

Effect of Different Types of Seam, Stitch Class and Stitch Density on Seam Performance

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Abstract

Compatibility of the seam for functional and aesthetic requirement is very important for serviceability and life of the apparel. The serviceability of apparel can be increased by selecting the suitable type of fabric, thread, and seam. Selection of type thread, fabric and seam are basic elements in garment durability, especially for the fashionable garments in terms of cost and quality. Seam quality is subjected to seam strength, strength efficiency, puckering, slippage, boldness and appearance. The strength and appearance of seam marks both functional and aesthetic performance of any finished apparel product. Both are considered as an important factor for durability of a garment. This research paper focuses on the effect of type of seam, stitch type and stitch density on seam strength of denim fabric. The results showed that, the overall seam performance of the garment is influenced by these factors. It was concluded from this research that, as SPI was increased, the seam strength was also increased and decreased when SPI was reduced vice versa.

Key words: Apparel, Seam, Seam Strength, Stitch, Stitch Density, Seam performance

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INTRODUCTION

Seam is one of the important parameter and considered as basic requirements in the construction of apparel. Seam quality has great significance in the production of finished apparel products. Consumers evaluate seam quality mainly based on the seam appearance and its durability after wear and care procedures. Various types of seams, stitches can be applied on finished fabrics (garments) with different stitch density (SPI) having diverse effects on seam strength, quality in general and performance in particular. The probability of seam performance for different garment is also different depending upon its end use. As a result, analysis of seam performance can provide a more significant study of various elements influence the seam performance. The quality of seam is generally evaluated by the manufacturers during product development and production. Further the quality level of the apparel requires the judgment of seam quality, strength and physical appearance. For some functional garments such as sportswear, the requirement of seam strength may be higher

than the need for seam appearance, while for some apparel products such as night gowns, the appearance of the seam is of higher importance. There are many factors which affect the seam strength. Seam appearance and performance depends on the type of fabrics, threads, stitch type, type of seam and sewing conditions, which include the needle size, stitch density, the appropriate operation and maintenance of the sewing machines. Basically, the quality of seam can be examined from two main aspects: functional and aesthetic performance (Bhalerao, 1997; Behera, 1998 and 1997b). The functional performance of seam mainly in terms of the seam strength and/or seam efficiency has been discussed (Bhalerao, 1997; Chmielowiec, 1987; Tarafdar, 2007). There are also various studies on the seam quality based on the aesthetic performance (Tarafdar et al., 2005; Carr and Latham, 1995; Gupta et al., 1992). However, these studies focus mainly on the seam defects such as the seam puckering (Tarafdar et al., 2005; Gupta et al., 1992) and seam damage (Carr and Latham, 1995). In this research bound, lapped and super

imposed seams were studied including effect of stitch density (SPI) on the seam strength as well as various stitches class (300, 400 and 600) were used and their influence on seam performance were studied. For common apparel products, the seam is an essential part of the garment (Stylos and Lloyd, 1990). A seam is manufactured employing sewing methods, with the idea that seam should satisfy all the requirements imposed by a number of end-users of apparel products (Stylos and Lloyd, 1990; Solinger, 1989). For any apparel, it is necessary to clearly understand the seam as one of the basic elements of an article of clothing. In the apparel industry, overall seam quality defined through various functional and aesthetic performances desired for the apparel product during their end use. The functional performance mainly refers to the strength, tenacity, efficiency, elasticity, elongation, flexibility, bending stiffness, abrasion resistance, washing resistance and dry cleaning resistance of the seam under conditions of mechanical stress for a reasonable period of time (Carr and Latham, 1995; Metha, 1985; Glock and Kunz, 1995; Sandow and Hixon, 1999). Properties like as, strength, tenacity and efficiency is required for determining the serviceability of apparel. Elasticity, elongation, flexibility, and low bending stiffness of seam are needed to easily bend, shift, and fold without damage to the seam or change to the silhouette of the garment. Seam also comes under abrasion with body parts at wear or at the time of washing or dry cleaning. It is expected that seam should have good abrasion and/or washing and/or dry cleaning resistance. There are also certain aesthetic requirements of a seam to the consumers' body sensory mechanism (hand, eye). (Carr and Latham, 1995; Metha, 1985; Sandow and Hixon, 1999). For proper appearance, seam should not contain any defects including skipped stitches, unbalanced stitches, looseness, seam grin, distortion or unevenness or puckering, unsteadiness, improper drapeability, uneven seam density and yarn severance or damage. A defect free seam is required for consumer satisfaction at the point of sale of apparel and help to increase the sale ability. Apart from all the above aesthetic mentioned requirements, seam

