Determination of the unpolished and polished pendulum test value of surfacing units

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Committees responsible for this British Standard

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Brick Development Association
British Cement Association
British Ceramic Research Ltd.
British Precast Concrete Federation Ltd.
Concrete Society
County Surveyors' Society
Department of the Environment, Transport and the Regions (Highways Agency)
Institution of Civil Engineers
Interlay (Association of Block Paving)
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Landscape Institute
Society of Chemical Industry
Stone Federation
Transport Research Laboratory

The following bodies were also represented in the drafting of the standard, through Subcommittee B/507/4, Slip/skid resistance testing:

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Consumer Policy Committee of BSI
Department of the Environment, Transport and the Regions (Building Research Establishment)
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Contents

Foreword

This British Standard has been prepared by Technical Committee B/507. It supersedes BS 7932:1998 which is withdrawn.

In this revision of BS 7932 the size of the test specimen, the width of the rubber slider and the swept length have all been increased.

This British Standard calls for the use of substances and/or procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 9 and a back cover.

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1 Scope

This British Standard describes a test method for determining the unpolished and the polished pendulum test value of surfacing units for pedestrian or traffic purposes, using a flat-bed polishing machine in conjunction with pendulum test equipment.

NOTE The pendulum test values obtained by this test method are used by manufacturers to determine the slip/skid resistance of the surfacing units.

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.

BS 410-1, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth.*

BS 410-2, *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate.*

BS 812-103.1, *Testing aggregates — Part 103: Methods for determination of particle size distribution — Section 103.1: Sieve tests.*

BS 903-A57, *Physical testing of rubber — Part A57: Determination of indentation hardness by means of pocket hardness meters* (ISO 7619).

BS 7976-1, *Pendulum testers — Part 1: Specification.*

BS 7976-2:2002, *Pendulum testers — Part 2: Method of operation.*

BS 7976-3, *Pendulum testers — Part 3: Method of calibration.*

3 Terms and definitions

For the purposes of this standard, the following definition applies.

3.1
surfacing unit
single unit of clay, concrete or natural stone used in surfacing pedestrianized and/or trafficked areas

4 Principle

The test methodology for determining the unpolished and the polished pendulum test values of surfacing units consists of measuring the pendulum test value of a surfacing unit before and following the application of an accelerated polishing regime using a flat-bed polishing machine. Measurements are carried out using pendulum test equipment.

5 Apparatus

5.1 *Straight-edge*.

5.2 *Feeler gauge*

5.3 *Pendulum test equipment*, conforming to BS 7976-1.

5.4 *Flat-bed polishing machine*, (see Figure 1) consisting of the following:

a) a machined, flat circular cast iron or steel grinding plate not less than 600 mm in diameter, which can be rotated in a horizontal plane at a speed of (29 ± 1) r/min;

b) a flat, smooth-surfaced styrene butadiene rubber annulus of 600 mm maximum external diameter, approximately 320 mm internal diameter and 5 mm thickness, attached to the upper surface of the grinding plate.

NOTE If glue is used to attach the annulus to the grinding plate, care should be taken to ensure it does not affect the hardness of the rubber.

The rubber annulus shall have an initial hardness of (69 ± 3) IRHD determined in accordance with BS 903-A57. It shall be stored in the dark at a temperature in the range 5 °C to 25 °C and shall be conditioned by bringing to a temperature of (30 ± 2) °C throughout its mass before attaching to the grinding plate. After attachment, the grinding plate and annulus shall be kept in the dark at a temperature in the range (20 ± 5) °C. The annulus shall not be used after three years from the date of manufacture or after testing 500 specimens, whichever occurs soonest;

c) two adjustable metal holders, each capable of loosely holding in place a test specimen with dimensions conforming to **6.2** or control stone tablet with dimensions conforming to Annex A.

