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Jute Fabric in Road Construction
Les "tissés" jute pour la construction des routes

There has been a rapid growth of road development in the developing countries. Exploring successfully the possibility of using cheap and alternative types of locally available fabrics for stabilizing poor subgrade soils in place of the synthetic geotextile versions would mean a lot to these countries in terms of dollars and cents.

The jute fabric appears to hold promise as a cheap alternative to the imported synthetic versions in so far as the filtering ability, efficiency and non-clogging properties are concerned. From the point of view of durability however, long term studies are needed to be carried out.

In this paper, the authors discuss the feasibility of using jute fabric as an alternative substitute to the synthetic non-woven types of application in road construction for the developing countries.

Les pays en voie de developpement connaissent actuellement une importante croissance du reseau routier.

Des enconomies importantespeuvent etre realisées utilisant des geotextiles ayant des materiaux locaux comme counstituants.

Les tissés jute, sont une alternative economique et ayant toutes les proprietes de filtre et couche anticontaminante.

Quant a la longevite, des etudes a long terme doivent etre realisées.

Cet articles analyse la faisabilite d'utilisation des "tissés" jute en remplacement des geotextiles "non tissés", pour les foundations de routes dont les pays sont en voie de developpement.

1 INTRODUCTION

As the cost of aggregates and haul costs rise, filter fabric becomes an increasingly viable alternative to stabilize the subgrade in road construction. The use of jute fabric increases the soil CBR value and therefore the stability, prevents the intermixing of aggregate and subsoil, improves compaction and permits vertical and lateral drainage. The use of jute fabric permits material saving in the design depth of road structure reduces maintenance costs in terms of materials, labour and equipment, allows construction to proceed in inclement weather and from environmental considerations reduces the cost of excavation and therefore the silt transportation into drains and water courses. It can therefore be said that the jute fabric holds great promise for use as a geotextile in subgrade stabilization in Asian and Southeast Asian countries. The two major jute producing countries of the world are India and Bangladesh. If these two countries make use of their own product in the form of jute fabric to stabilize the subgrade soils for their several thousands of kilometers of rural roads alone for light and medium traffic, at least 10% to 20% of reduction would result by way maintenance costs. It would mean a savings of several millions of dollars which would have been spent otherwise in extra maintenance costs in local currency or in terms of foreign exchange if an alternative imported synthetic fabric had been used.

It has been reported (1) that jute has been extensively used successfully and economically in projects requiring high strength with a caution as to its rapid decay as a result of its water absorptive nature. The tests by authors have confirmed the good aspects of strength qualities of jute fabric in its fresh condition. Under the water content and temperature variations occuring within the subgrades of Singapore, the decay of jute fabric has been observed to be so slow that it does not disqualify its use as a geotextile to separate the subgrade from the sub-base in road construction. An interesting study on the feasibility of using jute fabric as a geotextile in road construction has been reported in this paper.

2 PROPERTIES OF JUTE FABRIC

2.1 Strength

The jute fabric reported in this paper consisted of tightly woven burlap of 850 g/m^2 weight. The threads used were of 3 mm diameter being made out of well twisted bundle of minute hair-like jute fibres. Typical properties of the jute fabric tested were as in Table 1.

Table 1. Properties of Jute Fabric

Grab tensile a strength (wet), N	760
Elongation at break (wet), %	15-20
Trapeziodal tear strength, N	350
Permeability, cm/sec	
- Unstressed condition	more than 10^{-2}
- Under an all round pressure of 500 kN/m^2	10^{-3} - 10^{-4}

Since the strain at failure is relatively small compared with many other non-woven synthetic fabrics, the jute fabric has a relatively high tensile modulus. It is obvious that the higher the modulus, the thinner is the required aggregate layer (2). The reduction of aggregate thickness resulting from the use of any geotextile is known to range from 20% to 60% for a subgrade soil of CBR = 1 for light to medium traffic (2).

The high tensile strength while facilitating rugged handling and damage free installation also guarantees performance ensuring continuity even under heavy compaction. The average properties of the jute fabric were not significantly different either when the fabric was dried up in the hot sun or wetted under pouring rain. Therefore it can be said that storage of jute fabric in the open despite sun or rain may not be forbidden and wet ground or rain does not impede laying of the fabric.

