

## AN INVESTIGATION OF THE EFFECTS OF POOR SPECIFICATION ON BUILDING COLLAPSE IN NIGERIA

B. Adewale, G.M. Alalade, A. Akinwande, A. Daramola, A. Joseph, A. Odili, A. Odugbesan, A. Ogunleye, J. Adeleke, M. Oyeyiola, O. Famurewa, M. Oladapa, O. Olumuyiwa, S. Eyiario, T. Oyeshomo, U. Ugah, W. Eke

*Covenant University Ota Ogun State Nigeria, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria*

**ABSTRACT.** This paper examines the effects of specification on building collapse in Nigeria. The study became necessary due to the ugly cases of buildings collapsing in the country over the years. In doing so, the study begins with review of relevant literature on the concept of specification, as well as the factors associated with building collapse. The need for specification in building construction projects was enunciated upon. Other factors that culminate in building collapse, such as load types; man-power; technical skills, etc. are discussed herein. The study further examines identifies and documents cases of building collapse in Nigeria to identify the causes and factors responsible for the collapse. Interviews were conducted with practicing professionals in the construction industry. This was done to obtain professional insights and experiences used as part of the data in the research. Findings from this study highlights consequential role of poor specification in causing building collapse, loss of lives and properties. This paper concludes with identifying the relevance of specification in ensuring adherence to appropriate materials and construction methods for structural stability. Recommendations are given to guard against poor specifications that result in the collapse of buildings, properties and ultimately loss of lives.

**KEY WORDS:** architecture, building collapse, specification

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## ИССЛЕДОВАНИЕ ВЛИЯНИЯ ПЛОХОЙ СПЕЦИФИКАЦИИ НА РАЗРУШЕНИЕ ЗДАНИЙ В НИГЕРИИ

Б. Адевалле, Г.М. Алаладе, А. Акинванде, А. Дарамола, А. Иосиф, А. Одили, А. Одугбесан, А. Огунлес, Ж. Аделеке, М. Ойейола, О. Фамурева, М. Оладапа, О. Олумуйва, С. Эйяро, Т. Оешумо, У. Уга, У. Эке

*Университет Ковенант, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд*

**АННОТАЦИЯ.** В этой статье рассматривается влияние спецификации на разрушение зданий в Нигерии. Исследование стало необходимым из-за уродливых случаев разрушения зданий в этой стране на протяжении многих лет. Исследование начинается с рассмотрения соответствующей литературы по понятию спецификации, а также факторов, связанных с разрушением зданий. Была отмечена необходимость спецификации в строительных проектах зданий. В статье также обсуждаются другие факторы, которые приводят к разрушению зданий, такие как тип нагрузки, людские ресурсы, технические навыки и т.д. В исследовании далее рассматриваются и документируются случаи разрушения зданий в Нигерии для выявления причин и факторов, ответственных за это разрушение. Были проведены интервью с практикующими специалистами в строительной отрасли. Это было сделано, чтобы выявить их точку зрения. Выводы, сделанные из этого исследования, подчеркивают последовательную роль плохих спецификаций в причинении разрушения зданий, гибели людей и потери имущества. В статье делается вывод о важности спецификации в обеспечении соблюдения выбора соответствующих строительных материалов и методов строительства для устойчивости конструкций. Предлагаются рекомендации во избежание плохих спецификаций, которые приводят к разрушению зданий, имущества и, в конечном итоге, к гибели людей.

**КЛЮЧЕВЫЕ СЛОВА:** архитектура, разрушение зданий, спецификация

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## INTRODUCTION

Building collapse can be explained as the inability of the building to perform its principal function of satisfaction, comfort, stability and safety as a result of a total or partial/progressive failure of one or more components of the building. In the life span of a building, it is required of the building to meet certain requirements, which include buildability, timely completion, design performance, cost effectiveness, quality and safety [1]. The prevalent rate at which building collapses in Nigeria poses a grave concern and serious challenges to all the stakeholders in the building construction industry including; building consultants, governments, developers, landlords and users [2]. The resulting destruction from each building collapse often leaves a trail of destruction of lives and loss of properties in locations where they occur, mostly in the urban cities of Port Harcourt, Abuja and Lagos in Nigeria [3].

A specification is a contract document that gives detailed description in words what cannot be visualized or seen in the working drawings about the construction and formation of a building to be erected [4]. Specification is relevant in giving details of materials to be used, the extent of work, the way components are installed, and to which degree of accuracy the work is put together quality of craftsmanship for work. The specification document is most times used alongside the working drawings because they complement each other [5]. Studies conducted by researchers have identified the major causes of buildings collapsing in Nigeria to be an intricate play of many factors such as uncontrollable climatic conditions, use of poor materials, among others, which can be categorized either as human errors or natural [2]. Most prevalent cause of building collapse identified is poor specification documentation of materials and its compliance during construction [3].

## PURPOSE

This paper investigates the effects of specifications on building collapse in Nigeria. The scope of the paper covers the concept of specification, its content and use in the construction industry. The study also discusses building collapse in Nigeria, the causes of building collapse, the views of construction professionals and various authors on building collapse and the effects of specification on building collapse is discussed. The body of literature regarding effects of specification on building collapse available is limited as most fail to properly document the specific effect specification has on building collapse. A large number of articles available study the general causes of building collapse with little attention on specification as a key point. This paper attempts to fill this gap in literature.

## LITERATURE REVIEW

### Specification Definition

As earlier defined specification in building construction is a document that describes with great amount of detail and accuracy the extent of work to be done, the materials involved, and methods through which they are installed, and quality and accuracy of craftsmanship required for a portion of work to be carried out as stipulated by the contract document. Also as earlier said, the specification document is read with the working drawings, this is because they complement and not contradict each other [5]. The preparation of the specification document is prepared by the Architect and therefore provides knowledge of all the activities and processes that would be involved in a building from start to finish of construction process.

