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Compressive creep testing of geocomposites for the development of the European standard

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ABSTRACT: The Compressive Creep Test is needed to measure the way in which the thickness of geosynthetic materials reduces with time under load. The tests are carried out over a period of 1 000 hours and the results of the tests may be used to predict the In-Plane Flow capacity of materials used as drains. The development of the European Test Standard has been carried out under the Measurement and Test Programme, the work has included research and intercomparison tests carried out in seven European laboratories. This paper describes the features of the test Standard and the research work carried out to develop the procedure for the Intercomparison tests which are being carried out.

1. INTRODUCTION

The Compressive Creep test procedure has been developed by Technical Committee 189 Geotextiles to allow the compressive characteristics of geocomposites to be measured using a common European test method. The Compressive Creep test is needed to measure the reduction in thickness of geosynthetics with time. The Compressive Creep test is linked to the In-plane Water Flow test procedure to facilitate the prediction of the medium to long term flow capacity of geosynthetics for drainage and venting purposes. Some of the procedures and the requirements of the Standard had been questioned and the experts decided that these points could only be resolved by undertaking comparative tests. The overall reliability and repeatability of the Standard will be examined in the Intercomparison tests.

2. THE DRAFT TEST PROCEDURE

The draft test procedure has been published as a pre-Norm prENV 1897. The test procedure contains two methods of testing geocomposites:

Section 5: for specimens to be tested with a normal pressure only,

Section 6: for specimens to be tested with both a normal pressure and a horizontal shear force.

The draft CEN In-plane Flow test procedure (prEN ISO 12958) requires that specimens of geocomposites which are to be subsequently tested in the In-plane Flow test must be tested using the method described in Section 6 of prENV1897, i.e. with the normal pressure and shear force. The standard shear force applied is 20% of the vertical pressure.

The draft Standard, prEN1897, requires that the specimens are cut to satisfy the following criteria:

1. a minimum size of 100mm by 100mm square or circular to encompass the 100mm square
2. the minimum length of the side of the specimen to be not less than five times the nominal thickness
3. if the specimen has a well-defined structure with specific load carrying contact points, there shall be not less than three contact points in each perpendicular direction.

The Standard requires that specimens are tested submerged in water, unless the laboratory can demonstrate that testing the material dry does not give a different result.

The shear load can be applied by either using a horizontal force to the top loading plate or by using loading plates which are inclined at an angle of 11.3° to the horizonal. When using the inclined plates the bottom loading plate needs to be set on rollers to ensure that the vertical load does not move out of its line of application during the test.

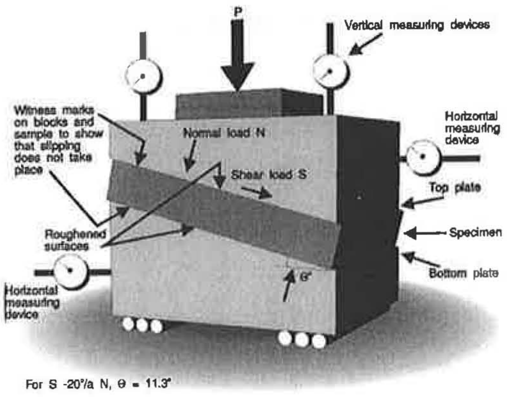

Figure 1. Typical wedge plate arrangement

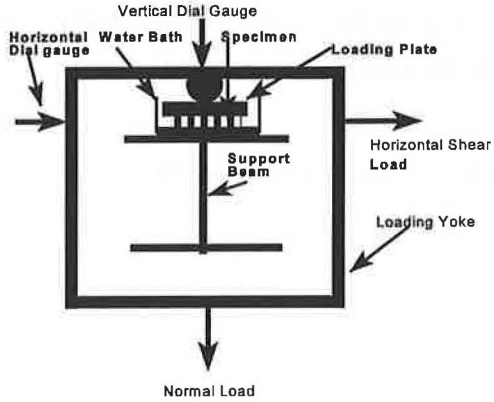

Figure 2. Typical dead load arrangement.

The vertical load can be applied using any method which ensures that the load remains constant throughout the duration of the test.

Figure 1 shows a typical wedge block arrangement and Figure 2 shows a typical arrangement where the shear force is applied directly to the top loading plate. The vertical load can be applied in either case using either simple dead loads where the full load required to generate the test pressure is applied to the specimen, the weights are normally supported on a hanger beneath a beam on which the specimen is placed. Alternatively the vertical load can be applied using a lever arm system, the use of a lever arm reduces the magnitude of the weights needed to generate the test pressure.

