Stiffness

Fabric Stiffness indicates the resistance of the fabric to bending and it is a key factor in the study of handle and Drape. It is a fabric property to describe resistance against deformation. In case of yarn, subjected to a tensile force or pull, stiffness is the ability to resist elongation and in case of circular bending of textile, resistance to multidirectional bending.

Methods of Measuring Fabric Stiffness

1. By the thickness of a folded sample
2. By the sag of projecting strip of sample-Cantilever test
3. By the length of a Heart loop (Heart loop test)
4. By means of a Flexometer
5. By means of a Planoflex
6. By the moment of rotation

The cantilever Test is the preferred method because it is simple to carry out. However, it is not suitable for testing fabrics which are very limp and which have a marked tendency to curl or twist at a cut edge. For these types of fabrics, the Heart-Loop test may carry out. The unit of stiffness is gm/denier per elongation

These methods measure the **Bending Length** of fabric, and from this the **Flexural Rigidity** and **Bending Modulus** can be calculated.

Bending Length(C)

Bending Length is also called as Drape Stiffness. This is the length of fabric that will bend under its own weight to a definite extent. It reflects the stiffness of a fabric when bend in one plane under the force of gravity and is one component of drape.
A rectangular strip of fabric is mounted on a horizontal platform and slided until the fabric overhangs like a cantilever, as shown below-

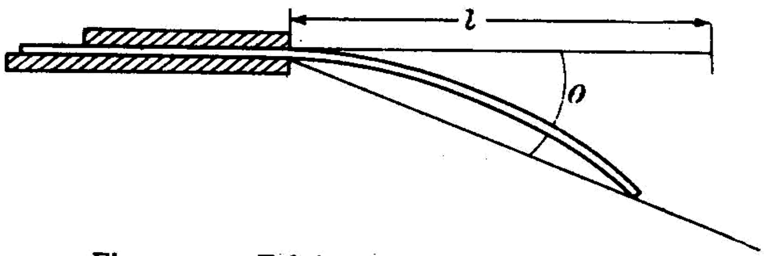

Figure . Fabric stiffness, cantilever principle

The length of overhang l when it is depressed under its own weight and the angle between the line joining the tip to the edge of the platform θ are measured and from these values, the bending length is calculated-

Bending Length, C = l × $f_1(\theta)$

$$c = l\left(\frac{\cos \frac{1}{2}\theta}{8\tan\theta}\right)^{\frac{1}{3}}$$

Where, l = unsupported fabric length or length of overhang.
Θ = the angle between the line joining the tip to the edge of the platform.

The Labour of calculating the function of Θ is avoided by consulting a prepared Table. For example, when θ=41.5° then $f_1(\theta)=0.509$. Bending length is calculated for warp and weft way of the fabric.

Flexural Rigidity(G)

Flexural rigidity is a measure of stiffness associated with handle. It is also called Flex Stiffness. This method of testing stiffness shows a close relationship with the personal judgment of stiffness.

It is calculated from the bending length and weight of per square yard of fabric.

Flexural Rigidity, $G = 3.39 \times W_1 \times C^3$ mg/cm
Or $G = W_2C^3 \times 10^3$ mg/cm

Where, W_1=Cloth wt in oz/yd^2
W_2=Cloth wt in gm/cm^2
C=Bending length

Flexural Rigidity is calculated for warp and weft way of fabric and the overall flexural rigidity is calculated as the geometric mean of those two values.

Overall Flexural Rigidity, $G_o = \sqrt{Gw \times Gf}$

Where, G_w = Warp Flexural Rigidity
G_f = Filling Flexural Rigidity.

Bending Modulus(q)

This value is independent of the dimensions of the strip tested and may be regarded as the intrinsic stiffness. This value may be used to compare the stiffness of the material in fabrics of different thickness values. For this calculation, the thickness of the fabric is measured at a pressure of 1 lb/sq. inch then,

$$q = \frac{732G}{g_1^{3}} kg/cm^2$$

$$= \frac{12G \times 10^{-6}}{g_2^{3}} kg/cm^2$$

where **g_1**= Cloth thickness in thousands of an inch. (Thou)
g_2 = Cloth thickness in cm.
G = Flexural rigidity.

Cantilever (Principle)Test

1. The Shirley stiffness tester.
2. The Heart loop tester.
3. The drape meter.

1.The Shirley Stiffness Tester

Basic principle:

[mentioned earlier Bending Length, Flexural Rigidity and Bending Modulus]

Construction:

- The stiffness tester consists of a platform having which is supported by two side pieces made of plastic. Index lines are engraved on these side pieces, inclined at an angle of 41.5° below the plane of the platform surface. At this angle, $f_1(\theta)$ is 0.5.
- A mirror is attached to the instrument to enable the operator to view both index lines from a convenient position.
- A scale is supplied with the instrument to measure the bending length and is graduated in cm of bending length. It also serves as a template for cutting the samples of size.
- This instrument is used in the finishing departments where the control of the process is used and to note the effects of varying the process.

