Impact of Support Fabrics on Breaking Strength, Elongation and Time Taken for the Test for Woven Fabrics in Different Fiber Contents

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Abstract

The study examined the influence of support fabrics on strength, elongation and time taken to complete the test for acetate, linen, rayon, and wool fabrics. ASTM D1683 was used with superimposed seams, ½ inch seam allowance and 301 stitch. It was hypothesized that support fabrics will increase breaking strength and time taken for break and elongation will decrease. Hypotheses were tested by t-test and one-way analysis of variance (ANOVA). Findings revealed that addition of lining enhanced breaking strength. Differences were noted for warp and weft directions. Mixed results were found for the time taken and elongation. So was true for the impact of interfacings. Even though this exploratory is needed beginning in the area of determining compatibility between and among the fabrics used in layered garments, there is need to repeat the research with other structural variables for refined understanding of these relationships. Some of the existing assumptions were supported and some were refuted.

Keywords - *Breaking strength, breaking time, elongation, fiber content, stitch density, seam type, stitch type, woven fabrics*

I. INTRODUCTION

Importance of seam strength and efficiency was reported in a seminal research to determine relationship between quality of ready to wear and price. Previous literature mentions several research studies on the impact of stitch density, sewing thread, seam type and stitch types ([1], [2], [3], [4], [5], [6], [7], [8]). Another research study reported that woven and knitted fabrics are stronger than the nonwovens [9]. Researchers also found that bonded fabrics were stronger than the seamed fabrics [10]. Two studies compared strength of dyed and undyed fabrics and found that undyed fabrics were stronger than the dyed fabrics ([11], [12]).

Support fabrics have been used in apparel products to provide professional look to the garments for centuries. Two most commonly used support fabrics include interfacings and linings. Interfacings can be woven and non-woven. Most commonly used lining fabrics are acetate and polyester. Only one scholar examined the impact of five fusible and non-fusible interfacings on breaking strength and elongation of the fashion fabric [3]. Findings revealed that for a medium weight fabric, heavy weight interfacing resulted in the highest breaking strength increase, and lightweight fusible interfacing showed the lowest increase for the warp direction. For weft, lightweight fusible increased the strength most and a decrease was noticed for the feather weight sew-on type interfacing. For elongation, highest increase was observed for Sew-on type interfacing and lowest for the fusible shirt in the warp direction. For weft direction, elongation increased the most for heavy weight and least for the fusible shirt interfacing. The author reported that differences were significant for all five interfacings in the warp direction and only two for the weft direction. For elongation, all five had significant differences in the weft direction and only four of the five were significant in the weft direction. The scholar recommended extension of this research for other type of fabrics and interfacings. None of the previous work focused on linings. Limited work on interfacings and nonexistent research on the contribution of linings toward strength and elongation necessitated the need to conduct the reported research.

Purpose of the reported research was to examine the impact of interfacings and linings on the breaking strength and elongation of fabrics in different fiber contents used for lined garments. The fabrics chosen for the study were wool, rayon, linen and acetate. Comparisons were made for individual fabrics with interfacing or lining to determine their exclusive impact. Acetate has been the most commonly used lining material in the past that is now substituted with polyester because the later one is stronger than the former one [13]. Polyester is the most commonly used lining material these days. Therefore, wool was also tested with fabric, interfacing and polyester combination.

Based on the literature review, following three hypotheses were developed.

Hypothesis 1: Breaking strength will be higher for fabrics with interfacing and lining in both warp and weft directions.

Hypothesis 2: Elongation will be lower for fabrics with interfacing and lining in both warp and weft directions.

Hypothesis 3: Time taken to break the specimen will be higher for fabrics with support fabrics in both warp and weft directions.

