Indian Journal of Fibre & Textile Research
Vol. 51, June 2026, pp. 252-262
DOI: 10.56042/ijftr.v51i2.19413

A Study on the influence of weave parameters on fabric fraying and performance in recycled fabrics

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Received 5 May 2025; revised received and accepted 20 March 2026

Fabric fraying is considered a major problem in the apparel industry, as excessive fraying reduces seam allowances, causes quality issues such as size jumps, and leads to rejections during quality audits. This study started with identifying the root cause of fraying that happens in existing samples, including plain, warp rib, matt, and ordinary honeycomb weave, and then compared with newly developed samples such as combination plain, 2x2 twill, herringbone, and Brighton honeycomb across different groups in terms of fraying behavior and performance. All samples had the same yarn count, thread density, and fabric composition, differing only in their weave structure. The weave parameters, such as the Crossing Over Firmness Factor (CFF) and Floating Yarn Factor (FYF), were studied in relation to fabric properties, including tensile strength, tearing strength, seam strength, seam slippage, and air permeability, to assess fraying behaviour. Results indicated that CFF had a strong positive correlation with tensile strength (r = +0.81, +0.78) and resistance to seam slippage (r = +0.87, +0.96), but a strong negative correlation to air permeability (r = -0.70). FYF exhibited reverse trends. Combination plain weave, Herringbone weave and Brighton Honeycomb weave were the best weaves with respect to fray resistance and fabric performance. These results provide useful information to enhance fabric quality and minimize waste during garment production in the apparel industry.

Keywords: Air permeability, Crossing Over Firmness Factor (CFF), Floating Yarn Factor (FYF), Fabric Performance, Fraying, Weave Structure

1 Introduction

The fraying of fabric is considered to be a major problem in exports, as these industries uses loosely woven fabric made with recycled or staple fibers that tend to unravel at the edge during cutting[1]. It is also observed that a change in customer attitude towards fast fashion is another reason for the use of loosely woven fabrics. As the interlacement between the yarns is less, it leads to a high risk of yarn slippage and fraying, particularly during cutting, sewing, and other mechanical operations[2]. The fraying of fabrics reduces productivity in export manufacturing, where the loosely woven fabrics create many quality issues in the industry leading to redoing of seams, additional finishes and quality audit failure affecting production expenses and lead time[3]. Firmness of the fabric depends on the frequent interlacing of warp yarns and weft yarns. Plain weave with a high degree of interlacement creates a compact structure, which in turn prevents fabric fraying, whereas satin weaves have more floats, reducing yarn cohesion and making it susceptible to fraying[4].

As the fraying of the fabric is interrelated to the structural parameter of the weave, fraying can be predicted by two weave parameters, namely, Crossing Over Firmness Factor (CFF) and Floating Yarn Factor (FYF). In addition to focusing on fraying of the fabrics, it is important to consider the durability and air permeability, as well as garment manufacturing. The strength of the fabrics can be assessed by measuring their tensile strength, tearing strength, seam strength, and seam slippage.[5] Padaki *et al.* investigated these associations in multilayer interlocked woven structures by using the Interlacement Index (I) and Float Index (F) metrics closely tied to CFF and FYF. The results indicated that fabrics with a high CFF exhibited enhanced tensile strength and dimensional stability because of the improved load distribution across multiple yarns[6]. Nikolić *et al.* discovered that plain weaves demonstrated greater tensile strength than twill and satin weaves because of their increased interlacements, which enhance load distribution, indicating a balance between tensile and tear capabilities[7].

Vimal *et al.* studied the tear strength of eleven cotton woven fabrics based on the weave parameters CFF, FYF, Fabric Firmness Factor (FFF) and Weave

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Factor (P1) and found that CFF and FFF showed a negative correlation to the tearing test, as higher interlacement reduced yarn movement leading to a decrease in the tearing strength, and an opposite result was found in the case of FYF[8]. Another study shows that the type of weave and densities in both warp and weft influence seam slippage. Unfinished fabric with higher interlacing has better seam strength and slippage resistance[9]. Chen & Cheng stated that weave structure and finishing play an important role in seam strength and seam slippage. It was found that chemical treatment enhances yarn mobility and increases slippage, and that this effect can be reduced by using tighter weaves[10].

Fatahi & Yazdi discovered that FYF positively influences air permeability due to longer floats with more pore size; conversely, CFF decreases air permeability with more interlacement and diminishes pore size[11]. Sunita & Sinha examined the comfort properties of twill and found that 2x2 twill has more air permeability than herringbone weave[12]. It was also found that air permeability depends on weave parameters, weave structure, and fabric thickness.

This study aims to find the main cause of fabric fraying in current industry samples using cause-and-effect analysis. Based on the analysis, common and variable factors that contribute to fraying were identified in the existing samples. To explore the influence of weave structure on fraying, weave parameters such as CFF and FYF are calculated for the existing samples. These parameters measure the interlacement and average float length of weaves in a repeat which is crucial for understanding fraying behavior. A critical study will be done for a base style, which is a Men's Half-Sleeve Shirt, to examine the fabric fraying at different stages of garment production, namely, the cutting stage, pre-assembly stage, mid-assembly stage and final assembly stage. This will help identify the best and worst performing weaves in terms of fabric fraying behavior. Based on the findings, four new samples with similar characteristics will be developed with similar fabric characteristics and different weave structure. The new samples will be compared with existing samples for fabric fraying and performance to identify the weave structure that resists fraying best.

