Designation: D5262 − 21

Standard Test Method for Determining the Unconfined Tension Creep and Creep Rupture Behavior of Planar Geosynthetics Used for Reinforcement Purposes[1]

This standard is issued under the fixed designation D5262; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method is intended for use in determining the unconfined tension creep and creep rupture behavior of geosynthetics at constant temperature when subjected to a sustained tensile loading. This test method is applicable to all geosynthetics.

1.2 The test method measures total elongation of the geosynthetic test specimen, from the time of loading, while being maintained at a constant temperature. It includes procedures for measuring the tension creep and creep rupture behavior at constant temperature of conditioned unconfined geosynthetics as well as directions for calculating tension forces to plot creep and creep rupture curves.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D1776/D1776M Practice for Conditioning and Testing Textiles

D2990 Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics

D4354 Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing

D4439 Terminology for Geosynthetics

D4595 Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method

D6637/D6637M Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

E6 Terminology Relating to Methods of Mechanical Testing

2.2 *ISO Standard:*[3]

ISO/TR 20432 Guidelines for the Determination of the Long-Term Strength of Geosynthetics for Soil Reinforcement

3. Terminology

3.1 For definitions of many terms used in this test method, refer to Terminologies D123, D4439, and E6.

4. Summary of Test Method

4.1 The tension creep and creep rupture behavior of unconfined geosynthetics is measured by applying a sustained load in one step and measuring the total elongation of the test specimen as a function of time while maintaining a specified temperature and humidity.

5. Significance and Use

5.1 This test method is developed for use in the determination of anticipated total elongation over time or time to rupture that may occur in geosynthetics under sustained loading conditions.

5.1.1 The test data can be used in conjunction with interpretive methods to determine creep strain potential at design loads.

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[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.02 on Endurance Properties.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standards's Document Summary page on the ASTM website.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

5.1.2 The test data can be used in conjunction with interpretive methods to determine creep rupture potential at various loads.

5.2 This test method is not intended for routine acceptance testing of geosynthetics. This test method should be used to characterize geosynthetics intended for use in reinforcement applications in which creep or creep rupture is of concern. The plane strain or rupture condition imposed during testing must be considered when using the test results for design.

5.3 The basic distinctions between this test method and other test methods for measuring tension creep and creep rupture behavior are: (*1*) the width of the specimens (Section 8), and (*2*) the measurement of total elongation over time or time to rupture from the moment of specimen loading. The greater widths of the specimens specified in this test method minimize the contraction edge effect (necking) that occurs in many geosynthetic materials and provides a closer relationship to actual material behavior in plane strain tension conditions.

5.4 The creep or stress rupture of a given geosynthetic is likely to be reduced in soil because of confining stresses and load transfer to the soil. The unconfined environment represents a controlled test in which the results are conservative with regard to the behavior of the material in service. Confined or in-soil testing may model the field behavior of the geosynthetic more accurately.

6. Apparatus

6.1 *Clamps:*

6.1.1 Clamps should be at least as wide as the specimen, with appropriate clamping power that will prevent slipping or damage of the test specimen within or at the faces of the clamps. The clamps and clamping technique shall be designed to minimize eccentric loading of the specimen. A swivel or universal joint shall be used on one of the clamps at the end of the specimen. It is recommended that clamps permit the final centering of the specimen prior to application of the load.[4]

6.1.2 *Geotextiles and Geomembranes*—Each clamp shall be sufficiently wide to grip the entire width of the specimen, 200 mm (8.0 in.), and a minimum of 50 mm (2.0 in.) length in the direction of the applied force.

6.1.3 *Geogrids*—These should be clamped to ensure complete tension load transfer through test direction members. The type of clamp and load transfer mechanism should be detailed in the test report. Roller grips or low melting point alloy with adequate strength may be used to assist proper clamping. See Test Method D6637/D6637M.

6.1.4 *Other Related Products*—Where special clamps are used to grip these products, they should conform to the general requirements for clamps used to grip geotextiles, geomembranes, and geogrids, and the clamping methods used should always be detailed in the report.

