Prediction of Garment Appearance from FAST Mechanical Properties and fabric drape

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Abstract: Garment appearance is considered as one of the most important aesthetic properties of garment which attracts the attention of most people. In this study a term of garment appearance value was visually assessed. It is constructed based on some questionnaires evaluated by experts and semi experts from academic and industrial fields. Then an attempt to correlate or predict this garment appearance from FAST mechanical properties, and fabric drape was done. It is important to correlate the properties determined by subjective evaluation of fabrics with the properties obtained objectively to avoid human error in evaluation.

[El-Gamal M. A., Hassouna A., El-Newashy R. F., Shawky M. and Ashmawi B. A. **Prediction of Garment Appearance from FAST Mechanical Properties and fabric drape.** *Life Sci J* 2014;11(12):1054-1059]. (ISSN:1097-8135). http://www.lifesciencesite.com. 181

Keywords: Garment appearance, FAST mechanical properties, Fabric drape, Formability

1. Introduction

The appearance of a tailored garment on either a coat hunger, or manikin, or a suitable wearer is dependent on a combination of the skill of the garment manufacturer, particularly in relation to seaming, fabric setting and garment design and the forming and draping properties of the component fabrics. Forty suit coats were subjectively rated for appearance by a small team of experienced personnel from a major Japanese tailoring company. Each garment was hung on a coat hanger and rated as being of good, average, or poor appearance. Then fabric mechanical properties were measured by KES. It was found that fabric extensibility at 500 (gf/cm) is a better parameter to discriminate objectively between the subjectively assessed good and poor suit appearance than fabric formability. Fabric shear properties alone are not sufficient to discriminate between fabrics making up into suits of good and poor appearance [1]. Garment designers or buyers often rely on the personal subjective experience to select their draped pleat fabrics. They do not get information about fabric properties from the textile manufacturers, so they could not determine if the fabric is suitable for the draped pleat design or not [2]. Objective evaluation equation was developed for the aesthetic appearance of swinging flared skirts. Subjective appraisals were obtained from 29 girls. The swinging terms which were used were rhythmical, blowy, airy, graceful, dynamic, and most beautiful. The fabric mechanical properties were measured by KES. It was found that the beautiful movement is dominated mainly by combined parameter $\sqrt[3]{g/w}$. If the fabric easily deforms in shearing deformation and has a larger weight, the skirt made from that fabric has a high score for beautiful movement [3].The phenomena of fabric drape was studied. Also the relation between bending rigidity and drape coefficient was studied. It was found that the drape coefficient decreases with increasing bending rigidity [4]. The subjective evaluation of fabric tailorability and other judgment criteria (stretchability, stiffness, roughness, thickness, and density) was investigated.. The results indicate that the experts are in good agreement on evaluating fabric stretchiness, density, thickness, and tailorability, while the coefficient of concordance for stiffness is poor. The difficulty in assessing the fabric's stiffness because it was difficult to distinguish the small differences in testing specimens. Also the stiffness definition (fabric resistance to bending, compression and shear) may be less clear than other definitions. It was suggested that the criterion of tailorability must be described more precisely or divided into narrow parts (sewability, formability etc) [5]. The effect of knitting conditions on the mechanical and hand properties measured with KES-F method of weft knits were studied. Eighteen different kinds of weft knits with different structures and densities were produced. It was found that values associated with bending properties were lower in single knits than double knits, hence the single-pique and crossmiss interlock double knits will perform poorly in conforming to a curved surface compared to an interlock [6]. Fabrics with the same conventional drape coefficient have different appearance in many cases so a 3D Dc was developed to measure fabric drape for grey and dyed fabrics. Five types of cotton and polyester/cotton shirt fabrics were used. In each type three different pick densities were produced. They found that 3-D drape coefficient increase with increasing picks/inch reaching maximum value and then it decreases. It was found that the drape coefficient decreased when fabric seamed in radial direction than the unseamed fabric. But with more number of seams, the number of nodes and the stiffness of fabric increase, resulting in higher drape coefficient values. This trend observed in both grey and dyed fabrics. Dyeing decreases the value of drape coefficient [7]. The fabric construction parameters, such as fabric sett, cover factor and weave, change the fabric performance, especially fabric low stress mechanical properties. Fabric stiffness increases if the cover factor of the fabric increased, and then fabric total hand value changed. Plain weave fabrics have higher shear rigidity compared to other weave fabric. Twill weave provides higher extensibility. They also stated that bending and shear rigidity of twill fabric is lower than that of plain fabric [8]. The relationship between fabric drape coefficient and fabric mechanical properties tested on KES was investigated. It was found that eight parameters have significantly high correlation coefficients with the drape coefficient (five bending and shear properties and fabric weight/ unit area, MMD from the surface roughness twist and LT from tensile test) [9]. It was found that when fabric cover factor increased the bending rigidity increased. While fabrics with different weaves but similar cover factors showed differences in drapability. Also fabric tightness influenced the fabric drape by increasing the shear rigidity [10].

