Designation: D5993 – 14

Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners[1]

This standard is issued under the fixed designation D5993; 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 covers the laboratory determination of the mass per unit area of a sample of a geosynthetic clay liner (GCL). The test method is also applicable to a multicomponent GCL. The dry mass of the clay can be found by simply subtracting the manufacturer's reported nominal mass of the geosynthetic component(s) from the total mass of the dry GCL. The moisture content of the GCL can also be determined by subtracting the initial total mass of the GCL from the total mass of the dry GCL.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.* See Section 8 for specific precautionary statements.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D4439 Terminology for Geosynthetics

D4643 Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

E145 Specification for Gravity-Convection and Forced-Ventilation Ovens

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 *geosynthetic, n*—a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure, or system. **D4439**

3.1.2 *geosynthetic clay liner, n*—a manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetic material(s).

3.1.3 *moisture content, n*—that part of the mass of a geosynthetic clay liner that is absorbed water, compared to the mass of dry clay.

3.1.4 *multicomponent GCL, n*—GCL with an attached film, coating, or membrane decreasing the hydraulic conductivity or protecting the clay core, or both.

3.1.5 *oven-dried, adj*—the condition of a material that has been heated under prescribed conditions of temperature and humidity until there is no further significant change in its mass. **D123**

4. Summary of Test Method

4.1 The mass per unit area is determined by weighing (oven-dried) specimens of known initial size after drying in an oven over a sufficient time period to remove the moisture from the GCL.

4.2 The mass per unit area of the clay component of the GCL can be estimated by subtracting the manufacturer's reported nominal mass per unit area of the synthetic component(s) from the total GCL mass per unit area.

NOTE 1—The supplier of the geosynthetic clay liner must be able to verify that the actual mass/unit area of the synthetic component(s) is within ±10 % of the reported nominal value. A more accurate estimation of the actual dry clay mass per unit area could be obtained by using the actual average value for the synthetic component(s) (as obtained from the manufacturer for the actual lots used to make the GCL) rather than the nominal value.

4.3 The moisture content of the GCL can be estimated with this test method.

5. Significance and Use

5.1 This test method is used to determine if the GCL material meets specifications for mass per unit area at approximately 0 % moisture content, by oven-drying. It can be used as

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.04 on Geosynthetic Clay Liners.

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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 standard's Document Summary page on the ASTM website.

an index test for quality control or quality assurance to determine specimen conformance.

6. Atmosphere Conditions

6.1 *Atmospheric Conditions:*

6.1.1 The atmospheric conditions of the laboratory performing mass per unit area of GCLs shall be: relative humidity of ≤ 70 % and temperature of 23 ± 4°C.

7. Apparatus

7.1 *Drying Oven*—Thermostatically-controlled, preferably of the forced-draft type, meeting the requirements of Specification E145 and capable of maintaining a uniform temperature of 110 ± 5°C throughout the drying chamber.

7.2 *Microwave Oven*—A microwave oven, preferably with a vented chamber, is suitable. The required size and power rating of the oven is dependent on its intended use. Ovens with variable power controls and input power ratings of about 700 W have been found to be adequate for this use. Variable power controls are important and reduce the potential for over heating the test specimen.

NOTE 2—Microwave ovens equipped with built-in scales and computer controls have been developed for use in drying soils. Their use is compatible with this test method.

7.3 *Balances*—All balances must meet the requirements of Specification D4753 and this section. A Class GP1 balance of 0.01 g readability is required for samples having a mass of up to 200 g (excluding mass of sample container) and a Class GP2 balance of 0.1 g readability is required for samples having a mass over 200 g.

7.4 *Sample Containers*—Suitable containers made of material resistant to corrosion and change in mass upon repeated heating, cooling, exposure to materials of varying pH, and cleaning. Microwave sample containers should be microwave safe.

7.5 *Desiccator*—A desiccator cabinet or large desiccator jar of suitable size containing indicator silica gel. It is preferable to use a desiccant that changes color to indicate it needs reconstitution.

7.6 *Container Handling Apparatus*—Gloves, tongs, or suitable holder for moving and handling hot containers after drying.

7.7 *Die,* of known dimensions.

7.8 *Miscellaneous,* knives, spatulas, scoops, quartering cloth, sample splitters, and so forth, as required.

8. Hazards/Precautions

8.1 Handle hot containers with a container holder.

8.2 Safety precautions supplied by the manufacturer of the microwave oven should be observed.

8.3 Do not use metallic containers in a microwave oven (if used).

9. Test Specimens

9.1 The sample received at the testing laboratory should be in satisfactory condition and representative of the product manufactured or delivered to a site, or both.