2 Materials and Methods

2.1 Materials

Eight fabric samples were used for the study, out of which four samples were procured from the industry, and four samples were specifically developed. The samples chosen and developed were recycled fabrics made with 70 % cotton and 30 % recycled polyester, with a warp and weft count (Ne) of $2/20^s$ x $2/20^s$ and thread density (EPI X PPI) of 40 x 36. The samples were developed in a bit loom with a width of 24 inches and a length of 5 meters. For easy understanding of the existing and newly developed samples used in the study, a unique referral code of "ES" was given to the existing samples, and CS was given for the newly developed samples. The new samples were developed with the same parameters as the existing samples, facilitating easy comparison of fabric fraying behaviour between the two. Table 1 gives the details of all the samples used for the study.

2.2 Methods

2.2.1 Analyzing Weave Parameters of Existing and Newly Developed Samples

To understand the effect of weave on fabric fraying behaviour of existing and newly developed samples, two weave parameters namely CFF and FYF were calculated and analyzed.

2.2.1.1 Crossing Over Firmness Factor (CFF)

The term was originally introduced by Ogawa.The primary drawback was that it was not clearly defined for further exploration[13]. To address this, Morino *et al.* redefined CFF as follows:-

CFF = Number of crossing over lines in the complete repeat (N_c)

Number of interlacing points in the complete repeat (N_i)

The CFF is useful for understanding yarn interaction and interlacing firmness, but it does not account for density[14].

2.2.1.2 Floating Yarn Factor (FYF)

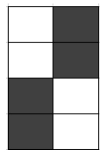
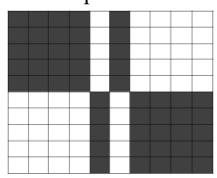
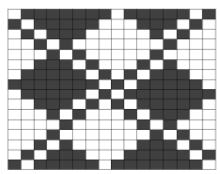
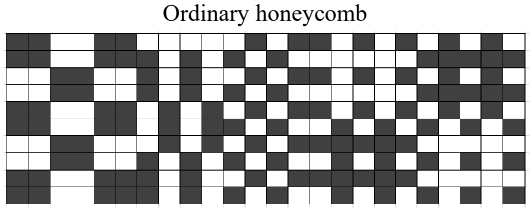
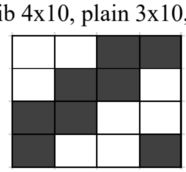
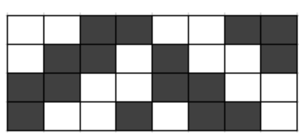
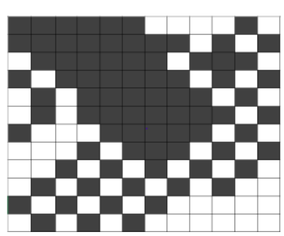
It is defined as follows :-

FYF = (Type $_{I\sim IX}$ -1) x (Existing number of type$_{I\sim IX}$ in the complete repeat)

Number of interlacing points in the complete repeat[15]

The FYF is used to find the average float length of a weave in a repeat and is most effective for evaluating fabrics with longer floats, although it might be less beneficial for tighter weaves[16]. Values were calculated and cross-checked with Kumari *et al.* These calculations helped in determining the fraying

Table 1 — Fabric structure and properties of existing and newly developed samples

Existing and newly developed samples			Fabric properties	
Sample Code	Weave	Weave Matrix	Areal Density, GSM	Thickness, cm
ES1	Plain	 Plain 2x2	204	0.56
ES2	Warp rib	 Warp Rib 2x4	208	0.57
ES3	Matt	 Matt 10x10	190	0.58
ES4	Ordinary honeycomb	 Ordinary honeycomb	192	0.69
CS1	Combination Plain	 Matt 6x10, warp rib 4x10, plain 3x10, leno weave 10x10	200	0.67
CS2	2x2 Twill	 Twill 4x4	194	0.58
CS3	Herringbone	 Herring bone 4x8	200	0.65
CS4	Brighton Honeycomb	 Brighton 12x12	196	0.66

