(REFEREED RESEARCH)

THE EFFECTS OF SEAM PARAMETERS ON THE STIFFNESS OF WOVEN FABRICS

DİKİŞ PARAMETRELERİNİN DOKUMA KUMAŞLARIN EĞİLME DAYANIMI ÜZERİNE ETKİLERİ

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ABSTRACT

This paper presents a study of the effects of seam parameters on the stiffness of woven fabrics with vertical plain seams. To investigate the stiffness of a sewn fabric, bending length and flexural rigidity must be obtained. In this study, the effects of seam parameters such as sewing thread size, stitch density and seam allowance on bending behaviour were evaluated. Cantilever test was used to determine the relationships between the bending properties and seam parameters of the sewn fabrics. It was found when sewing thread size , stitch density and seam allowance of a vertical plain seam on the cotton woven fabric increased, bending length, flexural rigidity and stiffness of fabric also increased. Therefore there is necessity to optimize the seam parameters such as sewing thread size, stitch density and seam allowance in order to decrease the stiffness of the fabric on the garment. The fabrics with the seams with 3 stitch/cm and 2 mm seam allowance and sewing thread with 140 ticket number had lower flexural rigidity and stiffness.

Key Words: Seam, Plain seam, Stiffness, Bending length, Flexural rigidity.

ÖZET

Bu çalışma; dikiş parametrelerinin, düz dikişli dokuma kumaşların eğilme dayanımı üzerine etkilerini incelemektedir. Kumaşın eğilme dayanımını araştırmak için, eğilme uzunluğu ve eğilme rijitliği bulunmalıdır. Bu çalışmada, dikiş ipliği kalınlığı, dikiş sıklığı ve dikiş payı gibi bazı dikiş parametrelerinin eğilme davranışı üzerine etkileri değerlendirilmiştir. Cantilever testi, dikilmiş kumaşların dikiş parametreleri ve eğilme özellikleri arasındaki ilişkileri belirlemede kullanılmıştır. Araştırma sonucunda, pamuklu ve düz dikişli dokuma kumaşta dikiş ipliği kalınlığı, dikiş sıklığı ve dikiş payı arttıkça kumaşın eğilme uzunluğu, eğilme rijitliği ve eğilme dayanımının artmakta olduğu bulunmuştur. Bu nedenledir ki; dikiş sıklığı, dikiş ipliği kalınlığı ve dikiş payı gibi bazı dikiş parametrelerinin, giysinin kumaşının eğilme dayanımını azaltmak için optimize edilmesi gerekliliği önemlidir.3 dikiş/ cm dikiş sıklığı, 2 mm dikiş payı ve 140 etiket numaralı dikiş ipliği ile dikilmiş kumaşlar düşük eğilme rijitliği ve eğilme dayanımına sahiptir.

Anahtar Kelimeler: Dikiş, Düz dikiş, Eğilme dayanımı, Eğilme uzunluğu, Eğilme rijitliği.

Received: 28.01.2009 Accepted: 10.06.2009

1. INTRODUCTION

In apparel industry, the sewing process is one of the critical processes in the determination of productivity and the quality of the finished garment (1). The seams affect the fabric stiffness greatly. Fabric stiffness may not be wanted too high for a good drape in apparel and garment fabrics. Therefore there is necessity to optimize the seam parameters such as sewing thread size, stitch density and seam allowance in order to decrease the stiffness of the fabric on the garment.

Studies of fabric bending have been mainly restricted to fabric without seam. Nevertheless, the formation of a seam in a fabric changes its bending properties and eventually influences its drape. Obviously, it is also believed to affect garment drapesignificantly with the implications of seam parameters such as seam allowances, stitch density and sewing thread size (2,3,4).

However, evaluation on fabric drape with seams is still lacking in the literature. Resistance to bending or flexural rigidity is called stiffness in textile test methods. The longer the bending length, the stiffer is the fabric (6,8). Fabrics with very high bending rigidity values may lead to sewing and handling problems as they are too stiff to be manipulated and controlled (1).

During recent years, the investigation of fabric stiffness has attracted the attention of many researchers because of the attempts to realize the clothing CAD system by introducing the fabric properties (4).

