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Research Article

Investigating the Influence of Yarn Density and Seam Construction on the Seam Performance of Woven Linen Fabric

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Abstract

The impacts of fabric thread density and seam structure on woven linen fabric seam slippage and tensile strength characteristics have been investigated. Two different types of woven fabric samples were produced and prepared for the sewing process, with various levels of fabric thread density. The samples are sewn with different seams (superimposed, lapped, and bound), stitch density (10, 12, and 14 stitches/inch), and stitch type (single needle lock stitch, double needle lock stitch and double needle chain stitch). Fabric tensile characteristics, seam slippage, and seam strength in both the warp and weft directions have been tested and evaluated. The research reveals that seam strength and seam slippage are dependent on the seam type, stitch type, and SPI. Furthermore, we found that the fabric's EPI and PPI had a considerable impact on its seam performance, with greater EPI and PPI resulting in better seam performance.

Keywords: Woven Linen Fabric; Stitch Density; Seam Slippage; Seam Strength; Seam Performance

Introduction

One of the most basic requirements of human life is clothing. With the historical growth of fashion and culture, this fundamental need has become fashionable now. To accommodate need, the apparel or garment sector contains a variety of different stylish goods. Latest technologies are used in the garment industries. The fashion industry changes frequently as the demand changes [1]. Today's clothing and fashion business is extremely volatile, and in order to maintain competitive advantage, fashion designers must focus on quality rather than price. And, as a result of these considerations, input materials' qualities, stitching efficiency, and seam perfection become extremely critical [2].

Seams are commonly employed in the textile business to link various pieces of cloth to create a product with the necessary attributes based on the demands of the customer. Toughness, flexibility, longevity, rigidity, and the look of a well-formed seam determine seam performance [3]. Seam performance is governed by seam type, stitch density (stitches per unit length) of the seam and stress of the sewing thread. Seams are continually subjected to a variety of strains, usually in diverse orientations, because of physical movement concealed by the garment. When a seam is subjected to transversal strain, the stitch can be displaced (referred to as seam slippage) respect to the fabric layer [4]. In exceptional circumstances, the force applied may cause a rupture before the seam fails [5], since such damage is not easily repaired by seaming, sufficient yarn slippage (weft yarns slipping over warp yarns or opposite) occurs to leave the item useless [6]. As a result, determining the durability of yarns in woven textiles against slippage is critical in apparel quality management [7].

A variety of features of seam slippage have already been studied. To determine the amount of seam slippage, Galuszynski [4] established a model focused mostly on fabric structure and associated characteristics. The degree of seam slippage rises as yarn-to-yarn friction, thread contact angle (fabric architecture), the number of weft yarns in the fabric, stitch density, and yarn bending stiffness rise. Miguel et al. [8] tested seam slippage in a variety of woolen and worsted textiles in both the warp and weft directions. They discovered that clarity, polyamide content, finishing type, and cover factor are the traditional characteristics that have the greatest influence on seam slippage. To anticipate the seam opening qualities of woven upholstery textiles, Yildirim developed a method that uses non-linear regression numerical method. According to these unique materials, the researcher concluded that textile material physical attributes, particularly filling yarn density, have a larger impact in seam opening behavior than stitch density. Malciauskiene et al. [9] looked at the influence of weave pattern on imbalanced cloth seam slippage. The weaving type was discovered to have a substantial impact on seam slippage. In a separate study they have studied the influence of weave, weft yarn density and warp yarn density on seam slippage in textiles made from wool fiber [9]. They came to the conclusion that the fabric weave and weft setting parameters have a significant impact on the slippage tolerance of yarns at a seam in woven textiles, which can be projected using a two-factor polynomial second order formula [10] Pasayev et al. [11] investigated ways for reducing chenille fabric seam slippage. Weft yarn density of textile, the amount of interwoven chenille yarns over warp yarns and stitch density are all affected by seam slippage and sewing orientation according to researchers. They also proposed a conceptual framework that discussed the energy distribution supplied to stitched structures under applied loads to back up their research observations [12]. It was discovered that increasing the number of cloth layers sewed together will reduce seam slippage. Upon an inspection standpoint, seam integrity as a result of seam slippage increase is a further essential characteristic

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of stitched structural behavior [13]. Brain [14] attempted to connect stitch toughness qualities to thread ductility by applying certain adjustments to Burtonwood and Chamberlain's minimal level loop strength hypothesis [15]. Whereas the suggested approach showed encouraging results on observations. It was considered that more research into the fabric's influence to seam durability was required.

