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Original Article

A Comprehensive Investigation of Coir Geotextiles in Sustainable Pavement Engineering

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Abstract **-** *The geotechnical characteristics of soil samples and the effectiveness of coir geotextile reinforcement in improving pavement performance are both thoroughly investigated in this work. According to the geotechnical investigation, the soil had a fine-grained composition dominated by silt and clay, and it showed the usual density. Tests using the California Bearing Ratio (CBR) showed that adding coir geotextile reinforcement greatly increased soil strength and load-bearing capacity, with potentially positive effects on pavement design and construction. The results highlight the potential of coir geotextiles to improve the resilience and lifespan of pavement structures by reducing pavement distresses, including rutting and cracking. Suggestions for future research encompass investigating the enduring efficacy of coir geotextiles in diverse scenarios and refining their positioning arrangements within pavement networks. This study contributes to advancing sustainable infrastructure solutions by harnessing the potential of natural materials for pavement reinforcement.*

Keywords **-** *Geotechnical properties, Soil analysis, California Bearing Ratio (CBR), Coir geotextile reinforcement, Pavement engineering, Sustainable infrastructure.*

1. Introduction

The purpose of the study is to investigate the possible benefits of using coir geotextile materials in pavement systems. Given the vital function that pavements play in infrastructure, pavement engineers have traditionally placed a high value on knowing how stable the pavement structure is. Soil subgrades vary in their ability to support traffic loads. Therefore, inadequate stability can occasionally cause subgrades to fail. The stability of the soil subgrade has been preserved or improved through the use of several geotextile kinds. However, coir geotextile has been taken into consideration in these specific circumstances due to the kind of soil in the state of Haryana near the NCR. Enhancing the strength and load-bearing capability of soil with Coir Geotextile is crucial.

In order to guide future pavement design and construction methods, the research aims to determine the effectiveness of Coir Geotextile reinforcement through laboratory tests and analysis, taking into account both the technical and practical elements.

2. Literature Review

2.1. Introduction to Geotextile Reinforcement

Because of its many uses and long history of development in the sector, geotextile reinforcement is now a fundamental component of contemporary pavement engineering techniques. Geotextiles, which were first created as a way to reduce soil erosion, are now essential for improving the durability and structural integrity of pavements [12]. They fulfill two functions in pavement systems: they give drainage, filtration, and separation solutions, as well as mechanical support to soil subgrades [6].

Because geotextiles can reduce problems like rutting, cracking, and moisture-induced deterioration, they have completely changed the way pavements are designed and built. Their importance stems from their capacity to disperse loads, lessen strains, and enhance pavement performance overall, rendering them essential elements in the creation of sustainable infrastructure. The importance of geotextile reinforcement in creating durable pavement systems that can resist a range of traffic and environmental conditions cannot be overstated as pavement engineering advances.

2.2. Effectiveness and Applications of Geotextiles in Civil Engineering

[12] investigated the efficiency of geosynthetic reinforcing in sand-mat layers over soft ground with the goal of improving bearing capacity and stability. The study's extensive laboratory testing and field assessments showed that geosynthetic reinforcements significantly increased load-bearing capacity and decreased settlement, demonstrating their effectiveness in reducing ground deformation.

[19] evaluated the effects of various geotextile kinds and placements on lead (Pb (II)) removal from runoff in porous asphalt pavement systems. The significance of strategically placing geotextiles to promote stormwater treatment was highlighted by controlled laboratory tests that examined the filtration effectiveness of different geotextile configurations and found that certain geotextile kinds and placements considerably improved Pb (II) removal.

[6] gave a historical synopsis of geotextiles, tracing their creation and advancement. The study demonstrated important advancements in material science and the use of geotextiles in a range of civil engineering projects through an examination of historical documents and technological turning points.

[1] provided a summary of the various applications and advantages of geotextiles in civil engineering. The study concluded that geotextiles are adaptable materials utilized in soil stabilization, erosion control, and drainage applications, proving their broad applicability and performance. A review of the literature and case studies achieved this.

The purpose of their research on biodegradable geotextiles, according to [14], was to discover promising and already available materials. A thorough analysis of existing biodegradable geotextiles and their characteristics revealed their advantages over synthetic materials, including their capacity to stabilize soil effectively and their environmental sustainability.

[9] looked into novel methods of building shallow tunnels in mixed boulder-cobble terrain with the goal of increasing both the productivity and security of the work. Innovative methods, such as the use of geotextiles, greatly improved tunnel stability and decreased construction hazards, according to field tests and simulations.

[11] sought to comprehend the impact of cyclic water flow and blockage on nonwoven geotextile permeability. The necessity for maintenance in geotextile applications is shown by the results of laboratory testing that mimic real-world settings, which show that blockage greatly affects permeability but that cyclic water flow can partially restore it.

[5] investigated how biological geotextiles affected the stabilization of gullies with the goal of assessing how well they controlled erosion. Biological geotextiles have been shown in field studies in São Luís, Brazil, to greatly minimize erosion and stabilize gullies, making them an efficient and sustainable option.

[3] summarized research on how well geotextiles work to cut down on runoff and soil loss. Geotextiles are useful in sustainable land management because they effectively reduce soil loss and decrease erosion, according to a meta-analysis of previous research.

In order to evaluate the long-term performance and durability of rural roads reinforced with coir geotextiles, [4] carried out a field investigation. Coir geotextiles considerably increased road stability and longevity, according to long-term field observations and performance evaluations, making them an affordable and environmentally friendly option for reinforcement.

2.3. Advancements in Geotextile Technologies and Applications

[7] created multipurpose geotextiles for distributed strain measuring that have embedded polymer optical fibers. The technique comprised measuring strain distribution in a lab setting and embedding optical fibers. The outcomes indicated possible uses in structural health monitoring by demonstrating efficient strain monitoring capabilities.

[2] created a fiber optics textile composite sensor to track geotechnical constructions in real-time. The sensor was designed and tested in various geotechnical conditions as part of their methodology. The results demonstrated its usefulness in long-term geotechnical monitoring by showing accurate monitoring of structural changes.

[10] utilized optical fiber sensor geotextiles to study the long-term deformation of reinforced retaining walls. By putting optical fiber sensors in geotextiles and carrying out prolonged monitoring, they were able to track and examine deformation. Deformation detection has been improved, which has improved our understanding of retaining wall behavior.

[8] used wicking fabrics to characterize the materials used in pavement structures. Their methodology included performance evaluations and in-depth laboratory testing on material qualities. Results indicated that by lowering moisture levels, wicking materials increased pavement durability, possibly improving pavement performance and lifetime.

[9] assessed the efficiency of wicking geotextiles in reducing soil moisture. Their research sought to comprehend the potential of these geotextiles to manage soil moisture-related problems. A controlled laboratory experiment involving the measurement of soil moisture levels with and without wicking geotextiles was part of the technique. The results demonstrated that wicking geotextiles significantly reduced soil moisture, providing a workable option for moisture control in a variety of applications.

[11] investigated how long-lasting high-strength spun bonded needle-punctured geotextiles made of polypropylene were. The study's objective was to evaluate their long-term effectiveness in several environmental settings. Evaluations of mechanical properties and accelerated aging tests were part of the methodology. The durability and effectiveness of these geotextiles were demonstrated by the results, indicating their appropriateness for long-term use.

[6] forecasted how nonwoven geotextile fabrics composed of polypropylene and polyester fibers would behave. To evaluate mechanical characteristics and behavior under stress, they used both theoretical modeling and experimental testing as part of their methodology. The results showed that both polyester and polypropylene geotextiles performed dependably and that their behavior under varied conditions could be accurately predicted.

[12] looked into how wear resistance in polyester geotextile fabrics was affected by bio destructors. The purpose of their investigation was to assess material durability while bio destructors are present. The methodology included biological degradation process simulations in the lab. The findings showed that although bio destructors, polyester geotextiles impacted wear resistance and generally maintained enough durability for practical application.

A thorough summary of geotextiles in civil engineering was given in [5]. The goal of their review was to summarize the creation, characteristics, and functionality of geotextiles. The methodology comprised a thorough examination of the literature and a synthesis of the research that has already been done. It highlighted the usefulness and adaptability of geotextiles in civil engineering applications and emphasized their crucial role in contemporary infrastructure projects.

2.4. Properties of Coir Geotextiles

Coir geotextiles possess distinct physical and chemical characteristics that make them suitable for a variety of engineering applications:

2.4.1. Physical and Chemical Characteristics

Coir geotextiles are derived from coconut husks and exhibit unique properties such as high tensile strength, flexibility, and resilience [1]. They have a fibrous structure that promotes soil stabilization, erosion control, and drainage. Coir geotextiles are biodegradable and resistant to degradation from UV radiation, moisture, and microbial activity, ensuring long-term performance in harsh outdoor conditions [2].

2.4.2. Environmental Sustainability

One of the key advantages of coir geotextiles is their environmental sustainability [3]. As a natural and renewable resource, coconut husks are readily available and do not require extensive processing or manufacturing, thereby reducing the environmental footprint associated with their production. Coir geotextiles are biodegradable, breaking down into natural components over time [4]. This eco-friendly characteristic makes coir geotextiles ideal for erosion control, slope stabilization, and other environmentally sensitive applications where minimizing environmental impact is crucial.

