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INFLUENCE OF NONWOVEN LINING MATERIALS ON THE PRFORMANCE PROPERTIES OF ASSEMBLED APPAREL FABRICS

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Abstract

This work evaluated the properties of a group of apparel fabrics before and after they are fused with synthetic lining materials. Results showed that tactile properties of the assembled fabrics, especially bending and shear properties, undergo a manifold change after fusing. While the property changes moderated somewhat after dry cleaning, the gap in properties between the fused and unfused fabrics remained substantial even after dry cleaning. The observed changes in properties were substantial both for woven and knitted fabrics and also for polyester and nylon lining materials. The weight of the lining material showed a direct association with the level of change in the bending and shear properties, and this was true for both woven and knitted fabrics. For the same basis weight, nylon-rich lining material caused a lower increase in bending and shear rigidities compared to polyester-rich lining material.

In terms of durability of the assembled fabric, both nylon and polyester lining materials contributed to an improvement in the tensile and abrasion resistance properties but they did not influence the tear strength of the fabric to an appreciable extent.

Materials and Methods

Materials

The construction particulars of the face fabrics and the lining materials used in are given in Tables 1 and 2.

The face fabrics represented both woven and knitted construction and also three common fiber types of apparel fabrics that are subjected to fusing with synthetic lining materials namely, wool, polyester, and a polyester-cotton blend. The cotton polyester fabric was a light weight fabric while the other three were medium weight fabrics. Fabric 2 was a plain knit (jersey) fabric while the other three were plain woven fabrics.

All six lining materials used in the study were adhesive bonded nonwovens produced from super imposed card webs and all six materials carried both polyester and nylon fibers. Lining materials A, E and H carried at least 80% polyester in the fabric while linings C, F and G carried at least 65% nylon in the fabric. Lining E represented average weight, while linings F, G, & H represented below normal weigh, and linings A & C represented above normal weight.

Test Methods

The major forces acting on a fabric when it is rubbed between fingers for subjective hand evaluation are bending, shear, compression and tensile forces. The instruments developed by Kawabata basically characterize fabric response to these forces under low stress conditions. The shape of the force-deformation curves and certain numerical values extracted from these curves characterize the response of the fabric under a given set of deformation and recovery conditions. The following paragraphs provide a brief description of the individual Kawabata tests and the parameters evaluated from each test. More detailed description of test methods and measuring principles can be obtained by referring to the publications of Kawabata et al.

Shear. The shear test is carried out on the same instrument used to run the tensile test (the KES Tensile and Shear Tester performs both the tensile and shear tests, one at a time). As in the case of the tensile test, the fabric sample is mounted between two sets of clamps (forward and backward clamps) but the front set of clamps moves side ways to impose a shear stress on the fabric. The size of the test specimen used is again 20 cm by 5 cm. Starting from the initial position, the 20 cm wide fabric sample is first sheared 10 degrees to the right and then the horizontal shearing motion of the front clamps is reversed until they reach their original(zero shear angle position). The sample is again sheared 10 degrees to the left and then the shear motion is fully reversed as before. The shear test therefore permits the measurement of both shear modulus and shear hysteresis properties when the fabric is sheared in both directions. The physical parameters computed in the shear test are:

G. shear modulus (gf/cm.degree), which is the slope of the shear curve, and

2HG. hysteresis width at a shear angle of 0.5 degrees (gf/cm)

2HG. hysteresis width at a shear angle of 5 degrees (gf/cm)

Bending. The bending test involves bending a 20cm by 1cm sample to a standard curvature and then reversing the bending motion in order to study both bending and recovery behavior. The fabric sample is bent not only in the warp and filling directions, but also on the face and reverse sides. Average values of test parameters(bending rigidity and bending hysteresis)are reported for the fabric as a whole, taking into account both warp and filling direction tests and forward and backward tests. Thus the parameters evaluated to characterize the bending behavior are:

B. bending rigidity (modulus), which is the slope of the bending curve that lies between the radius of curvatures 0.5 cm^{-1} and 1.5 cm^{-1} (gf.cm/cm2), and

2HB. hysteresis width at a bending curvature of 1.0 cm^{-1}(gf cm/cm).

