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# A Study on Tensile Properties of Emulsion Coated Sisal Geotextile

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**Abstract.**

This study investigates the effect of three types of bitumen emulsion coating, i.e., dipping, painting, and spraying techniques, on woven sisal geotextiles' physical and mechanical properties. The physical properties include mass per unit area, while the mechanical properties involve tensile strength and elongation. The results revealed that dipping has the maximum mass per unit area and extension at break compared to painting and spraying. Furthermore, the painting technique gave better tensile strength than spraying and dipping. The study outcomes are compared with the literature wherever applicable.

***Keywords:*** *Geotextile, woven, strength.*

## 1 Introduction

Geotextiles are mainly used to increase soil stability, control erosion, and improve bearing capacity. They can be manufactured from either synthetic products like polyester and polyamide or natural materials like jute, coir and others. Natural geotextile usage is gradually increasing due to sustainability concerns, particularly for short-term stability problems in Geotechnical engineering.

A major drawback in using these products is their hydrophilic nature leading to their decomposition over time. The literature suggests ways to extend its longevity by slowing biological degradation with treatments using antimicrobial chemicals and coatings, thereby preventing microbial assaults [2], [3]. For instance, the effectiveness of cashew nutshell liquid- modified coir geotextiles in preventing microbial assaults and environmental degradation has been studied [4]. The study conducted by researchers ([8], [5], [12]) on the durability of emulsion-coated jute/coir geotextiles indicated a reduction in the degradation effect of the samples and thereby increasing their longevity. [13] mentioned that the lifespan of emulsion-coated jute geotextile may range upto 90 days.

Following the literature, it is perceived that there is a lack of concern in studying the effect of sisal geotextile coated with bitumen emulsion. The present study tries to fill this gap. The current study tries to find the best method for emulsion coating through dipping, painting and spraying to achieve better tensile properties. It is anticipated that the outcome of this study will help promote the use of sisal geotextile as reinforcement in various problems in Geotechnical engineering. Following these observations from the literature, it is anticipated that the present emulsion-coated sisal geotextile will be durable with a lifespan similar to that of coated-coir/jute geotextile. However, a detailed study in this regard is required, which forms the future scope of the work.

## 2 Materials and Methods

### 2.1 Materials

Figure 1 shows the woven sisal geotextile used for the study procured from a handloom factory. The bitumen emulsion for coating the geotextile was procured from the local market. The emulsion had a penetration of 46 mm at 25 °C per 100 gm and softening point of 46.5° [8].

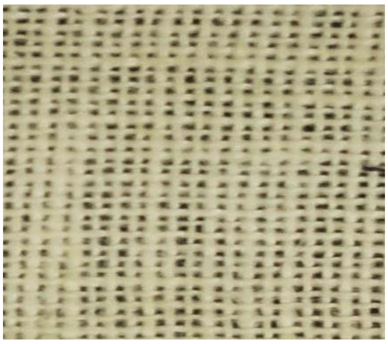

**Fig.1.** View of the sisal geotextile

### 2.2 Coating Techniques

As stated, the geotextile was coated using three different techniques: dipping, painting, and spraying. The dipping process involves direct dipping of the sisal geotextiles into bitumen emulsion and taken out immediately. Bitumen emulsion is applied at an application rate of 0.03g/ $cm^2$ and 0.01 $g/cm^2$ in case of painting and spraying respectively. The specimens are painted using a soft brush and sprayed using manual sprayer. The prepared


samples were kept under shade for a week and then in sealed plastic wrappers for testing. The visual appearance of dipping, painting, and spraying samples are depicited in Fig. 2.

**Fig.2**. Visual appearance of (a) Dipping, (b) Painting, and (c) Spraying samples

### 2.3 Mass per unit area

The samples were cut in sizes of 100 mm×100 mm and then weighted in a sensitive balance of accuracy of 0.001g [7]. The mass of the sample was divided by its area to get the mass per unit area. The average was calculated by testing the three pieces.

### 2.4 Tensile strength

The wide-width tensile strength in the machine (MD) and cross-machine direction (CMD) was performed as per [1]. Two replicated samples of each type and in each direction were tested, and strength and elongation at break were averaged and reported. A similar number of replicas has been tested by [8].

## 3 Results and Discussions:

### 3.1 Variation in mass per unit area

Table 1 shows the mass per unit area. The mass per unit area of untreated, dipping, painting, and spraying are 240 g/m$^2$, 516.9 g/m$^2$, 297.5 g/m$^2$, and 256.3 g/m$^2$. Compared to untreated, the mass per unit area increased by 115.4%, 24%, and 6.8% with dipping, painting, and spraying, respectively. The dipping technique maximizes as more material adheres to the surface, followed by painting and spraying.

**Table 1.** Table showing mass per unit area

| Coating Type | Mass per unit area (g/m$^2$) |
|---|---|
| Untreated | 240.0 |
| Dipping | 516.9 |
| Painting | 297.5 |
| Spraying | 256.3 |

### 3.2 Variation in Tensile properties

Figure 3 shows the strength elongation curves for untreated, dipping, painting, and spraying specimens, and Table 2 shows their corresponding peak values. In Figure 3, the solid line represents MD, whereas the broken lines correspond to CMD. The tensile curves have three parts. The first part begins with a shallow slope indicating yarns' crimping and de-crimping effect. De-crimping of the yarns happens simultaneously with crimping in the CMD when a force is applied along the MD, and vice versa. The second part indicates that strength increases linearly with elongation, implying the yarns have started taking load until failure. Following the summit, a zig-zag pattern happens because of the breakage at different stress levels. Failure of yarn probably starts at a thinner location. If one fails, another starts taking a load, resulting in a saw-toothed type curve.

