# Use of Geotextiles in Roads over Weak Subgrades

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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:** Geotextile, subgrades, pavement, separation, embedment soil.

## 1 Introduction

Transportation contributes to the all-around development of a country and hence, plays a vital role towards its progress. India being predominantly rural in nature, road links are found to have distinct advantages over other modes of communication. However, economy, time, environmental constraints among several other factors make a highway professional's job more challenging in delivering a safe and cost effective road network to its users. 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. This strata being of considerable depth cannot be removed by excavation. Thus leaving no choice but to build roads over them. This condition may be further worsened if supplemented with poor drainage or a lack of it.

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 context that jute fabric when applied at the interface of the sub-grade is found to resolve the issue by improving the quality of weak soil sub-grade. However, this concept of incorporating an extra indigenous element at the sub-grade level is by means a modern idea.

# 2 Literature Review

## 2.1 General

Bacteria and fungi are the two-main groups of microorganisms responsible for the microbial decomposition of natural textile materials [3]. 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]. It was reported that the strength reduction may be due to the alkaline environment rather than moisture in the soil.

The limited literature reveal that the rate of degradation of jute geo-textile in various environmental conditions has not been a subject of detailed study. A basic knowledge will certainly help the rational design and selection criteria for jute geo-textiles. A permeable textile material (usually synthetic) used with soil, rock or any other geotechnical engineering related material to enhance the performance or cost of a human–made product, structure or system.

## 2.2 Functions 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.

**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. For these structure different underdrain systems should be constructed. Due to use of geotextiles in these structures for drainage, efficiency of under drainage system is increased it is very easy to construct.

## 3 Geotextiles in Road Applications

This part of the paper discusses the use of geotextiles for asphalt concrete (AC) ove lays on roads and airfields and the separation and reinforcement of materials in new construction. The functions performed by the geotextile and the design considerations are different for these two applications. In an AC pavement system, the geotextile provides a stress-relieving interlayer between the existing pavement and the overlay that reduces and retards reflective cracks under certain conditions and acts as a moisture barrier to prevent surface water from entering the pavement structure. When a geotextile is used as a separator, it is placed between the soft subgrade and the granular material. It acts as a filter to allow water but not fine material to pass through it, preventing any mixing of the soft soil and granular material under the action of the construction equipment or subsequent traffic.

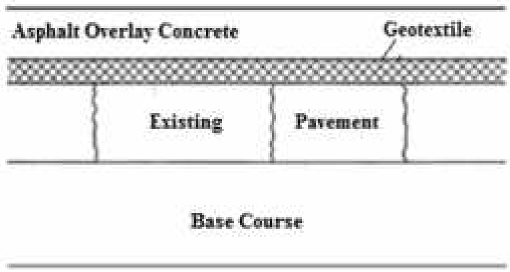


**Fig. 1.** Geotextile in asphalt concrete overlay

### 3.1 Paved Surface Rehabilitation

Under an AC overlay, a geotextile may provide sufficient tensile strength to relieve stresses exerted by movement of the existing pavement. The geotextile acts as a stress-relieving interlayer as the cracks move horizontally or vertically. Impregnation of the geotextile with a bitumen provides a degree of moisture protection for the underlying layers whether or not reflective cracking occurs.

### 3.2 Reflective Crack Treatment for Pavements

Geotextiles have been successful in reducing and retarding reflective cracking in mild and dry climates when temperature and moisture changes are less likely to contribute to movement of the underlying pavement; whereas, geotextiles in cold climates have not been as successful. Even when the climate and thickness requirements are met, there has been no consistent increase in the time it takes for reflective cracking to develop in the overlay indicating that other factors are influencing the performance.

### 3.3 Pavements Separation and Reinforcement

Soft subgrade materials may mix with the granular base or sub base material as a result of loads applied to the base course during construction and/or loads applied to the pavement surface that force the granular material downward into the soft subgrade or as a result of water moving upward into the granular material and carrying the subgrade material with it. Also, the subgrade can be stabilized with lime or cement or the thickness of granular material can be increased to reduce the stress on the subgrade. Geotextiles have been used in construction of gravel roads and airfields over soft soils to solve these problems and either increase the life of the pavement or reduce the initial cost.