6.2 *Loading System*—The loading system must be designed so that the load applied and maintained on the specimen is within ±1 % of the desired load. Loads may be applied by weights, weights and fulcrums, hydraulics, or pneumatics. The loading mechanism must permit reproducibly rapid and smooth loading, as specified in 11.5. No dynamic forces on placement of the loads shall be allowed. Provision must also be made to ensure that shock loading caused by specimen failure is not transferred to other specimens undergoing testing.[4] If a non-weight or gravity system is used to apply the load, a backup system shall be available to ensure continuity of load application. The type of backup system available shall be described in the report.

6.3 *Extension Measurement*—LVDTs or dial gauge extensometers are preferred for the measurement of elongation in geosynthetics when testing specimens with short gauge lenths. Whenever possible, other means of measuring elongation should be calibrated against extensometers. In any case, the device chosen shall be capable of measuring deformations to an accuracy of at least 0.1 % of the gauge length of the specimen. The means of measuring elongation should be indicated clearly in the report.

6.4 *Vibration Control*—Creep and creep rupture tests are sensitive to shock and vibration. The location of the apparatus, test equipment, and mounting shall be designed so that the specimen is isolated from vibration. Multi-station test equipment must be of sufficient rigidity so that no significant deflection due to shock or vibration occurs during testing.

6.5 *Time Measurement*—The accuracy of the time measuring device shall be ±1 % of the elapsed time of each creep or creep rupture measurement load increment.

6.6 *Temperature Control and Measurement:*

6.6.1 The temperature in the test space, especially close to the gauge length of the specimen, shall be maintained within ±2.0 °C (±3.6 °F) of the targeted value by a suitable automatic device and shall be stated in the report. It is generally recognized that thermal contraction and expansion associated with small temperature changes during the test may produce changes in the apparent creep rate, especially near the transition temperature.

6.6.2 Temperature measurements shall be recorded at frequent intervals, or recorded continuously, in order to ensure an accurate determination of the average test temperature and compliance with 6.6.1.

6.7 *Environmental Control and Measurement:*

6.7.1 When the test environment is air, the relative humidity shall be maintained between 50 and 70 % unless the creep or creep rupture behavior of the geosynthetic has been shown to be unaffected by humidity. The relative humidity shall be recorded at frequent intervals to ensure that an accurate determination of the average test humidity can be made.

6.7.2 The test environment shall be maintained constant throughout the test. Safety precautions should be taken to avoid personal contact during the test. The area should be isolated adequately and fenced such that only the test operator has access to the test station.

7. Sampling

7.1 *Laboratory Sample*—For the laboratory sample, take a full-width swatch at least 1 m (40 in.) long in the machine

[4] Examples of clamping, loading, and extensometer systems that have been used successfully are found in the appendixes.

direction from each roll in the lot sample. The sample may be taken from the end portion of a roll, provided there is no evidence that it is different from other portions of the roll. See Practice D4354.

7.2 *Test Specimens:*

7.2.1 *Geotextiles and Geomembranes*—For tests in the machine and cross-machine directions, respectively, take from each sample the number of specimens as directed in 9.1. Take the specimens from a diagonal on the sample, with no specimens closer than one tenth the width of the roll or 150 mm (6 in.), whichever is smaller. For geomembranes, exercise care in selecting, cutting, and preparing the specimens to avoid nicks, tears, scratches, folds, or other imperfections that are likely to cause premature failure.

NOTE 1—Nonreinforced geomembranes are extremely sensitive in this regard.

7.2.2 *Geogrids and Other Related Products*—For tests in the machine and cross-machine directions, respectively, take from each sample the number of specimens as directed in 9.1. Take the specimens at random from the laboratory sample. For measurement of machine direction properties, take specimens from different positions across the width of the sample. For the measurement of cross-machine direction properties, take specimens from different positions along the length of the sample. Take no specimens nearer to the edge than one tenth the width of the roll or 150 mm (6 in.), whichever is smaller.

