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Building Collapse in Lagos State, Nigeria: Towards Quality Control in Materials, Batching and Placement of Concrete

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Abstract: The collapse of buildings is not a new phenomenon in Nigeria and other developing countries. Evidence from Nigeria has shown that the occurrence of building collapse is mostly prevalent in the informal sector of the building construction industry in Lagos State. Several studies revealed that building collapse is mainly caused by failure of the structural components of a building. Concrete is a dominant material for building structural components in Lagos State, Nigeria and has often been identified as the major cause in many instances of building collapse. This study evaluates the quality control aspects of concrete used especially with respect to its constituent materials, batching and placement in the informal building construction sector of Lagos State, Nigeria using structured questionnaires administered to building construction practitioners working on construction sites in the study area to gather data for the study. Data was analysed using frequency and percentages. Findings were qualitatively discussed. The study found that while the practitioners were conversant with quality assurance aspects of concrete, issues relating to quality of materials used for concrete, trial mix of concrete however, the challenges associated with outsourcing of concrete batching and placement still pose serious threats to concrete quality within the study area. The study recommends that professionals in the construction industry should be involved in all aspects of building procurement and, at the same time, subscribe to quality control measures before and after concrete casting to improve the quality of building construction.

Keywords: building collapse, concrete batching, informal construction, quality control.

1.0 Introduction

The issue of quality control and assurance are very central to the production of any man-made object as its objective is to ensure that the product meets both the specification and expectations of the users. Quality assurance is a planned process aimed at ensuring that products and services conform to established requirements (Okereke, 2003). The construction industry is very important as it delivers the bulk of the fixed capital formation of any country especially in the areas of buildings and infrastructure. Quality assurance, in the building construction industry, is necessary to ensure that such huge national capital is kept durable, safe and serviceable all through their estimated life cycles. Quality assurance can also be described as a subset of overall quality management in the construction industry, the highest form of which is total quality management (TQM). Quality management, in construction, ensures that the quality of construction is maintained at a specified acceptable level which implies timely and cost effective delivery in addition to the product complying with specification and performance expectations (Ozaki, 2003). TQM on the other hand focuses on the processes leading to the making of a product and ensures that the processes are right and that the product is right (Polat, Damei and Tatar, 2011). The assessments of some aspects of the building construction industry in Nigeria indicate that the adoption of quality management strategies is still rudimentary. For example, Oludare and Oluseye (2016) in their study of construction firms in Lagos, Nigeria, found that the most prevalent system in place, for construction quality, was the supervision of workers and work processes. Hence, the level of quality achieved is totally dependent on the expertise of the supervisor, a development that is usually counter-productive especially when the supervisor lacks requisite knowledge and experience. Similarly, Opoko, Ezema and Ediae (2014) opined that the utilisation of low impact building materials in the Nigerian context could be traced to non-existent quality management processes for their production.

The issue of construction quality assurance is very central to achieving an effective building delivery system. In the Nigerian building construction industry, attempts have often been made towards ensuring construction quality right from the project design stage up to project implementation stage. Hence, some level of stability has been achieved in the design and consultancy stage with legal backing from professional bodies such as Architects Registration Council of Nigeria (ARCON), Council for the Regulation of Engineering in Nigeria (COREN), Quantity Surveyors Registration Board of Nigeria (QSRBN) and Council for Registered Builders of Nigeria (CORBON). In addition, building laws and regulations exist in all the States of the country for achieving effective development control. However, the construction implementation side falls short of expectation due to a number of reasons which include unethical contract practices coupled with weak regulatory framework (Longtau, Justina, Majidadi and Makwin, 2016; Fernandez, 2014).

