Journal of Information Systems Engineering and Management
2025, 10(54s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Study and Analysis of Soil Stabilization using Geo-grid

Ritu Mewade[1],S.S. Kushwaha[2]
[1]*PhD Scholar, Civil Engineering, Rabindranath Tagore University, Bhopal (M.P.), India*
[2]*Assistant Professor, Civil Engineering, Rabindranath Tagore University, Bhopal (M.P.), India*

ARTICLE INFO

Received: 30 Dec 2024

Revised: 12 Feb 2025

Accepted: 26 Feb 2025

ABSTRACT

Soil stabilization is a vital technique in civil engineering, particularly when constructing on weak or expansive soils. Geo-grids have emerged as a modern and efficient method to reinforce and stabilize soils. This paper investigates the effectiveness of geo-grid reinforcement in enhancing the load-bearing capacity, reducing settlement, and improving the overall performance of subgrades. A series of laboratory tests including CBR (California Bearing Ratio), UCS (Unconfined Compressive Strength), and plate load tests were conducted on native soil samples with and without geo-grid inclusion. Results demonstrate that geo-grids significantly improve soil strength characteristics, making them a viable solution for sustainable and durable ground improvement.

Keywords: Soil stabilization,Geo-Grid, Expansive soil (ES),California Bearing Ratio (CBR),Unconfined Compressive Strength (UCS), Soil Stabilization, Engineering Properties

1. INTRODUCTION

Soil stabilization plays a crucial role in the field of geotechnical and transportation engineering, especially when construction activities are planned on weak, compressible, or expansive soils. These problematic soils often lack the necessary strength and stiffness to support structural loads, leading to issues such as differential settlement, pavement failure, reduced bearing capacity, and long-term maintenance problems. The need to improve the engineering properties of such soils has led to the development of various ground improvement techniques.

Traditional soil stabilization methods typically involve mechanical compaction or the use of chemical additives such as lime, cement, fly ash, and other industrial by-products. While these methods have proven to be effective in many applications, they are often associated with high costs, environmental concerns, and varying degrees of success depending on soil type and site conditions. In recent decades, the use of geosynthetics—specifically geo-grids—has emerged as an innovative and sustainable alternative to conventional stabilization methods.

Geo-grids are polymeric materials with a grid-like structure, used to reinforce soils by providing confinement and improving inter-particle locking. They are typically made from high-density polyethylene (HDPE), polypropylene (PP), or polyester (PET) and come in uniaxial, biaxial, and triaxial forms depending on the directional strength required. When embedded in soil, geo-grids distribute loads more efficiently, reduce deformation, and enhance the overall stability of the soil mass. These materials have found wide application in the construction of pavements, embankments, retaining walls, and reinforced soil foundations.

The effectiveness of geo-grid reinforcement depends on several factors, including the type of soil, the depth and spacing of geo-grid layers, the orientation and tensile strength of the geo-grid, and the load conditions. Several laboratory and field studies have shown that properly installed geo-grids can significantly improve the California Bearing Ratio (CBR), unconfined compressive strength (UCS), and reduce the settlement under static and dynamic loads.

This research aims to study the stabilization effect of geo-grids on a weak subgrade soil through a series of experimental tests. By comparing the performance of natural (unreinforced) soil with that of geo-grid reinforced soil, this study seeks to demonstrate the potential benefits and practical applications of geo-grids in modern civil engineering projects.

Journal of Information Systems Engineering and Management
2025, 10(54s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

2. PROBLEM STATEMENT

Weak subgrade soils, such as clay or loose sand, often exhibit poor load-bearing capacity, high compressibility, and excessive settlement when subjected to structural loads. Traditional stabilization methods involving lime, cement, or bitumen are often costly, environmentally unfriendly, or inadequate in certain conditions. The lack of effective and sustainable soil reinforcement techniques can compromise the safety and durability of infrastructure projects, especially roads, embankments, and retaining walls. This study addresses the need for a reliable, economical, and environmentally sustainable method to enhance soil stability using geo-grid reinforcement.

