SSRG International Journal of Civil Engineering
ISSN: 2348 – 8352 /doi:10.14445/23488352/IJCE-V6I12P102

Volume 6 Issue 12, 12-18, December 2019


# Design and Analysis of Foundation over Weak Sub grade Layer with Geo Synthetics

Amit Kumar Singh

*Assistant professor, Civil Engineering Department, Laxmi Devi Institute of Engineering and Technology college Chikani, Alwar, Rajasthan, India*

***Abstract***

*The pull-out resistance of reinforcing parts is one among the most vital factors in increasing bearing capability. During this analysis a new reinforcing element that features attaching components to normal soil for increasing the resistance strength of reinforcements is introduced. The objective of the present work is to analyze performance of geogrid reinforcement placed below the footing on non-homogeneous soil and to investigate the behavior of geogrid- reinforced beds by analytical study. The work presented in the thesis will lead to a better understanding of the mechanism of foundation on geogrid reinforced soil beds. Based on results obtained from the current investigation it is said to be that the saving is created in subsoil depth for constant collapse settlement performance by victimization geogrid reinforced foundation system. A load settlement response was measured when geogrid reinforcement was provided. The stiffer response was determined at a comparatively a lot of reduction in settlement concerning 28.77% and 27% for foundation model to u equals to 0 and 150mm respectively. A load and stress response was measured when a geogrid reinforcement was provided and a response was determined that, comparatively a lot of reduction in stresses concerning 50.24% and 49.15% for foundation model comparable to u equals to 0 and 150mm respectively. It is determined that comparatively a lot of reduction in total elastic strain concerning 47.71% and 19.37% comparable to u equals to 0 and 150mm respectively. The results were obtained from the analysis indicates that a depth of placement of geogrid reinforcing layer is below the footing that is u=0mm and u=150mm for layered foundation conditions.*

**Keywords** *Footing, Reinforcement, Geogrid Fiber, Loading Condition, Shallow Foundation, etc.*

## I. INTRODUCTION

### *A. General*

The increasing utilization of geotextile-reinforced soil structures for important earth structures needs legalise comprehension of their conduct and approval of the suppositions in their definition. Geotextile support materials are especially valuable in reinforced soil structures fabricated utilizing indigenous refill soils, which might be better grained, more plastic and less porous than balance materials generally indicated in soil reinforcement practice. Four parts of the execution of geotextile-reinforced soil structures were researched by performing: (I) An assessment investigation of the appropriateness of ineffectively depleting soils for reinforced soil structures; (2) a limited component study on the deformability and outline parts of geotextile-reinforced soil dividers; (3) an axis study on the disappointment systems and on the reasonableness of point of confinement harmony strategies to anticipate disappointment of geotextile-reinforced soil inclines; and (4) a field instrumentation study to assess the execution of a lasting geotextile-reinforced slant assembled utilizing deteriorated stone as refill material. Every investigation gives particular lessons valuable to comprehension the execution of the designed composite material which is reinforced soil. All in all they outline that the conduct of reinforced soil structures (and most likely of earth structures as a rule) may challenge the portrayal by a solitary technique for investigation. Rather, by supplementing qualities and confinements of various methodologies, critical comprehension of numerous features in the execution of a geotechnical structure can be accomplished. The assessment of exploratory and scientific studies attempted to research the durable soil-reinforcement communication and the support waste qualities demonstrates that porous incorporations can successfully reinforce mud structures. This conclusion is reinforced by lessons gained from case histories of structures developed utilizing negligible soils. Advantages and uses of strengthening inadequately depleting refills are tended to, and explore needs went for planning a predictable configuration technique for these structures are displayed.

The utilization of Geosynthetic materials to enhance the bearing limit and settlement execution of shallow establishment has picked up consideration in the field of geotechnical building.

### *B. Modes of Foundation Failure*

An establishment is that part of the structure, which is in direct contact with, and transmitting burdens to the ground gives backing to the structure. Safe bearing limit is characterized as the most extreme weight, which the dirt can convey securely without the danger of shear disappointment. Shear disappointment may come about because of establishment disappointment and also from inordinate settlement. A definitive bearing limit is the base gross weight force at the base of the establishment at which the dirt fizzles in shear. Prior to the utilization of burden, the dirt underneath the base of the balance is in elastics balance, when burden is connected settlement happens and the dirt goes from flexible to plastic harmony with disappointment. The three rule methods of shear disappointment in soil are appeared in fig.1. (i) General shear Failure (ii) Local shear Failure (iii) Punching shear Failure.

