

## Experimental Model of Determining Drape Coefficient of Fabric through Image Analyzing Techniques

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### ABSTRACT

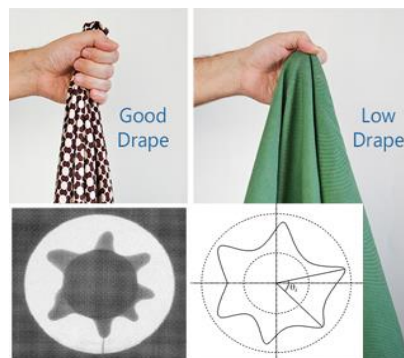
Softness is an essential key in designing, processing and using a lot of textile products. This paper is to approach fabric softness based on an experimental model of determining drape coefficient (i.e., a ratio of projected area of fabric sample to its undraped area) through analysis of digital images obtained from pixel histogram on a graphic software (PTS). Such investigations help to not only quantitatively evaluate but also significantly enhance accuracy for measurements of fabric softness owing to advances in digital image processing technology. Moreover, as comparing to previously conventional methods of calculating projected area such as tracing paper and edge contour, this model presented many advantages, especially time saving. Particularly, the results of drape coefficient obtained from cotton (CT) and polyester (PE) fabrics measured by this model clarified the affected factors on structural characteristics for both textile fiber and textile fabric. The experimental measurements of crease recovery and bending angle on textile woven fabrics were conducted to give additional affirmation about drape coefficient for the model with high reliability and practicality.

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### 1. Introduction

Fabric softness plays an important role to determine the ability of comfort and design for garment products [1]. Recently, the scientists have studied on the fabric softness in terms of qualitative opinion (i.e., according to the hand feeling or skin contact) and quantitative opinion (i.e., related to bending deformation of textile materials under force or gravity) [2]. Evaluation methods of fabric softness by using hand feeling clearly depend on human senses through skin sensitivity to fabric surface with many subjective assessments in terms of satisfaction in contact. Particularly, appearance of material surface with hairy ends fully induces supported feeling due the decrease in acceleration (or damping) as skin collides with textiles in order to generate the satisfaction. However, almost authors have studied the fabric softness according to the experimental methods with the specific results that might evaluate highly objectively the material deformation under certain conditions such as friction, extension, shear, compression and crease recovery.



**Figure 1.** Evaluation method of fabric softness through drape manner [3,4]

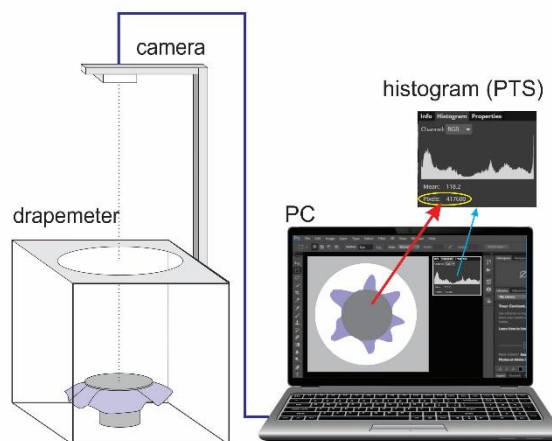
Some common methods to evaluate the fabric softness are (1) the ring methods which an imitated scarf undergoes the impact of stretching, bending and rubbing force; (2) the sledge method which the static and dynamic frictions are applied on fabric surface with a specific load [5]; and (3) the bending method which the fabric is deformed itself under gravity [6]. These models help to clarify the flexibility of fibers and yarns in fabric structure, thereby evaluate objectively the fabric softness owing to the reliable data.

Especially, a model of determining drape coefficient based on the comparison calculation of projection between undraped (flatted) sample and draped (hanged) sample was mentioned in many researches because of being like the reality of textile fabrics [7], [8]. Normally, there are two ways to measure the drape coefficient of fabric including direct measurement (i.e., it is calculated according to the area of tracing paper obtained from projected shape of draped sample through the comparison between weight and area) and indirect measurement (i.e., the boundary or curve of draped sample is calculated by a graphic software) [9], [10]. Obviously, above experimental results ought to be carried out via several procedures and low accuracy.