Jute fabric surface is rough enough to provide a good bond either with the subgrade beneath or with the aggregate layer above it.

Single layer of a coarse and heavy sacking jute fabric has been found suitable for packaging with a holding capacity of as much as 10 kN (3). Strength and creep tests have confirmed that jute fabric packs are preferable to the traditional bulk containers of metal or timber.

The strength of individual threads consisting of twisted bundle of hair-like fibres and its light weight makes the jute fabric flexible, easy to handle and to work with. The jute fabric is tough enough to resist damage due to rough handling during installation and tamping of the granular sub-base. The fabric strength prevents propogation of tears and punctures and provides excellent energy absorption capability.

2.2 Drainage

The jute fabric for use as a geotextile should consist of twisted jute fibres into threads of 2 mm to 4 mm in diameter closely woven to form a sheeting of comfortable width around 4 m rolled and supplied to the site for easy spreading on the subgrade. The jute fabric when closely examined reveals tiny square openings cris-crossed by a number of minute fibres which in turn contribute in considerable measure to the further reduction in the side of openings and aid in the filtering process. The size of the openings for the woven fabric itself can be specified to the supplier. An interesting point to note is that apart from the regular tiny openings available in the woven fabric, each twisted jute thread itself can provide a path for water by capillary action. Jute fabric therefore has the ability to absorb water and under-layment use, water moves along the plane of the fabric by siphoning action.

The filter fabric for road construction should have good mechanical-strength, sufficient permeability, capacity to retain fine soil particles, resistance to chemical and biological attack. The only non-synthetic woven fabric which satisfies most the desired properties is the jute fabric.

2.3 Clogging

It has been found by triaxial tests that clay intrustion into the jute fabric when confined alround by soft clay and subjected to gradually increasing alround pressures of up to 100 kN/m^2 was insignificant. The permeability under such conditions was never reduced below a value of 10^{-4} cm/sec.

2.4 Durability

The jute fabric is manufactured from jute fibres which are by nature strong, durable and highly resistant to decomposition under chemicals or adverse environmental conditions. The fibres are extracted from the jute plants by a process of keeping them under water for several weeks and therefore are resistent to deterioration under prolonged exposure in wet soil. The subgrade moisture in Singapore (4) and other neighbouring countries under similar climatic conditons is known to vary between 18% to 30% the year round with not much variation in subsoil temperature which would be around an average of 30°C irrespective of the season. In fact there is no well defined season for countries like Singapore and Malaysia. The jute fabric embedded in soil in such an environment is expected to remain always moist. It is never subjected to conditions such as intermittent wetting and drying or freezing and thawing. Under such conditions, the durability of the jute fabric may not be a matter of concern for a period of at least one year.

The use of jute fabric sacks for storing materials such as common salt, cement, fertilizers etc is quite well known and attests for the chemical inertness of the fibres. Laboratory studies on jute fabric exposed to acidic and alkaline environments (pH = 3 and 12)have shown that in a period of one year the tensile and tear strength are only decreased between 10% to 30%.

It is the opinion of the authors that since the subgrade gets consolidated under the self weight of the pavement as well as under the construction rolling and traffic wheel loads, it is expected to attain the maximum stability within about an year's time. The subgrade so stabilized can take care of itself without the aid of jute fabric in so far as withstanding the stresses and strains are concerned unless the traffic intensity increases beyond the one to which the subgrade has been used to with the aid of jute fabric within its first year of carrying the road on it. The question of durability of jute fabric should not therefore seriously affect its usage as a geotextile for subgrade stabilization. The drainage layer above the stabilized subgrade would stay intact and function as long as the subgrade is not overstressed.

3 PLACING OF JUTE FABRIC

The geotextile reported in this paper is made up of jute fibres woven in the form of coarse and thick (2 mm to 4 mm) fabric which can come in rolls of 4 m or more in width to facilitate easy unrolling on the surface of the subgrade to be treated.