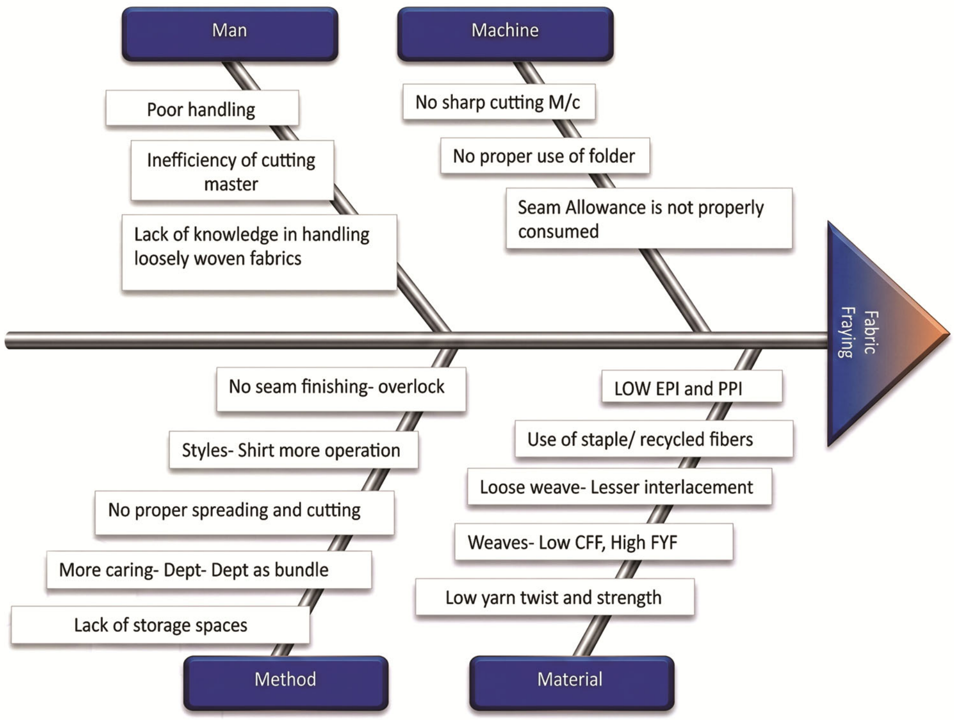


Fig. 1 — Cause and effect analysis of major causes of fabric fraying

behavior of existing samples and identifying the most effective weave in the newly developed sample[17].

2.2.2 Identification of Major Causes of Fabric Fraying in Existing Samples Using Cause and Effect Analysis

The first step was to identify the different causes of fabric fraying within the industry in terms of man, material, method, and machine. This helped in identifying the root cause of fabric fraying by keeping the main problem as the head of the fish and sub-causes as branches (Fig. 1).

2.2.3 Analysing Fabric Fraying Behavior of Existing and Newly Developed Samples Through Critical Study

To find the fraying behaviour of four existing samples in the industry, a critical study was performed to analyse how weave structures and production phases impact the fabric's fraying behaviour. For consistency and to facilitate a proper comparison, the garment employed was a standardized Men's Half-Sleeve Shirt. The fraying was measured in millimetres (mm) using a measuring tape at the end of cutting, pre-assembly (storage), mid-assembly (before sewing, back yoke attachment, front placket preparation and shoulder attachment) and final assembly stage (sleeve attachment, slit stitching, collar preparation and collar attachment) in key areas, namely, neck, armhole, side seam and hem.

2.2.4 Analysing the Fabric Performance of Existing and Newly Developed Samples

Fabric performance was analyzed for existing and newly developed samples by testing for the tensile strength (ASTM D 5035), tearing strength (ASTM D 1424), seam strength and seam slippage (ASTM D 1683) and air permeability (ASTM D 737). Ten readings were taken for each test, and the mean was calculated.

2.2.5 Statistical Analysis Used in the Study

Two-way Analysis of Variance (ANOVA) at 95 % confidence level was used in the critical study to find the influence of two independent variables, namely weave type and production stage, on fabric fraying. Null Hypothesis (H_o) states that there is no influence of weave type and stages of production on fabric fraying. The alternate hypothesis (H_1) states that weave type and production stages influence fabric fraying.

One-way ANOVA was performed to assess the influence of weave parameters (CFF and FYF; independent variables) on fabric performance (dependent variables), including tensile strength, tearing strength, seam strength, seam slippage, and air permeability, for both existing and newly developed samples. Null Hypothesis (H_0) states that there is no influence of CFF and FYF on fabric performance, whereas the Alternate Hypothesis (H_1) states that there is

Table 2 — Weave parameters of existing samples

Samples	CFF	FYF	Fabric fraying behaviour
ES1	2	0	Very Low
ES2	1.5	0.5	Low- Moderate
ES3	0.65	1.35	Very High
ES4	0.875	1.125	High

a significant influence of CFF and FYF on fabric performance. In both cases, p-values were inspected to find the significance of the results. If the p-value was less than 0.05, it indicated that the data was statistically significant; otherwise, it was not statistically significant. Furthermore, the relationship between CFF and FYF on fabric performance was analysed using the Correlation Coefficient (r). The strength of 'r' lies between +1 and -1, where +1 indicates very strong positive correlation, and -1 indicates very strong negative correlation[18].

3 Results and Discussion

3.1 Analysing Fabric Fraying Behavior of Existing Samples

3.1.1 Analysing Fabric Fraying Through Weave Parameters of Existing Samples

Fabric fraying behaviour based on CFF and FYF is shown in Table 2. The calculations were done to analyse the fraying of the existing samples with respect to their weave parameters, namely CFF and FYF. It was found that ES1 has the highest CFF and lowest FYF values in comparison to all the samples with ES3 having the highest FYF and lowest CFF values. As fraying is related to interlacing of yarn, when the CFF of fabric increases, it increases the interlacing of yarn, resulting in less fraying. Conversely, when FYF increases, the average float of the weaves increases, making them more susceptible to fraying. This shows that ES1 with a plain weave had the least fraying, followed by ES2 with a warp rib weave. ES3 with a matt weave had the highest fraying.

3.1.2 Analysing Fabric Fraying Using Cause and Effect Analysis of Existing Fabrics

The various causes of fabric fraying in the existing samples were identified across four factors, namely man, material, method, and machine, using Cause and Effect analysis as shown in Fig. 1.

3.1.2.1 Man-Related Causes

The different causes of fraying related to the man are shown in Fig. 1. It was found that fraying occurred due to poor operator handling, inefficiency of the cutting master, and lack of knowledge in handling loosely woven fabrics.

