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Effect of basic weaves on mechanical properties of cotton union fabrics

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Abstract
The present study was conducted with the objective to know the influence of basic weaves on mechanical properties of union fabrics. Four different yarns of different yarn count *viz.*, cotton (2/40s), polyester (2/150d), silk (8/20d) and viscose (2/40s) were used as weft keeping cotton (2/40s) as warp to produce union fabrics with three basic weaves (1/1 plain, 2/2 twill and 1/3 twill) on traditional handloom at KHDC, Gadag. The developed fabrics were assessed for mechanical parameters like cloth tensile strength, elongation, tearing strength, abrasion resistance and pilling. The results revealed that, the even and uneven twill woven fabrics showed highest tensile and tearing strength compared to plain woven fabrics in all the weaves. Whereas, the weight and thickness loss of samples was maximum among twill weave fabrics compared to plain woven fabrics and plain weave woven union fabrics possessed higher pilling resistance than twills.

Keywords: Basic weaves, union fabrics, mechanical properties, tensile, tearing abrasion resistance, pilling

1. Introduction

The weave of a textile is determined by its intended usage, which has more impact on the fabrics practical and aesthetic features. As a result, knowing the relationship between the fabric structure and its functional and aesthetic features is required for a cohesive textile design. Woven fabrics have more strength and durability than other manufacturing techniques. The interlacing of yarns in the warp and weft directions, thread count per inch, twist type and yarn count are all used to determine the performance behaviour in terms of strength, flexibility, extensibility and sturdiness of fabrics.

The mechanical behaviour of finished fabrics, such as the quantity of load, stress and strain curve, percentage of extension and applied force are affected by the weave structure (Ijaz *et al.*, 2020). The end use requirements are not only limited to aesthetics but also towards comfortability and functionality. Therefore, the comfort and functional properties have become highly important in case of textile fabrics (Rehman *et al.*, 2019). These properties of fabrics depend upon the type of fiber used along warp and weft directions.

Cotton is the most widely used natural fabric for apparel manufacturing across the world because of its comfortability, absorbency, durability and it is ideal for all seasons. It is natural agro-originated cellulosic fibre accounts for about 46 per cent of all fiber produced on the planet. Cotton continues to be the backbone of the global garment and textile industries and has a number of unique characteristics, including high flexibility, good cohesion, low coefficient of friction, small diameter and low linear density.

Union fabric is formed by weaving distinct yarns in the warp and weft directions. To minimize the cost of cotton fabric as well as the weight of the fabric, many types of union fabrics can be made by combining cotton, rayon, ramie, polyester, acrylic and other materials with silk. Blending, according to Garbyal (2015) [7], is a strategy for combining fibres so that the positive aspects are highlighted while the bad qualities are minimized. Blending occurs when one type of yarn is used in the warp and another type is used in the weft during the opening of fibres, yarn production, or weaving.

The aim of the present study is to weave a series of cotton union fabrics using the same cotton yarn count as warp and suitable cotton, polyester, silk and viscose yarn counts as weft. It is an attempt for the assessment and development of cotton union fabrics, as well as to determine the influence of weave structure on the mechanical qualities of cotton union fabrics.

2. Material and Methods

Scoured griege cotton yarn of count 2/40s for the warp, cotton (2/40s) and polyester (2/150d), silk (8/20d) and viscose (2/40s) for the weft were collected from KHDC, Gadag The selected yarns were woven with three basic weaves *viz.*, plain (1/1), even (2/2) twill and uneven (1/3) twill weaves. Totally twelve union fabrics were developed on traditional handloom with reed count of 56, cloth width of 40 inches and the denting order of 2 threads/ dent. From each weave, four union fabrics were produced and analysed using three factorial ANOVA design using WINDOSTAT software developed by INDOSTAT services.

Before weaving, the selected griege cotton, polyester, silk and viscose yarns were subjected to assess the yarn properties *i.e.*, yarn twist, yarn strength & elongation and yarn evenness to know the effect of yarn properties on physical properties. After weaving, the woven cotton union fabrics were subjected to assess the mechanical properties *viz.*, cloth tensile strength & elongation, tearing strength, cloth abrasion resistance and cloth pilling. After the preparation of samples all the fabrics are tested in standard atmosphere temperature and relative humidity and the following tests are done to assess the mechanical properties of cotton union fabrics.