This work proposes an indirect method to determine drape coefficient of fabric based on image pixels at which are limited by projected figure through histogram of photoshop (PTS) software. Some limitations in previous drape measurements have been eliminated owing to this approach leading to high reliability for experiments of fabric softness.

## 2. Experimental Methods and Equipment

Three types of woven fabrics including 100% cotton (CT), 100% polyester (PE) and 65% polyester - 35% cotton (CP) were conditioned at  $23\pm 1^\circ\text{C}$ ,  $65\pm 1\%$  RH for 24 hours. A drapemeter was illustrated as **Figure 2**. A round sample with diameter of 300 mm ( $D_o$ ) was concentrically placed in an inox round disc with diameter of 180 mm ( $D_d$ ). All draped samples were photographed and analyzed on the PTS software. The number of pixels from draped region were compared to the number of pixels from original region corresponding to the undraped area ( $A_o = \pi R_o^2$ ), thereby the draped area ( $A_n$ ) was calculated according to the right rule of three.



**Figure 2.** Experimental model of drape coefficient using digital image analysis

A crease recovery tester (TF110) was used for samples (40 mm x 15 mm) that were folded in the middle along lengthwise grain under the certain load of  $500\pm 5\text{g}$  in  $300\pm 5\text{s}$  and were measured after  $60\pm 2\text{s}$  of releasing the load (ISO 2313, AATCC 66)

A stiffness tester used the method (also called as Pierce cantilever) to evaluate flexibility of textile fabrics with specific dimensions (200 mm x 25 mm) according to the ASTM 1388-18.

## 3. Results and Discussion

### 3.1 Determining drape coefficient based on image pixel data

Digital images were processed by PTS to collect pixel data. It is known that pixel density closely related to PPI (pixel per inch) on photo. Image size (rectangle shape) was defined as a multiplication of pixel number in height ( $N_{pH}$ ) and pixel number in width ( $N_{pW}$ ) (e.g., image resolution of 1024x731 will have 748,544 pixels). Moreover, when all photos were taken in the same distance, ratio and magnification, their projected area was proportional to each other. On the other hand, total number of image pixels ( $N_{pn}$ ) of different objects are always proportional to the actual area ( $A_n$ ) on the same plane and the same PPI. It can be presented as:

$$N_{pn} = \mu A_n \text{ (px)} \quad (1)$$

where  $\mu$  is factor of  $N_{pn}$  and  $A_n$

Factor  $\mu$  is defined by experimental data through values of  $N_{pn}$  and  $A_n$  as presented in **Eq.1** and **Table 1**, particularly.

**Table 1.** Factor  $\mu$  in relationship between number of pixels and projected area

Sample	R		$A_n$	$N_{pn}$ px	$\mu$
	cm	inch	inch <sup>2</sup>		
SP <sub>1</sub>	9	3.5363	39.2868	204,120	5195.6400
SP <sub>2</sub>	12	4.7151	69.8432	362,801	5194.5089
SP <sub>3</sub>	15	5.8939	109.1300	566,988	5195.5300
SP <sub>4</sub>	18	7.0727	157.1471	816,360	5194.8764
SP <sub>5</sub>	21	8.2515	213.8947	1,111,124	5194.7236
<b>Average <math>\mu</math></b>					<b>5195.0558</b>

Several previous authors have given formula to define **DC** for textile fabric based on projected area of draped sample ( $A_n$ ) and projected area of undraped sample ( $A_o$ ) as follows:

$$DC (\%) = 100 \frac{A_n - A_d}{A_o - A_d} \quad (2)$$

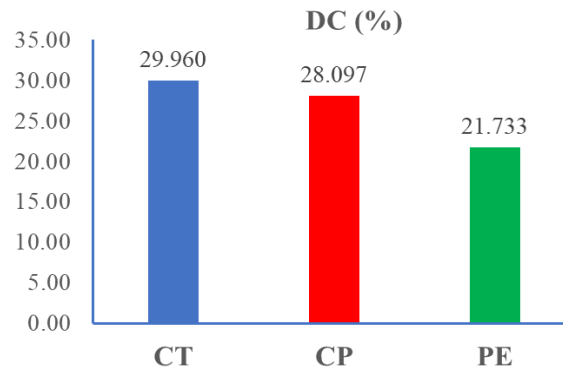
where,  $A_d$  is area of disc (undraped). According Eq.1, the DC might be rewritten as:

