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Destructive and Non-Destructive Assessment of Collapsed Structures in Onitsha, Anambra State, Nigeria

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Abstract

This project work identifies the incessant building failure which has been reported, resulting in the loss of lives and properties in Anambra State Nigeria. A study of some selected collapsed buildings in Onitsha, Anambra state, Nigeria is carried out in this work. The methodology includes conduct of site investigations, and site inspections, destructive testing and non-destructive testing of collapsed structural element to establish their strength by the determination of the yield strength of the reinforcements and sieve analysis of the soil at the site, the use of Schmidt hammer instrument in determining the strength of the concrete. From the results of the test carried out in the case study 1, the column strength ranges from13N/mm^2 to 22N/mm^2, beam ranges from 13N/mm^2 to 21N/mm^2 and slab strength ranges from 15.67N/mm^2 to 21N/mm^2. In the case 2 collapsed building the column strength ranges from 14N/mm^2 to 23N/mm^2, the beam strength ranges from 15.53N/mm^2 to 21N/mm^2 and slab from10N/mm^2 to 21N/mm^2.the reinforcing bars has a strength hardness value of 21.19HRC for EC, 20.22HRC for IC and 19.63HRC for SC. These values are compared with BS4449 and Nst-65-Mn standards and 24N/mm^2 concrete strength at maturity in accordance to BS8110. The findings show that improper mix of concrete, the use of substandard materials and poor supervision of work, contributed to the collapse of the building.

Keywords: Building; Collapse; destructive; strength and testing.

1. Introduction

The frequency of collapse of building structures in Nigeria in the past few years had become very alarming and worrisome. Many lives and properties have been lost in the collapse of buildings mostly in Onitsha metropolitan, Anambra state.Some multi-storey buildings, one of them belonging to churches, have collapsed in Onitsha in the past month. Five persons were killed in one of the incidents while many other people working on the buildings were critically injured. Also, 5 Storey Building Collapsed In Mgbuka, Nkpor at No 8 alloy Offia cresent on 5 July 2014, An uncompleted four-storey building had a catastrophic structural failure and collapsed at St. Andrews Anglican Church, Odoakpu, Onitsha, Anambra State on 2 June 2014.Four persons, all adult

males believed to be workers on the site died while numerous students and parishioners who frequent the building thankfully were not affected. The day before the collapse some 300 students had reportedly used the building for a church event. Hundreds of students were playing in the vicinity of the building when it collapsed, another five-storey building still under construction at Obanye Street Fegge. A visit to the collapsed scenes were as revealing as they were pathetic and one could not but wonder why such, could have been allowed to stand or to what extent people can go to cut corners at the expenses of respect for safety and respect for lives. Unfortunately, there are still a number of buildings of similar circumstances dotting the skyline of many cities in Nigeria. Building collapse incidence are still regularly occurring despite increasing diffusion of engineering knowledge over the years calls for some reexamination of developments in building production and control process. As observed by Adeniya in[1],why must a preventable incidence continue to traumatize us all the time. These incidents have brought to question the effectiveness of building contractors in the country. The menace also casts a slur on the competence of the nation's building professionals, who are responsible for designing and monitoring construction works at building sites. These professionals are being attacked from all angles because of the recurring incidents of building collapse. As stated by Ogunsemi in [2]. The building professionals should not bear the blame alone. This is because, firstly, it has been proved that owners of building under construction derail from their approved plans relying more on imagination and fantasy. Secondly, the approving authorities are also known to have fail to monitor compliance with approved plans. Thirdly, some building owners shun professionals in order to cut costs. Fourthly, the high cost of building materials has led greedy contractors with eyes on profits, to patronize substandard materials. These short-cut measures have contributed immensely to the occurrence of failed buildings in the country. This report will critically examine the reasons for building failures or collapse and types of failures. It will also examine the roles of stakeholders in building and construction industry and articulate strategies that would help to arrest these ugly occurrences. The first tower of Babel built by our fore fathers to reach heaven collapsed by the acts of God, Genesis 11:1-9 as in Levy and Salvadori[3]. Thus the first structural collapse was attributed to God almighty. This work is intended to find out the causes of the collapse and hence serve as a reference document to Engineers, contractors and consultants in the building profession, the recommendation will also help to reduce the rate of building collapse.