Observations show that the Nigerian building construction industry is dominated by informal construction activities which often do not follow laid down procedures. Also their activities cannot be fully monitored due to the informality of their operations. As a result, instances of quality breaches in the building construction industry abound with several examples of building structural failures leading ultimately to building collapse. Often the collapse is attributed to a number of factors prominent of which is poor quality of materials and construction processes. In this respect, the central position occupied by concrete, as a structural material and as a culprit in many instances of building collapse, deserves some serious consideration. Hence this study is aimed at examining the use of concrete, in some informal and semi-formal construction sites in Lagos State, Nigeria with a view to identifying practices that have quality implications on concrete.

2.0 Literature Review

The Nigerian construction industry constitutes a critical aspect of the economy of the nation. This is because it plays important roles in both employment generation and economic development. In the area of employment generation, the construction industry provides direct and indirect employment to about 25% of the Nigerian working population (Danwata, 2017). In the area of economic development, sustained economic growth has always been associated with increase in construction related activities (Isa, Jimoh and Achuenu, 2013). Also, the construction industry's contribution to GDP has been estimated to be up to 16% (Danwata, 2017). However, one of the major challenges of the industry is the preponderance of informal activities. According to the International Labour Organisation (ILO), the informal sector in Sub-Saharan Africa, of which Nigeria is a prominent part, is regarded as the largest concentration of informality worldwide (ILO, 2002). The implication of this is that a lot of what goes on in this sector is not fully captured in national economic accounting. This situation presents a huge challenge to both planning and implementation of government programmes. The informality is also largely responsible for the high rate of building collapse.

Incidences of building collapse in Nigeria are fairly well documented in literature. There has been incessant collapse of buildings in all parts of the country but it is more prevalent in the urban areas where there are relatively high levels of construction activities. Hence, more collapse of buildings has been recorded in Lagos State than in any other part of Nigeria (Windapo and Rotimi, 2012; Ebehikhalu and Dawam, 2014). It is pertinent to note that majority of the collapsed buildings were residential buildings, thus emphasizing the culpability of the informal sector in building collapse in Nigeria (Ebehikhalu and Dawam, 2014; Fagbenle and Oluwunmi, 2010). The major causes of building collapse have been attributed to structural failure, poor supervision and workmanship as well as the use of substandard materials (Windapo and Rotimi, 2012). Akinyemi, Dare, Anthony and Dabara (2016) however grouped the causes of building collapse into three namely: types and quality of materials used, operational and personnel problems, while Oloyede, Omoogun and Akinjare (2010) identified poor design, incompetent contractor, faulty construction methods, poor development control strategies, non-compliance with specifications, substandard building materials, poor supervision and conversion of existing building to other uses as the causes of building collapse in Nigeria. However, Arum (2008), in his study of causes of building collapse in Nigeria, pinpointed poor quality control as the major reason for building collapse in the country. Where the immediate cause of collapse has been traced to concrete, the fault is usually associated with silty fine aggregates and cement of substandard grade (Olanitori, 2011; Adewole, Oladejo and Ajagbe, 2014).

Given the preponderance of reinforced concrete structures in the study area, almost all the structural failures had something to do with either concrete or steel reinforcement or both. For example, Olanitori (2011) linked building collapse in Akure to poor concrete caused by the use of silty sand and inappropriate placement of steel reinforcement. However, Adewole et al. (2014) further identified the use of low grade cement as a cause of low quality concrete that may eventually result in building collapse. In addition, Akinyemi et al. (2016) pointed out that poor concrete mix ratio can also lead to building collapse. The foregoing underscores the critical role of concrete in building structures and that its inappropriate use may result in building failure and ultimately collapse.

