**Journal of Architecture and Construction**
**Volume 1, Issue 3, 2018, PP 34-43**

# Evaluation of Traditional Methods in the Maintenance of Mud Houses for Environmental Sustainability in Northern Nigeria

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**ABSTRACT**

*Over the years, one of the major problems of traditional housing provision is poor maintenance habit/technique. Building maintenance is a subject that has to be considered seriously if buildings are to live up to their expected life span. Earth has been in use in all ancient cultures, every continent, in every age and is being recorded as one of the oldest and sustainable building materials on the planet known for over 9000 years but has the highest challenge of rapid deterioration. The research evaluated the problems caused as result of negligence in regular maintenance of mud houses in Nigeria and as well proffered various traditional methods to their maintenance which consequently improves the sustainability of the built environment. Qualitative research carried out through the administering of questionnaires, interviews and observations in some villages in the northern part of Nigeria has shown that buildings are left without proper maintenance or cared for minimally not following any particular routine. This scenario has resulted to diversified problems such as rapid depreciation or deterioration; low life span and eventually building collapses. The research concludes that there should be routine and regular maintenance of structures for apt environment sustainability.*

**Keywords**: *Deterioration, Environmental Sustainability, Evaluation, Maintenance, Mud Houses.*

## INTRODUCTION

The traditional earth building materials are the most common building material utilised in nearly all hot-arid and temperate climates all over the world, particularly in many parts of Africa, Asia and South America (Minke, 2006; Akinkunmi, 2015). Morris and Booysen (2000), Adam and Agib (2001), Minke (2006) and Rael (2009)averred that over one third of the human population resides in earthen houses; earth construction techniques known for over 9000 years with Mud brick (adobe) houses dating from 8000 to 6000 BC have been discovered in Russian Turkestan. Challenges of traditional (earth) housing provision can be enormous and includes water penetration, erosion of walls at level by splashing of water from ground surfaces, attack by termites and pests and high maintenance requirements (Vador, 2012; Roy &Chowdhury, 2013; Akinkunmi, 2015).

Maintenance is paramount to traditional mud structures since its conservation is advantageous to the energy embodied in the fabric of an existing building rather than creating a completely new building that will require energy for manufacture of materials, transportation and construction (Akinkunmi, 2015). Maintenance is generally defined as the work that is done on a regular basis to keep a building in good working condition (Urban Homesteading Assistance Board [U-HAB] and Housing Preservation and Development [HPD],nd; Canada Historic Places, 2014).

Maintenance objective is primarily to preserve buildings in their initial functional, structural and aesthetic states (Adejimi, 2005) since buildings depreciate at different points as the material used for its construction owing to sunlight, rain, and wind (Donnelly, 2007). Proper maintenance of buildings enhances the quality of life of the occupants, their neighbours, and the community at large. The combination of the artistry and craftsmanship of handmade building materials, generous living spaces, and the sense of continuity with the past are the advantages of historic and traditional buildings (Donnelly, 2007). Sustainability is further achieved when there is maintenance of existing buildings which reduces waste generation; conserves the energy embodied in the original

building materials and construction; enhance their neighbourhoods, and retain their economic value.

Building repairs and maintenance services mainly include works undertaken for maintaining proper condition of buildings, its services and works in ordinary use. The use for which buildings are designed is the main factor in determining the required standard of maintenance (The Constructor - Civil Engineering Home,2015). Building maintenance is very beneficial in several ways as have been averred by several authors. According to Society for the Protection of Ancient Buildings [SPAB] (2010) and Donnelly (2007)building maintenance preserves heritage, keeps up a building's appearance, extends its life and also prevents the loss of original fabric; it prevents large repair bills by reducing or potentially eliminating the need for, and the extent of, major repair projects; preserving resources by conserving the amount of energy that was required to extract the materials and construct the building, reducing need for new materials, new green field development, waste and energy use; promoting guardianship by ensuring that building is in fit state to be handed over to future generations because its general belief that historic buildings enrich our quality of life, preserve our sense of identity, give character to the places we live in, form a physical and tangible link between our generation and those of the past, providing a sense of continuity and providing employment since it is steady source of all year round work. Maintenance problems in buildings could be prevented or minimized by optimizing processes of design, using certain tested components which give maintenance strength to buildings.