3.1.2.2 Method-Related Causes

The different causes of fraying related to the method are shown in Fig. 1. It was found that improper seam finishing (overlock and flat lock), styles with a higher sequence of operations, in this case, Men's Shirt, inaccurate cutting and sewing, excessive movement of fabric bundles between departments, and insufficient storage space were the reasons for method-related fabric fraying

3.1.2.3 Machine-Related Causes

The different causes of machine-related fraying are shown in Fig. 1. It was found that improper use of sharp cutting machines, incorrect use of folders, and inadequate consumption of seam allowance were the machine-related causes of fabric fraying.

3.1.2.4 Material-Related Causes

The different causes of fraying related to the material are shown in Fig. 1. It was found that the material-related problems were considered to be the root cause of fabric fraying. Low EPI and PPI constructions, use of staple or recycled fibers, loosely woven fabrics with fewer yarn interlacements, low CFF, high FYF, and the use of yarns with lower twist and strength were the various reasons for fabric fraying. This study focuses on solving material-related issues by improving the fabric quality with more interlacement and a tighter weave structure, thereby making an attempt to reduce fabric fraying.

3.1.3 Analysing the Fabric Fraying of the Existing Samples Through Critical Study

The consolidated data of fabric fraying across different parts of the garment of existing samples were collected and compared across different stages of production as shown in Table 3. It is found that ES3 has the maximum fraying of 1.59 mm in the cutting stage, 2.93 mm in pre assembly stage, 5.07 mm in the mid-assembly stage, and 5.19 mm in the final assembly stage followed by ES4 having a fraying of 1.82 mm in the cutting stage, 2 mm in the pre-assembly stage, 4.51 mm in mid assembly stage, and 5.21 mm in final assembly stage. ES2 frayed less

Table 3 — Fabric fraying results of existing samples through critical study

Samples	Fabric fraying, mm			
	Cutting stage	Pre assembly stage	Mid assembly stage	Final assembly stage
ES1	0.82	1.52	2.04	2.12
ES2	1.29	1.8	2.57	2.13
ES3	1.59	2.93	5.07	5.19
ES4	1.82	2	4.51	5.21

compared to ES3 and ES4, with fraying of 1.29 mm in the cutting stage, 1.8 mm in the pre-assembly stage, 2.57 mm in the mid-assembly stage, and 2.13 mm in the final assembly stage. ES1 has the least fraying among all the samples, with fraying of 0.82 mm in the cutting stage, 1.52 mm in the pre-assembly stage, 2.04 mm in the mid-assembly stage, and 2.12 mm in the final assembly stage. The results of the critical study matched the weave parameter value of CFF and FYF as shown in Table 2, where ES1 had the least fraying. This indicates that the fraying behaviour of existing samples depends on their weave parameters.

3.2 Development of New Samples

From Table 3, it was found that ES1 and ES2 had the least fraying across the different stages of garment production, as determined through a critical study. To assess the influence of weaves on fraying, four new samples were produced: CS1, CS2, CS3, and CS4. The reasons for producing the new samples are given below:-

3.2.1 Combination Plain Weave (CS1)

This weave is developed by integrating the basic plain weave and its derivative, the warp rib weave, with additional leno weave for improved air permeability. This structure provides a good balance between strength and breathability.[4,11,12]

3.2.2 Twill Weave (CS2)

This 2x2 twill has an equal number of interlacements and floats which gives a high seam performance along with good air permeability when compared to the rest of the twill weaves.[12]

3.2.3 Herringbone Weave (CS3)

This weave has more interlacement and performs better in seam slippage resistance, seam strength, and tensile strength of fabric.[12]

3.2.4 Brighton Honeycomb Weave (CS4)

This weave has more CFF and less FYF than ordinary honeycomb weave[19]. Based on the above reasons, these four samples were produced with similar fabric properties to the existing samples, and varied only by the weave structure as shown in Table 1.

Table 4 — Classification of existing and newly developed samples

Group	Existing samples	Newly developed samples
Rib-based weave	ES1	CS1
	ES2	
	ES3	
Twill-based weave	Nil	CS2
		CS3
Complex weaves	ES4	CS4

3.3 Classification of Existing and Newly Developed Samples

To compare the existing samples (ES1-ES4) and the newly developed samples (CS1-CS4), all samples were grouped by weave structure into three groups, as shown in Table 4. It included grouping rib-based weaves (ES1, ES2, ES3 and CS1), twill-based weaves (CS2 and CS3) and complex weaves (ES4 and CS4)[9]. The plain weave can be included in rib-based weaves, as it is considered to be the basic element in a weave structure. The study focuses on comparing the influence of weave parameters between existing and newly developed samples on fabric fraying behaviour during the critical study and on fabric performance.

3.4 Analysing Weave Parameters of Newly Developed Samples

The fabric fraying behaviour, based on CFF and FYF, of the newly developed samples is shown in Table 5. It was found that CS4 has the highest CFF and lowest FYF values among all newly developed samples, while CS2 has the highest FYF and lowest CFF values. This shows that CS4 with a Brighton honeycomb weave had the least fraying, followed by CS1 with a combination plain weave. CS2 with a 2x2 twill weave had the highest fraying.

