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Geosynthetics — Determination of friction characteristics —

Part 1:
Direct shear test

Géosynthétiques — Détermination des caractéristiques de frottement —

Partie 1: Essai de cisaillement direct

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 12957-1 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 221, *Geosynthetics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

ISO 12957 consists of the following parts, under the general title *Geosynthetics — Determination of friction characteristics*:

— *Part 1: Direct shear test*

— *Part 2: Inclined plane test*

Contents

Foreword

This document (EN ISO 12957-1:2005) has been prepared by Technical Committee CEN/TC 189 "Geosynthetics", the secretariat of which is held by IBN, in collaboration with Technical Committee ISO/TC 221 "Geosynthetics".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2005, and conflicting national standards shall be withdrawn at the latest by August 2005.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This document describes an index test method to determine the friction characteristics of geotextiles and geotextile-related products in contact with a standard sand, i.e. with a specified density and moisture content, under a normal stress and at a constant rate of displacement, using a direct shear apparatus.

The procedure can also be used for testing geosynthetic barriers.

When geogrids are tested with a rigid support, the results are dependent on the friction with the support and the results are not necessarily realistic. The accuracy of the test should be verified by calibration tests.

2 Normative references

The following referenced documents are indispensable for the application 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 6344-2, *Coated abrasives – Grain size analysis – Part 2: Determination of grain size distribution of macrogrits P 12 to P 220.*

EN ISO 9862, *Geotextiles – Sampling and preparation of test specimens (ISO 9862:2005).*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
relative displacement (*s*)
displacement of the sand relative to the specimen during shearing, in millimetres

3.2
normal force *(N)*
constant vertical force applied to the specimen, in kilonewtons

3.3
shear force (*S*)
horizontal force, measured during shearing at a constant rate of displacement, in kilonewtons

3.4
normal stress (σ)
normal force divided by the contact area of the specimen, in kilopascals

3.5
shear stress (τ)
shear force along the sand/geotextile interface, divided by the contact area of the specimen, in kilopascals

3.6
maximum shear stress (τ^{max})
maximum value of shear stress developed in a shear test, in kilopascals

3.7
angle of friction (ϕ_{sg}) (between geosynthetic and sand)
slope of the "best fit straight line", through the plot of maximum shear stress, in degrees

3.8
apparent cohesion (c_{sg}) (between geosynthetic and sand)
calculated value of the shear stress on the "best fit straight line" corresponding to zero normal stress, in kilopascals

3.9
maximum shear stress in sand (τ_s^{max})
maximum shear stress developed during a shear test on sand alone, in kilopascals

3.10
maximum shear stress sand/support (τ_{sup}^{max})
maximum shear stress developed during the shearing along the sand/support interface (without geosynthetic), in kilopascals

3.11
friction ratio ($f_g(\sigma)$)
ratio of the maximum shear stress τ^{max} (friction test sand/geosynthetic) to the maximum shear stress τ_s^{max} (shear test on sand alone) for the same normal stress σ

4 Principle

A geosynthetic is submitted to direct shear at its contact surface with standard sand in a shear box or similar apparatus. The angle of friction at the sand/geosynthetic interface is determined.

5 Test specimens

5.1 Sampling

Take specimens in accordance with EN ISO 9862.

5.2 Number and dimensions of test specimens

Cut four specimens from the test sample for each direction to be tested. The size of the specimens shall suit the dimensions of the apparatus.

If the two faces of the sample are different, both faces shall be tested; four specimens shall be tested for each face.

6 Conditioning

Condition the test specimens and conduct the tests in the standard atmosphere for testing, defined in ISO 554, i.e. at a temperature of (20 ± 2) °C and a relative humidity of (65 ± 2) %, until the change in mass between successive readings made at intervals of not less than two hours does not exceed 0,25 % of the mass of the test specimens.

NOTE Conditioning and/or testing at a specified relative humidity may be omitted if it can be proved that the results are not affected by this omission.

