The Role of State and Professional Bodies in Developing Code for Structural Concrete – Learning from other Nations

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Abstract- In order to arrest the rampant structural failures of buildings, there have been call for the development and adoption of structural design codes that will capture all relevant environmental issues that are peculiar to Nigeria. This paper presents the results of analysis of data collected from the public domain (libraries and internet sources) on Nations with acceptable structural design codes in concrete and allied materials. Some of the findings are that: (i) Code or Standard does not necessarily need to be a legal document or backed by the state to enjoy wider acceptance or be recognized, (ii) it is possible for people in the same professions to form professional association and regulate the operation of the profession by setting standard of practice which can be recognized, not only by people, but also acceptable to the State and (iii) whether a standard developed as a legal document or recommendations of professional association, openness and consideration for the inputs for all are necessary. This is to ensure that the operation of the standard will not run contrary to the public good, or in violation of the common law, or infringe the rights of a subject/citizen.

Keywords- Building failures, Codes, Concrete, Legal document, Professional bodies, Structures.

1 INTRODUCTION

The primary requirement of all structural design is to achieve an acceptable probability that a structure will perform satisfactorily during its design life. The word "structure" on the other hand was from the Roman Latin word "*structura*", meaning "to construct, to fit together" (Vocabulary, 2019). The purpose of which is to create an undistorted protected space, in form of all manner of infrastructures, firstly for military security, because Roman society was laid essentially on military foundation (Barrow, 1955). Inherent in this perspective of structure is the expectations of strength, robustness and durability. Thus, many Roman public infrastructure exhibit these traits and have stood the test of times. Some of them are being used to this present day in Rome (Milliken, 1952; Delatte, 2001 and Atkins, 2018). Afterall, the fact that there is cessation of wars (to give birth to civil engineering, as history teaches us), does not mean that people should now be dwelling in unsafe and fragile building. Whether during war or peace times, building should be strong, robust and durable.

In our days, civil engineering structures are designed to demonstrate the same traits of Roman structures of strength (against all forms and manner of loading conditions), robustness (against unforeseen loadings conditions) and durability in the domiciled environment (against the elements). Buildings in form of human shelters in particular, are usually given more attention, in relation to safety and durability requirements, because it is a fundamental need of all apart from food and clothing. Its design has thus assumed a national attention in the form of guiding legislation. Thus, structural designs of buildings are carried out based on national or international codes of practice, aimed at preventing failures. Codes are as old as the antiquity. For example, there was what is now known as the code of Hammurabi, the King of ancient Babylon, enacted around 1760 BC. The code stipulated that the builder of a failed structure shall forfeit his own life, or his own son, or his own slave, if the failed building killed the owner of the house, or the son of the owner or the slave of the owner respectively.

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Implicit in this code is that anyone without a son or slave cannot be a builder, and neither can a woman. Otherwise, the code will unenforceable. Also, the writings of Moses (1982) the legislature for the ancient nation of Israel, about 1400 BC, contains a provision for a parapet round the roof of the house to prevent a person falling down. Implicit assumption is that the roofs of houses are used for re-creation and leisure. Thus, this provision was to prevent a person from dying by falling from the roof of a house.

The provision of the code (Institute) of Justinian (1911), the Emperor of Roman empire around 535 A.D, guarded against the possibility of demolishing a house built on another man's land out of ignorance. In all these cases, attempts were made by the reigning power to protect lives and building properties. In our modern day, many nations have developed their own codes (or standards) to regulate and guide, especially the structural design of buildings, giving details of types of loadings, structural systems, materials selection, amongst others. Since varieties of materials like concrete, steel, woods, aluminium, amongst others, are available for building and civil engineering construction; national codes exist for each of these materials. Within each material, there are also variations, and different codes govern their designs. For example, in concrete, there is prestressed concrete, high strength concrete, precast, composite, amongst others. These are done in an attempt to prevent building failures and the attendant loss of lives and properties.

Opinions are divided on whether the stated ancient codes gave specific recommendations in relations to loadings, structural systems, materials stress/strain relationships, etc. as are in the present codes of the nations. The Romans in particular, seemed to have an instinct to know what will work. For example, the imperial Caesar, in one of his numerous wars, suddenly encountered a broad, deep and swift river Rhine, where he must cross with his infantry (foot soldiers), cavalry (horses) and other war machines. He thought it "beneath his own dignity and that of Roman people to cross the river by any other way but by building a bridge over it (Caesar, 1994)". He did build a piled wood bridge in 10 days, and thereafter described the way he built it in about in about 250 words. (Caesar, 1994).

