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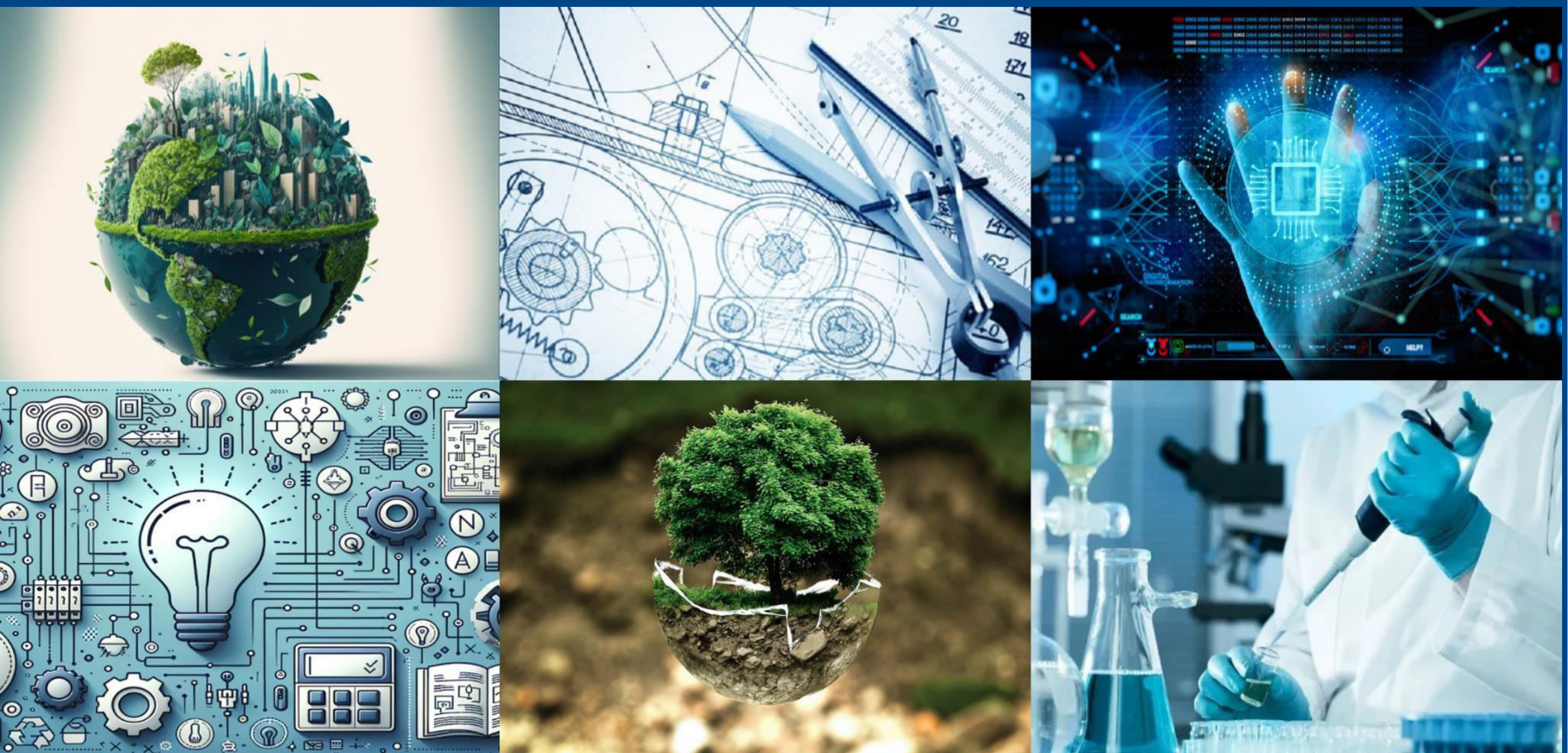

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Organized by

Mookambigai College of Engineering, Keeranur, Tamil Nadu, India

Hybrid System of Soil Nailing and Bio-Geotextile System for Unstable Slopes

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ABSTRACT: This project develops a hybrid slope stabilization system integrating steelsoil nails for structural support and bio-geotextiles for environmental sustainability. It aims to mitigate risks from unstable slopes and eroded embankments through site investigations, stability assessments, and eco-friendly design solutions. The system enhances mechanical stability and vegetation growth, reducing rain-induced failures. Project outcomes include engineering designs, environmental assessments, and cost-benefit analyses, promoting a sustainable and resilient approach to slope protection.

