

BUILDING EXTERIOR PAINT PERFORMANCE IN TROPICAL SALTY  
ENVIRONMENT OF LAGOS

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## **DEDICATION**

This thesis is dedicated to the glory of God and for the benefits of mankind

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## ABSTRACT

Materials that are used for exterior finishes of buildings are their last line of defence against the elements of climate. The compliance of the materials with the environment will determine their performance and consequent repainting. A high percentage of buildings' exterior surfaces are finished with paint in Lagos in the south-western region of Nigeria that has additional climatic stress of saline air from the Atlantic Ocean. This research examines the factors that influence the use of paint and the occurrence of salt impact indicators as parameters for measuring its performance in Lagos, Nigeria, in order to determine the repainting requirement when applied as exterior finish. A mixed approach of qualitative and quantitative methods was used. Survey was done to collect data for the analysis. The study area was bifurcated into two zones (Zone A & B) in order to compare the performance of painted exterior of the buildings along the coast with the hinterland. After exhaustive literature search, variables identified were used to investigate the phenomenon. While some variables were measured using Likert's scale, some were simply measured through categorical and continuous scales. A total of 317 questionnaires were returned out of the 384 sample size of the first target population. Guided interview was conducted on sixteen (16) architects and six (6) paint manufacturers provided information on salt resistant paint of the second and third target population respectively. Various appropriate statistical models were used with the significance level set at  $p < 0.05$  in processing the data to obtain results for inferences. Findings show that the choice and usage of paint as exterior finish for buildings in the study area depend on experience, professional advice, availability, cost, societal influence and cultural values. The performance and climatic compliance are jettisoned because of cultural attachment to colour that paints make available with relative ease. All salt impact indicators appeared earlier in Zone A than Zone B. These also necessitate earlier and frequent repainting in Zone A. The number of years required for repainting in Zone A and Zone B are 2 and 4 years respectively compared with 5-7 years established in past researches as required for repainting in other parts of the tropical region. The outcome of the research facilitates maintenance forecast and schedule for painted exterior in the tropics.

## ABSTRAK

Sebarang bahan yang digunakan sebagai kemasan luar pada sesebuah bangunan membentuk pertahanan terakhir terhadap ancaman iklim. Kesesuaian bahan tersebut dengan alam sekitar akan menentukan prestasi dan pengecatan semula. Banyak permukaan luar bangunan dikemaskan dengan cat di Lagos, satu kawasan di barat daya Nigeria, yang mana udara bergaram dari laut Atlantik menjadi ancaman tambahan. Kajian ini meneliti faktor-faktor yang mempengaruhi penggunaan cat dan kewujudan indikator kesan garam sebagai parameter untuk mengukur prestasinya di Lagos, Nigeria demi untuk menentukan keperluan pengecatan semula apabila diaplikasikan kemasan luar bangunan. Pendekatan kaedah campuran adalah pendekatan kualitatif dan kuantitatif yang digunakan di dalam kajian ini. Kajian soalselidik digunakan untuk mengumpulkan data bagi tujuan analisis. Kawasan kajian adalah terbahagi kepada dua zon (Zon A dan B) bagi membolehkan perbandingan prestasi cat luaran pada bangunan sepanjang persisiran pantai dan pendalaman dilakukan. Setelah kajian literasi secara menyeluruh dilakukan, pembolehubah yang dikenalpasti digunakan untuk menyiasat fenomena ini. Sebahagian dari pembolehubah tersebut diukur menggunakan skala Likert, sementara yang selebihnya diukur menggunakan skala berkategori dan berterusan. Sejumlah 317 borang soal selidik telah dikembalikan daripada 384 saiz sampel bagi sasaran populasi kajian pertama. Temubual secara langsung telah dijalankan ke atas enam belas (16) arkitek dan enam orang (6) pengeluar cat telah memberikan maklumat mengenai cat tahan garam daripada populasi sasaran kedua dan ketiga setiap satunya. Pelbagai model statistik yang bersesuaian digunakan dengan kadar keyakinan diletakkan pada  $p < 0.05$  ketika pemprosesan data dilakukan untuk mendapatkan keputusan bagi membuat kesimpulan. Kajian ini mendapati bahawa pemilihan dan penggunaan cat sebagai kemasan luaran bagi bangunan-bangunan di dalam kawasan kajian adalah bersandarkan kepada pengalaman, nasihat profesional, ketersediaan, kos, pengaruh masyarakat dan nilai budaya setempat. Prestasi dan kesesuaian terhadap iklim tidak menjadi penentu sebenar penggunaan cat kerana pengaruh budaya yang banyak berkait dengan warna juga memainkan peranan, serta cat mudah pula diperolehi di mana-mana. Semua indikator impak garam wujud lebih awal di Zon A dari Zon B. Ini juga menyebabkan proses pengecatan semula berlaku lebih awal dan kerap di Zon A. Zon A memerlukan pengecatan semula setiap 2 tahun sementara Zon B memerlukan 4 tahun, berbanding 5-7 tahun tempoh pengecatan semula bagi kawasan-kawasan tropikal yang lain seperti yang diterbitkan dalam kajian-kajian yang terdahulu. Hasil kajian ini mempermudah anggaran dan penjadualan pemeliharaan cat sebagai kemasan luaran bangunan di kawasan tropika.

