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Effect of fibre and constructional parameters on the functional properties of Indian hand-knotted carpets

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The effect of wool fibre parameters and constructional changes made during the hand-knotted carpet weaving has been studied on 16 commercial carpet samples. It is observed that constructional changes dominate the fibre parameters and affect the resiliency and compressibility behaviour of the carpets. Contrary to the general belief, it is observed that finer wool carpets are more resilient than coarser wool carpets since these carpets have lesser pile height. However, such carpets suffer on their compressibility part.

Keywords: Carpet compressibility, Carpet resiliency, Hand-knotted carpets, Pile density, Pile height

1 Introduction

The effect of fibre parameters on carpet performance properties has been studied by some workers. Ince and Ryder[1] evaluated some carpets made from wools of 48s-36s having 1.1-49% medullation content and concluded that a correlation exists only between medullation and carpet appearance. Gupta *et al.*[2], while studying the influence of medullated fibres on mechanical processing and product performance, observed that the presence of medullated fibres improved resilience, visual appeal and handle of the carpet, retaining the compressibility behaviour. They suggested that a compromise of these characteristics with abrasion resistance must be sought while selecting a wool mix for carpet manufacture as abrasion loss and intensity of chalky whiteness increase with increase in the proportion of medullated fibres.

2 Materials and Methods

Sixteen carpet samples differing in fibre and constructional parameters were obtained from different sources. These samples were put to various tests after brushing.

Fibre diameter and medullation % were measured with the help of a projection microscope following the standard procedures[3,4]. The fibre sample was obtained by cutting the wool pile from the carpet sample.

Carpet pile height was measured with the standard pile gauge. Density was measured by counting the number of piles per decimeter in warp and weft directions. This was done by removing the pile from the back side of the carpet sample.

Carpet resiliency and compressibility were measured with the help of Shirley carpet thickness gauge. Resiliency was calculated by measuring the pile thickness by successively increasing and decreasing the pressure from 0.25 to 12 lb/in^2 in steps of 0.25, 0.75, 3, 6, 9 and 12 lb/in^2. By plotting the values on a graph sheet, the resiliency was calculated as the ratio of the area recovered to the area compressed. Compressibility was calculated as the ratio of the thickness at 0.25 lb/in^2 to 12 lb/in^2 pressure[5].

All the tests were performed after conditioning the samples for 24 h at 65 ± 5% RH and 27 ± 2°C.

Statistical analysis to calculate the coefficient of correlation between various parameters was carried out as reported elsewhere[6]. To observe the group differences, three groups, viz. G_1, G_2 and G_3 of pile height 3-7, 10-15 and 17-21 mm and pile density above 1000, 500-1000 and below 500 per dm^2 respectively, were formed.

3 Results and Discussion

The carpet constructional particulars like pile height and pile density, fibre parameters like fineness and medullation %, and carpet resiliency and compressibility are given in Table 1. The correlation coefficients between constructional and fibre parameters and carpet resiliency are given in Table 2 and

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Table 1—Constructional particulars and fibre and carpet characteristics of commercial carpet samples

Pile height mm	Pile density per dm^2	Fibre		Carpet	
		Av. diam. μm	Medullation %	Resiliency %	Compressibility %
6	864	27.53	25	52	42
6	1600	28.02	37	63	39
7	3212	29.54	30	76	45
3	2496	31.53	34	81	35
5	1806	34.88	33	79	33
21	432	35.00	53	34	57
13	630	35.01	40	38	45
10	540	36.70	51	33	48
19	325	36.78	50	27	59
20	575	38.06	62	28	52
10	552	38.20	60	40	47
17	580	38.75	63	19	45
15	1056	38.92	48	33	53
12	664	40.12	62	29	48
19	345	41.66	70	35	54
19	192	58.11	73	20	56

Table 2—Coefficient of correlation between carpet resiliency and other parameters

	Carpet resiliency	Pile height	Av. fibre diam.	Medullation, %	Pile density
Carpet resiliency	1	—	—	—	—
Pile height	−0.8392^b	1	—	—	—
Av. fibre diam.	−0.6374^b	0.6087^a	1	—	—
Medullation, %	−0.7991^b	0.7696^b	0.8184^b	1	—
Pile density	0.8895^b	−0.7255^b	−0.5604^a	−0.7072^b	1

^{a}Significant at 5% level; and ^{b}Significant at 1% level.

