An Analytical Research on Amplification of Soil-Reinforcement Friction and Bearing Capacity

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Abstract- An experimental inquiry has been conducted in order to improve the testing soil's load bearing capability by the adoption of a textile-based substance known as geotextile material. In the present investigation, geotextile is employed as a geosynthetic material, with sand serving as the primary and most fundamental material under consideration. The results of load tests conducted in a laboratory on a strip footing, which is presumed to be rectangular in shape and supported on a sand substrate, are reported below. We have compared the deflections noticed in the sand when reinforcement is being applied to the sand that has been oven-dried without reinforcement. Furthermore, a comparison is made between the geotextiletested footings' bearing capability and soil devoid of geosynthetic material.

Keywords— *Improve Testing Soil's, Load Bearing Capability, Textile-Based Substance, Geotextile Material.*

INTRODUCTION

Reinforcement in soil, sometimes referred to as reinforcing soil, is the process of strengthening soil by incorporating geosynthetic material into the soil mass. The substance may be offered as metal strips, geocell, geosynthetic, geogrid, or geofibers, among other forms. Since clay is typically utilised in the subgrade during pavement building, sand is used for the subgrade construction at seashores, docks, and harbours when clay is not readily accessible. In the current study, the usage of geotextile as a geosynthetic material has boosted the bearing capacity of the sand. The major purpose of utilising geotextile, a permeable fabric having the potential to function as a separate filter when used in conjunction with soil, is to manage pore water pressure. The provision of this material stabilises the soil. This technique may be applied to stabilise the soils before using them as soil subgrade for building pavements, embankments, harbours, landfills, and drainage systems. Structural damage is usually caused by laying the foundation of the building on loose soil strata. The structural load of the buildings cannot be supported by these loose earth layers. As a result, the buildings experience settling, fractures form, and eventually collapse. In these loose soil layers, individuals decide to build their structures using a deep foundation. However, the use of deep foundations might occasionally result in higher building expenses. Therefore, the ground improvements are implemented to prevent the aforementioned issues. The most popular technique for improving the ground is the use of geo synthetics. Because the soil strata are strengthened by the application of these geo synthetics, they have a higher density and strength (bearing capacity). A soil that has been fortified by the insertion of reinforcing material such as bars, strips, sheets, or grids within the soil mass is referred to as reinforced soil (meshes). These materials resist tensile stresses that form inside the reinforced soil mass when load is applied to it. An element that has a low tensile strength may break or yield, losing its usefulness. When constructing a foundation resting on poor or weak soil, geotextile reinforcements work well to boost the bearing capacity and decrease settlement. It is suitable for a wide range of geotechnical works, including embankments, retaining walls, and foundations. Geo textiles are permeable materials that have the capacity to drain, separate, filter, strengthen, and protect when used in conjunction with soil. Products like geogrids and meshes have been developed, and geotextile composites have been introduced as the use of geotextile textiles has grown. These materials are collectively known as geotextiles and associated goods. Depending on the materials that make up its composition, geotextiles can be roughly categorised as either natural or synthetic. The most often used natural geotextiles that degrade naturally are geojute and coir nets; on the other hand, synthetic polymer-based geotextiles are permanent and do not degrade. The majority of jute plants cultivated in Bangladesh and India are used to make geojute. Jute geotextile (JGT) has been attempted to be used in several civil engineering applications in recent years.

USED MATERIALS

The following materials are being gathered and utilised in order to conduct more tests and complete the investigation of the soil media's load-bearing capability, or sand.

(i) Sand- The Markanda River near Mullana, Ambala, is the source of the sand that is used. In order to get rid of the organic debris, the sand is cleaned and attempts are made. After being adequately sieved from 4.75 mm and held in a pan after passing through a 75 µ sieve, the sand is then preserved for oven drying and utilised for additional testing. Sand is extracted from Sambalpur, Odisha's Mahanadi riverbed. To ensure that it is devoid of organic materials, the collected sand is cleaned and washed. Following oven drying, the sand is carefully sieved to get the necessary grade. After being filtered via a 2 mm IS sieve, dry sand is held in a 75 micron IS sieve. The sand is categorised as poorly graded sand (SP) by the Bureau of Indian Standards, IS 1498. Sand's specific gravity (G) is determined to be 2.62. The specific geotechnical characteristics of sand are described.

(ii) Geotextile/Geojute- The geotextile employed in this work is geojute (Figure 1). Jute gunny sacks, which are gathered from the local market, are used to produce this geojute. The necessary sized cut piece of geojute is created from the jute gunny sacks. Each strand of jute thread used in the fabric has a tensile strength of 2.4 kN/m and a thickness of about 1.0 mm. For every strand, the geotextile fabric has a thickness of almost 0.2 cm.

