British Standard

A single copy of this British Standard is licensed to

Akin Koksal

11 December 2002

This is an uncontrolled copy. Ensure use of the most current version of this document by searching British Standards Online at bsonline.techindex.co.uk

BRITISH STANDARD

BS 6906-8:
1991

Methods of test for

Geotextiles —

Part 8: Determination of sand-geotextile frictional behaviour by direct shear

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Textiles and Clothing Standards Policy Committee (TCM/-) to Technical Committee TCM/35, upon which the following bodies were represented:

Association of Consulting Engineers
British Polyolefin Textiles Association
British Textile Technology Group
Chemical Industries Association
Department of Transport
Department of Transport (Transport and Road Research Laboratory)
ERA Technology Ltd.
Federation of Civil Engineering Contractors
Institution of Civil Engineers
Lambeg Industrial Research Association
Ministry of Agriculture, Fisheries and Food
Ministry of Defence
Society of Engineers Incorporated

This British Standard, having been prepared under the direction of the Textiles and Clothing Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 29 March 1991

The following BSI references relate to the work on this standard:
Committee reference TCM/35
Draft for comment 89/39361 DC

ISBN 0 580 19278 4

Amendments issued since publication

Amd. No.	Date	Comments

Contents

Foreword

This Part of BS 6906 has been prepared under the direction of the Textiles and Clothing Standards Policy Committee and is Part 8 of a comprehensive British Standard on methods of test for geotextiles.

The standard describes procedures for investigating the index shear properties of the following:

a) geotextile against geotextile;

b) geotextile on rigid substrate against sand;

c) geotextile on sand substrate against sand.

However, the procedure may be modified using soils as found on site, for which additional procedures are recommended in Appendix A.

The procedure is carried out on three identically prepared specimens of sand and geotextile under different normal pressures to determine the relationship between shear stress and normal stress.

Information on accuracy of the test is given in Appendix B.

Other Parts of BS 6906 are as follows.

— *Part 1: Determination of the tensile properties using a wide width strip;*

— *Part 2: Determination of the apparent pore size distribution by dry sieving;*

— *Part 3: Determination of water flow normal to the plane of the geotextile under a constant head;*

— *Part 4: Determination of the puncture resistance (CBR puncture test);*

— *Part 5: Determination of creep;*

— *Part 6: Determination of resistance to perforation (cone drop test);*

— *Part 7: Determination of in-plane waterflow.*

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 6906 describes methods for determining the frictional or shear resistance of a geotextile against sand.

The test is applicable to all geotextiles which will transmit load from the geotextile to soil.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 6906, the following definitions apply.

2.1
adhesion

apparent shear stress at zero normal stress

2.2
angle of bond friction

the angle of friction between geotextile and soil, defined as the slope of the best fit straight line, in degrees, through values of shear stress plotted against corresponding values of normal stress

2.3
coefficient of friction

the tangent of the angle of bond friction

2.4
direct shear test

a shear test in which a specimen sand/sand, sand/geotextile or geotextile/geotextile interface, contained within a shearbox, under an applied normal load, is stressed to failure by moving one section of the shearbox relative to the other in a horizontal plane

2.5
normal stress

a constant vertical stress applied to the specimen interface contained in the shearbox (in kPa)

2.6
shear stress

the ratio of shear resistance to the contact area of a specimen interface (in kPa)

2.7
shear resistance

the resistance to horizontal shearing along a specimen interface at a given displacement of the shearbox (in kN)

2.8
peak shear resistance

the maximum shear resistance measured during a test at a given normal stress (in kN)

2.9
residual shear resistance

the shear resistance measured during a test whilst the soil is shearing at constant volume, usually obtained at large displacements (in kN)

2.10
residual/peak ratio

the ratio of the residual angle of bond friction to the peak angle of bond friction

2.11
friction ratio

the ratio of the peak angle of bond friction to the peak angle of shearing resistance of the soil

3 Principle

The coefficient of friction between a geotextile and sand or between any combination of geotextiles selected by the user is determined by placing the geotextile and sand at the contact surface within a direct shearbox (see Figure 1). A constant normal compressive stress is applied to the specimen and a tangential (shear) force is applied to the apparatus so that one section of the box moves in relation to the other along the contact surface. The shear force is recorded as a function of the displacement of the moving section of the shearbox.

