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The Role of Construction Materials in Building Collapse in Nigeria: A Review

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Abstract

Building failure or collapse happens both in the developed and developing countries but the rate of occurrence in the developing country such as Nigeria is quite alarming and therefore call concern. The menace of building collapse in Nigeria is very alarming and appalling. Building collapse in Nigeria has become the norms they are easily swept under the carpet whenever it occurs. It is rather unfortunate that both human and economic loss we record each time there is a failure or building collapse is rather humongous. There is also a lot of blame game among professional stakeholders in the industry once failure or collapse of building occur and unfortunately, there is no proper scientific investigation in most developing countries such as Nigeria to ascertain the cause of failure or collapse as the case may be in order to avoid any future occurrence. In the cause of this review, it was discovered that building materials such as reinforcing steel, cement, sand, granite, sandcrete blocks and concrete play huge important role in either the collapse or stability of buildings in Nigeria. The roles of these materials are so vital that they contribute immensely to the collapse of buildings. It was concluded that 10-25% of buildings that collapse in Nigeria are as a result of the use of poor quality building materials. The review has extensively dealt with building collapse in relation with the role of building materials during construction.

Key words: Collapse, building, construction materials

1. Introduction

Buildings is said to collapse when it can no longer satisfy its primary function of being safe, stable, comfortable and satisfying the occupants [1]. Building is therefore used to provide adequate shelter and form of protection to her occupants without any fear of being collapsed [2]. Building construction industry has experienced a huge boom in the last two decades but not without these ugly occurrences of myriad building collapse in Nigeria. Since the boom in the building industry, it has been one of the main drivers of development in our economy. Hence, the reason why we should take all the pains to look deeply into the reasons behind collapse of building in Nigeria. There have been genuine and wrong approaches to the demand for more buildings in Nigeria in order to meet the population surge in Nigeria [3]. The wrong approach, which include but not limited to the use of sand Crete blocks as beams, as shear and load bearing walls, sub-standard materials such as reinforcement, cement and also poor concrete, has contributed greatly to the collapse of many building in Nigeria [4].

According to Amadi et al. [5] and Dimuna [6] collectively alluded to the fact that collapse of building occurs globally and that it is majorly caused by either of the two main factors: the man-made or natural factors. The natural factors may be as stated thus: mud-flow, hurricane and thunder-storm, earthquake, erosion & flood, landslide, and that of man-made factors are



nothing but purely human errors ranging from design, construction method, planning process and building materials. Therefore, there may be scarcity of reliable data as to the cause of building collapse in Nigeria. According to Flaga [7], there seem to be no decline in the calamitous building collapse over the years because of corruption from every quarter of the stake holders, design errors, quacks in the system, wrong construction methodology any many other. This review has technically identified the gaps in the materials deployment to building construction as contributing immensely to the collapse of buildings.

2. Buildings and Building Collapse in Nigeria

Buildings are structures, houses or edifice built or constructed to offer accommodation/shelter to mankind or its handwork and or animals for day to day exercises [8]. There has been a lot of innovative ideas and cutting-edge technology for mankind in ensuring safe, more beneficial and advantageous shelter for the use of mankind [9]. According to Dimuna [6], building design is very necessary to be produced but that it must meet the client's fundamental requirement and must be able to fulfil the purpose for which it was conceived and also satisfy safety in all ramifications. Building, therefore, are constructed or built to have desired designed satisfaction, comfort and safety. If any of these becomes vulnerable, then the purpose for which the building was built has been defeated [10]. Architects, Structural Engineer and Contractors are three main professionals required to meet the minimum or basic requirement of an economically safe, functional and aesthetic building. It was noted by Olusola & Atta [11] that building, as matter of necessity, must satisfy buildability, design performance, cost effectiveness, sustainability, timely completion, quality and safety requirement in its designed lifetime.

