Alex. Eng. J., Alex. Univ., Volume 28 No.3 , pp. 129-135 (1989)

EFFECT OF YARN TYPE AND FABRIC STRUCTURE ON FABRIC TENSILE PROPERTIES

A.S. EL-Geiheini

Textile Engineering Department

Faculty of Engineering, Alexandria University

Alexandria, Egypt

Abstract

The dependence of fabric tensile properties, tenacity and elongation, on different factors concerning fabric dimensions were studied. These factors are ends/cm, picks/cm, warp count; yarn type in both warp and weft: open-end or ring spun; fabric design: plain, 2/2 basket, 2/2 twill and 1/3 twill. The study indicates that the fabric weft tenacity fabric elongation in both weft and warp direction, are affected by both fabric design and yarn type . Significant regression relation concerning fabric tensile properties indicate that the most significant factors are picks/cm and the interaction between picks/cm and ends/cm in case of tenacity, while for elongation, the fabric design is the significant factor for warp and weft.

Nomenclature

X_1 = Weft type, X_2 = Warp type, X_3 = Fabric design
X_4 = Weft count, X_5 = ends/cm, X_6 = Picks/cm
X_7 = Warp cover factor X_8 = Weft cover factor.
Y_1 = Fabric weft strength in kg. Y_2 = % elongation in weft.
Y_3 = Fabric warp strength in kg. Y_4 = % elongation in warp.
Y_5 = Weft tencity. Y_6 = Warp tenacity.
Y_7 = Global tencity = $(Y_5 * Y_6)^{\frac{1}{2}}$.

Introduction

Fabric properties depend on fabric structure, both yarn and fibre properties [4]. The maximum weavability of fabrics was theoretically and practically determined by [2-4,6-8]. While different models of fabrics depending on yarn extension, crimp and spacing in weft and warp direction were obtained based on several assumptions [1,8]. The effect of yarn type: open-end or ring spun, on fabric properties were studied [5].

This study is concerned essentially with carrying an experimental investigation concerning the effect of fabric structure on fabric tensile properties and the determination of the significant factors and the regression relation.

Experimental Procedure And Results

Two qualitative factors were applied in the study which consist of the yarn type in: weft and warp, and fabric design. Two yarn types: ring spun and open-end were applied, while four fabric designs: plain,

basket 2/2, twill 2/2 and twill 1/3, were produced. The level coding of qualitative factors are shown in table 1. While three other quantitative factors were changed which consist of weft count, ends/cm and picks/cm. Constant cover factors in both weft and warp were obtained for different combinations of count and fabric density.

Table 1: Coding of qualitative factors

	YARN TYPE		FABRIC DESIGN			
NAME	OPEN-END	RING SPUN	PLAIN	BASKET 2/2	TWILL 2/2	TWILL 1/3
CODE	+1	-1	+2	+1	-1	-2

The different factors combination are shown in table 2. The warp used a cotton yarn of 37 tex.

The tensile properties of fabrics were measured in a standard atmospher.

Discussion

The analysis of variance for the obtained results are shown in table III.1. From this table, it is clear that the fabric design affects to a great extent the percentage elongation for both weft and warp direction and it attains a significance of 0.01 %, while the fabric design has no significant effect on fabric tenacity in both

directions. The yarn type indicate a significance of 5 % on elongation in warp direction and also a 3% significance on tenacity in weft direction.

Table 3: Analysis of variance for fabric tensile properties

Source of VARIATION	Elongation				Tenacity				Global	
	WARP		WEFT		WARP		WEFT		TENACITY	
	F	SIG	F	SIG	F	SIG	F	SIG	F	SIG
YARN TYPE	3.0	4.500	1.7	N.S.	0.90	N.S.	3.6	2.6	1.9	N.S.
FABRIC DESIGN	20.4	0.001	8.1	0.001	0.70	N.S.	0.6	N.S.	0.7	N.S.
INTERAC-	0.5	N.S.	2.2	5.000	0.06	N.S.	0.1	N.S.	0.1	N.S.

