

Comparative Analysis of Flexible Pavement With and Without Geotextile Fabrics

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ABSTRACT

Flexible pavements constructed over weak or moisture-sensitive subgrade soils frequently experience premature distress in the form of rutting, excessive settlement, and cracking. Conventional solutions that rely on increasing pavement thickness often lead to higher construction and maintenance costs without proportionate performance benefits. In recent years, non-woven geotextile fabrics have gained attention as an effective ground-improvement technique due to their multifunctional roles of separation, filtration, drainage, and reinforcement. This study presents a comparative experimental investigation of flexible pavement performance with and without non-woven geotextile reinforcement. Laboratory tests including moisture content, specific gravity, grain size distribution, Atterberg limits, compaction characteristics, California Bearing Ratio (CBR), and permeability were conducted on locally available weak subgrade soils. Pavement models were prepared in unreinforced and geotextile-reinforced configurations, with the geotextile placed between the subgrade and granular sub-base layer. The results demonstrate significant improvement in CBR values, reduction in settlement, and enhancement of drainage characteristics due to the inclusion of non-woven geotextile. Although the initial construction cost increases marginally, the long-term benefits in terms of improved structural performance, reduced maintenance, and extended service life make geotextile-reinforced pavements a technically and economically viable solution. The findings confirm the suitability of non-woven geotextiles for flexible pavement construction over weak subgrades.

Keywords: Flexible pavement, Non-woven geotextile, Subgrade reinforcement, CBR, Drainage, Pavement performance

1.INTRODUCTION:

Transportation infrastructure plays a crucial role in economic growth and social development. Flexible pavements form a major part of road networks due to their adaptability and lower initial construction cost. However, pavements constructed over weak subgrade soils often suffer from early deterioration caused by inadequate load distribution, moisture ingress, and poor drainage conditions. These issues result in frequent maintenance, increased lifecycle cost, and reduced serviceability. Geosynthetics, particularly geotextiles, have emerged as an innovative solution to improve pavement performance. Geotextiles are synthetic, permeable materials manufactured from polymeric fibres such as polypropylene or polyester. Depending on their manufacturing process, they are classified as woven or non-woven geotextiles. Among these, non-woven geotextiles are widely used in pavement engineering due to their superior filtration and drainage properties. When incorporated into pavement systems, non-woven geotextiles act as a separator between subgrade and aggregate layers, prevent intermixing, improve load transfer, and enhance drainage. These functions collectively contribute to improved structural capacity and durability of pavements. The present study aims to experimentally compare flexible pavement performance with and without non-woven geotextile reinforcement under laboratory conditions.

2.NON-WOVEN GEOTEXTILES IN PAVEMENT ENGINEERING

2.1 Definition and Manufacturing Process

Non-woven geotextiles are produced by bonding randomly oriented synthetic fibers through mechanical, thermal, or chemical methods. Unlike woven fabrics, non-woven geotextiles do not follow a regular pattern, which provides them with high permeability and flexibility. These characteristics make them suitable for applications where filtration, drainage, and separation are required.

2.2 Functions of Non-Woven Geotextiles in Pavements

The primary functions of non-woven geotextiles in pavement construction include separation, filtration, drainage, reinforcement, and protection.

2.3 Advantages and Limitations

Non-woven geotextiles offer several advantages such as ease of installation, excellent drainage capacity, chemical resistance, and durability. They contribute to reduced rutting, improved pavement life, and lower maintenance requirements. However, their tensile strength is generally lower than that of woven geotextiles, and improper handling during construction may lead to damage. Appropriate selection based on soil conditions is therefore essential.

3.LITERATURE REVIEW

Previous studies have shown that the performance of flexible pavements is greatly affected by subgrade strength and drainage conditions. Weak and moisture-sensitive soils often lead to early pavement failures such as rutting and settlement. Researchers have identified geotextiles as an effective solution to improve pavement behavior under such conditions.

Giroud and Han reported that geotextile reinforcement improves load distribution and reduces surface deformation in pavements constructed over weak subgrades. Koerner emphasized that non-woven geotextiles are especially suitable for pavement applications due to their filtration and drainage capabilities, which help control moisture-related damage. Indian design guidelines provided by IRC and MoRTH highlight the importance of proper separation and drainage between pavement layers, functions that can be efficiently achieved using geotextiles.

Studies by Perkins demonstrated that geotextile-reinforced pavement sections show reduced rutting and improved service life. Soil behavior studies by Das, along with pavement design principles discussed by Khanna and Justo, further support the need for reinforcement in weak subgrade conditions. Experimental investigations by Rao and Reddy confirmed that the inclusion of geotextiles leads to improved CBR values and better overall pavement performance.

From the reviewed literature, it is evident that non-woven geotextiles enhance the strength, drainage, and durability of flexible pavements. However, comparative experimental studies under controlled conditions remain limited, which justifies the need for the present investigation.

4.OJECTIVES

The main objectives of the present study are:

- To determine the engineering properties of weak subgrade soil through laboratory testing
- To evaluate the effect of non-woven geotextile placed between subgrade and sub-base layers.
- To compare the strength, drainage, and settlement behaviour of flexible pavements with and without geotextile reinforcement.
- To assess the economic feasibility of using non-woven geotextiles in flexible pavement construction.

