

**RESILIENCE CHARACTERISTICS OF PAKISTANI WOOL**

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Resilience or percentage recovery characteristics of 6 different types of Pakistani wool i.e. Lohi-Harnai, Hashtnagri, Dumba, Kaghani and Azad Kashmir have been studied using a small cylinder with pistons and applying pressure on a definite weight and volume of wool pellets. Percentages of recovery have been recorded at various intervals of time. The first 4 breeds have almost 100 percent recovery after 24 hours while the latter 2 breeds covered a period of 48 to 72 hr. Possible effect and relation of fibres length, diameters and tensile strength of each of the six breeds with percentage recovery have been observed and the importance of it in woollen apparel cloth and specially in carpets, manufactured from Pakistani wool, has been discussed.

Pakistan produces mostly carpet wool which is quite suitable for manufacturing carpets, having the characteristics of ideal carpets. Majority of wool is exported, but considerable quantity of it is utilized within the country for manufacturing machine and mostly hand-made carpets. In 1967-68 traditional<sup>1</sup> hand-made carpets worth Rs. 30,483,000 have been exported. Hand-made carpets of Pakistan are appreciated abroad for good resilience characteristics, i.e. the springiness<sup>2</sup> of a fibre mass, or the ability of fibre to come back to its original volume after being compressed. This property is desired to a high degree in carpet wool. This is one of the reasons that Pakistani hand-made carpets piles hold their shape even after a prolong use

More valuable work has been done on resilience by Hamburger<sup>3</sup> Harris,<sup>4</sup> Robinson,<sup>5</sup> Schiefer<sup>6</sup>, Fox, Schwarz<sup>7</sup> and Dillon.<sup>8</sup> Various definitions of resilience have been given by these authors and very interesting results on the definition and the numerical characterisation of resilience of wool have been determined.

Various tests are performed<sup>9</sup> to obtain a 'rough' estimate of resilience of wool fibres. There are hand tests and machine tests. In hand test, if a given bunch of wool fibres is to be classified as 'resilient', such a bunch of irregular fibres should perform either (i) it must offer a certain moderate resistance to compression. If this resistance is too little, the material is 'limp' or 'stiff'; (ii) it has to spring back quickly upon relaxation, even if it has been kept under compression for a considerable time. If the recovery is slow the fibres will be classified as 'unresilient'. In testing resilience of wool on machine, there are several methods, one of which is performed in the present work. A carpet is subjected to stresses Dillon<sup>10</sup> of two types. Impact stresses of short duration, caused by walking on it and, constant stresses of long duration caused by furniture. For the former, rapid recovery of piles is required, for the latter, complete but not

necessarily rapid recovery is desirable. In apparel cloth resilience or the recovery of fibres is also important. This quality of wool fabrics hold their shape, drape gracefully and do not wrinkle easily. In Pakistan majority of wool produced within the country is utilised in carpet manufacture and very little quantity of it is consumed in woollen cloth manufacture.

Our present study deals with the resilience or percentage recovery characteristics of Pakistani carpet wool. But some fine quality carpets are also manufactured from fine wool produced within the country, therefore, we have included two Pakistani fine wool breeds in our study for the comparison of piles recovery. The present work deals with the resilience or percentage recovery characteristics of different types of Pakistani wool already categorized<sup>11</sup> as ideal carpet wool and utilisation of it in low to medium type woollen cloth as medullation and strength point of view.

**Material and Method**

Ten samples each of Lohi, Harnai, Hashtnagri, Dumba, Kaghani and Azad Kashmir wool breeds have been selected at random from the big lots of each of the above breeds. All these samples were scoured and their residual matters determined according to ASTM standards (D-584-53T).<sup>12</sup>

*Residual Matters.*—All the samples were hand dusted thoroughly. The scouring solution contained 0.3% sodium carbonate and 0.1% 'surf' a textile scouring detergent. The samples were scoured in 'malmal' bags made from a country made fine cotton cloth. In order to avoid felting in the scouring, solution in the hand scouring machine maintained at 53°C. The scoured samples were rinsed in the hydraulic rollers and dried in the oven at 105°C to 110°C.

