भारतीय मानक

Indian Standard

IS 18433 (Part 2) : 2023

सतही घर्षण गुणधर्म का मापन — परीक्षण पद्धतियाँ

भाग 2 रैंप टेस्ट

Measurement of Surface Frictional Properties — Methods of Test

Part 2 Ramp Test

ICS 13.340.60

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

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Flooring, Wall Finishing and Roofing Sectional Committee, CED 05

FOREWORD

This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards, after the draft finalized by the Flooring, Wall Finishing and Roofing Sectional committee had been approved by the Civil Engineering Division Council.

The selection of any type of floor surface finish for use for use at home or at commercial space (especially in industry) is very much important. One of the selection criteria involves frictional properties of the tile surface. Frictional resistance can be measure by various methods. The method described in this standard is the ramp test method. The other standard in this series is:

Part 1 Pendulum test

This test method works on the concept that a tester wearing testing footwear/barefoot walks forwards and backwards in an upright position across the floor covering to be tested, which is initially in a horizontal position and then gradually tilted until the acceptance angle has been reached. The acceptance angle is determined using a floor covering coated/circulated with lubricant. The mean acceptance angle reached is used to classify the degree of slip resistance.

While formulating this Standard, considerable assistance has been derived from DIN 51130 : 2014 ‘Testing of floor coverings — Determination of the anti-slip property — Workrooms and fields of activities with slip danger — Walking method — Ramp test’.

Informatory Annex on testing and evaluation (*see* Annex B) and special requirements of footwear (*see* Annex C) used are included for general guidance.

The composition of the committee responsible for the formulation of this standard is given in Annex D.

This standard contributes to the United Nations Sustainable Development Goal 9. ‘Industry, innovation and infrastructure, build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation’.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'.

Indian Standard

MEASUREMENT OF SURFACE FRICTIONAL PROPERTIES — METHODS OF TEST

PART 2 RAMP TEST

1 SCOPE

1.1 This test method covers the procedure for measuring surface frictional properties of a floor using the ramp test.

1.2 This standard (Part 1) also specifies a method of measuring the volume of the displacement spaces in floor coverings with profiled surfaces.

1.3 This test method is applicable to all types of surfaces (plain as well as self-designed/profiled).

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in the text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 TERMINOLOGY

For the purpose of the standard, the following definitions shall apply.

3.1 Acceptance Angle — Angle of slope of the tilted surface at which the tester reaches the limit of safe walking.

3.2 Displacement Space — The open cavities formed by the ridges and valleys of a profiled floor which lie beneath the walking surface of the floor covering.

NOTE — The displacement space enables the distribution and collection of excess lubricants underneath the walking surface, contributing to the anti-slip capacity of the floor covering.

3.3 Profiled Surface — Surface of flooring materials where the clear distance between profile ridges does not exceed 40 mm.

3.4 Slip Resistance — Capacity of a floor covering to prevent slipping.

3.5 Tester — Person who walks along the tilted surface.

3.6 Workplaces and Working Areas — Workplaces and working areas where lubricants routinely contaminate the floor, for example grease, oil, water, food products, food scraps, dust, flour and plant waste.

4 SYMBOLS

For the purpose of this standard, the following letter symbols shall have the meaning indicated against each:

α_{St}	–	Standard acceptance angle;
CrD_{95}	–	Critical difference at significant level of 95 percent;
α_{KSt}	–	Standard test acceptance angle;
D_1	–	Correction as a function of the size of the mean test acceptance angle;
α_{ges}	–	Corrected mean overall acceptance angle;
R9/R10/R11/R12	–	Slip resistance class; and
A/B/C	–	Slip rating class.

5 PRINCIPLE

5.1 Slip Resistance

A tester wearing testing footwear/barefoot walks forwards and backwards in an upright position across the floor covering to be tested, which is initially in a horizontal position and then gradually tilted until the acceptance angle has been reached. The acceptance angle is determined using a floor covering coated/circulated with lubricant. The mean acceptance angle reached is used to classify the degree of slip resistance. Subjective influences on the acceptance angle are limited by means of a calibration procedure.

5.2 Displacement Space

The test specimen is levelled out by filling the profile cavities with paste until this is flush with the surface. The mass of the test specimen is measured before and after this process. The volume of the displacement space is calculated from the difference in mass and the density of the paste.

