THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Effects of Weather on Service Lives of External Building Finishing: A Case Study of Ilaro, Nigeria

A. A. Aiyegbajeje
Lecturer, Department of Architectural Technology, Federal Polytechnic Ilaro, Nigeria

Abstract:
Building finishes are the final internal and external coating of a building used to protect and beautify it. External finishes are exposed to environmental conditions hence are usually more rugged than the interior coatings This paper reviews the effect of weather on the service lives of exterior finishing materials of some selected buildings in Ilaro by visual observation of the types of defects and questionnaires to determine the ages and other factors necessary to determine the causes of the defects. The result shows that the effect of weather on service lives of these finishing materials depends on other factors like construction methods and workmanship, location of the buildings, usage and frequency of maintenance of the building and so on.

Keywords: *Weather, service lives, external building finishes*

1. Introduction

Service life of a building finishing material is the period within which the material will serve before it deteriorates. All finishing materials have a service lives however most of these materials do not always attain their service lives before they deteriorate. A number of factors are responsible for this. Climate is one of the major factors causing deterioration of building envelope and coatings.

Chew and Harikrishna (2005), Norvaišiene Miniotaite and Stankevicius (2003) classified atmospheric factors into natural (precipitation, wind, temperatures, solar radiation) and complex chemical and biological processes caused by air pollution. However,Aluko O. Olanipekun O. Olu O. (2013) grouped the major factors that influence the service life of building finishes under four categories vide climate, material composition of the finishing materials used, degree of workmanship and building characteristics. They stated that the climate across the country aids the deterioration of building materials particularly those used in the facades.

External coatings of buildings are subjected to external environmental conditions such as humidity from rainfall, heat from sunlight and abrasion from the wind and polluted environment. High humidity on wall can cause Peeling of paint and growth of mold and mildew. Sunlight on painted exterior building walls can result in blistering, peeling, fading chalking and cracking**.**

2. Significant of the Study

Nigeria of today is going through economic problems thus maintenance cost needs to be reduced as much as possible. That is why it is pertinent to reduce the frequency of building maintenance by maximizing the service lives of façade materials. In Ilaro the common exterior walls coating material is paint on cement sand screed walls, plastered and unplastered walls. Few commercial and institutional buildings have glass as their external wall finish. All these buildings have attained various degree of deterioration and require maintenance even the ones that were completed within the last ten years. Going by the current trend materials that are designed to last for fifteen years before deterioration may have their service lives reduced by less than half of its expected time.

The beauty of a building depends on prompt maintenance of its façade. If the service lives of the exterior coating are not maximized the cost of building maintenance will be very high. Life cycle costs (LCC) analysis – following service-life prediction results – leads to the conclusion that maintenance and replacements costs account for 10–80% of initial capital costs. Igal M. and Monica P (2004). In Singapore, where building maintenance is done as at when due, the annual maintenance expenditure for residential buildings has risen from$11/m2 to $38/m2 over a period of about 10 years (Building and Construction Authority Pilot Study Report 2000). Aluko, Olaniyi O, Ogunsote, Olu. Ola. (2013) on the other hand observed that in Nigeria, the cost of maintaining FESTAC Building, National Stadium and various Housing Estates all in Lagos has been on the astronomical increase. Thus, they are usually left to decay to dilapidation state before they are rehabilitated.

This study looks critically into the effects of the wet and humid environment in Ilaro town have on materials used for exterior coatings of buildings and that whether those materials actually attain their normal service life before deterioration, and proffer solutions on how to protect building exterior from clement weather for sustainable performance to reduce maintenance cost.

3. Aim of the Study

The aim of this paper is to identify the rate of reduction of service lives of external coating s of building materials caused by the elements weather as well as their damaging effects on these exterior coatings and suggest how to maximize the service lives in order to reduce maintenance cost and hence maintain a beautiful environment.

4. Review

In Ilaro paints of different types and colour on sand screed cement plastered facades are used extensively as an external wall finishing material. They are also applied on concrete surfaces, non-plastered brick and block walls façade, mosaic wall tiles and other decorative wall tiles finish.

