Contribution of Quality Management Practices towards Building Collapse in Nigeria

ABSTRACT

Nigeria like many other countries is experiencing collapse of buildings at an alarming rate; this has become of great concern to all stakeholders in the Construction Industry. This situation is linked to the finding that the prevalent quality system on sites is the supervision of workers and work processes. Achieved levels of quality are thus totally dependent on the supervisor's expertise; this can be counterproductive where supervisors lack requisite knowledge and experience. This paper examined the quality management practices on construction sites as it affects the menace of building collapse in Nigeria. The study is exploratory in nature, and employs the use of secondary data in conjunction with primary data obtained through a questionnaire survey. Findings suggested that a cyclical trend might exist in the incidence of building collapses which may be represented by a 2-period moving average trend-line. Collapses were more prevalent in buildings employed for residential and commercial uses (a total of 72% of the entire sample). The dominant cause of building failures in the study area was structural failure (46%) and use of substandard materials (21%). Design and Material issues (Mean score = 4.62 and 3.56) had the highest influence on the quality of the construction product. Three main recommendations were offered, including the need to design and implement proactive measures such as routine testing of building integrity which could be built into an 'annual renewal of building approval' process.

Keywords: *building; collapse; ethics; integrity; quality.*

1 INTRODUCTION

Quality assurance is a planned process aimed at ensuring that products and services conform to established requirements (Leong, Zakuan and Saman, 2014; Okereke, 2003). The construction industry 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 sector of the industry, is necessary to ensure that such huge national capital is kept durable, safe and serviceable all through their estimated life cycles. Assessments of the building construction sector in Nigeria indicate that the adoption of quality management strategies is still rudimentary. 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 counterproductive especially when the supervisor lacks requisite knowledge and experience. The major weaknesses of construction firms in Nigeria, according to Kado (2010) are in the areas of staff training, education and skills, objective measurement, feedback and use of total quality tools and techniques. Concerns involving quality in the Nigerian Construction Industry (NCI) are typified by the increasing cases of collapse of buildings (Abdulkareem and Adeoti, 2010). To mitigate this, Ashokkumar (2014) opined that the management of building quality encompasses material variability, testing variability, judgment factor, contractors' variability, poorly skilled workmen and unprofessional conduct.

Similarly, Opoko, Ezema and Ediae (2014) opined that the utilisation of substandard building materials in the Nigerian context could be traced to non-existent quality management production processes. Nigeria, like many other countries (Paul and Otieno, 2018) is experiencing collapse of buildings at an alarming rate; this has become of great concern to all stakeholders in the building sector (professionals, government, private developers, clients and users). Growing concern about the increasing incidents of building failure formed the basis for this paper on the collapse of buildings in Nigeria. This paper examined the quality management practices on construction sites as it affects the menace of building collapse in Nigeria. This would be achieved by collating recent, documented incidences of building collapses, determining the quality management practices involved in building construction and relating frequency of building collapse to the level of quality management practiced on sites.

Construction projects are capital intensive, and defects / failures in constructed facilities can result in delays and costs increases or cause personal injuries or fatalities (Sanni and Windapo, 2008). In the NCI any extra cost means huge losses to contractors and increased cost to clients (Aibinu and Odeyinka, 2006). The benefits of strict adherence by professionals like Architects, Engineers, Builders and contractors to the need for quality management has not been given the required attention in spite of a major developmental projects (Jimoh, 2012). It is significant to carry out this research in order to suggest best practices that improve quality management in building construction, which will in turn result to improved project delivery and reduced occurrence of collapsed buildings. This study focussed on the

contribution of quality management practices to building collapses in Lagos state, Nigeria. The data for the study will be collected from consultants, contractors and artisans in the construction industry in Lagos State

LITERATURE REVIEW

Nigeria's striving to develop her built environment is being held back by exponential population growth. As a result, people have had to explore different approaches to housing and infrastructural development. The quality of some of these structures falls below acceptable standards; this inevitably leads to structural failures (Ede, 2010). In Nigeria the most frequent causes of building collapse are abnormal, and of a criminal shade. The cost of building failures in terms of human lives and loss of productive assets, returns on investments and livelihoods has mounted to what can only be described as significant. Also important is the dent such failures make in the reputation of construction professionals and the entire Nigerian construction industry.