Each metal holder shall allow the test specimens or control stone tablets to be positioned as follows:

— with the centre points of their outer edges (270 ± 1) mm from the centre of the grinding plate;

— diametrically opposite to each other;

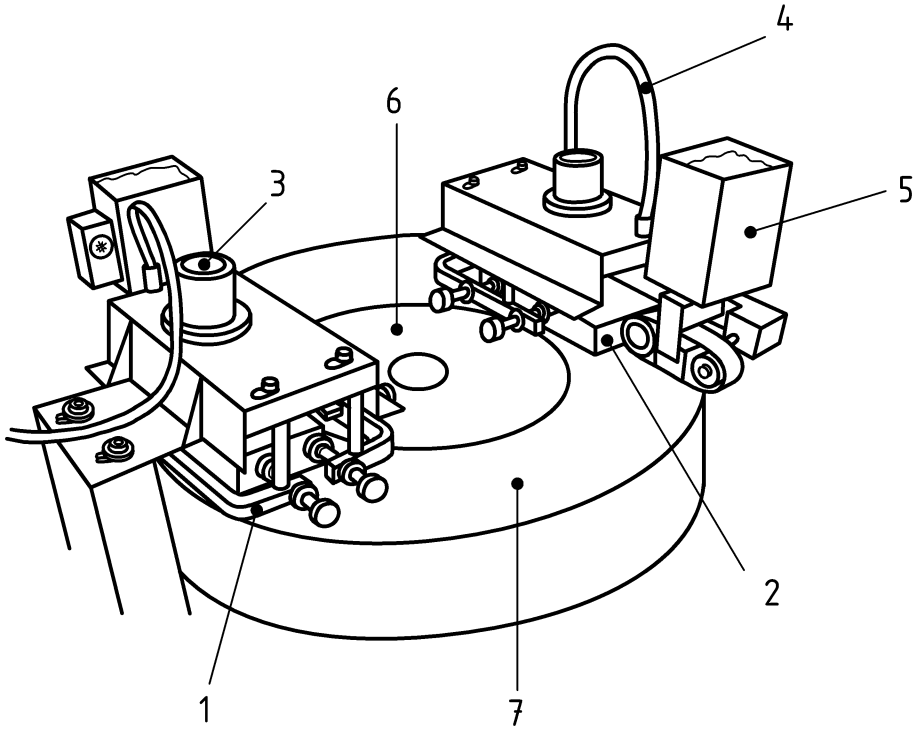
— with their longest sides lying in the direction of rotation of the grinding plate;

— so as to allow free movement in a vertical plane but be restrained from moving in the horizontal plane;

d) a means to ensure that the required load can be applied evenly to each test specimen, enabling the test specimen and applied weight to move in a vertical direction;

e) adjustable weights which permit uniform loading of the test specimen against the surface of the rubber annulus to provide a contact stress (test specimen plus adjustable weight) of (2 276 ± 10) N/m^2 over the area of the test surface;

f) separate mechanisms to feed corn emery and emery flour and a means to feed water.



Key

1 Sample holder
2 Sample
3 Adjustable mass
4 Water supply
5 Emery hoppers with adjustable conveyors
6 Grinding plate
7 Rubber annulus

Figure 1 — Flat-bed polishing machine

5.5 *Polishing media*, consisting of the following:

a) fresh natural corn emery, of a grading that conforms with Table 1;

b) fresh air-floated or water-washed emery flour, which passes a 50 µm test sieve.

Polishing media shall be used once only.

Table 1 — Grading requirements for corn emery

Nominal width of sieve aperture µm	Total passing %
600	98 to 100
500	70 to 100
425	30 to 90
355	0 to 30
300	0 to 5

6 Sampling and preparation of test specimens

6.1 A sample of ten surfacing units shall be obtained in accordance with Annex B, from which four surfacing units shall be selected and prepared for testing in accordance with **6.2**, **6.3**, **6.4** and **6.5**.

6.2 The flatness of the test surface of each test specimen shall be measured using a feeler gauge and a straight-edge across the width of the specimen at a distance approximately 25 mm from either end and at the centre, along the centre of the length and across the two diagonals. The results for flatness shall be recorded.

If the deviation from flatness at any point on the test surface of the test specimen is less than 0.5 mm the surfacing unit shall be tested as a (200 ± 2) mm × (100 ± 2) mm test specimen (where a manufactured surfacing unit exceeds this size, it shall be cut to the required dimensions).

