10
Objective evaluation of fabric handle

10.1 Handle

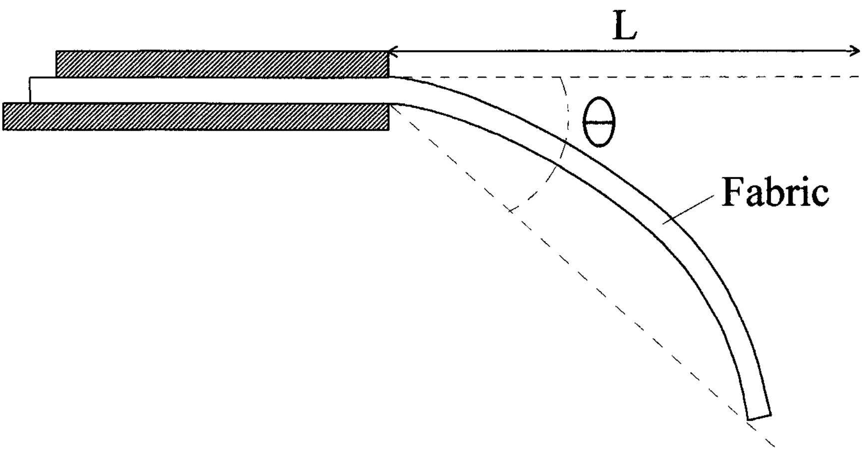
Fabric end uses can be roughly divided into industrial, household and apparel. Fabrics for industrial uses can be chosen on straightforward performance characteristics such as tensile strength, extension and resistance to environmental attack. However, fabrics intended for clothing have less emphasis placed on their technical specification and more on their appearance and handling characteristics such as lustre, smoothness or roughness, stiffness or limpness and draping qualities. Handling the fabric is one of the ways of assessing certain of these properties. 'Handle', the term given to properties assessed by touch or feel, depends upon subjective assessment of the fabrics by a person. Terms such as smooth, rough, stiff or limp depend strongly on the type of fabric being assessed, for instance the smoothness of a worsted suiting is different in nature from that of a cotton sateen. Because of the subjective nature of these properties attempts have been made over the years to devise objective tests to measure some or all of the factors that go to make up handle. Fabric stiffness and drape were some of the earliest [1] properties to be measured objectively.

10.1.1 Bending length

A form of the cantilever stiffness test is often used as a measure of a fabric's stiffness as it is an easy test to carry out. In the test a horizontal strip of fabric is clamped at one end and the rest of the strip allowed to hang under its own weight. This is shown diagrammatically in Fig. 10.1.

The relationship among the length of the overhanging strip, the angle that it bends to and the flexural rigidity, G, of the fabric is a complex one which was solved empirically by Peirce [1] to give the formula:

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



10.1 Bending length.

where L = length of fabric projecting,
θ = angle fabric bends to,
M = fabric mass per unit area.

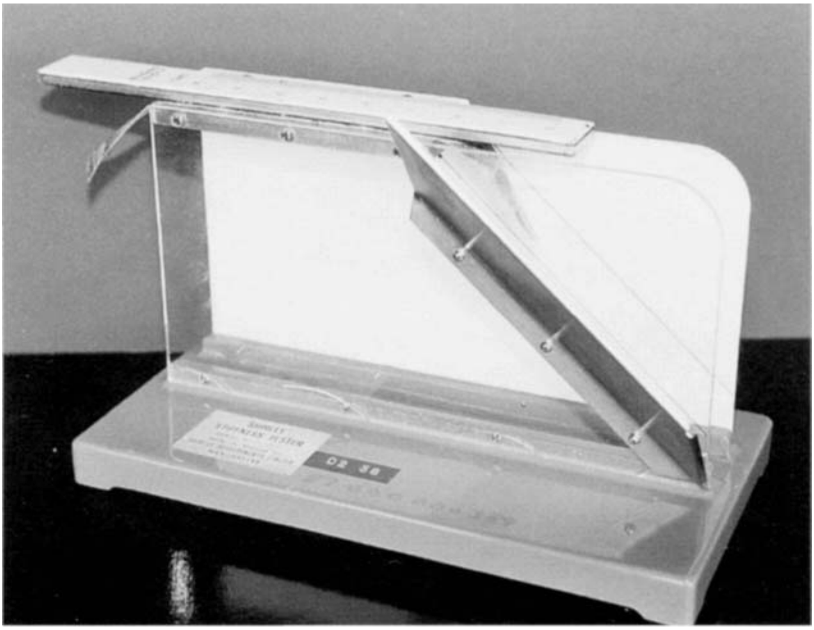
From this relationship Peirce defined a quantity known as the bending length as being equal to the length of a rectangular strip of material which will bend under its own mass to an angle of 7.1° [1]. The bending length is dependent on the weight of the fabric and is therefore an important component of the drape of a fabric when it is hanging under its own weight. However, when a fabric is handled by the fingers the property relating to stiffness that is sensed, in this situation, is the flexural rigidity which is a measure of stiffness independent of the fabric weight.