II. MATERIALS AND METHODS

ASTM standards were used to measure breaking strength and elongation. ASTM-D 1683/D 1683M -17 was modified for attaching interfacing and lining to the fashion fabric. The modification included testing strength and elongation of sewn materials rather than seam efficiency. To allow accurate interpretation of results, fabric count (D3775, 2012), thickness (D-1777 – 96 (reapproved in 2015) and weight (D3776, 2012), were provided for all fabrics used for the experiment (Table I). ASTM D1776/D1776M-16 (reapproved in 2015) was used for conditioning of various fiber contents chosen for the investigation. Interfacing and lining were sewn with 301 stitch, superimposed seam half inch seam allowance and 10-11 stitches per inch. Stitch density was controlled based on findings from previous research that reported impact of stitch density on seam strength {[2], [4], [7]).Instron 5544 was used to conduct this test. Its carriage moves at the speed of 12 inches per minute. It provides mean and standard deviation for breaking strength in pounds per square inch, elongation in percentage, and time in seconds. Mean, standard deviation, t-test, and Analysis of Variance were used to describe and analyze the data. 95% level of confidence was used to test the hypotheses.

TABLE 1: Means and Standard deviation of Structural Attributes

Fabric Content	Fabric weight g/m^2		Fabric Thickness mm		Fabric Count per inch	
	M	SD	M	SD	M	SD
Wrinkled Rayon	186.022	8.249	0.320	0.000	97.200	0.837
Unwrinkled Rayon	135.399	3.954	0.900	0.022	187.600	0.548
Acetate	103.205	3.030	0.180	0.000	123.000	1.581
Linen	192.161	3.786	0.448	0.022	86.800	1.304
Woven Wool	231.362	5.048	0.568	0.000	106.000	1.225

III. RESULTS AND DISCUSSION

Five fabrics in light to medium weights and medium to high fabric count with thickness ranging from .18 to .9 mm. were tested for impact of support fabrics on their breaking strength and elongation. Findings from the hypothesis texting are provided below.

Hypothesis 1: Breaking strength will be higher for fabrics with interfacing and lining in both warp and weft directions.

Wrinkled rayon had significant decline in strength for filling direction (Tables 2-3). However, decrease was not significant in the warp direction. Addition of lining, significantly increased strength in both directions. For wool, interfacing enhanced strength but was not significant. So was true when fabric was lined with acetate for both directions. Strength increased significantly, when polyester lining was added by itself or along with interfacing. It was interesting to note that fabric with acetate lining was weaker than fabric with interfacing in the warp direction. Both interfacing and lining enhanced strength for unwrinkled rayon and acetate for filling direction. However, fabric became significantly stronger only with lining for acetate as well as unwrinkled rayon. For linen lining improved strength significantly but interfacing did not in the filling direction. For the warp direction, interfacing and lining did not add strength of the linen fabric.

Table 2: Impact of interfacing and lining on strength of woven acetate, linen, rayon, and wool in filling direction.

Fiber Content/ Condition	Strength Mean	SD	t/F-value	
Wrinkled Rayon	A 41.96	5.096	AxB	5.801*
Fabric + Interfacing	B 25.99	2.087	BxC	-34.211*
Fabric + Lining (Polyester)	C 138.579	6.242	AxC	-23.981*
Wool	A 74.668	16.114	AxB	-1.134 ns
Fabric + Interfacing	B 86.474	13.193	BxC	-0.982 ns

Fabric + Lining (Acetate)	C 104.472	36.640	AxC	-1.489 ns
Wool	A 74.668	16.114	AxB	-1.134 ns
Fabric + Interfacing	B 86.474	13.193	BxC	-11.009*
Fabric + Lining (Polyester)	C 170.935	7.729	AxC	-10.773*
Fabric + Interfacing +Lining	180.6	20.361	F3,16	67.390*
Unwrinkled Rayon	A 28.924	1.853	AxB	-13.642*
Fabric + Interfacing	B 45.022	1.462	BxC	-11.341*
Fabric + Lining (Polyester)	C 136.772	16.114	AxC	-13.298*
Linen	A 114.102	43.140	AxB	-0.299 ns
Fabric + Interfacing	B 123.036	41.459	BxC	-2.584*
Fabric + Lining (Polyester)	C 180.497	16.111	AxC	-2.884*
Acetate	A 62.39	13.933	AxB	-2.49*
Fabric + Interfacing	B 97.594	24.588	BxC	-1.649 ns
Fabric + Lining (Polyester)	C 118.451	5.940	AxC	-7.403*

*Significant at .05 level ns= not significant

Table 3: Impact of interfacing and lining on strength woven acetate, linen, rayon, and wool in warp direction.