If the deviation from flatness at any point on the test surface of the test specimen is greater than 0.5 mm a test specimen of 140^{+5}_{0} mm × 80^{+5}_{0} mm, shall be cut. If the dimensions of the manufactured surfacing units are less than 140 mm × 80 mm then they shall be glued together to give a test specimen no less than 140 mm to no more than 200 mm long and no less than 80 mm to no more than 100 mm wide.

The thickness of the test specimens shall not exceed 85 mm.

6.3 The test specimens shall have no transverse or longitudinal warp. If a test specimen has any formed or natural surface features such as ridges, domes, plateaux, channels or cracks, it may either be tested on the reverse surface, providing that the specimen is of the same material throughout and that the reverse surface does not present any similar surface features, or alternatively if the surface of the specimen contains formed ridges, domes or plateaux greater than 0.5 mm high, these shall be removed by grinding. This shall be noted in the test report. Any formed grooves on a test specimen shall be approximately parallel to the length of the specimen.

6.4 Each specimen shall have a bevel of 2 mm to 3 mm at an angle of approximately 45° along the leading edge, to enable the emery polishing agents to access the contact area between the specimens and the rubber annulus more readily. The bevel may comprise the natural chamfer of the surfacing unit or may be specifically ground.

NOTE The contact area excludes the bevel or chamfer on the surfacing unit.

6.5 The required load (adjustable weight plus test specimen) necessary to give a contact stress of (2 276 ± 10) N/m^2 over the area of the test surface shall be calculated.

7 Accelerated polishing

7.1 Procedure

WARNING The application of emery polishing agents during the course of the operations described in this clause can generate particles that could be injurious to health. It is essential to ensure that appropriate precautions are taken, e.g. the use of dust masks and/or dust extracting facilities. It is also essential to ensure that the equipment is electrically safe in wet test conditions.

7.1.1 Set up the apparatus as shown in Figure 1 and ensure that the ambient temperature is (20 ± 5) °C.

7.1.2 Place the test surfaces of two specimens face down in the metal holders of the flat-bed polishing machine according to the configuration given in **5.4**c). Apply the appropriate loads calculated in accordance with **6.5**. Set the machine in motion at a speed of (29 ± 1) r/min.

7.1.3 Feed corn emery of the grading specified in Table 1 evenly onto the surface of the rubber annulus immediately in front of each of the test specimens at a rate of (20 ± 2) g/min, for (700 ± 10) revolutions. Simultaneously feed water onto the surface of the rubber annulus at a rate just sufficient to carry the corn emery under the test specimens without being washed away.

NOTE A water feed rate of 6 ml/min has been found to be satisfactory.

7.1.4 Stop the machine and, within 30 min, remove the test specimens from the machine and remove all traces of corn emery from them under running water using a stiff-bristled brush. Remove any corn emery from the surface of the rubber annulus.

7.1.5 Repeat steps **7.1.2** and **7.1.3**, substituting fine emery flour of the grading specified in Table 1 as the polishing agent. Feed the flour at a rate of (2 ± 0.2) g/min evenly over the surface of the rubber annulus in front of each of the test specimens with water applied simultaneously at a rate sufficient to maintain a wet paste under the specimens. Polish the specimens for a further (700 ± 10) revolutions.

NOTE A water feed rate in the range 1.0 ml/min to 3.0 ml/min has been found to be satisfactory in maintaining a creamy paste.

7.1.6 Stop the machine, remove the test specimens from the machine within 30 min of the completion of the polishing process and thoroughly wash them in running water to remove all trace of the emery flour. Remove any emery flour which has packed into cracks on the surface by scrubbing with a stiff-bristled brush.

7.1.7 After washing the test specimens, store them face downwards under water at a temperature of (20 ± 2) °C for at least 2 h to ensure that they are within the temperature tolerance. It is essential not to allow the specimen to dry out before it is subjected to the pendulum test.