Paint on plaster finish may not perform in the manner intended and fails to provide the desired functionality for the intended time period possibly due to its exposure to the adverse wet and humid environmental conditions, poor workmanship during application and inadequate quality of the finishing material or substrate. Durability of the external coating of building surfaces depends on prevailing climate effects and on a complex of physical and mechanical values of the materials used (Lentinen, 1996; Freitas, 1996, Bednar and Dreyer, 1999).

There is a clear need to identify the different nature and influence of these factors in order to arrive at cost effective ways of preventing and dealing with such defects. The beauty of a building depends solely on the quality and appearance of its exterior walls that is why more attention is paid to exterior wall during maintenance. The cost of maintenance is sometimes up to 80% of the initial capital. Boussabaine and Kirkham (2004); Hajj and Horner (1998) also agreed that the maintenance and upkeep of the external finish of a building is seen as an essential component of any building programme because of its decorative or aesthetic purpose thus epitomizing its image and provides protective functions to its underlying layers. Aluko, Olaniyi O, Ogunsote, Olu. Ola. (2013) on the other hand observed that in Nigeria, the cost of maintaining FESTAC Building, National Stadium and various Housing Estates all in Lagos has been on the astronomical increase. Thus, they are usually left to decay to dilapidation state before they are rehabilitated.

In Singapore, where building maintenance is done as at when due, the annual maintenance expenditure for residential buildings has risen from $11/m2 to $38/m2 over a period of about 10 years (Building and Construction Authority Pilot Study Report 2000).

4.1. External Finishes and Climatic Factors

Exterior part of building enclosures and its coatings are affected directly by the climate of its environment. Climate is one of the major factors causing deterioration of building envelope and coatings. Chew and Harikrishna (2005), Norvaišiene Miniotaite and Stankevicius (2003) classified atmospheric factors into natural (precipitation, wind, temperatures, solar radiation) and complex chemical and biological processes caused by air pollution. (Ramanauskas and Stankevičius (2000) maintained that the durability of external finishes is determined by the following properties;

- Frost resistance, i.e. the capability of a moisture-saturated material to resist temperature fluctuation through freezing and thawing cycles
- Moisture resistance, i.e. the capability of a material to resist the periodical moisturizing and drying cycles
- Corrosion (chemical impact) resistance, i.e. the resistance to solutions of dissolved aggressive destructive chemical agents. UV radiation, causing photochemical reactions on surfaces, can also be considered as a chemical impact.

In addition to these there is also the construction method that allows the periodic capillary action of underground water from the foundation to the super structural walls in waterlog areas (fig. 1).

Haneef, Dickinson and Johnson (1999) summarized the mechanisms that contribute to deterioration as:

- Physical mechanisms. The presence of water is known to be a key factor in promoting the fracturing and erosion of building envelope and coating. Water penetrates the pores and cracks and causes mechanical stresses both by freezing and by the hydration and subsequent crystallization of salts. High-quality acrylic latex paint works best in the sun, since this type of paint includes durable pigments and a top-shelf binder that prevents it from breaking down. Weatherproof or sun proof paint can give your home even more protection from the elements of weather
- Chemical mechanisms. Some deposited chemical agents react with surfaces. Sulphur compounds have been indicted as the most critical factors in this regard, mainly because they are often acidic and can have high concentrations in city and suburban air; however, nitrogen compounds should be considered as well. Fluxes of trace gases (e.g., sulphur dioxide) can be high, especially when promoted by biological activity. Dissolution by chemical reactions with contaminants contained in precipitation is one of the most familiar eroding processes, particularly in the case of carbonaceous stone.
- Biological mechanisms. Many different biological factors have been found to be important. Growths of lichens, mosses, algae, mould, fungi and bacteria are capable of promoting surface deterioration. Some bacteria can synthesize sulphuric (or nitric) acid from airborne sulphur dioxide (or nitrogen oxides).