Prevalence of Building Collapse

Research in Nigeria has established that collapse usually occurs in buildings having between two and five floors. A total of 33 and 22 incidents of building collapse were recorded in 2012 in Lagos and Abuja respectively. The problem of building collapse is not limited to Nigeria alone; Paul and Otieno (2018) found that in Kenya, between 2006 and 2014, an estimated 17 buildings collapsed spontaneously, causing 84 deaths and more than 290 injuries. The main immediate causes of such collapse included use of substandard building materials, poor workmanship and noncompliance to housing policy.

Oloyede, Omoogun and Akinjare (2010) found that wide variations exist in individual opinions on which of the construction professionals is most responsible for the collapse of buildings. Rising incidence of building collapse in major Nigerian cities have forced the government to enact specific rules and regulations related to safety of buildings. The problem is however in the application of such rules. Those administering Town Planning rules and regulations must be held accountable when buildings approved by them suffer collapse. However, accountability in Nigeria is generally weak (Dare, 2009)

Identified Causes of Building Collapse

Oyedele (2018) identified the causes of building collapse incidents as due to poor workmanship, sub-standard building materials, unsuitable sites and poor building design. Based on a case study of six collapsed buildings across Nigeria, the study traced the rampant nature of building collapse to corruption and greed of developers who reduce the quantity of cement and steel reinforcement used in concrete and refuse to employ qualified professionals. Oyedele (2018) opined that the National Building Code of 2006 is not effective due to lack of enforcement and because owners of collapsed buildings are not taken to task even where lives have been lost.

Some studies have examined the causes of building collapse from the angle of adequacy and quality of materials employed in the building process. Joshua, Olusola, Ogunde, Amusan, Ede and Tunji-olayeni (2017) investigated building collapse due to failure in reinforced concrete. Their study was limited to the production of low standard concrete, based on the premise that failure in substandard reinforced concrete is broadly based on the use of substandard materials or poor production process. The results of the study revealed that not all the test samples met the strength standards. The researchers believed that other factors as haulage, poor storage and use of expired cements might have compromised the test samples; they thus recommended that cements sold commercially should bear expiry dates. Another finding of the study was that the strength of samples of class 32.5 cement taken from sites failed to reach a marginal value of 20MPa. This led to recommendation that class 42.5 cements be used in storey structures where design concrete values greater than 20MPa are specified. A third finding of the research was that only eleven of the eighty professionals that were sampled possessed greater-than-average knowledge of cement utilization.

A study conducted by Omran, Bamidele and Baharuddin (2016) determine the remote causes of incessant building collapse in Nigeria to be mainly due to use of quacks, substandard/inadequate material, poor workmanship, non-adherence to design specifications, improper supervision, professional negligence/compromise, and corruption in governance.

Remedies to the Problem of Building Collapse

Quite a number of studies have made recommendations on how the malady of building collapse can be ameliorated, if not totally eradicated. Oloke, Oni, Ogunde, Joshua and Babalola (2017) noted that more buildings suffer collapse while in use than during construction or immediately after construction. Only 4% of a sample of 56 collapsed buildings was under construction, according to Ayedun, Durodola and Akinjare (2012). In the case of Chendo and Obi (2015), 60% of a sample of ten building collapse cases represented buildings that were already in use. In view of the high proportion of occupied buildings that suffer collapse, Ede (2010) and Olagunju (2011) stressed the importance of carrying out periodic post-construction maintenance of buildings.