The test pressure is to be applied smoothly and in less than one minute. To comply with this the Standard suggests that the weights are supported on a hydraulic jack prior to the start of the test and that the jack's hydraulic pressure is released to lower the weights and apply the test pressure.

The measurements of vertical thickness, can be taken at the centre of the specimen or at three or more points spaced equally around the specimen. When more than one measurement of thickness is made, the readings are averaged to give a mean thickness, the mean thickness is used in the subsequent calculations.

The result of the tests are plotted as the vertical strain and shear strain expressed as :

$$\epsilon_v \% = (\Delta t / T) \cdot 100$$

$$\epsilon_s \% = (h/T) \cdot 100$$

Where:

ϵ_v = vertical strain
ϵ_s = shear strain
Δt = change in vertical thickness
T = Nominal thickness at 2kPa.
h = shear displacement

The standard duration of the test is 1 000 hours, if the specimen collapses or reduces to less than 10% of the nominal thickness, the test can be terminated.

The results of the tests are presented as the absolute values of thickness and also normalised by dividing by the nominal thickness, expressed as a percentage change of the original thickness. Figures 3 shows typical graphical test results for a test with only normal loads applied to the specimen, Figure 4 shows the results for a test with both normal and shear loads applied to the specimens, where the specimens collapsed before the end of the 1 000 hour test period.

3. TASK 2.1 RESEARCH

3.1 *The Questions*

The circulation of early drafts of the test procedure had resulted in several points being raised which could not be answered using data available from

