Investigation into the Strength and Durability of Floor Finishes in Residential Building Projects in Anambra State, Nigeria

Abstract

The constant failing of floor finishes and the cost of repairs of residential building in the study area motivated the study. The aim of the study was to ascertain: the prevalent floor finish types used in the study area, the critical material properties of typical floor finish in the area, their strength and durability. The choice of sample floor finish was determined by the frequency of usage of such floor finish in the study area and the availability of such floor finish types in the market. The population for the survey was reduced to 278 participants. Mixed method design (survey and experiment) was adopted. The result indicated that floor tiles is the most preferred and used floor finish in residential building constructions in the area while water absorption by weight, abrasion resistance, and modulus of rupture were critical material properties which determined strength and durability of floor tile finish. Also, SON laboratory test experiment revealed that typical floor tile finishes used in area did not reach class 5 standardization with only one floor tile finish out of four other types reaching class 4 at 0.1% coefficient of water absorption, ≤ 2100 resistance to surface abrasion and 37.4 modulus of rupture without recordable finish failure. Furthermore, the relationship between floor finish strength and durability was ascertained at $k = 46.74$, $p < .05$ ($n = 277$, $df = 9$) indicating that floor finish strength influenced its durability at $r = .734^*$, $p < .05$, ($n = 277$). The study concluded that floor tile finish material properties used in the study area do not comply with the regulatory standard which is the reason for constant floor finish failure in the area. It is recommended that regulatory authorities should enforce compliance to industry standard and sanction offenders.

Keywords: Building construction, coefficient of water absorption, floor finish, modulus of rupture, residential building, resistance to surface abrasion, tiles.

1. Introduction

Building as a major type of shelter has been regarded only second to food in the hierarchy of human needs (Maslow, 1943) as it plays an important role in determining the general well-being of a person and the society at large. Building as essential physical facilities, constitutes part of our most valuable assets (Ogunoh, Okolie, and Ezeokonkwo, 2015). However, without standardization in the building processes especially regarding material use, building can constituted threats to human life and a major source of reoccurring expenditure in terms of repairs occasioned by usage wear and tear (Oguno, 2015).

Every building according to Bany (2004) is composed of elements and components, which include; foundations, floor, walls, beams, columns, roofs, doors and windows, stairs and rooms, surface finishes; and depending on the services they render, these element and components are constructed in such a way that they must work together as a system in order to fulfil the functions for which the building was designed and constructed. Many studies such as; Harris (2017) and Akinyemi, Dare, Anthony, and Dabara (2016) have exemplified that the utility of many building is well dependent on its floor upon which the activities in the building are carried out. This very nature of floor (as most used part of the building) puts the greatest burden on building and thus implies that its construction and finish ought to be robustly build to withstand the test of wear and tear from constant usage.

Given the volume of floor failure and consequent maintenance in the study area which is a potential threat to building utility, cost-benefit and health and lack of statistical data, it is obvious that either material usage is substandard or the construction is faulty. The authors were more inclined to believe that the materials used in the floor construction in the area are substandard; hence, the frequent floor failure in the area.

1.1 Objectives of the study

The objective of this study was to assess preferred floor types, their strength and durability and their suitability in residential buildings in the study area. The following specific objectives were pursued:

1. To establish the prevalent floor finish types used in the design constructions of buildings in Anambra State.
2. To ascertain the critical material properties of a typical floor tile finishing in building constructions in Anambra State.
3. To ascertain whether the typical floor finishes preferred and used within the study area will conform to specified Standard Organization of Nigeria (SON) material property requirements for relative strength and durability.
4. To ascertain the relationship between strength and durability of typical floor finishes in building constructions in Anambra State.

1.2 Research questions

In order to achieve the objectives of the study, answers were provided to the following research questions:

1. What are the prevalent floor type finishes used in residential building constructions in Anambra State?
2. What are the critical material properties of typical floor finishing types used in residential building constructions in Anambra State?
3. Do typical floor finishes preferred and used within the study area conform to specified Standard Organization of Nigeria (SON) material property requirements for relative strength and durability?
4. What is the relationship between strength and durability of floor tile finish in Anambra State?

2. Review

The floor (of a building) is the horizontal structural element of the building. It is the covering unto which the finishing materials are applied to provide a walking surface (Harris, 2017). It is also that part of the building on which the occupants move and materials are stored. The prior function of floor is load-bearing. It increases the strength by connecting the walls in solid masonry systems. At skeleton systems it has to carry its own load and transfer it to the system. It also has to be resistant to some effects such as; heat, water, moisture and noise, according to its location in building. Floor's section can be categorized into four layers; floor coating, base, structural system and ceiling coating. Floor and ceiling coatings are finishing layers and have to create a visually and functionally favorable impact (Olotuah, 2010). The most important layer is structural system and the others support it. Flooring is very important to the overall impact of buildings as it also affects the psychology of the users and their health (Onochie, Emoh, and Anyanwu, 2017).

Finish is the appearance of a surface; floors are finished with different types of materials. The use of different materials ensures that taste, comfort and aesthetics of users are met. Floor types also ensure that varying materials used are in accordance to the cost preferences of users as regards strength and durability of floor finish aesthetics etc. Some of these materials in use in flooring buildings include: asphalt, concrete, cork, linoleum, magnetite (mixture of magnesium oxide, pigment and an inert material, e.g. saw dust), mud, stone, terrazzo concrete where marble chips are used as aggregates and polished with carborundum stone, tile and timber, plastic (PVC) – Rubber (mixture of raw rubber, tillers e.g. fibre, pigment, with percentage of sulphur (Ekwelem, 2009). Consequently, floor finishing is a critical part of all building as it mostly comes in direct contact with the users and typically bears the brunt of everyday load and activities. Onochie, Emoh, and Anyanwu (2017) contended that due to daily usage of floors, they are usually the first part of the building to reflect wear and tear. As such, the importance of strong, long lasting, durable floor finish cannot be over emphasized. There is always the need to invest in floors which will keep pace with your daily life and add value while simultaneously infusing the building with a touch of class.

