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Geotextiles and geotextile-related products — Determination of tensile creep and creep rupture behaviour

Géotextiles et produits apparentés — Détermination du comportement au fluage en traction et de la rupture au fluage en traction

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 221, *Geosynthetics,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 189, *Geosynthetics,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 13431:1999), which has been technically revised.

The main changes are as follows:

— normative references have been updated;

— units have been added in the Notes to entry in Clause 3;

— the possibility of other test conditions, upon agreement by parties, have been added in 4.2, 5.3.3, 5.3.5;

— conditions for lateral contraction have been added in 4.3.3;

— figure keys have been slightly modified;

— charts of the recorded temperature and humidity have been added to the test report for the duration of tests in Clause 8.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html

Geotextiles and geotextile-related products — Determination of tensile creep and creep rupture behaviour

1 Scope

This document specifies a method for determining the tensile creep and creep rupture behaviour of geotextiles and geotextile-related products in an unconfined situation.

Application of this document is limited to products and applications where the risk of collapse of a structure due to premature failure or to strain and time variation of the reinforcement under constant load is of essential importance.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 9862, *Geosynthetics — Sampling and preparation of test specimens*

ISO 10318-1, *Geosynthetics — Part 1: Terms and definitions*

ISO 10319, *Geotextiles — Wide-width tensile test*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10318-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
tensile strength
maximum load per unit width, developed in a specific material subjected to an external tensile load, when measured in accordance with ISO 10319

Note 1 to entry: Tensile strength is expressed in kilonewtons per metre (kN/m).

3.2
pre-tension force
F_p
tensile force, equal to 1 % of the *tensile strength* (3.1), but not more than 10 % of the *tensile creep load* (3.7), applied to the specimen to enable the gauge length and strain zero to be determined under reproducible conditions

Note 1 to entry: The pre-tension force is expressed in kilonewtons (kN).

3.3
nominal gauge length
initial distance between two reference points located on the specimen parallel to the applied load before the application of the *pre-tension force* (3.2)

Note 1 to entry: The gauge length should be set to be completely clear from the clamping devices. The gauge length should be a representative part of the specimen, e.g. the gauge length for grid structures should be a whole number of meshes or ribs.

Note 2 to entry: Nominal gauge length is expressed in mm.

3.4
technically representative width
TRW
small width that exhibits tensile strength and strain characteristics per unit width, under identical test conditions and within ±5 % of *tensile strength* (3.1) and ±20 % of strain at the maximum load, of the values measured in accordance with ISO 10319

Note 1 to entry: Technically representative width is expressed in millimetres.

3.5
tensile creep strain
time dependent change in tensile strain of a specimen subject to a constant tensile load

Note 1 to entry: Tensile creep strain is expressed as a percentage.

3.6
tensile creep rupture
tensile failure of a specimen subject to a constant tensile load, which is less than the *tensile strength* (3.1)

Note 1 to entry: In some materials, tensile creep rupture is preceded by an increasing rate of strain.

3.7
tensile creep load
constant tensile static load per unit width, applied to the specimen

Note 1 to entry: The tensile creep load is usually expressed as a percentage of the *tensile strength* (3.1) of the sample. The tensile creep load includes the *pre-tension force* (3.2) and, if applicable, any load due to the loading device.

Note 2 to entry: Tensile creep load is expressed in kilonewtons per metre (kN/m).

3.8
loading time
time required to apply the full *tensile creep load* (3.7)

Note 1 to entry: Loading time is expressed in seconds.

3.9
creep time
time elapsed from the end of the *loading time* (3.8)

Note 1 to entry: Creep time is expressed in hours.

3.10
time to tensile creep rupture
time elapsed from the end of the *loading time* (3.8) until *tensile creep rupture* (3.6) of the specimen

Note 1 to entry: Time to tensile creep rupture is expressed in hours.

3.11
lateral contraction
decrease in the width of the specimen during the tensile test, expressed as a percentage of the width of the specimen under *pre-tension force* (3.2), measured at the centre of the gauge length

Note 1 to entry: Lateral contraction is expressed in percentage.