2. Materials and methods:

Twenty four fabrics were used in this study. These fabrics are from different materials, cotton, polyester, and cotton polyester fabrics with different weights and different fabric structures. The following table shows fabrics used.

Table (1) Fabric specifications

Material	No. of samples	Weight range (g/m2)	Structure
Cotton	5	101-124	Plain, twill 2/1
Cotton/polyester	9	127-158	Plain, twill 3/1, satin 4
polyester	10	163-227	Plain,twill2/1,twill3/1,satin4

Evaluation of garment appearance:

The twenty four fabrics were classified into three groups according to their weight (light, medium, and heavy weight fabrics).Each group contains eight fabrics. Eight designs were created for each group. A mood board was inspired from the historical military costumes. Each group designs are based on the silhouette that suits the fabric weight group. A three level questionnaire sheet with (agree, agree to some extent, do not agree) was constructed to choose the optimum design for each group. A questionnaire was examined by academic and industrial experts. Each fabric group was applied on its optimum design and the garment appearance value was calculated from a five levels questionnaire shee (1 bad, 2 acceptable, 3 good, 4 very good,5 excellent). The visual assessment included 24 fabrics, after their making-up process. The garment appearance quality was visually assessed. It was evaluated on the mannequin and a high resolution camera captured the images for the garment piece in a room with black walls to prevent any color reflection and a flat florescent unit was used as a light source.

Three photos were captured for each garment piece (front, back and lateral side view). Images were retouched to transform them to be in grayscale in order to prevent the color effect in judgment.

Fabric Measurements

Fabric low stress mechanical properties:

FAST System was used to measure fabric low stress mechanical properties as follows:

Table (2) FAST system components

	Property measured	Value determination
FAST 1	Thickness under different loads from which fabric thickness (ST) could be calculated.	ST=T2-T100 T2 fabric thickness at 2 gf/cm^2 in mm. T100 fabric thickness at 100 gf/cm^2 in mm.
FAST 2	Bending length in warp and weft directions from that bending rigidities could be calculated.	$B=WxC^3x9.81x10^{-6}$ B: bending rigidity in μN.m. W: mass per unit area g/m^2. C: bending length in mm.
FAST 3	Extension under different loads in warp and weft and bias direction. The extension in warp and weft direction measured at loads of 5,20, and 100 gf/cm. Fabric formability in warp and weft directions could be calculated from extension.	G=123/EB5 G: shear rigidity in bias direction EB5: average extensibilities in bias directions. F=(E20-E5)x B/14.7 F: fabric formability in mm^2. E20: extension at 20 gf/cm. E5: extension at 5gf/cm. B: bending rigidity in μN.m.

Drape Measurements:

The drape coefficient obtained using a drape tester constructed by Mona Shawky [11]

The drape tester using image processing technique was used to calculate the drape coefficients of fabrics under study.