F = CALCULATED VALUE SIG = LEVEL OF SIGNIFICANCE

N.S. = NON - SIGNIFICANT

Since the warp yarn had been applied in different count for the different designs, the variation in elongation can be due to the count variation and the yarn type. While, since one count only is applied in weft, the difference in strength is due to yarn type, as the fabric made from ring spun yarn give a higher tenacity of about 5 % - 15 % and reaches its maximum value for twill fabrics, this is very small compared to the difference in yarn tenacity between the two yarns.

TABLE III.2

SIGNIFICANT REGRESSIONS FOR DIFFERENT EXPERIMENTAL CONDITIONS

F.R.=>>	X4 - X8												X3 - X8			X2 - X8		
F.D.=>>	PLAIN			BASKET 2/2			TWILL 2/2			TWILL 1/3			ALL			ALL		
PR.	F.	C.	S.	F.	C.	S.	F.	C.	S.	F.	C.	S.	F.	C.	S.	F.	C.	S.
Y2	X68	0.01	0.1	X67	0.02	0.4	X44	0.003	0.1	X56	0.006	1.4	X36	0.02	0.01	X36	0.020	0.01
	X0	3.43	0.3	X0	3.83	0.1	X0	5.86	0.01	X0	4.25	0.1	X68	0.016	0.01	X68	0.016	0.01
													X0	4.13	0.01	X0	4.130	0.01
Y4	X68	0.04	0.7		N O		X78	-0.5	1.2	X8	-37.7	1.7	X38	0.071	0.01	X38	0.071	0.01
	X0	2.76	N.S.		S T E P		X0	67.4	0.5	X58	1.53	3	X0	11.53	0.01	X0	11.530	0.01
										X0	86.1	0.2						
Y5	X77	0.012	0.01	X6	0.02	0.01	X56	0.001	0.01	X6	0.017	0.01	X67	0.00376	0.01	X67	0.004	0.01
	X0	-1.12	0.01	X0	0.1	2	X0	0.08	2.3	X0	0.1	0.3	X68	-0.0015	0.1	X68	-0.002	0.1
													X44	-0.0001	3.6	X44	-0.0002	3.6
													X0	0.0018	N.S.	X0	0.002	N.S.
Y6	X67	0.001	0.02	X6	0.03	0.1	X56	0.001	0.2	X56	0.001	0.01	X56	0.00337	0.36	X56	0.003	0.2
	X0	0.084	9.4	X0	-0.1	N.S.	X0	0.042	N.S.	X0	0.015	N.S.	X66	-0.0013	4.4	X28	-0.001	0.1
													X0	-0.27	6.3	X66	-0.001	3.8
																X0	-0.240	6.3
Y7	X48	0.001	0.01	X6	0.02	0.02	X56	0.001	0.1	X56	0.001	0.01	X56	0.00305	0.2	X56	0.003	0.01
	X0	0.2	0.01	X0	-0.01	N.S.	X0	0.06	N.S.	X0	0.06	6.1	X66	-0.0012	0.1	X28	-0.001	0.2
													X0	-0.2	4.3	X66	-0.001	0.7
																X0	-0.180	4.3

F.R. = FACTOR RANGE F.D. = FABRIC DESIGN PR. = PROPERTY N.S. = NON-SIGNIFICANT
F. = FACTOR C. = COEFFICIENT S. = SIGNIFICANCE X0 = CONSTANT VALUE

