KLINE, MARY JANE. Compressional Resilience of Selected Carpeting. (1969) Directed by: Dr. Pauline E. Keeney. pp. 45

The objectives of the study were to determine whether differences exist in the compressional resilience of plush cut carpeting of wool, acrylic and nylon fibers of high and low pile heights under immediate and extended recovery periods.

Samples to be tested were coded to indicate the carpets of each fiber type and pile height. Five samples of each fiber type of high pile height and five samples of each fiber type of low pile height served as replicates of the fiber. Samples were conditioned at 70 ± 2 degrees Fahrenheit and 65 ± 2 per cent relative humidity prior to and during the collection of data.

The C & R Tester was used to determine original thickness, compressed thickness, and thickness under three recovery periods. Compressional resilience was determined from these measurements of the pile height under different conditions of compression.

An analysis of variance was utilized to determine any differences in compressional resilience (1) among carpet fibers, (2) between pile heights, and (3) among recovery periods.

The results indicated that (1) the greatest differences in the compressional resilience of the carpets were between

the low and high pile height carpeting and among the three recovery periods, (2) the recovery periods of thirty seconds and one minute indicated the best measurements of per cent recovery, (3) nylon showed the greatest per cent recovery at all three recovery periods, and wool showed the next greatest per cent recovery at all three recovery periods, and (4) the greatest per cent recovery occurred between zero and thirty seconds.

COMPRESSIONAL RESILIENCE OF SELECTED CARPETING

by

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APPROVAL SHEET

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

This study compares physical properties of carpeting made of three fibers currently popular for use in rugs and carpets available to the consumer. Particular emphasis is placed upon the property of fiber resilience since this is a measurable property which influences both the appearance and performance of carpeting in consumer use.

The structure and technology of the carpet industry has changed greatly in the last decade. Prior to this time practically all machine-made carpets marketed were of woven construction. Currently, all but a small percentage of the carpeting is manufactured by the tufting process. This more rapid method of production combined with the availability of man-made fibers has made it possible to produce carpeting at progressively lower costs. It has also changed carpeting from a predominantly luxury item to one of practical significance.

Prior to and in the years immediately following World War II, most surface yarns used in the production of broadloom carpets were wool. Wool has been and still is the basic carpet fiber since it tends to serve as a standard for carpeting manufactured from man-made fibers. Its relative importance has declined in the past decade due to the decreasing availability of the fiber. The decline in supply has also affected the cost of wool available to the consumer.

Man-made fibers are an essential part of the carpet industry today because they provide a means by which production can be expanded at reasonably stable costs. Many of the newer man-made fibers can be used in the manufacture of carpeting. At the present time the two used in the greatest volume are acrylic and nylon. Nylon used in carpeting dominates in the volume markets and has the characteristic of being highly durable. Acrylic, being the most wool-like of the man-made fibers, has assumed second position in the carpet market.

Regardless of the fiber used in carpeting, there are factors which determine the newness retention or overall service retention performance. Four of the most important factors to be considered are (1) durability, (2) resilience, (3) soil resistance and cleanability, and (4) color fastness. Of these factors, resilience is one about which the consumer is least informed. It could be one of the most important to the consumer since it is closely related to the comfort, appearance and durability of the carpet.

Consumers, when purchasing carpet, should be more aware of the importance of physical characteristics such as pile type, the height of pile and the influence of these properties upon the resilience of the carpeting. Unfortunately, there is little or no informative labeling of rugs or carpets. When such information is given by sales personnel, it is often secondary to information related to the aesthetic properties and too technical to be understood by many consumers.

I. STATEMENT OF THE PROBLEM

This study was undertaken to obtain more information as to the property of fiber resilience of carpeting. The purpose of the study was to investigate differences in the compressional resilience of the selected carpeting manufactured from wool, acrylic and nylon fibers, and to ascertain how it might be affected by recovery periods of different lengths.

The specific objectives of this study were:

1. To determine whether differences exist in the compressional resilience of plush cut carpeting of wool, acrylic, and nylon fibers.

2. To determine whether differences exist in compressional resilience of plush cut carpeting of high and low pile heights.

3. To determine whether differences exist in the compressional resilience of plush cut carpeting tested under immediate and extended recovery periods.

II. DEFINITIONS OF TERMS USED

<u>Compression</u>

The amount of work done due to pressure equivalent to 12.48 pounds per square inch as expressed in .001 inches.

Recovery

The amount of work recovered after release of pressure equivalent to 12.48 pounds per square inch.

Compressional Resilience

The ratio between the thickness following recovery from compression and the original thickness.[1]

Plush cut

The term is applied to carpeting of cut pile construction giving a soft luxurious texture.

Work

The physics term representing "....the force times the distance through which the force acts."[2]

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[1]S.L. Anderson and D.G. Clegg, "Physical Test Methods for Carpets," Textile Institute and Industry, I (February, 1963), 6.

[2]Harvey E. White, Modern College Physics (Princeton, New Jersey: D. Van Nostrand Co., Inc., 1966), p. 80.

CHAPTER II

REVIEW OF LITERATURE

With the tremendous growth of the American carpet market and the wide variety of fibers now being used, the consumer is in need of information concerning overall service retention performance.

There has been extensive information in recent years pertaining to the many phases of carpet manufacturing. Manufacturers of fibers used in the construction of carpeting have been particularly interested in publicizing the relative merits of their products. Many manufacturers publish technical reports which include factual information and reports of research studies pertaining to the aesthetic and performance qualities of carpeting. Unfortunately, this information is not readily accessible to the consumer.

In most of the literature reviewed in relation to this study, resilience of carpets and carpet fibers was of primary importance. According to a technical bulletin used by the Chemstrand Company, a Division of the Monsanto Company,

> Resilience of the pile yarn is an indication of the durability of the carpet. This characteristic is customarily measured by pile height retention, the portion of the original pile height retained after being bent, compressed or otherwise deformed in normal wear and by residual compression, a measure of the springiness

of the carpet.[1]

Some studies have been conducted on the compressional resilience of carpeting. However, measurements as to the amount of recovery at various time intervals and for the different pile heights of carpet fibers were not cited in detail of those reviewed.

