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Effect of Crimp% on Fabric Drape in Woven Fabric

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ABSTRACT

Precision in quality control and innovation in product development are the important criteria for the textiles as the end uses of textile materials are being diversified. Hence study about physical characteristics and the aesthetic propertyis an important issue. Drape and crimp have an impact on fabric appearance; therefore, study about these characteristics is needed to be concerned. The drape is a term used to describe the way a fabric hangs under its own weight. It has important criterion on how good a garment or end-product looks in use. Crimp means the waviness of warp and weft of fabric due to interlacement. The aim of this study is to discover the relation between crimp% and drapability of different weaves (Plain, Twill, and Satin) and their behavior. A total of 24 samples were produced by varying count, picks per inch and weave. It is found that in any condition if crimp% is changed, drape co-efficient is also changed. There is a significant effect of crimp% on fabric drape for different weave structures, counts and weft densities.

Key words: Woven fabric, Drape, Crimp

INTRODUCTION

Over the millennial, textile fabrics have been used for clothing and household purpose by the human race. Fabrics can be broadly categorized based on (a) origin of raw materials and (b) fabric construction or end process. According to construction, there are three types of fabric; woven, knit and non-woven. There are some unique properties such as elongation, elasticity, flexibility, crimp, texture, and durability in a fabric. Such characteristics are necessary to obtain comfort, protection, and design aesthetics. The most commonly used fabric construction is a woven fabric.

Fabric drape is a low-stress mechanical property that always has been the centre of interest by manufacturers and the fashion designers because it influences the characteristics of end products. Another important property of a woven fabric is yarn crimp which means curly or waviness of two sets of yearns when they are interlaced in a woven fabric. The property affects abrasion resistance, shrinkage, texture, hand feel and durability in textile products. In our study, we will emphasize determining the inter-relation of drape-coefficient and crimp% in fabric for different weave structures.

Weaving

Weaving is an art and its earliest application is traced back to the Egyptian civilization. The process of weaving begins with a fiber, a long, thin material with a significant amount of structural strength. Weaving is the process of making fabrics by interlacing the threads lengthwise and width wise commonly known as warp and weft in a regular order. Two sets of yarns are interlaced, almost always at right angles to each other. Woven cloth is generally much longer in one direction than the other. The operation is performed in a machine called a loom [1].

Woven Fabric

Woven fabrics are produced by the interlacing of warp yarn and weft yarn in a regular pattern or weave style.Woven fabrics are often produced on a loom The fabric's integrity is maintained by the mechanical interlocking of the yarn. Drape (the ability of a fabric to conform to a complex surface), surface smoothness and stability of a fabric are controlled primarily by the weave structure[2].The main difference between woven and knit fabrics is in the yarn composes them. A knit fabric produced of a single yarn, looped continuously. Two sets of yarns comprise a woven fabric, crossing each other at perpendicular direction. Different types of woven fabric according to weave construction has been discussed below.

Plain weave

Each warp yarn passes alternately under and over each weft yarn. The fabric is symmetrical, with good stability and reasonable porosity. However, it is the most difficult of the weaves to drape, and the high level of yarn crimp imparts relatively low mechanical properties compared with the other weave structures. Coarser yarns are not used for producing very heavy fabrics [3].

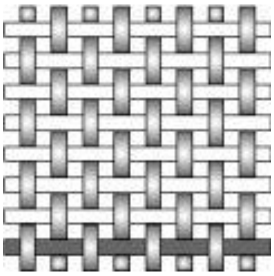


Fig. 1 Plain weave structure

Drape property of this weave is very much poor because of its structure and interlacement of warp and weft. Here, each warp passes alternately under and over each weft.

Twill Weave

One or more warp yarns alternately weave over and under two or more weft yarn in a regular repeated manner. This produces the visual effect of a straight or broken diagonal line to the fabric. Superior wet out and drape is seen in the twill weave over the plain weave with only a small reduction in stability. With reduced crimp, the fabric also has a smoother surface and slightly higher mechanical properties [3].

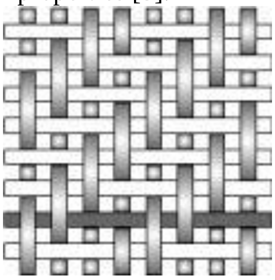


Fig. 2 Twill weave structure

In twill weave, superior drape is seen than the plain weave. As here, in its structure, one or more warp alternatively weaves over and under two or more wefts in a regular repeated manner.

