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Application of Geotextiles in Road Construction

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Abstract

The present scenario in India demands maximum transit facilities to develop at a low cost within shortest feasible time. Analysis performed on majority of the failed roads owe them to the founding soil over which these roads were constructed. Jute geo-textiles, produced abundantly in this subcontinent, may be used beneficially and economically with great efficacy for stabilization of such weak sub-grades. Though there have been extremely limited but successful construction of roads over soft soils using jute geo-textile in India, their systematic use is yet to be resorted to. Since the experience gained from their adoption in practice and also from ongoing research certainly prove to be rewarding, the geotechnical community should perhaps exploit this potential and encourage such applications which result in enhanced performance of highways at an optimal cost. A tentative design methodology thought to be adopt for this is also presented.

Keywords: *Black Cotton (BC) soil, Subgrade, Granular Sub Base (GSB), Pavement Geotextile, subgrades, pavement, separation, embedment soil.*

1. Introduction

Transportation leads to a country's all-round growth and therefore plays a crucial role in its advancement. As India is largely rural in nature, road connections have distinct advantages over other connectivity modes. Economy, time, environmental restrictions, and many other variables, however, make the task of a highway specialist more complex to provide its users with a healthy and cost-effective road network. One of the major problems faced by the engineers in highway construction in plains and coastal areas of India is the presence of soft soil at ground level. The substantial depth of this layer will not be removed by drilling. Therefore, there is no alternative but to construct roads above them. If supplemented with bad drainage or a lack of it this situation can be further exacerbated.

Majority of the investigations on failure of such roads built on soft soil attribute it to the presence of fine-grained soil which gets intermixed with the aggregate base materials destroying the structural strength of the aggregate by interfering with stone to stone contact. It be also mentioned here that unsatisfactory performance of poor sub- grade is again associated with lateral displacement of the sub-grade and the base materials under load. The conventional remedy to overcome this phenomenon is the provision of a blanket course of alternatively usage of stabilized local soils as a sub- base layer. Though this may to some extent aid in resolving the problem, the remedial measures may prove to be time consuming and quite expensive and in many cases many compromise in terms of cost benefit ratio or quality which could further aggravate the problem.

The lacuna identified with the traditional approach commands the problem to be tackled at its rudimentary level by rectification of the basic weakness of the formation sub- grade and to settle for a strategic solution. It is in this sense that jute fabric is found to solve the problem by improving the consistency of poor soil sub-grade when added at the interface of the sub-grade. This principle of integrating an additional indigenous feature at the sub-grade level, though is a new thought by way of a modern idea.

2. Coir Geotextile (CG)

Bacteria and fungi are the two-main groups of microorganisms responsible for the microbial decomposition of natural textile materials [3, 10]. The probability of bacterial damage is greater when jute come in to contact with soil and soil bacterial. It is reported that the minimum moisture requirements for the growth of bacteria and fungi on jute are 20% and 17% respectively. Jute attains these moisture contents when exposed to atmospheres of 90% and 80% relative humidity respectively for aerobic soil bacterial growth a temperature of 37^0 C is ideal whereas for growth it is 30^0 C. Jute materials when exposed to sunlight and rain, will become more susceptible to fungal attack [6, 9].

A change in initial pH value of the medium from acidic to alkaline and vice versa when jute specimen were embedded in mediums and kept in an incubator [5]. It was stated that this occurred due to the action of fungi only. Very limited studies were conducted on soil burial test using jute [2, 4]. The degradation studies reported above an overall view of the complex factors governing the same. However, they cannot be directly used by a geo-technical engineer from an engineering point of view [1]. The strength reduction of jute embedded in a soil having pH 8.7 after 10 months as 70 to 80% [8, 10]. It was reported that the strength reduction may be due to the alkaline environment rather than moisture in the soil. Following are the applications of geotextiles.

Fluid Transmission. Geotextile can provide fluid transmission. In the fluid transmission geotextile collects a liquid or a gas and conveys it, within its own plane towards an outlet.

Filtration. Geotextile acts as filter. In this it allows the liquid to pass through it normal to its own plane. It prevents most of soil particles to pass through it. Therefore it allows only water to pass not the soil particles.

Separation. When a geotextile placed in between fine particles and course particles it act as separator. In this geotextile avoids mixing of fine particles and coarse material like gravel and stones under the repeated action of loads.

Protection. Geotextile protects a material when it distributes the stresses and strains transmitted to the material. Under this two cases are considered, both surface protection and interface protection.

