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THE INFLUENCE OF BENDING RIGIDITY ON DRAPE COEFFICIENT OF SELECTED LIGHT WEIGHT WOVEN FABRICS WITH SEAMS

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ABSTRACT

Fabric drape which is a unique characteristic provides a sense of fullness and a graceful appearance that distinguishes fabrics from other sheet materials. It is an important component for a garment's aesthetic appearance and also plays a crucial role in garment comfort and determining the fit of clothing around the human figure. Draping characteristics of fabrics has received major attention in fashion designing since designers have exploited the draping property of fabric in creating new styles in accordance with changing fashion trends. Though the drape is considered as a qualitative term assessed by human eye, it is important to have a realistic evaluation to understand not only the nature of drape with respect to the type of seams, number of seams and type of stitches but also the influence of other mechanical properties on drape.

Thus the research focuses to explore the influence of bending rigidity which is one of the mechanical properties of fabrics on drape coefficient of selected light weight woven fabrics with seams. For the study, two main experiments; draping testing and bending testing were done. The outcome of the research will help to understand, evaluate, and give assurance of the appearance of the final garment. Moreover the result will shed more light on ways of using the drape behavior of fabrics with seams during the apparel designing and pattern construction process.

KEYWORDS: Bending Rigidity, Drape Coefficient, Fabric Drape, Seam Direction

INTRODUCTION

One of the most important properties of fabric is its ability to fall under its own weight into wavy folds. This unique property enables to mold the fabric to required shape or let it fall on its own & produce free flowing form. Drape provides graceful aesthetic effects in garment. It relieves monotony of shape and enhances beauty of garment. That is why it has been used as a device of special adornment in costumes.

The study of historic costumes revealed that the importance of drape of fabrics from the beginning of civilization. There is sufficient evidence to prove the influence of drape in early days which is evident even today in the form of sculpture and art works. Lord Buddha statues in eastern countries, the statue of woman and child in Rome, Capitoline museum, the statue of Nero in Paris, Louvre museum and the statue of Augustus in Rome, Palazzo museum are the evidence for the above.

Before the invention of sewing machine and stitch craft, garments were only draped over the body. The Indian sari is one of the finest examples of draped garment. How the sari will drape around the body depends upon the draping quality of material whether it is cotton, silk, nylon, georgette, chiffon etc.[1]

Drape enables fabric to be molded into a desirable shape or to produce a smooth, flowing form by its own weight. When a fabric is draped, it can bend in one or more directions based on its configuration. Curtains and drapers usually bend in one direction, whereas garments and upholstery exhibit a complex three dimensional form with double curvature. Hence, fabric drape creates complex mathematical problem involving large deformations under low stresses.[2]

When two-dimensional fabrics are converted to three- dimensional garment form, a number of operations involved affected drape behaviour of the fabric. The way in which seam drapes over an object is complicated to some extent because of the changing patterns of folds are arising from both the gravitational and bending forces. It is logically expected that the drape of a garment depends not only on fabric weight, but also on seam type and stitch type. Since the induced drape depends upon factor of stitch craft.

Drape is considered as a qualitative term, since it is usually assessed by human eye. The subjective evaluation of fabric drape can provide an understanding of human perception and fashion trends. However the results are inconsistent because of personal preference and changes in fashion trend. Thus, it is important to have effective objective evaluation of fabric drape. Objective evaluation gives a more realistic evaluation of fabric drape because three-dimensional fabric drape profiles that contributed to the understanding of the nature of fabric drape. However, fabric drape is not an independent fabric property. It related to fabric bending, shear, tensile, fabric thickness and fabric weight.[3,4]

In 1950s, Chu (cited Cusick[5]) developed a drape meter, and derived a dimensionless term, drape coefficient to quantify the fabric drape. In 1968, Cusick re-investigated a drape measuring system with similar principle.

Drape is very important factor in garment designing. Drape profile; the vertical projection of three dimensional fabric drape is used to evaluate drape of particular fabric. Over last several decades researches have contributed to the field of drape profile measurement by the parameter called drape coefficient. The drape coefficient describes any deformation between deformed and non deformed fabrics. Drape coefficient provides an objective description of deformation, although it is not a complete description. A low drape coefficient indicates easy deformation of a fabric and a high drape coefficient indicates less deformation.

