SCHOOL OF ENVIRONMENTAL TECHNOLOGY,
FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA, NIGER STATE, NIGERIA

EDITORS IN CHIEF
R. E. Olagunju
B. J. Olawuyi
E. B. Ogunbode

SETIC 2020 INTERNATIONAL CONFERENCE

BOOK OF PROCEEDINGS

MAIN THEME:
Sustainable Housing And Land Management

3RD -5TH MAY, 2021

SCHOOL OF ENVIRONMENTAL TECHNOLOGY COMPLEX,
FUT, MINNA, NIGER STATE, NIGERIA

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School of Environmental Technology International Conference (SETIC 2020)

3RD – 5TH MAY, 2021

Federal University of Technology Minna, Niger State, Nigeria

CONFERENCE PROCEEDINGS

EDITORS IN CHIEF

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ISBN 978-978-54580-8-4

Proceedings of
The 3rd School of Environmental Technology International Conference
(SETIC 2020)

Published by
School of Environmental Technology,
Federal University of Technology Minna.
PMB 65, Minna,
Niger State Nigeria.

ISBN 978-978-54580-8-4

PREFACE

The School of Environmental Technology International Conference (SETIC 2020) is organised by School of Environmental Technology, Federal University of Technology Minna, Nigeria. In collaboration with Massey University New Zealand, Department of Civil Engineering Faculty of Civil Engineering and Built Environment Universiti Tun Hussein Onn Malaysia, Malaysia Centre For Professional Development and Industrial Project Development School of Professional and Continuing Education (SPACE) UTM-KL Malaysia, Global Academia, Department of Architecture, Faculty of Engineering and Architecture, Istanbul Gelisim University Istanbul Turkey, Sustainable Environmental and Technology (SET) Research Group, Department of Architecture, Universiti Sains Islam. The main theme for this year conference is "SUSTAINABLE HOUSING AND LAND MANAGEMENT". This promotes and encourage innovative and novelty for policy issues for inclusive and sustainable housing, access to finance for housing and land development, sustainable building materials, building cost management, sustainable and resilient cities, geoinformatics for land management, rapid urbanization, sustainable land use and spatial planning, gender issues in access to land.

The responses from participants for this conference are overwhelming, well attended, and successful. The operation mode was Virtual for all participants who choose the oral presentation mode. While, Physical for all poster medium presenters. Our participants are from various Universities and other sector across the globe, from countries like United State for America (USA), Turkey, Malaysia, China, Saudi Arabia, Kenya, New Zealand just to mention a few. Hence, this conference provides a good platform for professionals, academicians and researchers to widen their knowledge and approach on latest advances in research and innovation. Papers presented in this conference cover a wide spectrum of science, engineering and social sciences.

Finally, a note of thanks must go to SETIC 2020 Local Organizing Committee (LOC) for their remarkable dedication in making this conference a success. We hope the event will prove to be an inspiring experience to all committee members and participants.

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Contents

Towards Developing Standards for Earthquake Resilience and Sustainability of Public Buildings in Abuja, Nigeria.

Bulama, H. H.[1a] & Akande, O.[1b]
[1]*Department of Architecture, Federal University Technology Minna, Nigeria.*
[a]*ptbulama@gmail.com*; [b]*fkakande225@goolemail.com*
Corresponding author: ptbulama@gmail.com

Abstract:
Architecture in different countries has proven to be pragmatic and dynamic in nature, because of how we have seen it evolve over the years. Natural and manmade disasters are some of the factors that cause this dynamic nature of design and construction. Nigeria has experienced and documented Earthquakes since 1933 to date. On the fifth to seventh of September 2018, Abuja experienced an Earth Tremor and the National Space Research and Development Agency (NSRDA) has identified selected locations in Bayelsa, Ogun, Oyo, Kaduna and Abuja as hot spot for Earthquake. This information has drawn the attention of the professionals of the built environment to draw out strategies and plans to stand out in the event of an occurrence. This study is aimed at accessing the need for developing standards in design and construction of buildings to resist future occurrences of Tremor in the Federal Capital Territory (FCT) Abuja. Qualitative method of Research was used and questionnaires were administered to different professionals in the building industry, some of the tools employed were indirect interviews. An average of 90% of professionals strongly agrees to the need for developing standards for earthquake resilient buildings along seismic fault lines in Abuja.However it was recommended that there is a need to first of all identify the areas along seismic fault lines by using state of the art Seismometer and then set policies and standards that govern design and construction in those locations.