6 TESTING OF SLIP RESISTANCE

6.1 Apparatus and Test Equipment

6.1.1 *Testing Footwear*

The tester wears testing footwear with an outsole of nitrile rubber with a shore hardness of A/73 ± 5 [according to IS 13360 (Part 5/Sec 11)] with a profile as in Fig. 1.

After the completion of the tests, the soles of the testing footwear shall not remain in an oil bath for storage. The soles are to be thoroughly cleaned and the oil removed, but without the use of any detergents or hydro treated light naphtha, and stored in a dry place.

For barefoot tests, the test person shall soak their feet in the barefoot lubricant (*see* **6.1.4**) for ten minutes before starting the test.

6.1.2 *Test Apparatus with Safety Equipment*

For the test apparatus a flat warp resistant platform shall be used with a width of approximately 600 mm and a length of approximately 2 000 mm. In the longitudinal direction, the ramp shall be adjustableto an incline of 0° up to approximately 40° (*see* Fig. 2). The lifting speed of the drive shall be such that the angular velocity of the ramp is not more than 1° per second. The tester shall be able to control the movement of the ramp, with the ability to move it up or down either continually or in incremental steps of 0.5°. There shall be an angle measuring device attached to the test apparatus that is capable of indicating the angle of inclination to the horizontal to an accuracy of ± 0.2°. The test apparatus shall be constructed such that the angle of inclination does not fluctuate by more than ± 1° when walked along. The angle measuring device display is to be positioned such that the tester is not able to see it while the test is being performed.

To ensure the safety of the tester, handrails are to be installed on each longitudinal side of the test apparatus. The tester is also to be protected from falls by the use of appropriate safety equipment (safety harness and fall protection system).

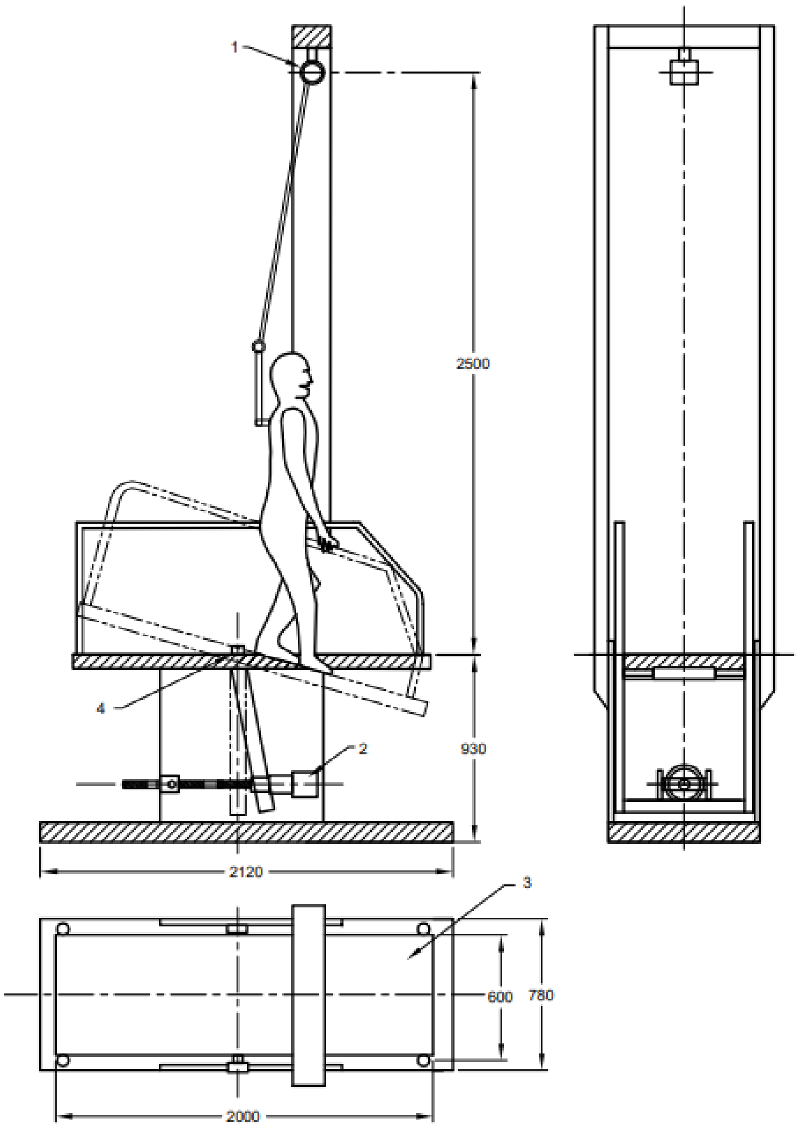
6.1.3 *Lubricant for Testing with Footwear*