4.2. Effects of Acid Rain on Buildings

Acid rain has been shown to have adverse impacts on forests, freshwaters and soils, killing insect and aquatic life-forms and having impacts on human health. (Miller and Galloway 1987). External buildings finishes have always been subject to attack by weathering; the effects of rain, wind, sun and frost accelerate the rate of this damage. Acid deposition affects marble, sandstone and paint. Cathedrals such as York Minster and Westminster Abbey have been severely affected in recent years. The Taj Mahal in India, the Colosseum in Rome and monuments in Krakow, Poland are continuing to

deteriorate. Cologne Cathedral, Notre Dame, Westminster Abbey in Sweden, medieval stained-glass windows have been affected by acid rain. (Schulz, Trubiroha, Schernau and Baumgart 2000). In Nigeria, Festac Building, National Stadium and various Housing Estates all in Lagos are typical examples. Ilaro is very close to Dangote Cement at Ibese and Lafarge cement at Ewekoro and they emit cement dust into the atmosphere.

4.3. Effect of Capillary Action on Buildings

Capillary action occur on building that are not properly constructed in waterlog areas, the foundation walls are raised directly from the footings through the soil to the roof without the provision of damp proofdevices. Periodic rainfalls soak the wall from the foundation to the super structural walls by capillary action, fig.1, thereby weakening the wall finishing materials and gradually reducing the service lives of the finishing materials such as plaster and paint. Plate 1is an example of buildings that are affected by capillary action.

4.4. Visual Survey

Visual surveys were conducted from a sampling frame comprising buildings randomly selected in Ilaro town photographs of some selected buildings were also taken. These surveys recorded information about:

- Building characteristics pertaining number of storey, and colour of the external paintwork.
- Environment of the building which included proximity to, traffic and industrial areas.
- The occurrence of the various defects on the external finish in terms of extent of spread or area of façade affected. selected buildings are residential, commercial and institutional buildings of various shapes and sizes.

Individual owners of residential buildings and commercial buildings are responsible for their maintenance while the management of the institutions is responsible for the maintenance and upkeep of their various structures. Information about the age range to which these buildings belong was obtained from interview from respective landlords and Works Department of the institutions. Random sampling was adopted in the selection of these buildings.

Locations	Number of Buildings Surveyed	Percentage (%)
Express	17	20
Orita. Oja Odan road	38	45
Library area	5	6
Ona Ola Road	25	29
Total	85	100

Table 1: Location of Buildings
Source: Field Survey (2017)

5. Findings and Discussion

Information obtained from the field revealed that element of weather form the major factors in the service lives reduction of external coating materials. Other factors like material composition of external finish used, quality of workmanship and building characteristics act as catalyst to the climatic condition of the ambient environment.

Factors	Characteristic Features	Associated Defects
Temperature	Temperature and temperature fluctuations Amount of absorbed radiation depends on colour	Physical weathering and Cracking
Ultra violet Radiation	Amount of Ultraviolet radiation influenced by latitude, hours exposed to sunlight and angle of exposure of façade.	Discolouration and Chalking
Moisture	Affect substrate and underlying layers of building	Blistering Efflorescence Blistering Efflorescence Microbial growth, Flaking
Wind	Wind speed affects concentration of pollutants hence rate of deterioration. Nature of wind affects dispersion of atmospheric pollutants	Microbial growth Deposit of dirt.

Table 2: Factors under Building Characteristics and Associated Defects
Source: Chew and N. Harikrishna (2005)

Factors	Characteristic Features/ Considerations	Associated Defects
Orientation	+ Façades directly exposed to sunlight undergo greater physical weathering leading to chalking of paint. + Facades facing away from direct radiation are comparatively colder and damper providing ideal conditions for algae and other microbial growth + The intensity and duration of sunlight that a surface receives affect the limit of runoff flow, the type of biological stains and hence the pattern of staining.	+Chalking +Algae Growth +Staining
Height	+ Tall buildings are at greater risk to deterioration due to their direct exposure to impacting rain and ultraviolet radiation [Choi 1994] + Wind speed varies with height due to the level of openness as well as the instability of air at higher levels + Costs of maintenance and repair of defects to the façade higher for higher storeys due to additional costs in the form of scaffolding + Safety during work in higher storeys is another concern	+ Greater rate of weathering and discolouration at higher storeys
Surrounded by Other Buildings	+` Presence of adjacent buildings provides a sheltering effect + May result in slower drying period for façade after it has been wetted, leaving it damp for longer periods and therefore promoting biological staining	+Biological Staining +Algae growth
Age	+Natural tendency of material to undergo deterioration with time + Condition and serviceability period of the underlying substrate layers of the building have an effect on the exterior paint finish +Gradual loss of protective and other properties of the paint finish itself with age	+ Cracking +Chalking +Flaking/ Peeling