Keywords: Standards, Earthquake, Seismic wave, Sustainability, Resilience.

BACKGROUND

Studies have proven that the earth is in constant motion in two ways, on its axis and around its orbit. This information tells us that the earth could react to different forces trying to adjust or settle while in motion, because about seventy percent (70%) of the earth is water (). These movements cause sea floor spreading at high pressure point and transform faults which are known as those on land and at the margins of continental tectonic plate. The action of these plates rubbing against one another while moving in opposite direction, results to an intense seismic wave that translates to an earth Tremor or earthquake in a community.

Resilience as regards to hazardous events is defined as "the ability to plan and create against, to absorb or resuscitate from, and better yet, adapt to adverse situations" (NAC 2012). Resilience is also known as the ability to resist and recover from intentional attacks, accidents, or act of nature. For the purpose of this research, we will consider resilience to earthquake and earth tremor activities to the earth's crust or lithosphere.

Codes and standards that are adopted and enforced are the determinant of high performance of the built environment (T, McAllister, 2013). Standard sand Codes for structures and buildings

weather condition.

This study is aimed at assessing the need to develop standards and policies for the design and construction of buildings along fault lines, to be resilient to earthquake and to also plan for the timely recovery from Earthquake in the Federal Capital Territory (FCT) Abuja. In recent years, earth Tremors and Earthquakes have been experienced in different part of Nigeria like; Bayelsa, Ogun, Oyo, Kaduna and Abuja, which have been listed as hot zones for possible frequent earthquake occurrence by the National Space Research and Development Agency

(NSRDA).This study is of significance to the professionals of the built environment, as guardians of our own expertise. The joy of every professional is to solve problems with their creativity, but in a situation where disasters like Earthquakes reduces the life span of this creative work. We will wake to no Heritage sites or buildings that can translate centuries of culture and city administrative operations of a people, it is also of significance to the government of Nigeria, to create Standards and Policies that will save lives and properties in the advent of an Earthquake, thereby reducing the economic menace that results to millions of citizens dead or homeless.

The scope of the study is carried out within the Federal Capital Territory (FCT) of Nigeria, Abuja. It is limited to the professionals of the built environment in five (5) Federal agencies of Nigeria and two (2) professional bodies of the built environment namely; Federal Housing Authority (FHA), National Emergency management Agency (NEMA), Nigerian Geological Survey Agency (NGSA), Federal Capital Development Agency (FCDA), Department of Development Control (DDC) Abuja, The Nigerian institute of Architects (NIA) and the Nigerian Society of Engineers (NSE). Interviews were conducted to each category or agency focusing on the need to develop standards and policies to guide the design and construction of buildings along seismic fault lines or seismically active areas in Abuja to be resilient to earthquakes.

Concept of earthquake

An earthquake is the trembling of the Earth's surface, caused by the rapid emission of energy from the Earth's crust that creates seismic waves. Earthquakes differ in magnitude and nature from those that are so weak that they cannot be felt to those violent enough to toss people around and destroy whole cities (ISBN, 2011).. The lithosphere (earth's crust) is made up of several pieces, called plates. They extend to the mid-oceans and are called mid oceanic plates while the rest are continental plates. The plates are moved around by the motion of the earth along its axis and orbit at through the deepest part of the ocean. These plates are constantly colliding into each other, withdrawing away from each other, or slide past each other. Because of the size of a tectonic plate the movement is not felt by humans until there is a collision.