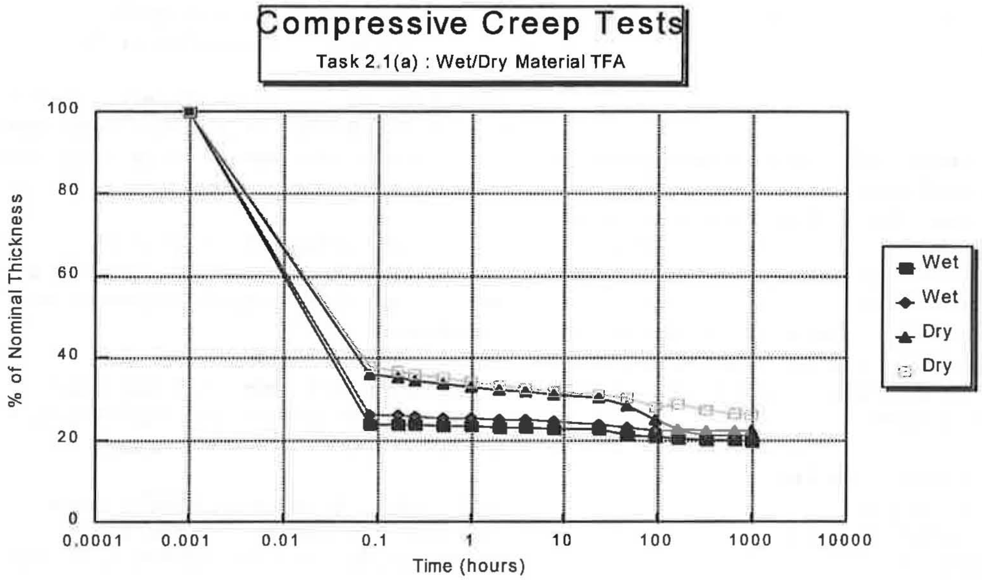

Figure 3

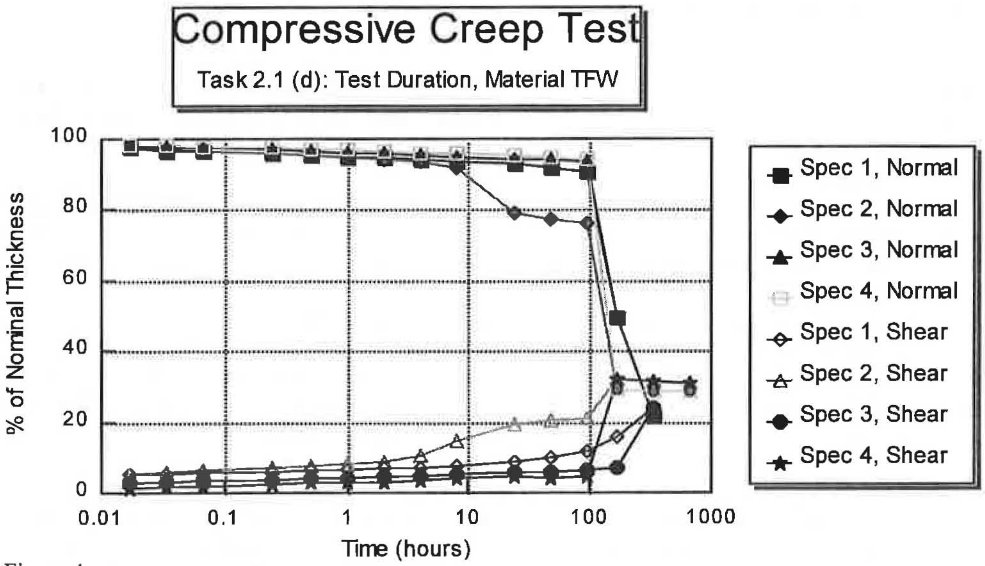

Figure 4

previous experience of carrying out similar tests. The points which needed to be addressed by the research task were:

1. Do the tests need to be carried out with the specimens submerged in water as the default procedure?.

2. Can the specimens be round as an alternative to a square specimen without affecting the results?.

3. Is the test duration of 1 000 hours sufficient?

4. Are the requirements that specimens have at least three contact points necessary or can all

geocomposites be tested with a specimen size of 100mm square?

3.2 *Market Research*

Before starting work on the research Maunsells, as Task Coordinators, carried out a review of geosynthetics used for fluid or gas transmission , available on the European market. The review identified 50 different products which were manufactured from four different base polymers. The type of polymer used in the manufacture was adopted as the first grouping for the consideration of which materials should be used in the tests. The polymers identified were:

i) High density polyethylene
ii) Polyamide (nylon)
iii) High impact polystyrene
iv) Polypropylene

The products were next grouped based upon the form of the core, the main types of core identified were :

i) cuspated cores
ii) net cores
iii) random fibre cores
iv) pillar cores (one product only)

The materials chosen for use in the tests were selected so that they would be representative of the polymers identified and the types of core. The pillar core type was not used in the tests as there is currently only one product manufactured using this type of core and the supplies of the product, manufactured in the USA, are such that the material is not in common use.

Having completed the survey a selection was made jointly with the Task Leader for Task 5, Intercomparisons for the In-plane Flow test, from the materials on the market so that the same products were used in both sets of intercomparisons. In using the same materials it will be possible to carry out an analysis of the data to see if the two tests can be used together to determine the medium or long term In-plane Flow capacity of geosynthetics.

3.3 *The Work carried out*

The work to study the research questions was carried out by two laboratories:

Akzo-Nobel bv, The Netherlands
RDB Plastotecnica (now Tenax). Italy.

Akzo-Nobel were commissioned to carry out the tests to study the differences, if any, which result when specimens are tested immersed in water compared to the results for specimens tested dry.

Tests were carried out on specimens cut in accordance with the provisions of the draft Standard from samples of the materials obtained from the manufactures.

Tenax carried out the tests which were planned to look at the other questions which had been raised during the circulation of the draft standard.

a) The shape of the specimens, round or square
b) The size of the specimens, constant minimum size (100mm square) or to square with dimensions which are determine to satisfy the requirements of the draft Standard with respect to geometry and initial thickness.
c) The duration of the test.

The materials chosen for the research works were chosen to represent the extremes of the aspects being studied.

All specimens were prepared by the laboratory from samples of the selected materials obtained from the manufacturers.

3.4 *The results of the research*

The results of the tests were published in full in a report to The European Commission in November 1995 (Task 2.1 Report on Compressive Creep Research).

The results of the research programme showed that the draft procedure could be used for the intercomparison tests with only one modification. It was found that it was possible to cut specimens of some cuspated cores to give a preferential number of contact points when the specimens were cut on the diagonal from the roll. An additional requirement was added to the draft Standard, to the section on specimen preparation, to require that specimens be cut with the sides parallel to the roll and cross roll directions of the sample.

The tests carried out to study the shape of specimens and the size of specimens showed that these factors did not affect the results.

The duration of the test at 1 000 hours was found to be sufficient to allow materials which were loaded with a pressure which was likely to cause creep rupture to fail in this mode. It was found that some cuspated cores can collapse in 100 to 300 hours when loaded with 50% of the short term crushing strength.

All of the materials were subject to a short term crushing test. The value measured in the short term crushing test has been used as the base value for expressing the percentage load for the tests.

The tests carried out to look at the possible effects of carrying out the tests with the specimens either dry or submerged in water showed that only one of the polymers used in the manufacture of the geocomposite cores showed any difference when tested wet when compared with the results of the dry performance. The geocomposite manufactured using polyamide showed 15% more compression in the first hour of the test, the extra compression reduced to 10% extra at 50 hours, after 100 hours the difference reduced further and by the end of the test at 1 000 hours the wet and dry specimens had compressed to about the same thickness. The differences observed are important particularly when considering the results of the In-plane Water Flow test as the flow measurements are taken over a period of about 10 to 30 minutes when the differences in thickness are most significant. During the Intercomparison Tests some laboratories are making further tests with specimens in both wet and dry conditions to gather further data about this behaviour.