Motor lubricating oil of viscosity grade 40 according to IS 13656 is to be used for the test. The oil is to be stored in a tightly closed container to prevent changes in viscosity. Before beginning the test, 200 ml ± 20 ml of the lubricant per square metre shall be applied evenly with a brush to the surface of the flooring test piece. The outsole of the footwear shall be coated with the lubricant using a brush.

6.1.4 *Lubricant for Barefoot Tests*

A non-ionic surfactant such as LS45 (structure shown in Fig. 3) mixed with water in a concentration of 1 gram/litre (0.1 percent solution in water) shall be used as lubricant for barefoot tests. A continuous flow of the lubricant is to be applied prior to and during the tests at the rate of 6 litre/min ± 1 litre/min in a manner to form a largely uniform distribution of the lubricant over the test surface. The lubricant may be used only once and shall not be re-circulated.

FIG. 1 TYPICAL OUTSOLE OF THE TESTING FOOTWEAR



Key

1 Safety harness and fall protection system
2 Drive unit
3 Inclinable platform upon which the flooring test piece is attached
4 Angle transmitter

FIG. 2 EXAMPLE OF A TEST APPARATUS (INCLINED PLANE) WITH SAFETY EQUIPMENT

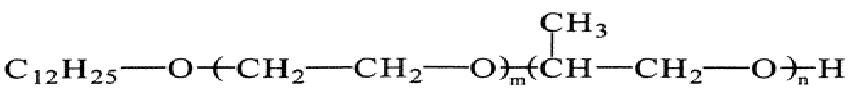


FIG. 3 STRUCTURE OF LS45 NON-IONIC SURFACTANT (M = 4, N = 5)

6.1.5 *Flooring Test Piece*

The flooring test piece measuring approximately 1 000 mm × 500 mm is to be obtained from the floor covering to be tested. The floor covering to be tested shall either be self-supporting or comprise a warp-free sheet with a flat underside, or else shall be affixed to flat, resilient, warp-free material. The surface to be tested shall be easily identifiable as such or be clearly marked.

Floor coverings with directionally-oriented profile or roughness are to be tested in such a manner that the orientation producing the lowest slip resistance is in line with the walking direction. This is to be determined in preliminary tests.

Floor coverings made up of individual rectangular pieces without directionally-oriented profile or roughness are to be positioned with the longitudinal side in the walking direction.

The surface of the floor covering shall be clean for the test and free from manufacturing residues, separating agents, or flashes.

The preparation of the flooring test piece from the floor covering shall be done in a manner consistent with the way this type of covering is used in practice. The overall flooring test piece shall be rigidly fixed on the platform with appropriate locking mechanism.

6.2 Calibration (Selection and Training of the Testers)

There are three standard floor coverings available for the calibration method, (St-I, St-II and St-IIIA), whose acceptance angles α have undergone extensive testing and have been specified as standard acceptance angles $\alpha_{S,St\text{-}I}$, $\alpha_{S,St\text{-}II}$ and $\alpha_{S,St\text{-}IIIA}$ (*see* Table 1).

The tester walks across each of the standard floor coverings three times before the test is carried out according to **6.3**. The mean values $\alpha_{KSt\text{-}I,j}$, $\alpha_{KSt\text{-}II,j}$ and $\alpha_{KSt\text{-}IIIA,j}$ are calculated from the resulting calibration acceptance angles determined by this pre-test. The individual corrections $\Delta\alpha_{St\text{-}I,j}$, $\Delta\alpha_{St\text{-}II,j}$ and $\Delta\alpha_{St\text{-}IIIA,j}$ are obtained from the respective difference between these mean values and the standard acceptance angles.