2.5. Applications of Coir Geotextiles

Coir geotextiles are used in a wide range of environmental and engineering applications [5]. They are frequently used to stabilize shorelines, embankments, and slopes in order to stop soil erosion and encourage the growth of vegetation. In drainage applications, coir geotextiles are also used to help with water filtering, retention, and flow control [6]. To improve groundwater recharge, lower runoff, and lessen the risk of floods, they can be included in stormwater management structures, French drains, and subsurface drainage systems. Furthermore, the use of coir geotextiles in pavement engineering is growing in order to increase soil stabilization, improve load-bearing capacity, and prolong pavement lifespan [7]. They act as layers of reinforcement in driveways, parking lots, and unpaved roads, lowering maintenance expenses and preventing rutting and cracking while encouraging environmentally friendly building techniques.

2.6. Challenges and Considerations

The usage of coir geotextiles in engineering applications might come with concerns and obstacles despite its many advantages. When exposed to extended periods of moisture, sunlight, and microbiological activity, coir geotextiles can break down more quickly than their synthetic counterparts [1]. For coir, geotextiles to be efficient and long-lasting in outdoor settings, proper care and protection are necessary. Furthermore, coir geotextiles may differ from synthetic geotextiles in their mechanical and physical characteristics; therefore, installation and design must be done with great care [2]. To guarantee optimum performance and lifetime, compatibility with current pavement materials, construction methods, and environmental factors should be assessed. Furthermore, even though coir geotextiles have advantages for environmental sustainability, in some applications, they might be more costly than synthetic substitutes [3]. Conducting cost-benefit analyses is crucial to assess the long-term economic viability of using coir geotextiles compared to traditional materials and methods.

Table 1 above provides a concise summary of geotextile reinforcement and its diverse applications in civil engineering, covering properties, challenges, and considerations.

2.7. Future Directions

The use of coir geotextiles in engineering applications appears to have a bright future as the need for ecologically acceptable and sustainable building materials grows. More investigation and advancement are needed in a few areas. The long-term durability, mechanical qualities, and environmental compatibility of coir geotextiles under various loading and environmental circumstances will be evaluated with the support of ongoing research into novel testing strategies and performance evaluation approaches. Furthermore, the creation of thorough design standards, requirements, and best practices for the implementation of coir geotextiles in a range of technical applications would promote their broad use and guarantee a uniform level of performance and quality throughout projects. For the purpose of assessing the efficacy, performance, and environmental impact of coir geotextiles in practical settings, field research and extended monitoring are necessary.

Table 1. Summary of geotextile reinforcement and applications in civil engineering

Aim	Methodology	Results	Applications	References
Enhance pavements	Historical overview	Improved performance	Reinforcement, drainage, filtration	[1, 2]
Stability, bearing capacity	Lab and field tests	Improved load-bearing, reduced settlement	Soil stabilization	[1]
Pb (II) removal	Lab experiments	Improved Pb (II) removal	Stormwater treatment	[3]
History, advancements	Literature review	Progress in material science	Various civil projects	[2]
Applications summary	Literature review	Versatile uses	Soil stabilization, erosion control	[4]
Biodegradable materials	Comprehensive review	Environmental benefits, soil stabilization	Synthetic alternatives	[5]
Shallow tunnels	Field experiments, simulations	Enhanced stability, reduced risks	Tunnel construction	[6]
Clogging, water flow	Lab tests	Reduced permeability, restored by water flow	Maintenance in geotextile applications	[7]
Gully stabilization	Field experiments	Reduced erosion, stabilized gullies	Erosion control	[8]
Runoff, soil loss	Meta-analysis	Effective erosion control	Sustainable land management	[9]
Coir geotextiles in roads	Field study	Improved stability, longevity	Rural roads	[10]
Strain measurement	Lab tests	Effective strain monitoring	Structural health monitoring	[11]
Composite sensor	Design, testing	Accurate monitoring	Geotechnical structures	[12]
Retaining walls	Long-term monitoring	Improved deformation analysis	Retaining wall behavior	[13]
Wicking fabrics	Lab tests	Improved durability	Pavement performance	[14]
Soil moisture	Lab experiments	Reduced soil moisture	Moisture control	[15]
Polypropylene geotextiles	Aging tests	Maintained strength	Long-term applications	[16]
Material behavior	Tests, modeling	Reliable performance	Various conditions	[17]
Wear resistance	Lab tests	Sufficient durability	Practical use	[18]
Overview	Literature review	Versatile, effective	Civil engineering	[19]
Physical-chemical traits	Review	High-strength, biodegradable	Erosion control, stabilization	[1, 3]
Environmental benefits	Review	Eco-friendly, renewable	Erosion control, slope stabilization	[2, 4]
Various projects	Review	Versatile, sustainable	Slopes, drainage, pavements	[6, 7, 8]
Rapid degradation	Review	Need protection, maintenance	Outdoor environments	[9]
Different from synthetics	Review	Careful consideration	Design, installation	[18, 20]
More expensive	Review	Cost-benefit analysis	Economic viability	[17, 14]

2.8. Research Gap

There are still a lot of unanswered questions about the characteristics and uses of coir geotextiles in pavement systems despite recent progress. The absence of long-term performance evaluations makes it difficult to have a thorough grasp of the robustness, efficiency, and environmental sustainability of coir geotextiles in actual pavement situations. There are few mechanistic studies explaining how coir geotextiles interact with pavement materials and affect pavement performance, which hinders the development of design and construction methods that are optimized for their application.

Furthermore, there has not been much study done on evaluating the environmental effects of coir geotextiles at every stage of their lifecycle, which makes it harder to make well-informed decisions on which ones to use and how to utilize them in pavement projects. Filling in these gaps will help us understand the functionality and applicability of coir geotextiles better, which will lead to the development of future pavement systems that are more resilient and sustainable.

3. Methodology

The research approach used to assess the advantages of Coir Geotextile materials in pavement systems is described in this section. A variety of laboratory tests were carried out, such as testing for the California Bearing Ratio (CBR), Grain Size Analysis, Specific Gravity of Soil, Moisture Content, Free Swell Index, Consistency Limits of Soils, and Compaction.

To examine the impact of geosynthetic materials, single- and multi-layer Coir Geotextile reinforcement was used for the CBR experiments on unpaved parts. The study further looked at the distribution of stress on the subgrade layer with and without reinforcement. It also carried out an analytical analysis of geosynthetic materials and the base course layers' equivalent thickness.

4. Results

The table below presents the geotechnical properties of the soil sample under investigation, including results from various tests such as Specific Gravity, Grain Size Analysis, Moisture Content Test, Free Swell Index, Atterberg Limits, and Modified Proctor's Density Test. Key parameters such as Specific Gravity, Gravel Content, Sand Content, Silt and clay Content, Average Moisture Content, Free Swell Index, Liquid Limit (LL), Plastic Limit (PL), Plasticity Index (PI), Maximum Dry Density (MDD), and Optimum Moisture Content (OMC) are provided, offering insights into the soil's characteristics essential for pavement engineering analysis.