Satin/Sateen Weave

Sateen weaves are fundamentally twill weaves modified to produce fewer intersections of warp and weft. Sateen weaves are very flat, have good wet out and a high degree of drape.

Satin/Sateen weave are either warp or weft faced structures having only one binding point in each end or pick and no continuous twill lines. To construct this weave use of move numbers is necessary. They have poor seam strength due to thread mobility and more thread density is possible in warp and weft in this structure [4].

Sateen weaves are fundamentally modified or re-arranged twill weaves to produce fewer interlacements of warp and weft. This weave has a high degree of drape than plain and twill [3].

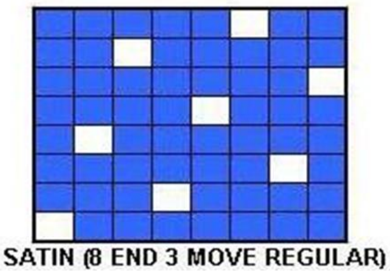


Fig. 3 Satin Weave Structure

Count:

Count indicates the fineness or coarseness of sliver, roving and yarn which is expressed by mass per unit length or length per unit mass. There are two systems for expressing count. Those are-

i) Direct system such as Tex, Denier, lb/spyndle

ii) Indirect system such as Ne, Nm, Nw

Warp density (EPI)
Warp density indicates the number of warp yarn present in unit space. Ends per inch (EPI) is one of the units to express warp density.
In general, the higher the ends per inch, the finer the fabric is.

Weft density (PPI)
Weft density indicates the number of weft yarn present in unit space. Picks per inch (PPI) is one of the units to express weft density.
In general, the higher the picks per inch, the finer the fabric is.
Drape and Crimp are the distinctive mechanical properties of fabric. In a woven fabric when warp and weft yarn interlace in fabric they follow a wavy path. According to Pierce "crimp", geometrically considered is the percentage excess of length of the yarn axis over the cloth length. It is only seldom realized that crimp affects the finishing process as well as such fabric physical properties as strength, elongation, abrasion and serviceability.

Crimp
In a woven fabric when warp and weft yarn interlace in fabric they follow a wavy path. According to Pierce "crimp", geometrically considered is the percentage excess of length of the yarn axis over the cloth length. It is only seldom realized that crimp affects the finishing process as well as such fabric physical properties as strength, elongation, abrasion and serviceability [5].

Crimp %
Percentage crimp is defined as the mean difference between the straightened thread length and the distance between the ends of the thread while in the cloth, expressed as a percentage. From the definition of crimp two values must be known, the cloth length from which the yarns are removed and the straightened length of the thread. In order to straighten the thread, tension must be applied, just sufficient to remove all the kinks without stretching the yarn. In practice it is seldom possible to remove all the crimp before the yarn itself begins to stretch. We can calculate the crimp percentage with the following formula:

$$C = \frac{(l-p)}{p} \times 100$$

where,
C = crimp,
l = un-straightened length,
p = straightened length
Crimp is related to many aspects of the fabric. It affects the cover, thickness, softness and hand of the fabric. It affects, softness and hand of the fabric.With the increase of crimp, the take-up percentage of dye-uptake will also increase [6].

Drape
Drape is the term used to describe the way a fabric hangs under its own weight [7]. Fabric draping behavior is very important to many industrial applications where fabrics are used to cover a non-flat surface such as in apparel design and manufacturing, and in textile structural composites [8].
It is one of many factors that influences the aesthetic appearance of a fabric and has an outstanding effect on the formal beauty of the fabric. For this reason, the measurement and understanding of drape are required to specify the performance of fabric used in clothing [8]. In use, this unique characteristic provides a sense of fullness and a graceful appearance which ultimately distinguishes fabric from other sheet materials [9].

Drapability
Fabric drapability is an important factor from an aesthetic point of view [10]. It is a property of textile materials which allows a fabric to orient itself into graceful folds or pleats when acted upon by force of gravity. Hence a fabric is said to have a good drapability when the configuration is pleasing to an eye [11].