By and large shear disappointment the dirt properties are thought to be such that a slight descending development of the balance grows completely plastic zones and the dirt lumps out. It happens in moderately incompressible soil.

### *C. Ground improvement*

The bearing limit of soil relies on the property and sort of soil. If there should arise an occurrence of overwhelming and vital structure it is crucial to build the bearing limit of soil by embracing reasonable systems for the upgrade of burden conveying limit of soil which is known as ground change. Contingent on the sort of soil, nature of change required accessibility of materials and economy different sorts of ground change have been created. Primary reasons for ground change are (i) To decrease the settlement. (ii) To build the bearing limit.

### *D. Ground improvement by providing reinforcement in soil*

The bearing limit of soil can be improved by giving diverse sorts of reinforcement s, for example, nets, engineered, geogrids, polymer crushes, metal strips and etc. The procurement of geo support imports anisotropic mechanical properties, expanded firmness, elastic qualities, expanded bearing limit. It likewise lessens the generous base thickness and enhances the execution of establishment.

## II. LITERATURE REVIEW

### *Work Done So Far Using Geogrid Reinforcement*

This segment examines about the trial work completed by the few analysts in the field of geotechnical building to expand solidness and bearing limit of the establishment of adaptable asphalt. It incorporates an outline of literary works containing the impact of geosynthetics support in a subgrade layer of adaptable asphalt and underneath the balance. The impact of geocell and in addition layers of geogrid in parkway configuration, dike and establishment is additionally examined.

Patra et al. (2005) [1] Laboratory model test results for a definitive bearing limit of a strip establishment upheld by multi-layered geogrid-reinforced sand are introduced. The profundity of installation of the model establishment, df, was changed from zero to B (width of establishment). One and only kind of geogrid and one assortment of sand at one relative thickness were utilized. A definitive bearing limit got from the model test program has been contrasted and the hypothesis proposed by Huang and Menq 1977. In light of the present tests, it creates the impression that the hypothesis gives a preservationist expectation of a definitive bearing limit.

Patra et al. 2006 [2] Results are displayed for research center model tests directed to decide a definitive bearing limit of a capriciously stacked strip establishment bolstered by geogrid- strengthened sand. One and only sort of sand at one relative thickness of compaction and one kind of geogrid were utilized for the tests. The profundity of the establishment was shifted from zero to B (width of establishment). Taking into account the research facility test comes about, an exact relationship called lessening variable has been recommended that corresponds the proportion of a definitive bearing limit of a capriciously stacked establishment with that for an establishment where the heap is connected halfway.

Cocoa et al. 2007 [3] A progression of examinations are portrayed including the full-scale recreation of geogrid fortification for railroad soil, which permitted the key parameters impacting the lessening in vertical settlement (perpetual disfigurement) under rehashed stacking to be contemplated. The outcomes exhibited that lattice geometry, firmness, rib cross-sectional shape and intersection quality are all persuasive. The examination information was connected as a feature of a far reaching study to enhance the viability of soil fortification and comprehension of the basics of lattice/total communication.

Kuo-Hsin Yang et al. (2014) [9] took a shot at the exploratory examinations of the conduct of geogrid strengthened sand including support with safe havens, reenacts the fortification associated with the divider facings in various in-situ circumstances. Exploratory results show that in respect to unreinforced examples, both moored and non-tied down geogrid fortifications can upgrade the top shear quality and smother the volumetric widening of strengthened soil. Geogrid dock added to an expansive rate of the aggregate shear-quality change, about 3-times more than the commitment of the dirt geogrid connection in non- secured examples.

Das et al. (2011) [14] directed huge scale research facility model tests to decide the perpetual settlement because of cyclic heap of the rail street bed for a proposed rapid train course reaching out from Seoul to Pusan in South Korea. They assessed that the perpetual settlement of the rail burden is consistent after the utilization of 105 quantities of cycles furthermore they presumed that the settlement diminishment is lessened more successful when the geogrid set in the middle of the interface of subgrade and sub base.

Rajagopal et al. (2012) [18] portrayed a two-dimensional limited component model for the reenactment of unpaved street test segments. Base total was displayed utilizing a nonlinear flexible model and the support was demonstrated as a basic two-hub straight versatile layer component. A contact shear cooperation model was utilized for the interface between the fortification and base total. They depicted a harm (rutting) model for the base total and subgrade layers. Results from research center model tests on unpaved street segments were utilized to adjust the model.