The test is performed at a minimum of three different normal stresses. The peak and residual shear stresses obtained are plotted against their corresponding values of normal stress. The slope of the best fit straight line passing through the points of peak shear stress defines the peak coefficient of friction. Similarly, the slope of the best fit straight line passing through the points of residual shear stress defines the residual coefficient of friction.

CAUTION. This standard involves high loads and forces when operating the test apparatus. The standard does not address all of the safety problems associated with the use of the test apparatus. Appropriate safety precautions should therefore be taken.

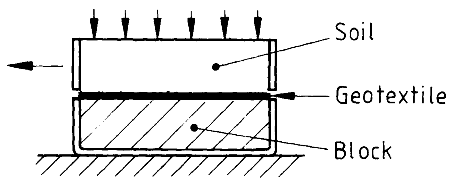

Figure 1 — Details of test

4 Apparatus and material

4.1 *Shearing apparatus* comprising the following:

4.1.1 *Container for the specimen (the shearbox),* about 300 mm square in plan, divided into upper and lower halves. It shall be constructed of steel sections rigid enough to resist distortion under maximum load. It shall be possible to lock the two halves of the shearbox together and to lift the upper half of the box off the lower half. When released, the lower half shall move freely relative to the upper half.

4.1.2 *Rigid carriage,* in which the shearbox can be secured. It is supported on the bed of the machine by a low friction bearing allowing movement in the longitudinal direction.

4.1.3 *Two spacer plates,* about 2 mm smaller than the internal plan dimensions of the shearbox.

4.1.4 *Rigid loading plate,* fitted with a central spherical seating through which vertical load is applied. It shall be about 2 mm smaller in plan than the internal dimensions of the shearbox and shall be rigid enough to transmit load uniformly.

4.1.5 *Means* of applying force to the rigid loading plate, to an accuracy of ± 1 %.

4.1.6 *Motorized loading device,* capable of applying horizontal shear to the specimen at a rate of 2.0 ± 0.2 mm/min.

4.1.7 *Calibrated force measuring device.*

4.1.8 *Means* of measuring the relative horizontal displacement of the two halves of the shearbox, to an accuracy of ± 0.01 mm.

4.1.9 *Means* of measuring vertical deformation of the sand during the test to an accuracy of ± 0.01 mm.

4.1.10 *Modifications to the apparatus,* to enable fixing of the geotextile specimen as follows.

A metal or wooden substrate shall be placed within the lower half of the shearbox [see Figure 2(a)] the upper surface of which shall be 0 mm to 1 mm above the upper edge of the lower half of the shearbox. The substrate shall not crack or buckle during the test.

The geotextile shall be placed on the surface of the sand substrate within the lower half of the shearbox and clamped to the trailing edge of the stationary half of the shearbox [see Figure 2(b)] in a manner which does not interfere with the shearing surface or cause the geotextile to lift during completion of specimen preparation.

NOTE This standard requires the use of a large shearbox. For certain applications, e.g. routine quality control testing, a smaller, e.g. 60 mm × 60 mm shearbox may be satisfactory.

4.2 *Sand,* conditioned at 20 ± 5 °C, complying with fraction B (1.18 mm to 600 μm) of BS 4550-5.

5 Test specimens

Prepare a minimum of nine specimens, from the laboratory sample, for shearing in a direction parallel to the machine direction. If required, prepare nine specimens, from the laboratory sample, in a direction parallel to the cross-machine direction.

NOTE The frictional characteristics of some geotextiles may depend on the direction tested. In many applications it will be sufficient to perform shear tests in one direction only.

The specimens shall be slightly smaller than the inside dimensions of the shearbox. Space the specimens along a diagonal of the laboratory sample. Do not take specimens nearer the selvedge or edge of the geotextile than 1/10 the width of the sample.

In the case of geotextile samples where the frictional properties may differ from face to back (e.g. composites) either carry out the test on both surfaces or record in the test report which surface was tested.

6 Conditioning

The specimens shall be conditioned and the test conducted in an atmosphere at 20 ± 5 °C.

