भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDRADS

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भारतीय मानक मसौदा

वस्त्रादि - कपड़ो की अकड़न को निर्धारण करने की परीक्षण विधियाँ

(पहला पुनरीक्षण)

Draft *Indian Standard*

TEXTILES — TEST METHODS FOR DETERMINATION OF STIFFNESS OF FABRICS

(*First Revision*)

ICS 59.080.30

Physical Methods of Test Sectional Committee
TXD 01

Last date for receipt of comments
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FOREWORD

(*Formal clauses will be added later***)**

This standard was first published in 1971. This standard was prepared with the view to specify a test method for determination of stiffness of fabrics by the measurement of bending length using cantilever test.

This revision has been made in the light of experience gained since its publication and to incorporate the following major changes:

a) The title of the standard has been modified;
b) The Scope of the standard has been modified;
c) A new test method “Heart Loop Test” has been incorporated;
d) A new clause for “Principle” has been incorporated;
e) The clause ‘Calculations’ has been modified;

f) The clause “Test report” has been modified; and
g) References to Indian standards have been updated.

In the original standard, the test method, i.e. Cantilever test, given for determination of stiffness of fabric is not applicable for very limp fabric or those that show a marked tendency to curl or twist at a cut edge. Therefore, a new test method, i.e. Heart Loop test, has been introduced in this revision which can also be applicable for determination of stiffness for very limp fabric or those that show a marked tendency to curl or twist at a cut edge.

In the preparation of this standard, considerable assistance has been derived from the following:

ASTM Designation: D 1388-64 Methods of test for stiffness of fabrics, American Society for Testing Materials.

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

Indian Standard

TEXTILES — TEST METHOD FOR DETERMINATION OF STIFFNESS OF FABRICS

(*First Revision*)

1 SCOPE

1.1 This standard prescribes two methods for determination of stiffness of fabrics made from any textile fibre or a blend of two or more textile fibres by the measurement of bending length.

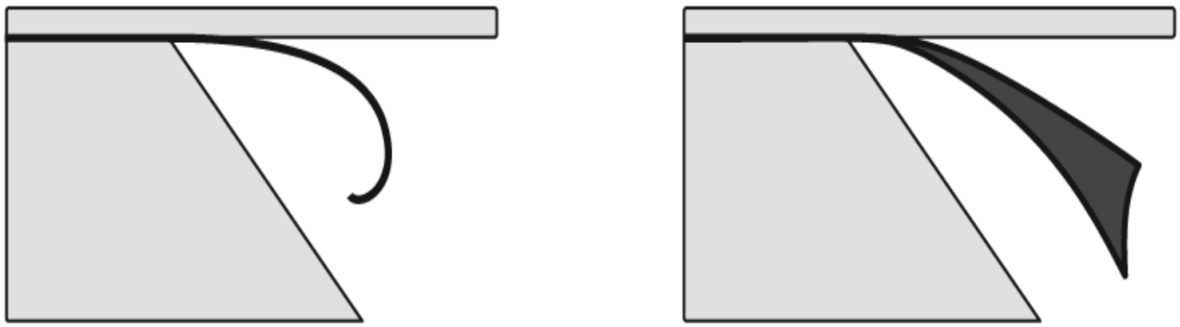
— Method A – Cantilever Test; and

— Method B – Heart Loop Test.

1.2 This test method applies to most fabrics including woven fabrics, air bag fabrics, blankets, napped fabrics, knitted fabrics, layered fabrics, pile fabrics. The fabrics may be untreated, heavily sized, coated, resin-treated, or otherwise treated.

1.3 The 'Method A' is not suitable for very limp fabric or those that show a marked tendency to curl or twist at a cut edge (*see* Fig. 1). Whereas the 'Method B' is suitable for very limp fabrics or the fabrics which shows a tendency to curl or twist.

NOTE — These methods are more suitable for testing woven fabrics than knitted fabrics.



Curl **Twist at a cut edge**

FIG.1: EXAMPLES OF FABRIC NOT SUITABLE FOR CANTILEVER TEST

2 NORMATIVE REFERENCES

The standards listed below contain provisions which, through reference in this 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 edition of the standards indicated below.