should also meet the design requirement of the consumers for apparel. The different degree of boldness of seam can help to fulfill different purposes as design features and affect the appearance of garment. In the apparel industry, seam boldness is commonly used as a prime dimension for evaluating the design prominence of a seam (Bhera, 1997b; Ukponmwan et al., 1997a; Kadolph, 1998). Therefore, overall quality of a seam depends on the requirements imposed by the consumers. Good overall seam quality is essential for the longevity of an apparel product, which together with consumer satisfaction during wear and care procedures affect its sale ability. The apparel industry use different dimensions for the evaluation of seam quality on the basis of the requirements of a seam from consumers' point of views (Brown, 1992). The degree of requirement of functional or aesthetic performance of seam also varies, based on the intended use of apparel (Sandow and Hixon, 1999; Salhotra, et al., 1994). For example, a military cloth must provide protection from highly hostile environments. Aesthetic appearance is of comparatively little importance as long as an extensive list of functional needs is required. By contrast, aesthetic performance is of primary importance for bridal wear. For any bride, a high quality gown should possess aesthetic performance its appearance and design prominence to the wearer are paramount. In order to understand various seam performances, knowledge of various factors affecting the seam quality is necessary. Seam quality is governed by a broad spectrum of factors including sewing thread type and size, fabric, sewing machine speed, needle kind and size, stitch type and density and operator skills (Gribaa et al., 2006; Krasteva and Petrove, 2008; Choudhury, 2000; Shimazai, 1976). For better seam quality, it is important to consider the complete harmony of the key fabric properties, sewing thread properties and sewing condition parameters used. The functional and aesthetic performance of the seam line is the result of all these factors. In the previous research, different methods were used for measuring various dimensions for seam quality evaluation: seam strength, seam efficiency, seam slippage, seam

elongation, seam damage, seam puckering and seam boldness. Seam strength refers to the load required to break a seam. This measure the strength and tenacity of a seam. Two pieces of woven fabric are joined by a seam and if tangential force is applied the seam line, rupture ultimately occurs at or near the seam line. Every seam has two components, fabric and sewing thread. Therefore, seam strength must result from the breakage of either fabric or thread or, in more cases, both simultaneously. Research has revealed that the load required to rupture the seam is usually less than that required to break the un-sewn fabric (Behera and Sharma, 1998; Lin, 2004). A large number of studies (Bhalerao et al., 1997; Behera and Sharma, 1998; Behera, 1997b; Tarafdar et al., 2007; Lin, 2004; Mohanta, 2006; Cheng and Poon, 2002; Gurarda, 2008) have determined the seam strength according to ASTM 1683-04 standards, which express the value of seam strength in terms of maximum force (in Newton N) to cause a seam specimen to rupture. This is measured by using the following equation,

$$Ss = KSb \quad (1)$$

Where:

Ss = Sewn Seam Strength (N)

K = a constant equal to 1000 for SI units

Sb = Observed Seam Breaking Force (N)

The study of the seam quality of denim fabric has been done (Behera, 1997b). They evaluated seam quality by measuring each of these five dimensions: seam strength, seam efficiency, seam slippage, seam puckering and seam damage. In their study, five different fabrics (6.5, 10, 12.5, 14.5, 15.5 oz/yd²) and 12 different sizes of sewing thread was used for seam quality evaluation. Regression analysis was carried out to understand the various affecting factors for seam quality. The result revealed that for light weight fabric (6.5 oz/yd²) seam strength, seam efficiency increased with lower sewing thread size, whereas seam pucker, seam damage and seam slippage decreased. The reverse trend was observed in the case of medium (10, 12.5 oz/yd²) and high weight (14.5, 15.5 oz/yd²) fabrics.

