COMPLIANCE WITH THE PROVISIONS OF ACOUSTIC REGULATIONS IN THE NIGERIAN BUILDING CODE: A CASE STUDY OF CATHEDRAL ROAD, AKURE

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Abstract

There are three problems that this present generation has to find solution to: Poverty, Population and Pollution. Industrialisation and urbanisation have taken the problems of noise pollution to an unprecedented catastrophic in the modern world. While the advanced countries have taken some legislative measures in form of Acoustic Building Codes to control the problem of noise and its attendant effects, developing nations like Nigeria may not have fared well in this regard. This paper appraised the level of compliance with the acoustic provisions in the Nigerian Building Code. The paper reviewed some selected building codes with particular emphasis on their acoustics regulations. The selected building codes include that of the United Kingdom, United States of America, New Zealand, Australia and Nigeria. A practical case study of the Cathedral Road, Akure was made to assess the level of compliance with the provisions of the building code, if any.

A building code, according to WorldNet 3.0, is a set of standards established and enforced by local government for the structural safety of building. Farlex (2011) defined building code as 'systematic statement of a body of rules that govern and constrain the design, construction, alteration, and repair of buildings'. The essence of building codes are for the protection of public health, safety and general welfare of the occupants of buildings and non-building structures. The codes are meant to proffer lasting solutions to the hazardous trends in the building industry. These problems might have resulted from planlessness of the built environment, use of non-professionals, use of substandard materials, insufficient referenced design standard for professionals and lack of adequate regulations and sanctions against offenders (Toluhi, 2009). The resulting effects of these problems include frequent building collapse, fire outbreaks, environmental pollution and other disasters.

Noise can be defined as an unwanted sound and acoustics as the science of sound in general. However, acoustics is more commonly and technically used to describe the special branch of that science of sound. Architectural acoustics, however, deals with the science of sound as it pertains to buildings. The three major branches of architectural acoustics are: 1. Room acoustic which deals with the design of the interior of buildings for appropriate levels and qualities for music and speech; 2. Noise control or management which involves the reduction and control of noise between noise source and a listener; and 3. Sound reinforcement and enhancement systems which involve the use of electronic equipment to improve the quality of sounds heard in rooms.

The nuisance of noise is regarded as a health and safety issue for persons living in dwellings and all occupants of a dwelling should be allowed to follow normal domestic activities, including sleep and rest, without threat to their health from noise. Noise is transmitted in a building by both airborne and impact sound sources, hence, both of these noise types should be controlled. Practical guidelines to ensure this should be provided in the relevant section of the building codes of every country. Sound insulation, in general terms, is the prevention of airborne and impact sound being transmitted from one part of the building to another through separating floors, ceilings or/and walls.

Statement of the Research Problem

The current patterns of urbanization and human activities have led to environmental degradation, and have created serious threat to continuous human existence (George, 2008). The rate of urbanization and industrialisation of the urban cities with its attendant high level of noise pollution is affecting the quality of life in the built environment. Hence, there is need to assess the level of compliance with the provisions of the national building code with respect to noise control. To measure the level of compliance with the national building code, a study of Cathedral - Isikan road, Akure will be undertaken.

Purpose of the Study

Research Aim: The aim of this study is to assess the level of compliance with the acoustic provisions of the Nigerian Building Code with a view to identify areas of improvement required in the Nigerian Building Code for the betterment of the built environment.

Research Objectives: To achieve this aim, the following objectives were set out; to:

i. review the acoustics provisions in the Nigerian Building Code,
ii. review the Acoustic Building Codes of some selected countries, and
iii. study Cathedral – Isikan road in Akure with a view to reveal the degree of compliance with the provisions of the acoustics regulations in the Nigerian Building Code.

Research Methodology

The research methodology adopted for this study are survey method of the study area and analysis of secondary data collected through internet surfing and relevant literatures.

Research Design: The research design for this study is essentially survey design which involves studying samples chosen from the population to discover the level of compliance with the provisions of the Nigerian Building Code.