According to Harris (2017) most floor systems of a building are not exposed to the climatic element and their weathering effects, since a floor system must support traffic; however, durability, resistance to wear/tear and ease of maintenance are critical factors in the consideration and selection of a floor system and its finish. The desired finishes and their visual properties (materials, color, texture and pattern) help to determine the choice of floor system which can mostly support these finishes. Consequently, inefficient performance of these floor finishes may constitute challenges to house occupant, the utility of the building and to the environment (Olotuah, 2010). Lack of proper and regular maintenance has also left its floor finishes with lots of deficiencies which include; cracks, squeaky floors, buckling, burns and so on. These challenges impact heavily on the building quality as much as the users and property owners. Additionally, building quality are also affected by poor floor finishing to the extent that the entire value of the building may be compromised, lost (collapse or structurally damage) or significantly undervalued with great loss of value financially and otherwise to the owners. It is otherwise an economic loss to the owners or government as good buildings are supposed to edify the environment, promote it and add value to it (Akinyemi, Dare, Anthony and Dabara, 2016). Poor floor finishes among other things also reduce the aesthetics of the building and make the building less appealing both the users and beautification of the environment (Ekwelem, 2009). Equally, there are health implied consequences of poorly finished floors on the users; such as: domestic accident proneness; falls, abrasion of human skin, instability, sinking and collapsing. Some of these dangers are increased if the floor is slippery, too sharp and not smooth. To the extent that they exist, they constituted human hazards may lead to untimely death and injuries grave consequences.

Judging by the experiences of the researcher and reported cases in Anambra State, incidence of poor floor finishing abound at an alarming rate. The causes may be as a result of varying factors but notably: poor quality of floor design, poor quality of floor material, poor quality work by the builders and general inefficiency of enforcement by regulatory organizations. These factors in no little ways contribute to the growing problems caused by poor floor finishing in the buildings in the state which defect the quality, utility, and appeal of buildings with unpleasant negative impacts on humans and on the environment. It is against this background, that this study seeks to investigate strength and durability of floor tile finishes for building projects in three major cites of Awka, Nnewi and Onitsha in Anambra State.

Studies such as Nwosu (2014) and Yeang (2012) buttressed that there are critical components which are required in buildings for its effective utility; good floor finishing is one of such; although, not much studies have been devoted to the problems of floor finishing especially as regards floor tile finishing. There is the problem of ascertaining the impacts of individual types of floor finishing such as tiles, terrazzo, concrete, marble and others on the floor finishing quality in buildings. There are also gap in studying critical components of floor finish strength and durability such as: modulus of rapture (N/mm^2), coefficient of water absorption and resistance to surface abrasion and how these critical components may affect floor finish quality. Such gaps necessitated the investigation of this study. For instance; Nwosu's (2014) study provided the cost relationship with floor finishing to buildings without ascertaining the impacts of floor types in relation to its strength and durability to the overall floor impact on buildings. The obvious gap has left more questions as to which type of floor type impacts greater strength and durability to floor finishing. To further understand this impact, there is the need to classify floor types and take them individually to ascertain the impact of each type on strength and durability of the floor finishing in building construction. Without segmenting the floor types, it will be difficult to classify their relationship to strength and durability since different material properties come with varying strength and durability. This situation provided an entry for this study which is focused only on the relationship of floor tile finishing to strength and durability of floor finishing in Awka, Nnewi and Onitsha environs in Anambra State; being locations for the most rapid development in the state with many upcoming residential buildings.

Although, studies such as one carried out by Dosunmu and Olusanya (2011) together with other studies on the durability of floor finishes in commercial building in Lagos State reported that there are significant failures in floor finishes in commercial building constructions in Lagos; however, it did not narrow it down to the typical types of floor finishes with such inherent failures. The reoccurring

problem inherent in these studies is that they are not precise as to which type of floor finish that has failures in the recorded area and what was the cause or causes of such failures bearing in mind that a number of factors could be directly involve in dealing with strength and durability of floor finish such as material property quality, workers' handling expertise, environmental and climate factors and nature of usage. These aspects need to be studied individually in order to understand floor finish failure and be able to proffer solutions.

There is also the empirical problem of providing real-time testing of floor finishing materials as they are in the building market to ascertain the real nature of their strength, durability and appropriateness of use in building. Many gaps exist in this direction as many studies carried out in this area are often post-mortem impacts and evaluation of floor finishing failures such as in the studies of Onochie, Emoh, and Anyanwu (2017); that of Ogunoh, Okolie, and Ezeokonkwo (2015). In these instances, availability and testing current market materials in the area of the study for different floor finishing were not ascertained in order to pre-empt their impacts on duration and strength which would shed some light on the reasons of floor finishing failure and problems in the area. This situation has equally opened an important window to evaluate a typical floor finish material properties in the area of the study (Awka, Nnewi and Onitsha in Anambra State) in order to understand the proposed association among the floor type finishing, strength and durability.

There are also pragmatic problems not accounted for in most previous studies. For instance; some studies (Harris, 2017; & Akinyemi, Dare, Anthony, and Dabara, 2016) weren't designed in a way to help laymen such as owners of building with little or no knowledge about building to understand the association among floor type finishing, strength and durability. Therefore this study attempted to fill this gap by providing material sampling and testing of the common floor tile types heavily used in the area of study and could be used to provide typical examples of floor tile finishing impacts on building in terms of durability and strength. This will enable laymen such as some building owners and users understand the implications of using non – tested materials in their building projects.

No doubt the review of the literature on floor finishing has revealed a number of gaps which this study hopes to fill. For instance, presently there is lack of empirical evidence regarding the strength and durability of floor finishes for residential buildings in Nigeria, particularly buildings in Anambra State. Also, there were only a few studies which focused only on the strength of floor tile finishing in Anambra State although at different setting and with divergent parameters where this study provides firsthand data on the problems of strength and durability of floor tile finish in Anambra State. Equally, studies which deal on floor finishes lacks real time regulatory body experiments such as Standard Organization of Nigeria (SON) on the typical floor materials to determine the compliance of floor material properties in the floor finishes in Anambra State. Such laboratory test exclusion creates an information gap on the standardization of material properties of the floor materials and thus makes it difficult to ascertain their strength and relative durability. Furthermore, several studies in literature have not critically analyzed each material property as to ascertain the minimum acceptable quality for each property and how it relates to strength and durability. These gaps have necessitated a new study; which this study attempts to fill guided by two hypotheses.

