

Effect of Weave Type Variation on Tensile and Tearing Strength of Woven Fabric

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ABSTRACT. Among the functional properties of fabric, Tear & Tensile strength has the paramount importance and weave variation has a significant effect on this. The effect of a weave on the strength of the fabric is discussed in this research. For this purpose, five weave variations on a piece of fabric were woven having the same construction by using the Air Jet loom. Titan 5 Universal Tester was used for testing and previous works took under consideration. These results are presented in this paper with numeric value tables and graphs.

KEYWORDS: Tear strength, Tensile strength, Plain weave, Twill weave, Matt weave.

1. INTRODUCTION

The research work aimed to analyze the tensile and tearing strength of fabric made of the same fiber with the same construction but different weave design for the different cover factor. Tearing strength of the fabrics depend on the mobility of the yarn within the fabric structure [1]. In this study, the tearing strength of five types of fabrics 1/1 plain, 2/2 z twill, 2/2 s twill, 3/1 z twill, 2/2(2) matt weave were analyzed. Tearing can be described as the sequential breakage of yarns or groups of yarns along a line through a fabric [2]. The tearing strength is often used to give a reasonably direct assessment of serviceability than the tensile strength and fabric with low tearing strength is generally an inferior product [1]. In the case of tensile loading, all the yarns in the direction of loading share the load; in tear loading, only one, two, or at most a few yarns share the load. The tearing strength is affected by changes in yarn geometry, fabric geometry, relaxation of the fibers, and their frictional characteristics [1]. The movement of the yarns will be restricted in tight constructions and results in a low tearing strength. Loose and open constructions allow yarns to move and group together, thus resulting in a high tearing strength. The tear strength is high with the designs having groups of yarns woven together, such as matt weave. The studies on tearing strength began with Krook and Fox [1]. They named the triangular distortion at the active region of tearing as 'del'. They stated that fabric structure is more important, which determines the Del shape in the region of tear and strongly affects the tear strength of the fabric. At the beginning of a tongue tear test when the loads on the tails are first applied, the cross yarns pull out of the fabric and become del yarns, the crimp is taken out of both sets of yarns near the del and

crimp exchange occurs within the untorn fabric, the untorn fabric ahead of the del becomes jammed in the direction of tear. The more easily the cross yarns pull out of the fabric, the longer the Del yarns and the longer the Del resulting high tear strength [1]. Moreover, they found that if the density of longitudinal yarns was decreased (while holding the number of transverse yarns constant), the average tear strength of a sample increased. On the other hand, there was little effect on the measured tearing strength if the density of the transverse system of yarns was altered (while holding the number of longitudinal yarns constant). Furthermore, they stated that increased tear resistance was achieved by using yarns with higher tensile strength or by decreasing the effect of friction in the fabric through the use of more slippery yarns or longer floats. Hager also studied tear strength [3]. Morton investigated fabric strength in relation to yarn properties and density of structure [4]. The result reveals that the increase in cover factor gradually increases the tensile and tearing strength.

1.1 Literature Review

- Tensile strength, the maximum load that a material can support without fracture when being stretched, divided by the original cross-sectional area of the material. Tensile strength is commonly expressed in units of pounds per square inch, often abbreviated to psi [5].
- Tearing strength is defined (ASTM D1682) as the force required to start or to continue to tear a fabric, in either weft or warp direction, under specified conditions. A tear in a fabric or garment generally occurs progressively along a line, and can be initiated by a moving fabric being caught on a sharp object [6].

2. MATERIALS AND METHODS

2.1 Fabric making procedure:

The specimen produced by using the Air-jet picking and cam shedding mechanism. During production the relative humidity and the temperature were standard. 100% yarn-dyed cotton grey fabric with warp yarns having light blue and the weft yarns having white color was used. “Z” twisted yarns were used and the fabric has a poor handle and dull appearance due to grey form. It also has a high creasing tendency, because it’s made of cotton yarn. The warp yarn has a TPI (twist per inch) value of 26 and weft has a TPI value of 22. The specimen is 75 “long and 58” wide. The construction was 90x60/40x30/58. Each of five weave variations was 12 inches long.

2.2 Testing procedure:

The Titan 5 Universal Strength Tester is used. First, we cut a specimen for tensile (strip) test and tear test. For the tensile strength test, the specimen size is (150*50) mm. For tearing test it is (100*150) mm. Then the standard is set on the machine. This tensile strength is measured by using EN ISO 13934-2013. The CRE (constant rate of elongation) of the machine is 100mm/min.



