Prediction of Garment Drapability Based on Fabric Properties

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Abstract: The fabric drape represents indication of garment appearance properties when fabric orients itself into folds in more than one plane under its own weight. For many years textile researchers studied this fabric attribute in order to evaluate the drape quality, improve and design the drape ability of garments. The fabric drape represents indication of garment appearance properties when fabric orients itself into folds in more than one plane under its own weight. The color, tone, luster and surface roughness of fabric have their it's own importance and play a crucial role in contributing to the beauty of external appearance of the fabric such as the aesthetic appearance and dynamic drape. The paper investigates the effect of FAST (Fabric Assurance by Simple Testing System) mechanical properties on drape coefficient for cotton fabrics. Results obtained show that the drape properties of the fabric can be connected to various fabric structure parameters. The greatest correlation is obtained between fabric drape and bending stiffness, warp formability, fabric weight and shear rigidity.
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Key words: woven fabric, drapeability, bending stiffness, fabric weight, shear rigidity.

1. Introduction

Fabric drape is one of the most important aesthetic properties in apparel. Drape is defined as "the extent to which a fabric will deform when it is allowed to hang under its own weight"[1]. Drape can be generally classified into two categories, namely two dimensional drape and three-dimensional drape. A two-dimensional drape means that a fabric bends under its own weight in one plane while three-dimensional drape allows a fabric to be deformed into folds in more than one plane under its own weight. Each fabric takes different three-dimensional forms. The study of three-dimensional drape has being undertaken by Chu *et al.*[2] when they established a measuring method for fabrics drape using F.R.L. drapemeter. The drapeability of a fabric has been quantified into a dimensionless value termed the drape coefficient which is defined as the percent of the area from an angular ring of fabric covered by a vertical projection of the draped fabric. The apparatus was further studied by Kaswell [3]and latter revised by Chu[4,5].

Finally,Cusick[6]investigated the experimental method again by using a parallel light source that reflects the drape shadow of a circular specimen from a hanging disc into a piece of ring paper. The effect of bending and shear stiffness on fabric drape has also been studied and confirmed by statistical analysis. Cusick also found that shear stiffness was highly correlated with drape coefficient[7]. Mooreka[8] analyzed the relation between drape coefficient and mechanical properties. He found that bending rigidity and weight are the most determinative parameters of drape. The actual draping at any point in a garment depends upon the total weight suspended from that point. Chaudhary[9]conducted a study to predict drape coefficient by weaving parameters. He stated that drape is closely related to the weaving parameters. Zeong & Philips[10] found that fabric cover has a large effect on fabric drape because of its effect on bending rigidity. Yarn interaction and crimp, which are determined by weave structure, also influence the drape. Similarly fabric tightness also influences the drape. Chen and Govindra[11]observed that young's modulus, shear modulus, thickness have varying effect on extent of fabric drape but poisson's ratio does not have appreciable effect on drape. Pant[12]found substantial increase in drape coefficient of fabrics finished with acrylic and polyvinyl acetate finishes as a result of increase in stiffness. In case of silicone finish, drape coefficient decreased slightly. The aim of this paper is to investigate the correlation of fabric structure parameters and the drape properties of cotton woven fabric for women's outerwear.

2. Experimental

The investigation of fabric drape was carried out on cotton fabrics for production of women's outerwear. The fabric parameters are presented in Table1.The fabric weights ranges from 73-344 g/m^2. All the samples are produced from100% cotton type of yarns. Also, all fabrics are in plain weave while only the three samples have twill weave. The tested samples have higher warp density.The samples were drape tested according to BS5058[1]. A measure of fabric drapeability is expressed via drape coefficient (DC), which represents the ratio of the surface of draped fabric to the surface of flat fabric and obtains values from 0-100%. A low DC value indicates easy deformation of a fabric, while high value indicates lesser deformation.Circular fabrics sample of 30 centimetres in diameter are tested on drape tester. The samples were positioned over a horizontally placed circular rigid disk of 18 centimetres in diameter. The fabric deforms into series of folds around the disk. The paper ring containing the shadow image of the draped configuration represents the weight w_1. The shadow image cut from the paper ring is weighed and marked as w_2. The drape coefficient was calculated by equation:

