Periodicals of Engineering and Natural Sciences ISSN 2303-4521
Vol.5, No.2, June 2017, pp. 181~186
Available online at: http://pen.ius.edu.ba

Compression Properties of Woven Carpet Performance under Dynamic Loading

Deniz Vuruşkan[1], Esin Sarıoğlu[2], Halil İbrahim Çelik[2], Hatice Kübra Kaynak[2]
[1]Gaziantep University, Faculty of Fine Arts, Department of Fashion and Textile Design
[2]Gaziantep University, Faculty of Engineering, Textile Engineering Department

Article Info

Article history:

Received May 27th, 2017
Revised June 15th, 2017
Accepted June 17th, 2017

Keyword:

Acrylic
Dynamic loading
Wilton woven carpet
Pile height
Pile denisty

ABSTRACT

Although carpets are seen as decorative products for consumers, it is important that they must have optimum quality performance. The most important features affecting quality performance are pile fiber, pile yarn, pile height, pile density, carpet surface structure (cut pile or loop pile), carpet construction etc. During usage the carpet are exposed to a number of forces due to compressional loading such as dynamic or static. To counteract these forces, the resilience of pile yarn is vital. This paper demonstrates the influence of pile density and pile height of structure parameters on compression performance which was exposed to dynamic loading. In that respect, acrylic fiber was used as pile to manufacture Wilton face-to-face cut-pile carpets at two pile densities (2400 piles/dm^2, 2880 piles/dm^2) and three pile heights (7 mm, 11 mm and 16 mm). To determine the compression properties, carpets were subjected to dynamic loading at 50, 100, 200 and 1000 impacts. Thickness of carpets was taken at each of these four impacts. Finally, thickness loss of carpets as well as compression performance was detected. In order to identify the effect of pile density, pile height and number of impact on thickness loss of carpet after dynamic loading, analysis of variance was performed statistically. Results showed that pile height, pile density and number of impact have statistically significance on compression performance of carpet samples.

Corresponding Author:

Esin SARIOĞLU
Gaziantep University, Faculty of Engineering,
Textile Engineering Department, 27310
Şehitkamil/ Gaziantep, Turkey.
Email: sarioglu@gantep.edu.tr

1. Introduction

Carpet is predominantly used in home floor covering as an indispensable decorative product and also preferred by its heat and sound insulation feature. Compression performance in general terms of mechanical properties influences carpet performance under dynamic or static loads. Carpet thickness will be deformed when it is exposed to dynamic and static loads which are created by walking and furniture, respectively. During daily usage of the carpet, thickness loss is directly affected by raw material, pile height, carpet construction, pile density etc. There are a lot of studies focused on effects of these parameters on carpet performance based on static loading, dynamic loading and compressibility [1-15]. Javidpanah *et al.* studied cut-pile carpets made of heat process modified polyester pile yarn thickness loss of cut-pile carpets after dynamic loading. Four different 1800 denier and 96 filament in the cross section of air textured polyester pile yarns; normal, frieze, heat set and twist heat set were used as pile yarn. In order to analyze the carpet compression performance 50, 100, 200, 500, 1000 and 2000 dynamic impacts were acted on carpet samples. It was stated that physical and mechanical properties of air textured polyester pile yarns do not have significant changes after heat processing [4]. Çelik and Koç investigated on some selected carpet samples made of wool,

DOI: 10.21533/pen.v5i2.111

acrylic and polypropylene pile yarns to evaluate the performance of carpets under dynamic loading. In this study, carpets were exposed 50, 100, 200, 500 and 1000 dynamic impacts and then thickness losses were analyzed. They put forward that an increase in the number of impacts increase the thickness loss. It was found that acrylic fiber carpet had highest recovery capability than wool and polypropylene fiber carpets [13]. Çelik determined the effect of acrylic fineness, 2.75 denier, 6 denier and 8 denier, on carpet performance. Among the all analyses in order to identify carpet performance, dynamic loading tests were performed under 50, 100, 200, 1000 and 2000 impacts. It was resulted that acrylic fiber fineness had significant effect on thickness loss of carpet samples. The highest thickness loss was detected at carpet sample produced from acrylic pile yarn with 2.75 denier fiber fineness [8].
The aim of this study is to investigate the influences of pile height and pile density on woven carpet compression performance under dynamic loading with 50, 100, 200 and 1000 impacts. To determine the relationships between independent variable (pile height, pile density and number of impact) and response variable (thickness loss) multivariate variance analysis (MANOVA) was performed by SPSS package program.

2. Materials and Methods

Six acrylic cut-pile carpets were manufactured by Wilton face-to-face carpet weaving machine with three rapiers which enables three weft shots. The structure for all carpets was chosen as 2/3V weave construction which is illustrated in Figure 1.

