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Tests on woven and non-woven fabrics for pore size and damage by aggregate

Essais sur tissés et non-tissés pour mesurer les dimensions des pores et les dégradations dues aux graviers

SOMMAIRE

On décrit: (1) Une méthode de mesurer les dimensions des pores en agitant des 'ballotini' de verre sur le textile. On trouve les résultats pour les tissés et les 'spunbondeds' valable, si on se sert de ballotini plus grand que 90 micron. (2) Une méthode de blesser les textiles par graviers sous des pressions variées, et de juger les effets par essais de la résistance à rupture. On trouve des différences importantes entre les tissés, les 'spunbondeds' et les textiles composés d'un tissé avec une nappe de fils aiguilletés.

INTRODUCTION

When fabrics of different types are considered for a particular engineering use, it is necessary to apply tests which give valid and comparable results for the different types of material. This paper describes two test methods and the results obtained for a selection of woven, non-woven and composite fabrics.

FABRICS TESTED

The fabrics tested are listed in table 1. The weights of all except fabric N were between 100 and 200 g/m^2. Fabric N weighed 320 g/m^2.

PORE SIZE DISTRIBUTION

The pore sizes measured are not actual dimensions of the openings through the fabric. They are effective pore sizes for the passage of dry spherical glass balls (ballotini) when subjected to standard vibration on a sample of the fabric. The pore size distribution curve records for each grade of ballotini the percentage by weight which was retained on the fabric after the standard time and intensity of vibration. In the graphs this is called the 'percentage of pores finer' than the median size of the grade; but it is actually only an empirical measure which is assumed to be related to the true 'percentage of pores finer'. If reproducible results can be obtained for individual fabrics, the curves of pore size distribution are, at the least, useful for comparison between fabrics.

Twelve grades of ballotini were used, varying in median size from 600 micron to 30 micron. Eighty per cent of the ballotini in any one grade is guaranteed to lie within a given range, and the width of the range varies from 195 micron for the coarsest grade to 25 micron for the finest grades.

After some preliminary tests the following procedure was adopted. The fabric sample was stretched just taut over a wire sieve of coarse mesh 200 mm diameter and 30 g of ballotini of a coarse grade was placed on it. The sieve was vibrated in a sieve shaker for 10 minutes and the ballotini which had passed through the fabric (and the sieve) were then weighed. The ballotini retained on the fabric were brushed off with a camel hair brush. The procedure was then repeated several times with finer grades of ballotini on the same sample. At least four grades of ballotini were tried on each sample.

Figure 1 shows the average pore size distribution curves for two spunbonded and six woven fabrics. The curves are average results from three or four samples of each fabric. Figure 2 shows the average curves for three needleweave fabrics and for the fabrics which form the woven components of the needleweaves (see table 1).

The scatter of results was large for all the fabrics. The detailed results for fabric W6 are given in table 2 as an example of the scatter.

Discussion

With so much scatter the average curve cannot be regarded as a very accurate property of a fabric; but repetition of the whole series of tests on a