I. FIBERS CURRENTLY USED IN CARPETS

The recent expansion of the carpet industry has resulted, in part, from the availability of many new fibers manufactured to have properties specifically suited for this end-use. According to a recent report published by the Textile Economics Bureau, Incorporated, tufted face yarns include fibers of cotton, wool, rayon and acetate, and man-made fibers of acrylic, modacrylic nylon, olefin and polyester generic groups.[2]

Although carpets of olefin and polyester fibers have increased in popularity, the literature reviewed pertains to the three fibers used as the experimental carpeting for the study.

A study by J.L. Nevin and R.B. Mumford showed that

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[1]Chemstrand Company, The Manufacture, Styling and Performance Characteristics of Carpets of Textured Continuous Nylon (Alabama: Chemstrand Company, November, 1963).

[2]Textile Economics Bureau, Incorporated, "End Use Consumption Summary," Textile Organon, XL (January, 1969), 10.

out of a total fiber consumption of some 475 million pounds used in 1966 by the carpet industry, three fibers - nylon, acrylic and wool, in order, accounted for about 440 million pounds of carpeting produced. The fact that no single fiber predominated illustrates that there is considerable diversity in the market, and that the criteria applied will vary from one segment to another.[3]

II. COMPARISON OF FIBER PROPERTIES

Various properties have been considered highly desirable. Because of the importance of the relation of the physical characteristics of the fibers to the property of resilience, these were of concern in this study.

Wool Fibers

Wool can be regarded as a fiber very well suited for the pile of carpets. Until recently, it was unchallenged for the better qualities of carpet.[4]

Since wool is an economic commodity of more importance to Great Britain than to the United States, British research personnel have contributed to the technical information pertaining to the use of wool in carpeting. The properties of

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[3] J.L. Nevin and R.B. Mumford, "Carpet Fiber Evaluation," Textile Industries, CXXXI (February, 1967), 97.

[4] G.B. Angus, "Basic Structures and Fibers Used in Carpet Manufacture," Textile Institute and Industry, III (December, 1965), 316.

wool carpeting are also important to research personnel in this country and have served as a standard for the newly developed fibers used in carpeting.

A consideration of the physical and chemical properties of wool shows that it possesses many of the properties desired in carpeting. It is nearly white in color, easily bleached, is a poor conductor of heat and possesses remarkable elastic recovery (resiliency). The strength in the dry state is moderate and in the wet state is relatively high. Wool has a high moisture retention without feeling damp. The scaly surface retards the penetration of grit through the carpet pile. The resistance to abrasion is good. It is not easily wetted, does not soil readily and is easily cleaned. It is resistant to weak acids, dyes readily and may be resistant to moth larvae and bacteria.[5]

According to Angus, a British authority, carpets made from either woolen or worsted yarns have a "spongy" soft, warm feeling in the pile. The worsted-type yarn usually gives a closer, more lustrous effect, which has a more luxurious appearance. Carpets constructed of the worsted-type yarn possibly last longer in use than do carpets of the woolen type.[6]

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[5]George Robinson, "Wool and Other Fibers as Components of Carpet Pile," Journal of The Textile Institute, XLIII (August, 1952), 523.

[6]Angus, loc. cit.

Nylon Fibers

From a humble start in the late 1950's, nylon has become more widely used than any other carpet fiber. The combination of current development in nylon yarns presents opportunities that have not existed previously and which will favor nylon over any competition.[7]

A current study by Reg Burnett revealed that nylon is the most widely used fiber in today's carpets. During 1967 the carpet industry used 306 million pounds of nylon. It is estimated that during 1968, these figures have risen to 360 million pounds.[8]

According to Burnett, there are two major technical reasons for nylon's popularity:

> First, it is a fiber which is easily dyed to almost any color that is desired; and secondly, it is a tough fiber which will wear almost indefinitely.[9]

Nylon also has other advantages in that it has good crush recovery. Nylon may be heat set to give excellent texture retention coupled with good resilience. Because of nylon's exceptional resistance to abrasion, carpets made of all-nylon pile do not require as high ounce weight as do

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[7]J.L. Nevin and R.B. Mumford, "Nylon-Progress and Prognosis," Modern Textiles Magazine, XLVIII (May, 1967), 70.

[8]Reg Burnett, "Carpet Fibers for the Retailer - Short Course in Non-technical Approach," Modern Textiles Magazine, L (January, 1969), 61.

[9]Ibid.

wool carpets.[10]

Nevin and Mumford found the wearability of nylon to be unexcelled. Wool and acrylic performed satisfactorily but were limited in durability. Because of this outstanding quality nylon carpeting is used extensively in commercial areas. Whenever durability coupled with economy is of great importance, nylon is the best carpet fiber to select.[11]

Acrylic Fibers

Introduced in carpeting in 1957, acrylics have rapidly increased in volume. Acrylic carpets are the next to nylon as the most popular carpet fibers, representing about 25 per cent of all fibers used in the manufacture of American carpets. It was estimated that during 1968, 170 to 175 million pounds of acrylic fibers were used in carpet construction.[12]

The acrylic fibers have many of the desirable properties of wool with additional properties of their own. They are basically wool-like in both appearance and hand and in most textile applications are used where wool would formerly have been used.[13]

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[10] Dow Badische Company, Fiber Facts (New York: Dow Badische Company, n.d.), 6.

[11] J.L. Nevin and R.B. Mumford, loc. cit.

[12] Reg Burnett, loc. cit.

[13] G.M. Jeffrey, Courtaulds Ltd. "Carpet Fibers: the Choice for Tufters," Skinner's Record, XXXVIII (January, 1964), pp. 70-71.