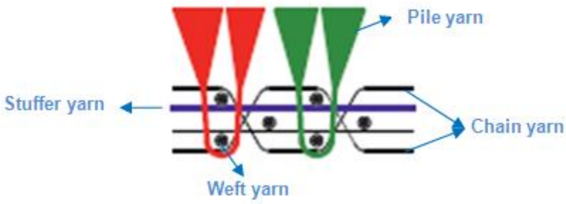

Figure 1. 2/3 V weave construction [16,17]

Acrylic fiber was used as pile with 5.6 denier linear density. All carpet production parameters were kept constant such as machine speed, weft and warp yarns used, construction. Carpet compositions are shown in Table 1. Carpet specifications are given in Table 2 with respect to pile height and pile density variables.

Table 1. Carpet samples composition

	Pile yarn	Warp yarn		Weft
		Stuffer yarn	Chain yarn	
Material	Acylic	80% Polyester/ 20% Cotton	Polyester	Jute
Yarn linear density, tex	200	197	89	491

Table 2. Carpet specifications

Warp density (ends/dm)	Weft density (picks/dm)	Pile Density (piles/dm^2)	Pile Height (mm)	Pile Weight (g/m^2)	Carpet Weight (g/m^2)
48	50	2400	7	918.549	1929.882
48	60	2880	7	1205.600	2413.000
48	50	2400	11	1374.654	2476.000
48	60	2880	11	1611.245	2846.064
48	50	2400	16	1980.400	3071.200
48	60	2880	16	2431.240	3728.400

All carpet specimens were conditioned with 65±4 % relative humidity and 20±2 °C temperature according to ISO 139:2005 [18]. Five test specimens were prepared as 125mm*125mm dimensions for each carpet. In order to perform dynamic loading test WIRA dynamic loading machine which drops free falling weight on carpet specimen at every five seconds was used. Carpet specimen was clamped on to a steel plate that is slowly and continuously traversed in such a way that there is 3.2 mm movement between each drop of the weight at each impact. Tests were conducted according BS ISO 2094:1999 [8,19,20]. Before applying dynamic loading all carpet thickness were measured in accordance with ISO 1765:1986 with WIRA digital thickness gauge under standard pressure of 2 ±0.2 kPa and this process repeated after 50, 100, 200 and 1000 impacts immediately [21]. Thickness loss in percentage was determined as a difference between the thickness at zero impact and at each stage of impact by using Equation (1).

$$Thickness\ loss, \% = \frac{h_0 - h_c}{h_o} x100 \quad (1)$$

where: h_0 is initial thickness and h_c is thickness after dynamic loading at each stage of impacts.
For statistical analysis SPSS package program was used to assess the effect size and significance of pile height, pile density and number of impact on thickness loss of carpet for each stage of impact at 95% confidence interval.

3. Results and Discussion

Thickness losses in percentage of acyclic carpets with different pile densities and pile heights after 50, 100, 200 and 1000 impacts are shown in Figure 2.
Thickness loss of acrylic cut-pile carpets increases from 50 to 1000 impacts with the increase in number of impact. Performance of carpets at 7 mm pile height for each pile density against compression is higher than that of 11 mm and 16 mm carpets. In addition, it is clearly seen that increase in pile density contributes to the compression performance of carpets with 11 mm and 16 mm pile heights. This situation can be explained with having more pile yarns within the unit area results higher resistance against dynamic load impacts. On the other hand, the same situation is not directly observed for carpets with 7 mm pile height. Thickness loss difference between 2400 piles/dm^2 is lower 3% than that of 2880 piles/dm^2 for 100 impacts.

