PARETO ANALYSIS ON THE QUALITY SECTIONS/FACTORS PREVALENCE OF NIGERIAN DESIGN FIRMS

Dikko Kado[1] and Kabir Bala

Department of Building, Ahmadu Bello University, Zaria, Nigeria

Design Organisations bear greater responsibility in ensuring quality as they define the requirements of owners into drawings and specifications to contractors. The aim of this research is to establish the prevalence of Nigerian Design Firms in meeting requirements of identified quality management section/factors as well as identifying the vital quality sections/factors which have greater influence on their adherence to quality management provisions based on identified 20 quality sections/factors. Questionnaire survey was used to generate data for the study. Average Percentage Prevalence and Pareto Analysis approaches were adopted for analysis. The study established 73.22% overall average percentage quality section prevalence among the Nigerian Design Firms. This result placed the firms in the category that 'Require Serious Improvement.' Pareto Analysis identified Employee Training and Education (59.49% Overall Average Percentage Prevalence), External Design Review (62.01%), Design Contract Review (65.21%) and Performance Quality Audit (69.12%) as the major (vital) factors among the 20 that had influence on the design firms. It is recommended that adequate attention and action be paid by the Nigerian Design Firms in meeting the requirements of the identified quality section/factors for improved performance.

Keywords: design firms, pareto analysis, percentage prevalence, quality management.

INTRODUCTION

Construction is the fundamental foundation upon which humanity exists, develops and survives. This is because the industry provides the facilities and infrastructure that make people function (Windapo and Omeife, 2012). Design is one of the processes employed by the industry in the evolution of new building projects; normally assembled from selected products designed to suit certain requirements (Tunstall 2000). According to Hutley (1987), *"good design embraces such things as getting a proper brief, ensuring the design matches the client's requirements, prescribing the best material for the job and making sure that what is linked on the drawing board can be built"*. Design quality involves the degree to which features of facility conform to the client's need and it is the quality determined by the consultants on behalf of the client. It is also the quality standards required by the contract and described in the appropriate production information issued by the designers to the production team (Bamisile 2002)."

Building designs are generally guided by client's requirements and standards. Similarly, design and construction quality require appropriate systems, procedures, communication and documentation. Such system is obtainable in various standards

[1] dikkobb@yahoo.com

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that establish minimum quality frameworks and requirements. Variation of standards is attributed to among many reasons, differences in local requirements and specific industry requirements. Hendrickson and Au (1989) mentioned that about 8,000 localities are having their own building codes. Bubshait *et al* (1999) discovered that International Standard Organisation - ISO9000 series, Malcolm Baldridge (MB) and BS 5750 standards provide framework covering 13, 14 and 10 quality sections relevant to design, respectively. Ducan *et al*, 1990 and Bamisile (2004) identified designer qualifications, design contract review, documents preparation, circulation and approval, external design review, design buildability, design maintainability and computer usage as other aspects of design. Moreover, other relevant aspects such as design contract review documents preparation, circulation and approval were also highlighted by Stebbing (1987).

Requirements of Quality Management System (QMS) and other standards paved way for the development of quality management practices. This is in attempt to provide theoretical foundation to scientifically connect traditional Quality Management philosophies with practical activities (Kim *et al* 2012). In such an attempt, Bubshait *et al* (1999) conducted an exploratory survey among local design organisations of the Eastern Province of Saudia Arabia. The survey was aimed at evaluating the prevalence of the quality practices among the design firms. Seventy quality practices were identified, which were grouped under fifteen quality sections. The survey identified a significant need for improvement in 'working relationship', employer training and education', and 'performance audit' among the other sections.

In Nigerian, the issue of quality and standard has been the subject of concern in the country's construction industry due to incessant collapse of building structures around the nation (Abiodun and Afangadem, 2007). Despite the existence of standards in the country, yet shortcomings still persist in the construction industry. A large part of the blame has been attributed to design. Bamisile (2004) remarked that *"one could say that the design team has not yet adopted any quality culture in their contribution to production of buildings in Nigeria"*. Therefore, the aim of this research is identify the prevalence of the practices of the Nigerian design firms using the approach of Bubshait *et al* (1999) and to identify the vital factors which influence their adherence to the requirements of quality management practices using Pareto analysis. As a result of additional factors (quality sections) identified, this research worked with twenty quality sections. The choice of Bubshait *et al* (1999) approach was informed by its applicability to Nigerian set-up. Pareto analysis was identified to be useful due to its simplicity and focus on identifying vital factors out of a total whole.