Figure 1-Geotextile/Geojute

INVESTIGATIONS USING EXPERIMENTS

(i) Loading Arrangement and Test Tank- A model tank with interior measurements of 900 mm in length, 900 mm in breadth, and 900 mm in height was used for the tests. The wooden foundation utilised in this 1g model test has dimensions of 150 x 150 x 20 mm. The concrete composition of the tank contributes to its great rigidity. The base plate with anchor bolt configurations supports the portal frame from the floor. The pre-calibrated proving ring and hydraulic loading jack arrangement are supported by a sturdy beam. The top of the sandy dirt has been flattened. The proving ring is positioned on top of the isolated footing, which is positioned in the middle of the tank. With the aid of a hydraulic jack, the piston in the loading frame makes contact with the proof ring. To measure the settlement, two dial gauges are mounted on the footing.

(ii) Properties of Test Medium- The test medium of choice was river sand that had been graded uniformly. Sand samples were tested for strength, maximum and lowest dry densities, specific gravity, and gradation. To create homogenous sand beds, controlled pouring was used. The total weight of the sand bed was calculated by weighing the needed amount of sand for each layer in order to obtain the unit weights examined in this inquiry. The measured unit weights for soil with a relative density of 17% (RD) were 14.4 kN/m3, and for soil with a relative density of 59% (RD), 16.6 kN/m3. The corresponding friction angles were 33° and 37°, respectively.

(iii) Properties of Reinforcing Material- Using a vernier calliper, the thickness and aperture size of the chosen geogrid material were determined. A geogrid sample of 100 mm in length and 200 mm in width is used to calculate the tensile strength using the broad width grasp technique. Here is a list of some of the geogrid materials that are sold commercially. The geogrid of CE 111 was chosen for the current study and is shown below in Table 1. The manufacturers' tabular data shows the typical ultimate tensile strength of the suggested reinforcing material at a maximum strain of 10%.

Materials	Thickness	Aperture size	Ultimate tensile strength
CE 111	2.8mm	2.8mm	2.00KN/m
CE 121	3.2 mm	3.2 mm	7.68KN/m
CW 131	5.5 mm	5.5 mm	5.80KN/m

Table 1- Properties of Reinforcing Material

(iv) Fabrication of Geogrid Cages- For an isolated footing, the depth of effect for bearing capacity is B, and for settlement, it is 2B. The 40 cm diameter geogrid circular pipes are constructed and utilised as vertical reinforcement by altering the spacing as indicated in the image. 2. One 500mm-long geogrid cell is employed, and it is positioned 0.3B depth from the footing's base, where B is the footing's breadth. There are four geogrid reinforcement rows and four geogrid reinforcement columns.

Figure 2- Geogrid Cages

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SETTING UP THE TEST BED

For the purpose of testing, a 0.65 m × 0.65 m × 0.3 m brick masonry tank is built in the lab. The tank's dimensions are chosen such that the sides and bottom of the tank do not restrict the failure zones that form during testing on model footings. Next, sand with or without geojute is used to prepare the test bed in the tank (Figure 3). Initially, the test tank's volume is determined by precisely measuring its inside measurements. The necessary amount of dry sand is calculated based on the tank's volume and its unit weight of 15.9 kN/m^3. By using a funnel, the above-dry sand is poured into the tank so that the funnel's tip stays 10 cm above the sand's surface. The goal of this is to have the sand medium within the tank to have a consistent density. The funnel is slid spirally from the perimeter of the tank towards its centre throughout the pouring process. Once the tank is fully filled, a straight edge smoothes the sand's upper surface. Using a spirit level, the horizontality of the sand's upper surface is verified. When conducting a test with a reinforced soil bed, the geo jute or other reinforcing material is positioned at the necessary depth, and the tank is then filled with sand using the funnel as previously mentioned. Using a straight edge, the sand surface at the depth is levelled before to the placement of the geo jute (reinforcing material). The surface's horizontality is carefully preserved. A similar process is used to completely empty and fill the tank with sand in preparation for further testing.

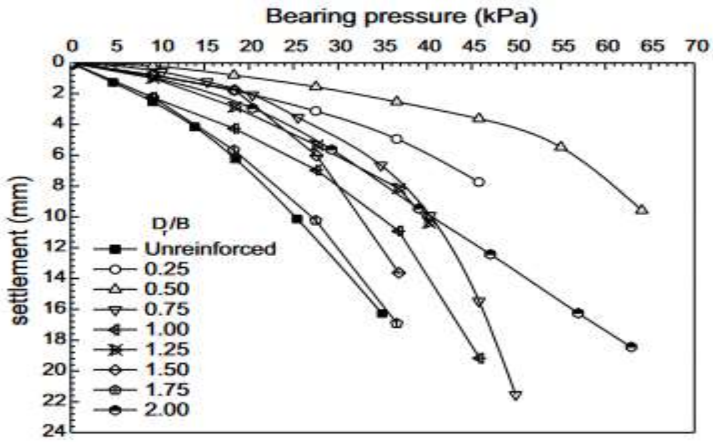

Figure 3- Bearing pressure-settlement behavior of 50 mm square model footing on geojute reinforced sand

METHODOLOGY

The silty clay soil and sand sample's specific gravity (Gs) was ascertained using the ASTM D 854 technique. The average specific gravity is derived from the findings of three tests for accuracy's sake.

