The Use of Sisal Fibre as Natural Geotextile to Control Erosion

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ABSTRACT: A study was conducted into the use of a natural, biodegradable geotextile for the containment and control of soil erosion. The viability of using the natural fibre from the sisal plant (Agave sisalana) for the manufacture of such a geotextile was assessed and the performance of this material was compared to more commonly used fibres like coir and jute. This report provides a brief summary of the various laboratory and field tests which were used to evaluate the different materials and some significant test results. The report shows that sisal fibre compares very favourably with other natural fibres. The sisal fibre geotextile provides protection against soil erosion for a period of up to two years while at the same time creates a suitable micro-climate for the germination and growth of new vegetation.

1 INTRODUCTION

Erosion control methods of particular interest to civil engineers are classified as engineered agronomic systems. Agronomic methods involve the utilization of vegetation or a covering of some kind to offer protection against the forces of erosion. (Ingold and Thomson, 1990)

2 THE EROSION PROCESS

This paper addresses the phenomena of surface erosion by rainwater and subsequent runoff and disregards the influence of other types of erosion such as glacial, marine and river erosion.

The forces responsible for rainwater erosion can be divided into two main mechanisms:

- detachment and movement of soil particles due to rain drop impact.
- detachment and transport of soil particles due to surface water flow.

3 NATURAL GEOTEXTILE AS EROSION CONTROL MEASURE

The purpose of a natural geotextile is to protect and support the natural environment for a limited timespan. This task is complete when nature, through soil and vegetation, eventually provides adequate protection. The natural geotextile provides temporary aid for the establishment of natural vegetation used as long term erosion control. The use of vegetation for this purpose is particularly attractive for the following reasons:

- self-regenerating
- minimal maintenance costs
- environmentally acceptable
- aesthetically pleasing
- inherent engineering properties.

(Morgan and Rickson, 1988)

When one considers that much of Southern-Africa is classified as a semi-arid region and that the bulk of rainfall is in the form of heavy thunder showers, it can be understood that soil erosion becomes a very real problem.

4 SISAL AS NATURAL GEOTEXTILE

Sisal is a perennial plant (Agave Sisalana) originating from Central-America. Sisal fibre is derived by stamping the leaves to pulp and extracting fibres from this pulp. The fibres are dried and woven into geotextiles by mechanical means.

5 LABORATORY TESTS

Tests were conducted in order to determine some characteristics for the different materials used for the manufacture of natural fibre geotextiles.

5.1 Unit weight of fibre

Unit weight of four types of geotextiles were determined as follow:

Table 1. Unit weight of natural geotextiles tested.

Name	Unit weight g/m^2
"Light" sisal	300
"Heavy" sisal	1000
Coir	1100
Jute	330

5.2 Water absorption

The higher the water absorption by a natural geotextile, the better it is because of less water available for slope runoff. Tests done by Ingold and Thomson (1986) concluded that the effectiveness of a jute geotextile has much to do with reductions in run-off. This phenomenon is related to the absorption of the rainwater by the material and also to the surface depression storage of water in the cells of the thick mesh. Figure 1 illustrates the different water absorption capacities of the materials tested.

It is clear that the jute fibre absorbs more than twice the weight of water compared to sisal or coir. The sisal compares favourably with the water absorption capacity of the coir.

