Rammohan Sharma. 2026, 12:6
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology

An Open Access Journal

Review on Optimizing CBR of Expansive Soil Subgrades Using Woven Geotextiles for Road Construction

[1]Rammohan Sharma, [2]Hariram Sahu
M.Tech. Scholar, Department of Civil Engineering EU Damoh (M.P.)
Assistant Professor, Department of Civil Engineering EU Damoh (M.P.)

Abstract- The construction of flexible pavements on expansive soil subgrades presents challenges due to their poor strength, high moisture sensitivity, and volume instability. Expansive soils, such as silty clay, exhibit significant swelling and shrinkage behavior, often resulting in pavement failure. This review evaluates the effectiveness of woven geotextiles in improving the California Bearing Ratio (CBR) of expansive soils, focusing on their reinforcement capabilities, placement depth optimization, and comparative performance. The study discusses previous research findings, highlighting the advantages of geotextiles as cost-effective, durable, and sustainable solutions for subgrade stabilization. It concludes by emphasizing the potential of woven geotextiles in addressing the limitations of traditional stabilization methods and providing recommendations for future studies.

Keywords- California Bearing Ratio (CBR), Expansive Soil, Geotextiles, Soil Subgrade Stabilization, Woven Geotextiles, Soil Reinforcement, Pavement Performance.

I. INTRODUCTION

The stability and strength of soil subgrades are critical for the performance and durability of roadways. Expansive soils, known for their significant swelling and shrinkage due to moisture fluctuations, pose a substantial challenge in transportation engineering. Traditional methods for stabilizing such soils, including chemical treatments and soil replacement, often prove expensive and environmentally taxing. In recent years, geosynthetics, particularly woven geotextiles, have emerged as an innovative solution to enhance subgrade performance. This review explores the role of woven geotextiles in addressing the challenges of expansive soils, focusing on their ability to improve CBR values and overall pavement performance.

1. Characteristics of Expansive Soils

Expansive soils, predominantly composed of clay minerals such as smectite and montmorillonite, exhibit unique behavior due to their high-water absorption capacity. These soils undergo significant volume changes, causing pavement distress, including cracking, settlements, and surface unevenness. Critical parameters, such as the plasticity index (PI) and liquid limit (LL), are used to evaluate the swelling potential of these soils. High PI values indicate greater swelling behavior, necessitating stabilization methods to ensure subgrade stability.

2. Traditional Stabilization Methods

Traditional approaches for stabilizing expansive soils include chemical and mechanical methods:

- **Chemical Stabilization:** Lime and cement are commonly used to reduce soil plasticity and improve strength. While effective, these methods are costly and environmentally impactful.
- **Mechanical Stabilization:** Techniques such as compaction and soil mixing improve soil density and load-bearing capacity but often fall short in addressing moisture-induced volume changes.
- **Soil Replacement:** This involves replacing expansive soils with stable materials like sand or gravel, which is impractical for large-scale projects.

3. Role of Woven Geotextiles

Woven geotextiles are synthetic fabrics with high tensile strength and durability, designed to reinforce soil by distributing applied loads and preventing excessive deformation. Their primary functions include:

- Reinforcement: Providing tensile strength to the subgrade.
- Separation: Preventing mixing of subgrade soil with aggregate layers.
- Filtration and Drainage: Controlling moisture movement within the soil.

4. Previous Studies on Geotextile Reinforcement

Several studies highlight the effectiveness of woven geotextiles in enhancing the performance of expansive soil subgrades:

- CBR Improvement: Studies show a significant increase in CBR values with geotextile reinforcement. For instance, CBR values doubled when woven geotextiles were placed at optimal depths.
- Placement Depth: Optimal depth is critical for maximizing geotextile effectiveness. Research indicates that shallow placements, typically around 4 cm, yield the best results.
- Comparative Analysis: Woven geotextiles outperform non-woven types in terms of load-bearing capacity and tensile strength.

5. Advantages of Geotextiles Over Traditional Methods

Geotextiles offer several advantages compared to traditional stabilization techniques:

- Cost-Effectiveness: Reduced material and labor costs.
- Environmental Benefits: Minimized use of chemicals.
- Durability: High resistance to environmental factors, ensuring long-term performance.
- Flexibility: Suitable for various soil types and conditions.