DESIGN ORGNISATIONS AND PARETO ANALYSIS

Role of Design Organisations in Quality Management

Quality Management is a major management function within construction companies (Harris and McCaffer 2005). Design stage is a vital component of construction QMS. Quality of design involves the degree to which the features of a facility conform to the client's need. Any deviation in defining owner's requirements at design stage can lead to increased costs of project. Oladokun and Adelakun (2008) identified factors that affect quality of building projects. These are; nature of project; design; labour; equipment; subcontractors; systems (computer software and application); process of execution; financial issues; owner, and environment. Similarly, a survey conducted on 159 construction professionals and academics in Egypt to establish relative

importance of factors needed to improve construction by Abdel-Razek (1998) revealed that improving design and pre-construction planning was ranked first.

Design quality is many-faceted; there are a host of factors and considerations that influence design quality (Barret 2000). Proper co-ordination could be difficult but necessary in order to prevent occurrence of defects.

Bubshait *et al* (1999) opined that design organisations bear the greater burden in ensuring quality. They need to provide a high quality of service to ensure that their client's project achieves the best possible standards of cost, time and quality. To achieve quality in design, organisations are required to be innovative in developing quality management practices guided by standards. Quality management practices are critical activities that lead directly or indirectly, to improved quality performance and competitive advantage (Kim *et al* 2012).

Application of Pareto Analysis in the Construction Management

Reh (2014) mentioned that *"in 1906, Italian economist Vilfredo Pareto created a mathematical formula to describe the unequal distribution of wealth in his country."* This was as a result of his observation that 20% of his people owned 80% of country's wealth. Pareto principle states that majority of errors come from only handful of causes. In ratio terms 80% of the problems are linked to 20% of the causes. Eventually, Pareto analysis was employed as a problem-solving tool in many sectors, including construction industry. The Constructor (2015) asserted that *"problem solving for quality management in construction can be achieved by tools like combination of brainstorming sessions, Fishbone diagrams and Pareto analysis"*. Similarly, Faucheux (2013) identified Pareto Principle as one of the *"top"* Total Quality Management (TQM) tools available. 'Six sigma' was also identified among the tools of TQM (EPA 2015). It consists of a set of methods for systematically analysing process to reduce process variation. Sigma quality level serves as an indicator of how often defects are likely to occur in a process. However, according to Harris and McCaffer (2005) Pareto Analysis is a simple technique that helps separates the major causes of problems from the minor ones. It is identified as an effective means of visually representing major causes of a problem. It is useful in helping focusing attention on relevant issues.

Durdyev and Ismail (2012) used Pareto analysis with an aim to identify nature of improvement measures for 20% of factors causing 80% of the on-site productivity problems in the New Zealand construction industry. The study identified project management, project finance, and workforce and project characteristics (out of seven factors) accountable for bulk on-site productivity problems.

RESEARCH METHODS

Sample frame and Sample Sizing

Nigerian building design firms were the target population for the study. To obtain sample size, a list of registered design firms was obtained from Corporate Affairs Commission (CAC), Abuja. 6,990 Architectural and Engineering Consultancy firms registered with the body. By using the approaches outlined by Krejcie and Morgan, (1970), Cochran (1977) and Bartlett et al (2001), a sample size of 237 was calculated at 95% confidence level.

Data Collection

Primary data was obtained using survey questionnaire based established quality sections/factors. 100 quality practices were identified under 20 quality sections/factors. The quality sections correlate with the major design quality sections in the ISO 9000 family series, Malcolm Baldridge Standards, BS 5750 and other sources (Stebbing 1987, Ducan et al, 1990, Bubshait et al, 1999, Sebastian et al, 2003 and Bamisile, 2004). The specific quality sections (coded QS for the purpose of the research) are; Organisational Quality Policy (QS1); Designer Qualifications (QS2); Employee Training and Education (QS3); Design Contact Review (QS4); Design Planning (QS5); Design Inputs (QS6); Design Process (QS7); Documentation Preparation, Circulation and Approval (QS8); Interface Control (QS9); Design Review (internal) (QS10); Design Changes (QS11); External Design Review (QS12); Subcontractor Control (QS13); Documents Control (QS14); Design Maintainability (QS15); Design Buildability (QS16); Computer Usage (QS17); Working Relationship (solely with client) (QS18); Working Relationship (jointly with client and contractor) (QS19); and Performance Quality Audit (QS20).