2.1 Hypotheses

The following hypotheses guided the study:

1. The strength of typical floor finish materials used in Anambra State does not fall below the Standard Organization of Nigeria (SON) quality for floor finish material properties.
2. There is no significant correlation between floor tile strength and floor tile durability in floor tile finish in Anambra State.

3. Method

The research approach for this study involved the combination of quantitative methodologies and laboratory test experiment on materials. This study has the advantage of gaining a stronger research

design and achieving more valid and reliable findings. As such, questionnaire survey and literature reviews were the methodologies conducted to carry out the objectives of the research. Respondents were asked to rate their perceptions regarding the level of importance of these strategies on a five-point Likert ordinal scale where 5 = Strongly Agree, 4 = Agree, 3= partially agree, 2 = Disagree and 1 = Strongly Disagree. Tables, means, standard deviation, percentages and relative importance index were used to describe the results. These were carried out using Microsoft Excel and statistical package for the social science (SPSS).

3.1 Design

This study adopted a mixed method design (descriptive, experimental and correlation). The survey research design, according to Nworgu (2015), is one in which a group of people or items is studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group using questionnaire or interview where as the experimental design is observation of cause and effect under a controlled environment. This design was considered appropriate for this study since it is explored the opinions of the respondents on the strength and durability of floor finishes for building projects.

3.2 Survey

For the survey, the questionnaire designed for this study was both structured and semi-structured questionnaires (multiple choices) and included both open ended and closed ended questions. The open ended questions was used for demographic information whereas the closed ended or forced choice part of the questionnaire was used to assess the respondents on a number of issues in which they are to express their opinion by choosing one of the provided options to the items in the questionnaire. The questionnaire of this study has two sections, section A was on the demographic data of the participants which included their biodata while section B was on the factors related to the residential buildings in Anambra State which included: preferences of floor finish types for residential buildings, critical material properties for floor finishes and relationship between floor finish strength and durability. A total of two hundred and seventy-eight (278) copies of questionnaires being the required number of the sample were hand distributed among the building professionals in Anambra State by the researcher with the help of research assistants. The responses of the participants were analyzed and interpreted.

3.3 Experiment

For the experiment, the researcher carried out a Standard Organization of Nigeria (SON) NIS 427:2000 material component requirement analysis which involved laboratory testing of sample floor tile finish types which was tested at Standard Organization of Nigeria laboratory Center at Enugu (the SON Regional Headquater). The sample type of the floor finish was determined by the frequency of usage of such tile types in the study area and the current availability of such floor finish types (tiles) in the market. The experiment focused on material properties which were determined by building professionals in the questionnaire as critical material properties for relative strength and durability of the typical floor finish (tile). The experiment focused on which of the floor finish sample type that will comply to the standardized material properties at different levels.

3.4 Sample and sampling techniques

The sample of the study is 278 building professional made up of: Nigerian Institute of Builders, Nigerian Society of Engineers, Nigerian Institute of Quantity Surveyors and Nigerian Institute of Architects who were drawn from a population of 907 building professionals in Anambra (Source: Nominal Registration of the professionals' association in Anambra State). The sampling techniques for study is multi stage sampling for non probabilistic sample whereby purposive sampling was used to select the State (Anambra) while cluster sampling was used to select the three senatorial district as clusters in the state for even distribution and simple random sampling was used to select each of the building professionals in the three senatorial zones of Anambra Central (Awka), Anambra North (Onitsha) and Anambra South (Nnewi). Okolie, (2011), illustrated that multi stage sampling in a non-probabilistic technique improves the representativeness of the sample in terms of variables used in the stratification, and can be used to select a sample of building professionals as in this study.

The population of this study constitutes all available professionals in the building industry under the registration as: Architects, Builders, Engineers, and Quantity Surveyors in the study area duly registered in Nigeria with the Corporate Affairs Commission (CAC) whose population is 907. The sample size for this study was determined using Taro Yamane's sample reduction formular as cited in Ogunoh (2008)

n = N/(1+N〖(e)〗^2)

when n = sample size

N = population

e2 = Margin of error (assumed 5%)

1 = unity or constant

3.5 Validity and reliability of research instruments

An assessment of the statistical reliability is necessary before any further validation analysis. This study validity simply means that a test or instrument is accurately measuring what it's supposed to measure while reliability is a measure of the dependability, stability or consistency of test scores and the ability for a test or research findings to be repeatable (Okolie, 2011). For the purpose of this study, a pilot test was carried out to ascertain the reliability of the instruments and the result revealed that the survey instrument had a Cronbach's alpha value of 0.74 for its internal consistence. The instrument is therefore suitable for use in the current study. The statistical analysis comprised two stages. The first stage examined the descriptive statistics of the measurement items and assessed the reliability and validity of the measure used in this study. The second stage tested the proposed research model and this involved assessing the contributions and significance of the manifest variables path coefficients.

