Bearing Capacity Analysis of Granular Soil with Geogrid

SYNOPSIS OF THE THESIS

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Introduction

The soil usually has the characteristics of low tensile strength and is highly dependent on environmental conditions. The types of soil improvement methods such as grouting, vertical drains, soil replacement, complete, piling and geosynthetic reinforcement has developed to solve the problems. A geosynthetic may be defined as “a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure or system”. Geosynthetics have been successfully used in several areas of civil engineering including roadways, airports, railroads, embankments, retaining structures, reservoirs, dams, landfills, etc. The concept of reinforced soil as construction material is based on the existence of soil-reinforcement interaction due to tensile strength, frictional and the adhesion properties of the reinforcement and was first introduced by the French architect and engineer Henri Vidal in 1960. The soil–reinforcement interaction mechanism has a prime importance in the design of reinforced soil structures. This mechanism depends on the reinforcement characteristics, the soil properties, and the interaction between reinforcement and soil Therefore, one of the very important aspects of geotechnical engineering practice is the improvement of load carrying capacity of such loaded slopes. One of the possible solutions to improve the Bearing Capacity is to reinforce the sloped fill with series of more efficient layers of geosynthetic reinforcement material

Nowadays geosynthetics are being used for many methods in the geotechnical engineering. Geosynthetic reinforcement material encompass a range of polymeric products such as geogrids, geotextiles, geomembranes, geocells, geosynthetic clay liners and geocomposites which are used in various civil engineering applications. As compared with the unreinforced base, the geosynthetic-reinforced base can provide lateral and vertical confinement, tensioned membrane effect, and wider stress distribution. The layout and configuration of geosynthetic reinforcement needs to be optimized to get the optimum benefits from its reinforcement to soil.

Geogrid is used in layers with aggregate fills or other suitable soils to create a strong layer. So the bearing capacity of soil under the load of the foundation will be improved. Geogrids are polymeric products formed by joining intersecting ribs. They have large open spaces also known as "apertures". The directions of the ribs are referred to as machine direction (md), orientated in the direction of the manufacturing process or cross machine direction (cmd) perpendicular to the machine direction ribs. Geogrids are mainly made from polymeric materials, typically polypropylene (PP), high density polyethylene (HDPE) and polyester (PET).

Geogrids are manufactured as either biaxial or uniaxial. Biaxial geogrids are those that exhibit the same strength in both the machine and cross machine directions while uniaxial geogrids exhibit the primary strength in the machine direction with minimum strength, enough to maintain the aperture structure, in the cross machine direction

Geogrids are classified based on the method of manufacturing,

- Extruded Geogrid: A flat polymeric sheet of material is made into a geogrid by extrusion and holes of desired dimensions are punched in the flat sheet to form the apertures. Then stretching is done to impart the tensile strength.
- Woven Geogrid: It is manufactured by weaving fibrous yarns and apertures are formed in between the flexible joints. These types of geogrids have high tenacity.
- Welded Geogrid: In this type of geogrid, extrusion of ribs is carried out by passing it through rollers, and then they are sent to the welding section to form apertures. This method makes use of automated machines.

Objectives of Research

Following are the objectives of proposed research study:

1. To study the Load Settlement curve for different parameters with experimentation.
2. To carry out bearing capacity analysis of unreinforced soil and reinforced soil in terms of Bearing Capacity Ratio (BCR)
3. To study optimum use of geogrid in the proposed study.
4. To validate the experimental results numerically.

Review of Literature and Development in the subject

Jewell et al. (1985) the interaction between the geogrid and soil is very complex. He identified three main mechanisms of interaction between soils and geogrids: 1. soil shearing on plane surfaces of the grids, 2. soil bearing on lateral surfaces of the grids, and 3. soil shearing over soils through the apertures of the grids. The first two are the skin friction and passive pressure resistance of the contact area between soils and geogrids. The third one is the interfacial shear on the surface of a rupture zone created during shearing. The relative size of soil particles to the grid apertures has significant influence on the size of the rupture zone. As the ratio of this relative size (soil/geogrid) increases, the size of the rupture zone increases. Hence, the type of biaxial geogrid that should be used is dependent on the grain size distribution of the soil that will be placed around it.

Dash et al. (1994) have done model studies on circular footing supported on geocell reinforced sand underlain by soft clay. The test beds are subjected to monotonic loading by a rigid circular footing. The influence of width and height of geocell mattress as well as that of a planar geogrid layer at the base of the geocell mattress on the overall performance of the system has been systematically studied through a series of tests. The test results indicate that the provision of geocell reinforcement in the overlaying sand layer improves the load carrying capacity and reduces the surface heaving of the foundation bed substantially.

