

Design Error Costs in Commercial Construction Projects: The US Perspective

Khalid Siddiqi¹ and Aslam Hayath²

^{1&2} Kennesaw State University, USA
ksiddiqi@kennesaw.edu

Abstract

Design errors are a part of almost all construction projects, and they have led to considerable impact in terms of project costs, quality and performance. These errors have contributed to project failures and deliberate efforts are required to analyze and restrain them for successful completion of projects. The objective of this study was to determine the magnitude of design error's costs in mid-sized commercial projects in Atlanta, US with project value up to 20 million, regardless of procurement or contract methods. The research methodology includes collecting data from industry experts who have completed projects in this range through a structured survey questionnaire. In addition, few general contractors were also interviewed in person to seek responses on design-error-based cost increases in their projects. The intended audiences for this study are design professionals and design firms associated with commercial construction projects. This study concluded that design errors, irrespective of contracting methods, contributed to an increase of up to 8 % of project cost in commercial construction projects.

Keywords

Design errors, error costs, project costs, commercial construction, procurement methods.

1. Introduction

The objective of this study was to determine the magnitude of design error's costs in mid-sized commercial projects in Atlanta with project value up to 20 million, regardless of procurement or contracting methods. The study was based on the hypothesis that design errors contribute to an increase of project cost on an average of 5%, in commercial construction buildings in general. Design errors could trigger major project impacts the expectations of owners and contractors in terms of cost, time and quality. To manage and control such risks of design error costs, there is a need to analyze the probabilistic assessment of estimate before construction. The prime purpose of the study was to determine percentage cost increase caused by design errors in scoped range of commercial projects. Extensive literature survey of design errors, causes, classifications, effects, solutions, influences on project type, preventions, identification and quantification methods was carried out, to acquire background information on this subject. Later a structured questionnaire was developed in consultation with contractors impacted by design errors. A pilot questionnaire preceded the actual survey. The pilot and its results were discussed, refined, re-framed in collaboration with industry experts before rolling out the survey. The questionnaire survey circulated generated twenty-two respondents, in addition seven industry experts were interviewed in person to seek their feedback to confirm the findings from the study.

In construction industry it has been widely acknowledged that design errors have a greater influence on the project outcomes in terms of quality, time and cost. Design errors dominate the cause of accidents, and it has been revealed that gross errors cause 80 to 90% of failures in buildings, bridges, and other civil engineering structures [9]. Considerable amount of research has been done to learn about error impacts on construction and engineering projects [1]. Even at a project level design error costs are rarely measured, although a proclivity exists for them to manifest as change orders or claims [6]. Much of the past research has examined design error costs is anecdotal or based upon a limited number of cases [1,8].

Design error costs in terms of percentage of project value were determined [11] for construction projects in Australia. This study was based on an approach, similar to the above mentioned research and was intended to determine magnitude of design error costs for mid-sized commercial construction projects in Atlanta US with different

parameters. To understand what design errors meant, numerous definitions of error were identified in normative literature [9]. Tucker and Edmonson [13] define error as “the execution of a task that is either unnecessary or incorrectly carried out”.

Similarly, another definition of error by Reason and Hibbs was “the failure of planned actions to achieve their desired goal, where this occurs without some unforeseeable or chance intervention” [12]. The term “failure” is often used interchangeably with error; however, a subtle difference between error and failure exists. A failure is “an unacceptable difference between expected and observed performance [2]. A lack of definition has resulted in a great deal of confusion pertaining to the underlying causes and costs of errors in projects [3].

For this study the authors used definition of error as defined by Reason and Hibbs in 2003. According to their definition “An outcome that essentially involves a deviation of some kind whether it is a departure from the intended course of actions, departure from a path of actions planned towards a desired goal or deviation from appropriate behavior at work” [12]. It is important to note that several latent conditions reside within project systems that influence error-provoking activities to take place and, therefore, contribute to design errors occurring downstream during construction [6]. Moreover, when Design Firms are placed under schedule pressure by clients to design and document, a propensity exists for them to omit task or detail to conform to schedule. This often result in errors in contract documentation, which was identified as a major cause of disputes within construction projects [8].

