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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

Abstract

In the first part of the article, an evaluation was made of the characteristic parameters defined as the squeezing susceptibility or compression sensitivity S, permanent deformation D_P, elasticity E and resilience R, all quantities expressed in per cent, which determine the behaviours of carpets of different pile materials (wool, acrylic and PP). This second part consists of an extended analysis covering the energy absorption, work done on the carpet, damping characteristics and hysteresis effect of pile materials on the behaviours of carpet during recovery after unloading the static pressure. Therefore, some more definitions are also presented, such as the rigidity coefficient, withdrawal force, total energy, elastic energy, damping energy, elastic recovery coefficient, damping coefficient and decompression coefficient. Throughout the paper, these parameters are specifically symbolised and explained for each carpet, and the results are discussed at the end.

Key words: *Wilton-type carpets, static loading, rigidity coefficient, energy absorption, damping coefficient, hysteresis effect.*

Introduction

Many studies have already been reported in the first part of this article [1]. Furthermore, a number of other references may be cited from the literature including information about the reasons for appearance type and loss in the carpets (i.e. pile flattening, reduction in tuft clarity, shading, soiling, and loss of colour), the mechanical properties of the carpets such as thickness loss, appearance retention, resilience, flattening, abrasion resistance, measuring techniques for the wear test under/after static or dynamic loading, and the compression characteristics and energy are essential during the carpets' recovery periods [2-9]. Of these, Carnaby & Wood [7] collected and reported past research studies to give a comprehensive understanding of the physical properties of a carpet and the instrumental techniques in order to quantify the texture characteristics of the pile. Beech [8] stated that the only theoretical approximation was worked out by Wyk to explain the relationship between the pressure and volume of a fibre mass during its compression, which provided excellent agreement ?through the neglected slippage factor and fibre-friction effects that may occur during the compression of a fibre mass. He pointed out that, apart from Wyk's study, many studies and investigations into the compression properties of fibre masses had given empirical equations to fit the fibre compression and decompression characteristics.

Hersh & El-Sheikh [9] studied the factors influencing the resilience of cut pile carpets, and reported that the pile recovers after deformation if the energy stored exceeds the resisting energies. It was proposed that the source of the stored energy was the elastic energy resulting from tuft bending, and that the energies resisting recovery arise from two sources: the potential energy required to restore the tuft to its initial height, and the fibre-to-fibre friction resisting recovery. Hersh & El-Sheikh also separated the frictional energy into two parts; the first part arising from the lower or curved portion of the deformed tuft, and the second from the upper straight portion of the tuft. It was indicated that tuft-to-tuft friction would be small, provided that no tuft-to-tuft entanglement took place.

This is an extended study on carpet behaviours during the recovery period, including the energy absorption, damping characteristics and the hysteresis effect of pile materials. Therefore, apart from the parameters given in the first part and elsewhere [1, 10], some other definitions are presented here in this part, such as the rigidity coefficient k (in N/mm), withdrawal force F_R (in N), total energy W_T (in Nmm), elastic energy W_E (in Nmm), damping energy W_D (in Nmm), elastic recovery coefficient Ψ (in %), damping coefficient φ (in %) and decompression coefficient c (in mm/N). Variations of these parameters through the recovery period and the values obtained are discussed on the basis of assumptions and approximations adopted for the carpet samples examined. The overall results evaluated are given at the end of the article.

Materials and method

The structural parameters of the carpets examined and the applied experimental procedures have already been explained in part 1, and will therefore not be repeated here. However, some of the characteristic parameters are re-stated as in part 1, because it was felt that it is necessary to recall the basic definitions in the method adopted, in order to provide a better understanding of the expressions used in this forthcoming part. Accordingly, Figure 1 (see page 88) and the following equations show the static loading procedure and measuring periods of the thickness after unloading the pressure [1].

$$\delta_S = h_0 - h_1 \quad (1)$$

$$\delta_P = h_0 - h_3 \quad (2)$$

$$\delta_E = h_3 - h_1 \qquad (3)$$

where:

h_0 is the original mean thickness of a carpet sample at the standard pressure before applying the static load,

h_1 is the mean thickness measured after recovery for 2 minutes,

h_0 is the mean thickness measured after recovery for 24 hours,

δ_S is the difference (or the deformation) between the original thickness and the thickness measured after recovery for 2 minutes,

δ_P is the difference (or the deformation) between the original thickness and the thickness measured after recovery for 24 hours,

δ_E is the recovered thickness difference between the thickness after recovery for 24 hours and the thickness after recovery for 2 minutes,

all quantiten are measured in mm.