Compression. In the compression test, a standard area of the fabric 3.14 sq.cm) is subjected to a known compressive load (50 g/sq.cm) and then the load is gradually relieved. The load is applied through a movable plunger that moves up and down and compresses the fabric sample kept on a stationary platform. The following physical parameters characterize the compression and recovery behavior of the fabric:

TO. fabric thickness (mm) at a very low compressive load (0.5 g/sq.cm),

TM. fabric thickness (mm) at the maximum compressive load (50.0 g/sq.cm),

WC. work done in compression, represented by the area under the compression curve, (gf.cm/cm2),

RC%. compressive resilience, which is the ratio of work recovered to work done, expressed as a percentage, 100(WC'/WC)

LC. linearity of the compression curve (no units),

EMC%. compressibility which is the ratio of measured reduction in thickness to the original fabric thickness, expressed as a percentage, 100(TO–TM)/TO

The instrument settings and stress levels used in compression, shear, and bending tests are listed in Table3.

Breaking Load and Breaking Elongation – The breaking load and breaking elongation of the fused and unfused fabrics were measured using the Instron tester. Six cut strips measuring 1" by 6" were tested for each direction to compute the average breaking load. Fabric strength and elongation were obtained as the averages of the warp and filling direction tests.

Tear Strength – Tear strength was also measured on the Instron tester. Four specimens were subjected to tear in each direction. Measured strengths in the warp and filing directions were averaged to obtain the fabric strength.

Abrasion Resistance – Abrasion resistance was measured on the CSI universal abrasion tester. Six specimens were abraded for each fabric. The number of abrasion cycles were decided on the basis of initial trial runs that produced 2-3% weight loss on face fabrics. The level of rubbing was varied for the four fabrics to keep their weight loss around the same level.

Results and Discussion

Relationship between the Type of Lining and the Bending Rigidity of the Assembled Fabric

Figures 1 illustrates the effect of the bending rigidity of the lining material on the bending rigidity of the assembled fabric. Figure 2 illustrates the relationship between the weight of the lining material and the bending rigidity of the assembled fabric.

It can be seen from Figure 1 that the bending rigidity of all four face fabrics exhibits a direct relationship with the bending rigidity of the lining material. Stiffer lining caused stiffer assembled fabric and this is true for all four fabrics. Looking at the bending rigidities of linings G and H and of their assembled fabrics, it can be seen that lining H which is lighter than lining G is actually stiffer to bend than G and so are the assembled fabrics containing H. Lining H carries 90% polyester while lining G carries 70% nylon. Therefore, it is clear that from the point of view of fabric bending rigidity a nylon-rich lining is better than a polyester-rich lining.

Relationship between the Weight of Lining and the Bending Rigidity of Assembled Fabric

From Figure2 it is clear that lining weight is a good predictor of the bending rigidity of the lining material as well as that of the assembled fabric. In fact the figure shows that using lining weight, one can predict the bending rigidity of both the lining material and of the assembled fabric at about the same level of accuracy (about 80%).

Relationship between the Type of Lining and the Shear Rigidity of Assembled Fabric

Figure3 shows that shear rigidity of the lining material also directly influences the shear rigidity of the assembled fabric. Also looking at the shear rigidities of linings G and H and of their assembled fabrics, it can be readily interpreted that nylon contributes to a lower increase in shear rigidity of the assembled fabric than polyester.

Relationship Between the Weight of Lining and the Shear Rigidity of Assembled Fabric

Figure 4 shows that weight of lining is even a better predictor of shear rigidity than bending rigidity. The weight of lining predicts the shear rigidity of the lining material close to 93% accuracy. It predicts the shear rigidities of the assembled woven fabrics close to 80% accuracy and that of the assembled knit fabric close to 75% accuracy.

Effect of Dry Cleaning on the Bending Rigidity of Assembled Fabric

Figure 5 shows the influence of dry cleaning on the bending rigidities of woven (#4) and knit (#2) fabrics that were fused with linings E and G. It is clear that after dry cleaning, the assembled fabric looses some of its initial bending rigidity and this is true both for woven and knitted fabrics and also for lining materials E and G.

Effect of Dry Cleaning on the Shear Rigidity of Assembled Fabric

Figure 6 shows that while the shear rigidity of the polyester knit fabric has dropped substantially after dry cleaning, that of the woven wool fabrics has actually increased by a considerable margin. It is clear that the dry cleaning induced relaxation/consolidation of the assembled 100% polyester knit fabric makes the assembled fabric discard some of its initial resistance to both bending and shearing deformations. However, the dry cleaning induced relaxation of the woven wool fabric substantially increases the shear rigidity, while at the same time allowing for a drop in bending rigidity of the fabric assembly. The difference in the relaxation patterns and in the low-stress mechanical properties of the relaxed fabric assemblies appears to arise from both fabric construction and fiber content. From this study it is not possible to identify which of the two factors made the two relaxed fabric assemblies to behave differently.