The seam quality of apparel grade fabrics had been experimented (Bhalerao et al., 1997). Seam strength and seam efficiency were measured to assess seam quality in 2/1 twill fabrics. ASTM standards were used to evaluate the seam quality. The investigation was carried out by using two types of seam (plain and double stitched), sewing thread (70 and 50 ticket no.) and stitch density (12 and 10 Stitches per inch). It was found that seam strength and seam efficiency increased with higher stitch density and lower ticket number sewing thread size. The seam quality for suiting and shirting fabrics of polyester/viscose, linen, and cotton by evaluating seam strength, seam efficiency and seam slippage has been done too (Behera and Sharma, 1998). Seam was prepared by using high speed sewing machine with 3200 stitches/min, having 16 needle sizes and 8 stitches/inch. Multiple linear regressions modeling methodology was used for the analysis seam quality. It was concluded that seam efficiency decreased with increase in fabric strength, bending rigidity, cover factor and thickness. Furthermore, seam slippage increased with the increase in fabric weight, thickness and cover factor in both suiting and shirting fabrics. The seam quality of plain, 2/1 twill, 3/1 twill fabrics using spun polyester sewing thread at 12 stitches per inch had been evaluated too (Malek et al., 1993). The authors emphasized that the seam quality can evaluated by seam efficiency, and seam slippage. Correlation coefficient was calculated to understand the various factors affecting the seam quality. From their study, factors which affect seam efficiency and seam slippage included fabric weight, thickness and extensibility. They observed that heavier and thicker fabric leads to lower the seam efficiency. In addition, seam efficiency is higher when fabric extensibility is greater. In their study, although the authors studied the correlation coefficient of various factor with seam efficiency and seam slippage, they did not formulate any regression models for seam quality evaluation. The seam quality of polyester, silk, polyester/cotton blend, polyester/rayon blend and cotton fabrics in combination with cotton/polyester sewing thread had been

analyzed (Cheng and Poon, 2002). The author evaluated seam strength and seam puckering as dimensions for seam quality evaluation. He found that fabric strength, thickness, sewing thread size has positive dependency on seam strength. On the other hand, fabric cover factor has negative correlation with seam puckering. Lin's study evaluates two dimensions – seam strength and seam puckering for analyzing seam quality. The seam quality of suiting and shirting fabrics were analyzed; They selected polyester, cotton, polyester/cotton, polyester/viscose fabric for the evaluation of seam quality (Tarafdar et al., 2005). Sewing was carried out in a singer sewing machine with 3200 stitches/min, at 8 spi with needle size 16 for each seam specimen. Study on seam quality of cotton, polyester and cotton-polyester fabric using cotton and polyester sewing thread has been done (Gurarda 2008). Sewing was done on industrial sewing machine using three different needle sizes- 11, 14 and 16. The seam quality of garment stitched from plain and twill fabrics were also studied (Tarafdar et al., 2007). The authors evaluated seam quality in terms of three dimensions – seam strength, seam efficiency and seam slippage. Two types of 100% cotton fabrics of different construction [plain (136×68) and Twill (138×68)] were stitched by six different stitch densities (6, 8, 9, 10, 12 and 13 stitches/inch) for the analysis of seam quality. The seam quality of light weight fabrics were also measured (Shimazai, 1976). Seam strength, seam elongation and seam puckering was evaluated by considering its three affecting factors including straining of the upper thread, needle size and load on the pressure foot. Their formulated model is very helpful for optimization of seam quality. The seam quality of PET/Nylon-elastane woven fabrics was investigated (Kothari, 1999), in which Plain and twill weave pet/nylon fabrics were stitched by spun-polyester sewing thread of 80 and 140 Ticket number. In one recent study (Kothari, 1999) evaluated seam quality by focusing on three individual dimensions- seam efficiency, seam strength and seam slippage. Although previous researchers put considerable effort into evaluating the seam quality, the restriction of their studies is that