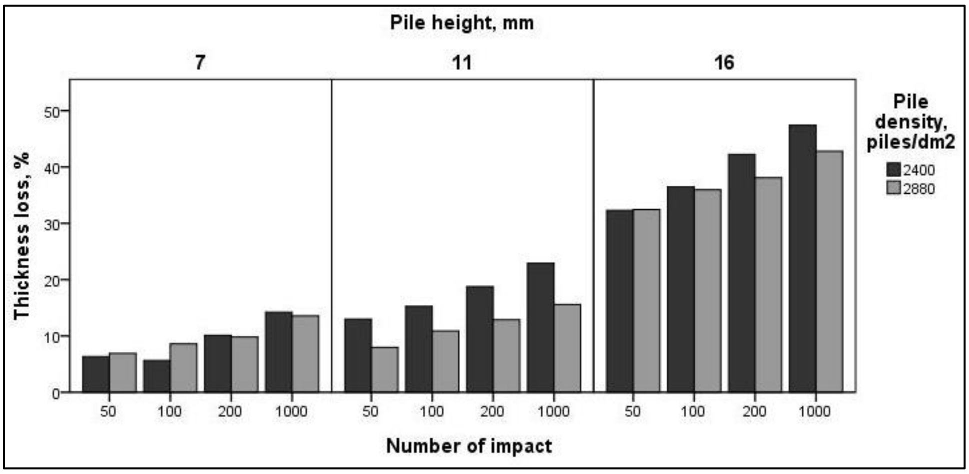

Figure 2. Thickness loss of cut-pile carpet samples versus to number of impact

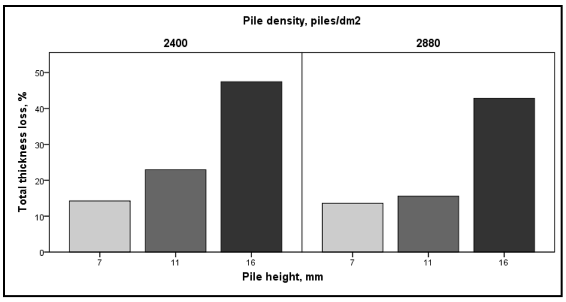

Figure 3. Total thickness loss of cut-pile acrylic carpet samples

Total thickness loss in percent of cut-pile acrylic carpet samples with different pile density and pile height is shown in Figure 3. When constant pile height is taken into consideration, the difference of thickness loss in percent for 2400 piles/dm^2 carpet has the higher value of 4.7% than 2880 piles/dm^2. This result is similar for 11 mm and 16 mm cut-pile carpets with the thickness loss value of 32% and 9.7%, respectively. In conclusion, the influence of pile density on thickness loss is clearly stated that the higher the pile density, the lower the thickness loss after dynamic loading at 1000 impacts.

MANOVA results for thickness loss after dynamic loading for independent variables are seen in Table 3. When the effect of pile height, pile density and number of impact on thickness loss is examined, thickness loss values are seen as statistically significant (R^2= 96.6 %).

In order to evaluate the effects of subgroups for number of impact and pile height (pile density was not considered because of lower than three subgroups), Duncan's multivariate range tests were achieved and results are illustrated in Table 4 and Table 5, respectively. In Table 4, increase in number of impacts affects the carpet thickness loss negatively. Furthermore, carpets with higher pile height have lower resistance to dynamic loading with higher thickness loss (Table 5).

Table 3. MANOVA for thickness loss under dynamic loading

Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	17024.242[a]	23	740.184	88.220	.000
Intercept	41680.710	1	41680.710	4967.758	.000
Number of impact	1242.777	3	414.259	49.374	.000
Pile height, mm	15343.407	2	7671.704	914.360	.000
Pile density, piles/dm^2	142.241	1	142.241	16.953	.000
Number of impact * Pile height	75.874	6	12.646	1.507	.188
Number of impact * Pile density	50.026	3	16.675	1.987	.123
Pile height* Pile density	158.538	2	79.269	9.448	.000
Number of impact * Pile height * Pile density	11.381	6	1.897	.226	.967
Error	604.098	72	8.390		
Total	59309.050	96			
Corrected Total	17628.340	95			

a. R Squared =.966 (Adjusted R Squared = .955)

Table 4. Duncan's multivariate range test results according to number of impacts

Duncan[a,b]					
		Subset			
Number of impact	N	1	2	3	4
50	24	16.4952			
100	24		18.7959		
200	24			21.9790	
1000	24				26.0773
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means. The error term is Mean Square (Error) = 8.390.
a. Uses Harmonic Mean Sample Size = 24.000.
b. Alpha = 0.05.

Table 5. Duncan's multivariate range test results according to pile heights

Duncan[a,b]				
		Subset		
Pile height, mm	N	1	2	3
7	32	9.4018		
11	32		14.6518	
16	32			38.4569
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed. Based on observed means.
The error term is Mean Square (Error) = 8.390.
a. Uses Harmonic Mean Sample Size = 32,000.
b. Alpha = 0.05.

4. Conclusion

In order to assess the influence of pile density and pile height on thickness loss of carpet exposed to dynamic loading at different impacts, acrylic cut-pile carpets were used in this study. It is expected and desired that the carpets should have the highest performance under the dynamic loading which simulate the traffic wear during the usage. In accordance with the statistical analysis, both the pile density and pile height parameters have significant effect on dynamic loading performance of the carpet samples. As a conclusion to the test results, it can be said that the lowest thickness loss was obtained with the carpet sample at 7 mm pile height and 2880 piles/dm^2 pile density. Since performance of carpets at 7 mm pile height for each pile density against compression is higher than that of 11 mm and 16 mm carpets, it can be resulted that lower pile heights provide better dynamic loading performance. It is also clearly seen that increase in pile density contributes to the compression performance of carpets with 11 mm and 16 mm pile heights.