## III. FINITE ELEMENT METHOD AND METHODOLOGY

### *A. Finite Element Method*

The limited component technique is a numerical examination strategy utilized by specialists, researchers, and mathematicians to pick up answers for the differential conditions that portray, or about depict a wide type of physical (and non-physical) inconveniences. Real issues assortment in assortment from solid, liquid and soil mechanics, to electromagnetism or progression. The hidden reason of the system expresses that a confounded territory can be sub-isolated into a progression of littler areas wherein the differential conditions are around illuminated.

### *B. Discritization Using Finite Elements*

The utilization of the FEM, the answer region is discretized into littler regions known as components, and the answer is resolved in expressions of discrete estimations of some main order variables φ (e.G. Removals in x, y z bearings) at the hubs. The wide assortment of obscure essential order variables at a hub is the confirmation of flexibility at that hub. As a case, the discretized territory made out of triangular molded components is appeared underneath left: In this illustration each hub has one level of opportunity.

### *Advantages*

Any numerical re-enactment, together with the main by utilizing limited subtle element, is not an end in itself however on the other hand surrendering personality to plan and assembling. There are various reasons why a specialist or a researcher must investigate a numerical methodology, particularly the limited component approach;

1.Many inconveniences in building and actualized mechanical expertise are represented by method for differential or key conditions.

2.The answers for these conditions could give a bona fide, shut shape route to the extraordinary issue being contemplated. be that as it may, complexities inside the geometry, houses and in the limit conditions that are obvious in greatest genuine world issues usually implies that an exact arrangement can't be gotten or got in a sensible measure of time.

3.The fem is a numerical strategy for getting surmised answers for the different issues experienced in building assessment.

4.Within the fem, complex region characterizing a continuum is discredited into straightforward geometric shapes known as components.

5.The properties and the overseeing connections are expected over these variables and communicated scientifically as far as obscure qualities at exact components in the components known as hubs.

### *C. Disadvantages of the Finite Element Method*

A particular numerical result is gotten for a particular issue. A general shut structure arrangement, which would allow one to look at framework reaction to changes in different parameters, is not delivered.

1.The FEM is connected to a guess of the scientific model of a framework.

2.Experience and judgment are required with a specific end goal to build a decent limited component model.

3.An effective PC and solid FEM programming are key. Info and yield information might be expansive and dull to get ready and decipher.

4.Info and yield information might be expansive and dreary to get ready and decipher.

### *D. Ansys*

ANSYS is a far reaching universally useful limited component PC program that contains more than 100,000 lines of code. ANSYS is fit for performing static, dynamic, heat exchange, liquid stream and electromagnetism investigation. ANSYS has been a main FEA program for well more than 20 years. The present rendition of ANSYS has a totally new look, with numerous window consolidating Graphical User Interface (GUI). Pull down menus, exchange boxes and instrument bar. Today we might discover ANSYS being used in numerous designing fields, including aviation, car hardware and atomic. ANSYS is effective and great designing device that might be utilized to take care of an assortment of issues.
doesn't comprehend the inward working of a PC.

### *Basic analysis procedure in ansys*

The three basic procedures are involved in ANSYS software for solving any problem & these are following;

1.Preprocessing
2.Solution
3.Post processing

***Preprocessing***

It consists of following steps-

1.CAD modeling.
2.Meshing
3.Boundary condition
4.Loading condition

### *E. Different Test Series*

In this study test specimen a soil foundation system sized 1500mm x 1500mm x 900mm having concrete footing on it having size 300mm x 300 x 75mm of grade M-25 is analysed in both conditions such as unreinforced which is base model and reinforced with different geogrid material is taken for FEM analysis for the investigation of settlement, strain and stresses.

Following series have been taken for analysis i Primary objective of the analysis is to study the performance of geogrid reinforced foundation model with unreinforced model with respect to settlement, strain and stresses.

### *F. Material Used*

Materials used in the analysis are reinforced cement concrete footing, geogrid and soil. All materials used for the system are considered as linear, elastic, isotropic material. Table 5.2 provides the properties of the geogrid, soil and RCC used in this study.

### *G. Modulus of Elasticity & Poisson's Ratio*

The Young's modulus of elasticity is defined as within the linear elastic range, the ratio of axial stress to the axial strain under uniformly distributed loading. The code IS-456 gives the following empirical expression for the static modulus in terms of the characteristics cube strength fck (in N/mm$^2$).