all studied seam quality using an individual dimension either based on functional or aesthetic performance. Moreover, the previous researchers can not carried out any studies on seam boldness, which is one of the important dimensions for evaluating the design prominence of a seam. Thus, their study of seam quality is limited, fragmented and rarely deep enough. Until the present, very limited work has been undertaken on seam quality by considering its seam functional and aesthetic performance together. A study which considers both functional and aesthetic performance of seam together will definitely contribute to the knowledge of the overall seam quality for apparel products. A knowledge on the overall seam quality will help the apparel engineers to evaluate the quality of apparel products more precisely, when a particular sewing thread size and stitch density are applied on a particular type of fabric. This will facilitate the apparel engineers for proper planning and control of quality during the course of apparel manufacturing.

MATERIALS AND METHODS

The major portion of the experimental work was carried out in the Garments manufacturing department of National Textile University, Faisalabad. However the remaining work and test analysis was conducted in the testing lab of the same institute. This study was carried out in four steps. That includes constant elements, variable elements, model generated and the results, shown in below figure.1.

The material used in this research study was based on 100% cotton Denim fabric, and the 100% staple spun Polyester thread for the sewing the specimens. The twill weave fabric, with the GSM 429, 75 ends per ends and 45 picks per inch was used for this study. The sewing thread of two ply with the 18 (TPI) twist per inch, the linear density (Tex) and ticket numbers were 60 and 50 respectively. The elongation percentage of the sewing thread was 15-21%. The equipment used in this study commercially produce by "JUKI" company, all the sewing was performed on the machines of JUKI. Sewing of the specimens or samples formation was done in the garments lab of the National Textile

University, Faisalabad. The sewing machines used in this study were *Single Needle Lock Stitch Machine (JUKI DDL-8700)*, *2 Needle, 3-5 thread Over edge machine (JUKI MO-6716S)*, *Multi Thread Chain Stitch (Juki MH-1410D)*.

AATCC-88B was used to measure seam puckering (Gupta et al. 1992, Malek, et al. 1993, Kothari, 1999, Cheng and Poon, 2002, Lin, 2004, Tarafadar, et al. 2005, Tarafdar et al. 2007). This test method is designed to evaluate the puckering of seams after stitching. Evaluation was performed using a standard lighting and viewing area by rating the appearance of the specimen in comparison with an appropriate reference standard provided by AATCC. The tensile strength of the fabric was tested on textile tensile strength tester Model KG-300 by strip test method. The (ASTM D-1683-04) test method was used to measure the tensile strength of the fabric. The test method uses the strip test procedure to measure the breaking of the seam. The tensile strength machine model KG-300 was used to test sample, also called pendulum type tester with a low elongation percentage, such as paper, rubber, plastic and textile material for tensile strength and elongation percentage. The load of three categories according to the maximum loading (light, medium and heavy weight) can be selected and used for different materials. Elongation percentages can be indicated with a dial gauge. CRE (Constant Rate of Extension) method of tensile testing machine is capable of perform several mechanical tests of yarn and fabrics. The machine with jaws separation rate of 305610 mm/min (12.0 6 0.5 in/min) was used, standard testing method (ASTM D-1683-04) for failure/rapture in sewn seam of woven fabrics, followed by ISO 13935 specifications were used to determine the seam strength, when the force is applied perpendicularly to the seam. The ISO 13935 specifies the method known as the strip test. The method is mainly applicable to woven textile fabrics. It can be related to fabrics produced by other techniques. This method is suitable for straight seams only and not for curve seams.