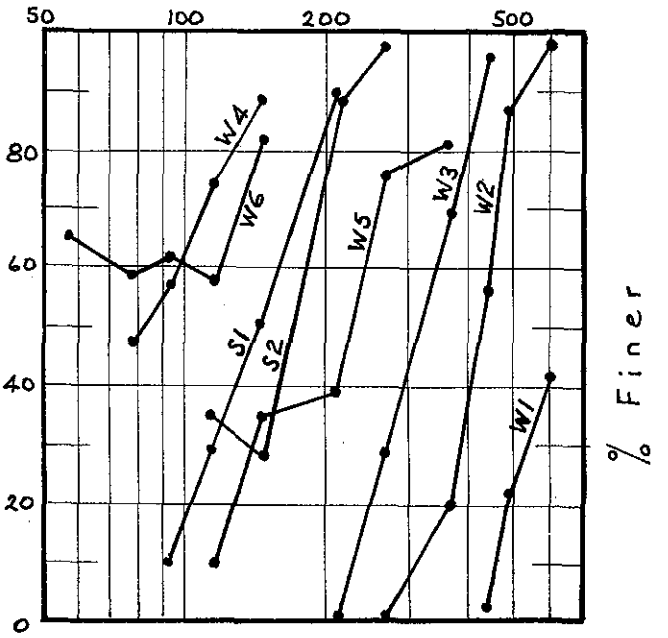

Figure 1 Pore Size Distributions

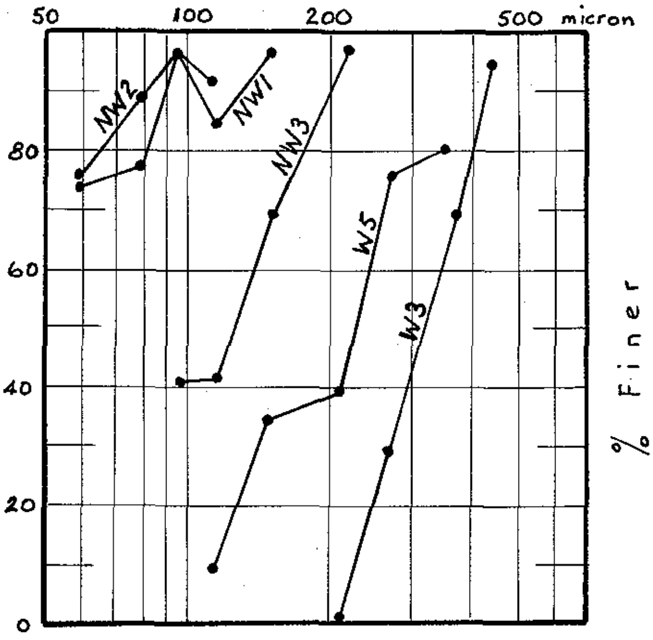

Figure 2 Pore Size Distributions

woven fabric produced a very similar average curve. And the separation between various curves in figure 1 or figure 2 is large enough to reveal serious differences between the materials even if there is some inaccuracy.

Careful study of all the results reveals three reasons for the scatter: 1. Individual 'freak' samples are common. Sample 2 in table 2 is an example, and there was at least one 'freak' in almost every group of four samples, both wovens and spunbondeds. This simply means that there are large variations in the pore sizes of all the materials as manufactured. 2. The energy of vibration of individual particles of the finest grades of ballotini is insufficient to make them penetrate any fabric with a hairy or fleecy consistency (fabrics with a high specific surface). On this account it is unwise to regard as reliable any results for ballotini of less than 90 micron median size. 3. Ballotini of different grades may interact in different ways with the same fabric, as well as different fabrics of nominally similar type. This may be illustrated with reference to woven fabrics. If fabrics W2, W3 and W4 are manufactured without irregularities the warp tapes provide complete coverage of the area. The weft tapes are thicker and narrower and do not provide complete coverage. Holes of significant and fairly regular size therefore occur between the warp tapes as they weave up and down (figure 3a) and the ballotini must pass through these holes in a more or less horizontal direction. In fabric W1 there is less warp material and complete coverage is not attained by either warp or weft, which leaves a regular system of holes through which ballotini can pass vertically. In fabrics W5 and W6 both the warp and the weft tapes provide full coverage and, the weft tapes being thin (figure 3b), a particle can only pass through the fabric (assuming it has been manufactured without irregularities) by working its way horizontally under the edge of, say, a warp tape and then turning a right angle to move over the edge of the weft tape underneath. Both these movements are resisted by the friction between the particle and the tapes, and the relationship between energy of vibration and frictional resistance varies markedly with the size of the particle.

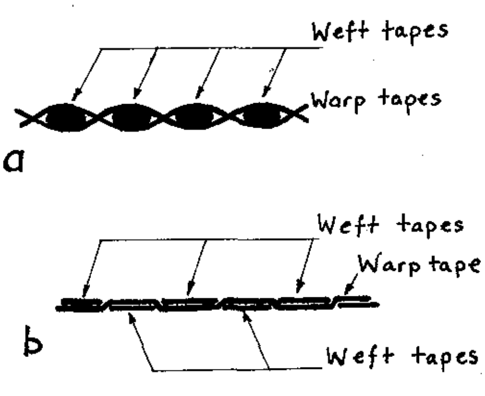

Figure 3 Cross-sections of Woven Tape Fabrics (Schematic)

The difference between the measured pore sizes of fabrics W5 and W6 could be explained by the fact that there were more manufacturing irregularities in W5. This was obvious on visual examination.

It is concluded that the test gives valid comparisons of effective pore size distributions within the series of woven fabrics W1 to W4, a valid comparison between W5 and W6, and a valid comparison between S1 and S2. It is also felt that the test results for S1, S2 and W5 are broadly commensurate with those for W1-W4, and that the order of difference between all of these and the needleweave fabrics NW1 to NW3, as well as the needle-punched fabric N, is realistic. But no credence is given to the numerical results of the tests on needleweave and needle-punched samples where the ballotini used were less than 90 micron in size. A similar comment applies to sample W6.

DAMAGE BY AGGREGATE

Method and Results

The intention is to develop a test which can be used either for comparison of fabrics, by standardising the conditions of damage, or for assessing the damage to a single fabric by various aggregates over one or more strengths of subgrade. To date the work has been limited to comparison of fabrics under standard conditions of damage.