Note 2 to entry: See Figure 2 for an illustration of lateral contraction.

4 Specimens

4.1 Sampling

Take a sample and prepare specimens in accordance with ISO 9862.

4.2 Number of specimens

For the determination of tensile creep behaviour (see Clause 5), cut a minimum of 12 specimens from the sample.

For the determination of tensile creep rupture (see Clause 6), cut a minimum of 12 specimens from the sample.

A higher number of specimens may be cut upon agreement between the parties.

4.3 Dimensions of specimens

4.3.1 The size of the specimens is determined:

— to suit the dimensions of the apparatus being used;

— to suit the accuracy of the measuring equipment being used;

— to conform to the TRW;

— to allow the minimum gauge length to be established within the grips such that there is not less than 20 mm between either end of the marked gauge length and the grips.

4.3.2 The minimum gauge length of the specimens shall be in accordance ISO 10319 (see Figure 1) and:

— not be less than 200 mm;

— for geogrids, not be less than two full elements;

— for all samples, be of such a length that enables the measurement of the gauge length to an accuracy of ± 0,1 %.

4.3.3 The width of the specimens shall be as follows:

— for products which exhibit significant lateral contraction (>10 %), when tested in accordance with ISO 10319 (see Figure 2): 200 mm;

— a specimen less than 200 mm wide may be used only if the value of the lateral contraction is not more than 10 % (see Figure 2), where:

Lateral contraction in % = $((W - W')/(W)) \cdot 100$

where W is the original specimen width before contraction and W' is the specimen width after contraction;

— for geogrids: not less than three full elements;

— for all other materials: a TRW.

NOTE The size of the specimens has a major influence on the feasibility and the accuracy of the test. The loads required are dependent upon the width of the specimen.

4.4 Conditioning

Condition the test specimens in a standard atmosphere for testing as specified in ISO 554, until the change in mass between successive readings made at intervals of not less than 2 h does not exceed 0,25 % of the mass of the specimens.

Tests shall be carried out under the same conditions.

The temperature of the test shall be controlled and reported.

Either conditioning or testing, or both, at a specified relative humidity may be omitted if it can be shown that the results are not affected by this omission. As this test is carried out over a period of 1 000 h, the omission of humidity control is based upon experimental evidence from tests carried out over a similar period of time on similar samples of the same polymer.

5 Determination of tensile creep behaviour

5.1 Principle

The specimens are loaded with a constant static force, in constant ambient conditions of temperature and humidity.

The load is distributed evenly across the specimen width.

The elongation of the specimen is recorded continuously or is measured at specific time intervals. The load is maintained for a minimum period of 1 000 h. If the specimen fails before 1 000 h, the time to tensile creep rupture is recorded.

Specimens from the sample shall first be tested in accordance with ISO 10319 to determine the tensile strength and the TRW of the specimen.

As the test is carried out over a long period of time and the procedure is complex, the test should not be considered a routine quality control test. The results of the test cannot be representative of the performance of the products when subject to soil pressures.

5.2 Apparatus

5.2.1 General

A schematic representation of suitable equipment is shown in Figures 3 and 4.

The apparatus shall consist of a device to grip the specimen without slipping, a loading system and a system to measure the change in gauge length with time.

5.2.2 Specimen grips

The grips shall be wide enough to hold the specimen firmly across the full width. The grips shall hold the specimen without slippage and in a way which does not cause any damage to the specimen, which can in turn result in either the failure of the specimen in the grips or in incorrect measurements, or both.

The grips shall be fixed to the loading system in such a way that the load is applied to the specimen without any eccentricity, i.e. by using a universal joint or spherical seating.

5.2.3 Loading system

The loading frame shall be stiff enough to support the loads without apparent deformation.

The loading frame shall be insulated from vibrations from outside sources.

The loading frame shall not be susceptible to the disturbance caused by the failure of other specimens in the frame, in adjacent frames or by any other means.

The tensile creep load shall be constant within ± 1 %.