The content of a specification is required to be brief, but contain sufficient details to enable all relevant parties that are involved in the construction of the building to be able to cost and construct the building. All the technical terminologies should be as is commonly used in each trade/construction industry. Apart from the use of drawings, models, schedules, and bills of quantities for effective and successful execution of a building project, the specification document becomes most essential with increasing complexity of the building projects. There are many design decisions that cannot be expressed in drawings but can be communicated in detail when written in words. The specification is thus created to complement the drawing, so that together they convey the architect's intentions.

### Elements of Specification

A specification often refers to a set of documented requirements to be satisfied by a material, design, product, or service. Specifications should contain: type of materials to be used on the project, the acceptable quality of the selected materials, systems and equipment to be used, the quality of craftsmanship, the way the material or component is manufactured or fabricated, the method of erection or installation, the options and alternatives, the required code to be conformed with and also the method of testing for certification. Also, the specification document should contain the allowances, staffing and co-ordination general organization. For reasons of writing, convenience, ease of reference and speed in estimating, specifications are separated according to various categories of building components [6].

### Building Collapse

Without the fear of deforming extremely buildings are designed to sustain certain loads. These loads are grouped into two including the live loads (humans, objects, rain, snow, wind pressure etc.) and the dead loads (the building). Buildings with low number of floors are usually very rigid due to less impact of lateral and other external forces which features the design of the roof which spans large open spaces. Likewise, in high rise

buildings with large number of floors, the design of the roof is usually done minimally in order not to add extra weight to the building.

Building collapse occurs when all criteria involved in the construction project are not taken into consideration from the on-set of the scheme. Specification becomes vital with proper understanding of the nature of the load acting on the structure. Different weights and types of loads have different requirements of them. These requirements are in terms of manpower qualification for installation, materials specified etc.

In other parts of the world, especially regions where the use of timber is prevalent, building collapse can occur as a result of excessive water moisture [7]. Building failure caused by excessive water entry creates structural and fire rating problems, which is very common. This excessive moisture leads to timber decay especially in buildings where timber or lumber construction had been adopted. For further understanding, the common causes of building collapse related to building technology are discussed below:

**1. Bad design**, this is usually due to negligence on the part of the professional, it occurs when they do not take into consideration the total load to be borne by the building or rely on some form of inaccurate data or theory in the design of the structure [8–9].

**2. Faulty construction**: may result from the use of the wrong material that is not suitable for the climatic condition or particular project. Also, when there is laxity in supervision and the right method of construction or work with a particular element is not done accordingly then faulty construction may occur [8–9].

**3. Extraordinary Loads**: these types of loads include heavy snowfalls accumulating on the roof which were not initially envisaged during design or seismic loads laid on the building by reason of earthquakes [8–9].

Below is an example of a building that collapsed in South Asia.

Location: Dhaka District, Bangladesh, South Asia.

Building Description: Nine storey commercial building containing garment factories, banks, shops and apartments.

Date of Collapse: 24 April 2013 (8.45am BST)

Casualty: 1134 dead, about 2500 injured

Cause of Collapse: Use of substandard construction methods and materials, Addition of 3 floors above the original permit, Conversion of original function of building.

The day before the collapse, a television station in Bangladesh showed extensive cracks seen on the ground floor of the Plaza. After it was aired, the building was evacuated, however, the owner of the building, Sohel Rana, assured the public that the building was safe and workers were to resume the following day. The morning of the collapse, there was a power outage that led to the diesel generators on the top floor being used; it is believed that the vibrations from the generators were what finally brought the building down.

The Architect of the Plaza, Moshood Reza, said the building was planned to house only shops and offices, not factories and it was discovered after the collapse that the last 4 floors had been built without a permit.

The direct causes of the collapse included the following:

The building was erected on a filled in pond but the foundation was designed for stable subsoil. According to Garvin H, an Engineer who investigated the collapse, “Part of the building was on much softer soil than the other so that part of the building settled down a little bit more”.

1. The conversation of the building from its designed commercial use to industrial use. According to



Figure 1. The Plaza before the collapse (Source: The Daily Star, 2013)

## The building

The Rana Plaza site was prepared by draining water from a pond and filling it with concrete foundations, according to local residents. It was originally planned to have six storeys, but other floors were added, even though no plans were filed with authorities. Bangladesh's Home Ministry said Thursday it suspects vibration from electrical generators on the top floor "is one of the reasons for the building collapse."