Research Limitations: The following limitations were confronted during the research:

i. The Nigerian Building Code does not specify how to ensure compliance with the prescribed noise limits.
ii. Access to the buildings for actual measurement of the level of compliance with the prescriptions of the code was not possible.

Research Questions: This research provided answers to the following questions:

i. What does the Nigerian Building Code specify with regards to acoustics regulation?
ii. How does the Nigerian Building Code compare with other building codes in terms of acoustics provisions?
iii. Are people complying with the acoustics regulations in the National Building Code?

Research Population: The research population included all the forty-nine (49) buildings on both sides of the Cathedral – Isikan Road. These buildings include all the residential, religious, commercial and institutional buildings directly along the road.

Sampling Technique and Size: The sampling technique adopted for the study is total enumeration of all the buildings on both sides of the Cathedral – Isikan road. In all there are forty-nine (49) buildings that were studied. Cathedral road is one of the busiest roads in Akure. The choice of the road was based on its strategic location and a major link between two primary roads (Adesida-Oyemekun road and Ondo road) in Akure. Akure was declared a millennium city in 2006 by the Millennium Cities Initiative based on its high rate of urbanisation. Igbekele (2011) hinted that the city is already facing challenges in the area of pollution, waste disposal and sanitation.

Procedure and Instrument for Data Collection: The research relied on the data collected by Ganiyu and Ogunsote in 2010 through a structured questionnaire which was administered on all the buildings along the road. The questionnaires were administered with the help of some 500level students of Architecture who were taking a course in Environmental Control – Acoustics.

Methods of Data Analysis: The questionnaires were used to collect data regarding salient variables relating to noise. Among the variables examined are:

1. Type of building.
2. Source of noise.
3. Setback from road.
4. Type of barriers.

Each of the variables was analysed using frequency analysis and percentage of their occurrences.

Nigerian Building Code

Introduction: The Nigerian Building Code is a document evolved to proffer lasting solution to the hazardous trends in the Nigeria building industry. The code was promulgated and signed into law on 25th January, 2007 (Toluhi, 2009; Oresegun, 2010, p. 2-3). Section 6 of the Code is titled ‘Environmental Requirements’ and is meant to regulate the lighting, ventilation and sound transmission control required in all buildings intended for human occupancy.

Sound Transmission Control: Sub-section 6.2.11 is dedicated to sound transmission control in residential buildings whose scope apply ‘to all common interior walls, partitions and floor/ceiling assemblies between adjacent dwelling units or between a dwelling unit and adjacent public areas such as halls, corridors, stairs or service areas in all buildings of Use Group H’. The section considered both the air-borne noise and structure borne noise.

a. **Airborne Noise:** The Code required that walls, partitions and floor/ceiling assemblies separating dwelling units from each other or from public or service areas shall have a sound transmission class (STC) of not less than 45 for airborne noise when tested in accordance with ASTM E90. This requirement shall not apply to dwelling unit entrance doors, but such doors shall be tight-fitting to the frame and sill.

b. **Structure Borne Noise:** The Code required floor/ceiling assemblies between dwelling units and between a dwelling unit and a public or service area within the structure to have an impact insulation class (IIC) rating of not less than 45 when tested in accordance with ASTM E492.

Acceptable Noise Level: As preventive measure, the Code recommended the following daily maximum exposure to noise to avoid any hearing damage.

Table 1: Recommended Maximum Daily Exposure to Noise.

Sound Pressure Level (dBA)	Max. Exposure In Any 24 Hours
85 or less	24 hours
87	16 hours
90	8 hours
93	4 hours
96	2 hours
99	1 hour
102	30 minutes
105	14 minutes
108	71/2 minutes
110	3-3/4 minutes

Source: Nigerian Building Code, 2007

Acoustics Building Codes of Some Selected Countries

Building Code of New Zealand

Introduction: The Building Code of New Zealand is a schedule to the building regulation, 1992 (Consumer Build, n.d.). The code is a performance-based code. It sets out performance standards that building work must meet, and covers aspects such as structural stability, fire safety, access, moisture control, durability, services and facilities. The Building Code consists of two preliminary clauses and 35 technical clauses. Each technical clause contains:

1. Objective **-** The social objective that completed building work must achieve
2. Functional requirement - What the completed building work must do to satisfy the social objective
3. Performance criteria **-** Qualitative or quantitative criteria which nominates how far the completed building work must go in order to comply (Whare, 2006).