The tensile creep load may be applied using weights acting directly or through a system of levers, or by the use of mechanical, hydraulic or pneumatic systems. The loading system shall be calibrated before each test to demonstrate that the required load is being applied to the specimen.

NOTE Special attention can be necessary to ensure that the tensile creep load is constant when using loading systems other than dead loads, e.g. the angle of lever systems is kept nearly constant in order to ensure that the applied creep load remains within the accuracy specified.

The loading system shall be capable of applying the pre-tension force to the specimen.

The loading system shall allow the specimen to be loaded smoothly, such that the full tensile creep load is applied in not more than 60 s.

5.2.4 Strain measuring system

The change in the gauge length or strain, shall be measured between two parallel lines across the full width of the specimen or between two points on the central axis of the specimen in the loaded direction.

The change in the gauge length may be measured with any apparatus which is able to measure the change with an accuracy of ± 0,1 % of the gauge length. A mechanical, electrical or optical apparatus is normally used.

NOTE 1 Extreme care is needed to ensure the reproducibility of the readings and the long-term stability of the apparatus. The apparatus can be connected to a continuous reading system or data logger, or the changes in length can be measured at the specific time intervals given in 5.3.

NOTE 2 Extreme care is needed when marking the reference points or lines on the specimen, to avoid any displacement or distortion during the test.

5.3 Procedure

5.3.1 Tensile characteristics

Determine the wide-width tensile characteristics of the sample in accordance with ISO 10319, including the strain to rupture and lateral contraction of the specimens.

5.3.2 Technically representative width

Evaluate the validity of using a specimen with a TRW of less than 200 mm, if so required. The procedure for the evaluation of the validity of tests using specimens with a TRW of less than 200 mm is described in the examples given in Clause 7. Determine the tensile strength and strain at the maximum load of the TRW specimens.

5.3.3 Test loads

Carry out the test at least at four load levels selected from the following range: 5 %, 10 %, 20 %, 30 %, 40 %, 50 %, 60 % of the measured tensile strength.

Other loads may be selected upon agreement by parties.

Load each specimen with one of the selected loads, such that each specimen is loaded with a different tensile creep load.

5.3.4 Specimens preparation

Prepare the specimens for the tensile creep test and mount the specimens in the test apparatus. For woven geotextiles, the procedure described in ISO 10319 for the preparation of specimens shall be used.

Mark the reference lines or points, on the specimens, to give the required gauge length. Apply the pre-tension force and measure the gauge length to within ± 0,1 %.

Assemble and fix the strain measurement system in place and set it to zero, if applicable.

Smoothly apply the full tensile creep load (see 5.3.3) within not more than 60 s.

The zero time for the test is the time at which the full tensile creep load is applied to the specimen.

5.3.5 Measurements

Measure the change in the gauge length to within ± 0,1 %, at the following times:

— 1, 2, 4, 8, 15, 30 and 60 min;

— 2, 4, 8 and 24 hours;

— 3, 7, 14, 21 and 42 days (42 days = 1 008 h).

Measure the change in the gauge length to within ± 2 %, after the full tensile creep load has been applied.

Longer test duration can be applied upon agreement between the parties. In such case, continue measurements with a minimum frequency of once every 2 weeks.

Alternatively, continuous measurement or measurement at similar or more frequent time intervals may be used, provided that the first reading is taken within 1 min of the application of the full tensile creep load and that the final reading is taken at 1 000 h or later from the start of the test.

Record the graph of the tensile creep strain versus time for each specimen.

6 Determination of tensile creep rupture

6.1 Principle

The specimens are loaded with a constant static force, in constant ambient conditions of temperature and humidity.

The load is distributed evenly across the specimen width. The load is maintained until the specimen ruptures.

The time to tensile creep rupture is determined by means of a timing device which is stopped when the specimen ruptures.

6.2 Apparatus

6.2.1 General

A schematic representation of suitable equipment is shown in Figures 3 and 4, omitting the strain measuring system and adding an automatic timing device.

The apparatus shall consist of a device to grip the specimen without slipping, a loading system and a system to record the time to tensile creep rupture.

