International Journal of Scientific Research & Engineering Trends
Volume 9, Issue 4, Jul-Aug-2023, ISSN (Online): 2395-566X

Analysis on Particle Shape on Shear Behavior Of Aggregate-Geogrid in Pavements

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Abstract –Poor soil conditions make it impossible for civil engineers to build anything. A ground structure with sufficient bearing capacity is a necessary condition for a building's stability. Weak soil can have its qualities enhanced by inclusion and confinement through reinforcement. It may fix the issues of shallow foundations with soft soil, such as insufficient bearing capacity and excessive settling. In this study, both experimental approaches and numerical analysis were used to calculate the ultimate bearing capacity of geogrid-reinforced soil. Geosynthetic material's inclusion and confinement in the soil were studied for their effects. For this experiment, researchers utilized dry sand the Godavari River, close to Mancheryal Telangana. Soil reinforcement using biaxial geogrid, made by Strata Geosystem Private Limited of Hyd, India A reaction frame, mild steel tank, hydraulic cylinder, power pack, electrical panel, and a model foundation are all part of the experimental set-up. The 750mm x 750mm x 750mm Mild Steel tank was used for the tests. The dirt was compacted with the use of a plate vibrator, and a hydraulic cylinder with a 50 kN capacity was employed to provide the vertical load. Experiments were conducted on a total of 208 separate test sets with five variables in mind: the influence of the geogrid's topmost layer, the spacing between succeeding , the number of geogrid layers, the geogrid's breadth, and eccentric loading conditions. Plotting the load settlement curves for each of tests allowed us to calculate the ultimate bearing capacity of the soil for each geogrid arrangement. Using the finite element program , the experimental test findings were verified. OPTUMG2 models were used to examine this study's research topic from the perspectives of the many factors considered. The collapse multiplier, or ultimate carrying capacity, is calculated by the program using analysis theorems. This research demonstrates that the location of geosynthetic reinforcement in the soil is the most important factor in determining the effectiveness of the reinforcement. The soil collapsed in general shear failure, as shown by the load settlement curves obtained from experimental tests. When the geogrid's breadth is four times that of the footing, the first layer of the geogrid is 0.25 b from the base of the footing, and the number of layers is four with 0.25 b spacing and zero eccentricity xiv loading, the geogrid performs optimally. The experimental method and computational results both determined that the ultimate bearing capacity of the soil was 1981 kN/m2 at the optimal configuration of geogrid parameters. As x/b grows from 0.25 to for geogrid widths 3b and 4b, the contact area between soil particles decreases, leading to less frictional resistance on the failure plane. As a result, there is less peak load. Eccentrically loaded footing has a 39% lower ultimate bearing capacity than concentrically loaded footing in unreinforced soil. The ultimate load intensity in reinforced soil was 22 percent lower at e = 20 mm compared to a footing with a concentric load. This was because the geogrid in the soil mitigated the eccentricity impact. For each set of tests, the Bearing Capacity Factor (BCF) was experimentally computed to represent the increase in bearing capacity owing to geosynthetic inclusion. The best geogrid layout was determined to have a BCF of 5.69. There was a 19.61 percentage point increase in bearing capacity between concentrically loaded footing and eccentric loading circumstances when geogrid was used. Geogrids with a width of 4b were shown to efficiently resist greater horizontal shear loads.

Keywords- Godavari River, BCF etc.

I. INTRODUCTION

History and Motivation Bamboo, reed, timber planks, metal, etc. have all been utilized historically as a means of soil reinforcement. The development of soil reinforcement throughout time has adapt to new requirements and innovations in terms of size, shape, and composition. At first, sheet-type reinforcements in soil were used instead of the composite building material previously used, which consisted of metallic strips and dirt. After that time, geosynthetics such as geotextiles, geogrids, and geocells were far superior to their competitors.A soil with suitable carrying capacity is one of the most crucial factors in ensuring a stable foundation. Poor soil conditions make it impossible for civil engineers to build anything.

Insufficient bearing capacity and excessive settlement difficulties of shallow foundations owing to poor soil conditions can be solved using this cost-effective approach to reinforcement (Sridhar and Prathapkumar, 2017). The ultimate bearing capacity of the soil can be calculated using either analytical solutions or experimental experiments. Many analytical theories, such as Terzaghi's analysis, Meyerhof's analysis, Vesic's bearing capacity equation, etc., have been established to determine the ultimate bearing capacity (Sadoglu et al., 2009). Soil's tensile strength is low and largely dependent on its surrounding . Mechanical, hydraulic, chemical, and physical alterations, as well as inclusion and confinement by reinforcement, are only some of the ground modification techniques that may be used to enhance the qualities of poor soil. Estimating soil carrying capacity using geosynthetic reinforcement has been the focus of several experiments. Biswas,

Krishna (2016); Dash, Rajagopal (2007). Manash and Debarghya (D. Chakraborty and Kumar, 2014) used numerical analysis to calculate the load-bearing capability of geosynthetically reinforced soil. There has been a scarcity of high-quality land in India because of the country's rapid development in recent decades. If the weak or collapsible soil is not sufficiently corrected, it will have disastrous effects on the proposed project. Several ground 2 improvement strategies were considered for this investigation, but the inclusion and confinement by reinforcement strategy was selected due to its diversity in technical, economic, and application aspects (Patra et al., 2006). Adding reinforcement in the direction of tensile stress improves the soil's tensile strength. Due to the interaction between the soil and the reinforcement, the frictional resistance, and the adhesive qualities of the reinforcement, reinforced soil is employed as a construction material. As opposed to an unreinforced base, a geosynthetic-reinforced one can offer lateral and vertical confinement, a tensioned membrane effect, and a wider stress distribution (Krishnaswamy, 2007).

