International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 01, January 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

BREAKING TENSILE PROPERTIES OF DOUBLE LAYERS POLYESTER FABRICS

Samer Said Sayed Radwan

Department of Spinning, Weaving and Knitting, Faculty of Applied Arts, Helwan University, Egypt

ABSTRACT

The tensile properties of double layers fabrics were evaluated. The twill weaves used to bind polyester warp ends and weft yarns according type of compound weave and size of the repeat. The layers of double weave samples were stitched by dropped ends whereby satin base Analysis of variance applied to breaking tensile strength results in warp way and weft way. Results referred that weave factor and type of intersections floats played an important role in controlling the breaking tensile strength and elongation of double layer woven fabrics. The comparison between breaking tensile strength and elongation of warp ends and weft yarns were plotted and discussed.

Keywords: Double Layer, Fabrics Properties, Breaking Tensile, Polyester Fabrics, Twill Weaves

I. INTRODUCTION

Tensile strength of a woven fabric is one of the most important properties, which makes it superior in many applications as compared to non-woven and knitted fabrics. Buyers add a demand of minimum fabric strength to the mandatory fabric specifications because it is not only an indication of fabric quality but also of yarn and fiber used in the fabric [1].

Attempts to investigate the mechanical behavior of woven fabrics have more or less followed three paths. The Peirce geometrical model assumed a woven fabric as a highly idealized geometrical object and described the deformational behavior of the fabric under external loading [2]. Hearle's extensive studies on the mechanical behavior of woven fabrics, included geometrical and mechanistic models [3]. Another approach was based on continuum mechanics to study the directional dependence of the tensile modulus [4].

Theoretical concepts of woven behavior during mechanical fatigues like tensile strength and elongation are more complicated, so there is a need to overcome this problem via applying the empirical and computational models such as artificial neural network or classical regression analysis [5-8].

Literature review implied that the tensile strength of the woven fabric reflected the strength of their constituent yarns, the structure of yarn and fabrics, and other factors [9-12]

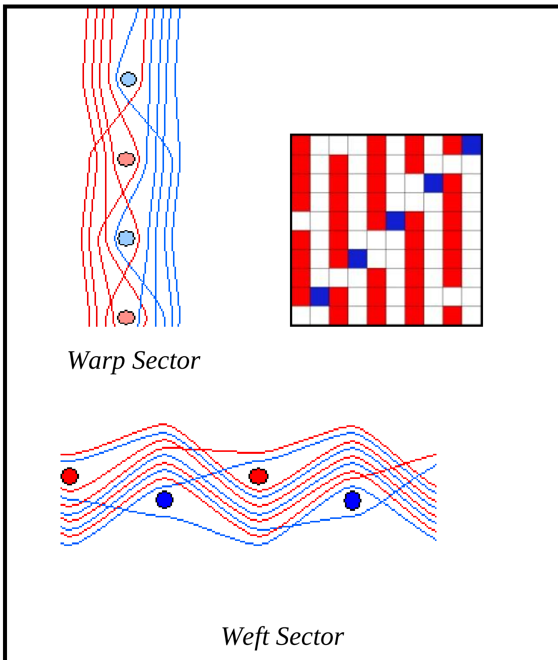
The studies about compound weaves haven't exceeded aesthetic purpose but distributing yarns in double layers for one or both directions and their effect on properties of wonen fabrics are inedicatelly uncovered. The current research imperically investigted the tensile properties of double layer fabrics woven by twill bindings.