4. Result

Table 1: Descriptive statistics showing preference of various types of floor finishes in use in Anambra State

S/N	ITEM	Responses								
		1	2	3	4	5	N	$\overline{X}$	SD	R
1	Concrete	-	-	41	95	141	277	4.4	.1570	2nd
2	Tiles	-	-	-	121	156	277	4.6	1.842	1st
3	Terrazzo	47	63	45	57	65	277	3.7	.8839	3rd
4	Marble	31	114	39	50	43	277	2.8	1.256	4th
5	Stone	79	145	38	9	6	277	1.9	.2750	5th
6	Hardwood	135	137	5	-	-	277	1.5	.4008	7th
7	Synthetic Carpet	140	85	32	13	7	277	1.7	1.005	6th
8	Resilient Floor	169	103	5	-	-	277	1.4	.6963	8th
9	Natural Granite	193	74	7	3	-	277	1.3	.7642	9th
10	Artificial Stone	201	74	2	-	-	277	1.2	.3920	10th

Source: Field Survey Result, 2019

Objective 1 which deals with the prevalent floor type finishes used in building constructions and to rank

their preferences in building constructions in Anambra State was tested using research question 1 as shown in Table 2. From the table the researcher identified 10 floor type finishes and requested the respondents to ascertain their use and preference in building construction Anambra State. The descriptive statistics in Table 2 indicated that floor tiles with a mean point of 4.6 is the most preferred and used floor finish in building constructions in Anambra State whereas artificial stone with mean point of 1.2 is the least preferred and used floor type in building constructions in Anambra State. Other floor types significantly preferred and used in floor finishes in Anambra State include: concrete floors with a mean of 4.4, terrazzo floor with a mean of 3.7 and marble floor with a mean of 2.8. Although other types of floors are preferred and used in Anambra State, their preference and use did not reach significant proportions. The floor type finish in focus in this study is floor tiles and it is the most preferred and used floor type in building constructions in Anambra State.

Table 2: Critical material properties of a typical floor tile finishing used in building construction in Anambra State

S/N	ITEM	Responses								
		1	2	3	4	5	N	$\overline{X}$	SD	Rank
1	Water Absorption by weight	-	-	-	155	122	277	4.4	.6130	1st
2	Density	20	74	54	96	33	277	3.1	.5802	6th
3	Compressive strength	48	35	41	73	80	277	3.4	.4984	5th
4	Modulus of Rupture	-	7	31	169	70	277	4.1	.5806	3rd
5	Abrasion resistance	-	-	-	197	81	277	4.3	.6228	2nd
6	Flexural strength	11	25	61	116	64	277	3.7	.8126	4th

Source: Field Survey Result, 2019

To achieve objective two, a survey was carried out and responses of building professionals on critical material properties of a typical floor tile finishing used in building construction in Anambra State was elicited. Data analyzed indicated that “Water absorption by weight”, “Abrasion resistance” and “Modulus of rupture” was identified as the most critical material components for floor finishing in building construction at mean point of 4.4, 4.3 and 4.1 respectively on a 5-point likert scale. This implies that for material components of floor tile to be suitable for floor finishing, the “Water absorption by weight”, “Abrasion resistance” and “Modulus of rupture” properties ought to be high enough to guarantee strength and durability in addition to other material properties such as: compressive strength, density and flexural strength.

Table 3: SON material components requirements analysis for typical floor tile finishing in residential building construction in Anambra State

Floor Finish Type	NIS 427:2000 Requirement			Measured Observation	Remark
	Coefficient of Water	Resistance to	Modulus of		

	Absorption (%)	Surface Abrasion (Revolution)	Rupture		
Floor Tile 1	0.1	≤ 2100	37.44	Class 4	No failure
Floor Tile 2	0.6	≤ 600	37.46	Class 2	Failed
Floor Tile 3	0.5	≤ 750	22.16	Class 3	Failed
Floor Tile 4	0.04	≤ 650	14.66	Class 2	Failed

Source: SON Test Report, 2019

Table 4 revealed the SON test report on the relative strength and durability of common used floor tiles in building construction in Anambra State. The test report is categorized into 5 classes in accordance to strength of the floor file to physical components such as coefficient of water absorption, resistance to surface abrasion and modulus of rupture. The result of the SON test report is indicative that typical floor tile materials for floor finishes used in building construction in Anambra State did not reach class 5 being the best standard. However, only one floor tile reached class 4 at 0.1% coefficient of water absorption, ≤ 2100 resistance to surface abrasion and 37.4 modulus of rupture certifying all parameters for class 4 and thus, no failure was recorded for floor tile 1. Floor tiles 2 and 4 belonged to class 2, however, both failed the SON test with Floor tile 2 failing in resistance to surface abrasion and water absorption although it has a good value in as regards modulus of rupture while floor tile 3 failed in all three dimensions of coefficient of water absorption, resistance to surface abrasion and modulus of rupture. Floor tile 4 also failed in resistance to surface abrasion at ≤ 650 and modulus of rupture at 14.66 although it has a good outlook at coefficient of water absorption at 0.04. The outcome of the SON test is indicative that only one floor tile (floor tile 2) conformed to the SON prescribed building standard for strength and durability on critical parameters of coefficient of water absorption, resistance to surface abrasion and modulus of rupture at class 4 level.

Table 4: Descriptive statistics for the relationship between floor tile strength and floor tile durability

Descriptive Statistics			
	Mean	Std. Deviation	N
Floor Strength	3.8	1.0846	277
Floor Durability	3.9	1.2250	277

Table 5: Hierarchical regression analysis showing model for the predictive effects of floor tile relative strength on floor tile relative durability used in residential buildings in Anambra State

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	16.700	1.239		13.482	.000
	Floor tile strength	.501	.039	.572	13.000	.002
a. Dependent variable: Floor tile relative durability						

The fourth specific objective of the study evaluated the relationship between floor tile strength and durability of floor tile finishes in building construction in Anambra State. Hierarchical regression analysis was run using the data obtained from the field and the result confirmed predictive effects of floor tile strength on floor tile durability at $\beta = .57$, $p < .05$ ($n = 277$) see Table 6. The finding is indicative that as floor tile strength increased the floor tile durability also increased evidence that the more the strength of the floor, the more it tends to last longer (less floor finish failure). Consequently, for a floor tile finish to last longer there is the need for the tile to meet the physical property requirements and this can be ascertained

during the laboratory tests to ascertain the quality standard.

4.1 Test of hypotheses

To further provide empirical evidence the study tasted to critical hypothesis as regards typical material property quality of floor tile finish used in residential building constructions in Anambra State.

