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Influence of Geocells in Road Pavement in Landslide-Prone Areas

Muzammil Shaikh[1], Nishant Katmore[1], Vedant Ingole[1], Prof. Y.Y. Shaikh[2], Prof. N.G. Deshingkar[3]

[1]Diploma Students, Department of Civil Engineering, (MIT) Marathwada Institute of Technology Polytechnic, Chhatrapati Sambhajinagar, Maharashtra, India

[2]Professer, Department of Civil Engineering, (MIT) Marathwada Institute of Technology Polytechnic, Chhatrapati Sambhajinagar, Maharashtra, India

[3]Head of department, Department of Civil Engineering, (MIT) Marathwada Institute of Technology Polytechnic, Chhatrapati Sambhajinagar, Maharashtra, India

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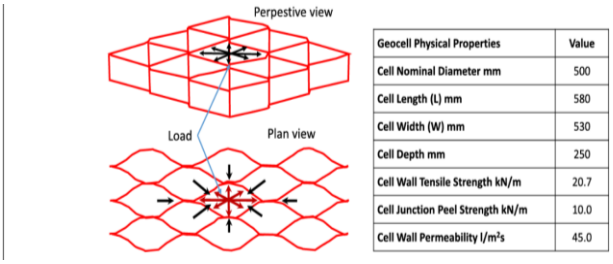
Abstract - *Due to weak subgrade soils, steep slopes, high rainfall intensity, and frequent slope failures road construction in landslide-prone hilly areas is a major engineering challenge. Conventional or traditional road pavement system are often expensive, time consuming and very difficult to maintain in such areas. This review paper examines the influence of Geocells High-Density Polyethylene (HDPE) material reinforced in road pavement construction for landslide-prone areas, emphasizing the use of ecofriendly and locally available material. Geocells road pavement system provides a three-dimensional confinement to fill with material such as local soil and aggregate, improves in load distribution, shear strength and erosion control while minimizing environmental impact and maintenance requirements. The methodology integrates geocell technology with eco-friendly materials to reduce construction costs by up to 10-80%, decrease construction time, and enable community-based maintenance. This study highlights construction methodology, advantages, cost effectiveness, ease of maintenance, and suitability for rural and remote areas. Geocells reinforced pavement system is a viable and low-cost solution for landslide regions.*

***Key Words*: Geocell, HDPE Geocells, Landslide-Prone Areas, Road Pavement, Soil Reinforcement, Geosynthetics, Slope Stabilization, Weak Subgrade Soil, Erosion Control.**

1. INTRODUCTION

Road infrastructure in mountainous and hilly regions is highly vulnerable to landslides due to steep terrain, weak subgrade soils, and heavy rainfall. These conditions often lead to pavement distress, slope failures, traffic disruption, and increased maintenance costs, severely affecting connectivity in rural and remote areas. Conventional road construction methods require heavy machinery, high-quality materials, and skilled labour, making them expensive, time-consuming, and unsuitable for landslide-prone locations.

In this context, geosynthetic-based solutions offer a sustainable alternative for road construction. Among them, geocell-reinforced systems made from High-Density Polyethylene (HDPE) provide an effectivee means of improving pavement performance over weak soils. Geocells form a three-dimensional honeycomb structure that confines infill material, enhances load distribution, reduces deformation, and improves slope stability. The us+e of locally available materials, reduced construction time, and ease of maintenance make geocell-reinforced roads a cost-effective and eco-friendly solution for landslide-prone regions.



Geocell Physical Properties	Value
Cell Nominal Diameter mm	500
Cell Length (L) mm	580
Cell Width (W) mm	530
Cell Depth mm	250
Cell Wall Tensile Strength kN/m	20.7
Cell Junction Peel Strength kN/m	10.0
Cell Wall Permeability l/m²s	45.0

Figure 1: Load Distribution of Geocells

Figure 2: Geocells

1.1 GEOCELLS

Geocells are three-dimensional honeycomb-like cellular confinement systems made from polymeric materials (mainly HDPE).

When expanded and filled with soil, sand, gravel, or concrete, they create a **strong composite structure** that improves load-bearing capacity and reduces soil movement.