References

[1] Y. Korkmaz and S. Dalcı Kocer, "Resilience behaviors of woven acrylic carpets under short- and long-term static loading," *The Journal of the Textile Institute*, vol.101, issue 3, pp. 236-241, 2010.

[2] E. Koç, N. Çelik and M. Tekin, "An experimental study on thickness loss of Wilton-type carpets produced with different pile materials after prolonged heavy static loading: Part 1: Characteristic parameters and carpet behavior," *Fibres & Textiles in Eastern Europe*, vol. 13, issue 52, pp. 56–62, 2005.

[3] N. Çelik and E. Koç, "An experimental study on thickness loss of Wilton type carpets produced with different pile materials after prolonged heavy static loading. Part 2: energy absorption and hysteresis effect," *Fibres & Textiles in Eastern Europe*, vol.15, issue 3(62), pp. 87-92, 2007.

[4] M. Javidpanah, N.S. Shaikhzadeh and M. Dayiary, "Study on thickness loss of cut-pile carpet produced with heat process-modified polyester pile yarn. Part I: static loading," *The Journal of the Textile Institute*, vol. 105, issue 12, pp. 1265-1271, 2014.

[5] S.M. Ishtiaque, K. Sen and A. Kumar, "Influence of yarn structures; part A: on carpet compressional performance under static and dynamic conditions," *The Journal of The Textile Institute*, vol. 106, issue 11, pp. 1190-1202, 2014.

[6] S.A. Mirjalili and M. Sharzehee, "An investigation on the effect of static and dynamic loading on the physical characteristics of handmade Persian carpets: Part I – the effect of static loading," *The Journal of The Textile Institute*, vol.96, issue 5, pp.287-293, 2005.

[7] H. Sheikhi, N.S. Shaikhzadeh, S.M. Etrati and M.D. Bidgoly, "Effect of the acrylic fibre blend ratio on carpet pile yarn compression behavior," *Fibres & Textiles in Eastern Europe*, vol. 20, issue 4(93), pp.77-81, 2012.

[8] H.İ. Çelik, "Effects of fiber linear density on acrylic carpet performance," *Journal of Engineered Fibers and Fabrics*, vol.12, issue (1), pp.1-11, 2017.

[9] M. Dayiary, N.S. Shaikhzadeh, M. Shamsi , "An experimental verification of cut-pile carpet compression behavior," *The Journal of The Textile Institute*, vol.101, issue 6, pp. 488-494,2010.

[10] N. Özdil, F. Bozdoğan, G. Özçelik Kayseri and G. Süpüren Mengü, "Compressibility and thickness recovery characteristics of carpets," *Tekstil ve Konfeksiyon*, 3/2012, pp. 203-2011, 2014.
[11] Ü.H. Erdoğan, "Effect of pile fiber cross section shape on compression properties of polypropylene carpets," *The Journal of The Textile Institute*, vol.103, issue 12, pp. 1369-1375, 2012.
[12] M. Javidpanah, N.S. Shaikhzadeh and M. Dayiary, "Study on thickness loss of cut-pile carpet produced with heat process modified polyester pile yarn. Part II: dynamic loading," *The Journal of the Textile Institute*, vol. 106, issue 3, pp. 236-241, 2015.
[13] N. Celik and E. Koc, "Study on the thickness loss of Wilton-type carpets under dynamic loading," *Fibres & Textiles in Eastern Europe*, vol.18, issue 1(78), pp. 54-59, 2010.
[14] K. Dubinskaite, L.V. Langenhove and R. Milasius, "Influence of pile height and density on the end-use properties of carpets," *Fibres & Textiles in Eastern Europe*, vol.16, issue 3(68), pp. 47-50, 2008.
[15] N. Çelik, H.K. Kaynak and Z. Değirmenci, "Performance properties of Wilton type carpets with relief texture effect produced using shrinkable, high bulk and relaxed acrylic pile yarns," *Association of Textile, Apparel and Material Professionals*, pp. 43-47, September 2009.
[16] Van De Wiele carpets weave structure catalogue.
[17] D. Vuruşkan, "Carpet fiber mobility due to traffic wear," *Industria Textila* (Accepted for publishing).
[18] ISO 139:2005-Textiles. Standard atmospheres for conditioning and testing.
[19] http://www.wira.com/media/other/37656/WiraDynamicLoading.pdf (Available on 18.02.2017).
[20] BS ISO 2094:1999 Textile floor coverings. Determination of thickness loss under dynamic loading.
[21] ISO 1765:1986 Machine-made textile floor coverings. Determination of thickness.