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## LIST OF ABBREVIATIONS

-2LLD	-	-2Log Likelihood
ANOVA	-	Analysis of Variance
AWT	-	Accelerated Weathering Test
BG	-	Between Groups
COE	-	Coefficient of Expansion
CSS	-	Continuous Salt Spray
df	-	Degree of Freedom
DV	-	Dependent Variables
EUT	-	Expected Utility Theory
H-L	-	Hosmer and Lemeshow
IV	-	Independent Variables
LB	-	Lower Bound
LGA	-	Local Government Area
LLR	-	Likelihood Ratio for Individual Variables
LRT	-	Likelihood Ratio for Overall Variables
MFC	-	Model fit Criteria
MFI	-	Model Fitting Information
MS	-	Mean Square
MV	-	Major Variables
PG	-	Predicted Group
PPI	-	Paint Performance Index
PPM	-	Permille (parts per thousands)
PRG	-	Percentage Recovered per Local Government
PRZ	-	Percentage Recovered per Zone
QA	-	Questionnaires Administered
QR	-	Questionnaires Recovered
RF	-	Repainting Frequency

SCA	-	Salt Content Analysis
SD	-	Standard Deviation
SIIs	-	Salt Impact Indicators
SS	-	Selected Status / Sum of Square
SSR	-	Regression Sum of Square
SST	-	Total Sum of Square
TPR	-	Total Percentage Recovered
TRG	-	Total Respondents per Local Government
TRZ	-	Total Respondents per Zone
UB	-	Upper Bound
WG	-	Within Groups

**LIST OF SYMBOLS**

$\bar{X}$	-	Mean
$X^2$	-	Chi-Square
'B'	-	Unstandardized Coefficient
<i>F</i> -value	-	Fisher's F Statistics
$\beta$	-	Standardized Coefficient
$R^2$	-	Multiple Correlation Coefficient
<i>p</i>	-	Significance value
$\epsilon$	-	Residual Error
$\Theta$	-	Logit Transformation
$\alpha$	-	Constant

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background of Study**

The current appreciation of architectural edifices (aesthetically pleasing and high-tech or modern day buildings) all over the world is one of the attractions and catalyst for the current boom in property development and tourism. However, most of these buildings are not known by their functions and interior spaces to the people who mill around such wonders of the modern world. The external outlook and the treatment of the facade are usually the attracting factors. Majority are not even interested in the activities that go on in such buildings not to mention their concern for the comfort of the occupants. This suggests why the treatment and maintenance of the exterior surfaces require attention. This is why Reis and Lay (2010) advocated for proper external aesthetics evaluation and adequate maintenance of the exterior surface.

Though these parameters are actually basic and germane to the success of the architecture but the facade is the point of attraction to passers-by. These spell out the importance of building skin even beyond cost consideration. It dictates the worth of the building to the common people, adds to the aesthetic appeal of the cityscape and contributes to environmental friendliness. The selection and use of appropriate external finishes demand thorough understanding of its performance in any particular environment. Buildings in coaster areas are subjected to dampness due to the

presence of surface, ground, underground water and high humidity. Rising damp- a major source of moisture in building according to Goncalves, et al (2009) increases the amount of moisture and is detrimental to building fabric. Lagos has a high level of humidity with salt content (Adepelumi et al, 2009). These combined to deteriorate the building skin faster than the hinterland.

The aesthetic appeal, structural value of buildings and other public infrastructure in Nigeria easily depreciate. This is predicated on the inadequate information and knowledge about the content, properties and performance of materials and the types used in relation to the environment. Buildings nowadays are deteriorating at an alarming rate due to the erratic nature of the climate with its attendant consequences (Stewart et al, 2011). The effects of ocean salt built-up, intense solar radiation due to the depletion of the ozone layer, vegetal cover degradation, and high torrential rain are major concern on building exterior finishing materials.

