1529

FINAL REPORT

USE OF WASTE CELLOPHANE IN THE CONTROL OF SEDIMENT

by

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Virginia Highway and Transportation Research Council
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INTRODUCTION

The commitment of the Virginia Department of Highways and Transportation to minimize the environmental impact of its operations involves constant upgrading and improvement of environmental safeguards. The gratifying rate of improvement is particularly evident in the control of erosion and sediment, where the development of new materials and techniques has been very rapid over the past decade. Another aspect of the Department's commitment involves the constructive use of industrial waste materials whenever feasible in its operations.

During 1977 it was brought to the attention of the Department that low cost waste cellophane was available from a plant at Fredericksburg, Virginia. Waste in the form of ribbon and strips could be purchased for approximately $0.75 per bale. Since this price was less than that for straw, the Environmental Quality and Management Services Divisions requested that the Research Council determine the feasibility of using waste cellophane in the control of erosion and sediment. The purpose of this report is to present the results of tests conducted to determine the capabilities of the cellophane for this use.

WASTE CELLOPHANE

Cellophane is a clear film made from wood cellulose. It is inexpensive to produce and has been widely used in the packaging industry. In addition to pure cellophane, large volumes of plastic coated cellophane and laminated cellophane-plastic films are manufactured for use in the packaging industry. Banerjee and Wielicki (1974) estimated the amount of waste cellophane and plastic film would reach 1.46 million tons per year, or 2% of the total U. S. solid-waste load, by 1976. They foresaw part of this total coming from waste generated during manufacturing and packaging operations. It is this material which could be available in large quantities from a supplier such as the plant at Fredericksburg.

Cellophane is biodegradable, breaking down rather rapidly in a soil environment. Banerjee and Weilicki (1974) found that pure cellophane film degrades in two weeks or less in soil. Cellophane with plastic coatings takes longer — up to 12 weeks, which is still less than the 12 to 15 weeks noted for the disintegration of maple leaves but equal to or longer than the time required for the breakdown of straw.

Waste cellophane at the plant takes the form of ribbons and stringers of material. It was found that when baled or stuffed into net bags, these wastes might have sediment filtering properties similar to those of baled hay or straw.

LABORATORY TESTS

The tests conducted for this research were designed to evaluate the sediment filtering efficiency and the rates at which water flowed through waste cellophane stuffed in net bags. All of the work was done in the Research Council laboratory with a flume especially constructed for testing the sediment trapping capability of materials used for sediment control. A total of 9 net bags stuffed tightly with waste cellophane were used in the tests.

Three soils were used to simulate sediment-laden storm water. Figure 1 shows the gradation curve of each soil. The three soils were selected as typical of those occurring in the major geologic regions of Virginia. One was a clayey soil overlying limestone bedrock collected in the Valley and Ridge areas of western Virginia. A silty soil overlying a mica rich granite was obtained from the Piedmont area; and the third was a sandy soil overlying the relatively young sediments that underlie the Coastal Plain area.