The wearing qualities of acrylic carpet are almost identical to those of wool carpet; adequate, but not as good as nylon. In almost every other consideration, however, acrylic fibers do have an advantage over wool. The resilience of acrylic carpet pile is good and because a moderately high fiber strength is related to high extensibility, the work of rupture is high and the abrasion resistance is good.[14]

The new trend toward bicomponent acrylic fibers for carpet use is claimed to offer improved properties of crimp, yarn strength, resilience, and dyeability.[15]

III. COMPARISON OF RESILIENCE CHARACTERISTICS OF FIBERS

Resilience is an extremely important characteristic of a carpet fiber. It is that tendency of a fiber to recover its original form after being bent, compressed or otherwise deformed.

Due to the importance of the resilience retention of the carpet fibers, the following section was included to compare specifically the property of resilience of wool, nylon, and acrylic fibers.

In a 1963 report on fiber performance characteristics, the Chemstrand Company stated the importance of resilience

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[14] Ibid.

[15] The Monsanto Company, Carpet Technology (Bulletin A-71) Monsanto Textiles Division, Decatur, Alabama, 1969, p. 9.

as a fiber property:

> Good resilience is a vital ingredient of lasting carpet beauty and the better a carpet can recover from pressure and retain its original thickness, the longer it keeps its brand new look and deep, dense pile under foot.[16]

It has been found that, under heavy traffic conditions acrylic carpets retain their original height to a far greater extent than do wool carpets and show little loss of pile thickness. Acrylic carpet fibers in the pile were found to demonstrate unusual ability to yield under compression and recover well to give a desirable springiness under foot. In this respect, acrylic carpets surpassed wool carpets despite heavy traffic.[17]

A result of this study by Chemstrand, indicated that a lower specific gravity combined with superior resilience gave to the acrylic carpet fiber approximately ten per cent more bulk and cover than wool - pound for pound. Therefore carpet pile made with acrylic fiber is more dense and luxurious and stays newer looking longer than wool.[18]

According to Nevin and Mumford, each fiber has a characteristic pile density which must be exceeded to yield

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[16] Chemstrand Company, The Manufacture and Performance Characteristics of Carpets Made with Chemstrand's Type 41 Acrylic Carpet Fiber (Alabama: Chemstrand Company, 1963), p. 3.

[17] Ibid.

[18] Ibid.

a carpet that does not experience a severe walk-out. The better the inherent recovery properties of the fiber, the lower is the density required to achieve acceptable performance from this standpoint. Conversely, at any given pile density, the rate of walk-out is directly related to the recovery properties of the fiber. Nylon is unexcelled in this regard. Wool and acrylic perform satisfactorily but are limited by durability.[19]

In a report issued by the American Enka Corporation, the elasticity of nylon is compared to that of rubber. While the elasticity is comparable, nylon does not recover after release of tension as rapidly as rubber. About one-half the extension is recovered immediately; the remainder much more slowly. Increases in temperature and humidity will increase the rate of recovery.[20]

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[19]J.L. Nevin and R.B. Mumford, loc. cit.

[20]American Enka Corporation, Nylon Bulletin #NFP-1, (New York: American Enka Corporation, 1967), p. 2.

IV. SUMMARY

No one fiber necessarily makes a superior carpet. However, there are differences among fibers used in the manufacture of carpeting. Nylon is the leading carpet fiber in use today, while acrylic fibers rank second in carpet-fiber consumption. The use of wool as a carpet fiber is declining due to the great degree of availability and popularity of man-made fibers.

Service performance and luxury comprise a number of factors and constitute the main areas of interfiber competition in carpets. Both service performance and the elements of luxury are affected by the fiber used, to a considerable extent.

At least four factors which are determined by the characteristics of the yarn to be used, need to be considered in determining the newness retention or overall service performance of a carpet. These are durability, recovery, soiling and cleanability, and color fastness. Of these, it was felt that recovery is one about which the consumer is least informed.

It is a well-established fact that nylon fibers have the greatest recovery rate. Nylon is known for its long-wearing qualities and exceptional abrasion resistance. Most sources indicated that nylon ranks above acrylic and wool carpet fibers in total carpet sales.

The study also disclosed that acrylic ranked second in the rate of recovery and in sales. Acrylic, being the most wool-like of the man-made fibers, appears to be the chief competitor of nylon.

Wool, the former traditional carpet fiber, has been on a steady decline for the past decade. Wool's loss of its share of the market to the new synthetic fibers has been considerable.

CHAPTER III

PROCEDURE

I. SELECTION OF CARPET SAMPLES

The carpeting used was specially manufactured by a leading North Carolina carpet manufacturer for a series of studies related to the comparison of fiber resilience. It was manufactured to attempt to provide controlled experimentation on the differences in resilience of the three carpet fibers. While the carpet was specially manufactured for controlled experimentation, each type manufactured was according to the specifications of carpets for consumer use.

All carpets used in this study were of tufted construction and plush cut pile. The face yarns were of three fiber types - wool, acrylic and nylon. The two pile heights within each fiber type were low and high. Carpets of low pile height were manufactured to be within 0.2 to 0.4 inch. Carpets of high pile height were manufactured to be within 0.4 to 0.6 of an inch.

II. PREPARATION OF SAMPLES

Samples were coded to indicate the carpets of each of the three fiber types and two pile heights. Five rectangles measuring 5 x 8 inches were cut at random from each of the six lengths of carpet (two wool, two acrylic, and two nylon). These five rectangular samples of each fiber type of low pile height and five rectangular samples of each fiber type of high pile height were used to serve as replicates of the fiber. One measurement was taken on each half of the five samples.

The carpet samples were conditioned pile side up on a flat surface under standard conditions of testing 70 ± 2 degrees Fahrenheit and 65 ± 2 per cent relative humidity. The samples were conditioned for a minimum of 24 hours before testing.

All laboratory testing was done under these standard conditions.

III. DATA COLLECTION

Carpet Specifications

Information concerning certain construction specifications of the carpeting was supplied by the manufacturer. Others were obtained from laboratory measurements. Information given by the manufacturer included the stitches per inch, courses per inch and pile weight in ounces per square yard.