Saline laden air which is on the increase due to climate change and ocean salt build-up is becoming devastating on building materials (Kaufman, 2003; Zahn, 2007; Ken, et al 2010 and Lstiburek, 2011). This has resulted into defaced buildings and inefficient performance of infrastructures which dot the cities-scape. Poor maintenance culture also pervades the polity (society). The level of ignorance about the characteristic properties of available building materials is very high. Onwuka (1989) states that paint (which is primarily used in the study area) if applied on any external surface in the tropics will only last for a short period of time thus signifying that maintenance has to be embarked upon more often and at a higher cost. Roy et al (1996) put it succinctly at 5-7years after which maintenance will be required. This agrees with NAHB (2000); ASTM (2005) and Bliss (2006) in respect of paint lifespan.

Okereke (2003) avers that different climatic conditions impose different requirements on the use of building materials. It determines the selection and methods of application of such materials and the need for maintenance (Butt et al, 2010). The availability, choice of materials and construction techniques greatly combine to influence and modify the form, outlook and lifespan of buildings. Buildings are found to respond to physical stresses of climate, heat, high humidity, solar radiation and saline-laden air around the Atlantic coast. The landscape around buildings also suffers the impact of these factors (Baltrenas et al, 2006).

Traditional buildings in the past took into account the forces of climate, site, height of buildings and severity of exposure to weathering (Umeokafor, 2003). Primitive builders were able to conserve their materials because they have detailed and precise knowledge of their behaviour and characteristics not just in terms of climatic response and construction but also in regard to weathering. They understood how the materials and building fabrics respond to the ravages of time and weather. This understanding tends to lead to clear and straight forward solutions to the problems of maintenance cost. Modern builders need to consider these factors carefully in the light of obvious changes in the pattern of climate. New materials are used thoughtlessly without due attention to their characteristics and reaction to climate change in the area. The use of environment compliant materials is given low consideration due to preference for culture, aesthetics desire, ignorance and economic consideration.

The poor performance of building and degradation of value being witnessed in the built environment arise primarily from the inappropriate use of materials (Folorunso, 2006a; Oni, 2010 and Adebamowo, 2011). Buildings generally are left at the mercy of the weather, and all components of buildings suffer from the influence of the same weather. The structural part are fairly agreed to be stable and require lesser maintenance. However, the last layer, the external surface which is the finishes, bears the brunt more than others thus requiring more care in terms of maintenance.

Prominent attendant problems arising from degrading factors of solar radiation, saline air, wind abrasion and torrential tropical rain to mention a few include corrosion, discolouration and fungi growth on materials with organic contents. These factors have been the cause of fast deterioration of building outlook in Lagos which falls within the warm-humid zone of Nigeria and lies along the coast of the Atlantic Ocean. This is the cause of the frequent maintenance works being carried out in the region with enormous financial implication.

A high percentage of annual budget in the past few decades have been earmarked by both the Federal and Lagos State Governments to the building industry in the name of capital projects (Oshodi, 2010). Governments at various tiers have invested billions of naira on buildings and other physical infrastructures. Individuals, corporate bodies and other organized private sectors have equally sunk enormous fund into the constructions of buildings and maintenance (Lemo, 2007; Mailafia, 2007). The building industry all over the world is waking up to the reality of erratic climate behaviour which exerts great influence on the performance and life span of finishes applied. External finishes are the worst hit by inclement weather due to the position it occupies as the last line of defence (first point of contact) in buildings (Folorunso, 2006b).

Increase in population with growing urbanization, resorted to increase of floor space, massive buildings and alteration of the ecosystem without proper structural and technical input. Akingbohunge (2002) observed that a building occupies a central place with a high premium attached to it by individual and nature. The entire global world is bereft of their adequacies quantitatively and qualitatively, due to a soaring population growth, economic meltdown and other militating forces.

Lack of equitable distribution of common wealth which determines the choice of material is gradually creating a “rot –gap” within the cities. In this part of the globe, the cost of building materials is always on the increase. By the time renovation or maintenance is required in buildings; it will be on upward spiral cost.



Maintenance cost is one of the crucial factors to be considered while selecting materials for exterior finish and not just the initial ability to purchase (Ononugbo, 2008). The prevailing global economic recession is a pointer to the fact that materials with high resistance to inclement weather that will maintain its quality over a long period of time will lessen the burden on the nation (Adebamowo, 2011). The population situation in the city also made it inevitable for the developers to exploit vertical expansion option. Lagos has the highest drift of population in Nigeria. Studies have shown that it accounts for about 10% of Nigeria's population (George, 2008). This accounts for the high number of existing high rise buildings in the city.

