Indian Journal of Fibre & Textile Research
Vol. 48, March 2023, pp. 99-102
DOI: 10.56042/ijftr.v48i1.58171

Short Communication

Drape behaviour and shear properties of fabrics

Pravin Ukey[a] & P V Kadole
DKTE's Textile & Engineering Institute,
Ichalkaranji 416 115, India

Received 13 December 2021; revised received and accepted 29 June 2022

The studies have been carried out using 15 fabric samples (linen, cotton, polyester-cotton blend, denim and corduroy) of varying areal density for investigating fabric shear properties at different angles. It is observed that there is a high correlation between the drape and the shear properties of the fabric at different shear angles.

Keywords: Bending properties, Corduroy, Cotton, Denim, Drape behaviour, Fabric handle, Linen, Polyester, Shear properties

The drape of the fabric is its ability to fit on a three-dimensional object under its own weight. During this fall, the woven fabrics are subjected to a wide range of complex deformation[1]. In woven fabrics, in-plane shear deformation is induced due to the occurrence of double curvature or more complex geometrics. Fabric drape is crucially determined by the shear properties with the bending. The ability of a fabric to be deformed by shearing distinguishes it from other thin sheet materials, such as paper or plastic films[2]**.** This property enables the fabric to undergo complex deformations and to conform to the shape of the body. Customers, while purchasing the garments are mostly influenced by the visual appearance and its feel by touching, rubbing, or squeezing. These are nothing but fabric hand values. The handle property of a fabric is its sense of feel or touch, which comes from the low-stress mechanical properties of the fabrics[3].

The Kawabata instrument is used for measuring basic mechanical properties of the fabrics, papers and nonwoven follows the KES (Kawabata's Evaluation System). These characteristics are closely related to the hand feeling of the fabrics. The mechanical properties of the fabrics under tensile and shear stress are very important characteristics. The uniaxial tensile test is popular for its simplicity of measurement; however, the combined tensile and shear measurement and properties are sometimes more useful information when studying fabrics[4].

For assessing the shear properties, the sample is clamped between the two chucks and stretched. This deformation is akin to biaxial tensile deformation. When conducting the shear test, the sample is given a constant tensile force and then submitted to a shear deformation to a preset shear angle (8^0 degree for the standard measurement)[5]. While most of the earlier investigations in this area were conducted with the conventional drape method, it will be interesting to report drape obtained with a sophisticated drape meter and its relationship with the shear properties[6].

Several researchers have studied the relationship between the drape coefficient and the shear properties of the fabric. According to Hearle *et al.*[7], the major factor for draping is fabric bending but due to the occurrence of double curvature, some shearing could also be seen. *Sharma et al.*[8] have studied the relationship between the drape and the low-stress mechanical properties of the various types of fabrics. They suggested drape distance ratio as the alternative measure for drape. Treloar[9] found the relationship between the drape and the shear stiffness, Hu and Chan[10] studied the relationship between the fabric drape coefficient and the low-stress mechanical properties obtained on the KES-F instrument. In their study, they found a high correlation between drape and bending and shear properties.

Morooka and Niwa[11] have reported that bending rigidity and weight per unit area are the most determinative parameters of the drape coefficient. They also stated that as the hysteresis in fabric shearing and bending is large, both the stability and reproducibility in the drape coefficient become small. Collier[12] investigated that shearing and bending properties are the most important in determining the drape of woven fabrics. However, he concluded that shear stiffness is not as important as bending behaviour in assessing fabric drape.

Sharma and Behera[13] have reported that the shear rigidity of fabrics shows a very good correlation with the drape parameters. This is because of the tangential

[a]Corresponding author.
E-mail: Ukeypravin@gmail.com

stresses being generated. An important research carried out by Shanbeh *et al.*[14] found that the shear behaviour of the fabrics along the principal directions is dependent upon the structural parameters of woven fabrics in the weft direction, It was also concluded that the observed high correlation between the fabric shear rigidity and the fabric integrated structural factors not only confirms the suitability of the structural parameters for an objective description of woven fabric shear behaviour but also encourages their use in the investigation of functional properties of woven fabric.

A study by Domskiene & Strazdiene[15] reveals that the drapability is correlated with shear rigidity. As the fabric is fitted onto a three-dimensional surface, shearing occurs increasingly until the critical shearing angle is reached. When this angle exceeds a strict value, the specimen starts to buckle. In other words, when the sample on the drape tester is clamped, it starts with shearing, followed by shearing and sliding, which is nothing but the buckling of fabric, next followed by sliding which means the formation of the node.

