Buildings Collapse and Socio-Economic Development of People in the Federal Capital Territory, Abuja, Nigeria

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ABSTRACT

This study examined buildings collapse and its effects on the socio-economic development of people in the Federal Capital Territory, Abuja. A collapsed building at house number 54 on Oba Overanwen Road in Gwarimpa Housing Estate was used as a case in point to ascertain the remote causes of its collapse. Factors, such as failure in foundation, the use of poor and substandard building materials, cement adulteration and seepage of ground water into foundations were investigated. The study adopted the expository and experimental approaches. Findings showed that the bearing capacity of the underlying soil in Gwarimpa collapsed site is 17.5% below the load intensity exerted on it. Concrete specimens obtained from the site and tested gave very poor results which did not meet minimum required strength of concrete of 1:2:4 or 1:3:6, respectively. Steel reinforcement bars tested also showed inadequate characteristic strength (fy) well below 410N/mm². This study discovered among others that most of the high rise buildings do not have provision for collection and channeling of storm water away from the buildings, thereby causing weakness to the underlying soil in foundations due to excess water intake during the rainy season. The study, therefore, recommends consistent concrete strength test during building production and the choice of foundation should be based on knowledge of the bearing capacity of the underlying soil.

Keywords: *Building collapse, lose property, poor concreting foundation failure, drainage.*

INTRODUCTION

Buildings collapse in Nigeria, especially in Abuja, which brings about loss of investments, property and human life has become a major source of concern to house-holds and government. It becomes necessary that the causes of these collapsed buildings be examined. Building collapse is the failure in part or whole of a structure which is unable to fulfill the purpose for which it was constructed (Jambol, 2012; Oloyede, Akinjare and Omoogun, 2010). There can be no failure of a building without a prior failure of some building

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components. The technology of building production can never guarantee complete elimination of some degree of failure because of the fact that structures eventually settle down after they are constructed, however slightly, on completion, as a result of subsoil consolidation due to the weight of the structure. Thus, depending on the magnitude of this movement, failure can develop. It is this failure in the subsoil and other causes of building failure that this study seeks to investigate (Jambol, 2012). According to Amobi (2006), in Nigeria, when a building collapses as a result of component failure, professional bodies tend not to accept responsibility for the incidence(s). Rather, each of the bodies that represents Town Planners, Quantity Surveyors, Architects, Builders and Building Organisations will often seek to attribute the blame outside their professions. Adequate measures will start once designers take a holistic consideration of their designs and become aware of the financial and psychological implication of any failure of the building components both during and after completion.

According to Matawal (2012), the poor applications and use of inferior materials, especially concrete, have been identified as a major causative factor for the collapse of buildings in Nigeria. Moreover, Nigerian Building and Road Research Institute (NBRRI) Technical reports of almost the entire collapsed buildings, in 2011, indicate that the buildings collapsed catastrophically, implying that the structure and loads came down without prior warning and the deformation movements were so fast that there was no time to evacuate. Speaking further, Matawal (2012) reported that the collapse of one of the structures investigated was by rapid disintegration of concrete elements and almost transformation of sand blocks into sand. This is a case of the use of substandard building materials which is one of the major causes of building collapse in Nigeria.

The problem of building failure is a major one, because buildings that are young in age are collapsing along with the aged ones in Abuja metropolis. A situation where a building is designed and constructed to serve a certain purpose and to last for a certain number of years, say, thirty to ninety nine years (Austin, 2012), ends up collapsing even before it spends one tenth of its supposed life span can be described as pre-mature and catastrophic. Every building owner would love his/her building(s) to outlive him/her. However, many buildings are coming down just after their completion when their owners have a sigh of relief thinking that their investments will yield good returns. Some of the buildings even come down at construction stage.