On the other hand, building collapse is the partial or total falling apart of building structural members such as roof, beam, slabs, and columns [12]. This is said to occur when it can no longer support the loads it was originally designed to carry which will result in building element having excessive deformation that becomes unsafe to both occupants of such building and the neighbours before it finally breaks up in shambles. Building collapse is not new anywhere in the world [13]. It does happen both in the developing and developed countries but the causes of building collapse in Africa calls for serious examination while the causes in Nigeria seem very barbaric, callous, wicked and unfathomable. According to [3], [14], [15], factors contributing to incessant building collapse in Nigeria is not easily traceable to usual human factors such as ageing, design errors, negligence, accident, force majeure, material fatigue, terrorist attack and other unfavourable environmental condition but that of a typical factor as identified by The Lagos State Government. These abnormal factors are identified as: inexperienced professionals, deficient foundations, under reinforcement, sub-standard materials, poor workmanship and hasty construction, lack of soil test, greediness, poor supervision and finally non-adherence to the codes of practice available in the country. This is further grouped as: poor or sub-standard materials, Ignorant of relevant building codes, outright deviation from building codes specifications, patronising of unskilled labour, lack of supervision, poor material, poor maintenance, overloading by addition of extra floors as against approved number of floors, professionals' conflict of interest by trying to assume some other roles or filed of profession which appear lucrative at a time without formal and technical skill in such field before venturing into such, endemic corruption and propensity to cheat in cause of building construction from conceptualization to execution and acceptance. Hamma-adama and Tahar [9] also noted in their research that the principal causes of building failure in Nigeria

are that of substandard materials, defective design and lack of adequate building supervision. About 90.9% alluded to fact that sub-standard building materials ranked number three (3) amongst the causes building failure in Nigeria [8]. The major materials being compromised are: reinforcement steel, structural steel and cement. Obot & Archibong [16], researched into why building collapse in Nigeria, materials and poor quality control were on the front burner in the study. Adewale et al [17] showed the Tables 1 and 2 and photographs below in their work to further establish the causes of building failure in Nigeria where building materials played some significant role in the collapse of buildings.

Table 1: Presenting Some Reported Cases of Collapsed Buildings in Nigeria from 2000–2016. Source: [18, 17].

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	Odolkoyi, Akure	2001	Foundation problem	Nil
5	Odoso compound, Ikare	2002	Fire disaster	Nil
6	Ojuelegba, Akure	2003	Poor workmanship & under reinforcement	Nil
7	Stadium road, Akure	2003	No structural members	Nil
8	Onyearugbule 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	Ajgunle, 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	2013	Structural degeneration	14 died
31	Jos	2013	Change in dead load	14 died
32	Lagos	2014	Structural defect	116 died
33	Lagos	2016	Change in dead load	34 died

Table 2: Showing Some Old Reported Cases of Collapsed Buildings in Nigeria. Source [17]

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	Bamawa Housing Estate Kaduna	Residential building	Aug.1977	Faulty design	28
3	Govt. Sec. Schl. Markafi, Kaduna	School building	July 1977	Carelessness	7
4	Bamawa Housing Estate, Kaduna	3 residential buildings	1980	Faulty design	6
5	Iponri Lagos	Uncompleted 4 storey 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	Two 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

According to Adewale et al [17] case study of Meiran building collapse which is a bungalow with a decked shop extension collapsed on 22nd of July 2017 with two deaths toll. The building is said to have collapsed due to the use of inferior materials used during construction to support

the heavy loads the building was subjected to. The building had no building permit from the state government.



Figure 1: Meiran Building Collapse. Source [17].