7.1.8 Repeat steps **7.1.2** to **7.1.7** of the procedure for two further test specimens.

7.2 Validation of the accelerated polishing procedure

7.2.1 *General*

In order to maintain the integrity of the polishing procedure, a pair of control stone tablets shall be polished immediately after replacing the rubber annulus [see **5.4**b)] and at a frequency of one pair of control stone tablets every 100 test specimens or once annually, whichever occurs soonest.

7.2.2 *Procedure*

7.2.2.1 Prepare a pair of control stone tablets in accordance with Annex A.

7.2.2.2 Carry out the accelerated polishing procedure on the control stone tablets in accordance with **7.1**.

7.2.2.3 Carry out the pendulum test procedure on the control stone tablets in accordance with Clause **8**.

7.2.3 *Interpretation of results*

In order for the polishing procedure to be validated, the mean, without rounding, pendulum test value of the two polished control stone tablets shall fall within the range 49–55. If the value falls outside this range, the flat-bed polishing machine shall be examined to check whether the feed rate of the grit and water and the hardness of the rubber annulus are correct. If they are not correct, the flat-bed polishing machine shall be adjusted and, if necessary, the rubber annulus replaced.

8 Pendulum test

8.1 Validation and calibration of the pendulum test equipment

To determine the consistency of readings, the operation of the pendulum test equipment shall be validated in accordance with BS 7976-2:2002, Clause **8**.

The pendulum test equipment shall have been calibrated in accordance with BS 7976-3, prior to its use for testing. The calibration values shall be compared with the validation results and used to monitor the performance of the equipment until it is next calibrated.

8.2 Pendulum test procedure

The pendulum test procedure shall be carried out in accordance with BS 7976-2, using a TRL rubber slider conforming to BS 7976-1.

9 Test report

The test report shall include the following information:

a) the sampling plan including the method of sampling used (see Annex B);

b) the results for measurement of the flatness of the test specimens in accordance with **6.2**;

c) the mean pendulum test value of the four test specimens before polishing;

d) the mean pendulum test value of the four test specimens (or two control stone tablets) after polishing;

e) any additional observations made during testing, for example, the surface texture of the test specimens;

f) the number of this standard;

g) the hardness of the rubber slider.

Annex A (normative)
Preparation of the control stone tablets

A.1 General

This annex specifies the method for preparing the control stone tablets for validation of the accelerated polishing procedure (see **7.2**).

A.2 Apparatus and materials

A.2.1 *Control stone.*[1)]

A.2.2 *Two fine-haired brushes*, of approximately 3 mm diameter.

A.2.3 *A stiff-bristled brush.*

A.2.4 *A knife or spatula.*

A.2.5 *Release agent*, for preventing the control stones from sticking to the metal moulds or flat plates.

NOTE Water-based release agents should not be used.

A.2.6 *Cleaning solvent or a mixture of 90 % acetone and 10 % kerosene by volume*, for cleaning the metal moulds and flat plates.

A.2.7 *Polyester resin and hardener.*

A.2.8 *Container*, made from metal or plastic, for mixing resin and hardener.

A.2.9 *Fine sand*, (100 % passing a 212 μm test sieve conforming to BS 410-1) to prevent the polyester resin from squeezing downwards between the individual pieces of aggregate.

A.2.10 *At least two machined metal moulds*, for preparing control stone tablets, manufactured with removable ends and with internal dimensions of (150 ± 0.5) mm long × (90 ± 0.5) mm wide × (16.5 ± 0.5) mm deep.

NOTE The metal moulds should be cleaned after use using cleaning solvent.

A.2.11 *At least two machined flat plates*, made from 5 mm mild steel plate, sized approximately 120 mm × 170 mm.

A.2.12 *Means of clamping the flat plate in contact with the mould*, during the resin curing period.

A.2.13 *A 10 mm, square-holed perforated-plate sieve*, conforming to BS 410-2.

A.2.14 *A 14 mm to 10 mm slotted flake sorting sieve*, conforming to BS 410-2, having a slot width of (7.2 ± 0.1) mm and a slot length of (40 ± 1) mm.

A.2.15 *An elongation gauge*, with pins of (6 ± 0.1) mm diameter, (25 ± 1) mm height and a gap between the pins of (14.7 ± 0.2) mm.

