NATIONAL DURABILITY STANDARDS, GUIDES AND STRATEGIES FOR BUILDING STRUCTURE DURABILITY. A CASE STUDY OF AKWA IBOM STATE.

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ABSTRACT

The durability of structures is one of the primary concerns in building industry. Poor durability in design may result in a structure losing its performance to the extent where structural integrity is no longer satisfied and human lives are at stake. Moreover, the associated costs of maintenance and repair due to inadequate design considerations are high. Thus, designing for durable structures not only helps sustain our infrastructure, it also reduces future costs. This article identifies the key factors that affect the durability of structures, with particular attention paid to the effect of material choice on overall durability. This follows a study of durability and conservation and finally the national durability standard and rules. This further enhances the understanding of the impact that the design choices make, during the early stages of the project, on the overall durability of the structure.

One of the recommendations was that appropriate technology should be utilized in the manufacture of building materials and construction techniques to have durable buildings.

Key Words: Durability, building construction, national standard and guide, strategies

INTRODUCTION

A building is basically a shelter for the protection of man, his goods and animals. To this end, the whole development of building materials and construction techniques are related. Apart from providing shelter, a building must satisfy man's desire for mental and spiritual satisfaction from his environment as well as the function of enclosing space so that satisfactory internal environment that is safe and comfortable may be created relative to the purpose of the particular building. To achieve this, buildings must be well designed and efficiently constructed to exclude not only the adverse environmental factors such as weather, noise and heat but should provide adequate light and ventilation. In addition, adequate strength and stability must be provided together with adequate fire protection for the occupants, contents and fabric of the building (Foster and Greeno, 2006).

According to Fridley (2002), the durability of a building relies on the choice of materials suitable for the environment in which it is to operate and the correct detailing of its constituent parts to enable it to withstand the ravages of weather. A choice of unsuitable materials has frequently been the cause of failure of a building to perform satisfactorily, such as the incorrect use of high alumina cement in prestressed concrete floors or red shale- full of sulphates - as hardcore, but by far the largest single cause of degradation over the years has been due to the lack of suitable details with which to keep the weather at bay.

Bijen (2003) asserts that design and detail considerations, or rather the lack of them, have resulted in premature degradation of many buildings in Nigeria. The lack of attention to the details of design, deflections and crack control, joints (movement, daywork and precast) architectural features and drainage have led to the expenditure of many millions of pounds in remedial work which, with a little foresight would have been quite unnecessary. Many of these defects have occurred in buildings less than 20 years old, especially parking structures, and yet similar buildings constructed well before the second world war are still functioning adequately without undue maintenance problems.

The durability of a building also relies upon attention to detail, an understanding of the limitations of the materials of construction and an appreciation of their qualities. Mehta and Bridwell (2004) asserts that if we are to progress as a society, new techniques must be allowed to develop, and mistakes may continue to be made. It is the scale upon which these mistakes have been made in the past which is so frightening, and the fact that even today with a wealth of information available, the same basic errors are repeated again and again.

Statement of the Problem

Over the years, the durability of structures has been of great concern to engineers, architects, and designers and the demand for durable designs has been increasing. Lack of durability in designs may result in a structure losing its performance to the extent where structural integrity is no longer satisfied and human lives are at stake. To a less severe extent, lack of structural durability results in high long-term costs for repair and adjustments. One consequence may be shutting down the structure, which may cause inconvenience for the users and have additional costs for rerouting traffic in the case of a bridge, or displacing people from their homes in the case of a building. Hence, this study seeks to assess the improved means of durability in building constructions.

Purpose of the Study

The general objective of this study is to examine the durability of structures as one of the primary concerns in building industry. The specific objectives therefore include:

> To determine the influence of the various national durability Standards, Guides and strategies for building structure durability on the actual durability of building structures in Akwa Ibom State.

Research Questions

The following research questions will be answered:

> What is the influence of various national durability Standards, Guides and strategies for building structure durability on the actual durability of building structures in Akwa Ibom State

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Hypotheses

There is no significant influence of various national durability Standards, Guides and strategies for building structure durability on the actual durability of building structures in Akwa Ibom State.

LITERATURE REVIEW

Factors Affecting the Durability of Structures

According to Nireki (2006), the design for durability is a process that needs to be carried out throughout the design life of the structure. It starts with the design and decision process carried out by the engineer and client, and ranges from the construction sequence carried out by builders, to the type of maintenance procedures implemented throughout the structure's design life. For any structure, there is a set of factors that need to be defined and that all individuals involved in the decision-making, engineering, constructing and maintaining processes must be aware of. Some of these factors are:

- Type of structure: Exposed versus unexposed; example: a building would require different design considerations compared to a sculpture in a museum or a bridge.
- Type of material used in design and construction.
- Type of surrounding environment; Dry versus wet climate and probability of an re-occurring natural disaster in the region, example: seismically active regions.
- Restrictions given by the client: This has to do with timeline given for the project and allocated budget for the project.
- Future adjustments to original scope: This involves possible expansion of the project in the future, possible relocation of structure and use of structure for additional services.