Respondents were asked to rate their quality practices, namely; 'Always – 100%'; 'Mostly – 75%'; 'Sometimes – 50%'; 'Rarely – 25%' and 'Never – 0%'. 100% rating of a particular quality practice means all requirements are met or available. Responses obtained were used for conducting analysis and values obtained were used to draw inferences. Targeted respondents were the Executive/Senior Management of the design firms since management quality management system is normally their responsibility.

Both stratified random and cluster sampling methods were adopted to ensure groups and geopolitical zone representations, respectively. This is in line with assertion by Fellows and Liu (2003) *"stratified sampling is appropriate where the population occurs in 'distinct' groups or strata."* Similarly, Keller and Warrack (2003) pointed out that cluster sampling is useful whenever the population elements are widely dispersed geographically.

Data Analysis Techniques

Average Percentage Prevalence
This part of the analysis was based on the criteria used by Bubshait *et al* (1999). Average percentage prevalence for each quality practice was calculated using equation 1.

$$\text{Average Percentage Prevalence} = \frac{\sum(\boldsymbol{aixi})}{\sum(\boldsymbol{xi})} \quad \text{----------} \quad (1)$$

Where ai takes the value (rating) 100, 75, 50, 25 and 0; and xi (x1, x2, x3, x4 and, x5) represent the number of corresponding respondents answering always, mostly, sometimes, rarely and never, respectively. Average values were also calculated under each quality section to establish average quality section's prevalence. Averages across the groups were also computed.

Generally, based on the results obtained, observations and inferences on groups' performance in relation to a particular quality sections/factor were drawn using four categories of performance as identified in the work of Bubshait *et al* (1999). They are;

'Commendable (90-100%)'; 'Satisfactory (81-89%)';'Require slight improvement (75-80%)' and 'Require serious improvement (less than 75%)'

Average Percentage Prevalence Approach
Haughey (2014) outlined eight steps involved in Pareto Analysis that lead to indentifying 'vital few' from 'trivial many.'

1 Create a vertical bar chart; causes on the x-axis and count on the y-axis.
2 Arrange the bars in descending order of cause importance.
3 Calculate the cumulative count for each cause in descending order.
4 Calculate the cumulative count percentage for each cause in descending order
5 Create a second y-axis with percentages descending in increments 10; (100% to 0%).
6 Plot the cumulative count percentage of each cause on the x-axis.
7 Join the points to form a curve.
8 Draw a line at 80% on the y-axis running parallel to the x-axis. Then drop the line at the point of intersection with the curve on the x-axis (parallel to y-axis). This point on the x-axis separates the important causes on the left (vital few - 20%) from the less important causes on the right (trivial many – 80%).

RESULTS

Response Rate

The response of the administered questionnaires revealed a response rate of 44.7% (106 questionnaire were returned out of the 237 copies administered). Out of this figure, 96 questionnaires (40.5%) were identified to be usable for analysis. Based on the assertion of Moser and Kalton (1971), result of a survey could be considered as unbiased and significant if return rate falls between 30 to 40%. In that premise, the percentage of usable questionnaires was also adequate for analysis.

It was discovered that Multi-disciplinary firms formed the largest group with 44.8%. This suggests that most of the design firms engage or coordinate more than one design activity. Architectural firms followed with 28.1%, then Structural design firms (16.7%) and lastly, Mechanical and Electrical design firms had 10.4%. Therefore, all the groups of firms identified were represented.

Average Percentage Prevalence

Table 1 presents the average percentage prevalence calculated for the groups of firms with respect to each quality section/factor. Individually, the prevalent practices among the Architectural firms relate to Computer Usage - Q17 (86.11%) and Design Buildability - Q16 (80.56%). Both were satisfactory. However, the remaining quality section/factors require either slight or serious improvement.

The only commendable practices recorded by the Structural firms in relations to Q16 (90.63%). Similarly, the group recorded satisfactory performance in Design Planning - Q5 (87.26), Design Review - Q10 (80.60), Design Changes - Q11 (82.69%), Documents Control - Q14 (82.74%), Design Maintainability - Q15 (83.58%) and Q17 (84.67%). This placed the group above others despite its overall average of 77.4% which generally suggests need for slight improvement.

Standing as the last group with overall average percentage prevalence value of 67.94%, is the Mechanical/Electrical firms which recorded neither commendable nor

satisfactory statuses. The prevalent practices for the groups relates only to Subcontractor Control - Q13 (80.00%), Working Relationship Jointly with Client and Contractor -Q19 (77.50%) and Q10 (75.00%) which all require slight improvement.