Types, causes and effects of earthquakes

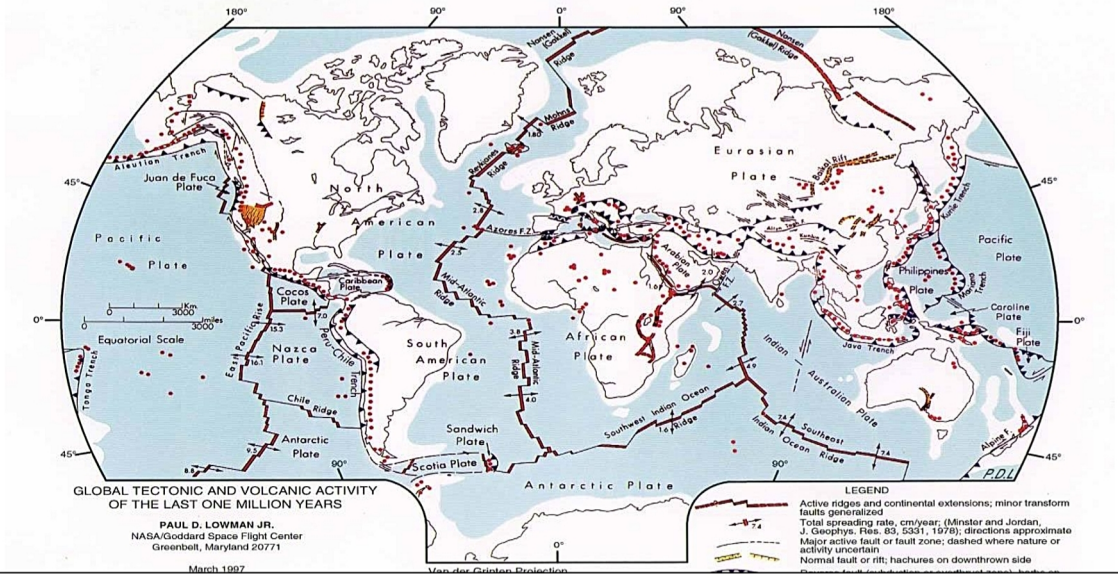
Earthquakes are different in nature and effect depending on the type of earthquake. We have seven types of earthquakes; Tectonic earthquakes, Volcanic earthquakes, Earthquake Fault source, Dilatancy in the crustal rocks, Earthquakes Explosion, Large reservoir induced earthquakes and earthquake as a result of collapse (BA Bolt, 2001). Earthquake has a devastating and terrible effect on lives and structures. Many infrastructures are destroyed due to earthquake while properties worth billions of dollars have been lost across the world in a period of 50 years in only Asia and America (BA Bolt, 2001). The environmental effects of it are that including surface faulting, tectonic uplift and subsidence, tsunamis, soilliquefaction, ground resonance (See Figure 1).

The Atlantic landslides and ground failure either directly linked to a quake source or provoked by the ground shaking.

Figure 1 Ecuador earthquake, 2016 after a 7.7 magnitude.Source: P, Brannen 2016.

Seismicity of the world

Readings from different seismographic observation stations for earthquake have been documented and calculated to locate the epicentre of earthquake distribution around the world. A specific ring of seismic reaction divides large oceanic and continental regions usually not completely away from earthquake epicentres (BA BOLT, 2001). Some concentrations of earthquake epicentres can be seen in the oceanic ridge, which is along the Atlantic and Indian Oceans. The geological activities that occur all through this global ridge system are confirmed by land forms like mountain peaks and deep rift valleys. We have regular volcanic eruptions, and earthquakes occurring along continental ridges often occur in multiples, so that hundreds of shocks are concentrated in a small area within a short time.



Bulama & Akande: *Towards Developing Standards for Earthquake Resilience and Sustainability…*

Figure 2 seismotectonic map of the world Source; D. Paul, J.R Lowman, 1997

Seismotectonic Map of Africa

Africa is made up of various interesting geological structures which includes areas of active deformation. Regions that are seismically active are mainly located at the rift zones, mountain belt, thrust and folds, transform faults and volcanic fields. The seismotectonic map of Africa (CGMW, 2010) zoned Africa into six (6) different seismotectonic active provinces;

- Western-central Africa
- North-West Africa
- North-East Africa
- Central Africa
- East-Africa
- South African shield and the cape fold belt.