The Requirements: The section of the New Zealand Building Code that deals with acoustics is clause G6 under the title "Airborne and Impact Sound". It is aimed at safeguarding people from illness or loss of amnesty as a result of undue noise being transmitted between abutting occupancies or common spaces to habitable spaces of household units. It requires separating wall, floor and ceiling elements to have a sound transmission class (STC) of not less than 55 dB and the floors must have an impact insulation class (IIC) rating of not less than 55.

According to Clause G6/VM1, the performance of the airborne sound in the building code may be verified in accordance with ASTM E 336 (measurement) and ASTM E 413 (rating) while the performance for the impact sound insulation may be verified using the International Organization for Standardization ISO 140: Part VII (measurement) and ASTM E 989 (rating).

Verification Method G6/VM1 states that field (F) test results shall be within 5 dB of the performance requirements, and the general market interpretation of this is that onsite measurements of field sound transmission class (FSTC) 50 and FIIC 50 satisfy the requirements of the Building Code.

The provisions of this code are limited to habitable spaces within apartments intended for permanent living and do not apply to non-habitable spaces, temporary accommodation, offices and external or environmental sound.

England and Wales Acoustic Code Requirements

The section that deals with acoustics regulation for United Kingdom is given within the approved document, Part E, under "Resistance to the passage of sound (England and Wales) 2003" which requires that both airborne and impact sound sources are controlled (Building Regulations, 2010).

The Part E of the code focussed on four major areas:

- E1: Protection against sound from other parts of the building and adjoining buildings

- E2: Protection against sound within a dwelling house
- E3: Reverberation in the common internal parts of buildings containing flats or rooms for residential purposes
- E4: Acoustic conditions in schools.

To ensure compliance, there are two routes:

1. **Robust Details** for new buildings which requires no pre-completion testing. It is designed to achieve higher sound insulation standards than the minimum requirements in Part E. Each approved Robust Detail contains a checklist which must be completed on site. This is a quality control check to confirm that all the critical factors that affect sound performance have been built correctly.

2. **Pre-completion Testing** for all new buildings, refurbishment, remedial and extension work in buildings with rooms for residential purposes. Part E of the building code calls for pre-completion testing of separating walls and floors before handover to ensure that the level of performance specified is being achieved. The tests are to be performed on a minimum of one in every ten dwellings of the same type before completion and to meet the standards of ISO 140 series.

United States of America Acoustics Building Code

Introduction: The noise regulations in U. S. A. were established in 1972 under the United States Noise Control Act. After the passage of the act, the United States Environmental Protection Agency (EPA) promulgated regulations setting maximum noise limits in a gamut of motor vehicles, industrial machinery and household appliances.

State and Local Planning: States passed two different types of legislation starting in the 1970s, echoing the Federal lead in noise control. Many states began requiring each municipality and county to have a Noise Element of the General Plan, a substantial noise data base and blueprint for making land use decisions in that jurisdiction. The Noise Element further states goals for each land use class and even numerical planning standards in order to evaluate future development proposals with regards to noise pollution.

Compliance with the Provisions of Acoustic.

Portland, Oregon continues to innovate through their almost 35years old Noise Control Office at the City's Bureau of Development Services. Today, their code is still one of the only comprehensive codes in the USA that not only regulates based on a given decibel level, but also includes sound limitations based on the specific pitch or frequency of the given noise.

Local Noise Ordinances: This is principally aimed at construction noise, power equipment of individuals and unmuffled industrial noise penetrating residential areas. Thousands of USA cities have prepared noise ordinances that give noise control officers and police the power to investigate noise complaints and enforcement power to abate the offending noise source, through shutdowns and fines. In the 1970's and 1980's, there was even a professional association for noise enforcement officers called "National Association of Noise Control Officials" (NANCO). Today, only a handful of properly trained Noise Control Officers remain in the United States.