IS No.	*Title*
IS 196 : 1967	Atmospheric conditions for testing (revised)
IS 1964 : 2001	Textiles – Methods for determination of mass per unit length and mass per unit area of fabrics (second revision)
IS 3919 : 1966	Methods for sampling cotton fabrics for determination of physical characteristics
IS 6359 : 2023	Method for conditioning of textiles (*first revision*)
IS 6668 : 1972	Method for preparing test specimens from fabric samples for physical tests

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall be used.

3.1 Stiffness — Resistance of fabric to bending.

3.2 Flexural Rigidity — Ratio of the small change in bending moment per unit width of the material to the corresponding small change in the curvature, expressed in milligram centimetres (mg-cm).

NOTE — This quantity is a measure of the resistance of cloth to bending by external forces. It is related to the quality of stiffness that is appreciated when a fabric is handled; that is, the cloth having a high flexural rigidity tends to feel stiff.

3.3 Bending Length — Cube root of the ratio of flexural rigidity (milligram-centimeters) to the weight per unit area (milligram per square centimetre) of the fabric. Bending length equals to the half of the length of rectangular strip of fabric that will bend under its own weight to an angle of 41.5°. It is also equal to the length of a rectangular strip of materials that will bend under its own weight to an angle of 7.l °. It is expressed in centimetres.

NOTE — This quantity is one of the factors that determines the manner in which fabric drapes. It is related to the quality of the stiffness that is appreciated by visual examination of the draped material, that is, the cloth having high bending length tends to drape stiffly.

4 PRINCIPLE

4.1 Method A works on the cantilever principal where a specimen slides at a specified rate in a direction parallel to its long dimension, until its leading edge projects from the edge of a horizontal

surface. The length of the overhang is measured when the tip of the specimen is depressed under its own mass to the point where the line joining the tip to the edge of the platform makes a 0.724 rad (41.5°) angle with the horizontal. From this measured length and the specimen's fabric mass per unit area, the bending length and flexural rigidity are calculated.

4.2 In Method B, a strip of fabric is formed into a heart-shaped loop. The length of the loop is measured when it is hanging vertically under its own mass. From this measured length and the specimen's fabric mass per unit area, the bending length and flexural rigidity are calculated.

5 SAMPLING

Follow the method of drawing the test sample from the gross sample with respect to the lot as given in the relevant specification for the material or as agreed to between the buyer and the seller.

NOTE — For cotton fabrics, IS 3919 may be followed.

6 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

Prior to test, the fabrics shall be conditioned to moisture equilibrium and tested in standard atmospheric conditions of (65 ± 2) percent RH and (27 ± 2) °C temperature as laid down in IS 6359 (*see also* IS 196).

7 METHOD A — CANTILEVER TEST

7.1 Apparatus

7.1.1 *Bend Angle Indicator* — A platform inclined at an angle of 41.5° ± 0.5° (0.724 rad ± 0.01 rad) below the plane of the horizontal platform surface.

7.1.2 *Horizontal Platform* — A platform with a minimum area of 38 mm by 200 mm (1.5 in. by 8 in.) and having a smooth, low-friction, flat surface such as polished metal or plastic.

7.1.3 *Movable Specimen Slide* — It shall consist of a metal bar not less than 25 mm by 200 mm (1 in. by 8 in.) by approximately 3 mm (1/8 in.) thick and having a mass of 270 ± 5 g. A motorized specimen feed unit set to 120 mm/min ± 5 percent may be used.

7.1.4 *Scale* — It shall be of 25 × 200 mm weighing (10 ± 2) g/cm with rough bottom surface to grip the specimen and graduated in centimeters and millimeters.

NOTE — A typical sketch of stiffness tester based on cantilever test is given in Fig. 2.