2. Aims and objectives of the research

The aims and objectives of the research are as follows:

- To carry out destructive and Non-destructive tests on the Structural elements of the 3 collapse structures in Onitsha
- To evaluate the strength of the construction materials used in the collapse buildings.
- To review the general human values of causes of some building's collapse and especially the reason for the collapse of the multi storey buildings in Onitsha.
- To determine the roles of structural members on the effect of collapse buildings.
- To determine the relationship between poor construction supervision and unsustainable building construction practices (use of substandard designs, materials, manpower & procedures) in Anambra state.
- To make some suggestions on safe delivery of structure particularly building projects.

2.1 Research questions

From the above research objectives, the following research questions were formulated:

1. What is the factor responsible for structural failures in Anambra State?

2. Does any significant relationship exist between poor construction supervision, substandard material and increased rate of building failures in Anambra State?

3. What would be the solutions or remedies to the collapse of buildings?

2.2 Research hypotheses

In view of the above research questions, the following hypotheses were formulated:

1: There are factors responsible for structural failures.

2: There is no significant relationship between poor construction supervision and increased rate of building failures.

3. Literature review

Buildings are required to provide conducive and safe environment for various human activities. Naturally, one of the three basic needs of man is shelter, which is universally accepted and recognized as essential for life sustenance and survival. Several factors including greed, incompetence and corruption has affected the continuous existence of buildings during production and these have been associated with the recurring decimal of deadly collapse of buildings These practice are common among some construction professionals which include Contractors/ Builders who may use specified materials or going for sub-standard material in order to cut cost for his selfish interest, Chinwokwu as in [4]. According to Iyagba in [5] doctors kill in unit while builders kill in tens. This statement has passed the test of time as a result of the increasing building collapse that has claimed many lives in our society. Buildings fail, not only because of how they are designed, but also because of how they were built and the management of a building during its life will also affect its life expectancy. The subject of building failure came into existence during the Babylonian days. It is interesting to note a part of it, as reproduced by Mc Kaig, reported in Iyagba[5]. It reads: If a contractor builds a house for a man, the man shall give the contractor two shekels of silver per cent (a unit of weight) as reward. If a contractor builds a house for a man, but does not build it strong enough, and the house, which he built, collapses and causes the death of the owner of the house, then the contractor shall be put to death. If it causes the death of the son of the owner, then the son of the contractor shall be put to death. If the collapse destroys property, the contractor shall replace what has been destroyed, and if the house collapses, without any loss of life or property destruction, he shall rebuild the house at his own expense. In concise the message contains in the code is a tooth for tooth or an eye for an eye. During this period, the responsibility for building failures laid basically on the contractor. Today the situation is different due to the

rapid advancement in construction, technology and revolutionary changes because of the experts that are now involved.

3.1 Basic Functional Requirements of a Building Structure

The basic requirements that a structure must satisfy may be summarized thus:

(a) Each and every member of a structural system should be able to resist, without failure of collapse, the applied loads under service conditions. In other words, it must possess adequate strength. This demands that the materials of the structure must be adequate to resist the stresses generated by the loads and the shape and size of the structure must be adequate. This is the work of a Civil Engineer.

(b) Every component of the structure should be able to resist deformation under loading conditions. Deformation implies a change in size or shape when a body is subjected to stress. Excessive deformations that are deformations exceeding specified acceptable limits will impair the functional performance of a structure and any attached services. This demands that the stiffness of a beam or column is a measure of its resistance to bending or buckling. It should be noted that a component may be strong and not stiff, and vice-versa. The Civil Engineer determines that.

(c) Every component of a structure must be stable otherwise the whole structure is assumed to be unstable. Structural stability is needed to maintain shape. It is the ability of a structure to retain, under load its original state of equilibrium. It can mean anything from resistance to a minor degree of movement to resistance to sliding overturning partial or complete collapse. Any phenomenon (which will be a potential source of load) that can alter the load carrying behavior of a structure, if not properly taken care of can lead to instability, a condition in which the support reaction is less than applied load. Thus to ensure stability, loads must be balanced by reaction, and the moments due to loads must be balanced by the moments due to reactions.