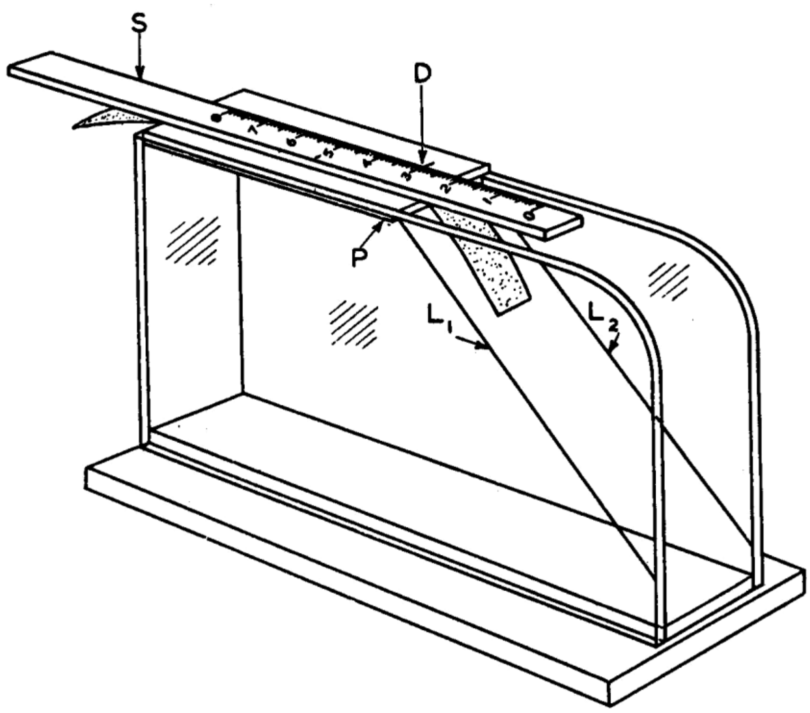

Figure . *Fabric stiffness tester* (From B.S. Handbook No. 11, *Methods of Test for Textiles* reproduced by permission of the British Standards Institution, 2 Park Street, London W.1)

S=Fabric Sample, P=Platform, D=Datum line, L_1 and L_2=Index lines

Sample Preparation:

The sample is conditioned in the standard testing atmosphere and using the template, specimens are cut to the size of 6″ × 1″. Four specimens in warp way and weft way are prepared for the test. If the fabric is not uniform or a high degree of accuracy is required then more samples can be tested. The specimens are cut in such a way that the warp specimens do not contain the same warp yarns and the weft specimens contain different warp yarns. Selvedges, end pieces, crease or folded places must be avoided and the specimens must be handled as little as possible.

Working procedure:

1. The test is carried out in the standard testing atmosphere. The tester is set on a table so that the horizontal platforms are the index line are at eye level.
2. The Specimen is placed on the platform with the template at the top of it so that the leading edges coincide. Both are slowly pushed forward until the leading edges of the specimen and the template project beyond the edge of the platform. With the eye in a position so that the index lines coincide, the sliding of the specimen is stopped when it cuts both index lines.
3. If the specimen has a tendency to twist, the reference point at the centre of the leading edge is taken. For the specimens which twist more than 45°, this method should not be used.
4. Four readings are taken from each specimen, with each side up, first at one end and then the other and again with the strip turned over. Mean values for the **Bending Length** in warp and weft way are calculated and the **Flexural Rigidity & Bending Modulus** are also determined.

$$C = l \times f_1(\theta)$$

$$c = l\left(\frac{\cos \frac{1}{2}\theta}{8\tan\theta}\right)^{\frac{1}{3}}$$

2. Heart Loop Test

Some Fabrics are too flexible or limp and they will have a tendency to twist or curl when hanging. For this type of fabrics, the heart loop test is recommended. Pierce recommended a method for stiffness called the heart loop method for use of very soft material where the stiffness can be determined by the cantilever principle.

The apparatus used for this test consists of a clamp for hanging the specimens and a scale, suitable mounted, for measuring the length of the specimen.

Sample Preparation:

1. Specimen length for various fabric types

Bending length, cm	**Specimen length, cm**
Less than 2	15
2 to 3	20
More than 3	at least 25

2. For fabrics having only a slight tendency to curl, a 2.5 cm wide strip is satisfactory. If the tendency to curl increases, the strip width should be increased. However, strip widths of more than about 7.5 cm have not been investigated and should be used with caution.

3. Test Specimen are cut from the samples 5 cm longer than the specimen length selected to allow for clamping at the edges. Four specimens in warp way and four specimens in weft way are prepared. If the fabric is not fairly uniform or if greater precision is required, a greater number of specimens should be tested.

Procedure:

The free ends of the specimen are mounted in a clamp in the apparatus so that the loop is free to hang vertically. A stiff fabric will hang as first figure and very limp fabric will hang vertically as shown in the right figure.

After an interval of 1 minute, the distance between the top edge of the clamp to the bottom of the loop, l is measured. In this test, stiffness is inversely proportional to the length, l.