The question is why are buildings collapsing, particularly in Abuja where the city itself is a very young one and almost all its buildings still very new? Abuja prides itself as having a very stringent planning process leading to the construction of buildings yet, some buildings collapse. What could be responsible for this? Are some people not doing their work? Or is the planning law itself inadequate? Studies have been carried out in the area of what went wrong, who did or did not do what, and assessment of damage (human and material) caused as a result of these collapses (Ede, 2010). There is the need for a shift from being reactionary, which has been the style of the Nigerian Building community where poor building production is allowed from inception, to the emphasis of quality from design to completion. This will greatly minimise repair and maintenance work (cost) during the life of the building and will also minimise building collapse. Many authors have worked on the aspect of the causes of building collapse particularly asking the "WHY" question, but the question on "HOW TO STOP COLLAPSES" seems unanswered. It is the question on how to stop building collapse that this study seeks to address. The study also desires to draw attention to law, the carefully prepared building code that the National Assembly has refused to pass into law. The study will also help inform Gwarimpa/Abuja residents of the need to provide drainages for their buildings, as that will drain off excess storm water and reduce weakness of sub soil, hence reduce the magnitude of differential settlement. The study intends to inform project supervisors on the need to avoid shallow foundations and finally to encourage the enforcement of the quality management plan which encourages the construction of buildings that will stand the test of time from inception of the project to completion.

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Chudley and Greeno (2006) say the function of any foundation is to safely sustain and transmit to the ground on which it rests the combined dead load, imposed and wind loads in such a manner as not to cause any settlement or other movement which would impair the stability or cause damage to any part of the building. According to Matawal (2012), a very important factor to be considered in relation to the catastrophes in our building industry is the impropriety of designing and constructing structures with no geotechnical investigations, tests and reports; which are requested to provide for proper design of the foundations. A structural foundation is aimed at transferring the structural loads from the superstructure safely to the ground below. He further says that if foundation load exceeds maximum passive pressure of ground (that is, bearing capacity), a downward movement of the foundation could occur. He again added that the remedy to this kind of problem is to increase the plan size of the foundation to reduce the load per unit area or alternatively reduce the loadings being carried by the foundation. Matawal (2012) further states that the minimum thickness of a structural foundation (even for nominal situations below a wall) is 150mm prepared using concrete grade 25. According to Chudley and Greeno (2006), most shallow types of foundations are constructed within 2,000mm (2m) of ground level. Braja (1999) explains that for shallow foundations to perform satisfactorily, they must be safe against overall shear failure in the soil that supports it and should not undergo excessive displacement (that is, settlement).

Braja (1999) further says that the load per unit area of the foundation at which the shear failure in the soil occurs is called ultimate bearing capacity (general shear failure). Amobi (2006) classifies factors that contribute to sub structural components failures to include differential settlement of foundation, shear failures and design failures. Austin (2012) gave the following as the causes of foundation movement: Variation in climate, change in depth of water table, removal of trees, planting of trees, inadequate drainage, seepage along construction interfaces, irrigation, leaking utility lines, drying of soil below heated rooms, seepage of moisture along utility trenches, poor compaction of fill, improper fill material. A lot of substandard building materials are in use in the construction industry.

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Some are inadequate in sizes, particularly iron rods. Bulky materials too are not usually the specified ones, sand crete blocks are mostly molded sand with a very little cement content in them and concrete mix in most cases is usually of a very poor mix ratio, thereby giving very poor quality of building components produced (Oloyede, Akinjare and Omoogun, 2010). Umaru (2012) explains that when a building material manufacturer deliberately manufactures an 'A' standard and a 'B' standard where there should only be one standard then he has, potentially, started a cascade of failures. When a building merchant knowingly orders the 'B' standard in addition to or in place of the 'A' standard then he has propagated that cascade. These failures create an opportunity for unjustifiable 'cost savings' on the structure of a building - something that should not pass the quality control processes of the project consultants (if they are present) or the inspection of the planning authorities if inspection milestones are involved. Umaru (2012) further says the Standards Organisation of Nigeria (SON) has the responsibility of ensuring that the country does not become a dumping ground for substandard materials. It should not become users, producers or exporters of substandard goods. Unfortunately it would appear that not just the people of Nigeria, but the international community has come to see the nation as one that accepts the second rate. Oloyede, Akinjare and Omoogun (2010) say the collapsed buildings were found to be constructed with low quality building materials and incompetent craftsmen rather than professionals were found to be engaged, while the existing building codes meant to guide builders were rendered ineffective because of lack of political will to enforce same by the Planning Authorities.