3.5 Analysing Fabric Fraying Behavior of Newly Developed Samples with the Existing Samples Through Critical Study

The critical study was conducted on existing and newly developed samples, and the data were compared with those of the existing samples in each

Table 5 — Weave parameters of newly developed samples

Samples	CFF	FYF	Fabric fraying behaviour
CS1	1.44	0.56	Low
CS2	1	1	Very High
CS3	1.125	0.875	Low- Moderate
CS4	1.80	0.20	Very low

group at different stages of garment production, namely the cutting stage, pre-assembly stage, mid-assembly stage, and final assembly stage, as shown in Fig. 2 (a-c).

3.5.1 Analysing the Fabric Fraying Behavior of Rib Based Group

Fig. 2 (a) shows the fabric fraying of the samples in the rib-based group. It was found that CS1, with a plain-weave combination, has the lowest fraying in the first three stages of garment production and slightly higher fraying in the final stage than ES1 with a plain weave, due to the presence of leno weave in its structure. This is in agreement with the weave parameter values as shown in Tables 2 and 5, where a higher CFF value indicates less fraying. Similarly, ES3 with a matt weave is found to have the highest fraying in all the stages due to its higher float presence as indicated by higher FYF values, which increases the yarn movement and fraying behaviour of the fabric[8].

3.5.2 Analysing the Fabric Fraying of the Twill-Based Group

The fabric fraying of different weaves in the twill based group at various stages of production is shown in Fig. 2 (b). It was found that CS3 with herringbone weave has the lowest fraying when compared to CS2, which is a 2x2 twill weave in all stages of garment production. This is in agreement with the findings of Table 5, wherein 2x2 twill weave had the highest FYF and lowest CFF due to its equal interlacement and float presence, which increases the yarn movement and fraying behaviour of fabric[8].

3.5.3 Analysing the Fabric Fraying of a Complex Group

The fabric fraying across different weaves in the complex group at various stages of garment production is shown in Fig. 2(c). It was found that CS4 with the Brighton honeycomb weave has the lowest fraying compared to ES4 with the ordinary honeycomb weave at all stages of garment production. This is in agreement with the findings of Table 2 and 5 wherein ordinary honeycomb weave had the highest FYF and lowest CFF which increases the yarn movement and fraying behaviour of fabric[19].

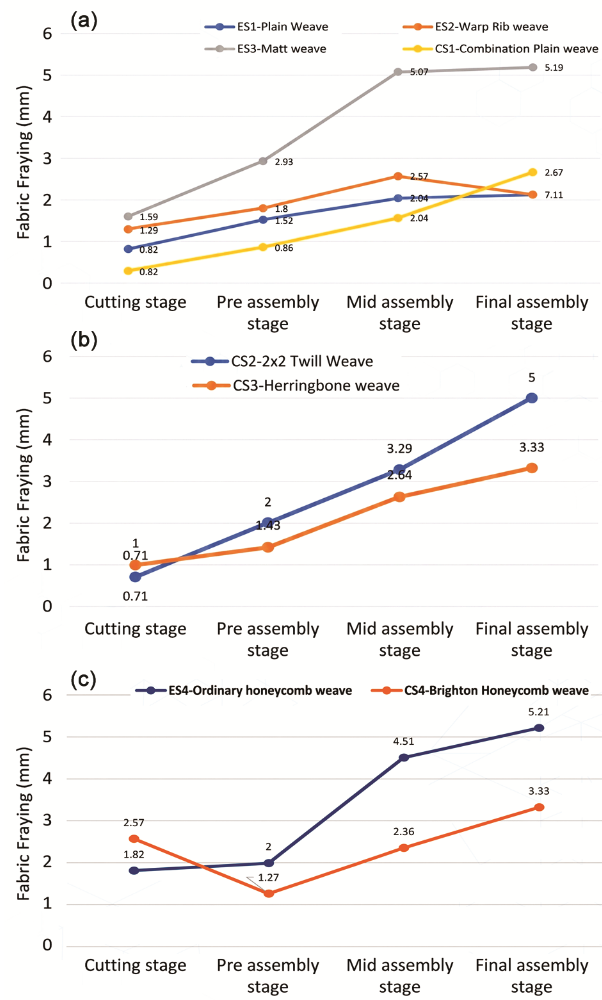


Fig. 2 — Fabric fraying behavior of (a) rib, (b) twill, and (c) complex groups through critical study

Thus, from the above critical study, it was found that the newly developed samples had the lowest fabric fraying in all the stages of garment production, with CS1 in the rib-based group, CS3 in the twill-based group and CS4 in the complex group performing best.

3.6 Statistical Analysis of Critical Study

Table 6 presents the results of a two-way ANOVA to assess the influence of different weaves and garment production stages on fabric fraying during

Table 6 — ANOVA results on critical study

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Weave	19.0	7	2.7	5.73	0.000826	2.48
Stages of production	29.0	3	9.67	20	1.99E-06	3.07
Error	9.96	21	0.47			

Table 7 — Weave parameters and fabric performance of existing and newly developed samples

Group	Sample Code	Tensile Strength, N		Tearing Strength, lbf		Seam Strength, lbf		Seam Slippage Resistance, lbf		Air Permeability, $cm^3/cm^2/s$
		Warp	Weft	Warp	Weft	Warp	Weft	Warp	Weft	
Rib based	ES1	536	501.6	9.5	9	38.7	58.9	30.2	38.8	45.7
	ES2	515	502.3	10.5	11.3	57	51.4	24.3	25.7	95
	ES3	483	421.9	17.7	16.2	16.6	15.8	6.2	7	104
	CS1	545.8	502.8	12.6	8.8	22.3	46.1	25	17.3	113
Twill based	CS2	486.7	392.5	11.8	12.4	20.3	52.2	11.7	16.7	121
	CS3	507.4	387.7	12.6	11.5	21.1	51.1	10	16.7	106
Complex	ES4	457.9	402.3	11.3	10.9	35.9	44	16.7	10.3	162
	CS4	503.1	452.7	25.9	23	41.6	60.9	10.7	17.3	72.2