$$DC=W_2/W_1 *100 \ [\%]$$

Table 1. Investigated fabric constructions:-

Sample ID	Yarn count Warp, tex	Yarn count Weft, tex	Warp density cm^{-1}	Weft density cm^{-1}	Fabric thickness mm	weave	Fabric weight g/m^2
C1	39x2	59x2	46	18	0.726	twill1/3	344
C2	20x1	25x1	30	25	0.425	plain	142
C3	15x2	15x1	37	28	0.361	plain	110
C4	15x2	15x2	42	30	0.401	plain	119
C5	49x2	49x2	18	18	1.007	twill2/2	210
C6	15x1	15x1	36	28	0.623	plain	108
C7	16x2	16x2	38	23	0.349	plain	107
C8	20x2	20x2	45	25	0.533	plain	156
C9	14x2	14x2	38	27	0.334	plain	111
C10	15x2	15x2	52	35	0.400	plain	146
C11	40x2	40x2	36	17	0.516	plain	248
C12	14x2	12x1	52	26	0.353	plain	127
C13	30x1	60x1	23	18	0.893	plain	203
C14	14x2	12x1	44	26	0.327	plain	116
C15	15x2	12x1	40	30	0.316	plain	110
C16	15x1	15x1	52	28	0.365	plain	132
C17	15x2	15x1	36	30	0.268	plain	104
C18	12x2	12x1	52	42	0.433	twill2/2	130
C19	15x2	15x1	42	27	0.413	plain	128
C20	12x2	15x1	36	28	0.313	plain	108
C21	12x2	12x2	52	30	0.291	plain	106
C22	12x1	12x1	32	28	0.318	plain	73
C23	15x2	10x1	60	30	0.329	plain	131
C24	15x2	12x1	48	27	0.345	plain	117
C25	30x2	40x2	48	22	0.629	plain	265

3. Results and Discussion

The drape coefficients were measured for the tested samples. Then the fast mechanical properties were obtained for each sample. The results of FAST mechanical properties of each fabric with its drape coefficient are shown in Table 2.

It can be seen that drape coefficient is ranges from 30.73 to 56.86%. It is noticeable, that sample C1 obtains significantly higher drape coefficient in relation to all other fabrics. This sample has very high bending stiffness (almost several times higher compared to other samples) and high fabric weight. These values justify the end use of the fabrics which is intended for clothing which outer fabric does not need to be very drapeable[13].The values of the woven fabric parameters which are expected to have greater influence on fabric drape are shown in Table2.When fabric hangs and creates folds, bending and shear deformation act on the fabric. So, substantially higher values of all aforementioned parameters of fabric structure are good indication and explanation of the very high value of drape coefficient[14].

The samples having minimum drape coefficient values (C6,C7,C18 and C20) have a lowest fabric weight but do not have a low value of bending length. It is interesting that fabric with the lowest bending rigidity in warp direction (C21) achieves a relatively high drape coefficient .Since it is expected that twill weave have lower drape coefficient and lower shear rigidity compared to plain weave, the higher drape coefficient could be attributed to fabric weave[15].