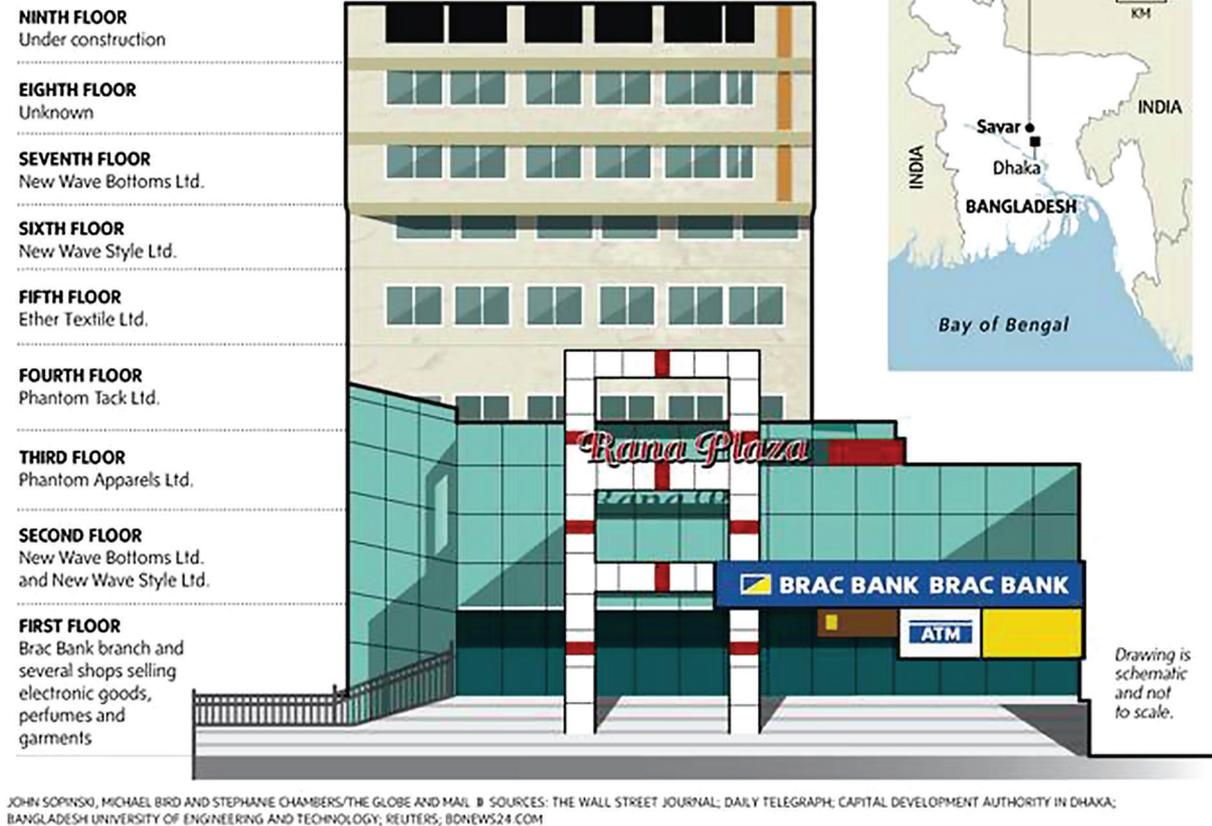


Figure 2. Occupants of all 9 floors of the Plaza (Source: The Wall Street Journal)

Than K. (2013), since the building was not designed to house factories, the possible combinations of load and vibration caused by machinery was never considered by any professional.

2. Addition of floors without building permit. At the time of the collapse, the ninth floor was still under construction with 3 lower floors being occupied by garment houses. In a press interview, Bangladesh Home Minister, Muhiuddin Alamgir noted that the building was not built in compliance with the safety rules and regulations and stern legal actions was to be taken against the people who built the structure.

3. An overload of the building aggravated by vibrations from of the generators also the use of substandard construction material according to Than (2013), the substandard construction methods are a common problem in developing countries where construction materials can be expensive and building inspections infrequent. Dan Jansen, a civil engineer who investigated the collapse suggested that not enough reinforcement bars were used due to the way it collapsed. The quantity of reinforcing steel used did not allow optimal

load transfer and in addition, there may have not been enough cement in the concrete mix.

From the above findings, it can be seen there were design flaws in relation to the materials and methods adopted for the project right from the substructure. The foundation type suitable for the location was not used but rather a cheaper one was used. In addition, substandard materials were used either due to corruption or due to lack of having a proper specification document for the project. It is therefore important to have a specification document drawn up before construction and adhered to during construction to avoid partial or complete collapse of a structure.

### 2.4 Building Collapse in Nigeria

[10] identified attributed building collapse to be caused by natural disasters such as tremors, tornadoes, flood, among others. Other causes as indicated by him incorporate factors of human error, for example, oversight, carelessness, utilization of deficient structural drawings non-attendance of legitimate supervision of projects, change of approved drawings, utilization of substandard materials, corruption in the Nigerian sys-



