GRAY, C. G.
ICI Fibres, Pontypool, Gwent, U.K.

Abrasion Resistance of Geotextile Fabrics
La résistance à l'abrasion des géotextiles

The resistance to abrasion of various Geotextile fabrics was measured on a purpose-built apparatus where the fabric was subjected to a vibrating ram the end of which consisted of aggregate set in resin. The resulting damage to the fabric was assessed first visually and then quantitatively using the California Bearing Ratio test. Repeat samples were assessed using the 50 mm strip tensile test. A wide range of resistance to abrasion was shown by tbe different fabrics. By modifying the apparatus other fabrics were subjected to vibrating steel cones, the object being to pierce the fabric. When this happened the cones came into contact with a bed of finely-divided metal thereby completing an electric circuit and causing a lamp to light. The times taken to do this for various fabrics were measures of their resistance to the vibrating cones. Finally a modified Martindale abrasion tester, with a roughened steel surface as abradant, was used to compare woven and non-woven fabrics.

La résistance à l'abrasion de plusieurs géotextiles fut mesurée sur un appareil spécialement developpé dans lequel le textile est sollicité par un plongeur vibrant dont la face se compose de pierres concasses fixées en résine. Le dommage au géotextile fut mesuré visuellement, dans l'essai CBR et dans l'essai a bande de 50 mm. La resistance à l'abrasion varie de geotextile en geotextile. Dans une modification de l'essai, des cônes en acier remplacent les pierres avec le but de percer le géotextile et de faire contact avec une couche de granules en acier située en dessous, ce qui allume une lampe par moyen d'un circuit électrique. Les délais des différents géotextiles sont une mesure de leur résistance à la pénétrations par les cônes vibrants. Enfin, avec une modification de l'essai d'abrasion Martindale utilisant une surface abradante en acier rugueuse, des comparaisons sont faites entre les geotextiles tissés et non-tissés.

1. Introduction

With the increasing variety of types of fabrics being used for Geotextile purposes it became important to develope tests which could assess the performance of these fabrics with regard to abrasion resistance, and in particular with the type of abrasion which the products would meet in the field. With this objective, three different abrasion tests were initiated, or modified, and used to test a range of fabrics designated for different end-uses.

2. Experimental

2.1 Simulated Vibrating Road

An apparatus was set up which could subject a fabric sample to the type of abrasion produced by aggregate when used on railway tracks or during the construction of roads. Using an epoxy resin, the appropriate aggregate was set into a metal cup which could be mounted on the end of a ram. The ram was vibrated in three different directions simultaneously, the directions being mutually at right angles. One direction was vertical, the other two horizontal. A circle of fabric 250 mm in diameter was cut out, clamped into the apparatus and subjected to the abrasion. The photographs, Figures (1) and (2), show the apparatus used.

Figure (1). Aggregate fixed in cup.

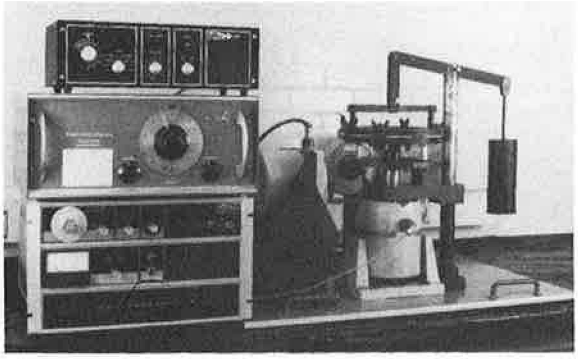

Figure (2). General View of simulated Road Abrasion apparatus.

Eight different fabrics were tested as follows:-

A. Continuous filament spun bonded Polypropylene.
B. Needle punched Staple Polypropylene.
C. Composite fabric, a needled Staple with a woven split-tape, all Polypropylene.
D. Continuous filament needle punched Polyester.
E. Needled and Thermic bonded Staple 95/5 Polypropylene/Polyester.
F. Continuous filament heat bonded 70/30 Polypropylene/Polyethylene.
G. Needled Staple Polyester.
H. Continuous filament spun bonded Polyester.

After preliminary trials to establish the correct degree of abrasion, the conditions of test used to give a reasonable comparison of these fabrics were as follows:-

Three planes of vibrations, each at 10 Hertz, Amplitude setting 2 (approximately 4 mm) vertical load 2.7 kg, time 1 hour. This equates to 36,000 vibrations. The Photograph shown in Figure 3 illustrates the abrasion produced on a sample of each of the eight different fabrics.

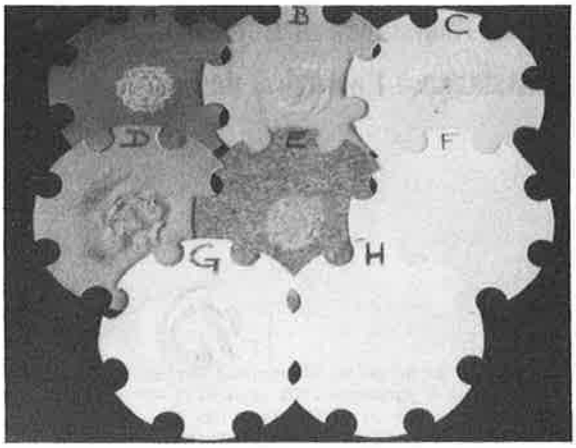

Figure (3). Abraded fabric samples.