A typical noise ordinance sets forth clear definitions of acoustic nomenclature and defines categories of noise generation; then numerical standards are established, so that enforcement personnel can take the necessary steps of warnings, fines or other municipal police power to rectify unacceptable noise generation. Ordinances have achieved certain successes but they can be thorny to implement.

USA Acoustic Code Requirements: In the case of construction of new (or remodelled) apartment, condominiums, hospitals and hotels, many US states and cities have stringent building codes with requirements of acoustical analysis, in order to protect building occupants from : (a) exterior noise sources and, (b) sound generated within the building itself.

Exterior Noise: With regards to exterior noise, the codes usually require measurement of the exterior acoustical environment in order to determine the performance standard required for exterior building skin design. The architect can work to arrive at the best cost effective means of creating a quiet interior (normally 45dBA). The most important elements of design of the building skin are usually: glazing (glass thickness, double pane design, etc.), roof materials, caulking standards, chimney baffles, exterior door design, mail slots, attic ventilation ports and mounting of through the wall air conditioners.

Interior Noise: Regarding noise generated inside the building, there are two principal types of transmission. Firstly, airborne sound travels through walls or floor/ceiling assemblies and can emanate from either human activities (e. g. voice, amplified sound systems or animal noise) in adjacent living spaces or from mechanical noise (e. g. elevator systems, boilers, refrigeration or air conditioning systems, generators, and trash compactors) within the building systems. The principle of regulation requires the wall or ceiling assembly to meet certain performance standards (Sound Transmission Class of 50), which allows considerable attenuation of the sound level reaching occupants. The second type of interior sound is called Impact Insulation Class (IIC) transmission. This effect arises not from airborne transmission, but from transmission of sound through the building itself. The most perception of IIC noise is from footfall of occupants in living spaces above. Commonly a performance standard of IIC equal to 50 is specified in building codes.

Occupational Regulations: The U.S. Occupational Safety and Health Administration has established maximum noise levels for occupational exposure, beyond which mitigation measures or personal protective equipment is required. Noise Criteria (NC) are noise level guidelines applicable to cinema and home cinema. It is a measure of a room's ambient noise level at various frequencies. For example, in order for a theatre to be THX (Tomlinson Holman's Xperiment) certified, it must have an ambient sound level of NC-30 or less.

Building Code of Australia

Introduction: The Building Code of Australia (BCA) is the national technical document which sets the standards for building work in Australia. The Building Code of Australia is produced and maintained by the **Australian Building Codes Board** (ABCB) on behalf of the Australian Government and State and Territory Governments. The Australian Building Codes Board (ABCB) which was inaugurated on 1^{st} of March, 1994 and reaffirmed by ministers in July, 2001, is a joint initiative of all levels of Australian Government and includes representatives from the building industry (Planning in South Australia, 2011). The Building Code of Australia (BCA) which came into effect from 1^{st} of May, 2004 in most part of Australia requires that building elements have certain levels of insulation from airborne and impact sound.

The Requirements of the Code: The Building Code of Australia (BCA) requires that the acoustic performance of a construction system (Rw) and correction factor relating to lower medium frequency noise (Rw + Ctr) should be determined in accordance with AS/NZS 1276.1 using results from laboratory measurements. The Code classifications for acoustic performance are categorized based on the building type as Class 1, Class 2 or Class 3, etc.

Class 1 buildings include single dwellings that do not have another dwelling above or below it, such as a stand-alone house or a row of townhouses, Class 2 buildings include buildings that contain two or more sole-occupancy units, such as an apartment unit while Class 3 buildings include residential buildings that contain a number of unrelated persons, such as a guest house or the residential part of a school, hotel, etc. Table 2 shows an overview comparison of the selected building codes of the selected countries.

