NP, Beena KS and Krishna Kumar R (1997).** Settlement of reinforced sand in foundations. *Journal of Geotechnical and Geoenvironmental Engineering* **123**(9) 818–827.

**Ramaiah Shivashankar R and Jayaraj J (2012).** Some Studies on Prestressed Reinforced Granular Beds OverlyingWeak Soil. *Geotextiles and Geomembranes* **24** 1-7.

**Vidal H (1978).** The development and future of Reinforced Earth. Keynote Address, *Proceedings of Symposium on Earth Reinforcement, ASCE* 1-61.