To assess the strength of the fabrics after abrasion a bursting test was carried out on the abraded portion of the fabrics. The test used was the California Bearing Ration (CBR) test as used in the laboratory with a Tensile test instrument. In this test a steel ram of circular cross-section, diameter 50 mm, is forced against a fabric sample which is securely clamped. The force required to break the fabric is measured. With the circle of abrasion on the fabrics being 80 mm, the 50 mm diameter ram on the CBR test should give a measure of strength of the abraded portion of the fabric. The CBR breaking loads of non-abraded fabric samples were tested as controls. The results are shown in the following table (Figure 4), each result being the mean of three samples tested.

Figure (4). Table of Mean CBR Results.

(Each result is the mean of 3 samples tested and the means are normalized to a fabric weight of 200 g/m^2 so that they can be compared more easily.)

Fabric	Fabric Weight (g/m^2)	Normalized CBR (N/200 g/m^2)		% Loss
		Before Abrasion	After Abrasion	
A	200	1918	1084	43
B	355	1066	1010	5
C	315	1078	1034	4
D	425	1828	1640	10
E	430	1776	1310	26
F	270	2532	2420	4
G	395	830	412	50
H	216	1584	1460	8

An alternative way of assessing the strength of the fabrics before and after abrasion is to use the 50 mm wide Strip Tensile test. This is a standard test used frequently in Europe, mainly because it is used extensively for woven apparel fabrics. Normally it does not have much relevance to Geotextile fabrics because they are used in a much larger mass and hence localized tensions are supported by the surrounding mass of fabric. In this abrasion treatment, however, there is an abraded area of fabric of 80 mm diameter, hence a strip 50 mm wide cut through the centre of the abraded area and tested for tensile strength should be indicative of the extent of abrasion. Samples from each of the previously described eight Geotextile fabrics were abraded using the vibrating "aggregate" ram, and then a 50 mm wide strip was cut out from each sample. Each strip was tested for breaking load on a tensile tester using a gauge length of 180 mm and a cross-head speed of 200 mm per minute. Four samples from each of the eight fabrics were abraded and tested in this manner and the mean results are given in the following table (figure 5). Control tests were carried out on unabraded samples and the percentage loss in strength produced by the abrasion was calculated and is given in the table.

Figure (5). Table of Mean 50 mm wide Strip Tensile Results.

(Each result is the mean of 4 tests.)

Fabric	Fabric Weight (g/m^2)	Normalized 50 mm wide Strip Tensile Strength ($N/200\ g/m^2$)		% Loss
		Before Abrasion	After Abrasion	
A	200	581	283	51
B	355	383	308	20
C	315	298	114	62
D	240	500	500	0
E	430	415	410	1
F	270	511	481	6
G	395	259	221	19
H	216	546	409	25

2.1.1 Discussion on and Conclusions from 2.1.

The objective in this experiment was to simulate the abrasion produced on Geotextile fabrics by aggregate used for railways and during the laying of roads. The severity of the abrasion force applied by the equipment used, ie extent of amplitude of vibration, frequency and mean pressure applied, was selected so that the fabrics being assessed showed as wide a range of abrasion as possible and this is illustrated by the photograph of the eight fabric samples in figure 3. The aggregate used was set in the epoxy resin in such a way that a convex surface presented itself to the fabric to give as large an area of abrasion as possible.

Visual examination of the abraded fabrics showed substantial differences, with some severely abraded while others were affected very little. Visually, the fabrics most resistant to abrasion were F and H, both continuous filament products, the former heat bonded polypropylene/polyethylene, the latter spun bonded polyester. The CBR results shown in figure 4 indicate fabrics G, A and E to have suffered the greatest loss in strength the others relatively little loss. The strip tensile results given in figure 5 show five of the fabrics giving a much reduced strength, C, A, H, B and G. The other fabrics, D, E and F were affected very little. Overall, the continuous filament heat bonded polypropylene/polyethylene fabric (F) appeared to show most resistance to this type of abrasion, with fabrics A, C and G being most affected by the abrasion.

2.2 Vibrating Steel Cones

The reason for this type of abrasion test was that certain customers wanted to use Geotextile fabrics as protection layers for impermeable liners against the abrasion and puncturing by stone or rough concrete. A laboratory test was needed to determine which would be the best fabrics for their particular use. An apparatus similar to that used in experiment 3.1 was set up, but with the following differences:- the aggregate ram was replaced by a metal dish filled with "shattered" metal (small particles of steel, see figure 6), the fabric sample under test was clamped over the divided metal, and a circle of small steel cones was pressed against the fabric from above. The ram was vibrated vertically at a frequency of 10 Hertz with an amplitude of 5 mm and a load of 1 kilogram. An electrical circuit was made connecting the steel cones via a battery - and - lamp combination to the steel dish containing the divided metal. When the cones pierced the fabric they came into contact with the divided metal and completed the electrical circuit causing the lamp to light. The whole apparatus is shown in figure 7.