Table 2. Drape coefficient and structural parameters of sample fabrics

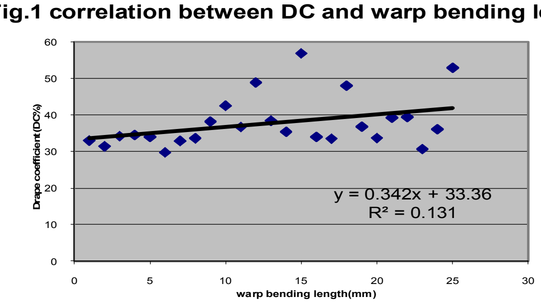
Sample ID	C1	C2	B-1	B-2	E5-1	E5-2	E20-1	E20-2	E100-1	E100-2	EB5	F-1	F-2	G	T100	ST	DC%
C1	23.9	24.0	46.6	47.1	0.1	0	0.7	0.2	3.3	1.1	0.5	1.90	0.63	198	0.578	0.147	56.86
C2	21.7	20.0	14.5	11.4	0.1	0.1	0.4	0.4	2.3	3.5	0.8	0.3	0.35	136	0.312	0.112	52.91
C3	15.6	14.9	4.1	3.6	0.1	0.2	1	0.8	3.2	3.1	3.8	0.21	0.14	30	0.225	0.136	33.04
C4	20.6	15.0	10.2	3.9	0.1	0.6	0.2	2.5	1.3	7.4	6.3	0.15	0.54	18.9	0.255	0.135	36.10
C5	16.2	15.1	8.9	7.1	0.4	0.7	1.2	2.2	3.1	5.5	4.8	0.46	0.77	24	0.600	0.407	35.45
C6	16.1	13.8	4.4	2.7	0.2	1.6	1	2.2	3.1	5.1	5.4	0.20	0.12	22	0.228	0.324	31.47
C7	16.8	14.1	5.0	3.0	0.1	0.3	0.8	1.1	3.3	3.5	5.5	0.21	0.16	21	0.238	0.110	30.73
C8	14.3	14.5	4.5	4.8	0.2	0.1	0.7	0.5	2.5	2	1.8	0.17	0.10	62	0.258	0.274	38.46
C9	16.9	14.3	5.3	3.2	0.3	0.3	1.1	0.7	3	3	3.1	0.23	0.1	37	0.214	0.120	34.24
C10	21.6	14.9	14.5	4.8	0.2	0.6	0.5	1.7	1.3	5.8	5.5	0.26	0.3	21	0.266	0.133	39.43
C11	20.6	18.5	21.7	15.6	0.3	0.3	1	0.8	5.6	4.5	0.6	1.08	0.52	184	0.404	0.112	48.93
C12	17.6	13.2	6.9	2.9	0.1	0.2	0.7	0.6	2.2	2.2	3.4	0.28	0.07	34	0.257	0.086	34.58
C13	18.9	15.7	13.6	7.8	0.4	1.3	0.7	3.7	1.2	9.3	2.9	0.24	1.32	40	0.555	0.336	39.29
C14	17.5	14.5	6.1	3.5	0.3	0.6	0.9	2.3	3	3.4	3.1	0.24	0.43	37	0.228	0.098	36.73
C15	16.1	13.7	4.5	2.8	0.2	0.1	0.8	0.7	3	3	3.3	0.18	0.10	35	0.206	0.110	34.03
C16	17.0	13.3	6.4	3.1	0.2	0.1	0.8	0.7	3.1	3.4	2.4	0.26	0.13	48	0.182	0.182	33.73
C17	20.0	14.6	8.2	3.1	0.1	0.1	0.4	0.7	1.8	3.6	3.2	0.16	0.12	36	0.188	0.080	42.54
C18	16.0	13.7	5.2	3.2	0.3	0.2	1	0.7	2.7	1.5	6.7	0.24	0.10	17	0.289	0.143	29.77
C19	17.7	14.9	7.1	4.2	0.1	0.1	0.8	0.7	3.2	4.1	3.2	0.32	0.16	36	0.306	0.107	38.22
C20	16.2	14.8	4.5	3.4	0.3	0.3	1	1.1	3.3	4.4	4.6	0.21	0.18	25	0.211	0.102	32.92
C21	15.3	14.4	3.7	3.1	1	0.1	1.8	0.5	4.6	2	3.6	0.21	0.08	32	0.190	0.098	34.00
C22	17.6	15.1	3.9	2.4	0.2	0.4	0.4	1.7	1.3	5.1	9.1	0.04	0.21	12	0.185	0.133	36.79
C23	17.8	12.2	7.3	2.3	0.1	0.1	0.6	0.4	3	2.5	2.4	0.23	0.04	48	0.225	0.103	33.55
C24	19.0	14.1	8.0	3.3	0.5	0.1	1.1	0.4	4	2.3	3.1	0.34	0.06	37	0.226	0.118	33.63
C25	19.9	19.7	20.8	20.1	0.3	0	1.1	0.2	3.3	1	1.2	0.73	0.13	90	0.471	0.157	48.03

To get idea about fabric structure parameter that gives best indication of fabric drapeability, the correlation between drape coefficient and various fabric structure parameters is investigated. As expected, there is high correlation between fabric bending stiffness in warp and weft direction and fabric drape of 0.92 and 0.93 respectively. Also there is high correlation between drape coefficient and weft bending length (R^2=0.843),warp bending rigidity (R^2=0.709),weft bending rigidity (R^2=0.657), warp formability (R^2=0.537), shear rigidity(R^2=0.766) and fabric weight (R^2=0.549).

The figures below (Figs1,17) show the obtained correlations between drape coefficients and various fabric parameters.

Figures 1:17. Correlation between DC and:a) warp bending length (0.13);b) weft bending length (0.84);c)warp bending rigidity (0.71);d) weft bending rigidity (0.66);e) warp extension 5g (0.03);f) weft extension 5g (0.06);g) warp extension 20g (0.07));h) weft extension 20g (0.05);i) warp extension 100g (0.0);j) weft extension 100g (0.01);k) bias extension(0.39);l) warp formability (0.54);m)weft formability(0.13);n)shear rigidity (0.77);o) thickness (0.10);p)) surface thickness (0.0)and; q) fabric weight (0.55).