Jute fabric is spread directly over the roughly levelled poor subgrade soil. In the case of clayey subgrades (percentage of fines exceeding 50) it is recommended to spread the fabric after placing a layer of sand of 10 mm to 20 mm thickness. The fabric is then surcharged with granular material preferably sand of 30 mm to 50 mm thickness to act as a lower sub-base and it is rolled initially with light rollers and later if possible with medium to heavy rollers.

A layer of sub-base consisting of coarse aggregate or crushed rock (locally known as crusher-run) varying in thickness from 200 mm to 300 mm may be placed over the sand layer and compacted. Under the surcharge action of sub-base layer and compaction rolling, the subgrade loses water content through the filter fabric and gains strength.

Unrolling of the fabric can be done easily manually and great accuracy in alignment is not required. For multi-lane roads an overlap of at least 300 mm is preferred where necessary. Wastage in overlapping can be reduced by just folding the edges together and stitching longitudinally by using a portable sewing machine. The fabric covering the subgrade may be spiked if necessary by the use of U-shaped spikes driven at random as necessary to keep the fabric in place during construction and rolling.

Proper placement of fabric to ensure lack of continuity with suitable overlapping or stitching wherever required is important. The extreme flexibility of jute fabric allows it to bend, and fold making it quite versatile in easy spreading.

In the event of a tear occuring, the damage remains localized and does not spread progressively like in the case of a woven cotton fabric. In this respect, the jute fabric can be considered to behave much like any other non-woven synthetic fabric. Any accidental damage does not therefore affect the overall performance of the jute fabric.

For unstable and wet subgrades, jute fabric appears to provide a satisfactory solution to stability and drainage problems. Fig. 1 illustrates the jute fabric in position within the road structure.

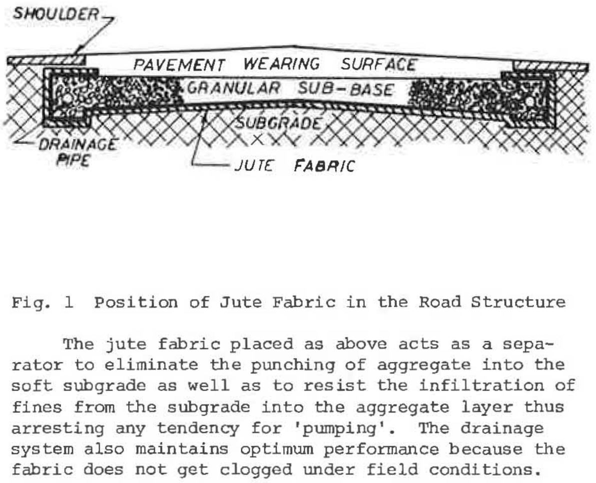

Fig. 1 Position of Jute Fabric in the Road Structure

The jute fabric placed as above acts as a separator to eliminate the punching of aggregate into the soft subgrade as well as to resist the infiltration of fines from the subgrade into the aggregate layer thus arresting any tendency for 'pumping'. The drainage system also maintains optimum performance because the fabric does not get clogged under field conditions. The high tensile strength and tear resistance make the jute fabric to act as a support membrane to reduce localized distress to the road surface by redistributing traffic loads over a wider area of subgrade. This would of courseresult in the reduction of thickness of overall road structure resulting in some reduction in the quantity of earthwork as well. It has been reported (2, 5, 6) that with the protection offered by geotextiles to the subgrade, less sub-base is needed and therefore less subgrade needs to be excavated.

Durability studies have confirmed that the fabric retains sufficient strength for about a year. Long term durability studies and the decaying of jute fabric with time under different environmental conditions are needed for proper long term assessment. In the opinion of authors, the strength and condition of the jute fabric beyond a period of one year after placement should not be of any concern as by that time the fabric would have already played a very important role in providing a self sustaining subgrade for most types of soils. After placement, the jute fabric will strengthen the subgrade by consolidating it by removing the water gradually in a step by step loading starting from the granular surcharge of sub-base, base and road surface layers, roller compaction of various layers and finally under the traffic wheel load compaction at least for a period of 6 months. The gain in strength of the subgrade with time can well be compensated for the loss of strength of the jute fabric within the same time frame. The granular drainage layer placed above the stabilized subgrade would continue to function permanently.