Building Failure: Building failure should not be taken to mean only a structural failure but also includes it's non-performing with the requirements expected of it. Failure in building can be defined as a defective construction, integrated by other factors such as structural, functional, material and environmental resulting in a short fall in performance occurring at any time in the life of the product, element or dwelling in which it occurs. Common examples of building failure includes defects as cracks in walls, deflection and overturning of beam, etc. majority of these failures arise during construction period or after while others are due to natural phenomena, Jack as in [6].

Building Collapse: This may arise as a result of failure in building, as the building may be either a partial, progressive and total or sudden collapse. The effect of any collapse of a building can be so detrimental as to cause loss of live, properties and money. A colossal waste is normally recorded as collapse of building occurs Salau in Abibo[7] and Ezeagu as in [8] there are basically three forms of collapse.

1. Partial Collapse: - This occurs when part of the building is affected, i.e. only a small fraction of the

building or one side of it falls down.

2. Progressive Collapse:- In this type of collapse, there will be signs of weakness noticeable either by seeing cracks which becomes widening with time or by noticing unusual sound in the building due to structural member gradually giving way from each other.

3. Total or Sudden Collapse:- As the name implies, it happens when the building falls down suddenly it may not even given any sign prior to falling down.

Implications of Building Collapse: Physical damage and psychological trauma are the aftermath effects of building collapse, the degree of which is often beyond easy prediction. Depending on the nature and extent of damage of building collapse incidents, the effects are felt almost in all human endeavors. These effects sometimes include loss of human life, and loss of materials and capital investments, as well as psychological pains.

i. **Loss of Human Life**: Loss of human life has become a common report of most of the collapse building incidents in Nigeria. From the newspaper survey conducted by Arayela and Adam as in [9], about two hundred and seventeen (217) people were reported dead with many injured from only fifteen selected cases of building collapse between 1974 and 2001. It is an irreparable loss to both the victims' relatives and the nation at large and thus called for the need to find a lasting solution to forestall its incessant occurrence. Recently in Nigeria, a multipurpose building being built by the synagogue of all nation church collapse killing over 80 South African indigenes,

ii. **Loss of Materials and Capital Investments**: When building collapsed, most of its structural components and materials will be damaged often beyond re-use, while capital investments in most cases are not recoverable. This kind of situation, more than often leads to bankruptcy on the part of the investor and high economic implications on the nation's economy

3.2 Factors responsible for structural failures of collapsed buildings

The inadequacies in the brief supplied by the clients can bring about defects even at the inception of the project when client fail to give all the necessary information on the functional requirements of the building Fadamiro as in [10]. He further said that design deficiencies also come under calculation errors, bearing support problems, deformation, secondary stresses, elastic cracking, temperature and shrinkage problems, detailing and drafting problems, errors in assumed loading, changes and alterations in existing buildings, all contributing substantially to building structural failures, disasters and may finally led to building collapse. Other causes of structural defects according to Oloyede as in [11] were attributed to the followings:

(a) **Effect of low quality sand Crete blocks on structural wall;** Sand Crete blocks are composite units made up of mixture of sand, cement and water in specified proportion. The quality of sand Crete block used in the construction of walls play a very significant role in the total strength of the wall.

(b) **Owner Construction Syndrome** : The owner in a bid to save cost wants to build by themselves using the so-called direct labour work force. The owner of the property purchase the materials by himself, buying cheap and inferior building materials without any idea of what type of materials should be for a particular part of a job. The failure of a 5 storey building collapses in Mgbuka, Nkpor Anambra state was partly attributed to the owner-construction syndrome.

(c) **Improper Supervision of Project during Construction:** As reported by Akeju as in [12] in Lessons from Recent Structural Failure'; involvement of competent professionals to handle the planning and design of a project does not entirely guarantee its stability. The project competently created on paper must be faithfully and accurately reproduced on the site. A structure is said to be as good as its construction and not its design. An appropriate qualified professional must supervise every stage of the work.