Table 3: Building Characteristics That Affect the Durability and Service Life of External Finishes
Source: Chew & Tan (2003)

5.1. Climatic Condition in Ilaro

Ilaro falls within the Tropical Rainforest zone, its geographical coordinates are 6^0 53' 20" North and 3^0 1' 0" East and it is at 73m above sea level.

Average annual temperature in Ilaro is 26.9°C and average annual precipitation is 1257mm. The lowest precipitation of 12mm occurs in January and the most in June with average of 218mm. Average temperature in August is 24.7C which is the lowest temp in the whole year. In March average temperature is 28.8C and it is the hottest month in the year. The daily temperature in Ilaro ranges between an average minimum of 23 °C to a maximum of 34.2 °C.

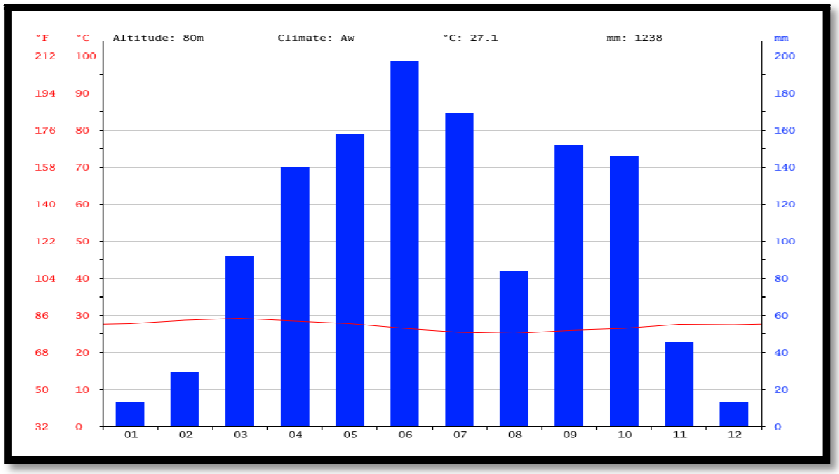

Figure 1: Annual Rainfall Pattern In Ilaro
Source: https://en.climate-data.org/location/392390/

The least amount of rainfall occurs in January. The average in this month is 13 mm. In June, the precipitation reaches its peak, with an average of 197 mm.

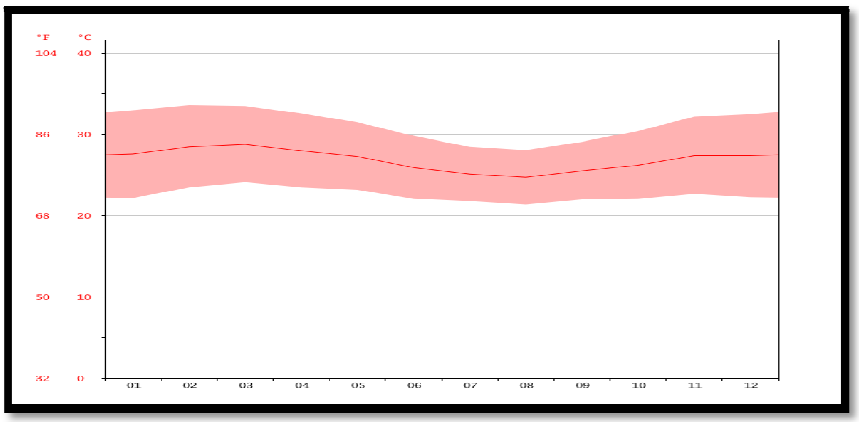

Figure 2: Temperature Graph Ilaro
Source: https://en.climate-data.org/location/392390/

At an average temperature of 28.8 °C, March is the hottest month of the year. In August, the average temperature is 24.7 °C. It is the lowest average temperature of the whole year.