Concrete is the most versatile structural material that offers flexibility of form not found in other structural materials. Concrete structures are also easy to analyse as they benefit from the huge data available on concrete performance (Arum, 2008). Concrete is made up of Portland cement, fine aggregates (sand), coarse aggregate and water with optional additives which are used to improve the performance of the concrete. When freshly mixed, concrete tends to be flexible and as such can be used to form any shape. However, on solidifying, concrete becomes a dense solid mass with good compressive strength. The process of transformation from the flexible to the hardened state is referred to as setting. After placement, concrete gains strength rapidly especially within the first seven days which are very critical for the attainment of the required strength. For purposes of determining the strength of concrete, the compressive strength at 28 days is usually considered. The strength of concrete primarily depends on the quality of constituent materials namely cement, aggregates and water. In addition to the quality of the constituent materials, the strength of concrete is also dependent on the quality of supervision and quality control mechanisms that attends its preparation and placement. As a result, the eventual strength of concrete produced on site is a random variable (Arum, 2008). An examination of the main constituents of concrete as well as other factors that affect the quality of concrete becomes necessary at this point.

Portland cement is one of the most prolific building materials in the study area. Cement acts as a binding agent in the preparation of concrete. Cement-based structures, of which concrete is a major part, constitute the largest surface area of all man-made structures the world over (Odigure, 2009). Cement production in Nigeria is dominated by Dangote Cement Company which controls about 65% of the market as at the end of 2017 (News Agency of Nigeria, 2017). The other major cement manufacturer in the study area is Lafarge Africa.

Cement grade is an important factor that contributes to concrete quality. It is critical in determining the compressive strength of concrete. The cement grades used generally for concrete-based production in Nigeria are grades 32.5, 42.5 and 52.5 (Ali, 2014). The Standards Organisation of Nigeria (SON) approves grade 32.5 for plastering work, grade 42.5 for general concrete works while the 52.5 grade is for special projects. As a confirmation, Adewole, Olutogbe and Habib (2014) investigated the effects of these cement grades on concrete compressive strength and the investigation revealed that the compressive strength of concrete produced with cement grade 42.5 is generally higher than that made with cement grade 32.5. In fact, if the standard 1:2:4 concrete mix is to be used, the minimum cement grade would be 42.5.

Adewole, Oladejo and Ajagbe (2014) pointed out that surveys conducted by the Standard Organization of Nigeria (SON) revealed that during construction of most privately owned buildings, where concrete trial mixes were not conducted, the standard 1:2:4 mix ratio was used irrespective of the cement grade/strength class. The survey further revealed that when concrete cubes were made with Portland cement grade 32.5 using 1:2:4 and 1:1.5:3 mix ratios, the compressive strength was less than the 25MPa and 30MPa cube strengths generally recommended for building superstructures and foundations respectively. Hence, with effect from May, 2014, the Standards Organization of Nigeria implemented the grade 42.5 for cement in Nigeria as the minimum cement grade to be used for structural components of buildings.

In a comparative study carried out to assess the compressive strength of concrete produced using different brands of cement indicated that the best compressive strength at 28 days for the 1:2:4 mix was achieved with Ibeto cement (38.8N/mm^2) while Elephant cement came second with a compressive strength of 27.9N/mm2 (Bamigboye et al. 2015). Dangote cement came third but was just able to achieve the required strength of above 25N/mm^2. Also Purechem cement was just able to achieve the minimum compressive strength while Unichem cement did not attain the required strength of 25N/mm2 for structural concrete made from the 1:2:4 category.

Aggregates which constitute about 60 to 80% of concrete volume are inert granular materials such as sand, gravel, or crushed stone that make up concrete alongside cement and water. They strongly influence freshly mixed concrete as well as its hardened properties, mixed proportions and economy (Gashemi, 2017). In order to get a good concrete mix, aggregates need to be clean, hard and strong materials and free of absorbed chemicals or any fine material that can cause deterioration of the concrete. According to Adewole et. al., (2014), the use of poor quality aggregates has been emphasized as one of the reasons for the low quality of concrete used for building construction in Nigeria.

Fine aggregates or sand are mined from water courses and peat (land) in locations around Lagos and Ogun States. However, fine aggregates from Ogun State are generally preferred for structural concrete works as it contains little or no salt and the silt content is also low. Coarse aggregates are mostly crushed granite stones obtained from quarries located at Abeokuta, Ogun State and Ibadan, Oyo State. In some instances, granite quarry dust is often partially substituted for sand in varying proportions to achieve acceptable concrete strengths. This helps to reduce intensity of sand mining which has adverse environmental implications in the study area.