Effect of Lining E on the Compression Behavior of Assembled Fabric

Figures 7 and 8 illustrate that the lining did not exert a major influence on the compression behavior of the assembled fabrics.

Influence of Lining E on Braking Load and Breaking Elongation of Assembled Fabric

Figure 9 shows that the lining increased the breaking load of all four face fabrics. The load bearing capacity of the three woven fabrics improved more than that of the knitted fabric. Figure 10 shows that the lining contributed to an increase in the breaking elongation of the to wool fabrics and also that of the knit fabric. The lining material slightly lowered the breaking elongation of the light weight polyester/cotton fabric.

Influence of Lining E on Tear Strength of Assembled Fabric

Figure 11 shows that the lining has slightly increased the tear strength of the knitted fabric while it did not influence that of the woven fabrics to a substantial extent.

Influence of Lining E on Tear Strength of Assembled Fabric

Figure 12 indicates that the fused lining material boosts the abrasion resistance of all four face fabrics.

Summary and Conclusions

This work demonstrated that the lining material has a major influence on the tactile and durability properties of assembled apparel fabrics. Results clearly demonstrate that by working together, the apparel manufacturers and the lining material manufacturers can produce assembled garments in which the properties of the lining material compliments and boosts that of the face fabric. By providing for a good marriage of the components through their appropriate design and selection, it may be possible to produce superior apparel products, while at the same time saving the material and manufacturing costs. Correct choice of the lining can certainly enhance the garment and the vast potential that exists to improve the end use performance of high end apparel products by paying close attention to the design and selection of both the face fabric and the lining material appears to remain largely untapped.

Table 1. Construction particulars of the face fabrics.

S. No	% Fiber Composition			Fabric Type	THREADS/INCH		THICKNESS mm	WEIGHT mg/cm2
	Wool	Polyester	Cotton		Warp	Fill		
1	-	65	35	Woven-P	66	66	0.638	12.9
2	-	100	-	Knit-SJ	31	34	1.253	23.26
3	100	-	-	Woven-P	49	38	0.569	21.74
4	100	-	-	Woven-P	63	52	0.567	18.67

Table 2. Construction particulars of the lining materials.

Sample	Fabric Type	% COMPOSITION Polyester	Nylon	Adhesive Type	Thickness mm	WEIGHT (mg/cm2) Base	Adhes	Total	Dots per Inch
A	Nonwoven	85	15	Polyamide	0.66	5.09	1.7	6.79	42
C	Nonwoven	26	74	Polyamide	0.655	5.09	1.36	6.45	42
E	Nonwoven	80	20	Polyamide	0.696	4.07	1.02	5.09	42
F	Nonwoven	35	65	Polyester	0.354	2.03	1.02	3.05	57
G	Nonwoven	30	70	Polyester	0.465	3.39	1.02	4.41	57
H	Nonwoven	90	10	Polyester	0.376	2.37	1.02	3.39	57

Table 3. KES Instrument Settings for Fabric Testing.

Compression
Rate of compression: 0. 02 mm/sec
Maximum compressive force: 50.0 g/sq.cm
Area compressed: 2.0 cm. diameter circle
Bending
Rate of bending: 0.5 cm-1/sec
Maximum curvature: ±2.5cm-1
Specimen size (LxW): 20cm x 1cm.
Shear
Rate of shearing: 0.417 mm/sec
Max. Shear angle: ±8 degrees
Pre-tension: 10 gf/cm
Specimen size (W*L): 20cm x 5cm

