EFFECT OF DESIGN ERRORS AND CONSTRUCTION COSTS IN THE NIGERIAN BUILT ENVIRONMENT

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ABSTRACT

Design errors, construction mistakes and building failure continues to plague us in the 21st century even though they are avoidable. Understanding the mechanisms of failure in relation to the building process enables us to design and construct more durable buildings and structures. The study assessed the impact of design errors on the cost of building project and investigated remedial measures in eradicating design errors in building project. By using a questionnaire survey, quantitative data for design error effect on construction cost were obtained from industry-based professionals and revealed that design errors arose by a wide range of factors and the most occurred factors according to this study were; demand for speedy construction, lack of detailed drawings, engaging unqualified designers, increasing complexity in project, poor supervision/coordination, poor workmanship, inadequate training, lack of systemic knowledge, errors in calculations and the use of newly introduced materials. The study recommended that there should be proper provision of comprehensive information and employing of the right procurement method which would aid in minimizing design errors resulting to cost overrun in building.

Keywords: Construction Cost, Design, Errors, Cost impact.

1.1 INTRODUCTION AND BACKGROUND

Construction cost plays a pivotal role in the AEC industry as it showcases the feasibility of the project, enable project team members to plan through the design phase to the lifecycle stages, misleading errors in vital phases such as the design stage forebodes hazardous implications in project delivery. According to Sweiss (2018), Design error is a deviation from the true value, lack of precision, variation in measurement owing to lack of human error and mechanical flaws. It is a departure from acceptable or desired practice on part of an individual that can result in unacceptable or undesired results. Atkinson (1998), Musa and Obaju (2016) defined it as failure of human to do a designed task within specified limit of exactness, sequence of time.
Designed errors are those emergences whose origin can be traced to the non-existence of information relevant to construction works and the constructive methodologies already recommended (Brito, 2005). It can adversely influence project performance and can contribute to failures, rework in construction phase, time and cost over-runs, also loss of life of workers and members of the public. Lately discovered omission or errors are responsible for approximately one-third of the contract value, expatiating on the above, a recent study in Australia estimated the cost of design errors from 139 projects; the direct and indirect cost for designed errors were unraveled to be 6.85% and 7.36% of contract value respectively. (Lopez & Love, 2012).

2.0 LITERATURE REVIEW

Design Error

Musa et' al (2016) stated that a large amount of country's maintenance resources is being expended on corrective or remedial measures to buildings and their services due to design or construction defects. Reichart (2006) attested that design errors are unavoidable failures occurring when information is erroneously applied or used or when the pertinent information is not accessible. It is also as a result of failure on the human part to design task within time limit accuracy, deviations from actual values, inadequate precision and inconsistency in measurement. Design errors refer to imperfection/flaws design omission and design conflicts (Coutio, 2012).

These types of errors are often associated with lapses and slips due human negligence, carelessness usually performed during unconsciously routine activities determined by mentally programmed instructions from previously stored thought pattern (Heneman and Gawlinski 2004), 'lapses' as used simply meant or regarded as memory and out of discrepancies/failure totally usually between the work intent and it actual performance (Henriksen and Dayton 2006) In spite of individual ability and attentive lapses are vastly prevalent and ubiquitous part of life (Cheyne & Smilek 2006). Lapses owned also imply absent mindedness which are rampant in individual daily occurrences (Carrier 2008). The 'slips' on the other hand as applied in construction perspective is a term most used interchangeably with 'lapses' in skilled/performance-based error as designed as Al Hattab, and Hamzeh, (2013). These are errors in the action process of a single individual and are likely to be diverged from the team activities as a whole. 'Slips' primarily emerged from the executing process of a task action cycle. According to (Zhang, Pates, Johnson, Shortlife, & 2004). ‘A slip’ is when the knowledge is erroneous, yet failure occurs; information is misinterpreted by an individual majorly owing to their expectations. A slip in action may arise when a quantity surveyor prepares a bill of quantities and raises a dimensional query with the architect when the contact details of the structural engineer and architect may be located adjacent to one another but mistakenly sent the query to the structural engineer instead of the architect. Knowledge based errors arises from human cognition where rational thinking is bounded by either misunderstanding or ignorance as the knowledge required to address the short coming of is inadequate, incomplete, inaccurate or incorrect (Chenyne, Carriera, & Smilek, (2006) Errors that are rule or knowledge based are typically regarded as mistakes. Zhang, Pates, Jonson, and Shortlife (2004) defined a mistake as a behavior that leads to a failure owning to erroneous or incomplete knowledge. According to Zhan, Pates, Johnson, and Shortlife (2004). The majority of mistakes that people makes involves incorrect or missing knowledge. ruled and knowledge-based mistakes are not dissimilar to kills and performance-based steps as they can occur at the same stages of the stages of the action cycle.