The basic technique is to lay a sample of fabric over a yielding substrate, to place over the fabric a damaging medium and subject it to a known load. A number of samples are damaged under different loads and the amount of damage measured by the change in some fabric property with increase of damage load. To date sand and rubber have been used as substrate and several types of gravel and crushed stone as the damaging medium. After several configurations had been tried, the set-up shown in figure 4 was adopted for the first series of tests. The rubber was of Shore hardness 70, the aggregate was sub-angular 6-9 mm.

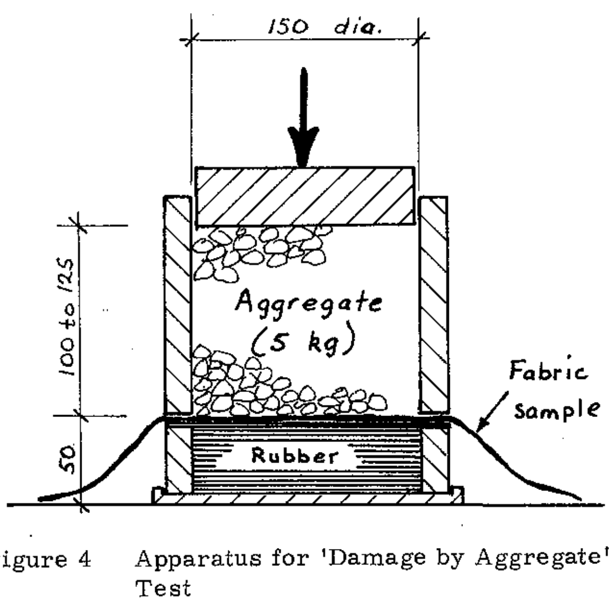

Figure 4 Apparatus for 'Damage by Aggregate' Test

Three methods of measuring the amount of damage were considered, namely, strength tests, pore size tests and simple visual examination. A few pore size distribution tests were made and showed increasing pore sizes with increasing damage load, but they are too expensive for general use. For strength tests a grab test method was considered appropriate because it tests a large proportion of the area damaged under the 150 mm dia load. Visual examination was used constantly as a first guide to the effects and the observations corresponded with the trend of grab test results.

The grab tests were made with an Instron machine, generally in accordance with ASTM D1682, but 50 mm grips had to be used initially because the standard grips (25 mm wide) were not available. The tests on fabric W3 were repeated when standard grips became available so that all the results in figure 5 can be compared. All samples were tested for strength in the warp or machine direction except where noted otherwise.

No curve is plotted for fabric N, because no peak load could be identified in grab tests on undamaged samples. Peak loads did occur in tests on damaged samples, indicating that the elongation at failure was reduced by the damage.

Discussion

There were large differences between the responses of the different types of fabric.

1. In non-wovens the damage cannot be assessed visually because many of the breaks in the fine filaments are not seen on the surface of the fabric.

2. The spunbonded fabrics lost strength with increasing damage load, and the more rigid S1 lost more than the less rigid S2.

3. In the woven fabrics considerable loss of strength occurred before it became noticeable that tapes were damaged or broken. The damage was greatest in the thin tapes (warp tapes of W3 and W4, warp and weft of W5). As the damage load increased the weft strength overtook the warp strength.

4. The strength of the woven fabrics remained higher than that of the spunbondeds up to damaging loads of about 200 kN (pressure of 11 MN/m^2).

5. A considerable reduction in the loss of strength due to damage by aggregate is achieved by addition of a light needled layer to a woven fabric. (Note that fabric NW3 is W5 with a needled layer and NW1, NW2 and NW4 are W3, each with a different weight of needled layer.

6. There are clear differences between the results for woven, non-woven and composite fabrics. The relationship between the test results and performance in the field can be determined by experience.

7. When the test is used purely for comparison of fabrics, it can be done with a metal damaging head in place of the aggregate. This reduces the cost of the test by eliminating the labour of sieving the aggregate after each use to remove the fine particles caused by crushing under load.