The bending length is related to the angle that the fabric makes to the horizontal by the following relation:

$$C = L\left(\frac{\cos\frac{1}{2}\theta}{8\tan\theta}\right)^{1/3}$$

where C = bending length.

When the tip of the specimen reaches a plane inclined at 41.5° below the horizontal the overhanging length is then twice the bending length. This angle is used in the Shirley apparatus (Fig. 10.2) to increase the sensitivity of the length measurement and the slide on this instrument is directly calibrated in centimetres.



10.2 The Shirley stiffness test.

10.1.2 Shirley stiffness test

This test [2] measures the bending stiffness of a fabric by allowing a narrow strip of the fabric to bend to a fixed angle under its own weight. The length of the fabric required to bend to this angle is measured and is known as the bending length.

The test specimens are each 25 mm wide and 200 mm long; three are cut parallel to the warp and three parallel to the weft so that no two warp specimens contain the same warp threads, and no two weft specimens contain the same weft threads. The specimens should not be creased and those that tend to twist should be flattened.

Before the test the specimens are preconditioned for 4 h (50 °C >10% RH) and then conditioned for 24 h. If a specimen is found to be twisted its mid-point should be aligned with the two index lines. Four readings are taken from each specimen, one face up and one face down on the first end, and then the same for the second end.

The mean bending length for warp and weft is calculated. The higher the bending length, the stiffer is the fabric.

Flexural rigidity

The flexural rigidity is the ratio of the small change in bending moment per unit width of the material to the corresponding small change in curvature:

$$\text{Flexural rigidity } G = M \times C^3 \times 9.807 \times 10^{-6}\,\mu\text{N m}$$

where C = bending length (mm),
M = fabric mass per unit area (g/m²).

Bending modulus

The stiffness of a fabric in bending is very dependent on its thickness, the thicker the fabric, the stiffer it is if all other factors remain the same. The bending modulus is independent of the dimensions of the strip tested so that by analogy with solid materials it is a measure of 'intrinsic stiffness'.

$$\text{Bending modulus} = \frac{12 \times G \times 10^3}{T^3}\,\text{N/m}^2$$

where T = fabric thickness (mm).

10.1.3 Hanging loop method

Fabrics that are too limp to give a satisfactory result by the cantilever method may have their stiffness measured by forming them into a loop and allowing it to hang under its own weight. A strip of fabric of length L has its two ends clamped together to form a loop. The undistorted length of the loop l_0, from the grip to the lowest point, has been calculated [1] for three different loop shapes: the ring, pear and heart shapes as shown in Fig. 10.3. If the actual length l of the loop hanging under its own weight is measured the stiffness can be calculated from the difference between the calculated and measured lengths $d = l - l_0$:

$$\text{Ring loop:} \quad l_0 = 0.3183L \qquad \theta = 157°\frac{d}{l_0}$$

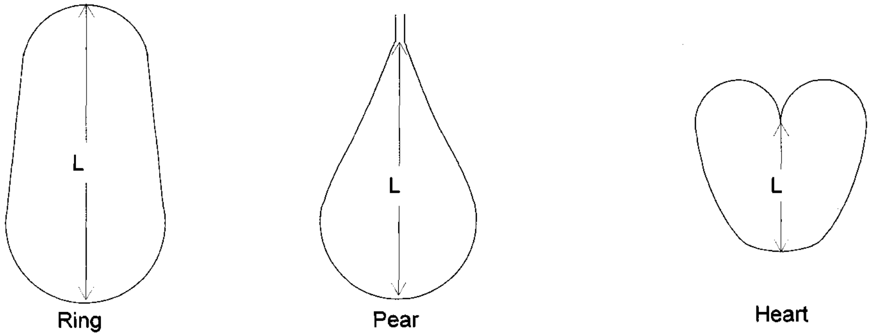
$$\text{Bending length } C = L0.133 f_2(\theta)$$