The drape coefficient, DC, defined as the fraction of the area of the annular ring covered by the projection of the draped sample, is used to judge the fabric drape.[2]

$$DC = \frac{\text{Area under the Draped sample} - \text{Area of supported disk}}{\text{Area of the Specimen} - \text{Area of supported disk}} \times 100$$

The textile and clothing industry have traditionally used the Cusick Drapemeter for assessment fabric drape.

Cantilever method for the evaluation of fabric drape were first introduced to textile specialists by Peirce (1930), based on drape ability which is mainly affected by fabric stiffness. In the past, the cantilever test was mainly used to determine fabric stiffness. The fabric sample in the instrument represents a cantilever beam that is uniformly loaded by its own weight and bends downward until it reaches 41.5° angle to the horizontal.

Then bending length is read from the scale marked on the platform.[2] By a mathematical formula, this angle is converted into a term called "bending length", which is a measure of fabric drape in two dimensions called "Drape stiffness". The longer the projected length indicates the higher stiffness of the fabric.

The relationship between bending rigidity and bending length has been given in the equation.[6]

$$B = W \text{ x.} c^3 \text{x} 9.81 \text{x} 10^{-6}$$

W- Fabric weight (gsm)

c - Bending length (mm)

Drape research has captured the interest of researchers in textile and apparel industries as well as computer graphic industries in recent years. Investigation of the impact of a seam on fabric drape is important to understand the overall appearance of final garment. Those who are using the latest technologies for designing garments, the prior determination of drape properties are really useful to identify and evaluate the final appearance of garment.

Thus the research focuses to explore the influence of the bending rigidity on drape coefficient of selected light weight woven fabrics with seams. Two hypotheses were build up for the study. The null hypothesis (H01) was developed for variation of drape coefficient and bending properties, assuming that, there is no positive correlation between drape coefficient and bending rigidity when varying the seam direction. Therefore

H01; bending rigidity α drape coefficient

Against alternative hypothesis; H_1: was developed assuming that there is the positive correlation in between bending rigidity and drape coefficient in each seam direction. Therefore,

H1; bending rigidity α drape coefficient in warp, weft & bias directions

METHODOLOGY

Experimentation is considered as the basic language of proof. For the study, two main experiments; draping testing and bending testing were done.

Previous relevant studies [6,7,8,9] were used heavy and medium weight woven fabric only for drape testing. In this research light weight, plain woven fabric was selected as sample material.

The physical properties of the selected fabric is as follows,

Fibre content		- 100% Cotton
Mass		- 63.032 gsm
Thickness		≈ 0.15mm
Thread density	Warp	- 95 thread per inch
	Weft	- 70 thread per inch

For the study, seam type SSa, which is classified under superimposed seam type is selected based on Federal standard 751a protocol and Lockstitch (301) which is classified under stitch class 300 is selected based on the British standard BS 3870. Part I: 1982

Draping Test

Draping test was done under the standard testing procedure of BS 5058: 1978. Altogether 48 samples were prepared for drape test with selected fabric. The drape test was done under six categories of samples.

Bending Test

The fixed angle Flexometer (brand name Shirley stiffness tester) is used for bending testing.

Table 1: Sample Description for Bending Test

	Code	Description
1	B-1	Sample with long edge parallel to warp direction
2	B-2	Sample with long edge parallel to weft direction
3	B-3	Sample with long edge parallel to bias (45°) direction
4	B-4	Sample with vertical seam, long edge parallel to warp direction
5	B-5	Sample with vertical seam long edge parallel to weft direction
6	B-6	Sample with vertical seam long edge parallel to bias direction

RESULTS ANALYSIS

Table 2: Correlation between Bending and Drape Coefficient in Warp, Weft and Bias Direction