3. Results and Discussion

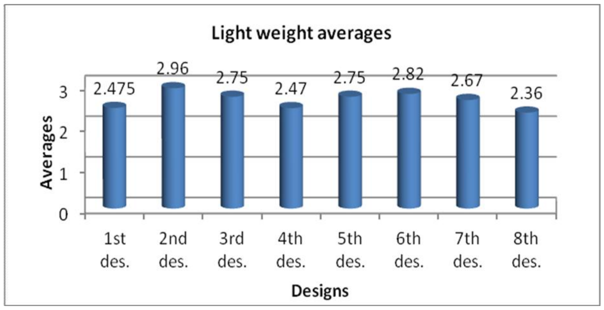

Figure (1): The normal averages of the weight average of the light weight group

It is clear that the second design recorded the best average. Figure 2 shows this design.

Figure 2: The optimum design for the light weight fabric

Figure 3 shows the normal average of the weight averages of the eight designs for the medium weight fabrics.

Selecting optimum design

As mentioned before the 24 fabrics are classified into three groups according to their weight (light weight fabric, medium weight fabric, heavy weight fabric). Eight designs were created for each group. A three level questionnaire was used for selecting the optimum design. It was found that all the correlation coefficients between each question score and the questionnaire total score are significant enough at the levels (0.01, 0.05) and that Person correlation coefficient is smaller than 1 and bigger than 0 which means that there is strong correlation between the questionnaire questions. Also the reliability test of the questionnaire was done and the reliability coefficient (α Cronbach and split half) are significant at the level 0.01.

Figure 1 shows the normal average of the weight averages of the eight designs for the light weight fabrics.

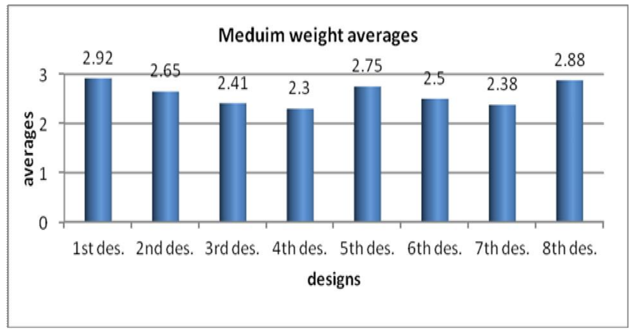

Figure (3) the normal averages of the weight averages for the medium weight group

It is clear that the first design recorded the best average. Figure 4 shows this design.

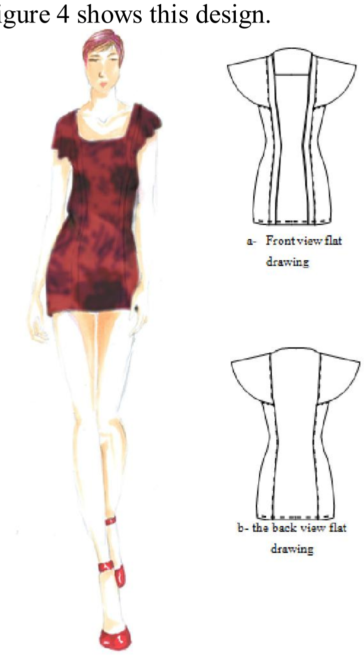

Figure 4 The optimum design for the medium weight fabric

Figure 5 shows the normal average of the weight averages of the eight designs for the heavy weight fabrics.

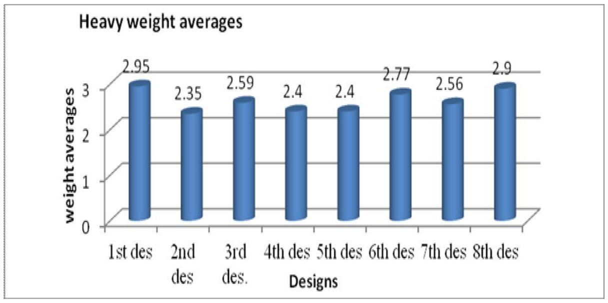

Figure (5) the normal averages of the weight averages for the heavy weight group

It is clear that the first design is the optimum one for the heavy weight fabrics. This design is shown in figure 6.