IJARSE
ISSN 2319 - 8354

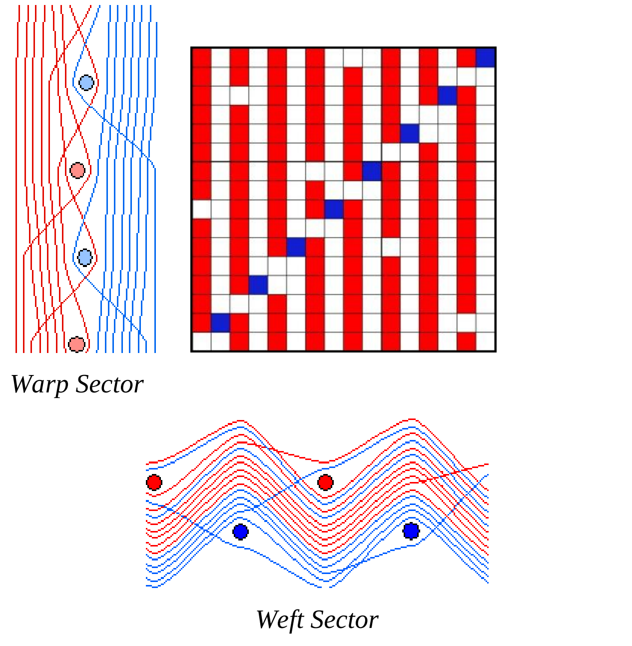
II. MATERIAL AND EXPERIMENTAL METHODS

2.1 Materials

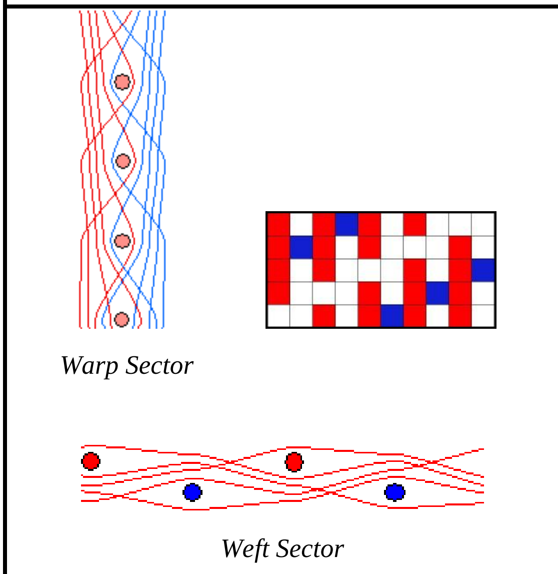
Experimental samples were woven by a Jacquard loom with 2400 hook, width=140 cm, speed= 200 picks/min. used as following:



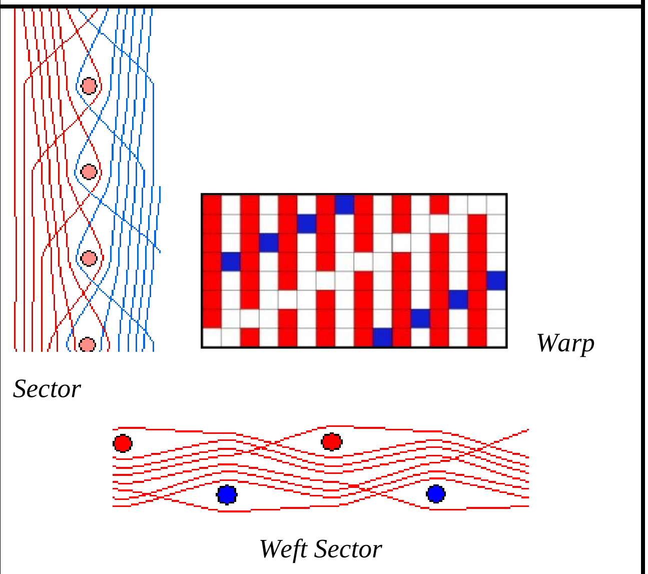
Double weave (D10)



Double weave (D16)