Design errors which were considered in this study are the ones which manifested into

- Rework
- Change orders
- Claims or any design error which trigger cost implications.
- Combination of one or more or all the above parameters.

The cost of design errors was reported to be lower in building projects (Love & Li ,2000) revealing that they accounted for 14% of rework costs. It was revealed that design errors contained within contract documentation alone can contribute to a 5% increase in a project’s contract value (Lopez & Love, 2012). Despite the considerable amount of research that has addressed error causation, effects in construction projects the actual costs associated with design errors remain unknown because they are not formally measured by organizations (Lopez & Love ,2012). This paper intends to address this shortfall by deriving design errors costs from experts estimates for the commercial construction projects in Atlanta.

2. Research Methodology

2.1 Data Collection

Atlanta a metropolitan city has always been considered as commercial hub for Real Estate Developers venturing into commercial construction projects. Availability of data and easy accessibility has led to focus this geographical location in the US for the purpose of the study. Projects of contract value up to 20 M were considered. Instead of developing a survey questionnaire that sought general opinions from respondents about errors in design, respondents were asked to select one of their recently completed projects to answer survey questions. The survey questionnaire focused on the perceived causes, associated costs, organizational and project management practices implemented.

The relevant data for this study was obtained through the following process. Initially a pilot survey questionnaire was devised and discussed with industry expert’s to obtain their feedback on its comprehensibility and suitability for identifying Design Error costs. Based on the feedback the survey questionnaire was altered and then administered among the General Contractors who were members of Associated General Contractors of Georgia. Survey questionnaire targeted a respondent pool of project professionals mainly from three disciplines designers, general contractors, owners or owner representatives who recently completed commercial construction projects within the range of 20 Million in Atlanta US.

The data was collected by circulating survey questionnaire through email, which had generated forty-two respondents. These include twelve respondents from design professionals, fifteen respondents from contractors and seven from owners. In addition, eight industry professionals, two from owners and three each from contractors and design professionals were also approached individually to cross check the the study findings. Each one of the eight industry professionals interviewed, possessed a minimum of 15 years’ experience in industry and had completed entire project involving design errors. Each interview in person lasted from 40 minutes to one hour. Almost all participants spent more than half of the interview time talking about design errors impacts on their project cost and time. Figure1 depicts the mixed pool of respondents based on their profession.

The scope of the study though was restricted to Georgia, but responses were solicited from members of Associated General Contractors (AGC), which is a national organization with chapters in each US State. The members of AGC execute projects all over the US and encounter common problems including design error issues focused in this study.

Preconstruction estimates completed by contractors are based on types of design drawings completed by Designers. These designers include architects, civil, electrical and mechanical engineers, in addition to numerous other designers involved in each construction project. These drawings may have various levels of design errors due to many factors such as unclear overview of the designs, lack of coordination process, and human errors & omissions and mistakes.