$E_c = 5000$ □□□

The Poisson's ratio is defined as the ratio of the lateral strain to the longitudinal strain, under uniform axial stress. Generally the value of Poisson's ratio for concrete lies between 0.1 and 0.3.

***Boundary Conditions***

Various boundary conditions taken in the analysis are;

1.Static conditions with the loading.
2.Fix boundary conditions at the all degree of freedom of the foundation system.
3.Plain strain condition exists within the foundation system.

## IV. RESULTS and DISCUSSION

### *A. FEMResultsforFoundationSystem*

We had conducted analysis for different loadings of 40, 80 and 120 kg/mm2 and measured the values of settlement, total effective strain and stresses. These results are arranged in the form of tables and graphs as below. The footing at different stages of load increment for Table5.1 presents the typical settlement response of different depth of placement of geogrid. It is observed that, in the case of unreinforced foundation system, the settlement increases with load and is higher at the top layers. However, in the case of geogrid reinforcement, percentage settlement at center is found to be reducing by 26.92% and 25.05% at u equals to 150mm and 300mm respectively. Maximum reduction in settlement has been found out at u equals to 0, which is about 28.77%.

Table5.2 presents the total elastic strain response of the footing at different stages of load increment for different depth of placement of geogrid. It is observed that, in the case of unreinforced foundation system, the strain is increases with load and is higher at the top layers. However, in the case of geogrid reinforcement, percentage strain at center is found to be reducing by 19.37% and 14.37% at u equals to 150mm and 300mm respectively. Maximum reduction in settlement has been found out at u equals to 0, which is about 47.71%.

Table5.3 presents the typical stress response of the footing at different stages of load increment for different depth of placement of geogrid. It is observed that, in the case of unreinforced foundation system, the stress values increases with load and is higher at the top layers. However, in the case of geogrid reinforcement, percentage stress at center is found to be reducing by 49.15% and 45.64% at u equals to 150mm and 300mm respectively. Maximum reduction in settlement has been found out at u equals to 0, which is about 50.24%.