6. Research Gaps and Future Directions

Despite promising results, gaps remain in understanding the long-term performance and cost-effectiveness of geotextile-reinforced subgrades under field conditions. Future research should focus on:

- Standardizing placement depth and material specifications.
- Evaluating the performance of geotextiles in multi-layer systems.
- Exploring sustainable and bio-based geotextiles as alternatives to synthetic materials.

Woven geotextiles provide a sustainable, cost-effective, and efficient solution for stabilizing expansive soil subgrades. By improving CBR values and mitigating moisture-induced volume changes, they enhance pavement performance and durability. Future research should address existing gaps to optimize their application in road construction projects, ensuring long-term benefits and sustainability.

II. LITERATURE REVIEW

- Babu et al. (2014): In this study, the researchers compared the performance of woven and non-woven geotextiles for reinforcing expansive soils. They found that woven geotextiles provided better tensile strength and more significant CBR improvements compared to non-woven geotextiles. The CBR value of soils reinforced with woven geotextiles showed an improvement of 55%, whereas non-woven geotextiles resulted in only a 30% improvement.
- Ravindra et al. (2017): This study focused on the use of geotextiles in moisture-sensitive soils and compared the performance of woven polyester and polypropylene non-woven geotextiles. The results showed that woven polyester geotextiles performed better in terms of load distribution and moisture control, leading to higher CBR values and better pavement performance under moisture fluctuations.
- Reddy and Sreedevi (2013) investigated the impact of woven polyester geotextiles on the moisture-induced swelling of expansive clayey soils. The results indicated that the geotextiles significantly reduced the swelling pressure exerted by the soil when exposed to moisture. The swelling potential of the soil was reduced by

up to 50% when the geotextile was placed at the optimal depth, demonstrating the geotextile's effectiveness in moisture control.

- Kumar and Sathya (2015) used non-woven geotextiles to control the moisture content and swelling behavior of expansive soils. The study found that the moisture infiltration was significantly reduced, and the swelling potential was minimized. The geotextile-reinforced soils exhibited more stable behavior under moisture fluctuations, with the CBR values showing up to a 60% increase in load-bearing capacity compared to untreated soils.
- Chowdary et al. (2011) evaluated the performance of woven jute geotextiles for reinforcing expansive soils. The researchers tested the CBR values of soil samples with geotextiles placed at depths of 4 cm, 7 cm, and 8 cm. The results showed that the optimal depth for the jute geotextile was 4 cm, which led to a 45% increase in the CBR value compared to the unreinforced soil. Placement at greater depths did not produce significant improvements, indicating that the placement depth plays a crucial role in maximizing the effectiveness of geotextile reinforcement.
- Woven polyester geotextiles were used by Srivastava et al. (2016) to reinforce expansive silty clay subgrades. The study found that the CBR values of the reinforced soil increased by up to 70% when the geotextile was placed at a depth of 0.4 times the total height (H) of the sample. For example, in a sample with a height of 10 cm, the geotextile placed at a depth of 4 cm resulted in the greatest improvement in the CBR value. This study reinforced the idea that shallow placement of geotextiles yields the most effective results in improving the strength of expansive soils.
- Naeini and Mirzakhanlari (2008) focused on the performance of non-woven geotextiles in expansive clay soils. The researchers placed the geotextiles at various depths within the soil samples and conducted CBR tests. They found that placing the geotextile in the middle of the sample yielded the highest CBR improvement compared to placing it at the top or bottom. The CBR value increased by up to 60% when the geotextile was placed at the optimal depth, indicating a significant improvement in the soil's load-bearing capacity. The study highlighted the importance of placement depth in maximizing the effectiveness of geotextiles for soil reinforcement.
- Sivapragasam and Vanitha (2010) examined the use of woven and non-woven geotextiles for reinforcing expansive soils. They conducted CBR tests on soil samples reinforced with both types of geotextiles placed at different depths. Their results indicated that woven geotextiles performed better than non-woven geotextiles in terms of CBR improvement. The best results were achieved when the geotextile was placed at the center of the soil sample. The CBR value of the soil with the woven geotextile at the optimal depth showed a 40% increase in strength, demonstrating that woven geotextiles are more effective in reinforcing expansive soils.
- Singh and Gill (2012) explored the impact of geogrid reinforcement on expansive soil subgrades. The researchers observed that using a single layer of geogrid increased the California Bearing Ratio (CBR) values by 50–100%, depending on the placement depth and soil type. The study highlighted that the optimal placement depth for the geogrid was typically at 0.3 to 0.4 times the height of the soil sample. Geogrids were found to significantly improve load-bearing capacity and reduce vertical deformation under loading. This result underscores the potential of geogrids as a cost-effective solution for enhancing subgrade performance in road construction.
- Pokharel et al. (2011) accelerated pavement testing was conducted on geocell-reinforced unpaved roads constructed over weak subgrades. The use of geocells, a three-dimensional honeycomb-like structure, resulted in substantial improvements in load distribution and reduction of rut depths. The study demonstrated that geocells could increase the service life of unpaved roads by distributing traffic loads more effectively. These findings are especially relevant for regions with weak subgrades, where geocells provide a durable solution for preventing pavement failure.
- Kumar et al. (2020) investigated the effectiveness of non-woven geotextiles in improving the strength and stability of expansive soils. When used as a reinforcing layer, non-woven geotextiles enhanced the soil's drainage properties, reduced water infiltration, and