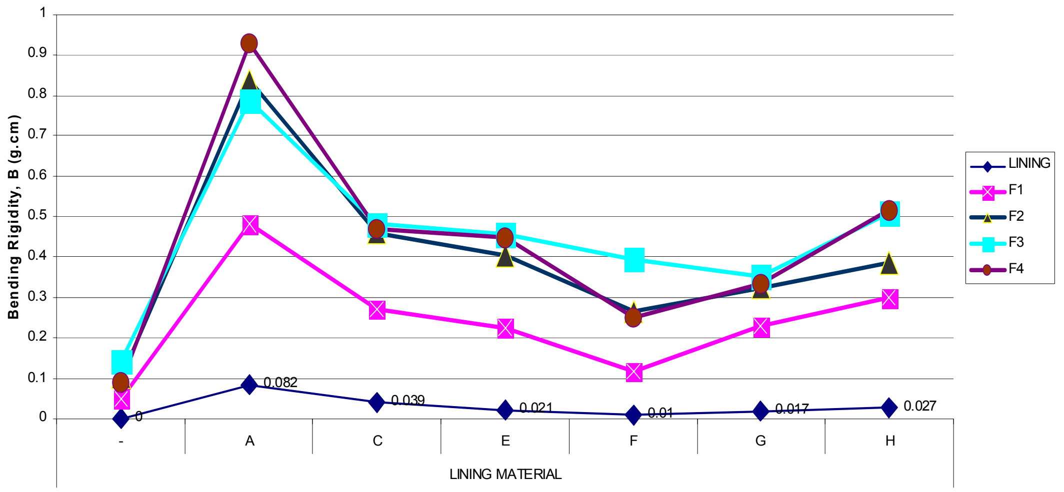
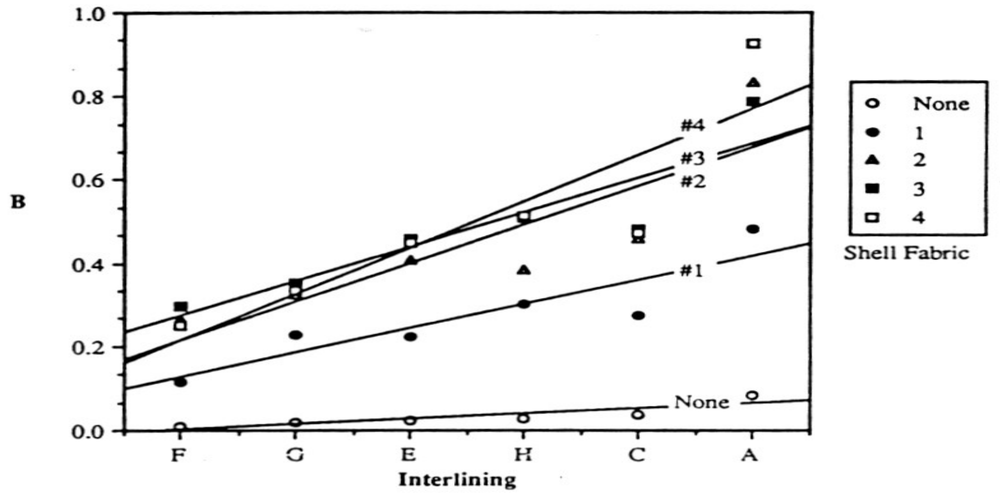


Figure 1. Influence of weight of lining on the bending rigidity of assembled fabric.



None : Y = -0.0105 + 0.0123X $R^2 = 0.783$

#1 : Y = 0.0672 + 0.058X $R^2 = 0.806$

#2 : Y = 0.1223 + 0.0923X $R^2 = 0.731$

#3 : Y = 0.1902 + 0.0829X $R^2 = 0.825$

#4 : Y = 0.1045 + 0.1104X $R^2 = 0.772$

Figure 2. Regression plot of bending Rigidity Vs weight of lining.