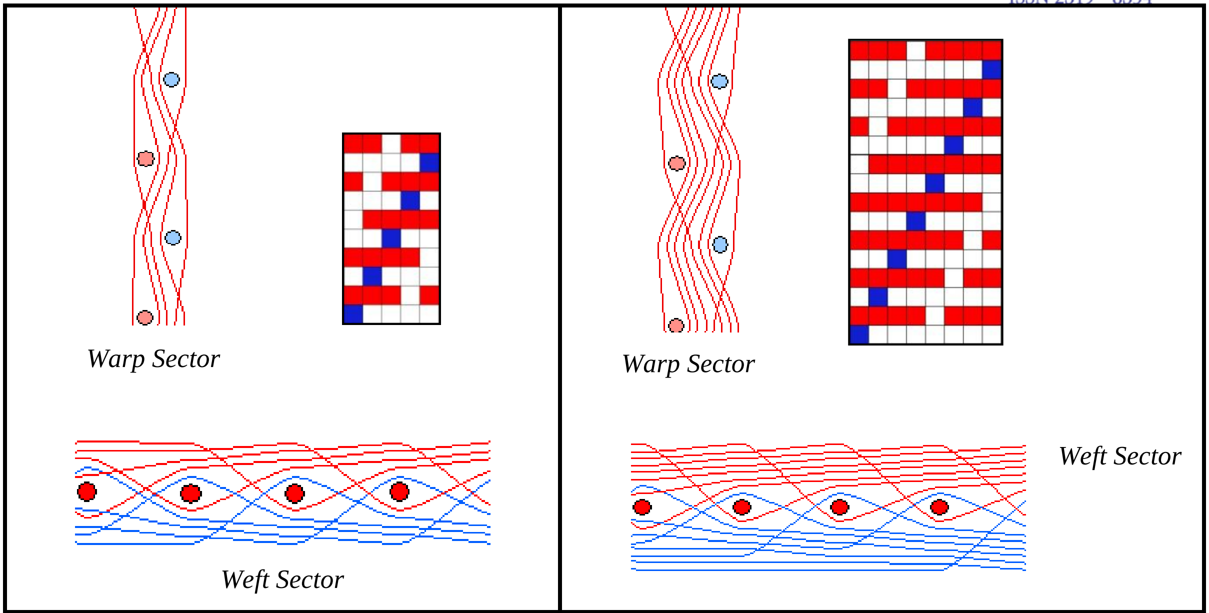


Warp Backed (WB10)



Warp Backed (WB16)

IJARSE
ISSN 2319 - 8354



Weft Backed (FB10)	Weft Backed (FB16)

Figure (1) Weaves used for experimental samples

- Warp specifications: bonded polyester yarns, 150 denier, and 66 threads/cm.

- Wefts specifications: flat polyester yarns, 300 denier, and 28 threads/cm.

- Warp backed: warp ends distributed in two layers and bind with one layer of wefts as following weaves:

a) Twill weave 4/1 for face layer and twill weave 1/4 for back layer “WB10”.

b) Twill weave 7/1 for face layer and twill weave 1/7 for back layer “WB16”.

- Weft backed: weft yarns distributed in two layers and bind with one layer of warp ends as following weaves:

a) Twill weave 1/4 for face layer and twill weave 4/1 for back layer “FB10”.

b) Twill weave 1/7 for face layer and twill weave 7/1 for back layer “FB16”.

- Double weave: warp threads and wefts distributed in two layers in both directions as following weaves:

a) Twill weave 4/1 for face and twill weave 1/4 for back layer “D10”.

b) Twill weave 7/1 for face and twill weave 1/7 for back layer “D16”.

Stitching between the layers was created by binding face warp and back wefts in satin base, all weaves used for warp backed, weft backed, and double weaves were shown in figure (1).

Where the number of intersections of each thread in the double weave repeat is not equal, the weave factories obtained by dividing the sum number of threads per repeat / sum number of intersections per repeat of the cross thread [13].

2.2 Methods

All Experimental samples were tested in the Textile Metrology Laboratory. The breaking tensile strength and elongation test was applied according to ISO 13934-1 [14] by Tenius Olsen instrument model (H5KT) - made in USA, the preload was 0.102 kgf and the tested speed was fixed to 100 mm/min.