Additionally, Equations 4 and 5 are used in order to calculate the static force F_S (in N) applied and evaluate the rigidity coefficient k respectively resembling a spring.

$$F_S = P_S \times A \qquad (4)$$

$$k = F_S/\delta = F_S/(h_0 - h) \qquad (5)$$

where,

P_S is the static applied pressure on a test specimen of a carpet sample, in kPa, which is a constant value of 700 kPa (700,000 N/m^2),

A is the test specimen surface area of a carpet sample in m^2, which is a constant value of 0.01 m^2,

F_S is the static force applied on the test specimen of a carpet sample, which is a constant value of 7000 N calculated by Equation 4,

k is the rigidity coefficient of a carpet defined in general through the recovery periods after releasing static force applied.

Table 1. *The coefficient k and deformation δ with recovery time.*

Recovery period	acrylic pile		wool pile		polypropylene pile	
	δ, mm	k, N/mm	δ, mm	k, N/mm	δ, mm	k, N/mm
2 minutes later	5.35	1308.41	2.93	2389.08	2.69	2602.23
1 hour later	4.55	1538.46	1.48	4729.73	1.18	5932.20
24 hours later	3.46	2023.12	0.52	13461.54	0.66	10606.06

Energy consideration and discussion

Table 1 gives the results of the rigidity coefficient k calculated using Equation 5, and the deformation δ for the recovery periods after releasing the applied static force F_S.

Figure 2 shows the variation of k with the recovery periods. As seen, the coefficient k increases with time in general. This increment is slower for acrylic pile, and the value of k is comparatively less than those of the other carpet samples in the beginning and after the recovery for 24 h. Normally, resembling the interpretation of a spring for carpets, the higher the k value, the worse is the carpet's resilience capability. In contradiction to the earlier evaluations in part 1, this will ensure that the carpet with acrylic pile has the best resilience capability. On the contrary, the carpet with wool pile is the worst, whereas the carpet with polypropylene is almost as bad as the wool carpet. However, this proves not to be true. This can be explained by the fact that the coefficient k is calculated by Equation 5 in which the force is constant. It was assumed that this force is the recovering force after unloading the applied pressure. Hence, the coefficient k varies only with the deformation δ. In this case, the similarity of pile recovery to a spring is inversely true. Thus the correct statement is that the higher the k value, the less is the deformation and the better the resilience capability during recovery. Nevertheless, this initial approach gives an idea of how a carpet should behave.

In the following parts of the analysis, for the sake of brevity, the work done on a carpet will be referred to as the energy represented by W in general. This energy is transferred by the static pressure. Moreover, the unit for the energy is in Nmm, wherein the force is in N and the deformation is in mm. All other parameters to be introduced are expressed on the basis of the above units. However, these units will not be shown throughout the entire paper, in order to simplify the expressions and explanations.

Expressions 6 - 8 give the total energy W_T, elastic energy W_E and damping energy W_D during the recovery period respectively. Here, it was accepted that the withdrawal force in Equation 6 as $F = k$ä is constant. So the energy calculated at each recovery varies with the deformation δ alone.