Tension Membrane. When the geotextile placed between two materials having different pressures, geotextile perform a function of tension membrane. It tries to balance the pressure difference between the two materials and the strengthening the structure. Also the geotextile act as a tensile member when it provides tensile modules and strength to a soil. This increase in strength is due to the friction, cohesion or interlocking between geotextile and soil.

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Drainage. As the geotextile is a permeable material and it plays an important role in drainage for most of the civil engineering structures like dams, road pavements, embankments etc. In which drainage of the water is most important.

3. Geotextile Applications for Drainage and Filtration

Although readily accepting water from the soil and extracting it from the field, a correctly working drain must maintain the surrounding soil. Granular and geotextile filters are covered by these general specifications. While granular sinks have a long history of success, the use of geotextiles in drains is relatively recent, with performance evidence restricted to around 25 years. The long-term output of properly chosen geotextiles was reasonable if they were not exposed to sunlight or abrasive interaction with rocks moving in response to moving surface loads or wave action. Geotextiles should not be used as a replacement for granular filters inside or on the upstream face of earth dams or within any inaccessible section of the dam embankment, provided that long-term experience is minimal. Geotextiles have been used in toe drains of embankments where they are easily accessible if maintenance is required and where malfunction can be detected. Caution is advised in using geotextiles to wrap permanent piezometers and relief wells where they form part of the safety system of a water retaining structure. Geotextiles were used to avoid the penetration into piezometer screens of fine-grained materials, but long-term efficiency was not assessed.

Granular Drain Performance:
The designer needs drain materials to meet grain size specifications depending on the grain size of the surrounding soil in order to ensure correct efficiency in granular drains. Via project experience and laboratory research, the two principal granular filter parameters, piping and permeability, have been established empirically.

Geotextile Characteristics Influencing Filter Functions:
Opening size (as compared to soil retention), flow power, and clogging potential are the key geotextile features affecting filter functions. The Apparent Opening Size (AOS) (ASTM D 4751), Permittivity (ASTM D 4491), and Gradient Ratio Test are indirectly calculated by these properties (ASTM D 5101). For the design life of the drain, the geotextile must also have the power and resilience to withstand installation and long-term conditions. Additionally, construction methods have a critical influence on geotextile drain performance.

Piping Resistance:

a. Basic Criteria
The potential of a geotextile to hold solid particles is piping resistance and is related to the size and complexity of the holes or pores in the geotextile. The critical parameter is the AOS for both woven and nonwoven geotextiles.

b. Percent Open Area Determination Procedure for Woven Geotextiles
(1) Geotextile assembly - A limited part of the geotextile to be checked should be mounted in a regular 2 by 2 inch slide cover so that it can be positioned on a slide projector and projected onto a frame. It is possible to use some strategy to retain the geotextile segment and keep it perpendicular to the projected light.
(2) Slide projector - In order to avoid the distortion of geotextile openings, the height of the slide projector should be set.

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(3) Representative area - On the 'projection board' sheet of paper, draw a rectangle of roughly 0.5 to 1 square foot area to obtain a representative area to be tested; then trace the outline of all the openings within the specified rectangle.
(4) Locating the area - After removing the cover, use a planimeter to locate the area of the rectangle. The defined area will be broken to fit the planimeter, if necessary.
(5) Total area of openings - Find the total area of openings inside rectangle, measuring the area of each with a planimeter.
(6) Compute POA by the equation:
POA=Total Area Occupied by Openings x 100 (Total Area of Test Rectangle)

c. Flow Reversals

In order to avoid drain material from penetrating holes in drain pipes, plumbing requirements are based on granular drain criteria. If flow through the installation of the geotextile drain is reversed and/or under high gradients (especially if reversals are very fast and entail major head changes), tests should be conducted to decide geotextile specifications, modeling prototype conditions.

d. Clogging

To evaluate the adequacy of the material, a gradient ratio test with observation of the material passing the geotextile might be appropriate. There would be limited internal migration for the remainder of natural soils. However, if one of the following conditions occurs, internal migration will occur under a proper gradient:

(1) The soil is graded very broadly, with a Cu coefficient of uniformity greater than 20.