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
Avg. Temp. (°C)	27.76	28.5	28.8	28	27.3	25.9	25.1	24.7	25.5	26.2	27.4	27.4
Min. Temp. (°C)	22.2	23.5	24.1	23.5	23.2	22.1	21.8	21.4	22	22.1	22.7	22.3
Max. Temp. (°C)	33	33.6	33.5	32.6	31.5	29.8	28.5	28.1	29.1	30.4	32.2	32.5
Avg. Temp. (°F)	81.7	83.3	83.8	82.4	81.1	78.6	77.2	76.5	77.9	79.2	81.3	81.3
Min. Temp. (°F)	72.0	74.3	75.4	74.3	73.8	71.8	71.2	70.5	71.6	71.8	72.9	72.1
Max. Temp. (°F)	91.4	92.5	92.3	90.7	88.7	85.6	83.3	82.6	84.4	86.7	90.0	90.5
Precipitation / Rainfall (mm)	12	33	93	131	180	218	156	72	146	154	45	17

Table 4: Climate Table // Historical Weather Data of Ilaro
Source: Https://En.Climate-Data.Org/Location/392390/

Between the driest and wettest months, the difference in precipitation is 206 mm. The average temperatures vary during the year by 4.1 °C.

5.2. Type of Buildings

The surveyed buildings are along Oja Odan road (it extends to Orita and Library area) Express road and Ona Ola road were classified as residential, commercial, Institutional, religious and mixed use. 39% of the buildings were used for residential and 26% as commercial purposes while 25% were used for both residential and commercial. 8% were used for institutional purpose and only 2% for religious purpose. This suggested that majority of the buildings (98%) were put to constant use. There were two religious buildings (Cathedral Church of Christ and Ilaro Central Mosque) selected for survey along Ona Ola road.

Figure 3: Commercial Building at Orita Oja Odan Road Completed for Over 20 Years fairly affected by Weather
Source: Authors Field Photograph 2017

Figure 4: Cathederal Church Ona Ola Road Completed for Over 50 Years Enjoys Regular Maintenance
Source: Authors Field

Figure 5: Central Mosque Completed between 20-30years fairly affected by weather
Source: Authors Field Photograph (2017)

Type	Number	Percentage (%)
Residential	33	39
Commercial	22	26
Mixed Use	21	25
Institutional	7	8
Religious	2	2
Total	85	100

Table 5: Types of Building
Source: Authors Field Survey (2017)

5.3. Age of Buildings

Analysis of data on the age of buildings in table 5 revealed that 27% of the buildings were built over 50 years ago while 42% were built within the period of 10-40 years. Only 31% were constructed within the last 10 years.

There was loss of protective properties and the conditions of the underlying substrate were in shambles in most of the buildings. 48% of the buildings external finishes have not been replaced for the past 40 years and above while 53% underwent some form of replacement within 10-50 years as shown in table 6. The two religious buildings were built within the last 20 years have also been affected by weather.

Plates 4-5. Generally, the external finishes were in a state of deterioration as a result of age of the buildings. Microbial growth, cracks, flaking and peeling were noticeable in some of the buildings. Plates 6-7.

Age (years)	Number	Percentage (%)
Above 50	23	27
30 – 40	25	29
10 – 20	11	13
Below 10	26	31
Total	85	100

Table 6: Age of Building
Source: Authors Field Survey (2017)

Figure 6: Laboratory Building Rehabilitated within The Last 10 Years at Federal Polytechnic Ilaro Badly Affected by Weather
Source: Authors Field Photograph 2017

Figure 7: Administrative Building Completed within The Last 10 Years at Federal Polytechnic Ilaro Fairly Affected by Weather
Source: Authors Field Photograph 2017

Time (years)	Number	Percentage (%)
Above 50	17	20
30 – 40	24	28
10 – 20	21	25
Below 10	23	27
Total	85	100

Table 7: Time of Replacement of Buildings Finish
Source: Authors Field Survey (2017)

Figure 8: Commercial Building with Glass/Painted/ Wall Finish along Library Area Rehabilitated within The Last 10 Years
Source: Authors Field Photograph2017

Figure 9: International Conference Centre of Finished with Glass Painted Wall at Federal Polytechnic Ilaro, Completed within the Last 10 Years Source: Authors Field Photograph 2017

