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Compressibility and resiliency properties of wilton type woven carpets produced with different fiber blend ratio

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Abstract.
Carpet is a textile structure that composed of three components: warp (stuffer and chain warp), weft and pile yarns. These textile products are used for areas which will stand up to the use of home, hotel, work place etc. Furthermore, the capable of carpets are related to it's especially pile performance during use in various areas. During usage, carpets made from various type of raw materials of pile yarn also acts differently that these differentiate determines carpet performance, as well.This study was focused on the compression and resilience behaviour of carpet composed of 100% viscose and 100% acrylic pile yarns and blended pile yarns of blend ratios, 80%/20%, 50%/50% and 20%/80% viscose/acrylic. During the yarn production process, all spinning conditions were kept constant in order to eliminate the yarn production parameters. Five different types of wilton face to face carpet samples were produced from these yarns at the same pile height and pile density on Van de Wiele carpet weaving machine at 110 picks/min machine speed and 1/1 V carpet construction. Compressibility properties of carpets were examined whether blend ratio was statistically significant on carpet resilience or not. The behaviour of pile yarns under pressure is important that leads to understand the growth characteristic which is exposed to decrease and increase loadings during usage of carpet made from these yarns. Results indicated that blend ratio of pile yarns have significance effect on compression behaviour of carpet samples.

1. Introduction
Compressibility and resilience properties of carpets are under influence of pile yarn materials, carpet construction, pile height etc. Pile yarn characteristic is the main parameter that affects resiliency directly. Several studies were related to determine the compressibility behaviour as well as change in thickness of carpets under loading and unloading [1-8]. Studies show that compressibility behaviour of carpets are affected by especially raw materials, fiber thickness and pile height.

This study was focused on determination of compression and resilience behaviour of carpet composed of acrylic/viscose fibers with different blend ratios. In the production of pile yarns all spinning production parameters was kept constant. Wilton face to face carpet samples were produced on the same weaving condition such as pile height, pile density and carpet construction.

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Compressibility properties of carpets were examined whether blend ratio was statistically significant on carpet resilience.

2. Material and Method

Viscose and acrylic fibers that have 38 mm length and 1.3 dtex linear density were used as raw materials. 100% viscose and 100% acrylic pile yarns and blended pile yarns of blend proportions 80%/20%, 50%/50% and 20%/80% viscose/acrylic were selected to manufacture 32.8 tex yarn samples at constant spinning production parameters (16500 rev/min spindle speed, 550 turns/m twist value). Then, these yarns were folded 4 times with 300 turns/m twist value in order to make them suitable yarn linear density for weaving carpet samples.

Wilton face to face carpet samples were produced on Van de Wiele Carpet weaving machine at the same condition in order to eliminate the weaving parameters. Weaving machine speed was 110 picks/min and carpet construction was 1/1 V. In addition, properties of yarns used for carpet production is illustrated in Table 1.

Table 1. Carpet yarn parameters

Yarn Type		Raw Material	Yarn linear density (tex)
Pile yarn		100% Viscose 80%/20% Viscose/Acrylic 50%/50% Viscose/Acrylic 20%/80% Viscose/Acrylic 100% Acrylic	131
Warp yarn	**Stuffer yarn**	80%/20% Polyester/Cotton	210
	Chain yarn	80%/20% Polyester/Cotton	126
Weft yarn		100 % Cotton	295

After weaving carpet samples; back coating, dusting, cutting processes were achieved. Before carrying out compressibility test, the specimens were conditioned in a standard atmosphere at 20±2°C temperature and 65±4% relative humidity for 24 hours according to the related standard [9]. Compressibility test was performed on SDL Atlas digital thickness gauge device which is illustrated in figure 1 under different loads in accordance with BS 4098 and BS 4051 standards [10-11].

Figure 1.SDL digital thickness gauge

Firstly, 100*100 mm carpet sample was placed under the press foot of the device (2 kPa) for 30 seconds, thickness was noted. Then, 5 kPa, 10 kPa, 20 kPa, 50 kPa, 100 kPa, 150 kPa and 200 kPa loads were applied for 30 seconds, respectively, thickness was again noted for each loads. After that, each load was removed individually and thickness was measured for each removing of loads. The thickness values of carpet samples versus to pressure were drawn so as to display the variation of each pressure. Thickness-pressure curve for 100% acrylic cut-pile carpet is given as an example in figure 2. In figure 2, loading part represents compression under loads and unloading part represents recovery of loads.