Figure 1. Titan 5 Universal Strength Tester

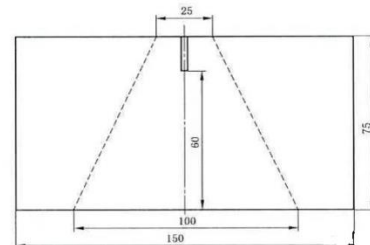


Figure 2. Tear test specimen

When the machine is ready first the sample of the tensile test is mounted on the machine one after one. Careful observations were made through the process, for the tensile tests when the yarn in the fabric starts to break the machine is stopped. All these processes are repeated for every specimen. Then the data are collected carefully.

For, tearing test, ISO 9073 is used. First, the specimens are set between the jaws as per the measurement then the machine is run. When it tears about 50mm of the fabric the machine is stopped. Careful observations were made through the process and the data is collected.

3. RESULTS AND DISCUSSION

3.1 Tensile Strength:

Our findings from the research are given below where table: 1 & 2 represent the data for the tensile test and table: 3 & 4 show the tear test data:

Tensile Strength (Warp result), Maximum Force (N)					
Specimen	1/1	2/2	2/2 S Twill	2/2 Z Twill	3/1 Z Twill
	Plain	Matt			
1	354.95	417.15	389.49	446.99	424.41
2	397.34	423.53	367.48	437.9	416.51
3	380.73	382.5	394.22	374.5	419.51
Mean	377.67	407.73	383.73	419.8	420.14
Range	42.39	41.03	26.74	72.59	7.9
Co-eff. of Variation	5.66%	5.42%	3.72%	9.41%	1.95%
Mean Elongation at Max force (%)	12.23	5.98	6.55	6.61	7.67
Mean Force at Rupture(N)	2.92	346.55	334.74	357.24	317.33
Elongation at Rupture	12.40	6.40	7.11	6.89	7.89
Time to break	0.07	0.03	0.04	0.04	0.04

Table 1: Tensile Strength on fabric's warp side

Tensile Strength (Weft result), Maximum Force (N)					
Specimen	1/1	2/2	2/2S Twill	2/2Z Twill	3/1Z Twill
	Plain	Matt			
1	310	299.89	310.24	317.78	275.94
2	374.31	263.28	339.3	297.14	306.19
3	312.16	266.23	330.63	305.02	257.4
Mean	332.18	276.47	326.72	306.65	279.84
Range	64.22	36.6	29.6	20.64	48.79
Co-eff. of Variation	1.10%	7.36%	4.07%	3.40%	8.80%
Mean Elongation at Max force (%)	11.3	13.1	13.64	13.15	12.18
Mean Force at Rupture(N)	247.37	217.2	248.91	228.71	197.84
Elongation at Rupture	11.44	13.29	13.75	13.28	12.4
Time to break	0.06	0.08	0.08	0.08	0.07

Table 2: Tensile Strength on fabric's weft side

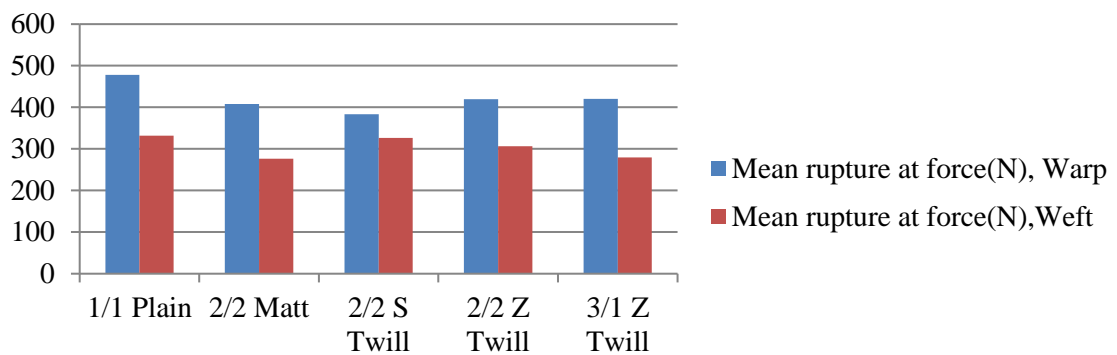


Figure 3: Tensile Performance of different weave

Plain woven fabrics tend to show the highest tensile strength as the interlacement points are more, providing a higher contact area, which causes greater frictional force and resistance to slippage of yarns in the fabric [7]. Again, tensile strength decreases in twill, the reason being increasing floats and lesser binding points. Matt weave also shows less strength than the plain weave as the number of interlacement is less in comparison with the plain structure [8].