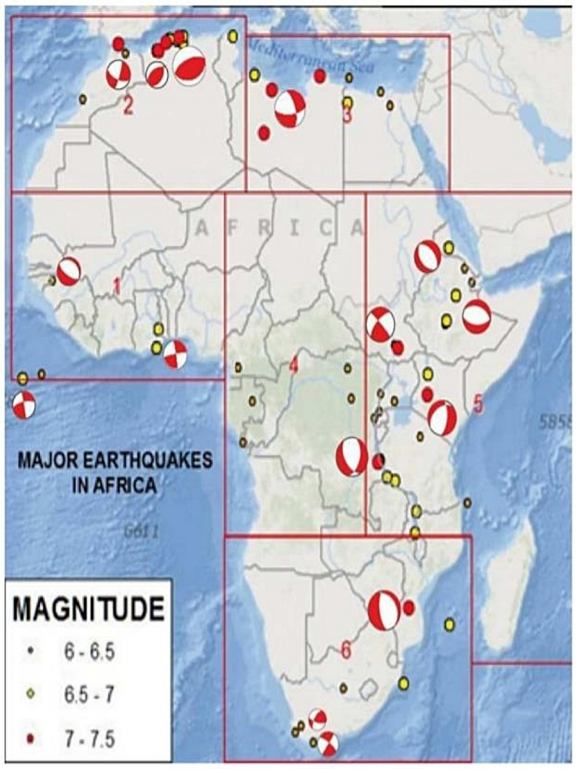


Figure 3.Seistectonic Zones in Africa

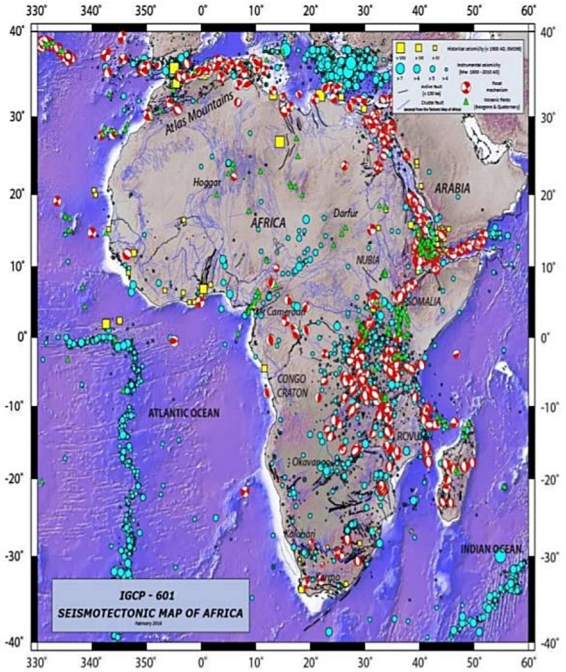
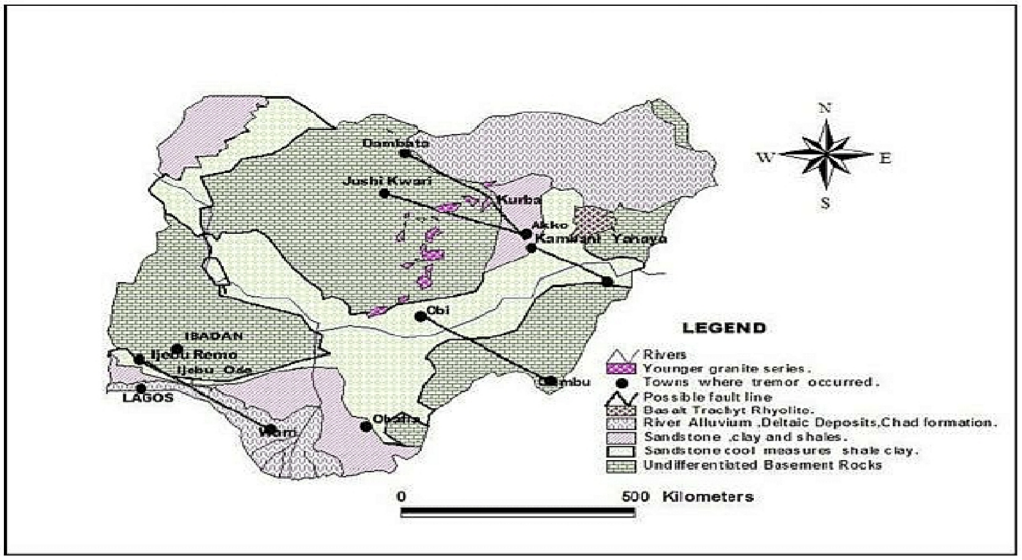


Figure 4.Seismotectonic Magnitude in Africa

History of earthquakes in Nigeria

Various studies have been carried out as regards the seismic fault lines in Abuja and different part of the country. Since 1923 when the first tremor was felt in the country, over thirty – nine

(39) events have been reported. Of these 39 seismic events, less than 20% were recorded instrumentally. The tremors felt in more than one locality at a time is estimated to be over forty-eight (48) instances and experienced in various communities cutting across about twenty-two (22) states of the federation including the Federal Capital City, Abuja giving, a percentage coverage of about 60%. The number of states in each region affected by the tremor is shown in figure 3. The Bar chart, figure 9 shows the number of seismic events experienced in each state per region. From Table 6, about 52% of the events occurred in the SouthWestern parts of the country with Ogun and Oyo states been the most affected occurring mainly within the Ijebu-ode and Ibadan axis.



