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Extant Roofing Pattern and Early Decay of Residential Buildings in Port Harcourt Municipality, Rivers State

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Abstract

The design and construction pattern of roofs in the tropical environment like Port Harcourt Municipality, Rivers State is a major factor that determined how functional and the life span of building components and materials. In recent time residential building components and materials had been observed to decay earlier than expected due the existing roofing pattern. This study is aimed at assessing the extant roofing pattern and identified factors responsible for early decay of residential building in Port Harcourt Municipality. The study adopted mixed-methods research approach using concurrent triangulation design for data collection. The study employed purposive and simple random sampling techniques to select three (3) neighbourhoods (Port Harcourt Township, Oromenike and Mgbundungwu) and respondents for collection of data which a total of 357 respondents were sampled. Structured interview questionnaire and key informant methods were used to collect data from the respondents including building occupants, MDAs and professionals in the built environment. Checklist, physical observation and photograph were also used to characterize roofing patterns in residential buildings of the study area. The following are the findings of the study: the design and construction pattern of roofs ; such as low roof angle (pitch), insufficient eave (overhang), and substandard materials, were the major factors inducing early decay of building components and materials, It was concluded that professionals in the built environment should take into conglenence the tropical climate of the study area as a guild to both the roof type, pitch and choice of materials in the study area The following recommendations are made, roof pattern of residential buildings should factor in the peculiar tropical climate from the design and construction stage, roof angles (pitch) should not be less than 25^0 and above with an overhang of 900mm and above.

Keywords: Roof, roof pattern, early decay, residential building, port harcourt city

INTRODUCTION

The life span of a building is a function of many variables such as: the design approach, choice of materials, construction method, quality of supervision and maintenance. The moment a building is completed it is expected for it to live its life span, every building regardless of purpose, type, and scope of construction consist of components and materials. These components and materials undergo decay at a varied rate depending on the prevailing factors (Adepoju, Adeaga, & Adepoju, 2017 [1] (Charles, 2022) [4]. Every building components and materials has a specific and collaborative function, just as the roof remains a major part of building and account for significant cost of building. if well designed and constructed, the roof structure can make up for several problems that might result in other parts of affected building,

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the consequences of building decay resulting from roof failure or decay can be devastating, however, architects and other professionals in the built environment had not paid attention to the peculiar climate and the desired roof structure. (Obianuju, Chidi & Ikebueze, 2022) [10].

Residential building undergoes various types of decay, some are due to climatic conditions, alterations and modifications that involves change in performance. There is also a natural decay, which occur at the end of materials life span or takes place due to the evolution of individual materials and components which impaired on their properties, the process of natural decay is predictive and time bound depending on building durability (Zuazua-Guisasola & Etxepare (2003) [13]. Nicastro and Surovek (2005) [9] describe five building types and their life span base on design life, that a selected design life for a building may be accomplishing if its materials and details are selected adequately to equate its durability. Alade, Ogunkan and Alade (2021) [2] looked at building and urban decay as a global phenomenon that induced various negative impact on both the urban centre and the neighborhoods. The problem of urban decay is more visible and lack attention in developing countries like Nigeria, Peru and Pakistan. In Nigeria, problem of building decay had not been giving adequate research attention especially in the area of early building decay resulting the roof components.

According to Obianuju *et al.* (2022) [10] building decay place a huge financial burden and psychological effects on the occupants and building owners, building components and material decay especially the roof is not limited to occupants but every element within and around the affected building. In view of the current associated design issues, climate change, and high cost of building materials that has result to poor standardization of building materials in Nigeria, there is need to investigate the causes of building decay in residential building in Port Harcourt Municipality, Rivers State.