2.1 Tensile strength & elongation: The specimens were tested as directed in IS 1969-Part1-2009. The method employed to determine the breaking load and elongation of the material by using the ravelled strip test' in "Unistretch" tensile tester. The specimen was a 5 cm wide piece of fabric prepared initially by cutting the material to a width of about 7 cm and the threads ravelled from both sides until the width attained 5 cm. The test length is 200 mm in between the jaws with the load range of 250 kgf and extra length was taken to grip within the jaws. The experiment was carried out at RTE Society Rural Engineering College, Hulkoti.

2.2 Tearing strength: Tearing strength is defined as the force required to tear a fabric in warp or weft direction. ASTM D1424-09 (2013) - Standard test method is used for tearing strength. In this experiment, the tear strength of fabric samples was determined by using Falling Pendulum Elmendorf's Apparatus with the sample size of 7.5cm ×10cm and amount of constant load applied was 6400 gms. The experiment was carried out at RTE Society Rural Engineering College, Hulkoti. The number of samples tested were 5 warp way and weft way (Jahan, 2017) [8]. Tearing strength was assessed by using the formula

Tearing strength (gms): Capacity of instrument × pointer reading /100

2.3 Cloth Abrasion resistance: The ICT Martindale multidirectional abrasion tester was used to determine the abrasion resistance of the test fabric with the sample size of 13.5 cm diameter. Five test specimens were cut, using the template and weighted. The samples were fixed in the sample holders, the counter was set for 100 cycles and the machine was run to the set cycles. The average weight loss and thickness loss of five specimens was noted and converted to percent of weight and thickness loss (Booth, 1996) [3]. The experiment was carried out at DKTE, Ichalkaranji.

2.4 Cloth Pilling: Pills are balls or bunch of entangled fibres clinging to the cloth surface and giving the garment an unsightly appearance. The specimens were tested using Heal's pilling tester. A piece of fabric measuring 5-inch × 5 inches was sewn to so that it fits firmly around the rubber tube. The cut ends of the fabric were covered by cellophane tape and four tubes were placed in a box lined with cork which is then rotated at 60 revolutions per min for 5 hours (18,000 revolutions). After tumbling, the extent of pilling was assessed visually by comparison with the arbitrary standard rating (Booth, 1996) [3].

Table 1: Effect of weave structure on tensile strength & elongation of cotton union fabrics

Sl. No	Weave	Union fabrics	Cloth tensile strength (kgf)		Cloth elongation (%)	
			Warp	Warp	Warp	Weft
1.	Plain (1/1)	Cotton x Cotton	86.67	76.97	1.21	1.03
		Cotton x Polyester	76.43	111.1	2.59	1.83
		Cotton x Silk	82.00	135.8	2.46	1.47
		Cotton x Viscose	108.3	78.47	3.17	1.83
2.	Even twill (2/2)	Cotton x Cotton	84.97	56.70	2.46	1.13
		Cotton x Polyester	77.38	205.6	3.08	1.61
		Cotton x Silk	85.17	116.8	1.15	1.53
		Cotton x Viscose	84.63	75.33	3.61	1.94
3.	Uneven twill (1/3)	Cotton x Cotton	95.08	79.30	1.13	1.10
		Cotton x Polyester	89.60	188.2	2.07	1.35
		Cotton x Silk	131.8	72.77	2.10	1.85
		Cotton x Viscose	88.17	82.24	2.73	1.83
S.Em.±			1.94		0.03	
C.D. (5%)			0.00*		0.00*	
C.V. (%)			3.41		3.54	

-*Significant at 5% level of significance CD- Critical difference CV- Coefficient of Variation

Table 2: Effect of weave structure on tearing strength and pilling of cotton union fabrics