Fiber Content/	**Strength**			
Condition	**Mean**	**SD**	**t/F-value**	
Wrinkled Rayon	A66.129	24.42	AxB	1.97 ns
Fabric + Interfacing	B 41.443	5.625	BxC	-7.856*
Fabric + Lining (Polyester)	C 226.459	46.762	AxC	-6.191*
Wool	A 126.454	13.714	AxB	-0.804 ns
Fabric + Interfacing	B 137.857	24.833	BxC	0.232 ns
Fabric + Lining (Acetate)	C 132.966	34.052	AxC	-0.355 ns
Wool	A 126.454	13.714	AxB	- 0.804 ns
Fabric + Interfacing	B 137.857	24.833	BxC	-8.409*
Fabric + Lining (Polyester)	C 245.154	5.888	AxC	-15.907*
Fabric + Interfacing +Lining	260.895	5.974	F3,16	112.734*
Unwrinkled Rayon	A 71.605	23.384	AxB	-1.598 ns
Fabric + Interfacing	B 99.239	24.441	BxC	-10.009*
Fabric + Lining (Polyester)	C 222.384	2.847	AxC	-12.802*
Linen	A 113.502	25.391	AxB	-0.698 ns
Fabric + Interfacing	B 123.823	28.48	BxC	-0.012 ns
Fabric + Lining (Polyester)	C 123.996	2.587	AxC	-0.822 ns
Acetate	A 41.680	2.81	AxB	-0.773 ns
Fabric + Interfacing	B 53.36	28.75	BxC	-1.683 ns
Fabric + Lining (Polyester)	C 77.952	5.287	AxC	-12.115*

Overall, in all cases, warp was stronger than the weft direction for all fabrics. This result is consistent with the conventional thinking. Except for acetate lining for wool, lining was found to strengthen the fashion fabric. This finding suggests that lining material enhances durability of the garment in addition to adding ease of donning and doffing and professional look. It was also interesting to note that there were variability in the contribution of support fabrics for different fiber contents. Hypothesis 1 was accepted for rayon fabric but was rejected for wool, linen and acetate fabrics. Testing strength of other fiber contents including blends with within fiber-content variability will further strengthen the understanding about relationship between support fabrics and fashion fabrics while considering compatibility between and among different layers for varying end uses.

Hypothesis 2: Elongation will be lower for fabrics with interfacing andlining in both warp and weft directions.

Results from the inferential statistics revealed that interfacing decreased elongation of the wrinkled rayon Significantly (Tables 4-5). However, differences were not significant when it was tested with lining in the filling direction. In thewarp direction, wrinkled rayon had higher elongation with lining than the fabric alone. For wool, interfacing made significant decline when interfacing was added. However, elongation decreased when materials were tested with addition of lining. It was true for testing both two and three layersof the fabric. For unwrinkled rayon differences were not significant in the filling direction. For warp, differences were significant with lining only. For linen, interfacing had significantly higher elongation when lining was added in the filling direction. However, differences were insignificant for the warp direction. Acetate showed significant increases when lining was added for both directions. Interfacing brought significant changes only in the warp direction. Overall, Hypothesis 2 was rejected because for most of the fabrics, elongation did not decline but increased after adding lining in most cases and interfacing in some cases. None of the previously published research addressed this relationship. Inverse relationship projected for fabric strength and elongation [3] did not hold true for the fabrics sewn with interfacings and linings. There is need to extend this exploratory research with more variability induced for each fiber content.

Table 4: Impact of interfacing and lining on elongation of woven acetate, linen, rayon, and wool for filling direction.