Tropical buildings are subjected to many mitigating elements of climate, prominent among which are sunshine and rainfall. However, the study area has an additional influence from the Atlantic Ocean which is just a few meters away from the buildings. The sea breeze is laden with high salt content as stated in the findings of Kaufman, (2003) and Adepelumi, et al. (2009). This has adverse effects and impacts on the materials used for building finishes. The outer skin-exterior surface of any building does not have any protection in most cases due to its function as the protective layer. It is pertinent therefore, to understand the characteristic behaviour of the materials in use in the area for fabric protection and its reaction to prevalent saline air. This will ensure the sustenance of aesthetic appeal, structural integrity and maintainable balance. The research is geared towards establishing the appropriateness of the use of paint in a saline air laden environment. It is also to evolve a model for its performance as exterior finishing materials for buildings in the various zones of the tropical region with Lagos, Nigeria as the case study. The research also established the longest possible period that paint applied as exterior wall finish in salty environment will last before repainting will be required.

## 1.2 Problem Statement and Formulation

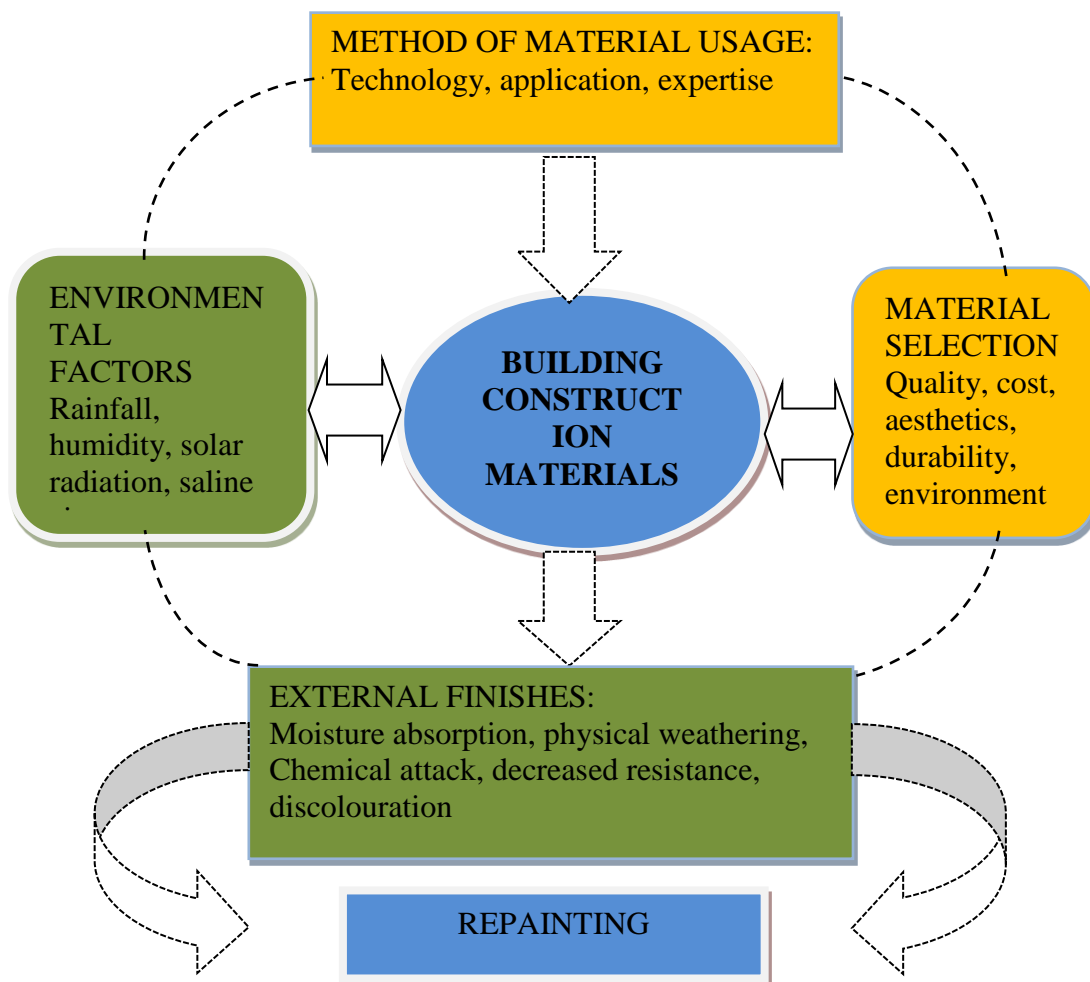
The saline content of the air in Lagos is a serious concern to developers, home owners, governments at all levels and professionals. Adepelumi et al (2009) and Ayolabi et al, (2010) identified the Atlantic Ocean as a major source of salt intrusion in Lagos which militates against the external skin of the buildings in the area. Studies have also shown that paint, the major external finishing material used in the area reacts poorly to salt in whatever form of contact (Roy, et al 1996; Morcillo, 1999; Yokoi, et al, 2002; Malshe and Waghoo 2004; Adepelumi, et al 2009, Goncalves, et al 2009, Vacher, et al 2010 and Gobakken, et al 2010).

