Design Errors in Building Construction Projects

Utpreksha Vashishtha¹, Vaibhav Bawaniya², Dr. Virendra Kumar Paul³

¹PG Student, ²Assistant Professor, ³Professor
¹, ², ³Department of Building Engineering and Management
¹, ², ³School of Planning and Architecture, New Delhi

Abstract - Design errors are inevitable in the construction industry. These are unavoidable failures occurring when information is incorrectly applied or used, or the pertinent information is not accessible. 'Design errors' refers to the failures of humans to design tasks within time limits and accuracy (E.D Love, 2016). Owing to the required level of accuracy and time constraints, common human errors lead to design errors. These problems can influence the quality of both design and construction. Deviation from actual values, inadequate precision and inconsistencies in measurement are also considered as design errors (Dosumua, 2017). 'Design errors' refers to design mistakes, design omissions, and design conflicts. These mistakes can occur due to memory failures or slips due to incorrect knowledge (Ali Haghani; 2015). Many researchers consider design errors as the most critical problems in construction industry. There is need to evaluate the types and causes of design error there are in a construction project. To create an effective strategy to manage design errors, it is important to recognize the level of their impact. Design errors in different building components may have different levels of impact. The aim of this study is to identify and evaluate the impact of design errors in building construction projects and develop a framework to address them effectively.

Key Words: Design errors, Errors, Rework, Cause of design error, Impact of design error.

1. INTRODUCTION

Construction is complex and uncertain by its own nature (Dedy Farhan Fuadie, 2017). Unlike other sectors of the economy such as manufacturing, the design and production activities of construction projects are separate functions (D, 2017). That is, the design and construction of a building are two separate functions performed by different parties working independently (Juliana, Ramirez & Larkin, 2005). Design errors are unavoidable in any construction projects and can adversely affect cost, schedule and safety and project performance (Peter E.D. Love, 2014). Despite stringent rules and procedures, regulations and standards, errors still manage to propagate themselves within the design process (Peter E. D. Love, 2009). Design errors are an inevitable and important issue which have negative impact on project management efficiency and effectiveness (E.D Love, 2016). They are the important contributors to reworks, cost overruns, schedule delays, and unsafe environments which affect project performance (Yogen Sadashiv Masurkar, 2014). Different types of design 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 mistakes (Dosumu & Aigbavboa, 2018). In construction project, all the stakeholders such as owner, contractor have different interests in the design implementation. These various interests leads to design errors which can arise at any time. The occurrence of these errors can increase many difficulties in construction management (Bijen, 2003). These difficulties can lead to between 80% and 90% of the failures occurring in construction projects (Robert Lopez, 2016). Engineering failures account for as much as 10% of the total investment in new buildings and structures (Musa Shamsudeen, 2016). Importantly, these failures are not restricted to simple direct cost considerations because they are also inextricably linked to less tangible environmental and social costs (E.D Love, 2016). They can also incur more cost that adds a project's value around 14.2% (Ali Haghani, 2015).

Despite the amount of research that has addressed error causation in construction and engineering projects, the actual costs associated with design errors remain unknown because they are not formally measured by organizations (Love et al. 2009). Even at a project level. Design error costs are rarely measured, although a proclivity exists for them to manifest as change orders or claims (E.D Love, 2016). If the occurrence of design errors cannot be effectively controlled and it can greatly affect the construction process. Design errors are thus very significant and should be carefully managed to ensure the success of construction projects and to minimise difficulties in project performance.

2. NEED IDENTIFICATION

Design errors are unavoidable in any construction projects and can adversely affect cost, schedule and safety and project performance (Peter E.D. Love, 2014). Despite stringent rules and procedures, regulations and standards, errors still manage to propagate themselves within the design process (Peter E. D. Love, 2009). Even at project level design error costs are rarely measured, although a proclivity exists for them to manifest as change orders or claims (E.D Love, 2016). A large proportion of
rework and non-conformance costs are also directly due to deficiencies in design and contractual documents and in the transfer of information during the design process (Peter E. D. Love, 2009).