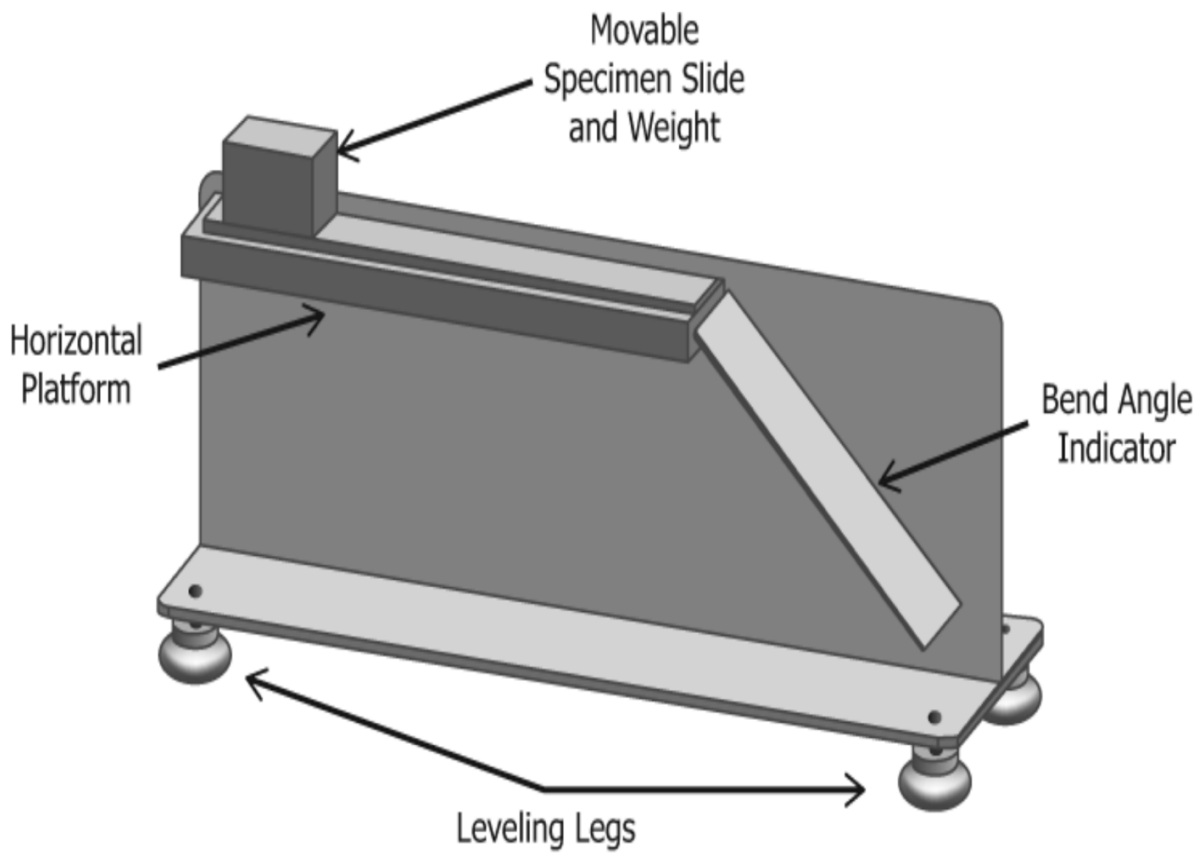


FIG. 2 A SUITABLE APPARATUS FOR DETERMINING STIFFNESS USING CANTILEVER TEST

7.2 Preparation of Test Specimens

7.2.1 From the samples, as selected in **5**, cut rectangular warp way and weft way test specimens of 25 mm × 200 mm size preferably with the help of a template from different portions of the sample under test. The lengthwise (longer) direction of specimens shall be parallel to the warp or weft direction for which the stiffness is to be determined. Specimens cut in each direction shall be scattered as far as possible so that no two warpway specimens contain the same set of warp yarns and no two weftway specimens contain the same set of weft yarns. Avoid selvedges (within 10 cm), end portions, creased or folded places (*see* IS 6668). The specimens shall be handled as little as possible.

7.3 Procedure

7.3.1 Place the tester on a table or bench so that horizontal platform and inclined reference line are at eye level of the operator. Adjust the platform with the help of a spirit level so that it is horizontal.