Drape co-efficient
Drape co-efficient is a measure of drape. It has been developed to describe the degree of drape and drape shape. It is the ratio of the mass of the draped specimen to its mass of the undraped specimen, after deduction of the supporting disc. Drape co-efficient is expressed by 'F'.
According to the definition,

$$F = \frac{Ws - Wd}{W_D - Wd}$$

Here, W_s= mass of the draped sample, W_D= mass of the sample, W_d= mass of the supporting disc
It can be also expressed as,

$$F = A_s - A_d / A_D - A_d$$

Where,
A_s= Area of the draped sample, A_d= Area of the support disc, A_D= Area of the sample [12].

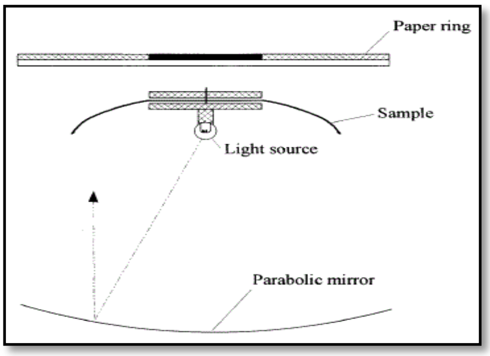


Fig. 4 Principle of Drape Testing

A lower co-efficient value (F) means the fabric is softer and its drapability is better. In other words, the higher the drape co-efficient (F) the stiffer the fabric is. There are three diameters of the specimen that can be used.

- 24cm for limp fabrics; drape co efficient below 30% with the 30 cm sample.
- 30cm for medium fabrics
- 36cm for stiff fabrics; drape co-efficient above 85% with the 30cm sample [10].

Drape value differs a lot according to the weave structures. For plain, twill and sateen it has been discussed

METHODOLOGY

All the fabric samples were produced in rapier loom at Ahsanullah University of Science and Technology Lab. The brand name of the rapier loom is Chiang Tex and model no.: IC 906. Twenty-four samples were produced using 1/1 Plain, 3/1 Twill and 8 end Satin weave. Three types of PPI (42, 52, and 66) and three weft count (20 Ne, 30 Ne, 40 Ne) were produced.

Determination of EPI and PPI

By using counting glass warp density and weft density were measured for 24 samples.

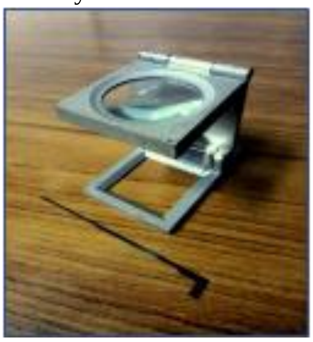


Fig. 5 Counting Glass

Yarn count calculation

The yarn count was calculated using following formula, N=$\frac{WXl}{L}$

Here,N= yarn count system in Tex
W= weight of the sample
L= length of the sample
l= unit length of the sample
We know, Ne **x** Tex=590.5 [13]

Table-1 Detail specification of the produced fabric

Fiber	**Cotton**		
Weave Structure	1/1 Plain	3/1 Twill	8-end Sateen
Ends Per Inch (EPI)	72	72	72
Ends Per Inch (PPI)	42,52	42,52,66	42,52,66
Warp Count	30/1 Ne	30/1 Ne	30/1 Ne
Weft Count	20^s Ne 30^s Ne 40^s Ne	20^s Ne 30^s Ne 40^s Ne	20^s Ne 30^s Ne 40^s Ne

Measurement of Crimp% Using Tautex Digital Crimp Tester:

Test Method: ASTM D-3883

Table-2 Pretension Calculation

Yarn type	**Count**	**Tension (gm)**
Cotton	Finer than 7 tex	0.75 tex
	Coarser than 7 tex	0.20 tex+4

Since the yarn count of all samples was above than 7 Tex, so pretention was calculated by following formula-
For cotton: 0.2 Tex + 4 (For above 7 Tex)

Test procedure

First of all, 30 cm length was marked in the sample. Then the yarn sample was taken out of the fabric and held very carefully so that no twist is lost. The power of the tester was switched on. The test length was set between the upper and lower jaws to less than the distance between the marks on the yarn applied to the fabric. Now one end marked on the yarn was clamped by the headstock jaw and the other end was clamped by tailstock jaw. Pretension was applied by sliding the lower jaw slowly down wards until the digital indicator showed the required pretension. Then the position of tailstock jaw against the scale was read and used as the straighten length.