The factors listed above play an important role in directing the design toward a specific path and in achieving durability and maintaining infrastructure. For instance, budget and schedule limitations restrain designers from investing in materials that may be more durable due to the high cost associated with it, while schedule limits the designer from looking further into different design alternatives that may enhance the durability of structures. Consequently, it is important to identify the key players in each stage of the project and their influence on the final outcome (Nireki, 2006).

Parry (2003) asserts that the initiation of a project begins with the client's willingness to invest in it. It is the client that decides on the purpose of the structure, the type of structure to be designed and constructed, the location of the structure, and the time and budgetary restraints. Therefore, having a clear scope of work that is identified by the client is essential. From there, a team of architects and engineers, varying from civil to electrical, depending on the scope of work, are brought on board with a project management team. Through collaboration of the different disciplines in the analysis and synthesis processes of the project, durable designs are achieved. In parallel, the project management team would work on tying the components of the project together to achieve the client's ultimate goal.

To achieve durability, the design life of the structure, its intended use and location are the first few factors that need to be identified in the early stages of the project. These depend on the client's requirements. Hence, identifying whether the structure is temporary or permanent and the importance of the structure's safety, for example a hospital versus a warehouse, narrows down the designer's vision. Given the design life of the structure, through recommendations made in conjunction with other conditions mentioned based on knowledge and experience of engineers, enables designers to develop a durable design. The type of material used and geometry of the structure are the type of decisions made based on the given constraints that in turn greatly influence the structure's durability. Furthermore, the type of construction sequence and maintenance procedures implemented greatly depends on the latter, which subsequently impacts the cost and the anticipated time required to complete the project (Parry, 2006). Throughout this process the project management team works in parallel with the designers to develop a schedule and a cost breakdown that best satisfy the client's requirements. It is through collaborative work between the different teams and the client that results in a durable/high-quality structural (Soronis, 1992).

Durability and Energy Conservation

Once constructed, a building becomes a machine that "needs to be fed." The more durable the building, the longer it is around. The longer the building is around, the more energy it consumes. Durable buildings need to be ultra energy efficient in order to be sustainable. Durability and energy efficiency are the cornerstones of sustainability. Bijen (2003) asserts that one of the lessons of durability learned through failure is that as energy efficiency is increased, durability is typically compromised. One of the key elements of energy efficient building enclosures is a high level of thermal insulation. However, as thermal insulation levels are increased, the rate of building enclosure drying decreases. This affects building durability as it affects the moisture balance.

Another lesson of durability linked to energy conservation learned through failure is that insulating sheathings, a key element of energy efficient building enclosures are prone to insect infestation. Ground contact insulating sheathings can act as "insect interstates" that provide pathways into buildings. The failures associated with ground contact insulating sheathings lead to a building code prohibition for their use in regions with a high probability of termite damage (Bijen, 2003).

Finally, one of the most poignant lessons of durability linked to energy conservation learned through failure is the one of CO poisoning. As the air tightness of building enclosures increases, the ability of combustion appliances to function is compromised. The durability issue here is the durability of the occupant. The failures associated with combustion appliances lead to building code changes and the development of new equipment and systems to address the failures. The key role of water control in the durability of buildings has been long recognized and some good guidance on water control in buildings exists. Unfortunately, the guidelines on water control are not tuned or adapted to different uses and climates. Additionally, what is missing is guidance on heat, ultra-violet radiation and insects. If the historical lessons of failure are matched with the appropriate physics and engineering judgment guidelines for the control of water, heat, ultra-violet radiation and insects can be developed for use in a practical durability standard and risk assessment protocol for use by designers, engineers, architects and contractors (Bijen, 2003).