Fakere et al [18] and Adewale, et al [17], reported case of Naval building collapse in Nigeria as showed in Figures 2 and 3. The building located at Naval quarters 45 road, 1st Avenue, Gwarimpa Estate collapsed at about 10 am on 28th January, 2012. The contractor or construction team was already issued a stop-work order on the renovation works being carried out because of some noticeable structural defects. The stop-work order was issued by Federal Capital Development Authority (FCDA) and marked the structure as a 'tragedy waiting to happen'. It is noteworthy to say that the investigation unveils the deterioration of the building element over time. The columns were becoming twisty and also noticed to be wangling. The steel later buckled, materials crushed and the cover to concrete gave way while the entire reinforcing steel was exposed because of the manual and crude demolition method employed. The building collapsed suddenly without any notice in less than a minute of loud noise as the steel yielded. From investigation and report of Fakare et al [18] impurities were discovered to be mixed with aggregates utilized for the erection of the said structure which could have been one the major factors leading to state of unhealthy structural members of the building. It was inferred that oxidation might have taken place due to impurities found in the components of the concrete which might have also be accountable for the poor strength of the structural members. Further investigation of the collapse revealed that materials that are sub-standard, such as reinforcement and poor concrete mix ratio must have contributed immensely to the sudden collapse of the building.



Figure 2: Clearing of debris on the Naval Building site. Source: [18].



Figure 3: Another view of the building showing the wreckage. Source: [18].

3. Construction materials in building industry

Building materials are materials or components (Natural and Man-Made) used purposely for construction of buildings in any location of choice [19]. The two main categories of materials aforementioned may be further broken down as follow: Natural Materials such as Stone/granite/gravel or coarse aggregates, Sand and the like or fine aggregates. Man-Made Materials such as Cement, Reinforcement, Irons, Metals, Tiles, Blocks or Bricks, Concrete and etc. The construction or Building materials that are still being used today are dated to about 400 BC [20]. However, several researches in our modern day life and technological advancement has modernized some materials which are readily available for use and in actual sense, these materials have been developed to adapt to harsh weather conditions and enhance environmental protection without depleting the ecosystem [21]. North America and Europe, because of they are covered with forest gave rise to the use wood in the early time and in Concrete was first used by the romans and later the mixture of concrete and steel gave birth to reinforced concrete in 1849 [22].

Building and or Construction Materials are very essential and should be critically looked into because they contribute immensely to the production of carbon dioxide in the globe and could further trigger global warming. Therefore, building materials should be sustainable to meet our current need and without impairing on the future and still be able to meet the said future need [23]. Building materials constitute the highest percentage of input in the building components and according to Elkhalfifa & Shaddad [24], taking into consideration all elements or components that make up a building in terms of cost, the cost of materials alone in relation to all other elements, ranging from equipment, labour, finance, administration, space and acquisition is humongous and takes the largest share in percentage. It was noted in the UNCHS-United Nations Center for Human Settlements [25] that of all the inputs in construction, about 50% to 80% account for building materials and that said it the single largest input is materials. Therefore, materials in the building industry cannot be over emphasized by saying then that professionals' searchlight should, however, at all times be on the quality of material input in the construction industry. Borrowing a leave from the "Construction Industry Development Council Survey in India reported by Elkhalfifa & Shaddad [24] in the Table 3 below. It is therefore evident that in all the construction components as outlined in the Table 3 below, construction materials dwarfed all other components in an unimaginable percentage margins.

Table 3: Share of Construction Cost Components (%) into different construction categories.

Source: [24]

Category	Material %	Equipment %	Labour %	Finance %	Enabling %	Admin. %	Surplus %
Building	58-60	4.5	11-13	7-8	5.5-6.5	3.5-4.5	5-6
Roads	42-45	21-23	10-12	7-8	5.5-6.5	3.5-4.5	5-6
Bridges	46-48	16-18	11-13	7-8	5.5-6.5	3.5-4.5	5-6
Dams	42-46	21-23	10-12	7-8	5.5-6.5	3.5-4.5	5-6
Power	41-43	21-24	10-12	7-8	5.5-6.5	3.5-4.5	5-6
Railway	51-53	6-8	16-18	7-8	5.5-6.5	3.5-4.5	5-6
Mineral	41-44	20-22	12-14	7-8	5.5-6.5	3.5-4.5	5-6
Plant							
Medium	50-52	7-6	16-18	7-8	5.5-6.5	3.5-4.5	5-6
Industry							

