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Survivability of Subgrade Separators

I. Introduction

One of the earliest roles for geotextiles was as a separator between an aggregate base and underlying weak soils. This remains as one of the primary uses for geotextiles. In this application, the geotextile must prevent the movement of fines from the subgrade into the base aggregate. This separation maintains the integrity of the base aggregate and allows an increase in the allowable bearing stress acting on the subgrade.

This paper presents the results of observations and laboratory testing on four different types of fabrics which have been exposed to very similar construction stresses and traffic loadings.

II. Application Background

In 1981 four different geotextiles were utilized in the construction of a paved parking lot at the S&ME, Inc. (now Westinghouse-EGS) Atlanta branch office. As shown in Figure 1, the fabrics were placed in strips perpendicular to the flow of traffic in the parking area. Two of the fabrics were woven slit tape material. The others were nonwoven fabrics: one spunbonded and the other needlepunched.

The fabrics cover two distinctly different traffic zones as shown in Figure 1. Area A was used primarily for parking, while area B was subjected to traffic consisting of delivery trucks, various construction vehicles, lowboys carrying drill rigs, and client and employee automobile traffic.

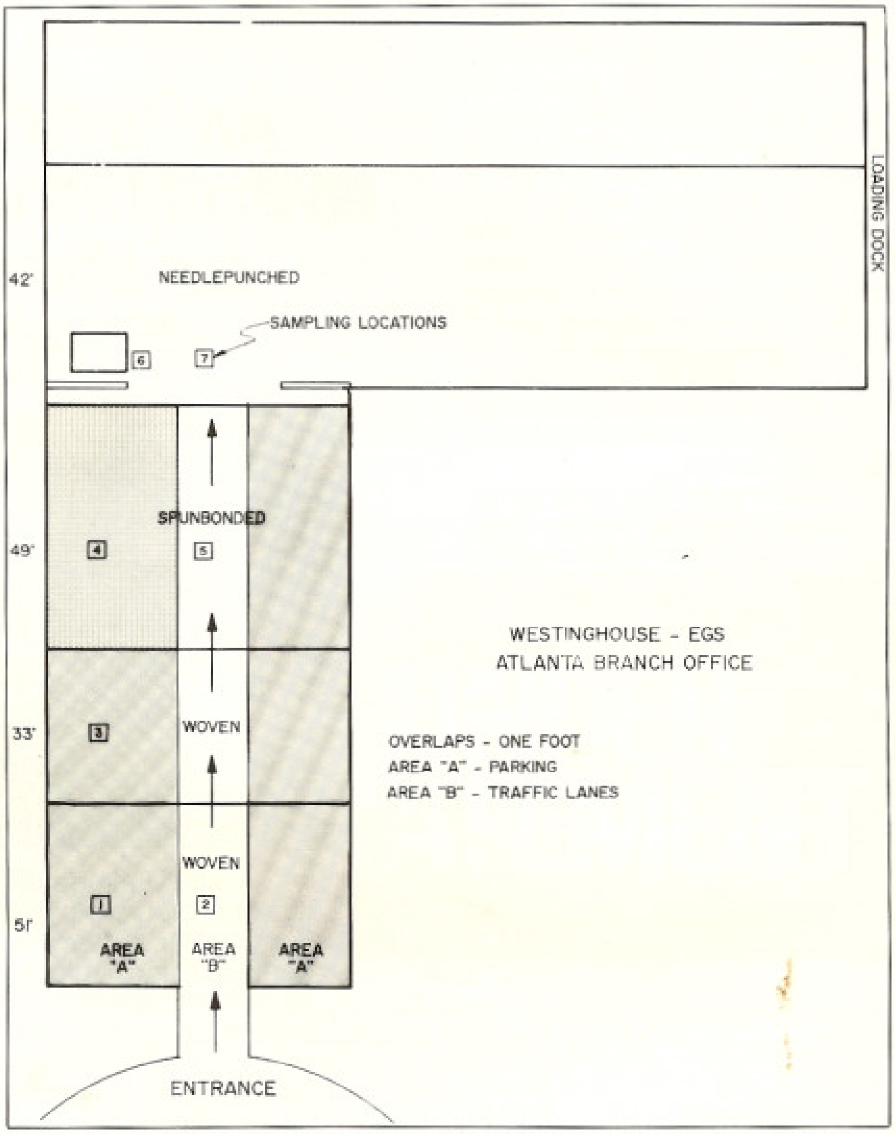

Figure 1: The fabrics cover two distinctly different traffic zones. Area A was used primarily for parking. Area B was subjected to traffic consisting of delivery trucks, various construction vehicles, lowboys carrying drill rigs and automobile traffic.