The foregoing provides a strong case for structural integrity tests during the use of any property. Oloke *et al*., (2017) therefore investigated how post-completion management of properties could be employed to arrest the collapse of buildings in Nigeria. Their investigation was based on data from a survey of one hundred and fifty residential and seventy-five commercial properties across Lagos State, Nigeria. The findings of the research revealed that integrity assessment is rarely carried out on the properties. Ezema and Olatunji (2018) observed that building laws and regulations exist in all the 36 States of Nigeria as well as the Federal Capital Territory which can

be employed to achieve effective development control. However, the inadequate government oversight of building construction activities have been attributed to unethical contract practices coupled with weak regulatory framework (Longtau, Justina, Majidadi and Makwin, 2016; Fernandez, 2014). This situation has allowed breaches of quality in the building construction industry to multiply and fester, in several cases leading ultimately to building collapse.

Quality Management in Construction

Research has revealed that poor quality performance results in increased rework, which generally has adverse effects on construction cost and schedule. Traditional methods of assuring of quality which the industry is still using depend on the inspection of work in progress. Total Quality Management (TQM) assures quality by re-engineering the entire construction process to achieve quality. In the long run this is a cheaper approach; the cost of correcting defects is around 12 percent of project cost, whereas the cost of providing TQM is between 1 to 5 percent (Xiao and Proverbs, 2002).

The problem of quality management in construction is epitomized by the case of sandcrete blocks in Nigeria. Sandcrete blocks are a very important material in building construction, which is widely used in Nigeria, Ghana, and other African countries as load bearing and non-load bearing walling units. Nine out of ten physical infrastructures in Nigeria are constructed using sandcrete blocks (Baiden and Tuuli, 2004). The Standard Organization of Nigeria (SON) prescribed the minimum requirements and uses of different kinds of sandcrete blocks in a reference document coded as NIS 87:2000 series. Anosike and Oyebade (2012) investigated whether block manufacturers meet the minimum specified standard in NIS 87:2000, which ranges between 2.5N/mm2 to 3.45N/mm2. Their results revealed that there was very low compliance with NIS 87:2000; compressive strength of blocks as low as 0.66N/mm2 was recorded. The researchers opined that poor quality control, poor selection of constituent materials and inadequate curing period contributed to the negative results obtained.

The current situation is that the industry uses traditional methods to achieve quality, thus impeding the use of advanced quality techniques. This results in increased rework, with attendant cost and schedule implications. It has been estimated that correction of defects costs about 12% of project cost, whereas providing TQM throughout the project cycle will cost less than 6% of project cost (Xiao and Proverbs, 2002). Leonard (2010) noted that although quality management is expanding in other industries globally, the construction industry's focus is still fixated exclusively on inspection processes.

Gap Identified in Literature

This study has been able to show through a review of literature that there are quality management issues that are associated with structural failure of buildings. Some studies have documented appreciable number of cases of structural building failures. However, there is a need to begin to explore the association between how quality is managed on construction sites, and how frequently building failures occur. This represents a gap in knowledge which this study aspires to fill.

2 METHODOLOGY

This study is exploratory in nature, and employs the use of secondary data in conjunction with primary data obtained through a questionnaire survey; this is a single method quantitative research approach. Kothari (2004) defined research design as the arrangement of conditions for collection and analysis of data in a manner that serves as the blue print for the collection, measurement and analysis of data. Questionnaires were used to collect data on quality management as practiced on construction sites, while historical data provided some limited details of the various buildings that have collapsed in the study area.

The population for this study comprises consultants, contractors and artisans in the construction industry in Lagos. The artisans that were sampled were limited to Masons/Blocklayers, Iron-benders/Steel-fixers and Carpenters, because these artisans are those that actually construct the structural carcass of buildings. The professions that were sampled were limited to Architecture, Building, Civil Engineering and Quantity Surveying. These professionals are responsible for the design of buildings, and their work can influence the quality of the building structural carcass as well.

The exploratory nature of the study provided justification for the use of a sample of respondents that was not based on probability sampling. This study intends to sample at least fifteen (15) respondents from each of the 11 categories identified in Section 3.3.2. This translated to a total sample of 165 respondents, who were selected through using the snowballing technique where a sample is built up from recommendations of people who have been sampled already (Trochim, 2006).