## 4 Experimental Programme

### 4.1 General

Degradation behavior was studied by conducting tensile strength tests at different intervals on specimens of jute fabric embedded in different environments. Accelerated degradation tests on specimens of jute were conducted in different environments by keeping them in a humidity cabinet maintained at a temperature of 300 $^0$C and a relative humidity of 90+1%. Since it has been reported in the literature that this condition is ideal for fungi growth in natural materials. The minimum moisture requirements for the growth of fungi and bacteria were also maintained in almost all the soil environments.

### 4.2 Embedment Conditions

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 $YK_1$)
d. Clay mixed with manure in equal proportion (1:1) at a water content of 50% (Admixture $K_1$)
e. Sand mixed with clay and manure in equal proportion (1:1:1) at a water content of 30% (Admixture $YK_1$)
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 |

## 4.3 Result and Discussion

We did 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.

**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)

| Admixture | Combination of Materials | Organic Content (%) | Initial moisture content (%) | Final Strength (kN/m) | % reduction in strength |
|---|---|---|---|---|---|
| K | Clay | 0 | 45 | 21.3 | 17 |
| Y | Sand | 0 | 12 | 16.94 | 34 |
| G | Garden Soil | 8 | 30 | 12.83 | 50 |
| B | Burial | 3 | 6 | 11.55 | 55 |
| $YK_1$ | Sand + Clay + | 12 | 30 | 3.34 | 87 |

| | | | | | |
|---|---|---|---|---|---|
| | Manure (1:1:1) | | | | |
| $K_1$ | Clay + Manure (1:1) | 22 | 50 | 1.28 | 95 |
| $Y_1$ | Sand + Manure (1:1) | 22 | 20 | 0.51 | 98 |

### 4.4 Influence of fabric Density

For admixture $Y_1$, Type A lost its complete strength within 35 days and Type B within 24 days whereas it was 147 days and 90 days respectively in Admixture K. In all other Admixtures, Type A variety took longer for complete strength loss which could be to its high areal density.

### 4.5 Influence of Embedment soil

The comparatively faster rate of decrease in strength in Admixture $Y_1$ could be due to the aerobic environment prevalent in the freely draining sand which enables faster growth of microorganisms in manure. The strength of Type A has been reduced by 98% in 14 days in Admixture $Y_1$ (with manure) while that in sand alone, was only 19% in 14 days. It clearly implies that organic content accelerates the decay of the jute fiber. A large number of black spots were visible on the surface of the jute geo-textiles retrieved from Admixture $Y_1$.

The strength reduction after 14 days in Admixture $K_1$ were 86% and 58% whereas in clay alone (Admixture K). The faster rate of decomposition in the former could only be due to the presence of organic content. A general order of degradation was observed in both the verified with the exemption of Admixture G and $B_1$ (Garden soil and Burial). The Type B Variety showed a smaller strength reduction in Admixture B compared to Admixture G. More investigation is required to understand this trend.

### 4.6 Influence of soil Burial

From the burial test, it was observed that Type A variety lost its complete strength within 70 days. Whereas it was 49 days for Type B. By this time the fabric could not even withstand the handling. However the fabric was found to be in an impaired condition in the test pit but with no strength for nearly 10 and 8 months respectively before it completely coalesced with the soil. From the accelerated up gradation studies conducted, it was found that jute losses its complete strength within 3.5 months and 5 months in sand and clay respectively. Even though the fabrics lost their strength within a short span of time which depends on the type of soil moisture and organic content of soil as well as the climatic conditions, it was found that jute fabric was in an impaired condition for a further duration for a further duration of time before it coalesced with the soil. During this period, it can be presumed that fabric can perform the functions which do not require strength.

## 5 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 on the basis of 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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