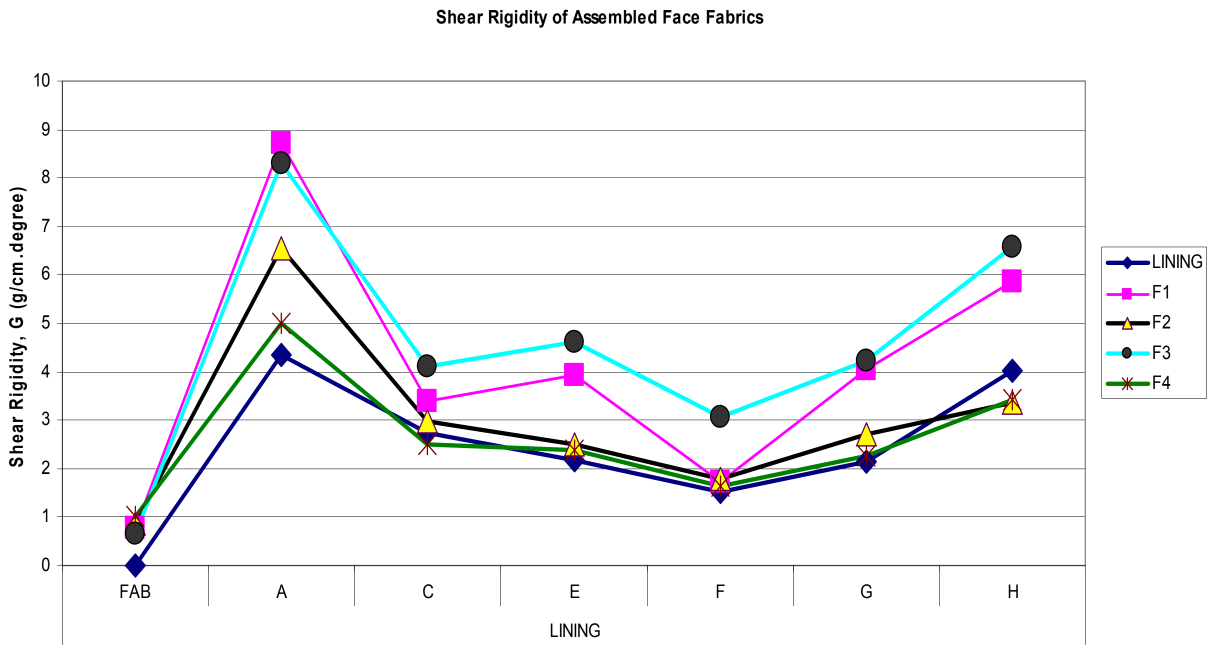
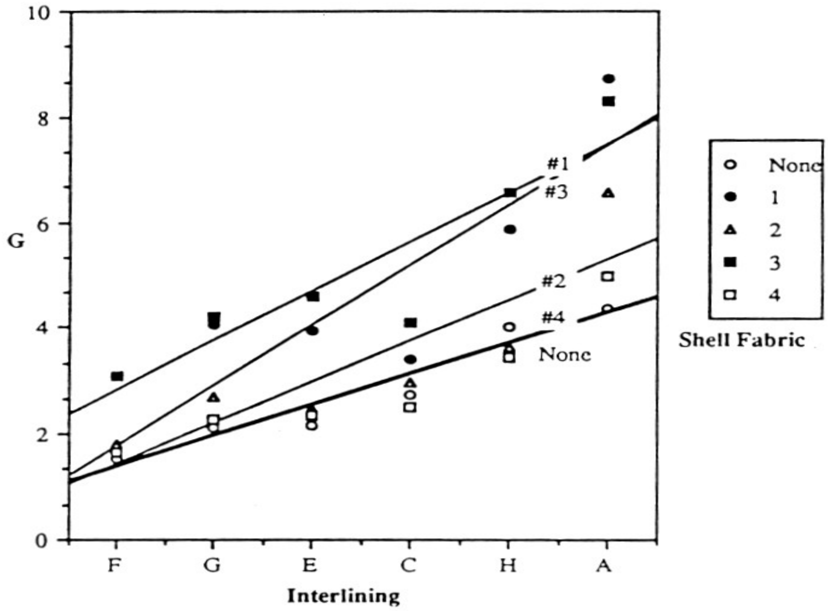


Figure 3. Influence of shear rigidity of the lining on the shear rigidity of the assembled fabric.



None : Y = 0.79056 + 0.58071X R^2 = 0.931
#1 : Y = 0.61978 + 1.1406X R^2 = 0.779
#2 : Y = 0.65400 + 0.77338X R^2 = 0.744
#3 : Y = 1.8749 + 0.93448X R^2 = 0.823
#4 : Y = 0.83089 + 0.58133X R^2 = 0.836

Figure 4. Relationship between Lining Weight and the Shear Rigidity of Assembled Fabric.

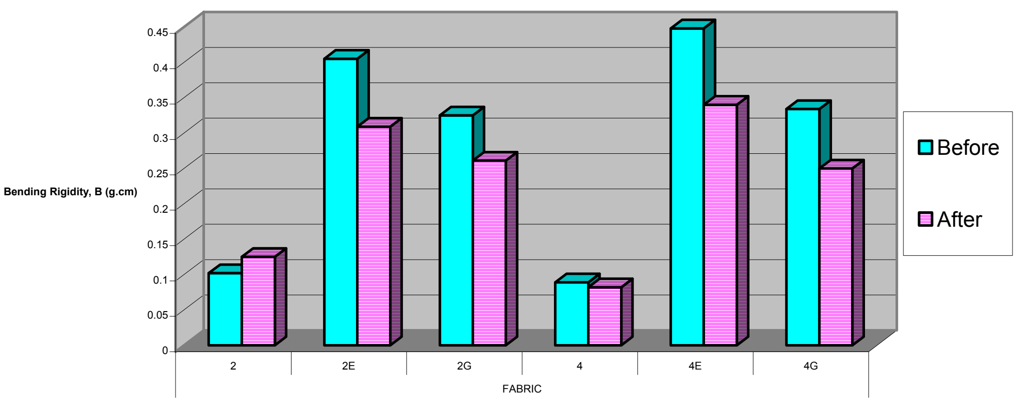


Figure 5. Effect of dry cleaning on the bending rigidity of the assembled fabric.