Aim and Objectives of the study

This study is aimed at assessing the extant roofing pattern and early decay of residential buildings in Port Harcourt Municipality, Rivers State

The specific objectives of the study are to:

i. Assess the existing roof pattern in the study area;
ii. Examined how extant roof pattern contributes to the decay of residential building components in the study area; and
iii. Proffer design solution to the extant roof pattern as a measure to mitigate early building decay spaces in the study area

Scope of the Study

The scope of this study is limited to residential buildings in selected neighbourhoods in Port Harcourt Municipality. The buildings in the selected neighbourhoods comprises of single family bungalows, semi-detached bungalow and blocks of flat and are been occupied by residents. It should have been ideal that the study covers all residential buildings in the study area, but study opted to restrict the scope of the study to three (3) neighbourhoods namely; Port Harcourt Township, Oromenike (D/line) and Mgbundungwu (Mile 2) all in Port Harcourt Municipality, Rivers State which the findings will be used to better the conditions of the residential buildings in the study area and the country as a whole (see Figure 1).

LITERATURES REVIEW

Residential buildings could be said to have failed to meet the required standard if one or more of the components and materials are not durable enough to withstand climatic impact, or negatively impacted by climatic elements or human activities (Duncan, Derek, Rogers 2003) [6]. The roof structure is that part of a building component that provides coverage on top of the building and it is considered the most impacted part of the building due to is continuous exposure to elements of climate and agents of degradation in a hot-humid tropical weather like Nigeria (Obianuju *et al.,* 2022) [10]. The primary function is to isolate and protect the building from the negative effect of snow, rain, sun, and wind

(Punmia, Ashok, & Arun, 2008 [12] Ivor, 1995) [8]. Every roof structure whether roof decking/members or roof covering according to Ivor is expected to perform the following functions; Weather resistance, Adequate strength, Durability, Fire resistance, Insulation, Condensation and Good appearance. Whenever the above-mentioned functional requirement is not satisfied, roof decay could occur. Other causes of failure can result from poor design and specification, unprofessional execution of works lack of maintenance and negligence, lack of compliance with technical regulations, and choice of materials. Failure or decay of roof structures may also be a result of having outlived their designed life expectancy (Martin, 2019 [7], Duncan, Derek, & Rogers 2003) [6].

Among the building components, the roof structure is the most susceptible to intense solar radiation, and rain and is more exposed and subject to the destructive forces of nature. In order, to cushion the effect the choice of roof cover, slop, size and strength of structural members, and the local climate must be put into consideration as some environments allowed for steep roofs and others with low-slope roofs (Allen, 1938) [3]. Dilshan, Roshida and Mohd (2008) [5] further recommended large roof eave to create good shade around the building as to protect the outer walls from excessive exposure to rain, but the actual depth of roof eave was not stated thereby creating a gap. All roof structure is required to protect the building envelope, its occupants, and equipment against weather effects.