The critical difference (CrD) characterizes the range of variation of measured values within which differences randomly occur for either measurements on the same object in different laboratories or during different measurements in the same laboratory.

The critical differences, CrD_{95}, have been determined for the three standard floor coverings for a significance level) of 95 percent on the basis of the reproducibility limits and repeatability limits as in IS 15393 (Part 2) or IS 15393 (Part 5).

Two testers are required for testing the floor coverings to be evaluated. The calibrated acceptance angles determined for the standard floor coverings apply here $\alpha_{KSt\text{-}I,1}$, $\alpha_{KSt\text{-}II,1}$ and $\alpha_{KSt\text{-}IIIA,1}$ and respectively, $\alpha_{KSt\text{-}I,2}$, $\alpha_{KSt\text{-}II,2}$ and $\alpha_{KSt\text{-}IIIA,2}$ as well as the individual corrections $\Delta\alpha_{St\text{-}I,1}$, $\Delta\alpha_{St\text{-}II,1}$ and $\Delta\alpha_{St\text{-}IIIA,1}$ and respectively, $\Delta\alpha_{St\text{-}I,2}$, $\Delta\alpha_{St\text{-}II,2}$ and $\Delta\alpha_{St\text{-}IIIA,2}$.

Table 1 Standard Acceptance Angle and Critical Differences

(*Clauses* 6.2, B-1 *and* B-3)

Sl No.	**Standard Floor Covering**	$\alpha_{S,}$i	CrD_{95}
(1)	(2)	(3)	(4)
i)	St-I	8.7°	3.0°
ii)	St-II	17.3°	3.0°
iii)	St-IIIA	27.3°	3.0°

If the individual corrections $\Delta\alpha_{St\text{-}I,j}$, $\Delta\alpha_{St\text{-}II,j}$ and $\Delta\alpha_{St\text{-}IIIA,j}$ fall within the critical differences, they will be included in the analysis, but if they fall outside the range, the responsible tester will be excluded from the test. Tester shall be replaced by another tester the same day.

6.3 Procedure

The temperature of the test room, as well as the footwear, lubricant and flooring test piece shall be 27 °C ± 5 °C. The lubricant is to be applied in a manner specified in clause **6.1.3** (for tests with footwear) or clause **6.1.4** (for barefoot tests), as applicable.

The tester then walks in an upright position with the line of vision downhill, taking steps of half a foot/shoe length forwards and backwards along the flooring test piece. The flooring test piece starts in a horizontal position and the incline is gradually increased at a speed of approximately 1° per second. When the tester reaches the limit of being able to walk safely, the tester walks up and down multiple times to determine the critical range of the acceptance angle (the angle of slippage). The acceptance angle of the flooring test piece is determined three times, each time starting in the horizontal position or starting with an angle 10° below the acceptance angle of the previous measurement. Before each second and third measurement, lubricant is to be re-applied to the surface area with a brush. The test shall be carried out by two testers.

NOTE — In order to maintain an even gait, it is recommended that the pace frequency be set by an acoustic clock-pulse generator, for example, a metronome. The tester's pace frequency should be approximately 140 steps per minute at an angle of inclination up to ≈ 20°.

6.4 Evaluation

For each tester, the three acceptance angle results are averaged to give the mean test acceptance angle $\alpha_{0,1}$ and $\alpha_{0,2}$.

For each tester, a correction of D_j is calculated. Depending on the size of the mean test acceptance angle reached $\alpha_{0,1}$ and $\alpha_{0,2}$ the calculation is carried out according to one of the four scenarios listed in Table 2.

The addition of the correction D_1 and the mean test acceptance angle $\alpha_{0,1}$ gives the corrected mean acceptance angle α_1.

The scenarios in Table 2 are outlined for tester 1. For tester 2, the calculation of the correction D_2 is carried out accordingly.

6.5 Classification and Typical Applications

The corrected mean acceptance angles α_1 and α_2 are added together and divided by 2. The result is the corrected mean overall acceptance angle α_{ges} used to determine the slip-resistance/rating classification according to Table 3 and Table 4 (for barefoot tests).

7 MEASUREMENT OF THE DISPLACEMENT SPACE

7.1 General

The measurement of the displacement space shall only be carried out subject to agreement. Floor coverings with a displacement space of more than 10 cm^3/dm^2 (for example, grating) owing to their open structure will be classified as V 10 according to Table 5 without the displacement space being measured.