7 Calibration

The shear device shall be calibrated to measure the internal resistance to shear inherent in the device. The inherent shear resistance is a function of the geometry and mass of the shearbox, the type and condition of the bearings and the type of shear loading system.

Completely assemble the shear device without placing a specimen inside it. Do not apply a normal stress. Measure the maximum shear force required to traverse the shearbox at a rate of 2.0 mm/min through a displacement of 50 mm. Record this force as the internal shear correction (S_i) (in kN).

8 Procedures

8.1 Method A. Geotextile against geotextile friction

8.1.1 Fix the geotextile specimen over a rigid substrate which may consist of wood or other rigid material. Suitable methods of fixing the geotextile specimen to a substrate are shown in Figure 2. Where an adhesive is used, this shall not seep through to the exposed surface of the geotextile. For specimens such as geogrids, which are stiff in bending, the specimen may be fixed to a wooden substrate using fine panel pins. The heads of these panel pins shall not project above the surface of the specimen.

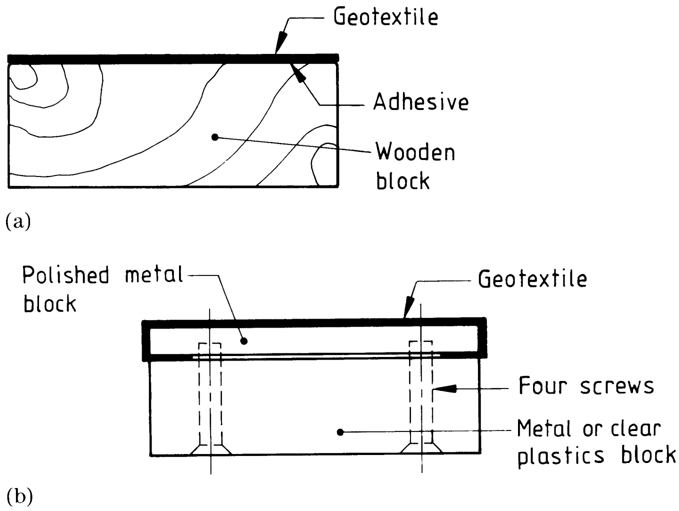

Figure 2 — Examples of methods for fixing geotextile specimens to substrate

8.1.2 Place the lower substrate into the lower half of the shearbox with the mounted geotextile specimen uppermost. The substrate shall be shimmed, over its plan area, such that the upper surface of the geotextile specimen extends above the upper edges of the lower half of the shearbox and is parallel to the shearing plane.

8.1.3 Place the upper half of the shearbox over the lower half and align the two halves in preparation for shearing.

8.1.4 Fix the upper geotextile specimen over a rigid substrate using the procedure in **8.1.1**. Place the upper substrate into the upper half of the shearbox with the mounted geotextile specimen lowermost, such that the lower surface of the geotextile specimen protrudes below the lower edges of the upper half of the shearbox and is parallel to the shearing plane. Both upper and lower geotextile specimens shall be flat and free from folds and wrinkles.

8.1.5 Place the rigid loading plate over the upper substrate so that a uniform stress may be applied to the entire specimen. Fix the loading plate and apply a compressive normal stress of 50 kPa to the specimen.

8.1.6 Fix and zero the displacement indicators on to the travelling container. Assemble the shear force loading device such that the loading ram is in contact with the travelling container, but no shear force is applied.

8.1.7 Apply the shear force using a constant rate of displacement of 2.0 mm/min.

8.1.8 Record the measured shear force (S_m) as a function of the displacement. If data are not recorded continuously, a minimum of one datum point for every 2 mm displacement over the first 10 mm of movement shall be taken, and then a datum point for every subsequent 5 mm of displacement recorded.

8.1.9 At the end of the test, remove the normal stress from the specimen and carefully disassemble the device. Inspect the failure surface and record the failure mechanism, evidence of shear strains or other deformations within the specimen.

8.1.10 Repeat **8.1.1** to **8.1.9** using new specimens at normal stresses of 100 kPa and 200 kPa.

8.1.11 Repeat **8.1.1** to **8.1.10** a total of three times.

8.2 Method B. Geotextile on rigid substrate against sand friction

8.2.1 Fix the geotextile specimen over a rigid substrate using the techniques described in **8.1.1**. Place the substrate into the lower half of the shearbox with the mounted geotextile specimen uppermost so that the upper surface of the geotextile specimen extends above the upper edges of the lower half of the shearbox and is parallel to the shearing plane. The geotextile specimen shall be flat, free from folds, wrinkles, etc.