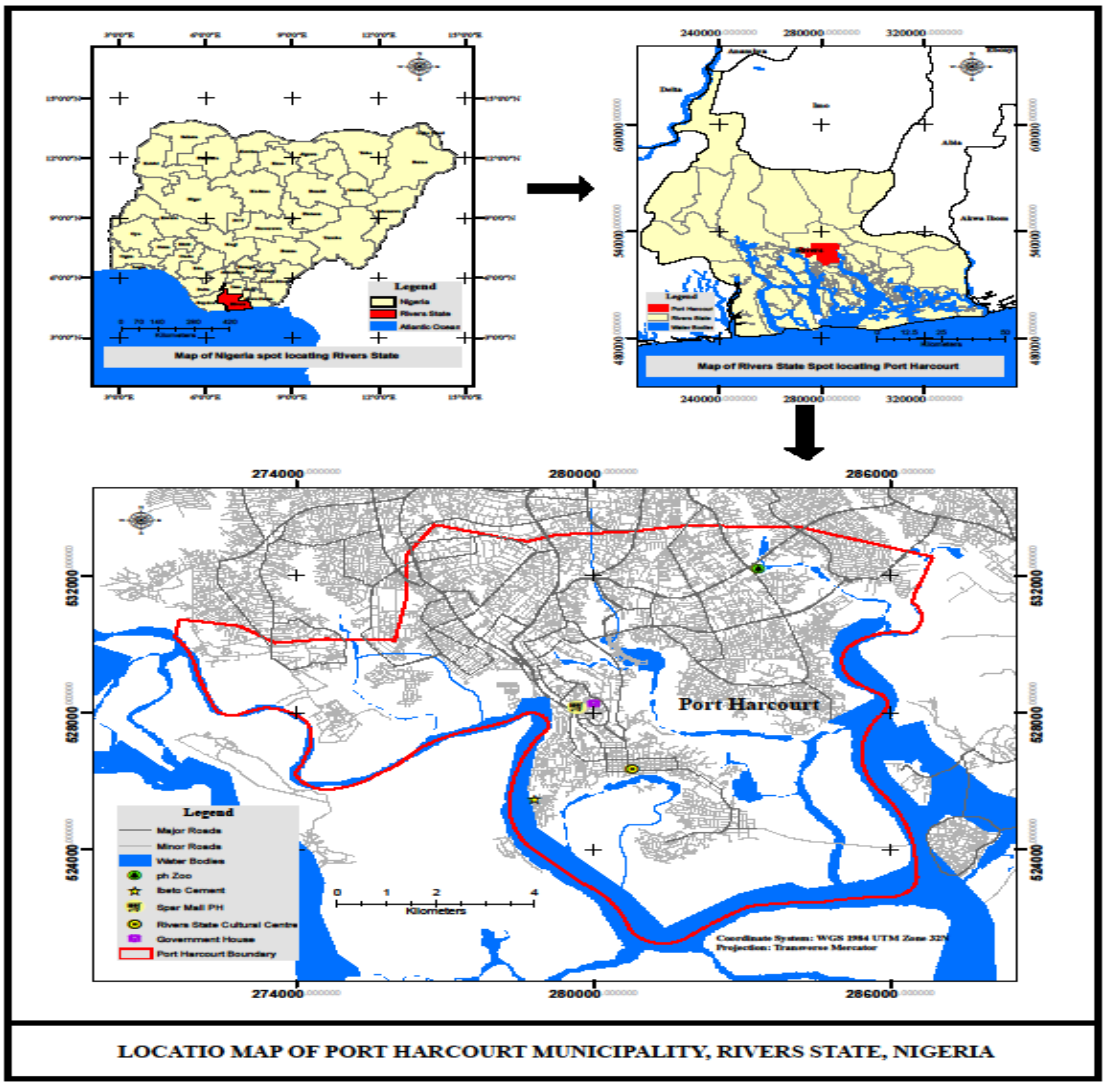

Figure 1. Location map of port harcourt municipality, rivers state, nigeria.
Source: Department of Urban and Regional Planning GIS Lab, Rivers State University, 2024

Osuagwu, Okolie, Nkelem, Okoye, and Onwuka (2021) [11] observed that a good design, constructed and maintained roof should sustain and elongate the life of a building. the researchers further observed that during roof construction the intention to save money for clients and contractors by using substandard and unspecified materials had left a weighty dislocation of occupancy or impaired the activities within the building. Osuagwu *et al.* (2021) [11] further asserted that a leaking roof impact the health of occupants and also induced a high level of decay in building materials and component, such as floors, walls, ceiling, and finishes including electrical and mechanical finishes which is a case in the study area.

METHODOLOGY

The study adopted a mixed-methods research approach utilizing concurrent triangulation design for data collection. Purposive and simple random sampling techniques and key informant methods were used for collection of data. The study also carried out a reconnaissance survey to established coordinate and boundaries of each neighbourhoods under study, which were inputted in an ArcMap and digitalized Geographic Information System (GIS) and (Open Street Map) to determine the total number of buildings (population) in the studied neighbourhoods (see Figures 2, 3 and 4). The study purposively selected three (3) neighbourhoods including Port Harcourt Township, Oromenike (D/line) and Mgbundungwu (Mile 2) with a total population (buildings) of five thousand seven hundred and seventeen thousand (5717). The study adopted Krejcie and Morgan (1970) sample size determination table to determine the sample size of three hundred and fifty-seven (357) which was distributed proportionately across the three neighbourhoods studied (see table 1). A sample random sampling technique was used to select head of household (respondents) that were sampled for the study. However, the key informant interview approach was used to select and interview the staff of the Rivers State Ministry of Housing, Rivers State Housing Authority and Property Development and other professionals/experts in the built environment such as Architects and Town Planners to draw from their professional opinions about the subject under study. Also, a checklist was used to assess the physical condition of the roof while carrying out the physical observation and photographs of residential building components and materials undergoing decay to characterize the roofing conditions of residential buildings.