6.2.2 Specimen grips

The grips shall be wide enough to hold the specimen firmly across the full width. The grips shall hold the specimen without slippage and in a way which does not cause any damage to the specimen, which can in turn result in failure of the specimen in the grips.

The grips shall be fixed to the loading system in such a way that the load is applied to the specimen without any eccentricity, i.e. by using a universal joint (see Figure 4).

6.2.3 Loading system

The loading frame shall be stiff enough to support the loads without apparent deformation.

The loading frame shall be insulated from vibrations from outside sources.

The loading frame shall not be susceptible to the disturbance caused by the failure of other specimens in the frame, in adjacent frames or by any other means.

The tensile creep load shall be constant to within ± 1 %.

The tensile creep load may be applied using weights acting directly or through a system of levers, or by the use of mechanical, hydraulic or pneumatic systems. The loading system shall be calibrated before each test to demonstrate that the required load is being applied to the specimen.

NOTE Special attention is needed to ensure that the tensile creep load is constant when using loading systems other than dead loads, e.g. the angle of lever systems is kept nearly constant to ensure than the applied creep load remains within the accuracy specified.

The loading system shall allow the specimen to be loaded smoothly, such that the full tensile creep load is applied within not more than 60 s.

6.2.4 Time recording system

The time recording system shall be accurate to ± 1 second per day. It shall be capable of being set to zero at the time when the full tensile creep load is applied. It shall also be capable of automatically recording the time at which tensile creep rupture occurs.

6.3 Procedure

6.3.1 Wide-width tensile characteristics

Determine the wide-width tensile characteristics of the sample in accordance with ISO 10319, including the strain to rupture and lateral contraction of the specimens.

6.3.2 Technically representative width

Evaluate the validity of using a specimen of less than 200 mm, if required. Determine the tensile strength and strain at the maximum load of the TRW specimens.

6.3.3 Load levels

Carry out the test at least at four load levels selected from a range between 50 % and 90 % of the measured tensile strength.

Set the system to control the constant temperature and humidity for the test. Record the temperature and humidity for the whole test duration.

Load each of the minimum four selected load levels on three specimens, i.e. test a total of minimum 12 specimens.

Four logarithmically, equally spaced times such as 100 h, 500 h, 2 000 h and 10 000 h, should be chosen at first in order to estimate the load level likely to lead to rupture at 100 h and to perform three parallel tests. From the results, make an estimate of the load likely to lead to rupture at 500 h. Then proceed to the other two load levels.

6.3.4 Specimens preparation

Prepare the specimens for the tensile creep rupture test and mount the specimens in the test apparatus. For woven geotextile specimens, the procedure described in ISO 10319 for the preparation of specimens shall be used.

Smoothly apply the full tensile creep load within not more than 60 s.

The zero time for the test, that is, the time at which the time to tensile creep rupture starts, is the time at which the full tensile creep load is applied to the specimen.

6.3.5 Time recording

Record the time at which tensile creep rupture occurs.

6.3.6 Graph

Record the graph of tensile creep loads vs time to tensile creep rupture on a logarithmic time scale.

7 Calculations (for use of TRW specimens)

7.1 General

When using specimens with a TRW of less than 200 mm, or samples from geotextiles with a coarse weave or from geogrids, the way in which the specimen width is determined is important. The number of tensile elements per metre width is determined as follows.

Lay the sample, a full roll width, if possible, on a flat surface and smooth out any wrinkles and creases. Using a ruler, at least 1,5 m long, measure the width corresponding to the number of tensile elements present in approximately one metre. The actual width shall be measured to the nearest millimetre. Use the number of elements to calculate the number of tensile elements per metre width to within 0,1 units. Record the number of tensile elements in the specimen.

When using specimens where the resolution of the fabric structure into individual tensile elements is not practical and a TRW of less than 200 mm is to be used, the procedure specified in 7.1 shall be followed.