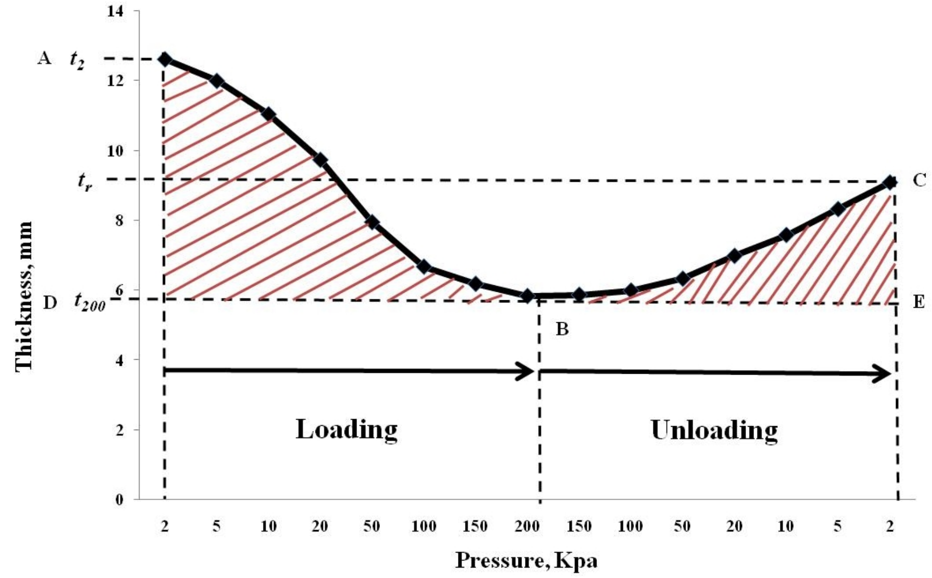

Figure 2. Thickness-pressure curve for 100% acrylic cut-pile carpet

In order to examine the blend ratio effect on compressibility of carpet samples, compression recovery can be obtained from equation (1).

$$Cc \quad r \quad (\%) = [t_r - t_2 \;/ t_2 - t_2 \;] * 100 \tag{1}$$

where;

t□; is the initial thickness at 2 kPa pressure (A)

t□□□; is compressed thickness at 200 kPa pressure (B)

t_r; is recovered thickness at 2 kPa pressure after loading to 200 kPa pressure (C)

The work of compression (t□- t□□□), in joules per square meter, can be expressed as equation (2) as the area under the loading area "*ABD*" in figure 2.

$$W \quad cc \quad j/m^2 = 1.5t_2 + 4t_5 + 7.5t_1 \; + 20t_2 \; + 40t_5 \; + 50t_1 \; + 150t_1 \; - 173t_2 \tag{2}$$

The work of recovery (t□- t□□□), in joules per square meter, can be expressed as equation (3) as the area under the unloading area "*BCE*" in figure 2.

$$W \quad cc \quad j/m^2 = 1.5t_2 + 4t_5 + 7.5t_1 \; + 20t_2 \; + 40t_5 \; + 50t_1 \; + 150t_1 \; - 173t_2 \tag{3}$$

The percentage work recovery, as estimated by the ratio of the work of recovery to the work of compression, can be calculated with equation (4).

$$W \quad r \quad \% = (w \quad cc \quad / w \quad r \quad) * 100 \tag{4}$$

In order to compare the significance effect of blend ratio statistically, analysis of variance (ANOVA) was performed by using SPSS package program. The experimental results of compression recovery, work compression, work recovery and percentage work recovery as response variables were statistically analysed using ANOVA at 95% confidence interval.

3. Result and Discussion

The average values of compressibility performance of carpet samples calculated from related equations are given in table 2. Figure 3 illustrates thickness changes of carpet samples under loading and unloading pressure. It can be said that 100% acrylic, 20%/80% viscose/acrylic and 50%/50% viscose/acrylic cut-pile carpets behaviour under compression are similar and lower than 100% viscose and 80%/20% viscose/acrylic carpets compressibility performance. That means if a carpet has a higher resilience and compression energy against pressure applied, the pile yarn demonstrates better recovery. As a result, more resistance against the compression energy of cut-pile carpets with acrylic fiber blend ratio ≥50% and thus a higher carpet thickness will be obtained.

Table 2. Compressibility performance of carpet samples

Carpet Sample	Compression recovery (%)	Work compression (J/m^2)	Work recovery (J/m^2)	Work recovery (%)
100 % Viscose	37.30	215.36	67.91	31.55
80%/20% Viscose/Acrylic	42.60	240.32	75.43	31.47
50%/50% Viscose/Acrylic	45.87	280.75	92.11	32.82
20%/80% Viscose/Acrylic	48.28	277.56	87.87	31.57
100% Acrylic	48.03	295.81	80.29	27.18