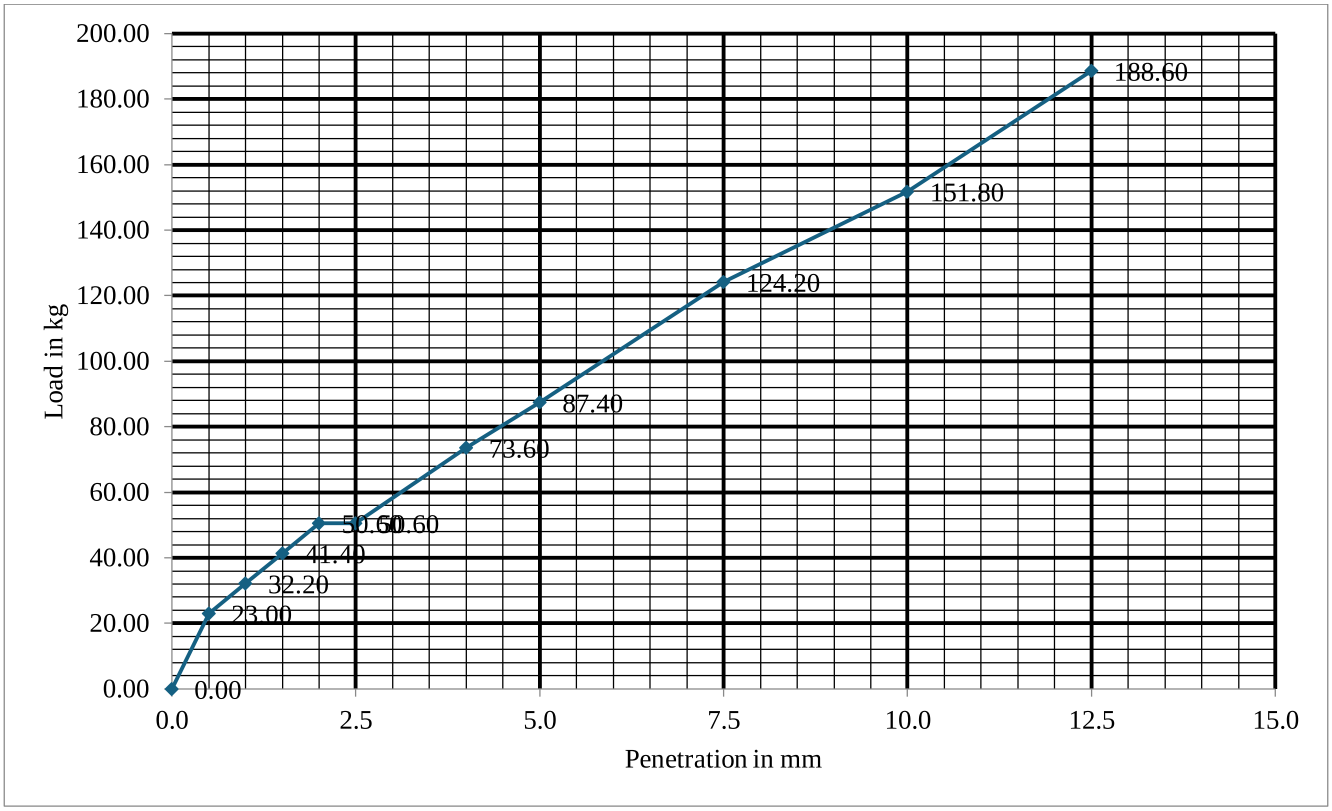
Table 2 above presents the geotechnical properties of a soil sample. The specific gravity is 2.4, indicating typical soil density. Grain size analysis shows no gravel, 13.35% sand, and a dominant 86.65% silt and clay, classifying the soil as fine-grained. The average moisture content is 21.82%, reflecting the water present in the soil.

The free swell index averages 57.50%, suggesting moderate to high swelling potential. Atterberg limits reveal a liquid limit of 35.58%, a plastic limit of 19.06%, and a plasticity index of 16.52%, indicating moderate plasticity. The Modified Proctor's Density Test results show a Maximum Dry Density (MDD) of 1.952 gm/cc and an Optimum Moisture Content (OMC) of 13.03%, indicating the compaction characteristics of the soil.

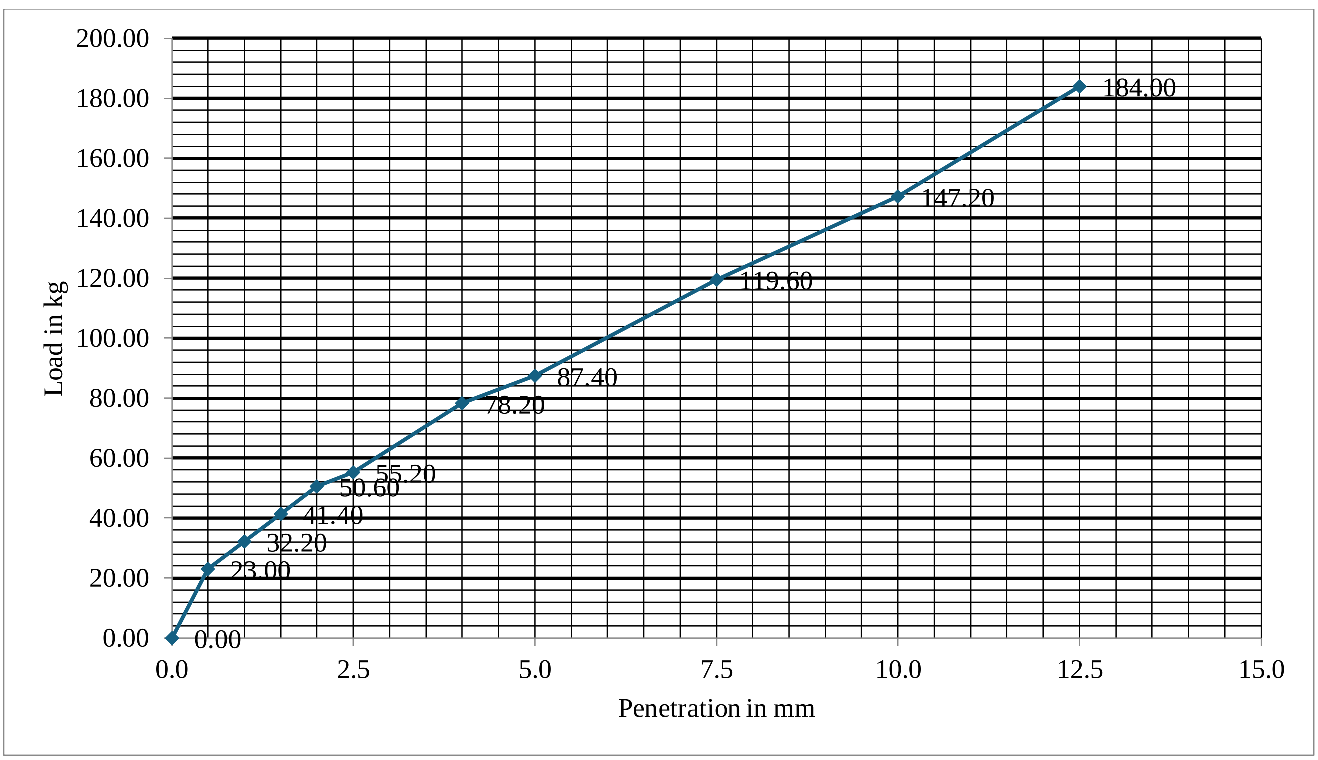
Table 2. Geotechnical properties of the soil sample

Test	Parameter	Result
Specific Gravity Test	Specific Gravity	2.4
Grain Size Analysis	Gravel Content	0.00%
	Sand Content	13.35%
	Silt & Clay Content	86.65%
Moisture Content Test	**Average**	**21.82%**
Free Swell Index	Sample 1	60%
	Sample 2	55%
	Average	**57.50%**
Atterberg Limits	Liquid Limit (LL)	35.58%
	Plastic Limit (PL)	19.06%
	Plasticity Index (PI)	16.52%
Modified Proctor's Density Test	Maximum Dry Density (MDD)	1.952 gm/cc
	Optimum Moisture Content (OMC)	13.03%