The pile height and density in ounces per square yard per .001 inch pile height were measured in the laboratory.

<u>Pile Height</u>. This method was based on ASTM methods[1] and the use of a compressometer. Measurements of the total carpet thickness were made with the C & R tester. The pile was removed from a six inch square area in the center of the sample by burning, cutting, or dissolving the fiber. The thickness of the remaining back construction was measured. The net pile height was calculated as the difference between the total thickness and the thickness of the backing.

<u>Pile Density</u>. The density expressed in terms of ounces per square yard per 0.001 inch pile height was determined by dividing the pile weight in ounces per square yard by the pile height in 0.001 inch according to the following equation:

$$\frac{\text{Ounces per Square Yard}}{\text{Pile Height}} = \frac{X}{0.001\ \text{inch}}$$ [2]

<u>Measurement of Compressional Resilience</u>. No instrument was available that would indicate compressional resilience as such. Compressional resilience was determined by measuring the pile height under varying conditions of compression. The C & R tester, a model of the compressometer designed to measure both compression and recovery, was used to determine carpet thickness before pressure was applied, the compressed

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[1]American Society For Testing and Materials, <u>1966 Book of ASTM Standards</u> (Philadelphia: American Society For Testing and Materials, October, 1966), pp. 356-357.

[2]Nancy Jane Sears, "Relation of Fiber Resilience to the Consumer Selection of Carpeting," (Unpublished Doctoral Dissertation, University of North Carolina at Greensboro, 1969), p. 36.

thickness, and the thickness under three recovery periods. This instrument was considered by the manufacturer as capable of measuring compression and recovery. The action of this instrument is described as follows:

> The thickness measurement is made with a preload of one-half ounce on the sample. The indenting load is transferred from a ballbearing support to the indenting plunger by means of a screw, and handwheel. With this arrangement the indenting load (dead weight) may be applied to the sample without impact to measure the compression and removed to measure the recovery.[3]

The indenting load specifically recommended by the manufacturer for testing fiber resilience of carpeting was the combination of 22 ounces of weight with a pressure foot 3/8 inch in diameter. This combination of factors provided an indenting load equivalent to 12.48 pounds per square inch of pressure and was reported to approximate the compression exerted by a person walking on carpet.[4]

The measurement of pile height included the thickness of the pile and carpet backing. The sample was placed on the instrument base when readings were taken. Since the base of the instrument was smaller than the sample, it was extended with pieces of wallboard of equal thickness so that the entire sample was on a level surface throughout testing.

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[3]Custom Scientific Instruments, Inc., C & R Tester Model CS-55 (Kearney, N.J.: Custom Scientific Instruments, Inc.,[n.d.]), p. 1.

[4]J.R. Barach, "Dynamic Studies of Carpets," Textile Research Journal, XIX (June, 1949), 355.

The compressed pile height thickness was obtained by rotating the handwheel until the carpet pile was totally compressed. The recovered pile height was the thickness measured after rotating the handwheel in the opposite direction and lifting the pressure foot from contact with the sample pile. The recovery readings were then taken following thirty seconds, one minute and five minutes.

Two readings were taken at the various stages of compression and recovery of the five samples. These measurements were taken of carpets of low pile height and of high pile height of each of the three fiber types. The mean of the two readings from each of the five samples was used to serve as a replicate of the fiber.

The percentage of compressional resilience was determined by subtracting the compressed from the original, the compressed from the recovered and then dividing the latter by the former. This figure was then multiplied by 100. The following formula was used for calculating the percentage of compressional resilience:

$$\text{Per cent Resilience} = \frac{R - C}{O - C} \times 100$$

O = Thickness of sample before compression

C = Thickness of sample under compression

R = Thickness of sample at recovery interval

IV. ANALYSIS OF DATA

The statistical analysis included an evaluation of three factors for each of the fiber types of carpets tested: (1) the differences among carpet fibers, (2) the differences between pile heights, and (3) the differences among recovery periods. These were analyzed for compressional resilience. Standard analysis of variance techniques were utilized to determine any significant differences.

An analysis of variance was computed according to the following model:

Sources		Degrees of Freedom
Between Columns		17
Fiber Type	2	
Pile Height	1	
Recovery Time	2	
Type x Height	2	
Type x Time	4	
Height x Time	2	
Type x Height x Time	4	
Between Rows		4
Columns x Rows		68
Row x Type	8	
Row x Height	4	
Row x Time	8	
Row x Type x Height	8	
Row x Type x Time	16	
Row x Type x Height x Time	8	
	16	
Total		89

Data were also tabulated and presented graphically to show percentage changes of the resilience of each fiber type of high and low pile height at the three recovery periods.

CHAPTER IV.

ANALYSIS AND INTERPRETATION OF DATA

I. CHARACTERISTICS OF CARPETS

The carpets used in the study were specifically manufactured to be of comparable commercial qualities and were purposely made of plush cut pile in two different heights. All carpets were of tufted construction.

There was, however, a slight difference in the three types of carpeting. Since nylon has a lower specific gravity than either wool or acrylic fibers, carpeting made of the exact specifications as the wool and acrylic carpeting would be of lighter weight and have a lower density. The three types of carpeting were made as nearly alike as possible in appearance, performance and texture.

Data for pile weight, courses per inch and stitches per inch were supplied by the manufacturer. Pile height in inches and pile density were determined as a part of this study. Data pertaining to these characteristics are presented in Table I.

TABLE I

CHARACTERISTICS OF CARPET CONSTRUCTION

		Characteristics				
Pile height	Fibers	Pile height (inches)	Pile density (oz./.001 inch)	Pile weight (oz./sq. yd.)	Courses/ inch	Stitches/ inch
High	Wool	0.579	.076	44.0	5.33	8.0
	Acrylic	0.546	.077	42.0	5.33	9.0
	Nylon	0.423	.071	30.0	6.40	9.0
Low	Wool	0.395	.071	28.0	5.33	8.0
	Acrylic	0.362	.073	26.5	5.33	9.0
	Nylon	0.296	.068	20.0	6.40	7.0

Pile Height. Carpets were manufactured in such a way that there were two pile heights represented within each fiber type. Carpets of low pile height were specified as being within a tolerance of 0.2 to 0.4 inches. Carpets of high pile height were within a tolerance of 0.4 to 0.6 inches. A laboratory check of the finished carpeting was made prior to experimentation. This measurement represented the difference between the backing thickness and the original thickness.