H_0 Typical floor tile material in use in building construction in Anambra State will not fail Standard Organization of Nigeria (SON) Test NIS 427:2000 IS 13630 being Nigeria's recommended index for building material strength.

H_1 Typical floor tile material in use in building construction in Anambra State will fail Standard Organization of Nigeria (SON) Test NIS 427:2000 IS 13630 being Nigeria's recommended index for building material strength.

Table 6: Mean score for SON material property requirements for typical floor tile finishing in residential building construction in Anambra State

Floor Finish Type	NIS 427:2000 Requirement			Remark
	Coefficient of Water Absorption (%)	Resistance to Surface Abrasion (Revolution)	Modulus of Rupture	
Mean	0.31	1025	27.93	Quality Failure

Source: SON Test Report, 2019

Table 8 revealed the mean quality evaluation of material property quality of four typical floor tiles used in residential building construction in Anambra State using the average of SON test report on the relative strength index for water absorption, surface abrasion and modulus of rupture. The mean score values on the properties are indicative that on the average, floor tile materials used in residential building constructions in Anambra State fall short of the SON standards on material property quality on floor tile finish. The mean water absorption coefficient is 0.31% although this indicated that averagely floor tiles used in the area do not absorb much water than required, their mean surface abrasion resistance is poor compared to the SON standard at 2100 for class 4. Equally, the material average score on the modulus of rupture quality which is 27.93n/mm^2 is an indication that typical floor tiles used in floor tile finishing in the area is less than the SON recommended material quality for MOR which is >35N/mm^2. The average score is an indication that the typical floor tiles used in residential buildings in Anambra State failed SON MOR test and thus are not acceptable as the industry standard. Consequently, based on the findings which revealed that the average material quality of sample floor tiles used in residential building construction in Anambra State failed the SON laboratory test during the experiment, the null hypothesis is not confirmed; therefore the alternate hypothesis is confirmed and accepted (see Table 7 for remarks).

Hypotheses II

H_{02} Floor tile strength will not significantly correlate the floor tile durability of floor finish in residential building in Anambra State.

H_2 Floor tile strength will significantly correlate the floor tile durability of floor finish in residential building in Anambra State.

Table 7: Correlation between floor tile finish strength and floor tile finish durability in residential building construction in Anambra State

Pearson product moment correlation

		Floor Tile Finish Strength	Floor Tile Finish Durability
Floor Tile Finish	Pearson Correlation	1	.734*

Strength	Sig. (2-tailed)		.002
	Sum of Squares and Cross-products	498.000	486.000
	Covariance	6.674	6.027
	N	277	277

To test hypothesis II, relationship between floor tile strength and floor tile durability was ascertained using Pearson Product Moment Correlation coefficient. From the correlation result in the Table 5, it was observed that Floor Tile Finish Strength positively and significantly correlated Floor Tile Finish Durability at $r = .734^*$, $p < .05$, ($n = 277$). The error margin/significant value is less than p value at .002 ($p < .05$). Based on this statistical findings as in Table 8, the null hypothesis II which stated that floor tile strength will not significantly correlate the floor tile durability of floor finish in residential building in Anambra State was not confirmed while the alternate hypothesis which stated that Floor tile strength will significantly correlate the floor tile durability of floor finish in residential building in Anambra State was confirmed and accepted.

5. Discussion

The study ascertained that among the ten types of floor finishes used in Anambra State, floor tile finish, concrete floor finish, terrazzo floor finish and marble floor finish were ranked first, second, third and fourth commonest used floor finish used in residential building construction in Anambra State with the floor tiles ranked the most preferred. (See Table 2). Answers to research question one is indicative that floor tile finish which is the focus of this study is a very important floor finish used in residential building constructions in Anambra State.

The study further identified the critical material properties of typical floor finish material in building constructions in Anambra State as answers to research question three they are as: water absorption by weight; density, compressive strength, modulus of rupture, surface abrasion resistance and flexural strength. Using likert format, these physical properties of floor finish materials were ranked in accordance to mandatory minimum requirement and only three were chosen to be further study they are: water absorption, modulus of rupture and surface abrasion resistance which can be ascertained from Table 3. Furthermore, the study carried out an experiment in order to provide answers to research question three. The result of the SON laboratory test indicated that only floor tile 1 among other typical floor tile samples commonly used in residential building construction in Anambra State passed the SON quality assurance test whereas others did not conform to SON standard see Table 4. The outcome of the test is indicative that most of the floor tile finishes in use in residential building in Anambra State lacked quality in most of the material properties of ascertained in Table 3.

Equally, the study was concluded with the evaluation the building professionals' perception of floor tile finish in relation to its material strength and its durability. Analyzed data was indicative that the more the strength of the floor tile, the more it is guaranteed of durability and lasting long as shown in the tables of mean and correlation in Tables 5 and 6. The Pearson Chi-Square coefficient of 46.749^a confirmed a relationship between floor tile strength and floor tile durability at .000 ($n = 4$) asymptotic significance for the four sample tiles in the study at $df = 9$. In the hypothetical testing, the two null hypotheses of the study were not confirmed while the alternate hypotheses were confirmed (See Table 7 and 8). The confirmed alternate hypotheses were indicative that on the average, the typical floor tile material quality used in residential building construction in Anambra State failed the standard quality test of SON (Table 7) while significant correlation was recorded by floor tile finish strength and floor tile finish durability (Table 8).

After the statistical analysis of data, the result of indicated that the first objective of the study on the prevalent floor type finishes used in building constructions and to rank their preferences in building constructions in Anambra State which was ascertained by answering research question 1 which found that among 10 types of floor finishes prevalent in use in building construction in Anambra State, floor tiles is the most preferred and used floor finish in building construction having recorded the highest mean as the most preferred and used floor finish in Anambra State (see Table 2). Next to floor tiles is concrete floor; the third most preferred and used floor finish is terrazzo while articial stone is the least preferred floor finish in

the area as indicated in Table 2.

