

# Impact of Filling Yarns on Woven Fabric Performance

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## Abstract

*Work wear woven fabrics have wide application in the area of sports, industrial textiles and defense. The performance characteristics of these fabrics are important with respect to their specific application. To improve the performance of woven work wear fabrics, different compositions of weft yarns with polyester/cellulosic material were used to produce fabric specimens on a picanol air jet loom. The effect of the composition on the tensile strength, tear strength and pilling of woven fabric specimens was studied. It was concluded that the fabric with a higher composition of modal and polyester produced better tensile strength in group G-1 as well as in group G-2. The fabric produced with modal as weft yarn also exhibited higher tear strength along the filling direction. The effect of pilling was also studied and it was found that modal and combed cotton produced low pilling as compared with other materials.*

**Key words:** woven fabric, tensile strength, tear strength, pilling.

## Introduction

The use of woven fabric is very prevalent in industrial applications like industrial textiles, sports and defense. The performance properties of work wear woven fabrics are important with respect to the life of the garment. The performance of woven fabrics is evaluated from strength, dimensional stability and service ability. The woven fabric composition can be easily modified during production by changing the composition of filling yarn by introducing the concept of tertiary blends. The changing of filling yarn is much easier as compared to that of warp yarn to improve the performance during fabric production without losing the efficiency. Hence such a technique was introduced to change the blend ratio of fabrics by using weft yarns with different blend ratios and/or materials. Using this concept we might be able to change the technical application of these fabrics.

Fasola et al. [1] explained in his study that the performance properties of woven fabric depends upon both the inherent fibre properties and geometrical arrangement of fibres in yarn and fabric as well as on process parameters. Chattopadhyay [2] stated that factors like fibre, yarn and fabric construction have a significant effect on the performance properties of woven fabrics. Emel et al. [3] studied the mechanical properties of lightweight wool/polyester blended fabrics. It was found that the maximum tensile and tear strength value for light weight apparel fabric can be obtained by blending polyester due to its softer and better handle and drape. Hussain et al. [4] studied that

the performance specifications, including the fibre and blend type, yarn and fabric count, weave, fabric areal density, breaking force and fabric colour and finish. Sulzer [5] explained that woven fabric technology is based on geometry. Fabric is produced from millions of fibres assembled together in a specific geometry. The properties of fabric depend upon the fibre type, yarn structure and fabric geometry.

Khoddami et al. [6] studied the effect of hollow fibres on the tensile, pilling and abrasion resistance and concluded that the breaking force of yarn and fabric has a negative relationship with the fibre porosity. It was also evident from the results that the hollow fibres possess higher stiffness and bending resistance by keeping all other properties similar to those of solid polyester fibre. S Abdel-Fatah et al. [7] showed that high tenacity fibre like polyester exhibits higher pilling, while the low tenacity fibre like wool displays low pilling in woven fabric. Thus a blend of wool and polyester produced better performance and pilling results.

Das [8] studied the frictional characteristic of 100% polyester fabric, 100% viscose, polyester /cotton and polyester/viscose blended fabrics. It was concluded that factors like fibre and blend type as well as the proportion, crimp height, yarn and fabric structure determine fabric frictional properties. In polyester/cotton and polyester/viscose blended fabric the frictional force increases with an increase in the cellulose component.

Malik et al. [9] stated that the strength of yarn depends upon the constituent fibres, yarn and fabric structure and also some other factors. S. Bhardwaj and S. Juneja [10] stated that blending makes the fabric manufacturing process more economical because of the price stability of man-made fibres.

In this study tertiary blends were used with cotton/polyester in the warp direction and blends and pure yarns of cellulosic fibres in the weft direction to improve the performance of woven fabrics.

## Experimental part

### Material

Polyester/cotton (60:40) blended yarn with 29.53 tex linear density was used for fabric warp and 36.91 tex yarns with different blend ratios and materials in the weft direction to develop nine different fabric samples. The blend ratio of weft yarns is given in *Table 1*.

Nine different grey fabric samples with 29.53 tex warp and 36.91 tex weft, respectively, and 45 ends/cm and 25 picks/cm were woven in a 2/1 S-twill design with 160 cm width on a Picanol Omni air jet loom (PICANOL GROUP, Belgium) using the material mentioned in *Table 1*.