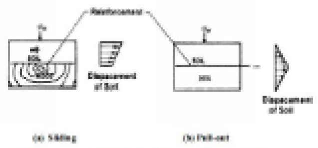
1. Method for Changing the Ground: Poor soil conditions can be avoided if they are discovered during construction. The same soil can be used if it is absolutely necessary to do so, though. Several methods of ground improvement exist, all of which involve either removing and replacing inappropriate soil or altering preexisting soil conditions.

2. Types of Methods for Altering the Ground Mechanical Alterations Applying external mechanical increases soil density. Compact rollers and plate vibrators are two examples of static vibratory equipment used for surface layer compaction. Deep compaction may also arise from heavy tamping on the surface. Adjustments to the hydraulic system Pore water is extracted from the spaces via drains or wells. The groundwater table in coarse-grain soil can be lowered by pumping water from boreholes or trenches. In contrast, fine-grained soils are subjected to long-term external stresses or electrical pressures. Alterations made chemically and physically To stabilize soil, adhesives can be physically mixed with the top layers of soil. During the grouting operation, the adhesives are pumped into soil cavities via boreholes at high pressure.

(c) Alteration through enclosing and including The tensile strength of the soil is improved when geosynthetic sheets are included as reinforcement. Shear strength is also greatly enhanced by this method. What this means is that the soil's ultimate bearing capacity improves. Under Section 1.6, the reinforced soil mechanism is explained.

1.3 Soil With additives Frictional soil is combined with tension-resistant materials like sheets, bars, grids, galvanized or stainless steel strips, polymer, wood, plastic, etc. to create reinforced soil. To mitigate the effects of gravity and boundary forces on the soil mass, it is embedded there. By using reinforcing materials perpendicular to tensile stresses, soil performance may be greatly improved. Footings, subgrade, railroads, embankments, retaining structures, dams, pipes, etc. all benefit greatly from its use.

3. Friction between the Soil and the Reinforcement Interface friction between soil and reinforcement is a complex phenomenon in reinforced soil. The traction forces produced inside the soil are transferred to the reinforcements via friction at the soil-reinforcement contact. Two tests are used to determine the coefficient of friction between the soil and the reinforcement: Both shear and pull tests are performed. When conducting pullout tests, the reinforcement is extracted from the soil, whereas sliding shear tests include the soil mass moving over the reinforcement. Soil movement is restricted by the reinforcement in sliding shear tests and rises with increasing distance from the interface (Fig. 1a), in pull-out tests, soil movement is greatest near the interface due to the soil's resistance to the reinforcement's pulling force. diminishes with increasing separation from the source of the motion (Fig. 1.b).



(a) Sliding (b) Pull-out

Fig 1.1 Soil movements in Mobilization of Interfacial Friction Resistance

4.Geological According to the American Society for Testing and Materials (1995), geosynthetic materials are "flat products made of polymeric material used with soil, rock, or earth as an integrated part of an artificial structure." Roadways, airports, railways, embankments, retaining structures, reservoirs, dams, landfills, etc. have all made extensive use of geosynthetic materials in civil engineering. The vast majority of

geosynthetics are produced using synthetic polymers, including polypropylene, polyester, polyethylene, polyamide, PVC,
etc.
5. Geosynthetic materials are Geosynthetics fall into a wide variety of types depending on their production process. "(a)Geotextiles “The geotextile is made up of synthetic fibers matted together in a random non-woven pattern or woven into flexible, porous textiles. Water may easily pass through and within the geotextiles because of their porous structure. Geotextile polymer is typically made from polyester or polypropylene. Polypropylene is so lightweight that it may float on water. It has a solid reputation for durability and longevity. Polyesters, on the other hand, have a higher density than water and greater tensile and creep resistance.

Fabrics always have a purpose, whether it be separating, reinforcing, filtering, or draining. Woven geotextiles and non- woven geotextiles are the two main types of geotextiles. Yarns and non-woven geotextiles can be made from polypropylene filaments and staple fibers, respectively. Monofilament, multifilament, and slit film yarns are woven together to create geotextiles. Producing the filaments and weaving are the two steps involved in creating woven fabrics. Slit films are utilized in sediment control and road stability tasks. However, they are not ideal for subsurface drainage or erosion management because of their limited permeability. A non-woven geotextile is a fabric created from a web or sheet of fibers that may be oriented in any of five different directions. It can be made by combining different materials or by using heat or chemicals.

The permeability and stretchability of non-woven geotextiles are particularly noteworthy. Geogrids,b) Polymers may be made into geogrids by shaping them into an open grid pattern. The apertures in the grid construction are rather large. There are openings in both machine and cross-machine directions between the ribs. These holes improve the connection to the ground. The interlocking between soil and geogrid is insufficient for lower aperture sizes. However, as geogrid holes get bigger, the friction between the materials decreases.

Soil-geogrid interface properties are greatly influenced by aperture size. Geogrid Manufacturing Process Classification Three commercial production methods for geogrids are described here. The apertures of a geogrid are formed by extruding a flat sheet of polymer and punching holes of a certain size into it. Stretching provides the tensile strength. Knitting and Weaving: Woven fibrous threads and holes formed between bendable joints make up geogrids. Thesegeogrids are extremely resilient. Apertures are welded into the ribs after they have been extruded via rollers, a process that is otherwise comparable to extrusion. This process is entirely mechanized. Geogrid Stress Transfer Classification There are two

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distinct categories of geogrids, distinguished by the direction of stretching or stress transfer during production. When a biaxial geogrid is stretched in both the transverse and longitudinal directions, the stress is distributed uniformly along all axes. In biaxial geogrids, the machine direction (MD) is the longitudinal axis, and the cross-machine direction (CD) is the transverse axis. Because of their uniform strength in both directions, biaxial geogrids find widespread application in the building industry. A geogrid that is solely stretched in the longitudinal direction is called a uniaxial geogrid. Therefore, the majority of the stress is distributed in a longitudinal direction. Uniaxial geogrids have greater longitudinal tensile strength than transverse tensile strength.