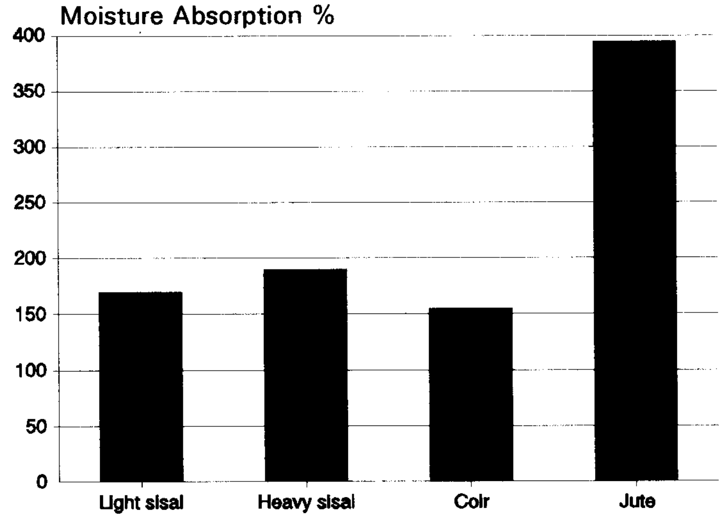

Figure 1 Moisture absorption as percentage of dry weight of natural fibre geotextiles.

5.3 Ageing tests

Ageing tests were conducted in order to determine the tempo and the mechanism in which the sisal fibres decompose compared to the coir and jute materials. Two series of ageing tests were done:

- ultraviolet radiation
- exposure to the atmosphere.

5.3.1 Ultraviolet radiation test

South-Africa have amongst the highest levels of ultraviolet radiation in the world. It is therefore important for any exposed material to be resistant to this radiation.

The tests were conducted by doing tensile strength tests on strands of the various materials before and after exposure to accelerated radiation. The strands were exposed to 240 hours of radiation in a Xenon radiation accelerator. The strength of the strands prior to radiation was taken as 100 % of the tensile strength. The strength measured after radiation was compared to these values. Figure 2 shows the results of these tests.

From these tests it was clear that sisal fibre outperforms both the coir and the jute fibres. After the radiation period, the sisal fibre has lost approximately 30% of its strength compared to the 57% of the coir and the 34% of the jute.

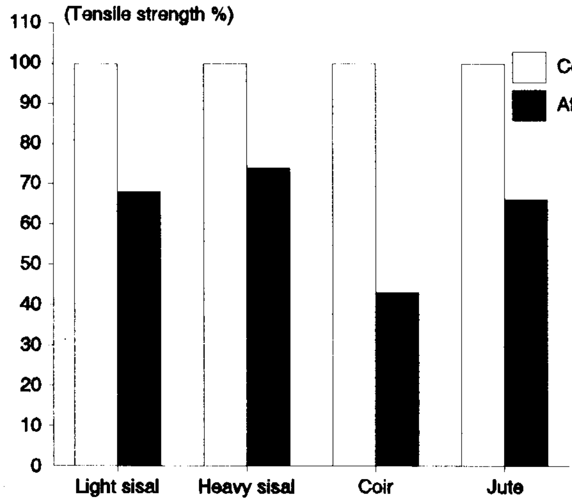

Figure 2 Tensile strength of natural fibre strands after ultraviolet radiation.

5.3.2 Exposure to the atmosphere

Sisal and coir samples were exposed to atmospheric conditions in Johannesburg for a period of one year. Every 30 days, samples of the fibre were subjected to tensile strength tests. Using this data, a graph of tensile strength vs. exposure time was constructed. The result is an indication of the expected lifespan of the different materials and is presented in figure 3.

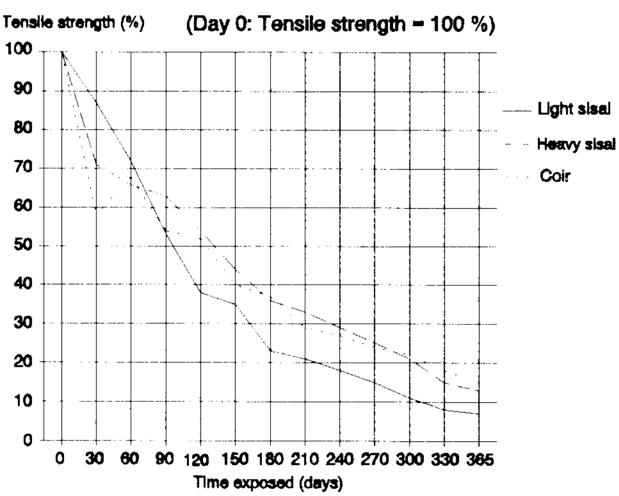

Figure 3 Tensile strength vs. time of exposure to atmospheric conditions in Johannesburg, South-Africa.