Fig.1 correlation between DC and warp bending length



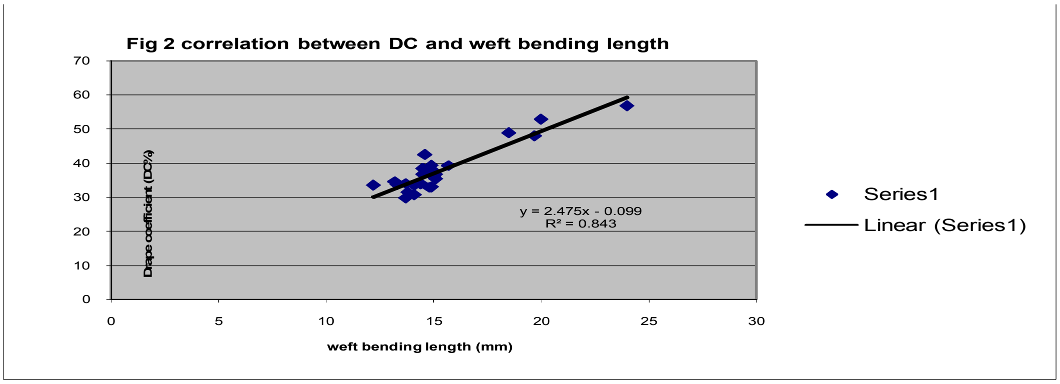


Fig 2 correlation between DC and weft bending length

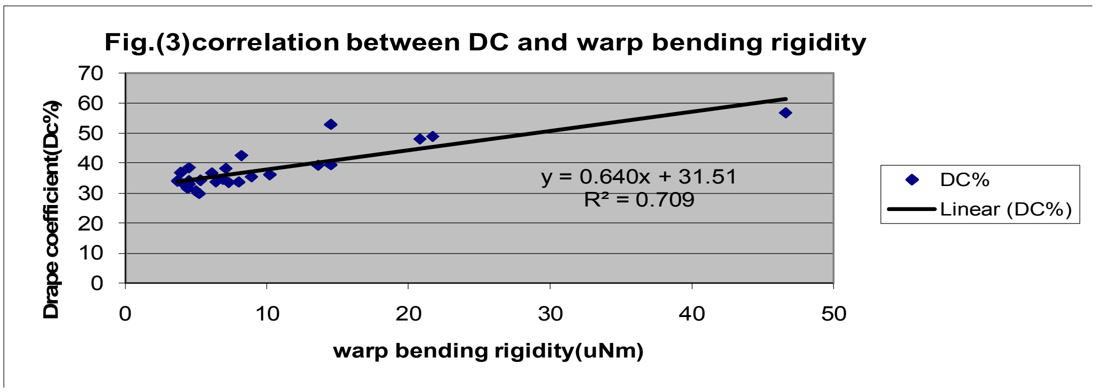


Fig.(3)correlation between DC and warp bending rigidity

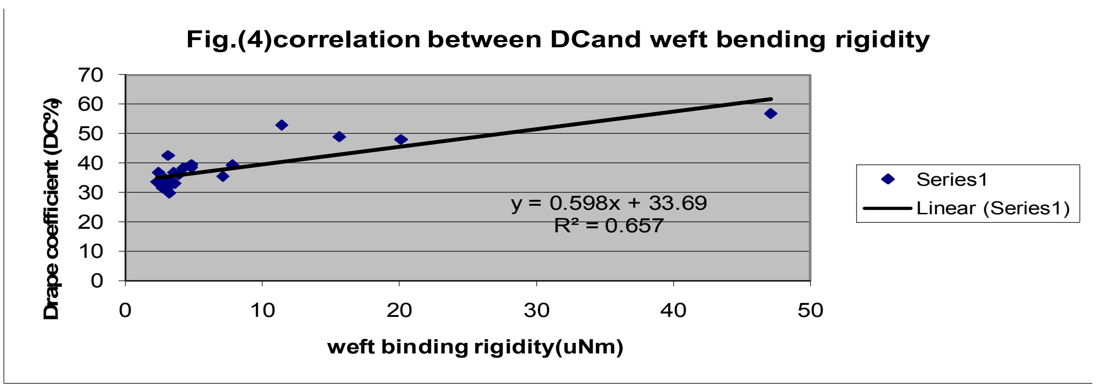


Fig.(4)correlation between DCand weft bending rigidity

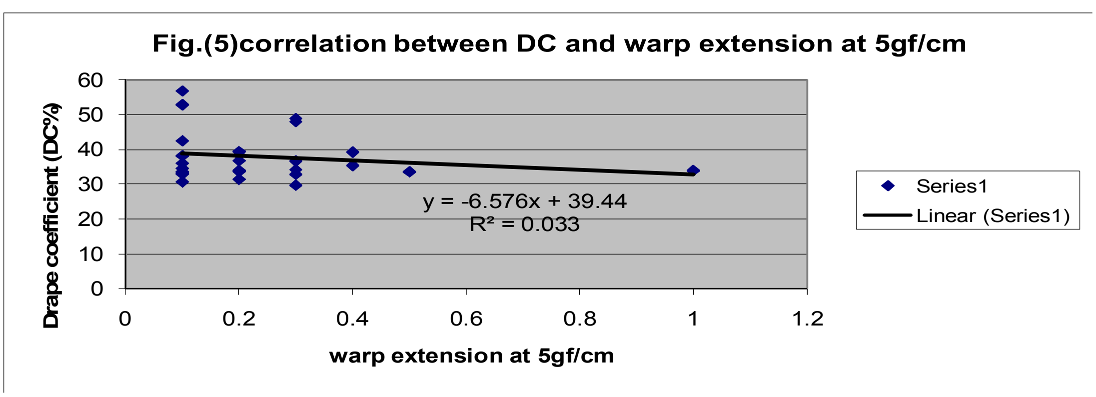