Fiber Content/	**Elongation**			
Condition	**Mean**	**SD**	**t/F-value**	
Wrinkled Rayon	A65.36	5.303	A x B	16.823*
Fabric + Interfacing	B 13.96	1.301	B x C	-15.268*
Fabric + Lining (Polyester)	C 64.07	6.433	A x C	0.310 ns
Wool	A 37.311	2.235	A x B	3.431*
Fabric + Interfacing	B 31.79	2.315	B x C	1.897 ns
Fabric + Lining (Acetate)	C 36.64	4.557	A x C	0.394 ns
Wool	A 37.311	2.235	A x B	3.431*
Fabric + Interfacing	B 31.79	2.315	B x C	-4.748*
Fabric + Lining (Polyester)	C 60.17	11.731	A x C	-3.828*
Fabric + Interfacing +Lining	60.32	10.475	F3,16	– 17.474*
Unwrinkled Rayon	A 60.115	8.995	A x B	-0.281 ns
Fabric + Interfacing	B 61.448	3.025	B x C	1.942 ns
Fabric + Lining (Polyester)	C 57.795	2.235	A x C	0.501 ns
Linen	A 20.974	9.909	A x B	-0.182 ns
Fabric + Interfacing	B 31.500	13.487	B x C	-3.112*
Fabric + Lining (Polyester)	C 69.000	21.717	A x C	-4.024*
Acetate	A 12.600	4.768	A x B	-0.871 ns
Fabric + Interfacing	B 14.640	1.406	B x C	-3.905*
Fabric + Lining (Polyester)	C 29.28	7.364	A x C	-3.803*

Table 5: Impact of interfacing and lining on elongation of woven acetate, linen, rayon, and wool for warp direction.

Fiber Content/	**Elongation**			
Condition	**Mean**	**SD**	**t/F-value**	
Wrinkled Rayon	A 47.89	5.775	A x B	2.342*
Fabric + Interfacing	B 26.32	17.494	B x C	-5.211*
Fabric + Lining (Polyester)	C 74.87	6.414	A x C	-6.253*
Wool	A 48.94	0.898	A x B	4.120*
Fabric + Interfacing	B 45.838	1.208	B x C	-2.309*
Fabric + Lining (Acetate)	C 55.430	8.221	A x C	-1.570 ns
Wool	A 48.94	0.898	A x B	-6.253*
Fabric + Interfacing	B 45.838	1.208	B x C	-5.457*
Fabric + Lining (Polyester)	C 77.410	11.508	A x C	-4.933*
Fabric + Interfacing +Lining	77.89	3.305	F3,16	42.148*
Unwrinkled Rayon	A 30.147	5.745	A x B	-0.436 ns
Fabric + Interfacing	B 31.45	1.644	B x C	-8.775*

Fabric + Lining (Polyester)	C 65.538	7.621	A x C	-7.412*
Linen	A 25.391	9.677	A x B	-0.585 ns
Fabric + Interfacing	B 28.480	4.206	B x C	-1.491 ns
Fabric + Lining (Polyester)	C 41.228	16.574	A x C	-1.650 ns
Acetate	A 25.930	0.503	A x B	-3.629*
Fabric + Interfacing	B 28.750	1.47	B x C	-2.405*
Fabric + Lining (Polyester)	C 34.270	4.348	A x C	-3.810*

Hypothesis 3: Time taken to break the specimen will be higher for fabrics with support fabrics in both warp and weft directions.

Based on the assumption that more layers will make the fabric stronger, it was assumed that it will take the layered fabric longer than the single fabric. Results from the F-test for wool revealed that time taken for the three-layered fabric to break was significantly higher than the single fabric alone for both warp and filling directions (Tables 6-7). For wool, predicted relationship held true based on the t-test analyses as well for lining in both warp and filling direction. However, it did not hold true with interfacing for the filling direction. Time dropped for wrinkled rayon with interfacing in the filling direction but improved for every other condition. The time to break did decrease significantly only for addition of polyester as lining to acetate fabric in the filling direction. Lining had a significant impact in warp direction for the unwrinkled rayon. For linen, it took longer to break the fabric with interfacing as well as lining in filling direction. However, differences were not significant for the warp direction. Overall, mixed results were found and hypothesis 3 was rejected. None of the prior work discussed this relationship. Therefore, results could not be compared.