Significant effects of independent variables were statistically concludes by analysis of variance test (ANOVA).

III. RESULTS AND DISCUSSION

Table (1) displays the means of breaking strength (KG) and elongation (%) in warp way and weft way of all weaves used for experimental samples.

Table 1. Estimated Marginal means of fabric breaking tensile strength and elongation in both directions

Weave	Breaking Strength in Warp way (Kg)	Breaking Elongation in Warp way (%)	Breaking Strength in Weft way (Kg)	Breaking Elongation in Weft way (%)
D10	165.300	28.627	87.900	27.957
D16	159.633	23.833	103.767	32.163
FB10	173.300	37.580	73.300	23.060
FB16	183.967	39.800	66.600	15.800
WB10	168.800	32.573	80.000	26.027
WB16	162.800	25.743	100.900	30.207

3.1 Breaking Tensile Strength in Warp Way

Analysis of variance results referred to a high significant effect of weave structure on fabric breaking tensile strength in warp way; F=171300.129, Sig (0.000). Results showed that the weft backed weave "FB16" had the highest breaking tensile strength rates in warp way while the double weave "D16" had the lowest breaking tensile strength rates in warp way.

Table (2) displayed the weaves' means differences of breaking tensile strength in warp way, all differences were highly significant. The highest significant difference in warp way's breaking tensile strength rates was between weft backed weave "FB16" and double weave "D16", while the lowest significant difference in warp way's breaking tensile strength rates was between warp backed weave "WB16" and double weave "D10".

Table 2. Pairwise Comparison between means of fabric breaking tensile strength in warp way and their significant difference

(I) Weave	(J) Weave	Mean Difference (I-J)	Sig.(a)
D10	D16	5.667(*)	.000
	FB10	-8.000(*)	.000
	FB16	-18.667(*)	.000
	WB10	-3.500(*)	.000
	WB16	2.500(*)	.001
D16	FB10	-13.667(*)	.000
	FB16	-24.333(*)	.000
	WB10	-9.167(*)	.000
	WB16	-3.167(*)	.000

FB10	FB16	-10.667(*)	.000
	WB10	4.500(*)	.000
	WB16	10.500(*)	.000
FB16	WB10	15.167(*)	.000
	WB16	21.167(*)	.000
WB10	WB16	6.000(*)	.000

Based on estimated marginal means

* The mean difference is significant at the .05 level.

The weave factor in warp way as shown in table (3) was function to the number of the warp yarns intersection so the decrease in weave factor as weft back "FB16" while the decrease in the warp threads intersection and the increase in float length rates of double weave "D16" increased the opportunity to break the warp threads faced the tension fatigue.

Results referred to the significant increasing of warp breaking tensile strength of weft backed weaves due to increasing the number of warp threads that lined up in one layer to withstand the tensile fatigue but in case of warp backed or double weave distributing the same number of tested yarns on two layers (theoretically half of the warp ends) decreased their ability to resist the applied tensile strength.

3.2 Breaking Elongation in Warp Way

Analysis of variance results referred to a high significant effect of weave structure on fabric breaking elongation in warp way; F=878.565, Sig (0.000). Results show that the weft backed weave "FB16" has the highest breaking elongation rates in warp way while the double weave "D16" has the lowest breaking elongation rates in warp way.

Table 3. Weave Factor in Both Directions

Weave	Weave factor	
	Warp way	Weft way
D10	3.85	1.35
D16	5.82	1.2
FB10	1.667	2.5
FB16	1.33	4
WB10	2.5	1.667
WB16	4	1.333

Table (4) displays the weaves' means differences of breaking elongation in warp way, all differences are highly significant. The highest significant difference in warp way's elongation rates was between weft backed weave "FB16" and double weave "D16", while the lowest significant difference in warp way's elongation rates was between warp backed weave "WB16" and double weave "D16".