Low quality of concrete, that is, concrete with low compressive strength, can be traced to high silt content of fine aggregates even when the mixing ratios and cement grades are strictly adhered to (Olanitori, 2011). Sometimes, sharp sand is partially substituted with crushed stone dust in certain proportion to reduce the impact of sand mining.

The quality and quantity of water used in concrete is also important. Roy (2015) affirms that the quality of hardened concrete is strongly influenced by the amount of water used in concrete; as it influences compressive and flexural strength, permeability, workability of concrete as well as the bond between concrete and reinforcement. The water for concrete must be clean and free from salt and other chemicals likely to impair the quality of the concrete.

Common concrete mix proportions (cement: sand: crushed stones) include 1:3:6, 1:2:4 and 1:1.5:3 which may correspond with compressive strengths of 20N/mm2, 25N/mm2 and 30N/mm^2 depending on quality of aggregates and grade of cement. The mix ratios are volume ratios and are closely monitored during batching of concrete. The ratios are subject to adjustment based on the type of constituent materials available and the expected strength. In new projects, it is advisable to determine the mix proportion that would deliver the required strength through a number of trial mixes. For example, 1:2:4 mix ratio with cement grade of 42.5 can give a compressive strength of 25N/mm^2 after 28 days while a 1:1.5:3 mix ratio would be needed to deliver the same strength if 32.5 cement grade is used (Adewole, Ajagbe and Arasi, 2015).

Chemical admixtures are constituents of concrete other than water, cement and aggregates that are added to the mix either before or during mixing. The American Concrete Institute (2013) reckons admixtures as important components of concrete used to improve its performance. This could include adjusting setting time or hardening, modifying the properties of the hardened concrete, reducing water required in the concrete, reducing the cost of concrete construction. This is done to ensure that the quality of the concrete is maintained during mixing, transporting, placement and curing, to increase workability, and to overcome certain emergencies during construction. Successful usage of admixtures depends on using appropriate methods of batching and concreting; and a good knowledge of the rate of reaction between cement and water. Chemical admixtures are used in extremely small quantities and can pose a threat to the quality of the concrete when they are not added properly. The use of blended cement, that is, ordinary Portland cement blended with some cementitious materials, is gaining ground but not very popular in the study area.

Concrete is a brittle material, hence, its porosity primarily governs its strength. Concrete has air/water permeable properties and this has a great influence on its strength as well as its durability. The presence of pores and air voids influences concrete permeability. Kim et al. (2014) pointed out that deteriorating agents that can cause steel corrosion, like chloride ions and carbon dioxide, intrude into concrete through pores or their connectivity. Naik (1997) identified factors that can affect concrete porosity to include water to cement ratio, air content, and consolidation, use of admixtures, degree of hydration, the aggregates and the mixture proportioning.

Curing refers to the maintenance of moisture inside the body of the concrete during the early days of concrete placement (Kulkami and Pereira, 2011). This is done to develop its properties in terms of strength and durability. It should begin as soon as possible after the concrete has been placed. Curing of concrete allows the concrete to gain strength gradually and attain improved durability. It also enhances its serviceability, improves its microstructure, and decreases its porosity. (Kulkarni and Pereira, 2011). Also, Ayuba, Olagunju and Akande (2012) opined that curing of concrete is probably the most abused aspect of the concrete construction process. This is usually as a result of stringent construction deadlines resulting in hasty construction. However, concrete requires an adequate amount of time to cure, usually 28 days, at proper temperature and humidity before it is loaded. If curing is not done effectively, the concrete may not develop the characteristics that are expected to provide necessary durability.