The results of this laboratory check indicated that the pile height of the finished carpeting fell within or closely approximated the pile height specified by the manufacturer. The mean height of carpets of low pile height ranged from the 0.296 inches of the nylon carpeting to the 0.395 inches of the wool carpeting. The mean height of the carpets of high pile height ranged from the 0.423 inches of the nylon carpeting to the 0.579 inches of the wool carpeting.

Pile Density. The mean pile density of carpets of low pile height ranged from the 0.068 ounces per thousandths of an inch of the nylon carpeting to the 0.073 ounces per thousandths of an inch of the acrylic carpeting. The mean pile density of the carpets of high pile height ranged from 0.071 ounces per thousandths of an inch of the nylon carpeting to 0.077 ounces per thousandths of an inch of the acrylic carpeting.

The nylon carpets of high and low pile height were less dense than the wool and acrylic carpets of high and low pile heights. These differences in the pile density were noticeable on the surface of the carpets.

Pile Weight. The mean pile weight of the nylon carpeting was less than the mean pile weight of either the wool or acrylic carpeting. As would be expected, the pile weight of the carpets of high pile height of all three fiber types was greater than the pile weight of the carpets of low pile height. There was a marked difference in the pile weight of the nylon and the other two fibers in both low and high pile carpets. The pile weight of the nylon carpeting of high pile height was 30.0 ounces per square yard as compared with the 42.0 and 44.0 ounces per square yard of the wool and acrylic carpeting, respectively representing a difference of approximately 30 per cent. The same trend was noted in the carpets of low pile height.

Courses Per Inch. The number of courses per inch of the nylon carpeting was higher than the number of courses per inch in the wool and acrylic carpeting. This difference in the courses or rows compensated for the lower weight of the nylon yarns.

Stitches Per Inch. Differences in the number of stitches per inch were small. The main difference was in the nylon carpeting of low pile height where there were only 7.0 stitches per inch.

These differences in the pile height, pile density, pile weight, courses per inch and the number of stitches per inch were due to changes in the manufacturing process of the carpets to make them comparable in appearance and quality to other carpets on the consumer market. Had the manufacturing specifications been identical for carpeting of the three fiber types, there would have been noticeable differences in the appearance, texture, and performance of the test carpeting.

II. CHANGES IN PILE HEIGHT UNDER COMPRESSION

Measurements of the pile height of each of the three fiber types--wool, acrylic and nylon were recorded for the original pile height, the compressed pile height and the pile height at the three recovery periods--thirty seconds, one minute and five minutes.

Changes in pile height were determined from thickness in inches of the carpeting. The amount of change in the pile height was determined by subtracting the compressed pile height measurement from the original pile height measurement. Data pertaining to these measurements of pile height are presented in Table II.

TABLE II

MEAN PILE HEIGHT OF CARPET FIBERS OF HIGH AND LOW PILE AT THREE RECOVERY PERIODS

(Expressed in thousandths of an inch)

Carpet samples	Repli-cations	Orig-inal	Com-pressed	Recovery Periods: Thirty seconds	One minute	Five minutes
HIGH PILE						
Wool	1	.666	.071	.239	.244	.249
	2	.665	.073	.273	.278	.282
	3	.670	.080	.231	.235	.241
	4	.668	.085	.242	.245	.250
	5	.666	.080	.240	.244	.254
	m	.667	.078	.245	.249	.255
Acrylic	1	.635	.075	.238	.243	.247
	2	.646	.085	.247	.251	.257
	3	.649	.072	.239	.244	.250
	4	.651	.077	.244	.249	.255
	5	.645	.073	.255	.259	.277
	m	.645	.076	.245	.249	.257
Nylon	1	.563	.075	.250	.256	.265
	2	.557	.075	.260	.266	.274
	3	.543	.074	.272	.272	.279
	4	.552	.075	.253	.257	.265
	5	.555	.080	.259	.265	.273
	m	.554	.075	.259	.263	.271
LOW PILE						
Wool	1	.439	.076	.249	.252	.260
	2	.431	.079	.241	.246	.251
	3	.430	.079	.255	.259	.264
	4	.429	.078	.236	.240	.244
	5	.435	.079	.245	.251	.255
	m	.433	.078	.245	.250	.255
Acrylic	1	.472	.075	.229	.235	.241
	2	.467	.075	.223	.226	.231
	3	.466	.073	.225	.229	.234
	4	.467	.074	.222	.226	.232
	5	.469	.073	.227	.230	.233
	m	.468	.074	.225	.229	.234
Nylon	1	.425	.066	.206	.211	.216
	2	.424	.069	.226	.232	.240
	3	.432	.065	.228	.233	.239
	4	.434	.065	.218	.223	.229
	5	.432	.065	.217	.222	.228
	m	.429	.066	.219	.224	.230

III. COMPARISON OF PER CENT RECOVERY OF CARPET FIBERS

An analysis of variance was used to determine significant differences in the compressional resilience of the three fiber types--wool, acrylic and nylon of high and low pile height at immediate and extended recovery periods. Each of the three variables--fiber type, pile height and recovery periods was analyzed for differences (1) among the three fiber types, (2) between the two pile heights, and (3) among the three recovery periods.

The per recovery of the three fiber types of high and low pile height at the three recovery periods are presented in Table IV and shown graphically in Figures 1 through 5. Figure 1 shows the per cent recovery of wool, acrylic and nylon carpet samples. Nylon showed the greatest per cent recovery among the fiber types of carpeting. Wool showed the next greatest per cent recovery among fiber types. There was a greater difference between the wool and acrylic carpeting than between the wool and nylon carpeting.