(a) Biaxial geogrid (b) Uniaxial geogrid

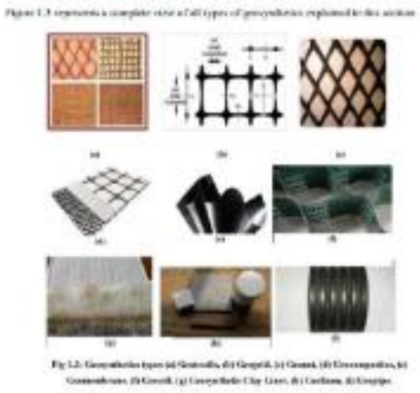
Fig 1.2 Geogrid types (a) Biaxial geogrid (b) Uniaxial geogrid

3. Geonets

Similar to a geogrid, a geonet consists of parallel sets of homogeneously linked ribs created by a continuous extrusion process into a netlike arrangement. Geonets' ribs work as a little dam to slow down surface runoff and reduce erosion. By efficiently transporting fluids along the geonet's plane, the drainage function is successfully provided. A Brief Introduction to Geocomposites When geotextiles, geogrids, and/or geonets are combined in a factory, the resulting unit is called a geocomposite. Both of these can be utilized as geocomposites when mixed wit soil. Geo-composites serve a wide variety of purposes, including partitioning, reinforcing, filtering, draining, containing, etc. Geomembrane, et al. In geotechnical engineering, a geomembrane is a synthetic membrane or barrier used in conjunction with soil or another geotechnical engineering material to regulate the flow of fluids.

It is commonly used on the inside and outside of storage tanks and silos. All reservoirs, canals, landfills, and other similar structures fall under this category. As a barrier against liquids and gases, containment is the principal function of role (f) GeocellThe geocell is a polymer honeycomb structure that is three-dimensional and quite thick. Soil is packed into a three-dimensional cell formed when strips are connected together. When the elastic modulus of the reinforced geocell increases, so does its rigidity. Geocells are frequently used for retaining walls on steep inclines, roadway bases, railroad tracks, container yards, etc. GCL, or geosynthetic clay liner, is the g.

Geosynthetic Clay Liners (GCLs) consist of a thin layer of finely crushed bentonite clay. Bentonite is used to create GCLs by creating sandwich with geotextiles and/or geomembranes. The clay expands as it becomes wet, creating a formidable hydraulic barrier. Geofoam, h)Most geofoam is made from polystyrene, which is a very common polymer. Large blocks are stacked to form a lightweight, thermally insulating mass that is then either buried in soil or covered with pavement. Soil embankments built on top of these unstable soils benefit from their utilization. A.I. Geopipe Draining liquids or gases is the job of geopipes, which are polymeric pipes with either perforated or solid walls. It is used in the process of draining landfill leachate. Polyvinyl chloride (PVC), high-density polyethylene (HDPE), polypropylene (PP), polybutylene (PB), and acrylonitrile (ABS) are some of the polymer resins utilized in the production of geopipes



II. LITERATURE REVIEW

General Analytical approaches Several methods were established to determine the ultimate bearing capacity of unreinforced soil, including Terzaghi's analysis, Meyerhof's analysis, Vesic's bearing capacity equation, and others. However, the focus of this investigation is on how to increase bearing capacity using the reinforcing technique. The primary goal of soil reinforcement is to increase stability and decrease vertical and lateral deformations. Because of their low cost, simple design, and convenience of usage, geosynthetics have been widely used as a reinforcing material in the building sector. Literature on geogrid, geotextile, geocell, and other geosynthetic materials used to strengthen soil is reviewed in this chapter. Researchers looked at the effects of reinforced soil using experiments, computer simulations, and statistical analysis.

A variety of studies on geosynthetically reinforced soil are summarized in the

articles that follow. The features of geogrid-reinforced sand on compressible soil were examined in 2.2 Studies on Geogrid-Reinforced Soil (Alawaji, 2001). The model testing used Tensar SS2 geogrid and a 100 mm diameter aluminum circular base plate. Using a combination of a chart and an equation based on experience, we were able to estimate the probability of soil collapse. Bearing capacity ratio and collapsible settlement were found to be affected by geogrid width and depth. According to the study results, using geogrid leads to less collapsible settlement and a greater bearing capacity ratio than not using geogrid under pressures of 100 kPa, with a maximum settlement of 0.66D in wet circumstances and a smaller settlement of roughly 0.02D in the dry state. Using a geogrid with a diameter four times that of the loaded area increased the elastic modulus by up to 2000%. In order to comprehend the interference effects on bearing capacity and settling of closely spaced strip footings on reinforced sand, 16 (Kumar and Saran 2003) developed the Interference Factor (IF). This is written as

Results showed that the interference factor for narrowly spaced strip footings ranged from 1.16 to 2.7. depends on the footing distance and the thickness of the reinforcement. When there is ample room between them, the interference factor drops. The weight of the footing

size was shown to improve the capacity of closely spaced footings. foundation dirt layers that provide support for the footing. The slant of the square next to its foundation's footings is thanks to the continuous reinforcing layers of earth for a foundation under the narrowly spaced footings. The experimental model tests for the ultimate bearing evaluation were conducted by Patra et al. (2006). a strip foundation's bearing capacity on geogrid-reinforced sand under eccentric loading Because of the oddness,

The embedment ratio of the base (e/B) was raised from 0 to 0.15, and the embedment ratio of the foundation (Df/B) was raised from 0 to 0.15. shifted from -1 to +1. The findings of the scientific experiments show that there is a correlation between the bearing capacity of eccentrically laden foundations and that of centrally loaded ones. factor (Rf) for less reinforcement under the same conditions. Results showed that the decrease in the Df/B and e/B ratios determines the factor (Rf). Latha and Somwanshi (2009) Used numerical simulations and experiments on laborator models to find out how much weight geosynthetically reinforced sand can take. To conduct the experiments, we tested using four grids, each with a different tensile strength, like a weak geogrid. There are four different types of geogrids: biaxial, weak biaxial, uniaxial, and a geonet. Geosynthetic: The depth of the reinforced zone beneath the footing was adjusted to provid reinforcement, and how many geosynthetic layers are there in the zone that has been reinforced.