IV. CONCLUSIONS

The key findings of the study follow. First, support fabrics impact strength, elongation and time taken to break the fabric(s) differentially for different fiber contents. Second, it is not necessary that increase in strength always results in decreased elongation for sewn fabrics. In most cases, third, the assumption that adding interfacing could increase strength of the fashion fabric was not supported for all fabrics. Fourth, Polyester was found to be stronger than acetate as lining. It is worth mentioning that acetate fades with exposure to gases that can come from deodorants, evaporating sweat, and vapors of perfumes. For example, if wool crepe is lined with acetate instead of polyester, it can start showing fading of color as well as tears much faster than the woolen fabric. Polyester will be more compatible than acetate from durability and colorfastness standpoint. However, it does not alleviate the dry-cleaning expense because both fiber contents cannot be laundered effectively by one method. The exploratory study addressed the ignored area of textile research. Previous research has focused on processes to improve efficiencies of different fiber contents with blending, dyeing and finishes. Textile is used to make apparel worldwide. However, very little attention has been paid to understand the dynamics of textiles when it is mixed with other woven, nonwoven or knitted materials foradding comfort and durability for the consumer. Compatibility of different types of fabrics for professional attire is an unattended area.The reported research offers a beginning of work in this direction. Poor choices have ramifications for textile and apparel industry. Once understood, the choices could optimize the product development process for manufacturers and consumers alike.

Table 6: Time taken in seconds to break specimens for strength and elongation for filling direction.

Fiber Content/	Time in seconds			
Condition	**Mean**	**SD**	**t/F-value**	
Wrinkled Rayon	A 7.377	0.374	A x B	25.310*
Fabric + Interfacing	B 2.062	0.192	B x C	-15.135*
Fabric + Lining (Polyester)	C 9.569	0.973	A x C	-4.207*
Wool	A 5.471	0.344	A x B	-3.100*
Fabric + Interfacing	B 4.693	0.367	B x C	1.846 ns
Fabric + Lining (Acetate)	C 5.413	0.686	A x C	0.151 ns
Wool	A 5.471	0.344	A x B	-3.100*
Fabric + Interfacing	B 4.693	0.367	B x C	-.027 ns
Fabric + Lining (Polyester)	C 8.964	1.784	A x C	-3.941*
Fabric + Interfacing +Lining	8.989	1.544	F3, 16	17.722*
Unwrinkled Rayon	A8.722	1.357	A x B	-.624 ns
Fabric + Interfacing	B 9.166	0.43	B x C	2.007 ns

Fabric + Lining (Polyester)	C 8.614	0.344	A x C	0.226 ns
Linen	A 3.061	1.474	A x B	-1.284 ns
Fabric + Interfacing	B 4.674	2.035	B x C	- 2.906*
Fabric + Lining (Polyester)	C 10.271	3.271	A x C	-4.019
Acetate	A 3.801	0.09	A x B	-3.795*
Fabric + Interfacing	B 4.264	0.227	B x C	-2.744*
Fabric + Lining (Polyester)	C 5.09	0.557	A x C	-4.571*

Table 7: Time taken to break specimens for strength and elongation for warp direction.