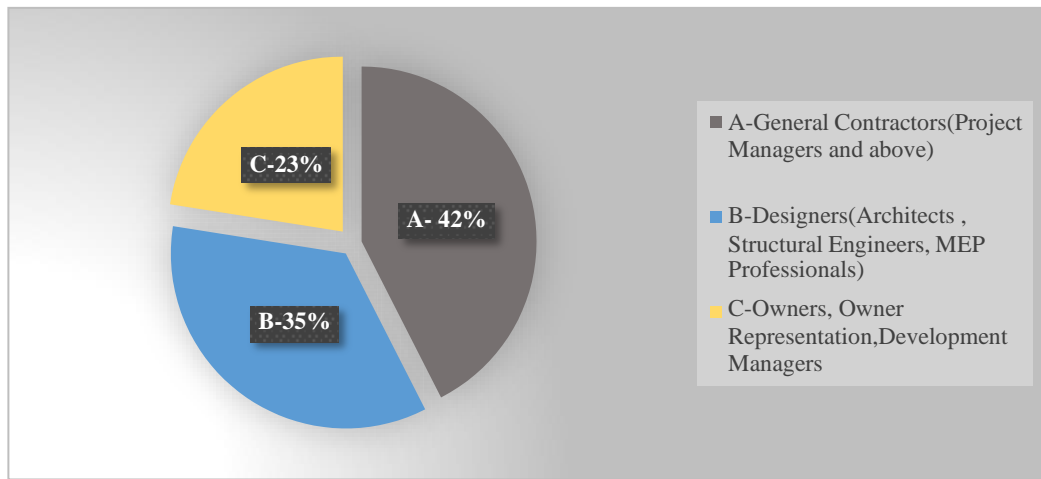


Fig.1. Survey respondents by professional disciplines

The overall data thus generated from both survey questionnaire by email and in person interviews resulted in a sample size of forty projects to arrive at conclusions. The perceptions of the participants are outlined in results and inferences

The Table 1 below indicates the project typologies and their contract value range which have been accounted in the data collection of forty projects. Certain outliers in the data has been excluded to arrive at design error costs with adequate precision on the basis of available data.

Table 1. Project typology

Project Type	Contract value range in million	No of projects
Hotels	16-18	3
Mixed Use	17-21	4
Commercial- offices	10-15	14
Commercial- retail	8-12	11
Commercial- recreational	8-20	8
Total	-	40

2.2 Data Analysis

The data collected was organized in tables, pie charts or bar graphs based on their suitability for analysis purpose. The dependent variable for the study was Design Error cost and the independent variable (Projects) within a range of \$ 20

Million project value. The distilled data was used to process and arrive at the magnitude of design error cost. Ratio scales were used to measure design error costs based on the project value. Mean, mode and average of design costs were extrapolated from the variables and percentage average was derived from the pool of the data collected. Empirical formula was adopted to arrive at the average cost of the grouped data. The data integrity was validated since the experts who both answered the questionnaires and who were involved in the person interview process had more than a decade of professional experience and expertise in the commercial projects within the prescribed geographical region.

3. Results and Analysis

The data reliability was ensured through the use of experienced professionals having expertise of handling start-to-finish each project surveyed. The Figure 2 below depicts the impact of design errors on time, cost and organization values on a scale of severity from 1 (least impact) to 5 (severe impact) with respect to three respondents a) Owners b) Design professionals c) General contractors.

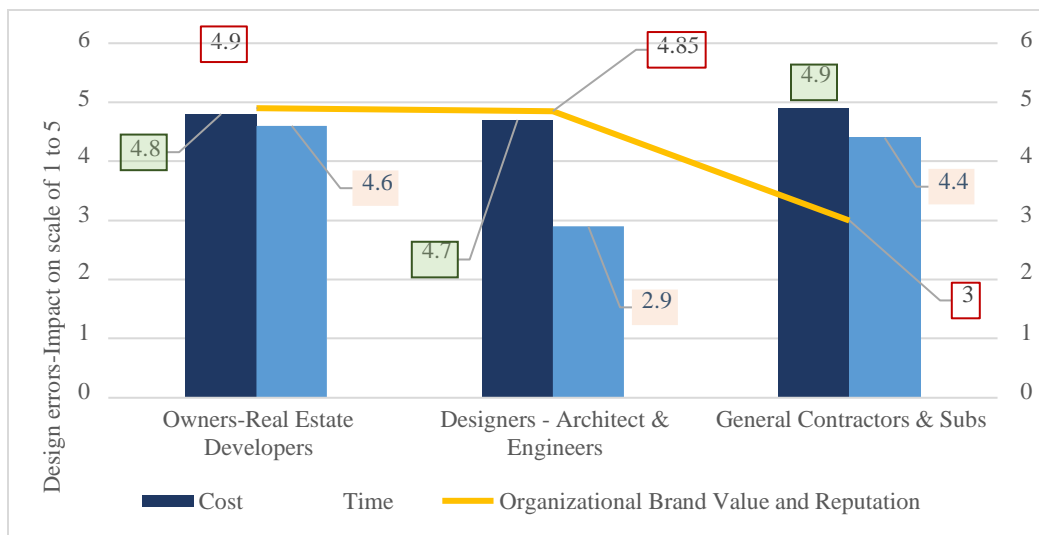


Fig. 2. Design Error impacts on Cost & Schedule and Organizational value based on the survey