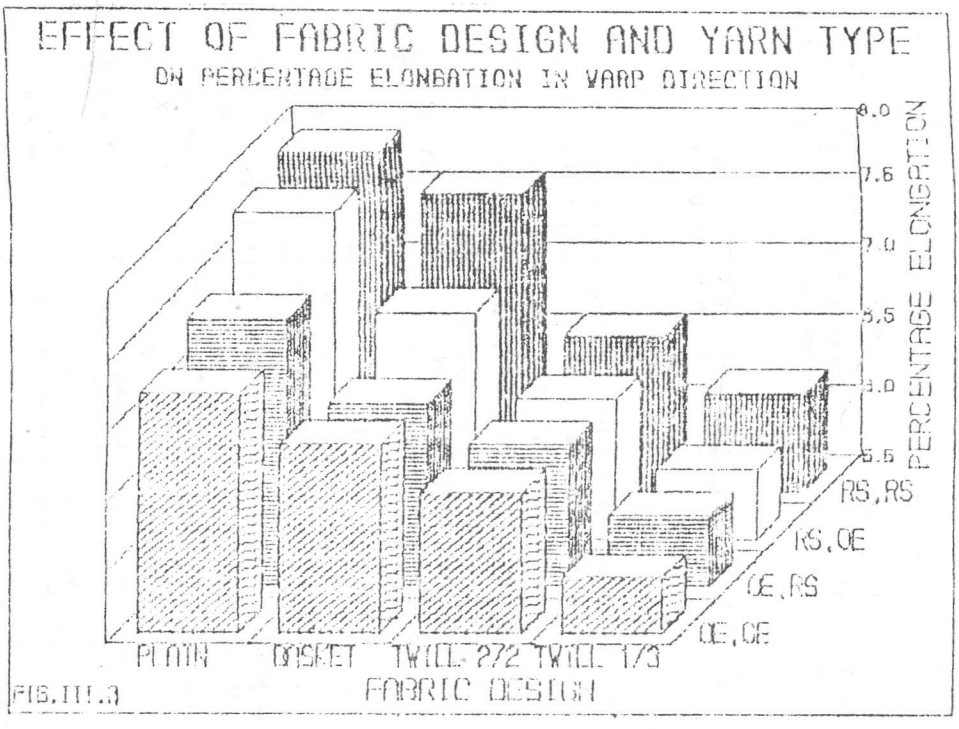

FIG.III.3

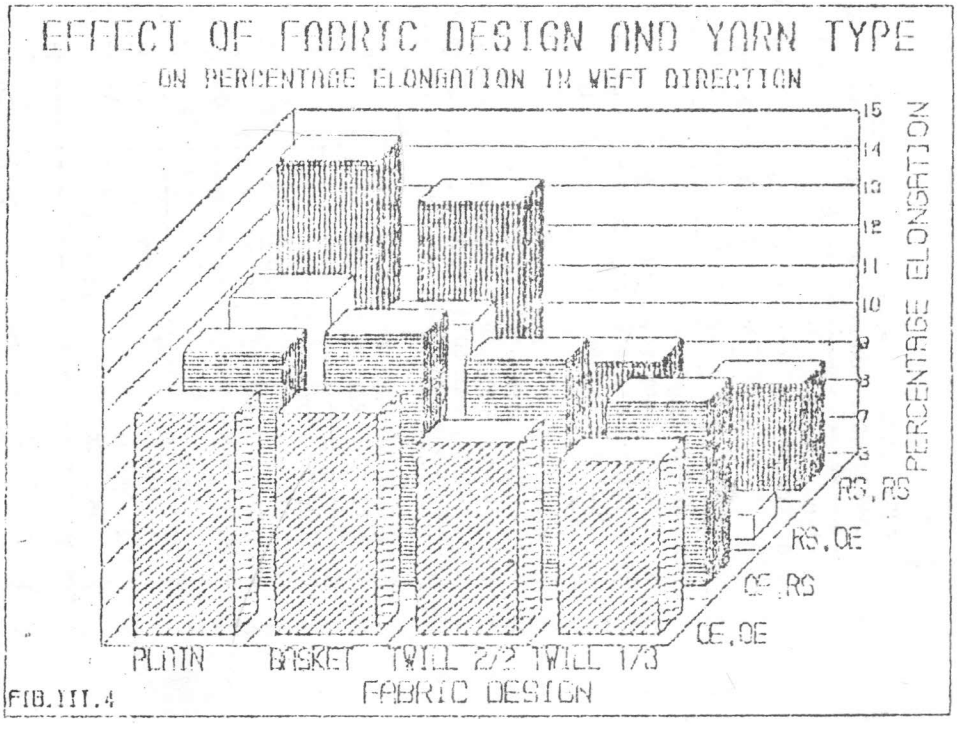

FIG.III.4

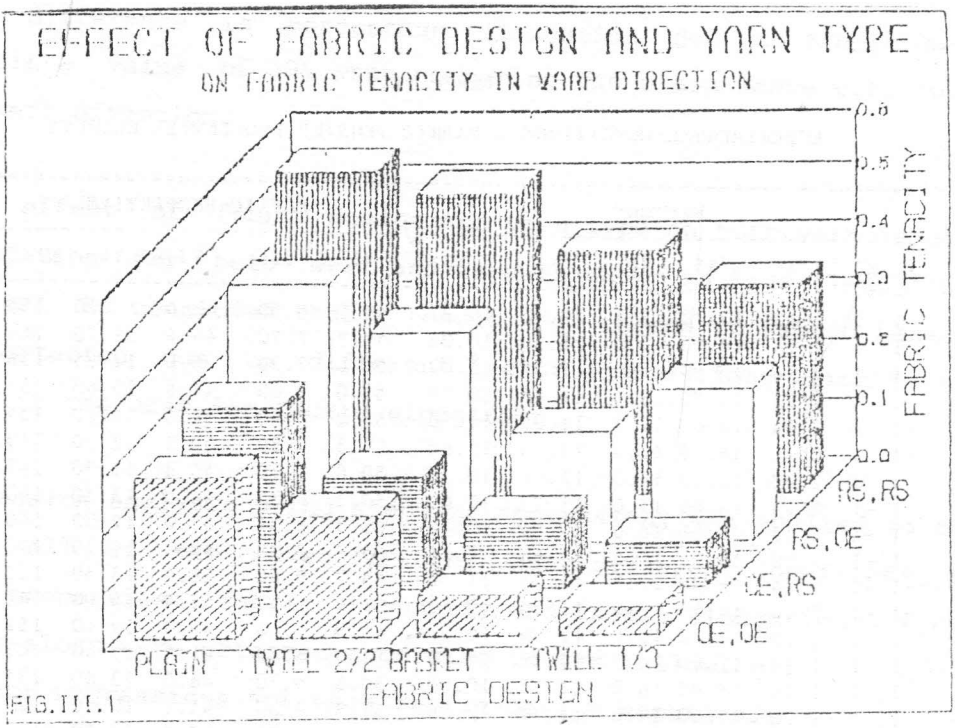

FIG.III.1

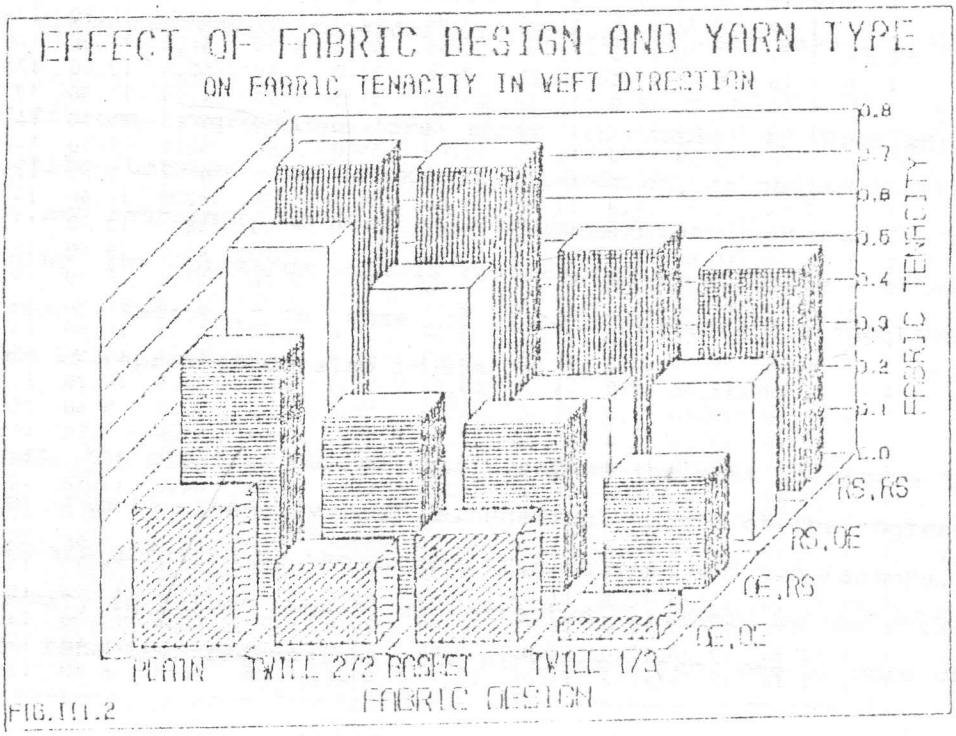

FIG.III.2

TABLE II.2

EXPERIMENTAL CONDITIONS & FABRIC TENSILE PROPERTIES RESULTS

FACTORS								FABRIC PROPERTIES				
X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Y3	Y4	WEIGHT
1	1	2	10	17.70	13.0	11.06	10.27	48.9	6.50	43.6	11.20	155.4
1	1	2	14	18.00	15.0	11.25	10.02	51.9	7.20	46.4	12.70	144.1
1	1	2	16	18.20	16.0	11.37	10.00	56.6	7.30	50.0	12.25	136.5
1	1	2	20	18.32	18.4	11.45	10.29	57.0	7.80	47.8	10.60	131.7
-1	1	2	14	18.00	17.3	11.25	11.56	57.2	8.00	54.0	14.60	154.6
-1	1	2	16	18.15	17.0	11.34	10.63	56.3	7.80	52.8	12.30	143.0
1	-1	2	12	17.70	14.0	11.06	10.10	50.0	6.70	45.8	11.30	146.4
1	-1	2	14	18.00	15.0	11.25	10.02	53.3	6.80	48.5	13.70	143.6
1	-1	2	16	18.00	16.0	11.25	10.00	55.3	8.34	53.6	12.30	140.2
1	-1	2	20	18.20	17.6	11.44	9.84	55.7	7.30	50.6	11.10	130.6