7.3.2 Remove the movable specimen slide. Place the specimen on the horizontal platform with the length of the specimen parallel to the platform edge. For instruments equipped with a reference point, align the leading edge of the specimen with the line scribed on the right-hand edge of the horizontal platform. For all other instruments, align the leading edge of the specimen with the edge of the horizontal platform edge (closest to the bend angle indicator).

7.3.3 Place the movable slide on the specimen, being careful not to change its initial position.

7.3.3.1 For automatic testers, turn the tester switch on and watch the leading edge of the specimen closely. Turn the switch off the instant the edge of the specimen touches the bend angle indicator.

7.3.3.2 For manual testers, advance the moveable specimen slide by hand in a smooth manner at approximately 120 mm/min ± 5 % until the edge of the specimen touches the bend angle indicator.

7.3.4 Using the scale, read and record the overhang length from the fulcrum (edge of the horizontal platform) to the nearest 1 mm.

NOTE - If the specimen has a tendency to twist, take the reading from at the center of the leading edge. Do not measure specimens that twist more than 45°.

7.3.5 Repeat **7.3.2 – 7.3.4** to test the face and back of both ends of each specimen for a total of four readings per specimen. Test the face and back of one specimen end before proceeding to test the face and back of the other end of the specimen.

NOTE — A typical sketch of fabric in bent position in cantilever test is given in Fig. 3.

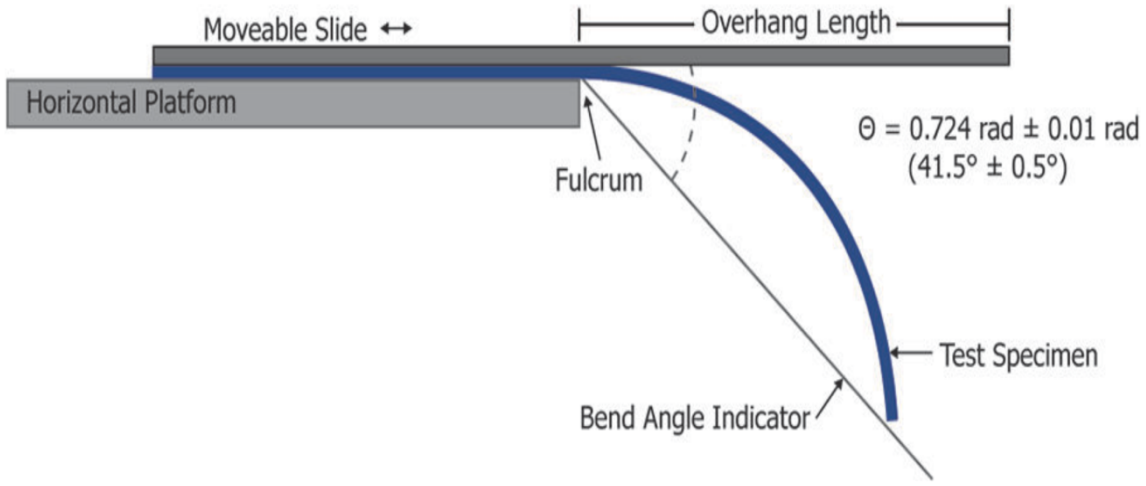


FIG. 3 FABRIC IN BENT POSITION UNDER CANTILEVER TEST

7.3.4 Similarly, test at least 4 test specimens for each warpway and weftway.

7.3.5 Determine the weight per unit area of the fabric according to IS 1964 and express in terms of milligrams per square centimetre. Alternatively, the weight per unit area can be determined by weighing all the warpway and weftway test specimens together after completion of stiffness test.

7.4 Calibration

7.4.1 Set the tester on a table or bench and adjust the platform so that it is level to horizontal.

7.4.2 Verify that the bend angle indicator is at the 41.5° (0.724 rad) angle marked on the scale.

8 METHOD B — HEART LOOP TEST

8.1 Apparatus

8.1.1 *Clamp and Stand* — It shall be suitable for hanging the specimen.

