

## Influence of Mechanical properties of Cotton Fabrics on Seam Quality

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**Abstract:** The purpose of this article is to study the effect of mechanical properties on seam quality of cotton fabrics. Twenty cotton fabrics are used for experiment. Mechanical properties of the fabrics on warp and weft directions were tested by FAST instrument. Seam efficiency, seam puckering and seam boldness were tested to evaluate seam quality. Curve regressions were used to analyze the influence of mechanical properties on seam quality. The results showed that the shear rigidity and extensibility were closely correlated with the seam efficiency and seam puckering rate, whereas the thickness, weight and shear rigidity were affecting on the seam boldness of the cotton fabrics. The regression equations of seam quality rate were obtained.

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**Keywords:** Seam quality, seam efficiency, seam puckering, seam boldness, fabric mechanical properties.

### 1. Introduction

In cut and sewn apparel products, seams are formed when two or more pieces of fabrics are held together by stitches. As the seam is one of the basic requirements in the construction of apparel, seam quality has great significance in apparel products.

There are several functional and aesthetic requirements for good quality seam. Seam quality is evaluated based on various dimensions: seam efficiency, seam elongation, seam bending, seam stiffness, seam abrasion resistance, seam density, seam slippage, seam puckering, seam tightness, seam boldness and seam damage<sup>[1]</sup>. Seam efficiency, seam elongation, seam density, seam slippage, seam bending stiffness and seam abrasion resistance are the dimensions for functional performance of the seam. In contrast, seam puckering, seam tightness; seam boldness and seam damage are mainly evaluated for better aesthetic performance of the seam. In order to simplify the analysis of seam quality, it is essential to choose only most important evaluating dimensions, which can well represent the overall seam quality. A subjective ranking given by different researchers to evaluate the most important dimension for the seam quality evaluation. The final ranking cleared that seam puckering; seam efficiency and seam boldness are the three critical dimensions for the evaluation of seam quality based on experts' viewpoints. The seam efficiency is used to evaluate the functional performance of seam in terms of durability<sup>[2,3]</sup>. Seam puckering and seam boldness are the two dimensions for the evaluation of seam aesthetic performance. Seam puckering used to measure the appearance along the seam line<sup>[4]</sup>. Seam boldness is the dimension for evaluating the design prominence of the seam<sup>[5]</sup>. Fabric properties affect the seam quality, are discussed by many previous researchers<sup>[6-11]</sup>.

### 2. Experimental

The investigation of fabric seam quality was carried out on twenty cotton fabrics sample for production of women's outerwear. Basic properties of experimental fabrics were as follow: warp density 24-160 Ends/inch, weft density 18-78 Picks/inch. The tensile strength of the fabric was tested on an Instron Tensile Tester; model 4411. The ASTM D 5034 test method was used to measure the strength of the fabric by using the grab test procedure to measure the breaking strength of textile fabrics. The cloth cover factor was calculated using the following formula<sup>[12]</sup>.

$$\text{Cloth cover factor } K_C = K_1 + K_2 - \frac{K_1 + K_2}{28}$$

[where  $k_1$  = warp cover factor,  $k_2$  = weft cover factor]. Fabric mechanical properties were tested and calculated by FAST instrument under standard conditions<sup>[13]</sup>. Contents of the fabric properties were described in Table 1. All the samples were in plain weave and produced from 100% cotton type of yarns. The three important dimensions for seam quality evaluation (seam efficiency, seam puckering and seam boldness) were inferred as critical dimensions for seam quality evaluation. Each selected fabric was sewn by different sewing thread size at various stitch density. Each critical dimensions measured by their standard evaluation method. Seam efficiency measures the durability along the seam line<sup>[14-16]</sup>. Many studies<sup>[3,17-19]</sup> measured the seam efficiency from strength tester according to the ASTM 1683-04 standard method. In this method, seam efficiency was measured by using the following equation:

$$\text{Seam efficiency (\%)} = \frac{\text{Seam Tensile Strength}}{\text{Fabric Tensile Strength}} \times 100$$

Seam puckering appears a long the seam line of garment when the sewing parameters and sewn materials properties are not properly selected. Puckering can occur due to excess fabric and not enough thread in the seam [20-23]. After analyzing the puckering behavior of various seamed fabrics, it has been found that seam puckering depends mainly on the thickness properties of the fabric [2,16]. As a result, seam puckering calculated by measuring the difference in fabric and seam thickness under constant compressive load. Seam puckering calculated by using the following formula [2,3,16,24]:-

$$\text{Seam puckering (\%)} = \frac{t_s - 2t}{2t} \times 100$$

[Where,  $t_s$  = seam thickness,  $t$  = fabric thickness]