Oloyede, Akinjare and Omoogun (2010) add that, findings from historical facts of past collapses revealed that building experts blamed building collapse on the use of low quality building materials coupled with employment of incompetent artisans and weak supervision of work men on site. They add further that, findings show that public opinion blamed building collapse on non-compliance with specifications and standards, use of substandard building materials and equipment and the employment of incompetent contractors. While the academia insists that the non enforcement of existing laws and an endemic poor work ethics are the root causes of building collapse in Nigeria. Uzokwe (2001) insists that the incidences of building collapse in Nigeria could be prevented by the Standard Organisation of Nigeria (SON). According to him, seventy percent (70%) of the collapsed buildings in the country was caused by the use of inferior, substandard and cheap building materials.

Matawal (2012) says building collapse can be traced to two major causes. These are the use of inferior and substandard materials, especially the quality of concrete in most buildings is at best very poor. He says this can be traced to the explosion that follows collapsed buildings as the concrete most of the times disintegrates into pieces. In explaining further, he says this has been identified as a major factor for the collapse of buildings in Nigeria. The following concrete test results were obtained from NBRRI Technical reports carried out on collapsed sites. The method used for their tests were non destructive method of concrete testing. Table 1 gives the result of Nigerian Building and Road Research Institute (NBRRI) investigation of one of the collapsed buildings in Lagos, Nigeria. As presented in

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the Table 1, every concrete element tested failed the test as all the results were poor. Jambol (2012) says every cause of building failure can very adequately be handled if and when all stakeholders know, accept and obey the rules of the game – by complying with the law. He further states that the saying goes that where there is no law, there can be no offense. For an industry as complex and strategic as the building industry, the absence of a robust, efficient and effective legal framework is a case of disaster waiting to happen. He further posits that several works have shown that the Nigerian building industry is fragmented, under-performing, uncoordinated, an "all comers" industry, undisciplined and operating as if there are no laws guiding its operations. This explains why buildings collapse, kill people, destroy property and no one was prosecuted. The professionals only come out to trade blame at each other, ego–massage their professions and leave the clients/users with pains, while they collect their fees and disappear. This is unprofessional, unethical and indeed, wicked! It is a direct affront on the provisions of the NBC 2006 and natural justice. Umaru (2012), in support of the NBC matter argued that "Resuscitation of the Building Code Advisory Committee" to achieve full implementation of the National Building Code, as an industry-wide guide for safe and effective building delivery is very necessary at this point. The guidelines for a properly structured construction industry have been set out in the National Building Code and its implementation will greatly help to tackle the problem of building collapse.

METHOD

This study adopts the expository and experimental research design. These are the approaches where materials were obtained from the collapse site and soil samples taken from trial pits and taken to the laboratory of the building department of the Federal University of Technology, Minna for experimentation. Random sampling of foundation depth and footing thickness was also carried out on buildings around the area of the collapse. Pictures of high rise buildings were also taken to ascertain storm water drainage arrangements. The results are presented and analysed using frequency tables and simple percentage. Results of physical observations, laboratory investigations and photographs were taken in an effort to determine the causes of the collapse of the building.

RESULTS AND DISCUSSION

Visual test result of the soil samples which includes the colours, texture and consistency noted are as presented in Table 2. Laboratory investigations were conducted on the following areas: Natural moisture content (NMC), specific gravity, consistency limits, direct shear box, sieve analysis and calculation of the bearing capacity were done. The summary of the results are presented in Table 4. A comparison between the load intensity of 171.22kN/m^2 and the worst calculated bearing capacity value of 145.9kN/m^2 shows that the load intensity is 17.5% greater than the safe bearing capacity of the soil, which was what value?. As a result of this, one can conveniently say that the soil bearing capacity is low and may

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not be safe enough to carry all the loads transmitted to it from the structures, since the foundation type designed for the structures within Gwarimpa Estate was the square pad foundations. It is therefore evident that foundation failure, particularly in Gwarimpa played a significant role in the collapse of the structure. This can be attributed to the fact that the minimum depth specified for the foundation was not achieved as investigation revealed an average foundation depth of just 450mm for a load bearing wall while the recommended depth of the foundation from ground level was to be 750mm-1.0m (see foundation & drawing details in appendix m). The investigation also revealed inadequate thickness of footing which will not be able to carry the transmitted loads. Table 5 shows the estimate of the expected load on the soil from the structure; this is of extreme importance so as to enable us determine whether the amount of loading on the soil is of a higher magnitude compared to the calculated bearing capacity values at the base of the foundations. Comparing, therefore, the load intensity of 171.22KN/m^2 and our worst calculated bearing capacity value of 145.969KN/m^2, shows that the soils bearing capacity is 17.5% lower than the load intensity exerted on the soil and so may not be safe enough to carry all loads transmitted to it from the structures, since the foundation type designed for the structures within Gwarimpa Estate was Square Pad Foundations. It is, therefore, possible to say that there was foundation failure. Result of foundation depth check reveals that the minimum depth specified for the foundations was not achieved as checks revealed an average foundation depth of just 450mm for a load bearing wall while the recommended depth of the foundation from ground level was to be between 750mm – 1.0m.

