

# Effect of Woven Polyester Geotextile on the Strength of Black Cotton Soil

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**ABSTRACT:** Black cotton soil show high volume change behaviour with change in water content leading to failure of structures constructed over it. Pavement constructed over such soil shows heavy settlement and cracks. The costly sub-base and base aggregates intrude into subgrade due to heavy wheel load and during compaction process it leads to loss of aggregates. The fine soil particles may enter the voids of base aggregates, thereby ruining its drainage capability. In order to overcome these problems soil stabilization has to be adopted. In the present work an attempt has been made to study the effect of using woven polyester geotextile in strength improvement of poor subgrade soil. California Bearing Ratio and Compaction test are conducted without geotextile and by placing geotextile at different depth of subgrade in single layer (25mm, 50mm, 75mm and 100mm from the top of mould). The maximum improvement occurs when geotextile was placed at 50mm depth from the top.

**KEYWORDS:** Subgrade, Black Cotton Soil, Pavement, Stabilization, Geotextile

## I. INTRODUCTION

The quality and life of pavement depends mainly upon the type of subgrade soil. The subgrade composed of clayey soil is very weak and overstressing due to wheel load can be a possibility leading to overall pavement failure. It increases the maintenance cost. Black cotton soil covers about 20% of land area of India covering states of Madhya Pradesh, Maharashtra, Gujarat, few parts of Uttar Pradesh, Tamil Nadu and Andhra Pradesh. It is very difficult to work with such type of a soil due to its low CBR and shear strength values. But the development activities cannot be stopped because of this and hence improvement in soil properties has to be done. With this the role of geotextile comes into action which when placed in subgrade provides multiple functions towards property improvement of poor subgrade soil i.e. reinforcement, separation, drainage and filtration.

Elshakankery et.al. [1] studied the benefit of using nonwoven polyester geotextile materials as reinforcement of different Egyptian soils and concluded that the improvement of reinforcement ratio of soils with geotextile materials depends on the soil type. Yeole et.al. [2] studied the effect of using nonwoven polypropylene geotextile in layers on granular soil and found that placing of geotextile material in soil improves the CBR and therefore the strength of soil. Ingle et.al. [3] studied and presented brief information on geosynthetics products and their standards. The study concluded that the impact of geo synthetics material (in terms of reduction of the base course thickness) is up to 40% as compared to unreinforced section. In addition to the basic economical benefits, there are significant environmental benefits associated with aggregate savings: less transportation of aggregate by trucks, hence less air pollution, less energy consumption and less green house gas (GHG) emissions. Rajkumar et.al. [4] studied experimentally the performance of woven and nonwoven geotextile, interfaced between soft subgrade and unbound gravel in an unpaved flexible pavement system utilizing the California Bearing Ratio (CBR) test and found that the improvement in reinforcement ratio of clayey soil with woven geotextile is more as compared with non-woven. Patil [5] studied the effect of woven polyester geotextile on the soaked CBR value of three different kinds of soils (B.C. soil, Morrur and both soil). The most optimum position of geotextile is 1/3 distance from the top.

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In this study the use of woven polyester geotextile sheet at different depth in subgrade in a single layer has been done. The geotextile is placed at H/5, 2H/5, 3H/5 and 4H/5 depths from the top, where H is the height of compacted specimen. CBR and heavy compaction tests are performed.

## II. MATERIALS AND TESTING PROCEDURE

### A. Soil

The soil sample used in this study is collected from Meja area of Allahabad, Uttar Pradesh, India. The area is largely covered with clayey soil. The soil is classified as clay of high compressibility (CH) as per Indian standard classification system. The soil is collected from the site after removing the top surface covered by organic matter. The soil is then air dried and is pulverized with a wooden mallet. The soil so pulverized is sieved through 4.75mm sieve. Fig.1 shows the route map of Meja area from MNNIT campus from where soil was collected. The various physical and index properties of soil are shown in Table 1.