Building materials are exposed to physical, mechanical, chemical, biological, and other factors acting in combination, or even all at the same time. Those used as external finishes have more militating factors to contend with – the elements of climate. These have impeded the performance of these materials and led to increase and frequent maintenance in recent years. Current global reality about climate change is exerting a negative influence on the built environment. Buildings cannot be divorced from the environment. The effect of climate change is more obvious on the external surface of buildings as the salt content of the ocean increases. Buildings expenditure has gulp a reasonable proportion of the total budget of the nation, corporate bodies and individuals (Ezezue, 2003). The cost required for maintenance of residential buildings is enormous because of the technicalities required especially these days of embrace of vertical expansion. Multi storey residential buildings are mostly required in Lagos because of the population. Lagos alone accounts for 27.8% of Nigeria housing deficit (Oshodi, 2010).

The use of paint as exterior finish in the tropics, especially in Lagos, Nigeria, is of late performing poorly due to the prevailing saline air and salt impacted substrate in the area. There is inadequate knowledge about the impact of saline air on the performance of paint that is commonly used in the area. Usages of non-climate

compliant and non-salt friendly building materials are posing great challenges to buildings around the coast of the Oceans around the world (Corvo et al, 2010). Figure 1.1 explains the dependence of maintenance on the type of building materials used. The performance of exterior finishes is dictated by material selection criteria, method of application and environmental factors. Although manufacturers have simple guide for repainting which stipulates 5-7years as obtained from various laboratory testing and past researches, the performance of paint in salt laden environment is better measured through actual experience (Arizzi et al, 2012; Yang et al, 2012; de la Fuente, 2007; Morcillo, 1999). This indicates that further studies are required to ascertain the actual requirement for repainting in such areas.

Salt content analysis (SCA), Continuous salt spray (CSS) or accelerated weathering test (AWT) could have been used for this research but only a limited result will be achieved. Salt content analysis will only confirm the presence of salt in the applied paint films while CSS or AWT will only confirm the occurrence of SIIs. All these experiments have been carried out and found to be inadequate (Lin et al, 1993; Morcillo, 1999; de la Fuente et al, 2006; Chico et al, 2008; Morcillo et al, 2011). It is only through field measurement that the time of the occurrence of SIIs can be measured in order to determine the frequency of repainting of exterior walls of buildings in salty environment such as the study area. This research seeks to investigate the performance of painted exterior of buildings that are subjected to the impact of saline air from the Atlantic Ocean.



**Figure 1.1** Problem Formulation

### 1.3 Aim

Apart from adding aesthetic value to buildings, the exterior finish is required to protect the fabric against the stresses of the environment. This underpins the importance of the compliance of materials used for exterior finish to prevailing micro-climate. This research is aimed at determining the performance of paint used as exterior finish of buildings in the tropical salty environment of Lagos, Nigeria with the intent of establishing the repainting frequency. This will serve as test bed for buildings' exterior in salty environment within the tropical region.

## 1.4 Objectives

The above stated aim will be achieved through the following objectives; to:

- (1.) Examine the factors that are responsible for the choice and use of paint as exterior finish within the peculiar environmental condition of Lagos.
- (2.) Establish correlation between the use of paint and the culture of the predominant people in Lagos.
- (3.) Compare the performance of paint as exterior building finish along the Atlantic coast with the hinterland.
- (4.) Determine the repainting frequency and reliability of paint in-service at the sea side compared with the hinterland.

## 1.5 Research Hypotheses

To achieve the aim and objectives of this study, the under listed hypotheses are proposed based on the theoretical framework. These were tested with appropriate statistical tools.  $H_0$  represents null hypothesis while  $H_1$  represents the alternative for each hypothesis:

1,  $H_0$ : The choice of paint as exterior finish does not significantly depend on the performance and environmental condition of Lagos ( $X_1=X_2$ ).

$H_1$ : The choice of paint as exterior finish significantly depends on the performance and environmental condition of Lagos ( $X_1\neq X_2$ ).

2,  $H_0$ : There is no significant correlation between the culture of the people and the use of paint in Lagos ( $X_1=X_2$ ).