In MD and CMD, the mean tensile strength of untreated specimens is 15.27 kN/m and 11.84 kN/m, respectively. It increases to 19.2 kN/m and 16.8 kN/m on dipping in the emulsion. More importantly, painting boosts the strength to 22.62 kN/m and 20.40 kN/m. Moreover, the tensile strength on spraying rises to 18.1 kN/m and 14.3 kN/m. Hence, dipping in MD and CMD boosts tensile strength by 25.74 % and 41.9% compared to untreated geotextiles. On a similar line, tensile strength improved to 48.1% and 72.3% after painting. Finally, spraying enhances tensile strength by 18.5% and 20.8% in MD and CMD, respectively.

In MD and CMD, elongation at the break of untreated specimens is 4.87% and 10.25%, respectively. It became 5.87% and 13.2% in dipping and 5.1% and 12.61% in painting, and 4.97% and 11.85% in spraying, respectively, in MD and CMD. Since MD is the weaving direction, it is stronger than CMD. Of course, the yarns are stiffer, for which the elongation is lesser.

Emulsion applied on woven geotextiles acts as a binder that strengthens the specimens by forming fibre–fibre and yarn-yarn bonding, resulting in an agglomerated type structure [10],[11]. Tensile strength is reported to decrease when a higher proportion of bitumen is applied [10], as in the case of dipping. This is due to increased web bonding caused by extra bitumen, which inhibits fibre mobility by removing friction between them, resulting in failure at a lower load [10]. The web bonding increases in the order of spraying, painting, and dipping. Simultaneously, the frictional resistance between fibres and yarns decreases in the order of spraying, painting, and dipping. As a result, the painting technique provides an optimum balance between the yarn bonding and friction for maximum improvement in tensile strength.

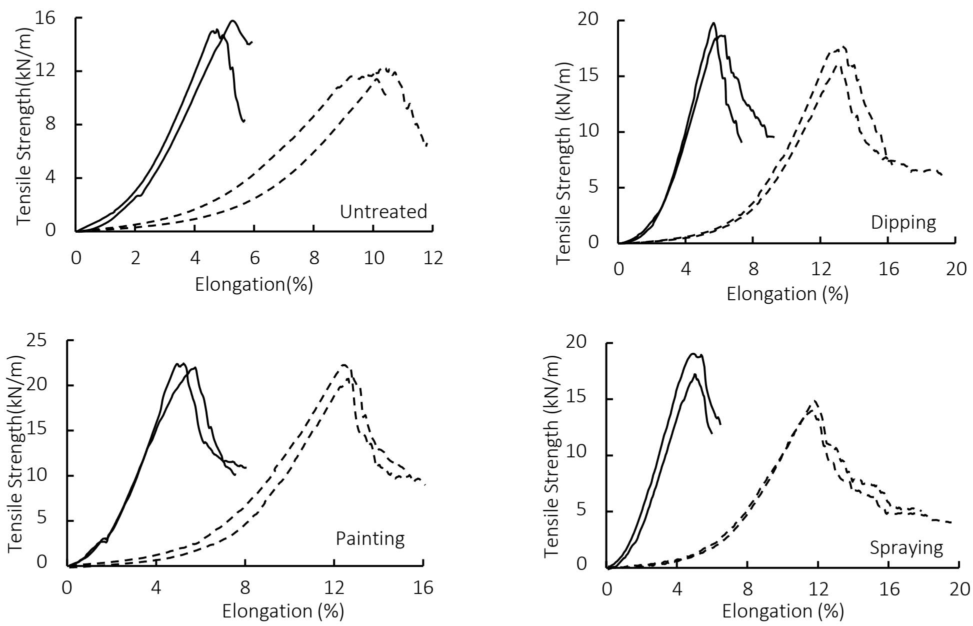


**Fig. 3.** Tensile strength vs. Elongation curves

**Table 2.** Average ultimate tensile strength versus elongation

| | | Untreated | Dipping | Painting | Spraying |
|---|---|---|---|---|---|
| Average tensile strength (kN/m) | MD | 15.27 | 19.2 | 22.62 | 18.1 |
| | CMD | 11.84 | 16.8 | 20.40 | 14.3 |
| Average tensile elongation (%) | MD | 4.87 | 5.87 | 5.10 | 4.97 |
| | CMD | 10.25 | 13.2 | 12.61 | 11.85 |

# 4 Conclusions:

Here is a summary of the study:

1. Compared to untreated samples, the mass per unit area of the coated sample increased from 6.8% to 115.4%. The dipping technique provided a maximum improvement of 115.4%, followed by painting and spraying.
2. The tensile strength of coated samples lies within (18.1 kN/m -22.62 kN/m) in MD and (14.3 kN/m - 20.40kN/m) in CMD, with painting leading to a maximum enhancement of 48.1% and 72.3%, respectively, followed by dipping and spraying.
3. Tensile elongation of coated samples ranged from 4.97% to 5.87% in MD and 11.85% to 13.2% in CMD, with a maximum for dipping followed by painting and spraying.

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