Figure 6 The optimum design for the heavy weight fabric

Garment appearance evaluation

The garment appearance questionnaire with 5 levels was applied to determine the garment appearance value. The garment appearance was evaluated on the basis of the elements for obtaining proper drape ie (achieving 3D shape, Garment fit, quality of the seams and quality of garment appearance as a whole). Grade 1 means lowest appearance criteria, while grade 5 means highest appearance criteria. The validity and reliability of the questionnaire were obtained. The questionnaire was evaluated by SPSS software to find the highest garment appearance fabric in each fabric weight group, and the final garment appearance value was calculated.

Fabric low stress mechanical properties and drape

Figure 7 shows the results of fabric weights used in this study.

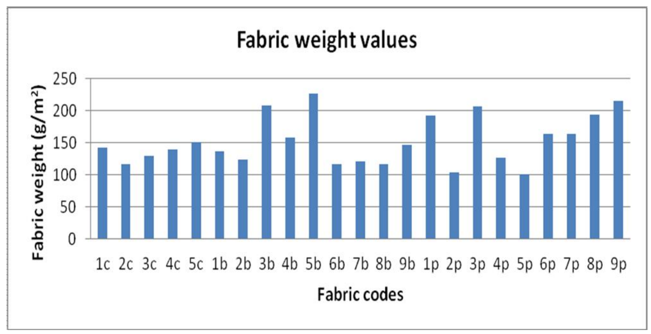

Fig. 7 fabric weights under study

Table 2 shows the correlation coefficients between garment appearance values, drape coefficients, and FAST properties for the fabrics under study.

Table (3) correlation coefficients between garment appearance values, drape coefficients, and FAST properties for the fabrics under study.

	W	G	C1	C2	B1	B2	E5 1	E5 2	E20 1	E20 2	EB5	F1	F2	Dc%	G.A.V.
W	1.000														
G	0.134	1.000													
C1	0.102	0.741	1.000												
C2	0.359	0.470	0.391	1.000											
B1	0.452	0.702	0.890	0.362	1.000										
B2	0.476	-0.004	-0.052	0.568	0.073	1.000									
E5 1	-0.145	-0.174	-0.299	-0.292	-0.270	-0.334	1.000								
E5 2	-0.137	-0.295	-0.109	-0.343	-0.262	-0.188	0.180	1.000							
E20 1	-0.207	-0.235	-0.358	-0.346	-0.357	-0.434	0.946	0.184	1.000						
E20 2	-0.140	-0.035	0.104	-0.160	-0.067	-0.129	0.250	0.653	0.255	1.000					
EB5	-0.379	-0.570	-0.532	-0.556	-0.543	-0.311	0.251	0.008	0.331	-0.085	1.000				
F1	0.380	0.410	0.675	0.199	0.719	-0.093	0.163	0.003	0.182	0.259	-0.398	1.000			
F2	-0.031	0.195	0.200	0.219	0.084	-0.009	0.096	0.266	0.056	0.741	-0.308	0.243	1.000		
Dc%	0.308	0.564	0.744	0.611	0.649	0.311	-0.518	-0.036	-0.607	0.129	-0.808	0.432	0.307	1.000	
G.A.V.	-0.130	-0.051	-0.276	-0.295	-0.194	-0.246	0.470	0.031	0.466	0.255	0.127	0.001	0.279	-0.382	1.000

It is obvious that properties that have the highest correlations with garment appearance value are extension at low loads in warp directions, drape coefficient, formability in weft direction, and bending properties.

Figure 8 shows the relation between garment appearance value and fabric drape.