The findings of this study demonstrated that a reinforcement depth equivalent to double the footing width is required. It was found that the tensile strength is les important than the arrangement of the reinforcement bearing capacity when geosynthetic material is used. 17 The geometric enhancement of was studied (Mirzaeifar, Ghazavi, 2010). footing. Geogrid load-bearing capability was studied by numerical analysis. The multi-edged, shallow base is reinforced sand. The carrying capacity reportedly rises dramatically with as many as three layers of geogrid reinforcement. In the form of a H, similar to a plus-shaped cross in terms of bearing capacity ratio, the footing was determined to be footing.

The optimal geometric dimension for +, H, and T-shaped footings was B/L = 0.6. Granular fill was made from blast furnace slag (Yadu and Tripathi, 2013). overlay on a subgrade that is too soft. Evaluation was performed using laboratory investigations on scale models. the effectiveness of granular fill overlays reinforced with geogrids on soft subgrade soil bearing capacity enhancement factors Bearing capacity and the effect of geogrid layer lengths: A parametric model was used to explore ways to increase capacity. Because of the presence of a geogrid in the granular fill overlay over the soft subgrade, soil bearing capacity and footing settling both significantly improved. It turned out showing a 4:b/B ratio (geogrid length/footing width) significantly enhances No appreciable increase in Bearing Capacity Ratio (BCR) was seen for b/B ratios over 4.

observed. The bearing capacity of circular footings in a seismic zone was determined using Geogrid (Demir et al., 2014). coarse fill layer of crushed granules on top of a clay deposit. It was clear from the data that Using granular fill layers supported by geogrids on top of natural clay soils boosts bearing capacity. capability and drastically
cuts down on foot movement in all directions. Using the limit analysis's upper bound theorem (M. Chakraborty and Kumar, 2014), There was an effort to calculate the ultimate bearing capacity of a circular footing. The foundation was laid on a horizontal layer of circular reinforcing sheets to fortify the soil. There were three distinct soil media explored in this investigation: (i) completely granular, (ii) cohesively frictional, and (iii) entirely cohesive with a supplementary allowance for the escalation in cohesiveness that occurs with increasing depth.

The result was that the diameter of the reinforcing sheet was observed to rise with a rise in the friction angle's internal value. How big the circular support is: sheets are located between 3.15 and 3.80 d. 18: Using a square footage model (Durga Prasad, Hariprasad, and Umashankar 2016), Examine the soil's load-displacement behavior in three situations: (1) an aggregate layer overlaying a layer of unreinforced sand; (2) a layer of sand reinforced with geogrids; and (3) a layer of aggregate putting a geogrid over a layer of . Variations in aggregate thickness across sand were 0.1B to 0.5B in the initial scenario. The load-carrying capacity decreased with increasing aggregate thickness. increased. For a layer of aggregate 100 mm thick, bearing pressure rose by 81%. a layer of sand with a settlement ratio of 10% on it. Incorporating geogrid as a sand reinforcement enhanced the footing's reaction to loading and settling. Only
one thin layer of The third scenario uncovered a value of 0.3B for geogrid reinforcement in the aggregate layer. The load improvement factor was determined for all three settlement ratios (5%, 10%, and 15%). cases, with values between 1.31 and 1.91 for the first, 1.11 and 1.81 for the second, and 1.31 and 2.70 for the third. in each of those circumstances. with the California Bearing Ratio (CBR) were conducted on poor-quality gravelly ground with the use of a geogrid.

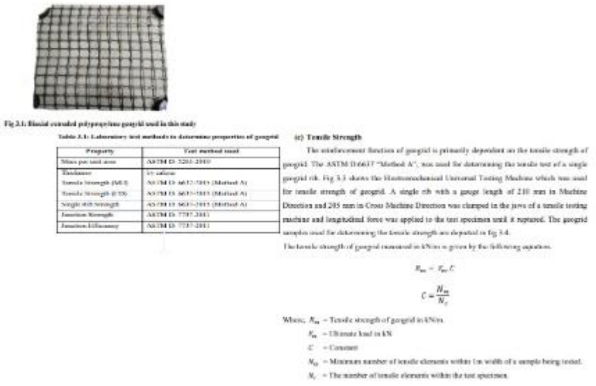


fig. 1 Possible advantages for increasing granular soil's compressive strength by utilizing a Geogrid They looked into utilizing a Geogrid. Tests on the granular soil showed that materials that did not meet the specifications for granular soil in Iraq performed poorly in class. C. In contrast, when granular material is placed on a geogrid of type Tensar SS2 at a thickness of 0.15 H, The CBR value of the granular soil is increased by nearly a factor of two after being treated with the material samples. Over untreated soil three times. Badakhshan & Noorzad n2017) performed tests in the lab using a shallow circular footing with a 120 mm diameter and a 120 mm square footing. central and eccentric loadings on unreinforced and reinforced sandy soil. A formula was constructed for eccentric loads on reinforced sand; both square and circular footings are supported.