minimized swelling behavior. The researchers found that CBR values increased by up to 65% when non-woven geotextiles were placed at an optimal depth. Additionally, the geotextiles improved the load-bearing capacity of the soil under cyclic loading conditions, making them suitable for use in both road construction and foundation improvement.

- Rao and Raju (2019) focused on the performance of woven geotextiles in reinforcing expansive soil subgrades. The researchers placed geotextiles at varying depths within the soil samples and measured CBR values under both dry and wet conditions. The results indicated that woven geotextiles provided excellent reinforcement, with CBR values showing an improvement of up to 70%. The woven geotextiles also reduced swelling pressure and moisture-induced deformation, making them particularly effective for use in areas with high seasonal moisture fluctuations.
- Kumar and Gupta (2012) examined the effect of single-layer geosynthetic reinforcement on the mechanical properties of expansive soils. The researchers found that placing a geosynthetic layer horizontally within the soil significantly enhanced its bearing capacity and reduced settlement under loading. The CBR value of the reinforced soil increased by approximately 80% compared to unreinforced soil. The study emphasized that the position of the geosynthetic layer within the soil matrix plays a crucial role in achieving optimal reinforcement performance.

III. MATERIALS USED IN THE STUDY

This study utilized expansive soil and geotextiles to investigate the effectiveness of geotextile reinforcement in stabilizing pavement subgrades. Expansive soils were chosen for their significant volume changes with moisture fluctuations, while geotextiles were selected for their ability to enhance soil strength and stability.

1. Expansive Soil

Expansive soils, also called shrink-swell soils, exhibit swelling when wet and shrinkage when dry, causing structural issues like cracking and deformation. For this study, locally sourced expansive silty clay with high plasticity and swelling potential was selected. Tests were conducted to determine its physical and mechanical properties, essential for understanding its behavior under geotextile reinforcement.

2. Geotextiles

Two woven geotextiles, HP-370 and PEC-50, were selected for their reinforcement potential. These geotextiles, made from durable synthetic materials, were chosen based on their tensile strength, elongation at break, and puncture resistance, ensuring compatibility with expansive soils and traffic stresses.

HP-370 provides flexibility, while PEC-50 offers higher strength and durability, making them ideal for pavement subgrade stabilization.

Geotextile	Tensile Strength	Elongation at Break	Puncture Resistance
HP-370	35 kN/m	15%	1.2 kN
PEC-50	50 kN/m	12%	1.5 kN

IV. METHODOLOGY

The methodology outlines the steps undertaken to investigate the impact of geotextile reinforcement on the stabilization of expansive soils. The study involves soil sample preparation, geotextile placement, CBR testing, and statistical analysis. Below is the detailed process:

1. Soil Sample Collection and Preparation

- Soil samples were excavated from a road construction site in Damoh.
- Samples were air-dried, pulverized, and sieved following IS 2720-Part 4 (1985).
- The physical and engineering properties, including specific gravity and Atterberg limits, were determined.
- Proctor compaction tests were conducted to identify the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD).

- Soil samples were prepared at the OMC for consistent testing.

2. Geotextile Selection and Placement

- Two woven geotextiles, HP-370 and PEC-50, were selected based on their tensile strength, elongation, and puncture resistance.
- Geotextiles were placed at varying depths (4 cm, 7 cm, and 8 cm) within compacted soil layers in CBR molds.
- Control samples were prepared without geotextile reinforcement for baseline comparison.

3. CBR Testing

- Soaked Test: Samples were submerged in water for 96 hours to simulate moisture conditions.
- Unsoaked Test: Samples were tested in their natural, dry state.
- CBR tests were conducted following ASTM D1883, recording the penetration resistance at depths of 2.5 mm and 5 mm.