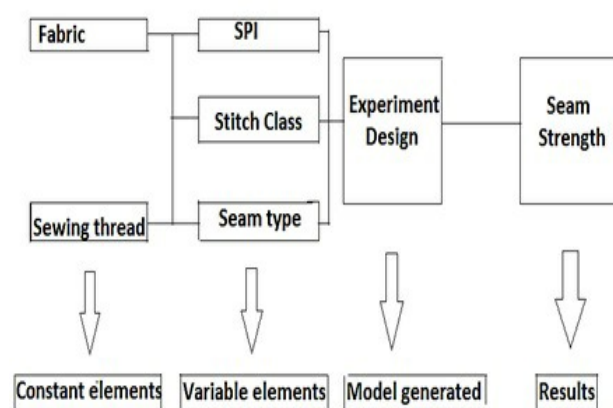


Figure 1: Process layout of the experimental design for research procedure

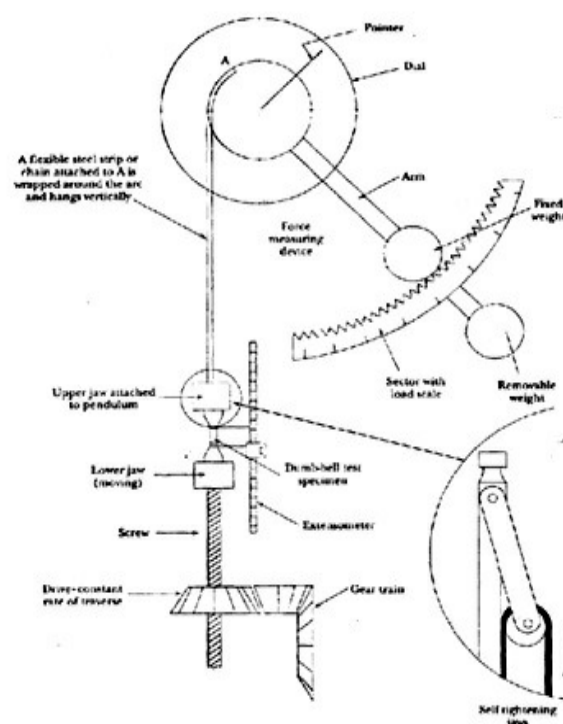


Figure 2: Mechanical parts of tensile strength tester

PARAMETERS

In order to analyze the seam strength or quality, at first sewing thread and fabric were selected. After the fabric selection the material was sewn with various densities of stitches, Stitch class and Seam types, then seam strength of the prepared specimens was measured with several experimental trails. The properties of the fabric and Sewing thread such as GSM, ends per inch, and picks per inch of fabric and count, twist per inch and construction of yarn were also identified respectively for the seam strength.

Selection of the sewing thread and Fabric

Commercially available sewing thread supplied by "COATS" was employed in this study. In order to investigate the strength of the seam 100% staple spun polyester sewing thread was used. The specifications of sewing thread selected for the seam strength is illustrated in table below. Denim is the most popular fabric nowadays in the apparel manufacturing industry. The fabric gives better quality and overall performance includes comfort ability, the criteria welcomed by customer today. Therefore the denim fabric was selected in this research for the seam strength analysis. The fabric specifications are illustrated in the Table. 1 as given below.

Table 1 : Specification of fabric and sewing thread

S. No	Composition	Construction	Linear Density (Tex)	Ticket Number	Elongation %
1.	Denim Fabric	Twill Weave	75x45	429 GSM	N/A
2.	Polyester 100 %	Staple Spun (TPI 18)	60	50	13-21

Staple Spun 100% polyester sewing thread is the dominant class of threads widely used in the apparel industry, because of its durability and stability in seam with good seam performance and because of its versatile nature makes it appropriate for manufacturing of normal apparel industry.

Selection of the stitch density

The Sewing of denim fabric can be originated with different density levels, but in this research study, the three different stitch levels were considered, with 8 ¼, 11 and 13 SPI.

Selection of the Stitch

Stitches are classified in six major classes; every class of the stitch is further divide in sub- classes. The stitch quality depends upon stitch tension, stitch sequence, elongation, elasticity, resilience, fabric distortion and yarn severance. Therefore in this research, three classes of stitches class 300, 400 and Class 600 were used for the study.