*Fibre Length.*—The length was measured by stretching the fibres on a black velvet board against

a scale in inches, placed along the sides, the distance between the two ends of the fibres was noted. Twenty to twenty five staples from each type of breed were measured.

**Diameter.**—Fifteen to twenty fibres were withdrawn at random from each of the reference samples. The fibres were aligned on a microscope slide and were covered with covered slips secured by Canada balsam. Fibres were measured at five different places to get an average by Lanameter a projection microscope at x 500 magnification.

**Tensile Strength.**—A Schopper dynamometric scale was used with clamps 1 cm apart and a pretension of 200 mg wt. One end of the single fibre was suspended from the upper clamps of the hydraulic type single fibre strength testing machine, while the pretension was suspended freely from the other end of the fibre and then fixed in the lower clamps of the machine. At the time of rupture of the fibre, the breaking force from the dynamometric scale was recorded. Twenty to twenty five fibres from each of the representative samples were measured. The approximate relative humidity and the temperature were 65% and 75°C respectively.

Calculations<sup>14</sup> of tensile strength were made as follows:

Breaking stress ( $P'$ ) = Breaking force in mg wt /  
cross sectional area in  $\mu$

Tensile strength (P.S.I.) = g/denier  $\times$  12800  $\times$   
specific gravity.

where g/denier = breaking strength in  
g/900,000  $\times$  area of cross  
section  $\times$  density, where  
density is 1.212.

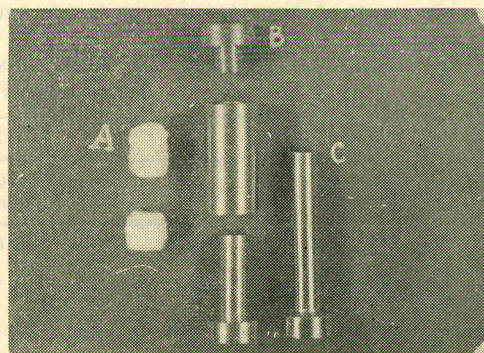
**Compression.**—0.5 g. of wool fibres was loaded into a cylinder 1" in diameter (see plate 1) of approximately  $\frac{1}{2}$  inch diameter bore and 2 pistons arrangement. The wool sample has been inserted into the cylinder and 2 pistons inserted afterwards into it. The whole assembly is then put under a suitable weight ranging from 9 g. to 11 g. (average 10 g), so that the length of the wool pellet inside the cylinder remains 1.8 cm before applying pressure. Three hundred pounds pressure square inch is then applied to the cylinder and pistons assembly having the wool sample, by the Hydraulic press. The pressure is then released and the wool pellet is brought out by a large piston. The instant recovery of the wool pellets and the recovery after 5, 10, 15, 20, 30 min, 1 hr and 24 hr have been recorded and the wool pellets

length before applying pressure were remained almost the same. The percentage recovery of each of the representative samples of 6 breeds determined and the 100% recovery of each samples ranging from 24 hours to 78 hours recorded.

## Results and Discussion

The 6 types of Pakistani wool, Lohi, Harnai, Hashtnagri, Dumba, Kaghani and Azad Kashmir have various percentages of medullation, various fibre length and a wide range of fibre thickness and tensile strength and could be utilized in the manufacture of low to medium woollen cloth, but the major quantity is consumed in carpet manufacture. Resilience is desired considerably for woollen cloth in order to maintain its crease resistance, but it is desired in high degree in yard used in carpet manufacture. The six important factors<sup>16</sup> i.e. (i) mean fibre thickness (ii) mean fibre length (iii) crimp depth (iv) the crimp length (v) the crimp depth to length ratio and (vi) tensile strength, influence to a considerable extent on the resilience characteristics of the fibres. Two characteristics i.e. the crimp length and the crimp length to depth ratio were avoided as the crimps of the last two breeds i.e. Kaghani and Azad Kashmir were not well defined and prominent, while the other breeds have no crimps. The major and the minor axis measurement was almost the same as that of the fibre thickness measurements. Our main study, therefore, included, the fibre length, fibre thickness, tensile strength and the effect and relation of these characteristics with the percentage recovery.

