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Research Article

STUDY ON THE PILE HEIGHT LOSS OF TUNISIAN HANDMADE CARPETS UNDER DYNAMIC LOADING

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ABSTRACT

Nine different Tunisian handmade carpets were used for the investigation. The raw material of the carpet pile yarns was wool. The influence of the different structure parameters (pile yarn linear density and pile height…) on the carpet compression was investigated. Carpets were tested under dynamic loading in order to evaluate and observe the thickness loss and carpet behavior under dynamic loads. To determine the loss of pile height under dynamic loading, the pile height carpets were measured. As regards the deformation, results showed that both of the structure parameters of the pile yarn and the pile height have an influence. The carpet with the higher pile and the less linear density of pile yarn showed the worst performance. Results of a polynomial regression analysis are highlighted. There is a good correlation between the loss of pile height and the impacts number of dynamic loads.

INTRODUCTION

The hand woven carpet represents the great history of Tunisiens arts. It is made of two different parts, namely; secondary backing fabric and pile yarns. Horizontal strand is placed between warp yarns usually after each course of knotting to create secondary backing fabric, and to support pile yarns in vertical or near vertical condition. Warp yarn is usually spun from cotton fibers and the most common fiber used for producing pile yarn is wool.

The handmade carpets, as all finished textile product, have a structure so complex that the only satisfactory resilience test is to determine how the products work under real wear conditions. The deformation and thickness loss of carpets compressed by dynamic loads in use are of great importance as an indication of their quality as floor coverings (Celik and Koc, 2010). Owing to this loss, not only does the carpet's appearance on the face lose its original form, but the carpet's resilience capability is also greatly reduced.

There are many studies that aim to evaluate this performance. Researches show that, using wool in the carpet leads to more reduction in pile height after applying compressive load and poor elastic recovery after removing the load (Mirjalili, and Sharzehee, 2005. Gharehaghaji and all, 2000). Ainsworth *et al* (Onions, 1967. Ainsworth and Cusick, 1965). developed a machine "The Tetrapod Walker Carpet-testing machine" to control the compression behavior of carpet because the feet. It measures the loss of thickness and resilience. They showed that resilience depends on the height of the carpet node.

A lot of works have been carried out to study the effect of the static and dynamic forces on the conventional (non hand woven) carpets, but a little has been done on the hand woven carpets. In this study we tried to find out how the construction parameters (linear density of pile yarn and pile height and the warp) will influence the mechanical and physical behavior of the hand woven carpet under dynamic force.

There are various international norms that are connected to the compression and loss thick carpets under dynamic loads such as, ISO 2094 and ISO 3416 which will be described and used in our experimental study.).

MATERIALS AND METHODS

In this study we chose to vary some carpets feature such as linear density of pile thread, the pile height and the warp tension. For this we have selected the tests to be performed by fractional factorial plane Taguchi 3k-1. These are factorial designs for studying all factors but the number of trials is reduced compared to full factorial designs. Table 1 gives the characteristics of the carpet that was studied.

To determine the thickness loss under dynamic loading, the pile height carpets were measured. The test method was treated according to the Tunisian standard NT 12,165, which corresponds to the standard ISO 2094. In the process, the initial

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thicknesses of carpet samples are measured under a pressure of 2 kPa before applying dynamic loads.

Table 1 Characteristics of studied carpet

Carpet	pile yarn linear density (tex)	Pile height (mm)	Warp tension (N)
C1	571	5	50
C2	571	9	60
C3	571	12	70
C4	870	5	60
C5	870	9	70
C6	870	12	50
C7	1300	5	70
C8	1300	9	50
C9	1300	12	60

Then the first dynamic load of 50 impacts is applied to specimens as defined in the relevant standards. Samples pile heights are measured immediately. The samples are then replaced on the supplementary dynamic loading machine for further treatment. The thickness measurements are made and recorded at intervals of up to 1000 (ie measures of the study were made after 50, 100, 200, 500, and 1000 impacts). The average values are then taken to show the variations in thickness. The loss of thickness is calculated using the variation between the initial heights and measured on the number of reported impacts (ISO 2094:1999).

RESULTS AND DISCUSION

Thickness variation

The corresponding arithmetic mean thickness and the mean thickness losses calculated by the following equations:

$$d = h_0 - h \quad (1)$$

$$HL = (h_0 - h)/h_0 \times 100\% = d/h_0 \times 100\% \quad (2)$$

Where,

h0 - is the original mean thickness of the carpet sample before the application of the dynamic load, measured at a pressure of 2 kpa in mm,

h - is the general mean thickness measured after a stated number of impacts in mm,

d - is the general difference (deformation) between the original thickness and that measured after a stated number of impacts in mm,

HL - is, in general, the thickness loss of the carpet after a stated number of impacts in %

Figure 1 shows the evolution of the average pile height on the number of impacts for carpet samples examined. We can also note that increasing the number of impacts caused a decrease of the average height of all samples and the maximum deformation took place after 1000 impacts.