Then the crimp% was calculated using the following formula.

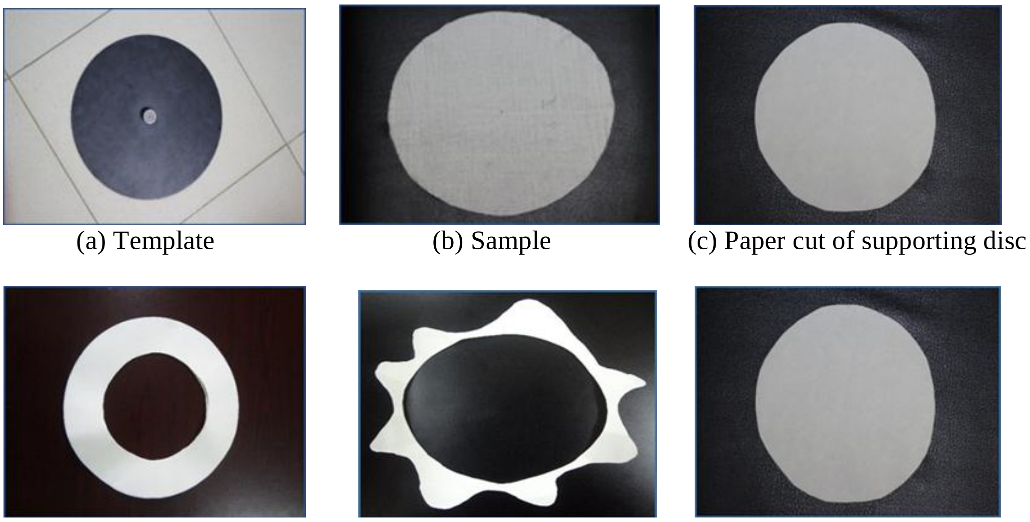
$$C = \frac{(l-p)}{p} \times 100$$

Where, C = Crimp,
l = Un-straightened length,
p = Straightened length

Fig. 6 Tautex Crimp Tester

Measurement of Drape Using CUSICK Drape Tester (Test Method: BS-5058)

The available template sizes are of 36, 30, 24 cm diameter and the selected template size was 30 cm. Then fabric samples were cut as 30 cm as circular shape template. Circular papers were also cut according to the selected template for each sample and from those annular paper rings were made. The light was turned on, the lid was raised and locked. The circular fabric specimen was held concentrically between smaller horizontal disc and circular fabric was allowed to drape into folds around the lower supporting disc by lowering the lid. Then the paper ring was placed on the lid around the locating disk. The shadow of the draped specimen was cast onto an annular ring of paper of same size as the unsupported part of the fabric specimen. The outline of shadow was traced onto the ring of paper. Then the paper was cut along the trace of the shadow and the mass of inner part representing the shadow is determined. Then weight of the circular size paper of 30 cm was taken and also the weight circular size paper having the same diameter of supporting disk was taken. The above process was repeated for other specimens. Then the drape co-efficient was calculated from masses.



(a) Template (b) Sample (c) Paper cut of supporting disc

(d) Annular paper (e) Paper cut of draped sample (f) Paper cut of supporting disc

Fig. 7 Steps of fabric drape analysis

RESULTS AND DISCUSSION

Table-3 Effect of weft count on crimp% for 1/1 Plain weave

Weave	PPI	Weft Count(Ne)	Crimp%
1/1 Plain	42	20	30.63
		30	25.93
		40	25.2
	52	20	29.27
		30	28.07
		40	27.6

Table-4 Effect of weft count on crimp% for 3/1 Twill weave

Weave	PPI	Weft Count(Ne)	Crimp%
3/1 Twill	42	20	25.8
		30	20.33
		40	18.67
	52	20	26.8
		30	21.33
		40	21.25
	66	20	32.73
		30	27.33
		40	24.87

Table-5 Effect of weft count on crimp% for 8-end Sateen weave

Weave	PPI	Weft Count(Ne)	Crimp%
8 -end Satin	42	20	14.33
		30	11.2
		40	6.87
	52	20	20.8
		30	12.73
		40	10.86
	66	20	17.6
		30	16.33
		40	10.67

From all of the above tables it is found that for a specific weave, crimp% is higher for courser weft yarn than the finer weft yarn for the same weft density. For 1/1 plain weave the crimp% is higher than 3/1 twill and 8-end satin weave for same weft density. The reason behind that in plain weave the no of interlacement is higher causing more yarn consumption than twill and satin weave. That is why showing more crimp% in case of plain weave. In 8-end satin weave there are more floats and that is why crimp% is lowest in 8-end Satin.