From the analysis done in Table 2, the findings indicated that most buildings in Anambra State rely on floor tiles for floor finishes which implies that most floor finish failure in the area depend on the relative strength and durability of floor tiles used by building professionals or supplied for floor finishes; and how well they are installed by building professionals during constructions. The extent to which floor tiles used in the area conforms to standard requirements of building regulatory bodies and how well the installation is to a large extent determines floor finish failure in the area as most floor finish in the area is made of floor tiles. The popular use of floor tiles as floor finish type may be due to its relative value in cost, aesthetics and its easy installation and maintenance in comparison to other floor finish types such as terrazzo, marble, stone, hard wood and artificial stone etc. The finding is indicative that there is a comparative advantage in the usage of floor tile finishes in building constructions in Anambra State. These advantages constitute and influence choice floor tile materials in relation to the needs and building specifications. For example, Onochie, Emoh and Anyanwu's (2017) evaluation of factors affecting the choice of the different floor finishes in the building industry within Abia State of Nigeria found that apart from aesthetic values and cost of floor finish material, advantages such as; ease of installation and relation strength to maintenance index contribute significantly to the choice of floor type finish in building construction.

The second objective of the study aimed to ascertain the critical material properties of typical floor tiles finishing in building constructions in Anambra State. With the aid of responses provided by building professionals on research question 2 as in Table 3; their responses indicated critical material properties of floor tiles as: "Water absorption by weight", "Density", "Compressive strength", "Modulus of rupture", and "Abrasion resistance", and "Flexural strength". However, analysis of their responses, ranked water absorption by weight, abrasion resistance and modulus of rupture as the most critical material properties required of typical floor tile finish in terms of strength and durability. The finding implies that for any floor tile to be suitable for floor finishing; there is the need to ensure that its surface abrasion resistance is high enough in order to withstand the pressures of wear and tear occasioned by movement of human beings and goods to and fro the building. Essentially, greatest user-impact on buildings is impacted on the floors and the floor bears the heaviest burden of wear and tear most especially caused by abrasion friction when the floor comes in contact with other surfaces. Ideally, building professionals are always mindful of this and ensure that the materials chosen and used promise high surface resistance to abrasion.

Also, the finding in research question 2 further identified modulus of rupture as critical index for floor tile strength and durability (see Table 3). The typical floor tiles are expected to show higher percentage of load carrying capacity and break or rupture resistance to pressure exacted on it which tends to break the floor tile finish. With high resistance to such pressures, tiles may ordinarily break at any given pressure leading to floor finish failure. This substantially leaves the floor rough, unattractive and risky as it may constitute hazards to the building users. Ability of floor tile to resist high pressure which is place on it without breaking is an indication that such tile material has strength and will last longer (durability). For example, Ekwelem's (2009) finding on durability of some floor finishes in building projects as a case study of floor finishes within Enugu metropolis found floor finish resistance to breakages and pressures is one of the physical properties which influence floor finish types in Enugu. Considering the proximity and similarities in the ways of life and culture of the areas of study (Enugu and Anambra), it is expected that such physical properties will also be a pre-determining factors in the choices of floor type materials in Anambra State as it influence floor finish strength and relative durability. Although, most floor type finishes would be said to be strong and durable if the right specifications are maintained during construction; however, there are always problem associated with the cost of maintaining the right standard for every floor type finish. Some significantly cost more than the others may be because of their higher aesthetic values which may be the reason for a search for affordable but yet strong, durable and easy to maintain floor type finish which may have being the reason for the choice of floor tiles as the most preferred and used floor type in Anambra States as indicated in Table 2. This idea on choice and use of a particular floor type that is affordable but with favourable physical properties which withstands the pressures of usage was also supported by Onochie, Emoh, and Anyanwu's (2017) findings on the factors affecting the choice of the different floor finishes in the building industry within Abia State which highlight affordability, strengths and durability as the leading factors. Ideally, favourable coefficients of modulus of rupture, resistance to surface abrasion and water absorption capacity of floor tiles as a floor finish type which most tiles show may have

influenced their high preference and usage in Anambra State.

Although, building professional ranked "modulus of rupture", "resistance to surface abrasion" and "water absorption capacity" as the most critical physical material properties of a typical floor finish from six most important factors identified in Table 3, Harris' (2017) findings on material world as a comparative study of flooring material influence on patient safety, satisfaction, and quality of care emphasized that there may be other physical material properties of floor finishes which should be considered in accordance to the use of the building. For instance, Harris found that certain floor types affect the health of patients as regards patients' safety, recovery, allergies and maintenance. The findings of the current study is also consistent with these observation considering that floor tiles comes in various shapes, colours and sizes to cater for these concerned and therefore make the physical material properties identifying as basics among other considerable specifications and requirements.

The third objective of the study which was to evaluate the specified Standard Organization of Nigerian (SON) relative strength and durability index of typical floor tile types preferred and used with Anambra State using the SON material property requirements for typical floor tile finishing was evaluated using research question 3 which sought the SON material property requirements for typical floor tile finishing test report. As such, the study carried out an evaluation report in order to determine the SON material properties status of common floor tiles in use in the study area in order to determine its strength index and consequent durability. Consequently, the laboratory tests carried out using SON facility in Enugu indicated that only one type of floor tile (Floor tile 1) passed the test on the three physical material properties of a good floor finish namely: "modulus of rupture", "resistance to surface abrasion" and "water absorption capacity" (see Table 4). This is indicative that most floor tile finish in use in Anambra State does not comply with the recommended industry standards as specified by the Standard Organization of Nigeria on the use of floor tile finish (See Appendix II for details of SON requirements and Classifications).

The SON material property NIS 427:2000 laboratory requirement analysis carried out for typical floor tile finishing in building construction in Anambra State revealed that although, most floor tile finishes used in the Anambra State have relatively low water coefficient absorption which helps to boost tile strength by reducing breakages which leads to floor failures, almost all (the 4 samples tested) except one have low resistance to surface abrasion which is the main cause of floor finish failure with lots of problems such as slipperiness and loss of aesthetic values. These factors greatly account for high incident of floor tile finish failure in the area as they are the critical physical properties of floor finish strength and durability as indicated in Table 3. The findings was also supported by the findings of the study carried out by Onochie, Emoh, and Anyanwu (2017) in Abia State and Ekwelem (2009) in Enugu State which bemoaned the high rate of floor finish failure in their respective states. The current findings may be said to be typical of such earlier findings judging the similarity and proximity of culture, economic power and values among the states which are from South-East Nigeria.