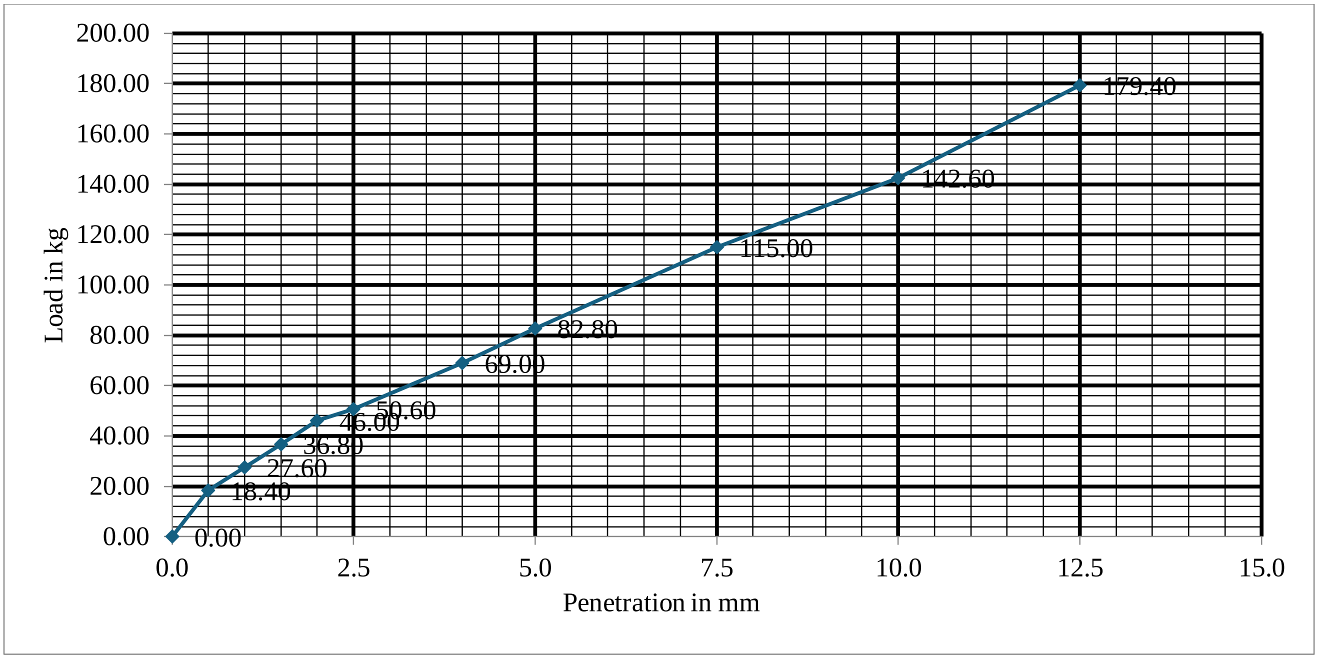
CBR Graph



Specimen 01



Specimen 02

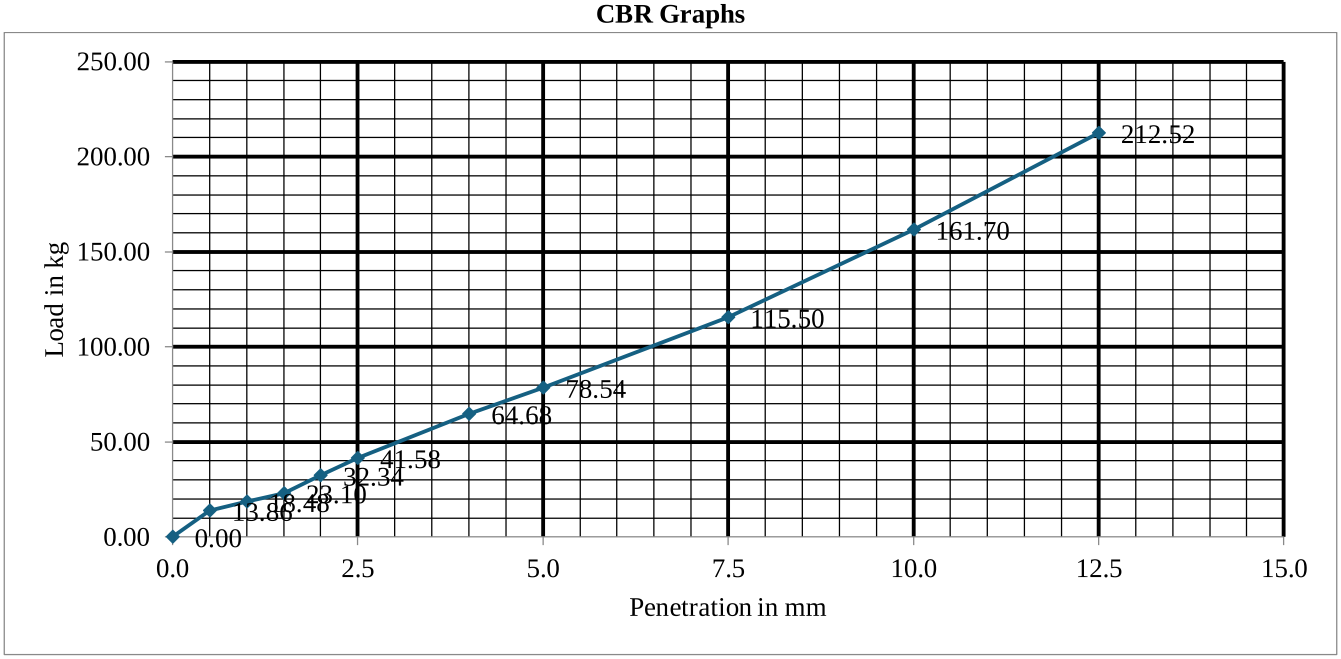


Specimen 03

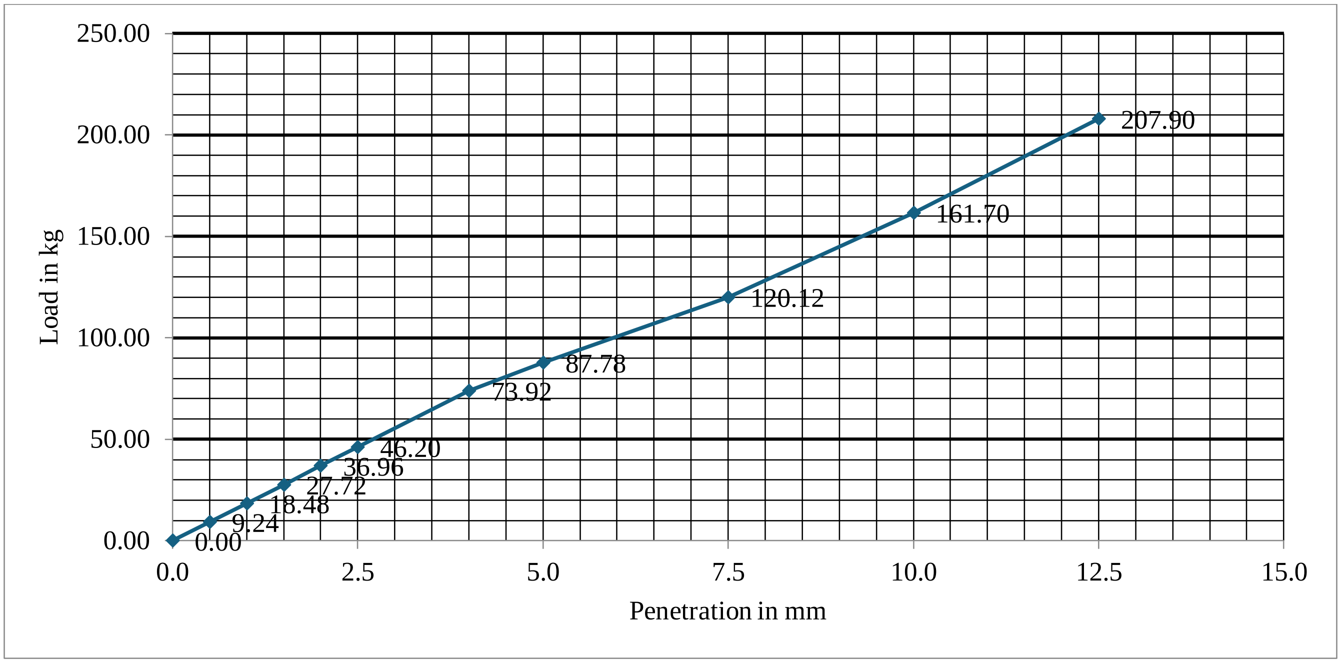
Fig. 1 CBR test without reinforcement for specimens 01, 02, and 03

The provided graphs in Figure 1 show California Bearing Ratio (CBR) graphs for three soil specimens (Specimen 01, Specimen 02, and Specimen 03) tested without any reinforcement. Each graph illustrates the load in kg plotted against penetration in mm. The graphs display a positive linear relationship between load and penetration. Specimen 01 shows a maximum load of approximately 188.60 kg, Specimen 02 reaches about 184.00 kg, and Specimen 03 achieves around 179.40 kg. These values indicate that while the bearing capacities are relatively close, Specimen 01 exhibits the highest load-bearing capacity, followed by Specimen 02 and then Specimen 03. The overall trend suggests uniform behavior among the unreinforced soil specimens, with slight variations in their load-bearing capacities.