3.2 Tear strength:

From Table 3 & 4, the outcome for the Tearing strength test is found. Tearing strength (warp & weft both ways) sequence from lower to higher in the plain to twill weaves [9]. Plain weave performs less tearing strength nearly 16N whereas 2/2 and 3/1 twill are stronger in tearing behavior 24N and 23N, It is clear that due to loose constructions and fewer interlacing, where yarns can easily move and bunch together, twill weave shows higher resistance to the applied force than plain weave because several yarns are broken simultaneously [9].

a= 5 Highest Peaks (N)

b= single Peak (N)

	Tear Strength (Length result)									
	1/1 Plain		2/2 Matt		2/2 S Twill		2/2 Z Twill		3/1 Z Twill	
Specimen	a	b	a	b	a	b	a	b	a	b
1	16.19	17.48	25.89	27	24.17	26.51	23.98	24.81	21.05	21.68
2	17.96	18.48	24.94	26.23	21.9	22.57	22.45	24.71	20.52	23.18
3	16.02	16.83	27.24	28.36	22.1	22.51	24.7	26.77	23.2	23.6
Mean	16.72	17.59	26.02	27.2	22.72	23.86	23.71	25.43	21.91	22.82
Range	1.94	1.62	2.31	2.12	2.27	4	2.25	2	3.92	3.92
Co-eff. of Variation	6.41%	4.62%	4.46%	3.95%	5.53%	9.61%	4.84%	4.56%	4.42%	4.42%

Table 3: Fabric's length wise tear strength

	Tear Strength (Width result)									
	1/1 Plain		2/2 Matt		2/2 S Twill		2/2 Z Twill		3/1 Z Twill	
Specimen	a	b	a	b	a	b	a	b	a	b
1	12.72	13.37	16.25	16.5	16.43	17.4	16	17.25	14.82	14.57
2	12.82	13.1	16.17	17.19	15.73	16.21	16.4	16.42	14.92	15.09
3	0.12	12.9	13.31	15.51	15.52	16.13	17.42	18.23	15.1	16.17
Mean	12.66	13.12	15.91	16.41	15.02	16.58	16.49	17.3	14.61	15.28
Range	0.36	0.47	0.94	1.68	0.91	1.27	1.42	1.81	1.28	1.6
Co-eff. of Variation	1.48%	1.81%	3.27%	5.16%	2.99%	4.29%	4.91%	5.23%	4.73%	5.34%

Table 4: Fabric’s width wise tear strength

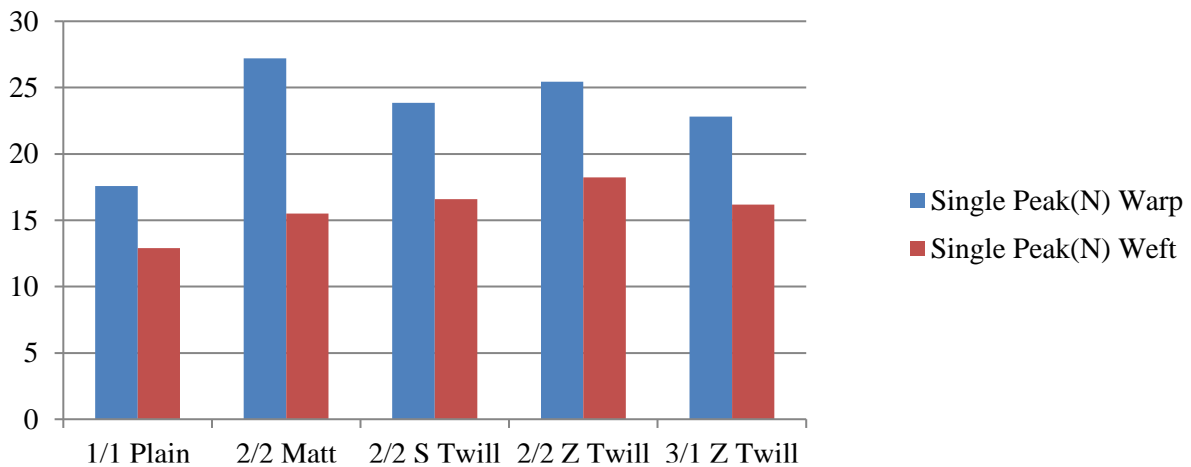


Figure 4. Tear Performance of different weave

Again Matt weave shows higher tear resistance which is 26N than the plain & twill one, this is because the threads in pairs [9]. The overall fabric quality depends on both tear and tensile strength, in that case, if we take both these properties under consideration, twill weaves are better than others weave that has been tested in this research which is followed by Matt and the plain weave.

4. CONCLUSION:

The fabric properties depend to a great extent on constructional parameters. This research shows the variation of mechanical properties (Tensile strength, Tearing strength) of cotton woven fabric from different weave structures. It was assumed to have variations in properties due to different weave structures and by this work, we found a bridge on the theoretical conceptions to the practical work. It was found that the tensile strength of plain weave is higher than twill weave, but tearing strength is more in twill than in plain weave. Further research work can be done on this work for the enrichment of the depth.

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