Certain minimum average fibre length<sup>17</sup> is necessary in order to make up an irregular fibre bunch which will not collapse upon compression. Fibres only a few millimeter long would be useless even if each of them was highly resilient. A



A: Instant recovered wool pellet and the recovered length after some time; B: Assembly of two pistons and one cylinder; C: A Puller designed for pulling out the wool pellet from the cylinder.

minimum length of 2 or 3 in is probably necessary in order to obtain compression percentage recovery. Great importance is of the fibre diameter, coarse fibres offer more resistance to compression and exhibit more tendency to return in the straight state while fine fibres act in reverse. Similarly tensile strength could also effect the percentage recovery of different types of wool fibres.

Table 1 shows the ranking of different types of Pakistani wool breeds and the percentage recovery of fibres after the release of pressure. The instant recovery of the first 4 breeds i.e. Lohi, Harnai, Hashtnagri and Dumba ranging from 77.70 to 78.82 percent while the latter two breeds Kaghani and Azad Kashmir have comparably lower recovery ranging from 74.66 to 76.62 percent. Recording of recovery of the wool pellet was continued and readings after 5 min, 10 min, 15 min, 30 min, and 1 hr have been taken. The percentage recovery getting slower after each five min and after one hour interval, the recovery is minimum. Lohi, Harnai and Dumba breed have 100 percent recovery after 48 hr i.e. the wool recovered to almost original length of 1.8 cm. Hashtnagri wool has 100% recovery after 24 hr while Kaghani and Azad Kashmir wool have 100 percent recovery after 72 hr. The first four breeds Lohi, Harnai, Dumba, Hashtnagri show comparably high compression resistance which may be due to high percentage of medullated fibres, a characteristic essential for carpet yarn.<sup>18,19,20</sup> The last two types of wool, Kaghani and Azad Kashmir have lower compression resistance and have lower percentage of medullation and has categorised<sup>21</sup> as lower to medium type of woollen cloth.

Tables 1,2,3,4, 5 and 6 are the measurements of diameters, staple length, tensile strength and the percentage recovery of the above six types of breed. Out of the six breeds, Hashtnagri wool (Table 4) has a wide range of diameters i.e. 25 to 72 $\mu$  and a

high percentage recovery of 32.6 to 46.2 percent. Harnai wool (Table 3) has a range of dia of 27.6 to 38 $\mu$  and a range of percentage recovery from 27.5 to 41.6 percent but on the other hand Kaghani wool (Table 6) which has a range of 18 to 25 $\mu$  diameter, but has a range of 25.6 to 43.7 percent recovery. Lohi wool comes next (Table 2) which has 24.6 to 35 $\mu$  diameter and percentage recovery of 27.7 to 41.3 percent while Dumba wool (Table 5) has 24.2 to 26.2 $\mu$  diameter, but has a lower percentage recovery ranges between 22.2 to 33.2 percent Azad Kashmir wool (Table 7) has a range of diameter of 22 to 27.7 $\mu$ , but has lower percentage recovery.

Out of the six breeds Hashtnagri wool (Table 4) has a wide range of mean diameters i.e. 25 to 72 $\mu$  and a high percentage recovery of 32.6 to 46.2. Harnai wool (Table 3) has a range of dia of 27.6 to 38 $\mu$  and a range of percentage recovery of 27.5 to 41.6, but on the other hand Kaghani wool (Table 6) which has a range of 18 to 25 $\mu$  dia but has a range of 25.6 to 43.7 percentage recovery. Lohi wool comes next which has 24.6 to 35 $\mu$  dia. and a resilience of 27.7 to 41.3 while Dumba wool (Table 5) has 24.2 to 26.2 $\mu$  dia, but has a lower resilience of 21.4 to 40.3, therefore, for a higher range of dia there is higher range of percentage recovery. The first three breeds with higher staple length have high percentage recovery i.e. Lohi, Harnai and Hashtnagri wool, while the remaining breeds i.e. Dumba Kaghani and Azad Kashmir with lower staple length has lower percentage recovery. (Table 8).