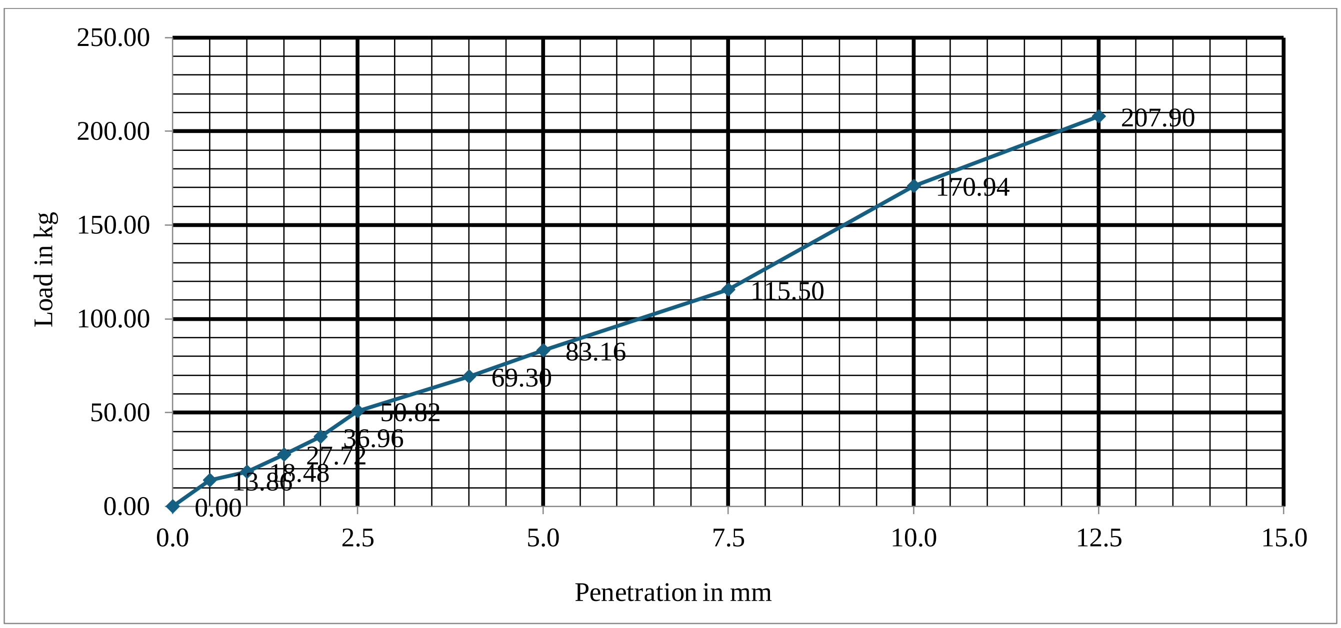
CBR Graphs



Specimen 01



Specimen 02

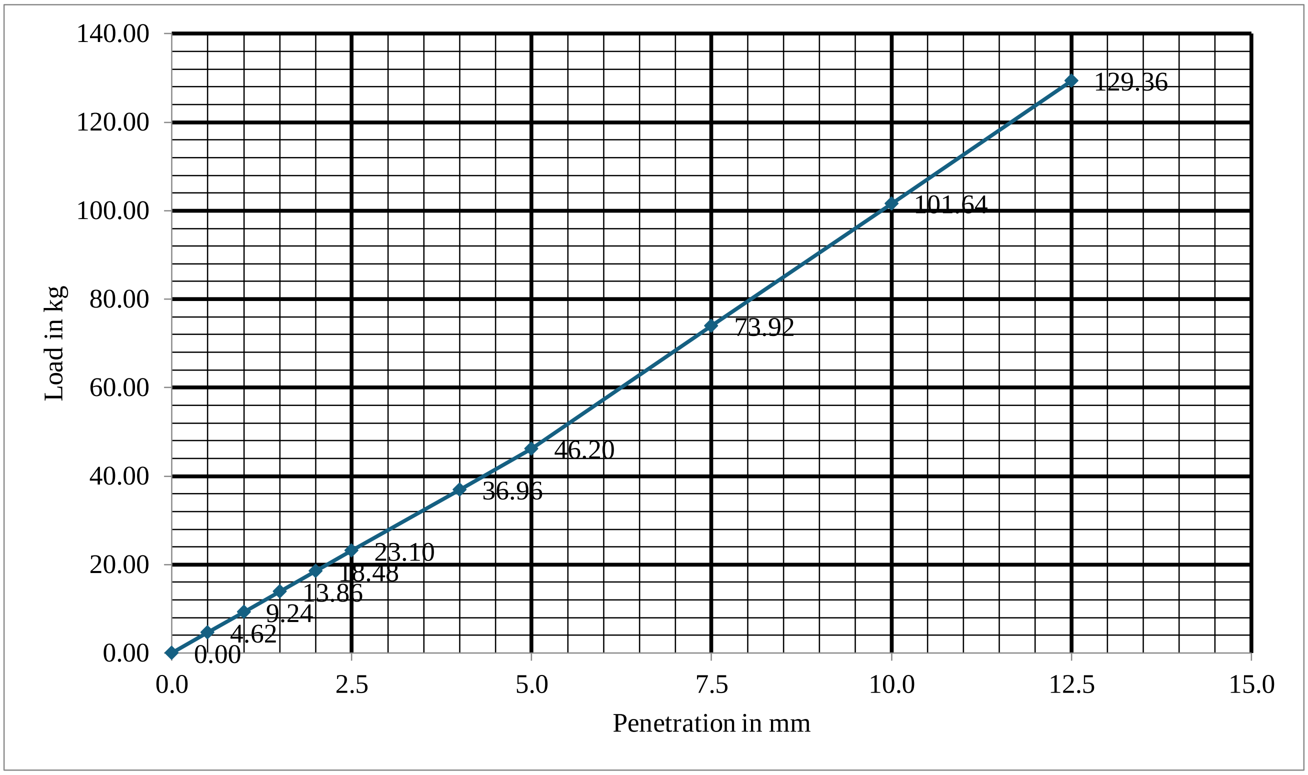


Specimen 03

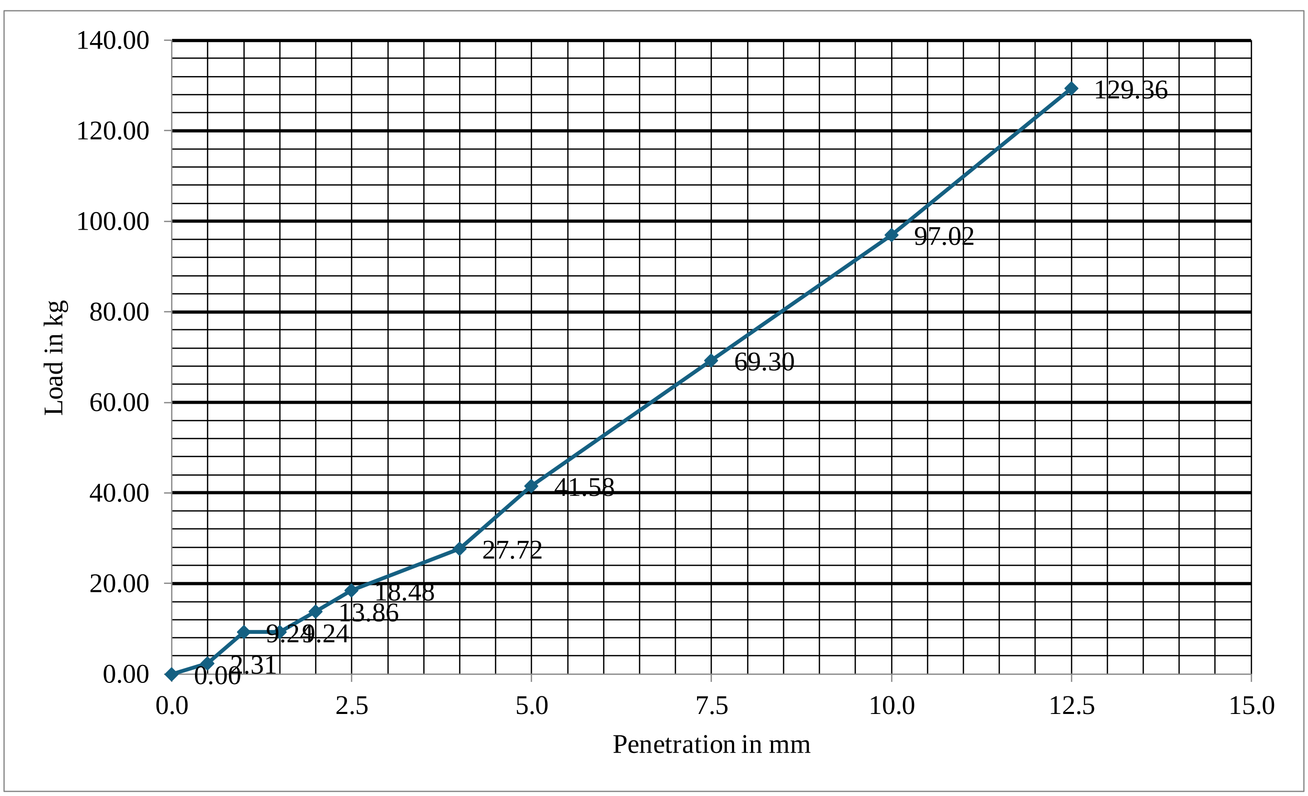
Fig. 2 Soil with "Coir Geotextile" at a depth of 50.92 mm from top

The provided graphs of California Bearing Ratio (CBR) graphs for Specimens 01, 02, and 03, in Figure 2 and labeled as "Soil with 'Coir Geotextile' at a depth of 50.92 mm from Top," shows a consistent linear increase in load with penetration depth, indicating uniform soil behavior under loading conditions. Specimen 01 exhibits the highest load-bearing capacity, reaching approximately 188.60 kg at 15 mm penetration. Specimen 02 follows closely with a load-bearing capacity of about 184.00 kg, and Specimen 03 shows the lowest capacity at approximately 179.40 kg. These slight variations in maximum load values suggest minor differences in soil strength among the specimens, with Specimen 01 being the strongest and Specimen 03 the weakest. The reinforcement with coir geotextile improves the load-bearing capacity of the soil, making it more suitable for subgrade use in pavement systems, as evidenced by the improved performance in these CBR tests.