In recent years, some researchers have investigated the effect of the seam allowance of a vertical plain seam on a fabrics drape. And also some researchers studied the effect of a plain seam on bending rigidity using the KES-F bending tester. They found that a plain seam has little effect on fabric shear rigidity and hysteresis but strongly influences bending rigidity. They also pointed out that bending hysteresis and bending rigidity were strongly affected by seam allowances (SA). They found from their experiments that the bending length (c) of a fabric strip increased with the addition of a vertical seam, but did not increase continuously with increased seam allowance. The increase rate was the most rapid at initial stage from SA= 0 mm (no seam) to 1 mm. When the seam allowance was greater than

2.5 mm, there was a limited increase in bending length (2).

Thread crimp, number of layers and seam allowance are the important factors affecting fabric bending, but the effect of a seam on fabric bending is also related to the sewing thread size. Although the effect of the sewing thread on seam performance is generally much less noticeable than that of the fabric, many situations occur when the use of better sewing thread represent a practical solution to a seam performance problem (7).

The measurement of fabric stiffness using Peirce's formula is known as the cantilever bending test. The stiffness of fabrics is commonly measured along the warp and weft directions in woven structure (5,8,10).

In this study, cantilever test was used to determine the relationship between the bending properties and seam parameters of the sewn fabrics.

2. MATERIALS AND METHODS

Cotton plain fabric was woven with weft and warp yarn 15 tex . The weigth per unit area of the fabric was 138 g/ m^2. The warp density was 60 thread/cm and the weft density was 36 thread/cm. The thickness of the fabric was 0.275 mm .

Table 1 shows the bending properties of the fabric without seam. Two different sewing thread (ticket number 80 and 140) made of 100 % PET were used for the upper and lower thread at the lockstitch sewing machine (Juki DDL-5550) for the seams of the fabric samples. Table 2 shows the properties of the sewing threads used. The code number of the needle was 90/4. The SSa-1 seam type and 301 stitch type were used at the samples. Two different sewing thread sizes, three different stitch densities and three different seam allowances were chosen for seams. Therefore 18 different fabric sample with different seam parameters were obtained.

All specimens were placed in the standard testing atmosphere for 24 hours before test.

The tests carried out during the study are decsribed in the following paragraphs.

The test to determine the "Stiffness of fabric" was carried out according to ASTM 1388-64 and TS 1409 with using a stiffness tester. Equation (1), (2) and (3) was used to calculate the stiffness of fabrics for each sewn fabric strip (6,9).

$$c = O / 2 \quad (1)$$

c = Bending length
O= The length of overhang, cm

$$G = W (O / 2)^3 = W \times c^3 \quad (2)$$

G = Flexural rigidity, mgcm
W = Weigth per unit area, mg/ cm^2

$$G_o = (G_w G_f)^{1/2} \quad (3)$$

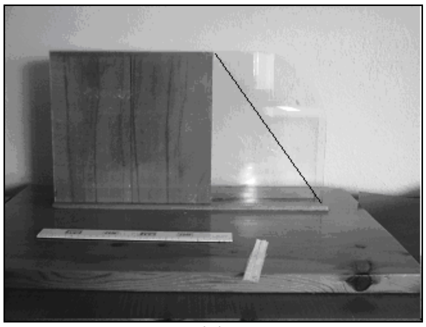
G_o = Overall flexural rigidity
G_w = Warp flexural rigidity
G_f = Weft flexural rigidity

A strip of fabric is slid in a direction parallel to its long dimension, so that its end projects from the edge of a horizontal surface. The length of overhang is measured when the tip of the test specimen is depressed under its own weigth to the point where the line joining the tip to the edge of the platform makes an angle of 41.5 deg with the horizontal. One half of this length is bending length (c) of the specimen. The cube of this quality multiplied by the weight per unit area of the fabric is the flexural rigidity. This method is also known as the Single Cantilever Test. The stiffness tester used in experiments was shown at Figure 1 (6,9).

Test specimens were cut 25 by 150 mm. (+/- 1). We cut our specimens with the long direction paralel to the warp and four with the long direction paralel to the weft. We took four readings from each specimen, with each side up, first at one end and then the other. We call these averages the "length of overhang" and express them in centimeters. Vertical seams were always arranged in the middle of the specimens (6,9). Figure 2 shows the back side of fabric strip with seam allowance and rigth side of fabric strip with a plain seam at the center and the cross- sectional area of fabric with a vertical seam (2). Table 3 shows the bending length, flexural rigidity and overall flexural rigidity results of fabrics with different seam parameters.

Costat (Version 3.3) was used for all statistic procedures. The results of bending length and flexural rigidity were evaluated by analysis of variance (ANOVA) and Student-Newman- Keuls (SNK- Version 3.30) tests. Analysis of variance were applied to data to understand the statistical importance of seam parameters on bending length and flexural rigidity.