The findings were fairly consistent with Meyerhof's method under unsupported assumptions. As load eccentricity grows, ultimate bearing capacity decreases. increased for both square and circular footings when load eccentricity is larger than the footing's kern footings. It was also determined how much the footing leans; this angle grows linearly with load eccentricity. The pace of growth slowed considerably closer to the tip. The increase in performance across the board multiplied by the square root of the number of layers of reinforcement added to the bearing capacity The relative quality increase was significantly greater for circular footing. There were two distinct kinds of 3D geogrids employed in Makkar, Chandrakaran, and Sankar (2017): a triangular opening in addition to a rectangular one.

A value of 2.7 was found for the Bearing Capacity Ratio. and 3.1 for geogrids with a triangular pattern in three dimensions and a rectangular pattern in three dimensions, respectively. It was spotted for a 0.75B gap between two levels of 3D rectangular geogrid; Get rid of the soil heave around the footing entirely. The findings showed that the bearing capacity was increased most noticeably by the four layers of reinforcement. capability in both 2D and 3D geogrids with a triangular design. In terms of bearing quality, three-dimensional geogrids outperformed more conventional geogrids. capacity and minimizing reinforced soil surface deformation. Sweta and Hussaini (2019) conducted a battery of large-scale direct shear experiments to examine the shear behavior of both unreinforced and geogrid-strengthened sub-ballast interfaces. The cutting down increases strain rates (Sr) and normal (n) from 20 to 100 kN/m2, respectively. 's theory of breakage was used to calculate ballast breakage (Bg). This manifested as shear deformation where the ballast and sub-ballast met. After n was grown from 20 to 100 kN/m2, Breakage rose from to at a shearing rate of 2.5 mm/min. The unreinforced interface might experience a loss of 2.84–4.07 percent.

However, with geogrid used as ballast and n = 20 kN/m2, the value of Bg decreased from 2.84 percent to 2.08 percent at the sub-ballast contact. and Standard Relative Speed (Sr) = 2.5 mm/min. Saha Roy and Deb 2020 built a model of two overlapping foundations and tested it in the lab. lying on top of the bare sand bed or the geogrid-supported sand bed. It was shown that the length-to-width ratio of a footing has a significant effect on Mbehavior, therefore the One, two, and three-to-one ratios, respectively. The bearing capacity changes caused by a single layer of geogrid, Improvements in capacity, and interference with footing were studied. Based on the results of the study,

The optimal geogrid depth for both interacting and isolated footings was one-third of its width, regardless of the footing's aspect ratio. How far apart are ? between adjacent footings was 1.5 times the footing's width. Strengthening of the Bearing Capacity Separated footings lying on sand benefited more from strengthening than densely packed foundation piers that sit in the sand. Research on Geogrid and Geotextile-Reinforced Soil (Abu-Farsakh, Chen, & Sharma, 2013) examined the geotextile behavior and foundations of geogrid-reinforced sandy soil. The experiments showed that footing loads can be reduced by using reinforcement to redistribute the load in a more consistent manner. a lessening of stress concentration and, by extension, of settling. The numbers indicate that the payout was lowered by 20% across the board with two or more layers of reinforcement. In this case, Compared to geotextile, geogrid showed greater performance on sandy soil in the study.

Top-layer thickness: For embedded square footing (Df/b = 1.0), it was determined that 0.33 times the footing in reinforcement was necessary. Geogrid-reinforced sand width The authors' previous analytical solution to the problem yielded a agreement between the study findings and the model-testing outcomes. The experimental results for footing on geosyntheticall sand were accurately predicted. Deb and Konai (2014) looked at the final cost of fines for varying percentages. load capacity of both natural sand and sand reinforced with geotextiles. All was determined to be well. The soil-geotextile interaction might be affected by the proportion of cement to sand (in percent). The Results show conclusively that the percentage increase in maximum load-carrying capacity of reinforced soil was increased when 5 percent particles were added to sand. 65 percent relative density sand. Since there will be no penalties at all if an interface of soil and geotextile has friction, 5 percent fines with sand have much more. Friction and adhesion at interfaces are new concepts. The benefits of reinforcing Increased bearing capacity were lost when excessive penalties were added. In order to determine the stability of a road embankment, we employed the PLAXIS 2D numerical method, and the road embankment reinforcement geotextile's optimal tensile strength was calculated after factoring in two variables: safety factors and allowable movement allowances.

According to the findings, as the amount of geotextile reinforcement grows, the safety factor does as well, up to a point. cost, after which it falls off gradually. Geotextile reinforcement with the optimal tensile strength was estimated at 600 kN/m when the safety criterion was taken into account. The second variable, or optimal tensile strength, was determined by taking into account displacement along the embankment base. robustness of geotextiles It was discovered that the movement along the embankment's base had decreased. if geotextiles had a higher tensile strength. Similarly, we found that relocation did not affect Geotextile tensile strength; thischaracteristic may be disregarded until it is considered when calculating the ideal geotextile tensile strength. Laboratory model experiments were performed to ascertain the bearing (Kazi, Shukla, & Habibi, 2015). strength equivalent to a 90% relative density reinforced sand bed. Geotextiles, especially the woven varieties, are utilized as reinforcement, with anywhere from one to five layers of reinforcement used. 4. The impact of the flooding on the ground's ability to settle and support weight was studied.

"In" both cases, In both unreinforced and reinforced examples, the author discovered that an increase in the water table led to a pronounced sinking of the foundation. However, the geotextile fails in wet environments. The rigidity and load-carrying capability of a sand bed are improved by reinforcing. relative sensitivity scale modulus When there are more than three levels of protection, the increase in There was not a Mnoticeable difference in load carrying or rigidity. Plate load testing was performed on footings measuring 270 mm by 900 mm (Tavangar and Shooshpasha, 2016). Plates of 270 mm and 350 mm sit on a bed of medium-density sand. Experimental Three-dimensional finite element studies and the obtained data were utilized to look into the impact of Increasing the ultimate bearing capacity of footings nonwoven geotextiles. Researchers discovered that the ultimate bearing capacity of a soil may be increased by using a system consisting of four geotextile layers and a foundation built on geotextile- reinforced sand made of nonwoven materials.