They are widely used in:

- Road construction
- Slope protection

- Erosion control
- Railway foundations
- Retaining walls
- Embankments
- Landslide mitigation

1.2 Objectives

1. To review the properties and working mechanism of HDPE geocell reinforcement systems.
2. To promote the use of eco-friendly and sustainable road construction methods
3. To compare geocell-reinforced road systems with conventional road construction methods in terms of cost, construction time, and maintenance.
4. To examine the suitability of geocell systems for rural and remote areas using locally available materials.
5. To highlight the sustainability and environmental benefits of geocell-reinforced pavements.

2. Literatures Review

- K. Rajagopal (2012): Pavement failures occur due to weak materials and subgrade. Geocell confinement
- improves sub-base strength and stiffness, increasing pavement life.
- K. H. Mamatha (2017): Weak subgrades cause rutting. Geocells reduce rutting by 13–71% and increase pavement life by 1.6–3.5 times.
- Jain Sanjaya Kumar (2021): Combined use of geocells, geogrids, and micropiles improves slope stability and overall performance.
- Mainak Majumder (2022): Geocells enhance bearing capacity and stiffness of weak subgrades. Double-layer geocells perform better and resist monsoon damage.
- Sayanti Banerjee (2024): Geocells reduce rut depth (13–71%) and increase modulus (2.5–3.5 times), improving pavement durability.

Overall: Geocell reinforcement significantly improves strength, reduces deformation, and increases pavement life, especially on weak soils.

3. Methodology

The study was carried out to evaluate the effectiveness of geocell reinforcement for stabilizing roads and slopes in landslide-prone areas. Initially, a literature review was conducted to understand weak subgrade behaviour and geocell reinforcement mechanisms. Based on this, suitable materials such as HDPE geocells and locally available infill materials were selected. Laboratory tests were performed to determine the properties of the subgrade soil.

Model sections with and without geocell reinforcement were prepared for comparison. Geocells were placed over the prepared subgrade, filled with soil or aggregate, and properly compacted. Drainage and surface protection measures were provided to simulate field conditions. Repeated loading tests were then applied, and parameters such as settlement, rutting, and deformation were observed. The performance of reinforced sections was compared with unreinforced sections to assess improvements in strength, stability, and durability.

Two road models will be prepared: a conventional (unreinforced) road and a geocell-reinforced road. Both models will be constructed using the same subgrade soil and pavement layers for uniform comparison. In the reinforced model, geocells will be placed over the subgrade, filled with locally available soil or aggregate, and compacted. Non-Destructive Testing (NDT) will be conducted on both models to evaluate stiffness, deformation, and load response, and the results will be compared to assess the effectiveness of geocell reinforcement.

Figure 3: Construction process of geocell road

Figure 4: Model for comparing tradition and geocells road

3. CONCLUSIONS

- Geocell reinforcement significantly improves **load-bearing capacity** of weak subgrade soils.
- Three-dimensional confinement provided by geocells reduces **vertical settlement and rutting**.
- Slope stability is enhanced by limiting **lateral soil movement and deformation**.
- Proper drainage combined with geocells ensures **effective performance during heavy rainfall**.
- Geocell-stabilized sections show **uniform load distribution** and reduced stress concentration.
- The system improves **durability and service life** of pavements and slopes.
- Maintenance requirements are minimal compared to conventional construction methods.
- Geocell-based solutions are **economical, eco-friendly, and suitable for landslide-prone areas**.

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BIOGRAPHIES

Muzammil Shaikh, Diploma Students, Department of Civil Engineering, (MIT) Marathwada Institute of Technology Polytechnic, ChhatrapatiSambhajinagar, Maharashtra, India

Nishant Katmore, Diploma Students, Department of Civil Engineering, (MIT) Marathwada Institute of Technology Polytechnic, ChhatrapatiSambhajinagar, Maharashtra, India

Vedant Ingole, Diploma Students, Department of Civil Engineering, (MIT) Marathwada Institute of TechnologyPolytechnic, ChhatrapatiSambhajinagar, Maharashtra, India

Prof. Y.Y. Shaikh Lecturer, Department of Civil Engineering, (MIT) Marathwada Institute of TechnologyPolytechnic, ChhatrapatiSambhajinagar, Maharashtra, India

Prof. N. G. Deshingkar, Head of Department, Department of Civil Engineering, (MIT) Marathwada Instituteof Technology Polytechnic, ChhatrapatiSambhajinagar, Maharashtra, India