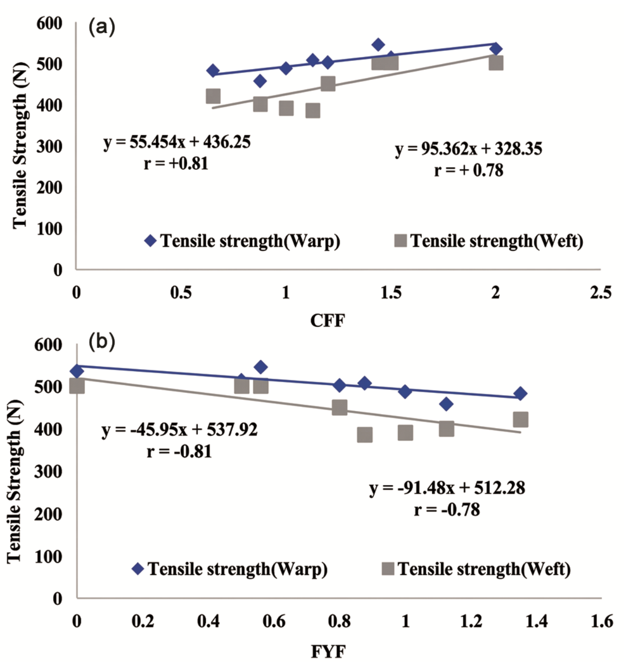


Fig. 3 — (a) CFF vs Tensile strength, and (b) FYF vs Tensile strength

the critical study. It was found that the p-value in both cases was <0.05, and the F-value (5.73, 20) > F crit (2.48, 3.07), thereby rejecting the null hypothesis and accepting the alternate hypothesis, which states that there is a significant influence of different weaves and stages of garment production on fabric fraying.

3.7 Analysing the Influence of Weave Parameters on Fabric Performance of Existing and Newly Developed Samples

The weave parameters and the fabric performance, such as tensile strength, tearing strength, seam strength, seam slippage resistance and air permeability, are shown in Table 7 for both existing and newly developed samples.

3.7.1 Tensile Strength

The tensile strengths of existing and newly developed samples are shown in Table 7. The highest tensile strength is seen in CS1 in the rib-based group, CS3 in the twill-based group and CS4 in the complex group. It is due to greater interlacing in their structure, which creates a tighter fabric. The lowest tensile strength is observed in ES3 in the rib-based group, CS2 in the twill-based group, and ES1 in the complex groups. This is due to the larger number of floats, which increases yarn movement and makes it break easily[7].

3.7.1.1 Effect of Weave Parameters on Tensile Strength

The relationship between CFF, FYF and tensile strength is shown in Fig. 3 (a, b). It was found that the correlation coefficient value of CFF and tensile strength was +0.81 in warp and +0.78 in weft, indicating a strong positive correlation (r = +0.70 to +0.90) between CFF and tensile strength.[18] It is apparent that as CFF increases, the interlacement of yarns also increases, enhancing load distribution and resulting in higher tensile strength[7].

The relationship between FYF and tensile strength shows a strong negative correlation (r = -0.70 to -0.90), with values of -0.81 in warp and -0.78 in weft. This shows that as FYF increases, tensile strength decreases, and as floats increase, load distribution among yarns decreases, and breaks occur more quickly. This aligns with the findings of Nikolic *et al*[7].

3.7.2 Tearing Strength

The tearing strengths of existing and newly developed samples are shown in Table 7. The highest tearing strength is observed in ES3 in the rib-based group, CS2 in the twill-based group, and CS4 in the complex group, due to the presence of more floats in the weave structure. The lowest tearing is seen in ES1 in the rib-based group, CS3 in the twill-based group, and ES4 in the complex group. This is due to the presence of more interlacing in the weave structure[8].

3.7.2.1 Effect of Weave Parameters on Tearing Strength

The relationships between CFF, FYF, and tearing strength are shown in Fig. 4(a, b). It was found that the correlation coefficient value of CFF and tearing strength was -0.40 in warp and -0.35 in weft, indicating a moderate negative correlation (r = -0.70 to -0.90) between CFF and tearing strength[18]. It indicates that as CFF increases, the tearing strength decreases due to greater interlacement in the weave. The results align with the findings of Vimal *et al.*

The relationship between FYF and tearing strength reveals a moderate positive correlation (r = +0.70 to +0.90) with the values of 0.40 in warp and +0.35 in weft. This indicates that when FYF increases tearing strength also increases due to the presence of more floats in the weave[8].

3.7.3 Seam Strength

Seam strength of existing and newly developed samples is shown in Table 7. The highest seam strength is seen in ES2 in the rib-based group, CS3 in the twill-based group and CS4 in the complex group. It is due to the presence of more interlacement in the weave structure[9]. Seam strength is lowest in ES3 in the rib-based group, CS2 in the twill-based group and ES4 in the complex group. This is due to more float presence in the weave[9]. It is also found that weaves with a good balance of interlacement and floats show a high seam performance[12].