A.2.16 *A balance*, with a capacity of at least 2.5 kg and accurate to ±0.5 g.

A.2.17 *A supply of metal mesh*, to reduce shrinkage in the resin sample backing, cut into sections approximately 149 mm × 89 mm, so that the mesh can fit into the moulds.

NOTE Steel wire mesh made from 0.9 mm diameter wire and with a mesh size of 20 mm × 12 mm has been found to be suitable and is available as chicken wire from builders merchants.

[1)] At the present time, the only recognized source of control stone is a stock of quartz dolerite aggregate controlled by TRL Old Wokingham Road, Crowthorne, Berks, RG45 6AU.

A.3 Manufacture of control stone tablets

A.3.1 Reduce the sample of control stone by quartering in accordance with BS 812-103.1 to a particle size sufficient to produce a test portion of at least 6 kg when sieved in accordance with **A.3.2**.

A.3.2 Sieve the reduced control stone using the 10 mm sieve. Take the proportion which passes the 10 mm sieve and sieve it again using the 14 mm to 10 mm flake sorting sieve. Wash and dry the proportion of the sample retained by the flake sorting sieve and use the elongation gauge to identify any elongated particles. Remove any elongated particles from the test portion and then weigh the test portion using the balance.

A.3.3 Lightly coat the internal faces and top edges of the metal moulds with release agent using a fine-haired brush.

A.3.4 From the test portion of control stone, select between 95 and 135 particles for each tablet. The particles selected shall have at least one fairly flat surface with no sharp, projecting edges, which shall form the test surface presented for polishing. Place the selected particles in the moulds in a single layer with their flat test surfaces lying on the bottom of the mould. Place them as close together as possible so that they cover the entire base of the mould.

A.3.5 Fill the interstices between the pieces of aggregate to approximately three-quarters of their depth with fine sand and level off with a fine-haired brush or by gently blowing. Suspend the metal mesh so that it is within 6 mm of the top of the mould. Mix sufficient resin and hardener to fill each mould to overflowing.

A.3.6 Coat two flat plates on one side with release agent, place them firmly on the moulds, coated side down, and hold firmly in position. When the resin has hardened (usually after 30 min), remove the plates and trim off the excess resin with a knife or spatula.

A.3.7 Remove the tablets from the mould and remove the loose sand with a stiff-bristled brush. Leave for a further 30 min before subjecting to the accelerated polishing procedure in accordance with Clause **7**.

A.3.8 Check each finished tablet and reject any with any resin exposed at the surface or with disturbed particles. The exposed surfaces of the control stone shall stand proud of the backing resin. Measure the flatness of each tablet in accordance with **6.2**.

Annex B (normative)
Random sampling of surfacing units for testing

B.1 General

The sample of surfacing units shall be taken from the manufacturing plant or the storage area of the plant, or alternatively from the test site if the stock of surfacing units has been relocated there prior to sampling.

The stock of surfacing units from which the sample shall be taken shall be not less than the equivalent of one day's production.

For every 1000 m^2 of laid area of surfacing units, ten units shall be sampled.

NOTE The random sampling method allows every surfacing unit in the consignment an equal chance of being selected for the sample.

A sampling plan shall be drawn up and documented in the test report.

B.2 Random sampling methods

The appropriate number of surfacing units shall be taken at random from positions throughout the consignment without any consideration being given to the condition or apparent quality of the surfacing units.

NOTE Where the surfacing units forming the consignment are being moved in a loose (unpacked) form from one place to another, or when they have been split into a large number of small stacks, e.g. immediately prior to placing, random number tables (e.g. as given in BS 6001-0:1996, Table 3) may be used to carry out the sampling.

Where the surfacing units form a large stack or access is limited, the consignment shall be divided into at least 10 actual or theoretical sections, each of a similar size. An equal number of not more than ten surfacing units shall be taken at random from each section.

NOTE It will be necessary to dismantle parts of stacks in order to gain access to the surfacing units.

Bibliography

Standards publications

BS 6001-0:1996, *Sampling procedures for inspection by attributes — Part 0: Introduction to the BS 6001 attribute sampling system.*

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