An Evaluation of Cost of Quality Failure for Building Projects in Nigeria

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Abstract

The overall aim of any construction project is the design and construction of a building that meet the specific requirement of the owner at optimal quality and cost. Many problems occur during the design and execution of construction project, which consume substantial amount of money for their rectification. The study identified various failure incidents and their respective costs within the construction process of a building project. To achieve this, case study of a construction project was carried out. The construction manager was required to monitor record and cost any failure incident that arose during the construction. The data collected was analyzed with the aid of simple statistical tools that include means and percentages. The findings reveal that about 5.8% of the total contract sum is used for the rectification of such failures. Plant and equipment, personnel, design, force majeure and suppliers are causes attributed to these. The study found that 20% of the incidents contributed about 75% of the total cost of failure. It was also revealed that the cost of failures was greater in the roof as it constituted 22.55% of the total cost of failure; the least cost was in staircases constituting only 0.86% of the cost. The study recommended that, Changes in design during the construction process should be avoided by ensuring that all anticipated causes of such changes are considered appropriately at inception stage. Moreover, Construction Managers should ensure that the work on site complies with specifications in terms of materials and workmanship, to minimize the extent of rework during construction.

Keywords: Building, Cost, Failure, Project, Quality

Introduction

Defects in construction projects are a persistently worrying problem despite continual improvement in technology and education (Ashworth, 2010). The construction industry has sometime been discredited because of dramatic failures of both the design and the construction of its product. The achievement of an acceptable standard in building is a combination of quality of design and quality of construction. Quality problems manifest themselves in almost every construction project. Costs due to failures represent the unnecessary additional cost incurred on a project if all processes could operate correctly the first time (Mark and Cyril, 2001). Quality failure costs are those costs incurred on the client or product because of nonconformity to specifications or failure to meet costumer's need. When it is necessary to correct the products that fail to satisfy the customer or meet the required specification, the costs incurred are non-value adding to the client or company i.e. wasteful (Feigenbaum , 1956).

Ashworth (2010) categorized Quality costs under three headings; prevention cost, appraisal cost and failure cost. Prevention costs are concerned with trying to ensure that no defective items are produced either in manufacture or in construction. Examples of such costs are design reviews, education, training, supplier selection, capability reviews, and process improvement projects. Appraisal costs are the cost expended on the measurement of specified characteristics to establish conformity to the specification. Examples of appraisal costs include inspections, material reviews, and calibration of measuring and testing equipment. Failure costs are the cost associated with the manufacture and replacement of a defective part of the construction project. They may occur through a faulty design or because the contractor has failed to comply fully with the specification. Failure costs can be divided into internal and external. Internal failure costs are costs arising during construction process due to defects or nonconformities, including scrap, re-work, retest, re-inspections and redesign. On the other hand, external failure costs are costs that occur when a non-conforming product reaches the customer such as those due to customer complaints and those associated with receipt, handling, repair, and replacement of non-conforming products. External failures can include loss of future business through customer dissatisfaction, although this rarely occurs (Tsai, 1998).

Estimates of the cost of quality (or, more accurately, the cost of poor quality or non-conformance with specification) vary across industries and between companies. In general, unless focused efforts are taken to minimize them, they are estimated to fall between 10% and 30%, with most analyses putting them at around 20% of the total construction cost (Atkinson, et al. 1991; Nylen, 1999). To this end therefore, there is need to identify such failures and their respective causes in order to drive them over time to be as near zero as possible. This study identified and analyzed the cost of quality failures (nonconformance) for the piloted case study, against which future projects could be compared, which assist in achieving significant reduction of failure costs.

Research Methodology

The aim of this research work was to investigate and analyze the cost of quality failure (internal failure cost only) of a piloted building project, with a view to minimizing their occurrences in future projects.

To achieve this aim case study of a construction project was undertaken. The project was a N165, 275, 690 building contract undertaken on a traditional procurement method. This excludes design fees; value added tax and contingencies, as the exercise was limited to construction process only. The project was a 500-seat public lecture theatre of low technical complexity located in Gombe state.

Data for the study were collected by means of checklist which was completed by the construction manager. The parameters of interests on the checklist were;

- Elements of the building
- Total cost of each element of the building
- Number of quality failures in each element
- Cost of quality failures
- Causes of quality failures
- Number of incidents in each cause.