**Seam boldness** is used to measure the design prominence over seam. Generally, high degree of

boldness is required for better ornamentation of apparel [25]. The evaluation is performed by using a standard lighting and viewing the specimens in five ratings in comparison with the appropriate reference benchmark. Seams are rated in five classes in which class 5 = highest prominence and class 1 = no prominence. Contents of the critical dimensions for seam quality evaluation (seam efficiency, seam puckering and seam boldness) were described in Table 1.

### 3. Results and Discussion

The tensile strength was measured and fabric cover factor calculated for the tested samples. Then the FAST mechanical properties were obtained for each sample. The results of fabric properties are shown in Table1.

**Table 1. Tested Properties of 100% Cotton Fabrics**

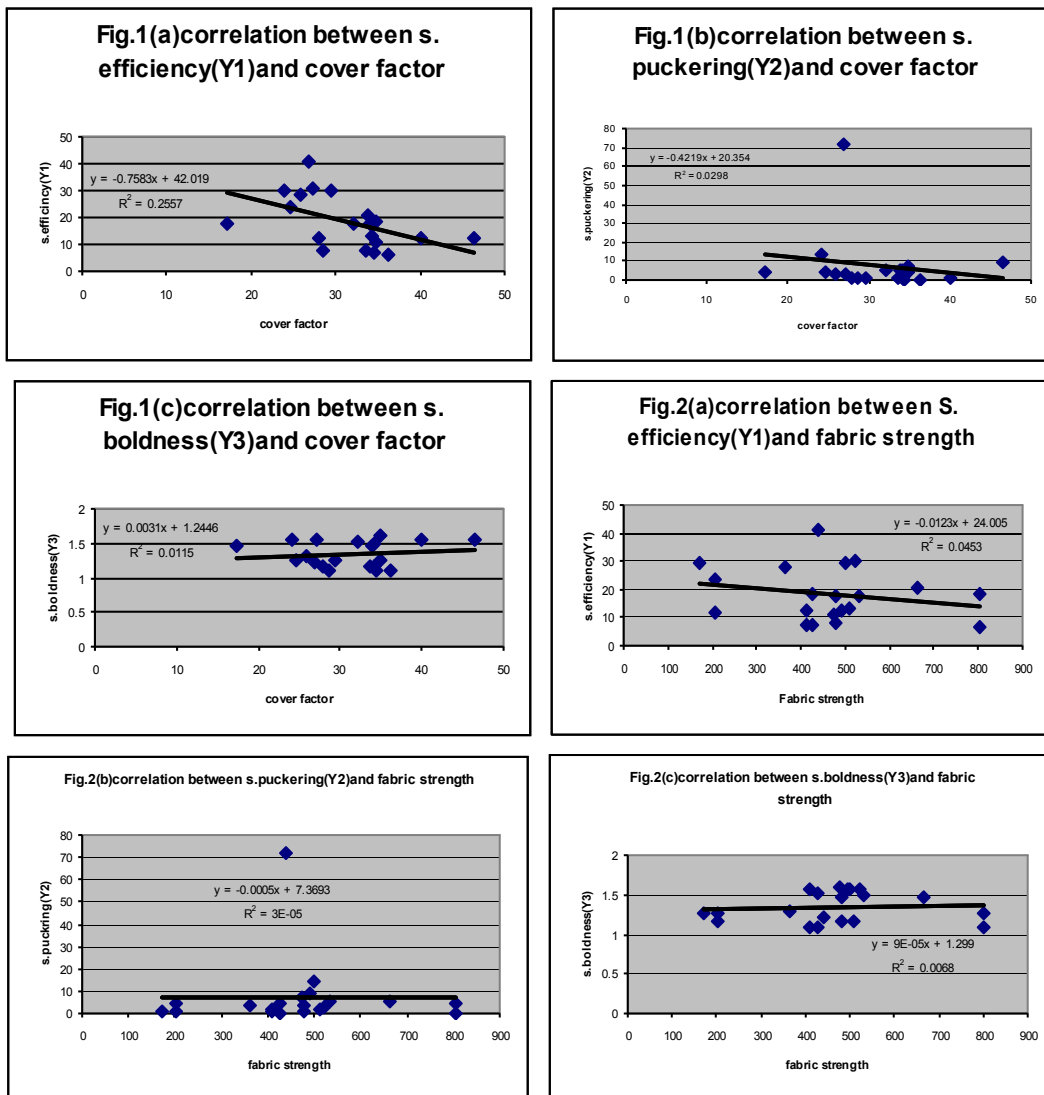
Fabric no.	Seam Effici. Y1	Seam Pucker Y2	Seam Bold Y3	Cover Factor X1	Strength (N) X2	Mean E (%) X3	Mean B(μ-Nm) X4	G (N-m) X5	T <sub>2</sub> (mm) X6	W g/cm <sup>2</sup> X7