$$\text{Pear loop:} \quad l_0 = 0.4243L \qquad \theta = 504.5°\frac{d}{l_0}$$

$$\text{Bending length } C = L0.133 f_2(\theta)/\cos 0.87\theta$$

$$\text{Heart loop:} \quad l_0 = 0.1337L \qquad \theta = 32.85°\frac{d}{l_0}$$

$$\text{Bending length } C = l_0 f_2(\theta) \qquad f_2(\theta) = \left(\frac{\cos\theta}{\tan\theta}\right)^{1/3}$$



10.3 Different shapes of hanging loops.

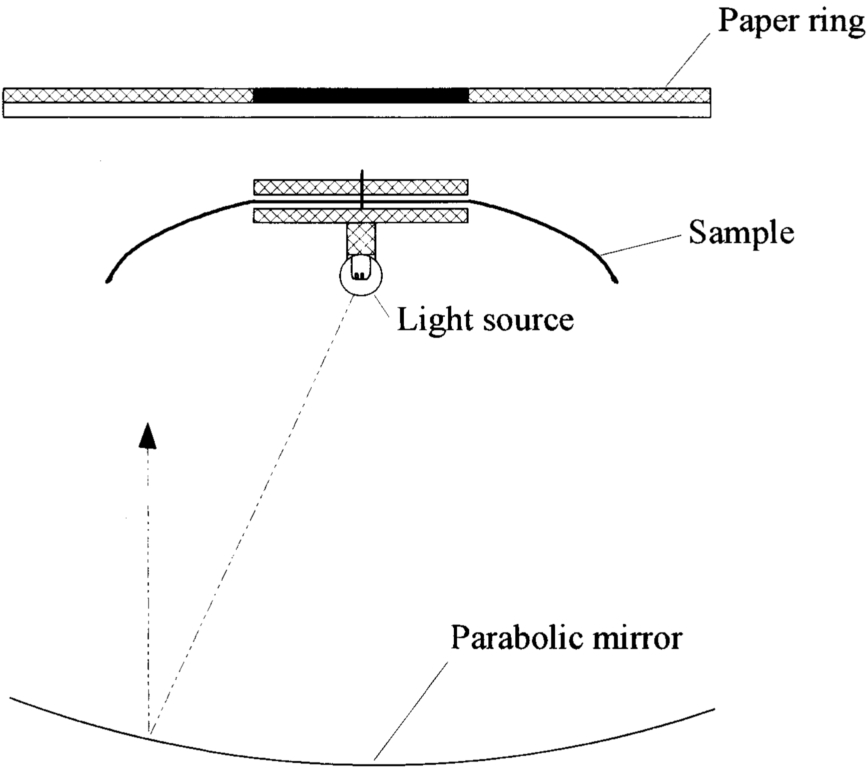
10.1.4 Drape

Drape is the term used to describe the way a fabric hangs under its own weight. It has an important bearing on how good a garment looks in use. The draping qualities required from a fabric will differ completely depending on its end use, therefore a given value for drape cannot be classified as either good or bad. Knitted fabrics are relatively floppy and garments made from them will tend to follow the body contours. Woven fabrics are relatively stiff when compared with knitted fabrics so that they are used in tailored clothing where the fabric hangs away from the body and disguises its contours. Measurement of a fabric s drape is meant to assess its ability to do this and also its ability to hang in graceful curves.

Cusick drape test

In the drape test [3] the specimen deforms with multi-directional curvature and consequently the results are dependent to a certain amount upon the shear properties of the fabric. The results are mainly dependent, however, on the bending stiffness of the fabric.

In the test a circular specimen is held concentrically between two smaller horizontal discs and is allowed to drape into folds under its own weight. A light is shone from underneath the specimen as shown in Fig. 10.4 and the shadow that the fabric casts, shown in Fig. 10.5, is traced onto an annular piece of paper the same size as the unsupported part of the fabric specimen. The stiffer a fabric is, the larger is the area of its shadow compared with the unsupported area of the fabric. To measure the areas involved, the whole paper ring is weighed and then the shadow part of the ring is cut away and weighed. The paper is assumed to have constant mass per unit area so that the measured mass is proportional to area. The drape coefficient can then be calculated using the following equation:



10.4 The Cusick drape test.

$$\text{Drape coefficient} = \frac{\text{mass of shaded area}}{\text{total mass of paper ring}} \times 100\%$$

The higher the drape coefficient the stiffer is the fabric.