Few researches have been carried out on the seam slippage phenomena of elastic woven textiles. In particular, Gurarda [3] examined the seam efficiency of PET/Nylon-elastane woven textiles, taking into account the weft density, weave pattern, and sewing thread as factors. The findings indicated that higher the sewing thread size improves seam effectiveness and performance. It was also discovered that utilizing lycra in the fabric's weft direction improves seam efficiency when compared to the warp direction, however employing elastic yarns in the weft direction eliminated the discrepancies. In another study, Gurarda and Meric [3] explored at the displacement and grinning tendency of lockstitch seams on stretchy woven textiles as they were cycled loading. The trials included two distinct textile weave patterns (twill and plain), two distinct weft densities (26 and 29 weft/cm), and two distinct lycra yarns (PET/elastane air-covered and twisted yarn). The findings indicate that when weft density decreases and fabric flexibility increases, seam displacement and the grinning rise.

There are several researches on various areas of stretchy cloth seam reliability and performance [3]. Earlier studies have also revealed that there is no detailed examination on the seam slippage and durability of stretchy woven textiles created with specified elastic values throughout a broad variety of levels [16]. So, more investigation about seam characteristics of these types of materials sewed with various stitch densities at various tensile stresses was needed. The principal focus of this study was to investigate the impact of material elongation and stitch density on seam slippage and durability of flexible textiles.

Methodology

Sample preparation

Woven fabrics (linen) were used for the study.

We had used three types of seams- superimposed, lapped and bound, three SPI variations- 10, 12 and 14 and three types of stitches- single needle lock stitch (SNLS), double needle lock stitch (DNLS) and double needle chain stitch (DNCS). The thread count was used for needle-20/3 Ne, bobbin and looper-20/2 Ne. For SNLS and DNLS, we used JUKI machine (Model: DDL-8000A) and for DNCS, YAMATA machine (Model: FY3800DA). We used stich per inch- 12 and single needle lock stich machine for "seam strength" and "seam slippage" determination where seam type was variable for the first case. In second case, superimposed seam was fixed and single needle lock stich machine was used for testing seam strength and seam slippage maintaining variable stich per inch. In third case, superimposed seam was fixed and stitch per inch was 12 for seam strength and seam slippage determination while stitch type was variable.

Fabric tensile testing

For testing tensile strength of fabric, Instron 5500R machine was used. ASTM D 5034 (2001) standard was followed for evaluating tensile properties of fabrics. Test speed made sure that fabric failure occurs within 20±3 seconds.

Seam slippage and strength testing

In this study a fixed seam opening technique was used to evaluate the seam slippages of samples.

British standard "BS EN ISO 13936-1(2004)" was used for dimension of the samples and apparatus setting. The universal tensile machine (Instron 5500R) was used to find out the seam slippage. The tests speed was maintained was 50mm/min. Following the ASTM D 1683 (2004) standard, values of seam strength were calculated. Here test speed maintained was 50 mm/min. Testing conditions were standard testing conditions i.e., 22±2°C and 65±2% relative humidity. Seam slippage of each sample was found using the ISO 13936-2 method where maximum force was 60N, speeds was 50mm/min and measurement time was 30 seconds. Seam slippage and seam strength values both in warp and weft direction were averaged.

Results and Discussion

Seam strength depends on seam type, stitch type, stitch density, fabric strength and the tension of the thread that is applied in the seam [17]. Stitch density (number of stitches over a given length of seam) has direct influence on seam strength. Seam failure in a piece of clothing can happen because of either the sewing string failing to leave the fabric unblemished or texture burst, or both breaking at the same. Seam quality is trying in nearly an indistinguishable way from texture breaking quality. The quality of a seam or sewing should measure up to that of the material keeping in mind the end goal to have adjusted development that will withstand the powers experienced in the piece of clothing of which the seam in a section. Seam quality differs texture to texture because of method for weave or development and string check varieties. Tension developed in the needle thread has a significant effect on seam efficiency and lower tension during stitching improves the seam strength and seams efficiency to a greater extent. This happens because under sudden stress, some flexibility allows the seam to improve seam strength. When the tension in needle thread is high, the fabric gets pulled at the seam leading to a puckered, unstable seam that ultimately results in low seam strength and efficiency.