The increase of intersections numbers generally and dominate the plain intersection especially on the warp threads movement of weft backed (FB16) caused increasing their crimp and so their breaking elongation increased.

Table 4. Pairwise Comparison between means of fabric breaking elongation in warp way and their significant difference

(I) Weave	(J) Weave	Mean Difference (I-J)	Sig.(a)
D10	D16	4.793(*)	.000
	FB10	-8.953(*)	.000
	FB16	-11.173(*)	.000
	WB10	-3.947(*)	.000
	WB16	2.883(*)	.000
D16	FB10	-13.747(*)	.000
	FB16	-15.967(*)	.000
	WB10	-8.740(*)	.000
	WB16	-1.910(*)	.000
FB10	FB16	-2.220(*)	.000
	WB10	5.007(*)	.000
	WB16	11.837(*)	.000
FB16	WB10	7.227(*)	.000
	WB16	14.057(*)	.000
WB10	WB16	6.830(*)	.000

Based on estimated marginal means

* The mean difference is significant at the .05 level.

3.3 Breaking Tensile Strength in Weft Way

Analysis of variance results referred to a high significant effect of weave structure on fabric breaking strength in weft way; F=3451.373, Sig (0.000). Results showed that the double weave "D16" had the highest breaking strength rates in weft way while the weft backed weave "FB16" had the lowest breaking strength rates in weft way.

Table (5) displayed the weaves' means differences of breaking strength in weft way, all differences were highly significant except the difference between the double weave "D16" and the warp backed weave "WB16". The highest significant difference in weft way's tensile strength rates was between double weave "D16" and weft backed weave "FB16", while the lowest significant difference in weft way's tensile strength rates was between double weave "D10" and warp backed weave "WB10".

The increase of weft way tensile strength of double weave due to decrease of weave factor in weft way and decrease of float length where regularly for each pick dominate plain interlacing (over one end) compared with float interlacing (over three ends) . The number of plain interlacing had overcome the distribution of picks in two layers.

Table 5. Pairwise Comparison between means of fabric breaking strength in weft way and their significant difference

(I) Weave	(J) Weave	Mean Difference (I-J)	Sig.(a)
D10	D16	-15.867(*)	.000
	FB10	14.600(*)	.000
	FB16	21.300(*)	.000
	WB10	7.900(*)	.003
	WB16	-13.000(*)	.000
D16	FB10	30.467(*)	.000
	FB16	37.167(*)	.000
	WB10	23.767(*)	.000
	WB16	2.867	.194
FB10	FB16	6.700(*)	.007
	WB10	-6.700(*)	.007
	WB16	-27.600(*)	.000
FB16	WB10	-13.400(*)	.000
	WB16	-34.300(*)	.000
WB10	WB16	-20.900(*)	.000

Based on estimated marginal means

* The mean difference is significant at the .05 level.

Figure (2) showed a comparison between breaking strength in both directions. Results revealed that the breaking strength rate in the warp way had preponderance for all weaves, the average increase rate of breaking tensile strength in warp way about 104.5%. The increase rate of breaking strength in warp way compared with breaking strength in weft way was more obvious by using one layer of warp ends and decreased by using double layers in both directions.

3.4 Breaking Elongation in Warp Way

Analysis of variance results referred to a high significant effect of weave structure on fabric breaking elongation in warp way; F= 5055.416, Sig (0.000). Results showed that the double weave “D16” had the highest breaking elongation rates in weft way while the weft backed weave “FB16” had the lowest breaking elongation rates in weft way.