7.2 Test Apparatus

The test apparatus consists of a base plate with a smooth surface, an adjustable metal frame to enclose the test specimen, a scale with a maximum permissible error of 0.05 g as well as a measurement device to determine the density of the paste used for testing, for example, dispersion adhesive.

7.3 Test Specimen

A piece of the floor covering measuring 100 mm × 100 mm serves as the test specimen. The test specimen shall be representative of the surface structure of the floor covering.

When using tiles or sheets with sides measuring between 90 mm and 100 mm, the displacement space determination is to be carried out on individual sections and the results projected to 10 000 mm^2.

When using tiles or sheets with sides measuring less than 90 mm, the test specimen is to be made up of individual tiles and sheets affixed together. The tiles or sections shall be glued onto a base plate, closely fitted next to one another with no gaps in between, and then cut into a 10 000 mm^2 test surface.

Table 2 Correction as a Function of the Size of the Mean Test Acceptance Angle

(*Clause* 6.4)

Sl No.	Scenario	Correction D_1
(1)	(2)	(3)
i)	$d_{0,1} < \alpha_{K,St-I,1}$	$D_1 = \Delta\alpha_{St-I,1} \times \frac{1}{\sqrt{2}}$
ii)	$\alpha_{K,St-I,1} \leq \alpha_{0,1} < \alpha_{K,St-II,1}$	$D_1 = \left[\Delta\alpha_{St-I,1} + (\Delta\alpha_{St-II,1} - \Delta\alpha_{St-I,1}) \times \frac{\alpha_{0,1} - \alpha_{K,St-I,1}}{\alpha_{St-II,1} - \alpha_{K,St-I,1}}\right] \times \frac{1}{\sqrt{2}}$
iii)	$\alpha_{K,St-II,1} \leq \alpha_{0,1} < \alpha_{K,St-III,1}$	$D_1 = \left[\Delta\alpha_{St-II,1} + (\Delta\alpha_{St-IIIA,1} - \Delta\alpha_{St-II,1}) \times \frac{\alpha_{0,1} - \alpha_{K,St-II,1}}{\alpha_{K,St-IIIA,1} - \alpha_{K,St-II,1}}\right] \times \frac{1}{\sqrt{2}}$
iv)	$\alpha_{K,St-III,1} \leq \alpha_{0,1}$	$D_1 = \Delta\alpha_{St-IIIA,1} \times \frac{1}{\sqrt{2}}$

Table 3 Slip-Resistance Classification based Upon the Corrected Mean Overall Acceptance Angle — Tests with Footwear

(*Clauses* 6.5 *and* B-4)

Sl No.	Corrected mean Overall Acceptance Angle α_{ges}	Slip Resistance Class	Typical Floor Applications
(1)	(2)	(3)	(4)
i)	Up to 10°	R 9	Low risk internal applications, customer reception areas
ii)	over 10° up to 19°	R 10	Toilet and bathroom areas, self-service cafeterias
iii)	over 19° up to 27°	R 11	Cold stores, dish washing areas
iv)	over 27° up to 35°	R 12	Liquid spillage areas, large commercial kitchens
v)	over 35°	R 13	High risk of slip, oil spillage or similar present

Table 4 Slip Resistance Classification Based on Angle of Slippage — Barefoot Tests

(*Clause* 6.5)

Sl No.	Corrected Mean Overall Acceptance Angle α_{ges}	Slip Rating Class	Typical Floor Applications
(1)	(2)	(3)	(4)
i)	12° to 18°	A	Dry areas including dry changing areas, dry barefoot corridors
ii)	over 18° up to 24°	B	As A + pools surrounds, community showers, pool beach areas, wet change areas
iii)	over 24°	C	As A and B + pool surround inclines, walk through pools, jacuzzi floors and seats, inclined pool edges and steps

7.4 Determination of Paste Density

Before the series of tests is begun, the density of the paste to be used for the test is to be determined using two samples. For this purpose, a specimen glass is filled with the paste, free from air bubbles. The paste is then levelled off flush with the upper edge of the glass. The fill density is calculated from the difference in mass between the filled and empty glass and the volume of the specimen glass, and then rounded to two decimal points.