Table 1: Quality Sections' Average Percentage Prevalence for Groups of Firms

Quality Section (Code)	AR (%)	ST (%)	M&E (%)	MD (%)	AVR (%)
QS1	72.37	77.97	70.83	74.01	73.80
QS2	69.91	80.32	73.75	71.43	73.85
QS3	52.00	69.79	53.33	62.83	59.49
QS4	65.08	69.85	56.67	69.24	65.21
QS5	78.70	87.26	72.08	84.14	80.55
QS6	70.84	74.22	71.25	71.73	72.01
QS7	73.79	77.78	71.12	75.49	74.55
QS8	69.67	75.47	65.06	70.47	70.17
QS9	67.12	80.04	68.89	74.54	72.65
QS10	76.49	80.60	75.00	81.78	78.47
QS11	72.10	82.69	72.50	78.85	76.54
QS12	65.23	62.13	56.25	64.41	62.01
QS13	78.50	68.39	80.00	75.63	75.63
QS14	74.25	82.74	70.34	82.60	77.48
QS15	76.39	83.58	63.75	83.25	76.74
QS16	80.56	90.63	62.50	86.25	79.99
QS17	86.11	84.67	68.75	87.82	81.84
QS18	71.19	72.32	77.50	77.02	72.32
QS19	68.76	69.77	60.40	71.25	71.90
QS20	67.81	78.35	67.94	69.92	69.12
AVR	71.84	77.40	70.83	75.63	73.22

AR = Architectural, ST = Structural, M&E = Mechanical/Electrical and

MD = Multi-disciplinary.

Multi-disciplinary firms recorded six quality sections/factors with satisfactory practices. These are Q5 (84.14%), Q10 (81.78%), Q14 (82.60%), Q15 (83.25), Q16 (86.25) and Q17 (87.82%). With overall average of 75.63% the group's status generally fall close to that of the Structural firms'.

However, the overall average percentage prevalence of 73.22% calculated for all the groups of firms implied that serious improvement is required in their practices with regards to the quality section/factors. As can be depicted from the general performance, certain quality sections/factors had more influence than others. While Q5 and Q17 appeared to be the most prevalent (both require slight improvement), their influence was outweighed by the influence of the values recorded in the remaining eighteen quality sections/factors. Thus Pareto analysis would be employed to identify those quality sections/factors which if given adequate focus would result in the improvement of the firms' performance instead of all the eighteen.

Result of Pareto Analysis

In order to carry out the Pareto Analysis, the overall average percentage prevalence values of the firms in the last column of table 1 were used. Maximum average percentage prevalence for each quality practice is 100%. Therefore the negative impact of each quality section/factor depends on the shortfalls recorded by each quality section/factor. Table 2 was constructed based on the steps outlined by Haughey (2014). Note that the cumulative value of 100 in the last column corresponds with the quality section/factor having highest shortfall (QS3).

Table 2: Quality Sections' Cumulative Count Percentages

Quality Section / Factor (Code)	SF (%)	CC	PC (%)	CPC (%)
QS3	40.51	535.68	7.56	100.00
QS12	37.99	495.17	7.09	92.44
QS4	34.79	457.18	6.49	85.35
QS20	30.88	422.39	5.76	78.86
QS8	29.83	391.51	5.57	73.10
QS19	28.10	361.68	5.25	67.53
QS6	27.99	333.58	5.23	62.28
QS18	27.68	305.59	5.17	57.05
QS9	27.35	277.91	5.11	51.88
QS1	26.20	250.56	4.89	46.77
QS2	26.15	224.36	4.88	41.88
QS7	25.45	198.21	4.75	37.00
QS13	24.37	172.76	4.55	32.25
QS11	23.46	148.39	4.38	27.70
QS15	23.26	124.93	4.34	23.32
QS14	22.52	101.67	4.20	18.98
QS10	21.53	79.15	4.02	14.78
QS16	20.01	57.62	3.74	10.76
QS15	19.45	37.61	3.36	7.02
QS17	18.16	18.16	3.39	3.39

SF = Short fall, CC = Cumulative Count, PC = Percentage Count and

CPC = Percentage Cumulative Count.

Figure 1 shows a curve plotted using the cumulative count percentage. The broken line separates the vital causes (factors) – top 20% (left side) from the trivial many – lower 80% (right side). It can be depicted that four quality sections/factors fall under the vital few. These are QS3 (Employee Training and Education), QS12 (External Design Review), QS4 (Design Contract Review) and QS20 (Performance Quality Audit). From the average percentage prevalence analysis the four quality sections/factors recorded 59.49%, 62.01%, 65.21% and 69.12%, respectively. All the figures fall below 75% which suggests serious improvement.