KEYWORDS: Unstable slope, Soil nailing, Bio – geotextile, Slope analysis with PLAXIS

I. INTRODUCTION

Unstable slopes and eroded road embankments pose major geotechnical risks to infrastructure and public safety. Traditional stabilization techniques, such as steel soil nails, provide effective mechanical support but often neglect ecological and sustainability aspects. The integration of bio-geotextiles—natural or biodegradable materials—offers an environmentally friendly alternative by enhancing erosion control, moisture retention, and vegetation growth. A hybrid slope stabilization system, combining soil nails with bio- geotextiles, provides both mechanical strength and ecological resilience. It reduces environmental impacts, lowers maintenance costs, and promotes long-term slope stability under conditions such as rainfall infiltration, which is a primary cause of slope failure due to increased pore water pressure.

II. OVERVIEW

Hybrid stabilization systems merge the mechanical support of soil nails with the ecological benefits of bio-geotextiles. These systems control erosion, retain soil moisture, and enable vegetation establishment, which collectively improve slope stability. Unlike conventional methods that rely heavily on steel or synthetic materials, hybrid systems minimize carbon footprint and enhance long-term sustainability. Vegetation roots and moisture retention further reinforce slopes by reducing stress and deformation, providing a balanced approach to both structural and ecological performance.

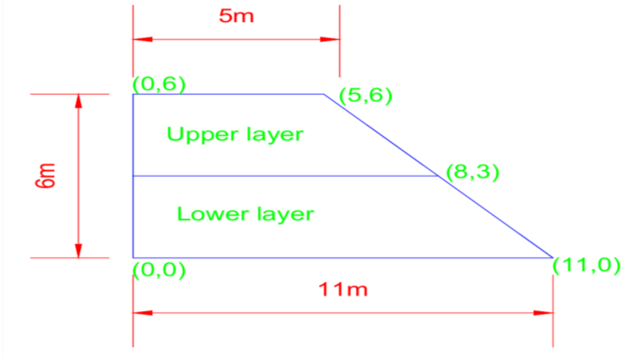

Fig.1. SLOPE GEOMETRY AND SOIL PROPERTIES

Vegetation is expected, and root networks may significantly trap both sediment and moisture and appropriately reduces the stress on the slope.Stabilizing the slope is optimized by minimizing strain to facilitate load transfer through the soils to the nails.Vegetation additions will produce moisture retention of the soil and establish roots that will serve as vegetation with lasting and effective stabilizing defense.

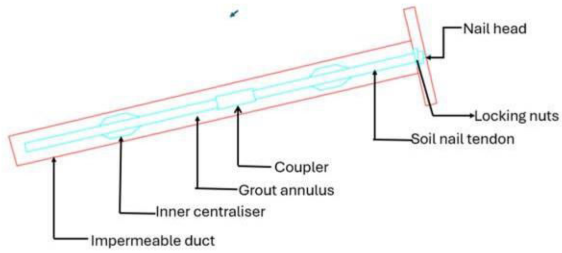

Fig.2. GEOMETRIC MODELLING NAIL

A hybrid stabilizing treatment would expect to reduce reliance upon steel or synthetic components while also having a lower carbon footprint and improved ecosystem sustainability. Vegetation can be expected, and root networks significantly trap sediment and moisture, and effectively reduce and appropriately apply stress off the slope.

Restoring slope stability is maximized by decreasing distortion, providing load transfer from soils to nails. The soil moisture retention and root establishment generated through vegetation additions provides vegetation that has a long-term stabilizing effectiveness.A hybrid stabilizing treatment will reduce any reliance on steel or synthetic materials, with both a lower carbon footprint and improved ecosystem sustainability.

1 Analysis data:

CASES (Load=20kPa)

1. Plain Slope (Without Nailing and Bio-Geotextile)
2. Slope with Soil Nailing only
3. Slope with Bio-Geotextile only
4. Hybrid System of Nailing and Bio-Geotextile (Tensile Strength=400kN/m)