Equation 9 was obtained to calculate the ratio Ψ of the energy elastic W_E after a certain recovery period to the energy W_{2m} after the recovery period for 2 minutes. Under the above circumstances or assumptions adopted, this ratio Ψ is used to show the potential of the elastic energy W_E in the total energy W_T conveyed to the piles by the static pressure. This energy W_E recovers the pile from the maximum deformation level δ_S to the permanent deformation level δ_P. Hence, δ_E may be called the elastic deformation, remembering that $(\delta_S - \delta_P) = \delta_E$ as the recovered deformation. The ratio

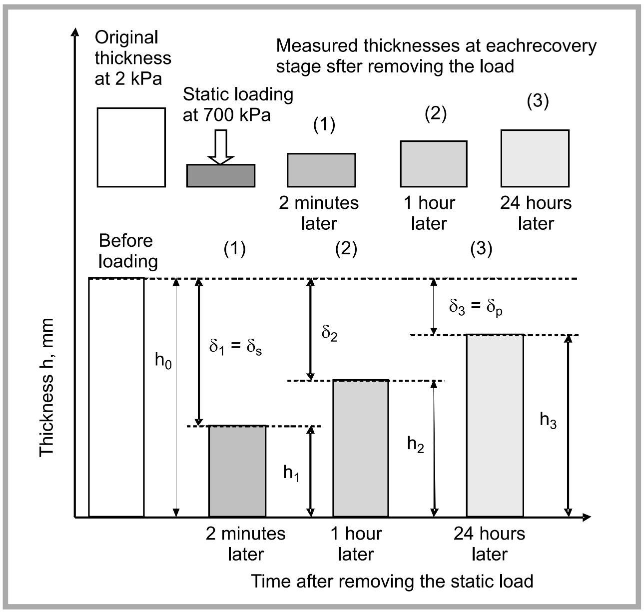

Figure 1. *Schematic diagram of static loading and measuring periods for thickness.*

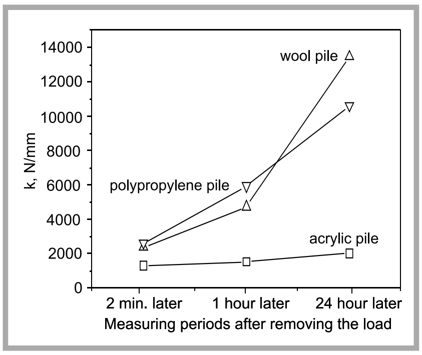

Figure 2. *The rigidity coefficient k variations with the recovery time.*

Ψ can thus be called as the elastic recovery coefficient.

In another way, equation 10 was used to calculate the ratio φ of the energy W_D after a certain recovery period to the energy W_{2m} at the recovery for 2 min. This ratio φ is also used to show the remaining energy, called damping energy W_D in the total energy W_T. The energy W_D is a dead energy, and it does not help to recover the pile. Therefore, in this analysis, the ratio φ was referred to as the spring-like damping coefficient.

Table 2 gives the results of the energies W_T, W_E, W_D and the coefficients Ψ and φ at the end of each recovery period, calculated by expressions 6 - 10.

$$W_T = 1/2\, k\, \delta^2 \quad (6)$$

$$W_E = W_{2m} - W \quad (7)$$

$$W_D = W_{2m} - W_S \quad (8)$$

$$\Psi = W_E / W_{2m} \times 100\% \quad (9)$$

$$\varphi = W_D / W_{2m} \times 100\% \quad (10)$$

Examining the data in Table 2; in terms of the elastic energy W_E and the elastic recovery coefficient Ψ after 24 h., the wool piles have the highest values, whereas that of the acrylic pile is the lowest. Hence, the wool has the highest capability to recover to the original position. On the other hand, the acrylic is the poorest at recovering. The polypropylene pile also demonstrates a good performance besides the wool. In contrast, considering the damping energy W_D and the damping coefficient φ after recovery for 24 h, they have the lowest values for the wool compared to those of the other piles, proving their better resilience property of the carpets examined.

Figure 3 shows the total energy W_T variation with the recovery period. It is seen that the energy W_T decreases with the recovery time. The total energy is the highest for the acrylic pile, in comparison with those of the other piles, and is the lowest for the wool pile after recovery for 24 h.

The overall results obtained for the carpets are as expected, which can be related to their resilience capabilities. Therefore the following statements in general may be made; if a carpet has a higher resilience to static loading, it resists more against bending or damping and absorbs the lesser total energy. Then, the damping energy in the total energy will be even less. On the other hand, the elastic energy will be higher in the total energy. However, if a carpet has a poor resilience property, it does not resist much and absorbs the higher total energy. Hence, it bears the higher damping energy and the lower elastic energy to recover the piles.