-1	-1	2	14	18.00	17.3	11.25	11.56	59.2	8.60	58.0	15.50	152.9
-1	-1	2	16	18.15	17.0	11.34	10.63	57.4	7.80	53.4	14.60	141.8
1	1	1	10	17.60	12.9	11.00	10.20	46.9	6.60	49.3	10.40	152.6
1	1	1	14	17.80	14.9	11.12	9.96	51.0	6.80	41.5	13.40	142.0
1	1	1	16	18.00	16.0	11.25	10.00	50.6	6.70	46.0	12.80	135.9
1	1	1	20	18.20	18.0	11.37	10.06	51.7	7.30	45.1	10.10	129.8
-1	1	1	14	17.80	17.1	11.13	11.43	55.8	7.00	52.4	14.00	154.2
-1	1	1	16	18.00	17.0	11.25	10.63	52.4	7.10	47.2	11.60	141.9
1	-1	1	12	17.70	13.8	11.06	9.96	47.0	6.00	42.5	11.70	144.7
1	-1	1	14	17.70	14.9	11.06	9.96	50.3	6.50	46.2	14.30	140.1
1	-1	1	16	18.00	15.8	11.25	9.88	51.0	7.40	50.6	12.90	139.0
1	-1	1	20	18.20	18.0	11.37	10.06	51.3	7.20	46.9	11.30	127.4
-1	-1	1	14	17.80	17.1	11.13	11.43	56.8	7.30	57.2	15.10	151.1
-1	-1	1	16	18.00	17.0	11.25	10.63	55.0	7.60	50.1	13.50	140.6
1	1	-1	10	17.70	12.9	11.06	10.20	47.7	6.30	41.2	9.60	153.0
1	1	-1	14	17.80	14.9	11.12	9.96	51.1	6.30	42.5	12.40	143.4
1	1	-1	16	18.00	16.0	11.25	10.00	53.0	6.40	48.4	12.10	133.4