NOTE — A convenient method for mounting and measuring the specimen involves the use of two bars 25 mm by 75 mm by 3 mm (1 in. by 3 in. by 0.125 in.), to which the strip is fastened and a clip for holding these bars and the attached strip in a suitable position in front of scale.

8.1.2 *Scale* — It shall be suitably mounted on the stand for measuring the length of the specimen loop and calibrated either in cm or directly in bending length.

NOTE — If a constant strip length is adopted, the scale may be calibrated to read directly in units.

8.1.3 *Pressure Sensitive Tape.*

8.1.4 *Jig (optional)* — It shall be constructed in such a way to allow positioning of the two bars with there inner edges parallel and at a distance from each other equal to the selected strip length.

8.1.5 *Balance* — It shall have a capacity and sensitivity to weigh within ± 0.1 percent of the specimen weigh being tested.

NOTE — A typical sketch of stiffness tester based on Heart loop test is given in Fig. 4.

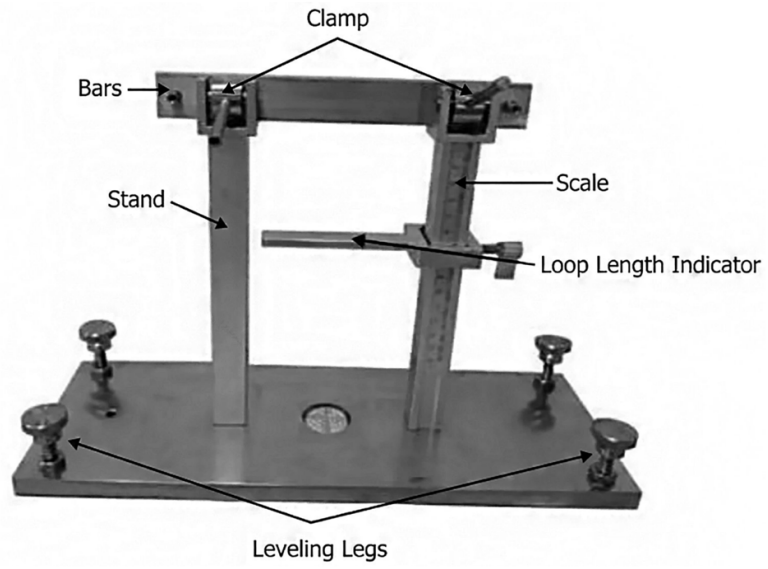


FIG. 4 A SUITABLE APPARATUS FOR DETERMINING STIFFNESS USING HEART LOOP TEST

8.2 Preparation of Test Specimens

8.2.1 This method does not require a standard size of the test specimen. When using two bars as described in **8.1.1,** cut test specimen of 5 cm longer than the selected strip length to allow for clamping at the ends. For other size bars, adjust the length to allow for clamping at the ends. As a starting point, use Table 2 to determine a suitable strip length for any given fabric.

NOTE — Strip length, L, is the circumferential length of the unclamped portion of the specimen.

8.2.2 Make several trial tests using various strip lengths selected from Table 2 to obtain an estimate of the loop length. Select a suitable strip length for a corresponding loop length from Table 3, such that the bending length is relatively independent of strip length.

NOTE — The bending length using the heart loop option is not entirely independent of the strip length. In general, the bending length rises with the strip length up to a value that remains relatively constant as the strip length is further increased. An additional rise may further be encountered for much longer strip lengths. Whenever possible, compare fabrics in the range where bending length is independent of strip length.

8.2.3 Select a specimen width at least 25 mm and no more than 75 mm with respect to the tendency of the fabric to curl. For fabrics having a slight tendency to curl, a 25 mm ± 1 mm wide specimen has been found to be satisfactory. As the tendency to curl becomes greater, increase the width up to a maximum of 75 mm.

8.2.4 From the sample, as selected in **5,** take at least four test specimens from the warp way and four test specimens from the weft way. Consider the long dimension of the specimen as the direction of test and also label the specimen to maintain identity.