The shear rigidity and shear hysteresis of woven fabrics could be mainly dependent on the warp and weft yarns, yarns bending rigidities, and also number of intersections per unit area of the fabric. Critical review of the literature shows a limitation and a very limited works carried out for the investigation of the effectiveness of structural parameters of woven fabrics on their shear properties. Thus, the aim of this work is to evaluate statistically the effect of structural parameters, such as weft density and count of yarn, on the shear rigidity and shear hysteresis.

Experimental

To study the dependence of drape behaviour on the shear properties of the fabrics, 15 different fabrics like linen, cotton, polyester cotton blend, corduroy and denim with varying areal density were used for the study. Consulting the apparel industry experts, the commercially available fabric samples were procured from the market. Fabric particulars are shown in Table 1.

Methodology

All the fabric samples were conditioned under standard atmospheric condition for 48 h subsequently, fabric bending rigidity and shear rigidity have been evaluated using Kawabata Evaluation System (KES). KES-FB1 module was used for evaluating fabric bending rigidity and shear rigidity. Sample preparation for the testing is very important as needs to keep the sample in an unstrained state. For evaluation of shear properties of the fabrics test specimen used is of 20 cm X 20 cm size. The samples were set by unravelling threads from a sample which was cut to approximately 21 cm X 21 cm size, to minimize strain at the sample edges during specimen preparation.

Results and Discussion

Correlation between Drape and Shear Stiffness

Table 2 shows the 15 different types of samples of varying areal density and their shear stiffness (G, gf/cm) and shearing force variation at 0.5° (2HG gf/cm) and at 5° (2HG5, gf/cm) of hysteresis cycles (Table 2).

The shear mechanism is one of the important properties which influence drape behaviour of the

Table 1 — Fabric particulars

Fabric	Construction particulars	Code	Ends / cm	Picks / cm	Warp count, tex	Weft count, tex	Areal density, gsm
Linen	Plain	L1	15.7	14.1	50	60	190
	Plain	L2	18.1	13.4	50	50	198
	Plain	L3	18.1	12.6	60	60	236
Cotton	3×3 Twill	C1	39.3	27.5	20	20	205
	3×3 Twill	C2	54.3	33	10	30	250
	3×3 Twill	C3	41.3	31.4	40	40	280
P/C blend	85/15 blend 2×2 Twill 2×2	PC1	27.5	20.5	20	20	140
	85/15 blend 2×2 Twill	PC2	27.5	21.3	30	20	185
	85/15 blend 2×2 Twill	PC3	18.9	14.2	60	70	245
Denim	3×1 Twill	D1	29.9	21.2	40	40	304
	3×1 Twill	D2	29.1	20.5	80	40	332
	3×1 Twill	D3	26.7	20.5	70	50	346
Corduroy	3×3 Twill	CY1	33.0	19.7	20	30	270
	3×3 Twill	CY2	23.6	15.7	40	40	320
	3×3 Twill	CY3	22.8	21.2	50	50	391

Table 2 — Shear values obtained from the Kawabata instrument

Sample	Code	Drape coefficient, %	Shear stiffness (G), gf/cm.deg	Shear hysteresis 2HG, gf/cm	Shear hysteresis 2HG5, gf/cm	Residual shear strain 2HG/G, deg	Residual shear strain 2HG5/G, deg
Linen	L1	75.66	0.42	0.53	1.79	1.26	4.26
Linen	L2	76.67	0.84	2.02	3.7	2.40	4.40
Linen	L3	81.85	1.74	1.83	6.17	1.05	3.55
Cotton	C1	74.63	0.40	0.49	1.44	1.23	3.60
Cotton	C2	80.01	1.04	3.17	5.17	3.05	4.97
Cotton	C3	82.39	1.80	3.52	8.78	1.96	4.88
P/C blend	PC1	62.39	0.28	0.34	0.95	1.21	3.39
P/C blend	PC2	63.21	0.29	0.34	0.91	1.17	3.14
P/C blend	PC3	66.36	0.33	0.48	1.04	1.45	3.15
Denim	D1	77.31	0.82	1.83	4.08	2.23	4.98
Denim	D2	82.86	1.84	3.79	9.09	2.06	4.94
Denim	D3	88.52	2.67	5.37	12.7	2.01	4.76
Corduroy	CY1	80.56	1.31	3.26	5.98	2.49	4.56
Corduroy	CY2	85.74	2.335	5.79	11.64	2.48	4.99
Corduroy	CY3	95.39	3.84	9.34	13.5	2.43	3.52