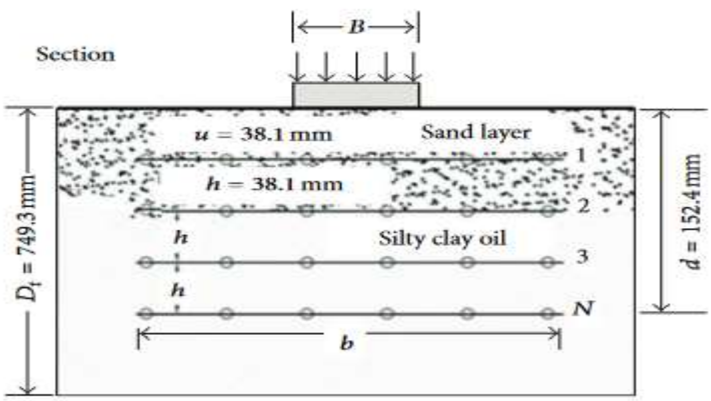

Figure 4- Layout of geogrid spacing in cross section of model tank and footing

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The maximum dry density and optimal moisture content (OMC) were ascertained by performing the standard Proctor compaction test in accordance with ASTM D 698 procedure. In accordance with ASTM D 422, the particle size distribution of the silty clay soil and sand samples was determined by hydrometer tests and dry sieve analysis. The silty clay soil's liquid and plastic limits were ascertained using the ASTM D 4318 technique, and the cohesion (c) of the soil was ascertained using the ASTM D 2166 method and the unconfined compression strength (UCS) test. The ASTM D 4253 and ASTM D 4254 techniques were used to determine the maximum index density (i.e., lowest void ratio) and minimum index density (i.e., maximum void ratio) of the sand samples, respectively. Sand was poured into a mould for the smallest index unit weight using a tiny funnel from a low height (25.4 mm), and it was vibrated for ten minutes for the maximum index unit weight. The ASTM D 3080 technique has been used to a direct shear test in order to ascertain the friction angle (ϕ) of the sand sample. The silty clay soil sample that had been prepared was placed in a large container. Next, 19% water, or the soil's OMC, was added to the soil and well mixed to create a homogenous, uniform mixture. The moisture content of the soil water combination was examined before to conducting the tests in the model tank. The silty clay soil was compacted in 13 layers to a depth of around 673.1 mm in the model test tank in order to achieve a homogeneous density. For each layer, a flat round hammer weighing around 12.25 kg was used to compress the silty clay soil. The silty clay soil in the model test tank had a unit weight that was 86.8% of its maximum dry unit weight at its ideal moisture content (OMC). A 76.2 mm thick layer of sand was deposited on top of the compacted silty clay soil in the model tank once the soil's silty clay content had reached 673.1 mm. The sand sample was compacted into two layers, each layer having a thickness of 76.2 mm, for the bearing capacity testing. Model footing base-level biaxial geogrid reinforcements were positioned at pre-established depths. The model footing was positioned on top of the layer of sand.

CONCLUSION

Experiments are conducted to assess the geotextile's potential for improving the sand's bearing capacity. Below the 50 cm x 30 cm x 40 cm in rectangular footings in testing soil, three layers of geotextile are positioned (for reinforcement). From 0.20 to 2, the ratio of reinforcement depth to the width of the corresponding footing (D/B) varies, resulting in reinforcement areas ranging from 1B × 1B to 4B × 4B. The final bearing capacity is increased to its maximum when the reinforcement is inserted half the depth of the footing (B).

- It is discovered that the bearing capacity ratio has increased by a factor of 2.03 to 2.47.
- The most productive zone is between 0.25B and 0.75B in depth for reinforcement.
- At the optimal (largest) size and optimum depth of reinforcement, the Ultimate Bearing Capacity is increased by an aspect factor of 2.7 to 3.6 compared to the typical, or unreinforced soil.
- The most advantageous reinforcement size, independent of footing size, is determined to be 3.5B × 3.5B. Therefore, the size 3.5B geotextile is utilised in the sandy soil's carrying capability.

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