### Method

All samples were produced on an air jet Picanol Omni Plus weaving machine at the Be Be Jan weaving unit limited, Faisalabad (Pakistan). The machine was equipped with a tappet shedding mechanism and ran at 1200 meters per minute. The weft was changed for sample production with nine different types of weft yarn materials, as given in *Table 1*. The fabric samples were produced in controlled atmospheric conditions: relative humidity 76% and temperature 26 °C. De-sizing and bleaching processes were performed at the processing lab of the National Textile University, Faisalabad, Pakistan. De-sizing, bleaching and scouring of grey samples were performed according to the chemicals and conditions given in *Table 2*.

All the woven fabric samples processed were conditioned before testing and characterisation. The fabric areal density was determined according to ASTM-3776, and the fabric thickness was measured according to ASTM-D1777. A standard test method - ISO 13934-01:1999 was used to determine the breaking force of

**Table 1.** Weft materials for fabric.

Sr.#	Sample Code	Description
1.	100% B	100% bamboo
2.	100% CC	100% combed cotton
3.	100% M	100% Modal®
4.	100% P	100% Polyester
5.	B:C (50:50)	50% bamboo and 50% cotton
6.	M:C(70:30)	70% Modal® and 30% cotton
7.	PC (52:48)	52% polyester and 48% cotton
8.	Hollow P	20% hollow polyester and 80% cotton
9.	L:C(55:45)	55% linen and 45% cotton

**Table 2.** Chemicals for desizing and settings.

Parameters	Units	De-sizing	Scouring	Bleaching
Enzyme De-sizer	ml/l	2	-	-
Wetting agent	g/l	1	2	1
NaOH	g/l	-	-	4
Detergent	g/l	-	2	-
Sequestering agent	g/l	-	-	2
Stablizer	g/l	-	-	2
L:R	-	8:1	-	-
pH	%	6.5	-	10.0 ~ 10.5
Temperature	°C	50 ~ 60	80 ~ 90	80 ~ 90
Time	h	0.75	1	1

**Table 3.** Fabric constructional components.

Group	Material	Fabric width, cm	Fabric area weight, g/m <sup>2</sup>	Thickness, mm	Warp crimp, %	Weft crimp, %
G-1	B:C (50:50)	58.50	244.80	0.51	16.77	6.37
	Bamboo	59.25	242.86	0.51	18.70	6.92
	Modal	57.25	242.15	0.51	14.56	8.48
	Hollow P	59.00	241.83	0.51	18.18	6.22
	M:C (70:30)	59.00	241.5	0.50	15.38	7.9
G-2	100% CC	60.50	234.66	0.50	18.74	6.73
	P:C (52:48)	59.50	233.86	0.48	16.69	6.81
	L:C (55:45)	60.90	233.70	0.49	17.48	7.28
	100% P	60.25	229.60	0.50	18.26	6.61

the specimens. The tear strength was determined according to ISO 13937-01:2000. Surface pilling of the fabric was measured by an ICI pilling box using the standard procedure BS 5811.

## Results and discussion

The mean of five values of each physical parameter of the fabric samples is given in the *Table 3*.

### Effect of weft material on breaking force

Nine fabric samples with different weft materials were tested for breaking force along the warp and weft direction in a scoured state. The mean of five values of breaking force for both the warp and weft is shown in *Figures 1* and *2* (see page 52).

### Effect of weft material on weft breaking force

Nine samples with different weft materials were tested for breaking force. The effect of the weft material on the breaking force is shown in *Figure 1*. The analysis of variance (ANOVA) in *Table 4* indicates that the effect of the weft material on the breaking force of the woven structure in the weft direction was highly significant, with a more than 95% confidence level (P-value less than 0.05).

The fabric samples in group G-1 almost have the same fabric area weight and weft density, among which the modal has the highest strength in the weft direction due to its higher tenacity and breaking force, while bamboo produces least breaking force because of its low tenacity and breaking force.

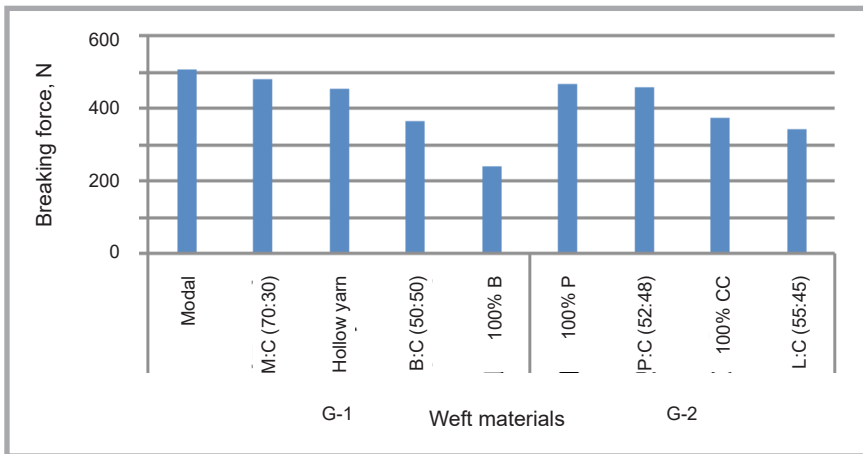


Figure 1. Effect of weft yarn material on weft breaking force.