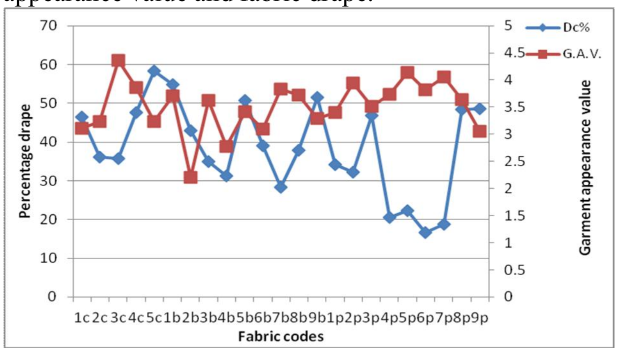

Fig. 8 relation between garment appearance value and fabric drape

From figure 8. It is obvious that garment appearance value and fabric drape does not have the same trend. This means that fabric drape by itself can not express the garment appearance.

Figures 9,10 show the relation between garment appearance value and formability in both warp and weft directions.

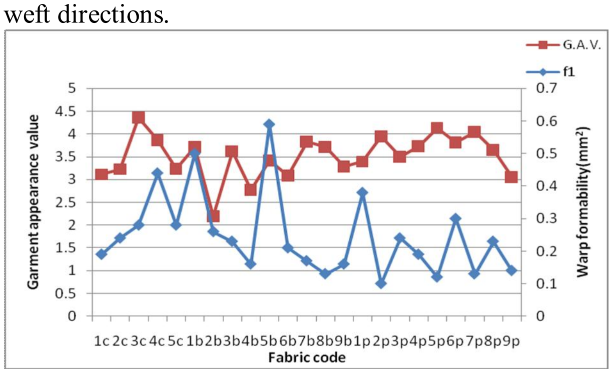

Fig.9 the relation between garment appearance value and formability in warp direction

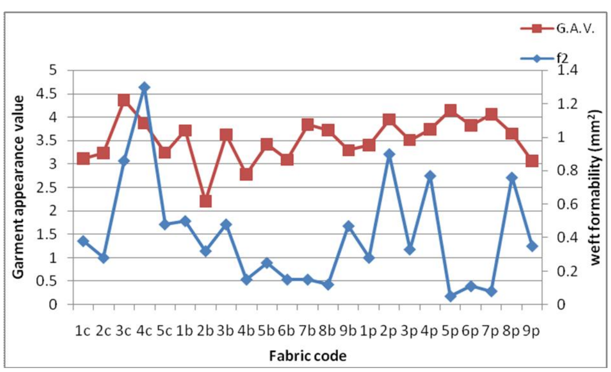

Fig.10 the relation between garment appearance value and formability in weft direction

It is clear from both figures 9 and 10 that garment appearance has different trend than fabric. formability in both directions.

Figures 11,12 shows the relation between garment appearance value and bending lengths in both directions.

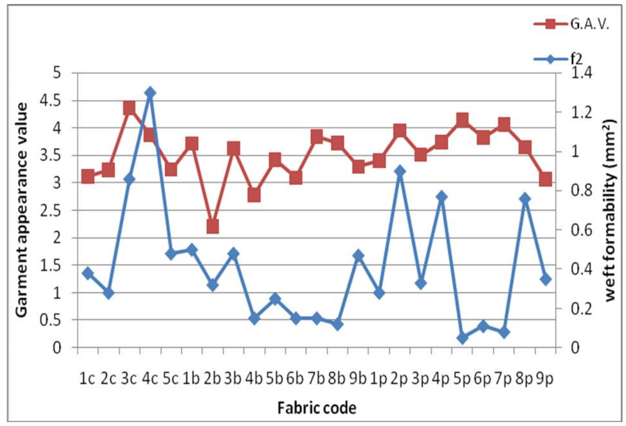

Fig.11 the relation between garment appearance value and bending length in warp direction.