The historical data employed in the study was derived from a variety of sources including published academic works and records maintained by the statutory agency for the control of building collapse in the study area, the Lagos State Physical Planning and Development Authority (LASPPDA). The data gathered from the respondents via the structured questionnaire was coded into Microsoft Excel as numbers representing the options selected by the respondents. Next, careful analysis of the data in relation to the stated objectives of the study was carried out. Descriptive statistical methods were employed for Objective 1 (Frequency, Percentile and cross-tabulation) and Objective 2 (Mean score and Relative Importance Index). Objective 3 employed deductive method (Simple Correlation). The analyzed data was presented using tables and charts.

3 RESULTS AND DISCUSSION

Respondents' Demographics

Quantity surveyors and Architects were most numerous in the sample followed by civil engineers and builders. The number of artisans (mason, iron-benders and carpenter) ranged between 11 and 14 per trade. Only 16% of the sample was female; this reflected a realistic picture of the NCI, where male dominance of trades and professions is highly pronounced and visible (Okoyeuzu et al., 2008). The sample was split equally between clients and contractors as employers of the sample professionals and artisans.

TABLE 1: DEMOGRAPHICS OF THE RESPONDENTS

Demographic aspect	Subcategories	Frequency	%
Type of professional	Architect	24	28.92
	Builder	16	19.28
	Civil engr	18	21.69
	Quant. surveyor	25	30.12
Type of artisan	Mason	11	28.95
	Iron bender	13	34.21
	Carpenter	14	36.84
Gender	Female	19	16.38
	Male	97	83.62
Employer	Contractor	60	50.00
	Consultant	60	50.00

Trend Analysis of Documented Incidences of Building Collapse

The numbers of building collapses dropped between 1999 and 2000; a gradual increase however commenced in 2002, continuing up to 2007. It appeared that the trend was cyclical, spanning a number of years; a 2-period moving average trend-line was found to best fit the data, as shown in Fig. 1. This might be due to the reactive measures usually rushed into on the heels of a series of collapse incidences. Such measures (which include testing, identification and demolition of unsafe structures) might depress the number of fresh incidents for a period of time, but owing non-sustenance of such reactive measures, the numbers of collapse incidents soon begins to increase after a few years of apparent decrease.

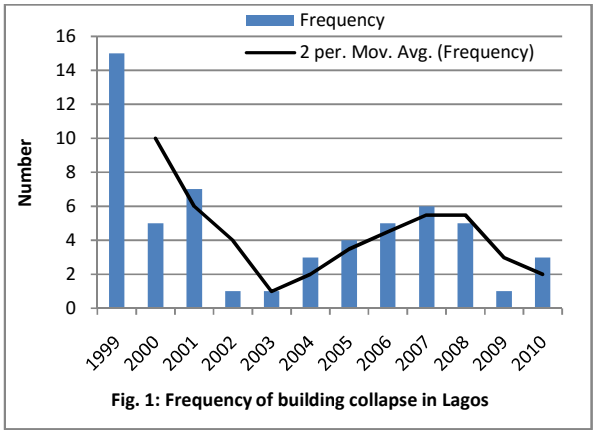

Fig. 1: Frequency of building collapse in Lagos

An instructive finding was the fact that over half of the sample of collapsed buildings consisted of buildings having not more than 3 floors as shown in Fig. 2. This finding agreed with that of Folagbade (2001), who had calculated that 76% of reported building collapses in Lagos state from 1980 to 1999 were buildings that more often than not, are constructed entirely by the informal subsector of the construction industry. Buildings having more than 3 floors are more likely to have properly drawn up plans for which statutory approval has been obtained.