## V. FIGURES AND TABLES

***Figures:***

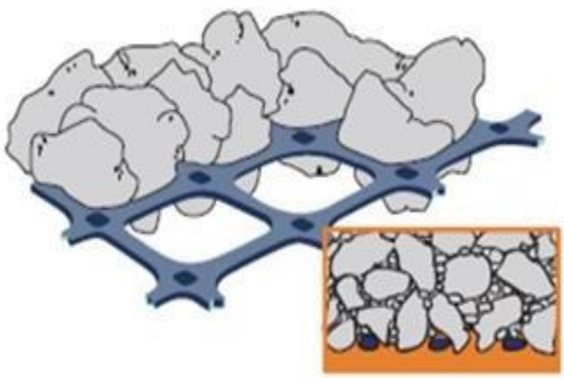

**Figure 5.1** Interlocking mechanism of Geogrid

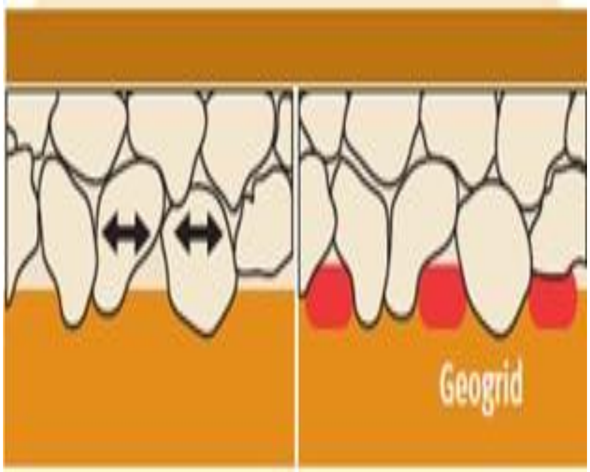


**Figure 5.2** Interlocking mechanism of geogrid with Soil

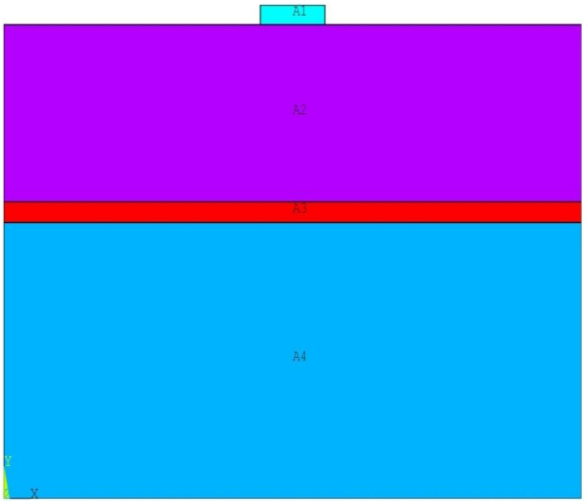


**Figure 5.3** foundation model

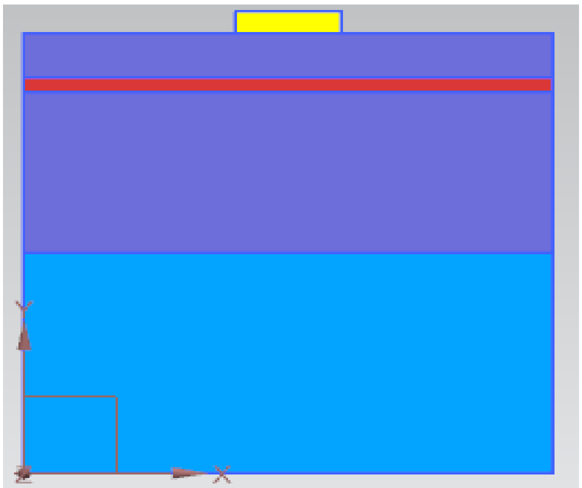

**Figure 5.4** FEM Model of foundation without geogrid

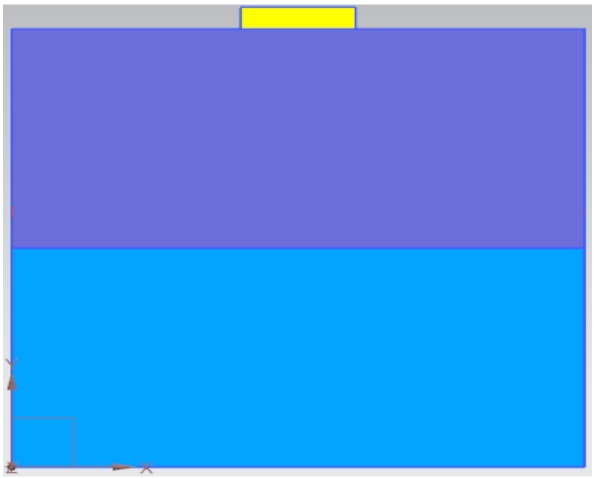

**Figure 5.5** FEMModel of foundation withgeogrid

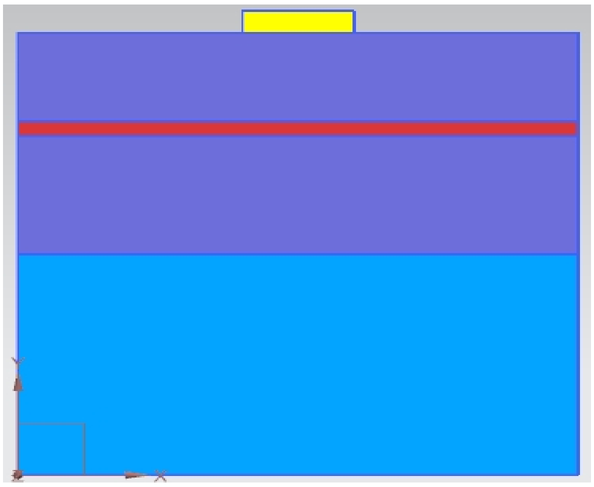

**Figure 5.6** FEMModel of foundation with geogrid at u=0mm (just below footing)

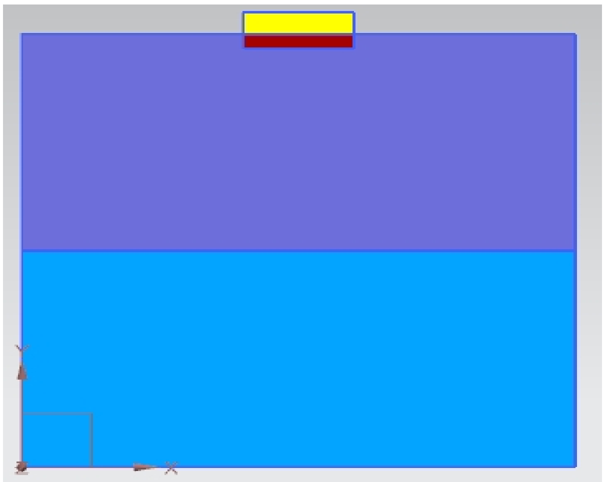

**Figure 5.7** FEMModel of foundation withgeogrid at u= 150mm

**Figure 5.8** FEMModel of foundation withgeogrid at u= 300mm

***Tables***

**Table 5.1** Settlement Values of Foundation System at different loading conditions

| Unreinforced Model Analysis | Reinforced Model Analysis With Different Geogrid Spacing |
|---|---|
| Loading conditions Kg/mm$^2$ | Geogrid placing from top of the surface (u) mm |
| **40** | **u= 0 just below the footing** |
| **80** | **u= 150** |
| **120** | **u= 300** |
| | |

**Table 5.2** Total Strain Values of Foundation System at different loading conditions

| **Load (Kg)** | **Settlement(mm)** | | | |
|---|---|---|---|---|
| | **Unreinforced** | **Reinforced** | | |
| 40 | | u= 0mm | u=150mm | u=300mm |
| | 5.824 | 3.214 | 4.256 | 4.365 |
| 80 | 6.254 | 4.025 | 4.109 | 4.210 |
| 120 | 7.326 | 5.218 | 5.287 | 5.424 |

**Table 5.3** Total Stress Values of Foundation System at different loading conditions

| **Load (Kg)** | **Stress (Pa)** | | | |
|---|---|---|---|---|
| | **Unreinforced** | **Reinforced** | | |
| 40 | | u= 0mm | u=150mm | u=300mm |
| | 2.254e9 | 1.125e9 | 1.254e9 | 1.365e9 |
| 80 | 4.509e9 | 2.213e9 | 2.332e9 | 2.421e9 |
| 120 | 6.321e9 | 3.145e9 | 3.214e9 | 3.436e9 |

**Table 5.4** Material used in subsoil and its properties

| **Material used** | **Modulus of Elasticity (E)Mpa** | **Poisson's Ratio (μ)** |
|---|---|---|
| RCC Footing | E= 21000 | μ=0.30 |
| Geogrid | E= 70000 | μ=0.30 |
| LooseSand | E= 35 | μ=0.21 |
| BlackCotton Soil | E= 10 | μ=0.25 |