Though these statements are quite reasonable, a slight difference can be observed when comparing the wool with polypropylene in Table 2. This may be attributed to the differences in structural and constructional parameters. In fact, the reason is thought to be that the energy calculations carried out up to this point have been made assuming a constant withdrawal force determined initially by the static pressure applied. Therefore, we feel that the withdrawal force is that which moves the pile to the original position; it should vary by recovery time, and there ought to be a nonlinear relationship between this force and the deformation level, because the pile never returns back to its original thickness, and it always remains with a permanent deformation D_P. Consequently, the theoretical analysis has been changed as shown in the following lines.

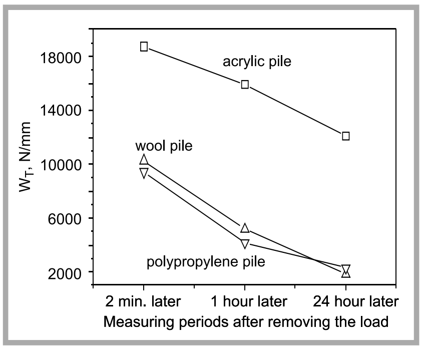

Figure 3. *The total energy W_T variations with the recovery time.*

A simple linear approximation for the calculated data of the coefficient *k* for the carpet samples is given by equations 11, 12 and 13, to be used in the later parts of this paper. Here, *x* represents the recovery time converted to hours and *y* represents the predicted coefficient *k* . The correlation coefficient R is also given next to the related equation. Table 3 (see page 90) compares the calculated values with the predicted results. As given in the table, the predicted results are well suited to the corresponding calculated values in general, especially after the recovery for 24 h. Figure 4 shows the *k* values, calculated by equation 5, with the respective lines fitted by the regressions for the carpet samples.

$$y = 1407.98 + 25.80\,x \quad R = 0.96, \text{ for acrylic} \quad (11)$$

$$y = 3320.23 + 424.21\,x \quad R = 0.99, \text{ for wool} \quad (12)$$

$$y = 4094.05 + 273.96\,x \quad R = 0.92, \text{ for polypropylene} \quad (13)$$

The following expression 14 is defined to calculate the withdrawal force F_R. This force is thought to be the force to recover the carpet thickness to the original

Table 2. *The energies W_T, W_E and W_D and the coefficients Ψ and φ.*

Recovery periods and energy parameters	acrylic pile			wool pile			polypropylene pile		
	2 minutes later	1 hour later	24 hour later	2 minutes later	1 hour later	24 hour later	2 minutes later	1 hour later	24 hour later
W_T, Nmm	18724.98	15924.98	12109.99	10255.01	5180.00	1820.00	9415.00	4130.00	2310.00
W_E, Nmm	-	2800.00	6614.99	-	5075.01	8435.01	-	5285.00	7105.00
W_D, Nmm	-	15924.98	12109.99	-	5180.00	1820.00	-	4130.00	2310.00
Ψ, %	-	14.95	35.33	-	49.49	82.25	-	56.13	75.46
φ, %	-	85.05	64.67	-	50.51	17.75	-	43.87	24.54

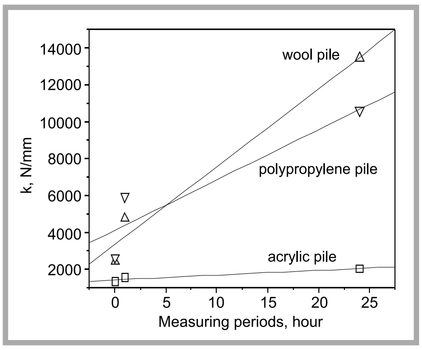

Figure 4. *Simple linear regression of the cosfficient k with the recovery time.*

position, and can be calculated at each recovery period. Here, the coefficient k is the predicted value, whereas δ is the deformation. Table 4 gives the values of δ, k and F_R.