4 LABORATORY STUDIES

In order to study the influence of jute fabric on the strength of clayey subgrade, unconfined compression tests and CBR tests were carried out in the laboratory on samples compacted with and without fabric layers in the saturated and unsaturated conditons. The standard proctor compaction tests were carried out on soils without fabric as well as on samples with 2 layers of fabric embedded at mid-depth. Fig. 2 shows the effect of a fabric layer on the soil compaction characteristics. For the same compaction effort, the soil is seen to be better compactible when the fabric is used.

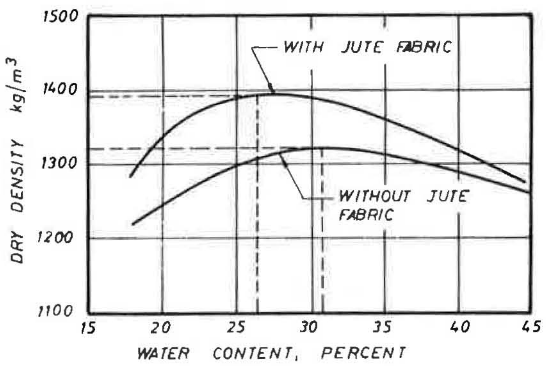

Fig. 2 Effect of Jute Fabric on Compaction Characteristics of Subgrade Soil

The unconfined compression tests were carried out on samples compacted to 100 mm diameter and 200 mm long at the standard proctor compactive effort using optimum moisture content of 25%. For these tests, two layers of jute fabric were introduced within the sample at equal intervals. The CBR tests were carried out compacting the samples in the standard CBR mould at the same moisture content as above. For these tests with jute fabric, two layers were interposed within the samples at equal intervals while compacting. Tables 2 and 3 respectively show the influence of fabric on the unconfined compressive strength and CBR values of samples compacted in the laboratory.

Table 2. Effect of Jute Fabric on Unconfined Compressive Strength

Water content, %		25	30	35
Unconfined Compressive Strength, kN/m^2	without fabric	110	45	36
	with fabric	300	115	65
% strain at failure	without fabric	8	10	22
	with fabric	26	30	42

Table 3. Effect of Jute Fabric on CBR Value

Water content, %		20	25	30	35
CBR Value %	without fabric	5.0	4.7	3.5	2.6
	with fabric	8.0	6.8	5.2	4.5

The laboratory test results conclusively show that the stress-strength characteristics of the soil are better with the jute fabric than without it.

5 FIELD TESTS

Since the laboratory tests gave only a qualitative indication of the beneficial effect of jute fabric, plate load tests were conducted to evaluate the insitu behaviour of the subgrade. The subgrade soil was soft to medium silty clay of natural water content of 35% and vane shear strength (insitu) of 20 kN/m^2. Plates of 300 mm diameter were loaded keeping them directly on the surface of the uncompacted subgrade in the first series and on the surface of jute fabric spread over the subgrade in the second series. The average results are shown in Fig. 3.

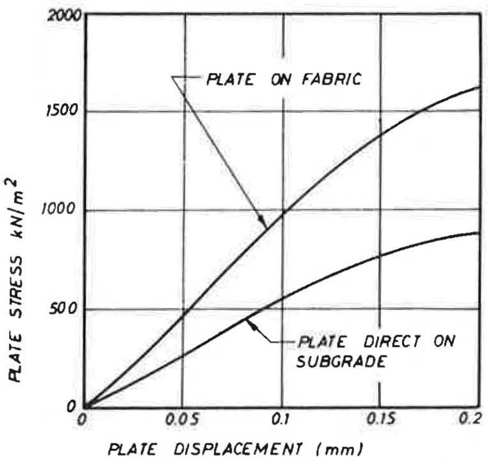

Fig. 3 Effect of Jute Fabric on Bearing Capacity of Subgrade Soil

The plate load tests confirmed that the jute fabric significantly improves the bearing capacity and settlement behaviour of the subgrade soil. The results of tests carried out using jute fabric were in tune with similar tests reported (7) using synthetic fabric.