National Durability Standards and Guides

Soronis (1992) asserts that due to time constraints, and constant upcoming deadlines that designers and engineers are required to meet, they do not have the privilege to further look into alternatives that may better their design. Therefore, the use of other resources to assist engineers in this matter is important. Some of these resources include consultation with material scientists on material properties and behavior, and the use of standards and guidelines that lay out procedures to further direct engineers during the design process. The first to address this matter was CIB W94 document in 1991 (Soronis, 1992). Two common standards are: The British Standards, BS7543 and The Canadian Standards, S478

British Standard, BS7543

The British Standards, BS7543 "Guide to durability of buildings and building elements, products and components" (first published in1992), provide guidance to engineers when determining the required and predicted service life, and design life of a structure. In addition, it discusse s the different type of deterioration mechanisms and their causes, and examples of premature deterioration. The scope of the BS7543 is aimed at new construction mainly related to buildings. It does not account for scope changes over the life cycle of the structure like, changes in the intended use of the structure to meet user's new requirements. It is the client who defines the type of structure to be engineered. With this information the service life of the structure can be predicted accordingly.

The service life of a structure is a specified period of time where the structure is expected to perform adequately taking into account maintenance procedures that include activities such as repair or replacement of parts of the structure. Having knowledge and data based on other structures placed in similar surrounding conditions and used for similar purposes greatly help in predicting the service life of a structure. With respect to the design life of the structure, the client, the designers and engineers will specify a recommended period of time that satisfies the owner's requirements. The design life of the structure impacts the choices made in attaining a durable design. To achieve durable designs, the structure's performance needs to be maintained throughout its design life.

Recommendations for the design life period for buildings ranges from performing scheduled maintenance procedures on the structure to replacement of elements of the structure due to failure. Additional factors such as surroundings conditions, level of performance and the time period over which the durability of the structure is evaluated need to be defined. The level of performance refers to the limit where the functionality of the structure's element is no longer acceptable. Moreover, the level of experience of each individual involved in the project has great influence on the decisions made that will eventually affect the level of durability a structure may exhibit. Furthermore, the standard discusses the different means of deterioration that affect building components and materials. This includes biological agents such as insects and micro-organisms, weathering agents due to environmental conditions, stress agents, chemical and physical agents, and agents due to users' interaction with the structure. The latter includes activities as simple as replacing a broken glass window to lack of regular inspection checks carried out on the structure that results in the acceleration of the deterioration mechanisms. Additionally, the standard outlines a few examples of structures that experience premature deterioration, where the service life of a component of a structure or a material is less than the design life.

One of the shortcomings of the British Standard is lack of sufficient guidance on structure's adaptation to new requirements. It is important for designers to address issues that may either involve incorporating new design requirements or adapting an existing structure to new design requirements. Careful reassessment of the structure's performance will need to be carried out to ensure the durability of the structure.

Canadian Standards, S478

Similar to the British Standards, BS7543, a Canadian Standard, S478: "Guideline on durability in Buildings" was first published in 1995. It outlines the different factors associated with durability, ways of assessing deterioration, and methods to predict the service life of a structure. Moreover, it provides guidance for incorporating durability-enhancing techniques into design, construction sequence and maintenance procedures to prolong the structure's design life. The standard defines durability in terms of service life, predicted service life and design service life. Service life is the period for which the structure does not experience any unanticipated costs and repair activities. Predicted service life is based on data collected from previous structures, models and tests that have been carried out. Unlike the British Standards that uses the principal of Masters and Brandt to predict the service life of a structure (Soronis, 1996).The Canadian Standards uses three different methodologies to determine the predicted service life. Illustrating the performance that an identical assembly exhibits, or modeling a possible deterioration mechanism, which depends on the factors that define the project, or by testing new means that will be used towards accomplishing higher level of durability are methods used in predicting the service life of a structure. Lastly, the designer in agreement with the client's requirements defines the design service life. The design service life of a structure is categorized into four parts: temporary, medium life, long life and permanent.

The fundamental durability requirement for a structure is to have a maintained level of performance through its defined design service life. According to the Canadian Standard, durability is achieved only if it is accounted for throughout the different stages of a project: conceptual design, detailed design, construction and maintenance. The extent of damage a structure may experience is categorized into eight different levels according to the consequence associated with each. It ranges from minor damages such as replacement of light fixtures to severe casualties such as endangering human lives.

Soronis (1996) asserts that showing the effect of durability from an economical aspect is not accounted for in both standards, S478 and BS7543. To achieve durable designs from an economic standpoint, the different engineering activities ranging from purchasing the different commodities to constructing and maintaining the structure need to be affordable. By further illustrating the effect of different choices made on the cost of durability will further aid designers in making suitable decisions.

Methods

Research Design

The research design for this study, as found fit was an Expost Facto type.

Area of the Study

The area of study is Akwa Ibom State.

Population of the Study

The population of the study consisted of all the architects, civil engineers, quantity surveyors, electrical engineers and teachers of building technology and technical education in Akwa Ibom State.