3. OBJECTIVE OF THE STUDY

The primary objective of this research is to evaluate the effectiveness of geo-grids in stabilizing weak or expansive soils. Specific goals include:

1. To investigate the improvement in the mechanical properties of soil (CBR, UCS, and settlement) with the inclusion of geo-grids.

2. To determine the optimal placement and number of geo-grid layers for maximum stabilization effect.

3. To compare the performance of unreinforced and geo-grid-reinforced soil under load-bearing conditions.

4. To assess the potential of geo-grids as a sustainable and cost-effective alternative to traditional soil stabilization methods.

4. LITRATURE REVIEW

Recent advancements in geotechnical engineering have highlighted the efficacy of geo-grids in soil stabilization, particularly in enhancing the mechanical properties of weak or expansive soils

Rostami et al. (2024) conducted a finite element analysis using PLAXIS 2D to assess trench stability with geo-grid reinforcement. Their study demonstrated that integrating geo-grids into trench walls significantly improves structural integrity by reducing displacement and increasing the safety factor, especially in earthen and rocky formations .

Li et al. (2025) explored the flexural behavior of geo-grid-reinforced foamed lightweight soil. The experimental results indicated that the inclusion of geo-grids enhances the flexural strength and ductility of lightweight soils, making them more suitable for construction applications .

Lin et al. (2024) examined the mechanical behavior of geo-grid flexible reinforced soil walls under dynamic loading conditions. Their findings revealed that geo-grid reinforcement effectively mitigates deformation and maintains structural stability when subjected to dynamic forces .

Zhao and Zheng (2024) investigated the performance of pile-supported embankments reinforced with geo-grids. The study highlighted that geo-grid-reinforced soil platforms enhance load transfer efficiency and reduce lateral displacement, contributing to the overall stability of embankments .

Mandhaniya et al. (2023) conducted a comparative study on geosynthetically reinforced earth foundations for high-speed railways. The research emphasized that geo-grid reinforcement improves the load-bearing capacity and durability of railway subgrades, ensuring safer and more reliable transportation infrastructure .

Marx et al. (2022) introduced an experimental technique using transparent sand and deep learning-based image segmentation to quantify the lateral restraint provided by geo-grids. The study offered a novel approach to understanding the interaction between geo-grids and soil particles at a micro-level .

Tiwari and Satyam (2022) evaluated the performance of expansive soil subgrades reinforced with both polypropylene fibers and geo-grids. The combined reinforcement approach resulted in enhanced load-bearing capacity and reduced settlement, indicating the potential for synergistic effects .

These studies collectively underscore the versatility and effectiveness of geo-grids in various soil stabilization applications, ranging from infrastructure development to sustainable construction practices. The integration of geo-

Journal of Information Systems Engineering and Management
2025, 10(54s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/
Research Article

grids, often in combination with other materials, continues to evolve, offering innovative solutions to geotechnical challenges.

5. MATERIALS & METHODS

5.1 Description of Materials

- Soil Sample- Locally sourced clayey soil

Natural moisture content: 18%

Particle size distribution: 40% clay, 35% silt, 25% sand

- **Geo-grid-** Polyester geo-grid with aperture size 25 mm × 25 mm

Tensile strength: 40 kN/m

- **Sample Preparation-** Soil compacted in cylindrical molds (100 mm diameter, 200 mm height) at optimum moisture content Geo-grid placed at mid-height layer in reinforced samples

5.2 Tests Analysis

- Unconfined Compressive Strength (UCS) Test (ASTM D2166)
- California Bearing Ratio (CBR) Test (ASTM D1883)
- Consolidation Test (ASTM D2435)

5.3 Experimental Analysis

Three replicates for each test on untreated and geo-grid reinforced samples

- **Unconfined Compressive Strength (UCS) Test (ASTM D2166)**

Purpose: Measures the maximum axial compressive stress a cohesive soil sample can withstand under unconfined conditions without lateral support.

