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Service Properties of Selected Locally Manufactured Carpets

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ABSTRACT
The service properties of selected made in Nigeria carpets have been investigated. Properties studied include; constructional details, fastness properties (wash fastness and light fastness), abrasion resistance, tuft withdrawal force, flammability test, static and dynamic loadings, electrostatic properties and soil retention properties. Assessment was carried out on those properties among the carpet samples and the results obtained shows that the density of the base materials, the characteristics of the pile yarns, the stitch density and the type of fibres used for the carpet as well as the type of finishing impacted on the carpet influenced the service properties of the carpet.

Keywords: Flammability, Carpet, Finishing, Electrostatic, Pile, Wash fastness, Light fastness.

INTRODUCTION

Carpets are thick coverings for floor or stairs, usually woven, knitted or tufted and are made of wool or other fibres which may be plain or having designs woven unto them. It could also be a textile soft floor covering that is produced by permanent orientation of fibres (synthetic or natural) into a substrate [1]. Often times, the term carpet is interchangeably used with the term "rug" although rug is a loose laid carpet traditionally smaller than room dimensions in size. A carpet is usually valued not only for its appearance but also for its performance during use as it offers great values along with the general benefit of security, aesthetic beauty, comfort underfoot, insulation factors, sound absorption and even some respiratory health advantage [2].

The end use performance of carpet is characterized by both mechanical and optical characteristics which make up the physical properties of the carpet and ultimately influence their performance significantly [3]. While the mechanical properties are used to explain the walking comfort and abrasion related wear, the optical properties are used to explain appearance. The major properties of importance in carpet assessment are durability, appearance retention, pile height and pile density [4]. Structural parameters for example were investigated through experiments to evaluate carpet appearance loss [5]. Mathematical models were established to understand wear mechanisms and to predict wear life of cut-pile and loop pile carpets [6].

However, in this study, the service properties such as tuft withdrawal force, abrasion resistance, light and wash fastness, flammability, electrostatic properties, soil retention, static and dynamic loadings, pile height and pile density of some locally manufactured (made in Nigeria) carpets were measured and the results obtained were used to rate the carpet by virtue of their appearance, performance and end use serviceability.

MATERIALS AND METHODS

Materials

The materials used for this study were five different tufted carpet samples manufactured by Nobel Carpet Company, Lagos, Nigeria. The carpets include; Hilite Red, Imperial Blue, Winners Brown, Prestige Red and Pentagon Red. These samples were labelled X_1, X_2, X_3, X_4, and X_5 respectively.

Equipment

Some of the equipment that were used for this study include but not limited to; Grey scale, weighing balance, counting needle, SDL Carpet abrasion tester (HD-D125), SDL WIRA Tuft withdrawal (K224), Gyrowash (FH 234), pile height gauge, Xenon arc lamp (M233) etc.

Conditioning of Samples

All the carpet samples were conditioned in a standard atmosphere of relative humidity 65$\pm$2% and temperature of 20$\pm$2°C for 172800 seconds prior to testing.

Methods

Construction Details
The method of determination of the construction details was in accordance with the procedure described in [7].

Pile Density and Pile Height
The usual method of counting which involves using a counting glass and counting needle was adopted by counting the piles (cut or uncut) in a unit area e.g. square centimeter over about ten different areas on the tufted carpet sample. The average of the number was then calculated which gave the pile density. Pile height was measured using the pile height gauge and the value calculated to the nearest mm. The results are shown in Table 1.

Total Pile Weight
100 tufts were weighed and the total pile weight was estimated from the weight. The results are show in Table 1.

Abrasion Resistance
The test was carried out using the WIRA Carpet Abrasion tester in accordance with the procedure described in [8]. A standard abrasive cloth was used to abrade the carpet specimen to rupture point and the number of rubs were recorded. Ten tests were carried out and the results tabulated.

Tuft Withdrawal Force
The test procedure was as described in [8]. The withdrawal force required to remove tufts from the carpet specimen was determined using WIRA Tuft Withdrawal Tensometer with a 550N load cell and accuracy of 5%. The force required breaking the bond between the tuft and the backing structure was recorded. Ten tests were carried out and the results tabulated.

Light Fastness Test
The test was carried out according to the procedure in[9]. The test specimen was exposed to artificial light source from Xenon arc lamp alongside with standard dyed material of known light fastness (blue wool standard).

Wash Fastness Test
The test procedure was in accordance with [10]. The test specimen of dimension 5cm X 4 cm was placed between two specified pieces of undyed cloth of dimension 10 cm X 8 cm. The three pieces were stitched together to form a composite specimen. The composite specimen was placed in a container containing 5 g/l soap and 2 g/l Na_2CO_3 solution previously heated to a temperature of 60$\pm$2°C to give a liquor ratio of 50:1. The composite specimen was removed, rinsed and assessed. Assessment of change in colour of the specimen and the staining of the adjacent fabric was carried out using a grey-scale.