1	6.2	0	1	36.23	803.2	3.12	5.84	13.25	0.8	380
2	7.36	0.73	1	28.59	410.7	2.93	1.98	4.63	0.85	480.2
3	7,13	0	1	34.44	426.6	2.64	1.5	9.03	0.81	344.3
4	12.06	0.78	1.15	27.92	204.4	4.49	1.05	7.7	0.83	376.2
5	8.01	0.93	1.15	33.63	479.5	5.86	0.28	3	0.57	432
6	13.36	2	1.15	34.23	510.3	7.37	0.15	2.58	0.52	273.6
7	41.09	71	1.2	26.75	440.2	8.42	0.12	1.36	0.59	214.4
8	29.6	1.02	1.25	29.47	170.5	9.22	0.06	0.96	0.42	153.2
9	30.48	3	1.55	27.18	520.4	7.61	0.05	0.72	0.43	254
10	29.71	13.9	1.55	24.01	498.3	8.86	0.04	0.74	0.47	308
11	10.82	6.95	1.5	34.83	475.7	3.39	0.13	2.38	0.49	151
12	28.17	3.55	1.2	25.88	363.8	2.85	0.24	1.36	0.5	167
13	17.89	5	1.4	34.07	532.9	5.47	0.14	0.96	0.35	150
14	20.62	5.25	1.45	33.86	663.9	7.05	0.11	0.72	0.52	181
15	12.19	8.84	1.55	46.42	492.9	6	0.1	0.74	0.46	136
16	18.61	4	1.25	34.84	803.2	6.17	0.12	2.38	0.45	151
17	12.21	1.48	1.55	39.97	410.7	6.66	0.1	4.69	0.55	184
18	18.02	4.81	1.5	32.04	426.6	8.66	0.08	1.7	0.38	131
19	23.69	4	1.25	24.53	204.4	8.17	1.03	1.79	0.42	102
20	17.87	3.98	1.45	17.24	479.5	3.15	0.12	1.62	0.44	167