The study aimed at evaluating the various traditional methods of maintenance of mud houses in northern Nigeria in order to advance environmental sustainability. The aim was achieved through identifying common maintenance problems and their causes; importance of maintenance; traditional methods of maintenance and the relationship between environmental sustainability and maintenance. It also establishes what parts or elements of the building requires regular maintenance; ascertaining how often maintenance should be carried out and lastly evaluating the traditional methods and processes of carrying out maintenance of mud houses in the Northern part of Nigeria.

## Maintenance Problems in Mud Houses and Their Causes

Adejimi (2005) averred that causes of maintenance problems basically originate from deficiencies in design, construction, commissioning, tenancy work and maintenance. According to Zubairu (2013) common building defects and their symptoms include varieties of issues such as building materials used; defective construction techniques application or method; severe site conditions distort or damaging performance standards; natural deterioration; attacks by pollutants and inappropriate uses of the buildings. The following explains further breakdown of the causes of maintenance problems.

- **Effect of Water: o**ne major cause of maintenance problems is the effect of water the greatest enemy of earthen houses and these comes through driving rain which damage earthen walls relentlessly; flooding which affects the typical earthen plinth deteriorating the base of walls and capillary rise of water into the walls which results in collapse of the entire building (Donnelly, 2007; Akinkunmi, 2015).
- **Attack by Pests and Insects:** another maintenance challenge is rodents; birds and insects (worms, termites and ants) attack which burrow into earthen walls and establish their habitats thereby weaken earthen plinths and walls to a large extent (Donnelly, 2007).
- **High Maintenance Requirement and Demand: e**arthen plinth and walls require regular maintenance, especially during the wet season, which puts lot of demands on house owners (Donnelly, 2007; Akinkunmi, 2015).
- **Inappropriate Construction/Lack of Technical-Know-How:** Akinkunmi (2015) averred that the construction of mud houses require adequate knowledge so as to avert the problem of deterioration. Every component of the building starting from the foundation is required to be executed well; effective drainage system provided; suitability of the earth tested and the appropriate depth that is suitable for land bearing on the ground attained.
- **Materials used: t**he choice of materials (soil) utilised in the construction of the building can also contribute immensely to

the maintenance challenge. Mud has varying qualities and constituents

- **Age:** Akinkunmi (2015) identified the age of the building as a source to maintenance problems since with age the building component or elements starts weakening and deteriorating.
- **Effect of Weather:** The effect of the weather on mud house considerably brings about deterioration Akinkunmi, 2015); the building elements react with weather, especially those areas that are exposed or external.
- **Usage:** both intensity of usage and careless or improper usage as avowed by are also causes of maintenance problems.

## The Importance of Maintenance

According to Eti, Ogaji and Probert (2006) maintenance exists because we have physical assets which deteriorate therefore it is required so as to avoid weakeningor depreciation of assets or systems. Prompt and apt maintenance works on buildings control or eliminate the problem of building deterioration and enhance the value of the property (Independent Commission against Corruption [ICAC], 2013).Eti*et al*. (2006) avow that maintenance is important because it affects the owners of the system, its users and the society as a whole. This is usually by owners getting maximum value for their property; users satisfied with the operation of the system and the society at large benefiting if the system does not fail in any way that threatens public safety or damages the environment. Breakdown of the system can affect output, safety, environmental integrity, product quality, customer service, protection and operating cost in addition to incurring repair costs therefore the need for maintenance (Eti et al, 2006). Building maintenance works are of importance to the public, owners' and occupants' safety and well-being (ICAC, 2013; Manitoba, nd)).Maintenance ensures that a building maintains its integrity; preventing deterioration of precious original materials; avoiding possible hazards; ensuring longevity; reducing costs and improving value.