Specimens of the geotextile shall be prepared at a width of less than 200 mm but greater than 50 mm, using the method of specimen preparation described in ISO 10319. Determine the tensile strength and strain at maximum load on specimens 200 mm wide and the reduced width using the procedure described in ISO 10319. Calculate the tensile strength and strain at maximum load for both the 200 mm and the reduced-width specimens.

7.2 Example 1

A geogrid has 43 ribs or tensile elements in a width of 986 mm. Therefore, the number of tensile elements per metre width is 43,6 per metre.

A specimen for a wide-width tensile test has eight tensile elements, representing a nominal width of:

$(8 / 43,6) \times 1\,000 = 183,5$ mm.

The mean specimen strength was determined to be 10,8 kN with a mean strain at maximum load of 12,8 %, lateral contraction 0 %.

The tensile strength per metre width is: (1 000 / 183,5) × 10,8 = 58,9 kN/m.

A TRW specimen of three tensile elements represents a specimen width of:

(1 000 × 3) / 43,6 = 68,8 mm.

The mean tensile strength of 10 TRW specimens is determined to be 4 086 N with a mean strain at the maximum load of 13,4 %. Hence the tensile strength per unit width is:

(43,6 / 3) × 4 086 = 59,4 kN/m.

Therefore, as the tensile strengths of the wide-width tensile test and the TRW specimens deviate by less than 5 % and the strain at maximum load deviates less than 20 %, the use of TRW specimens for the tensile creep test is permitted.

7.3 Example 2

For 200 mm wide specimens, the tensile strength was determined to be 220,4 kN/m and the strain at maximum load was 10,7 %.

For 60 mm wide specimens, the tensile strength was determined to be 213,4 kN/m and the strain at maximum load was 15,2 %.

The tensile strength measured using the 60 mm wide specimens is within 5 % of the strength measured using the 200 mm wide specimens, but the strain at maximum load measured using the 60 mm wide specimens differs more than 20 % from that measured using the 200 mm wide specimens, and therefore the use of 60 mm wide specimens as the TRW is not permitted.

8 Test report

The test report shall include the following information for both test procedures:

a) number and year of publication of this document;

b) identification of the sample, date of receipt;

c) conditioning atmosphere for specimens;

d) dates between which the tests were carried out;

e) mean wide-width tensile test strength, strain(s) and lateral contraction of the specimens;

f) details of the justification for the use of TRW specimens for the tensile creep test (if applicable);

g) dimensions, tensile strength specified by the manufacturer, mean tensile strength and strain(s) of the specimens used for tensile creep testing (if applicable);

h) atmosphere in which the test was carried out and the maximum and minimum values of the recorded temperature and humidity for the whole duration of tests;

i) description of the loading system, the grips and the extensometer apparatus;

j) tensile creep loads used (in kilonewtons per metre) and as a percentage of the tensile strength reported in e);

k) table of the results of the creep strain versus creep time measurements;

l) details of any deviations from the above procedures.

The test report shall include the following information for the determination of the tensile creep behaviour:

m) nominal gauge length;

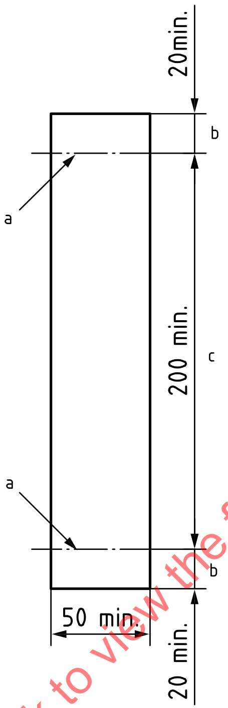
n) graphs of the creep strain versus log creep time for each specimen, for each tensile creep load and if applicable for each temperature.

The graph shall include all data points for the determination of the tensile creep rupture:

o) times to tensile creep rupture for each specimen (in a table);

p) graph of tensile creep loads against time to rupture (on a logarithmic time scales) for each temperature, if applicable, and a regression line and lower 95 % confidence limit.

Dimensions in millimetres



a Marks.

b Distance to grips.

c Gauge length.

Figure 1 — Specimen details