7.5 Procedure

The test specimen is placed on the base plate with the profiled side down and taped around each side flush with the surface from corner to corner. Then the test specimen is weighed to the nearest 0.1 g. The test specimen is again placed upon the base plate with the profiled or structured side facing down and enclosed by the metal frame, flush with the surface.

The test specimen is then turned over and the displacement spaces filled with the paste. The paste is smoothed out evenly so as to be flush with the tops of the profile ridges, leaving no grooves. After the metal frame is removed, the test specimen is weighed for the second time. The filling and smoothing of the paste, removal of the frame and the second weighing shall take place within one minute. The volume of the displacement spaces is calculated from the difference in mass and the determined density of the paste. This test is to be carried out on five test specimens for each type of profile or structure.

7.6 Evaluation and Classification

The size of the displacement space is determined by calculating the arithmetic mean of the five volume determinations and rounding to 0.5 cm^3/dm^2. The result is used to determine the class of displacement space according to Table 5.

8 TEST REPORT

The test report shall refer to this standard and include the following details:

a) Designation, name of the product manufacturer, product; if applicable the grade, colour and dimensions of the products which were used for the floor covering;

b) Structure of the surface (for example, flat, profiled, structured);

c) Mean overall acceptance angle, rounded to 0.1°;

d) Displacement space, rounded to 0.5 cm^3 per dm^2 or, if applicable, 'not tested';

e) Slip resistance class;

f) If applicable the class of the displacement space;

g) Test house; and

h) Abnormalities (for example, Irregularities in the surface).

Table 5 Relationship of the Class of Displacement Space to the Volume per Unit Area

(*Clauses* 7.1 *and* 7.6)

Sl No.	**Volume Per Unit Area of Displacement Space,** cm^3/dm^2 *Min*	**Class of Displacement Space**
(1)	(2)	(3)
i)	4	V 4
ii)	6	V 6
iii)	8	V 8
iv)	10	V 10

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 13360 (Part 5/ Sec11) : 2013	Plastics — Methods of testing — Determination of indentation hardness by means of a durometer (shore hardness) (*first revision*)
IS 15393	Accuracy (trueness and precision) of measurement methods and results:
(Part 2) : 2021	Basic method for the determination of repeatability and reproducibility of a standard measurement method
(Part 5) : 2003	Alternative methods for the determination of the precision of a standard measurement method
IS 13656 : 2019	Internal combustion engine crankcase oils for automotive application (diesel and gasoline) — Specification (*third revision*)

ANNEX B

(*Foreword*)

TESTING PROCESS

B-1 CALIBRATION

The testing calibration shall include the following:

a) Each test person *j* walks along each standard floor covering three times and the mean values are determined:

$\alpha_{K,St-I,j}$ $\alpha_{K,St-II,j}$ $\alpha_{K,St-III,j}$

b) The individual corrections:

$$\Delta\alpha_{ij} = \alpha_{S,i-}\alpha_{K,i,j} \ (i = St-I, St-II, St-IIIA)$$

are calculated and given as:

$\Delta\alpha_{St-I,j}$ $\Delta\alpha_{St-II,j}$ $\Delta\alpha_{St-IIIA,j}$

c) The test person is excluded if

$$|\Delta\alpha_{ij}| > CrD_{95}$$

See Table 1.

B-2 PROCEDURE

Each accepted test person *j* walks along the floor covering to be tested three times and the mean value $\alpha_{0,j}$ is determined.

B-3 EVALUATION

The correction D_j for the flooring test piece, depending upon the mean value $\alpha_{0,j}$, is calculated according to the equations in Table 1. The individual result of test person *j* is calculated as follows:

$$\alpha_j = \alpha_{0,j} + D_j$$

B-4 CLASSIFICATION

The end result of the test by 2 testers is given as:

$$\alpha_{ges=}\frac{\alpha_1+\alpha_2}{2}$$

and results in the assignment to a class according to Table 3.

ANNEX C

(*Foreword*)

OUTSOLES OF THE TESTING FOOTWEAR

C-1 Exposure to motor oil over longer periods as well as walking upon floor coverings with sharp surfaces can lead to changes in the sole of the test shoe. These changes can be determined optically or by calibration. Sanding the surface of the soles with unused sandpaper of grain 320 carbon silicide can remove these changes. After the surface of the soles is sanded, the sandpaper dust is to be removed and a test person shall carry out a calibration.