9.2 A sample of a GCL should be cut into specimens in a laboratory using a die or sharp razor blade or razor knife.

9.3 The minimum size of the die or template for cutting specimens is 0.01 m^2 (for example, 10 by 10 cm).

NOTE 3—The use of small specimens are not recommended due to the potential for edge loss of clay, which may create problems with accuracy and reproducibility.

9.4 Test specimens taken from the laboratory sample should be free from imperfections or other areas not representative of the material samples (such as dirt or labels).

9.5 Cutting of the laboratory specimens with a die or razor may contaminate the work area, die, or razor with particles of clay or geosynthetic material. The work area should be cleaned before cutting the specimen. Therefore, all excess or waste material should be cleaned away from the die and cutting area before removal of the specimen. The specimen, material on the die, and cutting area should be placed into a tared container. Wiping of the area should be performed with a non-clinging cloth or brush.

9.6 The loss of clay during the specimen cutting process could have a significant impact to the accuracy of this test method. The technician performing this test method should practice cutting test specimens from the laboratory sample until confidence is gained that a specimen can be cut without significant loss of clay.

9.6.1 The technician may choose to wet the perimeter of the GCL in an effort to bind the clay particles together and thereby reduce the possibility of clay granule loss during the cutting process. If the sample is wetted, the technician should try to limit the amount of clay that will attach itself to the die, cutting board, template, or cutting instrument, or combination thereof. However, if the technician attempting to determine the moisture content of the GCL, other cutting methods should be used that do not require the addition of water.

9.6.2 If a die is used to cut the specimen, loss of clay can be reduced by leaving the die in place and removing all the remaining sample outside the edge of the die. This includes brushing the cutting board clean. All material found within the edge of the die could then be placed in the sample containers.

9.6.3 Any waste clay left on the cutting board and die or razor for which the technician cannot determine if the clay came from the individual specimen or the original sample should be collected and weighed. It should be assumed the waste clay is edge loss from the individual specimen and the original sample. One half the weight of the waste clay should be added to the test specimen container and the other one-half discarded.

9.7 The number of test specimens should be a minimum of five, cut such that they are representative of the entire roll width.

10. Conditioning

10.1 Bring the test specimens to moisture equilibrium in the atmosphere for testing GCLs. Equilibrium is considered to have been reached when the increase in mass of the test specimen in successive weighing, made at intervals of not less than 2 h, does not exceed 0.1 % of the previous mass of the test

specimen. In general practice, the industry assumes equilibrium conditions exist in the "as-received" state.

11. Procedure (Assuming Moisture Present)

11.1 Using the die, or template and razor, and other necessary apparatus, carefully cut the laboratory sample into five 0.01-m^2 test specimens. The five specimens should be randomly selected from locations on the sample, but should be distributed across the sample. Any waste clay (including on the die or razor) should be collected from each individual specimen and divided in half. One half of the waste clay should be added to the test specimen container and the other one-half discarded.

11.2 The container to be used should be oven dried thoroughly and subsequently placed into a desiccator until ready for use so that the tare weight of the container will be recorded.

11.3 Determine and record the tare of the specimen container.

11.4 Select representative test specimens.

11.5 Place the test specimen in the individual container. Determine the mass of the container and GCL specimen as delivered using a balance selected on the basis of the sample mass. Record the value of the GCL specimen (M_i).

NOTE 4—To prevent mixing of samples and yielding of incorrect results, all containers should be numbered and the container numbers shall be recorded on the laboratory data sheets.

11.6 Place the container with the GCL specimen in the drying oven. Dry the GCL specimen to a constant mass. Maintain the drying oven at 110 ± 5°C unless otherwise specified. The time required to obtain constant mass will vary depending on the type of material, size of sample, oven type and capacity, and other factors. The influence of these factors generally can be established by good judgment, experience with the materials being tested, and the apparatus being used.

NOTE 5—In most cases, drying a test sample overnight (about 12 to 16 h) is sufficient for conventional ovens. In cases where there is doubt concerning the adequacy of drying, drying should be continued until the change in mass after two successive periods (greater than 1 h) of drying is less than 0.1 %.

NOTE 6—If a microwave oven is used to dry the test specimen(s), the user of this test method should follow the drying procedures as stated in Test Method D4643. It is also recommended that the total mass of the test specimen(s) be a minimum of 100 g.