7 Apparatus

7.1 Shearing apparatus

7.1.1 Constant contact area shear box (schematically represented in Figure 1)

The shear box shall be divided into upper and lower sections. The apparatus shall be sufficiently rigid to resist distortion under the loads applied. It shall be possible to lift the upper part of the shear box from the lower part.

The upper part of the shear box shall have internal dimensions of not less than 300 mm × 300 mm, the width of both boxes being not less than 50 % of their length. The box shall be sufficiently deep to accommodate the sand layer and the loading system.

For the testing of geogrids the minimum dimensions of the shear box shall be such that at least two full longitudinal ribs and three transverse bars are contained within the length of both the upper and lower box throughout the test.

The lower part of the shear box shall contain the support of the specimen and any clamping arrangements to prevent the specimen from slipping during the test.

The lower part of the shear box shall be sufficiently long to maintain full contact between specimen and sand over a relative shear displacement of at least 16,5 % of the internal length of the top box.

7.1.2 Reducing contact area shear box (schematically represented in Figure 2)

Alternatively a standard soil shear box with equally sized (300 mm × 300 mm minimum) upper and lower halves can be used.

7.2 Specimen support

The specimen shall be placed on a rigid, horizontal support in the lower part of the shear box. The specimen shall be fixed to prevent, as far as possible, any relative displacement between the specimen and the support. The geosynthetic should be clamped at the front part outside the shear area. Inside the friction area, it should be fixed by gluing or with a standard friction suppport, e.g. an aluminium oxide abrasive sheet (P 80 type in accordance with ISO 6344-2).

When using a rigid plate as support for geogrids (or geotextiles) with a high percentage of openings, friction tests between sand and the support shall be performed and the maximum shear stress (τ_{sup}^{max}) related to every normal stress shall be evaluated.

NOTE For geogrids with large apertures (> 15 mm) and a high percentage of openings (> 50 % of the overall surface of the specimen), a sand support may be used, i.e. by filling the lower box with standard sand at the specified density.

7.3 Rigid carriage

The shear box shall be supported on the machine bed on low friction bearings, which allow movement in the longitudinal direction.

7.4 Loading device

The loading device shall be capable of applying a horizontal shear force to the shear box at a constant rate of displacement of (1 ± 0,2) mm/min.

7.5 Application of the normal force

The normal force can be applied using any type of fluid filled soft membrane which ensures that the normal force is applied uniformly over the whole area of the specimen.

The normal force shall be measured to a precision of ± 2 %.

7.6 Measurement of shear force and displacement

The shear force shall be measured to a precision of ± 2 %.

The relative displacement shall be measured to a precision of ± 0,02 mm.

NOTE 1 The design of the apparatus should allow for the dilatation of the sand, i.e. a gap, equal to the thickness of the specimen plus 0,5 mm, should be left between the upper and lower parts of the apparatus.

NOTE 2 The upper box should be fitted with a rigid confinement system to prevent sand particles blocking the space between the upper part of the shear box and the geotextile or geogrid support.

The sand in contact with the specimen shall be a natural siliceous sand, consisting preferably of rounded particles and with a silica content of at least 98 %. The moisture content, determined as the loss of mass after 2 h drying at 105 °C, shall be less than 0,2 %, expressed as a percentage by mass of the dried sample. The grading is defined in Table 1.

Table 1 - Grading of standard sand

Sieve size (in mm)	Cumulative sieve residue (in %)
2,00	0
1,60	7 ± 5
1,00	33 ± 5
0,50	67 ± 5
0,16	87 ± 5
0,08	99 ± 1

If loss of fine particles is observed during a test, the grading of the sand shall be checked. The amount of sand entrapped shall be determined by re-weighing the specimen and reported.

NOTE 3 A visual check may be adequate to verify whether the grading has changed. Water may be added to the sand to avoid particle segregation but the moisture content should not exceed 2 %.

The internal angle of friction of the sand shall be measured in a common direct shear box. The same equipment as used for the friction test may be used if it satisfies the requirements of the common direct shear box.

8 Procedure

The specimen shall be flat, free from folds and wrinkles.

Fix the specimen to the support system. In the reducing contact area apparatus the top surface of the specimen shall be flush with the lower part of the shear box.