(d) **Failure caused by Foundational Problems:** Foundation is one of the major structural members of any building and any problem arising from it will surely affect the whole building. Fadamiro as in [10] averred that the crushing and collapse of concrete footing or other foundation members are usually due to unequal settlements which may be cause by changing sub-grade condition or by wrong assumptions in the design, inadequate or unequal support for foundations, soil and ground water movements as well as expanding soils. Hence, the most common form of abuse of foundation occurs due to abnormal loading situations especially in structures being converted to new use or having additional floors. Foundational failures are never due to a single cause, but there will always be one major cause. Olateju as in [13] considered that foundational failure may be due to any or combination of:

a. Absence of a proper investigation of the site or wrong interpretation of the results of such investigation

b. Faulty design of the foundation

c. Bad workmanship in the construction of the foundation

d. Poor construction materials during the construction of the foundation due to financial constraints.

e. Insufficient provision in the design construction for exceptional natural phenomena such as thermal and biological conditions, rainfall and floods, greater than those hitherto recorded at the site.

Use of Substandard Materials: Substandard material especially reinforcement rods, steel sections and cement can contribute immensely to failure of buildings. Other substandard materials can also contribute to failure of buildings. Aniekwu and Orie as in [14] identified low quality materials as the most important cause of failure of engineering facilities in Nigeria.

Remedies for building failures: Remedies for building failures include amongst many others: Use of standard materials and workmanship; Involvement of professionals in construction; Site investigation and trial holes; Good design; Prompt and adequate maintenance; Good and adequate supervision. The incessant collapse of buildings in Nigeria can be minimized if not curbed through adherence to some of the following

measures, namely,

i. Soil test, Environmental Impact Assessment (EIA) and structural analysis needs to be made mandatory to be submitted along with the building plans to planning authorities by all the developers or building approval seekers/applicants, especially for all institutional, commercial and industrial buildings.

ii. All plans for approval must be made to pass through all the professionals associated with building industry working in every State/Local Government Development Control Boards before its final approval.

iii. All plans for approval must be ensured to be in compliance with the Nigeria's new building code and all the affected local government's byelaws.

iv. Inspection team must be made to regularly be on the move to inspect all construction works in their locality with the aim of enforcing the building code and the local byelaws.

v. All the professional bodies associated with the building industry in Nigeria, should jointly embark on enlightenment campaign for the public to be aware of the evils behind quarks involvement in building construction activities and the use of low quality materials, untested building materials and local construction methods.

4. Research methodology

The compressive test of the concrete for the columns and beams were determined using the Schmidt hammer equipment. This is a device that measures the strength of a concrete, it is considered as a non-destructive test as no destroyed specimens takes place in it, the test hammer will hit the concrete at a defined energy and its rebound is dependent on the hardness of the concrete and then the compressive strength is read from the Schmidt hammer device. When conducting the test the hammer should be held at right angles to the surface. As this test is sensitive to the presence of aggregates and voids, multiple readings are taken in the test area and there average is taken as the compressive strength of the concrete.The tensile strength of the reinforcing bars were determined by the Brinnel hardness testing and chemical analysis of the reinforcing bars from the collapsed sites, Brinnel hardness test is an hardness test that can provide us with useful information about metallic materials, the information obtained correlate to tensile strength and ductility of the material. And also sieve analysis was carried out on the local aggregate materials at the site to determine the grain size analysis for the local aggregate by mechanical sieve analysis method. Reconnaissance surveys were carried out by visiting some of the collapsed sites. On the collapsed site, physical observations of the materials used in the construction of buildings.

5. Results

The result of the tests at different collapsed site are shown below

Case study 1:

PLATE 1: COLLAPSED 5 STOREY BUILDING AT NO 8 ALLOY OFFIA CRESENT MGBUKA NKPOR ONITSHA ANAMBRA STATE, NIGERIA.

Table 1: Results obtained from the column readings of the collapsed building:

Column	Horizontal Shooting (N/mm^2)	Vertical Downward Shooting (N/mm^2)	Vertical Upward Shooting (N/mm^2)	Average Reading (N/mm^2)
Ground Floor	18	22	18	19.3
Ist Floor	20	15	17	17.67
2^{nd} Floor	13	17	21	17
3^{rd} Floor	17	16.5	14	15.8
4^{th} Floor	20	16	10	15.33

Table 2: Results obtained from the beam readings of the collapsed building.

Beams	Horizontal Shooting (N/mm^2)	Vertical Downward Shooting (N/mm^2)	Vertical Upward Shooting (N/mm^2)	Average Reading (N/mm^2)
Ground Floor	15	21	18	18
Ist Floor	20.5	21	21	20.83
2nd Floor	20	21	15	18.67
3rd Floor	20	12	20	17.33
4th Floor	13	18	20	17

Table 3: Results obtained from the slab readings of the collapsed building.

