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Static and Dynamics Drape Of Fabric: An Emerging Arena of Fabric Evaluation

P. Pratihar
Department of Textile Engineering Faculty of Technology and Engineering, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, India

Abstract
Drape is one of the most important fabric properties from designer as well as end user point of view. The standard method of drape measurement is as per IS 8357:1977. This can be classified as static drape. In today's scenario, across all the areas, advancement of technology is remarkable. There is little doubt that the influence of technology has overtaken our lives. In the manufacturing field, technology solves a number of problems related to design, production and dispatching of products, providing the consumer with either low cost or large varieties of enhanced, sophisticated or unique products depending on the direction and philosophy of the company and its marketing strategy. One has to learn to co-exist with technology so are industries and it is not who will use the technology to combat competition in the world of markets of the future that is crucial, but rather who will develop new technologies to stay competitive. Dynamic drape behavior and simulations are gaining more and more popularity day by day. It is so, because it gives to some extent close to real life situation. Many research worker in abroad are working on the same since last decade, but unfortunately very few information, particularly data base information are available here. No readymade instrument is available here to study the dynamic drape behaviour of fabric.
Keyword:- drape, static drape, dynamic drape, instrument, simulation

I. INTRODUCTION

Drape is a very important property of fabric, as it plays major role in aesthetic appeal of fabric particularly when used as skirt, table-cloth, curtain, etc. It is directly related to textile aesthetics, which is important for the development, and selection of textile materials in apparel industries and especially for the design of clothes such as dresses and skirts. Drapeability of textiles is judged subjectively and is dependent on people's skill and experience, which render difficulties during drape comparisons, especially when judged by different people.

The next generation of textile and garment manufacturing and automated retailing system will need to predict the true 3-D behaviour of fabric and garment design and wear. It is generally accepted that one of the most important requirements for the development of a 3-D garment CAD system, is how to obtain the real shape of the garment in 3-D shape from the original 2-D design patterns. To do this effectively the deformable behaviour of textile material would play a very vital role in this area. Researchers have studied various methods to achieve this, however, unlike other engineering areas, the success of such modern methods are very limited in textile engineering. Commercial CAD system are still not able to meet those requirements. The major task is to find a precise and efficient approach to determine the real 3-D deformed shape of the cloth according to real fabric properties and to deal with complex 3-D design patterns [1].

II. TRADITIONAL APPROACH - STATIC DRAPE BEHAVIOUR OF FABRIC

A. Drape Measurement

The most widely accepted method of drape test is IS 8357:1977. In this test, a circular fabric sample whose diameter is 25.0 cm is placed on a circular disk of 12.5 cm. The cloth drapes and compresses internally owing to gravity, finally resulting in a flared shape. Then the drape coefficient is described as the ratio of vertical projection area to the entire sample area [2,3,4].

A diagrammatic representation of the same is given in the following Fig. 1 & 2

Fig.1: Actual Projection of Shadow (Photo taken from machine)

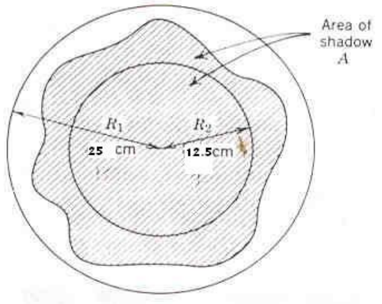

Fig. 2: Based on projections, various areas.

$$DrapeCoefficent = \frac{(A - \pi R_2^{\,2})}{\pi(R_1^{\,2} - R_2^{\,2})} \times 100\ \%$$

where A = Area within the projected outline of the draped fabric,

R_2 = Radii of the disk, R_1 = Radii of the fabric sample

The drape coefficient alone does not give a complete description of drape behaviour . There are many other aspects of the detailed form of draping. One other parameter which can easily be measured is the number of nodes formed as the fabric drapes. The following Fig. 3 illustrates how the number of nodes formed when the fabric bends symmetrically at the edge of the disc without double curvature and the number depends on the relative values of disc and fabric diameter. Flexible fabric will drape down by buckling into more folds than are shown in the Fig. 3

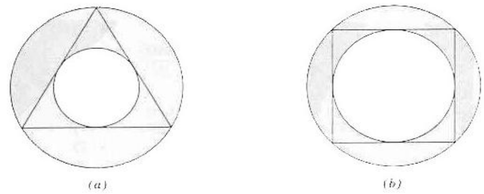

Fig.3: Influence of relative values of disc and fabric diameter on probable minimum number of nodes. (a) Specimen diameter 30 cm; disc diameter 15 cm – three nodes. (b) Specimen diameter 30 cm; disc diameter 21.3 cm – three nodes.

Cusick [5] (1962) confirmed this experimentally and the following Fig. 4 based on his schematic representation of how the number of nodes depends on fabric stiffness and disc diameter.