Figure 3. An aerial view of the collapsed plaza

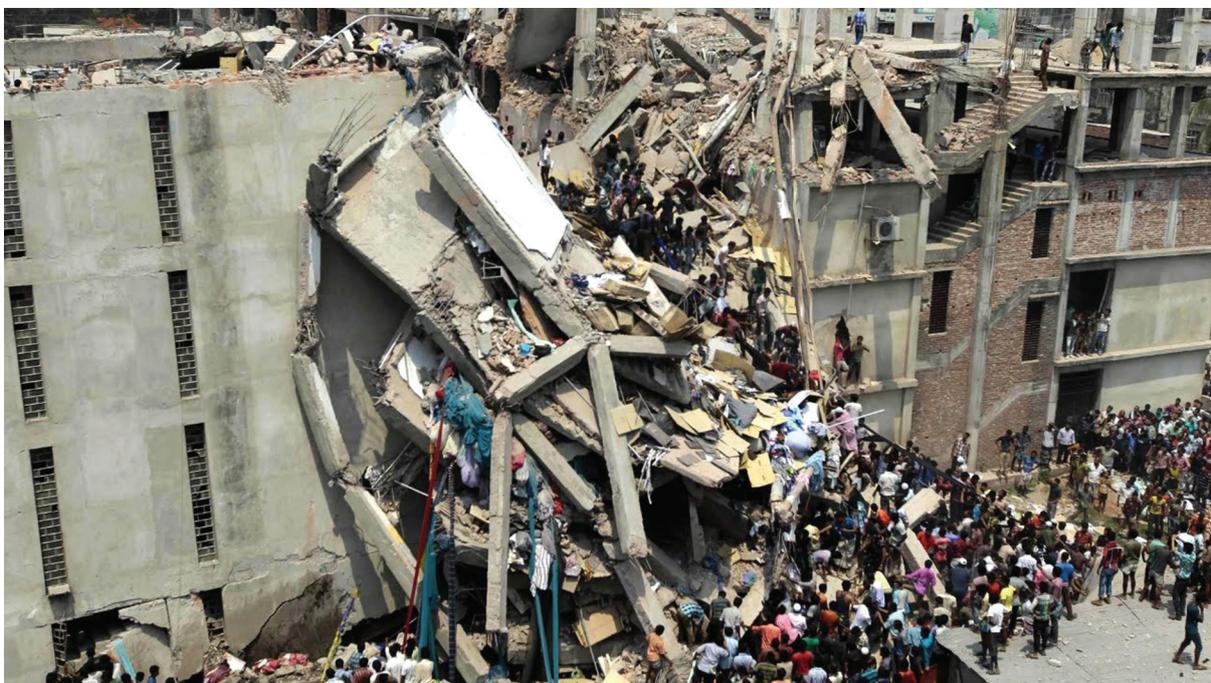


Figure 4. A closer view of the collapse

**Table 1.** Showing Some Reported Cases of Collapsed Buildings in Nigeria

S/ N	Building location	Type	Date	Suspected cause(s)	Remarks Life lost
1	Mokola, Ibadan Oyo state	Multi-storey building under construction	Oct. 1974	Excessive loading	27
2	Barnawa Housing Estate Kaduna	Residential building	Aug. 1977	Faulty design	28
3	Govt. Sec. Schl. Markafi Kaduna state	School buildings	July 1977	Carelessness	7
4	Bamawa Housing Estate Kaduna	3 residential buildings	1980	Faulty design	6
5	Iponri Lagos	Uncompleted 4 story building	May 1995	Excessive carelessness	13
6	Ojuelegba Road Lagos	Residential building	May 1985	Rain storm	undisclosed
7	Lagos Island, Lagos	Uncompleted	July 1985	Excessive loading	9
8	Gboko, Benue	Residential	Sept. 1985	Carelessness	1
9	Allen Avenue	Residential	1985	Carelessness	
10	Adeniji Adele, Lagos	Residential	1985	Carelessness	2
11	Osogbo, Osun State	Mosque	May 1986	Faulty design	2
12	Ona Street, Enugu Anambra State	Residential	1986	No investigation	2
13	Isiala, Imo State	High court	1986	Collapse ceiling	2
14	Agege, Lagos State	2 storey building under construction	May 1987	Carelessness	undisclosed
15	Idusagbe lane, Idumota Lagos	Residence	Sept. 14th 1987	Ignorant client, no structural design	17
16	Ikorodu road,	Commercial	Sept. 1987	Storm (nature)	4
17	Calabar, cross river	Residential	Oct. 9th 1987	Storm (nature)	3
18	Akinwumi street, Mende village, Lagos	6 storey hotel	Oct. 1989	Faulty design	No death

Sources: *Fakere, (2005); Nigeria Daily Newspapers (2000-2003); Ogunsemi, (2002); Oke. (2009).*

tem, building without approved drawings and. translocation of building plans to various sites.

[11] opines that building collapse occurrences can be controlled or limited when the client is prepared to pay for quality materials and for proficient services from professionals. As of late building collapse in Nigeria has been a wellspring of worry to such a significant number of individuals, especially those related 'with the building sector. This is so in light of the fact that there are such huge numbers of instances of building collapse everywhere throughout the world and especially Nigeria, most of these cases had come about into gigantic monetary losses as well as lives and property. Building collapse are a portion of the cardinal issues, which have made genuine worry to every one of the experts like Architects, Structural Engineers, and the Builders. [12] posits that the repeating event of collapse of buildings

has forced some state governments to, implement and authorize some laws prescribing relinquishment of such buildings and prosecution of their owners.

### 2.5 Causes of Building collapse in Nigeria

In building design, the architect first conceives the idea of the design before handing it over to the engineer to proffer solution to challenges regarding the structural stability of the building. It is paramount that the architect has prior basic knowledge of structural design to be able to assess the solution proffered by the engineer as well as design a structurally sound building. However, the collapse of buildings in Nigeria has been attributed to the sharp practices of clients who are ill advised to make structural alterations during the construction process without recourse to relevant Construction professionals. According to [13], poor application of materials as well as the use of inferior materials has also been

**Table 2.** Showing Some Reported Cases of Collapsed Buildings in Nigeria from 2000–2016

S/N	Building Location	Date	Suspected Causes	Remarks (life lost)
1	Mushin, Lagos	2000	Faulty Construction	Nil
2	Oke-Bola, Ado-Ekiti	2000	Poor quality control, rain storm	Nil
3	Ogbagi street, Ikare	2001	Fire disaster	Nil
4	OdoIkoyi, Akure	2001	Foundation problem	Nil
5	Odoso compound, Ikare	2002	Fire disaster	Nil
6	Ojuelegba, Akure	2003	Poor workmanship & underreinforcement	Nil
7	Stadium road, Akure	2003	No structural members	Nil
8	Onyearugbulem market, Akure	2003	Poor workmanship & under reinforcement of the cantilevering end	Nil
9	Ebute Meta	2003	Structural defect	8 injured
10	Elias Street, Lagos	2004	Rain storm	8 Died
11	Iponri	2005	Inappropriate Foundation	Nil
12	OkeSuna, Lagos	2005	Structural degeneration	1
13	Broad Street, Lagos	2006	Rainstorm	Not disclosed
14	Ebute Meta	2006	Structural defect	37
15	Oworonsoki	2006	Faulty Construction	1
16	Abuja	2008	Faulty Construction	3 died, 10 injured
17	Apongbon	2008	Structural defect	3 injured
18	Ikeja	2008	Faulty Construction	Several Injured
19	Alade Street, Lagos	2008	Structural defect	3 Died,5 Injured
20	Ojerinde Street, Idiaraba	2009	Excessive Loading, Faulty Construction	9 Died,3 missing, 21 Injured
21	Ajegunle, Apapa Lagos	2009	Structural degeneration	Not disclosed
22	Abuja	2010	Faulty Construction	Not disclosed
23	Garki, Abuja	2010	Overloading	23 died, 10 injured
24	Kano	2011	Rain storm	6 died
25	Abuja	2011	Overloading	100 died
26	Abuja	2012	Unsupervised demolition	2 died
27	Kaduna	2011	demolition-gone wrong	5 died
28	Ebute Meta	2013	Structural defect	7 died
29	Abia	2013	Structural defect	7 died
30	Kaduna Kaduna	2013	Structural degeneration	14 died
31	Jos Jos	2013	Change in dead load	30 died
32	Lagos	2014	Structural defect	116 died
33	Lagos	2016	Change in dead load	34 died

Sources: Fakere, 0 (2005); Nigeria Daily Newspapers (2000-2003); Ogunsemi, (2002); Oke, (2009); Personal Investigations

reasons for building collapse and failure. This is seen in the rapid disintegration of building components especially concrete elements and almost transformation of sand blocks to sand.