$$F_R = k\,\delta \quad (14)$$

A polynomial approximation was made between the withdrawal force F_R and the deformation δ for the given data in Table 4. Here, the correlation coefficient R^2 is also shown next to the related equation. The withdrawal forces F_R in Equations 15, 16 and 17 are demonstrated as F_A, F_W and F_P in order to express the forces with the carpet pile materials examined. It should be noted that the correlation coefficient R^2 is quite good for the acrylic. On the other hand, that of the polypropylene is relatively good compared to the wool pile. Because of the lack of data recorded under the static loading test, it was not possible to approximate ideally.

$$F_A = -277.85\,\delta^2 + 2865\,\delta \qquad R = 0.98, \quad \text{for acrylic} \quad (15)$$

$$F_W = -1302\,\delta^2 + 7108.1\,\delta \qquad R = 0.72, \quad \text{for wool} \quad (16)$$

$$F_P = -1280.5\,\delta^2 + 7538.7\,\delta \qquad R = 0.87, \quad \text{for polypropylene} \quad (17)$$

Figure 5 shows the variation of F_R with respect to the deformation δ. It is seen from the figure that the withdrawal force for the acrylic pile is the lowest at its maximum deformation, and the force trend from maximum to minimum deformation is slower in comparison with those of the other piles. As expected, this means that the acrylic pile does not have enough potential to recover. Hence, it is the weakest in resilience compared to the other piles examined. On the other hand, the wool and polypropylene show a similar trend. The withdrawal forces for these piles are notably higher at their maximum deformations, and the force variation of each pile from maximum to minimum deformation is more rapid, giving a relatively steeper slope of the curve. So the wool and polypropylene recover more rapidly to the original position, meaning that they have higher resiliencies.

Below, the total energy equations are given; the values were determined by the

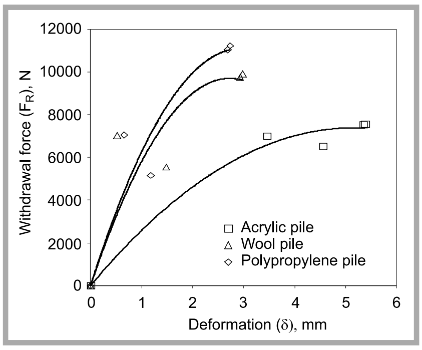

Figure 5. *The variation of withdrawal forces F_R with the deformation δ.*

integral of the withdrawal force Equations 15, 16 and 17 using the boundaries from δ = 0, meaning no deformation, to δ = δ_S, meaning the maximum deformation at the recovery period for 2 min. The total energies in Equations 18 - 20 are shown as W_{TA}, W_{TW} and W_{TP} for acrylic, wool and polypropylene piles respectively.

$$W_{TA} = \int_0^{\delta_S} F_A\,d\delta = \int_0^{5.35}\left(-277.85\,\delta^2 + 2865\,\delta\right)d\delta \quad (18)$$

$$W_{TW} = \int_0^{\delta_S} F_W\,d\delta = \int_0^{2.93}\left(-1302\delta^2 + 7108.1\,\delta\right)d\delta \quad (19)$$

$$W_{TP} = \int_0^{\delta_S} F_P\,d\delta = \int_0^{2.69}\left(-1280.5\,\delta^2 + 7538.7\delta\right)d\delta \quad (20)$$

In theory, it can be assumed that if there is no friction, the pile will return to the original position after releasing the load from the maximum deformation. However, this is not the reality in practice. In fact, the piles try to recover over time and never reach their original thickness, and different piles show different behaviours, as examined in this study. Considering this phenomenon, the following energy expressions, called the elastic energy, have been constructed from the deformations δ_S to δ_P. This energy has been determined at the maximum withdrawal force F_{max} at the recovery for 2 min, taking away a force estimated as 10% of F_{max}, referred to as a frictional force F_{FR}.