The construction manager was required to monitor quality failures on site through self-monitoring and observation. This means that the project construction manager was personally responsible for recording failure incidents and suggesting possible causes for the manifested effects. Each incident was recorded as it arose and valued by the resident Quantity surveyor. In the spirit of inclusiveness, all staff were involved in observing any incident that seemed to be relevant to the exercise, relating either to their own activities or those of other parties.

Table 1: Distribution of Cost of Quality failure on the Bases of Elements

S/N	Elements	Cost of elements in BOQ (₦)	No. of quality failures	Cost of Qty. failures(₦)	Causes of Qty. failure	Type and Number of incidents in each cause.
1	Preliminaries	2,500,000	5	125,000	Plant/equip.	Plant and Equipment =5
2	Substructure	22,325,800	3	2,005,250	Design/force Majeure	Design=2 Force majeure.=1
3	Frames	9,266,500	6	932,420	Design	Design=6
4	Block work	3,881,250	5	93,400	Design	Design=5
5	Staircases	903,500	4	82,370	Design	Design=4
6	Electrical services	2,998,700	5	103,500	Design/personnel	Design=3 Personnel=2
7	Mechanical services	5,097,840	7	99,450	Design/personnel	Design=6 Personnel=1
8	Roof	18,042,350	2	2,162,300	Design	Design=2
9	Doors & windows	8,375,450	5	204,200	Design/personnel	Design=3 Personnel=2
10	Fittings & fixtures	50,822,500	2	1,766,250	Design/supplier	Design=1 supplier=1
11	Finishes	14,915,900	4	820,000	Personnel/ Force majeure	Personnel=3 Force majeure.=1
12	External works	26,145,900	3	1,195,600	Design/personnel	Design=2 Personnel=1
	Total	165,275,690	51	9,589,740	---------------	---------------

Source: Construction Manager's record

Table 1 shows the breakdown of cost of quality failure for different elements of the construction project. The total cost of quality failure recorded for the project was N9,589,740, this figure represents only the costs of rework, repair, material loss, material overuse and equipment stand-by as they are elements of internal quality failure, but it does not contain the costs of external quality failure, prevention and appraisal cost as sub-sets of cost of quality. The total cost of the project as shown in Table 1 excludes design fees; value added tax and contingencies as the exercise was limited to construction process only. In total, 51 incidents were recorded which convinced the construction manager and the researcher to be deemed to merit inclusion as internal quality failure incidents.

Table 2: Distribution of Cost of Quality Failures by Size

S/N	Category(N)	Incidents		Total cost of incidents (N)	Average cost of incident (₦)	Percentage cost of incidents (₦)
		Nr.	%			
1	1 - 100,000 **(small)**	16	31.4	275,220	17,201	2.9%
2	100,001 - 500,000 **(medium)**	15	29.4	432,700	28,847	4.5%
3	500,001 - 1,000,000 **(large)**	10	19.6	1,752,420	175,242	18.3%
4	1,000,001 + **(very large**	10	19.6	7,129,400	712,940	74.3%
	Total	**51**	**100**	**9,589,740**	**204,037**	**100%**

Table 2 shows the distribution of cost of quality failure by size. The table shows that the category defined as small constitutes the highest number of incidents but they accounted for only 2.9% of the total cost of internal quality failure, then followed by category defined as medium which accounted for 4.5% of the cost. Both the small and the medium categories which contributed the largest number of incidents (31 incidences representing 60.8%) accounted for only 7.4% of the total cost of failure. On the other hand the largest contribution to the cost of quality failures (74.3%) was obtained from the ten incidents (representing 19.6% of the total number of incidents) categorized as very large (the relationship is in fact closer to pareto 80/20 rule). This finding support previous studies (Barber, et al. 2000).