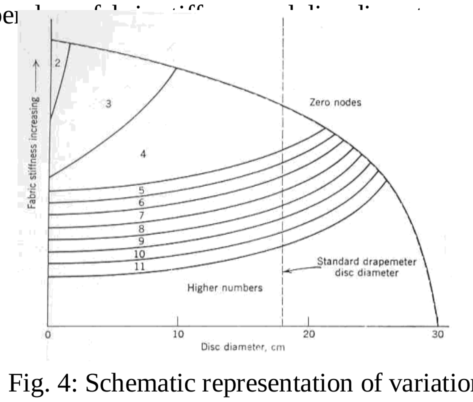

Fig. 4: Schematic representation of variation of number of nodes with disc diameter and fabric stiffness. Fabric diameter = 30 cm.

Very stiff fabric merely sag slightly without forming any definite nodes: this gives the area designated as zero nodes. The number of nodes increases as the disc diameter decreases and the fabric stiffness decreases.

There is general tendency for the number of nodes to decrease as drape coefficient rises. Same would be expected from the position of the disc diameter line in the fig above (Fig. 4).

A given fabric does not always drape with same number of nodes. In his work Cusick [5] (1962) found that 60 tests on a cotton cambric gave the following distribution of results:

6 nodes, 5 tests
7 nodes, 22 tests
8 nodes, 24 tests
9 nodes, 9 tests

The drape coefficient of the fabric was not much altered by differences in the number of nodes formed. The average value of drape coefficient with 6 nodes was 70% and with 9 nodes it was 72%. It is also possible to alter the number of nodes by disturbing the fabric. What this means is that there are a number of configurations where the energy passes through minimum values (corresponding to whole number of nodes) and the fabric does not necessarily fall in to the lowest of these configurations.

B. Various Fabric Properties and Drape of Fabric

From the discussions so far it can be seen that drape of fabric is a complex phenomena of various fabric properties like bending and buckling behaviour of fabric, shear properties, tensile properties, etc. Substantial amount of work has been done by various researchers and established lots of relationship between these parameters. Cusick [5,6,7] and Treloar [8] have done lots of work in this field and have investigated the dependence of drape of the fabric on bending and shear stiffness.

According to Hearle [9], in his text book, "Structural Mechanics of Fibres, Yarns and Fabrics" ch. 12, the major mode of deformation in draping is fabric bending, but due to occurrence of double curvature, some shearing also takes place. Sharma [10] *et* al have studied on low-stress mechanical properties of fabric and its relationship with drapability characteristics of a fabric. In their work, they have observed that the drape coefficient has a strong correlation with bending properties, good to strong correlation with shearing properties and poor correlation with tensile properties.

Nature of fabric deformation in drape is extremely important. The major mode of deformation in draping is fabric bending, but due to occurrence of double curvature some shearing also take place. Some tensile as well as compressive deformation also takes place, but as these are very small, can be ignored. Buckling behaviour also very important, but as it is related to bending stiffness, it will automatically be taken care of along with bending length, as stiffness is a function of bending length. Therefore, it was said that bending and shear properties are the main factors influencing drape. Again, as the fabric is draping under its own weight, the measure of bending length by Shirley stiffness test method will be appropriate. The general pattern of behaviour were also estimated by a considerations of what happens when the shear stiffness takes extreme values i.e. zero shear stiffness and infinite shear stiffness, in the said book [9].

Work done by Okur [11] *et* al gives the prediction of fabric drape coefficient from FAST data. In their work, relationship between fabric drape coefficient obtained from Cusick's drape meter and mechanical properties ascertained on the FAST system for women's woven suiting fabrics were examined and a multiple linear regression model was proposed.

Lai Sang-Song [12] had worked for establishing discriminant models of fabric characteristics. In the work four fabric groups, woven from cotton, linen, wool and silk were used. Discriminant analysis were used to characterize and discriminate between different fabric groups and 14 drape forms were able to classify the four groups of fabrics with a 98.3% classification accuracy rate.

In another interesting work by Lo [13] *et al*, have presented a model for predicting fabric drape profiles using polar coordinates. It is claimed that with the help of their developed model, the drape coefficient, node locations, node numbers and node shape in the fabric drape profile can be predicted. In this work polar coordinate fitting is used to determine the constants and a good agreement was observed between the theoretical and experimental drape profiles and drape coefficient%.

It was also claimed that drape profile can be directly predicted from bending and shear histeresis as constants in the drape profile model can be obtained by bending and shear histeresis using regression analysis. It was also suggested that for better prediction of the fabric drape profile, mean value should be taken in the warp, weft and ±45° directions than that in the warp and weft directions.