Source; Akpan and Yakubu, 2010
Figure. 5 map of nigeria showing seismic fault lines

This axis lies along the Ifewara-Zungeru lineament. Seismic events have been recorded in Nigeria since 1923 (Adepelumi et al., 2008) with about ten related seismic activities experienced in 2016 alone. Tsalha et al., (2015) reported about 31 incidences with about four emanating from neighbouring countries of Ghana and Cameroun. The tremors are distributed among the basement complex and the sedimentary basins. Compiled from various sources including Osagie (2008); Ofonime and Yakubu (2010); Eze et al (2011) &Tsalha et al., 2015 and other sources and in addition to the most recent Abuja tremor incidence, the number of seismic events recorded in the country till date (2018) is estimated to be about 39 in total with Oyo and Ogun states been the most affected.

Nwankwoala, 2018established that Nigeria is at the risk of undergoing a terrible earthquake in the future. It's likely to have a magnitude as high as 6.0 in the year 2020; 6.5 is expected between the year 2021 to 2022; in 2025 and 2026, 7.0 is expected and 7.1 in the year 2028. A

Table 1; showing the earthquake occurencies in Nigeria, Source; Nwankwoala, 2018.

S/N	Date	Time	Felt Area	State	Intern city/Magnitude	Probable Epicenter	Remarks
1	1933		Warri Ohafia	Delta Abia			

2	1939-06-22	19:19:26	Lagos, Ibadan Ile-Ife	Lagos, Oyo, Osun	6.5(Ml)	AkwanpainFasal in Ghana	
3	1948	-	Ibadan	Oyo	-	Close to Ibadan	
4	1949	-	Ibadan	Oyo	-	Close to Ibadan	
5	1961-07.02	15:42	Ohafia	Abia		Close to Ohafia Area	
6	1963-12.21	18:30	Ijebu-Ode	Ogun	V	Close to Ijebu-Ode	
7	1975-07:01		Damhara	Kano	-		
8	1981	12:00	Kundunu		III	At Kudunu Village	
9	1982-10:16	-	Jalingo-Gembu	Taraba	III	Close to Cameroom Volcanle Line	
10	1984-07.12		Ijebu-Remo	Ogun	Iv	Close To Ijebu Ode	House Rocked People Come Outside Cracks In Builkling
11	1984-07-28	12:10	Ijebu-Ode, Ibadan, Shagamu, Abeokuta	Ogun, Oyo	vi	Closes To Ijebu-Ode	Houses Rocked People Came Outside
12	1984-08-02	10:20	Ibadan, OyuIjebu-Ode ShagamuAbeakutaIjebu Remo	Oyo, Ogun	v	Close To Ijebu-Ode	Cracks in buildings
13	1984-12-08		Yola	Adamawa	iii	Close To Cameroun Volcanic line	
14	1985-06-18	21:00	Kambani-Yaya	Bauchi	v	KambaniYaya	Surface Fractures
15	1986	10:45	Obi	Benue	iii	Close to Obi Town	
16	1986	-	Abeokuta	Ogun			
17	1987-01-27		Gembu	Taraba	v	Close to Cameroon Volcanic line	
18	1987-03-19		Akko	Gambu	iv	Close to Akko	
19	1987-05-24		Kurba	Bauchi	iii	Close to Kurba	
20	1985-04		Amauzu Ede-Obela	Anambra			12km Of Land Cracked, Zinc house cracked
21	1988-05-14	12,17	Lagos	Lagos	V	Close to Lagos	
22	1988-09		Oseterun Hills	Gombe			Cracks caused by Volcanic eruption, lost three hectares
23	1990-04		Jere	Kaduna	V		
24	1990-06-27		Ibadan	Oyo	2.7(M1)	Closes to Ijebu- Ode	Buildings Vibrated
25	1994-11-07	05:07:51	Ijebu-Ode, Dan Gulbi	Ogun, Zamfara	4.2(M1)	Dan Gulbi	Cracks in the buildings
26	1997		Okitipapa	Ekiti`	iv	Close Okitipapa bridge	
27	2000-03-07	15:53:54	Ibadan, Oyo, Akure, Okitipapa, Abeokuta, Ijebu-ode, Shagamu	Oyo, Ekiti, Ogun	4.5(Ml)	Close To Okitipapa	
28	2000-03-13	15:53:54	Benin	Edo	iv	Benin City (55km From Benin	
29	2000-05-07	11:00	Akure	Ondo	iv	Close to Okitipapa	Ground Shaking
30	2001-05-19		Lagos	Lagos	iv	Close to Lagos City	
31	2002-08-08		Lagos	Lagos	iv	Lagos City	
32	2000-08-15		Jushi-Kwari	Kaduna	iii	Close To JushiKwari Village	
33	2005-03		Yola	Adamawa	iii	Close To Cameroun volcanic line	
34	2006-03-25	11:20	Lumpa	Niger	iii	Close to IfewaraZungeru falls	
35	2009		Saki	Oyo	iii-iv		
36	2009		Abeokuta	Ogun			
37	2011-11-05		Abeokuta	Ogun	4.4m	Close to Abeokuta	
38	2016-09-12	Kwol,	Kwoi border communities between Bayesal and Rivers (Igbogene)	Kaduna, Rivers, Bayesal	2.6. 3.0 M		Damage to structures
39	2018-09-05 to 08	Mpape	Abuja	ii-iv			No cracks, Magma likes substance coming out soil