Table 3: Percentage Distribution of failure cost

S/N	Elements	No. of quality failure	Cost elements in the BOQ (₦)	Failure costs (₦)	Percentage of Failure costs on cost of Elements	Percentage on Total Cost of Failure
1	Preliminaries	5	2,500,000	125,000	5	1.31
2	Substructure	3	22,325,800	2,005,250	9	20.91
3	Frames	6	9,266,500	932,420	10	9.72
4	Block work	5	3,881,250	93,400	2.4	0.97
5	Staircases	4	903,500	82,370	9.1	0.86
6	Electrical services	5	2,998,700	103,500	3.5	1.08
7	Mechanical services	7	5,097,840	99,450	2	1.04
8	Roof	2	18,042,350	2,162,300	12	22.55
9	Doors & windows	5	8,375,450	204,200	2.4	2.13
10	Fittings & fixtures	2	50,822,500	1,766,250	3.5	18.41
11	Finishes	4	14,915,900	820,000	5.5	8.55
12	External works	3	26,145,900	1,195,600	4.6	12.47
	Total	**51**	**165,275,690**	**9,589,740**	**5.8**	**100**

Table 3 Presents percentage distribution of failure cost. The results show that the internal quality failures accounted for 5.8% of the total contract sum. Considering specifically on individual elements, it was found that, the cost of failures was greater in the roof representing 22.55% of the total cost of failure, followed by substructure 20.91% , then Fittings & fixtures 18.41%.The least cost was obtained in staircases 0.86%, followed by block work 0.97% while mechanical services have 1.04%. On the other hand the number of incident of failures were greater in mechanical services (7nr) and frames (6nr), then followed by preliminaries, block work, electrical services and doors and windows (5nr each), but the least number of incidents were recorded in Roof and Fittings & fixtures elements each having 2 incidents while the substructure and external work have 3 incidents each. Although mechanical services have the largest number of incident of failures, the cost of failure for this element was low (1.04%), but the roof and Fittings & fixtures with least

number of incidents (2 each) contributed the highest percent 22.55% and 18.41% respectively of the total failure cost. This shows that a high percent of the failure costs was contributed by few numbers of failures incidents in certain elements. It is of interest to note that 20% of the incidents contributed to about 75% of the total cost of failure. The incidents occurred in the following elements; Substructure, Roof, Fittings & fixtures and External Work.

Table 4: Summary of value adding costs and non-value adding failure costs

Ref.	Elements	Cost of elements in BOQ (₦)	Non value adding failure costs (₦)	Value adding costs (₦)	Non value adding failure costs (%)	Value adding costs (%)
A	Preliminaries	2,500,000	125,000	2,375,000	5	95
B	Substructure	22,325,800	2,005,250	20,320,550	9	91
C	Frames	9,266,500	932,420	8,334,080	10	90
D	Block work	3,881,250	93,400	3,787,850	2.4	97.6
E	Staircases	903,500	82,370	821,130	9.1	90.9
F	Electrical services	2,998,700	103,500	2,895,200	3.5	96.5
G	Mechanical services	5,097,840	99,450	4,998,390	2	98
H	Roof	18,042,350	2,162,300	15,880,050	12	88
J	Doors & windows	8,375,450	204,200	8,171,250	2.4	97.6
K	Fittings & fixtures	50,822,500	1,766,250	49,056,250	3.5	96.5
L	Finishes	14,915,900	820,000	14,095,900	5.5	94.5
M	External works	26,145,900	1,195,600	24,950,300	4.6	95.4
	Total	**165,275,690**	**9,589,740**	**155,685,950**	**5.8**	**94.2**

Table 4 indicates the summary of the value adding cost and non-value adding failure cost of the construction project. The value adding cost was obtained by subtracting failure costs from the cost of each element. It was found that the total non-value adding cost accounted for N9,589,740 representing 5.8% of the total cost of contract, whereas the value adding cost accounted for N155,685,950 which represents 94.2% of the total cost. Although in previous study, the “non-value adding costs” constituted the cost of prevention, appraisal and failure (Mark and Cyril 2001), but for the purpose of this study only the cost of internal failure was considered, therefore, the figure 5.8% represents only internal failure cost which is a significant portion of the total non - value adding cost of the project.

