EPH - International Journal Of Science And Engineering
ISSN (Online): 2454-2016
Volume 07 Issue 01 March 2021

DOI: https://doi.org/10.53555/eijse.v7i1.139

INTEGRATING OPERABILITY AND MAINTAINABILITY IN BUILDING DESIGN & CONSTRUCTION PROCESS IN NIGERIA

Owajionyi L. Frank[1*] Warebi G. Brisibe[2]
*[*1,2]Department of Architecture, Rivers State University, Port Harcourt, Nigeria*

Corresponding Author:-

Abstract:-

It is no longer news that global building developers are required to ensure that the buildings they design and construct are expected to be sustainable and energy efficient; operated in such a manner as to use no more fuel and power than is reasonable in the circumstances. However, it is widely believed across the globe that buildings underperform in terms of capacity to deliver value, even in the face of new technologies fitted in the buildings. How these new and innovative technologies can be operated and maintained long into the future is yet to be given the desired attention, more so in Nigeria and other developing countries where maintenance culture appears to be elusive. This paper therefore sought to explore a best practice approach that could ensure that buildings in Nigeria are efficiently operated and maintained long into the future. Findings indicate that there is a need for change in the way buildings are delivered to the end-users if they must remain sustainable, and that there is need for clients to be placing demand on designers for proof of operability and maintainability from inception. The study seeks to identify and analyse existing maintainability regime in the UK with a view to identifying their barriers and enablers as effective maintainability approach, vis-à-vis the Nigerian environment.

Keywords:- *Buildings, Designers, Maintainability, Operability, Process Model*

1.0 INTRODUCTION

1.1 Maintainability & Sustainable Maintenance

Maintainability is described as "*a characteristic of design and installation, expressed as the probability that an item will be retained in or restored to a specified condition within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources*" (ITS, 1996). BusinessDictionary.com (2010) defines it as a *"Characteristic of design and installation which determines the probability that a failed equipment, machine, or system can be restored to its normal operable state within a given timeframe, using the prescribed practices and procedures"* (Businessdictionary.com, 2010). Blanchard and Lowery (1969) makes it more explicit; positing that *"Maintainability is a characteristic of equipment design and installation which is expressed in terms of ease and economy of maintenance, availability of the equipment, safety, and accuracy in the performance of maintenance actions."*

Deducing from the above definitions, maintainability can be said to be 'a design characteristic; which qualifys a design with respect to ease, safety and cost that will be involved in maintaining the designed building, after it has been built'. This is to say that,

'maintainability in building design' means 'a design that is conscious of the ease, safety and cost of maintenance, not compromising standards and quality, but ensures that building elements and components are kept in their continued good appearance and functional state, through the building life-cycle'. The outcome of maintainability will be a maintainable design.

Sustainable Maintenance is described in Frank (2014) as a practice where the building maintenance process is planned and carried out in processes that are resource efficient, exerting little or no impact on the environment, the building and/or its users and ensuring continued comfort, utility and beauty of the facility through its life cycle'. This stems from Sustainable development. OGC and DEFRA (2003) posit that the aim of sustainable development is to achieve four main objectives, which are:

- Effective protection of the environment,
- Prudent use of natural resources,
- Social progress which recognises the needs of everyone and
- Maintenance of high and stable levels of economic growth and employment. Therefore, sustainable maintenance would seek to attain these objectives and within the framework of achieving value for money.

Logically, to achieve a sustainable maintenance regime, the maintenance operation has to be thought out from inception of design, and the design solution must be influenced by the maintenance and operation considerations. In essence, a maintainable design will result in a sustainable maintenance.

1.2 Problems Associated with Building Operation & Maintenance in Nigeria

Maintenance problems are considered as twofold; significant consumption of resources and a lack of drive or culture for maintenance. Literature sources indicate that maintenance culture, particularly for public buildings is lacking in Nigeria. The country's urban landscape is smeared with dilapidation (Frank and Daminabo, 2015). Buildings representing huge capital investments are allowed to rot away as a result of lack of care (Haruna, 2009). The then President of Nigeria, Dr Goodluck Jonathan was quoted in a newspaper publication; lamenting the lack of maintenance culture for public infrastructure and how it impacts negatively on the national economic growth (Archibong 2010). There has also not been any concerted effort or policy by government at any level to promote maintenance culture for buildings (Zubairu, 2010).