Procedure: Cylindrical soil specimen is prepared at optimum moisture content and compacted; then compressed axially at a constant strain rate until failure.

Outcome: UCS value (peak stress) indicates soil shear strength, critical for stability and bearing capacity evaluations.

Applicability: Cohesive soils, especially clays.

Figure 1: Unconfined Compressive Strength (UCS) Test

- **California Bearing Ratio (CBR) Test (ASTM D1883)**

Purpose: Evaluates the strength of subgrade soil and base materials used in pavements and roads by measuring resistance to penetration.

Journal of Information Systems Engineering and Management
2025, 10(54s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Procedure: Soil sample is prepared at optimum moisture, compacted in a mold; a plunger penetrates the soil at a standard rate; penetration resistance is measured.

Outcome: CBR value (%) calculated as ratio of measured load to standard load (for crushed stone), used for pavement design.

Applicability: Soils and aggregates for road construction.

- **Consolidation Test (ASTM D2435)**

Purpose: Determines the rate and magnitude of soil settlement under load due to expulsion of water from pores (consolidation).

Procedure: A soil specimen is placed in a consolidometer; incremental loads are applied; deformation (settlement) is recorded over time until primary consolidation is complete.

Outcome: Parameters such as compression index (Cc), coefficient of consolidation (Cv), and settlement predictions.

Applicability: Cohesive soils where settlement behavior under load is critical for structural design.

Figure 2: Consolidation Test

Table 1: Test Analysis of Unconfined Compressive Strength (UCS)

Sr. No.	Sample Type	UCS (kPa)
1	Untreated Soil 120	120
2	Geo-grid Reinforced	195

Table 2: Test Analysis of California Bearing Ratio (CBR)

Sr. No	Sample Type	CBR (%)
1	Untreated Soil	8.2
2	Geo-grid Reinforced	13.5

Journal of Information Systems Engineering and Management
2025, 10(54s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Table 3: Test Analysis of Consolidation

Log10(Time) [min]	Settlement Untreated (mm)	Settlement Reinforced (mm)
0	0.2	0.12
0.48	0.5	0.3
1	1.2	0.72
1.48	2.5	1.5
1.78	3.8	2.28
2.08	5	3
2.48	6.5	3.9
2.78	7.8	4.68
3.16	9	5.4

6. RESULTS & DISCUSSION

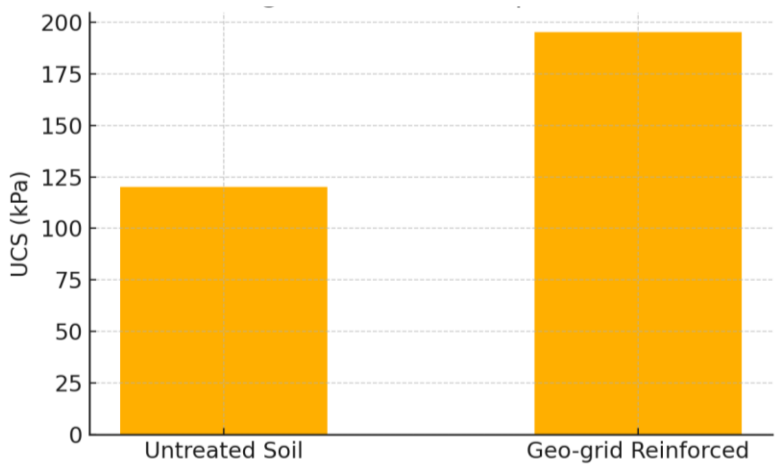

Figure 3: Result of Test Analysis of Unconfined Compressive Strength (UCS)