As is clear from expressions 21-23, the elastic force described is shown by F_E, whereas the difference between δ_S and δ_P is illustrated by δ_E as the recovered deformation. Here, the maximum force F_{max} is calculated using Equations 15 - 17 for $\delta = \delta_S$. The elastic energies in the equations have been symbolised as W_{EA}, W_{EW} and W_{EP} with respect to the piles.

$$W_{EA} = 1/2\,F'\Delta\delta = 1/2(F_{Amax} - F_{FR})(\delta_S - \delta_P) = 1/2F_E\,\delta_E \quad (21)$$

Table 3. *The coefficient k with recovery periods.*

Recovery Time	Material	k, N/mm	
		Calculated value	Predicted value
2 minutes later	Acrylic	1308.41	1408.86
	Wool	2389.08	3334.65
	Polypropylene	2602.23	4103.37
1 hour later	Acrylic	1538.46	1433.79
	Wool	4729.73	3744.44
	Polypropylene	5932.20	4368.01
24 hours later	Acrylic	2023.12	2027.34
	Wool	13461.54	13501.25
	Polypropylene	10606.06	10669.11

Table 4. *The deformation, rigidity coefficient, and withdrawal force; (* - approximated/ estimated value.*

Static loading and measuring periods after removing the load	acrylic pile			wool pile			polypropylene pile		
	δ, mm	k, N/mm	F_R, N	δ, mm	k, N/mm	F_R, N	δ, mm	k, N/mm	F_R, N
Before application	0	0	0	0	0	0	0	0	0
1 minute later *	5,38	1408,42	7577,31	2,98	3327,44	9915,78	2,74	4098,71	11230,47
2 minutes later	5,35	1408,86	7537,41	2,93	3334,65	9770,54	2,69	4103,37	11038,06
1 hour later	4,55	1433,79	6523,74	1,48	3744,44	5541,77	1,18	4368,01	5154,26
24 hours later	3,46	2027,34	7014,59	0,52	13501,25	7020,65	0,66	10669,11	7041,61

$$W_{EW} = 1/2\ F'\Delta\delta = 1/2(F_{Wmax} - F_{FR})(\delta_S - \delta_P) = 1/2 F_E\ \delta_E \quad (22)$$

$$W_{EP} = 1/2\ F'\Delta\delta = 1/2(F_{Pmax} - F_{FR})(\delta_S - \delta_P) = 1/2 F_E\ \delta_E \quad (23)$$

Expressions 24 - 26 give the damping energies of the piles as W_{DA}, W_{DW} and W_{DP}. The damping energy is a dead energy which does not contribute to the recovery of the piles.

$$W_{DA} = W_{TA} - W_{EA} \quad (24)$$

$$W_{DW} = W_{TW} - W_{EW} \quad (25)$$

$$W_{DP} = W_{TP} - W_{EP} \quad (26)$$

The slope of the tangent to the curves normally gives the rigidity coefficient k resembling a carpet recovery period to a spring-like system. However, through this study, all the ways and assumptions adopted and the results obtained accordingly suggest that the following coefficient c is more useful to define the decompression property of a carpet pile. Therefore, the coefficient c was inversely related to the coefficient k in order to define the ability of a carpet to recover as expressed in the following equations. So this coefficient c was called as decompression coefficient. Here, the rigidity coefficient k is defined as the ratio of the elastic force F_E, which is the force that actually recovers the pile, to the recovered deformation δ_E. Hence, it is thought that these coefficients k and c can physically represent a carpet for its decompression characteristic under the static loading examinations. Table 5 gives the evaluated parameters for a full review.

$$k = F_E / \delta_E \quad (27)$$

$$c = 1/k \quad (28)$$

Figures 6, 7 and 8 illustrate the characteristic energy changes from the elastic energy W_E to the damping energy W_D in the total energy W_T within the withdrawal force/deformation scale for the piles. On the figures, the vertical axis shows the withdrawal force, whereas the horizontal axis is the deformation.

It can be seen from the figures, the area of total energy W_T, derived from the integral of the force equation respected to the deformation, and those of the damping energy W_D and elastic energy W_E and the corresponding values as well as the force after the recovery for 2 min. as F_{max}, elastic force F_E, permanent deformation δ_P, maximum deformation δ_S and recovered deformation δ_E are symbolically given under the withdrawal force/deformation curve for piles of carpet samples.