Fiber Content/	**Time in seconds**			
Condition	**Mean**	**SD**	**t/F-value**	
Wrinkled Rayon	A 6.697	0.858	AxB	2.024 ns
Fabric + Interfacing	B 3.900	2.628	BxC	-5.190*
Fabric + Lining (Polyester)	C 11.171	0.974	AxC	-6.894*
Wool	A 7.161	0.138	AxB	3.343*
Fabric + Interfacing	B 6.80	0.167	BxC	-3.391*
Fabric + Lining (Acetate)	C 8.221	0.822	AxC	-2.542*
Wool	A 7.161	0.138	AxB	3.343*
Fabric + Interfacing	B 6.80	0.167	BxC	-13.188*
Fabric + Lining (Polyester)	C 11.508	0.695	AxC	12.280*
Fabric + Interfacing +Lining	11.648	0.498	F3, 16	181.774*
Unwrinkled Rayon	A 4.407	0.835	AxB	-0.619 ns
Fabric + Interfacing	B 4.675	0.232	BxC	-8.702*
Fabric + Lining (Polyester)	C 9.722	1.136	AxC	-9.024*
Linen	A 3.731	1.455	AxB	-0.420 ns
Fabric + Interfacing	B 4.206	1.73	BxC	-1.235 ns
Fabric + Lining (Polyester)	C 6.072	2.478	AxC	-1.630 ns
Acetate	A 1.828	0.709	AxB	-0.856 ns
Fabric + Interfacing	B 2.144	0.202	BxC	3.196*
Fabric + Lining (Polyester)	C 0.348	1.107	AxC	2.253*

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REFERENCES

[1] U. Chowdhary, "Does price reflect emotional, structural or performance quality? International journal of Consumer Studies, Vol. 26, pp. 128-133, 2002)
[2] U. Chowdhary, and D. Poynor, "Impact of stitch density on seam strength, seam elongation, and seam efficiency." International Journal of Consumer studies, Vol. 30, pp. 561-568, 2006.
[3] U. Chowdhary, "*Quality control, textile analysis and innovative uses*". Deer Part, NY: LINUS, 2009.
[4] N. Ali, A.M. Rehan, Z. Ahmed, H., Moman, and A. Hussain. Effect of different types of seams, stitches, and stitch density on seam performance. Journal of App. Em. Sc., vol. 5, pp. 31-42, 2014.
[5] M. Akter, and M.M.R. Khan. "The effect of stitch types and sewing thread types on seam strength for cotton apparel." International Journal of Scientific and Engineering Research. Vol. 6, pp. 198-205, 2015.
[6] I Frydrych, and A. Greszta "Analysis of lockstitch seam strength and its consistency." Journal of Clothing, Science and Technology, vol. 28, pp. 480-491, 2016..
[7] P. A. Danquah, and M.E. Grover.. "The influence of stitch density on the strength, elongation, and efficiency of plain seam in a real wax printed fabric. Vol. 2, pp. 10-21, 2016.
[8] H.A. Yassen "Study of the relationships between sewing and fabric parameters and seam strength. International Design Journal, vol. 7, pp. 125-129, 2017.
[9] M. S. Ahmadi, and S. Rahimi. "Effect of base cloth structure on seam strength and seam efficiency of the
[10] artificial leather." 18th AUTEX World Textile Conference, June 20-22, 2018. Pp. 647-651.
[11] N. Seram, and T. Nandasiri. A comparison between bonding and sewing: Application in sports performance wear. Journal of Academia and Industrial Research, vol. 3, 343-345, 2015.
[12] K. Farhana, M. Syduzzamen, D. Yeasmin. "Comparison of seam strength between dyed and undyed gabardine apparels: A research on lapped and superimposed seam. Journal of Textile Science and Technology, vol. 1, pp. 75-84, 2015.
[13] Nurunnabi, M.A.H. Shibly, T. A. Tamanna, and M.M. Rahman. "Seam performance evaluation of plain fabric using different dyes in garment dyeing. International Journal of Textile Science, vol. 6, pp. 119-127, 2017.
[14] C. Cohen, & I. Johnson, "Fabric Science", New York, NY: Fairchild, 2014.
[15] Annual book of ASTM standards Vol. 7.01. Conshohocken, PA: ASTM International,2017.
[16] Annual book of ASTM standards Vol.7.02. Conshohocken, PA: ASTM International,2016.,