There are six major types of conventional curing for concrete. They include shading of the concrete to reduce the rate of evaporation of moisture from the concrete as well as covering the concrete surface with wetted gunny bags. Other methods include sprinkling of water on the concrete, ponding, membrane curing and steam curing. In some studies of the Nigerian context, ponding is adjudged to be the best type of curing, followed by wet covering and sprinkling (James, Malachi, Gadzama and Anametemfiok, 2011; Bamigboye et al. 2015).

Given the in-situ nature of most construction projects, the human factor is also important for the strength and durability. This refers to the human resources involved in construction that need to be monitored and supervised for better construction outcome. When these persons are not trained and supervised, it poses a great threat to the construction work. This is especially so in the informal building construction sector where concrete batching is often carried out manually mainly by poorly trained and unskilled workers. In a study of concrete batching behaviour of artisans in the informal construction sector in Ghana, Hedidor and Bondinuba (2017) observed that concrete batching was done using visual measurement instead of the standard measurements recommended. As a result, cement to aggregate ratios often revealed insufficient cement content.

Closely related to the above is the issue of supervision. This is an act of critically watching, directing, overseeing the work performed by the workers at each stage of construction in a site by a qualified professional. A concrete construction job not well supervised or supervised by a half-baked professional could lead to failure in the concrete. Akeju (1984), cited in Adenuga (2012), affirms that competent professionals must not only be engaged to design and plan a project, but must also be involved in the supervision at every stage.

3.0 Methodology

The survey focused on practicing professionals, such as the architects, site engineers and builders, in Lagos State who are directly involved with the construction of buildings. Primary data was gathered with the use of structured questionnaires distributed to the above mentioned stakeholders. The questionnaire investigated the extent of the precautionary measures taken by the professionals to ensure good quality control for concrete. Fifty (50) copies of questionnaires were administered but forty-three (43) were returned and used for the analysis which is presented in a table format.

Two local government areas were selected for the study because of the preponderance of new building construction activities therein. They are Alimosho and Ibeju Lekki local government areas. While Alimosho is on the outskirts of Lagos on the mainland side, Ibeju Lekki is on the outskirts on the island side, in the area now referred to as the New Lagos. These areas are also dominated by privately owned building construction projects. Ongoing construction projects were identified in the study area and the questionnaire was administered to the professionals and supervisors working on the construction sites. Some critical construction activities were also observed on site and certain clarifications were sought from the supervisors and the skilled and unskilled workers.

4.0 Data Analysis

Detailed analyses of data gathered are as shown in the following tables with their discussion in subsequent paragraphs.

The structural failure rate of materials from the experience of professionals in the study area was investigated to corroborate or to annul findings from literature as to which structural material fails the most in Lagos, Nigeria. The results are as shown in Table 1.

Table 1: Structural Failure Rate of Material

Material	Frequency	Percentage
Concrete	14	93.3
Steel	0	0
Wood	1	6.7

From Table 1, it is evident that concrete is the structural material that experiences the most failures. This is understandable given the preponderance of concrete related structures in the study area. 93.3% of the respondents who have experienced structural failures on sites they have worked on indicated that the structural material that experienced failure was concrete.

The Portland cement brand used was investigated to know which brand(s) is/are widely used or specified in the study area by the professionals. The results are as shown in Table 2.

Table 2: Portland Cement Brand Used/Specified

Cement Brand	Frequency	Percentage
Dangote	30	76.9
Elephant	11	21.6
Lafarge	10	19.6
Reagan	0	0.0
Eagle	0	0.0

The study indicated that 76.9% of the respondents use or specify Dangote Portland cement brand for their concrete construction as against 21.6% and 19.6% of respondents that specified or used Elephant and Lafarge Portland cement brands that are very common in the study area.