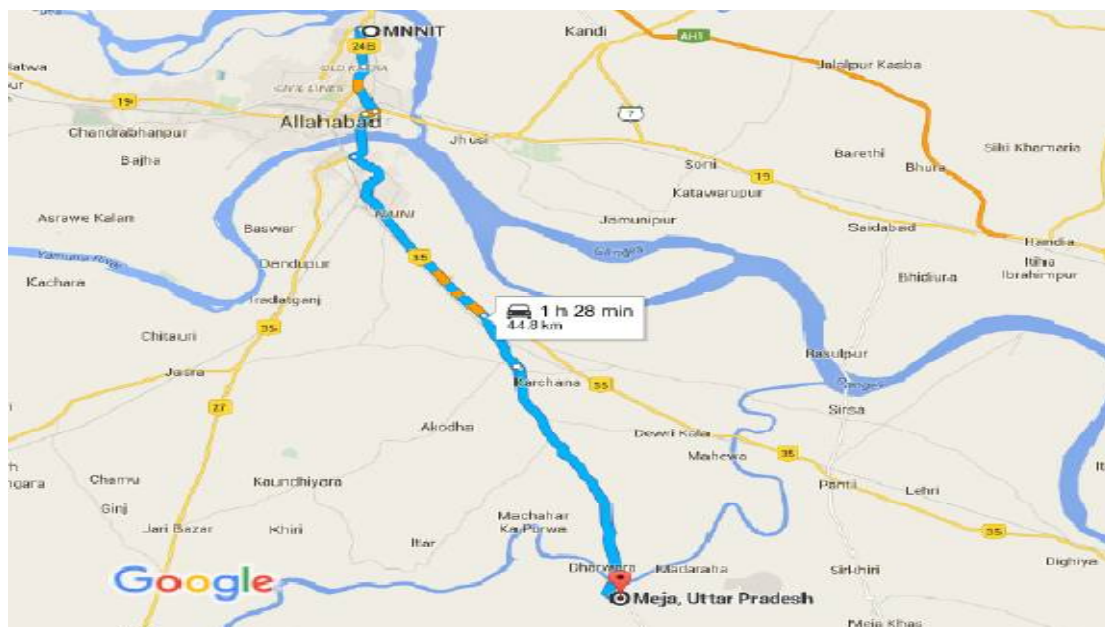


Fig. 1: Route Map of Meja from MNNIT Allahabad

Source: <https://www.google.co.in/maps/dir>

Various properties of soil are determined as per procedure laid down in Indian Standard Code (BIS). The Liquid limit and plastic limit as per IS 2720 (part5-1985), Shrinkage limit as per IS 2720 (part6-1972), Sieve analysis and hydrometer as per IS 2720 (part4)-1985, Heavy compaction test as per IS 2720 (part 8)-1983, Specific gravity as per IS 2720 (part-III/Sec2) and California Bearing Ratio (CBR) test as per IS 2720 (part 16)-1987.

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Table 1: Physical properties and Classification of soil

S.No	Properties	Value
1.	Specific Gravity	2.68
2.	Liquid Limit (%)	52.00
3.	Plastic Limit (%)	28.00
4.	Plasticity Index (%)	24.00
5.	Shrinkage Limit (%)	20.70
6.	Optimum Moisture Content (%)	17.00
7.	Maximum Dry Density	1.80
8.	Grain Size Distribution	
	Gravel (%)	0.74
	Sand (%)	5.96
	Silt (%)	55.86
	Clay (%)	37.44
9.	Indian standard classification	CH-Clay of high compressibility

## B. Geotextile

A woven synthetic geotextile made of polyester yarn is placed at different depth in soil subgrade. The geotextile used was obtained from Sieves and filters Corporation, New Delhi. The mass per unit area of geotextile is 130 GSM tested as per IS- 14716. The physical and engineering properties of geotextile provided by manufacturer are shown in Table 2. The view of woven polyester geotextile sheet is shown in fig 2.

