COMPARISON OF THE ACOUSTIC PROVISIONS IN THE NATIONAL BUILDING CODE WITH THE ACOUSTIC BUILDING CODES OF SOME SELECTED COUNTRIES

Sikiru Abiodun Ganiyu

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 level both in the developed and the developing nations of the modern world. While the advanced countries have taken some legislative measures in the form of Acoustics Building Codes to control the problem of noise and its attendant effects, developing nations like Nigeria may not have fared well in this regards. This paper, therefore, is an attempt to compare the building codes in some selected countries of the world with emphasis on the acoustics regulations of the building codes. The countries include: the United Kingdom, United States of America, New Zealand, Australia and Nigeria. The building codes of these nations will be compared with that of Nigeria in terms of acoustics regulatory provisions.

A building code, according to Wordnet 3.0, is a set of standards established and enforced by local governments for the structural safety of buildings. 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 professional and lack of adequate regulations and sanctions against offenders (Toluhi, 2009). The resulting effects of these problems include frequent buildings 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 buildings 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 evaluate the adequacy of the provisions of the national building code with respect to noise control by comparing its provisions with that of some selected countries.

Research Aim

The aim of this study is to compare the Acoustic Building Codes of some selected countries with the acoustic provisions of the National Building Code of Nigeria with a view to identify areas of improvement required in the National Building Code for the betterment of the built environment.

Research Objectives

To achieve this aim, the following objectives have been set out; to:

i. review the Acoustic Building Codes of some selected countries,
ii. review the National Building Code of Nigeria, and
iii. compare the provisions for noise regulations in the national building code with the provisions in the acoustic building codes of these selected countries.

Scope of the Study

The scope of the research is limited to acoustic related issues in the selected building codes. Hence, only issues related to noise control and regulations in these codes shall be reviewed with a view to draw comparison with that of the national building code.

Research Methodology

The research method adopted for this study is essentially literature review and analysis of secondary data collected through internet surfing and relevant literatures. The selected countries are New Zealand, England, United States of America and Australia. The codes of these countries were selected based on their advancement in legislative matters, especially in areas of noise control.

Research Questions

This research intends to provide answers to the following questions:

i. What do the building codes of these selected countries specify with regards to acoustics?
ii. Do these building codes have provisions for noise control and regulations?
iii. How does the National Building Code of Nigeria compare with other building codes in terms of acoustics provisions?

Acoustics Building Codes of 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 standard 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 require that both airborne and impact sound sources were controlled (Building Regulations, 2010).
The Part E of the code focussed on four major areas:

a. E1: Protection against sound from other parts of the building and adjoining buildings
b. E2: Protection against sound within a dwelling house
c. E3: Reverberation in the common internal parts of buildings containing flats or rooms for residential purposes
d. E4: Acoustic conditions in schools.

To ensure compliance, there are two routes:

1. **Robust Details** for new buildings which require 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.

1. **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 became an integral part of the municipal or county General Plan, especially in California. 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.

   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.

2. **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.

3. **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.

4. **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. A special case of building skin design arises in the case of aircraft noise, where the FAA has funded extensive work in residential retrofit.

5. **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.

6. **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 eXperiment) 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 1st 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 1st of May, 2004 in most parts 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 lower to 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. 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 1: Type of Noise Source Grouped by Corresponding Correction Factor

Correction Factor	Type of Noise Source
C	Living activities (talking, music, radio, TV) Railway traffic at high speeds Highway road traffic (>80km/h) Jet aircraft at short distance High and medium frequency factory noise

C_{tr}	Urban road traffic Railway traffic at low speeds Propeller driven aircraft Jet aircraft at large distance Low and medium frequency factory noise

Source: Sound Transformation Information, 2010

The Code requires common walls separating building units to have an Rw + Ctr of not less than 50. In addition, the construction must be discontinuous, if the wall separates a habitable room (living room, dining room, bedroom, study and the like) from a wet room (kitchen, bathroom, sanitary compartment or laundry). Discontinuous construction requires:

1. A minimum 20mm cavity between two separate leaves
2. Resilient wall ties such as those provided by Matrix Industries, if the wall is masonry, and
3. No mechanical linkage if the walls are not masonry.

The weighted sound reduction index (Rw) describes the acoustic performance of a construction system. It is a single number quantity for the airborne sound insulation rating of building elements. As the acoustic performance of a material or construction improves, the higher the Rw value will be. This means that certain sound performance levels for different building situations are specified. Rw ratings are determined by laboratory tests of a specimen of the construction system.
Correction factors (C and Ctr) can be added to Rw to take into account the characteristics of particular sound spectra and indicate the performance drop of the wall in the corresponding sound frequency range. The factor C relates to mainly mid to high frequency noise, whilst Ctr relates to lower to medium frequency noise. Some typical noises have been grouped by their corresponding correction factor as shown in the table 1.

National Building Code, Nigeria

Introduction: The National 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). The section 6 of the Code is titled 'Environmental Requirements' and is meant to 'govern the means of light, ventilation and sound transmission control required in all buildings intended for human occupancy'.

Sound Transmission Control: The 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 3: 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

Summary of Findings

Table 4 show the summary of findings of the (acoustic) building codes of the selected countries.

Table 4: Summary of Findings 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 $\geq$ 55dB IIC $\geq$ 55.	ASTM E 336 Within 5dB ISO 140: Part VII, ASTM E 989
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	Chapter 9.2.12 Sound Transmission Control in Residential Buildings	Airborne Noise Structure Borne Noise	STC ≥ 45 IIC ≥ 45	ASTM E90 ASTM E492

Source: Researcher, 2011.

Conclusion

The National Building Code of Nigeria can relatively be compared with other building codes around the world in terms of acoustics regulations. However, the provisions are not written in 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 to enforce compliance.

Recommendations

After the review of the selected acoustic building codes, the following recommendations are suggested for improvement of the national building code of Nigeria:

1. That the noise sources are better categorised as internal noise and external noise sources for easy understanding of the people, taking after that of the United States of America.
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 as contained in the code of the United State of America.
4. That there is need to form and fund noise enforcement agents and associations.

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