At this juncture, it is willy-nilly to further take a look at the contribution of construction materials to global warming. The importance of materials quality utilized in in the building industry cannot be over stretched in this short review and that is why this dimension of the effect of building materials on global warming is also worth considering. According to Marsono & Balasbaneh [26], Building materials is one the main contributors to the production of carbon dioxide (CO₂) which is released into the space. It was also discovered that of all the building materials being used for construction in Malaysia, wood has the list CO₂ emission. It was suggested that wood should be giving more preference over other building materials in Malaysia because the use of wood for construction has dropped drastically from about 60% to almost 5% and that Malaysia is seen as one the highest generation of CO₂ in the world. From here, it is noteworthy that selection of materials for building construction should be done with every sense of responsibility both to the local authority and humanity at large.

The issue of sub-standard materials in the construction/building industry in Nigeria has been on the front burner in all medium of communication emanating from the professional bodies, government agencies, scholars and all building stake holders [23]. The way and manner sub-standard materials permeate into every facet of building industry in Nigeria is endemic and curbing it has posed a rather herculean task to the government ministries or agencies saddled with such responsibility. In some cases, anyone in search of some quality materials is like embarking on a quest that is energy sapping either before the building commences or while it is ongoing. The varieties of standards in our market today leaves one wondering if Nigeria as it were ever had any form of standard(s) as to what is either locally fabricated or imported into Nigeria and yet there is an agency of the government called Standard Organisation of Nigeria (SON). SON is the apex regularization body in Nigeria established under Act No. 14, 2015 which has the following aims and objectives:

- i. Preparation of standards relating to products, measurements, materials and processes among others, and their promotion at the national, regional and international levels,
- ii. Certification of industrial products,
- iii. Assistance in the production of quality goods, and
- iv. Improvement of measurement accuracy and circulation of information relating to standards

With the above well-crafted aims and objectives of the agency, Nigeria is still fully saturated with sub-standard materials.

It is also interesting to know that Nigeria, under the aegis the Federal Ministry of Science and Technology, has an agency/parastatal called Nigerian Building and Road Research Institute (NBRRI) which was established on 1st April 1978 by the Federal Government. NBRRI was established to carry out some specific functions such as conduct integrated applied research & development (R&D) in road, building and construction sectors of economy. They are to research into both local building and construction materials to determine the most effective and economic methods of their use. The achievement of these two government agencies is commendable, hence there is huge responsibility beckoning on the Nigeria government to fashion out a way to address the menace of myriad sub-standard and poor quality material that have eaten deep into the fibre of construction and building industry. Hamma-adama & Tahar [9] reported that quality of building materials being compromised is one the main causes of building collapse in Nigeria apart from faulty design and lack proper and professional supervision. It was also gathered that a lot of people in the profession believe that inferior materials have contributed immensely to building collapse in Nigeria. The materials that are

easily compromised for greater gain are reinforcement steel, structural steel, cement, concrete mix and roofing sheet [27]. It was also noted that these materials ought to have been inspected, certified and approved by a qualified professional prior to being deployed to site while the onus will now be on the supervising engineer or professional to use the right materials with the right quantity during construction [28]. From Hamma-adama & Tahar [9] survey on the causes of collapse in Nigeria, 90.9% agreed to the fact that sub-standard building materials is the main cause of building collapse in Nigeria while only 9.1% disagreed. In their conclusion, it was evidently noted that poor or sub-standard materials is continued to be a conspicuous and disturbing issue in the collapse of building in Nigeria. Hamma-adama & Tahar [9], pointed out three main materials which are the main causes of building failures and collapses in Nigeria whenever the quantity and quality is being compromised. These are: Cement, Structural Steel and Reinforcing Steel in ascending order.

Ayininuola & Olalusi [29] found that in Nigeria, the locals employed the use of some materials that have no root in the current design code. Nigerians use lintels with its dimensions as structural beams in the construction of buildings. This precarious situation can only be addressed by ensuring close monitoring of all building project. They also make use of hollow sandcrete blocks to transfer loads from slab but unfortunately, these are not designed for such which has resulted in slabs failures such as sagging and it ultimately affect the supporting blocks. These supposed loadbearing walls have led to collapse of several buildings.