Table 2: Properties of Geo Textile

S.No	Property	Woven Geo Textile
1.	Mass / Unit Area ( $\text{g/m}^2$ )	130
2.	Thickness (mm)	1
3.	Tensile Strength (KN/m)	2.8
4.	Elongation (%)	30
5.	Puncture Strength (N)	350



Fig. 2: Woven geotextile sheet

Source: <http://www.geomat.eu/en/nonwoven-geotextiles>

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### C. Testing Procedure

Heavy compaction test is performed with a 4.9kg rammer falling through a height of 450mm in 5 layers with 55 blows given after placing each layer. About 2.8kg of air dried soil is taken and initial moisture content is determined. The soil is initially mixed with 12% water and packed in polythene bags for 24 hours; five such samples were prepared and after that water was added in increment of 2% to perform the test. The test is conducted for soil alone and then with geotextile placed in single layer at different depths of subgrade.

Soaked CBR test is conducted with a soaking period of 96 hour. The mass of soil is taken on the basis of maximum dry density and volume of mould; passing 4.75mm sieve. Optimum water is added as per compaction test and the sample is prepared as per IS code. First the soil is tested alone for CBR and then geotextile is placed in single layer (25 mm, 50mm, 75mm and 100mm from the top of mould).

### III. TEST RESULTS AND DISCUSSIONS

Maximum dry density value is reported as 1.80g/cc with optimum moisture content of 17.0% for virgin soil which increases to MDD of 1.83g/cc and OMC of 16.6% for geotextile placed at 3H/5 depth from top and maximum value of MDD comes out to be 1.84g/cc for 4H/5 depth (100mm) from top with minimum OMC of 16%. This increase in MDD with corresponding reduction in OMC is due to reduction in void spaces with application of geotextile at particular depth resulting in more compact system. However the MDD value decreases for H/5 and 2H/5 depths from top with a value of 1.79g/cc and 1.78g/cc respectively which is even lower than virgin soil sample. Table 4 show the values of OMC and MDD at different position of geotextile placement in subgrade and without geotextile in subgrade. Compaction causes increase in load carrying capacity, strength and bearing capacity of soil and reduction in compressibility of soil.

Table 4: OMC-MDD values for soil reinforced with Geo Textile of 130 GSM

S.No	Position of geotextile from top of specimen	Experimental Value (130 GSM)	
		OMC (%)	MDD (gm/cc)
1.	Without Geo Textile	17.0	1.80
2.	H/5	18.2	1.79
3.	2H/5	19.0	1.78
4.	3H/5	16.6	1.83
5.	4H/5	16.0	1.84

The CBR value of virgin soil is 2.33 which increase to 2.41 for 25mm depth of geotextile, the CBR value further increases to 2.47 for geotextile placed at 50mm depth and for 75mm and 100mm depth of geotextile, CBR value decreases and it comes out to be 2.11 and 2.18 respectively. The strength improvement occur for geotextile layer placed in upper portion of mould, this may be due to more resistance offered by geotextile layer against penetration. The CBR test results and load-penetration curves are shown in Table 3 and from Fig. 3 to Fig. 8 respectively.

Table 3: CBR Value for soil reinforced with Geo Textile of 130 GSM

S.No	Position of geotextile from top of specimen	Experimental CBR Value (130GSM)		
		CBR 2.5 (%)	CBR 5 (%)	CBR Value (%)
1.	Without Geo textile	2.33	1.84	2.33
2.	H/5	2.41	2.28	2.41
3.	2H/5	2.47	1.94	2.47
4.	3H/5	2.11	1.60	2.11
5.	4H/5	2.18	1.74	2.18