All test results were assessed at a significance level of 0.05. Table 4 shows the results of the SNK test. SNK test results show the significant ranges of the sewing thread numbers, stitch densities and seam allowances with a,b,c values. If mean values of all the variables were "a", then there wasn't any significant effect of these variables. According to SNK (Student Newman Keuls) test results, seams with 3 stitch/cm, 2mm seam allowance and sewing thread with 140 ticket number had lower flexural rigidity and stiffness.



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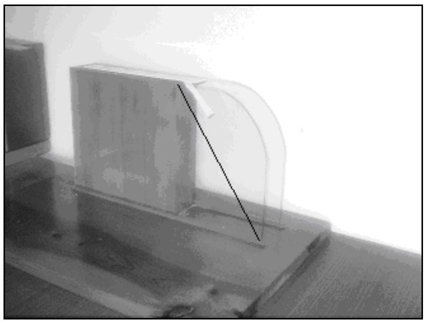

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Figure 1. (a) Cantilever tester without fabric strip, (b) Cantilever tester with fabric strip, (9)

Table 1. Bending properties of fabric without seam

Weave	Bending Length (cm)		Flexural Rigidity (mgcm)		Overall Flexural Rigidity (mgcm)
	Warp	Weft	Warp	Weft	
Plain	2.41	1.97	194.6	109.63	146

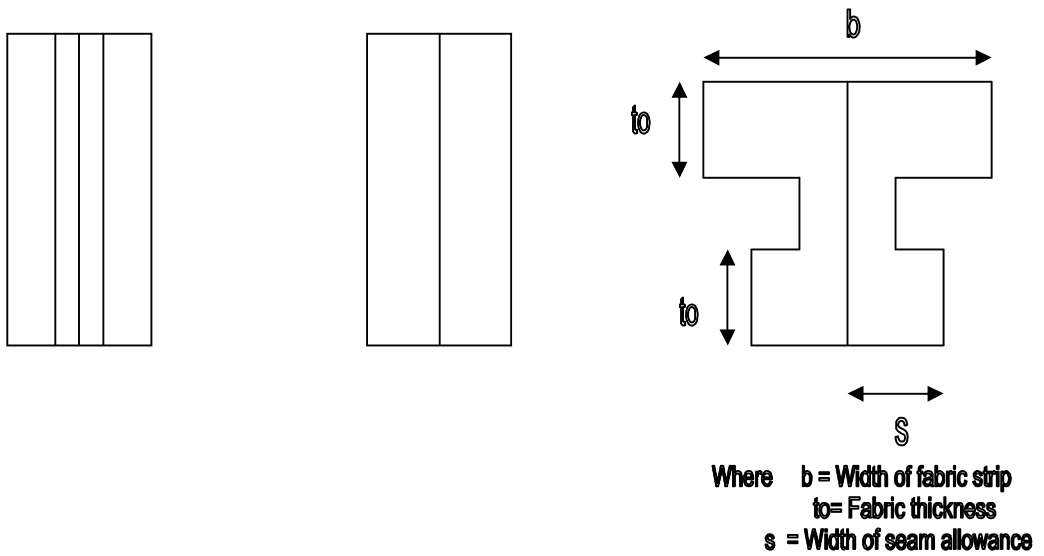


Figure 2. Fabric strip with vertical seam, (a) back side of fabric with seam allowance, (b) rigth side of fabric with a plain seam at the center, (c) geometric model and cross-sectional area of fabric with a vertical seams (2)

Table 2. The properties of sewing threads used

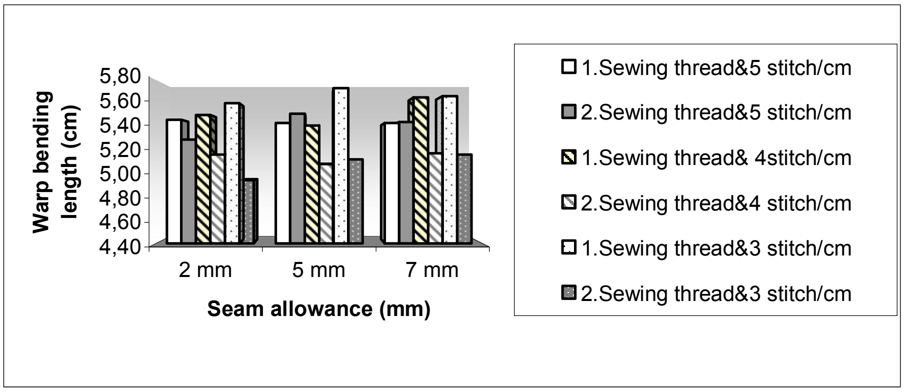
No	Ticket Number	Type	Twist (T/m)	Count (tex)	Tenacity (cN/Tex)
1	80	2 ply PET spun	805 (Z)	20.5 x 2	25
2	140	2 ply PET spun	1130 (Z)	11 x 2	23