In typical floor tile 1 as shown in Table 4, users are likely to enjoy high value in terms of low coefficient of water absorption, high surface abrasion resistance and low modulus of rapture. The finding implies that users of typical floor tile 1 or floor tiles of that category, will experience that their floors absorbs little water which increases its strength index since high water absorption increases moisture and reduce tile strength. With low absorption, the strength is bolstered and higher levels strength is associated with longer durability. Also, typical floor tile 1 showed high resistance to surface abrasion which is also a good physical material property because high resistance to surface abrasion prevents the tiles from rapid wear and tear occasioned by friction of two surface areas which corrodes the floor tile surface leaving it vulnerable to slipperiness due loss of its threads, and loss of its aesthetic values which makes the floor surface look ugly and unkempt. Another physical property evaluated is the modulus of rapture (MOR) which indicated that typical floor tile 1 promised good MOR capacity and as such will boost the floor tile's capacity to reduce floor breakages caused by flexural impacts. Floors carry weight burden of a building and this weight is carried critically by the floor finish material used. If the MOR is not good enough the weight on the floor finish could cause breakages leading to floor finish failure. These instances are causes of floor finish failure especially floors finished with tile materials in building constructions in Anambra State. On this regard, floor tile 2, 3, and 4 failed the SON property test and as such there is no guarantee of strength and durability if they are used. Their usage as floor finish material may be the consequences of rapid floor

tile finish in Anambra State.

The fourth and final objective of the study was to ascertain the relationship between strength and durability of floor tile finish in residential building constructions in Anambra State. From the correlation result in Table 5, it was ascertained that the responses of professional builders regarding floor tile strength index on typical floor tile finishes used in residential building constructions in Anambra State correlated their responses on the durability of typical floor tile materials used in residential building construction in Anambra State. The finding implies that the durability of floor tile finish is dependent on the strength of the floor. Which means that the more the physical properties of the floor tiles reach the standard requirements, the more the floor tile finish is likely to last longer. If a floor tile absorbs less water from the surface, it more likely to stay dry all through; dryness property has being adjudged as a material strength (Harris, 2017) and this quality prevents the floor tile from breakages as a result of pressures exacted on the floor tiles. Also, Akinyemi, Dare, Anthony, and Dabara (2016) emphasized that constant moinsture on the floor surface is a threat that should be eliminated to protect the floor tile finish and the users as it may lead to slipperiness and harm to the user and the damage to the floor. Without floor tiles easily breaking due to pressures, floor tiles last long as a floor finish of the building.

Another index of floor tile strength correlated in this study is resistance to surface abrasion. Surface abrasion damages the floor tile finish leading floor finish failure as it reduces its aesthetic values and durability. Abrasions are caused by constant friction on the floor tile surface when users come in contact with the surface. Floor finishes are regarded as strong if they have capacity to resistance surface abrasion to a reasonable extent. This quality ensures that the floor finish last much longer than when abrasion occurs. Floor tile failure as a result of abrasion is hazardous to the users because it leads to slipperiness of the floor which leads to domestic accident within the building. On many occasions this has led to death. In views of Onochie, Emoh, and Anyanwu (2017) this quality is among the leading factors which influence the choice of floor type finished chosen by builders and the building owners. In the current study, if floors do not fail abrasion tests, then such floors are strong and will last longer than those that fail the abrasion tests. This is also applicable to the flexural strength of the tiles and the modulus of rupture which ensures that pressures of the surface of the floor do not easily break the floor surface leading to floor finish failure.

Recommendations

Based on the findings of the research, the following recommendations were made:

1. Before any material is used as floor finishes, it should be tested and analyzed in order to determine and establish the compressive strength and duration.
2. Emphasis should be laid on suitable materials/finishes than cheep materials/finishes, so as to reduce failure in finishes.
3. Knowledge of finish serviceability duration should be known.
4. A good maintenance culture should be maintained.
5. Particularly, there is need for stakeholders to sensitize professionals in the area of floor finish testing to ensure that materials used conform to the Standard Organization of Nigeria specifications for floor finishes.
6. There is need for supervisory professional bodies to monitor and oversee the qualities of floor finishes in order to ensure that floor finish material qualities conform to industry standards. To actualize this, there is need for an enforcement team on standardized material testing on building sites. This will ensure compliance, apprehension of offenders and prosecution of culprits.
7. Varying penalties should be given to offending builders to serve as deterrents to others including seizure and suspension of practicing license.

Contribution to Knowledge

The study has buttressed that material properties of floor finishes to a large extent influence and determine the strength and durability of floor finishes. The study has further helped to sensitize the academia and building professionals on the importance of material testing before embarking on floor finish and the need for the regulatory bodies to conduct on the site test regarding the floor finish material quality as to ascertain if they conform to industrial standards. The study furthermore indicated that although a material may fail material property test, not all material quality fail at the same time. Without laboratory tests, this may be

exploited by the manufacturers to deceive the buyers and the professional builders into believing that a certain type of floor finish is good for use. The current study has equally informed us that there is a relationship between strength and durability of floor tile finish.

Areas for Further Studies

There is need to ascertain the compliance rate of professional builders in the use of standardized materials as floor finish materials in residential buildings in Anambra State which can only by ascertained by laboratory testing of the sample materials. There is also the need to carry out another study to ascertain the maintenance cultures of floor finishes in order to ascertain whether this affects the rate of floor finish failure in the area. Also, there is also need to replicate the same study in other regions of Nigeria with difference ethnic, economic and compliance culture in order to ascertain whether what was observed is a national antecedents or not. Furthermore, there is the need to carry out a study on the relationship between professional builders' compliance with industry standards and the rate of floor finish failure in the area of concern.