According to Figure 2 the carpets of low pile height of the three fiber types showed a greater per cent recovery than did the high pile height. Among the fiber types of low pile height, wool showed the greatest per cent recovery. (Figure 3). Nylon showed the next greatest per cent recovery among fiber types of low pile height. Among the fiber types of high pile height, nylon showed the greatest per cent

TABLE III

ANALYSIS OF VARIANCE

Source	Degrees of freedom	Sum of squares	Mean of squares	F value
Between columns	17	4226.73	248.63	
Type**	2	649.89	324.95	21.97*
Height	1	2595.32	2595.32	381.67*
Time	2	88.06	44.03	338.69*
Type x height	2	890.19	445.10	32.58*
Type x time	4	1.50	.38	4.75
Height x time	2	.98	.49	2.33
Type x height x time	4	.78	.20	1.67
Between rows	4	62.15	15.54	
Columns x rows	68	260.15	3.84	
Row x type	8	118.32	14.79	123.25
Row x height	4	27.21	6.80	56.67
Row x time	8	1.04	.13	1.08
Row x type x height	8	109.27	13.66	113.83
Row x type x time	16	1.33	.08	.67
Row x height x time	8	1.69	.21	1.75
Rox x type x height x time	16	1.99	.12	
Total	89	4549.72		

*Significant at the .001 level.

**Fiber Type

TABLE IV

PER CENT RECOVERY OF THREE FIBER TYPES OF HIGH AND LOW PILE HEIGHT AT THREE RECOVERY PERIODS

		Wool			Acrylic			Nylon		
		Recovery periods			Recovery periods			Recovery periods		
Pile Height	Replications	Thirty seconds	One minute	Five minutes	Thirty seconds	One minute	Five minutes	Thirty seconds	One minute	Five minutes
Low	1	47.7	48.5	50.7	38.8	40.3	41.8	39.0	40.4	41.8
	2	46.0	47.4	48.9	37.8	38.5	39.8	44.2	45.9	48.2
	3	50.1	51.3	52.7	38.7	39.7	40.1	44.4	45.8	47.4
	4	45.0	46.2	47.3	37.7	38.7	40.2	41.5	42.8	44.4
	5	46.6	48.3	49.4	38.9	39.6	40.4	41.4	42.8	44.4
	Mean	47.1	48.3	49.8	38.4	39.4	40.5	42.1	43.5	45.2
High	1	38.8	29.1	30.0	29.1	30.0	30.7	35.9	37.1	38.9
	2	33.8	34.6	35.3	28.9	29.6	30.7	38.4	39.6	41.3
	3	25.6	26.3	27.3	28.9	29.8	30.8	42.2	42.2	43.7
	4	26.9	27.4	28.3	29.1	30.5	31.0	37.3	38.2	39.8
	5	27.3	28.0	29.7	31.8	32.5	35.7	37.7	38.9	40.6
	Mean	28.4	29.1	30.1	29.6	30.4	31.8	38.3	39.2	40.9