Six samples of concrete specimens were recovered from the site and tested using the non destructive test method (rebound hammer). As shown in Table 6, average strength of concrete obtained was 25.4/6 = 4.23N/mm^2. This result is 78.85% poor compared to concrete grade 20. The average values of the characteristic strength and nominal reinforcement sizes were 394N/mm^2/11.38mm, 321N/mm^2/14.80mm and 335N/mm^2/ 19.41mm for diameters 12, 16 and 20 bars. This result gives 5.17%, 7.5% and 2.95% less than the required sizes for 12, 16 and 20 diameter bars respectively. Results of the non destructive concrete tests of the recovered concrete specimens from the collapsed site were very poor and fell below the minimum required strength for concrete whether 1:2:3 or 1:3:6 grade 25 concrete type. It is also evident that poor concreting coupled with poor construction practices and inadequate foundation are some of the major reasons why the building on 54 Oba Overanwen road Gwarimpa collapsed (Matawal, 2012).

Steel reinforcement bars were collected from the debris and tested in the laboratory, the summary of the result is presented in Table 7. Steel reinforcement tests results showed that all pieces of rods tested gave inadequate characteristic strength (fy) below 410N/mm^2 and none of the diameters of the rods measured was correct as all of them were below the standard sizes. These, pointedly suggest that inadequate reinforcement played a major role in the collapse of the building. Two cement brands were tested for strength namely, Elephant and Dangote cements, this was so because they were the brands that were used in the construction of the building. This was done to ascertain whether there was any quality problem with the cements, but results showed that the cement brands met minimum

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strength requirements for Portland/hydraulic cements used in concreting (Figure 1). From the result, it shows that the problem lies with the mix ratio used to produce concrete elements on the site using the cement rather than with the strength of the cement brands themselves. It should be noted that most of the collapsed buildings recorded occurred during the rainy seasons. This means that when there is a lot of intake of ground water into the subsoil particularly between construction interface and the ground, it usually weakens the subsoil beneath foundations thereby causing it to lose its shear strength/bearing ability. Investigation shows that most of the two storey buildings constructed in Gwarimpa housing estate are without provision for storm/surface water collection or channeling. Loads transmitted to the subsoil from the structure becomes too much for the subsoil when it is already weakened due to excessive moisture intake to carry, thereby causing failure. A beautifully constructed house may not last long due to lack of drainage provision for storm water collection and channeling.

If drainages are provided as buildings are constructed, a lot of excess water will be transported away from the buildings, leaving the buildings surroundings dry and the subsoil well drained, hence, no loss of shear strength or bearing ability of the soil; and it will also reduce differential settlement. Investigation further revealed that virtually all the high rise buildings within Gwarimpa have no provision for collection/channeling of storm water away from the buildings. It has been established that nearly all collapses occurred during the rainy season (Ede 2010). The building structures stand on shallow foundations which carry heavy loads and sit on underlying soils which have low bearing capacities. The excess moisture in the subsoil causes dampness of the walls in the buildings which also leads to spalling of plaster and concrete. In this study, it is also discovered that most of the high rise buildings do not have provision for collection and channeling of storm water away from the buildings, thereby causing weakness to the underlying soil in foundations due to excess water intake during the rainy season.

During investigation of foundation depth, it was found that the average depth was about 450mm and the concrete footing thickness was also found to range between 120mm and 200mm which is a far cry from the minimum depth of 750-900mm for bungalows and 300-450mm for footing thickness according to Barry (1976). It should be noted that the bearing capacity was calculated at the depth of 1.0 meter and foundations shallower than this depth are likely to stand on lower bearing capacities. Foundation checks show that most of the buildings stand on very shallow foundations with an average depth of 450mm and footing thickness ranged between 120 and 200mm. This study identified poor concreting and foundation failure as the major causes of the collapse. The study identifies the causes of building collapse during construction and post construction stage and presents the result in Table 9.