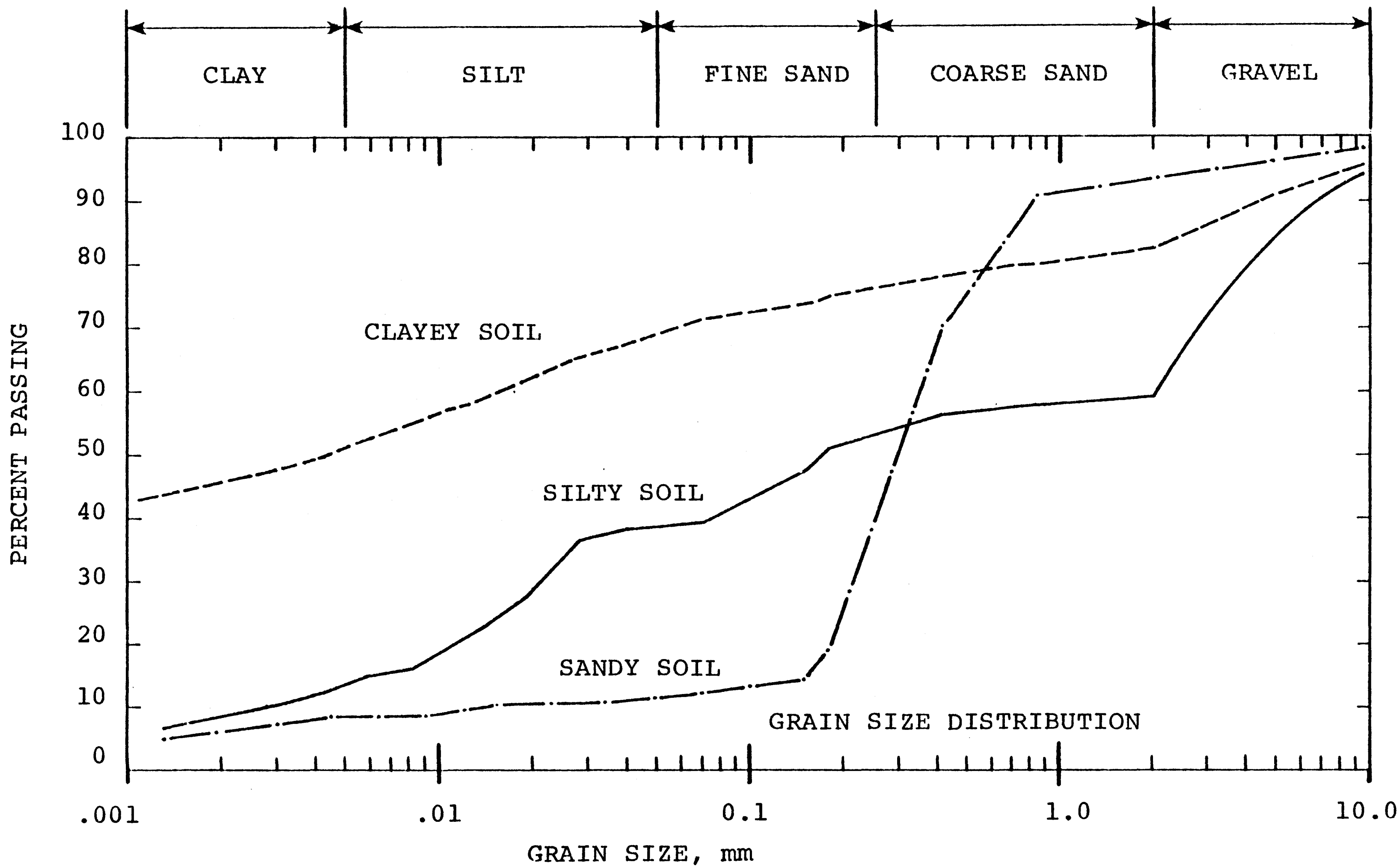

Figure 1. Gradation cur-es for three soils used.

1536

Fifty liters of water containing 3,000 parts per million (ppm) of suspended sediment were used for each test. Three cellophane filled bags were tested with each soil-water mixture, and three 50-liter runs were made on each bag. Table 1 contains a summary of all tests made in the flume.

TABLE 1

Summary of Laboratory Flume Tests Using Cellophane Bales

Soil	Bag	Run	Avg. Flow Rate, Gal/Min.	Sediment Trapped, %
Sandy (Coastal Plain)	A	1	5.3	98
		2	4.3	97
		3	3.7	97
	B	1	8.5	98
		2	4.6	97
		3	3.8	97
	C	1	8.7	98
		2	3.3	97
		3	3.2	98
Micaceous Silt (Piedmont)	A	1	20.4	84
		2	23.4	75
		3	31.4	76
	B	1	6.1	86
		2	4.7	80
		3	3.3	77
	C	1	12.7	84
		2	3.6	84
		3	3.1	82
Clayey (Valley and Ridge)	A	1	3.8	94
		2	1.7	95
		3	1.1	96
	B	1	8.0	93
		2	5.8	91
		3	2.8	95
	C	1	3.4	93
		2	2.3	94
		3	1.5	93