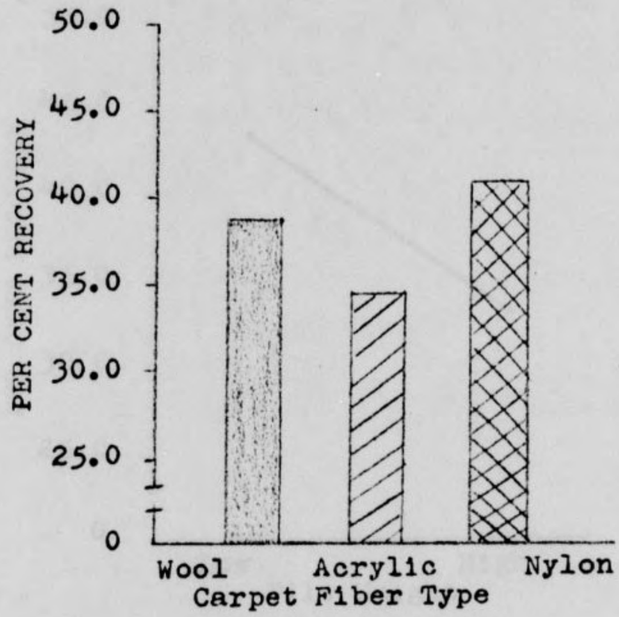

FIGURE 1

COMPARISON OF PER CENT
RECOVERY OF THREE FIBER TYPES

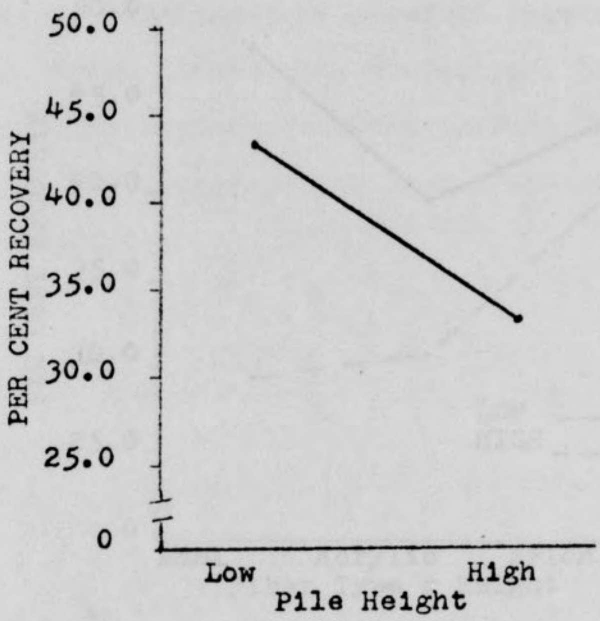

FIGURE 2

COMPARISON OF PER CENT
RECOVERY OF TWO PILE HEIGHTS

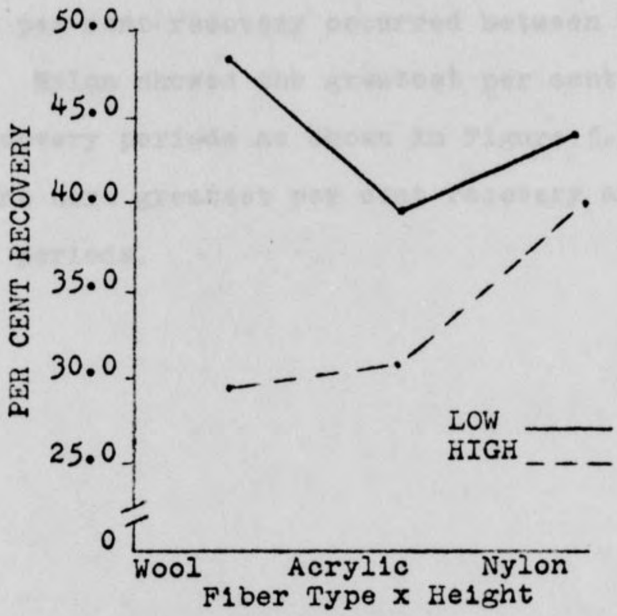

FIGURE 3

COMPARISON OF PER CENT
RECOVERY OF TYPE x HEIGHT

recovery. Acrylic showed the next greatest per cent recovery of the high pile height carpeting.

Figure 4 shows the per cent recovery that occurred at each of the three recovery periods. The greatest per cent recovery occurred between zero and thirty seconds. The next greatest per cent recovery occurred between one and five minutes. Nylon showed the greatest per cent recovery at all three recovery periods as shown in Figure 5. Wool fibers showed the next greatest per cent recovery at all three recovery periods.

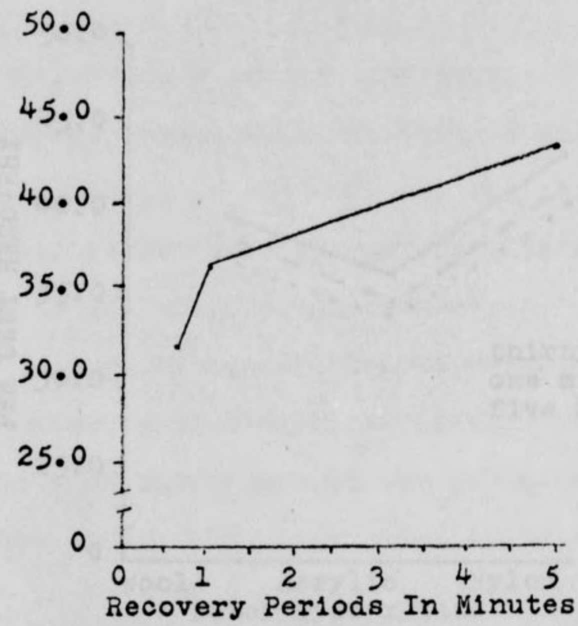

FIGURE 4

COMPARISON OF PER CENT
RECOVERY OF RECOVERY PERIODS

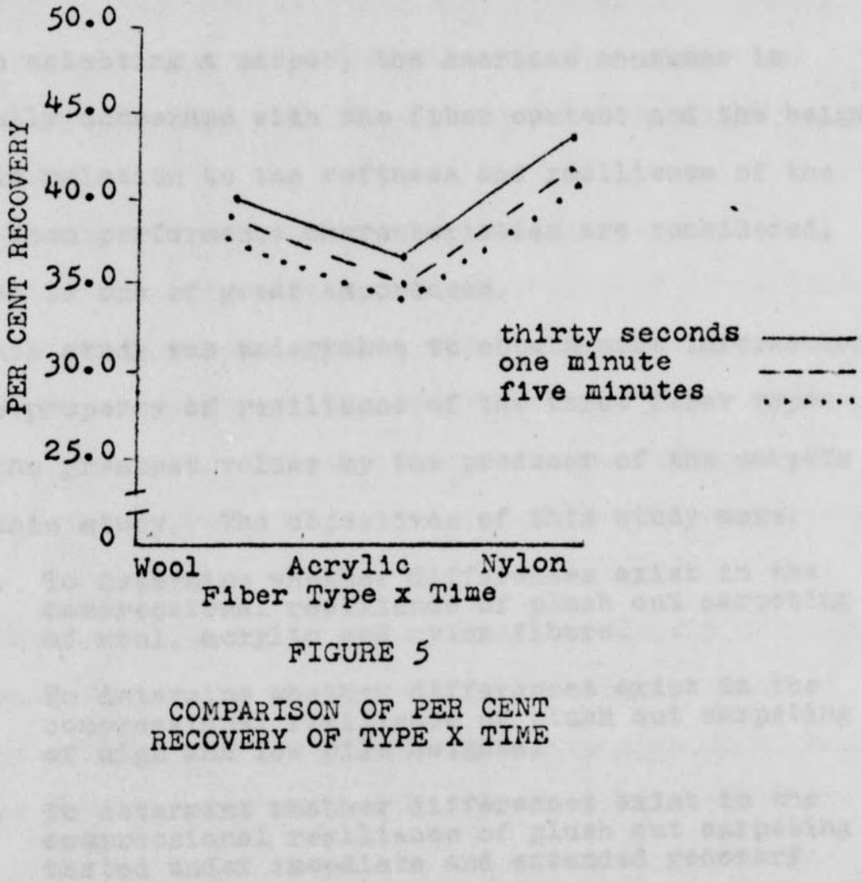

FIGURE 5

COMPARISON OF PER CENT
RECOVERY OF TYPE X TIME

CHAPTER V.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. SUMMARY

In selecting a carpet, the American consumer is specifically concerned with the fiber content and the height of pile in relation to the softness and resilience of the carpet. When performance characteristics are considered, resilience is one of great importance.

This study was undertaken to obtain more information as to the property of resilience of the three fiber types sold in the greatest volume by the producer of the carpets used in this study. The objectives of this study were:

1. To determine whether differences exist in the compressional resilience of plush cut carpeting of wool, acrylic and nylon fibers.