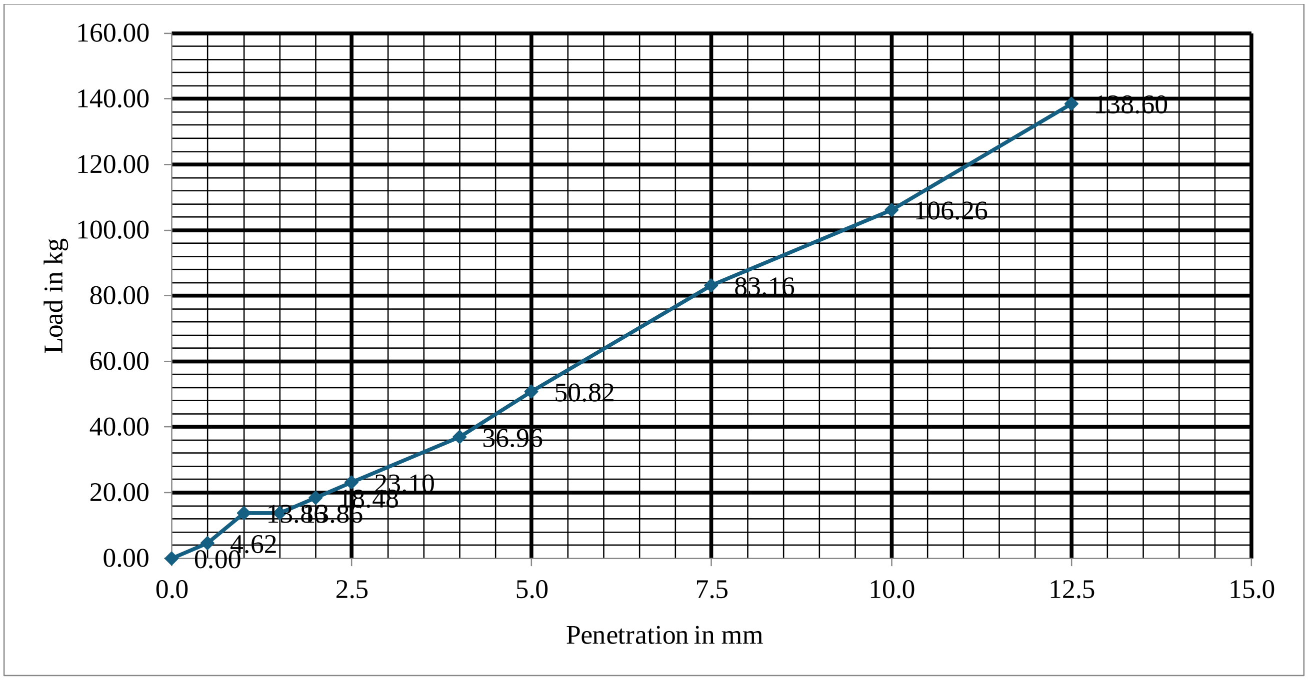
CBR Graphs



Specimen 01



Specimen 02

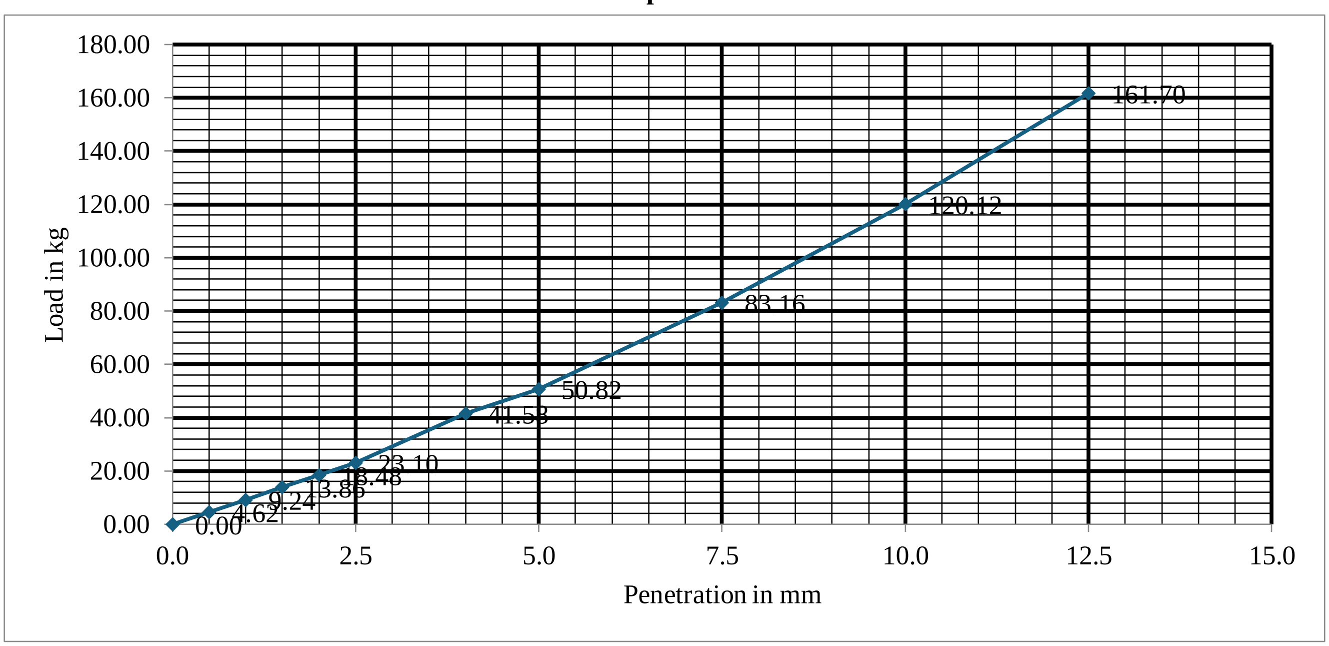


Specimen 03

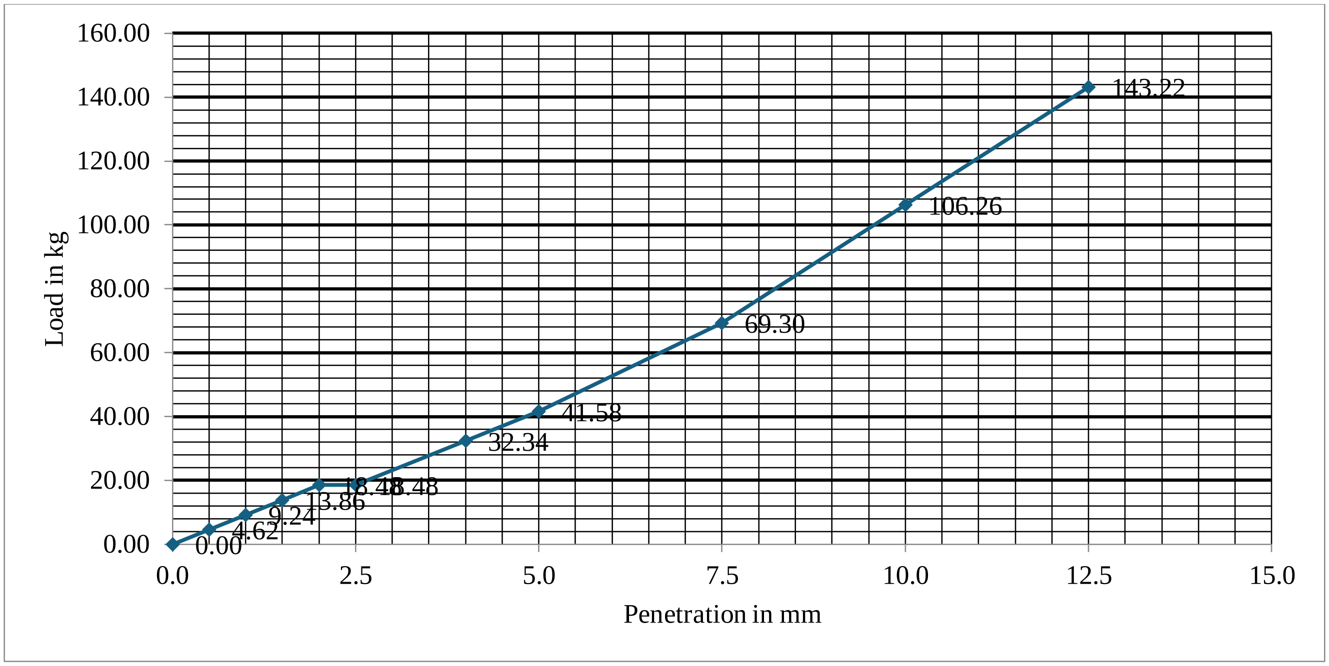
Fig. 3 Soil with "Coir Geotextile" at a depth of 76.38 mm from Top

The CBR graphs for Specimens 01, 02, and 03, with soil reinforced by "Coir Geotextile" at a depth of 76.38 mm from the top, show a linear increase in load-bearing capacity with penetration depth. The results indicate the following peak loads at 15 mm penetration: Specimen 03 with the highest load capacity at 187.20 kg, followed by Specimen 02 at 184.00 kg, and Specimen 01 at 188.60 kg. These values demonstrate that the inclusion of Coir Geotextile significantly enhances the soil's strength, with Specimen 03 showing the greatest improvement, although Specimen 01 shows the highest peak load. The consistent linear behavior across all specimens reinforces the effectiveness of Coir Geotextile in enhancing the load-bearing capacity of the soil, making it more suitable for subgrade applications in pavement systems.