Also, the Romans could build a concrete dome of 43 m high and 43 m in diameter without reinforcement. Today, no structural engineer dare builds such a structure without reinforcement. Perhaps, for lack of that instinctiveness that is characteristic of the Romans, in our age, structural codes of nations contain specific provisions on loadings, structural systems, materials, etc. to prevent structural failures. All these are evident in the American Standard, the Australian Standard, the British Standard, the Eurocodes (for the whole continental Europe), amongst others. Though, Nigeria at present uses the British Standard for her structural design project in concrete, steel, timber, and all others. But this has not stopped the incidence of structural failures. Embarrassingly, structural failures have been on the increase with the attendant loss of lives. This can be seen in Table 1.

Table 1. Summary of Collapse Buildings and Casualties between 1971 – 2016 in Nigeria (Omenihu et al., 2016)

S/No	Year	Number of Collapse	Number of Lives Lost	% Collapse Occurrence
1	1971 – 1975	2	51	1.14
2	1976 – 1980	8	99	4.57
3	1981 – 1985	14	71	8.00
4	1986 – 1990	15	144	8.57
5	1991– 1995	20	112	11.43
6	1996 – 2000	24	175	13.71
7	2001- 2005	23	235	13.14
8	2006 – 2010	28	324	16.01
9	2011 – 2016	41	244	23.43
Total		**175**	**1455**	**100**

Sadiq (2014) attributed the cause of incessant building collapse to be structural in nature. He carried out critical error analysis on the role of professional consultants vis-à-vis their actions and inactions in preventing collapse of structure. He opined, amongst others, that (i) any error committed by Architects may results in aesthetic defects, but not in failure (ii) the error of Quantity Surveyor may result in high project cost or underestimated cost, but will not lead the collapse of the structure, (iii) the error of Mechanical and Electrical Engineers in mechanical and electrical devices will only lead to malfunctioning of plumbing, electrical, air conditioning, and other services, but these will not threaten the stability of the structure and (iv) the inability of structural engineers, if presents, to carry out proper site investigations and provide adequate supervision of structural members, as well as errors in calculating design loads accurately can lead to collapse either during construction or in service. He thus concluded that, all other professionals in the built environment, by their training, have little or no power to prevent collapse of structures, except structural engineers.

But engineers of this age cannot work without acceptable National code. This has necessitated the call for the development of structural design codes based on Nigeria environment. This call is appropriate. Since sustainability and environmental issues are now involved in the design and practice of structural engineering, especially structural concrete. What is acceptable in one environment may not be acceptable in another. Though, Nigeria at sometimes had NCP 1 (1973), which seemed to be the only code, in the Country, that was cast in the mould of structural designs code as for other nations. But it has not enjoyed widespread usage. Absence of government backing has been given for this (Omenihu et al., 2016). But structural engineering as now practiced has a wider scope than in or before 1973. For example, the use of wastes of all sources, environmental concerns and technological advancement was not anticipated in the NCP 1 (1973). A new code is thus imperative to capture all these and, if possible, project into the future. In writing the code however for wide acceptability, it is necessary to learn from those countries whose codes have enjoyed wider acceptance, what they did right. Thus, the aim of this paper is to provide some useful guide, in this direction, to the stakeholders in Nigeria, as learnt from other nations, so that the code will enjoy wider acceptance and subsequently lead to safety of lives and properties

2 METHODOLOGY

The method used for this work is the collection and analysis of data and information on the existing codes for structural designs of nations that are available from in the public domain. These are in the form of textbook, journals, reports, and other materials that are available in the libraries (University of Lagos and Federal University, Oye-Ekiti.) and on the internet. The countries whose codes were examined are: The United States of America (USA), China, Egypt, European Union (Euro), India, Japan, and the United Kingdom (UK). Since cement, concrete and steel, as well as their products have become the most used materials in the framing and construction of structures, the data and information presented in this work relate to these two materials.

3 RESULTS AND DISCUSSIONS

From the analysis of the information collected from the public domain, two sets of procedures were involved in having acceptable national structural design code. The first was based on legal status, while the other was based on public confidence for a professional association. They are now discussed in the subsequent subsections.

3.1 STRUCTURAL DESIGN IN CONCRETE CODE AS A LEGAL DOCUMENT.

The nations that come under this category are European Union, Arab Republic of Egypt, India, and the United Kingdom. But the British Standard BS 8110 (Structural

Use of Concrete) issued by the British Standard Institute will be used as representative of this group with illustrations from others. The British Standard Institute (BSI) came into existence through a Royal charter (BSI, 2019). According to LN (2016), such charter confers on BSI a legal status, and so is her activities. Thus, her documents – including BS 8110 - are part of the "Law of the Land (LOL).". However, to ensure that her documents form part of the LOL, her activities must not run contrary to the public good or in violation of the common law, and it must not infringe the rights of a subject (LN, 2016). It is in pursuance of these that the followings were represented and made inputs into the document issued by BSI as BS 8110. These are:

1. Association of Consulting Engineers
2. British Cement Association
3. British Precast Concrete Federation Ltd
4. Concrete Society
5. Department of the Environment (Building Research Establishment)
6. Department of the Environment (Property and Building Directorate)
7. Department of Transport (Highway Agency)
8. Federation of Civil Engineering Contractors
9. Institution of Civil Engineers
10. Institution of Structural Engineers
11. Steel Reinforcement Commission.