Figure (6). Metal Dish containing "shattered" metal.

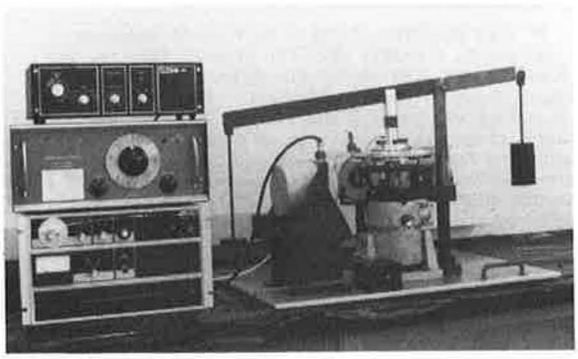

Figure (7). Vibrating Cones Apparatus.

For the initial experiments the times taken for the lamp to light for different fabrics were used as a measure of their resistance to this type of abrasion. However, some fabrics took a long time, hence to speed up the test each fabric was subjected to the above conditions of vibrating cones for two hours, after which the static load required for the fabric to be pierced was measured; the higher the load required, the higher the resistance of the fabric to this abrasion. Seven different fabrics were compared, five non-woven and two impermeable sheets. There were three polypropylene/polyethylene continuous filament melded fabrics of different weights, 100, 140 and 230 g/m^2, a high bulk c.f. polypropylene/polyethylene, a c.f. polyester and two polyvinyl chloride sheets of thickness 1.0 and 1.2 mm. The results are given in figure 8.

Figure (8). Table of Results from Vibrating Cones Apparatus.

Fabric	Static load required for Cones to pierce abraded fabric (kg)
c.f. polypropylene/polyethylene 100 g/m^2	0.25
c.f. polypropylene/polyethylene 140 g/m^2	6.0
c.f. polypropylene/polyethylene 230 g/m^2	8.0
high bulk c.f. pp/pe 230 g/m^2	10.0
c.f. polyester 250 g/m^2	8.0
Polyvinyl chloride 1.0 mm thick	8.0
Polyvinyl chloride 1.2 mm thick	10.0

2.2.1 Discussion on and Conclusions from 2.2.

The object of this test was to show the relative resistance of fabrics to sharp metal surfaces. The apparatus worked very well, although it should be noted that the divided metal must not be too fine otherwise the electrical contact with the cones is insufficient to light the lamp. The results show the non-woven thicker fabrics equate with the polyvinylchloride sheeting, and the high bulk product is particularly good..

2.3 Modified Martindale Abrasion Tester

In this test the standard Martindale abrasion test equipment, normally used for apparel fabrics, was modified for use with Geotextile fabrics because the abradant needed to be much stronger. The weighted sample holder was removed and its end modified by placing a ridged weld across it as shown in figure 9. The modified Martindale abrasion equipment is shown in figure 10. The Martindale tester works by moving in a horizontal plane first in one direction then gradually changing to a direction perpendicular to the first, thus giving a circular abrasion patch.

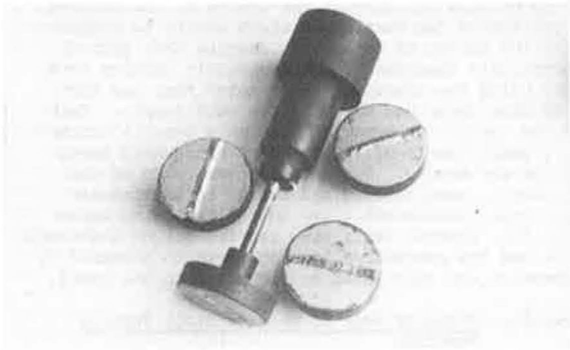

Figure (9). Modified weighted sample holder for use as Abradant.

Figure (10). Modified Martindale Abrasion Equipment.

The Geotextile fabrics compared in this experiment were two non-wovens and a woven split tape. The non-wovens were a continuous filament polypropylene/polyethylene melded fabric and a needle punched c.f. polyester; the woven fabric was of polyropylene. Two pairs of samples were abraded on the equipment at the same time until one pair was worn through. On each of 4 trials the woven split-tape was worn through, with the others showing visible signs of abrasion but not being destroyed. A visual assessment of the two non-wovens showed the needle punched fabric to be the more abraded.

2.3.1 Discussion on and Conclusion from 2.3

The purpose of this trial was to try to use a standard equipment for abrasion. The Martindale equipment which was chosen needed its abradant to be changed from a fabric to a solid metal. The weld modification was chosen because in one end-use there was frequent contact with welded materials. The results showed that this test too could differentiate between fabrics, but again only comparatively, not in an absolute sense. Further test development will be needed to standardize the equipment, in particular the abradant.

3. Recommendation

Experience has shown the relevance and validity of all three test methods for the evaluation of the abrasion resistance of Geotextile fabrics, therefore it is recommended that these tests be considered by the Committees on Abrasion Testing of the British Standards Institute and the American Society for Testing and Materials for inclusion in their list of tests for Geotextile fabrics.

4. Acknowledgements

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