Table 4. ANOVA for tensile properties in weft direction.  $S = 0.9986$ ,  $R-Sq = 98.72\%$ ,  $R-Sq(adj) = 98.43\%$ .

Source	DF	SS	MS	F	P
Factor	9	3072.626	341.40	342.33	0.000
Error	40	39.891	0.997		
Total	49	3112.518			

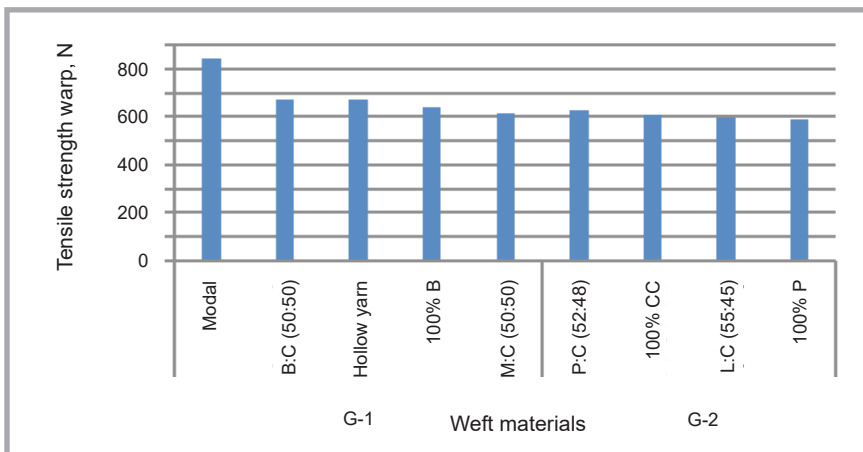


Figure 2. Effect of weft material on warp breaking force.

Table 5. ANOVA for tensile properties in warp direction.  $S = 1.536$ ,  $R-Sq = 96.15\%$ ,  $R-Sq(adj) = 95.28\%$ .

Source	DF	SS	MS	F	P
Factor	9	2356.36	261.82	110.99	0.001
Error	40	94.36	2.36		
Total	49	2450.72			

The group G-2 samples produced lower fabric area weight as compared with G-1. It can be inferred from these fabric specimens that the 100% polyester and polyester blend show the highest value of breaking force due to their greater tenacity and breaking force. The linen/cotton blend produces low breaking force due to its low tenacity and breaking force in this group.

#### Effect of weft material on warp breaking force

The effect of weft material on warp breaking force is shown in Figure 2. The analysis of variance (ANOVA) shown in Table 5 reveals that the effect of the weft material on the breaking force of the woven structure in the warp direction was also highly significant, with a more than 95% confidence level (P-value less than 0.05).

Noting the G-1 group in Figure 2, the specimen which is produced with modal weft yarn also has the highest breaking force in the warp direction, while bamboo possess the least strength, thus exhibiting low breaking force in the warp direction.

The specimens in group G-2 produced slightly lower fabric area weight due to the low crimp value. The fabric produced with PES/CO blend yarn in the weft direction produced higher strength in the warp direction.

#### Effect of weft material on tear strength

Nine fabric samples with different weft materials were tested for tear strength along the warp and weft direction in a scoured state. The mean of five values for the tear strength for both the warp and weft is shown in Figures 3 and 4.

#### Effect of weft material on weft tear strength

The effect of weft material on the weft tear strength is shown in Figure 3. Analysis of variance (ANOVA) indicates that the effect of the weft material on the tear strength of the woven structure in the weft direction was highly significant, with a more than 95 % confidence level (P-value less than 0.05 Table 6).

The samples in group G-1 have similar weight but the material has better tenacity, breaking force and elongation, producing good results for tear strength. Since the modal has the highest tenacity and breaking force in this group, it produces the highest tear strength. Bamboo has the least tenacity and hence gives poor tear strength.

When bamboo is blended with cotton its tear strength is improved due to the better tenacity and breaking force of cotton. Similarly in the case of modal when it is blended with cotton the tear strength of fabric is improved due to the higher tenacity and breaking force of modal.