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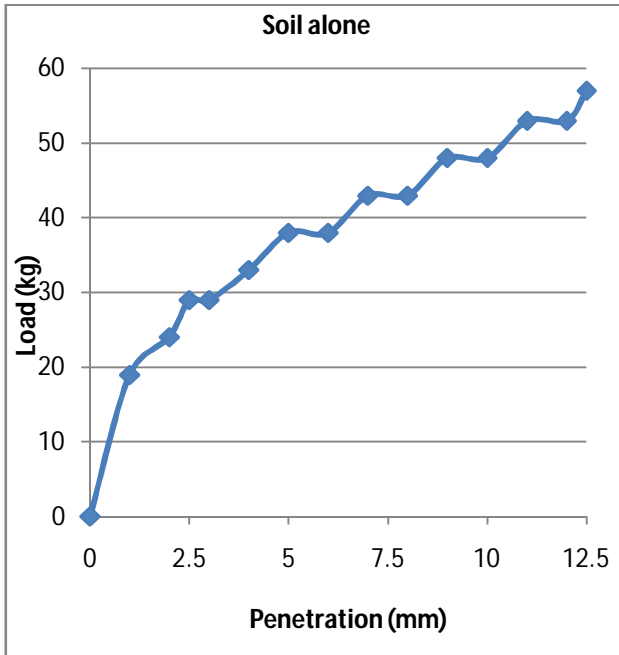