Table 9 shows the coefficient of correlation<sup>22</sup> percentage recovery with diameters, staple length and tensile strength. The first 4 breeds: Lohi, Harnai, Hashtnagri and Dumba diameter and resilience has simple correlation and is significant at 5 percent level, but insignificant at 1 percent level while Kaghani and Azad Kashmir wool

TABLE 1.—PERCENTAGE RECOVERY OF DIFFERENT TYPES OF PAKISTANI WOOL AT VARIOUS INTERVAL OF TIME.

Type of Breed	Percentage medullation			Percentage recovery at different time intervals									
	T	H	M	Instant	0-5 min	5-10 min	10-15 min	15-20 min	20-30 min	30 min-1 hr	1-24 hr	24-48 hr	48-72 hr
Lohi	53	20	17	78.26	50.5	40.0	36.1	33.3	28.8	27.5	—	100	—
Harnai	55	27	18	78.82	48.3	42.7	40.7	37.2	34.4	27.2	—	100	—
Hashtnagri	54	25	21	77.70	45.5	45.5	42.2	35.5	32.2	29.4	100	—	—
Dumba	33	49	17	78.82	48.3	31.7	31.7	28.3	21.1	18.3	—	100	—
Kaghani	65	22	13	76.62	41.1	36.1	31.1	28.3	22.9	16.6	—	—	100
Azad Kashmir	62	25	13	76.66	51.1	40.1	44.4	38.3	33.3	30.0	—	—	100

TABLE 2.—MEASUREMENTS OF DIAMETER, STAPLE LENGTH, TENSILE STRENGTH AND PERCENTAGE RECOVERY OF 'LOHI' WOOL.

Sample No.	Diameter	Staple length inches	Tensile strength kg/cm <sup>2</sup>	Percentage recovery
1	28	1.6	80	30.5
2	30	2.8	76	41.3
3	26	3.9	75	39.9
4	25	1.0	72	29.1
5	28.8	6.2	80	32.5
6	24.6	5.5	74	38.1
7	28	4.9	75	27.7
8	30	5.7	80	29.6
9	35	4.5	85	35.3
10	32	3.8	82	33.9
Mean	28.44	3.9	77.9	33.78

TABLE 3.—MEASUREMENT OF DIAMETER, STAPLE LENGTH, TENSILE AND PERCENTAGE RECOVERY OF 'HARNAI' WOOL.

Sample No.	Diameter	Staple length inches	Tensile strength kg/cm <sup>2</sup>	Percentage recovery
1	30	4.2	72	39.7
2	29	3.9	75	41.0
3	28.8	4.1	80	38.6
4	27.6	5.8	82	41.6
5	28	5.1	78	27.5
6	32	4.9	72	40.5
7	38	3.8	80	40.5
8	35	2.8	85	36.7
9	30	4.5	80	34.5
10	28	3.7	78	39.9
Mean	30.64	4.3	78.2	37.05

TABLE 4.—MEASUREMENTS OF DIAMETER, STAPLE LENGTH, TENSILE STRENGTH AND PERCENTAGE RECOVERY OF 'HASHTNAGRI' WOOL.

Sample No.	Diameter	Staple length inches	Tensile strength kg/cm <sup>2</sup>	Percentage recovery
1	25	2.9	85	32.6
2	26.2	4.0	80	33.8
3	26.4	3.8	75	36.6
4	30.8	2.8	65	38.8
5	35	5.4	72	41.2
6	38	2.5	70	33.3
7	40	4.1	85	34.3
8	72	3.6	65	40.5
9	60	2.9	82	46.2
10	70	1.6	85	
Mean	42.34	3.4	73.4	37.65

TABLE 5.—MEASUREMENTS OF DIAMETER, STAPLE LENGTH, TENSILE STRENGTH AND PERCENTAGE RECOVERY OF 'DUMBA' WOOL.

Sample No.	Diameter	Staple length inches	Tensile strength kg/cm <sup>2</sup>	Percentage recovery
1	25.0	2.9	85	27.0
2	24.5	3.9	75	28.2
3	26.20	4.8	80	27.7
4	24.6	3.0	75	22.2
5	24.2	1.9	75	22.6
6	25.1	2.7	85	30.5
7	25.0	4.2	80	33.9
8	26.3	3.9	85	30.5
9	25.0	2.6	75	33.2
10	26.0	1.9		
Mean	25.19	3.2	79.70	29.08

TABLE 6.—MEASUREMENTS OF DIAMETER, STAPLE LENGTH, TENSILE STRENGTH AND PERCENTAGE RECOVERY OF 'KAGHANI' WOOL.