1	1	-1	20	18.00	18.0	11.25	10.06	54.1	7.00	45.0	9.40	127.0
-1	1	-1	16	17.70	17.0	11.06	10.63	54.9	6.50	51.1	8.50	142.4
1	-1	-1	12	17.70	13.8	11.06	9.96	48.9	6.20	42.8	10.90	145.6
-1	-1	-1	14	17.80	14.9	11.12	9.96	51.6	6.20	46.9	14.00	141.1
1	-1	-1	16	18.00	15.8	11.25	9.88	51.9	6.80	52.1	12.50	130.2
1	-1	-1	20	18.00	18.0	11.25	10.06	51.3	6.90	46.9	10.20	127.3
-1	-1	-1	16	17.80	17.0	11.06	10.63	55.4	6.60	52.6	9.40	140.5
1	1	-2	10	17.60	12.8	11.00	10.12	46.7	5.80	39.6	8.10	153.5
1	1	-2	14	17.70	14.8	11.06	9.95	50.2	5.70	42.4	12.30	143.4
1	1	-2	16	17.80	15.8	11.50	9.88	49.8	6.00	44.0	11.50	132.3
1	1	-2	20	17.80	17.6	11.00	9.84	50.4	6.20	43.4	9.70	128.1
-1	1	-2	16	17.70	16.8	11.06	10.50	52.7	6.00	47.0	6.60	140.0
1	-1	-2	12	17.60	13.8	11.00	9.96	47.5	5.80	40.0	9.70	143.8
1	-1	-2	14	17.70	14.8	11.06	9.89	49.6	5.70	44.6	12.90	140.1
1	-1	-2	16	17.80	16.0	11.12	10.00	50.0	6.40	48.4	10.90	137.7
1	-1	-2	20	17.60	17.6	11.00	9.84	49.0	6.20	45.5	9.50	126.0
-1	-1	-2	16	17.80	16.9	11.06	10.56	53.6	6.20	46.8	8.80	139.2