Slab	Horizontal Shooting (N/mm^2)	Vertical Downward Shooting N/mm^2)	Vertical Upward Shooting (N/mm^2)	Average Reading (N/mm^2)
Ground Floor	15	18	20	17
Ist Floor	22	15	12	16.33
2nd Floor	14	24	22	20
3rd Floor	18	19	10	15.67
4th Floor	17.5	21	18	18.83

CASE STUDY 2:

PLATE 2: COLLAPSED 5 STOREY BUILDING AT NO. 10 UDI OBANYE STREET FEGGE ONITSHA ANAMBRA STATE, NIGERIA.

Table 4: Results obtained from the column readings of the collapsed building

Column	Horizontal Shooting (N/mm^2)	Vertical Downward Shooting (N/mm^2)	Vertical Upward Shooting (N/mm^2)	Average Reading (N/mm^2)
Ground Floor	17	16	16.5	16.5
1st Floor	11	23	13	15.6
2ndFloor	14	14	14	14
3rd Floor	21	19	10.5	16.8
4th Floor	17	23	21	20.33

Table 5: Results obtained from the beam readings of the collapsed building.

Beams	Horizontal Shooting (N/mm^2)	Vertical Downward Shooting (N/mm^2)	Vertical Upward Shooting (N/mm^2)	Average Reading (N/mm^2)
Ground Floor	19	20.5	14	17.83
1st Floor	10	19	21	16.67
2nd Floor	14	21	17	17.33
3rd Floor	20	18	16	18
4th Floor	14	18	14	15.53

Table 6: Results obtained from the slab readings of the collapsed building.

Slab	Horizontal Shooting (N/mm^2)	Vertical Downward Shooting (N/mm^2)	Vertical Upward Shooting (N/mm^2)	Average Reading (N/mm^2)
Ground Floor	19	15	22	18.67
1st Floor	21	21	17	19.67
2nd Floor	0	18	23	13.67
3rd Floor	23	17	19	19.67
4th Floor	15	15	25	18.33

5.1 experimental results of the reinforcing bars

Samples of reinforcing steel bars were obtained from three collapsed building site in Anambra State. The areas are Mgbuka Nkpor (EC), Fegge (IC) and Odoakpu (SC) in Onitsha, Anambra state. The major samples were 12mm diameter reinforced steel bars. The chemical compositions of the samples were obtained using optical emission spectrometer. Brinnel hardness testing machine was used for the hardness test. The chemical compositions of the samples are presented in Table 7. Figure 1 shows the phosphorus, sulphur, manganese and carbon content of the samples investigated comparing them with BS4449, ASTM706 and Nst-65-Mn standards. The results obtained from Brinnel hardness test are 21.19HRC for EC, 20.22HRC for IC and 19.63HRC for SC. These values are compared with BS4449 and Nst-65-Mn standards and presented in Figure 2.

Table 7: Result of the chemical analysis of the samples at collapsed building.

Element %	EC	IC	SC	Element %	EC	IC	SC
C	0.339	0.311	0.345	Cu	0.283	0.284	0.282
SI	0.231	0.223	0.206	W	0.012	0.012	0.011
S	0.080	0.086	0.079	Ti	0.002	0.002	0.002
P	0.069	0.079	0.068	Sn	0.016	0.016	0.015
Mn	0.983	0.991	O.806	Co	0.011	0.011	0.011
Ni	0.106	0.107	0.110	Al	0.006	0.003	0.004
Cr	0.223	0.223	0.225	Nb	0.001	0.001	0.001
Mo	0.030	0.030	0.031	Fe	97.602	97.615	97.618
V	0.006	0.006	0.006	-	-	-	-