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Figure 1: Collapsed House No. 54 at Oba Overanwen Road, Gwarimpa, Abuja
Source: Fieldwork, 2014

Table 1: Compressive Strengths of Concrete Elements Investigated as recovered from Collapse building at Adenubi Close Ikeja, Lagos

Structural Element type	No	Compressive strength (N/mm2)	Remark
Columns	1	12.3	Poor
"	2	8.9	Poor
"	3	8.7	Poor
"	4	7.1	Poor
Beams	1	8.3	Poor
"	2	7.3	Poor
"	3	15.7	Poor
"	4	8.1	Poor
Slabs	1	7.6	Poor
"	2	8.5	Poor
"	3	13.0	Poor
"	4	19.7	Poor
"	5	7.1	Poor

Source: NBRRI Technical Report No. 23 (2011)

Table 2: Summary of Colour and texture

Site	Depth (m)	Colour	Texture
Pit 1	1.0	Dark brown	Lateritic/fine grained
Pit 1	1.5	Reddish brown	Lateritic/fine grained
Pit 2	1.0	Dark brown	Lateritic/fine grained
Pit 2	1.5	Reddish brown	Lateritic/fine grained

Source: Fieldwork, 2015

Table 3: Summary of all Soil Investigations

Site	Depth (m)	N.MC Test	Gs Test	Consistency limits test			Direct Shear box test				Sieve analysis	Bearing capacity (KN/m²)
		(%)	-	LL(%)	PL(%)	PI(%)	LS(%)	C (KN/m²)	Θ(°)	γ (KN/m³)	(Passing no. 200 (%)	-
Pit 1	1.0	33.90	2.23	32.00	20.42	11.58	8.57	25	16	19.64	52.30	147.424
Pit 1	1.5	33.55	2.24	32.00	20.71	11.29	8.5	22	16	19.42	62.07	149.969
Pit 2	1.0	37.49	2.24	38.00	20.23	17.77	8.93	21	18	19.42	40.90	151.599
Pit 2	1.5	39.12	2.25	39.00	15.38	23.62	9.29	19	19	19.30	33.53	170.874

Source: Experimentation, 2015

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Table 4: Comparing Bearing Capacities and Moisture content Values

Site	depth (m)	Bearing capacity (N/mm²)	Moisture content(%)
Pit 1	1.0	147.424	33.90
Pit 1	1.5	145.969	33.55
Pit 2	1.0	151.6	37.9
Pit 2	1.5	170.9	39.1

Source: Experimentation, 2015

Table 5: Calculation of Loading intensity of the building

Load/M at Foundation

i.	Live load from roof (wind inclusive)	=	0.25x13.7/2	=	1.71x2.5 = 4.28
ii.	Dead load from roof	=	1.5x6.25	=	9.38
iii.	Wall own weight (1st floor)	=	1.5x3	=	4.50
iv.	Wall plastering (1st floor)	=	3.3x3	=	9.90
v.	Roof Bean load			=	5.0
vi.	Column own load (1st floor roof)			=	15.0
vii.	Slab load			=	13.0
viii.	Column own load (ground floor to 1st floor)			=	15.0
ix.	Wall own weight (ground floor)	=	1.5x3	=	4.5
x.	Wall plastering (ground floor)	=	3.3x3	=	9.90
xi.	Bean under the decking			=	5.0
xii.	Wall under slab (foundation)	=	3x1.0	=	3.0
xiii.	Slab own weight (150mm)			=	13.0
xiv.	Self weigh of footing	=	0.3x24x0.68	=	4.97
					116.43kN/m

Assume a foundation width of 0.68m

$$\text{Load intensity} = \frac{\frac{Load}{m} \times foundation}{Foundation\ width} = \frac{116.43}{0.68} = 171.22kN/m^2$$

Table 6: Summary of Compressive Strength of Recovered Concrete Specimens

Concrete Sample	Expected Minimum Strength (N/mm²)	Average Strength Obtained (N/mm²)	Remarks
A	20-25	4.3	Very poor
B	20-25	3.7	Very poor
C	20-25	4.0	Very poor
D	20-25	5.1	Very poor
E	20-25	4.8	Very poor
F	20-25	3.5	Very poor

Source: Experimentation, 2015

Table 7: Summary of Steel Reinforcement Test Result

Diameter	Characteristic strength (Fy) (N/mm²)	Average ultimate strength (N/mm²)	Average elongation (%)	Measured diameter (mm)	Remarks
Y 12	394	615	12	11.38	Inadequate fy, diameter & elongation
Y 16	321	459	17	14.80	Inadequate fy and diameter
Y 29	335	519	18	19.41	Inadequate fy and diameter.