The results of the tests carried out during the Research Tests on specimens of a polyamide core tested both wet and dry are shown in Figure 3.

4 TASK 2.2 THE INTERCOMPARISON TESTS

4.1 *The Programme of Work*

The Intercomparison tests are being carried out in seven laboratories who either had or were prepared to develop new equipment to carry out compressive creep tests. The laboratories who are taking part in the tests are:

Partner 2: tBU Institute, Greven, Germany
Partner 7: CEMAGREF, Paris, France
Partner 10: LGA, Nuremberg, Germany
Partner 12: Tenax SpA, Viganò, Italy
Partner 15: Netlon, Blackburn, UK
Partner 16: Akzo Nobel, Arnhem, NL
Partner 21: LNEC, Lisbon, Portugal

The materials selected for the intercomparisons are described using code letters assigned by the main programme coordinator. The materials being used are:

TFA: A random fibre mesh manufactured using a polyamide polymer.
TFH: A random fibre needle punched geotextile manufactured from a polypropylene polymer.
TFT: A mesh net core manufactured using high density polyethylene.
TFW: A double side cuspated core, 20mm thick, pressed from a high density polyethylene sheet with cusps at 25mm centres.
THH: A double sided cuspated core, 25mm thick, pressed from high impact polystyrene, with cusps at 34mm by 28mm centres.

The equipment developed by the seven laboratories made it impossible for an identical schedule of tests to be carried out in each laboratory. Some of the laboratories can not carry out tests with the specimens immersed in water and some can not apply horizontal shear forces to the specimens. To make the best of the equipment available and to enable sufficient data to be obtained, the work programme set out in Table 1 was developed for the intercomparison tests.

Table 1. Schedule of Intercomparison Tests

	Laboratory Ref						
Material Ref.	P2	P7	P10	P12	P15	P16	P21
TFA	1D	1W	1W	1W	1D	1W	1D
TFH	2D	2D	2D	2D	1D	1W	1D
TFT	1D	1D	1D	1W	1D	1W	1D
TFW	2D	2W	2W	2W	1D	1W	2D
THH	2D	2W	2W	2W	1D	1W	2D

D: Specimens tested dry
W: Specimens tested wet

1: Specimens tested to Method 1, Normal force only
2: Specimens tested to Method 2, Normal and shear forces

All materials being tested at 50kPa normal pressure with 20% shear force for Method 2, material TFA also tested at 20kPa and material TFT at 200kPa.

The size of the specimens used by the different laboratories also varies but all specimens have been prepared in accordance with the requirements of the draft Standard and the additional requirement that square or rectangular specimens are cut with their sides parallel to the roll and cross-roll directions.

The intercomparison tests started in the seven laboratories during October and November 1995.

However, due to the different types of apparatus being used in the laboratories at the time of writing this paper not, all the results are yet available.

4.2 *Description of the Types of Apparatus*

The basic types of apparatus illustrated in the draft standard are shown in Figures 1 and 2. The laboratories developed different types of equipment for the Compressive Creep Intercomparison Tests:

Partner 2:	Lever arm, no facility for wet tests, shear forces applied using wedge blocks, Plate 1.
Partner 7:	Lever arm, wet tests possible, shear forces applied by dead weight and pulley, Plate 2.
Partner 10:	Normal pressures applied by a vertical dead load, shear forces applied by dead weight and pulley, wet tests possible, Plate 3.
Partner 12:	As Partner 10 with small variations, Plate 4.
Partner 15:	Normal pressures applied by vertical dead loads, sheared forces not possible, wet tests not possible, Plate 5.
Partner 16:	Normal pressures applied through a rubber membrane using pneumatic system, wet tests possible, shear forces cannot be applied, Plate 6
Partner 21:	Lever arm system for normal pressure, wedge blocks for shear forces, dry tests only, Plate 7

Plate 1

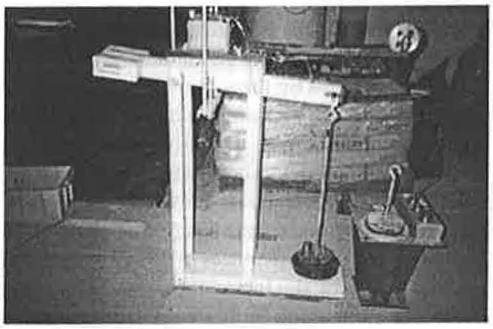

Plate 2.