The cement grade used was investigated to find out to what extent the professionals in the study area have knowledge about the different cement grades available and what grade is recommended by the Standards Organization of Nigeria (SON). The results are as shown in Table 3

Table 3: Cement Grade Used/Specified

Cement Grade	Frequency	Percentage
22.5	12	30.8
32.5	23	59.0
42.5	22	56.4
52.5	0	0.0
62.5	0	0.0

Cement grade 32.5 accounted for 59% of the used or specified grade of cement by the professionals. The prevailing national standard, as prescribed by SON, restricted the use of grade 32.5 cement. The relatively high proportion of grade 32.5 in use may be as a result of plastering works being executed. It is also possible that the difference between the two cement grades may not be fully understood by the site supervisors. However, the cement brands and grades in use vary with most of the respondents using the Dangote brand of cement which is mostly produced in the 42.5 grade category. This is partially in line with the recommendations of the Standards Organization of Nigeria (SON) that all structural concrete in Nigeria must be with grade 42.5 cement since lower grade cement grade of 32.5 is recommended for plastering works only.

The practices of professionals on construction sites were investigated to ascertain the extent to which the procedures and processes involved in concrete construction were adhered to by the professionals in the study area. The results are as shown in Table 4.

Table 4: Professional Practices on Construction Sites

Professional Practice	Never	Rarely	Sometimes	Often	Always
Presence of the Professional on site during concrete batching and placement	1(2.7%)	0(0.0%)	9(24.3%)	9(24.3%)	18(48.6%)
Measuring of aggregate on site	6(15.0%)	13(32.5%)	9(22.5%)	6(15.0%)	6(15.0%)
Testing of fine aggregate for salt	10(25.0%)	6(15.0%)	11(27.5%)	7(17.5%)	6(15.0%)
Conducting concrete trial mixes	0(0.0%)	7(17.5%)	11(27.5%)	14(35.0%)	8(20.0%)

Carrying out batching locally on site	2(5.4%)	5(13.5%)	9(24.3%)	13(35.1%)	8(21.6%)
Outsource batching	6(16.7%)	9(25.0%)	13(36.1%)	4(11.1%)	4(11.1%)
Vibrating wet concrete after placement	2(5.4%)	1(2.7%)	1(2.7%)	13(35.1%)	20(54.1%)

From Table 4, 72.9% of respondents indicated their regular presence on site during concrete batching and placement. This shows the importance the supervisors accorded the concrete component of their work. However, only 30% of the respondents took extra precaution to measure the size of their coarse aggregates when brought to site to ensure compliance. Likewise, 32.5% of the respondents regularly tested the fine aggregates for salt, which if present in the fine aggregate, could create problems in concrete strength and durability. It may also create a highly corrosive environment for steel reinforcement.

Table 4 further shows that 55% of the respondents frequently carried out concrete trial mixes to ensure that the actual strength of the concrete to be used meets the strength specified by the Structural Engineer. However, the study showed that 45% of the respondents were not keen on repeatedly ensuring the strength of the concrete used oat different sites they work on were adequate, which implies that they made use of concrete mixes they were used to or that had worked previously.

Furthermore, the study showed that 56.7% of the respondents carried out their batching locally on site regularly as against 22.2% who indicated that the batching were more often outsourced. On further inquiry, it was found that most of the concrete works in the study area were outsourced to independent concrete sub-contractors operating as a guild in many parts of Lagos. Patronage to the big concrete batching companies such as Lafarge and SPG was limited because of the size of project and/or cost of such sophisticated batching. Also, the road network in and around the construction sites may not permit the use of large mobile concrete batching plants.

The independent concrete sub-contractors belong to an umbrella organisation – Concrete Workers Association of Nigeria. The association is fairly well organised into contract, head-pan, vibrator and gang leader departments. However, they often pose problems to concrete quality as they use visual assessment to monitor concrete quality and workability instead of using measurements. Also, their main volumetric measuring tool is the head-pan which, in most cases, is often disfigured and dented by frequent usage to the extent that the volume measures cannot be relied upon. They also tend to put in more sand (fine aggregate) than necessary to improve workability while impairing the strength and durability of the concrete.