The activities of quarks in the construction industry have also been a contributing factor when investigating the cause of buildings collapsing in Nigeria. In a building collapse investigation carried out in Port Harcourt 2006, the Council for the Regulation of Engineering in Nigeria (COREN) recommended the persecution of a pharmacist who supervised a building that collapsed in 2005 [14]. The Nigerian Institute of Architects (NIA)

has also pursued severe sanctions for erring builders. However, there is little record of the success recorded in stemming out this menace. The Lagos State government pinpointed the major causes of building collapse in Lagos to be primarily as a result of either: faulty foundation, use of inadequate steel reinforcement, poor materials and workmanship to mention a few [14]. A number of important factor are being ignored by architect during design and these tend to lead to certain failure in the buildings and eventual collapse. Soil testing should be properly carried out as well as adequate inspections of the climatic features and site features of a particular

site before a structure is design or any specifications is made for the building materials, processes and workmanship. Failure to properly gather adequate details as such cause the inadequate design and specification which could lead to an eventual collapse.

## MATERIALS AND METHODS

In examining the effects of Specification on building collapse, the background to the study begins with review of relevant literature on specification, the content of specification and the relevance of Specification. The literature review also covered studies on building collapse and the causes of building collapse. To provide a clearer understanding of the subject matter, a number of selected case studies of buildings that have collapsed in Nigeria was carried out. The basis of selection involved the identification of some significant cases regarding specification in particular; among the cases documented in national reports. The researchers relied on secondary sources of data obtained from interviews in newspapers and reported eyewitness accounts of building collapse as captured in reports, investigative inquiries and other online sources.

Interviews were conducted to obtain primary. Interview of professionals in the construction industry in Nigeria were conducted using a structured question format. Questions asked in the interview included the profiles of the respondent, their awareness and opinion on specification writing, their opinion on building collapse in Nigeria and also their opinion on the effects of specifications on building collapse.

### Case Study 1: Meiran Building, Lagos

Building Description: Bungalow and shop extension.

Location: Seidu Ekeleji Street, Alaro, Meiran, Agbado–Oke Odo area of Lagos.

Casualty: 2 deaths, Mother and daughter.

Date of collapse: July 22, 2017.

Cause of collapse: Heavy loads placed/substandard materials used for the construction work.



Figure 5. Meiran building collapse (Source:360Nobs.com)

The Lagos State Government attributed the building collapse to overloading of the building structural members and the use of substandard building materials. Furthermore, the site on which the building collapsed has a completed bungalow and a shop extension in front of it, which had a decking stacked with loads of building materials. The building that occupied the site had no planning permit and work was to be halted on the site as building Control officers had instructed to ensure compliance and monitoring. It is safe to infer from the foregone that specifications did not play a vital role during the construction process. It is possible that the construction commenced without a clear direction concerning materials specification, or the builder cum contractor took the liberty of specifying when construction was already in process.



Figure 6. Rescue operations (Source:360Nobs.com)

### Case Study 2: Naval Building, Abuja

Building Description: Two (2) Storey.

Location: Naval Quarters, Nos. 45 Road, 1st Avenue, Gwarinpa Estate, Abuja.

Casualty: 2 deaths, 1 seriously injured while the others had minor injuries.

Time of Collapse: 10 am 28th January 2012 (Adepegba 2012).

Cause of Collapse: Structural defect/human error



Figure 7. Ruins of Naval Building (Source: google image, 2012)



Figure 8. Ruins of Naval Building(Source: Nnabugwu, 2012)



Figure 9. Ruins of Naval Building(Source: Adepegba, 2012)

It is then safe to assume that material specification, quality of workmanship, which is contained in a specification document, was either non-existent as part of the construction document or its instructions were deliberately ignored. This is a common practice of some contractors to maximize profit, which has led to death and loss of investment.

**Case Study 3: Three Storey Building, Ilasamaja, Lagos**

Address: Richard Abimbola Street, Ilasamaja, Lagos.

Casualty: 1.

Time of Collapse: 2pm May 18, 2017.

Cause of Collapse: Substandard Building Material and Faulty Foundation.



Figure 10. Ruins of the collapsed building

The building was initially being renovated, but a ‘stop order’ was issued and marked for demolition by the Federal Capital Development Authority (FCDA) due to structural defect observed as the building was said to have deteriorated over time. The collapse occurred when the building was being demolished [16]. The contractor proceeded with the demolition exercise without waiting for the approval of the formal application for demolition already submitted to the FCDA. Aside from starting the demolition without approval from the appropriate authority, inexperience man-power was used to execute the work. They started the demolition process from the ground floor, which was the primary trigger for the collapse [16].

Results from Investigations conducted, indicated impurities such as biotite and muscovite to be present in the concrete mixture, which was one of the factors that may have led to the deterioration of the structural elements [16]. Mica, Feldspar and quartz are composition of an aggregate stone. The mica portion is made up of biotite and muscovite and they are both oxidizing agents that caused structural members to weaken over time [17]. Under close observation, it was noticed substandard materials were used that includes the reinforcement and coarse aggregate. And as well as poor workmanship as the debris revealed poor mix ratio and an uneven distribution of the constituent of the concrete [16].



Figure 11. Ruins of the collapsed building

Observation from the site showed a building built with sand-crete blocks on a frame structure made up of reinforced concrete columns, beams and floor slab. Eyewitness account stated that the building was built on the foundation of a demolished structure, due to the perceived need for the client to complete the building in record time. Other possible cause of the building collapse has been attributed to use of sub-standard building materials and shoddy workmanship.