Sample and Sampling Technique

The respondents in the study consisted of 200 architects, civil engineers, quantity surveyors, electrical engineers and teachers of building technology and technical education. They were obtained through the simple random sampling method. Hence, the sample size of 200 respondents was used for the study.

Research Instrument

The researcher developed one instrument tagged "National Durability Standards Guides And Strategies for Building Structure Durability Questionnaire (NDSGSBSDQ). The instrument was made up of two sections, sections A and B. and used for data collection.

Validation of the Research Instrument

The instrument was face and content validated by an expert in test, measurement and evaluation. The corrections and comments were incorporated into the final form of the instrument.

Reliability of the Instrument

Pearson product correlation was used to determine the reliability of the instrument (NDSGSBSDQ), using 30 respondents who were not part of the main study but possess the character of the population. The reliability co-efficient was 0.84 showing that the instrument is reliable.

Data analysis technique

One research question was answered with descriptive analysis while the hypotheses were tested with chi-square analysis. The results of the statistical analysis for the hypotheses were tested for significance at 0.05 alpha level. Each result was considered significant if the calculated value was either equall to or greater than the critical value, but non-significant if the calculated value was less than the critical value.

Results and Discussions

Hypothesis One

The null hypothesis states that there is no significant influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State.. In order to test the hypothesis multiple regression analysis was performed on the data, (see table 1).

TABLE 1

Multiple regression of the joint influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State.

Model	R	R Square	Adjusted R Square	Std. error of the Estimate	R Square Change
1	0.97[a]	0.95	0.95	0.38	0.95

***Significant at 0.05 level; df= 128; N= 130; critical R-value = 0.197**

The table shows that the calculated R-value 0.95 was greater than the critical R-value of 0.197 at 0.5 alpha level with 128 degree of freedom. The R-square value of 0.95 predicts 95% the joint influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State. This rate of percentage is highly positive and therefore means that there is significant influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State. It was also deemed necessary to find out the extent of the variance of each class of independent variable as responded by each respondent (see table 2).

TABLE 2

Analysis of variance of the influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	334.30	2	167.15	1191.21	.000[b]
Residual	17.82	127	.14		
Total	352.12	129			

The above table presents the calculated F-value as (1191.21) and the computer critical f-value as (000). Being that the computer critical f-value (000) is below the probability level of 0.05, the result therefore means that there is significant influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State. It was also deemed necessary to find out the level of contribution of each independent variable (see table 3).

TABLE 3
Coefficient analysis of the influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State

	Unstandardized Coefficients		**Standardized Coefficients**	T	Sig.
Model	**B**	**Std. Error**	**Beta**		
(Constant)	-0.64	0.46		-1.41	0.16
Strategies	-0.06	0.05	-0.05	-1.07	0.29
National standards and guides	0.98	0.04	1.02	23.51	0.00

From the above table, the result was observed to be significant with National standards and guides having higher influence (0.98) on the actual durability of building structure in Akwa Ibom State than that exerted by the strategies (-0.06)

Discussion

The result of the data analysis in table 1 was significant due to the fact that the calculated R-value 0.95 was greater than the critical R-value of 0.197 at 0.05 level with 128 degree of freedom. The result implies that there is significant influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State. The result therefore is in agreement with the research findings of Nireki (2006), who stated the design for durability is a process that needs to be carried out throughout the design life of the structure. It starts with the design and decision process carried out by the engineer and client, and ranges from the construction sequence carried out by builders, to the type of maintenance procedures implemented throughout the structure's design life. The significance of the result caused the null hypotheses to be rejected while the alternative one was accepted.

Conclusion

Accounting for durability is necessary to maintain our surrounding infrastructures through out their life span. The choices made during the design phase of a project greatly influence the overall durability of the structure. Lack of durable design may result in a structure losing performance to an extent where structural integrity is no longer satisfied, potentially leading to fatal accidents. Identifying the key individuals involved in the decision-making process and the different factors that affect the structure's performance and overall cost is vital in achieving durable designs. The evolution of materials has indicated designers' effort in producing durable designs. The choice of materials used has a great impact on the performance and cost of the project. Understanding the material properties and its behavior depending on the intended use of the structure and surrounding conditions aids engineers in their decisions and recommendations to the client. It is important to have a good background in material properties and behavior to further incorporate durability into a structure's design and execution. Also, there is significant influence of various national durability Standards and Guides for building structure durability on the actual durability of building structure in Akwa Ibom State.

Recommendations

The following are recommended:

1. Appropriate technology should be utilized in the manufacture of building materials and construction techniques to have durable buildings.
2. There is a great need for the dissemination of existing knowledge and for advanced research in the field of service life planning and durability, including the development of using friendly dedicated tools.

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