Table 2: Overview Comparison of the (Acoustic) Building Codes of the Selected Countries

Country	Code Title & Year	Section & Section Title	Noise Types	Requirements	Verification /Compliance
New Zealand	New- Zealand Building Code	Clause G6, "Airborne and Impact Sound"	Airborne and Impact Sound	STC ≥ 55dB IIC ≥ 55.	ASTM E 336 Within 5dB ISO 140: Part VI ASTM E989
England	Acoustics Regulation for United Kingdom, 2003	Part E, under "Resistance to the passage of sound	Airborne and Impact Sound		ISO 140 series
United States of America	United States Noise Control Act, 1972		Exterior Noise Interior Noise	45dBA STC = 50 IIC = 50	THX certified, sound level of NC-30 or less.
Australia	Building Code of Australia, May, 2004		Airborne and Impact sound	Rw + Ctr ≥50 Rw ≥ 50	AS/NZS 1276.1
Nigeria	Nigerian Building Code, 2007	Section 6.2.11 Sound Transmission Control in Residential Buildings	Airborne Noise Structure Borne Noise	STC ≥ 45 IIC ≥ 45	ASTM E90 ASTM E492

Source: Researcher, 2011.

The Study Area

Akure is the capital of Ondo State. It is one of the fastest emerging urban cities in South-Western Nigeria. Cathedral Road is one of the busiest roads in Akure. The road starts from the junction of the popular Oba Adesida and Oyemekun roads and terminates at the point of intersection of Arakale and Ondo roads. The buildings along the road are characterised by mixed use. It starts with a Roman Catholic Cathedral on the left and terminates with a petrol filling station on the right. In all, there are forty-nine (49) buildings on both sides of the road (Figure 1).

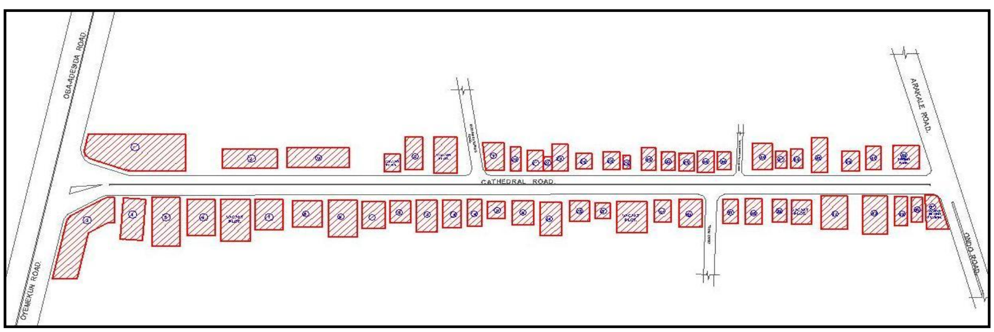

Figure 1: Cathedral Road, Akure - Location of buildings in the study area. Source: Ganiyu and Ogunsote, 2010.

Data Presentation

Type of Buildings in the Study Area

There were six distinct types of buildings along the Cathedral Road. The buildings were classified as residential, commercial, industrial, religious, institutional or mixed. There were two plots of land that were vacant. There was only one religious building (the Cathedral Church) along the road. The number of commercial buildings was twenty-seven (27) while those that were put to mixed use were fifteen (15). There were only two institutional buildings and one industrial building (Table 3).

Table 3: Types of Buildings.

Type of building	Number of buildings	Percentage (%)
Religious Buildings	1	2.0
Commercial Buildings	27	52.9
Industrial Buildings	1	2.0
Residential Buildings	3	5.9
Mixed-use Buildings	15	29.4
Institutional Buildings	2	3.9
Vacant Plots	2	3.9
Total	51	100

Source: Ganiyu and Ogunsote, 2010.

Sources of Noise in the Study Area

Four different sources of noise were identified in the study area. All the buildings were prone to noise from both vehicular and pedestrian sources (Table 4). Seven of the buildings close to the religious building complained of noise from the church while six of the residents of the buildings complained about noise from industrial buildings close by. All the buildings under study were also prone to noise from hawkers and advertising agents.

Table 4: Sources of Noise.

Sources of noise	Number of buildings	Percentage(%)
Vehicular traffic	49	96.0
Religious activities	7	13.7
Industrial noise (commercial Activities)	6	11.7
Pedestrian traffic	49	96.0
Hawkers	49	96.0

Source: Ganiyu and Ogunsote, 2010.