TABLE 2 Strip Lengths for Various Fabric Types

Sl. No.	Bending length, cm	Strip length, cm
(1)	(2)	(3)
i)	Less than 2	15
ii)	2 to 3	20
iii)	Over 3	At least 25

TABLE 3 Table of Bending Lengths for Heart Loop Test

Sl. No	Loop Length, cm	Bending length, cm		
		15-cm Strip Length	20-cm Strip Length	25-cm Strip Length
(1)	(2)	(3)	(4)	(5)
i)	4.0	2.19	-	-
ii)	4.2	2.07	-	-
iii)	4.4	1.99	-	-
iv)	4.6	1.86	344	5.43
v)	4.8	1.76	3.30	5.16
vi)	5.0	1.65	3.17	4.91
vii)	5.2	1.56	3.03	4.71
viii)	5.4	1.45	2.90	4.53
ix)	5.6	1.35	2.80	4.36
x)	5.8	1.25	2.67	4.20
xi)	6.0	1.14	2.57	4.06
xii)	6.2	1.04	2.47	3.92
xiii)	6.4	0.93	2.37	3.80
xiv)	6.6	0.81	2.26	3.67
xv)	6.8	0.69	2.16	3.56
xvi)	7.0	0.53	2.06	3.45
xvii)	7.2	-	1.96	3.34
xxviii)	7.4	-	1.86	3.21
xix)	7.6	-	1.76	3.12
xx)	7.8	-	1.66	3.02
xxi)	8.0	-	-	2.91
xxii)	8.2	-	-	2.82
xxiii)	8.4	-	-	2.72

8.3 Procedure

8.3.1 Remove the two bars from the clamp and stand, and place them parallel to one another on a horizontal surface such that the inner edges are separated by a distance equal to the selected strip length. This can be done easily with a jig (*see* **8.1.4**).

8.3.2 Lay the test specimen across the two bars (*see* **8.2.1**).

8.3.3 Attach one end of the specimen strip to one bar using pressure-sensitive tape, being careful to align to one edge of the bar. Apply just enough tension to the specimen to hold it taut, but without stretching, and attach the other specimen end to the second bar in a similar manner.

8.3.4 Turn the bars and mounted specimen over, such that the fabric is on the underside of each bar. Grasp one bar in each hand, lift and rotate each bar three-quarter turn or 270° (4.71 rad). Rotate the left-hand bar in a clockwise direction and the right-hand bar in a counterclockwise direction. Bring the bars together such that the fabric ends are touching one another. Insert the assembly on a suitable holder with the loop formed free to hang vertically.

8.3.5 Allow the looped specimen to hang freely for (60 ± 5) seconds. Measure the loop length as the distance from the top of the bars to the bottom of the loop to the nearest 2 mm (*see* Fig. 5).

8.3.6 Remove the bars from the holder and free the adhering tape from each end of the strips carefully to prevent distortion of the fabric. Turn the specimen strip and test the other side of the fabric by re-attaching to the bars and testing as described in **8.3.1 – 8.3.5**.

8.3.7 Determine the weight per unit area of the fabric according to IS 1964 and express in terms of milligrams per square centimeter. Alternatively, the weight per unit area can be determined by weighing all the warp way and weft way test specimens together after completion of stiffness test.