The parking lot was constructed on a residual silty fine sand having a low plasticity (PI = 10). Having nearly 50 percent silt size particles, the support integrity of the subgrade is significantly reduced by flooding. Thus the CBR of the soil would drop from 13 at optimum moisture to less than three when saturated. Above the fabric, the parking lot paving included eight inches of crusher run gravel and two inches of bituminous pavement. During construction, all gravel was placed by dumping onto previously placed gravel, Figure 2, and then spread by rubber-tired equipment. Thus the geotextiles were not subject to direct impact loads nor tracked equipment.

III. Exhuming of Samples

In 1989 samples were exhumed at the locations shown on Figure 1. At each location, a 2′ square was cut in the asphalt. The asphalt squares were removed by hand. The aggregate was loosened using pick axes with caution

Figure 2: During construction all gravel was placed by dumping unto previously placed gravel.

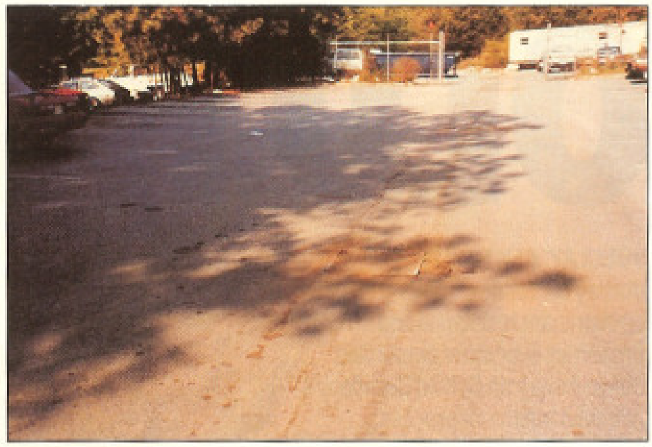

Figure 3: The square cut in the asphalt (center of photograph) corresponds to section B of Figure 1. The left and right sides of the lots correspond to Section A of Figure 1.

Figure 4: A slit tape woven fabric was exhumed from location 2. Subgrade pumping did not occur, and the fabric showed no signs of damage.

Figure 5: The slit tape woven sample on a backlighted inspection table. There are no signs of imperfections that would lead to any loss in hydraulic properties.

Figure 6: Slit tape woven fabric being exhumed from location 3.

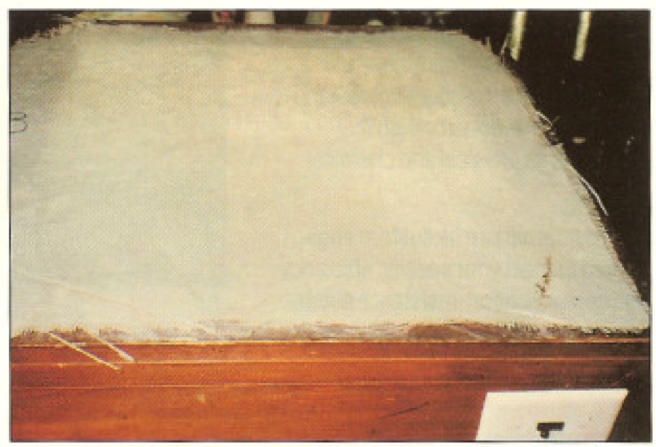

Figure 7: There was no evidence of subgrade pumping at this location.

taken to prevent any damage to the samples.

IV. Field Observations

Figure 3 is an overview of the parking area. The square cut in the asphalt can be seen in the center of the photograph. The center of the lot corresponds to Section B of Figure 1. The left and right sides of the lots correspond to Section A of Figure 1. The entire parking area is in excellent condition. There are no large cracks, buckling, or potholes anywhere in the lot.

Figure 4 shows a slit tape woven fabric being exhumed from Location 2. The pavement structure is in excellent condition. Subgrade pumping has not occurred, and the fabric shows no signs of damage. Figure 5 shows the same sample on a backlighted inspection table. There are no signs of holes, tears, or other imperfections that would lead to any loss in hydraulic properties.

Figure 6 shows another slit tape

Figure 8: Exhuming spunbonded nonwoven fabric at location 5. Both the fabric and pavement structure were in excellent condition.