Sample No.	Diameter	Staple length inches	Tensile strength kg/cm <sup>2</sup>	Percentage recovery
1	20	1.2	80	27.1
2	18	1.4	85	28.4
3	25	3.7	76	25.6
4	25.2	2.9	75	39.5
5	24.4	1.9	72	40.4
6	20.8	3.5	82	32.6
7	22	1.5	68	29.1
8	24	3.2	70	26.9
9	24	2.4	80	43.7
10	25	2.8	82	35.7
Mean	22.84	2.4	74.72	33.21

TABLE 7.—MEASUREMENTS OF DIAMETER, STAPLE LENGTH, TENSILE STRENGTH AND PERCENTAGE RECOVERY OF 'AZAD KASHMIR' WOOL.

Sample No.	Diameter	Staple length inches	Tensile strength kg/cm <sup>2</sup>	Percentage recovery
1	22	1.0	80	26.8
2	25	1.1	82	21.4
3	26	4.0	86	30.8
4	25.5	1.8	85	25.3
5	24.6	3.9	80	27.7
6	23.7	2.9	76	25.6
7	24.0	1.7	72	31.7
8	25	2.6	75	33.1
9	26	3.2	78	40.3
10	25	3.9	75	24.9
Mean	26.68	2.7	78.9	28.95

TABLE 8.—AVERAGE DIAMETER, STAPLE LENGTH, TENSILE STRENGTH AND RANGES OF LOHI, HARNAI, HASHTNAGRI, DUMBA, KAGHANI AND AZAD KASHMIR WOOL.

Type of Breed	Mean Dia. Range ( $\mu$ )	Mean staple length ( $\mu$ ) range	Mean tensile strength range	Percentage recovery range
Lohi	24.6-35	1-6.2	72-85	27.7-41.3
Harnai	27.8-38	4.1-5.8	62.85	27.5-41.6
Hashtnagri	25-72	4-5.4	70-85	32.6-46.2
Dumba	24.2-26.2	3-4.8	75-85	22.2-33.2
Kaghani	18-15	1.4-3.7	68.85	25.6-43.7
Azad Kashmir	22-27.7	1.2-4	72-86	21.4-40.3

TABLE 9.—COEFFICIENT OF CORRELATION OF PERCENTAGE RECOVERY WITH DIAMETER, STAPLE LENGTH AND TENSILE STRENGTH.

Wool type	Coefficient of correlation of percentage recovery with diameter, staple length and tensile strength		
	Relation of percentage recovery with diameter ( $\mu$ )	Relation of percentage recovery with staple length	Relation of percentage recovery with tensile strength
Lohi wool	0.63	0.78	0.12
Harnai	0.62	0.76	0.26
Hashtnagri	0.65	0.65	0.68
Dumba	0.61	-0.63	-0.09
Kaghani	0.44	0.26	0.05
Azad Kashmir	0.22	0.17	0.22

Mean value of simple correlation—at 5% level—0.602

Mean value of simple correlation—at 1% level—0.735

is insignificant at 5 percent level, simple correlation of resilience and staple length of Lohi and Harnai wool is significant at 1 percent level while Hashtnagri and Dumba are significant at 5 percent level in which the latter breed has a negative correlation. Kaghani and Azad Kashmir wool on the other hand is insignificant at 5 percent level.

Simple correlation of percentage recovery and tensile strength exists of Hashtnagri wool only which is significant at 5 percent level. Diameter and staple length of Lohi, Harnai, Hashtnagri and Dumba has higher correlation. All the six breeds have a wide range of (Table 8) diameters and staple length, but a small range of tensile strength. For all the above properties the percentage recovery

ranges from 21.4 to 46.2 percent. The study indicates that 53.6 percent of the variation to percentage recovery could be caused by diameter, fibre length and tensile strength.

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