Design organization need to foster a leadership enriched culture and structures that engenders groups and teams to develop error free work practices since their prevention can be achieved through a limited extent by interventions at an organization level. (Kalra, 2004, Stock 2007) Fundamentally, people need to take responsibility for their actions and take the necessary precaution not to succumb to slips or lapses, (kalra 2004), personal aids such as post it notes and tie on labels have been found to be an effective reminder towards overcoming issues pertinent to memory and lapses in consciousness (Reason 2000). More so, an individual’s ability to learn and reduce error can increase if incentives are granted like remuneration, additional leave because it would serve as a source of motivation in-order to improve process quality (Kroll and Ford 1992, Love and Smith 2003). Providing designers with adequate time to produce documentation, implementing audit, reviews and verification using cad applications and circumventing time boxing would go some way to containing errors, even though not their mitigation (Manavazhi and Xienzhi 2001, Reason 2002, Love, 2008). Parallel, the improvisation/implementation of construct-ability, analysis, building information, modeling bench marking, quality management, risk management, alliance and integrated procurement method can be used to contain errors at the project level even though there is a limitation in which such errors can be eliminated through the application of the above stated/highlighted strategies (Love and Edward, 2004). Furthermore, such strategies are rarely, even if they were to be implemented simultaneously in the construction an engineer project. Perhaps if it were the case then vastly all the shortcomings that arises in project due to safety, rework, claims and disputes could be prevented (Atkinson, 2002) that is to state that people, over and above through the process of situated learning and knowledge. Many of the errors that occur can be prevented through adherence of proper organizational and project management practices and providing and environment for individual to learn from their mistakes.

Significant organizational and project factors influencing design errors include by the client. A number of organizational and project related conditions cause human errors in construction project (Lopez, Love, Edwards and Davies 2010), (Love, Edwards and Han, 2011). Organizational related factors relate to those that are embedded in the day to day practices of the firm and can vary with the degree of implementation for projects that are undertaken according to Lopez, (2010). The following are factors that influences design errors within a project firm;

- Inadequate training
- Engaging unqualified designers
- Lack of knowledge about material performance
- Unrealistic scheduling of design task functions and the use of time boxing
- Underestimating the resources required for designing tasks.

3.0 RESEARCH METHODOLOGY

This study is based on simple survey, primary source of information which involves intervention and structured questionnaire to construction professionals. The target population for the research were construction professionals in Ogun State. They included Architects, Builders, Engineers and Quantity Surveyors. Purposive sampling was adopted for the sampling. A sample size of 50 was chosen from the sample frame of 91% of building professionals, primary data was collected through questionnaire. A total number of 50 copies of questionnaire were administered and 40 copies were retrieved. Questionnaire was design to elicit information using the primary data. Data obtained were subjected to inferential statistics. The readings were converted to relative significant value through the formula Relative Important Index

4.0 ANALYSIS AND DISCUSSION

Common Design Errors Observed in Construction Industries

The most common design errors observed in construction industries presented using the the relative importance index (RII) for the variables indicate the values 0.794, 0.694, 0.688, 0.675, 0.669, 0.650, 0.644, 0.638, 0.638 and 0.613 respectively, the RII values for electrical boxes made symmetrically, thermal insulation lining on a concrete, inner leaf of external walls not interrupted, omitting the solid barrier, continuous foundation/lowest floor, lack of detailing or bad detailing, insulating the cavity walls with a non-porous thermal material, position of installations, use of timber separating floors, and attic rooms not interrupted. The result suggested that electrical boxes made symmetrically (not staggered) on both sides of the wall ranked the first significantly influential factor that account for common design errors observed in construction industries.