## Methods of Maintenance

- **Breakdown (Reactive) maintenance**: is repair executed when equipment has completely deteriorated and failed; it is based on the "run it till it breaks" maintenance mode. No actions or efforts are taken to maintain the equipment as the designer originally intended to ensure design life is reached. This method usually occurs when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost.
- **Preventive maintenance:** are systematic actions carried out on a time- or machine-run-based to maintain a level of definite service on equipment or building which involves schedule that detect, preclude, or mitigate degradation of a component or system and knowing what is expected to be done at intervals to sustaining or extending its useful life and hinder breakdown. It is based on daily cleaning, inspection, oiling and re-tightening so as to preserve, ensure the fitness of equipment so as to prevent failure and deterioration. It is usually routine and periodic.

Preventive maintenance is divided into two namely

- **Periodic(Time Based Maintenance TBM)**: is based on TPM (Total Productive Maintenance)and it is the regular inspecting, servicing, cleaning and lubrication of equipment and replacing parts to prevent sudden failure and progression problems. TBM usually are carried out by users and not requiring extensive training.
- **Predictive maintenance (Condition-Based Maintenance):** is the process of inspection or diagnosis so as to forecast the service life of important part of the equipment in order to use the parts to the limit of their service life. It entails utilisation of advanced technical resources, strong mathematical and physical knowledge to eliminate or control prior to any significant deterioration of the component/building.
- **Corrective maintenance:** helps carrying out preventive maintenance by improving the equipment and its components, put it in a good state so as to effective take repairs. Corrective maintenance set of tasks is to identify and make right the defects found in equipment before putting in it use.
- **Maintenance prevention:** it is the design of new equipment after putting into consideration and studying limitations of current machines (on site information leading to failure prevention, easier maintenance and prevents of defects, safety

and ease of manufacturing) and integrating the details before commissioning a new equipment (Computerised Maintenance Management System Proactive [CMMS Pro], 2008;Rathod, 2014; Garrido, 2015; O&M Best Practices Guide,2015; The Constructor - Civil Engineering Home, 2015).

### Environmental Sustainability and Maintenance

Sustainability is to be able to have, keep, carry forward, support or sustain for a long-lasting time without end (Abolore, 2012). Lehrer and Teicholz (2001), defined sustainability as a goal that allows for the continuing improvement of standard of living without reversible damage to resources that we need to survive as species. The establishment of the World Commission on Environment and Development (WCED), (1987) report, 'Our Common Future', defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Feltes (2007) averred that sustainability involves design, construction and operation of buildings that are resource efficient by utilisation of minimal energy, control of waste, and provision of healthier and productive environments.

According to Donnelly (2010) good maintenance practice is environmentally sustainable especially on traditional buildings because of their design and construction methods. Traditional buildings should be conserved not only for their cultural value but also because it makes environmental sense and is cost saving (energy and fuel).Whole Building Design Guide (WBDG) (2014) averred that maintenance and sustainability (green goals) overlap and reconciling their difference are achievable. There are lots of social values and environmental benefits of persevering and maintaining traditional earth structures such as it keeps a society's culture and history alive; the environment is friendlier and less toxic; and it's also cost effective.

## METHODOLOGY

The methodology adopted for the research is descriptive survey design; primary data such as interview, observation and questionnaires were utilised as well as data from secondary sources via review of related literature. The study was conducted in Northern part of Nigeria from six (6) selected states alongside the Federal Capital Territory because of their proximity to each other and similarity in mud-construction techniques. These states are Kaduna, Kano, Katsina, Niger, Bauchi and Plateau. The population of the study was occupants of mud houses in the study areas. A minimum of ten (10) houses were sampled from each state. Quota sampling technique was adopted since the exact number of mud houses could not be established in the areas.

The questionnaire used the Semantic Differential Questioning Scale which was categorised into three (3) sections of Respondents data, Building details and Maintenance; the interview patterned according to the objectives while, the observation list had six items. A total number of 85 questionnaires, interview and observation lists were administered to the respondents but only 77 copies were valid upon receipt. Face and content validation of the research instruments were carried out by building maintenance and statistical experts respectively before being administered. The data were collected through the help of research assistants (students on Industrial Training (ITF) from the Department of Architecture) sent to the various study areas. Data collected were analysed using descriptive and content analysis and results presented in tables using the Statistical Package for Social Science (SPSS) software.