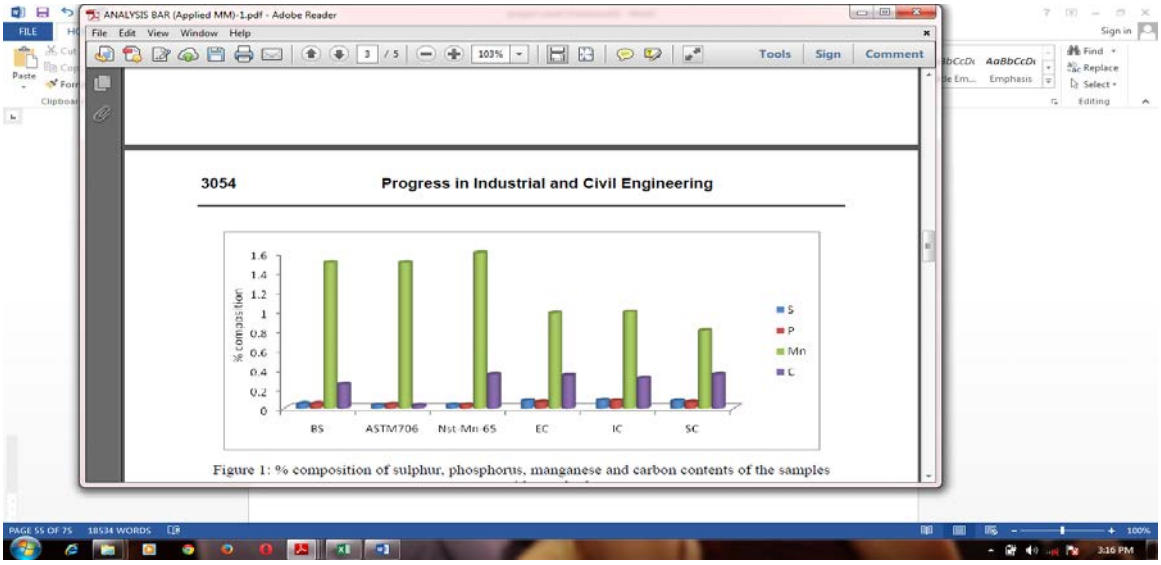

Figure 1: % composition of sulphur, phosphorus, manganese and carbon contents of the samples compare with standards.

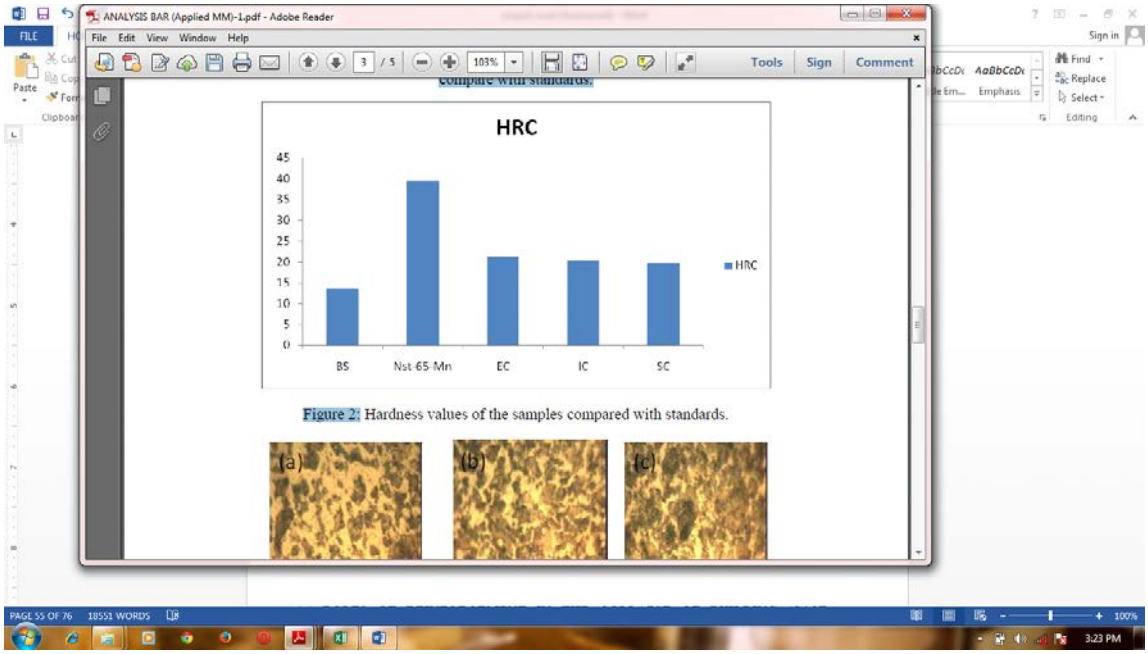

Figure 2: Hardness values of the samples compared with standards.