A typical case in Lagos State, Nigeria was reported in Adenuga, Odusami, & Faremi (2007); a survey carried out on the ranking of hypothesized factors responsible for poor maintenance management of public hospital buildings in the State. It identified and ranked the problems as:

1) Problems of new and unconventional technologies
2) High cost involved with maintenance jobs
3) General lack of maintenance culture and maintenance policy
4) Short supply of trained maintenance professionals
5) Improper design and construction decisions
6) Over-use of facilities (design capacity over-run)

If a design must be people (users) oriented, then Nigerian architects must bear these factors in mind and change their approach to design problems. They need to stand up to their social responsibility of providing safe, decent and economical shelter for the society.

1.2.1 New and Unconventional Technologies

In the global construction market, buildings are becoming more and more sophisticated and technologically advanced (Mills, 1994). New and unconventional service systems; mechanical, electrical, security, safety, information and communication systems, among others are being introduced to the market to support the required business functions of buildings (Wu, 2010). These systems are designed, selected and fitted in response to modern technologies, in line with international standards. However, some of these may seem new and unconventional to most of the users.

1.2.2 High Cost involved

If good practice of maintenance needs to take place, even in the advanced countries, it is highly resource demanding. In the United Kingdom, over 20 years ago, it was estimated that Building Maintenance accounts for about £20bn (Horner,

El-Haram and Mums, 1997). In Wood (2005), the 1998 Barbour Index was quoted to have reported that the UK's market for maintenance, repair and improvement (MRI) was estimated at £28bn as against new build of £10bn. Developing economies like Nigeria will see such investments a difficult one in the face of many other aspect of the economy demanding attention too.

1.2.3 General lack of maintenance culture and maintenance policy

Section 1.2 discusses this factor; it emphasizes the fact that there is absence of a form of planned maintenance programme and consequently, a general lack of maintenance culture in Nigeria, particularly for public buildings.

1.2.4 Short supply of trained maintenance professionals

The study revealed also the short supply of maintenance professionals in the Nigeria. The study also posits that the few maintenance staff available were not adequately trained for the emerging demands of new builds Adenuga et al. (2007). Trained personnel like facilities managers are also in short supply even in the developed countries. Davies (2011) has argued that the Facilities management sector has been bedevilled with the absence of real body of theoretical knowledge to underpin thinking and decision-making.

1.2.5 Improper design and construction decisions

Universally, it is a known fact that improper design, insufficient detailing and inappropriate constructional method impact greatly on the frequency and nature of maintenance works in a building. Seeley (1976) refers; "Case studies undertaken by the Department of Environment (DOE) Committee on Building Maintenance have shown that about one-third of the maintenance work on the buildings investigated could have been avoided if sufficient care had been taken at the design stage and during construction".

1.2.6 Over-use of facilities (design capacity over-run)

Onifade (2003) in Adenuga et al. (2007) argued that *"overcrowding has also led to the deterioration of facilities"*. This is not an uncommon phenomenon with public building in Nigeria, particularly Educational and Health facilities. One of the authors of this paper could recall taking a studio class of about 150 students of architecture, in a studio space that accommodates only 42 drawing tables. By the end of that academic session, no one single drawing tables and stools came out whole, the floor finish needed reworking; the walls were not spared either. Statistics published in the Punch Newspaper of 5/01/10 (Olugbile, 2010) shows that in the University of Lagos for example, total students enrolment increased from 11,713 in 1986/87 to 38,829 in 2008/09. Meanwhile the same classrooms, libraries, hostels, toilets, auditoria, etc are being used. This of course will cause more frequent break-downs.

1.3 Consideration of Maintenance at the Design Stage

It has been a well-established theory in architecture, that the architect is expected to give considerations to maintenance possibilities and cost (Seeley 1987; Mills 1994; Lush 1994). However, evidence in the study suggests that this still stands as theory rather than practice. Dunston and Williamson 1999 noted that maintenance problems in facilities are heavily attributed to design limitations, among other issues. They stated also that, "failure to acquire and communicate expert knowledge on the design requirements, systems/components incompatibilities, and performance limitations of products is a commonly cited source of subsequent problems for maintenance personnel. For a proper maintainability consideration the designer requires sound knowledge of available materials, their properties and their maintenance requirements (Zubairu 2010; Dunston and Williamson 1999). Seeley, 1987 noted that designers must ask themselves these 4 questions as they design each element or component of a building:

1) How can it be reached? 2) How can it be cleaned? 3) How long will it last? 4) How can it be replaced? Unfortunately, in Nigeria, architects are often more concerned with aesthetics of the materials than its maintenance requirement (Zubairu 2010). This is not likely to be much different elsewhere. In a study of 211 large architectural firms in the United States, to investigate the relationship between design practices and maintenance considerations (Arditi and Nawakorawit 1999), it was concluded that:

i) ease of repair and replacement, access to cleaning area and ease of cleaning were ranked by designers to be among the least important design factors considered during design,
ii) among the complains designers reported receiving from clients and tenants, maintenance related complains ranked much higher

It is therefore obvious that designers are largely responsible for the huge cost of operation and maintenance of buildings and should consequently be liable to finding an enduring solution. By the concept of 'Duty of Care' as contained in the English law of tort, a designer is expected to take reasonable care to ensure his client or the third party users do not incur any foreseeable economic loss as a consequent of his omissions or negligence (Speaight and Stone 2010). It therefore becomes imperative to put in place workable policies that can facilitate compliance to maintainability considerations.

2.0 THE STUDY DESIGN

The study seeks to identify and analyse existing maintainability regime in the UK with a view to identifying their barriers and enablers as effective maintainability approach, vis-à-vis the Nigerian environment. It draws data from a research conducted by the authors to explore a best practice approach to operability and maintainability of low carbon buildings

in the UK. A mixed method research approach involving across-method and within-method triangulation (interviews, surveys and case studies) were adopted. The study was also supported by extensive literature search.
The interview was populated by 5participants who are very experienced professionals, sitting at the topmost management level of their respective organizations. 80% of them (4 out of 5) had over 30 years' experience in their respective fields of practice. Although the interviewed population was small, it provided opportunity for detailed insight into the subject. Similar work reported in Dawood, Crosbie, Dawood, & Lord (2013) which was directed at understanding current architectural design practices with respect to low carbon designs in the UK was also informed by interviews involving five participants drawn from large architectural practices in the country. Although the spread did not go through all the built environment professional disciplines, it covered a wide spectrum of stakeholders in the built environment; clients, Designers, facilities managers and built environment researchers (see table 2). Secondly, the vast years of experience they have acquired in working with other building professionals provides a good level of reliability in their opinions. In addition, because most of the participants sit at the top decision making bodies of their organization, they receive and work with feedbacks from other experts. The interviews were conducted using a semi-structured qualitative interview format; adopting the interview protocol discussed in Creswell (2009). The data collected was analysed using the thematic content analysis method as discussed in (Burnard, 1991; Aronson, 1994 and Marks and Yardley, 2004). The analysis method involved the use of coding or themes drawn from existing theoretical ideas that the researcher brings to the data (deductive coding) and from the raw data itself (inductive coding) as discussed in Marks and Yardley 2004.

Table 2: Summary of Building Professionals who took part in the Interviews

S/no	Code No. of Participant	Years of Experience	Professional Background	Professional groups according to the nature of job
1	**001**	30	Engineer	Client & Facilities Manager
2	**002**	Less than 10	Planning & Development Surveyor	Client
3	**003**	30	Building Surveyor	Facilities Manager
4	**004**	30	Architect	Building Design Practitioner & Academic Researcher
5	**005**	37	Architect	Academic Researcher

After the interviews were conducted, transcribed and analysed, a structured questionnaire in web format was developed and the link was sent to some professionals who were not able to make out time for a one-on-one interview. It was also published on the RIBA knowledge community blog. A hard copy format was also developed, to reach facilities managers principally, since they are directly involved with the day to day running of buildings. The purpose of the surveys was to reach a wider population of participants and also to allow for quantitative analysis of data. It was also designed to complement the results of the interview; to further explore possible case studies and the associated O&M challenges of the specific buildings the participants may have been involved with. The web format survey was collected and analysed using the 'SurveyMonkey' (online survey software) for data collection and analysis, while the data collected through the hard copy survey were manually fed into the SurveyMonkey for analysis.