It may be noted that the maximum deformations were detected in 4 mm, 6.5 mm and 8 mm for carpets C1 C2 and C3, respectively. The reasons for these results can be interpreted in many respects, as the linear density of pile yarn, the structural parameters and construction properties of the samples examined, as explained in previous documents (Celik and Koc, 2010. Özdil and all 2012)

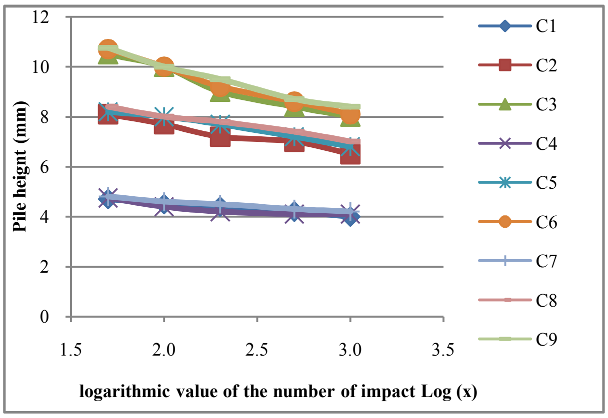

Figure 1 Logarithmic approximation for the thickness values

Thickness loss

Figure 2 shows the variation of loss of pile height for at the stated different number of impacts. Generally, the thickness loss increases with an increase in the number of impacts. The maximum thickness loss is 33.33%, 32.50% and 30.00% for carpet C3, C6 and C9 respectively. These carpets have the highest pile. From these results, we can see that the carpet with the higher pile showed the worst performance.

By comparing between the carpets that have the same pile height (C3, C6 and C9), we can also that the linear density of the pile yarn has a remarkable effect on the evolution of the thickness loss under dynamic loading. Indeed, the loss of thickness is low when the linear density of pile yarn is important. For the warp tension, it does not have a significant influence on the thickness loss.

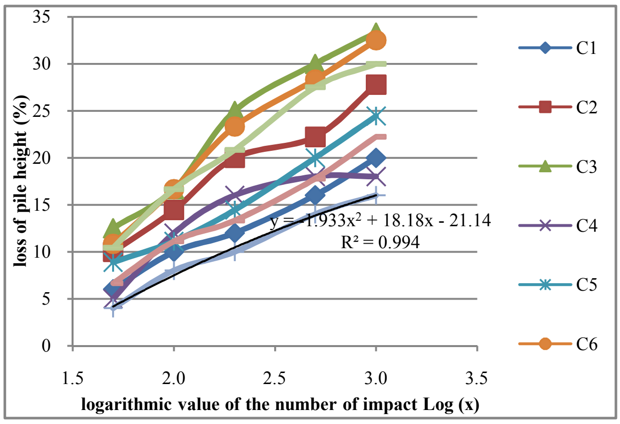

Figure 2 Variation of the pile height of losses according to the number of impact

By comparing between the carpets that have the same pile height (C3, C6 and C9), we can also that the linear density of the pile yarn has a remarkable effect on the evolution of the thickness loss under dynamic loading. Indeed, the loss of thickness is low when the linear density of pile yarn is important. For the warp tension, it does not have a significant influence on the thickness loss.

The Results of a polynomial regression analysis are highlighted in table 2 using the regression equations.

Where:
- x is the number of impacts

- HL average pile height loss %.

However, the horizontal axis is used to display the log values of impact numbers. One can see both Figure 2 and Table 2 that these equations are in good agreement with measured data. Because the prediction is reasonably accurate for all samples, these equations can also be taken into consideration when calculating the theoretical thickness loss for the considered carpet samples.

Table 2 Logarithmic regression approximation for the mean thickness loss

Carpet	Equation of the thickness loss HL% depending on the number of impact x	Regression Coefficient R%
C1	HL = 0,727(log x)2 + 6,864 log x - 7,404	0.991
C2	HL = -1,809(log x)2 + 21,54 log x - 21,21	0.977
C3	HL = -4,731(log x)2 + 38,88 log x - 40,54	0.985
C4	HL = -11,73(log x)2 + 64,82 log x - 71,06	0.996
C5	HL = 3,808 (log x)2 - 5,769 log x + 7,592	0.999
C6	HL = -4,665(log x)2 + 38,55 log x - 41,31	0.997
C7	HL = -1,933(log x)2 + 18,18 log x - 21,14	0.994
C8	HL = 0,808(log x)2 + 7,627 log x - 8,227	0.991
C9	HL = -4,399(log x)2 + 35,85 log x - 37,76	0.996

CONCLUSION

Based on the experimental study carried out on the performance of carpets examined as samples selected carpets and put under dynamic loading, the following conclusions can be drawn.

An increase in the number of impacts resulted in a decrease in the mean thickness for all the samples. Hence, thickness loss increases with an increase in the number of impacts.

The performance of Tunisians handmade carpet, depend on the height of the pile and the linear density of pile yarn. The carpet with higher pile might be the worst under dynamic loads as it is not very resistive in comparison with the other samples. However, the carpets fabricated by coarse pile yarn are the most performing.

By using the results obtained concerning the mean thickness level and thickness loss values, it is possible to predict thickness loss changes in similar carpet constructions. In other words, the variations exhibited can be used as models to estimate the behavior of these type of carpets in terms of thickness and thickness loss. So the manufacturer should choose the pile height and yarn construction very carefully to improve the life of the carpet.

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