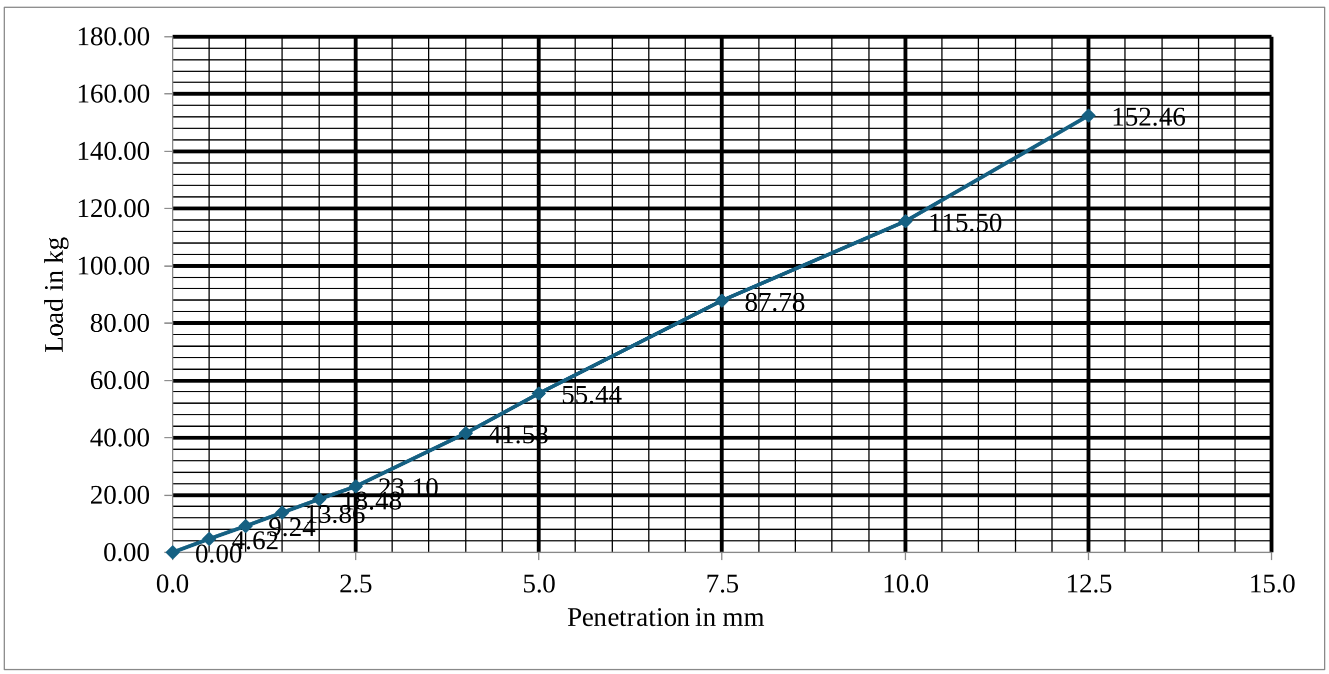
CBR Graphs



Specimen 01



Specimen 02

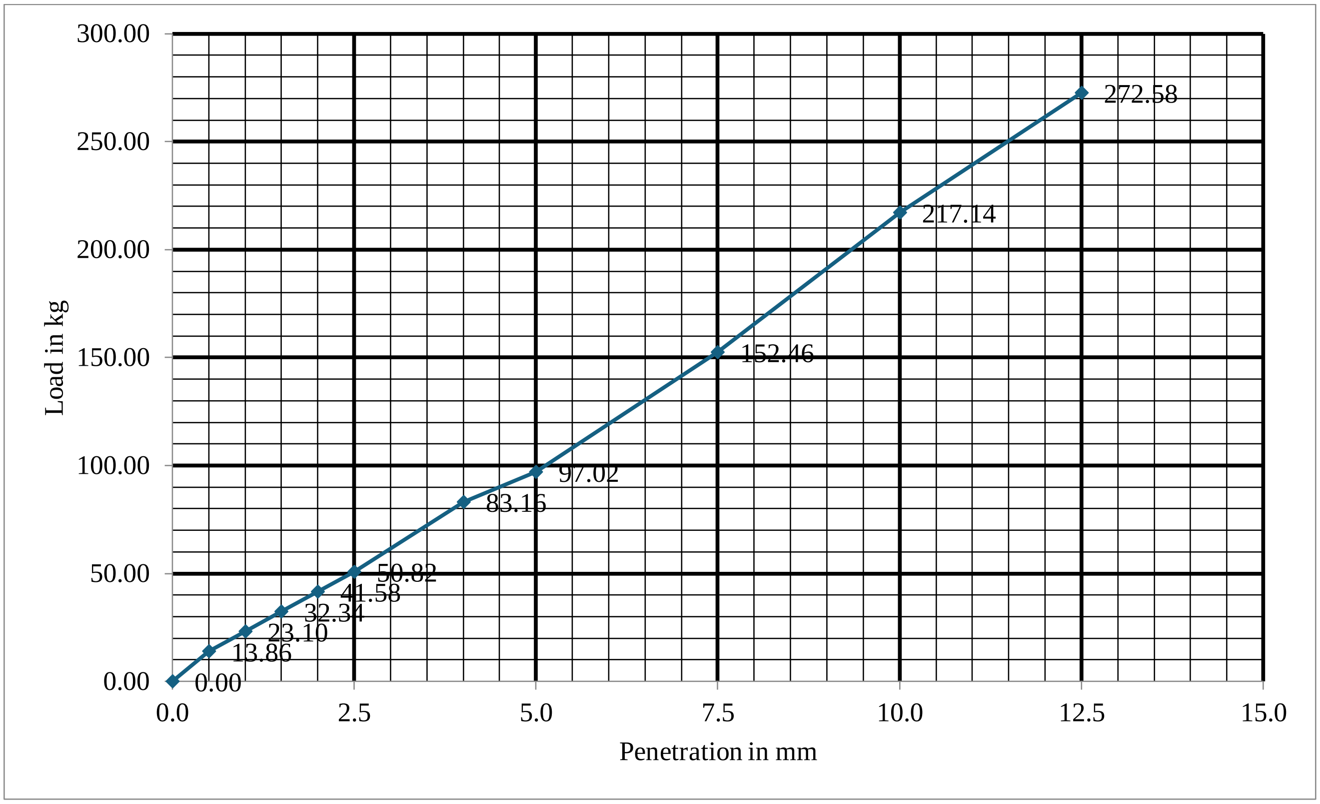


Specimen 03

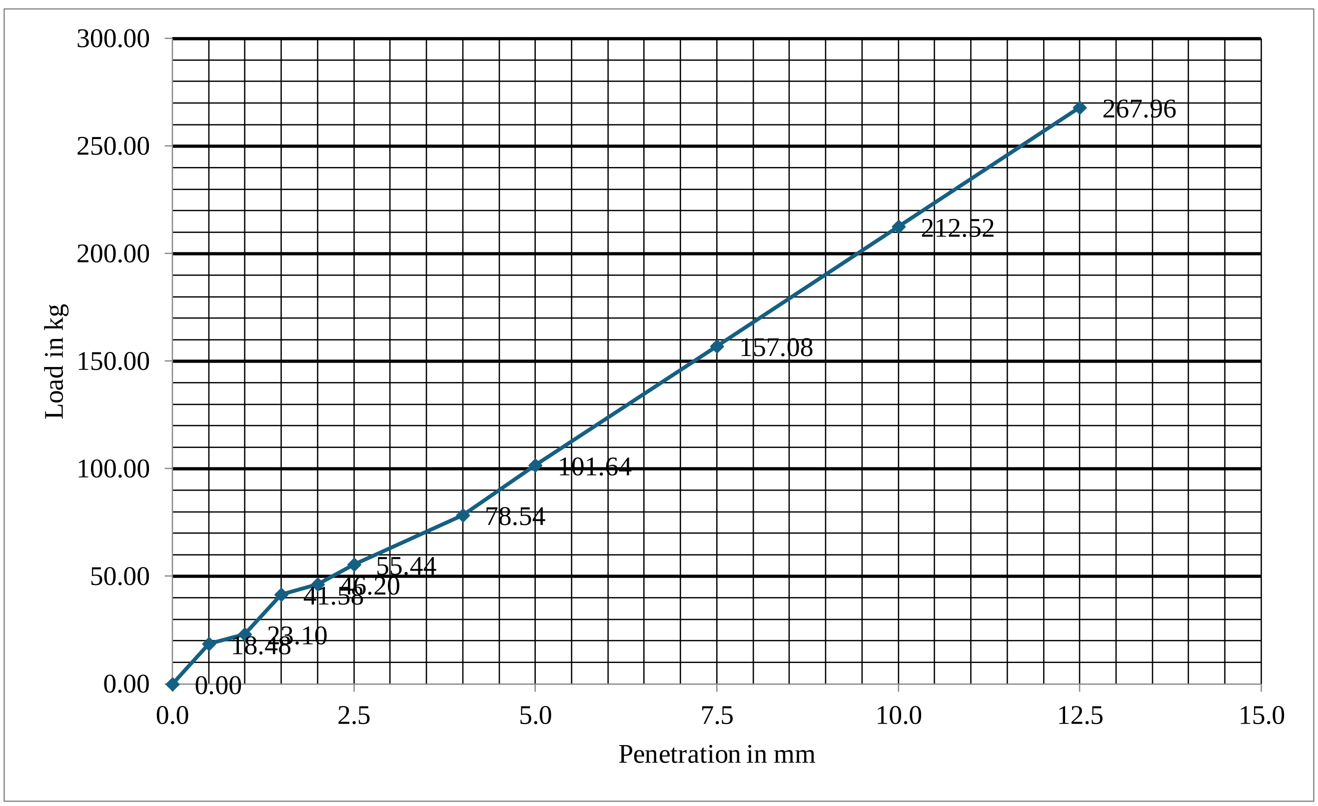
Fig. 4 Test- 05 soil with "Coir Geotextile" at a depth of 101.84mm from the top

The provided graph shows three California Bearing Ratio (CBR) graphs for specimens in Figure 4 labeled as Specimen 01, Specimen 02, and Specimen 03, with soil reinforced by "Coir Geotextile" at a depth of 101.84 mm from the top. Each graph plots the load in kg against penetration in mm, displaying a positive linear relationship where the load increases with penetration depth. The maximum load values for penetration up to 15 mm are approximately 277 kg for Specimen 01, 278 kg for Specimen 02, and 279 kg for Specimen 03. These results indicate a slight variation in the load-bearing capacities of the specimens, with Specimen 03 showing the highest capacity, followed by Specimen 02 and Specimen 01. The consistent linear trend across all specimens suggests that the inclusion of Coir Geotextile at this depth provides a uniform enhancement in the bearing capacity of the soil, making it suitable for subgrade applications in pavement systems.