The data presented in Fig. 3 revealed that collapses were more prevalent in buildings employed for residential and commercial uses (a total of 72% of the entire sample). This finding also agreed with Fagbenle and Oluwunmi (2010) who investigated the contributory role of the informal sector to building collapse incidents. They found that 70-0%, 23.3% and 6.7% of reported building collapse cases occurred in private, public and corporate organizations respectively. It must be pointed out that commercial enterprises are usually located in privately owned buildings; in some cases such buildings have been approved for residential use only.

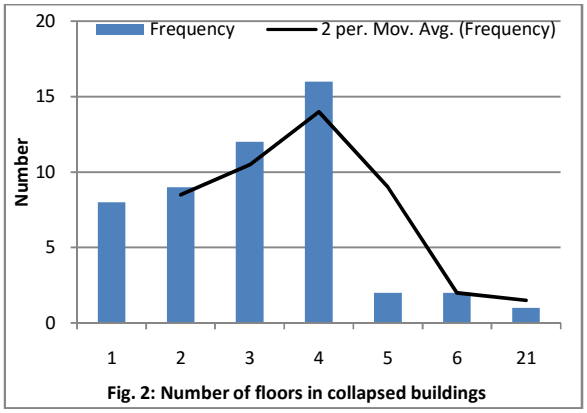

Fig. 2: Number of floors in collapsed buildings

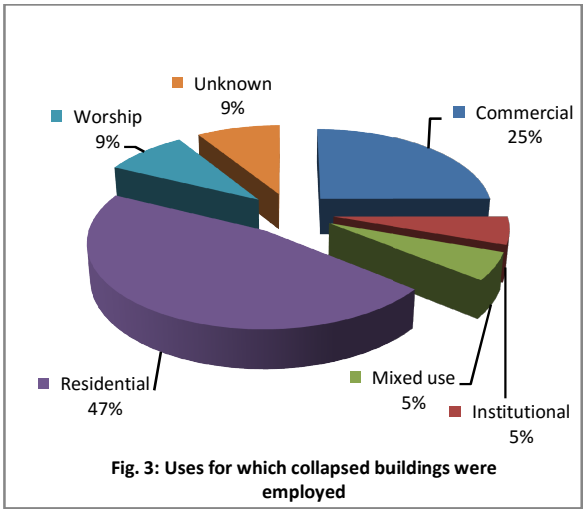

Fig. 3: Uses for which collapsed buildings were employed

Two thirds of all building failures in the study area were attributable to structural failure (46%) and substandard materials (21%). Fagbenle and Oluwunmi (2010) in their investigation of the contributory role of the informal sector to building collapse incidents had unearthed hasty construction, incompetent workmen, poor supervision and non-compliance with building regulations as causes of building collapse. It needs to be understood also that 'structural failure' is a blanket term that could cover all of the causes reported by Fagbenle and Oluwunmi (2010).

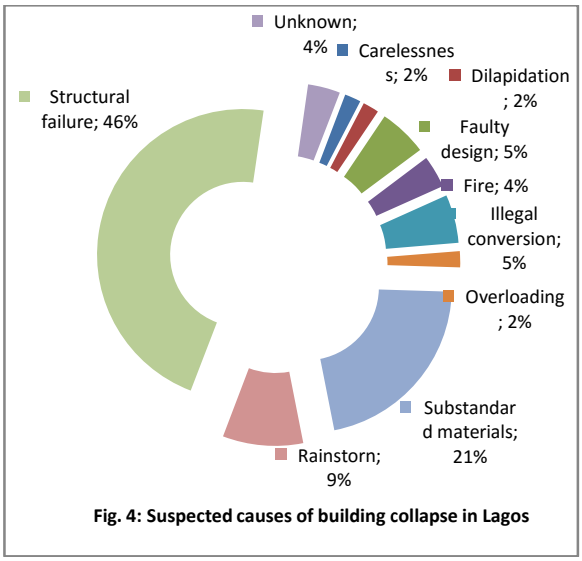

Fig. 4: Suspected causes of building collapse in Lagos

Buildings devoted to residential, commercial and worship uses had the highest casualty figures when collapse occurred in such buildings. This finding agreed with the work of Ede (2010) which used probabilistic linear regression model to establish the relationship between characteristics of collapsed buildings and number of casualties recorded. One of the findings of the research was that casualty rates in collapsed buildings were high and dynamic, dependent on building use, type and climatic season.