8.2.2 Place the upper half of the shearbox over the lower half and align the two halves in preparation for shearing.

8.2.3 Fill the upper half of the shearbox with a known mass of dry sand (see **4.2**) and lightly compact using a 2.5 kg rammer in accordance with BS 1377-4. Record the volume of the sand and calculate the dry density of the sand. The dry density achieved shall be in the range 1.65 Mg/m^3 to 1.70 Mg/m^3. For a given series of tests the dry densities achieved shall not vary by more than ± 0.01 Mg/m^3 from the mean density achieved.

8.2.4 Place the rigid loading plate over sand so that a uniform stress may be applied to the entire specimen. Fix the loading plate and apply a compressive normal stress of 50 kPa to the specimen.

8.2.5 Carry out the test as described in **8.1.6** to **8.1.11**.

8.3 Method C. Geotextile on sand substrate against sand friction

8.3.1 Fill the lower half of the shearbox with a known mass of dry sand (see **4.2**) and lightly compact using a 2.5 kg rammer in accordance with BS 1377-4. The top surface of the compacted sand shall project above the top edges of the lower half of the shearbox by 1 mm. Record the volume of the sand and calculate the dry density of the sand. The dry density achieved shall be in the range 1.65 Mg/m^3 to 1.70 Mg/m^3. For a given series of tests the dry densities achieved shall not vary by more than ± 0.01 Mg/m^3 from the mean density achieved.

8.3.2 Carry out the test as described in **8.2.2** to **8.2.5**.

9 Calculations

Calculate the shear stress applied to the specimen for each recorded shear force as follows:

$$\tau = S_c/A_c$$

where

- τ is the shear stress (in kPa);
- S_c is the corrected shear force ($S_m - S_i$) (in kN);
- S_m is the shear force measured during the test (in kN);
- S_i is the internal shear correction (in kN) (see clause **8**);
- A_c is the specimen contact area $A_o - (d \times w)$ (in m^2);
- A_o is the initial specimen contact area (in m^2);
- d is the horizontal displacement of the shear box (in m);
- w is the specimen contact width (in m).

Plot the test data as a graph of shear stress, τ, versus horizontal displacement, d. From this graph determine the peak and residual shear stresses. Repeat this procedure for each normal stress level. For the nine pairs of peak shear stress and normal stress, plot a graph of peak shear stress versus normal stress using the same scale for both axes. Draw the best fit straight line through the data points. The slope of this line, in degrees, is the peak angle of bond friction δ'_p.

The residual angle of bond friction δ'_r is determined in similar manner from a plot of residual shear stress versus normal stress. Typical results can be seen in Figure 3.

Any intercept of the best fit straight line with the shear stress axis defines an apparent adhesion. This shall be disregarded.

NOTE 1 The angle of bond friction cannot exceed the internal angle of shearing resistance of the sand at the sand/geotextile interface. Consequently, it is recommended that the internal shearing resistance of the sand be measured using the procedure described in method C except that the geotextile specimen is omitted.

Repeat the calculations for the results from the tests on sand against sand to define the peak angle of internal shearing resistance φ and the residual angle of internal shearing resistance φ'_r.

NOTE 2 φ'_r should be obtained when the sand is shearing at constant volume. This parameter is also known as the constant volume angle of shearing resistance.

10 Test report

The test report shall include the following particulars:

a) number and date of this British Standard, i.e. BS 6906-8:1991;

b) details of the geotextile(s) tested including the relationship between the direction of shear and the machine direction of the geotextile, e.g. geotextile sheared in machine direction or cross-machine direction. If the surface finish of the geotextile is different on the two faces of the geotextile, the respective frictional parameters should be identified. In the case of grids or meshes, the test results shall include a sketch or description of the specimen giving the number of longitudinal members and number of transverse members in the specimen together with their orientation in the direction of shearing;

c) the result obtained expressed as in clause **9**, including a description of the failure mechanism, and a note of the mean dry density achieved for the sand and the range of variation from this mean value;

d) if required, the internal angle of shearing resistance of the sand.