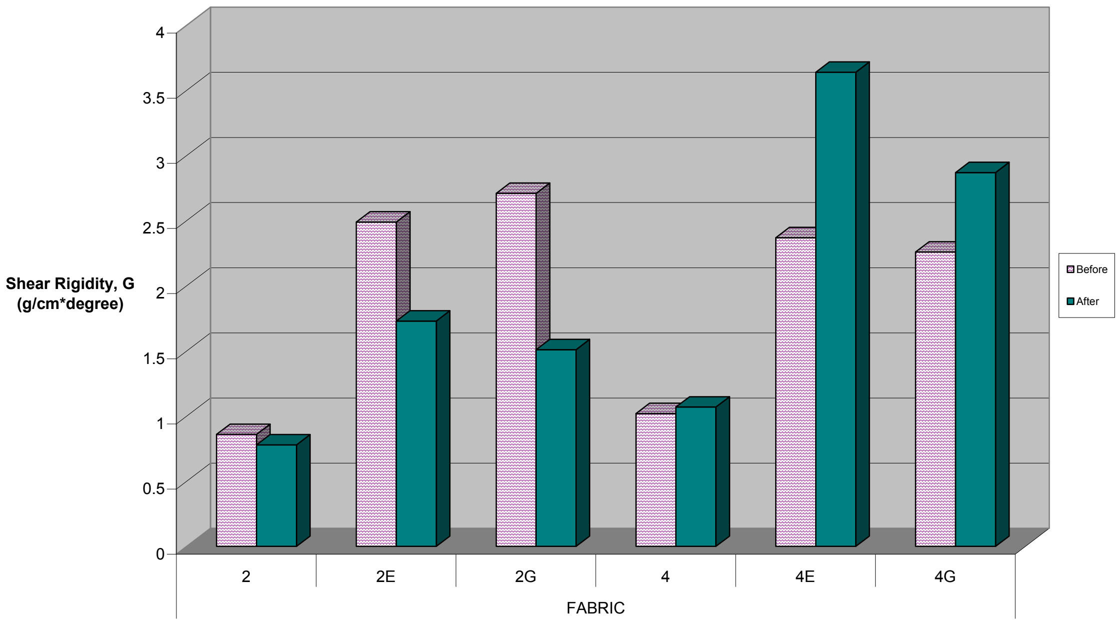


Figure 6. Effect of dry cleaning on the shear rigidity of assembled fabric.

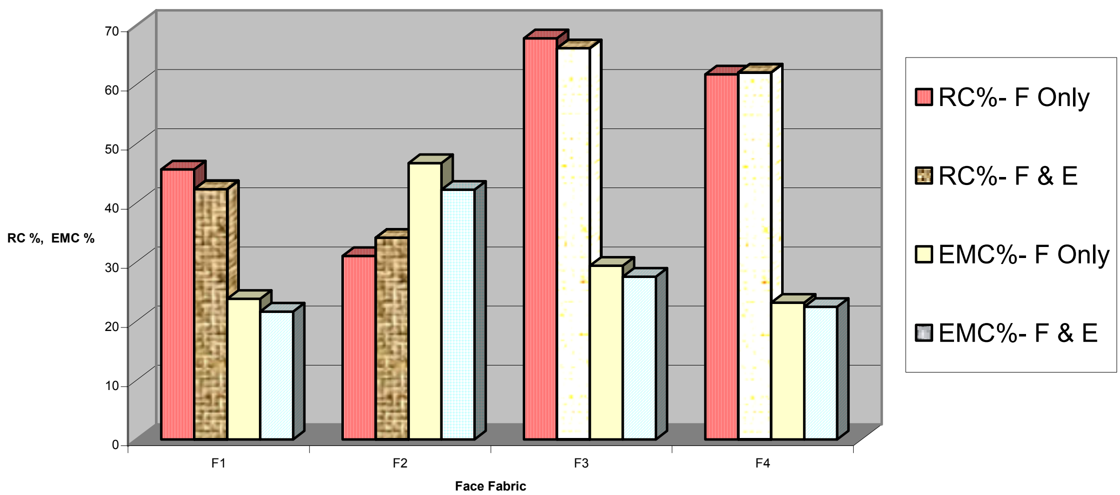


Figure 7. Influence of Lining E on compression properties (RT% & EMT %).