Table 5: Average cost of incident

S/N	Elements	No. of quality failures	Cost of qty. failures (₦)	Causes of qty. failure	No. of incidents in each cause	Average cost of incident (₦)
A	Preliminaries	5	125,000	Plant/equip.	Plant/equip. =5	25,000
B	Substructure	3	2,005,250	Design/force majeure	Design=2 Force majeure.=1	668,416.7
C	Frames	6	932,420	Design	Design=6	155,403.3
D	Block work	5	93,400	Design	Design=5	18,680
E	Staircases	4	82,370	Design	Design=4	20,592.5
F	Electrical services	5	103,500	Design/personnel	Design=3 Personnel=2	20,700
G	Mechanical services	7	99,450	Design/personnel	Design=6 Personnel=1	14,207.1
H	Roof	2	2,162,300	Design	Design=2	1,081,150
J	Doors & windows	5	204,200	Design/personnel	Design=3 Personnel=2	40,840
K	Fittings & fixtures	2	1,766,250	Design/supplier	Design=1 Supplier=1	883,125
L	Finishes	4	820,000	Personnel/ force majeure	Personnel=3 Force majeure.=1	205,000
M	External works	3	1,195,600	Design/personnel	Design=2 Personnel=1	398,533.3
	Total	**51**	**9,589,740**			**3,531,647.9**

Table 5 was presented just to assist in calculating the average cost of each individual incident, these was then used to find cost of failures for each cause.

Table 6: Causal analysis of quality failure

S/N	Cause	Number of failures	Percentage Failure	Cost of Incidents (N)	Percentage Cost
1	Plant and equipment	5	9.80	125,000	1.30
2	Force majeure	2	3.92	873,417	9.11
3	Personnel	9	17.65	1,150,821	12.00
4	Suppliers	1	1.96	883,125	9.21
5	Design	34	66.67	6,557,377	68.38
	Total	51	100	9,589,740	100

The quality failures were analyzed to determine their causes and, are divided into the following categories as identified in previous studies (Berber, et al. 2000)

- Plant and equipment e.g. breakdowns, punctures
- Force majeure e.g. third parties, weather, and ground condition
- Personnel e.g. carelessness, lack of training, poor workmanship, injury
- Suppliers (including sub-contractors) e.g. poor selection, errors and mistakes
- Design e.g. mistakes that 'get on to' the construction site

The findings of the causal analysis were aggregated by absolute numbers and cost of failures as shown in Table 6. In terms of absolute numbers of incidents, supplier and force majeure type of incidents were infrequent (1.96%) and (3.92%) respectively. The majority of incidents were attributable to design (66.67%), followed by errors and mistakes by specific individuals 17.65%, plant and equipment attributed 9.80% of the incidents. On the other hand, when the quality failures were analyzed in terms of relative cost, it was found that a high percent of the cost (68.38%) was attributed to design failure, while Plant and equipment accounted for the least cost having 1.30% of the total cost of failure.

Conclusion

The findings of the study reveal that quality failure costs are actually quite large. The internal failure cost constitutes about 5.8% of the total cost of construction, thus, it is an area where non-value adding costs could be reduced if the necessary attention is given.

The study shows that a high percent of the failure costs was contributed by few number of failures incidents in certain elements. It is of interest to note that 20% of the incidents contributed about 75% of the total cost of failure. The incidents occurred in Substructure, Roof, Fittings & fixtures and External Work.

It was also found that, the cost of failures was greater in the roof as it constituted 22.55% of the total cost of failure, followed by substructure 20.91%, then Fittings & fixtures 18.41%.The least cost was obtained in staircases, 0.86%, followed by block work, 0.97%.

On the other hand the number of incidents of failure was greater in mechanical services (7nr) and frames (6nr), and then followed by blockwork (5nr), but the least number of incidence were recorded in Roof and Fittings & fixtures elements each having 2 incidents while the Substructure and External work had 3 incidents each.
The major causes of quality failures were found to be as follows: Design 66.67%, Personnel 17.65%, Plant and equipment 9.80%, Force majeure 3.92% and Suppliers (including subcontractors) 1.96%.
Since the research work found design as the major cause of quality failure, it is recommended that Changes in design during the construction process should be avoided by ensuring that all anticipated causes of such changes are considered appropriately at inception stage. On the other hand, construction Managers should ensure that the work on site comply with the specifications in terms of materials and workmanship, this will minimize the extent of rework during construction. Moreover, plant and equipment should be hired only for the period required to perform a particular task as keeping them idle on site will add to the non-value adding cost; or else, they should be kept in a safe place where no damage or harm can reach them. In addition to these, all materials should be kept in a store free from dampness and leakages to prevent vulnerable materials like cement and the likes from spoilage. Furthermore, Selection of subcontractors and suppliers should be based on competency and experience and not on the basis of 'lowest bidder'. A thorough analysis of cost of quality such as the one presented in this work will provide the necessary information on ways of reducing all aspects that fail to add value to the final (constructed) product.

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