Conclusions

The main points of the study based on the analysis we carried out can be outlined as follows;

1. An attempt was made to take a theoretical approach to the study of the energy absorption, damping characteristics and hysteresis effect of pile materials on carpet behaviours during the recovery period. Apart from the characteristic parameters evaluated in part 1, some other parameters have been introduced and discussed, such as the rigidity coefficient k, withdrawal force F_R, total energy W_T, elastic energy W_E, damping energy W_D, elastic recovery coefficient Ψ, damping coefficient φ and decompression coefficient c on the basis of assumptions and approximations adopted for the carpet samples examined.

Table 5. *The evaluated parameters of the carpet samples.*

Parameters	Acrylic	Wool	PP
$W_T = W_{2m}$ in Nmm the total energy at the recovery for 2 min, determined by the Equation 6	18724.98	10255.01	9415.00
W_E in Nmm the elastic energy after the recovery for 24 h, determined by the Equation 7	6614.99	8435.01	7105.00
W_D in Nmm the damping energy after the recovery for 24 h, determined by the Equation 8	12109.99	1820.00	2310.00
Ψ in % the elastic recovery coefficient after the recovery for 24 h. determined by the Equation 9	35.33	82.25	75.46
φ in % the damping coefficient after the recovery for 24 h. determined by the Equation 10	64.67	17.75	24.54
W_{TA}, W_{TW}, and W_{TP} in Nmm the total energy after the recovery for 2 min. determined by the Equations 18 - 20	26819.31	19594.43	18967.04
W_{EA}, W_{EW}, and W_{EP} in Nmm the elastic energy after the recovery for 24 h. determined by the Equations 21-23.	6272.43	10464.55	10060.63
W_{DA}, W_{DW}, and W_{DP} in Nmm the damping energy after the recovery for 24 h. determined by the equations 24-26	20546.88	9129.88	8906.40
$\Psi = W_E/W_T \times 100\%$ the elastic recovery coefficient after the recovery for 24 h. shown in general	23.4	53.4	53.04
$\varphi = W_E/W_T \times 100\%$ the damping coefficient after the recovery for 24 h. shown in general	76.6	46.6	46.96
$k = F_E/\delta_E$ in N/mm the rigidity coefficient after the recovery for 24 h. (Equation 27)	3511.90	3603.32	4882.76
$c = 1/k$ in mm/N the decompression coefficient after the recovery for 24 h. (Equation 28)	0.000285	0.000278	0.00205