Fig.(5)correlation between DC and warp extension at 5gf/cm

Fig.(6)correlation between DC and weft extension at 5gf/cm

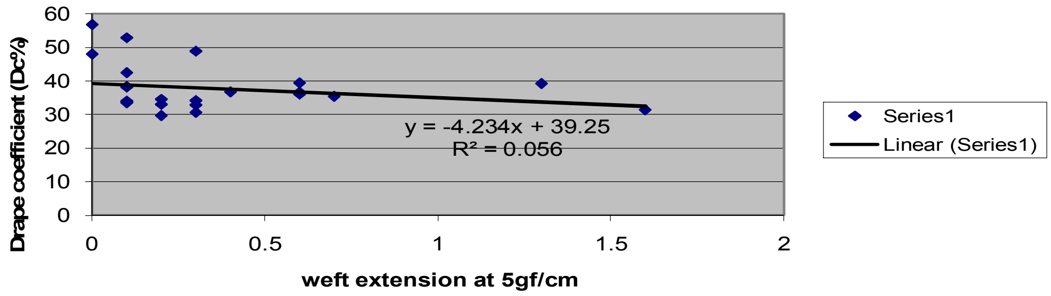


Fig.(7)correlation between DC and warp extention at 20gf/cm

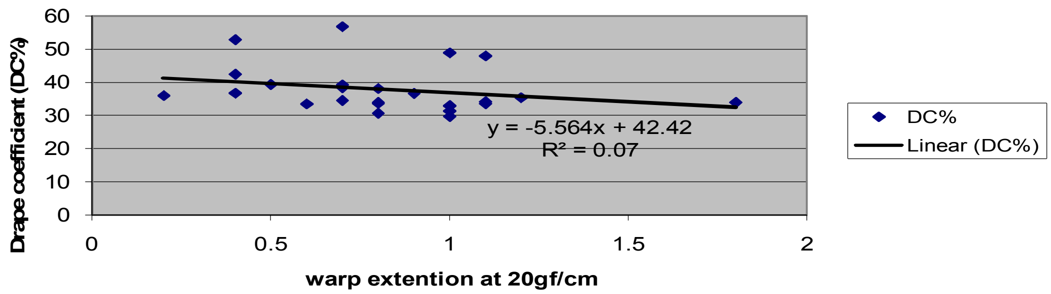


Fig.(8)correlation between DC and weft extension at 20gf/cm

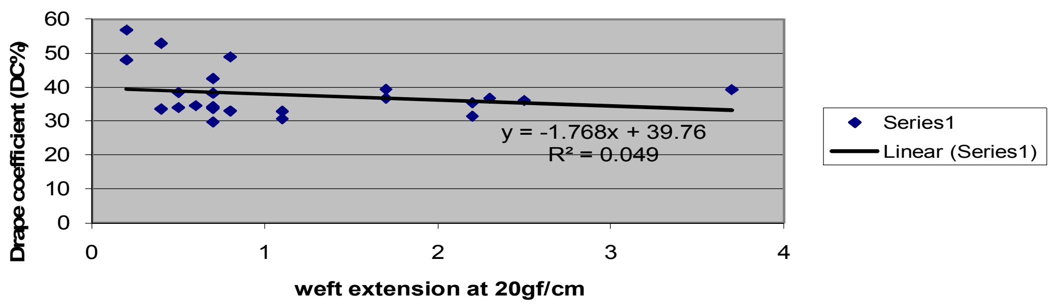


Fig.(9)correlation between DCand warp extension at 100gf/cm