**Case Study 4: The Don de Dieu plaza, Maryland, Lagos**

Building Description: Six-storey building.

Location: 11, Aderibigbe Street in Maryland area of Lagos state.

Occupants: over 10 organisations and about 350 occupants.

Casualty: No casualties recorded, as all occupants were evacuated before the structure collapsed.

Time of collapse: 6:45 pm, Wednesday 26th October, 2011.

Cause of collapse: Structural defect/human error.

The building was a modern five-storey building with a floor. Visual examination by the Nigerian Building and Road Research Institute (NBRRI) revealed that it was built from reinforced concrete and block walls. There was a communication mast on top of the

building and a large billboard that was hung on the building dangled loosely. Long span Aluminium roofing sheets were used in roofing the building and the building carried a large water tank. Concrete columns and beams were seen dangling loosely from what remained of the building. According to eyewitnesses, it was revealed that a loud bang was heard at about 3pm on the day of the collapse, the wall panels began to give way and fall apart leading to the caving-in of the core of the building at about 6:45pm. Some occupants were said to have earlier noticed cracks on the walls, which was reported to the owner who promised to rehabilitate the building but this didn't happen before the collapse.



Figure 12. Ruins of the collapsed building

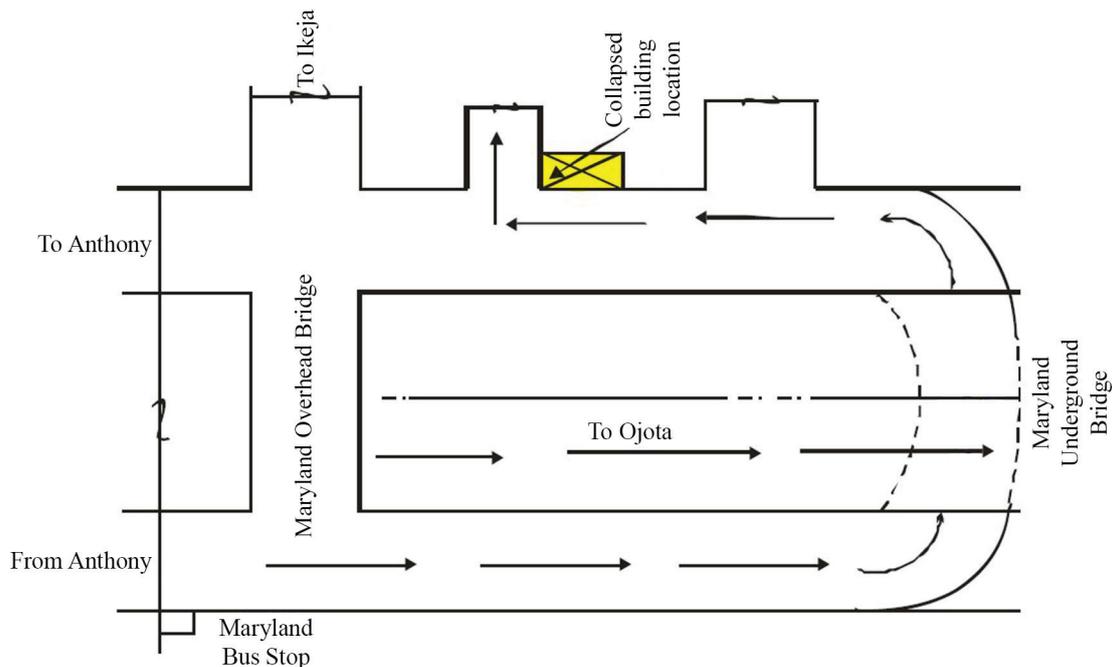
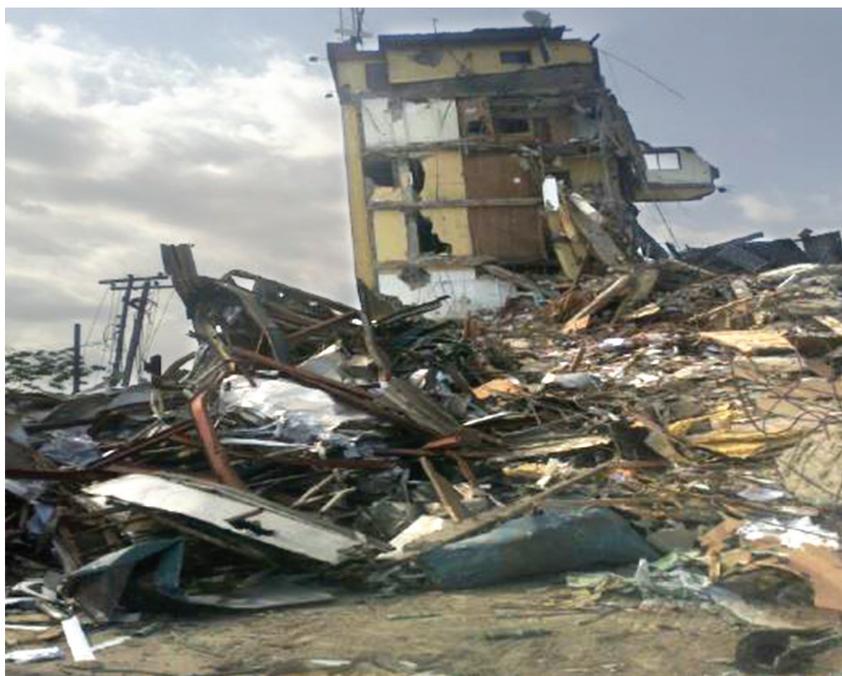