III. MODERN APPROACH - DYNAMIC DRAPE BEHAVIOUR OF FABRIC

The drape measurement technique IS 8357:1977 gives a fair idea about drape coefficient of a fabric in static condition. But, when skirt is hanged to body its drape pattern changes as the body movement takes place (Fig. 5 & 6). Even a same fabric when used as table cloth, may form different drape pattern, when its position is disturbed (Fig. 7). Therefore, it is needed to evaluate fabric drape coefficient, when it's static condition is disturbed. And also there is need to study what will be the drape coefficient after some movement in the fabric sample. This kind of study is called dynamic drape behavior study.

Fig. 5 : Using of Fabric as Long Skirt

Fig. 6 : Using of Fabric as Short Skirt

Fig. 7 : Using of Fabric as Table Cloth

Quite a bit of work has been done on static drape behavior of fabric by Cusick in 60s. In 70s & 80s, it was felt that drape is not much important. Therefore the main focus during this period was on tensile behavior of the fabric. But during 90s, due to rapid growth of readymade garment along with computerized manufacturing system, it was felt by various research workers and market surveyors that drape is very important property one need to look in to for giving proper shape of a garment after it's cutting and sewing. Moreover, to meet the customer requirement and stringent competition in the market one need to give best of the best quality of the fabric, so that when one uses the fabric, its drape property does not change much from morning to evening. The crease resistant fabrics with special finish etc. have come into existence because of this development.

To evaluate dynamic drape behavior of fabrics, a testing device was designed by Yang *et al*[11] and new adequate parameters which can represent dynamic drapeability were defined and the stability of those parameters were discussed. As the revolution of fabric increases, fabric overhangs and the projected area changes in three stages. Dynamic drape coefficient increases; which shows the degree of fabric overhanging with revolution speed, is defined as a parameter of dynamic drapeability. The effect of airflow is larger for rotating fabrics at higher revolution speed. Both the dynamic drape coefficient increase and the dynamic drape coefficient at 200 rpm showed high accuracy and reproducibility.

In another work on conventional static and new dynamic drape by Matsudaira & Yang[15], on Silk Fabrics finds that dynamic drape property is very useful for categorizing the fabric. In this work, conventional static and new dynamic drape coefficients of silk woven fabrics were examined precisely to distinguish those features of each classified fabric by its yarn structure using our regression equations.

IV. SIMULATION OF DYNAMIC DRAPE BEHAVIOUR OF FABRIC

The word Simulation means 'imitation' or 'replication', etc. As mentioned earlier, basically drape is fabric fall and it happens when part of the fabric is supported and part of it unsupported. Therefore, when a fabric is used as an apparel application or industrial application and whenever there is any movement of the object during its application its drape changes.

It has always been clear that woven materials have unique properties that allow them to deform in ways significantly different than other sheet materials, e.g. paper, vinyl or metal foils. Cloth's special deformation capabilities have been noted and recognized through the ages, but never really fully understood from a specific scientific or engineering perspective.

In engineering, great progress has been made in developing theories to explain and predict the deformation behaviour of nearly rigid materials like steel or stiff plastics. This has made possible the development of robust tools for computer-aided design (CAD), allowing engineers to design and analyze steel structures on computers long before any real structure is actually built. Unfortunately, same is not true for flexible materials such as cloth. For these material, few CAD tools exit, forcing apparel designer to use more traditional and less efficient design methods. One of the main reasons for the dearth of apparel CAD tool is the lack of good mechanical models of fabric that may be used to simulate and predict the folds and buckles of a draping cloth[16].

Today there are many design programs with various software tools and a wide choice of designing functions are available. These work on a sketching model that can produce a visual presentation on how colours, motifs and materials look on a scanned model. Production preparation steps such as pattern construction, grading system, pattern planning and optimization and automated cutting are realized with computer assistance. However, as reported by Fischer *et al* [17], CAD systems available in the market have two weak spots: the system work only two-dimensionally, and the material behaviour and parameters are not taken into account.

Therefore, it can easily be seen that true simulation of drape behaviour is not possible. But, alternately, what can be done is, attempt for partial simulation of fabric drape behaviour and from the partial simulated drape behaviour test data one can predict the further application behaviour of the fabric. It will also be helpful for categorizing the fabric in terms of its fabric fall behaviour.

V. CONCLUSION

Drape is one of the most important fabric properties particularly from designer point of view. Earlier researches in textile mechanics mainly focused on the understanding of relationship between the mechanical properties of fabrics and those of the yarns as well as fabric structures. To assist designers achieving satisfactory aesthetic objectives at the clothing design stage, many recent researches have focused on the development of computer aided design and engineering (CAD/CAE) programs for garment. Dynamic condition of a textile fabric is very complex than its static position. Therefore, dynamic drape behavior and dynamic drape coefficient are gaining more and more popularity day by day. It is so, because it gives to some extent close to real life situation.

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