8. Test Specimen

8.1 *Geosynthetics*—Prepare each finished specimen to the width appropriate for the particular geosynthetic with the length dimension parallel to the direction that the creep or creep rupture behavior is being measured.

8.1.1 *Geotextiles*—Cut specimen at least 210 mm (8.4 in.) wide by at least 200 mm (8.0 in.) long. Then strip yarns from each side to leave 200 mm (8.0 in.) width of intact fabric under test.

8.1.2 *Geogrids*—Prepare specimen width to include at least three longitudinal elements abreast parallel to the direction that the creep or creep rupture behavior is being measured with each element long enough to include at least three apertures.

8.1.2.1 *Uniaxial Geogrids*—Cut specimens as illustrated in Fig. 1(a).

8.1.2.2 *Biaxial Geogrids*—Cut ribs around the periphery of a specimen no closer than 10 mm (3⁄8 in.) to a junction. See Fig. 1(b).

8.2 The length of the specimen depends on the type of clamps being used. The specimen must be long enough to extend through the full length of both clamps, as determined for the direction of the test.

8.3 When specimen integrity is not affected, the specimen may be cut initially to the finished width.

8.4 This test method may not be suitable for some woven geotextiles or geogrids that exhibit breaking strengths in excess of 100 kN/m (570 lbf/in.), due to clamping and equipment limitations.

9. Number of Tests

9.1 Unless otherwise agreed upon, creep and creep rupture tests shall be conducted at load levels as specified by the designer or customer. Four load levels are recommended for characterization of the material. Loads shall be selected at intervals of the maximum load per unit width as determined by the applicable ASTM test methods that are appropriate for the product being tested.

9.1.1 For creep tests, appropriate loads may be between 20 and 80 % of the ultimate tensile strength of the sample being tested, depending on the material being tested.

9.1.2 For creep rupture tests, the loads may be between 30 and 90 % of the ultimate tensile strength of the sample being tested, depending on the material being tested.

NOTE 2—It is generally recognized that characterization involves

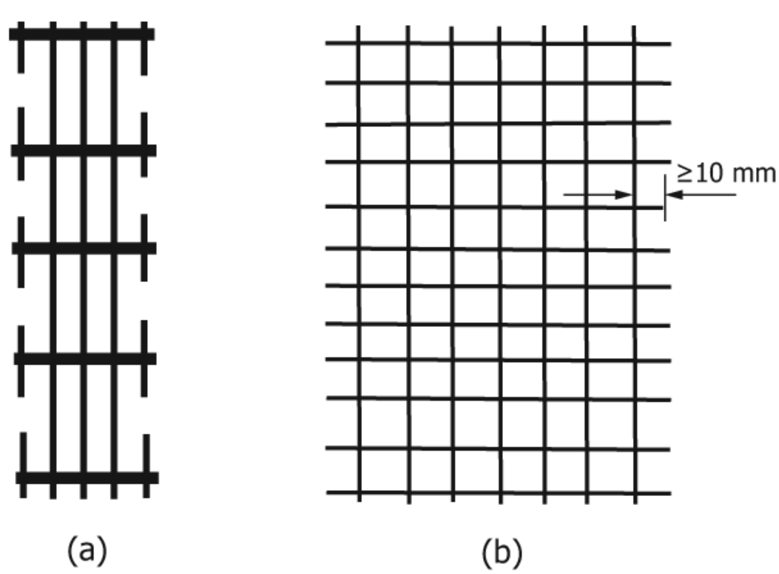


FIG. 1 (a) Uniaxial Geogrid; (b) Biaxial Geogrid

identification of the load levels at which three different stages of creep occur: primary (decreasing strain with time), secondary (linear increase in strain with time), and tertiary (exponential increase in strain with time).

9.2 To evaluate design creep strains, it is recommended that a minimum of two creep tests be performed for each test temperature (that is, one at the design load and one at a load that exceeds the design load, as specified by the designer).