Figure 13. location map of the collapse site at Maryland, Lagos



**Figure 14.** Ruins of the collapsed building

The professional responsibility cannot be ascertained as the structure had been in occupation for over a decade before its collapse. The post-mortem evaluation by Nigerian Building and Road Research Institute (NBRRI) discovered that since the occupants had observed and complained of several cracks which was a red flag on the imminent danger: this indicates that there was a gross Serviceability Limit Violation: and not an Ultimate limit state violation. From what remained of the structure it was deduced that the core of the structure had settled differently from the other parts, thereby leading to the redistribution of stresses prompting the splits in the auxiliary components such as columns, beams and slabs. Perhaps there had been any significant extension OR development joint between these parts of the structure, the settlement of the centre would not have constituted any problem if it were uniform over appropriate sections of similar loading. The settlement of the core would not have constituted any issue on the off chance that it was uniform over appropriate areas of that are loaded similarly. Nevertheless, for this situation, the stresses were transferred to the areas through the years and the pressure redistributions were kept away from failure by the steel reinforcements present. In any case, the cracks logically expanded throughout the years until the point that an ultimate resistance of a critical area gave way prompting the underlying spalling and cracking sounds that observers gave record of. Moreover, the primary Site examination has uncovered that the Pad foundations on location were in place, with no tilting or sinking, at the point of collapse. Thusly, the differential settlement could have been principally the after-effect of the indi-

vidual foundation movements. It is additionally conceivable that there were individual structural members that deflected.

Some of the field notes received by the NBRRI analysis team are as follows:

- (i) Inappropriate sizing of the columns;
- (ii) Improper bonding;
- (iii) Absence of stability ties for a structure with such height;
- (iv) Insufficient shear reinforcement;
- (v) Improper calculation of the load carrying capacity of the structure;
- (vi) Additional load on the structure (the big billboard and the spire at the top on the roof);
- (vii) Committee noticed the building's foundation even after collapse, did not sink into the ground.

The opinions presented the professionals include the possibility of undersized columns and beams, as evidenced in Figure 1 and 2. The insufficient cement mortar bonding also caused the weakening of the concrete with age. Additional loading must be verified through calculations when all drawings are collated for detailed scrutiny.

Be that as it may, an unmistakable choice isn't hard to make in this circumstance. There was adequate cautioning before the collapse of the Structure and the Owner of the Building must be considered completely responsible for not harkening to the protests and notices of a broke Structure and making legitimate and auspicious preventive measures. The Occupants have themselves to fault for taking the great risks to their Lives and Property after seeing the signs of a fast approaching failure of the structure.

## RESULTS FROM CASE STUDIES

From the case studies conducted, inferences drawn from the case studies are as follows:

In case study 1, the specification document did not account for proper construction of the substructure therefore leading to uneven settlement of the substructure. Although the building was not used for its intended purpose, the addition of floors to the building was not covered in the specification document hence leading to poor structural stability. Investigations carried out to identify the cause of the collapse revealed that the reinforcement bars used in the construction of the building were insufficient thereby attributing the collapse of the building to poor specification, lack of technical expertise and poor supervision. From case study 2 and 3, it is evident that specification was not carried out because there was no planning approval for the building for and compliance with code regulations for construction. Therefore, the lack of specification brought about the different material opinions for the construction of the building by the developers. Lack of specification document on the required technical expertise, quality of workmanship required during construction and installation of the building elements by the developers of the building resulted in the building collapse. In case study 4, the non-involvement of professionals and appropriate supervision in the construction of the building accounted for lack of proper specification document, resulting in improper construction of the substructure of the building that led to eventual collapse. Lastly, case Study 5, the materials used in the construction were not fit for the nature of the building that was constructed which invariably resulted in the structural defects and final collapse of the structure.

## FROM INTERVIEWS

Four professionals in the construction industry were interviewed. This consisted of two Architects and two Engineers; Arc A. Solanke, Arc O. Ekhaese (Ph.D.) and Engr. R. Olofinnade, Engr A. Ogiye (PhD).

Arc A. Solanke who has over 25 years of experience as a practicing Architect, in his words considers specification as *“key to the practice of architecture that brings to life the design of a project”*. He emphasized the importance of specification in any building project to help efficient construction and prevent the substitution for wrong materials when well documented. In his opinion, *“improper specification can lead to a disaster. Materials should be specified in respect to their properties, specify materials that are durable, cost effective, low maintenance cost. Specification entails having broad knowledge on the materials to be used in the building and it should be complete. An incomplete specification would make it hard for the construction of the project”*. He stressed that building collapse was caused mostly

by poor supervision on site that the specification which could be included in drawings or separate print may be met by incompetent site engineers. He recommended complete specification documentation with adequate research into material properties as this gives the client value for money.

Arc. O. Ekhaese also a practicing Architect with about 16 years of experience in industrial and institutional projects in Nigeria stated that specification document contains all building information therefore helping as an integral part of the construction. According to him, *“Building collapse is due to the use of inappropriate or substandard materials in the building project. And also, is caused by poor supervision most times”*. He stressed that it reduces waste through effective management of resources. He also recommended that it should be taken into consideration at the early design stage.

Engr. R. Olofinnade a civil engineer with 10 years of experience in Geotechnics and design of structures attributed building collapse to arise from poor specification. In his words, *“specification is vital in construction because if not done properly, it can lead to building failure”*. He also stressed that the materials usually specified were costly and not easily accessed, which most times leads to substitution for cheaper ones. He recommended that proper research be conducted on cheaper and more available materials, and the enforcement of construction guidelines to effectively save lives of building occupants and forestall cases of building collapse.

Engr. A. Ogiye a registered structural engineer with 27 years of experience in residential, high-rise, healthcare, water and solid waste retaining structure further corroborated the effect of poor specification to result in building collapse. In his words, *“Building collapse in general is caused by poor supervision most times... in the construction industry some professionals don't follow what has been specified”*, the major cause of building collapse. He recommended that government train on how to write Specifications.