According to the calculations, As plate thicknesses grew up to 650 mm, the Bearing Capacity Ratio (BCR) declined. mm; however, the BCR did not change when the plate size was extended above 650 mm. Geotextile-reinforced sand was employed in a model test (Sridhar and Prathapkumar, 2017). using anything from one to four layers of coir geotextiles. The outcomes of the model tests for different Geotextile layers made it easy to see that the maximum pressure rose from 120 to 1050 kN/m2. as The original N = 1 has been expanded to N = 4. After incorporating a geotextile layer into the sand, the peak stress grew at the same rate regardless of the strain. The weight that the footing support over the coir was observed to be five times that of unreinforced soil. footings. 22. What happens when cement is applied to the geotextile-aggregate interface? and sand on a foundation's bearing capacity were explored in this laboratory study. Study by numbers, etc. How well the cement-treated contact enhanced bearing performance capacity was more apparent with shorter augmentations. The outcomes of the laboratory tests showed that the bearing capacity was enhanced by anything from 1.46 to, depending on geotextil length, 2.2 times that of the unreinforced scenario. Nonetheless, therapeutically compared to unreinforced situations, the sand-geotextile interface zone increased it by 1.71-2.34 times. Also, The BCR of footings reinforced using geocells or geogrids was reported to be 1.1. Geotextile-reinforced foundations have a BCR that is 1.15 times higher. Soil-reinforcement interaction studies were carried out by adjusting the vertical spacing between the reinforcements. In the experiments, a mass of geosynthetically reinforced soil was divided into three layers.

Fig.3.3: Electromechanical Universal Testing Machine for tensile strength of geogrid

Fig.3.4: Geogrid samples used in single rib tensile strength

One of the reinforcement layers was actively tensioned, while the other two were merely restrained. Shear: Activelytensioned reinforcement caused passive reinforcement to experience stress. layers across the middle ground. Constantly tensing the load in an active manner. As the thickness of one layer of reinforcement grew, the weight was distributed to the adjacent layers. increases. Fordynamic loads typical of workplace stress, the extent of the burden had a little effect on transmission, but it increased with decreasingvertical spacing. no change in the amount of force transferred. In an experimental study (Panigrahi and Pradhan 2019), geotextile wasemployed to improve the soil's ability to support weight. The soil medium was river sand, and the bags were made of gunny (geojute). were put to use as geotextiles. To investigate the differences between single and multiple loads, 32 experiments were conducted. A reinforcing layer laid under the footings of a square model The results indicated that the Footings on reinforced soil (with geojute) saw a maximum increase in ultimate bearing capacity improvement of 3.37 times over soil without geojute. Furthermore, despite the fact that the optimal reinforcement size was determined to vary depending on the type of reinforcing materials used, 3.5B x 3.5B As discussed by Goodarzi and Shahnazari (2019), carbonate and siliceous sand exhibit quite different mechanical behaviors. The author looked into the use of geotextiles for reinforcement.

A succession of compressed drains, Both unreinforced and reinforced, were subjected to triaxial testing. The purely mechanistic conduct of 23 factors such as geotextile thickness, relative density, confinement tension, etc. Findings showed that using geotextiles increased both peak strength and reinforced carbonate sand, which had a higher strain at failure and a higher overall strength improvement than a siliceous sample subjected to identical stresses in the axial direction. Reinforced materials have a maximum number of specimens, which become more numerous as the density of the samples grows and more sand particles and geotextile layers interact with one another. Fault propagation in unreinforced specimens bulging in a shear plane was seen, although lateral expansion was inhibited by the geotextile. in the spaces between layers.

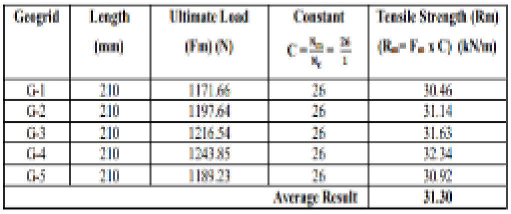
There was a similar ratio of strength between carbonate and siliceous samples. been seen to decrease as squeezing pressure rose. 2.4 Research on Soil Reinforced with Geocells and Geogrids According to the research of Hegde and Sitharam (2015), a square footing supported by a geocell-reinforced soft clay bed was examined with a finite-difference approach (FLAC3D). Compared to this, it was found that when geocells are used in an unreinforced scenario, the weight is dispersed horizontally across a wider region below the footing. More than half of the stressors were eliminated once geocells were included. One More In addition, two simulated situations were run: one with simply geogrid and another with geocell plus supplementary sub-basin geogrid.

The maximum load that unreinforced soft clay could take was gauged at 30 kPa when tested. Foundation beds made of geocells and geogrids are tested for their load-bearing capabilities. was calculated to be 150 kPa, and the separate influences of the geocell and geogrid base met the 110 and 70 kPa bed bearing capacities. The influence of geogrid and three- dimensional geocell structures (Biswas, Krishna, and Dash, 2016) The bearing capability of a layered clay and sand foundation structure, with and without reinforcements, was investigated. with credit to the writers. There are five distinct configurations that occur in homogeneous (clay or sand) and layered environments. The hypothesis was tested. The trials showed that both types of performance of the rigid clay foundation bed were substantially enhanced by the addition of reinforcements. This new development increased bearing pressure by as much as 50% by adding a layer of planar geogrid behind the geocell reinforcement. A total of three. The ideal thickness of a geocell mattress in a system with a firm clay base was 1.05 D for maximum efficiency gains. Method employing a flat geogrid: There was a 30% increase in bearing pressure when reinforcement was added to the sand-clay contact. 24.