Selection of the Seam

The place where two or more pieces of fabric were joined by application of a series of stitches or stitch types with a defined geometry to one or several thicknesses of

fabric material is defined as Seam. There are different kinds of seam constructions, used depending on whether the seam is a decorative element of the design, the kind of fabric used, or how much stress is placed on the seam. Some of the most commonly used seam types are superimposed seams, lapped seams, bound seams, flat seams, edge finished seams, ornamental seams. In this study three types of seam, i.e Bound, lapped and super imposed seam were selected and used for the sewing purpose of denim garment.

Three specimens with the 4 inch width parallel to the stitch line and 6 inches long were prepared after applying different stitches, such as lapped, bound, flat and super imposed seam respectively. After cutting the specimen were conditioned for 2 hours at 21° +/- 1C (70° +/- 2F) temperature and 65% +/- 2% relative humidity in testing lab. Then the machine gauge was set at 25 mm (3 in.) with 100 to 1000 lbs of capacity tension load cell. Later on the machine speed was set at 30.5 cm (12 in.) per minute. The samples were placed on the test specimen in the jaws of the machine. When the seam ruptured, machine was stopped manually and breaking force on the semi-circle scale was recorded manually. The same procedure was used for several trials for seam strength of all four categories of seam.

Preparation of Specimen

For the testing of specimens, three specimens 350 mm (14 in.) by 100 mm (4 in.) were cut and made for each experiment design. The Specimens dimensions should be parallel either to the warp (machine) direction or to the filling (cross) direction, and specimens were cut for testing from both directions if required. Preferably specimens for a given fabric direction should be spaced along a diagonal of the fabric to allow for representation of different warp and filling yarns, or machine and cross direction areas, in each specimen.

The specimen was divided into two pieces of 7 inch (specimen) and sewn with each other under different stitch density (SPI), stitch class and with different seams according to the experiment design.

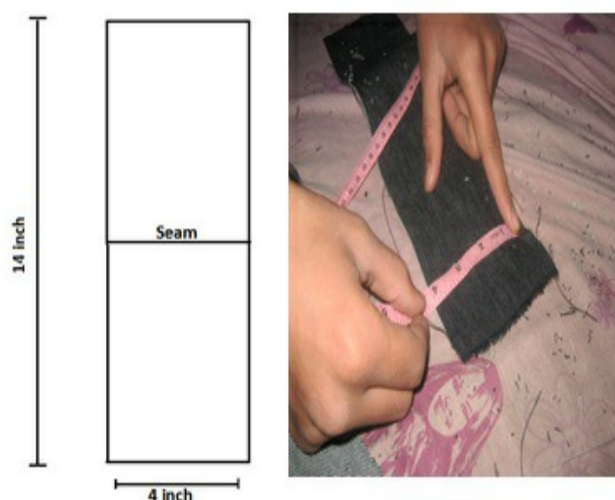


Figure 3:(a) specimen dimension from fabric b) Marking and c) cutting according to the Sample specifications

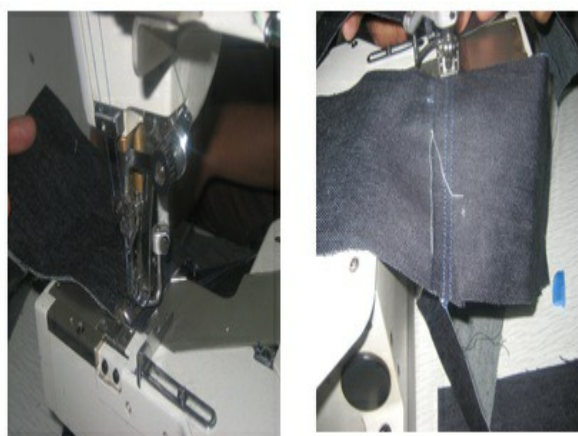


Figure 4:(a) Lapped seam sewing (b) Superimposed seam sewing

RESULTS AND DISCUSSION

Effect of Stitch Class and Stitch Density on Lapped Seam

Lapped seam was sewn with the three different stitch density 13, 11 and $8 \frac{1}{4}$ along with this three different stitch class imparted. Several experimental trails were performed repeatedly, so that the accurate results can be achieved for all three types of seams used in the study. In this testing section sometimes the fabric break instead of seam breakage, which showed that seam is much more powerful than the fabric, it depends upon stitch type and stitch density. According the table (1) most influential seam were lapped and superimposed with stitch (Class 600) independently.