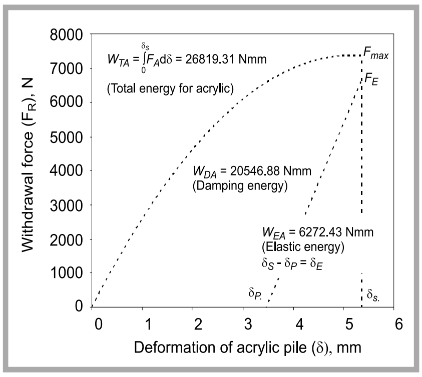

Figure 6. *The characteristic energy changes for the acrylic pile.*

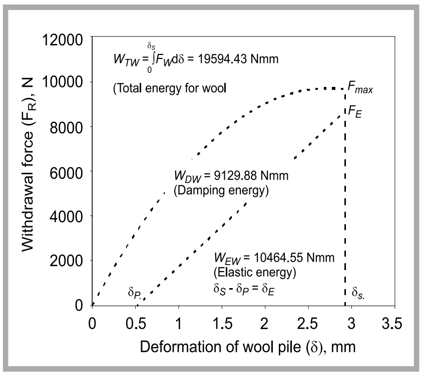

Figure 7. *The characteristic energy changes for the wool pile.*

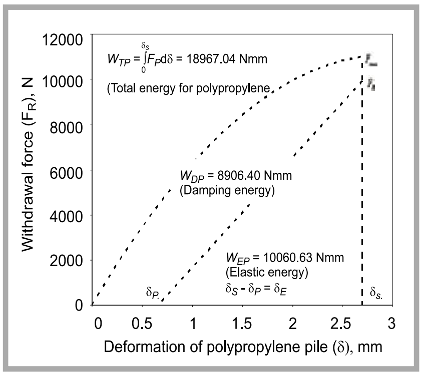

Figure 8. *The characteristic energy changes for the polypropylene pile.*

2. The initial approach was to cause the compressed pile to resemble a spring, and evaluate a coefficient to represent the carpet behaviours during recovery after unloading the applied pressure. This coefficient was called the rigidity coefficient k. In this approach, the coefficient k was calculated assuming a constant recovery force. Therefore, it was inversely related to the rigidity coefficient of a spring. Hence, the higher the k value, the lesser the deformation and the better the resilience capability during recovery for the samples examined. Moreover, the energy absorbed has been calculated at each recovery period, called the total energy W_T. It was divided into two parts as the elastic energy W_E and the damping energy W_D. Accordingly, the elastic recovery coefficient Ψ and damping coefficient φ have been defined in order to explain the decompression properties of a carpet. It was indicated that the higher the elastic recovery coefficient Ψ or the lower the damping coefficient φ, the relatively better resilience characteristics the carpets showed.

3. A second theoretical approach was developed, assuming that the recovering force of the piles, called the withdrawal force F_R in general, varies nonlinearly with recovery time. This force was related to the deformation level δ depending on the recorded data for the samples. The total energy equations were drawn and the values were determined by the integral of the withdrawal force equations using the boundaries from $\delta = 0$, meaning no deformation, to $\delta = \delta_S$, meaning the maximum deformation at the recovery period for 2 min. Similarly, the total energy W_T was divided into two parts, as elastic energy W_E and damping energy W_D. Accordingly, the elastic recovery coefficient Ψ and damping coeff-icient φ have been re-calculated to define the decompression property of a carpet.

4. All the results obtained showed that the coefficient c was more useful for defining the decompression properties of a carpet pile. Therefore, the coefficient c in mm/N was inversely related to the coefficient k in order to define the ability of a carpet to recover. So this coefficient c was called the decompression coefficient. It is thought that the coeff-icients k and/or c in can physically represent a carpet for its decompression characteristic under the static loading examinations. However, the second approach may need to be developed by recording more data during the recovery period of a carpet (i.e. 10 or 12 recording points from 2 min. and 24 h.)

References

1. Koc, E., Celik, N., Tekin, M., 'An Experimental Study on Thickness Loss of Wilton-Type Carpets Produced with Different Pile Materials after Prolonged Heavy Static Loading. Part-I: Characteristic Parameters and Carpet Behaviour', Fibres & Textiles in Eastern Europe, vol.13, No. 4/52, pp. 56-62, October/December 2005.
2. Pourdeyhimi, B., Xu, B., Nayernouri, A., 'Evaluating Carpet Appearance Loss: Pile Lay Orientation', Textile Res. J., 64 (3), 130-135, 1994.
3. Pourdeyhimi, B., Xu, B., Wehrle, L., 'Evaluating Carpet Appearance Loss: Periodicity and Tuft Placement', Textile Res. J., 64 (1), 21-32, 1994.
4. Pourdeyhimi, B., Sobus, J., Xu, B., 'Evaluating Carpet Appearance Loss: Surface Intensity and Roughness', Textile Res. J., 63 (9), 523-535, 1993.
5. Dunlop, J.I., Jie, S., 'The Dynamic Mechanical Response of Carpets: An Alternative Measurement Technique', J. Text. Inst., 82 (3), 353-359, 1991.
6. Dunlop, J.I., Jie, S., 'The Dynamic Mechanical Response of Carpets', J. Text. Inst., 80 (4), 569-578, 1989.
7. Carnaby, G.A., Wood, E.J., 'The Physics of Carpets', J.Text.Inst., 80 (1), 71-90, 1989.
8. Beech, S.R., 'Letters to the Editor: on the Compression Characteristics of Fibre Masses', J.Text.Inst., No.2, 92-98, 1983.
9. Hersh, S.P., El-Sheikh, A., 'Letters to the Editor: Energy Considerations in the Recovery of Carpets', J.Text.Inst., 660-663, 1971.
10. Patyk, B., Korlinski, W., 'Preliminary Analysis of the Pile Properties of Fur Knittings During the Process of Compression', Fibres & Textiles in Eastern Europe, pp. 49-51, October/December 2002.

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