Fig. 3: Load-Penetration curve without geotextile

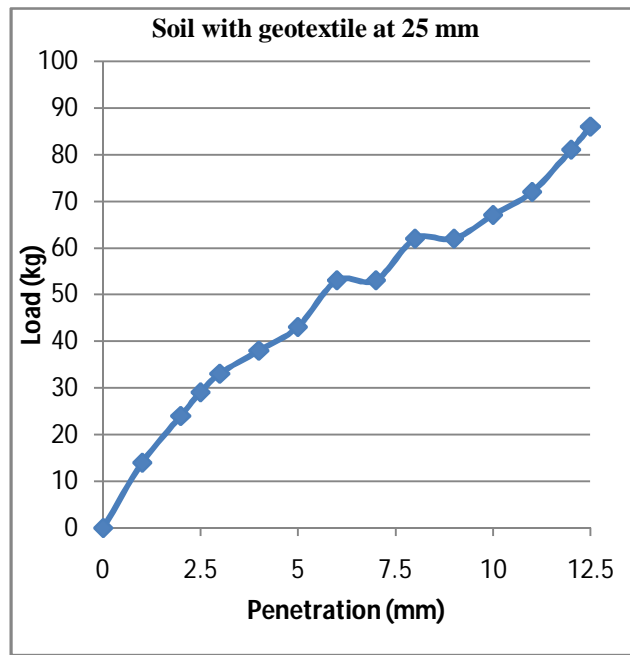


Fig. 4: Load-Penetration curve with geotextile at 25 mm from top

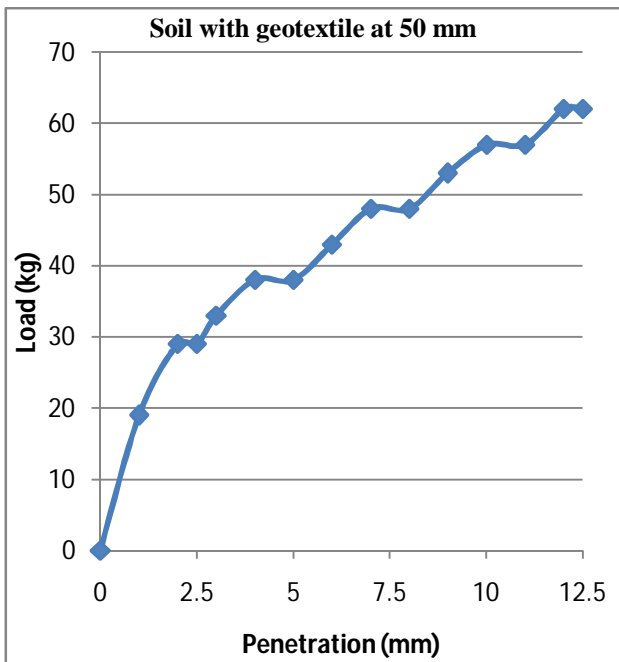


Fig. 5: Load-Penetration curve with geotextile at 50 mm from top

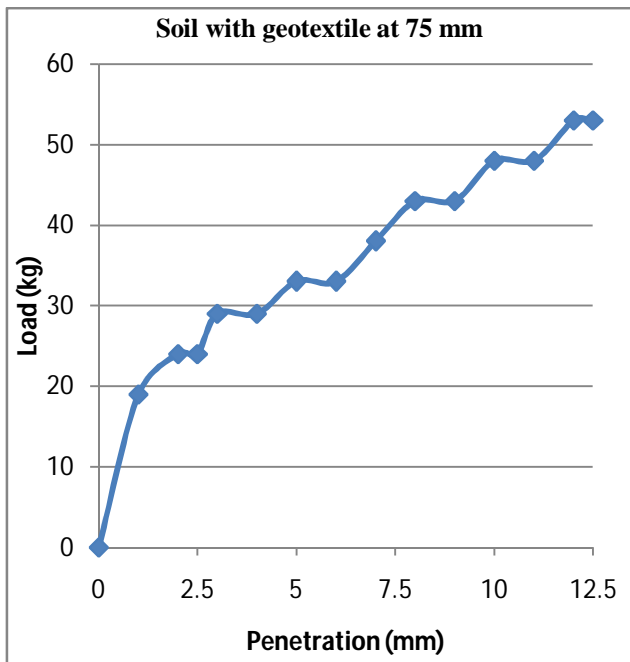


Fig. 6: Load-Penetration curve with geotextile at 75 mm from top

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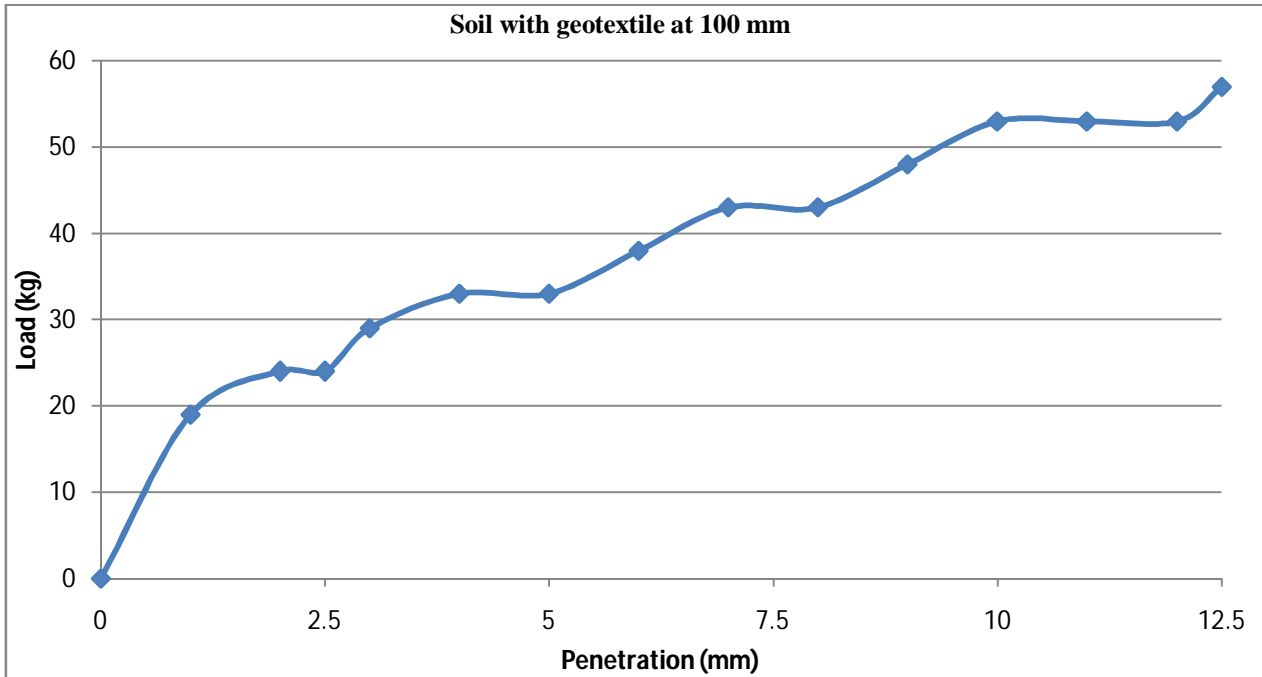


