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Research Article

Evaluation of Bending Length, Rigidity and Modulus of Woven and Knitted Fabrics

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Abstract: Performance evaluation of textile materials is necessary to determine the use of an end-product. Woven and knitted materials are most preferred manufacturing techniques due to their certain characteristics suitable for apparel and upholstery. The present study aims at determining the bending length, rigidity and modulus of fabrics through standardized test procedures to measure the draping behaviour of an end-product. The results identified the phenomenon that specimens manufactured with woven fabrics were better in drapability compared with knitted fabrics. Moreover, it was identified that type of fiber also plays an important role in determining stiffness of fabrics such as silk fiber showed excellent results. A comprehensive comparison was made between various types of fabrics. The study can be helpful for the textile producers to make amendments in their construction parameters to present acceptable stiffness and draping qualities of fabrics to the end consumers.

Keywords: Bending, Rigidity, Modulus, Draping, Woven, Knitted

1. INTRODUCTION

The evaluation of textile materials such as fiber, yarn or fabric plays an important role in describing the performance behaviour of an end-product [1]. An assessment of mechanical characteristics such as tensile strength, tear strength, bending rigidity, elongation and flexibility etc. needs to be expanded to obtain better results. Th evaluation process of fabrics is quite complex in theoretical terms and must be verified through experiments in laboratory settings [2]. Several testing instruments are used to measure the physical characteristics of fabrics such as its dimensional stability, handle, drape, elongation, lustre and fineness through standardized testing procedures [3]. There are certain indicators that can be used to depict the draping qualities of textile materials. To determine the drape of a product, it is important to consider the factors such as dimensions, stiffness, and elasticity of fabrics. A number of studies have revealed that drape coefficient is highly associated with the mechanical and structural characteristics of fabrics [4].

Drapability of fabric along with its other characteristics like color, texture, lustre or smoothness are taken as criterion to understand the appearance as well as performance. There are multiple factors that can affect the draping quality such as the surface on which it hangs, type of fiber, finish applied over its surface and surrounding environment. Fabric stiffness is an important quality to be considered by textile manufacturers before designing apparel or upholstery products [5]. Fabric rigidity is the ability of the fabric to bend under its own weight. It describes the way a fabric drapes when hang in vertical position. It is largely depending on its ability to resist bending or presents stiffness. Fabric stiffness has a direct relationship with its bending length; high stiffness results in higher bending length and vice versa [6]. Fabric modulus is one of the intrinsic qualities of stiffness of fabric related to its thickness and mass. It is used to measure the compactness and closeness of the fabric geometry made with fibers and yarns. Fibers having low modulus are considered as soft and high modulus as crisp to withstand their position [7].

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This current study focuses on identifying the bending length, bending rigidity, and bending modulus of selected woven and knitted fabrics. A comprehensive comparison was made between the samples to understand their requirements for draping in any end-product used for apparel or upholstery.

2. MATERIALS AND METHODS

Samples of woven and knitted fabrics were collected from Nishat Mills Private Limited. Their construction parameters were identified, and these were grouped and labelled accordingly. Two groups were formed; woven and knitted. Five samples from each category were taken and assessed for their bending behaviour. The construction specifications of specimens are given in the Table 1.

The determination of fabric stiffness was measured by ASTM D1388 test procedure. The specimens were preconditioned for 24 hours in a standard atmosphere according to the guidelines provided in ASTM-D1776 testing procedure [8]. Test was conducted in a testing atmosphere having 21°±1°C temperature and 65%±2% relative humidity, as per the instructions given in the test procedure. The bending length, rigidity and modulus was identified. Cantilever principle was employed to measure the stiffness behaviour of fabrics. Shirley fabric stiffness tester was used [9].

A rectangular specimen from each category was cut with the dimensions of 6×1 inches. It was then mounted on a horizontal platform from where it overhung. The tested specimen was moved slowly along with the template to bend downwards under its own weight. It was extended to the point where the specimen's edge intersected with the index lines, which were visible in the mirror. The bending length was read off from the template engraved in centimetres. Each specimen was tested three times in both warp and weft directions with their right and wrong sides.