From Figure 1, we can see the variation of the seam strength of different seams. The graphical representation shows that sample 2 with lapped seam has the highest seam strength 170.89 N in warp direction and 164.85 N in weft direction. Then the strength is good for

Table 1: Sample specification.

Fabric specification	Fabric sample 1	Fabric sample 2
Warp Count (Ne)	18	18
Weft Count (Ne)	14	14
Ends per inch (EPI)	61	80
Picks per inch (PPI)	53	74
Fabric width (Inch)	57	56
GSM	175	200

Table 2: Tensile strength of samples.

Fabric sample	Fabric strength (N)
1	284.81
2	307.59

bound seam and last one is for superimposed seam. Moreover, as the sample 2 has more GSM and strength in warp direction, it has more seam strength than the sample 1.

From Figure 2, we can see the variation of seam strength in different SPI's. The graphical representation shows that sample 2 with SPI-12 has the highest seam strength 161.90 N in warp direction and 155.44 N in weft direction. Then the strength is good for SPI-12 in weft direction as both the sample was sewn with superimposed seam. In this case, the GSM is responsible for the strength variation phenomenon.

From Figure 3, we can see the variation of the seam strength with different stitch type from the graphical representation; it has been shown that sample 2 with DNCS has the highest seam strength 164.82 N in warp and 160.29 N in weft. Then the strength is good for DNLS in warp direction as both the sample was sewn with superimposed seam. In this case, the GSM is responsible for the strength variation

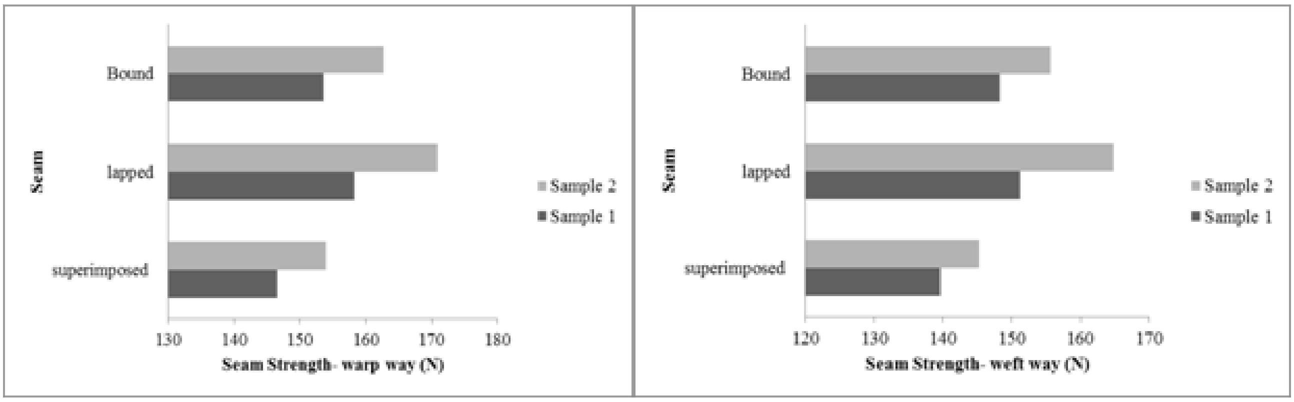

Figure 1: Seam strength- warp way and weft way *vs.* different seams.

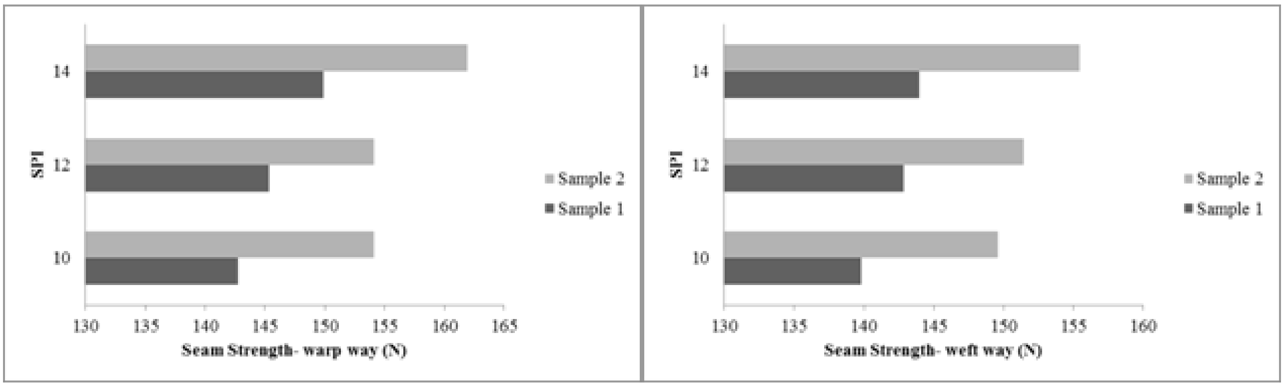

Figure 2: Seam strength- warp way and weft way *vs.* different SPI.