Soil Retention Test
A predetermined amount of soil of weight 0.8 g containing a mixture of dust under carpet, oil and clay was applied to each specimen of dimension 5 cm x 3 cm. It was then allowed to aerate for 86400 seconds. A standard solution of soap (containing 5 g/l soap and 2 g/l Na_2CO_3) was used to wash each specimen. The time taken for complete removal of the soil from each specimen was recorded. Ten tests were carried out for each sample and the results tabulated.

Flammability Test
The test was carried out in accordance with the procedure in [8]. The vertical strip test method was employed. The test specimen of dimension 4 cm x 1 cm was suspended in air-free cabinet and held at the top and over the topmost wire by clips. The flame from a candle-stick was put at one inch before the lower end of the specimen. With the aid of a stop-watch, the time taken to consume the specimen from its lower end to the topend was recorded and used for the carpet flammability grading. Ten tests were carried out for each sample and the results tabulated.

Dynamic Loading Test
The test procedure was in accordance with [11]. The WIRA Dynamic Loading Machine was employed for this test. A cam-operated load of nearly 1.3 kg was dropped freely at regular intervals of about 4 seconds from a height of 64 mm onto the carpet specimen. Thickness loss of the carpet specimen expressed as a percentage of the pile height after 1000 impacts was recorded. Ten readings were taken for each sample and results tabulated.

Static Loading Test
The test was carried out according to procedure described in [12]. A pressure of 7 kg/cm^2 was applied to a small foot on top of the carpet specimen for 86400 seconds and the indentation was measured after 86400 seconds of recovery. Ten readings were taken and results tabulated.

Electrostatic Properties
The test procedure is as described in [12]. The method of capacitor discharge was used. The resistivity of the carpet sample was measured along the longitudinal direction. The resistivity and the time were recorded and used to obtain the anti-static rating for the carpet samples.

RESULTS AND DISCUSSION

Carpet Construction Details

From Table 1, the carpet samples show acceptable properties in terms of pile height, pile type, pile density and total pile weight. Sample X_3 shows the best result having the highest pile density and one of those with high pile height while sample X_1 shows the least result having a low pile height and density. The carpet pile density and pile height are the main structure parameters of carpets, which have an influence on resulting deformations during compression. Any variation of these two mechanical parameters will have an influence on the end – use properties of carpets [13].

Table 1: Carpet Construction Details

Sample	**X_1**	**X_2**	**X_3**	**X_4**	**X_5**
Pile height (mm)	4	5	5	5	4
Pile type	Cut	Loop	Cut	Cut	Loop
Pile density (tufts/cm^2)	23	24	26	24	23
Total pile weight (g/cm^2)	0.3560	0.3610	0.3680	0.3620	0.3650

Abrasion Resistance

The abrasion resistance results in Table 2 show that, carpet sample X_3 has the highest abrasion resistance while sample X_5 has the least. It was observed that the pile density and pile height influenced abrasion resistance. Thus, sample X_3 with the highest abrasion resistance has the highest pile density and one of those with a high pile height. The order of abrasion resistanceis $X_3 > X_2 > X_4 > X_1 > X_5$. Generally, abrasion resistance results were better for the more dense carpets.

Table 2: Abrasion Resistance

Test Samples	**Mean No of Rubs**	**Standard Deviation**	**Coefficient of Variation**
X_1	5803	8.63	0.148
X_2	8350	7.07	0.085
X_3	20500	12.10	0.009
X_4	8150	4.12	0.051
X_5	4000	3.53	0.088

Tuft Withdrawal Force

From Table 3, the results of the tuft withdrawal force for the carpet samples followed this trend in order of increasing values: $X_5 > X_1 > X_3 > X_2 > X_4$. It was observed that the pile height has no significant influence on the force required to remove tufts from the carpets. The variation in the tuft withdrawal force for the samples may be attributed to the type of binder or latex used in coating the backing material.

Table 3: Tuft Withdrawal Force

Test Samples	**Mean Tuft Withdrawal Force (Kg)**	**Standard Deviation**	**Coefficient of Variation**
X_1	2.24	0.0158	0.7058
X_2	1.92	0.0057	0.2968
X_3	2.13	0.0043	0.2018
X_4	1.80	0.0151	0.8388
X_5	3.83	0.0032	0.0835

Light Fastness

The results in Table 4 shows that sample X_5 has the highest light fastness rating while sample X_2 has the lowest. The colour change of the carpets appeared to be influenced by the depth of shade of the dyes applied. All the carpet samples have an acceptable light fastness rating.The deeper the shade the more the change in colour as seen on the tabulated results.

Wash Fastness

The results in Table 4 show the wash fastness of the samples tested. The whole samples have very good to excellent wash fastness with sample X_1 and X_4 having the best wash fastness results.Wash fastness is usually influenced by the rate of diffusion of dyes and the state of dyes inside the fibre. In this case, the high wash fastness rating could be attributed to the better affinity of the dyes on the fibre and their tendency to aggregate thereby forming large molecular sizes within the fibre [14]. The colour change of the carpets appeared to be influenced by the depth of shade of the dyes applied. The deeper the shade the more the change in colour as seen on the tabulated results.