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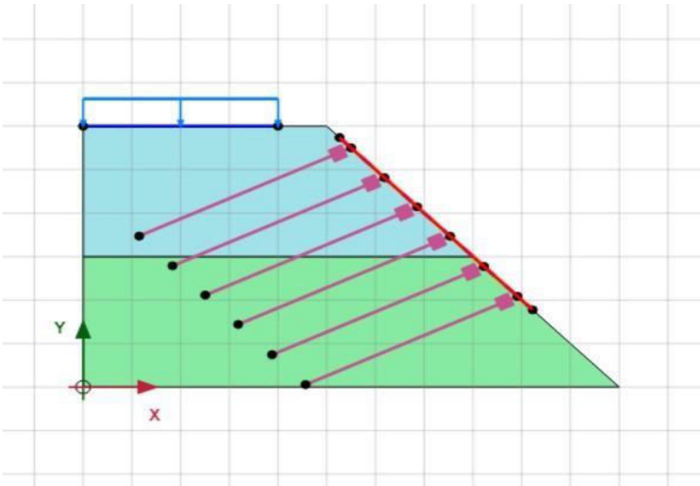
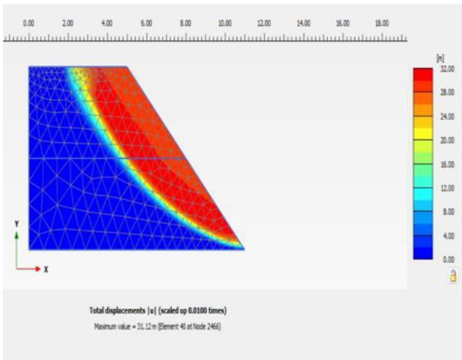


Fig.3. HYBRID SYSTEM OF NAILING AND BIO-GEOTEXTILE

2.1 CASE 1:
SLOPE WITHOUT REINFORCEMENT (FAILURE ZONE)



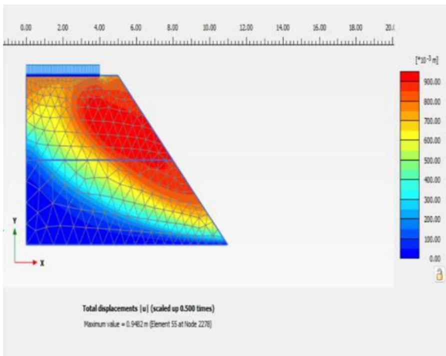


Fig.4. SLOPE WITHOUT LOAD

Fig.5. SLOPE WITH LOAD

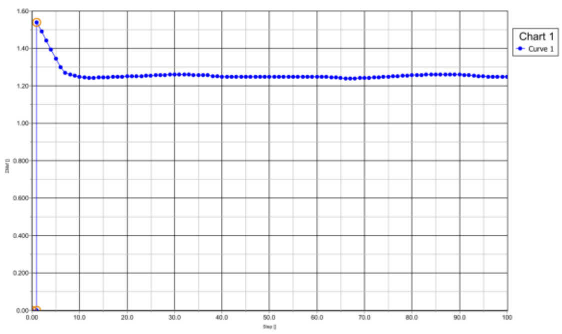


Fig.6. FOS FOR SLOPE WITH LOAD

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SOIL WITH NAILS AND GROUT
2.2 CASE 2:

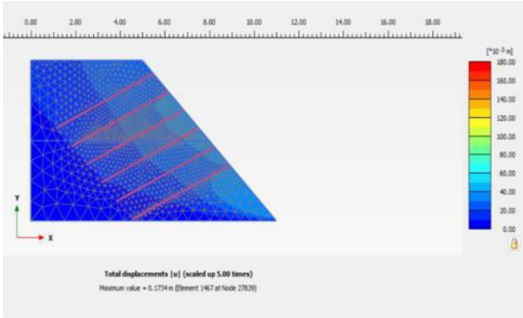


Fig.7. SLOPE WITHOUT LOAD

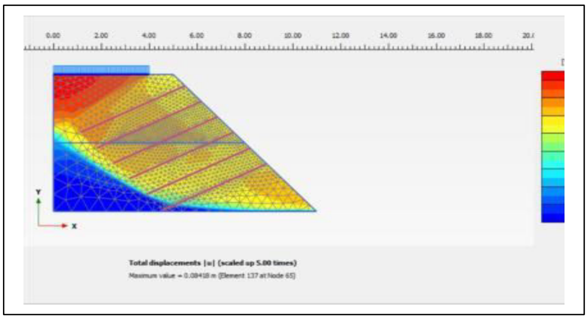


Fig.8. SLOPE WITH LOAD

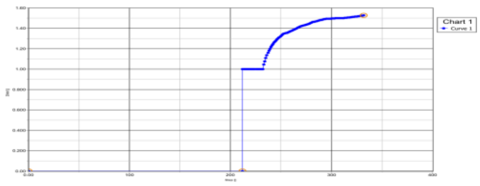


Fig.9. FOS FOR NAILS WITH LOAD

2.3 CASE 3:

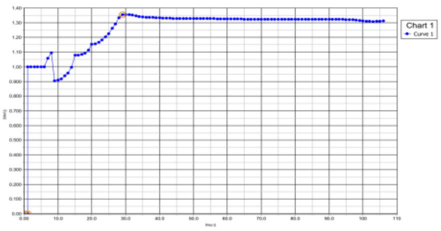


Fig.10. SLOPE WITH BIOGEOTEXTILE

2.4 CASE 4:

HYBRID SYSTEM

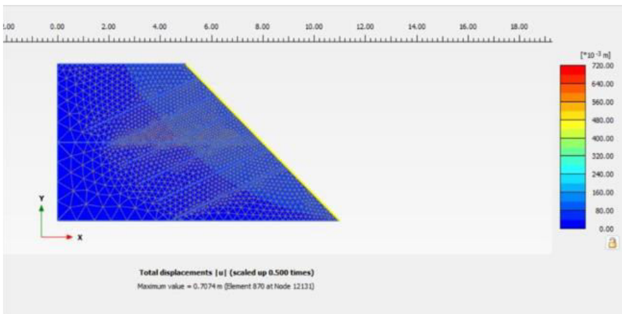


Fig.11. HYBRID SYSTEM

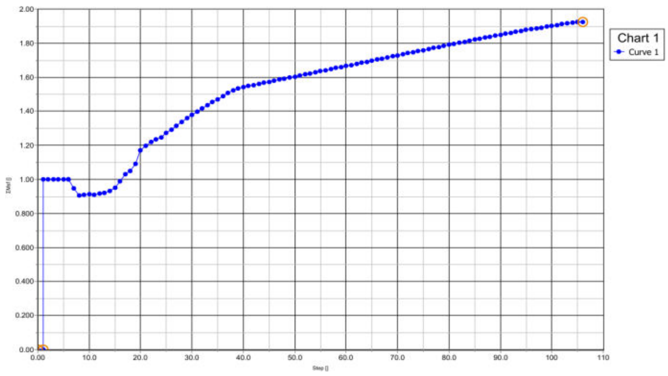
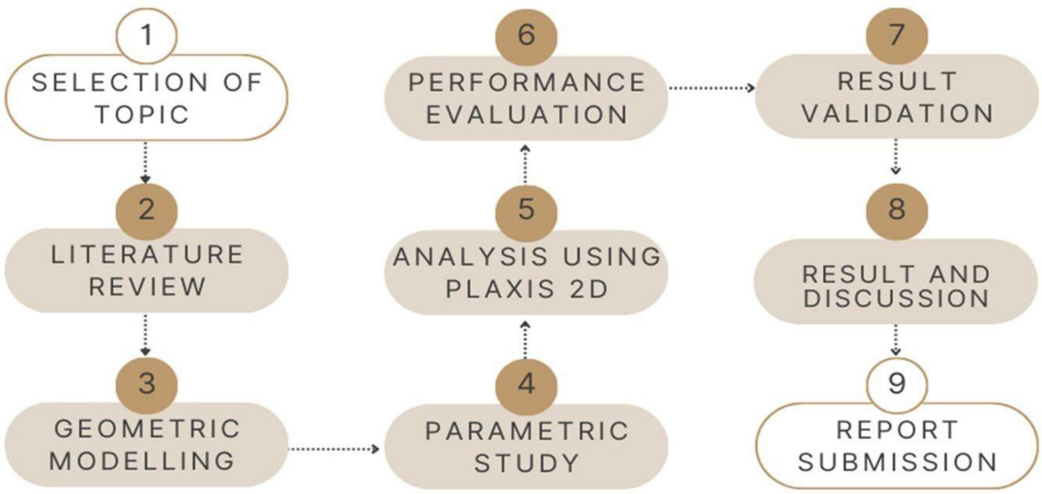


Fig.12. HYBRID SYSTEM

III. METHODOLOGY



IV. RESULT AND DISCUSSION

The hybrid slope stabilization system combines soil nails for deep stability and bio- geotextiles with plant roots for surface reinforcement. Using biodegradable materials like coconut fiber, the system promotes vegetation growth, reduces erosion, and cuts costs by 10– 33% compared to traditional methods. Performance depends on soil type, slope angle, and drainage. While suitable for stiff soils, it is less effective in soft or corrosive soils. Proper drainage and material selection are crucial for durability, ensuring long-term, low-cost, and eco-friendly slope stabilization.

V. CONCLUSION

The hybrid soil nailing and bio-geotextile system enhances slope stability by combining structural and ecological reinforcement. PLAXIS 2D analysis shows improved factor of safety, reduced pore water pressure, and sustained vegetation growth. It offers better control during rainfall, uses biodegradable materials, and reduces maintenance costs. Overall, this hybrid system is a sustainable, cost-effective, and reliable solution for stabilizing unstable slopes.

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