Conclusion

The current study was on the investigation into the strength and durability of floor finish of residential building projects in Anambra State. This research highlighted that floor tile finish is the most common floor finish in residential building in Anambra State. Also, the study established that the strength of floor finish material properties are determined by the testable qualities such as ability to resist surface abrasion, water absorption capacity and modulus of rupture as critical material properties of floor finish strength and durability. Typical floor tile materials in use in residential buildings in Awka were tested at the SON laboratory and the result was indicative that conformity rate is 1:4 since only one type of tile passed the test while the rest failed. After the laboratory tests, typical floor tile finish used in the area of the study showed that most of the tiles passed the water absorption test but failed the surface abrasion test and modulus of rupture tests which lead to may floor tile finish failure in Anambra State. Furthermore, the study established that there is a significant relationship between the floor finish strength and its durability and this was done by correlating the responses of the experience of the building professionals in Anambra State.

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Appendix I
Research Instrument

Section A: Demographics
Name (Optional) _____
Profession Tick one: [Architect] [Engineer] [Builder] [Quantity Surveyor] [Others indicate……..]
Professional Qualification Tick one: [NIA] [NSE] [NIOB] [NIQS] [Others ……..]
Years of Experience Tick one: [0-5yrs] [6-10yrs] [11-15yrs] [16-20yrs] [21yrs & Above]
Educational Qualification Tick one: [ND] [HND/BSc] [MSc] [PhD]

Section B: Questionnaire
Instruction: The following statements are what you are familiar with in Floor finish types and materials; please indicate how often you perform each of the statement using these responses:
5 = Most Preferred, 4 = Preferred, 3 = Mildly Preferred, 2 = Rarely Preferred, 1 = Not Preferred

S/N	Item	Responses				
		1	2	3	4	5
1	Concrete					
2	Tiles					
3	Terrazzo					
4	Marble					
5	Stone					
6	Hardwood					
7	Synthetic Carpet					
8	Resilient Floor					
9	Natural Granite					
10	Artificial Stone					

Critical Physical Properties of Floor Finish
Section A: Demographics
Name (Optional) _____
Profession Tick one: [Architect] [Engineer] [Builder] [Quantity Surveyor] [Others indicate……..]
Professional Qualification Tick one: [NIA] [NSE] [NIOB] [NIQS] [Others ……..]
Years of Experience Tick one: [0-5yrs] [6-10yrs] [11-15yrs] [16-20yrs] [21yrs & Above]
Educational Qualification Tick one: [ND] [HND/BSc] [MSc] [PhD]

Section B: Questionnaire
Instruction: The following statements are what you are familiar with in technology use in building delivery process; please indicate how often you perform each of the statement using these responses:
1 = Least Important, 2 = Important, 3 = Fairly Important, 4 = Very Important, 5= Most Important.

	ITEM	Responses				
		1	2	3	4	5
	Water Absorption by weight					
	Density					
	Compressive strength					
	Modulus of Rupture					
	Abrasion resistance					
	Flexural strength					

Appendix II
Statistical Analysis

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FREQUENCIES VARIABLES=Gender Profession Exp Location Marital Age Religion
  /STATISTICS=STDDEV MEAN
  /ORDER=ANALYSIS.
Frequencies
```

Statistics

		Gender	Type of Profession	Years of Experience	Location of Practice	Marital Status	Age in Years	Religious Affiliation
N	Valid	271	271	271	271	271	271	271
	Missing	0	0	0	0	0	0	0
Mean		1.1808	2.0074	2.1808	1.8007	1.2103	1.9815	1.3985
Std. Deviation		.38557	1.07494	.89472	.84160	.40830	.80486	.85410

Frequency Table

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	222	81.9	81.9	81.9
	Female	49	18.1	18.1	100.0

	Total	271	100.0	100.0	

Type of Profession

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Builder	111	41.0	41.0	41.0
	Civil Engineer	91	33.6	33.6	74.5
	Surveyor	25	9.2	9.2	83.8
	Architect	44	16.2	16.2	100.0
	Total	271	100.0	100.0	

Years of Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5 yrs	58	21.4	21.4	21.4
	6-15 yrs	136	50.2	50.2	71.6
	16-20 yrs	47	17.3	17.3	88.9
	Above 20 yrs	30	11.1	11.1	100.0
	Total	271	100.0	100.0	

Location of Practice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Awka Evirons	128	47.2	47.2	47.2
	Onitsha Environs	69	25.5	25.5	72.7
	Nnewi Environs	74	27.3	27.3	100.0
	Total	271	100.0	100.0	

Marital Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Married	214	79.0	79.0	79.0
	Not Married	57	21.0	21.0	100.0
	Total	271	100.0	100.0	

Age in Years

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	30-40 yrs	72	26.6	26.6	26.6

Valid	41-59yr	150	55.4	55.4	81.9
	60yrs & Above	31	11.4	11.4	93.4
	4.00	18	6.6	6.6	100.0
	Total	271	100.0	100.0	

Religious Affiliation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Christian	217	80.1	80.1	80.1
	Moslem	12	4.4	4.4	84.5
	African Religious Tradition	30	11.1	11.1	95.6
	Others	12	4.4	4.4	100.0
	Total	271	100.0	100.0	

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Floor tile durability
  /METHOD=STEPWISE Floor tile strength
```

Descriptive Statistics			
	Mean	Std. Deviation	N
Floor Strength	3.8	1.0846	277
Floor Durability	3.9	1.2250	277

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method

1	Floor tile strength	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Floor tile durability

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.572[a]	.328	.326	1.96495	.328	169.003	1	347	.000

a. Predictors: (Constant), Floor tile strength

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	652.526	1	652.526	169.003	.000[b]
	Residual	1339.778	347	3.861		
	Total	1992.304	348			

a. Dependent Variable: Floor tile durability

b. Predictors: (Constant), Floor tile strength

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	16.700	1.239		13.482	.000
	Floor tile strength	.501	.039	.572	13.000	.002

a. Dependent variable: Floor tile relative durability