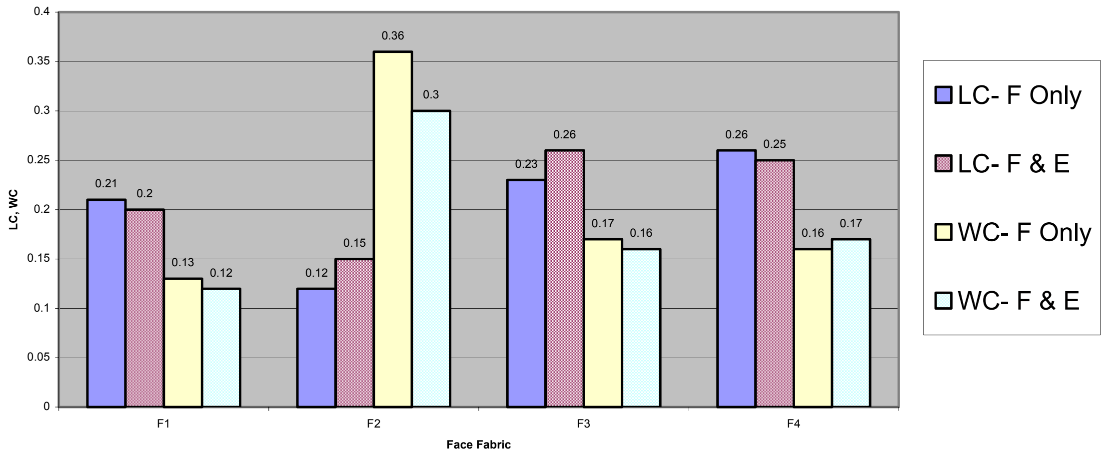


Figure 8. Influence of Lining E on compression properties (LC and WC).

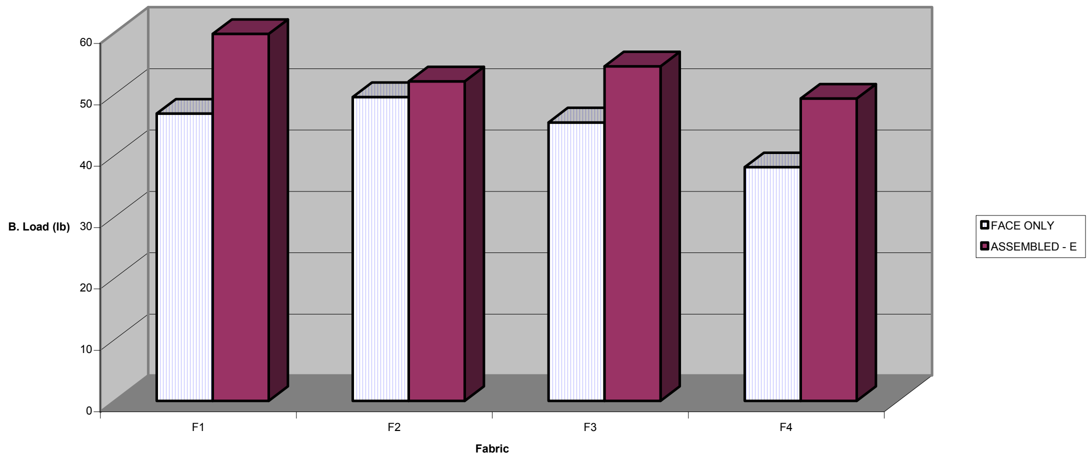


Figure 9. Influence of lining E on the breaking load of assembled fabric.