3.7.3.1 Effect of Weave Parameters on Seam Strength

The relationships between CFF, FYF, and seam strength are shown in Fig. 5(a, b). It was found that the correlation coefficient value of CFF and seam strength was +0.74 in warp and +0.61 in weft, indicating a moderate positive correlation (r = +0.70 to +0.90) between CFF and seam strength[18]. This indicates that as CFF increases, seam strength also increases due to the presence of more interlacements in the weave[9].

The relationship between FYF and seam strength reveals a moderate negative correlation (r = -0.70 to -0.90), with the values of -0.74 in warp and -0.61 in weft. This indicates that when FYF increases it decreases the seam strength due to the presence of more floats in the weave structure[9].

3.7.4 Seam Slippage Resistance

Seam slippage resistance of existing and newly developed samples is shown in Table 7. The highest

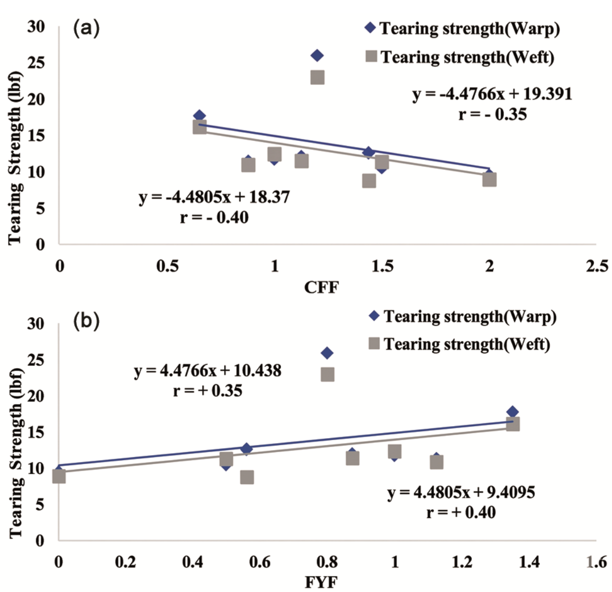


Fig. 4 — (a) CFF vs Tearing strength, and (b) FYF vs Tearing strength

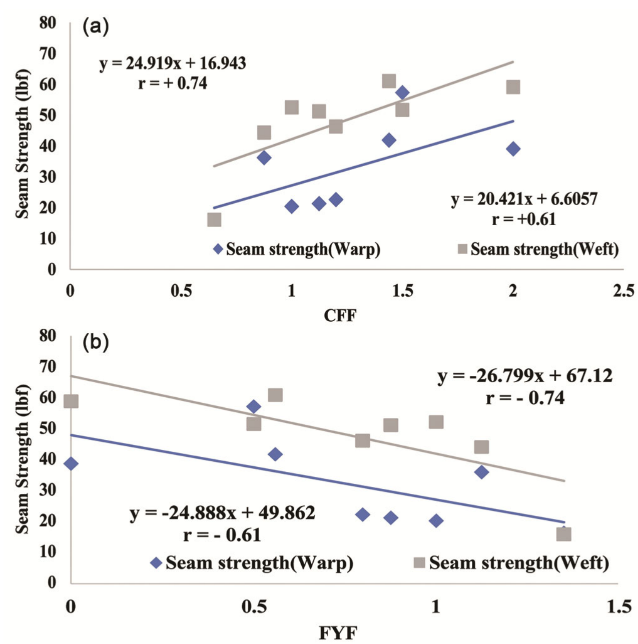


Fig. 5 — (a) CFF vs Seam strength, and (b) FYF vs Seam strength

seam slippage resistance is seen in ES1 in the rib-based group, CS2 in the twill-based group and CS4 in the complex group. It is due to the presence of more interlacing in the weave structure. The lowest seam slippage resistance is seen in ES3 in the rib-based group, CS3 in the twill-based group and ES4 in the complex group. This is due to a larger number of floats[10]. It is also found that the weave with a good balance of interlacement and floats shows a high seam performance[12].

3.7.4.1 Effect of Weave Parameters on Seam Slippage Resistance

The relationships between CFF, FYF, and seam slippage resistance are shown in Fig. 6(a, b). It was found that the correlation coefficient value of CFF and seam slippage resistance was +0.86 in warp and +0.95 in weft indicating a strong positive correlation (r = +0.70 to +0.90) between CFF and seam slippage resistance[18]. This indicates that as CFF increases, seam slippage resistance increases due to increased interlacements and better yarn stability at the seam. This aligns with the findings of Chen & Cheng.

The relationship between FYF and seam slippage resistance shows a strong negative correlation (r = -0.70 to -0.90), with values of -0.86 in warp and -0.95 in weft. This indicates that when FYF increases, it decreases the seam slippage resistance due to the presence of more floats in the weave structure which increases yarn movement in fabric and gets slipped easily at seams[10].

3.7.5 Air Permeability

Air permeability of existing and newly developed samples is shown in Table 7. The highest air permeability is seen in ES3 in the rib-based group, CS2 in the twill-based group and ES4 in the complex group. It is due to the presence of more floats in the structure. The lowest air permeability is seen in ES1 in the rib-based group, CS3 in the twill-based group and CS4 in the complex group. This is due to greater interlacing in the weave structure. Moreover, the air permeability of CS1 is higher when compared to ES1and ES2 due to the presence of leno weaves[4].