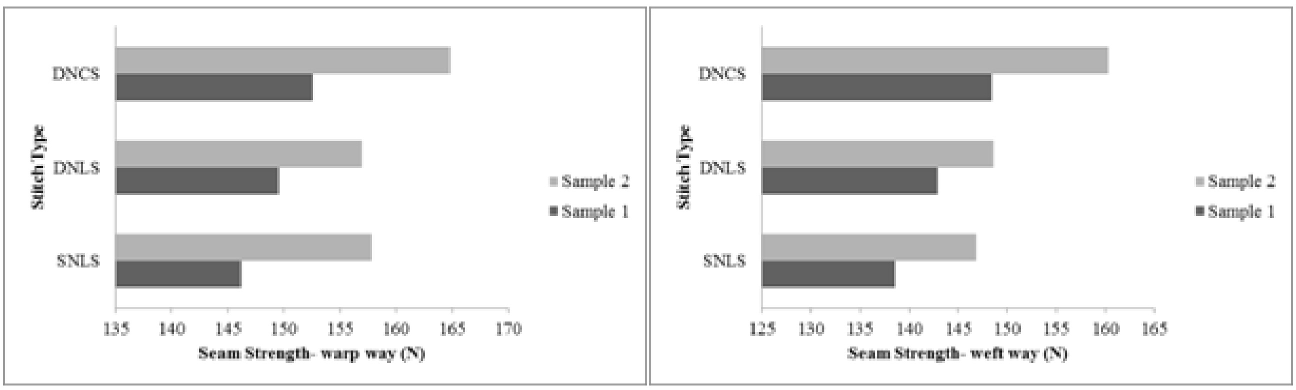

Figure 3: Seam strength- warp way and weft way *vs.* different stitch types.

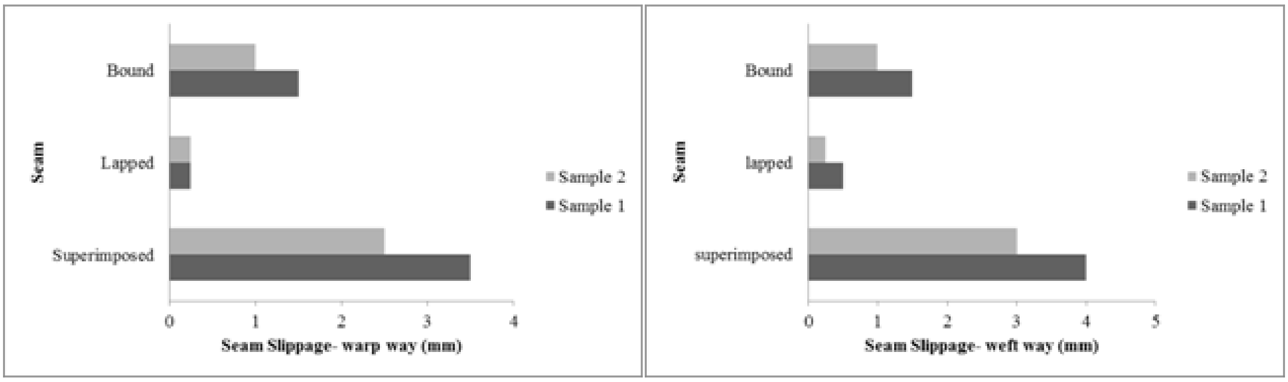

Figure 4: Seam slippage- warp way and weft way *vs.* different seams.