## CONCLUSIONS

As observed on the completion of this research, the importance of proper specification cannot be over emphasized as it has very substantial impact on project quality, cost of construction, and the safety of lives and properties during the entire construction process and the eventual occupation of structure. It can be inferred from the analysis that without proper specification, a building could fail structurally resulting in collapse and loss of lives and properties. To prevent such colossal damage, there is a need for proper Specification documents to be used for any Construction project. In addition to the proper documentation of the specification, conformity to the materials, processes and recommendations in the specification document must be coordinated and well supervised.

## RECOMMENDATION

Proper Specification of materials is relevant for any successful construction project to prevent structural failure and protect the safety of lives and properties. The following are therefore, recommendations to prevent this structural failure and building collapse:

i. **Proper research into availability of materials:** this is important to ensure that the materials that will be specified are the ones that the contractor can easily get. In construction projects where the materials have to be imported or specially produced, it may encourage the contractors to procure substitutes, which may not be appropriate for the project.

ii. **Proper on-site Supervision of construction projects:** This is necessary to ensure that the works that are expressed in the specification documents are conducted with the right materials, at the right time and with the correct skilled personnel to ensure the work is properly done.

iii. **Proper understanding of the nature of project for accurate specification:** it is important to have all the information that pertains to the project for proper specification writing. The natures of load, site conditions, etc. are all factors that must be put into consideration to ensure the building does not fail.

iv. **Specification of cheaper materials:** It is strongly recommended that materials with cheaper alternatives should have the less pricey alternatives (that will still support the loads) specified as if it is too costly, an alternative may be substituted which may not sufficiently carry the loads.

v. **Education and training of relevant personals:** It is recommended that the dangers of poor specification or not accurately following it for any project be communicated to the people involved. In addition, the education of the professionals involved in specification writing should be thorough to ensure a good understanding and effective skills in preparing this very important document.

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ABOUT THE AUTHORS: **Adewale Bukola** — Phd Architecture, Lecturer, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, bukola.adewale@stu.cu.edu.ng;

**Alalade Gbenga M.** — Phd Architecture, Lecturer, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, Gbenga.alalade@stu.cu.edu.ng;

**Akinwande Adeolu** — Bsc Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, adeolu.akinwande@stu.cu.edu.ng;

**Daramola Ayotilerewa Adeboye** — BTech Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, Ayotilerewa.Daramola@stu.cu.edu.ng;

**Joseph Anthonia** — Bsc Architecture, Miss, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria anthonia.joseph@stu.cu.edu.ng;

**Odili Adaobi** — Bsc Architecture, Miss, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, adaobi.odili@stu.cu.edu.ng;

**Odugbesan Ayotunde** — Bsc Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, ayotunde.odugbesan@stu.cu.edu.ng;

**Ogunleye Adeyemi** — Bsc Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, Adeyemi.ogunleye@stu.cu.edu.ng;

**Adeleke, Joyce** — Bsc Architecture, Miss, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, joyce.adeleke@stu.cu.edu.ng;

**Oyeyiola Moyosore** — Bsc Architecture, Miss, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, moyosore.oyeyiola@stu.cu.edu.ng;

**Famurewa Oluwasina** — BTech Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, Oluwasina.famurewa@stu.cu.edu.ng;

**Oladapa Mustapha** — Bsc Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, mustapha.oladapo@stu.cu.edu.ng;

**Olumuyiwa Oluwatobi** — Bsc Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, oluwatobi.olumuyiwa@stu.cu.edu.ng;

**Eyiario Segun** — Bsc Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, segun.eyiario@stu.cu.edu.ng;

**Oyeshomo Temilade** — Bsc Architecture, Miss, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, temilade.oyeshomo@stu.cu.edu.ng;

**Ugah Uzodinma** — Bsc Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, uzodinma.ugah@stu.cu.edu.ng;

**Eke Wonders** — Bsc Architecture, Mr, Post graduate student, **Covenant University Ota Ogun State Nigeria**, Km 10 Idiroko Road, Cannan Land Ota Ogun State, Nigeria, wonders.eke@stu.cu.edu.ng.

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ОБ АВТОРАХ: **Адевале Букола** — доктор философии по архитектуре, преподаватель, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, bukola.adewale@stu.cu.edu.ng;

**Алаладе Гбенга М.** — доктор философии по архитектуре, преподаватель, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, Gbenga.alalade@stu.cu.edu.ng;

**Аликванде Адеолу** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, adeolu.akinwande@stu.cu.edu.ng;

**Дарамола Айотилерева Адебойе** — Архитектура BTech, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, Ayotilerewa.Daramola@stu.cu.edu.ng;

**Джозеф Антония** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, anthonia.joseph@stu.cu.edu.ng;

**Одили Адаоби** — бакалавр по архитектуре, Мисс, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, adaobi.odili@stu.cu.edu.ng;

**Одугбесан Айотунде** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, ayotunde.odugbesan@stu.cu.edu.ng;

**Огунлейе Адееми** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, Adeyemi.ogunleye@stu.cu.edu.ng;

**Аделеке Джойс** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, joyce.adeleke@stu.cu.edu.ng;

**Ойейиола Мойосоре** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, moyosore.oyeyiola@stu.cu.edu.ng;

**Фамурева Олувасина** — бакалавр технологии по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, Oluwasina.famurewa @ stu.cu.edu.ng;

**Оладапа Мустафа** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, mustapha.oladapo @ stu.cu.edu.ng;

**Олумуйива Олуватоби** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, oluwatobi.olumuyiwa@stu.cu.edu.ng;

**Эйиаро Сегун** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, segun.eyiabo @ stu.cu.edu.ng;

**Ойешомо Темиладе** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, temilade.oyeshomo@stu.cu.edu.ng;

**Уга Узодинма** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, uzodinma.ugah@stu.cu.edu.ng;

**Эке Уандерс** — бакалавр по архитектуре, аспирант, **Университет Ковенант**, Нигерия, Ота, штат Огун, Каннан-лэнд, 10-й км Идиороко-роуд, wonders.eke@stu.cu.edu.ng.