		Warp		Weft		Bias	
		Bending	Drape Coefficient	Bending	Drape Coefficient	Bending	Drape Coefficient
Bending	Pearson Correlation	1	.952(**)	1	.856(*)	1	.846(*)
	Sig. (2-tailed)	.	.003	.	.030	.	.034
	N	6	6	6	6	6	6
DRAPE coefficient	Pearson Correlation	.952(**)	1	.856(*)	1	.846(*)	1
	Sig. (2-tailed)	.003	.	.030	.	.034	.
	N	6	6	6	6	6	6

** Correlation is significant the 0.01 level (2-tailed). For warp , 0.05 level for the weft and 0.05 level for the bias

The correlation has been derived by assessing the variations in one variable as another variable also varies. To build up correlation between draping coefficient and bending rigidity, bivariate correlation in SPSS has been applied. Regression analysis is the next step after correlation; it is used to predict the value of a variable based on the value of another variable. The liner regression analysis has been applied for warp, weft and bias direction separately. Following assumptions have been made for analyzing, variables are measured in intervals and there is a liner relationship between the two variables; bending rigidity and drape coefficient.

According to table 2, probability < 0.01 for warp, probability < 0.05 for weft and probability <0.05 for bias direction. Therefore null hypothesis (H01) can be rejected and accepted hypothesis is,

H1 ; bending rigidity α drape coefficient in warp, weft & bias directions.

R value 0.856 (0.80-1.0); represents the simple correlation and indicates a high degree of correlation.

The R^2 value indicates how much of the dependent variable, drape coefficient can be explained by the independent variable, bending rigidity. In this result, 73.2% can be explained.

That means a degree of correlations are lesser than warp directional correlation. Stiffness of weft direction is lesser than warp direction if it is included with seam line.

Table 3: Model Summary of Regression Analysis in Weft Direction

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.856(a)	.732	.665	.89296

A Predictors: (Constant), bending

The table 4, provides, information on each predictor variable. The regression equation can be presented follows for seam with weft direction.

$$Drape\ coefficient\ =\ 11.803\ +\ 3.426(Bending\ rigidity)\ \ldots\ldots\ eq \tag{1}$$

Table 4: Coefficient for Equation between Bending Rigidity and Drape Coefficient in Weft Direction

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.803	7.473		1.580	.189
	BENDING	3.426	1.036	.856	3.306	.030

A Dependent Variable: DRAPECOF

For fabric with seam in warp direction, R value 0.952 (0.80-1.0) indicates that a high degree of correlation between bending rigidity and drape coefficient. The regression equation can be presented in follows for the seams with warp direction.

$$Drape\ coefficient\ 31.62\ +\ 0.786(Bending\ rigidity)\ \ldots\ \ldots\ eq \tag{2}$$

Table 5: Coefficient for Equation between Bending Rigidity and Drape Coefficient in Warp Direction

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	31.620	1.260		25.097	.000
	BENDING	.786	.127	.952	6.198	.003

a Dependent Variable: DRAPECOF

Due to seam line and thread density parallel to warp direction, bending rigidity as well as drape coefficient achieved comparatively higher values than others.

Table 6: Coefficient for Equation between Bending Rigidity and Drape Coefficient In Weft Direction

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.803	7.473		1.580	.189
	BENDING	3.426	1.036	.856	3.306	.030

a Dependent Variable: DRAPECOF

The regression equation can be presented as for seams with bias direction for the selected light weight, woven fabric.

$$Drape\ coefficient = 14.383 + 6.065(Bending\ rigidity) \quad \text{......... eq} \qquad (3)$$

Graphical presentation of bending rigidity and drape coefficient relationship in seams in weft, warp and bias directions are shown in Figure 1, 2, 3 respectively.

For seam in weft direction, the experimental values have a significant deviation from the theoretical equation (1). (Figure 1)

Figure 2 displays the graphical representation of bending rigidity and drape coefficient, comparing with theoretical relationship equation of (2). Experimental values have less deviation from theoretical graph for seam in warp direction.