Type of Finish	**Number**	**Percentage (%)**
Painted Wall	59	69.4
Cement rendered wall	13	15.3
Glass finish/ painted wall	3	3.5
Unplastered block wall	10	11.8
Total	85	100

Table 8: External Finish Materials of the Buildings
Source: Authors field survey (2017)

Figure 10: Residential Building with Unplastered Block Wall in Use for Less Than 10 Years at Express Road
Source: Authors Field Photograph 2017

Figure 11: Sport Centre Unplastered Block Wall Abandoned
For Over 40 Years at Federal Polytechnic Ilaro. Badly Affected by Weather
Source: Authors Field Photograph 2017

5.4. External Finish Materials of the Buildings

The external building finishes used in the study areas are paint, mortar plaster, glass, stone and brick. The predominant building finish used was paint which was over 69% followed by cement rendered wall (over 15%). Glass/painted block walls, were rarely used it constituted less than 4 %. (Table 7). In the painted surfaces, the effect of greater rate of weathering was observed as cracks were noticeable and there **was** general loss of appearance, stains, peeling off, separation of layers and flaking of the paint. Building façades were directly exposed to sunlight and were subjected to greater physical weathering leading to chalking of paint. (Plates 5, 6, 7 and 8). Apart from paint, 15.3% of the buildings were rendered with cement plaster only, while 11.8% of the buildings were not plastered.

Most of the buildings in this category were of one-storey types and of mixed use; the lower part being used for commercial purposes while the upper storeys were mostly residential.

It was observed that buildings whose façades were directly exposed to sunlight underwent greater physical weathering and facades facing away from direct radiation are comparatively colder and damper providing ideal conditions for algae and other microbial growth. Discolouration and deposit of dirt were common features of these buildings. (Plates 5, 6, and 7)

Figure 12: Public Toilet at Federal Polytechnic Ilaro
Completed in Less Than 10 Years, Badly Affected by Weather
Source: Authors Field Photograph 2017

Figure 13: Classroom Building at Library Area Completed
Completed in Less Than 10 Years, Badly Affected by Weather
Source: Authors Field Photograph 2017

5.6. State of Buildings

The analysis of the state of buildings in table 8 showed that only two buildings werein sound condition and required no repair one of them (The cathedral Church) was over 50 years old and the other (International Conference Centre) was below 10years. The Cathedral was maintained regularly while the Conference Centre was new (completed in 2015). They both represented 2.4% of the surveyed buildings. A total of 41.20% required minor repairs while 56.4% needed major repairs. The table showed that4.7% of buildings below 10 years required major repair while 21.2% required minor repair that implied that 25.9% of the buildings below 10 years were affected by weather and a total of 97.6% required some form of repair or rehabilitation.

Findings showed that most of the buildings in the neighbourhoods were in very poor state as only about 2.4% of them were in sound condition. A greater proportion of the buildings required major repairs to bring them to good quality. The state of repairs of the buildings took into consideration the soundness of the roofs, walls, floors and external finishes. The soundness of wall and floor mean absence of cracks on walls, surface wear, tearing or peeling off of surface plaster and paints.

Minor repair mean repainting some parts of the wall changing broken window and /or door glasses and fixing leaking roofs. Major repair ranged from total repainting of entire building walls to general rehabilitation of the whole building.

State	Age	Number	Percentage (%)
Sound	Over 50years	1	1.2
	Below 10years	1	1.2
Require minor Repair	Over 50years	4	4.7
	30-40 years	6	7.1
	10-20 years	10	11.8
	Below 10 years	18	21.2
Require major repair	Over 50years	12	14.1`
	30-40 years	18	21.2
	10-20 yeasr	11	12.9
	Below 10 years	4	4.7
Total	85	100	

Table 9: State of Buildings
Source: Authors Field Survey (2017)

6. Conclusion

Considering various factors causing the reduction of service lives of the exterior coating of buildings it is evident that elements of weather play major destructive roles. 97.6% of the survey buildings were affected by weather which includes relatively new buildings, (buildings below 10 years of age).Other factors like poor workmanship, improper orientation of buildings, inferior materials and so on are catalysts for the weather to act. It is therefore important to protect buildings from the full effects of weather by design or legislation (formulation of National Building Code) to maximize the service lives of these materials in order to reduce maintenance frequency and cost. The occurrence of defects renders the paintwork unsuitable in performing its stipulated functions and consequently affects and influences the durability and service life of paintwork Chew and Harikrishna (2005).