A separate study of model footing on foundation soil reinforced with jute strips being conducted at the Department of Civil Engineering, National University of Singapore, has also confirmed that reinforcing the subgrade significantly helps in distributing the load over a wider area and thus resulting in enhanced bearing capacity and reduced settlement. In the case of a road, this would result in a reduced overall thickness of road structure and less earthwrok when jute fabric is used as an intervening membrane between the subgrade and the overlying thin granular sub-base layer.

6 JUTE FABRIC DRAIN

A type of flexible drain known as fibredrain made out of jute fabric suitable for consolidation of soft compressible soils under highway embankments etc., has been developed and field tested by the staff of the Department fo Civil Engineering, National University of Singapore. The fibredrain is patented in the United Kingdom. The drain consists of a rectangular strip of 100 mm width and 4 mm thick obtainable in the form of rolls in lengths of 200 m to 300 m. The drain strip itself consists of two fibre strands of 2 mm to 3 mm diameter laid longitudinally parallel to each other and enveloped by one or two layers of jute fabric held together by longitudinal stitches. Such drains can be inserted into the ground vertically at spacings of 1 m to 2 m in a triangular or square grid pattern and the ground surcharged by a preload fill of permeable soil. The rate of consolidation depends upon the type of soil being treated, the drain spacing and the surcharge load. Field tests have indicated (8) satisfactory performance of these drains with respect to drainage, non-clogging and non-deterioration within a period of 2 years of observation. Soft compressible marine clay upto 20 m depth was able to be consolidated to increase the shear strength from 15 kN/m^2 to 50 kN/m^2. These jute fibredrains besides being used for consolidating deep seated compressible soils under highway embankments can also be effectively used for vertical drainage to relieve hydrostatic pressure beind the retaining walls which occur frequently along roads in hilly terrain.

7 CONCLUSIONS

The jute fabric has the potential of being used to serve as a filter fabric as well as a fabric reinforcement to stabilize and protect weak subgrades in road construction. When the jute fabric is palced directly on the subgrade and topped with a granular backfill to form a sub-base for the pavement, it is found to function in a three fold way: (i) it separates the subgrade from sub-base thus preventing the punching of the base material into the subgrade and at the same time the fines from the subgrade are also prevented from gaining entry into the road structure, (ii) it acts as a drainage layer to remove excess water from softening the subgrade, and (iii) it helps to improve the bearing capacity and settlement behaviour of the subgrade by virtue of its action as a fabric reinforcement.

The jute fabric is expected to contribute towards better road performance by reducing road defects with the consequent reduction in maintenance costs. The economy resulting in reduced road thickness design and construction time is an added bonus.

While the jute fabric as a geotextile appears to function quite close to synthetic non-woven fabrics in performance, its durability aspect seems to pose a serious limitation on its use. However, jute fabric is founded to be fairly resistant to deterioration when embedded in wet soil under a narrow margin of annual variation in subgrade water content (18% to 30%) and subgrade temperature (25°C to 30°C) conditions prevailing in the geographical region of Singapore and Malaysia. There is little doubt that the jute fabric is initially very stong and ideal for use as a geotextile material. After it is placed on the weak subgrade, the subgrade stiffens and becomes stronger on consolidation within about a year or so under the action of granular sub-base surcharge, self weight of pavement, construction rolling and traffic loads. The jute fabric immensely helps in this rapid subgrade strengthening process in combination with the drainage layer above it. With time, the subgrade becomes less and less dependent on the fabric for its stability and therefore, the long term durability aspect of jute fabric should not deter its use as a geotextile for subgrade stabilization in road construction.

The jute fabric is useful for developing countries of Asia and South East Asia as a money saver as well as a construction expedient. The advantages resulting by its use will more than outweigh the cost of the material and laying. Being in the vicinity of jute producing countries, the developing countries of Asia and South East Asia can harness the benefits of jute fabric especially for subgrade stabilization in road construction. For these countries, the jute fabric could serve as an economical alternative to the imported versions.

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