“Avoidable errors are costing the £100bn a year construction industry £21bn annually, according the ‘Get it Right Initiative (GIRI)’ launched to help firms avoid construction errors.” The research shows that between 10% and 25% of project costs are lost through errors. This includes direct and indirect costs plus unmeasured costs.” (GIRI, 2019). On average 78% of the total numbers of contract deviations identified were design related and that these deviations made up 79% of the total deviation costs (Burati et al.2004). A national survey of Australian contractors by Tilley & McFallan in 2000 found that design documents deficiencies were directly responsible for approximately 50% of all variations, contract disputes and cost overruns (Tilley, 2005). A research by the USA’s Construction Industry Institute (CII) reveals that direct costs caused by rework average 5% of total construction costs (CII 2005) (but range from 0-25%). “Avoidable errors are costing the £100bn a year construction industry £21bn annually, according the ‘Get it Right Initiative (GIRI)’ launched to help firms avoid construction errors.” The research shows that between 10% and 25% of project costs are lost through errors. This includes direct and indirect costs plus unmeasured costs.” (GIRI, 2019). Architectural error amount 60% of errors in construction project based on a survey of 250 building projects (Vachara Peansupap, 2015). One of the main reasons for claims in construction projects is the engineering design for the project errors. Claims because of architectural errors are 20 % of the contract value (ER. Hassan Mohamed Abdulnabi, 2016). As per the research done in 2019 on risk in design management in SPA, Delhi, design error and change had the second highest risk severity with respect to design management after lack of coordination.

Design errors have been the root cause of several catastrophic accidents that have resulted in the loss of life and injury of workers and members of the public. So much emphasis is placed on the issue of time and cost that quality takes a back seat (Musa Shamsudeen and Obaju Biodun .N, 2016). Due to the complex nature of the construction industry, and the variety of definitions and interpretations of error or rework, there has been little agreement as to a common classification system for recording errors and rework. This leads to uncertainty over the true scale and source of the issue. To avoid errors in construction project and to complete the project on time without excessive cost overrun due to errors, specific attention should be paid in the planning and designing phase of the project.

3. AIM

Aim is to identify and categorize Design Errors in building construction project and their cost implications and to develop a framework to address the design error in building construction project.

4. OBJECTIVE

1. To develop an understanding of Design Error in Building construction projects.
2. To identify, evaluate and prioritize design errors and their causes in the building construction project.
3. To identify the impact of design errors on a building construction project and their cost implication.
4. To develop a framework for the mitigation of design error in building construction projects.

5. RESEARCH METHODOLOGY

To address the research questions or meet the research objectives, the following research steps are proposed-
Step 1 - Desk research for collecting the data on what constitutes as design errors, their types, their causes and impact.
Step 2 – Listing of design error, their causes and impact from literature, case examples and survey.
Step 3 – Ranking of Design Error on the basis of their occurrence and identifying most occurred error and using this ranking in framework.
Step 4- Development of steps involved in framework and demonstrating it through an example.
Step 5-Validation of framework through its application on case example.

6. LITERATURE REVIEW

Errors occur in all construction projects and cannot be avoided or disregarded. When an error occur, some modifications are required to the project design and specifications (A. Fleming, 2013). In the past, several researches have been done the design error in construction industry. The main focus of the literature review is to analyse design error in building construction industry, identify the cause of design error, its impact on a building construction project and the methodologies adopted for the mitigation of error, design management and their limitations in order to develop a framework to deal with the errors.
6.1 Design Errors

An error is defined by (Webster, 2017), as “a deviation from accuracy or correctness; a mistake, as in action or procedure; an inaccuracy, as in speaking or writing.” Design errors are the deviation from the plans and specification (Ali Haghani, 2015). Design errors are the occurrences which were unexpected and which could not be attributed entirely to chance or circumstances (Busby, 2001). A number of latent conditions reside within project systems that influence error-provoking activities to take place and, therefore, contribute to design errors occurring downstream during construction (Love et al., 2009). Deviation from actual values, inadequate precision and inconsistencies in measurement are also considered as design errors (Love et al., 2009). Researchers that have examined design errors in construction have often interchangeably used the terms inadequate design, design inefficiency, design changes, omissions, defects, quality deviations, non-conformances, and failures. (Josephson et al. 2002). 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” (Ayinuola Olalusi, 2004). With a failure an implicit expectation, exists; whereas, in the case of an error an unforeseeable or chance intervention takes place.