Aigen Zhao (1996) has presented the failure criterion for a reinforced soil composite. The failure criterion of reinforced soil presented here is anisotropic due to inclusion of geosynthetic reinforcement with preferred direction. The slip line method in relation with the derived failure criteria can be used for calculating the failure loads of geosynthetic reinforced soil structures. The stress characteristics of reinforced slopes, retaining walls and foundations are presented and compared with those without reinforcement. The inclusion of geosynthetic reinforcement enlarges the plastic failure region in a reinforced soil structure and significantly increases the load bearing capacity.

Benrabah et al. (1996) have done analytical work and undertaken experiments to explore the changes in stress distribution for a sand medium reinforced by geomembrane layers. The three results i.e. 1.from experiments; 2.using the Boussinesq method and 3.using the fast lagrangian analysis of continua calculation program (FLAC) are established. They have found that the presence of reinforcing layers has no bearing on the vertical stress, while the horizontal stress shows a large increase. The use of FLAC program leads to slightly lower calculated stress values, however the increase of the horizontal stress can be predicted by FLAC.

Sharma & Balton (1996) explored the behavior of reinforced embankments on soft clay using the technique of centrifuge modeling. Controlled in-flight construction of the embankment was carried out in a geotechnical centrifuge over a soft clay layer reinforced with scaled-down and instrumented geogrid reinforcement and the behavior of the subsoil and the response of the geogrid were observed.

Palmeira et al. (1998) have stated that geosynthetics reinforcement can be used to increase the factor of safety of embankments on soft soils, particularly for shallow foundation layers. They have presented back analysis of some reinforced embankments that can be found in literature using stability methods commonly employed. The results obtained suggest that these simple methods are useful tools for predicting factor of safety of reinforced embankments when the required input data are available and accurate

Kumar and Saran (2003) have conducted laboratory tests on closely spaced strip and square footings on geogrid reinforced sand. The study was carried out to evaluate the effect of spacing between the footings, size of reinforcement and continuous and discontinuous reinforcement layers on bearing capacity and tilt of closely spaced footings.

Raymond and Ismail (2003) have shown that, the improvement of bearing capacity of track, highway and runaway embankments on unbound aggregate can be done using geogrid. Geogrid reinforcement in unbound aggregate will improve the performance of the transportation support. They have presented experimental results for three different construction possibilities of geogrid reinforcement in the unbound aggregate layers. The aggregate layers are subjected to both repeated loading and static loading

Patra et al. (2006) published the results of a limited number of studies for the ultimate bearing capacity of strip foundation supported by Geogrid-reinforced sand and subjected to eccentric loading. They varied the eccentricity ratio (e/B) from 0 to 0.15 along with the foundation embedment ratio (D_f/B) from 0 to 1. The conclusions were drawn 1. For similar reinforcement conditions, the ratio of the ultimate bearing capacity of eccentrically loaded foundations to that loaded centrally can be related by a reduction factor. 2. The reduction factor is a function of D_f/B and e/B.

Basudhar et al.(2007) studied the behavior of 30 mm diameter model circular footing resting on sand beds reinforced with geotextiles. Both experimental and numerical studies were performed with number of layers of reinforcement varying from 0 to 3 and relative density of sand bed varying from 45 to 84 %. They reported bearing capacity ratio improvement of about 4.5 times that of unreinforced case when the sand bed was reinforced with three layers of reinforcement

Ghazavi and Mirzaeifar (2010) have studied uses of geosynthetics reinforcement to increase bearing capacity and reduced settlement of the soil. Many analytical, numerical and experimental studies have performed to evaluate the behavior of reinforced soil foundations built in various soil types.

Mosallanezhad and Hataf (2010) have done several experimental comprehensive tests on a laboratory small scale on reinforced soils. They used different geogrids for reinforcement. In all the studies cited, it was found that the bearing capacity ratio (BCR) greater than the unreinforced soil.

Zidan(2012) conducted numerical study using finite element analysis to investigate the behavior of circular footing resting over reinforced sand. Results indicated that the depth of top layer plays an important role in the behavior of the reinforced soil, and reported that the optimum depth of top layer was equal to 0.19 times the diameter of the footing. Load improvement ratio for reinforced coarse sand was higher than that of reinforced fine and medium sand

Scope of present work

In the proposed study, Bearing Capacity analysis will be carried out with the help of Finite Element Program “PLAXIS” as well as by experiment the behavior of load settlement curve for different parameters will be studied. The following parameters will be considered to analyze bearing capacity of soil with geogrid material.

1. Effect of depth to the first reinforcement layer
2. Effect of number of reinforcement layers
3. Effect of vertical spacing of reinforcement
4. Effect of reinforcement width.

Methodology

Collection of literature review of research work will be carried out. The methodology of proposed work includes, studying physical and mechanical properties of geogrid, studying characteristics of granular soil and to study the behavior of load settlement curve experimental work will be planned. The experimental work consists of square footing plate, testing steel tank. The load on the footing will be applied through a mechanical jack. Also Bearing Capacity analysis will be carried out with the help of Finite Element Program "PLAXIS" which is generally used to analyze most of the geotechnical engineering project.

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