## VI. CONCLUSION

In the present thesis an analytical work has been carried out to judge the performance of a soil foundation model on superimposed non-homogeneous soil strengthened with polypropene (PP) geogrid. The analytical foundation model was generated employing a finite-element software system program ANSYS. In ANSYS software system footing is assumed as an upper beam which is subjected to loading. Vertical loads were applied consecutive in ton 40, 80 and 120 Kg/mm2 for better computational accuracy. Analysis has been distributed to research the response of foundation system with relevancy settlements, stresses and total elastic strain.

Based on results obtained from the current investigation, the subsequent conclusions are created on the behaviour of soil foundation section resting on geogrid reinforced foundation:

1. Saving is created in subsoil depth for constant collapse settlement performance by victimisationgeogrid reinforced foundation system.
2. A load settlement response was measured when geogrid reinforcement was provided. The stiffer response was determined at a comparatively a lot of reduction in settlement concerning 28.77% and 27th for foundation model to u equals to 0 and 150mm respectively.
3. A load and stress response was measured when a geogrid reinforcement was provided and a response was determined that, comparatively a lot of reduction in stresses concerning 50.24% and 49.15% for foundation model comparable to u equals to 0 and 150mm respectively.
4. It is determined that comparatively a lot of reduction in total elastic strain concerning 47.71% and 19.37% comparable to u equals to 0 and 150mm respectively.

## REFERENCE


[1] Raymond, G.P., and Komos F.E., Repeated load testing on a model plane strain footing, Canadian Geotechnical Journal., 15(2), (1978), 190-201.

[2] Shin EC., Das BM., Puri VK., Yen SC., Cook EE., "Bearing capacity of strip foundation on geogrid reinforced clay,Geotech Test J 16(4), (1993),534–541.

[3] Omar et al.,Ultimate bearing capacity of rectangular foundations on geogrid reinforced sand,Geotech (1993).

[4] Yetimoglu et al,The bearing capacity of rectangular footings on reinforced sand,PhD, Thesis (1994).