NOTE 7—Since some dry materials may absorb moisture from moist samples, dried samples should be removed before placing moist samples in the same oven. However, this would not be applicable if the previously dried specimens will remain in the drying oven for an additional time period of about 16 h.

11.7 After the material has dried to constant mass, remove the container from the oven (and replace the lid if used). Allow the material and container to cool to room temperature in a desiccation unit or until the container can be handled comfortably with bare hands and the operation of the balance will not be affected by convection currents or its being heated, or both. Determine the mass of the container and oven-dried material using the same balance as used previously. Subtract the tare of the container from the mass of the sample to determine the samples' constant dry mass. Record this value (M_{GCL}).

12. Calculation

12.1 Calculate the mass per unit area of each of the specimens as follows:

$$m_{GCL} = M_{GCL}/A \quad (1)$$

where:

m_{GCL} = mass per unit area of the dried GCL product rounded to the nearest 0.1 g/m^2,
M_{GCL} = the dried mass of GCL specimen measured to the nearest 0.01 g,
= (oven-dried specimen + container mass) − (tare mass of container), and
A = area of the specimen, m^2 (0.01 m^2, if prepared in accordance with 11.1).

12.2 The mass per unit area of the clay component of the GCL can be estimated as follows:

$$m_{clay} = m_{GCL} - m_s \quad (2)$$

where:

m_{clay} = mass per unit area of dry clay component rounded to the nearest 0.1 g/m^2, and
m_s = nominal mass per unit area of GCL synthetic component(s), g/m^2, as provided by manufacturer (see 4.2, Note 1).

12.3 The percent initial moisture content of the clay component of the GCL can be estimated as follows:

$$w_{clay} = \frac{(M_i/A) - m_{GCL}}{m_{clay}} x\ 100 \quad (3)$$

where:

w_{clay} = initial moisture content of the clay component of the GCL, percent, rounded to the nearest 0.1 %, and
M_i = initial mass of GCL specimen.

12.4 Calculate the average of the mass per unit area results (and moisture content results, if desired) for the test specimens. (**Warning—**The dried mass/unit area may include the presence of adhesives, polymers, or other additives. Consult the GCL manufacturer for additional information.)

13. Report

13.1 Report the following information on mass per unit area of GCLs:

13.1.1 Sample identification (for example, sample number, roll number, or other traceable identifier),

13.1.2 Type of GCL tested, method used for cutting specimens, sample size, specimen size and shape, and number of test specimens used,

13.1.3 The assumed mass of the synthetic component(s) (m_{cc}) (for example, geotextile, membrane, coating) and source of information (that is, manufacturer's specification sheet),

13.1.4 Drying time, temperature, and method used to dry,

13.1.5 The average mass per unit area of the GCL (m_{GCL}) to the nearest 1 g/m^2,

13.1.6 Report the average mass per unit area of the dried clay component of the GCL (m_{clay}) to the nearest 1 g/m^2,

13.1.7 Report the average moisture content of the clay component of the GCL (w_{clay}) to the nearest 0.1 %,

13.1.8 A statement of any departure from the suggested testing procedures so that the results can be evaluated and used,

13.1.9 Indicate if any material (size and amount) was excluded from the test sample (such as waste clay, 11.1), and

13.1.10 Identification of testing agency, person performing the test, date of test, and client or project identification.

14. Precision and Bias[3]

14.1 *Precision:*

14.1.1 *Inter-Laboratory Test Program*—An interlaboratory study of the test method was run in 1997/1998. Three sets of five randomly drawn specimens of each of three materials were tested for bentonite mass/unit area in each of eight laboratories. The design of the experiment, similar to that of Practice E691, and within-between analysis of the data are given in Research Report RR:D35-1005.

14.1.2 *Test Result*—The precision information is given below. The test results are for the dry bentonite mass unit area and are in terms of coefficients of variation, CV%.

STATISTIC	
Within Lab Repeatability Limit, CV % Sr	2.3%
Between Lab Reproducibility Limit, CV % SR	3.9%
95% Confidence Limit Within Lab Repeatability, CV % r	6.6%
95% Confidence Limit Between Lab Reproducibility, CV % R	10.8%

14.2 *Bias*—The procedure in Test Method D5993 for measuring the mass per unit area of a geosynthetic clay liner has no bias because the value of the mass per unit area of a geosynthetic clay liner is defined only in the terms of this test method.

15. Keywords

15.1 clay; dry; geosynthetic; geosynthetic clay liner; mass per unit area; moisture

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D35-1005.