Table 8: Results of sieve Analysis of the local aggregate materials at the sites

SIEVE SIZE(mm)	MASS RETAINED(kg)	% RETAINED	CUMULATIVE% PASSING	CUMULATIVE% RETAINED
26.5	0.55	11.00	**89.00**	11.00
19	2.00	40.00	**49.00**	51.00
12.5	1.20	24.00	**25.00**	75.00
9.5	0.55	11.00	**14.00**	86.00
6.3	0.45	9.00	**5.00**	95.00
4.75	0.15	3.00	**2.00**	98.00
TRAY	0.10	2.00	**0.00**	100.00

The aim of this test is to determine the grain size analysis for a given soil by mechanical sieve analysis method. The broken local aggregate were carefully selected for the test, which is obtained from the collapsed site.

6. Discussion and Summary of findings

The conclusion drawn from the reading obtained is that the result is invalid. This was because the average reading was below the compressive strength of concrete which is 24N/mm^2 according to the British standard code of practice for structural use of concrete, BS8110 and the minimum calibration of the Schmidt hammer which is 50mm concrete cover to the reinforcement was less than 20mm which is the

nominal cover to all reinforcement under a mild condition exposure according to the British standard code of practice for structural use of concrete, BS8110.

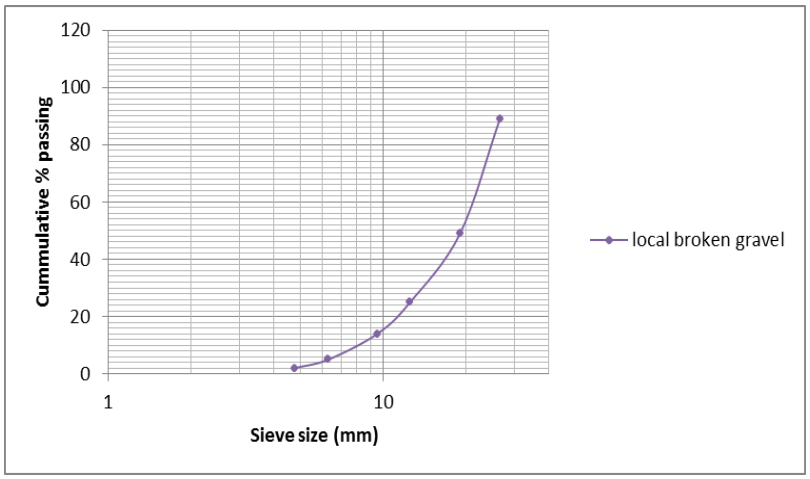

Figure 3: Graph showing the Sieve analysis grading of Broken Local Stone

6.1 Discussion on Causes of the collapse for at no.8 Alloy Offia cresent Mgbuka Nkpor

The building located at no 8 Alloy Offia crescent was under construction, at the fifth floor lintel level collapsed in the morning of Saturday, 5th July 2014 suddenly collapsed injuring two workmen at the site, and no death was recorded. This collapse causes include:-

a. Poor quality concrete mix and compaction methods used for works.

b. The reinforcements bars sizes used for the columns were not to specifications. 4M12 bars used.

c. All the top and bottom beams were either under or over reinforced with 2M16bars.

d. Concrete and steel were inadequately bonded, with non-provision for anchorages in some cases.

e. Slabs not properly reinforced, top reinforcements not provided to take care of negative bending moment at the support.

f. Uneven distribution of loads, columns and beams were put in random positions with inadequate reinforcement which lacked continuity in transmitting loads to the foundation.

6.2 Discussion on Causes of the collapse for at no.10 Udi Obanye street fegge

As the formworks of the floor where beam removed, the fifth floor fell directly on the fourth floor, it was such that the beams of the collapsed floor were lying directly on the beams of the lower floor. The owner of

the building disobeyed instructions given by the Anambra state government on stoppage of work until after recertification of the construction drawing.

a. The columns were badly reinforced with large voids at bases, creating gap before the foundation.

b. Demolition of the old structures where necessary restricted freedom of construction resulted in bad workmanships.

c. Some columns were inadequately reinforced

d. Poor quality concrete mixes were used for the works.

e. No resident supervision for the project.

f. The concrete in various sections of the slabs, beams and columns was weak. The blocks used had compressive strength of $0.6N/mm^2$.it was obvious that no quality control measures were taken.