Assemble the upper section of the box.

Fill the upper part of the shear box with the standard sand to a compacted thickness of 50 mm. The sand shall be compacted to a dry density of 1 750 kg/m³.

Fill the upper part of the box with a pre-weighed mass of sand, such that, when compacted, the material has the required density and occupies the required volume.

Assemble the loading devices and displacement measuring devices (transducers or dial gauges). Apply the normal force to obtain one of the following pressures: 50 kPa, 100 kPa or 150 kPa.

Measurements of the shear force shall be taken continuously or at intervals which correspond to displacements of 0,2 mm or 12 second time intervals. The actual relative displacement shall be recorded at the same time, and the plate (used to apply the vertical load) lift and rotation should be measured at the end of the test.

The test is terminated when the relative displacement reaches 50 mm for a shear surface length of 300 mm (or 16,5 % of the shear surface length in other cases).

Dismantle the apparatus, carefully remove the sand, inspect the specimen and record any stretching, wrinkles or damage.

Carry out the test twice for the 100 kPa normal stress and repeat, if required, for the different sides or directions of the sample. A new specimen shall be used for each test.

9 Calculations

Calculate the normal stress (σ) for each set of readings as:

$$\sigma = \frac{N}{A}$$

where

σ = normal stress, in kilopascals.

N = normal force, in kilonewtons.

A = the contact area, in square metres, corrected for each calculation if using the reducing area apparatus.

Calculate the shear stress (τ) for each set of readings as:

$\tau = S/A$

where

τ = shear stress, in kilopascals.

S = measured shear force, in kilonewtons.

A = contact area of the specimen, in square metres.

Plot the test results as graphs (shear stress versus relative displacement). Determine the maximum shear stress, using the definitions (see 3.6).

Plot the maximum shear stress against the normal stress for all four specimens. Draw the best fit straight line through the plotted points. The angle between the best fit straight line and the horizontal axis is ϕ_{sg}, the angle of friction between geosynthetic and sand and c_{sg} (apparent cohesion) is the intercept of this line with the vertical axis.

Calculate the friction ratio (f_g) for displacements in the range of 0 % to 10 % of the length of the sheer surface for each of the four tests, as:

$$f_g(\sigma) = \frac{{}_{\tau}\max(\sigma)}{{}_{\tau_s}\max(\sigma)}$$

where

${}_{\tau}\max(\sigma)$ is the maximum shear stress under the normal stress σ, in a sand/geosynthetic direct shear test, as defined in 3.6.

${}_{\tau_S}\max(\sigma)$ is the maximum shear stress under the normal stress σ, in a direct shear test on sand alone, as defined in 3.9.

10 Test report

The test report shall include following information:

a) number and date of this document;

b) identification of the sample, date of receipt and date of testing;

c) the conditioning atmosphere;

d) the temperature at which the test was carried out;

e) the orientation (machine or cross machine direction, top or bottom), of the specimens;

f) a graph of shear stress against displacement, showing the maximum shear stress used in calculation;

g) a graph of maximum shear stress against normal stress;

h) a graph of shear stress against displacement for the direct shear test on sand;

i) a graph of maximum shear stress against normal stress for the direct shear test on sand under similar conditions (density, moisture, normal stress);

j) a graph of the friction ratio against normal stress;

k) the angle of friction and the apparent cohesion for the sand-geosynthetic interface;

l) the angle of internal friction for the sand;

m) if necessary (see 7.2), a graph of maximum shear stress against normal stress for the sand versus friction support;