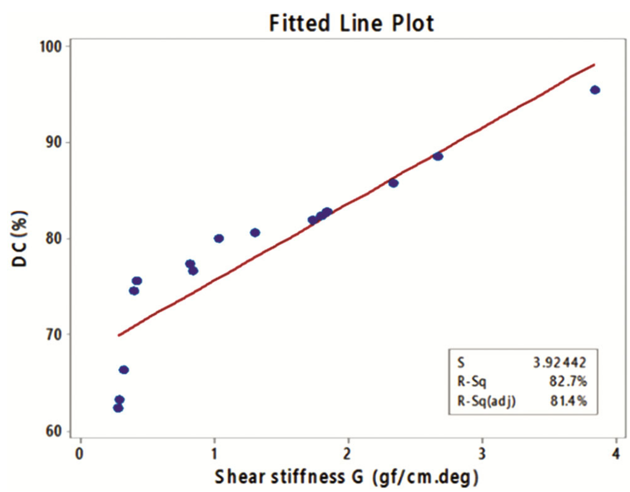


Fig. 1 — Correlation between shear stiffness and drape

fabric. When a shearing force is applied to the fabric (in-plane of the yarns), slippage at interlacing points of the warp and weft yarns occurs, which results in changes of yarn angular position towards each other. This phenomenon permits the deformation of fabric to complex shapes, as also happens during the draping of fabrics. It is observed that the correlation coefficient between the drape coefficient obtained by the digital drapemeter and the shear rigidity measured on KES-F1 is 0.81, which indicates the strong linear relationship between the shear stiffness and drapability of the fabrics (Fig. 1)

The shear hysteresis at 0.5 degree and 5 degree angles show a good positive correlation with the drape coefficient of the fabric. (Fig. 2) also, the interaction between shearing stiffness and shearing hysteresis with drape shows a positive correlation. For a woven fabric, shear deformation refers to rotation of one set of threads relative to the other at the yarn

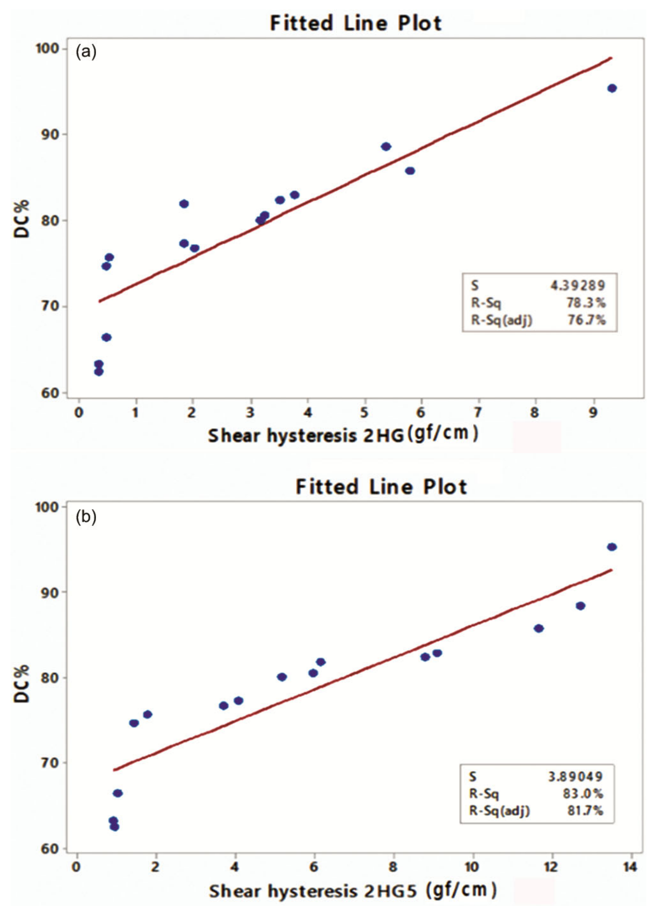
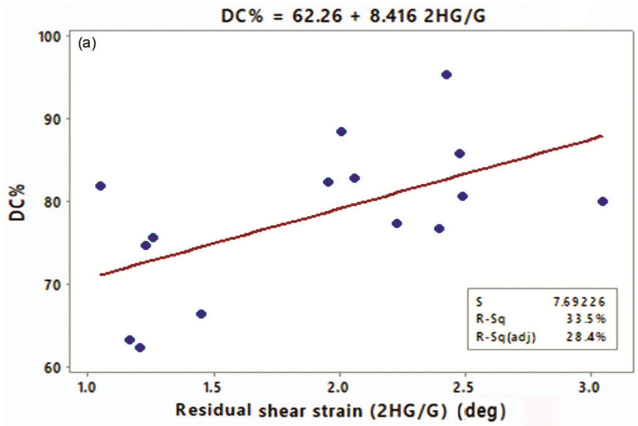