6.3 Summary of the findings from the brinnel hardness test on the reinforcing bars.

The carbon contents of the investigated reinforcing steel bars from the collapsed building sites surpassed the BS4449 and ASTM706 maximum limits of 0.25 and 0.30 carbon requirement for such steel bars but they are in close range with the Nst-65- Mn standards. Thus, the bars are harder than the recommended standard by BS4449 but not as hard as that of Nst-65-Mn standard even though their carbon content is in close range. This may be due to combined effects of other constituent elements of the bar. The phosphorus and sulphur impurities in the investigated reinforcing steel bars exceeded the standards, leading to increased hardness and strength, and decreased ductility, and thus making the bars brittle. The brittleness may be due to the formation of FeS and Fe3P, which are brittle compound.

6.4 Summary from the sieve analysis.

From the grade analysis the aggregate can be said to be coarse aggregate since it do not pass sieve 4mm. the criteria for grading of gravel in accordance with the unified soil classification system. For a gravel to be classified as well graded the following criteria must be met. $Cu \geq 4$ and $1 < Cc < 3$, if both of these criteria are not met, the gravel is classified as poor graded. From the graph in figure3 the coefficient of curvature and coefficient of uniformity was obtained, therefore from the above calculation it can be seen that the gravel was poorly graded since it did not met the criteria in accordance with the unified soil classification. Since $1.17 < 4$ and $1 > 0.942 < 3$. The local aggregate is said to be poorly graded which could also have resulted to the collapse of the buildings.

7. Conclusions

From the study carried out, it is evident that building failure is not caused by a single factor but multiple factors, most of which are human factors. The building industry today is full of quacks and inexperienced

contractors, who enrich their purses and consequently produce substandard buildings, which is hazardous to the owners and occupants. The major reason for building failure stems from the patronage of quacks, which invariably results in inadequate design and poor supervision. This has continued for ages despite the calls made over the years for the patronage of building professionals and the integration of design and construction process**.** Furthermore, the use of inferior building materials, which does not conform to the British standard and specification, is one of the factors affecting the construction of sound buildings. Most clients construct their buildings using just one quack, who serves as Architect, Builder, Quantity surveyor and Engineer. Poor management and leadership on the part of site Engineers and Builders has also caused a lot of building failures. Lastly, there is the absence of an effective planning approval authority, also where approval is obtained; it is not adhered to Finally, the collapse of two multi storey buildings and a church building, in Onitsha where five persons died and properties worth millions of naira was destroyed was caused by poor workmanship, lack of thorough supervision during construction, unsupervised manual demolition and defect of the coarse aggregate materials. From the foregoing analysis and discussion it became obvious that the causes of building failure range from sub-standard building materials, poor workmanship by contractors, incompetent contractors, faulty construction methodology, and non-compliance with specifications/standards by contractors, structural defects, defective design/structure, defective design/structure, defective design/structure and defective design/structure..

8. Recommendations

Based on the findings, it is pertinent to make recommendations on ways to reduce, if not eliminate the causes of building failures and to prevent the re-occurrence of the ugly situations that follows such failures such as social and economic results. The recommendations are as follows:

- A qualified and professional designer must always be allowed to undertake designs of buildings.
- Only professional and qualified engineers should take control of the supervision of buildings.
- Building contractors should be monitored to guarantee the use of high quality materials.
- The local planning authorities in charge of approving building plans should be properly organized, in order to enforce all building laws and regulations and establish a building control unit.
- Registered builders should be employed by engineer’s authorities to enforce the necessary building regulations.
- Prior to any design work, adequate investigation must be carried out as to enable the design of a suitable foundation..
- Cost of building materials, should be reduced by the government, in order to reduce the temptation to use substandard materials.
- All materials used in the building industry should strictly comply with the British standard. The authorities of the Nigerian society of Engineers should enforce this.
- Appropriate construction methods should be adopted.
- A better maintenance culture should be developed.
- Code of ethical conduct of building profession should be strongly enforced by the bodies concern as to

prevent ethical abuse by the professionals in the industry.

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