## FINDINGS AND DISCUSSION

The findings and discussions followed the sequence of the outlined objectives and also gave general information of the sampled population.

Table 1.0 indicates that Responses were drawn from six states in northern Nigeria including Abuja the Federal capital territory. Niger state the highest sampled while FCT was the least.

**Table1.0.** *Responses to Questionnaires and Interview.*

| State | Frequency | Percentage (%) |
|---|---|---|
| Kaduna | 11 | 14.3 |
| Kano | 10 | 12.9 |
| Katsina | 12 | 15.6 |
| Niger | 13 | 16.8 |

| | | |
|---|---|---|
| Bauchi | 10 | 12.9 |
| Plateau | 12 | 15.6 |
| FCT | 9 | 11.7 |
| **TOTAL** | **77** | **100** |

*Source: Researchers Fieldwork (2014).*

Table 2.0 shows the socio-economic characteristics of the respondents. The respondents comprised both of male and female with different age range and nature of employment. The male were highest at 77.9%, that is 60 in number; the highest number of respondents fallen within an age range of 31-40 years and were mostly self employed.

**Table2.0.** *Socio-Economic Characteristics of Respondents*

| S/N | Respondent Data | | Frequency | Percentage (%) |
|---|---|---|---|---|
| 1 | **Gender** | Male | 60 | 77.9 |
| | | Female | 17 | 22.1 |
| 2 | **Age Range** | 15-30 years | 21 | 27.3 |
| | | 31-40 years | 31 | 40.3 |
| | | 41-50 years | 21 | 27.3 |
| | | 51-60 years | 4 | 5.2 |
| 3 | **Nature of employment** | Public | 11 | 14.3 |
| | | Private | 15 | 19.5 |
| | | Self | 29 | 37.7 |
| | | Unemployed | 19 | 24.7 |
| | | Retired | 3 | 3.9 |

*Source: Researchers Fieldwork (2014).*

Table 3.0 gives details on the sampled buildings and indicated that most of the buildings sampled, 73%, were between 0-15 years; 78% of buildings sampled were used as residential houses and owner occupied; the number of occupants in the buildings varied but had the least of 4% between 1-3 occupants and 33 of the buildings had rooms ranging between 4-6 rooms at 43%.

**Table3.0.** *Information about the sampled buildings*

| **The Age of the building** | **0-15 yrs** | **16-30yrs** | **31-45yrs** | **46-60yrs** | **61 and above** |
|---|---|---|---|---|---|
| Frequency | 71 | 5 | 1 | 0 | 0 |
| Percentage (%) | 93.1 | 6.4 | 1.3 | 0.0 | 0.0 |
| **Current use of the building** | **Residential** | **Commercial** | **Institutional** | **Factory** | **Other uses** |
| Frequency | 60 | 11 | 2 | 1 | 3 |
| Percentage (%) | 77.9 | 14.3 | 2.6 | 1.3 | 3.9 |
| **Ownership Status** | **Owner occupancy** | **Tenant occupancy** | | | |
| Frequency | 60 | 17 | | | |
| Percentage (%) | 77.9 | 22.1 | | | |
| **Number of occupants in the compound** | **1-3** | **4-6** | **7-10** | **11-13** | **14 and above** |
| Frequency | 3 | 27 | 21 | 17 | 9 |
| Percentage (%) | 3.9 | 35.1 | 27.3 | 22.1 | 11.7 |
| **Number of rooms in the building/ compound** | **1-3** | **4-6** | **7-10** | **11-13** | **14 and above** |
| Frequency | 24 | 33 | 16 | 4 | 0 |
| Percentage (%) | 31.2 | 42.1 | 20.8 | 5.2 | 0.0 |

*Source: Researchers Fieldwork (2014).*

Table 4.0 indicates that several problems can be associated to buildings that will be requiring maintenance. The sampled population pointed out that cracking of wallswas their major problem while the least problem was leaking of roofs.