9.3 To determine creep rupture, it is recommended that a minimum of twelve creep rupture tests be performed, with at least four at each test temperature to sufficiently characterize the creep rupture curve. As a guide, at least four of the tests should have rupture times between 10 h and 1000 h, four should have rupture times between 1000 h and 10 000 h, and at least one test should have a rupture time of approximately 10 000 h or more.

NOTE 3—For each temperature, the four tests should be at different load levels. Ideally, two test loads at a temperature should be the same at the next lowest temperature and two should be the same at the next highest temperature for ease of time-temperature shifting.

10. Conditioning and Testing Atmosphere

10.1 Bring the specimens to moisture equilibrium in the atmosphere for testing geosynthetics. Equilibrium is considered to have been reached when the increase in mass of the specimen, in successive weighings made at intervals of not less than 2 h, does not exceed 0.1 % of the specimen mass. In general practice, the industry approaches equilibrium from the as-received state.

NOTE 4—It is customary that geosynthetic materials are frequently not weighed to determine when moisture equilibrium has been reached. While such a procedure cannot be accepted in cases of dispute, in routine testing, it may be sufficient to expose the material to the standard atmosphere for testing for a reasonable time period before the specimens are tested. A time period of 24 h has been found acceptable in most cases. However, certain fibers may exhibit slow moisture equilibrium rates from the as-received wet state. When this is known, a preconditioning cycle, as prescribed in Practice D1776/D1776M, may be agreed upon between contractual parties.

10.2 To characterize the influence of temperature and facilitate the application of the block shifting of data as described in Appendix X5 in addition to the standard temperature of 20 ± 2.0 °C (68 ± 3.6 °F), two or more additional temperatures should be used to cover the useful temperature range of the geosynthetic considered and higher temperatures. These should be chosen in suitable increments reflecting the variation of creep and creep rupture of the geosynthetic with temperature and phase transitions of the material. The test temperature will generally be determined by site conditions and should be agreed upon by contractual parties. Suggested additional temperatures are 10 ± 2.0 °C (50 ± 3.6 °F), 30 ± 2.0 °C (86 ± 3.6 °F), 40 ± 2.0 °C (104 ± 3.6 °F), 50 ± 2.0 °C (122 ± 3.6 °F), and 60 ± 2.0 °C (140 ± 3.6 °F).

11. Procedure

11.1 Determine the ultimate tensile strength (T_{ult}) of the sample(s) provided for creep testing in accordance with the wide-width method, Test Method D4595 or D6637/D6637M, Method B, as appropriate.

11.2 Test adequately conditioned specimens. Conduct the tests at the temperature(s) selected in 10.2 and relative humidity of 50 to 75 % (if required; see 6.7.1). Contractual parties may specify an additional temperature(s) based on expected service conditions for the installation.

11.3 Mount the specimen centrally in the clamps. The specimen length must be parallel to the direction of application of force. Note the direction being tested: either machine or cross-machine.

11.4 Attach the extension measuring devices directly to the specimen, if appropriate. If these are optical devices, set up the measurement mechanism accordingly. Make the initial or reference measurement.

11.4.1 It is recommended that the initial gauge length be set at a minimum of 75 mm (3 in.) for geotextiles and geomembranes.

11.4.2 The gauge length for geogrids should be the distance, in the machine direction, across *x* consecutive apertures including *x* nodes, where $x \geq 2$.

11.5 A pre-load of not more than 1 % of the ultimate tensile strength of the specimen may be applied, including the weight of a bottom clamp (if fitted at this point) and any extension measurement equipment fitted. Apply the pre-load rapidly and smoothly on the specimen. Record the pre-load and resulting extension. It is generally accepted that the application of a pre-load force is required when testing certain geosynthetics for which part of the extension on loading occurs from a realignment of fiber structure and is relatively variable, while the subsequent time-dependent elongation, which is due to creep of the fibers, is more consistent. The application of a pretension force has therefore been selected as a simple means of establishing zero strain.