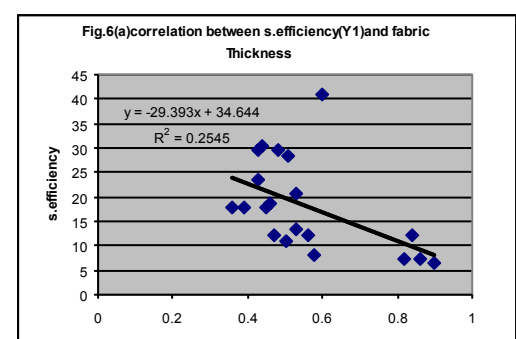
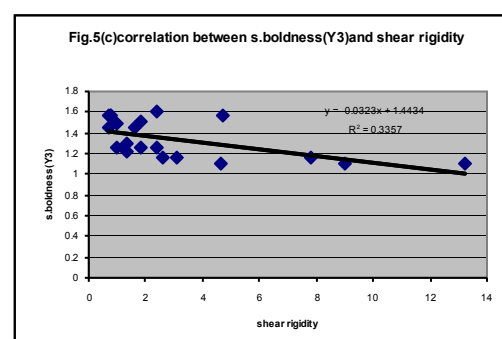
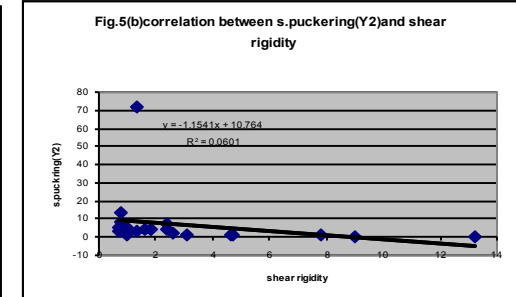
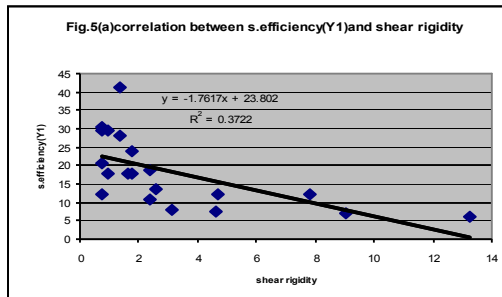
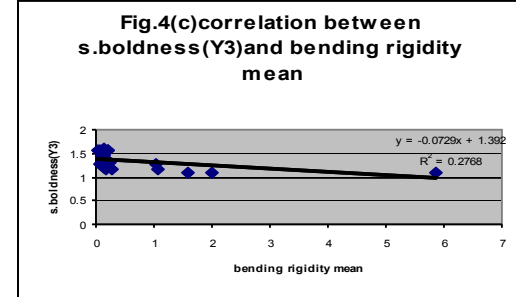
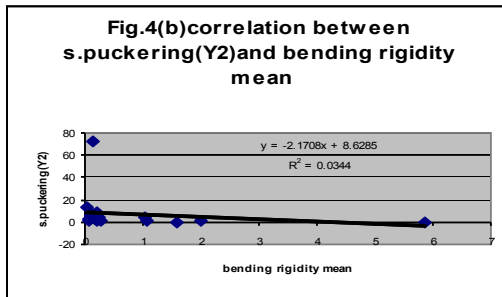
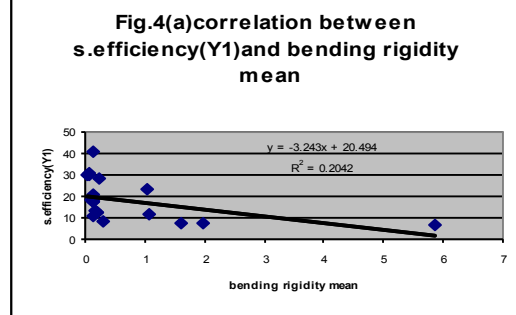
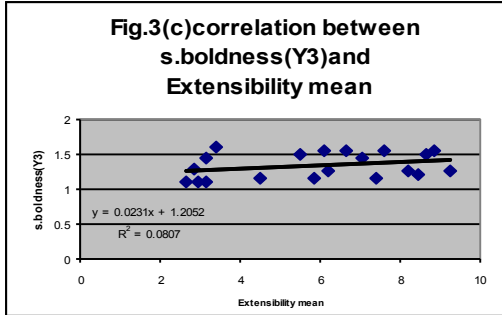
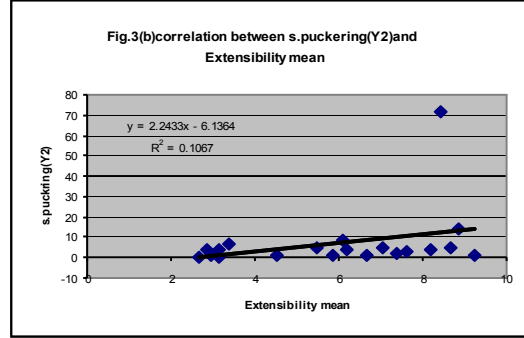
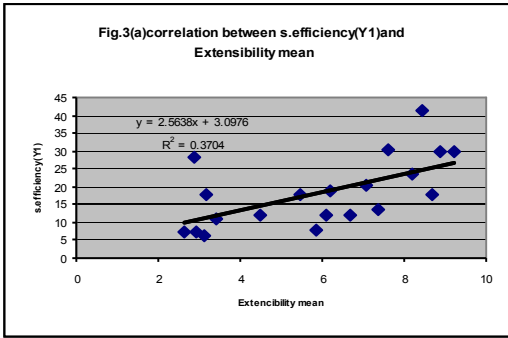
It has been found that there are different factors affecting the seam quality. They are considered as input variables of seam quality. The input variables are: cover factor (X1), tensile strength (X2), extensibility (X3), bending rigidity (X4), shear rigidity (X5), thickness(X6) and fabric weight(X7). These input variables are measured in the laboratory for seam quality evaluation of cotton fabrics. The previous input variables are given in Table 1. According to the evaluation of the different researchers, it has been found that there are three critical dimensions for seam quality evaluation. These critical dimensions