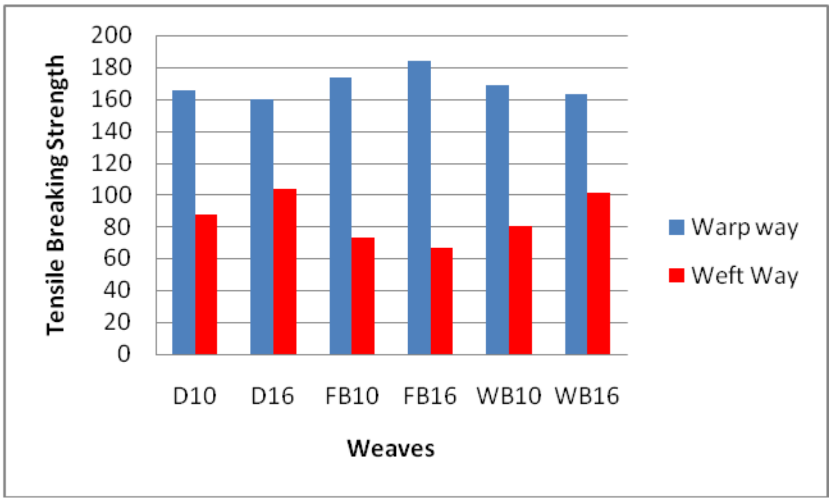


Figure (2) Comparison between breaking tensile strength in both directions

Table (6) displays the weaves' means differences of breaking elongation in weft way, all differences are highly significant. The highest significant difference in weft way's elongation rates was between double weave "D16" and weft backed weave "FB16", while the lowest significant difference in weft way's tensile elongation rates was between double weave "D10" and warp backed weave "WB10".

The increase of weft plain intersections numbers caused increasing their crimp and so their breaking elongation increased.

Table 6. Pairwise Comparison between means of fabric breaking elongation in weft way and their significant difference

(I) Weave	(J) Weave	Mean Difference (I-J)	Sig.(a)
D10	D16	-4.207(*)	.000
	FB10	4.897(*)	.000
	FB16	12.157(*)	.000
	WB10	1.930(*)	.003
	WB16	-2.250(*)	.001
D16	FB10	9.103(*)	.000
	FB16	16.363(*)	.000
	WB10	6.137(*)	.000
	WB16	1.957(*)	.003
FB10	FB16	7.260(*)	.000
	WB10	-2.967(*)	.000
	WB16	-7.147(*)	.000
FB16	WB10	-10.227(*)	.000
	WB16	-14.407(*)	.000
WB10	WB16	-4.180(*)	.000

Based on estimated marginal means

* The mean difference is significant at the .05 level.

Figure (3) showed a comparison between breaking strength in both directions. Results revealed that the breaking strength rate in the warp was more obvious by using one layer of warp ends and decreased by using double layers in both directions.

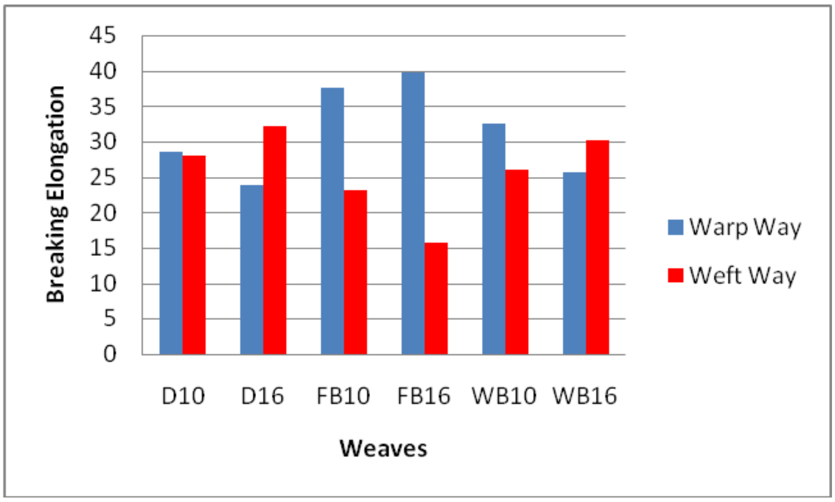


Figure (3) Comparison between breaking elongation in both directions

IV. CONCLUSION

The weave factor in warp way was function to the number of the warp yarns intersection so the decrease in weave factor the decrease of breaking strength in warp way. The decrease of the warp threads intersection and the increase in float length rates of double weave "D16" increased the opportunity to break the warp threads faced the tension fatigue. In the weft backed, all the warp threads lined up in one layer to withstand the tensile fatigue but in case of warp backed or double weave the warp ends the same number of tested yarns half distributed on two layers so their ability to resist the applied tensile strength decreased.