Sl. No	Weave	Union fabrics	Cloth tearing strength (gms)		Cloth pilling rating
			Warp	Warp	
1.	Plain (1/1)	Cotton x Cotton	3392.0	2880.0	5
		Cotton x Polyester	4949.3	4160.0	4
		Cotton x Silk	4864.0	4181.3	5
		Cotton x Viscose	3306.6	2581.3	4
2.	Even twill (2/2)	Cotton x Cotton	4778.6	2517.3	4
		Cotton x Polyester	4800.0	4330.6	3-4
		Cotton x Silk	4714.6	4458.6	4
		Cotton x Viscose	4821.3	4672.0	4
3.	Uneven twill (1/3)	Cotton x Cotton	4821.3	4842.6	4
		Cotton x Polyester	4842.6	4842.6	3-4
		Cotton x Silk	4842.6	4650.6	4
		Cotton x Viscose	4736.0	4757.3	4

5: No pilling 4: Slight pilling 3: Moderate pilling 2: Severe pilling 1: Very severe pilling

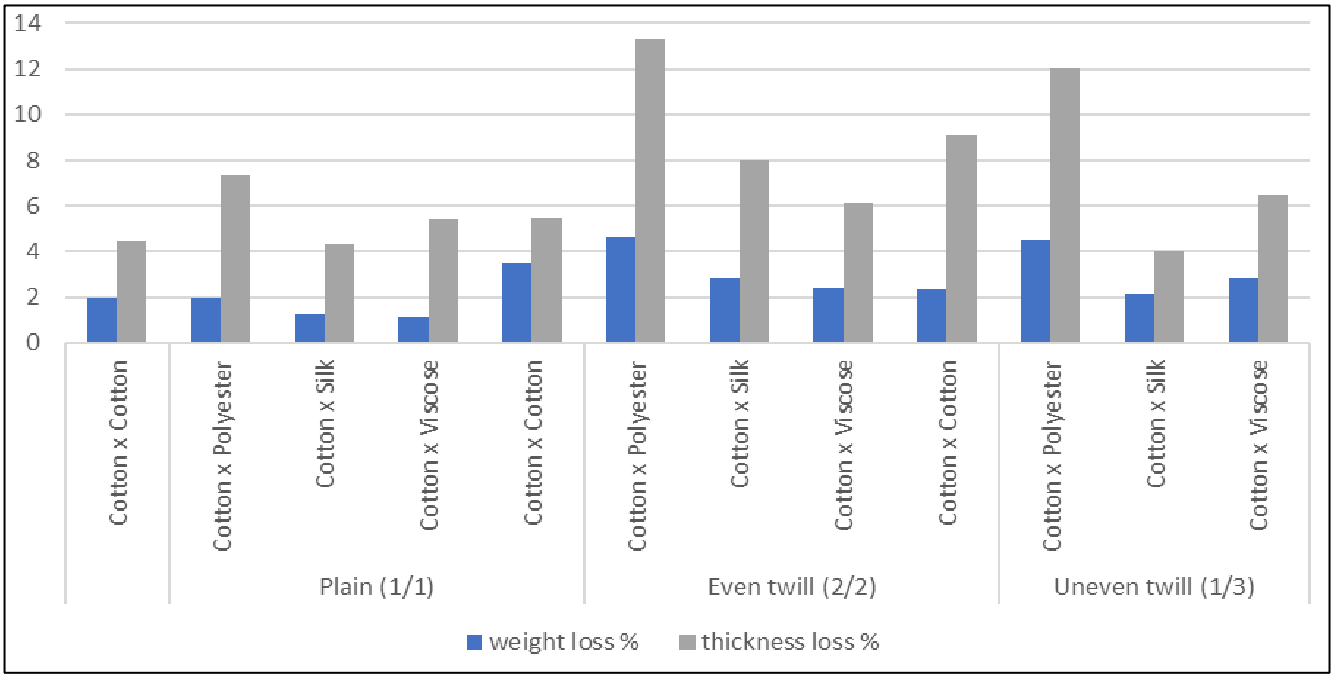

Fig 1: Effect of weave structure on weight loss & thickness percentage of cotton union fabrics

3. Results & Discussion

3.1 Effect of weave structure on cloth tensile strength and elongation of cotton union fabrics

Tensile strength is considered as the superior aspect for the fabric's excellence and performance of fabrics. It is the ratio between the maximum load that a material can support without damage to the original cross- sectional area of the fabric (Ahmed *et al.*, 2014) [5].

It was observed from the Table 1 that, twill weave fabrics showed maximum tensile strength compared to plain weave fabrics. It may be explained as, when the load is applied to the fabric in certain direction, at first it attains some position, then the crimp decreases and the fabric relatively expand more as the crimp diminishes (Ahmed *et al.*, 2018).