5.METHODOLOGY

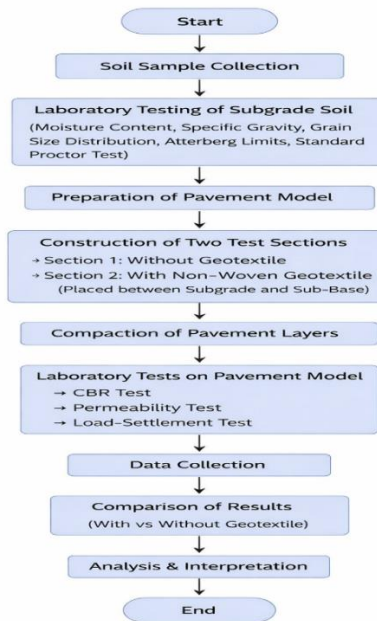


Fig. 5: Flowchart showing methodology adopted for comparative analysis of flexible pavement with and without geotextile

5.1 Soil Testing:

Soil testing helps determine the engineering properties of soil such as strength, bearing capacity, and moisture content so that a safe and suitable foundation or pavement design can be selected.



Fig 5.1: Location Sample - 1



Fig 5.1: Location Sample - 1

5.2. Specific Gravity (IS 2720 Part 3):

Specific gravity of soil represents how heavy the soil particles are compared to water, and it is used to assess soil type, mineral content, and overall behaviour in engineering applications.



Fig 5.2 : Specific Gravity

5.3 Grain Size Distribution (IS 2720 Part 4):

Sample	Cu	Cc	Interpretation
1	3.50	1.14	Cu < 6 → poorly graded soil (clayey).
2	3.33	1.01	Cu < 6 → poorly graded, uniform soil.

Table 5.5.3 Grain Size Distribution (Cu & Cc)

5.4 Atterberg Limits (IS 2720 Part 5):

The Atterberg limits define the consistency or state fine-grained soil (especially clay and silt) at various moisture contents.

5.5 Standard Proctor Compaction Test (IS 2720 Part 7):

Sample	OMC (%)	MDD (g/cc)	Interpretation
1	43.33%	1.22	Very high OMC & low MDD → very soft clay, weak subgrade, high settlement tendency.
2	24.68%	1.49	Lower OMC & higher MDD → denser soil, higher strength, better load bearing.

Table 5.5.4 Compaction Characteristics (MDD & OMC)

5.6 California Bearing Ratio (CBR) Test (IS 2720 Part 16):



Fig 5.6 : California Bearing Ratio (CBR) Test

Condition	Sample	CBR Without	CBR With	% Improvement	Improvement Ratio
Soaked Soil	1	1.34	3.65	172.39%	2.72
	2	1.66	4.15	150.00%	2.50
Geo between Subgrade– GSB	1	1.80	3.74	107.7%	2.07
	2	1.66	3.12	87.9%	1.88

Table 5.6.2. COMPARATIVE SUMMARY TABLE of CBR

5.7 Permeability Test (IS 2720 Part 17):



Fig 5.7 : Permeability Test

6. RESULTS AND DISCUSSION



Fig 6: Result

The laboratory test results indicated that the subgrade soil exhibited low bearing capacity and high moisture sensitivity. The inclusion of non-woven geotextile led to a substantial increase in CBR values for both soil samples. In soaked conditions, CBR improvement of more than two times was observed, indicating enhanced load-bearing capacity.

Permeability tests showed a notable increase in the coefficient of permeability for soil reinforced with geotextile, confirming improved drainage characteristics. Load-settlement behaviour demonstrated reduced deformation in reinforced pavement models due to better stress distribution. Although the initial cost of the reinforced pavement model was higher, the improved performance suggests long-term economic benefit.

OVERALL ANALYSIS – soil properties

Sample 1 (weak soil)	Sample 2 (stronger soil)
High moisture (38%)	Lower moisture (21%)
High LL	Lower LL
Medium PI	Similar PI
Poor grading	Poorly graded
Very high OMC	-
Lowest MDD (1.22)	Higher MDD (1.49)
Behaviour: weak, compressible, clayey soil → needs reinforcement → geotextile will make big improvement	Behaviour: stronger & denser than Sample A → better performance even without reinforcement.

Table 5.6.1- OVERALL ANALYSIS – soil properties

7. CONCLUSION

Based on the experimental investigation, the following conclusions are drawn:

- Non-woven geotextiles significantly improve the strength and bearing capacity of weak subgrade soils.
- Reinforced pavements exhibit better drainage and reduced settlement compared to conventional pavements.
- Placement of geotextile between subgrade and sub-base effectively enhances load distribution.
- The marginal increase in initial cost is justified by reduced maintenance and extended service life.
- Non-woven geotextiles provide a sustainable and economical solution for flexible pavement construction over weak soils.

8. SCOPE FOR FUTURE STUDY

Future research may focus on field-scale performance evaluation, life-cycle cost analysis, environmental impact assessment, and comparison with other types of geosynthetics. The use of natural or biodegradable geotextiles can also be explored for sustainable pavement solutions.

9. LIMITATIONS AND PRACTICAL IMPLICATIONS

Although the present study demonstrates significant benefits of non-woven geotextile reinforcement, certain limitations must be acknowledged. The experimental investigation was conducted under controlled laboratory conditions, which may not fully replicate field performance influenced by traffic loading, environmental variations, and construction practices. Additionally, only one type of non-woven geotextile was considered in this study.

Despite these limitations, the findings provide valuable insights for pavement engineers and planners. The results highlight the suitability of non-woven geotextiles for roads constructed over weak and moisture-sensitive subgrades, particularly in rural and low-volume road applications.

10. REFERENCE

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