3.7.5.1 Effect of Weave Parameters on Air Permeability

The relationships between CFF, FYF, and air permeability are shown in Fig. 7(a, b). The correlation coefficient between CFF and air permeability was -0.7, indicating a strong negative correlation (r = -0.70 to -0.90). This indicates that as CFF increases, air permeability decreases due to high interlacement. The high interlacing also decreases pore size and disrupts airflow. This aligns with the findings of Fatahi & Yazdi and Vimal[8].

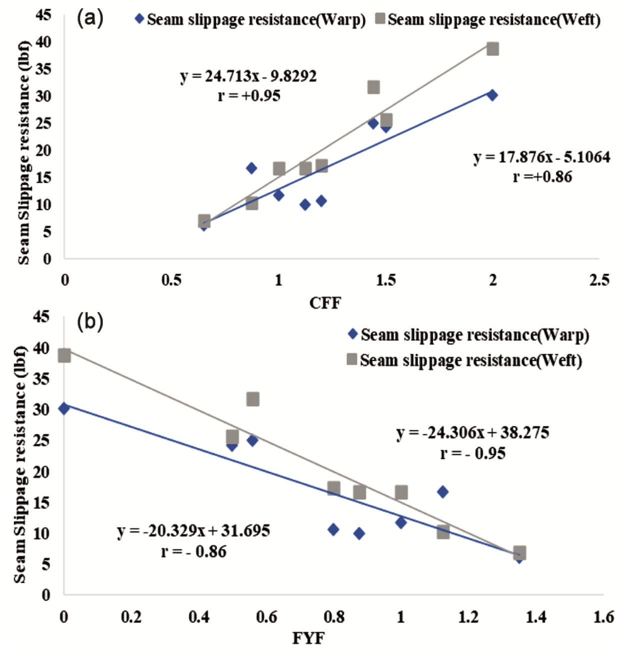


Fig. 6 — (a) CFF vs Seam slippage resistance, and (b) FYF vs Seam slippage resistance

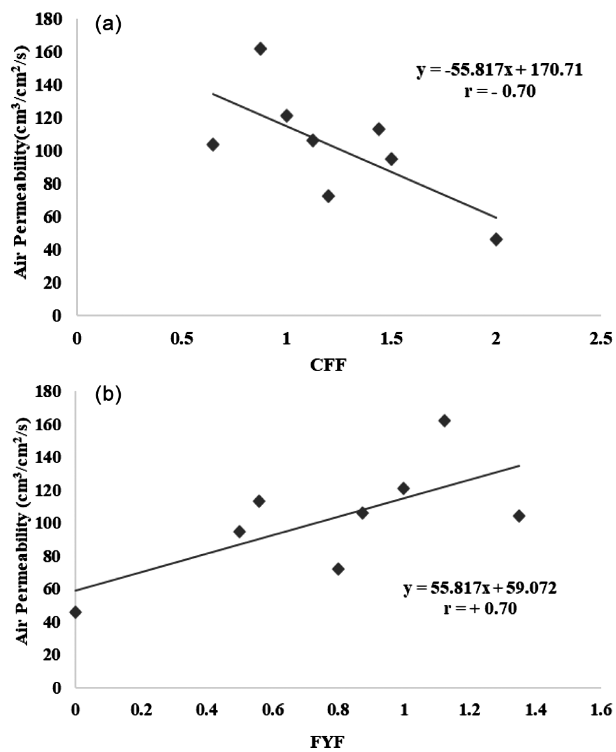


Fig. 7 — (a) CFF vs Air permeability, and (b) FYF vs Air permeability

The relationship between FYF and air permeability reveals a strong positive correlation (r = +0.70 to +0.90) with the values of FYF (+0.7). This indicates that as the number of floats increases, FYF also increases indicating a larger opening facilitating a greater air flow[11,15].

4 Conclusion

The study was undertaken to analyse fabric fraying in eight samples: four from the existing industry and four newly developed. Weave parameters (CFF and FYF) and a cause-and-effect analysis were conducted to identify the root cause of fabric fraying, followed by a critical study of the existing samples. It was found that plain weave and warp rib weave exhibit good fray resistance due to their tighter weave structures. Four new samples were produced: combination plain weave, 2x2 twill weave, herringbone weave, and Brighton honeycomb weave. The weaves were classified into three groups: the rib-based, twill-based, and complex groups. Fabric fraying behaviour was analysed using weave parameters and a critical study of the newly developed samples, and compared with that of existing samples. Two-way ANOVA confirmed that weave structure and fabric production stages significantly influence fraying behavior. In addition, fabric performance was analyzed with weave parameters. It was observed that CFF had a strong positive correlation with tensile strength and seam slippage resistance, and a strong negative correlation with air permeability, while FYF showed opposite trends. Weave structures, particularly those with high interlacement and balanced floats, such as a combination of plain and herringbone weaves, effectively reduce fraying and enhance fabric performance. The study focused on reducing fabric fraying and improving overall fabric performance by balancing CFF and FYF in the weave structure. However, the scope of research is wide. Further research can be conducted on changing fabric composition to create a stronger fabric, chemical or enzymatic treatment of the surface or yarn to enhance edge stability, or using advanced production techniques to improve the overall performance of the fabric with reduced fraying behaviour during various stages of garment production.

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