According to Tchamba & Bikoko [30], the use of sandcrete blocks as structural and load bearing wall is rather on the increase in Nigeria construction industry. Ayuba et al [31] reported that sandcrete blocks quality is dependent on how durable, strength and thermal conductivity. The quality of blocks also includes fire resistance, density, dimensional charges and efflorescence. It was noted that the quality largely depends on the ratio of the chosen constituent's materials, compaction type and curing period. Tchamba & Bikoko [30] concluded that part of the cause of building failures in Yaoundé and Douala is traceable to the quality of blocks being employed in the construction of building because they do not meet the minimum requirement. However, it was noted that most of walls act as load bearing walls and because the quality of blocks supplied to building construction site will not support the loadings placed on it, hence the wall will give way. It was said that concrete must be prepared with the right materials, specifications and quantity. Quality concrete is the final product of quality constituents and which must be placed rightly and compacted as may be required without leaving out the curing process. According to Tchamba & Bikoko [30], the use of poor quality materials, poor concrete processing, lack of soil investigation, wrong choice of foundation type and lack structural design and detailing contribute to building collapse in Douala.

4. The relevance of quality construction material

According to Twidale [32], the final product of crushing of rocks is simply granite chippings. Coarse aggregate (stones) is composed of quartz, feldspar and also mica. Biotite and muscovite are contained in mica and these are agents of oxidization and may get concrete strength lesser or weaken over a period of time. Since granite is good in strength, appearance and also resistance to weathering, it should be void of excessive crystals of mica-biotite and muscovite. A lot of care should be taken in selecting the right quality material for building construction [33]. It is not out of place to carry out test on water to be used, sieve analysis on aggregates, tensile strength on reinforcement and also ensure there is a design mix to follow during construction. Oduote & Adeleke [34] found that from the test carried out on rebars collected from collapsed building, it was discovered that the brittleness of reinforcement caused by the presence of high concentration of sulphur and phosphorous with FeS and Fe³P present

(deleterious materials) may actually have been responsible for many collapse of the buildings in Nigeria. It was discovered that the inherent ductility of the material has been greatly altered and compromised by these compounds which might have, invariably, aided the collapse of the building investigated. On a final note from the study, the results got from the investigated reinforcing bars are very brittle and therefore might have meaningfully contributed to the collapse of the building.

5. Choice of Construction Materials in Building Industry

Enno & Mohsin [35] concluded that cement is the main binding agent in the production of concrete and therefore cement as part of the constituents of concrete was investigated to see if it conforms to international standard in Bangladesh. It was discovered that compressive strength was satisfied for 3 and 7 days' test while that of 28 days deviated from the standard.

Enno & Mohsin [35] opined that cement procured directly from the manufacturer are a whole lot better in terms of quality than those sourced from retailers on the street of Bangladesh. It was also discovered that the mode of cement storage also affects the quality of cement and therefore may not yield its ultimate binding strength during concrete manufacturing. It was suggested that, since no cement brand was able to satisfy the 28 days standard compressive strength test until about 90-100 days, cement should be subjected to regular test to at least ensure quality is maintained in any developing country.

Construction materials must be carefully selected before the design is completed. It is very important to further ascertain the quality of materials to be employed juxtaposing it with the approved design.

Test on materials should also be carried out to further ascertain the quality of materials to be used in the building construction to be embarked upon.

6. General Finding

In the cause of this literature review, it has been discovered that sub-standard materials or poor quality materials have led to collapse of several buildings in Nigeria.

7. Conclusion

The role of building materials in building collapse in Nigeria is so significant because from the findings and reviews, materials compromise seems to have contributed greatly to the collapse of building in Nigeria. Although, we have seen very few people researching into the cause of the collapse using critical and rigorous science investigation that will be in our National archive for future referencing and policy formation for governmental bodies and establishment.

It will also help building monitoring control authority to set a better control for future monitoring and material testing to checkmate incessant building collapse in Nigeria.

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