Common Design Errors	**1**	**2**	**3**	**4**	**5**	**Weight**	**RII**
Attic rooms; (ventilated or not) not interrupted	-	7	12	17	4	98	0.613
Position of installations	-	6	11	18	5	102	0.638
Use of timbers separating floors	-	10	8	12	10	102	0.638
Insulating the cavity walls with a non-porous thermal material	-	4	12	21	3	103	0.644
Lack of detailing or bad detailing	-	9	6	17	8	104	0.650

Continuous foundation/lowest floor and no resilient interlayers	-	5	11	16	8	107	0.669
Omitting the solid barriers in the floor	1	8	8	12	12	108	0.675
Inner leaf of the external walls not interrupted	-	4	11	16	9	110	0.688
Thermal insulations lining on a concrete	-	8	4	17	11	111	0.694
Electrical boxes made symmetrically on both sides of the wall	-	4	5	11	20	127	0.794

Table 1.0: Most Common Design Errors Observed in Construction Industries

Contributing Factors to Design Errors Occurring Within Project

The relative importance index (RII) for the variables indicate the values 0.813, 0.831, 0.850, 0.881, 0.888, 0.888, 0.925, 0.938, 0.938, 0.956 for the use of newly introduced materials, errors of calculations, lack of systemic knowledge, inadequate training, poor workmanship, poor supervision/co-ordination, increase complexity in project, engaging unqualified designers, lack of detailed drawings, and demand for speedy construction respectively. The study revealed that the demand for speedy construction was the major factor responsible for design errors occurring within projects undertaken by the firms under review.

Contributing Factors to Design Errors	**1**	**2**	**3**	**4**	**5**	**Weight**	**RII**
The use of newly introduced materials	-	3	7	7	23	130	0.813
Errors of calculations	-	1	9	6	24	133	0.831
Lack of systemic knowledge	-	2	3	12	23	136	0.850
Inadequate training	-	2	3	7	28	141	0.881
Poor workmanship	-	2	3	6	29	142	0.888
Poor supervision/co-ordination	-	2	3	6	29	142	0.888
Increase complexity in project	-	1	2	5	32	148	0.925
Engaging unqualified designers	-	2	1	2	35	150	0.938
Lack of detailed drawings	-	2	1	2	35	150	0.938

Demand for speedy construction	-	-	1	5	34	153	0.956

Table 2.0: Contributing Factors to Design Errors

Cost Implication of Design Errors on Building Project

The table indicated that design errors can adversely influence project performance, also result in cost and time over-run, this was in accordance with the R.I.I. of 0.975 and 0.938 respectively. The Table also unraveled that "design errors makes the amount spent on rework at the design phase to be more than the amount at the construction phase" the least cost implication factor to design errors with R.I.I. of 0.731.

Cost Implication of Design Errors	**1**	**2**	**3**	**4**	**5**	**Weight**	**RII**
Design error makes the amount spent on rework at design face to be more than the one at construction stage	-	8	8	3	21	117	0.731
Design errors influence the quality of design	-	5	7	10	18	121	0.756
Design errors contributes to accident on site	-	1	5	13	21	134	0.838
The cost of rectifying errors and omission increases a project cost	-	1	3	4	32	147	0.919
Design errors contributes to project failures accidents and loss of life	-	-	2	6	32	150	0.938
Design error result in time and cost over run	-	-	2	6	32	150	0.938
Design errors can adversely influence project performance	-	-	2	-	38	156	0.975