All respondents unanimously agreed that design errors had severe impact on Cost with 4.9 value, but there were some variations in opinions with respect to Schedule. General Contractors and Owners both agreed that design errors had severe impact on Schedule with 4.6 value as average, however respondents from designer's pool indicated that impact on Schedule can be compensated by adopting appropriate mitigation measures and the severity was rated as 2.9. They did not consider design errors impact on Schedule as critical as Cost. While designers and owners were on the same page with respect to the impact of design errors on organizational brand value was severe, on the contrary General Contractors had different perspective and their rating was low as 3 out of 5 in terms of severity.

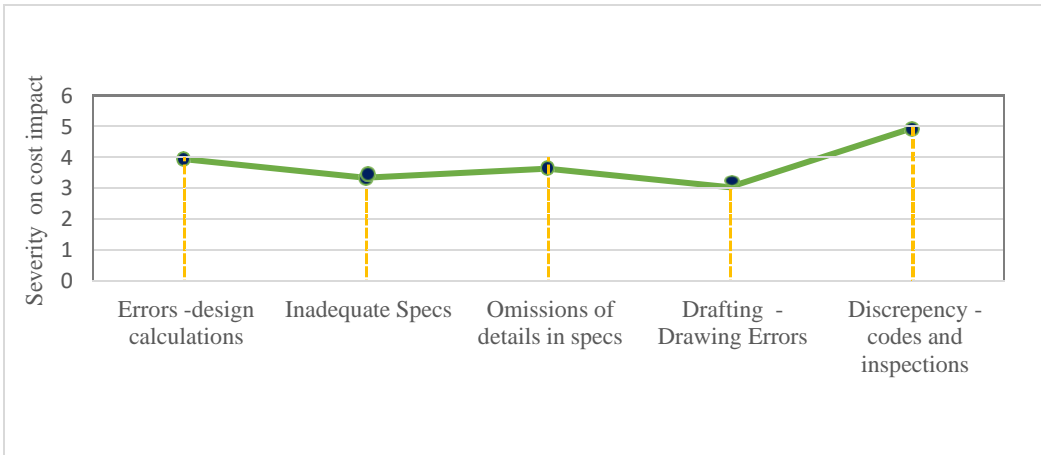


Fig. 3. Impact of Design Error types on Costs

Figure 3 illustrates the cost impact of each design error type on scale of 1 to 5, 1 being least impact to 5 being most severe. As per the data output discrepancies between codes and local inspections had value of 5 (most severe). One major concern of the respondents indicates that there is a gap or technical non-agreement between the Local Regulators. Infact 96% of the respondents indicated that though architects and owners comply with the codes, the local inspectors disagreed, which resulted in escalation of time, cost and additional unanticipated rework. However, 87% of the respondents suggested that Drafting & Drwaing error impact value on project Cost is 3, least but not null. Drafting errors mostly can be mitigated through the RFI process during the construction. It was observed that all respondents didn't rate any of the above factors listed in the graph below 3 in terms of severity.