3.0 FINDINGS AND DISCUSSION

The key findings that emerged from the study were that building designers attitude to maintainability is still very poor, and in most cases clients were never aware of the maintenance implication of their proposed buildings before they are erected. The findings also show that if designers are made to prove the operability and maintainability of their designs before they are constructed, they will for certain be maintainability conscious and the clients will be fully abreast of the maintenance requirements of their proposed building and be able to make informed choices at their own risk.

3.1 Attitude of Building Designers to Maintainability

The question about designers' attitudes to maintenance consideration during design featured both in the online and manual surveys. The online respondents which consist of nearly 70% of building designers (58.3% of architects and 8.3% of architectural technologists) were asked the question; *"From your experience as a professional in the building industry, how would you agree or disagree with the statement – most architects pay less attention to issues of maintenance and operation challenges in their designs?"* The result is reflected in figure
1. This could be said to reflect architect's opinion, since architects constitutes nearly 70% of the study population.
Figure 2 presents the result of the manual survey which has 50% of the study population made up of facilities managers (FMs). Other professionals in this population are just 7% (1 participant) each except the quantity surveyors which are 14% (2 participants). So it may also seem proper to say that this reflects the opinion of facilities managers.

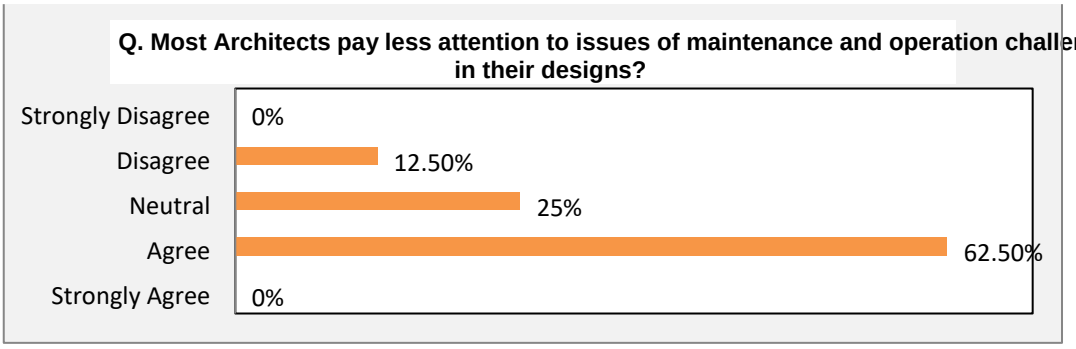

Figure 1: Attitudes of Architects towards Maintainability (Architects opinions)

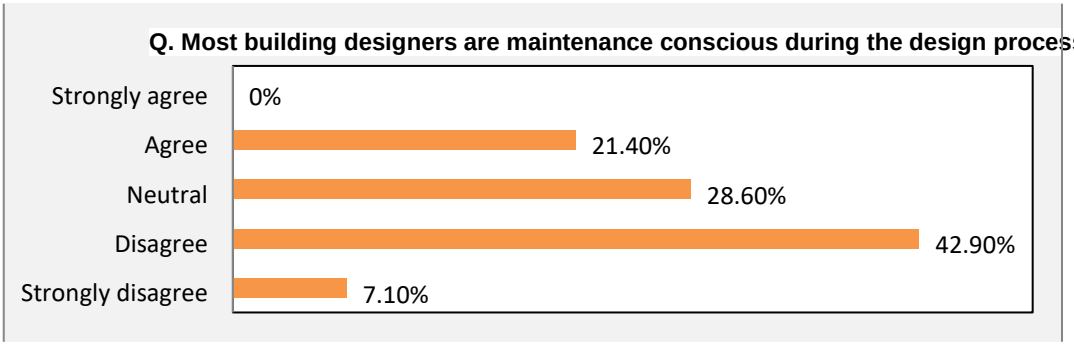

Figure 2: Attitudes of building designers towards Maintainability (FMs opinions)

Both results show that architects' attitude to maintainability has not improved much. While 62% of architects agree that most architects or building designers pay less attention to maintenance and operation issues during design, 50% of facilities managers corroborate this by disagreeing and strongly disagreeing that building designers are maintenance conscious during the design process. In both cases the percentage of neutrality are 25% and 29% respectively.