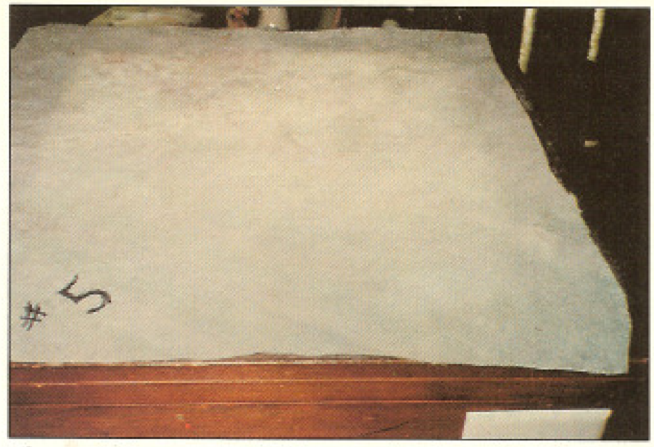

Figure 9: Nonwoven fabric samples from location 5 showed no problems.

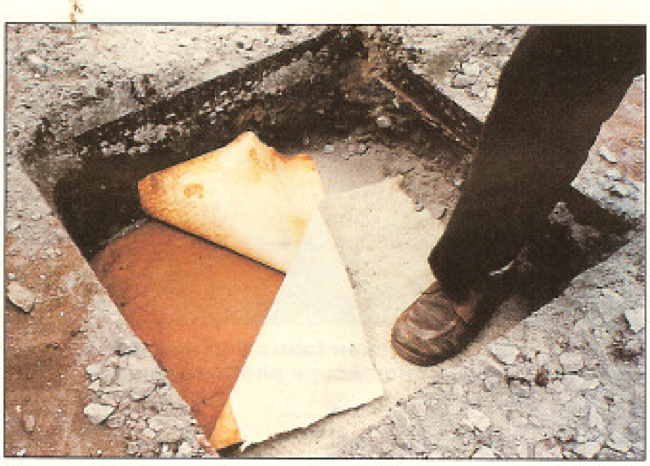

Figure 10: Exhuming needle-punched nonwoven fabric encountered an overlap at location 7, but no performance problems.

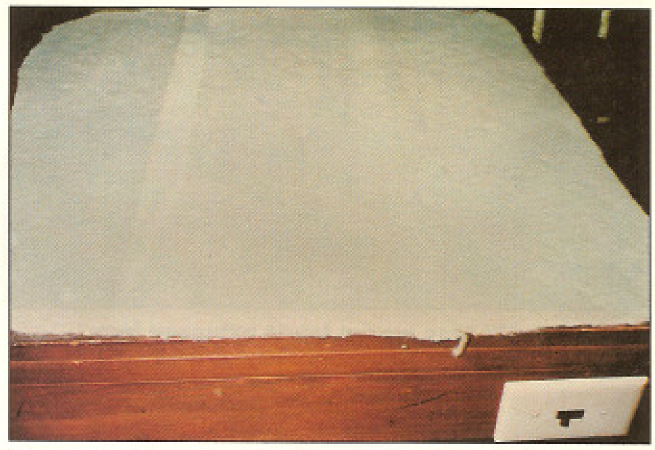

Figure 11: Needle-punched nonwoven fabric (exhumed from location 7) on a light table.

woven fabric being exhumed from Location 3. Again, the fabric is in excellent condition as shown in Figure 7. There was no evidence of subgrade pumping at this location.

Figures 8–11 show non-woven fabric samples from locations 5 and 7. An overlap was encountered at location 7, but there was no apparent performance problem caused by the overlap. As in the previous locations, both the fabrics and the pavement structures were in excellent condition.

V. Evaluation of Physical Testing Data

Each of the seven exhumed samples was tested to determine residual physical properties. The results of this testing are summarized in Table 1. The following properties were evaluated:

Properties	Test Method
1) Grab Tensile and Elongation	ASTM-D-4623
2) Puncture Resistance	ASTM-D-3787 (mod)
3) Mullen Burst	ASTM-D-3786
4) Weight (oz/yd)	ASTM-D-3776

Location	Fabric Type	Grab Tensile (lbs)		Percent Reduction		Grab Elongation (%)		Percent Reduction		Puncture Resistance (lbs)	Percent Reduction	Mullen Burst (psi)	Percent Reduction	Mass/ Unit Area (oz/yd²)
		Warp²	Fill	Warp	Fill	Warp	Fill	Warp	Fill					
1	Slit Tape	192	184	4	8	20.2	16.6	NA	NA	105	NA	340	15	5.19
2	Slit Tape	118	106	41	47	11.5	11.1	23	26	88	2	202	49	5.28
3	Slit Tape	189	152	6	24	19.8	17.1	34	43	95	NA	338	16	4.79
4	Spunbonded	104	97	20	25	63.9	43.4	NA	30	58	NA	500	NA	4.86
5	Spunbonded	88	66	32	49	47.8	35.6	23	42	50	13.8	144	71.2	4.84
6	Needlepunched	191	161	26	38	66	56.3	NA	14	98	32	302	32	7.32
7	Needlepunched	161	127	38	51	51.7	42.3	20	35	86	43	218	52	11.7

Notes:

1) Locations 2,5,7 are heavy traffic zones.