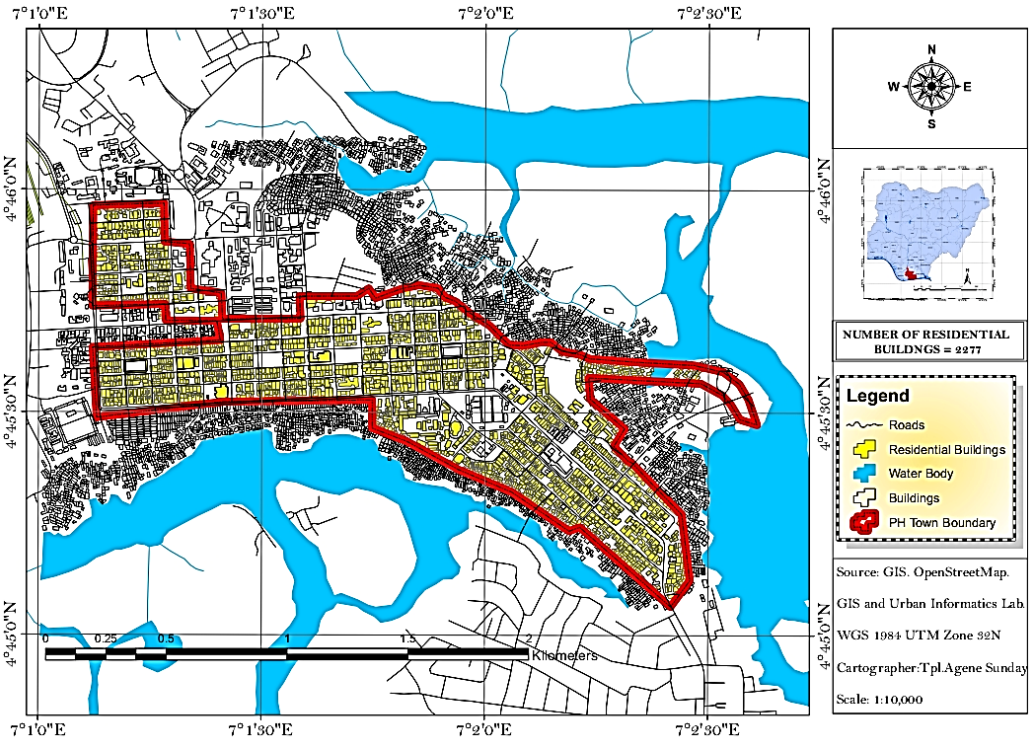

Figure 2. Map showing number of residential building in port harcourt township
Source: Department of Urban and Regional Planning GIS Lab, Rivers State University, 2024; Researchers' Fieldwork, 2024