**Table4.0.** *Maintenance Problems*

| Maintenance Problems Experienced | | | | | |
|---|---|---|---|---|---|
| | Cracking | Peeling of finishes | Leaking of roof | Washing away by erosion | Termite infestation |
| Mean | 1.56 | 1.49 | 1.25 | 1.42 | 1.35 |
| Std. Deviation | .500 | .503 | .434 | .496 | .480 |
| Sum | 120 | 115 | 96 | 109 | 104 |

*Source: Researchers Fieldwork (2014).*

Table 5.0 shows cause of maintenance and have usage to be at the least and material used was considered to be the major cause of maintenance work.

**Table5.0.** *Causes of Maintenance Problems*

| Causes of Maintenance Problem(s) | | | | | |
|---|---|---|---|---|---|
| | Age of building | Material used | Construction techniques | Weather | Usage |
| Mean | 1.44 | 1.77 | 1.58 | 1.58 | 1.39 |
| Std. Deviation | .500 | .426 | .496 | .496 | .491 |
| Sum | 111 | 136 | 122 | 122 | 107 |

*Source: Researchers Fieldwork (2014).*

**Table6.0.** *Part of the Building Requiring More/Regular Maintenance*

| Part of the Building Requiring More/Regular Maintenance | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Roof** | **Wall** | **Floor** | **Windows** | **Doors** | **Ceiling** | **Finishes** |
| **Mean** | 1.83 | 1.65 | 1.58 | 1.23 | 1.23 | 1.52 | 1.34 |
| **Std. Deviation** | .523 | .580 | .522 | .456 | .456 | .598 | .553 |
| **Sum** | 141 | 127 | 122 | 95 | 95 | 117 | 103 |

*Source: Researchers Fieldwork (2014).*

Table 6.0 indicates that the Roof followed by the Walls at 1.83 and 1.65 means respectively requires more/regular maintenance as compared to the Windows and Doors at the least mean of 1.23 respectively.

**Table7.0A.** *Frequency of Maintenance*

| Frequency of Maintenance been carried out | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Repair of leaking roof cover** | **Repair/replacement of termite infested roof members** | **Repair of holes/cracks on the floor** | **Repair of broken down/cracked walls** | **Repair of door/window hinges and locks** | **Replacement of damaged ceiling boards** | **Finishes** |
| Mean | 3.65 | 3.26 | 3.65 | 3.84 | 2.44 | 3.35 | 3.36 |
| Std. Deviation | 1.355 | 1.551 | 1.431 | 1.338 | 1.500 | 1.676 | 1.327 |
| Sum | 281 | 251 | 281 | 296 | 188 | 258 | 259 |

*Source: Researchers Fieldwork (2014).*

Table 7.0 shows various maintenance measures and level of maintenance carried out at each instance. Repair of broken down/cracked walls is at highest mean of 3.84 while Repair of door/window hinges and locks is at 2.44 least mean.

**Table7.0B.** *Frequency Level of Maintenance*

| **Items** | **Frequency** | | | | |
|---|---|---|---|---|---|
| | **Immediately** | **Never** | **Monthly** | **6-Months** | **Yearly** |
| **Repair of leaking roof cover** | | | | | |
| Frequency | 21 | 6 | 4 | 17 | 29 |
| Percentage (%) | 27.3 | 7.8 | 5.2 | 22.1 | 37.7 |