(2) The soil is graded by the distance. (If these requirements occur in accordance with the possibility of exceptionally high maintenance costs, a gradient ratio test could be needed if the filtration device fails.

e. Clogging Resistance

Clogging is the loss of a geotextile's permeability or permittivity due to pores being covered either by soil particles or by biological or chemical deposits. With all geotextiles in soil contact, any clogging takes place. The findings of the permeability test should also be seen only as a reference to geotextile suitability. For woven geotextiles, the geotextiles would be resistant to clogging when the POA is sufficiently high.
For woven textiles, the POA has proven to be a valuable indicator of clogging resistance, but is limited to woven geotextiles that have different, easily measured openings. Soil-geotextile permeameters to calculate soil-geotextile permeability and clogging have been developed for geotextiles that can not be tested by POA. The gradient ratio test can be used as a measure of the degree to which geotextile existence impacts the permeability of the soil-geotextile combination (ASTM D 5101).

4. Experimental Setup

On specimens of jute cloth immersed in various conditions, deterioration behaviour was examined by performing tensile strength tests at different intervals. In various conditions, rapid degradation experiments on jute specimens were performed by maintaining them in a humidity cabinet held at a temperature of 300 0C and a relative humidity of 90+1 percent. As this state is suitable for the growth of fungi in natural materials, it has been documented in the literature. In nearly all soil conditions, minimum moisture requirements for the growth of fungi and bacteria have also been maintained.

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Fabric specimens of 70 mm × 210mm length were embedded in the following soil environments, comprising of fine grained sand clay of medium plasticity, manure and garden soil.

a. In sand at a water content of 12% (Admixture Y)
b. In clay at a water content of 45% i.e. above its plastic limit value (Admixture K)
c. Sand mixed with manure in equal proportion (1:1) at a water content of 20% (Admixture YK1)
d. Clay mixed with manure in equal proportion (1:1) at a water content of 50% (Admixture K1)
e. Sand mixed with clay and manure in equal proportion (1:1:1) at a water content of 30% (Admixture YK1)
f. Garden soil having an organic content of 8% at a water content of 30% (Admixture G)
g. Burial soil having an organic content of 3% at a water content of 6% (Admixture B)

Narrow strip tensile strength tests were conducted at regular intervals on specimens of 50mm × 75mm length obtained from the degraded specimens. The durability studies were continued till percent reduction in strength of jute fabric took place in all the admixtures.

Table 1. Summary of Physical properties of Jute fabrics [7]

Property	Woven Jute fabric Type A	Woven Jute fabric Type B
Mass per unit area (g/m^2)	675	342
Thickness at 2 KPa (mm)	1.56	1.32
Mesh size per (cm)	Four, double strands in M/D and four single strands in XM/D	Four single strands each in M/D and XM/D.
Fabric density (g/cc)	1.47	1.36
Type of fabric structure	Plain woven	Plain woven
Tensile strength (kN/m)	24.05	12.60
Wide width M/D	17.58	10.30
XM/D	25.66	13.50
Narrow width M/D XM/D	18.70	10.65
AOS (mm)	0.28	0.19
POA (%)	5.0	6.5

5. Result and Discussion

The formulation of commonly used admixtures using clay, sand, manure, garden soil and burial [7]. The reduction in strength at the end of 24 days for jute Type a under different condition is presented in Table 2.

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Table 2. Summary of percentage Reduction in strength of jute fabric (Type A), kept in different environments at the end of 24 days. (Initial strength = 25.66 KN/m)

	Combination of Materials	Initial moisture content (%)	Final Strength (kN/m)	% decay
K	Clay	45	21.3	17
Y	Sand	12	16.94	34
G	Garden Soil	30	12.83	50
B	Burial	6	11.55	55
YK1	Sand + Clay + Manure (1:1:1)	30	3.34	87
K1	Clay + Manure (1:1)	50	1.28	95
Y1	Sand + Manure (1:1)	20	0.51	98

6. Conclusion

Fine grained saturated soils exist over wide areas in plains and coastal belts. Pressing necessity of accommodating the escalating population confronted with the dearth of unutilized land poses a bottleneck situation which demands construction activities over these adverse areas. Geotextiles can play a significant role in such situations which demands construction activities over these adverse areas. Jute geotextiles can play a vital role in such situations and serve as an effective and economic tool in the rehabilitation of the nation’s highway system. General apathy towards acceptance of a new technique over existing norms should not be a factor against their utilization as overall assessment evaluated based on trend of serviceability with time reveal their efficiency in mitigating such problems. Several case histories of its applications show very encouraging results and advantageous natural properties of the fabric indicate great scope for its application in difficult road construction situation.

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