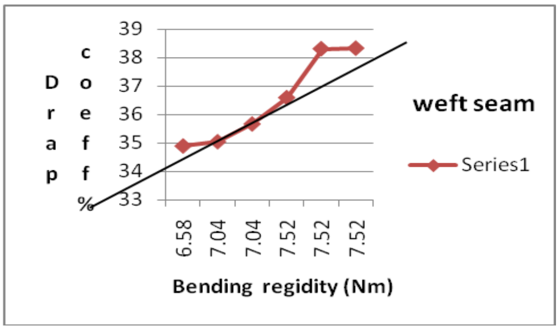

Figure 1: Drape Coefficient Vs Bending Rigidity for Weft Directional Seam

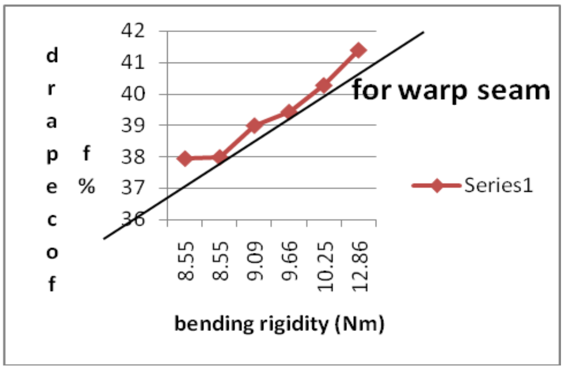

Figure 2: Drape Coefficient Vs Bending Rigidity for Seam in Warp Direction

Higher deviation have shown in experimental values of seam in bias direction, (Figure 3)

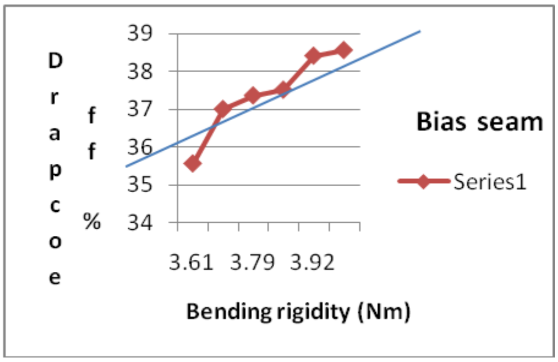

Figure 3: Drape Coefficient Vs Bending Rigidity for Bias Seam

In bending testing the sample group with seam in bias direction, took lesser value than other seamed samples. In draping test sample group with seams in bias direction took lesser values. This correlation indicates in figure 3 higher deformation along warp direction may cause for these lower bending values.

Comparing three graphical representations in figures 1, 2 and 3, actual correlation curve for warp direction seam is almost similar to the theoretical linear relationship. But in figure 2 and 3, actual curve lines somewhat deviated from the relevant theoretical linear relationships. There may be several factors affected on this deviation. These deviations may be due to the lesser coefficient of determination value is than R. value for seam with warp direction.

CONCLUSIONS

According to the analysis of the research, the drape coefficient varies with the number of seams. Seam in bias direction influences to decrease vertical projection or the drape coefficient. The bending rigidity of light weight fabric increases with seams with warp and weft directions, compared to the samples without seams. Lowest bending rigidity displayed in seams with bias direction. This will cause to higher deformation in bias direction. Due to seam line and thread density parallel to warp direction, bending rigidity as well as drape coefficient achieved comparatively higher values than others.

The results can be used as a guideline for

- Draping of patterns cut in different geometric angles:

  According to the results, the variation of drape values can be gained by different grain line orientation of the fabric. It will assist product developers to get various degrees of drape profiles by using similar fabrics.

- Evaluating the 3D modeling
  Evaluation of finish appearance of the garment can be done for 3-D model without assembling each panels.

Cotton fabrics and a very limited varieties of other materials, such as blends and synthetic fibers were considered for the previous research done by various researchers to evaluate the influence of other mechanical properties on fabric drape. The range of fabrics could be increased to the effect of a broad variety of fabrics with different fibre types on garment drape for future research.

Generally, garments are constructed with more than one type of seams and different layers of material. At present software systems in Computer aided design are not capable in 3-D draping of multiple layers of materials. Therefore researches on nature of drape with respect to multiple layers of materials and different varieties of stitches and seams are much important to be considered for further studies.

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