$H_1$ : There is significant correlation between the culture of the people and the use of paint in Lagos ( $X_1\neq X_2$ ).

3,  $H_0$ : The prevailing saline air does not have significant impact on the performance of paint used as exterior finish at the sea side compared with the hinterland ( $X_1=X_2$ ).

***H<sub>1</sub>***: The prevailing saline air has significant impact on the performance of paint used as exterior finish at the sea side compared with the hinterland ( $X_1 \neq X_2$ )

4, ***H<sub>0</sub>***: The frequency of repainting of painted exterior wall of buildings at the sea side is not significantly different from those at the hinterland in Lagos ( $X_1 = X_2$ ).

***H<sub>1</sub>***: There is significant difference between the frequency of repainting of painted exterior wall of buildings at the sea side and the hinterland ( $X_1 \neq X_2$ ).

The research hypotheses are measured by relating different variables with each other as later described in chapter four

## **1.6 Significance of the Study**

This research significantly impact the quality of buildings' outlook in the region by establishing relationship between saline air and the performance of paint applied as building exterior wall finish in the coastal region of the Atlantic Ocean and other parts of the tropical region. It enhanced the implementation of maintenance policy, planning and programme. It also provided property developers the assurance of the reliability of their choice and future expectations on maintenance. The impact of culture on the use of paint was established in the study area. The performance of paint in tropical salty environment is developed to enhance professional advice, specifications and repainting schedule in the tropical region.

In most cases and in most economies, architects are saddled with the responsibility of specifying materials for building construction (Folorunso and Fadamiro, 2009). The level of knowledge possessed by these professionals determines to a large extent the type of materials they specify especially the materials that are meant for exterior finish. Since exterior finishes in buildings are

required to mitigate the stresses of climate and primarily protect the fabric from degradation as stated in the opinion of Folorunso (2006a), adequate knowledge is required about the performance of these finishing materials under different climatic conditions.

Paint as a material that is commonly used for exterior finish of residential buildings in sub-sahara Africa especially in Nigeria requires investigation. Lagos alone accounts for about 10% of Nigerian population with over 1million housing stock (Oshodi, 2010). A high percentage of these residential buildings are finished with paint. However, with the presence of the Atlantic Ocean that stretches through the longer part of the state, the additional impact of saline air apart from other tropical climatic factors constitute a major source of paint degradation and concern for stakeholders.

The rate at which buildings outlook become defaced thus requiring repainting with enormous financial implication demand that researches are conducted to investigate the difference in the performance of paint that is commonly used in the area compared with other parts of the tropical region. This research understudied the impact of saline air on painted exterior in the area to avail architects as specifiers with adequate knowledge about paint. It also sought to advocate for possible improvement of the material in terms of its ability to resist salt attack. It provided insight into the preparation of maintenance schedule for painted exterior within the tropical region.

## **1.7 Scope and Limitations of the Study**

This study is focused on one of the climatic factors that determine the use and performance of paint applied on buildings' exterior in the area. It focused on the

impact of saline air on paint as exterior finishing material for residential buildings in Lagos which is located at close proximity to the Atlantic Ocean. The rate at which the prevailing saline air determines the frequency of maintenance was examined; appraisal of the characteristics of paint as exterior finishing materials and its reaction to different zones of the tropics was also examined. It focused on the maintenance need of paint in-service and other parameters involved in sustaining the qualities of residential buildings' outlook in salty environment.

The study engendered in its course fresh research into the implications of saline air on painted building surface. The need and time-year for repainting and alternative materials for external finishing with higher tolerance to saline air for buildings in Lagos as a case study for the buildings along the Atlantic Ocean are reviewed. The results of this investigation will provide a model for the selection of paint as external finishing materials and information for proper maintenance planning and policies. The focus on residential buildings is predicated on the fact that residential units form the bulk of housing stock in the area. Lagos also needs more residential units to cater for the large population with limited land mass. Due to high population, Lagos may be forced in no distant future to embrace vertical expansion. Though this may attract initial resistance from the populace because of cultural alteration that may ensue, however, the available inelastic land for construction of buildings may support this development.

The study is limited to Lagos out of all the numerous cities and human settlements that are located along the coast of the Atlantic Ocean both in Africa and America although similarities and difference between the climatic condition of Lagos and some cities that are located along the Atlantic Ocean are later described in the study. This indicates that a comparative analysis with other climate could not be achieved thus reducing the possibility of generalising the findings. The magnitude of the coverage area, selection of buildings and respondents and huge financial cost of enumeration also reduced the sample size to selected areas. The study was limited to residential buildings within selected areas in selected Local Government Authorities within Lagos State.