The interview result also returned 60% of the interviewees agreeing that most architects do not pay attention to maintenance and operation considerations during design. The question was put; 'there is an opinion that most architects are not maintenance conscious while making their designs. What do you think about that? It is interesting to quote their answers directly:

- *"Absolutely right!"* (Code no. 004). Interestingly, this participant is an architect with 30years experience in both private practice and in teaching and research in the UK.
- *"I think it is very variable, there is a school of thought that signature architects pay less attention to the issue of maintenance and operation challenges of the building in use".* (Code no. 001). This participant also has 30 years' experience and also involved in managing building procurement processes as well as managing the buildings in operation.
- *"It is not their primary concern how the building operates after construction".* (Code no. 002). Although this participant is less than 10 years in the industry, he sits on the management side of a renowned building developer company that has won several awards for the several buildings they have been involved with.

All three (3) study tools; the interviews, online and manual surveys, concluded that most architects do not give sufficient attention to issues of operation and maintenance in their designs.

3.2 Clients Awareness of O&M Implications

Following the strategy of inductive coding described by Marks and Yardley (2004), which involves drawing themes from the raw data itself, a comment from one of the interviewees was found to be interesting and worth further probing. Interviewee 001 represented a client body. The question about how as a client he would ensure that the building delivered to him was maintainable was put to him. His answer suggested that a skilled member of his team is usually assigned to work with the design team. This member uses his experience to identify any concern on the proposal as regards maintenance or operational challenges that are reasonable. Furthermore, a project management group, responsible for all of the individual projects will receive regular reports and presentations from the design team, and will use their collective skills also to voice out any concern regarding the proposals. This suggested that this client is usually armed with the operation and maintenance implications of his proposed buildings before they are constructed. So the online questionnaire was designed to also find out when low carbon building owners became aware of the maintenance implications of the buildings delivered to them. Participants were asked to indicate when the client for the exemplar LCB became aware of the maintenance implication of the technologies and when, by their respective experiences they think is best for the client to be aware.

The results from these two questions are reflected on figure 3. Although opinion was varied, however, results indicated that majority of the clients (37%) became aware of the maintenance implications during the design stage (RIBA stage C – E). Equivalent to Preliminary Design to early Detailed Drawing stages in Nigeria. This result seems to be in disagreement with other assertions in literature earlier discussed in section 1.5 which indicates that most architects do not

pay attention to maintainability issues during the design process. If the client became aware of the maintenance implication of his proposed technology at the design stage, then it most likely that the information would have been passed on to the design team, or even emanating from the design team.

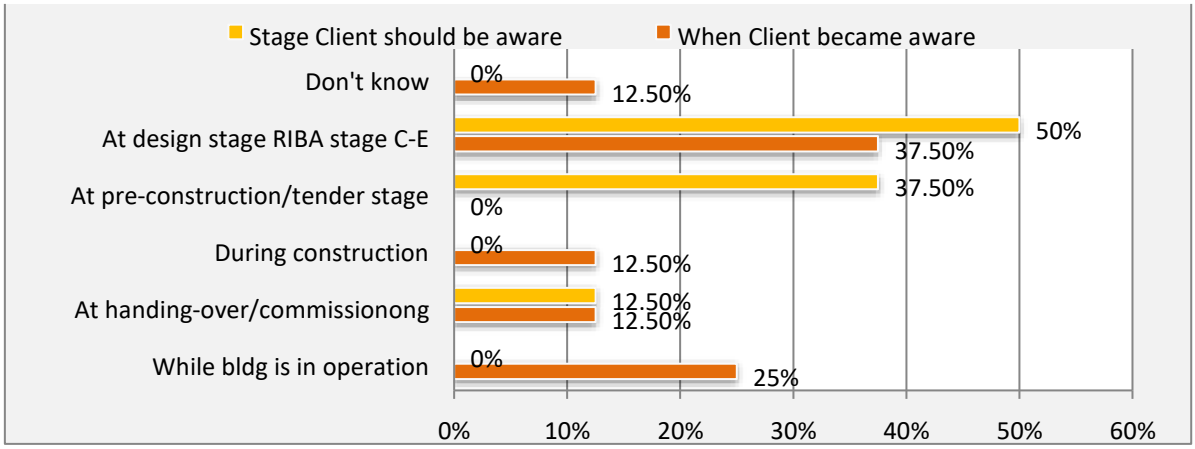

Figure 3: Clients' Awareness of O&M Implications of the Technologies (On-line Survey)

To validate this result, the question was reframed and included in the hard copy survey. Reframing the question became necessary because facilities managers whom the survey was targeted at are seldom involved in the design process. The reframed question reads; *"From your experience as a building professional, do you think that clients are usually aware of the operation and maintenance implications of their proposed building before construction?"* Figure 4 presents the results.