Table 3. Bending length, flexural rigidity and overall flexural rigidity results of fabrics with different seam parameters

Sewing Thread No	Stitch Density (stitch/cm)	Seam Allowance (mm)	Bending Length (cm)		Flexural Rigidity (mg cm)		Overall FlexuralRigidity (mg cm)
			Warp	Weft	Warp	Weft	
1	5	2	5.46	5.81	2268.25	2726.22	2486.71
1	5	5	5.43	6.22	2232.27	3335.94	2728.86
1	5	7	5.43	5.60	2222.64	2442.55	2330.00
1	4	2	5.50	5.37	2322.62	2152.96	2236.18
1	4	5	5.41	5.77	2186.29	2683.18	2422.02
1	4	7	5.65	5.81	2439.84	2728.31	2580.04
1	3	2	5.60	5.55	2432.90	2371.75	2402.13
1	3	5	5.73	5.91	2619.39	2869.92	2741.79
1	3	7	5.66	5.77	2510.73	2677.87	2592.95
2	5	2	5.29	5.36	2060.88	2136.22	2098.21
2	5	5	5.51	5.90	2320.84	2854.09	2573.69
2	5	7	5.44	5.38	2298.00	2162.08	2229.00
2	4	2	5.16	5.30	1902.08	2060.30	1979.60
2	4	5	5.08	5.69	1820.87	2569.69	2163.11
2	4	7	5.17	5.21	1914.08	1989.31	1951.33
2	3	2	4.94	5.07	1672.02	1807.45	1738.41
2	3	5	5.12	5.15	1864.63	1908.15	1886.26
2	3	7	5.16	5.39	1910.27	2179.35	2040.37

Table 4. Student- Newman- Keuls test results

		Bending Length		Flexural Rigidity		Fabric Flexural Rigidity
		Warp	Weft	Warp	Weft	
Sewing thread Ticket number	**80**	5.539 a	5.761 a	2359.44 a	2665.41 a	2494.77 a
	140	5.211 b	5.387 b	1973.74 b	2185.18 b	2069.76 b
Stitch density (stitch/ cm)	**5**	5.432 a	5.716 a	2233.81 a	2608.39 a	2403.22 a
	4	5.322 a	5.530 b	2097.63 a	2363.95 b	2213.80 b
	3	5.372 a	5.477 b	2168.32 a	2302.41 b	2229.78 b
Seam allowance (mm)	**7**	5.413 a	5.532 b	2215.92 a	2363.24 b	2280.35 b
	5	5.384 a	5.779 a	2174.05 a	2702.37 a	2414.22 a
	2	5.329 a	5.411 b	2109.79 a	2209.15 b	2152.22 c



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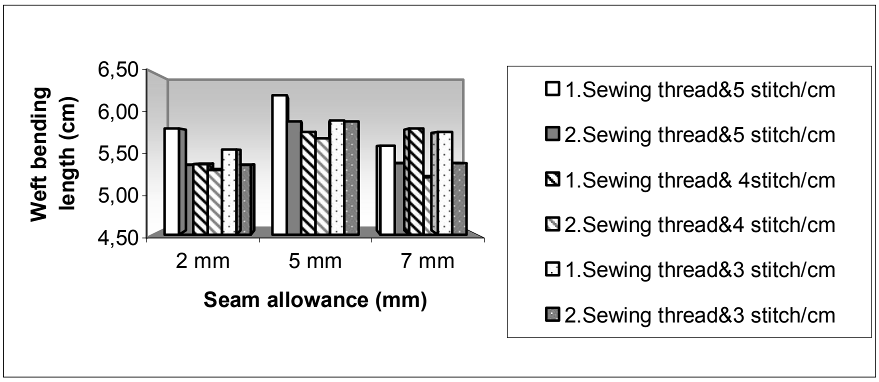

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Figure 3. The variation of bending length in the (a) warp (b) weft directions of the fabrics with different sewing thread sizes and different stitch densities according to the seam allowance.