Table 3—Coefficient of correlation between carpet compressibility and other parameters

	Carpet compressibility	Pile height	Av. fibre diam.	Medullation, %	Pile density
Carpet compressibility	1	—	—	—	—
Pile height	0.8891^b	1	—	—	—
Av. fibre diam.	0.5546^a	0.6087^a	1	—	—
Medullation, %	0.6639^b	0.7696^b	0.8184^b	1	—
Pile density	−0.6547^b	−0.7255^b	−0.5604^a	−0.7072^b	1

^{a}Significant at 5% level; and ^{b}Significant at 1% level.

that between constructional and fibre parameters and compressibility are given in Table 3.

The raw means and standard errors of carpet characteristics are given in Table 4. The analysis of variance to see the effect of groups on resiliency and compressibility is given in Table 5.

Table 2 shows that resiliency is significantly negatively related to pile height, fibre fineness and medullation % and positively related to pile density. The relation of resiliency and pile height at low pile level is due to the technique of measuring the resiliency, i.e. the ratio of area under decreasing load to area under increasing load will be high if the original thickness is very less. Langhlin and Cusick[7] have reported similar finding due to the effect of backing.

The relations, contrary to the general belief, between resiliency and fibre fineness and between resiliency and medullation % are due to the general trend of carpet weaving that finer fibres which generally have low medullation content are utilized to manufacture low pile height carpets. The positive correlation between resiliency and pile density is important to be maintained, i.e. a carpet with low pile height should have higher knottage and vice versa. The negative significant correlation value (−0.7255) between pile height and density further confirms the same.

Table 3 shows that the compressibility is significantly positively related to pile height, fibre fineness and medullation % and negatively related to pile density. The compressibility of a longer pile will be naturally high since the longer lengths are likely to

Table 4—Raw means and standard errors of carpet characteristics

Groups	Pile height mm	Pile density per dm^2	Resiliency %	Compressibility, %
G_1	3-7	> 1000	74.75 ± 4.05(4)	38.00 ± 2.65(4)
G_2	10-15	500-1000	35.00 ± 2.48(4)	47.00 ± 0.71(4)
G_3	17-21	< 500	29.00 ± 3.49(4)	56.50 ± 1.04(4)

Table 5—ANOVA to see the effect of groups on carpet characteristics

Source of variation	Degrees of freedom	Mean sum of squares	
		Resiliency	Compressibility
Group	2	2472.75^a	342.33^a
Error	9	46.31	11.44
Result of t-test		$(G_2G_3)(G_1)$	$(G_1)(G_2)(G_3)$

^{a}Significant at 1% level.

Any two means in same parentheses do not differ significantly.

compress easily. The similar relation with fineness and medullation % is due to the genral trend of carpet weaving that coarser wools are used for weaving carpets of low knottage with high pile height. The negative correlation of compressibility with density is due to less ability of a denser mass for compression.

Table 4 shows that a compromise of pile height and density should be sought to get an average level of resiliency and compressibility. Group G_2 having pile height and pile density of 10-15 mm and 500-1000/dm^2 respectively had an average resiliency and compressibility of 35 and 47% respectively.

Table 5 shows that the effect of groups on resiliency and compressibility is highly significant even at 1% level of significance. In the case of resiliency, G_1 significantly differs from G_2 and G_3 which can be grouped together. In the case of compressibility, all the groups differ significantly, the order being $G_1 < G_2 < G_3$. This order is reverse to that observed for resiliency values.

4 Conclusion

It is observed from the experimental carpet samples that generally finer wools are utilized to manufacture carpets with low pile height and high pile density to maintain the resiliency of the carpet at the cost of compressibility. To have a compromise of the two properties, i.e. resiliency and compressibility, the pile height and pile density of 10-15 mm and 500-1000/dm^2 will be suitable.

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