Source: Experimentation, 2015

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Table 8: Summary of Mortar Cubes Crushing Results in N/mm²

Cement Type	3 Days	7 Days	14 Days	21 Days	28 Days
Dangote	6.40	12.62	14.12	15.36	11.09
Elephant	6.21	13.41	17.01	17.19	10.51

Source: Experimentation, 2015

Table 9: Causes of Failure during and after Construction

S/N	During Construction	Post Construction
1	Wrong Construction Methodology	Poor Concreting practices
2	Over loading of structure when concrete is yet to develop full strength	Foundation failure due to excessive settlement, Shear failure of Sub soil and Inadequate concrete foundation.
3	Faulty Structural design leading to structural collapse of members during building production.	Use of Substandard building materials
4	Use of Quacks for Construction supervision	Seepage of Storm water back into Foundation
5	Use of Adulterated Cement	Use of Quacks for Construction Supervision
6	Use of Substandard building materials	Use of adulterated cement

Source: Fieldwork, 2015.

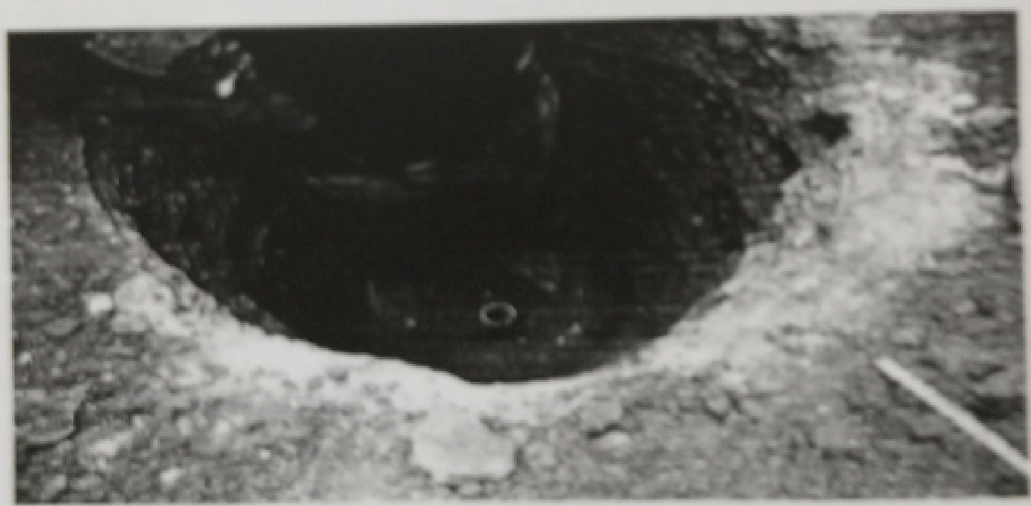

Figure 2: Trial pit with soil core cutter *Source:* Fieldwork, 2015

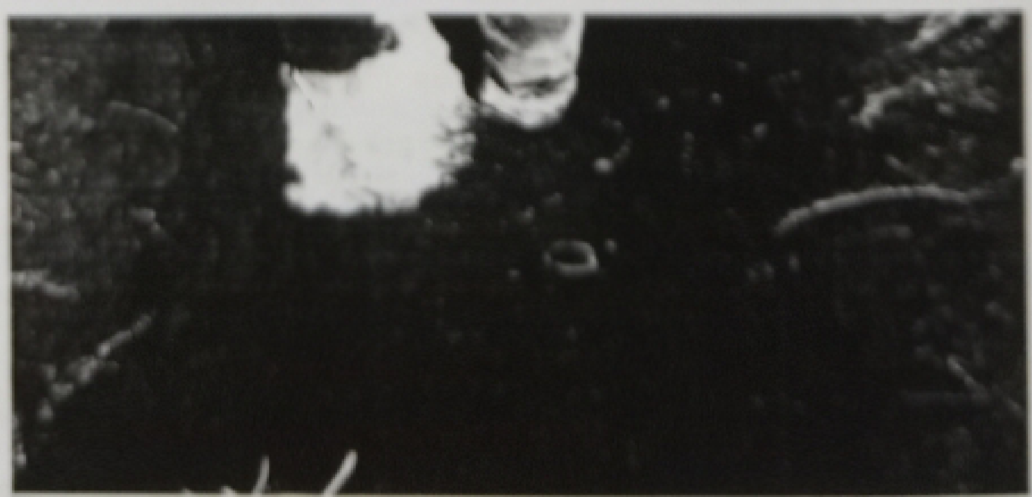

Figure 3: trial pit with core cutter *Source:* Fieldwork, 2015

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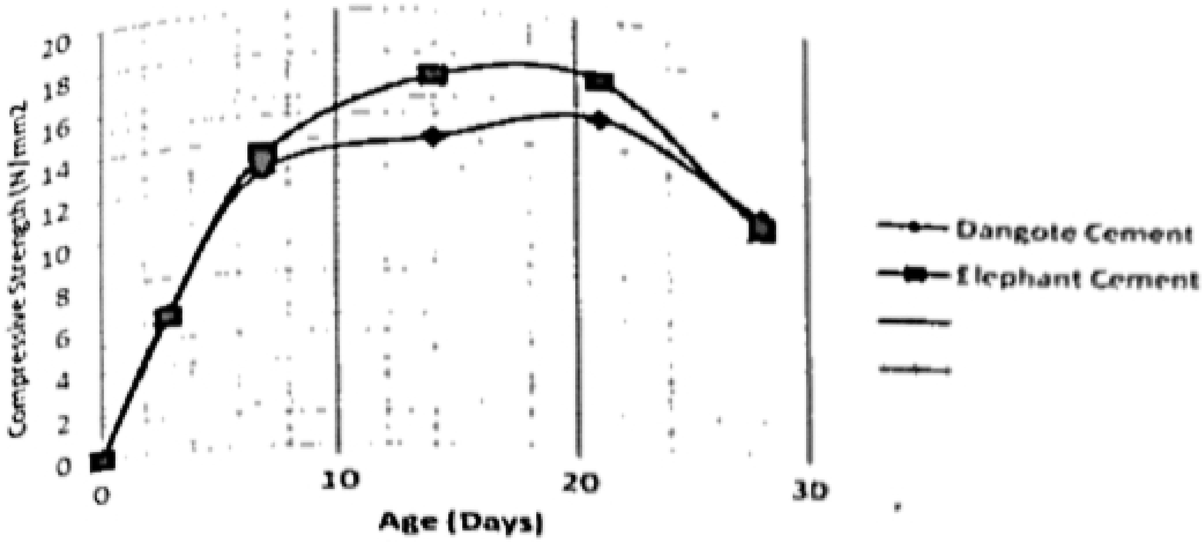

Figure 4: Variation in compressive strength of cement with age

Figure 5: No drainage provision in Gwarimpa *Source:* Fieldwork, 2015

Figure 6: High rise building without drainage in Gwarimpa. *Source:* Fieldwork, 2015

CONCLUSION AND RECOMMENDATIONS

Previous investigations revealed that there were problems with foundations of the buildings that collapsed in the past. These problems ranged from inadequate foundations to wrong choices of foundation types for soils with low bearing capacities. This study also confirms

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that there were foundation problems in Gwarimpa collapsed site as the loading on the soil was greater than the calculated safe bearing capacity. Foundation types and sizes of column bases were not suitable for the bearing capacity. This was identified as one of the causes of the collapse in Gwarimpa. Also identified was the fact that most of the buildings in Gwarimpa stand on very shallow foundations. Results of concrete test showed that extremely poor concrete was produced during the construction of the collapsed building. This clearly confirmed that substandard building materials were used to construct the collapsed buildings. Again it was discovered that the sizes of the re-enforcement bars used for the building were inadequate as measurement revealed that the sizes were not up to the standard sizes of re-enforcing steel bars. One can conveniently conclude that inadequacy of steel re-enforcing bars and poor concrete played key roles in the collapse of the buildings in Gwarimpa. Investigation also revealed poor drainage/lack of drainage arrangements for most of the high rise buildings in Gwarimpa. This gives room for storm water to permeate freely back into the subsoil beneath the foundations, thereby causing shear failure which leads to differential settlement and eventual collapse.