The effect of geocell reinforcement on shell foundation behavior is discussed (Ari and Misir 2021). is what PLAXIS 3D finite element software was used to look at. The geometry of a cone and a pyramid is utilized as the basis for a shell structure. Settlement was lessened thanks to geocell reinforcement. shells in the shape of a pyramid or cone by more than 70%. Researchers found that by spreading stress out across a broader region, the energy that is delivered to the sand substrate is reduced. empty containers. The greatest bearing capacity improvement for a conical shell foundation is a shrinking of the settlement. The results showed that as footing settling progressed, the improvement factor (If) rose. The upper bound: The conical base was determined to have an improvement factor of 3.5, whereas the octagonal base only had a value of 3. the base of a pyramid. It's possible that a conical rather than a pyramidal base might better contain dirt. Foundation with geocells included. 2.5 Research on Alternative Reinforcing Materials (Patel & Singh, 2017): Glass was subjected to California Bearing Ratio (CBR) tests. test the subgrade acceptability of the fiber-reinforced cohesive soil. The implications of CBR and secant modulus were measured, and their effects on fiber content and fiber length were investigated. They uncovered fiber content up to 0.75 percent that boosts the reinforcing effect for any given condition tested and fiber length measured. The compressive strength (CBR) of the native soil was measured to be 2.89 for 4 soaking days, 2.54 for 20 soaking days, and 2.33 for 40 soaking days. The glass fiber- reinforced soil had CBR values of 8.23, 6.24, and 5.03. When compressed at OMC, the secant modulus of the reinforced specimen is at its maximum, and it decreases with further compression. both on and off the OMC. To improve its quality, 0.75 percent 20-mm fiber was added. Soil's quality as a base material varies from disastrous to favorable. The outcomes of both experiments and computer simulations were provided (Beju & Mandal, 2017). HDPE pipe tests were performed using flyash material buried eneath stone. dust sheets. Extensive use of single and double layers of EPS (Expanded Polystyrene) was made in the model investigations. Compressibl inclusions made from geofoam were employed. As a reinforcing material, jute geotextile was used. flyash and expanded polystyrene foam (EPS) geofoam for the fill.

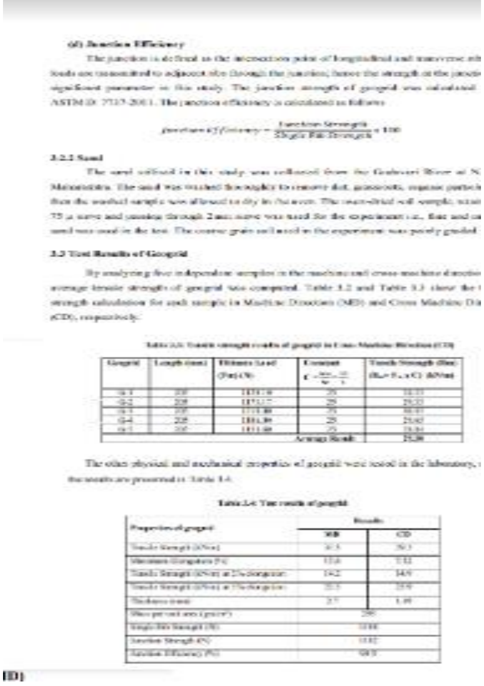
The study's findings showed that the breadth of the EPS affects the degree to which the pipe's vertical pressure is reduced. For the two-layer EPS geofoam scenario, its breadth is around 1.5D. The results of the tests demonstrated that a combination of jute geotextile and EPS geofoam significantly reduces fly ash surface settling and pipe stress. The optimal location for a single EPS block EPS geofoam layer was found to be 0 D, calculated from the viewpoint of vertical pressure. as well as pipe stress relief. An experimental study of geonet-reinforced concrete was conducted (Dastpak et al., 2020). sand on which an eccentric load was placed on a model of a circular foundation. The experiments were studied to ascertain how footing tilt, reinforcement size, and eccentricity interact depending on the strength of the foundation.

Table 3.2: Tensile strength results of geogrid in Machine Direction (MD)



Geogrid	Length (mm)	Ultimate Load (Fm) (N)	Constant $C = \frac{N_m}{N_t} = \frac{26}{1}$	Tensile Strength (Rm) ($R_m = F_m \times C$) (kN/m)
G-1	210	1171.66	26	30.46
G-2	210	1197.64	26	31.14
G-3	210	1216.54	26	31.63
G-4	210	1243.85	26	32.34
G-5	210	1189.23	26	30.92
			Average Result	31.30

The Bearing Capacity Ratio at Ultimate Load: As Dg, the diameter of the geonet, grows, so does the load (BCRu). Reinforcement of the soil's impact on an eccentrically loaded circular footing outweighed the benefits of soil reinforcement. on a circular base with axial stress. The shift in inclination that occurs during collapse showed almost nonlinear behavior. The decrease was shown to be true in all cases of reinforced soil in this investigation. factor (RF) dropped practically straight down. Inference 2.6: This chapter concludes from a comprehensive review of the literature that geosynthetics are a group of materials that include geotextiles, geogrids, geocells, and geocomposites, among others. being used for many purposes in civil engineering projects. Analytical techniques, including numerical analysis, experimental methods, and more, have all been applied in studies of geosynthetically enhanced soil. Characteristics of the soil-reinforcement interface, failure criteria in reinforced soil, geometry enhancement, and other related topics have been the focus of several studies. geosynthetic large-scale direct shear testing of foundations, CBR testing, etc. Evaluation of The motivation to study geosynthetically reinforced soil systems is provided by the existing literature. Optimize performance by thinking about geogrid layout and loading circumstances in terms of durability, steadiness, efficiency. Therefore, the emphasis of the present study is on strengthening the bearing ability. by burying a geogrid beneath the surface. The best possible setup is determined in this study. The optimal geogrid configuration for maximizing strength gains was explored via research based on parameters. Geogrid parameters such as top layer thickness, layer interval, and layer count are taken into account while determining geogrid's best application to the ground. Geogrid dimensions include the number of layers, geogrid width, and loading position (axial vs. eccentric). Implications for these factors in geogrid configurations were studied, and recommendations were made. Useful for the superficial 26 weak soil carrying capability foundations. Hence, the challenge facing researchers today discusses geogrid's potential for helping fix the issue of weak support structures.