$$DC (\%) = 100 \frac{N_{pn} - N_{pd}}{N_{p0} - N_{pd}} \quad (3)$$

**Table 2.** Relationship between drape coefficient and specific weight  $W_s$  and number of pixels  $N_{pn}$

Sample	$W_s$ (g/m <sup>2</sup> )	$N_{pn}$ (pixel)	DC (%)
CT	133.190	312,916	29.960
CP	128.241	306,155	28.097
PE	73.524	283,056	21.733

In this work, the experimental results of DCs measured on CT, PE and CP fabrics were presented in **Table 2** and **Figure 3**, indicating the deformation of samples in the hanging manner. Clearly, Deformation of CT fabric was higher than that of PE fabric but not that of CP fabric though crystalline region of polyester in CP fabric occupies up to 35%. It means that the specific weight of fabric was highly affected on drape coefficient.



**Figure 3.** *Drape coefficient of CT, PE and CP*

Consequently, pixel analysis to calculate projected area was significantly shortened experimental time and ensured more precision because it has been minimized some errors of sampling procedures from conventional methods such as tracing papers and edge scanning.

### 3.2 Effect of fabric's parameters on drape coefficient

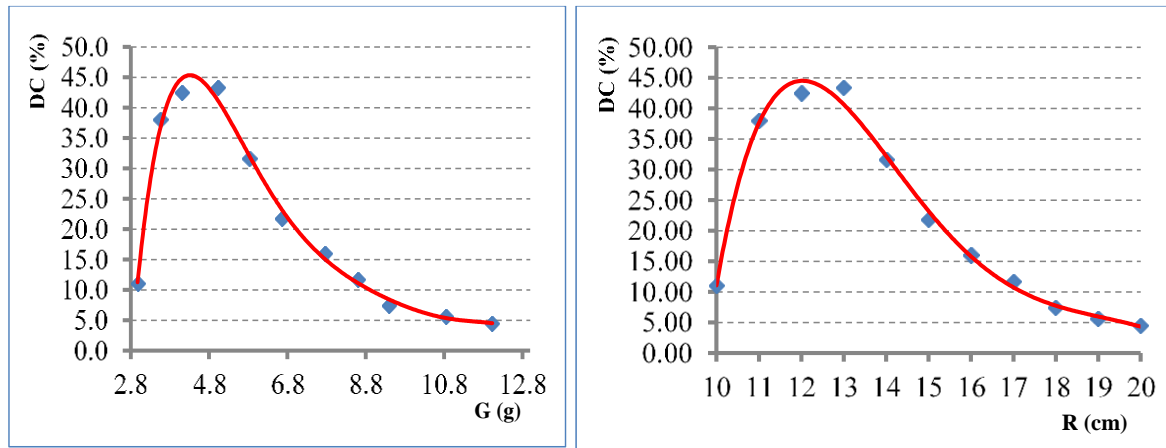
Through the model, it could be clearly observed that bending deformation of textile fabric depends on specific weight including  $D$  ( $\text{g/m}^3$ ) or  $W_s$  ( $\text{g/m}^2$ ) under gravity force. The results in **Table 2** show that values DC and  $W_s$  of CT and PE fabric are 29.960% and 21.733%, corresponding to 1.53  $\text{g/m}^2$  and 1.38  $\text{g/m}^2$ , respectively. It can be explained that ratio of crystalline region or intermolecular interactions for CT fiber is lower than that for PE fiber, meaning that CT fabric is highly flexible or easy to deform its shape. Simultaneously, amorphous structure of cellulose with many hydroxyl groups allows to keep and form hydrogen bonds with water molecules which significantly increase specific weight (i.e., high moisture).