Expected Outcomes

The study is expected to show significant improvement in the strength and stability of expansive soils reinforced with geotextiles, with higher CBR values compared to unreinforced control samples. Soaked conditions should demonstrate reduced moisture weakening, while unsoaked conditions will highlight improved load-bearing capacity due to geotextile reinforcement.

Optimal geotextile placement depth is anticipated to have a significant impact, with shallow placement (e.g., 4 cm) likely providing the best results by enhancing load distribution in the upper layers. Deeper placement (e.g., 8 cm) may show reduced effectiveness due to less interaction with load-bearing zones.

The type of geotextile is also expected to influence performance. HP-370 may excel in flexibility-dependent scenarios, while PEC-50 is likely to perform better under heavy loads due to its higher tensile strength.

Reinforced soils are anticipated to exhibit reduced moisture-induced swelling and shrinkage, enhancing stability and durability. Statistical analysis is expected to confirm that geotextile type and placement depth significantly affect soil stabilization.

Overall, the study will provide practical recommendations for selecting geotextile materials and placement depths to improve pavement subgrade stability in expansive soil regions.

V. CONCLUSION

This review emphasizes the effectiveness of woven geotextiles in stabilizing expansive soils for road construction. Expansive soils, prone to volume changes due to moisture fluctuations, challenge road infrastructure. Traditional stabilization methods are often costly and environmentally burdensome. Woven geotextiles, however, provide an efficient, cost-effective solution by enhancing the strength and stability of expansive soil subgrades.

Studies show that geotextiles significantly improve the California Bearing Ratio (CBR) and reduce moisture-induced deformations, with optimal placement around 4 cm providing the best results. Compared to non-woven geotextiles, woven geotextiles offer superior performance.

Geotextile reinforcement is advantageous due to lower costs, environmental benefits, and improved long-term durability. Despite promising outcomes, further research is needed to understand the long-term effects and field performance of geotextile-reinforced subgrades. In conclusion, woven geotextiles provide a sustainable solution for improving road construction in expansive soil regions.

REFERENCES

1. Kumar, P., & Singh, R. (2023). Behavior of Geosynthetics Reinforced Pavement Subgrades under Cyclic Loading: A Comparative Study. Geosynthetics International, 30(4), 252-265.

2. Patel, S., & Prakash, S. (2023). Effect of Geotextiles on the Shear Strength and CBR of Clayey Soils: Laboratory and Field Investigations. Geotechnical Testing Journal, 46(2), 385-394.
3. Reddy, G., & Narasimhan, S. (2022). Influence of Geotextiles on the Stabilization of Subgrade Soil: A Laboratory Study. Indian Geotechnical Journal, 52(1), 47-58.
4. Kaur, A., & Singh, A. (2022). Experimental Study on the Use of Geotextile for Soil Stabilization in Pavement Design. International Journal of Pavement Engineering, 23(5), 809-820.
5. Das, S., & Kumar, A. (2021). Optimization of CBR of Soils Reinforced with Geotextiles: A Comparative Study of Different Geosynthetics. Soil Dynamics and Earthquake Engineering, 149, 106022.
6. Rana, V., & Verma, S. (2021). Performance Evaluation of Geosynthetics Reinforced Subgrades under Different Moisture Conditions. International Journal of Geosynthetics and Ground Engineering, 7(2), 203-212.
7. Raj, M., & Sudhakar, P. (2021). Geotextile Reinforcement for Improving the CBR of Clayey Subgrade Soil: A Case Study from Southern India. Environmental Geotechnics, 8(4), 120-134.
8. Jha, P., & Raghunandan, S. (2020). Use of Geosynthetics for Improvement of Expansive Soil Subgrades for Pavement Applications. Geotechnical Testing Journal, 43(3), 519-529.
9. Vijayan, K., & Babu, P. (2020). Geotextile Reinforced Subgrade Soils: Performance Evaluation for Pavement Design. Journal of Geotechnical and Geoenvironmental Engineering, 146(12), 04020117.
10. Patel, R., & Banerjee, S. (2020). Geotextile Reinforced Pavement Subgrades for Improved CBR: A Study of Clayey and Silty Soils. Transportation Geotechnics, 22, 100259.
11. Khan, M., & Ahmed, I. (2019). Effect of Geotextile on CBR and Pavement Design for Expansive Soils. Geotechnical Research, 29(6), 421-432.