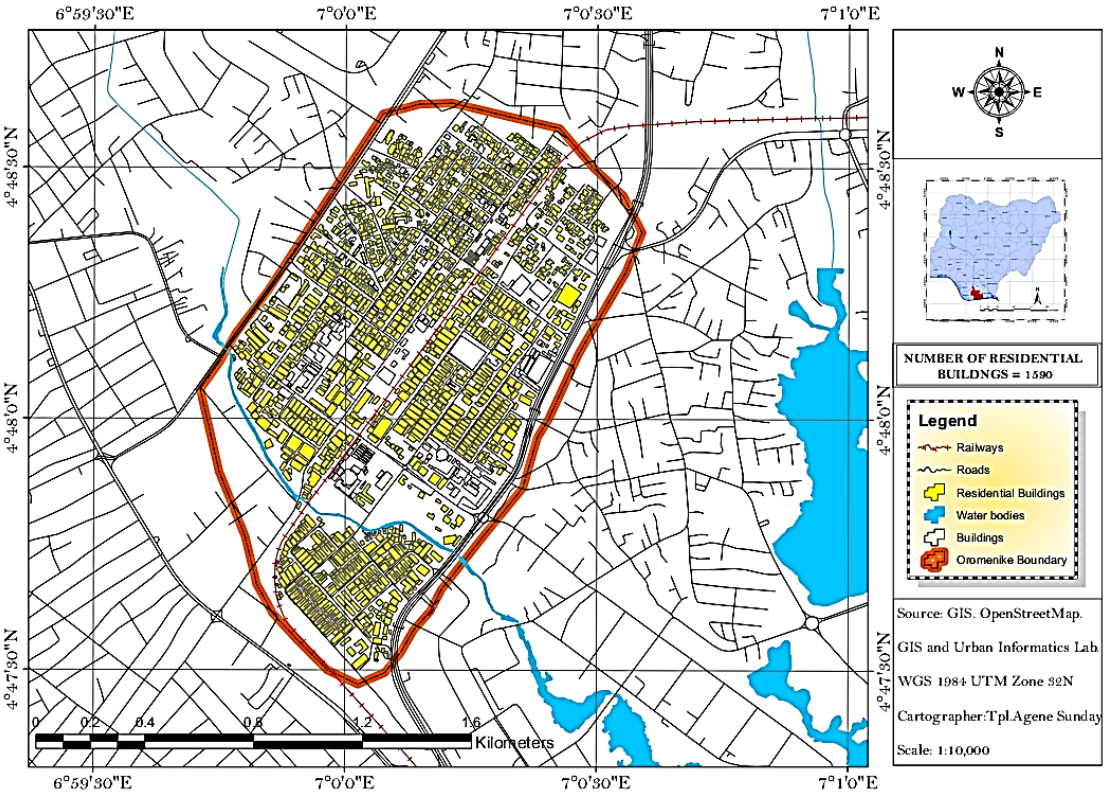

Figure 3. Map showing number of residential building in oromenike (D/line).
Source: Department of Urban and Regional Planning GIS Lab, Rivers State University, 2024; Researchers' Fieldwork, 2024