Table 2: Average Seam Strength of lapped seam with different SPI and stitch classes.

Seam type	Stitch density	Stitch class	Seam strength
Lapped Seam	13 SPI	300	73.4
		400	77.7
		600	104.5
	11 SPI	300	59.7
		400	78.6
		600	106.3
	$8 \frac{1}{4}$ SPI	300	53.4
		400	49.5
		600	103.3

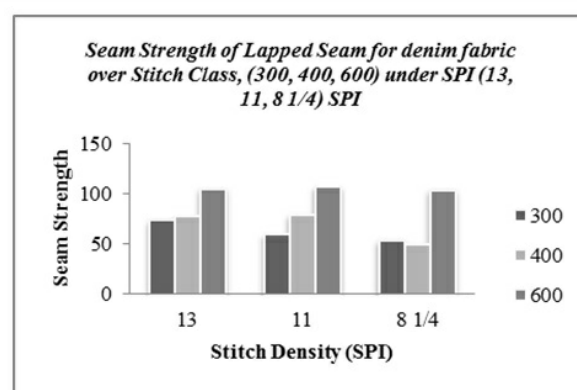


Figure 5: Strength of the Lapped Seam with three different SPI and three Stitch classes

The above figure shows the results obtained for the lapped seam. The class 600 showed maximum strength, actually in FTS (fabric tearing strength) seam was not break down in all tests performed under different SPI. The strength of class 300 and class 400 under different stitch density showed slight difference. At 13 SPI the seam strength of class 400 was greater than class 300, at 11 SPI the seam strength of class 400 was consistently greater than class 300 and at $8 \frac{1}{4}$ SPI the strength of class 300 increase again with the little increment comparing with class 400. It can be seen in the Fig. 5, that there is a greater change in strength over 11 SPI.

Effect of Stitch Class and Stitch Density on Bound Seam

Same as the above, bound seam was sewn with the three different stitch density 13, 11 and $8 \frac{1}{4}$ along with the combination of three different stitch class. This blend makes nine experiments of the bound seam as shown in

the Table 2. Several experiments were performed on bound seam and their mean value was obtained. The STB (seam tearing break) and FTS (fabric tearing strength) terms were used in this table because, during the testing of bound seam sometimes the fabric breakage phenomena was also faced. Many factors involved for this aspect such as weight of the fabric, picks per inch and ends per inch, specimen obtain (warp wise, weft wise or diagonally), stitch type using and stitch density. But as shows in the Table 2, it was because of the stitch type (Class 600).

Table 3: Average seam strength of bound seam with different SPI and stitch classes.

Seam type	Stitch density	Stitch class	Seam strength
Bound Seam	13 SPI	300	71.6
		400	70
		600	101
	11 SPI	300	61.1
		400	77.3
		600	89.5
	8 1/4 SPI	300	53.4
		400	44.7
		600	104.7