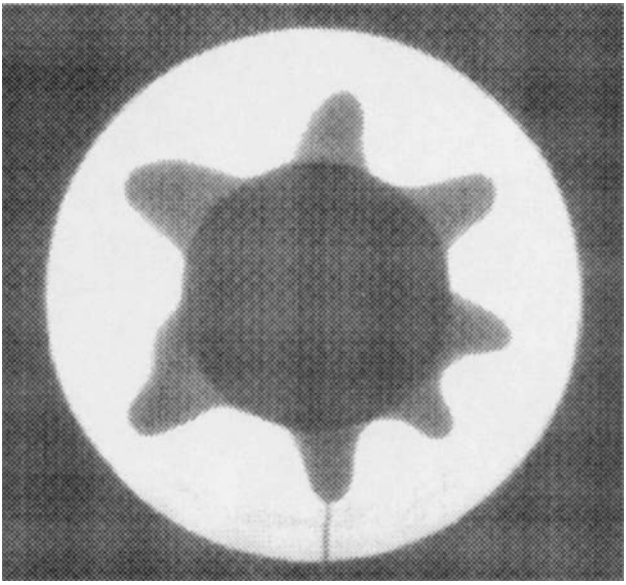
At least two specimens should be used, the fabric being tested both ways up so that a total of six measurements are made on the same specimen.

There are three diameters of specimen that can be used:

- A 24 cm for limp fabrics; drape coefficient below 30% with the 30 cm sample;
- B 30 cm for medium fabrics;
- C 36 cm for stiff fabrics; drape coefficient above 85% with the 30 cm sample.

It is intended that a fabric should be tested initially with a 30 cm size specimen in order to see which of the above categories it falls into.

When test specimens of different diameter are used, the drape coefficients measured from them are not directly comparable with one



10.5 Drape test, top view of draped fabric.

another. Figure 10.6 shows a drape tester fitted with a video camera and computer for instantaneous measurement of the drape coefficient.

10.1.5 Crease recovery

Creasing of a fabric during wear is not a change in appearance that is generally desired. The ability of a fabric to resist creasing is in the first instance dependent on the type of fibre used in its construction. Some fibre types such as wool and cultivated silk have a good resistance to creasing whereas cellulosic materials such as cotton, viscose and linen have a very poor resistance to creasing. Many fabrics have resin finishes applied during production in order to improve their crease resistance. This test was originally developed to test the efficiency of such finishes.

The essence of the test [4] is that a small fabric specimen is folded in two and placed under a load for a given length of time to form a crease and it is then allowed to recover for a further length of time and the angle of the crease that remains is measured.

The magnitude of this crease recovery angle is an indication of the ability of a fabric to recover from accidental creasing. Some types of fabrics, owing to limpness, thickness and tendency to curl, give rise to ill-defined crease recovery angles and therefore imprecise measurements. Many wool and wool mix fabrics come under this heading, therefore a different test using smaller specimens is used in this case.

10.6 Drape test.

The test can be carried out in two atmospheres, either the standard one or at 90% RH and 35 °C.

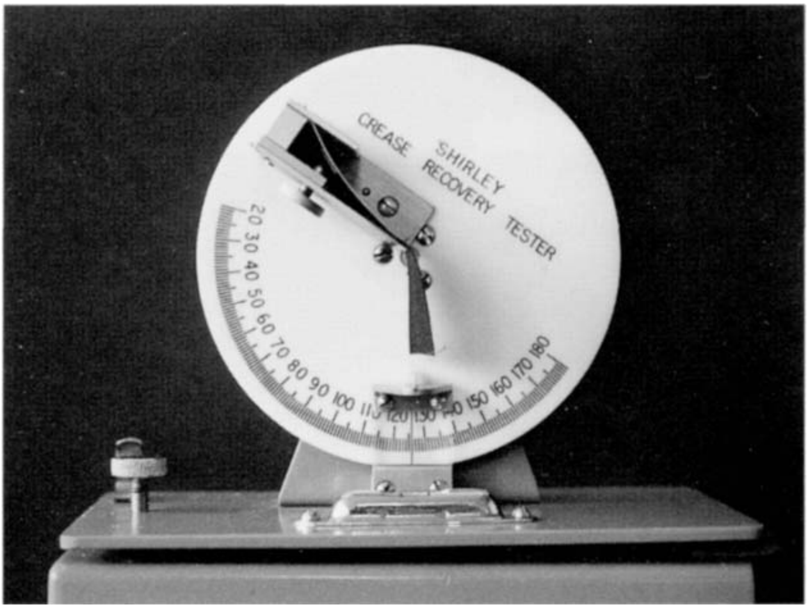
Twenty rectangular specimens are tested, each measuring 40 mm × 15 mm, half of the specimens cut parallel to the warp and half parallel to the weft.