ACKNOWLEDGEMENTS

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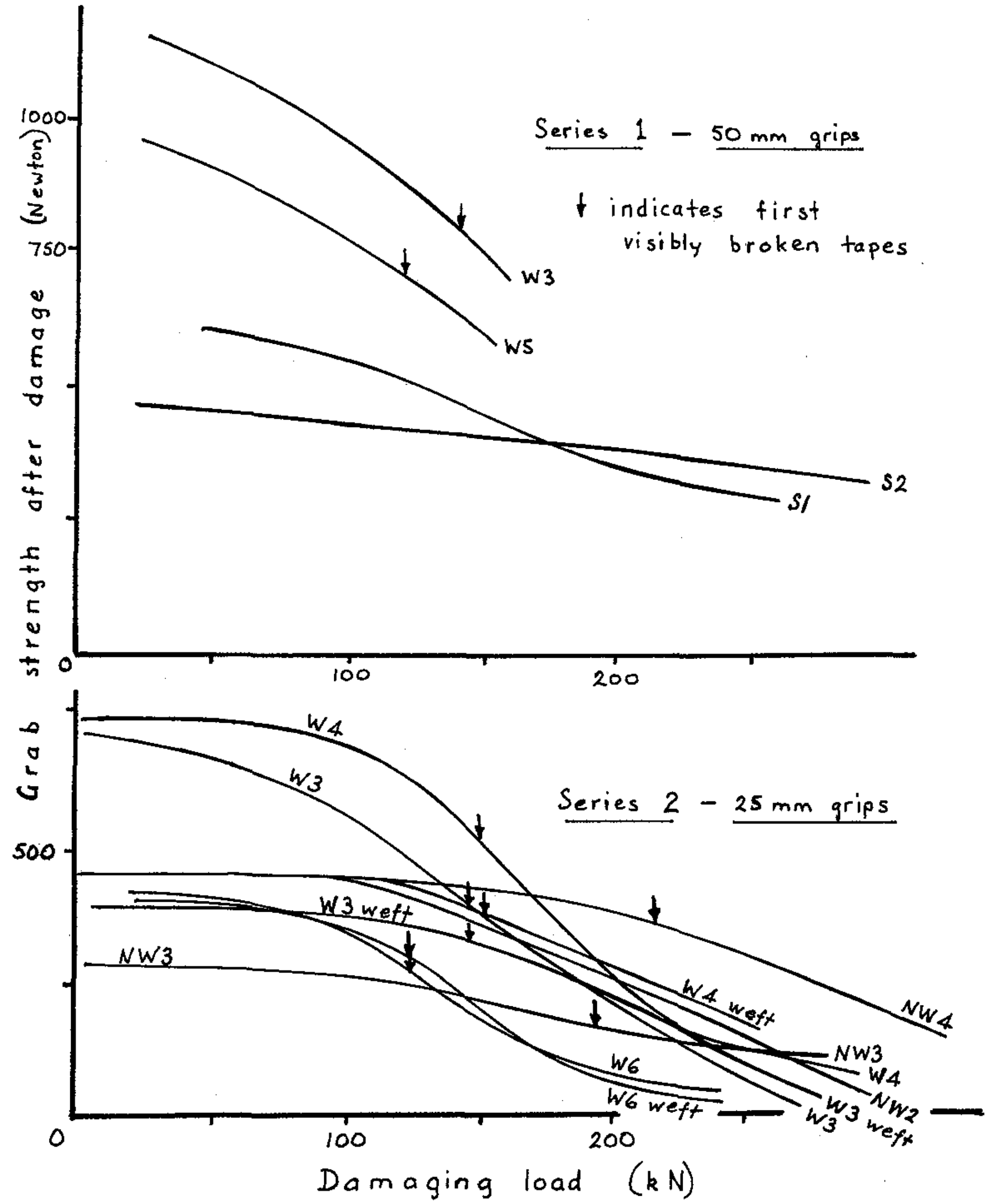

Figure 5 'Damage by Aggregate' Tests

Reference	Description
S1	Spunbonded polypropylene
S2	Spunbonded polypropylene/polyamide
N	Needlepunched polypropylene
W1	Woven polypropylene tape 72 x 60 (500, 1000)*
W2	Woven polypropylene tape 94 x 35 (500, 1000)*
W3	Woven polypropylene tape 94 x 43 (500, 1000)*
W4	Woven polypropylene tape 94 x 51 (500, 1000)*
W5	Woven polypropylene tape 37 x 39 (1000, 1000)*
W6	Woven polypropylene tape 37 x 39 (1000, 1000)*
NW1	Woven polypropylene tape 94 x 43 (500, 1000) with needled polyamide layer 17 g/m^2
NW2	Woven polypropylene tape 94 x 43 (500, 1000) with needled polyamide layer 34 g/m^2
NW3	Woven polypropylene tape 37 x 39 (1000, 1000) with needled polyamide layer 68 g/m^2
NW4	Woven polypropylene tape 94 x 43 (500, 1000) with needled polyamide layer 68 g/m^2

*72 x 60 (500, 1000) indicates 72 tapes/10 cm in warp or machine direction, 60 tapes/10 cm in weft or cross direction, denier of warp tapes 500, denier of weft tapes 1000.

Table 1 Fabrics Tested

Median size of ballotini	Percentage of pores finer					
	Sample 1	2	3	4	Average	Range
145	96	45	93	92	82	45-96
115	47	10	83	90	57	10-90
92	40	35	76	96	62	35-96
77	79	14	51	89	59	14-89
57	88	5	85	80	65	5-88

Table 2 Pore Size Distributions for Fabric W6