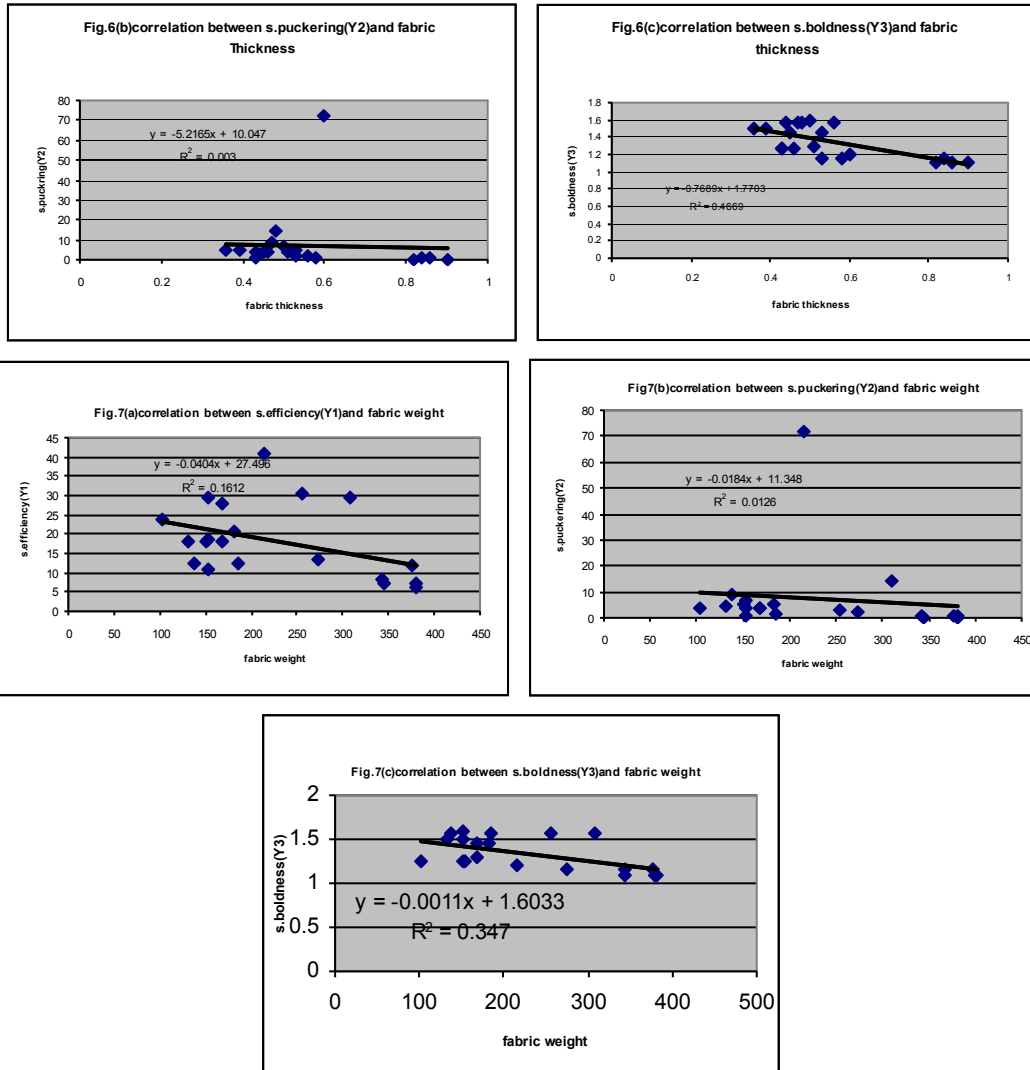
considered as output variables of modeling. The output variables are: seam efficiency (Y1), seam puckering (Y2) and seam boldness (Y3). The values of output variables (Y1, Y2 and Y3) obtained from the experiments are given in Table1. It can be seen that seam efficiency is ranges from 6.2 to 41.09%. It is noticeable, that sample no. (7) obtains significantly higher seam efficiency in relation to all other fabrics This sample has higher extensibility but low bending stiffness, shear rigidity, thickness, cover factor and tensile strength (compared to other samples) and, low