The image describes that due to design error and variation there is delay in completion of work and not completed work. Figure 2: Schematic model for understanding the dynamics of design errors. (Image source: Mathematical and Computer Modelling, 2013).

![Image](https://image-source.com/)

**Image - 1:** Schematic model for understanding the dynamics of design errors. (Image source: Mathematical and Computer Modelling, 2013)

**Table - 1:** Definition of design errors as described in various literatures. (Image source: Author)

<table>
<thead>
<tr>
<th>SNo.</th>
<th>Authors</th>
<th>Definition of Design Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>John J. Anumah, Lesado Anumah</td>
<td>Design errors are omissions and ambiguities from drawing or specification.</td>
</tr>
<tr>
<td>2</td>
<td>Reason and Hobbs (cited in Robert Lopez 2018)</td>
<td>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 toward a desired goal or deviation from the appropriate behavior at work.</td>
</tr>
<tr>
<td>3</td>
<td>Busby (2001)</td>
<td>Occurrences which were unexpected and which could not be attributed entirely to chance or circumstances.</td>
</tr>
<tr>
<td>4</td>
<td>Bea (cited in Atkinson 1998)</td>
<td>A departure from acceptable or desired practice on part of an individual that can result in unacceptable or undesired results.</td>
</tr>
<tr>
<td>5</td>
<td>Knocke (2000)</td>
<td>Any departure from correct construction including checking and supervision technical inspection; and absence of adequate instructions for maintenance and operation of the building.</td>
</tr>
</tbody>
</table>
7. Survey

A survey was carried out with the aim of ranking them in terms of their occurrence in construction project through the collected data of design error through survey and case examples. The survey consisted of 17 questions for the purpose of ranking. Design Errors were rated in terms of the frequency of their occurrence in a building construction project on a scale of 1 to 5.

1 - Rarely (Less than 5 times), 2 - Sometimes (5 - 10 times), 3 - Frequently (11 - 15 times), 4 - High (16 - 20 times), 5 - Very High (> = 20 times).

Relative Importance Index is calculated for each of the error and ranked accordingly.

RII = \( \frac{\text{Sum of weights (W1 + W2 + W3 + ……+ Wn)}}{A \times N} \)

Where W = weights given to each factor by the respondents and will ranges from 1 to 5
Where ‘1’ is less significant and ‘5’ is extremely significant. A = highest weight (i.e. 5 in this case), and N = total number of respondents.

Higher the value of RII, highest is the occurrence of that error.
RII has been calculated for every design error as explained below:

Q1: For Design Changes based Error: RII = 233/5x37 = 0.991

7.1 Survey Results

<table>
<thead>
<tr>
<th>Types of Design Errors</th>
<th>RII Value</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Design Change based: Due to frequent design changes during construction process.</td>
<td>0.991</td>
<td>1</td>
</tr>
<tr>
<td>2 Coordination based: Due to improper coordination between the stakeholders.</td>
<td>0.710</td>
<td>3</td>
</tr>
<tr>
<td>3 Scope based: Due to unclear scope of work.</td>
<td>0.629</td>
<td>7</td>
</tr>
<tr>
<td>4 Omission based: Due to omission of data in design drawings/documents.</td>
<td>0.689</td>
<td>4</td>
</tr>
<tr>
<td>5 Non-conformance based: Due to non-conformance of design with the standards.</td>
<td>0.557</td>
<td>11</td>
</tr>
<tr>
<td>6 Skill/performance based: Due to lack of skills of the designer.</td>
<td>0.548</td>
<td>12</td>
</tr>
<tr>
<td>7 Drawing/Documentation based: Due to improper documentation of shop drawings and</td>
<td>0.642</td>
<td>6</td>
</tr>
<tr>
<td>design data.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Process based: Due to the software/techniques used while developing the design.</td>
<td>0.463</td>
<td>16</td>
</tr>
</tbody>
</table>
8. FRAMEWORK FOR ADDRESSING ERRORS IN BUILDING CONSTRUCTION PROJECTS

Framework will have all the stages of design process in a construction project and all the errors that may occur in those identified stages and their impact on time and cost and resources required to mitigate them. One can identify the impact of design error at any stage of building construction process, which has been a constraint in past literatures.