Highest warp way tensile strength was attained by uneven twill woven cotton × silk (131.80 kgf) fabric which may be because of linearity and crystalline polymer system of silk fibre imparting better tensile strength to the fabric.

Cotton × polyester of even (188.23 kgf) and uneven twill (205.63 kgf) and cotton × silk (135.83) of plain woven fabrics obtained higher tensile strength. This may be because of the synthetic yarns in the weft and also polyester and silk fibres possess regular, linear and strong crystalline polymer system.

3.2 Elongation (%)

It is evident from the Table 1 that, may be due to the fibre composition, yarn twist, strength, and kind of yarn used in the fabrics, the warp way elongation % was higher than the weft way. Further, cotton × viscose fabrics attained maximum elongation percentage in almost all the union fabrics which may be because of the amorphous nature of the fibre and good drapability of viscose yarn.

3.3 Effect of weave structure on cloth tearing strength of cotton union fabrics

As the fabric tear strength depends on the number of yarn intersections *i.e.*, higher the number of interactions per unit, the lower the fabric tearing force in warp and weft directions. It is learnt from Table 2 that; the sequence of tear strength is from lower to higher in plain to even and uneven twill weave. It is due to the loose constructions and less interlacements of yarns that can move easily and bunch together, so that the twill weave exhibits higher resistance to the applied force compared to plain weave as stated by Jahan (2017) [8].

Irrespective of weave, cotton × silk (4842 gms) and cotton × polyester (4842 gms) union fabrics showed maximum warp and weft way tear strength which may be because of the silk fibre linearity and beta- configuration of silk polymers and synthetic fibre composition of polyester yarns.

3.4 Effect of weave structure on cloth Abrasion resistance of cotton union fabrics

Abrasion is the aspect of rubbing away of component fibres and yarns of the cloth. The resistance against breaking of threads due to the number of revolutions is evaluated by percentage of weight and thickness loss (Ahmed *et al*., 2014) [5].

Among all the union fabrics (Fig 1), no significant abrasion was observed in plain woven union fabrics. However, in 2/2 and 3/1 twill woven fabric showed high weight and thickness loss. This may be due to the more porous, loose weave construction. The results are in line with the study conducted by Jahan (2017) [8], wherein weight loss decreased with increase in abrasion resistance of woven fabrics.

Irrespective of weave, cotton × polyester fabric attained maximum weight and thickness loss may be due to the fibre content, fineness, fibre length, warp and weft density and lower twist in ply yarn of polyester resulting in loss in weight and thickness loss.

3.5 Effect of weave structure on cloth pilling of cotton union fabrics

The pilling parameter is a very prominent factor in the performance of textile materials. During pilling, fibres become entangled and protruded from the surface of the fabric to form ball like round structures causing a major default on the fabric (Doustaneh *et al*., 2013) [4]. It is found that, plain woven fabrics showed high pilling resistance compared to even and uneven twill fabrics (Table 2) may be because of fibres in the yarns of the fabrics are difficult to migrate due to the compact constructional structure of plain weave.

4. Conclusion

- In general, uneven twill woven cotton × silk (131.80 kgf) fabric and even twill woven cotton × polyester (205.63) along warp way obtained highest tensile strength compared to other union fabrics
- Among even twill woven fabrics, cotton × viscose fabric (3.61%) showed highest elongation percentage both in warp and weft way compared to other union fabrics
- Twill woven fabrics possessed maximum tear strength than plain woven fabrics both in warp and weft directions. Irrespective of weave, uneven twill woven cotton × silk (4842 gms) and cotton × polyester (4842 gms) fabrics along warp and cotton × cotton (4842 gms) and cotton × polyester (4842 gms) fabrics along weft showed higher tear strength
- The weight and thickness loss of samples was maximum among twill weave fabrics compared to plain woven fabrics. Irrespective of weave, uneven twill woven cotton × polyester (4.49%) showed higher weight loss percentage whereas, cotton × cotton (9.09%) of same weave showed highest thickness loss percentage.
- Among plain, even twill and uneven twill woven fabrics, cotton × cotton and cotton × silk union fabrics of plain weave obtained no pilling (5 rating).

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