11.6 Apply the full load rapidly and smoothly to the specimen, preferably at a strain rate of 10 ± 3 %/min. Record the total time for loading (excluding pretension). For test data interpretation, disregard extension measurements within five times of the loading time.

11.7 Measure the extension of the specimen in accordance with at least the following approximate time schedule: 1, 2, 6, 10, and 30 min; and 1, 2, 5, 10, 30, 100, 200, 500, and 1000 h. For creep tests longer than 1000 h, measure and record extension at least every 500 h until testing is complete.

NOTE 5—In design, it is generally accepted that creep or creep rupture data should not be extrapolated beyond one order of magnitude. In many cases, a test period of 1000 h therefore may not reflect the long-term behavior of the material accurately. For such cases, tests should be conducted for a minimum of 10 000 h. If, after TTS if used, extrapolation by more than one order of magnitude (one log decade of time) is necessary, then apply a correction to the calculated rupture strength in accordance with Clause 10.1 of ISO/TR 20432.

NOTE 6—For preliminary evaluation of newly developed products when testing is underway but has not yet reached 10 000 h, creep or creep rupture behavior may be inferred from completed test results on essentially identical products from the same family of products (that is, manufactured by the same organization using the same process technology, polymer type, polymer structure, polymer molecular weight, polymer additives, constituent materials, product configuration, etc.). Application of this inference is appropriate only when a minimum of 1000 h of testing is completed on the new product and a definable correlation exists with the available 10 000 h test results for the family of products which bound the ultimate strength and constant load level for creep or creep rupture testing of the new product.

11.8 Readings should be recorded more frequently if discontinuities in the creep strain versus log of time plot are suspected or encountered. To avoid such discontinuities, the use of automatic monitoring and measuring equipment is recommended.

11.9 Terminate a test when the specimen ruptures or at the end of the agreed-upon period or when the specimen reaches an agreed strain limit. If the specimen ruptures, report the type of failure, location, and time to failure.

12. Calculation

12.1 *Creep Curves*—The standard curve is a graph of strain versus log of time, as shown in Fig. 2. The data are prepared by use of the following calculations:

12.1.1 *Time*—Elapsed time intervals are calculated as hours.

12.1.2 *Strain*—The percent strain at each interval is calculated (to the nearest 0.1 %) using Eq 1:

$$\varepsilon = (\Delta L \times 100)/L_g \quad (1)$$

where:

ε = strain, %,

ΔL = change in specimen gauge length, mm (in.), from application of the pre-load, over the measured time period since application of the full test tensile load, and

L_g = initial nominal gauge length plus the pretension displacement, mm (in.).

12.1.3 The data are then plotted as percent strain as ordinate versus time on a logarithmic scale as abscissa. If several loads are used for testing, each plot shall be labeled clearly with the appropriate loading or force per unit width, expressed as % of actual T_{ult} and, if required, kN/m (lb/in.). For geogrids, the equivalent force per unit width is determined by the use of Eq 2:

$$a = (F/N_R) \times N_T \quad (2)$$

where:

a = equivalent force per unit width, kN/m (lbf/ft),

F = applied force, kN (lbf),

N_R = number of ribs tested, and

N_T = number of ribs per unit width.

NOTE 7—Actual T_{ult} means the ultimate tensile strength of the sample roll of product from which the specimens were cut.

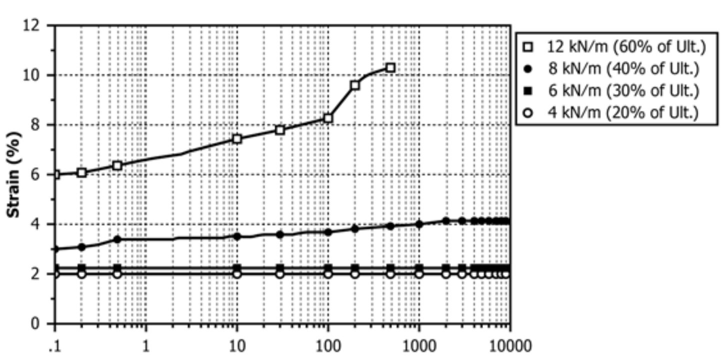


FIG. 2 Percent Strain versus Log of Time

12.2 *Creep Rupture Curves*—The standard is a graph of creep rupture load (% of T_{ult}) versus time on a logarithmic scale, as shown in Fig. 3.