8.1 Methodology of Framework

Step 1: Identify all the stages involved in designing process of a construction project from the inception to the completion of the projects.

Step 2: Identify errors which are possible to occur at the identified stages of design process.

Step 3: Identify resources required for the design process.

Step 4: Develop a schedule of a construction project with those stages.

Step 5: Develop a schedule for a construction project and introduce all the identified errors in those stages of project.

Step 6: Analyze the impact on time and the extra time required by the resources will result in added cost for the project.

8.2 Data Inputs in the Framework

Following data will be required for the development of the framework: Stages of construction projects, Time taken by every stage of project, Resources required for the design error, Cost of the resources required for the stages, Type of errors that occur in all those identified stages.

8.3 Outcome of the Framework

Following output will be developed from the framework: Impact of every error on the project schedule, Impact of errors of project time, Impact of errors on project cost, Delay occurred by each type of project, Time taken to rectify the errors, Resources required for rectifying an error.

8.4 Who can use the framework

Following project participants can utilize the framework: Project manager, Architect, Owner.

Detailed framework has been presented in the thesis report with detailed schedule and stages of design process. An example is presented here for demonstration of framework.

8.5 Demonstration through Case Example

Issue: Wall constructed in wrong location instead of partition wall because of absence of note.

Error type: Drafting Error

Identification Stage: First floor Brick work
Identification method: Monthly visit by architect

### Table 3: Example for the Framework (Source: Author)

<table>
<thead>
<tr>
<th>Construction stages (PMBOK)</th>
<th>Design Stages (RIBA Plan of Work 2013)</th>
<th>Milestone</th>
<th>Expected completion time</th>
<th>Delay In the activity</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation</td>
<td>Strategic Definition/Need for project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>Preparation of Brief</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concept Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developed Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Execution</td>
<td>Construction</td>
<td>Site work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Civil Works</td>
<td>16 days</td>
<td>30</td>
<td></td>
<td>Indirect impact on project schedule. 65 days lag with finish to start activity for MEP Maximum impact on MEP works</td>
</tr>
<tr>
<td>Monitoring and Controlling</td>
<td>Service MEP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finishing work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Landscape and external development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closing</td>
<td>Handover and Close Out</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Image 2: Schedule without the application of error (Source: Author)](image2.png)
Image 3: Schedule with the application of error, 21 days delay in ground floor work. (Source: Author)

<table>
<thead>
<tr>
<th>Solution:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time taken to rectify drafting error</td>
</tr>
<tr>
<td>Time taken to demolish the wall</td>
</tr>
<tr>
<td>Rework</td>
</tr>
<tr>
<td>Total delay for this error in the activity</td>
</tr>
<tr>
<td>After adding the error, delay in Schedule of ground floor</td>
</tr>
<tr>
<td>After adding the error, delay in Schedule of project</td>
</tr>
<tr>
<td>Time required by other consultants to coordinate the drawings</td>
</tr>
<tr>
<td>Resources required to rectify the error</td>
</tr>
</tbody>
</table>

The total costs of design errors were calculated from the sum of the direct and indirect design error costs respondents.

Total Cost of Design Error = Direct Cost + Indirect Cost
Direct Cost: Demolition cost + Resources cost/day cost X9 + Material cost + Architects/day fees X12

9. CONCLUSION

From the application of DE in project schedule it was derived that it has both direct and indirect impact on construction project and it varies depending upon the stage of the project. During plan stage impact of error mostly result in time overrun and it has less impact on the direct cost of the project. During construction phase, civil work - MEP work has the maximum amount of impact on the time and cost of the project. With the application of framework one can calculate the cost and time impact of design error which can be utilized in future projects as well. This framework can be utilized at initial stages of construction project to reduce the impact the design error in construction project.

REFERENCES

Dosumu, O. & Aigbavboa, C., 2018. An assessment of the causes, cost effects and solutions to design error induced variations on selected building projects in Nigeria.