This paper goes further to reveal that structural failure and substandard materials are related to the highest casualty rates in collapsed buildings. Collectively, these two causes account for 64% of all casualties recorded. Therefore, focusing efforts on the mitigation of collapses due to structural failure of building frames and use of substandard materials would have a significant effect on reducing overall casualty figures.

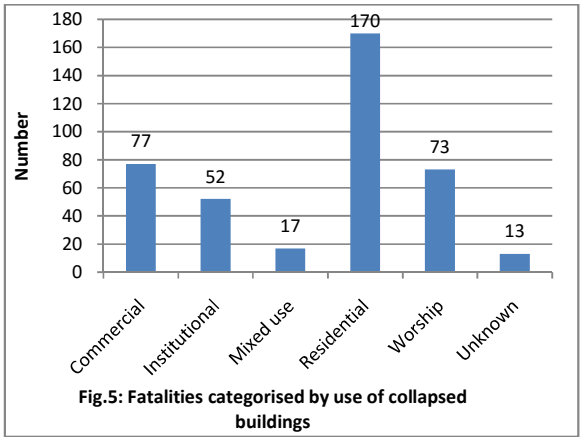

Fig.5: Fatalities categorised by use of collapsed buildings

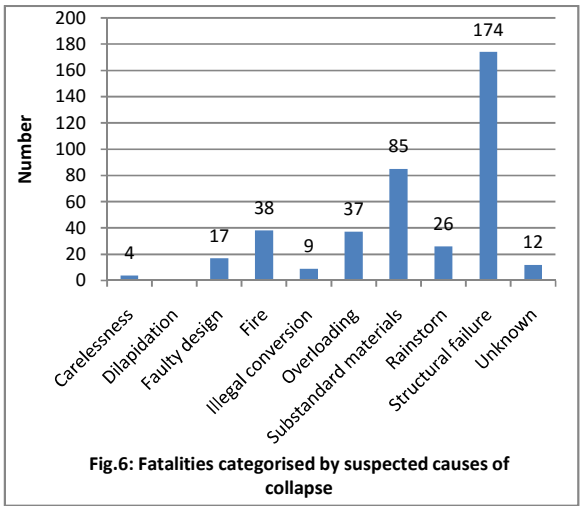

Fig.6: Fatalities categorised by suspected causes of collapse

Quality Management Practices on Construction Sites

Design related issues were found to be most influential with respect to the quality of the final product of the construction process. This was borne out of the fact that the derived Mean Score value of 4.62 fell within the response range (4.50 – 5.00) that was associated with the 'Very large extent' option in the research questionnaire. Material issues influenced construction quality 'to a large extent', since the Mean Score value was 3.56 which fell within the response range of 3.50 – 4.49. All other groups of issues related to construction quality (process,

compliance and labour) exerted influence 'to a moderate extent'. These findings are presented in Table 4.2.

TABLE 2: OVERALL PRACTICE OF SITE QUALITY MANAGEMENT

Categories of quality management practices	Mean Score	RII	Rank
Design issues	4.62	0.92	1
Material issues	3.56	0.70	2
Process issues	3.44	0.69	3
Compliance issues	3.16	0.63	4
Labour issues	3.05	0.61	5

The sole design issue explored in this paper was lack of detailed structural drawings; this was found to be the most influential issue (Mean score (MS) = 4.62) with respect to construction quality. The next three issues in descending order of influence on construction quality were 'carry out concrete trial mixes', 'lack of proper supervision by professionals', and 'unreliable measurements' (MS = 4.35, 4.22 and 4.01 respectively). These findings corroborate those of Ezema and Olatunji (2018) with reference to the use of concrete in construction.