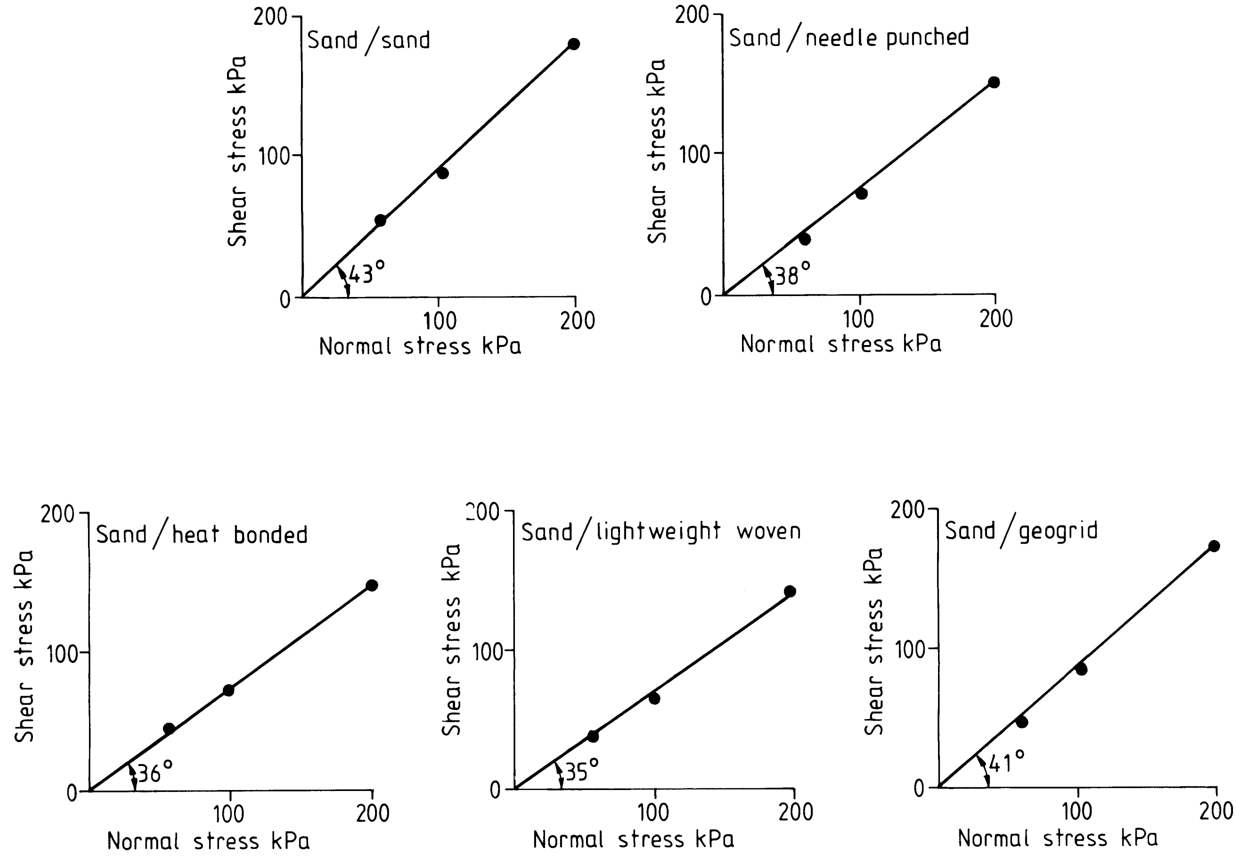

Figure 3 — Typical results

Appendix A Recommendations for use of this test for design purposes

A.1 General

This appendix gives recommendations for using the procedures in this standard using soils to simulate field conditions, although it should be noted that these cannot be exactly reproduced in an apparatus of finite size with a constrained shear plane.

A.2 Types of soil

Unless otherwise required, the maximum particle size of the soil tested should be not greater than one eighth of the depth of the shearbox. The inclusion of larger particles may lead to an erratic relationship between displacement and shear resistance. Since the shearbox is 300 mm × 300 mm and 150 mm deep, the soil cannot usually be tested if it contains particles larger than 10 mm.