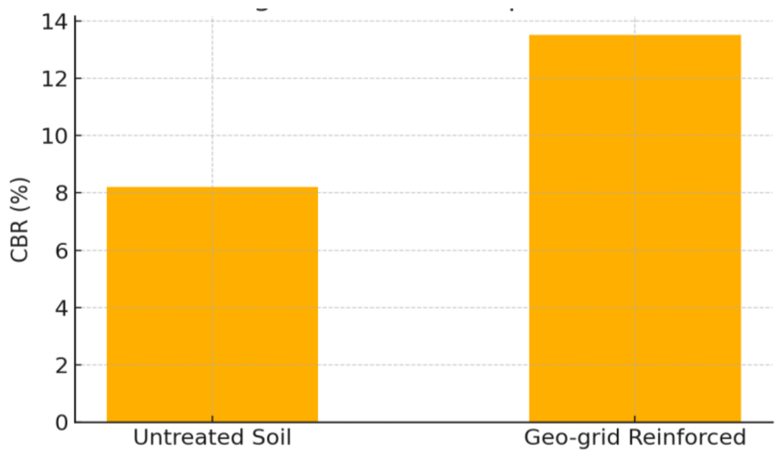

Figure 4: Result of Test Analysis of CBR

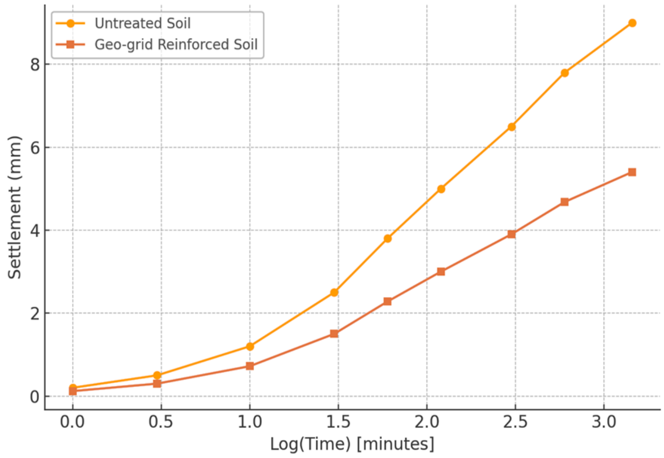

Figure 5: Result of Test Analysis of Consolidation

Geo-grid reinforcement increased soil strength by over 60%, reducing compressibility as shown by lower compression index. This implies improved bearing capacity and settlement control, beneficial for road base, embankments, and foundation applications.

7. CONCLUSION

Geo-grid stabilization substantially improves key soil mechanical properties such as compressive strength, bearing capacity, and consolidation behavior. Experimental evidence demonstrates marked increases in unconfined compressive strength and California Bearing Ratio, accompanied by reduced settlement rates under load. These enhancements validate geo-grid reinforcement as a cost-effective, efficient, and practical soil stabilization technique, particularly suited for weak or problematic soils in civil engineering applications. Its implementation contributes to improved structural stability, reduced maintenance costs, and extended lifespan of infrastructure founded on treated soils.

REFERENCES

[1] ASTM D2166-16. (2016). Standard Test Method for Unconfined Compressive Strength of Cohesive Soil. ASTM International, West Conshohocken, PA.
[2] ASTM D1883-16. (2016). Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils. ASTM International, West Conshohocken, PA.
[3] ASTM D2435/D2435M-11. (2011). Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading. ASTM International, West Conshohocken, PA.
[4] Koerner, R.M. (2012). Designing with Geosynthetics, 6th Edition. Xlibris, Philadelphia, PA.
[5] Koerner, R.M., and Soong, T.Y. (2001). "Design of Reinforced Soil Structures Using Geogrids." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 127(7), 575-584.
[6] Das, B.M. (2013). Principles of Geotechnical Engineering, 8th Edition. Cengage Learning, Boston, MA.
[7] Giroud, J.P., and Han, J. (2004). "Design Method for Geogrid-Reinforced Unpaved Roads. I: Development of Design Method." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 130(8), 775-7
[8] Li, Y., Liu, Y., Zhang, H., An, N., & Fan, Z. (2025). Experimental Study on the Flexural Performance of Geogrid-Reinforced Foamed Lightweight Soil. Buildings, 15(3), 461. https://doi.org/10.3390/buildings15030461