Evaluating drape coefficient depends on not only specific weight but also structural properties of textile yarn and fabric. DCs of CT, CP and PE increased with values of specific weight as 133.190, 128.241 and 73.524  $\text{g/m}^2$ , respectively. In fact, specific weight of fabric was obviously affected by yarn count, yarn density and fabric thickness.

### 3.3 Effect of sample size on drape coefficient of textile fabric

**Table 3.** *Relationship among drape coefficient, weight and diameter of sample*

Sample	R cm	R inch	G g	$N_{po}$	$N_{pi}$	DC %
				pixel	pixel	
$M_0$	10	3.929	2.977	1,061,837	882,635	11.07
$M_1$	11	4.322	3.561	1,284,822	1,021,875	38.06
$M_2$	12	4.715	4.112	1,529,045	1,144,667	42.52
$M_3$	13	5.108	5.033	1,794,504	1,265,430	43.36
$M_4$	14	5.501	5.831	2,081,200	1,246,981	31.67
$M_5$	15	5.894	6.651	2,389,132	1,193,512	21.79
$M_6$	16	6.287	7.758	2,718,302	1,158,635	16.06
$M_7$	17	6.680	8.608	3,068,708	1,119,614	11.74
$M_8$	18	7.073	9.392	3,440,350	1,054,023	7.51
$M_9$	19	7.466	10.858	3,833,230	1,027,651	5.63
$M_{10}$	20	7.859	12.032	4,247,346	1,011,763	4.47



**Figure 4.** Effect of radius (R) and weight (G) of sample on drapability coefficient (DC)

**Table 3** and **Figure 4** showed that DC of fabrics depends on sample’s radius (R) and weight (G). Particularly, DC rapidly increased and reached highest at 43.16% (R=13 cm) but it decreased with radius towards zero (0). As mentioned above, deformation of fabric was affected by its specific weight when it was in suspended state. Actually, this was evidenced that sample size for measuring drapability must be consistently defined in order to meet requirements of confidence and precision. Therefore, all samples in this study were prepared in the same size as  $R_o=9$  cm and  $R_n=15$  cm

To use pixel number to determine DC, drapability coefficient - radius and drapability coefficient - weight curves were shown in Figure 4, in which it was necessary to select a standardized value of radius before experiments. It means that when DC was too high (i.e., sample was too heavy) or too low (i.e., sample was too light), there was no difference in DC among samples, especially considering effects of material, yarn density, weave, etc. Normally, scientists have selected round sample with radius of 15 cm to determine DC for almost types of textile fabrics.

### 3.4 Relationship between crease recovery and drapability coefficient

Crease recovery (CR) of textile fabric is defined according to angle of crease recovery  $\alpha$  (°)

$$CR (\%) = 100 \frac{180 - \alpha}{180} (\%) \tag{4}$$

**Table 4.** Relationship of CR and DC on fabric

Sample	Grain	$\alpha_{medium}$ (°)	CR (%)	DC (%)
CT	Lengthwise	93	51.67	29.960
	Crosswise	89	49.44	
CP	Lengthwise	102	56.67	28.097
	Crosswise	113	62.78	
PE	Lengthwise	125	69.44	21.733
	Crosswise	133	73.89	

**Table 4** shows that DC is inversely proportional to percentage of crease recovery, meaning that the softer fabric was, the less crease recovery was or less anti-deformation which DC also affirmed in **Table 2**. However, elastic resilience as well as crease recovery of fabric was largely different between lengthwise grain and crosswise grain due to various yarn counts and densities. Thus, evaluation of softness in terms of drapability was more objective and more obviously than that of crease recovery because DC described actual manner in three-dimension of fabric.

### 3.5 Relationship between flexural rigidity and drapability coefficient

Based on method of Pierce Cantilever, K (flexural rigidity) was determined at specific bending angle of 41.5° (0.724 rad) under gravity or self-load by the following formula [11], [12], [13]:

$$K = W_s \cdot C^3 \text{ (mg/cm)} \quad (5)$$

where  $W_s$  (mg/cm<sup>2</sup>) is specific weight of fabric,  $C = L/2$  (cm) is bending length,  $L$  (cm) is length of fabric projecting.