The b-value for Nigeria is 0.99 and this implies that the seismotectonic setting of Nigeria is that of an Intraplate (within the tectonic plates not at the ridges or edges).

Therefore this requires for monitoring stations around the country and FCT, Abuja to constantly read seismic waves and analise the data to know the nature of the type of earthquake predominant in an area and the right measures to be proposed for buildings and other structures.

Methods used in the design and construction of buildings resilient to earthquakes

There are various ways a building can be protected from seismic waves or earthquakes using principles in architecture and engineering (A Chaleson, 2012). Therefore eight different priciples and methods were extracted for the purpose of this research;

1. Eccentricity of Building Forms
2. Rubber/friction Base Isolation
3. Buckle Resistant Braces
4. Pagoda Method
5. Hendison system
6. Construction of Basement floors
7. Tuned Mass Damper
8. Buffer system that uses water or gas reduce friction

These principles have proven to be effective in countries like Japan that had an average of 1,600 earthquakes in 2011 only (Ohto et al, 2015). Each method is used for certain reasons either of building height, type of structural system of the building.

METHODOLOGY

The method of research used to carry out this study was qualitative research methods, where primary and secondary forms of data was collected through interviews, observations, publications, internet extracts and from professionals in the built environment. The non-probability sampling technique was applied to determine if there is a need for developing standards for the design and construction of buildings along fault lines and earthquake prone areas, using the convenience method of Sampling. Tools implored were the use of in-depth indirect interview, conducted as the major tool in this research. However, content analysis and observations were also applied.

RESULTS AND DISCUSSIONS

The results from this exercise were presented in percentage of those in agreement either strongly agree, agreed or disagreed. The major question asked was, if they agree that Nigerian institutions needs to carryout serious studies to identify all fault lines within the country and Abuja to develop standards for the Architectural and Engineering Construction industry to institutions both federal and private were.

Table 2; interview results

Agency/Institute	Strogly Agree	Agree	Disagree
F H A (Federal Housing Authority)	25	75	-
N E M A (National Emergency Management Agency)	90	10	-
N G S A (National Geological Survey Agency)	80	20	-
F C D A (Federal Capital Development Authority)	72	28	-
DDC (Department of Development Control AMMAC)	100	-	-
N I A (Nigerian Institute of Architects)	95	5	-

N S E (Nigerian Society of Engineers)	100	-	-

Source: Field data

This result shows that most seem to be in strong agreement to the development of standards by the federal government agencies for design and construction of buildings resilient to earthquake. Very few are in agreement to this and non are in disagreement.

From the interviews conducted the professionals in the professional institutes where more informed of the occurrence of earth tremor in Abuja and environment and mentioned that it is necessary for a country like Nigeria to plan for the unexpected. The government agencies are ready to enforce the standards once passed by the government.

CONCLUSION

It was recommended that professionals in the built environment as well as the federal government agencies should come together to retrieve more accurate data of the transitional pattern of the seismic waves and tectonic movement in Abuja, so as to arrive at a more recent data. Having these parameters will help guide decisions and plan for an effective Standards and policies that will be used for building design and construction development in areas marked along the seismic fault line.

In conclusion, the study has been able to show that there is a high need for the development of standards for earthquake resilience in Abuja. This will help reduce the degree of loss of lives and properties to the barest minimum and the buildings will translate the culture and heritage of Abuja for a long time without an effect of earthquake that results to a collapse of the structure.

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