Table 4: Light and Wash Fastness Ratings

Test Sample	**Light Fastness Rating**	**Wash Fastness Rating**	
		Change in Colour	Change in Staining
X_1	5	4 - 5	3
X_2	4	4	2
X_3	5	4	2 - 3
X_4	5	4 - 5	3
X_5	6	4	2 - 3

Soil Retention Property

The results in Table 5 gave an indication that the higher the time taken to wash off the dirts completely from the carpet sample, the higher the soil retention property of the sample. The order of decreasing soil retention property is: $X_1 > X_3 > X_5 > X_2 > X_4$. The fibre type, as well as, the electrostatic properties of the samples may have influenced the soil retention property of the carpets [15].

Table 5: Soil Retention

Test Sample	Time (Sec.)	Standard Deviation	Coefficient of Variation
X_1	29	1.825	6.2956
X_2	16	0.974	6.0875
X_3	21	1.032	4.9142
X_4	15	1.012	6.7466
X_5	18	1.001	5.5611

Flammability Rating

The test results in Table 6show that all the carpet samples tested are flame retardant to different extent. The order of flame retardancy is: $X_1 > X_5 > X_2 > X_3 > X_4$. The variation in flame retardancy may be attributed to the pile material used, as well as, the type and extent of the flame retardancy finish imparted on the carpets [16].

Table 6: Flammability rating

Test Sample	Mean time of consumed specimen (Sec.)	Standard Deviation	Coefficient of variation
X_1	86	5.416	6.297
X_2	66	1.732	2.624
X_3	62	2.380	3.839
X_4	47	2.236	4.757
X_5	71	2.309	3.253

Dynamic Loading

Table 7 shows that sample X_4have the highest percentage loss in thickness expressed as a percentage of the pile height while sample X_3 has the least. The order of percentage loss in thickness is $X_4 > X_2 > X_1 > X_5 > X_3$. The dynamic loading test stimulates the two actions of walking (compression) and the shearing effect at the edge of the shoe. From the results obtained, it was observed that the percentage loss in thickness expressed as a percentage of the original pile height decreases with increasing surface pile density. Thus, the percentage loss in thickness of the different carpet may be due to the surface pile density, pile weight and the resilience properties of the pile material [17].

Table 7: Dynamic loading

Test sample	Loss of thickness	Standard variation	Coefficient of variation
X_1	24	8.63	0.148
X_2	28	7.07	0.085
X_3	10	12.10	0.009
X_4	30	4.12	0.051
X_5	20	3.53	0,088

Static Loading

Table 8 shows the recovery of the tested samples after 24 hours recovery period. Sample X_3 shows a better recovery of the pile after 24 hours thanthe other samples, while sample X_2 shows the least recovery. The superior recovery of samples X_3 over the other samples may be due to its superior resilience property and its pile density. This is in agreement with the findings of [18].

Table 8: Static loading

Test Sample	Original Thickness (mm)	24 Hours Recovery (mm)	Standard Deviation	Coefficient of Variation
X_1	6	1.05	0.0031	0.2952
X_2	6	0.62	0.0002	0.0322
X_3	8	1.07	0.0014	0.1372
X_4	6	1.00	0.0034	0,3400
X_5	6	1.04	0.0024	0.2307

Electrostatic Properties

The results in Table 9 show that the resistivity's of the pile materials were less than 10^{10} ohms indicating that the carpet samples have good anti-static rating. Also, it was observed that the resistance along the carpet sample determined the rate of leakage of charges from the electrified carpet sample.

Table 9: Electrostatic Properties

Test Samples	Thickness (mm)	Along Carpet Longitudinal Axis	
		Resistivity (ohms) X 10^9	Time (sec) x 10^{-2}
X_1	6	7.00	5.00
X_2	6	5.00	2.50
X_3	6	1.00	3.50
X_4	6	1.50	1.80
X_5	6	1.20	2.50

Static electricity in carpet has been higher from carpets containing stainless steel fibres [19]. The charges developed on shoe-sole materials and on human body have been investigated for carpets with and without steel fibres. The static electricity in carpets is affected by the following factors such as; relative humidity, fibre type, shoe-sole materials, carpet backing and underlay, carpet wear and human walking idiosyncrasies [15].

CONCLUSION

This study has been carried out in order to determine the physical properties of some selected carpets; and to assess the influence of these properties on the end use performance of these carpets.The end use performance of the carpets was greatly influenced by the constructional parameters, such as pile height, pile density, type of pile material, pile weight, pile anchorage, type of latex coating, resilience property of the pile material and the colour fastness properties of the dyes employed. These parameters were mostly interwoven and tend to influence one another. The dynamic and static loading properties of the carpets were influenced by the resilience property of the pile material, while the pile densityinfluences abrasion resistance and also, the dynamic and static loading properties of the carpets. Finally, the end use performances, that is, the service properties of the carpets are mainly dependent on the constructional variables amongst other variables.

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