**Table 5.** Correlation between flexural stiffness and drape coefficient

Sample	L (cm)	C (cm)	K (mg/cm)	DC (%)	K/DC
CT	3.25	1.63	571.520	29.960	19.076
CP	3.32	1.66	586.612	28.097	20.878
PE	3.62	1.81	435.978	21.733	20.061

To ensure that drape coefficients obtained from this work are reliable and subjective, values K ( $K_{CT}=545.546$ ,  $K_{CP}=747.902$ ,  $K_{PE}=633.418$ ) corresponding to values DC ( $DC_{CT}=29.960$ ,  $DC_{CP}=28.097$ ,  $DC_{PE}=21.733$ ) or ratios of K/DC on samples are relatively balanced at 19.076, 20.878 and 20.061, respectively.

#### 4. Conclusions

The work has proposed determining method of fabric softness through model of evaluating drape coefficient owing to pixel analysis of digital photos on graphic software. Accordingly, authors have shown some advantages of this experimental model such as time saving and high reliability. Also, the research has presented relationship between crease recovery angle as well as flexural rigidity and drape coefficient, so that fabric softness has been clarified more.

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#### REFERENCES

- [1] X. Liu, L. Wang, and X. Wang, "An experimental study on fabric softness evaluation", *International Journal of Clothing Science and Technology*, vol.18, no.2, 2005, pp. 83-95
- [2] R. Sanad, T. Cassidy, and V. Cheung, "Fabric and garment drape measurement (Part 1)", *Journal of Fiber Bioengineering and Informatics*, vol.5, no.4, pp. 341-358, 2012.
- [3] T. Šarac, J. Stepanović, and N. Ćirković, "Analysis of a Fabric Drape Profile", *Fibré and Textiles, Vlakna a Textil* vol.25, no.1, pp.27-34, 2018
- [4] A. Ragab, A. Fouda, H. El-Deeb, and A.T. Hemdan, "A simple method for measuring fabric drape using digital image processing", *Journal of Textile Science and Engineering*, vol.7, no.5, 2017.
- [5] D. Hermann, S. S. Ramkumar, P. Seshaiyer, and S. Parameswaran, "Frictional study of woven fabrics: The relationship between the friction and velocity of testing", *Journal of Applied Polymer Science*, Vol. 92, pp. 2420-2424, 2004.
- [6] L. Szabo and M. Halasz, "Examination of dependence of drape coefficient on sample size", *Tekstil-Zagreb*, vol.57, no.9, 2008, pp. 439-456,
- [7] G.E. Cusick, "The measurement of fabric drape", *The Journal of The Textile Institute*, vol.59, no.6, pp. 253-260, 1968.
- [8] N. Kenkare and T. M. Plumlee, "Fabric drape measurement: A modified using image processing", *Journal of Textile and Apparel, Technology and Management*, vol.4, no.3, 2015.
- [9] L. Vangheluwe, P. Kiekens, "Time dependence of the drape coefficient of fabrics", *International Journal of Clothing Science and Technology*, vol.5, no.5, pp. 5-8, 2017.
- [10] B. K. Behera, A. K. Pattanayak, "Measurement and modeling of drape using digital image processing", *Indian Journal of Fiber and Textile Research*, vol.33, no.3, pp. 230-238, 2008.
- [11] Nicolas Lammens, et al, "Improved accuracy in the determination of flexural rigidity of textile fabrics by the Peirce cantilever test", *Textile Research Journal*, vol.84, no.12, pp. 1307-1314, 2014.
- [12] A. B. H. Musa, B. Malengier, L.V. Langenhove, and C. Stevens, "The reliability of the newly developed bending tester for the measurement of flexural rigidity of textile materials", *IOP Conf. Series: Materials Science and Engineering*, vol.254, no.14, 2017.
- [13] L. Yang, K.O. Kim, and M. Takatera, "Effect of the fabric dimension on limits of the drape coefficient", *Textile Research Journal*, vol. 90, no.3-4, 2019.



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