The difference in percentage elongation due to fabric design can attain a value of 39% when comparing the plain weave with twill 1/3 in weft direction.

The effect of fabric design and yarn type on both yarn tenacity and elongation for both weft and warp is shown in Figs (1-4) from which it can be concluded that a tendency of change in fabric tenacity can be detected due to different factor combinations which is also the same in the case for fabric elongation.

Regression analysis using stepwise regression, was applied to the data with all of the seven factors, under different conditions, for the two properties: fabric ternality and fabric elongation six types of regressions were obtained according to the following :

1) Four regressions for each fabric design separately.
2) The fifth regression with the fabric designes a factor.
3) The sixth regression considering the type of weft yarnes after.

The different regressions are shown in table 4. From which the interaction between the picks/cm and ends/cm, is the most effective factor and represents 25 % of all the significant factors. The factor concerning the picks/cm only is represented in about 69 % of all the significant factors. In case of fabric percentage elongation, the picks/cm is represented also in 50%.

From that, the picks/cm can be considered as the most effective factor on both fabric tenacity and elongation. Most of the regressions obtained are affected by the interaction between and two factors, only the tenacity in basket weave is affected linearly by the picks/cm. In all tenacity regressions, the picks/cm affect one or more of the

interaction which are represented in the equation. The type of weft yarn affect only the tenacity of the weft.

Conclusion

1. The fabric produced from OE yarn in both warp and weft directions, give a lower tenacity than that produced from both of ring spun yarn in both directions . The drop in tenacity varies from 18 % in case of twill 2/2 to 6% for plain weave and has a minimum of 1% if one of the yarns is Ring Spun.
2. The percentage elongation is greatly affected by the fabric design and attains its higher value for plain weave.
3. The yarn type affects greatly the percentage elongation in warp direction, while affects the tenacity in weft direction.
4. The fabric tensile properties are highly affected by both picks/cm and ends/cm compared with the other factors under study.
5. The regression equation obtained, represents significantly the results with only one or two factors for elongation and maximum of three factors for tenacity.
6. Most of the significant factors obtained by the regression analysis consist of interaction factors, where the picks/cm or ends/cm are always represented.

References

[1] Clulow E.E. and Taylor A.M., J. Textile Inst., 54, T 323, 1963.
[2] Dicksor J.F. Textile Res. J., 24, 1083, 1954.
[3] Grosberg P. and Kedia S., Textile Res. J., 36, 71, 1966.
[4] Hearle J.S., Grosberg P., Backer S., Structural Mechanics of Fibers, Yarns and fabrics. VI, John Wite & Sons Inc., 1969.

[5] Mohamed M.H. and Lord P.R., Textile Res. J., 43, 155, 1973.

[6] Peirce F.T., J. Textile Inst. 19, T 237, 1928.

[7] Perce F.T., J. Textile Inst. 28, T 28.

[8] Weiner L.I., Design tables for Textile fabrics. U.S. Army Natick Laboratories, 1966.