fabric weight. Also seam puckering is ranges from 0 to 71%. It is noticeable, that sample no. (7) obtains significantly higher seam puckering in relation to all other fabrics This sample has higher extensibility, cover factor, bending stiffness and thickness but low tensile strength and shear rigidity (compared to other samples) and low fabric weight. The lasting output variables seam boldness is ranges from 1 to 1.55%. It is noticeable, that samples (9,10,15,17) obtain significantly higher seam boldness in relation to all other fabrics The samples have higher extensibility but low bending stiffness, shear rigidity, thickness, cover factor and tensile strength (compared to other samples) and low fabric weight. To get idea about fabric structure parameter that gives best indication of fabric seam quality, the correlation between seam quality variables and various fabric structure parameters is

investigated. There is a correlation between fabric shear rigidity ( $R^2=0.3722$ ), extensibility ( $R^2=0.3704$ ), cover factor ( $R^2=0.2557$ ), thickness ( $R^2=0.2545$ ), bending rigidity ( $R^2=0.2042$ ), weight ( $R^2=0.1612$ ) and tensile strength ( $R^2=0.0453$ ), with seam efficiency. Also, there is a correlation between fabric extensibility ( $R^2=0.1067$ ), shear rigidity ( $R^2=0.0601$ ), bending rigidity ( $R^2=0.0344$ ), cover factor ( $R^2=0.0298$ ), weight ( $R^2=0.0126$ ) and thickness ( $R^2=0.003$ ), with seam puckering. Finally, there is a correlation between fabric thickness ( $R^2=0.4669$ ), weight ( $R^2=0.347$ ), shear rigidity ( $R^2=0.3357$ ), bending rigidity ( $R^2=0.2768$ ), extensibility ( $R^2=0.0807$ ), cover factor ( $R^2=0.0115$ ), tensile strength ( $R^2=0.0068$ ),with seam boldness .The correlations between various fabric parameters and the critical dimensions for seam quality are represented in Figures from 1(a, b, c) to 7(a, b, c) respectively.







**Table 2. Regression coefficient of the input variables for Y<sub>1</sub>, Y<sub>2</sub> and Y<sub>3</sub> of cotton fabrics**

Input variables	Regression Coefficients (R <sup>2</sup> )		
	Seam Efficiency (Y <sub>1</sub> )	Seam Puckering (Y <sub>2</sub> )	Seam Boldness (Y <sub>3</sub> )
Cover Factor (X <sub>1</sub> )	0.2557	0.0298	0.0115
Tensile Strength (X <sub>2</sub> )	0.0453	3E-05	0.0068
Extensibility (X <sub>3</sub> )	0.3704	0.1067	0.0807
Bending Rigidity(X <sub>4</sub> )	0.2042	0.0344	0.2768
Shear Rigidity (X <sub>5</sub> )	0.3722	0.0601	0.3357
Thickness (X <sub>6</sub> )	0.2545	0.003	0.4669
Weight (X <sub>7</sub> )	0.1612	0.0126	0.347

Regression coefficients of 7 input variables (X<sub>1</sub>-X<sub>7</sub>) for the seam efficiency (Y<sub>1</sub>), seam puckering(Y<sub>2</sub>) and

seam boldness (Y<sub>3</sub>) for cotton fabric are shown in Table 2.

From Table 2, it is clear that the absolute values of regression coefficient of extensibility(X<sub>3</sub>) and shear rigidity(X<sub>4</sub>) are higher than the rest of input variables for the seam efficiency (Y<sub>1</sub>) and seam puckering (Y<sub>2</sub>) whereas, the absolute values of regression coefficient of thickness(X<sub>6</sub>) and weight(X<sub>7</sub>) are higher than the rest of input variables for seam boldness.

**Conclusion**

Based on the discussion, the following conclusion can be drawn. There are various factors for seam quality. Generally, all the fabric properties such as,weight, cover factor, thickness, tensile strength, extensibility, bending rigidity and shear rigidity have considerable effect on the seam quality of apparel products. The investigation of the seam quality of 100%cotton fabrics has shown correlation between various fabric structure parameters and critical dimension variables. The sample that has much greater

seam efficiency and seam puckering values have also much higher extensibility and lower shear rigidity, whereas the sample that has much greater seam boldness values has also much lower thickness, weight and shear rigidity. Seam efficiency has a positive value on the overall seam quality, as a high percentage of seam efficiency always represents good seam efficiency. In contrast, seam puckering always has a negative value on the overall seam quality because a greater seam puckering always leads to poor seam quality. Seam boldness may have a positive or negative value on the overall seam quality depending on the apparel. From the provided solution for evaluating the overall seam quality, the understanding of the requirements of critical dimension for seam quality of the apparel. This understanding will help in planning and control of the quality of apparel products at the time of sewing.

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