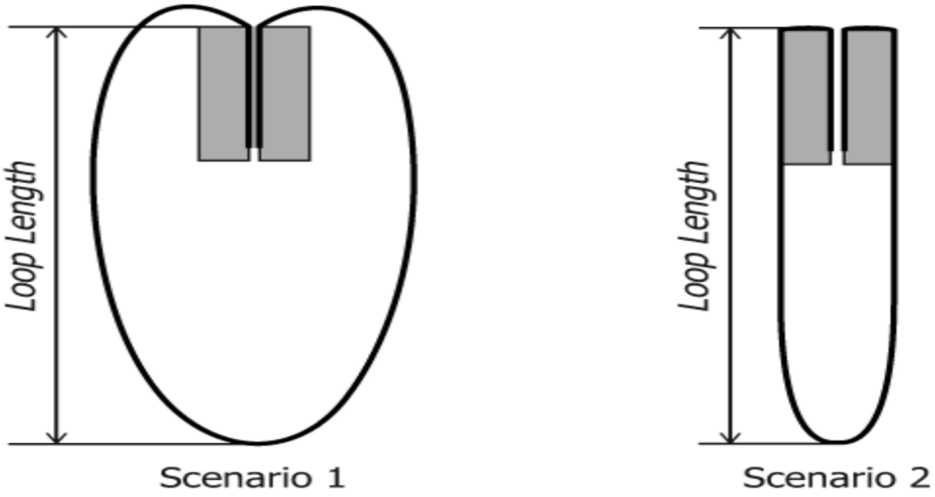


FIG. 5 MEASURING LOOP LENGTH FOR HEART LOOP TEST

8.4 Calibration

8.4.1 A suitable procedure for mounting and measuring the specimen is the use of two brass bars to which the specimen strip is fastened. The bars and the attached specimen strip are clamped to the stand in a suitable vertical position in front of a scale calibrated either in cm or directly in bending length.

9 CALCULATIONS

9.1 Calculate the average of the four readings of overhang length (in case of Method A) and of the two readings of loop length (in case of Method B) for each test specimen. Determine the average of the values for the warpway and weftway test specimens separately.

9.2 Determine the bending length for warp way and weft way specimens by using the following formula:

a) For Method A — Cantilever Test, bending length (C), in centimeters, can be calculated as -

$$C = \frac{L}{2}$$

Where

L = the mean length of over-hanging portion in centimetres.

b) For Method B — Heart Loop Test, bending length (C), in centimeters, can be calculated as –

$$C = l_o f(\theta)$$

$$\text{and } f(\theta) = \left(\frac{cos\theta}{tan\theta}\right)^{\frac{1}{3}}$$

Where,

l = Loop length in centimeters
$l_o = 0.1337L$
L = Strip length in centimeters
$\theta = 32.85° \, d/l_o$
$d = (l - l_o)$

NOTE – The values of $f(\theta)$ for different values of θ is given in Annex A.

9.3 Determine the flexural rigidity, in milligram-centimeters, for warp way and weft way specimens by using the following formula:

$$G = W \times (C)^3$$

Where

W = weight per unit area of the fabric in milligrams per square centimetre.

c) Overall flexural rigidity

$$G_o = \sqrt{G_W \times G_f}$$

Where

G_w = warp way flexural rigidity, and
G_f = weftway flexural rigidity.

10 TEST REPORT

10.1 The report shall include the following information:

a) Type of fabric.
b) Type of Method used.
b) Number of test specimens tested:
    1) Warp way, and
    2) Weft way.
c) Bending length:
    1) Warp way and
    2) Weft way.
e) Flexural rigidity:
    1) Warp way, and
    2) Weft way.
f) Overall flexural rigidity, if required.

Annex A
(Clause 9.2)

TABLE 4 Values of $f(\theta)$ For Different Values of θ

Θ, deg	0	1	2	3	4	5	6	7	8	9
0	--	3.855	3.059	2.671	2.425	2.250	2.115	2.007	1.917	1.841
10	1.774	1.716	1.663	1.616	1.573	1.533	1.496	1.462	1.430	1.400
20	1.372	1.345	1.319	1.294	1.271	1.248	1.226	1.205	1.186	1.164
30	1.144	1.126	1.107	1.089	1.071	1.054	1.037	1.022	1.003	0.986
40	0.970	0.954	0.933	0.922	0.906	0.891	0.875	0.860	0.845	0.829
50	0.813	0.799	0.784	0.768	0.753	0.738	0.722	0.707	0.692	0.676
60	0.661	0.645	0.630	0.614	0.596	0.582	0.566	0.549	0.533	0.516
70	0.499	0.482	0.465	0.447	0.429	0.411	0.392	0.373	0.354	0.333
80	0.313	0.291	0.269	0.246	0.222	0.197	0.170	0.140	0.107	0.067