Bending rigidity was determined through Eq. (1) [10].

$$BR(\mu\text{Nm}) = \text{W}\,(\text{g/m}^2) \times BL^3\,(\text{mm}) \times 9.807 \times 10^{-6} \quad (1)$$

Bending modulus was determined through Eq. (2) [10].

$$BM(\text{Kg/cm}^2) = 12 \times BL^3(\text{mm}) \times \text{W}\,(\text{g/m}^2) \times 10^{-7} / T100^3(\text{mm}) \quad (2)$$

3. RESULTS AND DISCUSSION

The Statistical Package for Social Sciences (SPSS) was used to analyze the collected data for the determination of bending length, rigidity, and modulus. Mean ± S.D were calculated. The bending length of woven and knitted fabrics (face side) is shown in Figure 1. It is measured in centimeters. It is depicted from the calculated data that specimen A-2 showed the highest value for the bending length in both warp and weft directions. One possible reason is that it was composed of silk fiber that has inherent ability to drape better as compared to other fibers. It was investigated [6] that characteristics of fibers, yarns and fabrics can significantly impact the way fabrics drape. It can be said that various construction parameters such as thread count, ends/ picks, yarn type, mass would manufacture fabrics with varied drape qualities. It was investigated [11] that yarn density, thickness and space ratio have significant effect on the mechanical behaviour of fabrics. On the other hand, specimen B-1 showed good draping quality due to the viscose yarn used in knitting process. A-3 and B-2 (Figure 1) specimen showed less values for the bending ability both in face and reverse sides of woven and knitted fabrics.

Table 1. Construction specifications of samples

Sample code	Construction type	Type of weave/knit	Fiber content	Thread count	Course / inch	Yarn count	Mass (gsm)
A-1	Woven	Plain	Cotton-100	105×80	-	115	155
A-2	Woven	Plain	Silk-60 Polyester-40	120×135	-	220	145
A-3	Woven	Twill	Cotton-60 Polyester-40	85×125	-	130	125
B-1	Knitted	Rib	Viscose-100	-	65	110	137
B-2	Knitted	Jersey	Cotton-50 Polyester-50	-	70	120	185
B-3	Knitted	Jersey	Cotton-100	-	80	105	229

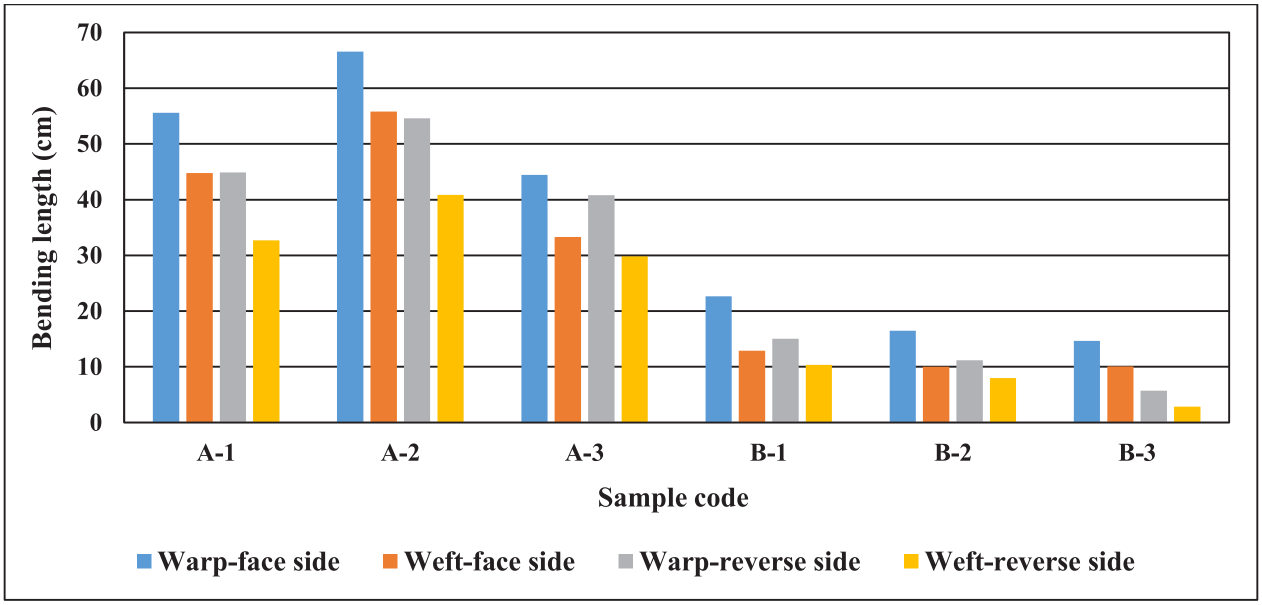

Fig. 1. Bending length of specimens

Low draping affect was investigated due to the long floats and fewer number of interlacing per inch in woven fabrics [12].