6 FIELD TRIALS

Field trials using various materials were conducted on Table Mountain in Cape Town as well as in Johannesburg. The purpose of these trials was to investigate the lifespan of the natural geotextiles under field conditions and to determine the effect of these systems on vegetation establishment and on the rate and amount of soil erosion.

The process of monitoring was done over a period of nine months and included such activities as taking soil samples for moisture content measurements, visual and photographic studies and taking of samples of the natural fibre strands to determine the rate of degradation by doing tensile strength tests.

6.1 Conclusions derived from field tests.

Figure 4 gives an indication of the loss in strength of the geotextiles after six months of in-situ service.

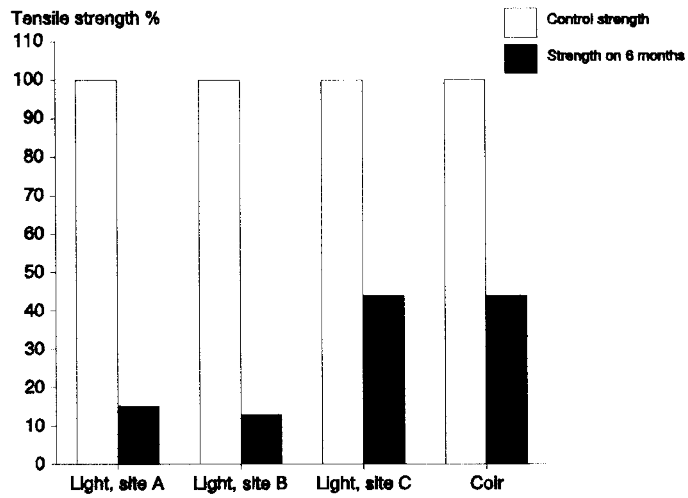

Figure 4 Strength of natural geotextile material six months after installation.

The percentage grading system as previously described was used. The light sisal geotextile installed at sites A and B had the greatest strength loss after the six month period. Reductions of respectively 85 % and 87 % in strength were recorded. The light sisal at site C however had a strength loss of 56 %. This could be attributed to the fact that sites A and B were more moist than site C. These results led to the conclusion that the rate of degradation of the sisal fibre is accelerated in the presence of prolonged moist conditions. The coir performed well under the circumstances and after the six month period had only lost 56 % of its initial strength.

6.2 Effect on vegetation

The effect of the material on vegetation establishment was visually determined by the taking of time lapse photographs. Areas with geotextiles and control areas without geotextiles were photographed every second month. These photographs were then visually compared to determine the growth rate and pattern of vegetation in these areas. By visual inspection it could be concluded that all the geotextiles had a positive effect on the germination and growth of the vegetation.