## 1.8 Research Gap

Many performance indicators (PIs) have been evolved in recent past in the field of building materials and maintenance. Some of these include building performance index (BPI), manpower sources diagram (MSD), managerial span of control (MSC), business availability (BA), manpower utilization index (MUI), urgent repair request index (URI), maintenance efficiency index (MEI), maintenance productivity (MP) and preventive maintenance ratio (PMR) (Augenbroe and Park, 2002; Barber and Hilberg, 1995; Chan et al, 2001; Shohet et al 2003; Flores-Colen et al, 2009a; Flores- Colen et al, 2009b and Flores-Colen et al, 2010).

A material performance index (MPI) that identifies the performance of materials to enhance awareness maintenance under specific climatic condition has not been developed. However, MPI is a broad area that covers all building materials which cannot be covered in a single research. Paint is one of the major materials used in building exterior finish and according to de Silva and Ranasinghe (2010). It is the third material on the rank of maintenance frequency. Although it had been established that paint as a finishing material for building exterior, requires maintenance when used in a normal condition after every 5-7years as posited by Onwuka (1989); Roy et al (1996); Bliss (2006); Ashafa (2010), its maintenance requirement has not been established when used in an environment with prevalent saline air.

The earliest time during which salt impact indicators (SIIs) will appear on the applied paint thus necessitating repainting has not been established for such environment. Current researches are focused on several types of façade renders especially on techniques to be applied to façade render in-service (Flores-Colen et al, 2011). Some of the materials under consideration are timber structure, renders or various plaster materials. Attention is not given to paint that is mostly used in residential buildings especially in the developing countries. This research fills this gap by determining the maintenance frequency of paint used as exterior finish in

areas that are subjected to direct and indirect saline air. It also compared the findings with previous researches earlier cited.

Again the longest part of Africa- a less developed part of the globe lies on the Atlantic Ocean which is one of the saltiest oceans in the world (Adepelumi et al, 2009). Because of low economic capability, most buildings are not finished with high-tech materials such as glass, glazed tiles, aluminium panels, synthetics to mention a few that can withstand the stresses of the saline content in the air for a longer period, hence, research on how to improve the usage of paint that is commonly used in the area remains an area that requires attention.

Most researchers do not even consider getting the outcome of their research in the area of building materials across to architects who actually specify what material to use in every building project. Ravikuman et al (2012) for example overtly omitted architects in the recommendation of their research findings. However the use and application of their recommendations in the building procurement process are the duties of architects. Several researches have been carried out in order to determine the critical level of salt (chloride and sulphate) attack above which paint applications will fail on different substrates (Lin et al, 1993; Morcillo, 1999; de la Fuente et al, 2006; Chico et al, 2008; Morcillo et al, 2011). These researches were borne out of the perennial problem of salt on building materials. These studies involved several types of methods such as field studies and laboratory test that are aimed at determining the effects of soluble salt on painted surfaces.

Some of the studies focused on how to prepare surfaces that are contaminated before paint is applied. Some of the aforementioned researchers adopted homogenous dosing system which is based on spreading of salt solution as a contaminant on the surface to effect simulation. This system was found not to adequately represent the real distribution of salts that occurs in the atmosphere (Morcillo, 1999; de la Fuente et al, 2006). Other methods include accelerated corrosion cabinets, impactor method through sub-microscopic or microscopic

crystals and droplet method that adopt spreading of salt droplet solution homogeneously on a polished substrate that generates salt agglomerations. The outcomes of these researches show that the presence of salt on substrate poses a negative impact on building materials (Komshin, 2010), increases demand for maintenance activities and consequently impact negatively on the environment.

## **1.9 Justification of the Study**

The population drift to Lagos constitutes a great pressure on the housing need of the city. This demand makes it exigent for the development of more residential buildings. It is obvious with this trend that most existing low rise buildings will still give way for future development that will cater for higher population as buildings in Lagos becomes more sophisticated (Olaleye and Adegoke, 2009). The maintenance of external surface of these residential dwelling units is a serious challenge due to the saline content of the air that is prevalent in the area, individual life style and low maintenance education of users and owners. These calls for attention on how these residential buildings are handled and how the materials used as external finish to ensure the continuous aesthetics of the city's vista are selected.