2) Warp—strongest principal direction

3) Grab tensile, elongation, weight and burst values are the average of five tests.

4) Weight values are approximate—some residual soil remained on fabrics.

NA—Not Applicable

Table 1 Test Results

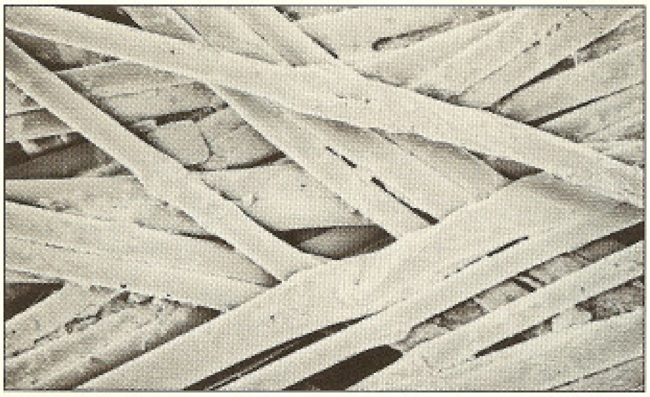

Figure 12: A scanned electron photomicrograph of exhumed spunbonded nonwoven fabric from location 5.

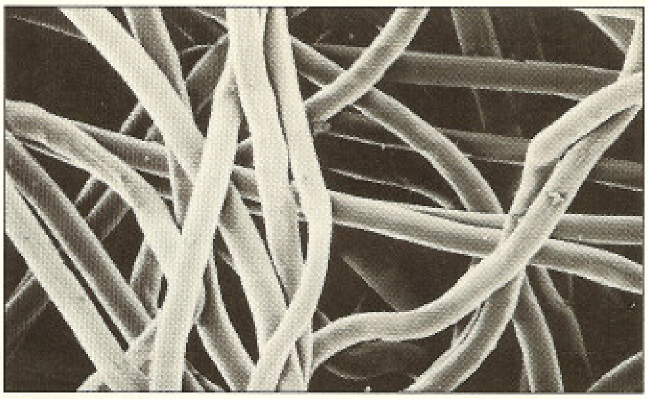

Figure 13: Needle-punched nonwoven fabric from location 7.

Figure 14: Slit tape woven fabric exhumed from location 3.

Figure 15: Slit tape woven fabric illustrated in a scanned electron microscope photomicrograph.

For purpose of this testing, warp is defined as the strongest principle direction. The Grab Tensile, Elongation, Mullen Burst, and mass per unit area values are the average of five tests.

As expected, a reduction in physical properties was found in locations in Area B. The amount of this reduction varies widely depending on the property being evaluated. The reduction in properties appears to be more dependent on traffic conditions than on fabric type.

VI. Photomicrographs

Figures 12–15 are scanning electron microscope photomicrographs of exhumed samples at various magnification levels. The photomicrographs correspond to the following locations:

Figure 12: Location 2—Slit Tape Woven
Figure 13: Location 3—Slit Tape Woven

Figure 14: Location 5—Spunbonded Nonwoven
Figure 15: Location 7—Needlepunched Nonwoven

The photomicrographs of the woven fabrics show some cracking and splitting of yarns, but no complete failure of the yarn systems is indicated. Also, no punctures or yarn movements which would lead to a degradation of hydraulic properties is indicated by the photographs.

The nonwoven fabrics are also in good condition as shown by the photographs. Some crushing of the fibers has occurred in the fabric in Location 5, but no failure of the system is shown.

VII. Conclusion

The geotextiles in this study have performed the intended separation function and have made a significant contribution to the long term success of the pavement structure. Although the definitions of failure and success in this application are sometimes difficult to determine, the geotextile performance in this case would certainly be deemed successful. After a period of eight years there is no evidence of sizeable chemical degradation of the polymers, nor is there a catastrophic loss in any measured physical property.

Measured physical properties do indicate that geotextiles degrade somewhat during installation and when exposed to repeated service loads. Installation damage can clearly be limited to an acceptable level by proper consideration of stone placement and equipment selection/operation. The service related degradation of the geotextiles was significant only for the spunbonded nonwoven. And even here, the photomicrographs indicate that individual fiber damage is very limited. Adjacent parking lots that lack the geotextile have developed pumping failures and are the most subjective indication of the benefits obtained from the use of geotextiles as subgrade separators. ◻

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