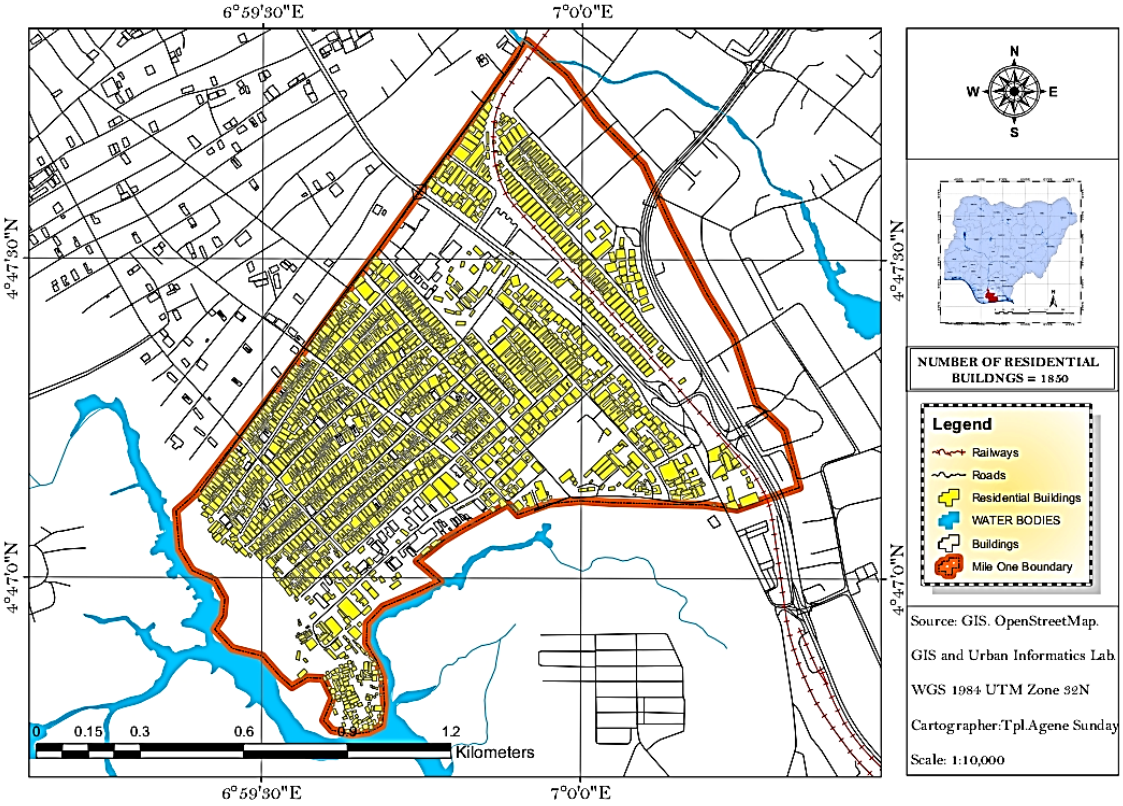

Figure 4. Map showing number of residential building in mgbundungwu (Mile 1)
Source: Department of Urban and Regional Planning GIS Lab, Rivers State University, 2024; Researchers' Fieldwork, 2024

Table 1. Sample Size Distribution Across Studied Neighbourhoods.

Sampled neighbourhoods	Population (number of buildings) in the neighbourhoods	Number of sampled buildings
Port Harcourt Township	2,277	142
Oromenike (D/Line)	1,590	99
Mgbundungwu (Mile 2)	1,850	116
Total	5.717	357

Source: Researchers' Fieldwork, 2024

RESULTS AND DISCUSSION

General Assessment of Residential Buildings Components Undergoing Decay

The study further reveals the occurrence of decay in the building components across the communities in the study area with a severe roof decay in Port Harcourt Township with a mean score of 4.71 (19%), followed by Mgbundungwu with 4.18 (17%), and moderate decay in Oromenike at 2.8 (19%) the roof decay was revealed to be the major causes of the decay of other components with Wall decay been the most frequent and most impacted from the roof with Port Harcourt Township leading at 4.43 (18%) and Mgbundungwu at 4.04 (17%), while Oromenike report lower values of 2.63 (18%), the severity in the roof decay has a corresponding decay impact on other building components (Osuagwu, Okolie, Nkelem, Okoye, and Onwuka 2021) [11] (see Table 2 and Figures 1 and 2).

Table 2. Residential Buildings Components Undergoing Decay.

Building parts undergoing premature decay	Port harcourt township		Oromenike (D/line)		Mgbundungwu(Mile 1)	
	Mean	***%***	***Mean***	***%***	***Mean***	***%***
Roof Decay	4.71	19.0	2.80	19.0	4.18	17.0
Wall Decay	4.43	18.0	2.63	18.0	4.04	17.0
Window and doors	3.06	12.0	1.86	12.0	3.13	13.0
Floor	3.71	15.0	1.99	13.0	3.27	14.0
Mechanical/plumbing components	3.60	14.0	2.21	15.0	3.57	15.0
Electrical components	1.84	7.0	1.01	7.0	1.97	8.0
Finishes	3.91	15.0	2.41	16.0	3.89	16.0
Mean Decay	3.61		2.13		3.37	

Source: Researchers' Fieldwork, 2024

Roof Materials

The study further revealed that the roof materials are predominantly constructed with zinc corrugated and aluminum roofing sheets covering 49.7% and 36.8% of the buildings and few asbestos roofing sheets observed majorly in Mgbundungwu (Mile 1) neighbourhood (see Table 2 and Figure 1). These building materials are peculiar in the study areas.