Diogu and Onyegiri (2007) put it succinctly that research and postulations will continue to be the pointer in discoveries on observable and discrete phenomena about reality. They aver that myriads of processes take place in the built environment and only a well-planned and thought provoking research can assist the understanding of these phenomena, and by extension, harness them to enhance human liveability. Akingbohunge (2002) agree that the vista condition of buildings in Nigeria reveals a pathetic picture of neglect, deterioration, decay, dilapidation and threatening collapse. Maintenance attitude at both private and public sectors of the national life remains discouraging, uncoordinated and dismal to the aggravation of the already critical cities vistas, values and sustainability. By persistently neglecting the choice

of appropriate materials, building decay and depreciate at a fast rate with attendant financial implication. The huge financial value of buildings, its place in human need and over bearing influence on human comfort confirm them as important physical assets. The extension of their structural, aesthetics and economic life cycle is therefore a matter of utmost concern.

In the findings of Hyde (2000) the design of the wall elements is of critical importance if a harmony with nature is to be achieved. The climatic forces of saline air, rain, sun and wind exert enormous pressure on building exterior so much that the wall element has to be considered in terms of resistance and regulation of these forces. Due to the number of relationships that require consideration, the external wall is the most complex of elements to design from the climate point of view (Hyde, 2000). The research is geared towards establishing the appropriateness of paint as external finishing material in an area laden with saline air, the merits and demerits of its usage in the face of rapid frequency of deterioration of paint used in salty environment.

## **1.10 Thesis Structure**

This thesis is divided into six chapters. Comprehensive background information about the subject matter, focus of the research and the whole thesis are presented in this chapter designated as **Chapter I**.

**Chapter II** presents a holistic search through literature on the performance of building materials in general and paints as exterior finish in particular. Adequate attention is given to the impact of salt on paint used as exterior finish of buildings around the Atlantic Ocean. Past researches that investigated different salt attack indicators or symptoms of painted surface under salt attack are critically reviewed

and evaluated. This chapter also reviews the culture of colour among the predominant Yoruba people of the study area which supports the use of paint in anticipation of achieving the subsisting cultural values though without due recourse to climatic compliance of paint. Issues relating to salinity of the Atlantic Ocean are thoroughly discussed. The prevalence of saline air in the area is established. Other types of materials used for exterior finish in the study area are briefly discussed. In addition, various methods of carrying out maintenance works on exterior façade are mentioned.

**Chapter III** discusses the study location in-depth. The peculiarity of the study area in comparison with other parts of the country is clearly stated. It described the study area with respect to adjoining areas. This chapter includes the climatic data of the area and climatic data of the salinity of the Atlantic Ocean which is observed twice daily. Climatic data for salinity is only taken in Lagos in the whole country because of the prevalence and the devastating effect of salt on the built environment.

**Chapter IV** presents the methodology used in investigating the usage of paint in Lagos as a whole and the performance of paint in the two zones into which the study area is bifurcated. The chapter opens with a review of various methodologies adopted in past researches carried out to investigate the performance and degradation of paint and decided on which method to adopt. The justification for adopting the selected method is also stressed. This chapter explicitly described all the statistical models used in analysing the obtained data and the suitability of each model to the types of data collected. Reasons for any cross tabulation done are also given. The reliability of the research instrument in measuring the phenomenon is presented in the pilot study report that was conducted before the actual field survey. Adjustments that were made to the instrument are succinctly discussed.

The results obtained through various statistical models are presented and discussed in **Chapter V**. These include descriptive analysis of all the variables for choice of paint and cultural influence on the use of paint in Lagos and the occurrence

of salt impact indicators in both zones as well as the variation in the frequency of maintenance of painted exteriors in both zones. Different regression models were used for hypotheses 1 and 2 while the difference in the occurrence of salt impact indicators and frequency of maintenance were tested through One Way ANOVA for hypotheses 3 and 4 for individual variables. The collective difference of the variables for hypotheses 3 and 4 were tested through binomial or binary logistic regressions. The results obtained are critically discussed in this chapter.

**Chapter VI** concludes the thesis with the theoretical statements on findings. The conclusion drawn on the maintenance requirements of paint used in areas prone to saline air are equally presented. The recommendations that require practical application and the importance of the findings to the building industry practitioners especially architects are emphasized. Further windows for future research are identified and opened. The limitations of this research are also itemized.

## **1.11 Chapter Synopsis**

This chapter identified the fundamentals and basis for this research. The aim and the objectives of the research were set with testable statements of assumptions. It identified various problems that are associated with the use of paint as exterior finish and justified the need for this study. Past researches that were carried out in the area of building materials and maintenance were itemized, areas that are yet to be researched into were mentioned and the gap that this particular research seeks to fill is clearly stated.

The expected contributions of the outcome of the study to the existing body of knowledge are discussed in the significance of the study. The possible shortcomings of the research are stated in the scope and limitations. The use of paint

as exterior finish for residential buildings by majority of the people in the study area justified the selection of paint for the study especially in a tropical zone with additional stress of saline air.

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