Table-6 Effect of crimp% on fabric drape (Plain weave)

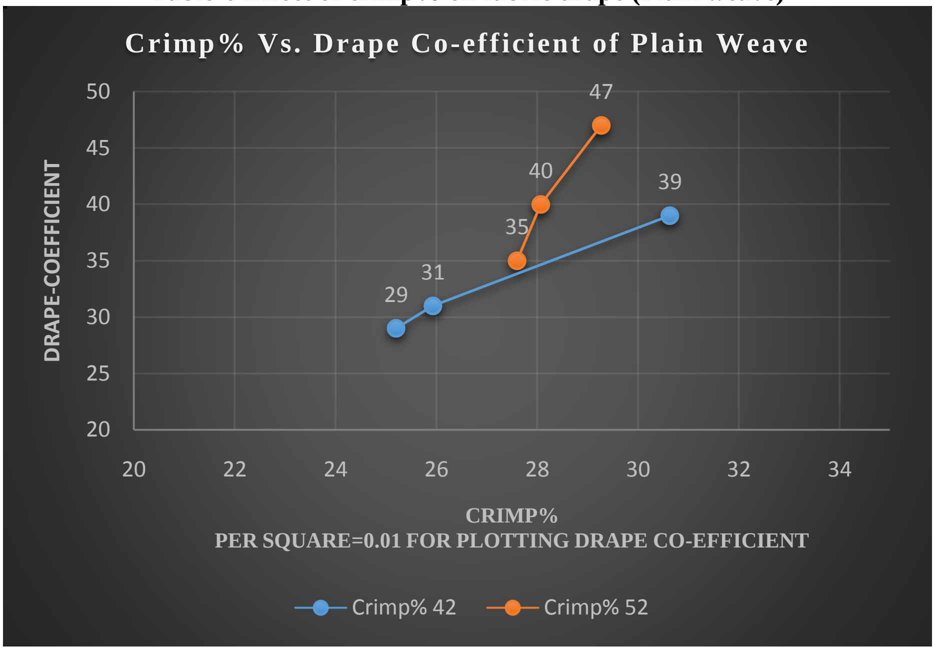


Fig. 8 Chart of Crimp% Vs. Drape Co-efficient of Plain Weave for 42 and 52 EPI

Table-7 Effect of crimp% on fabric drape (Twill Weave)

Weave	PPI	Count (Ne)	Crimp%	Drape Co-efficient
3/1 Twill	42	40	18.67	0.25
		30	20.33	0.29
		20	25.80	0.30
	52	40	21.25	0.26
		30	21.33	0.27
		20	26.80	0.37
	66	40	24.87	0.29
		30	27.33	0.32
		20	32.73	0.43