Low mass of fabrics can be the cause of high drape coefficient. It can be seen that specimen B-1 has the lowest mass compared with B-2 and B-3 results in high draping rating for knitted fabrics. Thickness of the fabrics did not show any significant effect on the draping ability [13]. The generic class of fibers is important to know the draping behaviours of most of the fabrics. The fiber content along with its percentage ratio has strongly affect the stiffness of knitted materials [14]. Fine fibers had better draping quality compared to coarse fiber [15]. Knitted fabrics manufactured with viscose micro denier fibers were stiffer than viscose regular denier fibers. One possible reason is the low bending rigidity and increased tightness and twisting factor of the resultant fiber [16].

Figure 2 explains that woven fabrics had better bending rigidity compared with knitted fabrics. Yarn interlacing pattern can change the draping ability of fabrics. It was found [6] that there was a positive strong relationship between tightness and compactness of weave and bending rigidity of the observed fabric. Similar phenomenon was observed

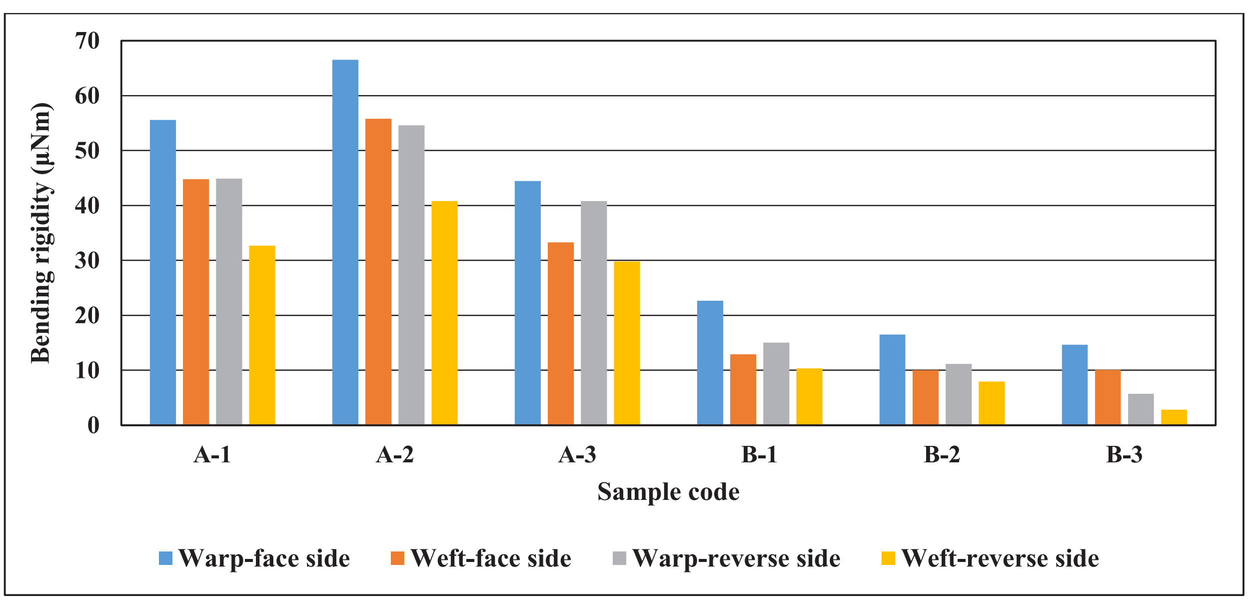

Fig. 2. Bending rigidity of specimens

in the current study that specimen A-1 and A-2 made with plain weave had better draping ability compared with twill weave having long floats in specimen A-3. Finishing treatments applied to the surface of woven fabrics in the relaxation form can reduce the frictional pressure between lengthwise and crosswise yarns, thus results in reduced bending length and rigidity and lowers the draping affect [17].

Elastomeric finishing agents can help in increase the bending strength and draping of fabrics as compared to treatments such as starch that make the fabric stiff in its behaviour [18]. The interlacing pattern of woven materials affect the bending rigidity of tested fabrics. It was found that fabrics made with basket weave presented less bending length than twill weave. It may be due to its long floats and less number of interlacings throughout its surface area [19, 20].

The tested specimens A-2 and A-1 had greater bending modulus for woven and knitted fabrics. (Figure 3). Cross section of fibers may impact the mechanical behaviour of manufactured fabrics. It was found [21] that high space ratio in the cross section makes the fabric more inelastic and soft. Other parameters including yarn count or linear density show higher impact on mechanical properties of fabric than its cross section. The density area was increased in the coarse yarns and decreased in the fine and smooth yarns [22]. It was found that fabrics with high density ratio were more prone to abruptly change the weave density in terms of measuring drapability. It was investigated that weave density significantly increase the drape coefficient of woven fabrics [11].