This information was in the first page of BS 8110 (1997). That the BS 8110 (1997) is a legal document, though not expressly stated at its cover is not in doubt, based on the provided background information. But this information was conspicuously stated in relation to the European Union's Eurocode (Figure 1) and the Code of India (Figure 2). At the cover of both the Eurocode and Code of India is the open statement, that the design code is a government document. The documents showed plainly for all to see that they have all passed through the legislative processes and procedures. Not only that, the public has a right to know it. The same information is also true for the Code of the Arab Republic of Egypt. The implication of code being a legal document is that it is bound to be enforced by the appropriate state authority and any offender can be taken to the court of Law. The above information is very instructive to us in Nigeria.

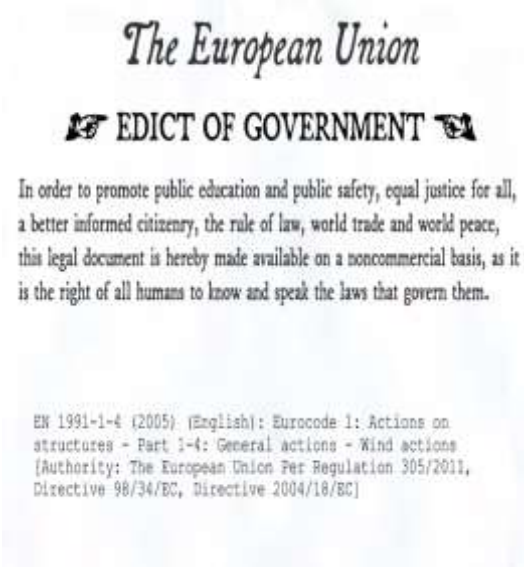

Fig.1: The Eurocode

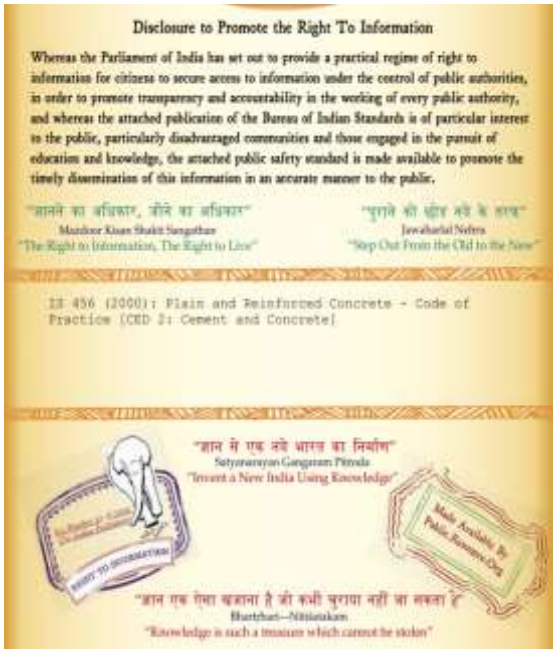

Fig. 2: Concrete Code of India

From this list of bodies that was represented in the drafting of BS 8110, it is obvious that we must seek out the equivalent in Nigeria as the first step. This calls for selflessness and consideration for others. All desires safety. In Nigeria, when one looks at the equivalent of the bodies that drafted BS 8110, and knowing that neither has the statutory power to summon the other, it is obvious that only the state can authorize the gathering of so many bodies, in the public interest, on the platform of the state.

3.2 Code that was founded on the Public Confidence for Professional Association.

In this category are the American Concrete Institute (ACI) in American and the Japanese Society of Civil Engineers (JSCE). The ACI published the Building Code Requirements for Structural Concrete (ACI 318-14) for the American society. Also, JSCE published the Standard Specifications for Concrete Structures for the Japanese

society. Using the ACI as representative of this category of codes, plainly stated in the introduction are statements consistent with this status. Thus, we can see the followings in the introduction of ACI 318-14 (2014):

> *ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.*

Another portion goes like this:

> *All information in this publication is provided "as is" without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.*

That the code is not a government document can be seen from the following statement:

> *Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.*

This is a bold statement that it is the government that is collaborating and not the Association. That, the association is independent of the government of America. And finally, that the code is not a legal document is stated clearly by this statement:

> *The Code has no legal status unless it is adopted by the government bodies having the police power to regulate building design and construction. Where the Code has not been adopted, it may serve as a reference to good practice even though it has no legal status.*

This statement is also included in the Japanese code JSCE-16 (2007). Despite all these declarations and many more on the preface, not only this code, but indeed, all other codes from the stable of ACI enjoy wider acceptability by professionals and government of the United States of America. Not only that, ACI codes are used for instructional and research purposes in Universities worldwide.