NOTE 8—Data could also be presented as log10 of creep rupture loading (%) versus log10 of time, if appropriate, to give a better straight line for the plot trend line. For example, this has been found to be appropriate for PP and HDPE geogrids.

12.2.1 *Time*—Elapsed times to rupture are converted to hours.

12.2.2 *Creep Rupture Loading*—Calculate the creep rupture loading as loading per unit width. For geogrids, the equivalent force per unit width is determined by the use of Eq 2.

12.2.3 For a given test temperature, curve fit the data with an appropriate correlation (for example, power law) as shown in Fig. 3.

12.2.4 When this curve fitting is carried out, it may be that one or more creep tests will not have yet terminated. The latest data from such tests may be included in the analysis if it improves the creep strength predicted.

13. Report

13.1 Report the following information:

13.1.1 Note that the specimens were tested as directed in this test method. Describe the material tested, including all pertinent information required for complete identification of the specimen.

13.1.2 Provide all of the following applicable items for the machine direction and cross-machine direction of the material tested:

13.1.3 Ultimate tensile strength of the roll of product from which creep specimens are to be taken, measured in accordance with the appropriate ASTM wide-width test standard.

13.1.4 Dates of the creep or creep rupture test.

13.1.5 Dimensions of the test specimen(s).

13.1.6 Preconditioning used and description of test conditions, which includes the following: relative humidity; temperature or temperatures; loads used; type and weight of clamping system, which includes any special details of clamping utilized to test the specimen and the reason for special measures (for example, alloy used for gripping); loading mechanism; pretension load; and associated extension.

13.1.7 For each creep temperature, plot creep strain in percent versus log of time in hours under a given load per unit width and as a percent of ultimate tensile strength, as determined in appropriate ASTM test methods (see Fig. 2).

13.1.8 For each creep rupture temperature, plot creep rupture loads as a percent of ultimate tensile strength per unit width versus log of time in hours and as determined by the appropriate ASTM test methods (see Fig. 3).

14. Precision and Bias

14.1 *Precision*—The precision of the procedure in this test method is being established.

14.2 *Bias*—This test has no bias because the unconfined tension creep and creep rupture of geosynthetics is defined in terms of this test method.