For group G-2, polyester with higher tenacity and breaking force along with better elongation produces better tear strength when blended with cotton. Cotton and linen yarn both have low tenacity, breaking force and elongation at break, and hence produce poor tear strength among this group.

#### Effect of weft material on warp tear strength

The effect of weft material on the tear strength of warp is shown in Figure 4.

The analysis of variance (ANOVA) in **Table 7** revealed that the effect of weft material was statistically significant, with a 95% confidence level (p-value less than 0.05).

The warp tear strength of the bamboo and bamboo blend is slightly higher than other samples in group G-1 due to the higher elongation at break of bamboo. If the two groups are compared with each other it is obvious that the trend of the tear strength is related to the weight of the fabric.

### Effect of weft material on fabric pilling

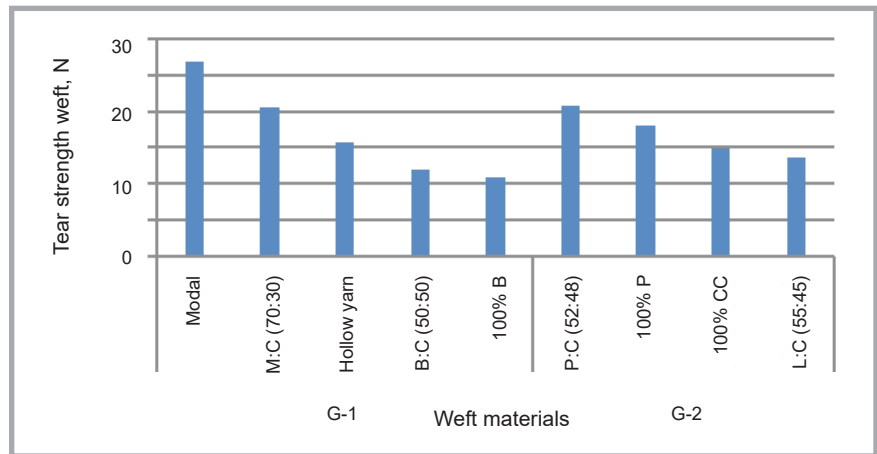
Nine samples with different materials were tested to study the effect of weft material on fabric pilling. The mean of five values for the pilling of fabric samples is shown in **Figure 5**.

Modal shows approximately no pilling in group G-1 and all other materials in this group produced slight pilling. 100% CC produced slight pilling, while the other materials in group G-2 produced moderate pilling in the fabric. The no pilling in modal might be due to its irregular cross section, like the bean and soft surface producing low friction with very little pills. Combed cotton, due to less short fibre, also has low harshness and a soft surface, and hence observed no pilling. The higher pilling in polyester and its blend is due to the higher tenacity and circular cross section of polyester fibre.

The higher pilling in polyester might be due to the higher breaking strength and low bending stiffness. The hollow polyester specimen produced slightly low pilling due to the higher stiffness when compared with the solid circular polyester fibre. The linen fibre specimen showed higher pilling due to the higher modulus of the linen.

### Conclusion

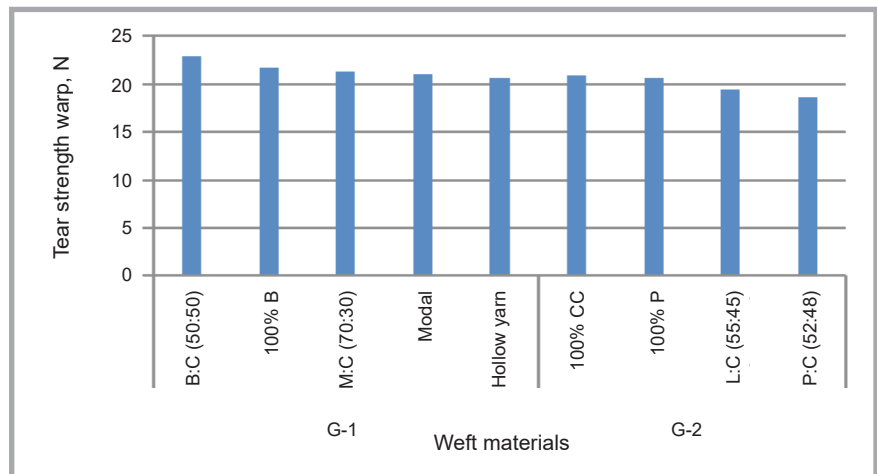
100% modal yarn in the weft direction produced higher tensile and tear strength because of higher yarn tenacity and elongation at break of this yarn among group G-1. The bamboo filling yarn gave low tensile and tear strength in this group because of its low tenacity. The polyester and its blend with cotton exhibited higher tensile and tear strength because of higher tenacity and elongation at break of such yarn among group G-2. The fabric produced with modal weft yarn from group G-1 and from combed cotton weft



**Figure 3.** Effect of weft material on weft tear strength.

**Table 6.** ANOVA for tear properties in the weft direction.  $S = 0.05593$ ,  $R-Sq = 98.82\%$ ,  $R-Sq(adj) = 98.55\%$ .