7. Recommendation

The following recommendations are vital in order to maintain the desired service lives of exterior coatings and minimize the frequency and cost of maintaining buildings in our towns and cities.

- National Building Code must be developed in line with various weather conditions of different parts of the country. This will set the minimum standard off materials and workmanship required for various types of building at different locations in the country.
- This should be supported by necessary legislation to ensure its enforcement at all tiers of governments

8. Reference

i. Aluko, O & Akingbohungbe, D. (2010)**.** National Building Maintenance Policy Sine Qua Non For Development in
ii. Nigeria Architecture and the National Development Agenda III . *Conference Proceedings of Architects Colloquium 2010.ARCON*, 28-34
iii. Aluko, O., Olanipekun O.& Olu,O.(2013). Assessment of External Building Finishes: A Case Study of Selected
iv. Buildings in Akure, Ondo State, Nigeria *International Journal of Engineering and Technology* 3 (5),
v. Bednar T. and Dreyer J. (1999). Moisture transport in masonry. Influence of different historic and modern
vi. renders on the moisture performance of walls under rain load, *Proceedings of 5th symposium on building physics in the Nordic Countries*, Gothenburg, Sweden, Vol. 2, 529-536.
vii. Boussabaine, A. & Kirkham, R. (2004). *Whole Life Cycle Costing: Risk and Risk Responses*, Blackwell Publishing, UK.
viii. Building and Construction Authority Pilot Study Report (2000).*Enhancing Maintainability of Buildings.* Singapore.

ix. Chew, M. & Tan, P (2003). *Staining of facades.* World Scientific, Singapore.
x. Evelyn, T. Chew M., & Harikrishna, N. (2005). An Assessment of Factors Affecting the Service Life of External Paint
xi. Finish on Plastered Facades. *International Conference On Durability of Building Materials and Components*. *LYON, France* Retrieved from http://www.irbdirekt.de/daten/iconda/06059020437 .
xii. Freitas, V. P., Abrantes V. and Crausse P. (1996). Moisture migration in building walls – analysis of the interface phenomena, *Journal of building and environment,* Vol 31, No. 2, 99-108.
xiii. Hajj, A. A & Horner, M.W. 1998, 'Modelling the running costs of buildings', *Construction Management and Economics*, 16, 459-470.
xiv. Haneef, S. Dickinson, C. & Johnson, J (1999). Effects of Air Pollution on Historic Buildings and Monuments and the
xv. Scientific Basis for Conservation, Corrosion and Protection Center, *University of Manchester Report on a Research Project Supported by the Commission of the European Community*.
xvi. Igal M. S. and Monica, P. (2004). Service life prediction of exterior cladding componentsunder standard conditions. *Construction Management and Economics.*22, 1081–1090.
xvii. Lentinen T. (1996). Capillary moisture transfer in combined porous building materials, *Proceedings symposium building physics in the Nordic Countries*, Finland, 483-490.
xviii. Miller, M & Galloway, J (1987). *Chemistry of precipitation from a remote, terrestrial site in Australia*. J. Geophys. Res. 92(D11):13,299-13,314
xix. Norvaišiene, R. Miniotaite, R. & Stankevicius V. (2003). Climatic and Air Pollution Effects on Building Facades.
xx. M*aterial Science.* 9(1)
xxi. Schulz, U., Trubiroha, P., Schernau, U.& Baumgart, H. (2000). The Effects of Acid Rain on the Appearance of
xxii. Automotive Paint Systems Studied Outdoors and in a New Artificial Weathering Test. *BASF Coating AG,*
xxiii. *Germany*.151 – 165.
xxiv. Website for Ilaro climate https://www.google.com.ng/?gfe_rd=cr&ei=tD4OWf7qLsTBaOWwl_AF&gws_rd=ssl#q=geographical+location+of+ilaro