Other notable issues that influenced the quality of construction as presented in Table 4.3 included 'provision of required tools' (MS = 3.95), 'Non-compliance with approved drawings' (MS = 3.86), and 'Use of more sand than necessary in concrete' (MS = 3.76). It is perhaps an indication of the level of awareness of ethical issues affecting the quality of construction that respondents rated issues such as 'Professional present on site during concrete works' and 'Professional Negligence/Compromise' quite low (MS = 2.57 and 2.11 respectively). It is also alarming that 'Poor workmanship' (MS = 2.55) was ranked as having only very moderate influence on the quality of construction works.

TABLE 3: EXTENT OF QUALITY MANAGEMENT PRACTICES

ID	Quality management practices	Mean Score	Rank
	Design issues		
QMP01	Lack of detailed structural drawings	4.62	
	Process issues		
QMP02	Carry out concrete trial mixes	4.35	1
QMP03	Lack of Proper Supervision by Professionals	4.22	2
QMP06	Unreliable measurements - head pan is dented	4.01	3
QMP07	Use more sand than necessary	3.76	4
QMP08	Use of unqualified supervisors - Quacks	3.43	5
QMP04	Remove defective work	3.26	6
QMP05	Testing of fine aggregate for salt	2.96	7
QMP09	Vibrate wet concrete after placement	2.94	8
QMP10	Vibrator applied intermittently not uniformly	2.87	9
QMP11	Visual quality assessment instead of measurements	2.61	10
	Compliance issues		
QMP14	Non-compliance with approved drawings.	3.86	1
QMP15	Non-possession of approved drawings.	3.73	2
QMP16	Observe statutory break periods	3.73	3
QMP13	Lack of Adherence to Design Specifications	3.28	4
QMP12	Disobeying Town Planning Laws	2.82	5
QMP18	Professional present on site during concrete works	2.57	6
QMP17	Professional Negligence/Compromise	2.11	7
	Material issues		
QMP20	Outsourcing of concrete batching	3.75	1
QMP21	Use of poor quality building materials	3.68	2
QMP19	Batching locally on site	3.24	3
	Labour issues		
QMP22	All required tools provided	3.95	1
QMP24	Insist on testing new workers	3.63	2
QMP25	Poor workmanship	2.55	3
QMP23	Check worker references	2.09	4

4 CONCLUSION

It has been proposed that a cyclical trend might exist in the numbers of building collapses which may be represented by a 2-period moving average trend-line. Collapses were more prevalent in buildings employed for residential and commercial uses (a total of 72% of the entire sample), buildings having not more than 3 floors (over half of the sample). The dominant cause of building failures in the study area were structural failure (46%) and use of substandard materials (21%). These two causes were also associated with the highest casualty rates in collapsed buildings (64% of all casualties recorded).

Design related issues were found to be most influential with respect to the quality of the final product of the construction process. Material issues influenced construction quality 'to a large extent' while process, compliance and labour issues exerted influence 'to a moderate extent'. A worrisome indication of the low level of awareness of ethical issues affecting the quality of construction was provided through low rating of issues such as 'Professional present on site during concrete works', 'Poor workmanship' and 'Professional Negligence/Compromise' quite low (MS = 2.57, 2.55 and 2.11 respectively). Given the tone of writings on ethics in the construction industry, it would have been expected that such practices that border on ethical conduct would be ranked highly.

This paper makes three main recommendations with respect to the improvement of construction quality in order to prevent the untimely collapse of buildings. Firstly, proactive measures to prevent building collapse need to be designed and implemented. Such measures could include routine testing of building integrity which

could be built into an 'annual renewal of building approval' process. At inception, to improve their workability, such proactive measures should target residential and commercial buildings having less than 4 floors. Secondly, a vigorous, wide ranging campaign to improve the prevalence of ethical practices in the construction industry should be mounted. Such a campaign should span the entire spectrum of ethical conduct, from awareness to enforcement. Thirdly, this study should be replicated in other states of Nigeria, in order to validate some of the trends observed in building collapse incidents in Lagos state.

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