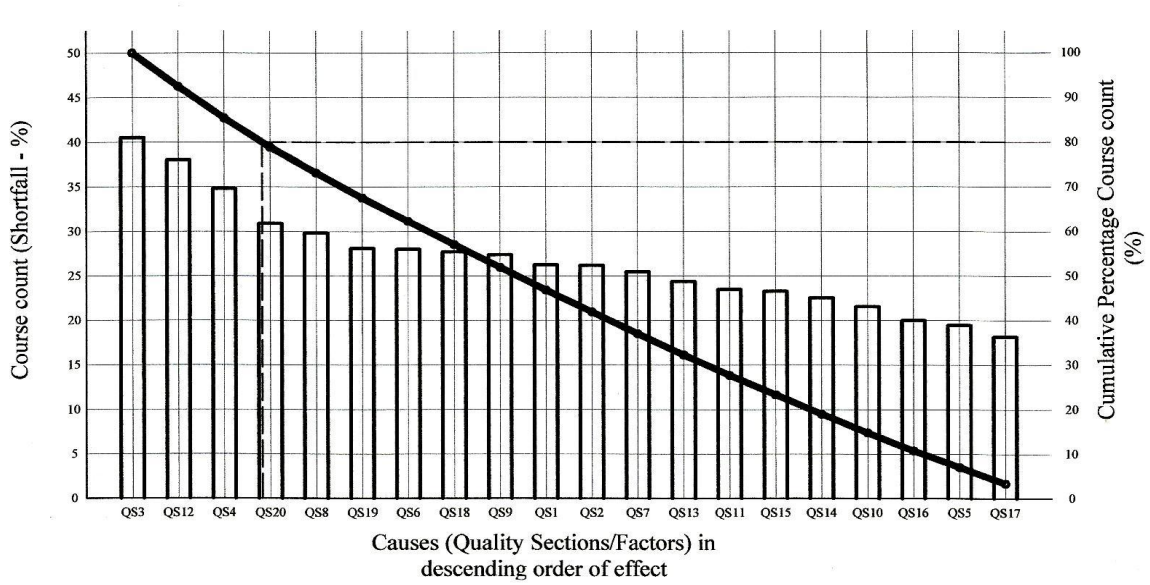

Figure 1, Pareto diagram separating vital from trivial factors

CONCLUSIONS AND RECOMMENDATIONS

The study established that the overall average percentage prevalence recorded by the Nigerian design firms registered by the Corporate Affairs Commission was 73.22% (based on quality section/factors studied). This indicates that the Nigerian design firms generally fall in the category of 'Require serious Improvement'.

The result of the Pareto analysis conducted identified four major (vital) quality section/factors which largely influence the performance of the Nigerian design firms. The sections/factors were; Employee Training and Education (QS3), External Design Review (QS12), Design Contract Review (QS4) and Performance Quality Audit (QS20). It is therefore imperative that quality management provisions relating to these quality sections are adhered to by the design firms. Hancock (1992) argued that *"many of the problems and conflicts within the construction industry are as a result of misunderstanding and a lack of perception founded in our education of construction industry professionals."* Similarly, Stebbing (1987) noted that design contract review is the *"most important activity, but insufficient emphasis is given to it in most QA standards."* Actions required to be performed on the specific practices relating to the identified quality sections/factors according Bubshait *et al* (1999) are follows.

Employee Training and Education (QS3)

In this respect it required that all the practices under the quality section need to be properly addressed. On-the-job training must be provided to employees; short courses and seminars need to be arranged; and organisations must provide library facilities to their employees.

External Design Review (QS12)

Firms must ensure that external design review are performed by client or contractors to verify design adequacy; verifying that consideration is always given to all contract clauses; ensuring that considerations are always given to results of field survey conducted by others; and in case of one man discipline, review of design from outside the organisation is always arranged.

Design Contract Review (QS4)

This requires that; a review team is always constituted comprising of project manager, discipline lead engineers and quality assurance representative to review new design project; the team should always consider the scope of works and ensure it is understood; the team must always ensures that quality assurance plan identifies the true scope of work involved; the team identifies all parties and exact nature of statutory requirements; and that the team should always identify all considerations relating to environmental issues.

Performance Quality Audit

With regards to this quality section/factor, it is regrettable to mention that Standard Organisation of Nigeria (SON) is yet to commence performance quality audit among the Nigerian design firms (Bamisile, 2004). Therefore, personal effort is required from among the firms in preventing, identifying and taking proper actions regarding non-conformance to quality provisions.

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