Fig. 2 — Correlation between drape and shear hysteresis at (a) 0.5° and (b) 5°



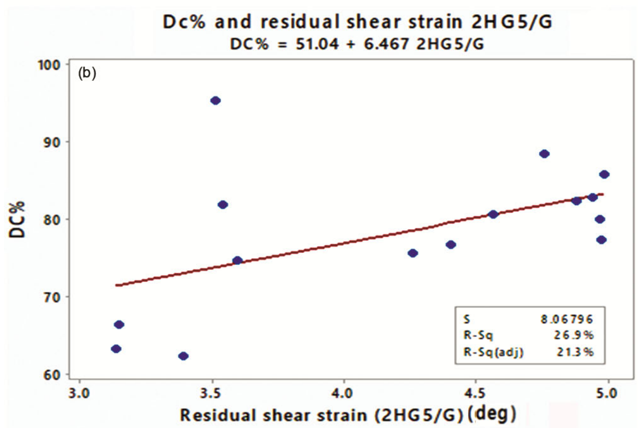


Fig. 3 — Correlation between drape and residual shear strain at (a) 0.5° and (b) 5°

crossover points in the weave. In most fabrics, shearing is largely by a change of angle between intersecting threads but may also be the result of bending and twisting of yarns between the intersections. The results are indistinguishable from the findings of Sharma and Behera[13], as the researcher stated a good correlation between drape coefficient and shear properties but not strong.

Correlation between Drape and Residual Shear Strains

The residual shear strain 2HG/G and 2HG5/G is the extent to which the fabric recovers from the shear deformation. It represents the energy loss in one shear cycle. It is assessed as the remaining strain in the return path when the stress comes back to its initial zero position. Table 2 shows the calculated value for the residual shear strain at 0.5 degrees and 5 degree angles (Table 2).

Pearson correlation coefficient of drape and residual shear strain (2HG/G) at 0.5 degree is 0.579, whereas at 5 degree the residual shear strain (2HG5/G) is 0.519 (Fig. 3). A moderately positive correlation is found between the drape and residual shear strain at 0.5 and 5 degrees.

The drape of the fabric has been determined by the digital drapemeter and the shear rigidity and shear hysteresis at 0.5^0 and 5^0 of 15 different woven fabrics are statistically analyzed. It is found that the correlation coefficient between drapability by the digital drapemeter and shear rigidity measured on KES-F1 is 0.81, which is quite significant. It implies that there is a strong correlation between drapability and shear rigidity. The values of shear hysteresis at 0.5^0 and 5^0 angles also show a good relationship for the drape coefficient of the fabric. Also, the interaction between the shearing stiffness and shearing hysteresis with drape shows a positive correlation. Furthermore, the residual shear strain values of 2HG/G and 2HG5/G show a relatively moderate positive correlation for the fabrics under study.

References

1 Hu J, *Structure and Mechanics of Woven Fabrics* (Woodhead Publishing Limited, Cambridge), 2000.
2 Buckingham P, *J Text Inst,* 88(1) (1997) 33.
3 Sun D, *High Performance Apparel* (Woodhrad Publishing), 2018.
4 Kawabata S & Niwa M, *J Text Inst,* 80(1) (1989) 19.
5 Das A & Alagirusamy R, Tactile aspects of clothing comfort, in *Science in Clothing Comfort* (Elsevier), 2010, 54.
6 Moiz A & Iqbal M, Kawabata Evaluation System, *Appl Chem Res Cent (Textile Sect.)* (online) 2010. www.fibre2fashion.com
7 Hearle J W S & Grosberg P, Stanley Backer, *Structural Mechanics of Fibres, Yarns and Fabrics* (Wiley-Interscience), 1969.
8 Sharma K, Behera BK, Roedel H & Schenk A, *Int J Cloth Sci Technol*, 17(2) (2005)75.
9 Treloar LRG, *J Text Inst Trans*, 56(10) (1965) T533.
10 Hu J & Chan Y-F, *Text Res J*, 68(1) (1998) 57.
11 Morooka H & Niwa M, *J Text Mach Soc Japan,* 22(3) (1976) 67.
12 Collier BJ, *Text Res J,* 10(1) (1991) 46.
13 Sharma KR & Behera BK, *Indian J Fibre Text Res*, (29) (2004) 57.
14 Shanbeh M, Johari S, Zarrebini M, Barbursk M & Komisarczyk A, *J Eng Fibres Fabrics*, 14(2019) 1.
15 Domskiene J & Strazdiene E, *Fibres Text East Eur,* 13(2) (2005) 26.