2. To determine whether differences exist in the compressional resilience of plush cut carpeting of high and low pile heights.

3. To determine whether differences exist in the compressional resilience of plush cut carpeting tested under immediate and extended recovery periods.

American consumers have an increased interest in the fiber resilience of various carpets. Therefore the primary interest of this study was to test the fiber resilience of carpet fibers sold in greatest volume on the consumer market.

Carpeting used in this study was specifically manufactured by a leading North Carolina carpet manufacturer. In order to manufacture carpeting of the three fiber types of high and low pile height that would be of comparable commercial qualities, it was necessary that there be some differences in the manufacturing specifications. These slight differences affected somewhat the appearance and physical properties such as pile density, pile weight and courses per inch.

Carpets selected for experimentation were of plush cut pile and tufted construction. They were of three fiber types--wool, acrylic and nylon. Pile heights within each fiber were low and high. Carpets of low pile height were within a tolerance of 0.2 to 0.4 of an inch. Carpets of high pile height were within a tolerance of 0.4 to 0.6 of an inch.

Samples to be tested were coded to indicate the carpets of each fiber type and pile height. Five samples of each fiber type of low pile height and five samples of each fiber type of high pile height served as replicates of the fiber.

Samples were conditioned at 70 ± 2 degrees Fahrenheit and 65 ± 2 per cent relative humidity prior to and during the collection of data.

Compressional resilience was determined by measuring the pile height under different conditions of compression.

The C & R tester was used to determine original thickness, compressed thickness, and thickness under three recovery periods.

Data analysis indicated an evaluation of three factors for each of the fiber type carpets tested: (1) the differences among carpet fibers, (2) the differences between pile heights, and (3) the differences among recovery periods. These were analyzed for compressional resilience. An analysis of variance was used to determine any significant differences.

Characteristics of Carpets

The surface appearance and pile density of wool and acrylic carpets were almost identical. The wool and acrylic carpets of high pile height had a better appearance than did the wool and acrylic of low pile height. Nylon carpet of high and low pile height differed the most in pile density from wool and acrylic carpets. Nylon carpet of high pile height, however, had a more pleasing appearance than did the nylon carpet of low pile height.

The pile height measurement represented the difference between the backing thickness and the original thickness. The mean pile height of carpets of low pile height ranged from 0.429 inches of the nylon carpeting to 0.468 inches of the acrylic carpeting. The mean pile height of the carpets of high pile height ranged from 0.554 inches of the nylon carpeting to 0.667 inches of the acrylic carpeting.

The mean pile density of carpets of low pile height ranged from 0.068 ounces per thousandths of an inch of the nylon carpeting to 0.073 ounces per thousandths of an inch of the acrylic carpeting. The mean pile density of carpets of high pile height ranged from 0.071 ounces per thousandths of an inch of the nylon carpeting to 0.077 ounces per thousandths of an inch of the acrylic carpeting.

The mean pile weight of carpets of low pile height ranged from 20.0 ounces per square yard of the nylon carpeting to 28.0 ounces per square yard of the wool carpeting. The mean pile weight of the carpets of high pile height ranged from 30.0 ounces per square yard of the nylon carpeting to 44.0 ounces per square yard of the wool carpeting.

The courses per inch of the nylon carpets were higher than the courses in the wool and acrylic carpeting. The number of courses per inch of the wool and acrylic carpeting was 5.33. The number of courses per inch of the nylon carpeting was 6.40.

The main difference in the stitches per inch was in the nylon carpeting of low pile height where there were only 7.0 stitches per inch. There were 8.0 stitches per inch in the wool carpeting and 9.0 stitches per inch in the acrylic carpeting of both high and low pile heights and 9.0 stitches per inch in the nylon carpeting of high pile height.

<u>Changes In Pile Height Under Compression</u>

Measurements of the pile height of each of the three fiber types--wool, acrylic and nylon were obtained for the original pile height, the compressed pile height and the pile height at the three recovery periods.

Comparison of Per Cent Recovery

Differences in the per cent recovery of the carpet fibers from a state of compression were highly significant for each variable. Nylon showed the greatest per cent recovery of the three fiber types. The differences in the mean per cent recovery ranged from 35.0 per cent for acrylic carpeting to 41.5 per cent for nylon carpeting.

The carpets of low pile height of the three fiber types showed a greater per cent recovery than did the carpets of high pile height. Wool showed the greatest per cent recovery among the fiber types of low pile height. Nylon showed the next greatest per cent recovery of the low pile height carpet samples. Nylon showed the greatest per cent recovery among fiber types of high pile height. Acrylic showed the next greatest per cent recovery of the high pile height carpet samples.

The greatest per cent recovery occurred between zero and thirty seconds. The next greatest per cent recovery occurred between one and five minutes. Nylon showed the greatest per cent recovery at all three recovery periods.

The analysis of variance indicated the differences in the fiber type, pile height and recovery time.

II. CONCLUSIONS

The results of this study indicated the following conclusions:

1. The greatest differences in the compressional resilience of the carpets were between the low and high pile height carpeting and among the three recovery periods.

2. The recovery periods of thirty seconds and one minute indicated the best measurements of per cent recovery. The five minute interval did not truly measure resilience. It might be beneficial in testing crush resilience.

3. Nylon showed the greatest per cent recovery at all three recovery periods. Wool showed the next greatest per cent recovery at all three recovery periods.

4. The greatest per cent recovery occurred between zero and thirty seconds.

III. RECOMMENDATIONS FOR FURTHER STUDY

Further investigation related to carpet, carpet fibers, and the compressional resilience of the carpet fibers would be desirable for a greater knowledge of the relationships of one factor to the other. The following recommendations are made for future study:

1. The relationship of the compressional resilience of wool, acrylic and nylon carpeting to that of polyester carpeting.

2. A study using longer time intervals that would indicate recovery from crushing.

3. The comparison of the compressional resilience of the carpets used in this study following floor trials.

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