3. RESULTS AND DISCUSSION

According to the SNK test results in Table 4, sewing thread size had significant effect on bending length and flexural rigidity in both warp and weft direction of the fabrics. Stitch density and seam allowance had non-significant effect on bending length and flexural rigidity in the warp direction but significant effect in the weft direction. Sewing thread size, stitch density and seam allowance had significant effect on overall flexural rigidity of the fabric.

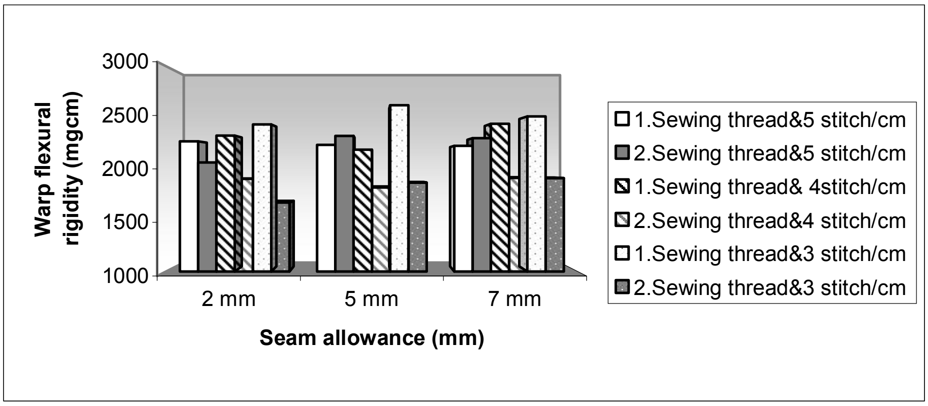
All the test results were evaluated seperately as given below.

3.1. The Results of Bending Length and Flexural Rigidity in the Both Warp and Weft Direction

From experiments, we found that the bending length (c) of a fabric strip increased with the addition of a vertical seam, but did not increase continuously with increased seam allowance. The increase rate was the most rapid at from SA= 0 mm to 5 mm. When the seam allowance was greater than 5 mm, there was a limited increase in bending length and also bending rigidity.

The SNK test results in Table 4 indicated significant effects of sewing thread size in the both warp and weft direction sewn fabric strips. Bending length and flexural rigidity of the sewn fabric strip with the lower ticket number was higher than the sample with higher ticket number of sewing thread. The stiffness of sewn fabric would be higher when we used sewing thread with small ticket number.

Stitch density and seam allowance have important effects in the warp and weft direction sewn fabric strips. The fabric samples which were sewn with 5 stitch/cm density and 5 mm seam allowance had higher bending length and flexural rigidity. High bending length and flexural rigidity also gives high stiffness properties to these spesific fabric. 3 stitch/cm density and 2 mm seam allowance were used in



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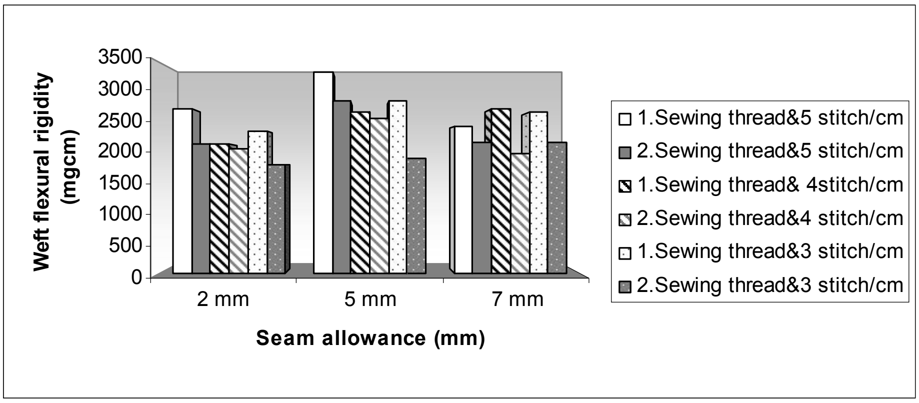

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Figure 4. The variation of flexural rigidity in the (a) warp (b) weft directions of the fabrics with different sewing thread sizes and different stitch densities according to the seam allowance