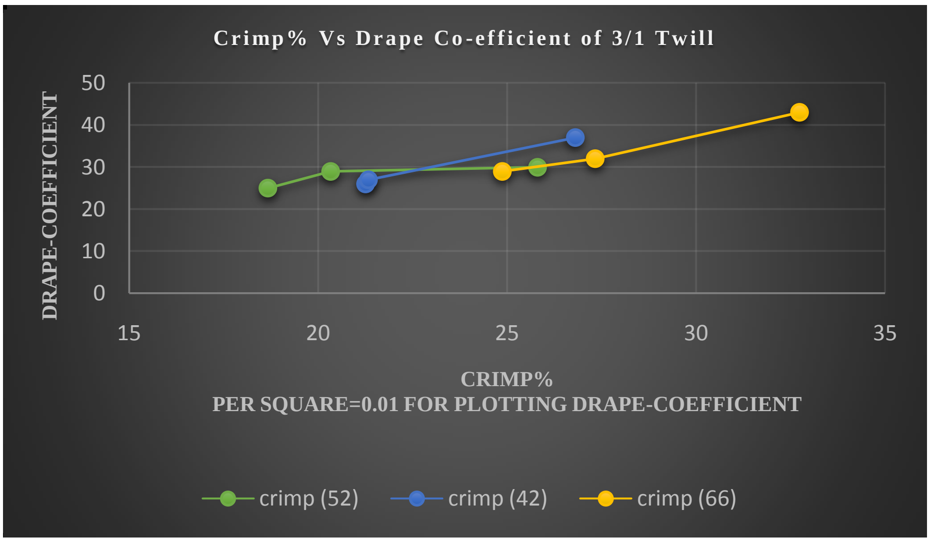


Fig. 9 Chart of Crimp% Vs. Drape Co-efficient of 3/1 twill weave for 42, 52 and 66 EPI

Table-8 Effect of crimp% on fabric drape (Satin Weave)

Weave	PPI	Count (Ne)	Crimp%	Drape Co-efficient
8 -end Satin	42	40	6.87	0.25
		30	11.20	0.26
		20	14.33	0.27
	52	40	10.87	0.26
		30	12.73	0.27
		20	20.80	0.30
	66	40	10.67	0.25
		30	16.33	0.27
		20	17.60	0.34

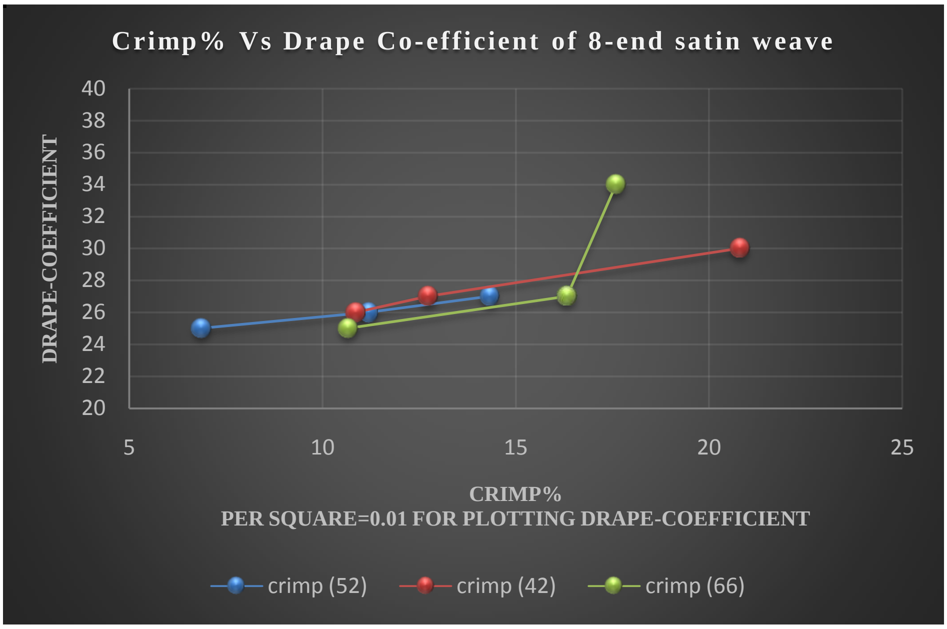


Fig. 10 Chart of Crimp% Vs. Drape co-efficient of 8-end satin weave for 42, 52 and 66 EPI

From all of the above tables and graphs it is found that for the same weave structure and weft density drape co-efficient increases with increasing crimp% and crimp% is higher for courser weft count. The reason behind that, for making the wavy configuration of the courser weft yarn required more modular length than finer weft yarn.

CONCLUSION

In this study work, twenty-four woven fabric samples were produced with different weave structures, weft counts, and weft densities. The aim of this study was to see whether there is any relation between crimp% and fabric drape. According to the aim, crimp% and drape co-efficient were measured, plotted on graphs and compared with each values. From this project work, it has been observed that if count, EPI and PPI are same, for different weave structures crimp% and drape co-efficient both increases with the number interlacement of the structures. It has also been found that with the increase of weft count, crimp% decreases keeping same weave structure and weft density. Again, if crimp% is increased, there is an increase in drape co-efficient value and if crimp% is decreased, drape value decreases. That means, crimp% is proportional to drape co-efficient. So, it can be said that there is an effect of crimp% and weave structure on fabric drape. Moreover, from the study it is observed that crimp% has an important impact on fabric production and costing.

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