Some researchers in Nigeria have attributed the neglect of the Nigeria's NCP-1 (1973) to the fact that it is not a legal document, or backed by Nigerian Law (Omenihu, et al., 2016). However, observing the high acceptability of ACI and JSCE codes and standards without any legal backing or state legislation, one is bound to revise this opinion. ACI now prides herself as the "leading authority and resource worldwide for the development, dissemination, and adoption of its consensus-based standards, technical resources, educational & training programs, certification programs, and proven expertise for individuals and organizations involved in concrete design, construction, and materials, who share a commitment to pursuing the best use of concrete. ACI has more than 100 chapters, 215 student chapters, and 30,000 members spanning over 120 countries" (ACI, 2019). But how did ACI achieved such a feat? From the publication of ACI (2004) titled "A century of Progress", we can learn many things about the ACI. Here are some of them, which is a tip of the iceberg, considering the limitation of space. The ACI is an association that came into existence in 1904, through the efforts of professionals in a competitive market of concrete block making. For lack of a serious standard practice in making concrete block at the time, conditions unsatisfactory for building with concrete had resulted.

Thus, ACI was born out of ideas conceived by concrete professionals, that better concrete for more durable, maintenance-free structures is possible. It is to be noted that at the time of the formation of ACI, concrete, was yet to assume the prestige it now has as the favored construction material all over the world. It was as if the professionals who birth the idea were able to see into the future to see the glory of concrete as construction material. Since then, ACI seemed to flown on the wings of the growth of concrete, with unwavering desire to make sure that the latest information is available to assure top-notch quality (Baker, 2001). This can be seen from the volume of publications in form of recommendation for standard practice, Journals, Magazine, Handbooks, Manuals, Reports, etc. on concrete design and construction, which are recognized in America, Europe, around the globe and all leading educational institutions in the world.

Thus, ACI was able to sustain herself financially by developing and sustaining a reputation of good service. Their society enjoy the confidence of Americans, and voluntarily patronize it without the activities of the state. This tells so such on the quality and integrity of the membership. We can thus see that practitioners of a particular trade can organize themselves into association with the aim of regulating the practice, through publication of recommendations for standard practice of that trade. The growth and survival of that association will now depend on the level of confidence it enjoys from the society, without inviting the law-enforcing agencies for enforcement of their services.

4 Conclusion and Recommendations

4.1 Conclusion

From the above studies, the followings can be concluded.

1. Code or Standard does not necessarily need to be a legal document or backed by the state to enjoy wider acceptance or be recognized.
2. For Nigeria to come up with acceptable Legal code of Structural Concrete Design and Practice, many professionals will have to be involved. Only the

Nigerian state can peacefully bring these professional bodies together, in the national interest.

3. It is possible for people in the same professions to form professional association and regulate the operation of the profession by setting standard of practice which can be recognized, not only by people, but also acceptable to the State.
4. Whether a standard developed as a legal document or recommendations of professional association, openness and consideration for the inputs for all are necessary. This is to ensure that the operation of the standard will not run contrary to the public good, or in violation of the common law, or infringe the rights of a subject/citizen.

4.2 Recommendation

In Nigeria today, there is a need. That need is how to build safely and durably. Buildings and structures are collapsing on a daily basis. Group of professionals (architects, builders, civil engineers, structural engineers, bricklayers, carpenters, etc.) and product manufactures (blocks, cement, concrete, etc.), that are actively practicing in the construction industry, can form a voluntary association to regulate it. They can then begin to publish recommendations for standard of safety and durability, born out of their own aggregate practical experience. They can be holding seminars and be organizing conferences to make known their findings to the society. The association need not involve the government. This is like using the ACI template, which was also born out of a need. This approach, is thus recommended for a trial.

5 Limitations of the Study

The information and data used in this research work was obtained exclusively from the public domain. Thus, the authors cannot guaranty the validity or completeness of the data. Also, the authors are not legal experts, so their interpretation of some legal instruments during the course of this work may be imperfect. Thus, the authors wish that their work will be used for what it is: just a guide to take note of, or information to consider in the development of the Nigerian Structural Design Concrete Code.

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