IV. EXPERIMENTAL PROGRAMME

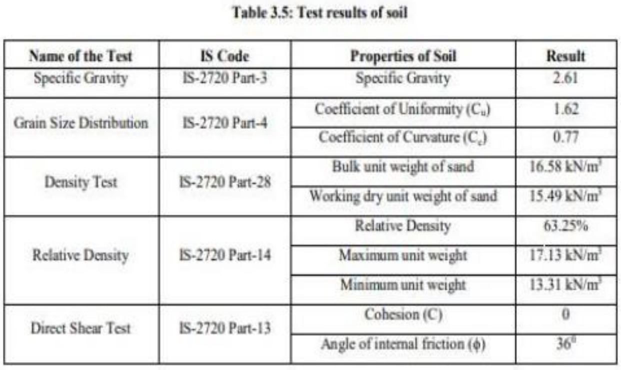
I.1 General

II. In this study, an experimental setup was built to test the effects of geosynthetic reinforcement on the ultimate bearing capacity of soil. Using a static load frame, we placed a focused load on the square mild steelmodel's footing. This investigation's experimental effort includes (1) biaxial geogrid testing to evaluate physical and mechanical features. Soil index and engineering tests to learn about the soil's characteristics. Experiments were conducted on geogrid-reinforced soil to determine its bearing capacity by altering the distance between the geogrids in the top layer,

The total number of geogrid layers, the width of the geogrids, and the locations at which they were loaded. 3.2 Components utilized In the laboratory testing, the ultimate bearing capacity of reinforced soil was determined primarily by using geogrid and sand. III. 3.2.1.1 Geogrid In this study, we employed the biaxial extruded polypropylene geogrid depicted in fig 3.1. Apertures in extruded geogrids are formed by punching holes of the required size into a flat sheet during production. SB 30-30 indicates that the MD and CD ultimate tensile strengths of Strata Base geogrid are both 30 kN/m. Table 3.1 details the various laboratory test techniques used to assess geogrid .

3.4 Test Results of soil

Table 3.5: Test results of soil



Name of the Test	IS Code	Properties of Soil	Result
Specific Gravity	IS-2720 Part-3	Specific Gravity	2.61
Grain Size Distribution	IS-2720 Part-4	Coefficient of Uniformity (C_u)	1.62
		Coefficient of Curvature (C_c)	0.77
Density Test	IS-2720 Part-28	Bulk unit weight of sand	16.58 kN/m^3
		Working dry unit weight of sand	15.49 kN/m^3
Relative Density	IS-2720 Part-14	Relative Density	63.25%
		Maximum unit weight	17.13 kN/m^3
		Minimum unit weight	13.31 kN/m^3
Direct Shear Test	IS-2720 Part-13	Cohesion (C)	0
		Angle of internal friction (ϕ)	36^0

Laboratory analysis of the soil sample utilized in this investigation followed the appropriate section of IS-2720. You may see the in table in table 3.1

V. CONCLUSION

Conclusions 6.2.1 in General

1. The lateral and vertical confinement of soil between two layers of geosynthetic and broader stress distribution below the footing enhance the soil's carrying capacity. The geosynthetic reinforcement's effect on the soil is very sensitive to where it is placed. For both concentric and eccentric loads on footing and geogrid widths 3b and 4b, an increase in the number of geosynthetic layers enhances the bearing capacity of the soil. For a limiting amount of eccentricity (e=20mm), the soil's ultimate load-carrying capability is less than it.

would be for a concentric load on a footing. A footing subjected to eccentric loading has a higher Bearing Capacity Factor than one subjected to axial loading 6.2.2 Distinct Inferences Specifically, we may draw the following inferences from our experimental research and numerical results on the intensity of the ultimate load.
General Shear failure is the sort of soil failure seen, and it can be located at a fixed location on all load settlement curves. At a 16 percent lower settlement, the ultimate load intensity for e=20mm occurs compared to e=0.

Third, in unreinforced soil, the ultimate bearing capacity of soil is 39% lower for a footing subjected to eccentric stress at 20mm from the center of the footing than it is for a footing with axial load. Compared to a footing subjected to axial stress, the ultimate bearing capacity of soil under eccentric loading is 22% lower in geogrid reinforced soil.
5. As the top layer geogrid depth ratio (x/b) grows from 0.25 to 1.00, regardless of geogrid width or loading circumstances, the peak load intensity falls in all four cases (N=1 to N=4). the geogrid's width is four times the footing's breadth, the first layer of geogrid is 0.25b from the base of the footing, and the total number of layers is four with 0.25b spacing and zero eccentricity loading, the best configuration of geogrid characteristics is observed. Soil ultimate bearing capacity is seen to be 1981 kN/m2 at the optimal configuration of geogrid parameters, according to experimental studies, and 1910 kN/m2 according to numerical findings.
8. The experimental technique yields a Bearing Capacity Factor (BCF) of 5.69 for the geogrid's optimal layout.

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