| | | | | | |
|---|---|---|---|---|---|
| **Repair/replacement of termite infested roof members** | | | | | |
| Frequency | 8 | 30 | 30 | 3 | 6 |
| Percentage (%) | 10.4 | 39.0 | 39.0 | 3.9 | 7.8 |
| **Repair of holes/cracks on the floor** | | | | | |
| Frequency | 6 | 22 | 18 | 17 | 14 |
| Percentage (%) | 7.8 | 28.6 | 23.4 | 22.1 | 18.2 |
| **Repair of broken down/cracked walls** | | | | | |
| Frequency | 7 | 15 | 9 | 33 | 13 |
| Percentage (%) | 9.1 | 19.5 | 11.7 | 42.9 | 16.9 |
| **Repair of door/window hinges and locks** | | | | | |
| Frequency | 31 | 12 | 14 | 11 | 9 |
| Percentage (%) | 40.3 | 15.6 | 18.2 | 14.3 | 11.7 |
| **Replacement of damaged ceiling boards** | | | | | |
| Frequency | 3 | 37 | 17 | 6 | 14 |
| Percentage (%) | 3.9 | 48.1 | 22.1 | 7.8 | 18.2 |
| **Finishes** | | | | | |
| Frequency | 10 | 25 | 4 | 11 | 27 |
| Percentage (%) | 13.0 | 32.5 | 5.2 | 14.3 | 35.1 |

Table 7.0B shows at what frequency different maintenance measures are done. For Repair of leaking roof cover the frequency and percentage29; 37.7% is highest at Yearly while is least monthly 4; 5.2% respectively. Repair/replacement of termite infested roof members 30; 39% Never and Monthly while the minimal is 3; 3.9% Yearly. The least for Repair of holes/cracks on the floor is at 6; 7.8% immediately and utmost at Never 22; 28.6%. Repair of broken down/cracked walls 33; 42.9% 6-Months is highest while 7; 9.1 is smallest at immediately. Repair/replacement of door/window hinges, locks and glasses is highest at Immediately 31;40.3 and Least Yearly at 9; 11.5 Replacement of damaged ceiling boards 37; 48.1is maximum at Never and minimum 3;3.9 Immediately. For Finishes, Yearly 27; 35.1 and Monthly 4; 5.2 maximum and minimum levels respectively.

**Table8.0.** *Interview Response in Line with the Research Objectives*

| **INTERVIEW RESULTS** | | | | | |
|---|---|---|---|---|---|
| **What are the factors that work or militate against the maintenance of the building** | Finance | Technical know-how/ Ignorance | Availability of Physical resources | Age of property | Belief/Social considerations |
| Frequency | 59 | 23 | 41 | 48 | 13 |
| Percent | 76.6 | 29.8 | 53.2 | 62.3 | 16.9 |
| **Why does some parts of the building require maintenance most** | Exposure to weather | Exposure to Constant friction | Exposure to insect and moles | Application of non-durable materials | Defective construction techniques |
| Frequency | 63 | 15 | 35 | 57 | 37 |
| Percent | 81.8 | 19.4 | 45.4 | 74.0 | 48.0 |
| **What measures can be taken to remove maintenance problem re-occurrence** | Change type of material | Improve the construction techniques | Protect from weather | Protect from insect and moles | |
| Frequency | 55 | 58 | 72 | 45 | |
| Percent | 71.4 | 75.3 | 93.5 | 58.4 | |
| **Why is it important to carry out maintenance as when required** | Increase life-span of the building | Preserves heritage | Preserves resources | Reduces the effect of weather | |
| Frequency | 67 | 47 | 50 | 27 | |

| | | | | | |
|---|---|---|---|---|---|
| Percent | 87.0 | 61.0 | 64.9 | 35.1 | |
| **What process do you go through when carrying out maintenance** | Identify problems, Prioritise, Carry out repairs | Prompt repairs | Repair in Stages | No particular sequence | Never carryout maintenance |
| Frequency | 15 | 17 | 11 | 27 | 7 |
| Percent | 19.4 | 22.0 | 14.2 | 35.1 | 9.0 |
| **Experiences of others and their influence** | Apt maintenance increases lifespan | Apt maintenance adds beauty | Apt maintenance prevents rapid deterioration | Apt maintenance is more economical | |
| Frequency | 73 | 55 | 70 | 67 | |
| Percent | 94.8 | 71.4 | 90.0 | 87.0 | |
| **Why do you change the types of materials originally used in the building to different (modern) types?** | Enhance beauty | Ensure easy maintenance | Weather friendly (environmental sustainable) | Cost effective | Durable and Strong |
| Frequency | 43 | 56 | 39 | 34 | 67 |
| Percent | 55.8 | 72.7 | 50.6 | 44.1 | 87.0 |
| **How did you finally solve the problem of maintenance?** | Utilisation of good material | Using effective construction Techniques | Addition of Additives to Mud | Prompt repairs | Not solved yet |
| Frequency | 41 | 38 | 57 | 71 | 21 |
| Percent | 53.2 | 49.3 | 74.0 | 92.2 | 27.2 |