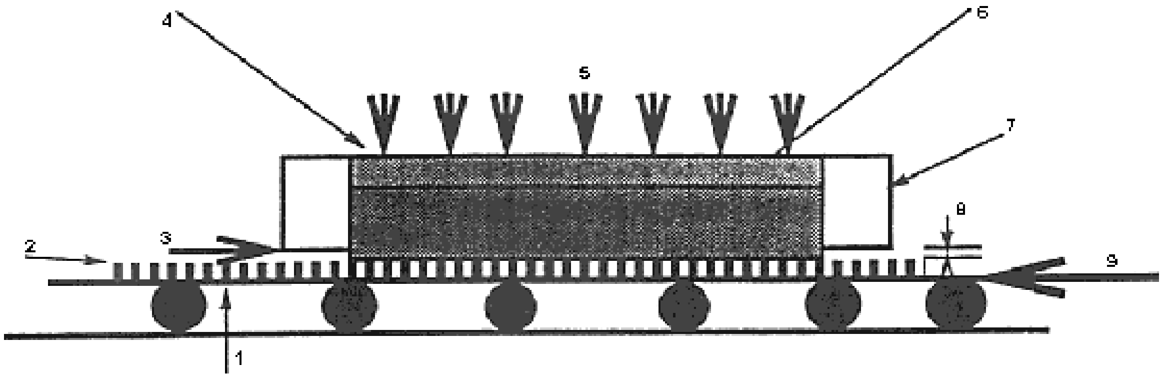
n) observations of any damage of the specimen or unusual behaviour, during testing;

o) a description of the "post peak" behaviour observed in each test (e.g. constant shear stress, strain hardening, strain softening);

p) any deviation from this procedure.

NOTE 1 Graphs f), g), j), k) should be produced for each face and direction tested, i.e. a maximum of 4 sets of graphs.

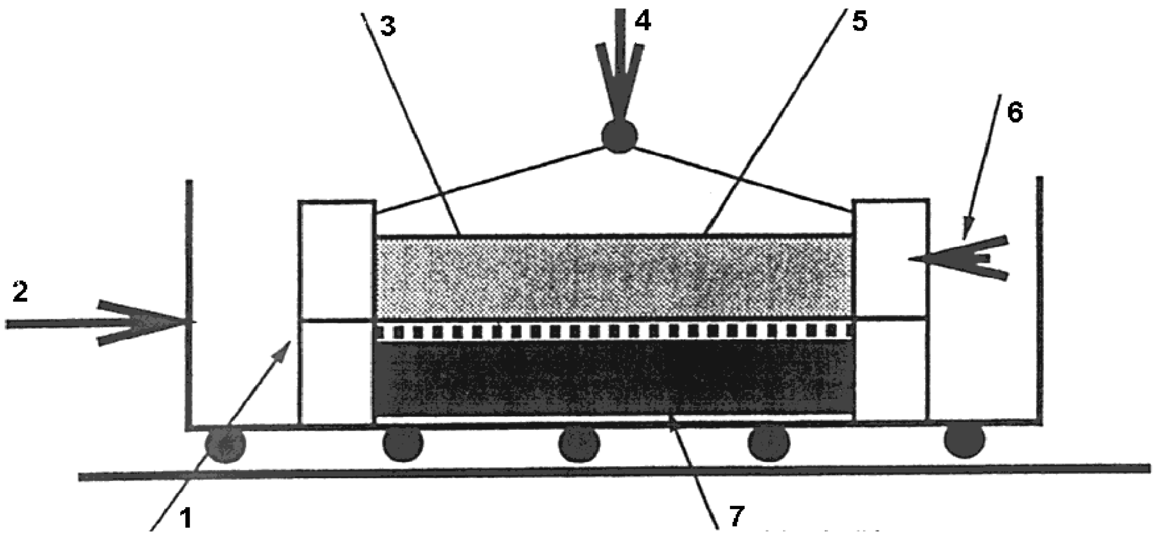
NOTE 2 For comparison of index test results, all graphs and data of the test report should be submitted to the judgement of an engineer.



Key

1 Rigid base
2 Geotextile specimen
3 Horizontal reaction
4 Loading system
5 Normal load
6 Standard sand
7 Rigid shear box
8 Gap of max 0,5 mm
9 Horizontal force

Figure 1 - Constant area direct shear test (typical layout)



Key

1 Standard shear box (300 mm x 300 mm)
2 Horizontal force
3 Geotextile specimen
4 Normal load
5 Standard sand
6 Horizontal reaction
7 Rigid support for specimen

Figure 2 - Reducing area direct shear test (typical layout)

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