Cement brands tested revealed good mortar strength, but literature observed pockets of cement adulteration across the country. This trend is a great danger for the construction of quality buildings. Furthermore, investigation reveals the inadequacy and ineffectiveness of the existing planning regulation in addressing quality concerns during building production. This is because the planning regulation is only interested in the number of dwelling units per plot, set backs of the building from the fence, height of the building and the likes. There is no mention of how quality of buildings can be achieved during construction. This situation gives developers the room to construct buildings that lack integrity which end up collapsing with time.

This study finally recommends that the CORBON quality management plan should be put to use so that building collapse can be reduced through its implementation. Also, soil investigation for the determination of Geotechnical property of sub soil leading to the calculation of the safe bearing capacity be made mandatory for every intended storey building development. When the bearing capacity is known, the foundation design should not be left in the hands of quacks, but should be handled by experts so that the wrong foundation is not designed.

There is also the need for the depth of excavations to be inspected before concrete foundations are casted. This will greatly reduce the problem of shallow foundations as was discovered during findings. If the bearing capacity is calculated at 1.0 or 1.5 meter depth and the foundation depth at construction fails to reach depth mentioned, there is the likelihood that failure will occur. Besides the depth check, there is the need for concrete foundation thicknesses to be pre gauged by site supervisors before commencement of concrete casting. This will help eliminate in adequate thickness of foundations.

Due to the very poor results of concrete tests obtained during the investigations of this work, there is the need to mandatorily insist on developers to make concrete test for each batch of concrete being produced on the site an integral part of the building production process. Where this is not done, punitive measures or sanctions should be applied on the

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defaulters. This will ensure that concrete quality is achieved and it will automatically translate to the construction of buildings of integrity. It is necessary for every steel re-enforcing bar to be tested for strength and the diameters also tested. Designed sizes of steel bars must be obtained or there will be shortfall in the overall diameter of the steel provided in the concrete element. There is also the need to enforce the Construction Quality Management Plan (QMP), because in it, minimum standards are outlined and spelled out. If followed, buildings of integrity will be constructed. The QMP be made part of the construction documents to be submitted to the Development Control department before planning approval can be granted. Investigation shows that the document is unknown to many building experts. CORBON should make it mandatory for every builder to own the QMP, the Development Control office should be liaised with to make it available to developers. Again an enforcement team should be raised by CORBON, security agencies and other build environment professional bodies who should be saddled with the task of enforcing the QMP on construction sites.

There is the need for the collection and channeling of storm water either through the construction of drainages/gutters around high rise buildings or the provision of septic tanks or any other method of channeling excess water away from the surroundings of the buildings in order to keep the foundations safe from being over saturated with water which leads to shear failure. Government must, through the standard organization, ensure availability of only good quality materials for the construction market. Cost reduction measures need to be employed to reduce the cost of construction. Dealers in poor quality construction materials should desist from such act. There is need for materials testing laboratories. This intervention will provide easy access to testing facilities so that there is no excuse for not supervising any project comprehensively. Government must demonstrate adequate interest in project safety by prosecuting, with all seriousness, offenders whose activities result in the collapse of structures.

No construction professional should carry out work in a specialty of which he is not qualified. If found, should be made to face the disciplinary panel. Also the law enforcement agencies should be mandated to enforce eviction in houses marked for demolition, as that could have saved the lives that were lost in some of the most recent cases. The menace of quacks should be checked so as to reduce the incidences of construction supervision being handled by non professionals or unqualified personnel. In view of this, a disciplinary committee should be set up to handle cases of violations. And where one exists, should be made to have powers to sanction and prosecute offenders. There is also the need for government to establish an academy to train and provide skilled labour for the construction sector in the areas of draughting, detailing, iron bending, artisanship, block making and laying, brick, concrete and mortar artisans and workmen, plumbing, and electrical works. This can translate into quality building production. Also, all high rise buildings should be provided with drainage around them.

The implementation/enforcement of the CORBON Quality management plan on Construction projects should be seen as an antidote to building collapse. The performance of this category of workers in the office and field can be improved upon by teaching them

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some basic details associated with their chosen areas of economic activity. Finally, the National Assembly should be prevailed upon to pass the National Building code (the Code) into law as its provisions are comprehensive enough to address the problems of the construction industry.

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