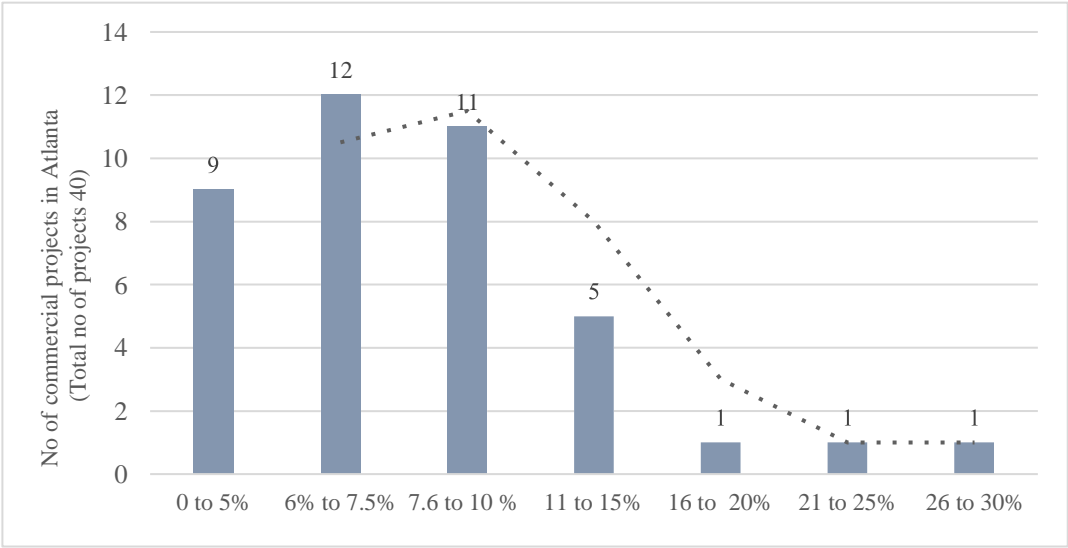


Fig. 4. Design errors costs as percentage of project contract value in commercial projects

In this study average project cost increase due to design errors a sample of 40 projects were analyzed in detail from the collected data. Figure 4 represents the variation of design error costs as a percentage of total project cost arrived at from data (X-Axis). The Y-Axis lists the number of projects included in the analysis. The range of Cost increase varied from 3.5 % to 30% due to Design Errors ,which were manifested as claims, reworks and change orders. It is quite evident from the graph that the mode is 6 to 7.5 % based on the survey. Few projects had the anomaly of 30% increase in terms of project cost. The specific case in which 30% increase in project cost was caused by improper

design briefs received by designers. The improper design brief led to inaccurate design calculations, which ultimately resulted in large technical impacts.

It was also quite evident that none of the respondents indicated that design errors costs were nil or zero based on their experience, which again reinforces the fact that design errors are part and parcel of construction industry.

Table 2. Design Error Rankings

Design Error costs range	Frequency	Percentage %	Ranking
0 to 5 %	9	22.5	3
6 to 7.5%	12	30	1
7.6 to 10%	11	25	2
11 to 15%	5	10	4
16 to 20%	1	2.5	6
21 to 25%	1	2.5	7
26 to 30%	1	5	5
Total	40	100	

Table 2 illustrates the frequency of the range of design error costs and their respective percentage and rankings. It is been evident that 77.5% of projects lie in the range of 0 to 10% out of which 30% lie in range of 6 to 7.5%. The mean(average) derived from the data was 8% based on the empirical formula for the grouped data collected from commercial construction projects in the scoped study.

4. Conclusions

This study was intended to determine the design error costs in terms of overall project value for commercial building projects in the range of \$ 20 Million in Atlanta, US. The results from the structured survey from the industry experts and subsequent in-person interviews indicated that range of design errors on Costs ranged from 3 % to 30%. In precision design errors increased project cost by 3.5 to 15% for most of the projects. In rare cases design errors had increased project cost by 30%.

The study concluded that the commercial construction project costs had an average increase of 8% of the project value due to design errors for the projects considered in the study scope. It was also revealed that design errors did not vary much based on the procurement or contracting method for commercial construction projects. The study also concluded that these design errors not only had impact on cost but they had also considerable impact on the owner's reputation..The results also indicated that design errors had been prevalent in commercial construction projects even when advanced software's were implemented. The use of software's as per the expert's feedback were able to minimize the design errors to a considerable extent but did not eliminate them. None of the respondents indicated that the design error cost was zero in their projects. Therefore, it is obvious that design errors and their cost implication in projects remains a concern in commercial construction industry.

One outcome of this study was that there is always some level of disagreement between Regulators and Project Team members in terms of code compliance in designs. The discrepancy persists despite code compliance claimed by the Designers. Survey indicated that owners, designers and contractors agree on the same unanimously that there is a technical gap existing between the codes and inspection results that impact Costs and Schedule. Further research is needed to identify specific areas of code compliance disagreements between Designers and Regulators.

This study provides initial platform to examine the design error costs in new commercial projects in scoped in the study. The study focus was for only new projects and did not cover renovation or other types of projects. Further studies are recommended to identify the average design error costs for renovation and refurbishments commercial construction projects.

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