Table 2. Roof Materials of Buildings Occupied.

Roofing material	Frequency	Percent
Asbestos	49	13.5
Aluminum	177	49.7
Corrugated	131	49.7
Total	357	100

Source: Researchers' Fieldwork, 2024

Depth of Roof Overhang

The depth of roof overhang was observed to be inadequate and a major contributor to the early decay of other building component, the study shows that buildings in Port Harcourt Township with 113 buildings out of 161 making (69.89%) fails within buildings with 000 to 600mm eave depth, Oromenike with (65.45%), and Mgbundungwu with (66.22%) all have a eave depth of 000 to 600mm depth which show the high level of poor design consideration for our local climate and the importance of roof eave as major element that gives cover to the external walls and other components (Dilshan, Roshida and Mohd, 2008) see table 3 and figure 5.). Similar problems were also recorded on the roof angle (pitch) were majority of the buildings in the study area has elevated roof pitch between 11^0 to 15^0 which is classified as a flat roof and not recommended for buildings in the study area (Allen, 1938) [3]. Dilshan, Roshida *et al.* (2008), in Port Harcourt Township making 43 buildings (26.88%), Oromenike (27.27%), and Mgbundugwu with 29 buildings with 32.38 all having 11^0 to 15^0 as the roof angles are almost flat and not adequate for easy runoff of water and poor elimination of heat and water vapor in the roof space and building (Duncan, Derek & Rogers, 2003) [6] (see Table 4 and Figure 5).

Occupants Responses on the Roof Condition

The study revealed a high dissatisfaction by occupants on the building conditions. No respondents found the buildings very satisfactory, and only in a Oromenike that uncertainty was rated high with a few of them been satisfactory. Most respondents across Port Harcourt Township, and Mgbundungwu found the physical state unsatisfactory or very unsatisfactory, with notable dissatisfaction in Mgbundungwu. While some in Oromenike were uncertain, the general consensus is that the roof conditions are poor which affirm the physical observation and checklist results (see Table 5).

Table 3. Depth of Roof Overhang.

Depth of roof overhang (mm)	Port harcourt township	Oromenike (D/line)	Mgbundungwu(Mile 1)
000-600	113 (69.89%)	70 (65.45%)	49 (66.22%)
600-900	33 (20.43%)	27 (25.45%)	19 (25.68%)
900-1200	15 (9.68%)	10 (9.09%)	6 (8.11%)
1200-1500	0 (0%)	0 (0%)	0 (0%)

Source: Researchers' Fieldwork, 2024

Table 4. Roof Pitch (Angle).

Roof pitch (°)	Port harcourt township	Oromenike (D/line)	Mgbundungwu (Mile 1)
5°-10°	26 (16.13%)	14 (12.73%)	13 (14.32%)
11°-15°	43 (26.88%)	29 (27.27%)	29 (32.38%)
16°-20°	17 (10.75%)	19 (18.18%)	14 (15.89%)
21°-25°	21 (12.90%)	13 (12.55%)	11 (12.73%)
26°-30°	17 (10.75%)	12 (11.63%)	11 (12.11%)
31°-35°	17 (10.75%)	11 (10.61%)	8 (8.46%)
36°-40°	12 (7.53%)	6 (5.41%)	3 (4.11%)
41°-45°	8 (4.31%)	2 (1.62%)	0 (0%)

Source: Researchers' Fieldwork, 2024

Table 5. Rating Physical State of the Roof in the Studied Neighbourhoods in Port Harcourt Municipality

Physical state of roof	Port harcourt township		Oromenike (D/line)		Mgbundungwu(Mile 1)	
	N	***%***	***N***	***%***	***N***	***%***
Very satisfactory	0	0	0	0	0	0
Satisfactory	0	0	5	5.00	0	0
Uncertain	33	20.41	87	80.00	39	4.42
Unsatisfactory	82	51.02	16	15.00	59	66.85
Very unsatisfactory	46	28.57	0	0	26	28.73

Source: Researchers' Fieldwork, 2024

Figure 5. Showing roof decay and impact on other component in port harcourt township and inadequate eave cover with a corresponding decay on external walls in mgbunbungwu neighbourhood.