Another important activity, when placing concrete, is the vibration of the freshly placed concrete to ensure there are no air gaps. The study showed that 89.2% of the respondents habitually vibrate their wet concrete after placement. However, the vibrator is usually applied intermittently to the placed concrete with the result that the vibration may not be uniformly applied.

In addition, horizontal structural elements, such as slabs as well as strip and pad foundations, were not often vibrated. There is reliance on the concrete workmen to manually vibrate the concrete placed in such horizontal members.

The length of curing specified was investigated to know for how long professionals in the study area carried out curing on freshly placed concrete to allow it achieve its maximum strength. The results are as shown in Table 5.

Table 5: Length of Curing Specified

Period	Frequency	Percentage
Less than 3 days	1	2.5
4-7 days	10	25.0
8-14 days	3	7.5
15-24 days	22	55.0
25-35 days	4	10.0

When it comes to curing of the concrete after casting, 65% of the respondents indicated that they specified a minimum of 15 to 24 days while 25% indicated 4 to 7 days as being sufficient. On further discussion with the supervisors, the predominant method of curing was the sprinkling of water on the setting concrete.

Testing of hardened concrete to check the end product performance was investigated to know how often the professionals in the study area ensure that the concrete that has been cast achieved the desired concrete strength to function optimally. The results are as shown in Table 6.

Table 6: Testing the Hardened Concrete to Check End product performance

Assessment	Frequency	Percentage
Never	1	2.6
Rarely	11	28.2
Sometimes	9	23.1
Often	11	28.2
Always	7	17.9

However, after curing, just 46.1% of respondents frequently test the hardened concrete to check the end product performance and ensure that the desired concrete strength was achieved. Ordinarily, there were no plans in place to test the compressive strength of the concrete being placed. It is generally assumed that once the volume batching ratios are adhered to, the required strength would be achieved. This would have been so if the constituent materials were all in excellent state but that is not always the case. Sometimes, concrete cube samples are taken by the Lagos Materials Testing Laboratory. However, such interventions are few, are occasional and are also fraught with irregularities.

5.0 Findings of the Study

The study found that, first, the professionals in the construction industry in the study area have sufficient experience in the use of concrete. Second**,** concrete with 93.3% score was the structural material that experienced the most failures. This is understandable given the preponderance of concrete related structures in the study area. Third, 76.9% of the respondents use or specify Dangote Portland cement brand for their concrete construction while fourth, the relatively high proportion (59%) of grade 32.5 in use, in the study area, may be as a result of plastering works being executed. The study also found that 55% of the respondents frequently carried out concrete trial mixes to ensure that the actual strength of the concrete to be used meets the strength specified while most of the concrete works in the study area were outsourced to independent concrete sub-contractors.

6.0 Conclusion and Recommendation

It can be concluded from the study that presence of the professionals during concrete works is encouraging but it is still very important that they subscribe to quality control measures before and after the casting of concrete. Hence, concrete-related structural failures may not be associated with projects where competent professionals are engaged. It could be mostly ascribed to buildings where the relevant professionals are not engaged. This thus brings up the need for relevant professionals to be involved in all aspects of building procurement.

On the measurement of coarse aggregates and the testing of fine aggregates for silt and salt, there may be need to create a method of ensuring these quality control measures are carried out. It may be possible to accomplish the aforementioned through effective collaboration between the government development control agency and relevant professional bodies. This is necessary as the relevant government agencies appear not to be adequately staffed, hence the need to collaborate with the relevant professional bodies. Some aspects of the materials testing aspect of construction monitoring have been outsourced but the conduct of the service providers often leaves much to be desired. Also, the enforcement of the stage certification component of development control should be enhanced so that areas of compromise in construction quality would be identified on time.

The important role played by the independent concrete subcontractors in the study area cannot be glossed over. Given the informal status of the construction industry, this group of workers would continue to thrive. Efforts should therefore be made to train them regularly to enable them give value added services to the local construction industry. With all stakeholders focused on improving quality of building construction, the incidence of structural failure and building collapse will be curtailed.

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