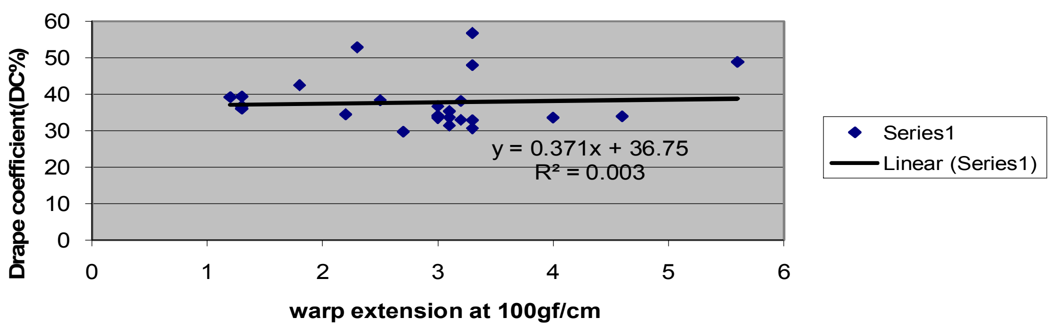


Fig.(10)correlation between DC and weft extension at 100gf/cm

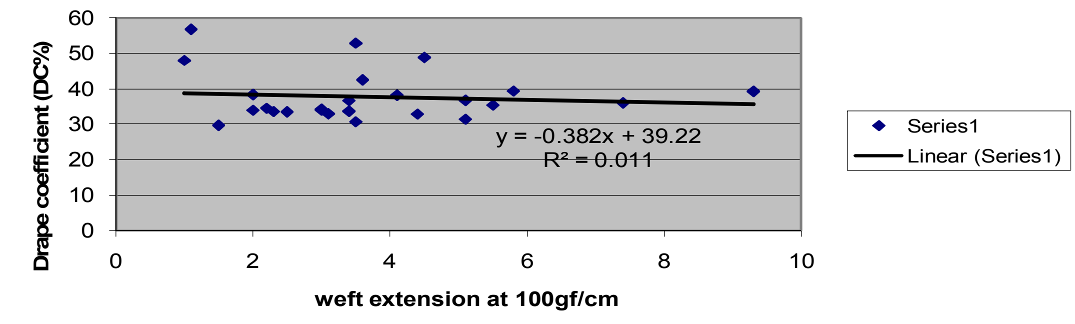


Fig.(11)correlation between DC and bias extension

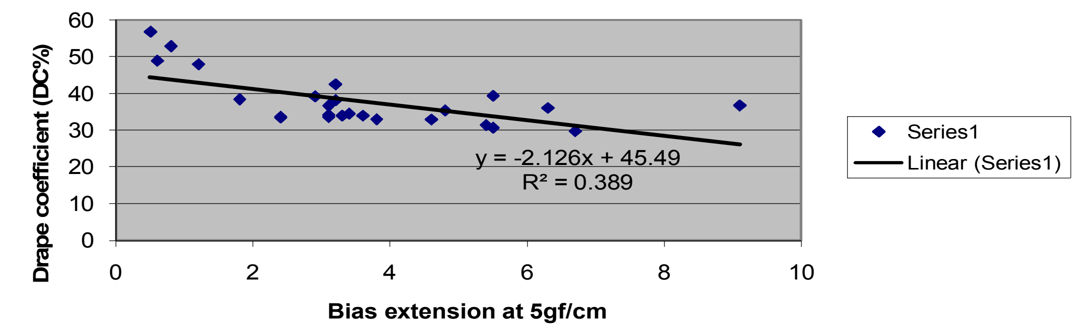


Fig.(12)correlation between DC and warp formability

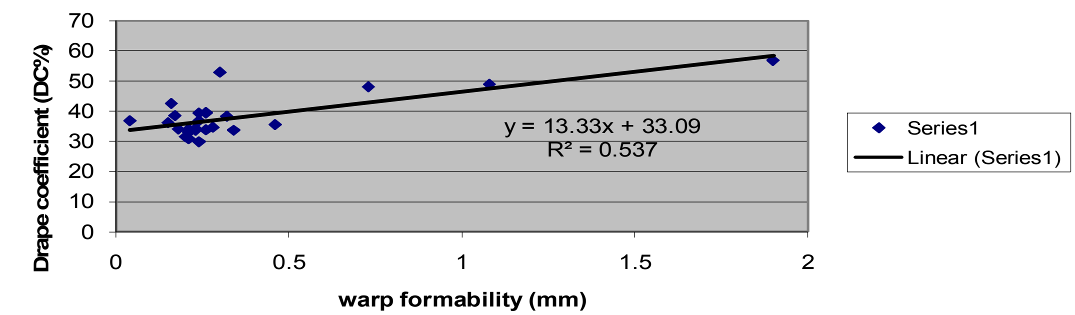
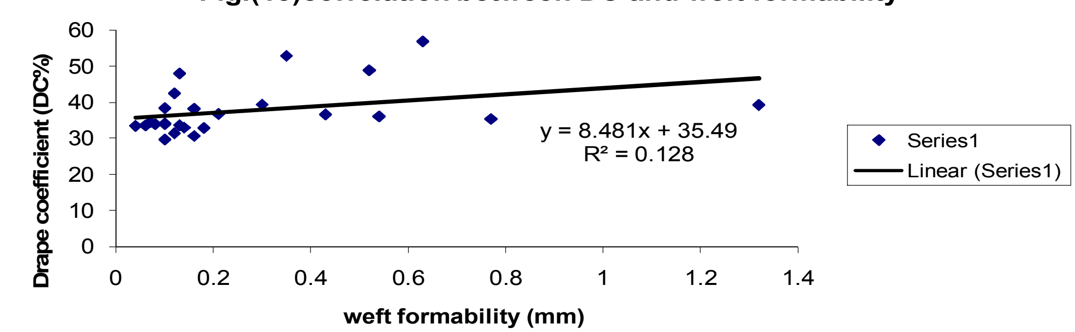