*Source: Researchers Fieldwork (2014).*

Table 8.0 shows the responses and result from the interview conducted, indicating that certain factor militates against maintenance of buildings but Finance is rated the highest at 76.6%; 81.8% of respondents pointed out that Exposure of building elements to weather is the reason why some parts of the building requires maintenance most; 72% agrees that if protected from weather maintenance problem re-occurrence will be removed; 67 persons believed among other things that maintenance of buildings will increase its lifespan; 27 respondents indicated that they donot follow any particular sequence in carrying out maintenance of their buildings; 73 and 70 participants said that from the experience of friends apt maintenance increases lifespan and prevents rapid deterioration respectively; 87% respondents signified that Durability and Strength is why they change the types of materials originally used in the building to different (modern) types and lastly 71 respondents averred that Prompt repairs helps in solving their problem of maintenance.

## DISCUSSION

**Objective 1:** Identify common maintenance problems and their causes.

- Maintenance problems in mud building have been identified to include Cracking; Peeling of finishes; Leaking of roof; Washing away by erosion and Termite infestation.
- Maintenance problems in mud buildings can be influenced by Age; Construction materials & techniques; Weather and Usage, these are via pollution, fungi, insect attack, subsidence, flooding, intensity of usage, careless usage, seepageetc

**Objective 2:** Establish what parts or elements of the building that requires regular maintenance.

- Every part of the mud building requires regular maintenance but the roof and walls require it more this is because they are the parts of the building that are exposed to weather more.
- Maintenance was carried out more on the broken down/cracked walls than other elements of the mud houses in the study areas because if not promptly done could lead to the collapse of the building.

**Objective 3:** Ascertain how often maintenance should be carried out in buildings.

- The frequency of maintenance depends on the part or component of the building on which the maintenance is to be carried out, such as areas with constant contact, friction

and abrasion, elements bared to weather, and materials with short life span.

- Nevertheless the frequency level ranges from immediately; daily; monthly; quarterly, half-yearly and yearly.

**Objective 4:** Evaluate the traditional methods and processes of carrying out maintenance of mud houses in the Northern part of Nigeria.

- One major factor that militates against maintenance is finance; apt maintenance increases lifespan, majority of the population noted that they had no particular sequence in carrying out maintenance; they would prefer using modern material for maintenance and prompt repairs/replacements would solve the problem of maintenance
- Amongst all the types of maintenance, planned (periodic) preventive and predictive maintenance are most appropriate and beneficial.
- Sustainability begins with maintenance, because the benefits of building preservation and reuse as compared to construction of new buildings cannot be quantified.

## RECOMMENDATIONS

The occupants and owners of mud (traditional) structures should:

- Ensure prompt repairs/replacements of deteriorated/damaged building elements so as to increase the lifespan of a building.
- Ensure preventive and planned maintenance programme.
- Get advice from experts on maintenance, so as to ensure proper repair techniques.
- Ensure the use of right materials.
- Carry out building repairs in stages meanwhile, considering the building as a whole not in isolation.
- Always consider Environmental friendly techniques and practices while carrying out maintenance in buildings.

## CONCLUSION

Maintenance ensures that a building maintains its integrity; preventing deterioration of precious original materials; avoiding possible hazards; ensuring longevity; reducing costs and improving value. Proper maintenance programmes have enormous benefits, they keep the building running longer; allow for scheduled, budgeted repairs; reduce unscheduled down time; make life less stressful and most importantly improve on the environment. Both preventive and periodic maintenance are required for mud houses so as to preserve the building, its neighbourhood and enhance the environment and its inhabitants in general.

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