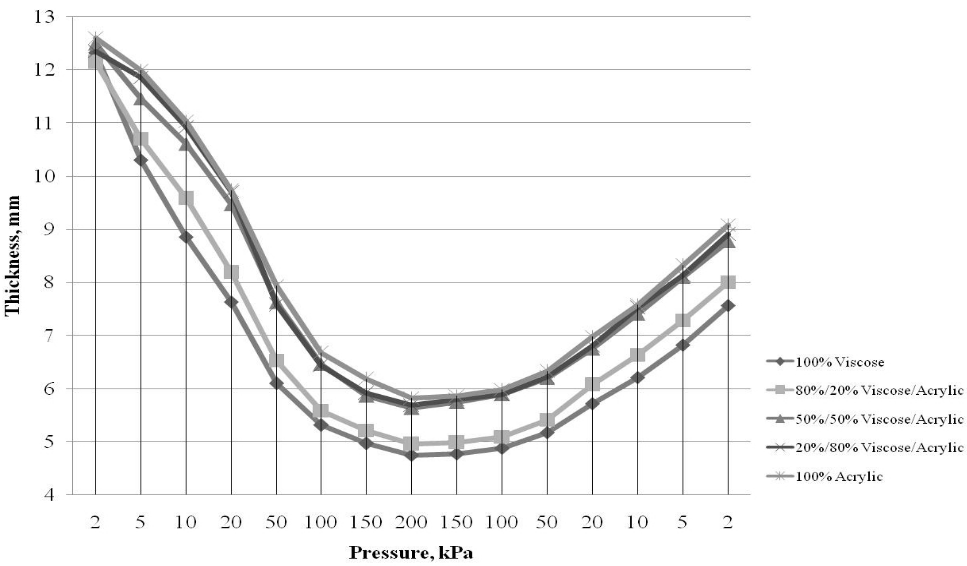

Figure 3. Carpet thickness versus to pressure curves at different fiber blend ratio

The compression recovery of cut-pile carpet samples with different blend ratio is shown in figure 4. It is clearly seen that the percentage of compression recovery increases with increasing the acrylic blend ratio. It can be probably said increase in the resilience of cut-pile carpets from low to high ratio of acrylic fiber in cut-pile carpets.

ANOVA results for recovery, compression recovery, work of compression, work of recovery and percentage work of recovery after compressibility test are given in table 3. ANOVA results indicate that fiber blend ratio has a statistically significant effect on compression recovery, work compression and work recovery variables with $p<0.005$ at the level of 95% confidence interval. On the other hand, it is seen that fiber blend ratio has no significant effect on work recovery in percent (p=0.149).

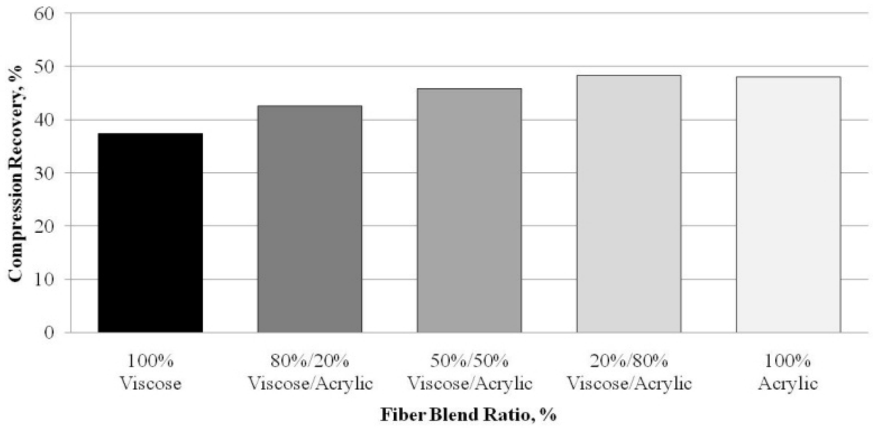

Figure 4. Compression recovery versus to fiber blend ratio

Table 3. ANOVA results of carpet samples compression behaviour

		Sum of Squares	df	Mean Square	F	Sig.
Compression recovery (%)	Between Groups	419.703	4	104.926	7.828	.001
	Within Groups	268.072	20	13.404	--	--
	Total	687.775	24	--	--	--
Work compression (J/m^2)	Between Groups	21907.701	4	5476.925	16.985	.000
	Within Groups	6449.184	20	322.459	--	--
	Total	28356.886	24	--	--	--
Work recovery (J/m^2)	Between Groups	1866.501	4	466.625	4.061	.014
	Within Groups	2297.977	20	114.899	--	--
	Total	4164.478	24	--	--	--
Work recovery (%)	Between Groups	93.685	4	23.421	1.902	.149
	Within Groups	246.220	20	12.311	--	--
	Total	339.905	24	--	--	--

4. Conclusion

In this research, the compression and resilience properties of acrylic and viscose cut-pile carpets consisting of different fibre blend ratios were investigated. It can be stated that results demonstrate the compression performance indications of the cut-pile carpet samples with ≥50% of acrylic fiber ratio can be less deformed under pressure. The most important predictor of resilience characteristics of carpet is compression recovery in percent, and result shows that high ratio of acrylic fiber contributes this response variable directly.

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