Woven fabrics had significantly higher bending modulus compared with knitted fabrics. These were ranked as follows A-2, A-1 and A-3 in the woven group from highest to the lowest rank. Whereas, B-1 showed the highest range followed by B-2 and B-3 in the knitted group of specimens. The bending modulus of woven fabrics was highly dependent on the direction in which the specimens were placed. It has been suggested that an increase in the number of covers in a particular direction causes a significant decrease in the bending rigidity of the same orientation. It was also observed that an increase in number of crossings in warp and weft direction and stiffening of liners in between significantly increased the bending rigidity of the tested samples [23].

4. CONCLUSIONS

From the present study, it can be concluded that woven fabrics depicted better draping quality in terms of length, rigidity and modulus as compared

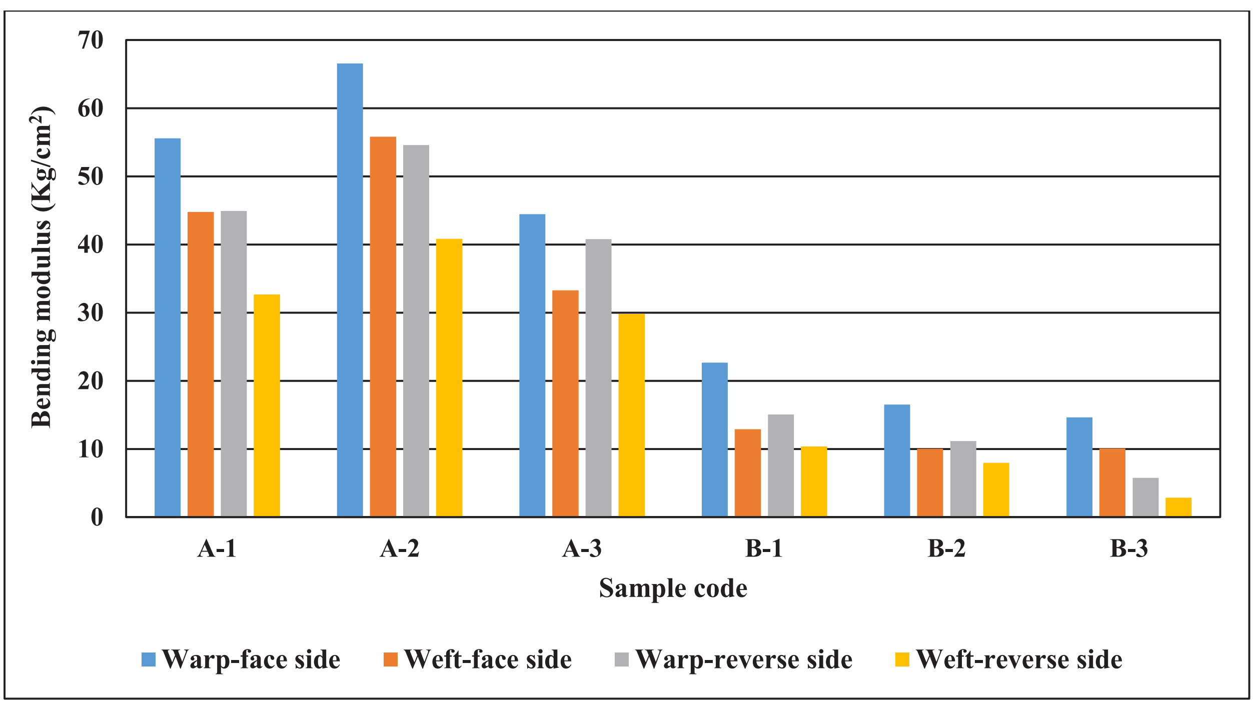

Fig. 3. Bending modulus of specimens

to the knitted fabrics. A2 specimen made with silk was better able to drape due to the inherent characteristics of the fiber and lesser number of interlacings per inch during the weaving. Specimen B1 showed good results in all aspects from the knitted group of fabrics attributed to the rib knit stitch and the inclusion of the viscose yarns. The study can be helpful for the textile producers to make the amendments in their manufacturing parameters for improved results of an end-product either used for apparel or upholstery. Follow up studies can focus on other mechanical properties of woven and knitted to improve their performance.

5. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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