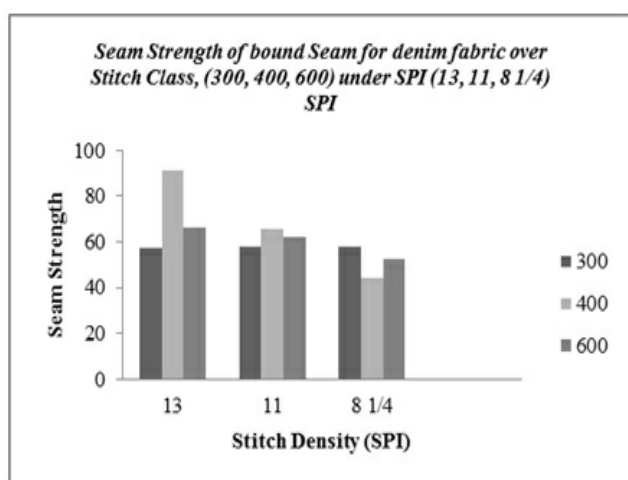


Figure 6: Strength of Bound Seam with different SPI and stitch classes

The Fig.6 shows the results for strength collected from the bound seam using the tensile strength tester. Three different class of stitch are presented with different colours under the three stitch densities. The yellow line represent the class 600, having large fluctuation at different SPI compared with other two classes. In yellow line, at SPI 13

and SPI 8 1/4 the FTS values are shown. Stitch class 300 and 400 shows interchanging strength value at different SPI respectively. At 13 SPI class 300 strength was greater than the class 400 and after that at 11 SPI the class 400 took the position of class 300 by gaining the strength. Whereas at the same time the strength of the class 300 increase again and class 400 falls down with 8 1/4 SPI.

Effect of Stitch Class and Stitch Density on Super Imposed Seam

The strength of the superimposed seam was checked out, by sewing the three different stitch density 13, 11 and 8 1/4 along with the combination of three different stitch classes. Several experiments of the superimposed seam were performed as presented in table.3. All the experiments were performed on super imposed seam and their mean value was obtained.

The below Figure. 7 Shows the seam strength collected from the super imposed seam. Three different classes of stitch are shown with different colors under the three stitch densities. The class 600, placed on the top, provided maximum strength at all three SPI among other classes. The class 300 and 400 showed seam strength close to each other along 13 and 8 1/4 SPI, whereas with 11 SPI the class 400 has greater strength as compared to class 300. With respect to strength class 600 shows the ideal stitch type selected for all three SPI and class 300 is most poor stitch type selected for sewing at all SPI.

Table 4: Average Seam Strength of Super Imposed Seam with different SPI and stitch classes.

Seam type	Stitch density SPI	Stitch class	Seam strength (STB)
Super imposed seam	13	300	57.4
		400	91.2
		600	62
	11	300	58
		400	65.5
		600	61
	8 1/4	300	44.6
		400	58
		600	52.6

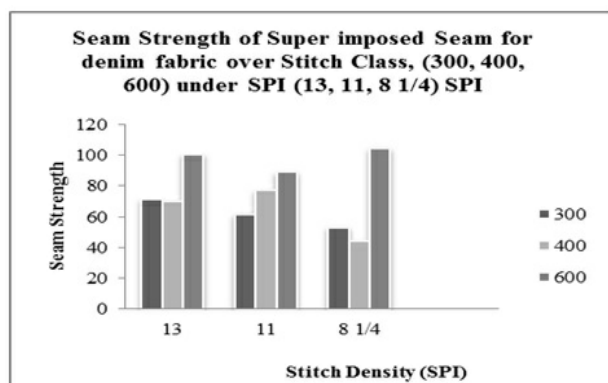


Figure 7: Strength of Super Imposed Seam with different SPI and stitch classes

CONCLUSION

It was found from experimental results that with increase in the stitch density the strength of the seam was also increase but up to some extent, after that the strength of seam decreased, Because increase in the stitch density after certain level may rapture the fabric. Further it was also found that different seams impact in a different way on the strength under different SPI and stitch type. In the lapped seam it was terminate that increase in the stitch density causes increase in strength of seam without depending upon class of stitch used. Individually every class of stitch almost gave average increase in strength with increase in SPI. It was conclude from bound seam that average maximum strength was achieved on 11 SPI in all three classes discussing in the research. Strength at the 8 1/4 SPI seam strength was so weak. But at 13 SPI the seam strength increased up to a certain limit, not linear in all classes less than 13 SPI. Super imposed seam was introduced with four different stitch classes and three SPI changes. Same result is obtained in this testing, that with increase in SPI the seam strength was also increased. Class 400 gave maximum strength in super imposed seam, with increase in SPI. Class 600 that introduces with superimposed also showing good strength but less than the class 400.

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