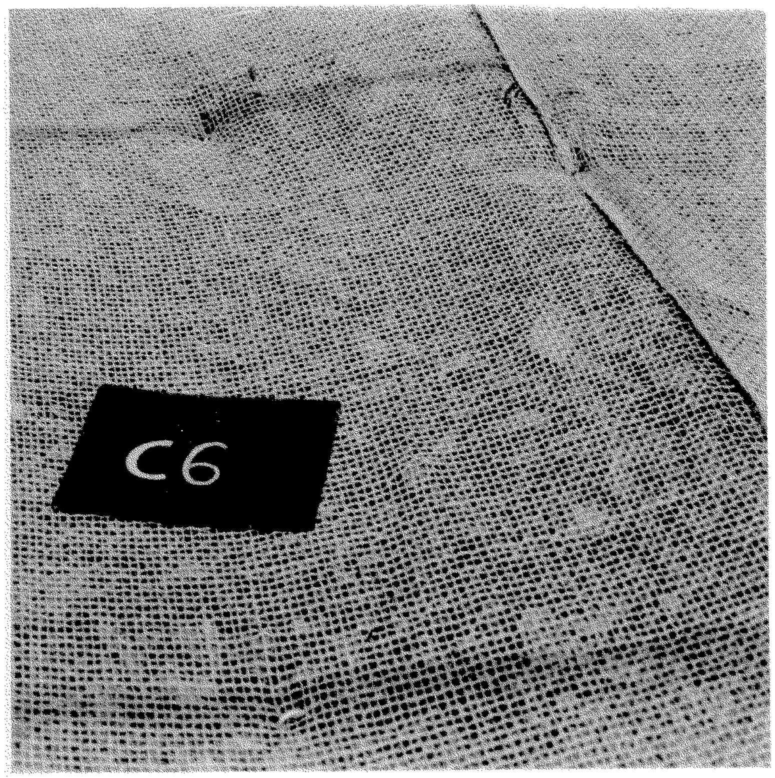

Figure 5 An example of a time lapse photograph taken just after installation on Table Mountain.

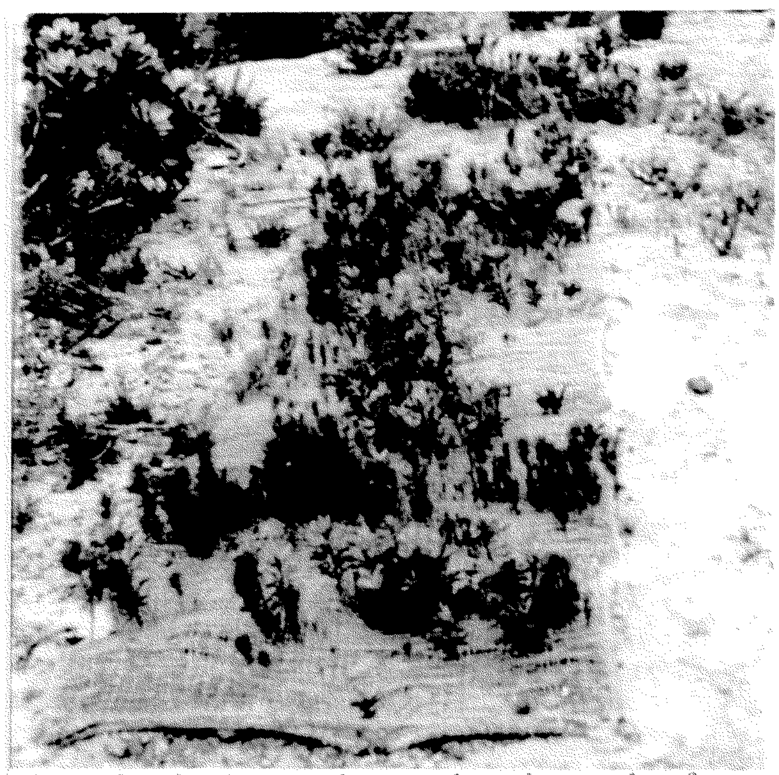

Figure 6 This photograph was taken six months after installation on Table Mountain.

7 CONCLUSION

Sisal fibre is available in abundance in Southern-Africa and the study has indicated that sisal fibre has all the physical characteristics to be used as a natural fibre geotextile material.

The authors of this paper are convinced that the large scale use of this fibre as a natural geotextile will prove to be economically feasible in Southern-Africa for two reasons:

- The use of the natural geotextile can assist in controlling the serious problem of soil erosion in Southern-Africa (and the rest of the world) in a natural and environmentally friendly way.
- Growth in the use of sisal for such products can stimulate the economy and create new employment opportunities.

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