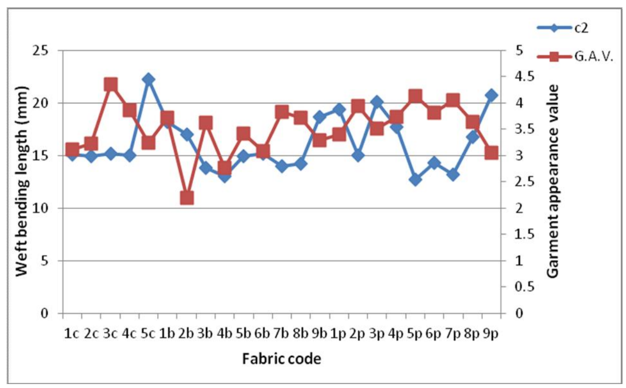

Fig.12 the relation between garment appearance value and bending length in weft direction.

Figure 13,14 shows the relation between garment appearance value and extinction at 5 g.f/cm in both directions.

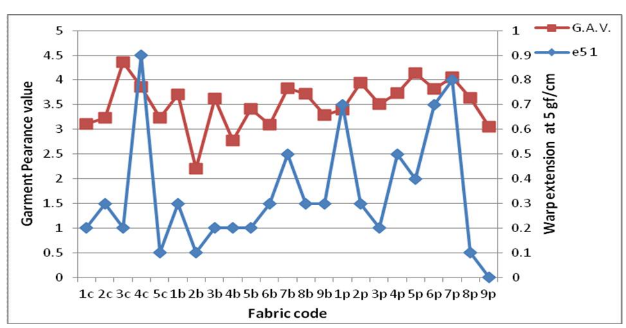

Fig.13 the relation between garment appearance value and extension at 5gf/cm in warp direction

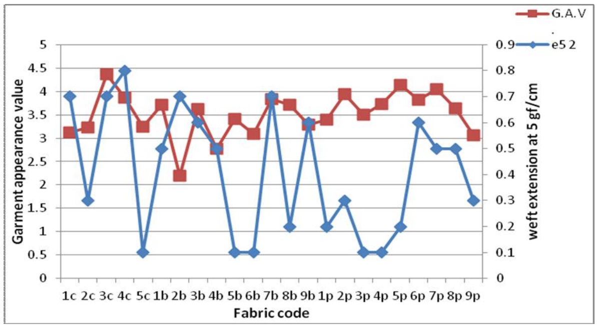

Fig. 14 the relation between garment appearance value and extension at 5gf/cm in weft direction

From all the previous figures it could be seen that there is no property could express the garment appearance value. So a step wise regression was done to try to find the relation between garment appearance value, FAST mechanical properties and fabric drape. The following regression equation was obtained with

G.A.V=5.5- 0.04 Dc - 0.01 EB5*C2 + 0.02 Dc*F2 - 0.03 E52*C1 R^2=0.51 (1)

Where G.A.V: garment appearance value, Dc: fabric drape coefficient, EB5: fabric extension at bias direction, F2: fabric formability in weft direction,C1: fabric bending length in warp direction, C2: fabric bending length in weft direction.

From equation 1. It is clear that there are different properties affect the garment appearance value. The relation between these properties and garment appearance is not linear. It could be seen that fabric drape appear in the equation twice once alone and once it interacts with fabric formability in weft direction and affects the garment appearance value. The lower the drape coefficient the higher the garment appearance value. Also the interaction between extension at 5 gf/cm and bending length in warp direction has a significant effect on garment appearance value. The equation may explain why in the previous figures there is no property by itself can express or determine the garment appearance value. The number of samples with their variability may be the cause of not obtaining a high R square in the equation.

6. Conclusion:

1. The garment appearance is affected by combinations of fabric properties.
2. There is no single fabric property that can describe the garment appearance.
3. Although fabric drape is important in garment appearance. It could not by itself describe the garment appearance.
4. Fabric drape combined with fabric formability in weft direction may helps in determining the garment appearance.
5. The more draped fabrics gives higher garment appearance.
6. Shear rigidity which expressed by extension in bias direction combined with bending length in warp direction helps to determine garment appearance.
7. The relationship between garment appearance, fabric mechanical properties, and fabric drape is not linear.

Further work:

It is recommended to study a garment appearance on a wide range of fabrics so that a clearer relationship between garment appearance and other fabric properties.

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12/22/2014