In the test the specimens are folded in two, the ends being held by tweezers. Half the specimens are folded face to face and half of them back to back. The specimens are then placed under a 10 N load for 5 min. They are then transferred immediately to the holder of the measuring instrument and one leg of the specimen is inserted as far as the back stop. The instrument is adjusted continuously to keep the free limb of the specimen vertical as shown in Fig. 10.7. The crease recovery angle is measured, by reading the scale when the free limb is vertical, 5 min after the removal of the load.

The following mean values are calculated

warp face to face	weft face to face
warp back to back	weft back to back

When a fabric is creased the resulting deformation has two components: one is the displacement of fibres and yarns relative to one another and the second is the stretching of the fibres on the outside of the curve. The

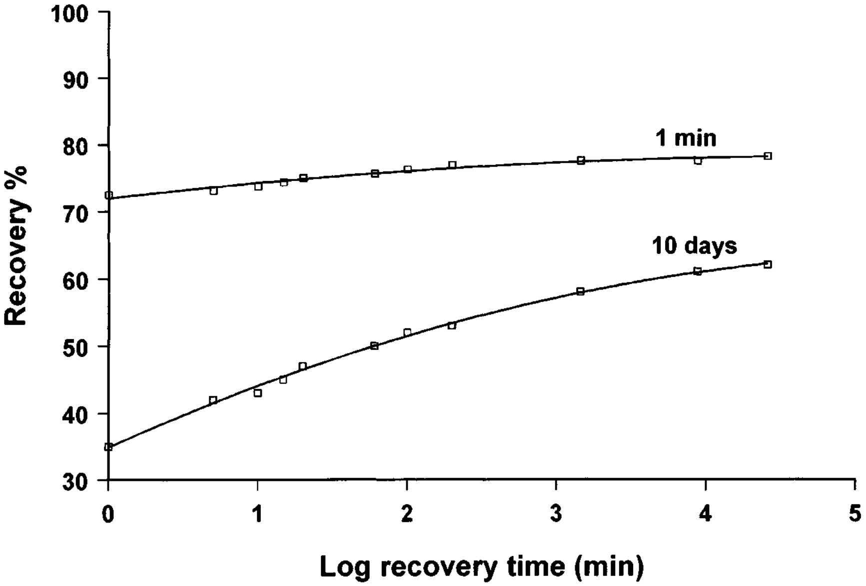


10.7 Crease recovery.

relative importance of these two mechanisms depends on the radius of the curve that the fabric is bent into. The smaller the radius of curvature, the more likely it is that the fibres are actually stretched rather than the curvature being accommodated by fibre displacement.

The unaided recovery of the fabric from creasing depends on the elastic recovery of the fibres, in particular whether the stored elastic energy is sufficient to overcome the friction that resists the movement of the yarns and fibres. Crease recovery in both resin treated and untreated cotton fabrics has been found [5] to increase with decreasing curvature but tending to the same limiting value at less than 100% recovery. This is thought to be because the crease recovery at low curvatures is governed by the frictional effects associated with fibre movement and at high curvatures by the elastic response of the fibre. The effect of the resin treatment is to improve the fibres' elastic recovery but it does not markedly affect the internal friction of the fabric which is dependent on structural factors such as tightness of weave.

The elastic recovery of the fibres is dependent on the time-related effects, such as stress relaxation, detailed in section 5.3.4. Hilyard *et al.* [5] have shown that the recovery from creasing of a fabric is a function of both the time the crease is maintained and the time allowed for recovery. There is an initial rapid recovery which takes place after removal of the restraint followed by a much slower rate of recovery which decreases with time.



10.8 Improvement in crease recovery as a function of recovery time for two different loading times: 1 min and 10 days. From [5].

The recovery with time of two identical samples, one creased for 1 min and the second creased for 10 days, is shown in Fig. 10.8 which is based on data from [5].