The tensile strength of double weave increased in weft way due to decrease of weft intersections and their float length where domination of plain which also had overcome the distribution of picks in two layers. This domination of plain weave intersections in any direction controlled the yarn crimp and increased the breaking strength in the same way.

The breaking strength rates in the warp way had preponderance compared with the breaking strength rates in the weft way for all weaves. Using single layer of warp ends obviously increased the difference between breaking elongation in warp way compared with breaking elongation in weft way; this difference decreased by using double layers in both directions.

REFERENCES

[1] Mali, Z. A., Husain T., Mali M. H., and Tamari A., "Selection of Yarn for the Predefined Tensile Strength of Cotton Woven Fabrics", Fibers and Polymers, Vol.12, No.2, 2011, 281-287.

[2] Peirce, F. T., The geometry of cloth structure, J. Textile Inst., 28, 1937, T45.

[3] Hearle, J. W. S., Grosberg, P. & Backer, S., Structural Mechanics of Yarns and Fabrics, Vol.1, WileyInterscience, New York, 1969.

[4] Kilby, W. F., Planar stress-strain relationship in woven fabrics, J. Textile Inst., 54, 1963, T9.

[5] Maunder, A.; Ghost, A.; Sasha, S.S.; Roy, A.; Barman, S.; Panigrahi, D.& Biswas, A., "Empirical Modeling of Tensile Strength of Woven Fabrics" Fibers and Polymers, Vol.9, No.2, 2008, 240-245.

[6] L. Cheng and D. L. Adams, "Yarn strength prediction using neural networks. I. Fiber properties and yarn strength relationship," Textile Research Journal, vol. 65, no. 9, 1995, pp. 495–500.

[7] P. K. Majumdar and A. Majumdar, "Predicting the breaking elongation of ring spun cotton yarns using mathematical, statistical, and artificial neural network models," Textile Research Journal, vol. 74, no. 7, 2004, pp. 652–655.

[8] Furferi, R., Gelli, M., "Yarn strength prediction: A practical model based on artificial neural networks", Advances in Mechanical Engineering, 2010, art. no. 640103.

[9] M. L. Realff, M. C. Boyce, and S. Backer, "A Micromechanical Model of the Tensile Behavior of Woven Fabric", Textile Research Journal, Vol. 67, No. 6, 1997, 445-459.

[10] R. Chattopadhyay, "Design of Apparel Fabrics: Role of fibre, yarn and fabric parameters on its functional attributes", Journal of Textile Engineering, Vol. 54, 2008, 179-190.

[11] H. Gabrijelcic, E. Cernosa, and K. Dimitrovski; "Influence of Weave and Weft Characteristics on Tensile Properties of Fabrics", Fibers and Textiles in Eastern Europe, Vol. 16, No. 2 (67), 2008, 45-51.

[12] S. Kawabata, M. Niwa , and H. Kawai, "The Finite-Deformation Theory of Plain-Weave Fabrics Part I: The Biaxial-Deformation Theory", Journal of Textile Institution, Vol.64, 1973, 21-26.

[13] Mishra, R., et al., Structural design engineering of woven fabric by soft computing: part II - Non-Plain weave, Autex Research Journal, Vol. 11, No2, June 2011, 43.

[14] ISO 13934-1, Determination of maximum International Design Journal, Volume 4, Issue 4 Technical Issues 185 force and elongation at maximum force using the strip method, 2013.