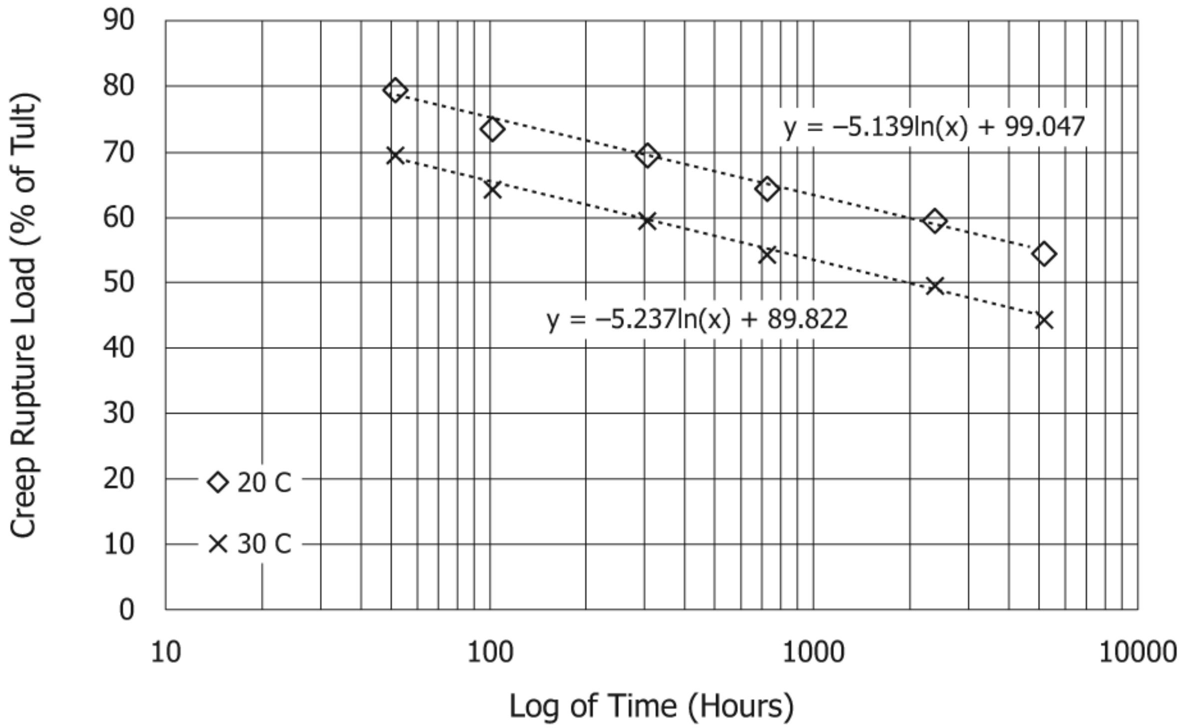


FIG. 3 Creep Rupture Load versus Time

15. Keywords

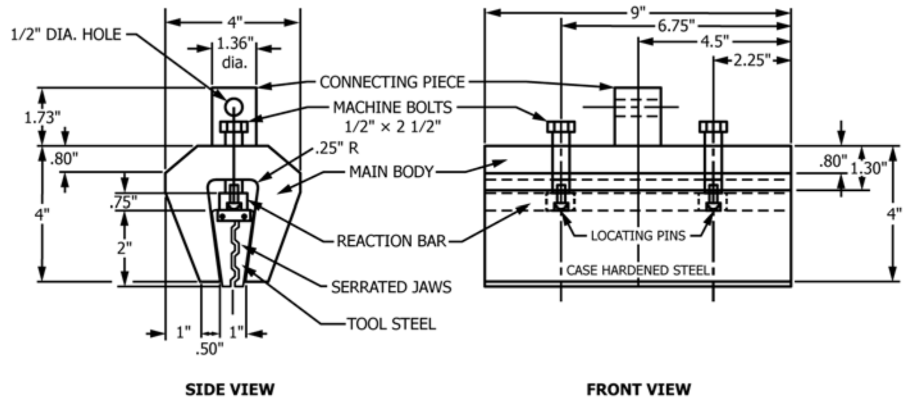
15.1 creep rupture; geogrid; geomembrane; geosynthetics; geotextile; tension creep

APPENDIXES

(Nonmandatory Information)

X1. CLAMPING SYSTEMS

See Fig. X1.1.

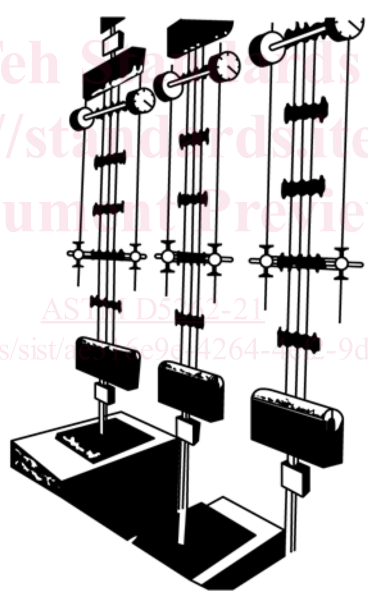


NOTE 1—Roller grips, not shown, are also suitable for tension creep testing.

FIG. X1.1 Example of Suitable Tension Creep Clamping System

X2. LOADING SYSTEM

See Figs. X2.1 and X2.2.



NOTE 1—Roller grips, not shown, are also suitable for tension creep testing.

FIG. X2.1 Example of Geogrid Loading System