Source	DF	SS	MS	F	P
Factor	9	10.435	1.594	370.71	0.000
Error	40	0.125	0.00313		
Total	49	10.560			



**Figure 4.** Effect of weft material on warp tear strength.

**Table 7.** ANOVA for tear properties in warp direction.  $S = 0.05593$ ,  $R-Sq = 98.82\%$ ,  $R-Sq(adj) = 98.55\%$ .

Source	DF	SS	MS	F	P
Factor	9	1.0650	0.11834	41.08	0.000
Error	40	0.1152	0.00288		
Total	49	1.1802			

yarn in group G-2 have no pilling, while fabric specimens produced from polyester and linen presented higher pilling. The tertiary blends in woven fabrics can improve the characteristics very significantly, which is useful for industrial application. In this study a quick and easy technique has been introduced

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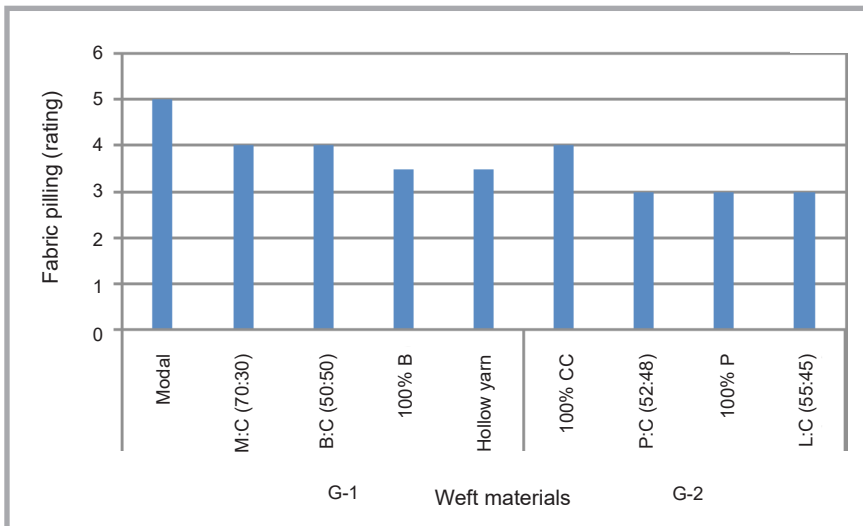


Figure 5. Effect of weft material on pilling.

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## INSTITUTE OF BIOPOLYMERS AND CHEMICAL FIBRES

### Team of Synthetic Fibres

The team conducts R&D in melt spinning of synthetic fibres

#### Main research Fields:

- processing of thermoplastic polymers to fibres:
  - classic LOY spinning:
    - fibres of round and profiled cross-section and hollow fibres
    - special fibres including bioactive and biodegradable fibres
    - technical fibres, eg. hollow fibres for gas separation, filling fibres for concrete
  - bicomponent fibres:
    - side-to-side (s/s) type self-crimping and self-splitting
    - core/sheath (c/s) type
- processing of thermoplastic polymers to nonwovens, monofilaments, bands and other fibrous materials directly spun from the polymer melt,
- assessment of fibre-forming properties of thermoplastic polymers including testing of filterability

#### Equipment:

Pilot-scale equipment for conducting investigations in melt spinning of fibres :

- spinning frames for:
  - continuous fibres of 15-250 dtex,
  - bicomponent continuous fibres of 20 – 200 dtex)
- drawing frames for continuous filament of 15 – 2000 dtex
- laboratory stand for spun bonded nonwoven 30 cm width
- laboratory stand for investigations in the field of staple fibres (crimping, cutting line)
- laboratory injection molding machine with a maximum injection volume of 128 cm<sup>3</sup>
- testing devices (Dynisco LMI 4003 plastometer, Brabender Plasticorder PLE 330 with laboratory film extrusion device)
- monofilament line for monofilaments of 0.3 – 1 mm diameter



#### Implemented technologies (since 2000):

- texturized polyamide fibres modified with amber for preparation of special antirheumatic products
- polyolefin hollow fibres for gas separation
- bioactive polypropylene POY fibres
- modified polypropylene yarns
- polyolefin fibres manufactured from PP/PE wastes

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