Flow rates ranged from 1.1 to 31.4 gallons per minute. Table 2 shows the average flow for bagged cellophane compared with other common sediment filtering materials when tested with a micaceous sediment-laden water. It is evident that flow rates for cellophane are faster than those for any of the other filtering materials (Table 2). As expected, the lowest flow rates were obtained with the clay-water suspensions. One set of test results for silty soil shown in Table 1 appear to be significantly higher than expected and may be due to incorrect packing of the cellophane in the net bag.

The sediment trapping efficiencies for bagged cellophane shown in Table 1 appear to be quite good. All runs with clayey and sandy soils resulted in over 90% sediment retention. Retention of the silty soil ranged from 75% to 86%; and even these values compare quite well to those of the other filter materials in Table 2. The average trapping efficiency of 81% for bagged cellophane is 14 percentage points higher than the 67% value for the baled straw and only slightly lower than the 87% trapped by burlap. All figures in Table 2 were generated using the silty Piedmont soil.

TABLE 2

Flow Rates and Trapping Efficiencies of Cellophane Bales and Other Sediment Filtering Materials, Tested With Piedmont Soils

Material	Flow Rates, Gal/Min	Sediment Trapped, %
Baled Cellophane	12.10	81
Straw Bale	5.52	67
A Typical Woven Filter Fabric	0.14	95
Burlap	4.96	87

The largest particles, on the average, passing through the bagged cellophane from the silt-sediment-laden water were the 0.01 mm grain sizes. As shown in Figure 1, the silty soil is a fairly uniformly graded material. For the more nonuniform clayey and sandy soils the largest particles passing through the bagged cellophane were 0.001 mm in size.

COST ANALYSIS

Table 3 contains relative cost data per linear foot of filter barrier for the common sediment filtering materials. These figures are for materials alone and do not include installation costs. As can be seen, waste cellophane is very competitive at $0.25 per linear foot. This rate puts bagged cellophane between the $0.07 per linear foot for burlap and $0.70 per linear foot for baled straw. Filter fabrics, as expected, are slightly higher at $0.90 per linear foot.

TABLE 3

Approximate Cost Data for Selected Sediment Filtering Materials

Material	Cost per Linear Foot of Filter Barrier
Baled Cellophane	$0.25
Straw Bale	$0.70
Filter Fabric	$0.90
Burlap	$0.07

CONCLUSIONS

Based on laboratory flume tests it appears that waste cellophane can be used effectively for trapping and filtering waterborne sediment. The removal of 81% of the silty sediment from suspension by cellophane is higher than for straw bales but less than for burlap and a typical woven filter fabric. Waste cellophane is also competitive in costs with other sediment filtering materials. For example, the $0.25 per linear foot for cellophane is significantly less than the $0.70 per linear foot now paid for baled straw. Like straw and burlap, cellophane has been found to be biodegradable in a soil environment and to give off no known toxic or other deleterious effects.

RECOMMENDATION

It is recommended that the use of waste cellophane bales or net bags stuffed with waste cellophane be allowed in place of straw bales for erosion and sediment control by the Virginia Department of Highways and Transportation.

Note: Due to the lack of general availability of waste cellophane in many areas and the fact that the Fredericksburg plant has recently suspended operations, cellophane should not be specified for sediment control but should be allowed as a substitute for straw bales.

1538

REFERENCE

Banerjee, S. K., and Wielicki, E. A. 1974. "How Quickly do Packaging Films Disappear Down in the Dirt?" Package Engineering, Cahners Publishing Company, Inc.