In this result, only 29% of the population (mainly facilities managers) agree that clients are usually aware of the maintenance implications while 71% said no. However, it is also noteworthy that the result of the first survey also shows that 25% of participants (mainly architects) indicate that clients became aware while the building is in operation. Another 25% said it was either during construction or during handing-over/commissioning and 12.5% do not know when. So the result in figure 3 could be interpreted as:
i) Clients are aware of O&M implications before construction – 37.5%
ii) Clients are not aware of O&M implications before construction – 50%
iii) Don't know – 12.5%
So the conclusion here would be that, in most cases clients are not aware of the maintenance implications of their proposed buildings before construction, however, in some cases they do.

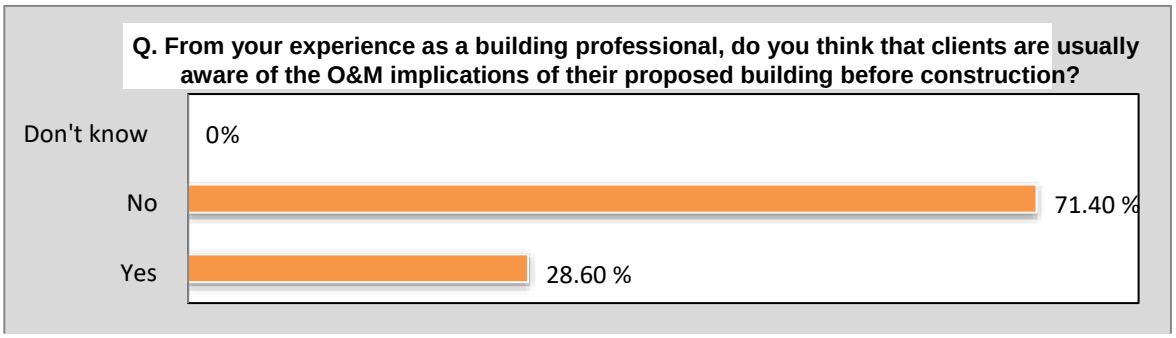

Figure 4: Clients' Awareness of O&M Implications before construction (Hard Copy Survey)

Figure 3 also indicated that 50% of the respondents suggested that it would be best practice for clients to be aware of the maintenance implications of their proposed developments at the RIBA stage C – E of the design process. Another 37.5% opined that the pre-construction/ tender stage (RIBA stage F – H) will be the best period. Both stages are before the construction stage. That means 87.5% are of the opinion that clients should be aware of the O&M implications of the design before construction.

3.3 Proving Operation and Maintenance

Commenting freely on what could be done to make architects think maintenance while designing, 60% of the interviewees said it will be necessary to prove how the building will be operated and maintained, before it is constructed. Interviewee code no. 004 commented thus; *"The first thing that is going to happen is that as the standards for low carbon buildings gets tighter, then architects will be required to prove that their buildings are going to perform and I suspect what is going to happen is that the building regulations will start to incorporate a maintenance regime or some kind of test after a year to see how it is working. The rest is how people feel in the building and that I think is bound to change".*

Interviewee 003 suggested that the architects need to demonstrate how the building operates *"before it is up".*
The second survey, directed at facilities managers was used to validate this opinion mainly because the facilities managers are those who engage with the building longer than other built environment professionals. In most cases, they represent the client, and in economic terms, they are consumers of the designers' and contractors' products. Tunstall (2006) argued that the consumer is in the best position to judge the success or failure of a product, and that their level of expectation is crucial. The result is shown on figure 5. In total about 93% of the study population agree or strongly agree that building designers need to demonstrate that the buildings they design will be maintainable (safely and economically maintained) before it is constructed.
In the opinion of Interviewee 001, this is already a requirement by law; "*the CDM regulations require designers to think through these things* (operation and maintenance), *the issue is how well do they do this?"*
The question of how well they do this or how well the law is being obeyed suggests that the best solution to improving designers' attitude to operability and maintainability should not end in legislation, but should extend to a cultural or process change. This change is inevitable if buildings in Nigeria need to be maintained long into the future and able to achieve value for money. CIRIA (2009) also argued that the obligation for building designers to provide their clients with safely and economically maintained and repaired assets, as well as wholelife considerations are already enshrined in law. However, it is often not well done and there is no practical guidance to this effect. It also suggested a *'cultural shift in work attitudes and thinking';* on the part of both clients and designers.
This suggests that there has to be a change in what clients expect from designers, and designers need to re-orientate themselves in the way they design. When clients constantly demand from their design consultants what the maintenance and operational implications would be (in terms of 'how' and 'how much'), then designers will sit up to their social responsibility of providing buildings with *'commodity, delight and firmness'* (Vitruvius in
Strelitz, 2008). Tunstall, (2006) describes firmness to refer to 'Constructability and Durability'. Meaning that, designers need to design buildings and their fixtures to be both constructible and durable.