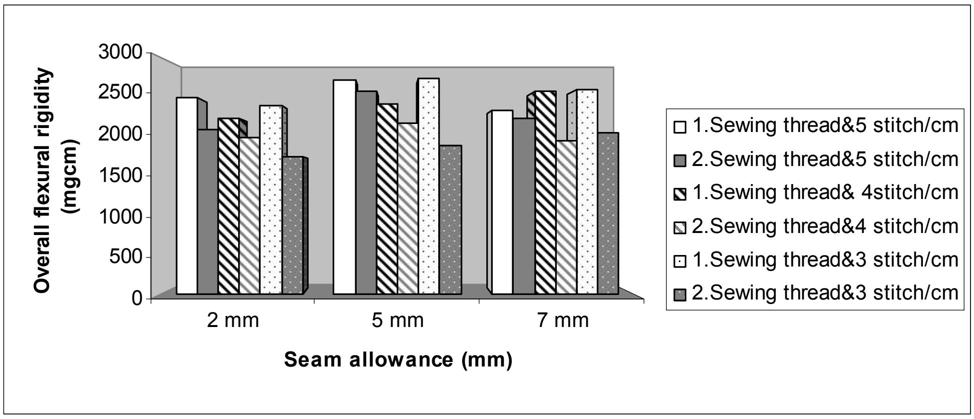

Figure 5. The variation of overall flexural rigidity of the sewn fabrics with different sewing thread sizes and different stitch densities according to the seam allowance.

both warp and weft direction of sewn fabrics, lower bending length and flexural rigidity would have been obtained with lower stiffness. Figure 3 shows the results of bending length in the both warp and weft directions of sewn fabrics.

Figure 4 shows the results of flexural rigidity in the both warp and weft directions of sewn fabrics.

3.2. Overall Flexural Rigidity Results

Figure 5 shows the variation of overall flexural rigidity of sewn fabric according to the seam allowance. The figure 5 shows that there was a significant effect of sewing thread size on the overall flexural rigidity. Overall flexural rigidity results were between 1735- 2740 mgcm.

The SNK test results in Table 4 showed that there were significant effects of sewing thread size, stitch density and seam allowance. Sewing thread with 80 ticket number had higher flexural rigidity than 140 ticket number.

The seams with 5 stitch/cm and 7 and 5 mm seam allowances had higher flexural rigidity values. The seams with

3 stitch/ cm and 2 mm seam allowance had lower flexural rigidity and stiffness.

4. CONCLUSIONS

The seams of a garment affect the fabric stiffness greatly. In this study, it was found when sewing thread size, stitch density and seam allowance of a vertical plain seam on the cotton woven fabric increased, bending length, flexural rigidity and stiffness of fabric also increased. Differences in the seam allowances affected bending length and flexural rigidity.

The fabric samples sewn with 80 ticket number sewing thread had higher flexural rigidity values compared with 140 ticket number. In this study, it has been shown that at fabrics seams when sewing thread size increased, bending length, flexural rigidity and stiffness also increased. Fabrics with very high bending rigidity values may lead to sewing and handling problems as they too stiff to be manipulated and controlled.

In general, overall flexural rigidity ranges between 1735-2740 mgcm, which can be optimized through various factors, such as sewing thread size, stitch density and seam allowance.

From experiments, we found that the bending length (c) of a fabric strip increased with the addition of a vertical seam, but did not increase continuously with increased seam allowance. The increase rate was the most rapid at from SA= 0 mm to 5 mm. When the seam allowance was 7mm, there was limited increase in bending length and also bending rigidity.

Overall flexural rigidity has been reported to be influenced mainly by seam parameters such as sewing thread size, stitch density and seam allowance. The fabric strips with the seams with 3 stitch/cm and 2 mm seam allowance and 140 ticket number had lower flexural rigidity and stiffness.

It has found that vertical plain seams increase the stiffness of the fabrics. Therefore there is necessity to optimize the seam parameters such as sewing thread size, stitch density and seam allowance in order to decrease the stiffness of the fabric on the garment. It is hoped that the results can be applicable in the apparel industries.

Acknowledgement

I would like to thanks to Associate Professor Dr Yasemin Kavuşturan for her help during this study with developed a stiffness tester at Uludag University textile laboratory.

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*Bu araştırma, Bilim Kurulumuz tarafından incelendikten sonra, oylama ile saptanan iki hakemin görüşüne sunulmuştur. Her iki hakem yaptıkları incelemeler sonucunda araştırmanın bilimselliği ve sunumu olarak **"Hakem Onaylı Araştırma"** vasfıyla yayımlanabileceğine karar vermişlerdir.*