Fig. 7: Load-Penetration curve with geotextile at 100 mm from top

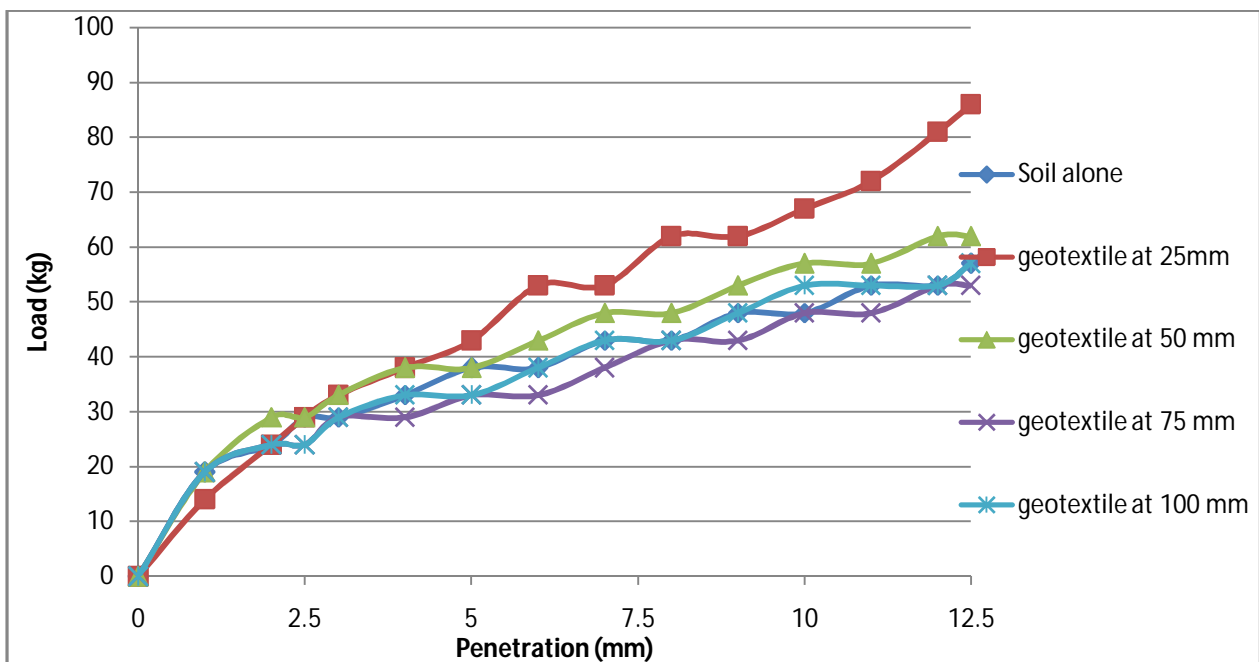


Fig. 8: Combined Load-Penetration curve

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## IV. CONCLUSION

The maximum dry density value is increasing with reduction in optimum moisture content with maximum value of 1.84g/cc at 16% OMC for 100mm depth from the top of mould, due to greater soil to soil interaction provided by geotextile, as the space which was earlier occupied by air particles are now replaced with soil particle having greater density. The CBR value of soil increases by 3.43% and 6% for geotextile placed at H/5 and 2H/5 depths from top of specimen. CBR value of soil decreases for 75mm (3H/5) and 100 mm (4H/5) depth of geotextile placement from top, which is even below the CBR value of unreinforced soil. The improvement in soil properties is seen in upper layers, this may be due to more resistance offered by geotextiles to penetration and there is improvement in load-penetration behaviour. The most optimum position of geotextile placement is at 2H/5 (50mm) depth from top of compacted specimen where maximum improvement in CBR value was seen. The use of geotextile in soft subgrade causes reduction in thickness requirement of pavement, increases the service life and reduces the frequency of maintenance required, resulting in economical pavement design.

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