ANNEX D

(*Foreword*)

COMMITTEE COMPOSITION

Flooring, Wall Finishing and Roofing Sectional Committee, CED 05

Organization	*Representative(s)*
In Personal Capacity (*L/109, Sarita Vihar, New Delhi - 110076*)	SHRI ASHOK KHURANA **(*Chairperson*)**
Acropolis Institute of Technology and Research, Indore	DR SATISH KUMAR SHARMA SHRI JAYANT AWASTHY (*Alternate* I) SHRI DEEPSHIKHA SHUKLA (*Alternate* II)
Aludecor Lamination Pvt Ltd, Kolkata	SHRI DEVESH KUMAR
Ardex Endura India Pvt Ltd, Bengaluru	SHRI K. P. PAULSON SHRI GOPINATH KRISHNAN (*Alternate*)
Central Public Works Department, New Delhi	SHRI A. K. SHARMA MS NANDINI MUKHOPADHYAY (*Alternate*)
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Construction Industry Development Council, New Delhi	SHRI P. R. SWARUP SHRI RAVI JAIN (*Alternate*)
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CSIR - Central Glass and Ceramic Research Institute, Kolkata	DR PARAG MANGALBHAI SOLANKI DR PARVESH AGARWAL (*Alternate* I) DR ASHA T. ANIL (*Alternate* II)
CSIR - Central Road Research Institute, New Delhi	DR RAKESH KUMAR
Delhi Development Authority, New Delhi	CHIEF ENGINEER (DWK) SUPERINTENDING ENGINEER (P) (*Alternate*)
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H. R. Johnson (India) Limited, Dewas	SHRI SUDIPTA SAHA SHRI SUBHASHISH MUKHOPADHYAY (*Alternate*)
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Organization	*Representative(s)*
Indian Institute of Technology, Gandhinagar	DR GAURAV SRIVASTAVA
MAPEI Construction Products India Pvt Ltd, Bengaluru	SHRI HANUMANTHA RAJU S. N. SHRI RAVI JAGTAP (*Alternate* I) SHRI ASHUTOSH KANDWAL (*Alternate* II)
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MYK Laticrete India, Hyderabad	DR P. ARJUNAN SHRI N. RADHAKANTH (*Alternate*)
National Council for Cement and Building Materials, Ballabgarh	SHRI AMIT TRIVEDI SHRI SANJAY MUNDRA (*Alternate* I) SHRI AMIT SAGAR (*Alternate* II)
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Plastindia Foundation, Mumbai	SHRI ARVIND GOENKA DR E. SUNDARESAN (*Alternate*)
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Shriram Institute of Industrial Research, New Delhi	SHRI MUKESH GARG SHRI RAMAN DHYANI (*Alternate*)
Steuler Industrial Solution (India) Private Limited	SHRI CHIRAG K BAXI SHRI BHARATBHAI D. PATEL (*Alternate*)
In Personal Capacity (*N96, Ground Floor, Mayfield Garden, Sector-51, Gurugram - 122018*)	SHRI R. D. MATHUR

Organization	*Representative(s)*
BIS Directorate General	SHRI ARUNKUMAR S., SCIENTIST 'E'/ DIRECTOR AND HEAD (CIVIL ENGINEERING) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
SHRI PRADEEP SINGH SHEKHAWAT
SCIENTIST 'D'/JOINT DIRECTOR
(CIVIL ENGINEERING), BIS

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in.

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Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.gov.in

Regional Offices:		*Telephones*
Central	: 601/A, Konnectus Tower -1, 6th Floor, DMRC Building, Bhavbhuti Marg, New Delhi 110002	2323 7617
Eastern	: 8th Floor, Plot No 7/7 & 7/8, CP Block, Sector V, Salt Lake, Kolkata, West Bengal 700091	2367 0012 2320 9474
Northern	: Plot No. 4-A, Sector 27-B, Madhya Marg, Chandigarh 160019	265 9930
Southern	: C.I.T. Campus, IV Cross Road, Taramani, Chennai 600113	2254 1442 2254 1216
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