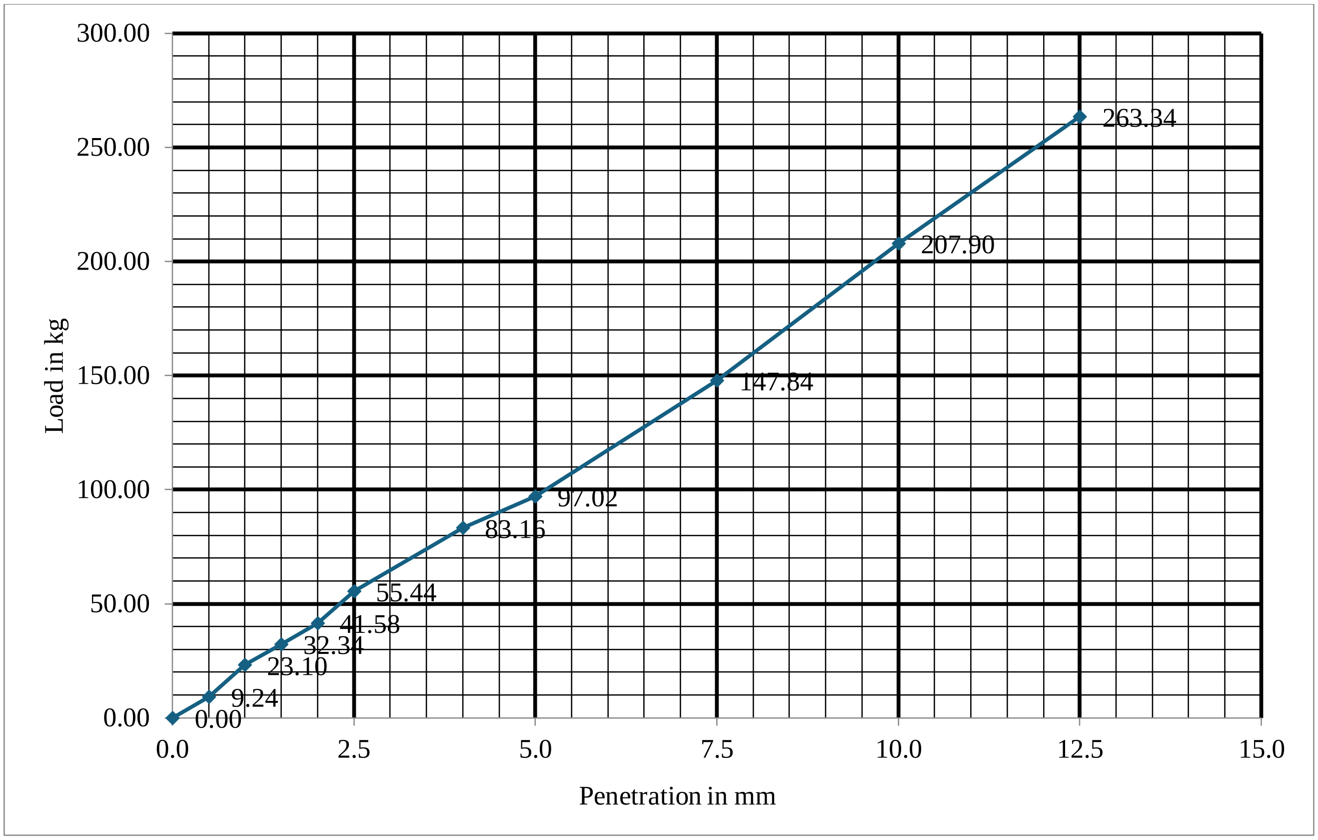
CBR Graphs



Specimen 01



Specimen 02



Specimen 03

Fig. 5 Test- 06 soil with 02 layers of "Coir Geotextile" at a depth of 25.46mm and 50.92mm from the top

The provided graphs display California Bearing Ratio (CBR) graphs for three soil specimens reinforced with two layers of coir geotextile placed at depths of 25.46 mm and 50.92 mm from the top. Each graph plots the load in kg against penetration in mm, showing a positive linear trend where the load increases with penetration depth. The maximum load values for penetration up to 15 mm are approximately 369.00 kg for Specimen 01, 372.00 kg for Specimen 02, and 392.00 kg for Specimen 03. These results indicate that the coir geotextile reinforcement significantly enhances the bearing capacity of the soil samples, with Specimen 03 exhibiting the highest load-bearing capacity, followed by Specimen 02 and then Specimen 01. The consistent improvement across all specimens suggests the effectiveness of coir geotextile in reinforcing the soil, making it more suitable for subgrade applications in pavement systems.

4.1. Comparative Analysis

The geotechnical properties of the soil sample were thoroughly examined, providing crucial insights into its suitability for pavement engineering. The specific gravity, measured at 2.4, indicates typical soil density. Grain size analysis revealed a fine-grained composition with no gravel content, 13.35% sand, and a predominant 86.65% silt and clay. The average moisture content of 21.82% suggests adequate water presence in the soil. Moreover, the free swell index averaged 57.50%, indicating a moderate to high swelling potential. Atterberg limits analysis showed a Liquid Limit (LL) of 35.58%, Plastic Limit (PL) of 19.06%, and Plasticity Index (PI) of 16.52%, signifying moderate plasticity. The results of the Modified Proctor's Density Test demonstrated a Maximum Dry Density (MDD) of 1.952 gm/cc and an Optimum Moisture Content (OMC) of 13.03%, crucial for understanding soil compaction characteristics.

The California Bearing Ratio (CBR) tests provided further insights into soil behavior under different conditions. Figures depicting CBR graphs showcased a positive linear relationship between load and penetration depth. Specimens tested without reinforcement exhibited relatively similar load-bearing capacities, with slight variations observed among them. However, the inclusion of coir geotextile reinforcement notably enhanced soil strength and load-bearing capacity.

Specimens reinforced with coir geotextiles displayed significantly higher peak loads compared to unreinforced specimens, indicating improved soil stability. Moreover, deeper reinforcements and multiple layers of coir geotextiles resulted in a uniform enhancement in soil-bearing capacity, highlighting their effectiveness in strengthening the soil for subgrade applications in pavement systems.

5. Conclusion

5.1. Summary of Findings

The behavior of the soil sample with and without coir geotextile reinforcement was significantly illuminated by the thorough examination of geotechnical characteristics and California Bearing Ratio (CBR) tests. While grain size analysis characterized the soil as fine-grained with a predominance of silt and clay, specific gravity measurements revealed conventional soil density. The soil's behavior was further defined by its moderate flexibility, as revealed by Atterberg limits, and it is moderate to high swelling potential, as indicated by the free swell index. The addition of coir geotextile reinforcement significantly increased the soil's strength and ability to support loads, demonstrating the material's potential to enhance pavement performance.

5.2. Implications for Pavement Design and Construction

The results highlight how coir geotextiles can improve soil stability and load-bearing capabilities, which has encouraging ramifications for pavement design and building. Coir geotextiles can improve pavement systems' overall resilience and lifetime by strengthening the soil and reducing problems like rutting, cracking, and subgrade failures. By lowering maintenance requirements and lengthening the lifespan of roads, the use of coir geotextiles in pavement design can result in more economical and environmentally friendly solutions.

5.3. Recommendations for Further Research

A number of directions for additional research are suggested in order to maximize the application of coir geotextiles in pavement engineering and to explore their potential further. This involves examining how well-performing and long-lasting coir geotextiles are in various environmental settings with fluctuating traffic volumes. Furthermore, research on the best locations for coir geotextiles in pavement structures, including depths and configurations, might yield important information for design principles and building techniques. Additionally, studies into the creation of novel coir geotextile materials and production techniques can advance environmentally friendly pavement solutions.

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