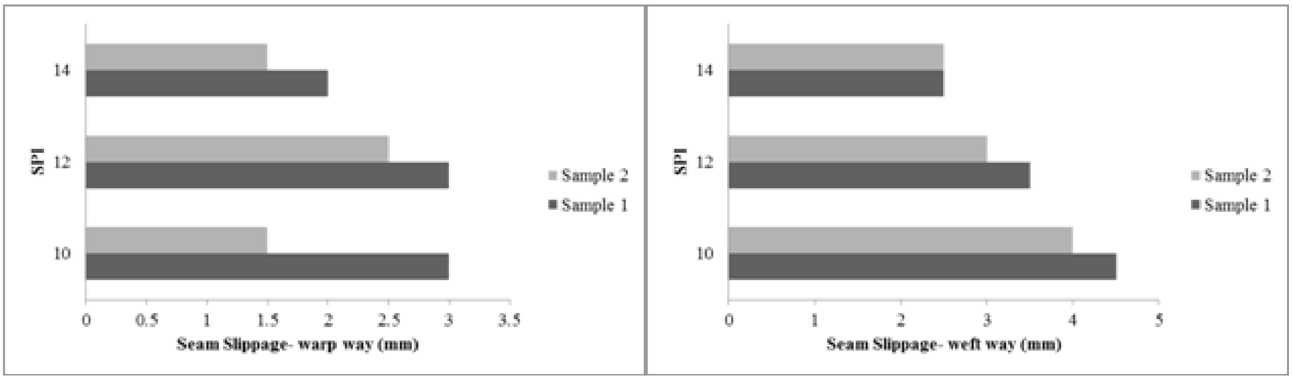

Figure 5: Seam slippage- warp way and weft way *vs.* different SPI.

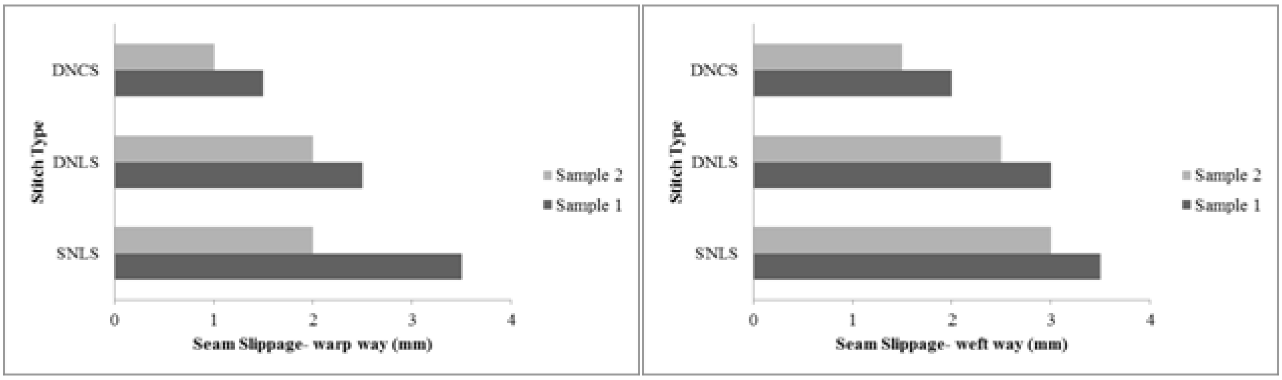

Figure 6: Seam slippage- warp way and weft way *vs.* different stitch types.

phenomenon.

From Figure 4, we can see the variation of the seam slippage with different seam type from the graphical representation, it has been shown that sample 2 with lapped seam has the lowest seam slippage in both warp and weft, while the sample 1 shows the same seam slippage in lapped warp direction and the highest in superimposed seam in both weave direction.

From Figure 5, we can see the variation of the seam slippage with different SPI from the graphical representation, it has been shown that sample 2 with SPI- 10, 14 has the least seam slippage in warp and slightly high in SPI- 12 weft direction, while the sample 2 shows slightly high seam slippage in SPI- 14 and the highest slippage in SPI- 10 in both weave direction.

From Figure 6, we can see the variation of the seam slippage with different stitch type from the graphical representation, it has been shown that sample 2 with DNCS type has the lowest seam slippage in warp and slightly high in weft direction, while the sample 1 shows the highest seam slippage in SNLS in both weave direction.

Conclusion

From the study it is apparent that seam strength and seam slippage rely on the seam type, SPI and stitch type. Moreover, it was observed that the EPI and PPI of the fabric have notable effect on the seam performance of the fabric as the higher EPI and PPI results in higher seam performance. In this study, we have found that lapped seam has the most seam strength with SPI- 12. Moreover, thread counts of both samples are same but sample 2 has higher thread density resulting better seam performance than sample 1. Finally, it can be concluded that higher thread density of the fabric, lapped seam, chain stitch and SPI play significant role in seam strength and seam slippage of linen fabric.

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