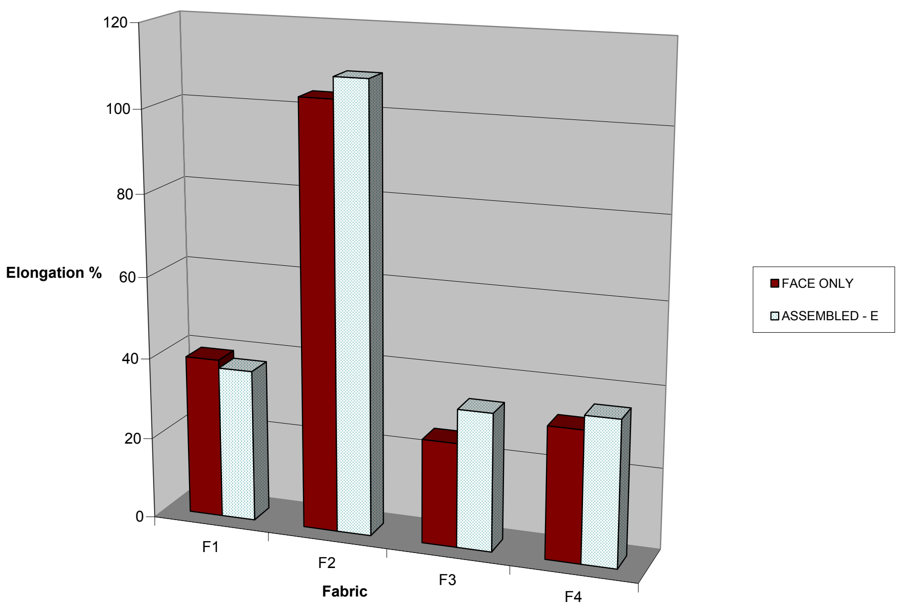


Figure 10. Influence of lining E on breaking elongation of assembled fabric.

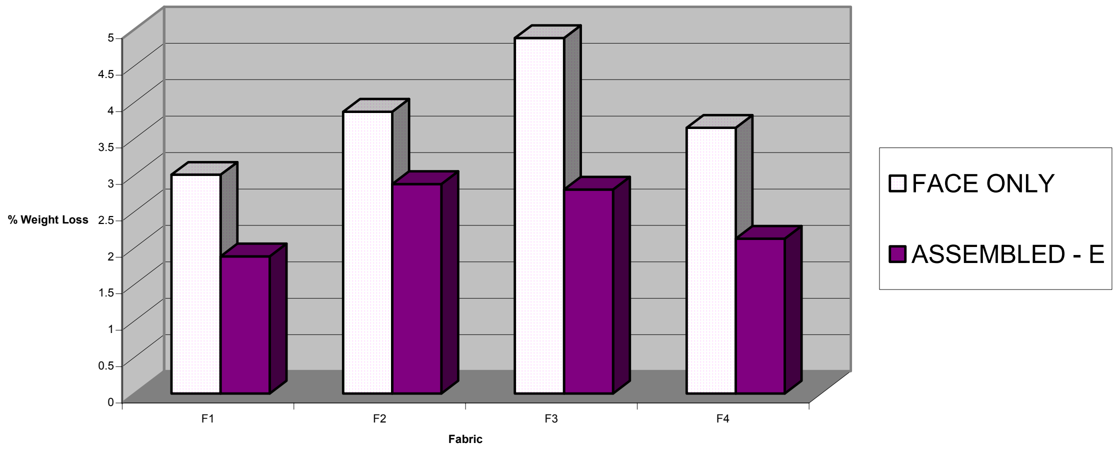


Figure 11. Influence of lining E on the tear strength of assembled fabric.

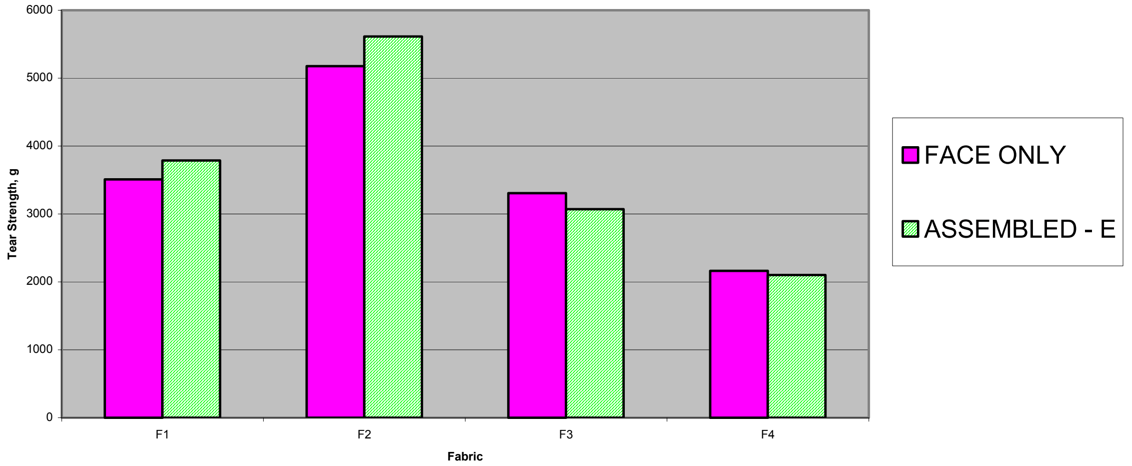


Figure 12. Influence of lining E on the abrasion weight loss of assembled fabrics.