Fig.(13)correlation between DC and weft formability



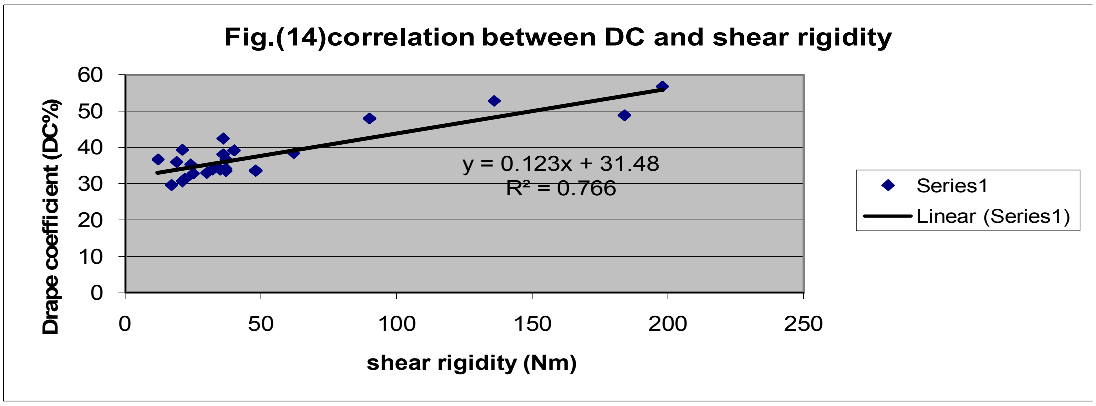


Fig.(14)correlation between DC and shear rigidity

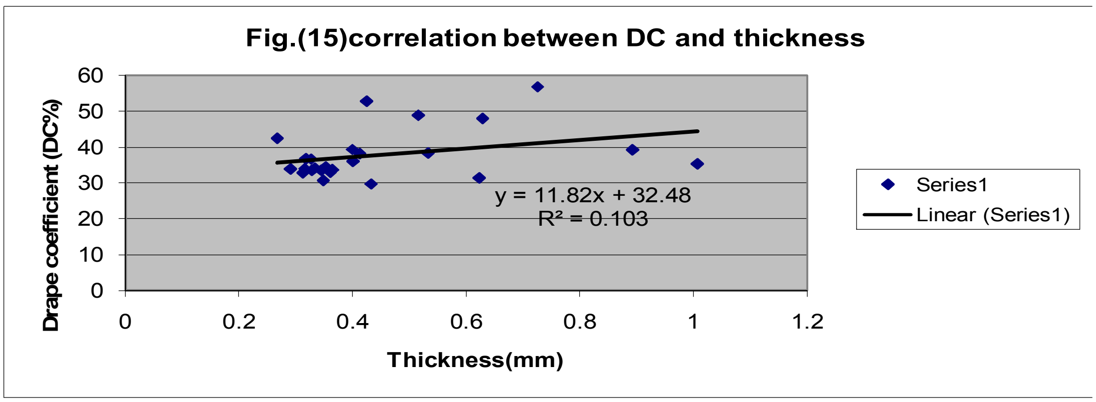


Fig.(15)correlation between DC and thickness

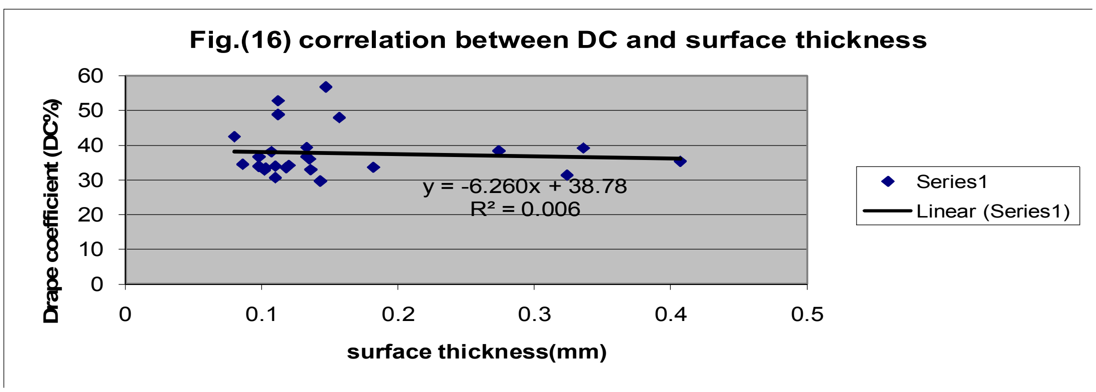


Fig.(16) correlation between DC and surface thickness

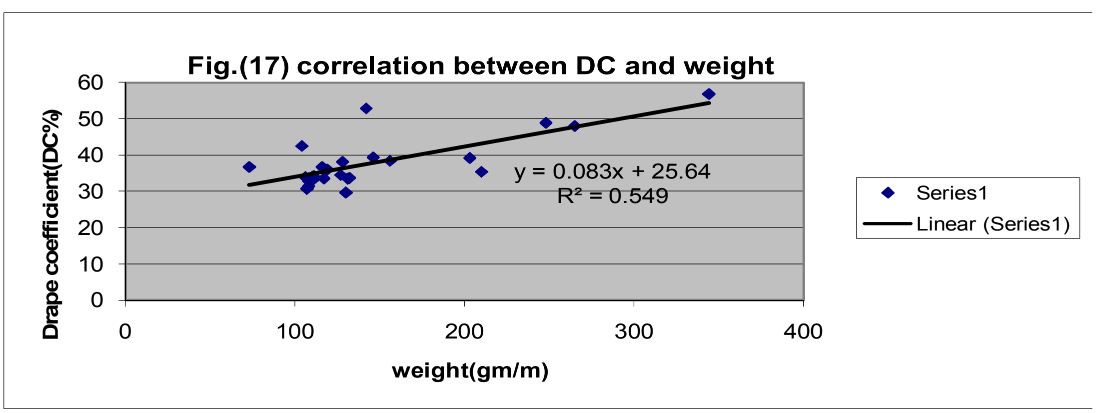


Fig.(17) correlation between DC and weight

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Conclusion

The drape coefficient alone is not sufficient information about a fabric, so the number of folds, their wavelength, distribution and amplitude is specified as well.In case of cloths the position compared to the projection and warp line is also specified for these data. This is a large amount of data, so it is difficult to handle it, so our goal was to develop a method with which the drape capabilities of different fabrics can be compared easily and fast. The investigation of the drape properties of 100%cotton fabrics has shown high correlation between various fabric structure parameters and the fabric drape. The drape coefficient values for most of the sample varies from 29.77 to 56.86% which is expected value for the woven fabric for outerwear women's tailored clothing.

The sample that has much greater drape value has also much higher bending stiffness (length&rigidity),warp formability, shear rigidity, and weight. The highest correlation has been found between the fabric drape and stiffness and the parameters which indicate fabric tightness.

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