Setback of the Buildings in the Study Area from the Road

The distances of each of the buildings from the road were measured to determine whether they meet up with the minimum setback of 6m from the road. It was discovered that only five of the buildings met this requirement. It was interesting to note that most of the buildings have setbacks that are less than half of the required setback of 6m (Table 5).

Table 5: Setback from the Road.

Distance from the Road(m)	Number of Buildings	Percentage (%)
0.1 – 1.0m	2	4.09
1.0 – 1.5m	11	22.45
1.5 – 2.0m	16	32.65
2.0 – 3.0m	17	34.69
Above 3m	3	6.12
Total	49	100

Source: Ganiyu and Ogunsote, 2010.

Type of Barrier

The kind of barrier used to minimise the effects of the noise on the residents were also examined. It was discovered that majority of the buildings were not protected from the effects of the noise at all by any form of barrier. Only three of the buildings were fenced while only one has a tree in front of the building (Table 6).

Table 6: Type of Barrier.

Type of barrier	Number of Buildings	Percentage (%)
Fence	3	6.12
Tree	1	2.04
No barrier	45	91.84
Total	49	100

Source: Ganiyu and Ogunsote, 2010.

Summary of Findings

It is evident from the above that of all the countries studied only Nigerian building code requires a sound transmission class and impact insulation class of less than 45 while other codes requirements are higher (see table 2). This requirement in the Nigerian building code is less than the noise from a light traffic or a noise from a departmental store (see table 7). However, the study revealed that all the buildings in the study area are exposed to heavy traffic and pedestrian noise (see table 4).

While the requirements of the National building code are strictly for residential buildings, the ~~study showed that only three (3) of the buildings in the study area are strictly residential~~ while fifteen (15) representing 29.4% are used for both residential and commercial purposes. Twenty-seven (27) of the buildings, representing 52.9%, are entirely for commercial purposes (see table 3).

To meet the requirements of the Nigerian building code, a minimum distance of 10feet (3m) must be observed from the source of the noise. However, only three (3) buildings meet this requirement (see table 5). It is important to note that only the United States categorizes its noise as exterior and interior noise while others merely classify noise as airborne and impact/structure borne sound. The classification of the US is more pragmatic in dealing with the problem of noise. It is also noteworthy that virtually all the countries studied have noise enforcement associations and trained officers except Nigeria.

Table 7: Relative Noise Levels and Subjective Impressions.

Noise Source	Distance from Noise Source (feet)	A-Weighted Sound Level in Decibels	Noise Environment	Subjective Impression
Civil Defense Siren	100	130		
Jet Takeoff	200	120		Pain Threshold
		110	Rock Music Concert	
Pile Driver	100	100		Very Loud
Helicopter	1000	90	Printing Press Plant	Loud
Freight Cars	50	80		
Vacuum Cleaner	10	70	Garbage Disposal	Moderately Loud
		60	Data Processing Centre	
Light Traffic	100	50	Department Store	
Large Transformer	200	40	Business Office	Quiet
		30	Quiet Bedroom	
Soft Whisper	5	20	Recording Studio	
		10		Hearing Threshold

Source: Adapted from National Institute of Health Environmental Management System (2010).

Conclusion

The Nigerian Building Code can relatively be compared with other building codes around the world in terms of acoustics regulations. However, the provisions are not written in a language that is comprehensible to a common man for easy compliance. The study revealed that the level of compliance with the provisions in the building code is very low and that there is no provision for enforcing compliance.

Recommendations

For the improvement of the building code and to ensure better compliance, the following recommendations are hereby suggested:

1. That the noise sources may better be categorised as internal noise and external noise sources for easy understanding of the people.
2. That the code should include practical and pragmatic means of measuring and verifying compliance with the specifications of the code.
3. That the code should specify punitive measures for violating the noise limits set in the code and ways of enforcing them.
4. That the minimum building setback from the roads, which is a major source of noise, must be enforced.

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