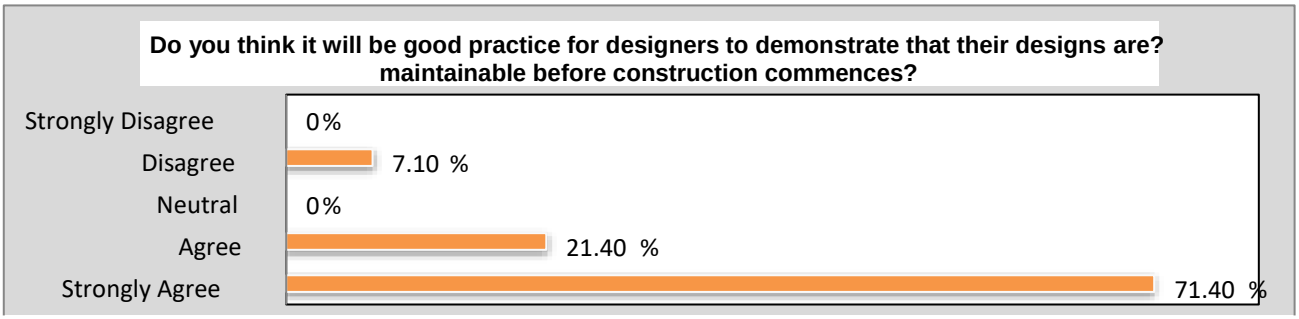

Figure 5: Need to Prove Maintainability

CONLUSION

The study has shown that building designers in the UK are not maintainability conscious, in most cases, clients are never aware of the maintenance implication of their proposed buildings before they are constructed. This agrees with assertions in literature concerning the situation in Nigeria as highlighted in sections 1.0 and 1.3. It is also an established fact that architectural education in Nigeria was greatly influenced by the British in its early days (Uji, 2001; Olotuah, 2006) which is just a little over 60 years ago. The first school of Architecture was established in 1952, in the then Nigerian College of Arts, Science and Technology Ibadan which transferred to Zaria in 1955 and the school later metamorphosed into Ahmadu Bello University Zaria in 1962 (Olotuah and Adesiji, 2005; Zubairu, 2007). American influence was also evident in the later schools of architecture in Nigeria (Olotuah, 2006). In section 1.5 it was noted from Arditi and Nawakorawit (1999) that the attitude of architects towards maintainability in the United States is neither different.
This study also highlighted the panacea to this apathy to maintainability; that clients must demand a proof of maintainability from building designers and designers on the other hand need to re-orientate themselves in the way they design buildings. In Nigeria, the architect is the prime consultant on every building project; s/he leads the design team and supervises the construction process to handing-over (NIA, 2000).
It is therefore right to conclude that there is need for a cultural/process change in the way buildings are delivered to end users by the architects in Nigeria. Public bodies are known to have in-house construction and/or maintenance teams. This team usually consists of building professionals; sitting on the clients' side of the table. They must need to request for proof of operability and maintainability if they must need to receive buildings that can be maintained long into the future, and achieve value for money.

ACKNOLEDGEMENT

This work consists largely of the results of a PhD research carried out in the University of Nottingham, United Kingdom, under the supervision of Prof Saffa B. Riffat, Chair in Sustainable Energy Technologies and President of WSSET, as well as Dr Siddiq Omer, an Associate Professor of Sustainable Energy Technologies; in the department of Architecture and Built Environment. Their contribution to this study is hereby acknowledged.

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