Plate 3.

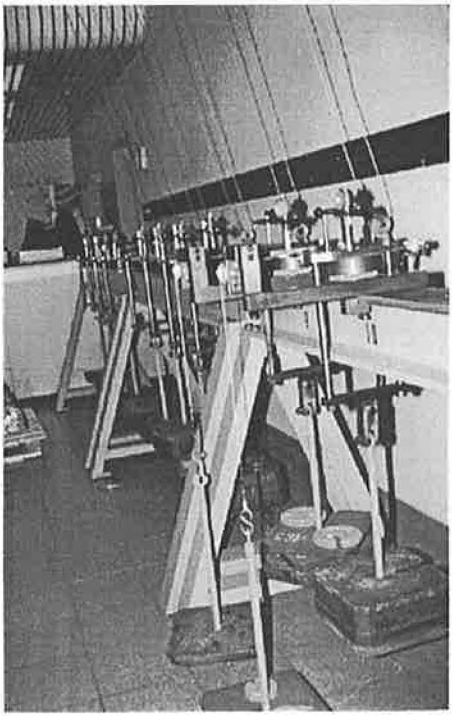

Plate 4.

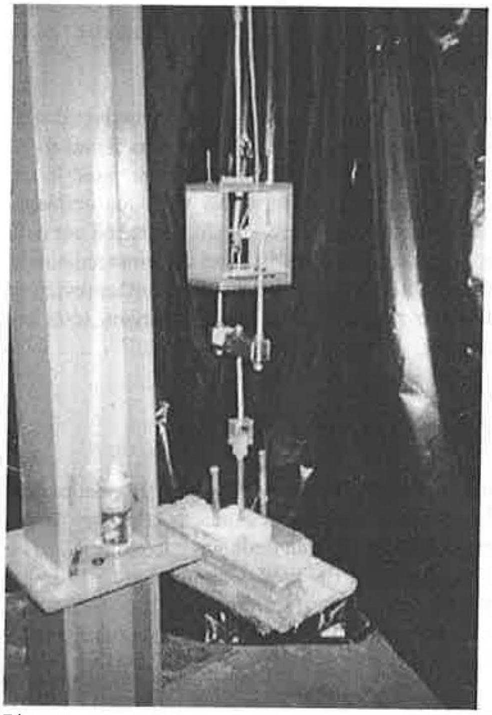

Plate 6

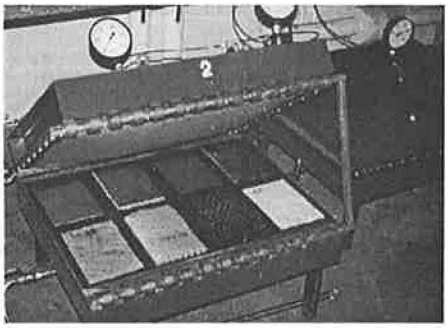

Plate 5.

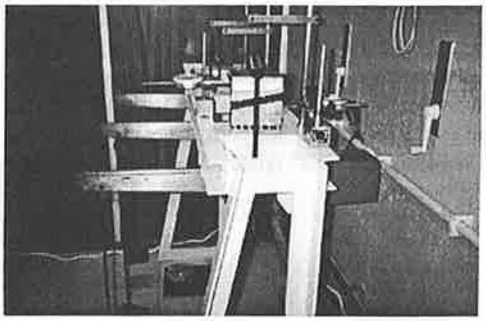

Plate 7.

4.3 *Results of the Intercomparisons*

At the time of preparing this paper the results of all the Intercomparisons (Task 2.2) are not available. The full results will be published in the final project report.

5 CONCLUSIONS

The Research work which was carried out as the first part of the project showed that some small changes to the test procedure were needed to ensure that the test specimens were always cut correctly.

The question of sample size showed that the size of the specimen was not critical and that any size specimen could be used. The minimum sized specimen should be 100mm square and specimens should have a minimum of three contact points in each direction where the sample has a defined geometric pattern. Circular specimens can be used but the minimum sized circular specimen is 142mm diameter.

The duration of the test is considered to be adequate for the determination of the compressive creep characteristics.

The requirement that tests should be conducted with the specimens immersed in water was found to be necessary for one of the polymer types used in the manufacture of geocomposites used for drainage. The requirement that tests should be carried out with the specimens immersed in water therefore remains in the draft prEN document, but will be further reviewed when the results of the Intercomparison tests are available.

ACKNOWLEDGEMENTS

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