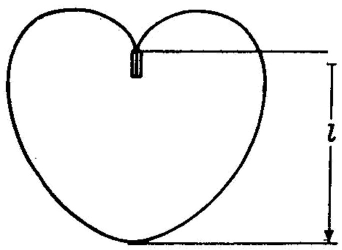

Figure . The heart-loop test (stiff fabric)

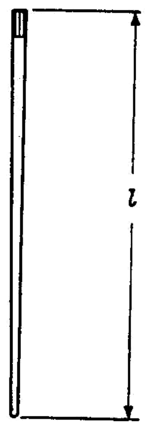

Figure The heart-loop test (limp fabric)

Then the specimen is removed form the clamp, turned over and the experiment is repeated and the length l is measured again.

The above procedure is repeated for all the test specimens and the average length l is calculated for all the warp and weft specimens. The length l is called as loop length, measured in cm.

A strip of fabric of length L is folded back on itself and is very stiff then length of loop would be 0.1337L but if the fabric is completely limp and the clamps were very thin, the length of loop would be 0.5L.

The bending length is calculated from the formula-

$C = l_0\, f_2(\theta)$

Where $\theta = 32.85° \times \frac{d}{l_0}$

$d = l - l_0$

l=Actual length of loop (Loop Length)

$l_0 = 0.1337L$

L=Specimen length

$f_2(\theta) = \left(\frac{\cos\theta}{\tan\theta}\right)^{\frac{1}{3}}$

From the value of bending length in warp and weft directions the Flexural Rigidity and Bending Modulus of warp and weft ways are calculated.

3. Drape meter

Drape:

Drape is the property of fabric which indicates the ability of a fabric to assume a graceful appearance in use. It is the opposite characteristically feature of stiffness of the fabric. It is important property of textile materials which allows fabric to orient itself into graceful folds or pleats as a result of force of gravity.

Measurement of Drape:

Drapability of a fabric can be determined using the instrument **Drapemeter** and is expressed in terms of **Drape Co-efficient.**

Drape coefficient, F:

It is the ratio of the projected area of the draped specimen to its undraped area, after deduction of the area of the supporting disk.

Thus, $F = \dfrac{A_s - A_d}{A_D - A_d}$

Where, A_s = The actual projected area of the specimen
A_D = The area of the specimen
A_d = The area of the supporting disk

Description and Working Procedure:

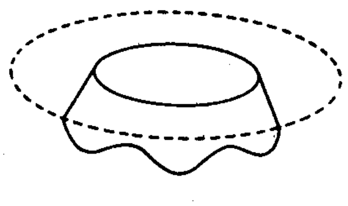

Figure . The Drapemeter. The circular specimen is 'draped' over the circular support

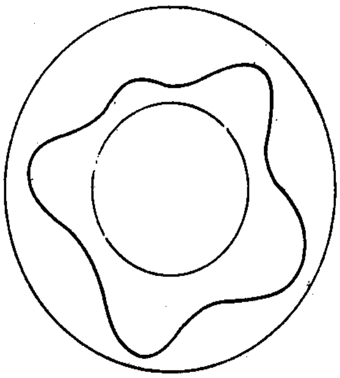

Figure . The Drapemeter. The projected outline of the 'draped' specimen

1. A circular specimen about 10″ diameter is supported on a circular disk about 5″ diameter and the unsupported area drape over the edge as fig(a)
2. If the specimen were, say, a 10 inch dia hard board, no draping would occur and the area of projection from the periphery would equal to the area of the record.
3. When its fabric, it will assume some folded configuration and the shape of the projected area will not be circular but something like the shape as fig (b)
4. The drape is then measured in terms of drape co-efficient, F considering areas.

Note: Instead of the areas of the draped and undraped specimen, their corresponding weights of paper projection can also be taken to calculate the drape co-efficient.

i.e. $$F = \frac{Ws - Wd}{WD - Wd}$$

Where, W_s= Weight of the paper whose area is equal to the area of A_s
W_D= Weight of the paper whose area is equal to the area of A_D
W_d= Weight of the paper whose area is equal to the area of A_d

Keep in Mind: The Thickness of the paper to trace the outline must be uniform.

The small value of F indicates the better drapability of the fabric and the large value of F indicates the bad drapability.

Weave/PPI	Plain	2/2 Twill	2/2 Warp Rib	2/2 Matt
56	64.6	45.6	46.8	49.2
64	67.6	53.8	51.1	51.8
72	78.8	58.1	54.0	55.1
82	81.6	63.4	62.2	59.6

From the above table, it can be seen that in all the weaves, drape coefficient increases with the increase in picks/inch which shows that the increase in picks/inch reduces the drapability.

Method of Improving the Drapability:

The drapability of a fabric can be improved by the following ways-
1. By providing the more float length by reducing the number of interlacements in the weave repeat.
2. By reducing the number of picks/inch

Fabric Handle

1. Fabric handle is concerned with the feel of mtl and so depends On the sense of touch
2. When the handle of fabric is judged the sensation of stiffness or limpness, hardness or softness and roughness or smoothness are all made use of.
3. Mr. Pierce states in the paper of the handle of cloth as a measurable quality.
4. Fabric handle depends on following factors:

   a. Weight and density.
   b. Surface tension.
   c. Flexibility.
   d. Compressibility.
   e. Resiliency.