[5] B.M Das and Shin E (1994),Strip foundation on geogrid-reinforced clay behaviour under cyclic loading, Geotextiles and Geomembranes., 13(10), (1994), 657–667.

[6] M.R. DeMerchant, A.J. Valsangkar, A.B. Schriver,Plate load tests on geogrid- reinforced expanded shale lightweight aggregate, Geotextiles and Geomembranes 20,(2002),173–190www.elsevier.com/locate/geotexmem.

[7] DeMerchant, M.R., Valsangkar, A.J., and Schriver, A.B., (2002). ,Plate load tests on geogrid-reinforced expanded shale lightweight aggregate,.Geotextiles and Geomembranes, 20,(2002), 173 -190.

[8] Gerald Raymond,Issa Ismail,The effect of geogrid reinforcement on unbound Aggregates, Geotextiles and Geomembranes21,(2003),355–380www.elsevier.com/ locate/geotexmem.

[9] B.B. Budkowsk*, J. Yu ,Mitigation of short term rutting by interlocking layer developed around a geogrid-sensitivity analysis.,Computers and Geotechnics 30,(2003),61–79www.elsevier.com/locate/compgeo.

[10] JoanjunLeng., and Mohammed A Gabr., (2003),Numerical analysis of stress deformation response in reinforced unpaved road sections,. Transpiration Research Board, 1-26.

[11] B.V.S. Viswanadham, D. K.onig,Studies on scaling and instrumentation of a geogrid, Geotextiles and Geomembranes 22,(2004),307–328www.elsevier.com/ locate/geotexmem.

[12] C.R. Patra, B.M. Das, C. Atalar ,Bearing capacity of embedded strip foundation on geogrid-reinforced sand, Geotextiles and Geomembranes 23,(2005),454–462, www.elsevier.com/locate/geotexmem.

[13] C.R. Patra, B.M. Das,_, M. Bhoi, E.C. Shin,Eccentrically loaded strip foundation on geogrid-reinforced sand,Geotextiles and Geomembranes 24,(2006),254–259, www.elsevier.com/locate/geotexmem.

[14] S.F. Brown,_, J. Kwan, N.H. Thom,Identifying the key parameters that influence geogrid reinforcement of railway ballast" Geotextiles and Geomembranes 25,(2007),326–335www.elsevier.com/locate/geotexmem.

[15] Robert W. Sarsby"Use of „Limited Life Geotextiles" (LLGs) for basal reinforcement of embankments built on soft clay"Geotextiles and Geomembranes 25,(2007),302–310www.elsevier.com/locate/geotexmem

[16] Al-Qadi I., Dessouky S., Kwon J., and Tutumluer E., ,Geogrid in flexible pavements: Validated mechanism.,Transportation Research Record 2045, Transportation Research Board, Washington, DC., (2008), 102–109.

[17] MoghaddasTafreshi, S.N., and Khalaj, O.,Laboratory tests of small- diameter HDPE pipes buried in reinforced sand under repeated load.,Geotextiles and Geomembranes,26, (8), (2008),145-163.

[18] Palmeira Marques Ennio.,Soil–geosynthetic interaction: Modelling and analysis, Geotextiles and Geomembranes, 27,(2009), 68-390.

[19] NazzalMunir, D., Abu-FarsakhMurad, Y., and Mohammad Louay, N.,Implementation of a Critical State Two-Surface Model to evaluate the response of Geosynthetic reinforced pavement, International Journal of Geomechanics, 10,(2010),202-212.

[20] Das, S.K., Biswal, R.K., Sivakugan, N., and Das, B., Classification of slopes and prediction of factor of safety using differential evolution neural networks,.Environ Earth Science., 64, (2011),201–210.

[21] Rajagopal, K., Veeragavan A., and Chandramouli S.,.Studies on geocell reinforced road pavement structures.5th Asian Regional Conference on Geosynthetics, (2012), 497-502.

[22] Liu Chia-Nan., Yang Kuo-Hsin., and Nguyen Duc Minh., ,Behavior of geogrid reinforced sand and effect of reinforcement anchorage in large scale plane strain compression., Geotextiles and Geomembranes, 42,(2014), 479 - 493.

[23] Sumit Bhardwaj, Qazi Naveed Mehraj, A Review on Foundation of Buildings& Structures, SSRG International Journal of Civil Engineering 2(3) (2015) 1-6.