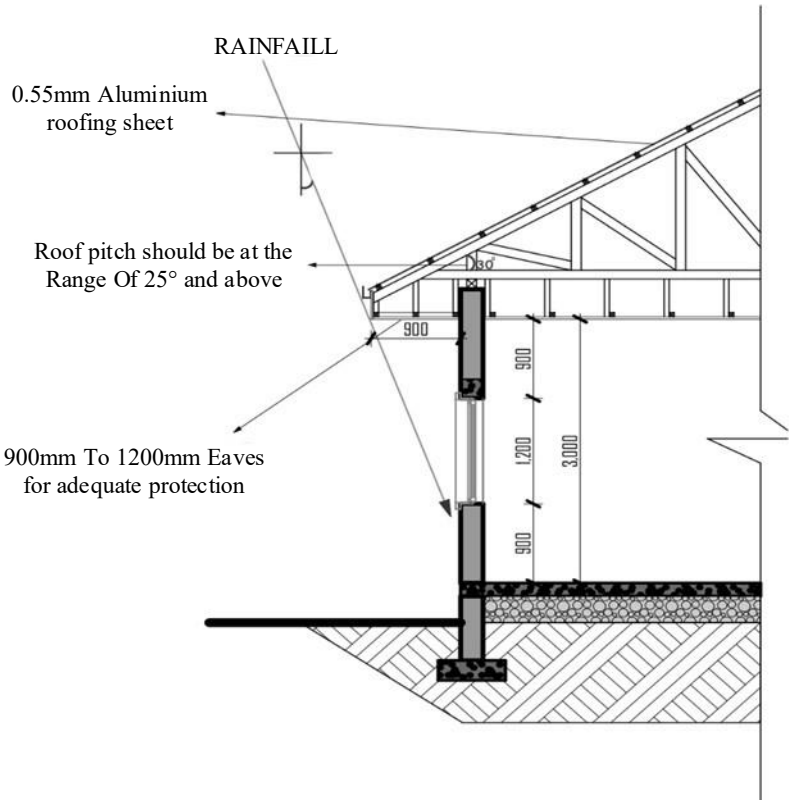

Figure 6. Showing recommended roof angle (pitch) and roof overhang (eave) for port Harcourt municipality

CONCLUSION

The study has assessed selected buildings across neighbourhoods in the study area, among the identified issues associated with the existing roof pattern includes failure resulting from faulty design and construction, roof decay was recorded as the prevalent and most impacted component resulting to the widespread of decay on other components. It was concluded that professionals in the built environment should take into cognizance of the tropical climate of the study area as a guild to both the roof type, pitch and choice of materials in the study area. This study has also added to the body of knowledge in the built environment especially architecture and in determining the best choice of roof design in the study area, ranging from materials choice, roof pitch and depth of overhang (eave).

RECOMMENDATIONS

Roof is a major residential building component that gives protection to the entire building and once affected or in a decay state the whole building structure suffers as identified in the study. It is therefore recommended that:

i. Architects should design and advocates the used of hipped roof with minimal number of roof-drain (gutters) as against gable ended roof in the study area due to its ability to give an all-round cover to the building without exposing any major part of the external walls;
ii. Roof angle (pitch) should be within the range of 25^0 to 45^0 to allow easy run-off of water, enough roof space for elimination of warm and humid air (see figure 6);
iii. The roof overhang (eave) should be within the range of 900mm and above for a good shield and protection of external walls, finishes, windows and doors against the elements of weather (see Figure 6); and
iv. Aluminum roofing sheet of 1000mm wide and 0.55mm thick should be used as a roof sheet in Port Harcourt Municipality due its durability, thermal property, cost, resistance to chemical attack and acid rain.

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