Table 3.0: Cost Implication of Design Errors

Design Errors Mitigation

The mitigation methods employed on a construction project to reduce design errors. The result indicates partnering (RII = 0.819), constructability (RII = 0.844), electronic document management system (RII = 0.894), adequate contingency allowance (RII = 0.900), effective and efficient project management (0.906), adequate financial provision (0.913), good communication among the construction project team (RII = 0.956), employing the right procurement method (RII = 0.963) and provision of comprehensive information (RII = 0.988). The result revealed that provision of comprehensive information was ranked first as the primary remedial measure that could reduce the design errors in building construction.

Remedies to Design Errors	**1**	**2**	**3**	**4**	**5**	**Weight**	**RII**
Partnering	-	-	10	9	21	131	0.819
Constructability	-	1	6	10	23	135	0.844
Electronic document management system	-	2	3	5	30	143	0.894
Adequate contingency allowance	1	1	3	7	29	144	0.900
Effective and efficient project management	-	2	1	7	30	145	0.906
Adequate financial provision	-	-	4	6	30	146	0.913
Design review management	-	-	2	6	32	150	0.938
Good communication among the construction project team	-	-	1	5	34	153	0.956
Employing the right procurement method	-	-	-	6	34	154	0.963
Provision of comprehensive information	-	-	-	2	38	158	0.988

Table 4.0: Design Errors Mitigation

Design errors are inevitable issue which have negative impact on project management efficiency and effectiveness, Iness (2004). The study revealed that electrical boxes made symmetrically (not staggered) on both sides of the wall is the most occurring type of design errors majorly experienced in design organizations. The study disclosed that the most key factor that often result to design errors were the high demand for speedy construction work as well as lack of detailed drawings. This was in agreement with the findings from the researchers such as (Lopez, Love, Edwards and Davies, 2010), (Love, Edwards and Han, 2011). It was also disclosed that the proportion of money and time spent on rework in design phase is usually higher than the one at the construction phase. Design errors therefore greatly influence the project performance. The study suggested various measures towards ameliorating design errors in projects, some of which includes; provision of comprehensive information and employing the right procurement method would aid in minimizing design errors in building projects. Nonetheless, it was suggested that the use or application of the aforementioned remedial measures would aid towards mitigating the design errors in building projects and invariably have greater impacts in design quality (Sweiss, 2018).

5.0 CONCLUSION AND RECOMMENDATIONS

This research work concluded that design errors arose by a wide range of factors and the most occurred factors according to this study were demand for speedy construction, lack of detailed drawings, engaging unqualified designers, increase complexity in project, poor supervision/co-ordination, poor workmanship, inadequate training, lack of systemic knowledge, errors in calculations and the use of newly introduced materials.

The following recommendations were based on the research findings which include:Enough time should be allocated for the precontract stage to ensure all necessary contract documents are adequately put in place, Quantity Surveyors should ensure they receive comprehensive information which will be used to prepare Bill of Quantities for the project,proper and adequate supervision should be made for design project for there to be a smooth running of the project work, well skilled professionals /designers with longer years of experience should be engaged on key projects in the construction industry, Cost Planning Techniques should be used during precontract stage and adequate supervision/monitoring and cost control of the project work should be done during the post contract period so that there will not be Cost Overrun, Clients and their representatives should make adequate and proper research and confirm the client's want before embarking on any design or building project and Professional bodies in the Built Environment must not undermine the essence of Continuous Professional Development (CPD) for members as this will make them produce competent, updated and upgraded skilled professionals from time to time via trainings, Workshops, Seminars and further provide comprehensive information which will enable Stakeholders in the construction industry to have access to the right professionals.

It was established through the result of this project work that the predominant occurrence of design errors in building project was majorly as a result of high demand for speedy construction. However, design errors can be mitigated or drastically reduced through provision of comprehensive information.

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