For a coarser soil the fraction of soil passing through an appropriate sieve may be tested. The shear properties measured may then underestimate those in the field to an extent depending on the proportion of coarse particles.

Sufficient soil should be available to make up the required number of test specimens without reuse. Bring the soil to the required moisture content and mix it thoroughly as described in BS 1377-4. Determine the mass of soil required to fill the shearbox at the required density either by calculation or by trial.

NOTE Appropriate means of compaction may range from hand tamping for a wet sand to a vibratory hammer for a well graded coarse granular material. One criterion for the level of compaction is 92 ± 2 % of maximum dry density in accordance with **3.5**, **3.6** or **3.7**, as appropriate of BS 1377-4:1990.

A.3 Preparation of geotextile

Unless otherwise specified, the geotextile should be soaked for at least 24 h, then blotted dry before being placed in the shearbox. Begin the test not later than 5 min after removing from the water.

NOTE The test is usually carried out with moist soils for which this conditioning is appropriate. If the soil is dry, or is suspected to be chemically active or biologically active the geotextile should be conditioned by storage in contact with the soil for at least 24 h.

A.4 Test procedure

The test is usually carried out in freedraining granular materials in which the shear test corresponds to the drained condition, i.e. the rate of shear is sufficiently slow to allow excess pore water pressure in the soil to drain away. For poorly drained granular and cohesive soils the test can be either drained or undrained depending on the rate of shear. The rate of 2.0 mm/min may be inappropriate in this case.

Soil geotextile friction in the field may be greater than that measured using the index test described in **8.1**. In assessing design parameters the lower substrate described in **8.1.1** may be dispensed with and the lower half of the box filled with compacted soil to model the substitute which may be found in the field. To carry out this test, place the soil in the lower container as required. Compact the soil to 92 ± 2 %, of maximum dry density according to **3.5**, **3.6** or **3.7**, as appropriate, of BS 1377-4:1990 so that the surface of the soil protrudes above the edge of the container, an amount equal to one half of the D_{85} of the soil. For fine grained soils a protrusion of 1 mm is sufficient. Carefully level the soil surface. Place the geotextile specimen loosely over the surface. Clamp or otherwise fix the specimen to the lower container and ensure that the geotextile is in complete contact with the soil (see Figure 4). Place the soil in the upper half of the shearbox.

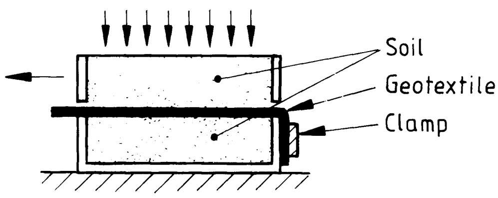

Figure 4 — Free shearbox test

Adjust the distance between the containers so that the distance between the surface of the geotextile specimen and the surface of the soil container is one half of the D_{85} of the upper soil or 1 mm for fine grained soils.

For frictional soil consolidate the soil for 1 h before shearing under a normal stress equal to the highest vertical effective stress likely to be realized in the field.

Continue with the test as described in clause **8**.

At the end of the test, remove the soil specimen and determine its density and moisture content according to the procedures in BS 1377-2.

In certain design applications it is necessary to determine the frictional behaviour of geotextile on geotextile. In this case two geotextile samples are mounted on substrates as described in **8.1.1**. One of these is placed in the lower half of the shearbox as described in **8.1.2**. The second substrate is mounted in the upper half of the shearbox so that the two geotextile specimens are in contact on the shear plane between the two halves of the shearbox. A rigid plate is placed over the upper substrate as described in **8.1.5** and the test procedure continued as described in **8.1.6** to **8.1.11**.

Appendix B Guidance on accuracy of test

Preliminary results from interlaboratory trials suggest that results from different laboratories, under otherwise identical conditions, should be reproducible to ± 5 %.

blank

Publications referred to

BS 1377, *Methods of test for soils for civil engineering purposes.*
BS 1377-2, *Classification tests.*
BS 1377-4, *Compaction-related tests.*
BS 4550, *Methods of testing cement.*
BS 4550-5, *Standard sand for concrete cubes.*

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL