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EFFECT OF DESIGN MANAGEMENT ON COST PERFORMANCE OF CONSTRUCTION PROJECTS

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Design management is one of the key processes of any construction project, and its effects across other construction processes are quite pivotal. Irrespective of the particular project delivery system, design management plays a significant role in overall cost outcomes in a project. Design management requires a careful investigation in relation to its potential influence on downstream cost over-run issues in most construction projects. In this research, a selected set of 25 attributes associated with design management have been analyzed from the perspective of three key stakeholders: designers, clients and contractors. Based on Factor Analysis, pre-design consideration is found to have significant effects on managing cost performance in project. Regression analysis reveals that the initial follow-up of design with respective parties potentially contributes in cost savings at the latter phase of project. The finding is expected to lead towards improvement of Design Management practices, and meeting the project objectives through better quality, improved constructability, and, eventually, providing value for money to both investors and owners in the project.

Keywords: Design management, Design-build, Cost performance, Indian construction.

1 INTRODUCTION

India is being considered as one of the major hubs for progression and development in construction industry with fast rate of infrastructure scope. The construction industry is the second largest industry in India after agriculture, comprising about 30% of overall Gross Domestic Product (GDP), thus an integral part of the country's infrastructure and industrial development. Indian construction industry GDP increase varied from 7.5% to 9.6% over the past 5 years, resulting in an unprecedented average growth rate of 8.5%. Construction is the basic input for socio-economic development, and has accounted for around 40% of the development investment during the past 50 years in India. Around 16% of the nation's working population depends on construction for its livelihood.

Cost is a prime factor for any construction project, and cost over-run is a major global problem. Among various phases of construction, implementation or executions of construction, projects generally involve a multitude of stakeholders ranging from designers, clients, and head contractors, to specialized sub-contractors for providing services and supporting operations. When considering cost variation, design management is often neglected or left out as insignificant, being considered just as a

process of overview drawing. Design management is not only the management of drawings needed for the execution of any project, but also a series of choices and decisions over a significant period, with control of design related to practical execution and maintenance. Technological, economic, and socio-cultural advancements in complex modern projects are creating new challenges in Design Management practices. For a building design, the objectives could include functionality/performance, aesthetics/impact, as well as buildability and quality (Ferguson, 1989, Thomson *et al.* 2003).

The real impact of design on benefits or building value lies in paying attention to those details that not only deal with how the building meets functional, emotional, and practical needs but also what the aesthetic user needs. Designs make a building enjoyable, with technical adequacy meeting environmental challenges (such as climate and structural safety, ease and convenience of maintenance, etc.); in short, all things that make architecture good (Thomson *et al.* 1993).

In this study, the potential influence of design management on cost over-run was investigated, and an attempt was made to identify the attributes of design management, requiring a careful consideration for controlling the chronic issue of cost over-runs in most Indian projects. This research identifies the key design management attributes associated with the cost performance of Indian construction projects.

2 METHODOLOGY

This research was carried out through the compilation of a survey questionnaire. A literature review was undertaken as a guideline to formulate questionnaires considering three key stakeholder categories - designers, clients and contractor. The finalized questionnaires were then distributed online personally through emails, and through an online survey system to those stakeholders in major Indian construction projects. An overall understanding of and involvement in design management was a major concern among most professionals in Indian construction projects within the valid responses. Responses were analyzed using SPSS for action, attribute, and attitude through bivariate correlation, regression, rotation, descriptive, and factor analysis.

2.1 Questionnaire Survey

Referring to a significant amount of previous research, a comprehensive questionnaire was developed in two stages. The chronic issue of cost overrun was addressed from a design management perspective. The first stage considered every stage of design and its relevance to the three stakeholder categories in detail, leading to a long list of cost-dependent issues of design process. Three individual sets of 125, 93, and 126 issues were addressed relevant to designer, client, and contractor respectively, along with a set of common questions. After reviewing the responses to the first-stage questionnaire, the perspectives of designers, clients, and contractors were integrated, and a total of 25 attributes were short-listed. These attributes were comprised of major design issues at various stages of design, resource, processing, and execution of a project, and were found to have a significantly higher impact on the cost of the project under 9 major categories: Organizational Policy, Procurement Method, Design Brief/Contract, Initial Design Phase, Design Planning and Execution, Design Supervision, Design

Discrepancies, Working Relationship, Project Completion, and Hand-over. The dataset was analysed using the Standard Statistical Method, namely Factor Analysis, for extracting the key factors affecting the cost performance in Indian construction projects (Field 2005).

2.1.1 *Data collection and respondents*

Stakeholder selection was done by considering their involvement in major infrastructure projects with high complexity rating and project budget, ranging from 1000 million - 9000 million Indian rupees in the north-central region of India, including New Delhi, that had incorporated a design-build delivery system. The questionnaire used a five-point Likert's Scale analysis: 1: Strong Agree; 2: Agree; 3: Neutral; 4: Disagree; 5: Strong Disagree. There were 83 valid responses total; 49 responses were received in the first stage comprised of 28 designer/architects, 10 from clients, and 11 from contractors. The remaining 34 responses were collected through an online survey in the second stage of questionnaire distribution.

Respondents' validity in the data sample was based on their level of professional understanding, experience, and expertise in construction industry, across government, semi-government and private organizations in India. The experience rating of respondents was highest, with 34% for respondents with an average experience of 15 years, and 16% with over 20 years of experience. The highest proportion (66% of responses) were from design professionals, as well as 19% of responses from contractors involved in construction process following designs, and 15% of responses from clients who invest in construction projects.

3 FACTOR ANALYSIS

Data analysis was carried out using Statistical Method and Factor Analysis approach. SPSS (Statistical Package for Social Sciences) was used to gain greater insight into the actions, attributes, and attitudes of designers, clients and contractor. Statistical analysis was followed with a series of tests conducted using SPSS, namely Reliability Analysis, Data Reduction with Extraction. The extracted data was used to run Varimax Rotation Analysis, Descriptive Analysis, Multiple Regression, and Pearson's Correlation (Field 2005).

Table 1 depicts the results of factor analysis. The details of each factor variance percentage and factor loading of attributes are shown in the last two columns. The impact of each attribute through factor loading ranges between 0.4 and 0.9, with only one attribute less than 0.5 explaining the influence of each on a total variance of 67.90%. The first four key factors are discussed below.

Table 1. Results of factor analysis with factor loading.

ID	Factors	Factor Loading	% Variance Explained
Factor 1: Pre-design Phase			
D1	Selection criteria of organization/team causes cost over-run.	0.514	16.60%
D2	Professionally qualified team members in the project team.	-0.658	
D12	Risk factors can be identified only after execution starts.	0.545	
D13	All design discrepancies are identified and resolved before execution starts.	0.722	
D14	Proper documentations can avoid almost all reasons of cost overrun.	0.761	
D22	Face-to-face communication and coordination amongst project team can avoid cost over-run.	0.768	
D23	Regular check with clients at every design phase can control cost over-run.	0.651	
D25	Client/contractor‘s evaluation are useful to control cost over-run, for future projects.	0.697	
Factor 2: Design Co-ordination			
D17	Alteration in design is most important reason of cost over-run of the project.	0.570	8.91%
D19	Inappropriate coordination between design and construction causes design changes mostly.	0.808	
Factor 3: Design Alteration			
D9	Waste during construction can be avoided at initial phase of design.	0.546	8.54%
D18	Clients’ last minute requirement causes most design changes.	0.637	
D24	Cost over-run due to minor finishing details of construction can be calculated accurately and avoided during initial planning stage.	0.728	
Factor 4: Design Understanding			
D5	Improper design brief and its understanding causes cost over-run.	-0.059	7.99%
D15	Contractor is sufficient to check the follow ups of the design.	0.768	
D16	Design review is necessary only if any discrepancies arises at site during construction.	0.749	

3.1 Factor 1: Pre-design Phase

Factor 1 categorized under Pre-designed Considerations comprised of eight attributes explains 16.60% of total variance of the linear component. The highest percentage of variance explained illustrates the importance of proper consideration and accumulation of design elements and processing at the initial phase of design. Design cost management is more than just “cost planning”. It follows a process of planning the cost implications of a project early in its design stages, and controlling the costs and design development simultaneously (Jaggar *et al.* 2002).

The first attribute, “Only face-to-face communication and coordination amongst project team can avoid cost over-run”, and highlights the need for communicating the expectations set on documents personally. Personal discussions on design process and execution on site could over-shadow and be delayed by flaws in documents.

3.2 Factor 2: Design Alterations

Factor 2 categorized under Design Alterations comprised of three attributes explains 8.91% of total variance of the linear component. The first attribute, "Inappropriate coordination between design and construction causes most design changes", illustrates specifically about the lack of proper coordination and communication of produced design for execution under specified scope, time, quality, and cost. Face-to-face communication is perceived to be the most effective communication medium. Meetings, both formal and informal, are perceived to be beneficial to the successful completion of construction projects (Gorse *et al.* 2007).

The second attribute, "Alteration in design is most important reason of cost over-run of the project", is indicative of the design discrepancy due to lack of adequate and timely coordination amongst design elements, team, and at site. Such discrepancy as discussed under Factor 1 leads to either alterations in design or rectifications at site, adding on costs to the designated project budget.

3.3 Factor 3: Design Coordination

Factor 3 categorized under Design Coordination comprised of two attributes explains 8.54% of total variance of the linear component. Coordination activities affect different dimensions of project success differently, and different stakeholders prioritize the activities differently (Jha and Misra 2007).

The first attribute, "cost over-run due to minor finishing details of construction can be calculated accurately and avoided during the initial planning stage", is not a high priority in small-scale projects, but for large-scale projects it has a large impact on costs due to the accumulation of minor details. Accounting for details in terms of material, time, and labor can control unnecessary discrepancies and monetary wastage.

The second attribute, "clients' last-minute requirements causes most design changes", refers to the indecisive mindset of clients, mostly due to lack of awareness about space comfort. The clients must, at an early stage, create a platform for a clear understanding of user needs, and ensure that the final product meets these wishes (Ryd 2004).

3.4 Factor 4: Design Understanding

Factor 4 categorized under Design Understanding with three attributes explains 7.99% of the total variance of linear components. The first attribute, "contractor is sufficient to check the follow ups of the design", follows the concern of discrepancy on site due to improper coordination between design and delivery system. As discussed earlier, minor faults on documentation can be over looked with the aid of proper communication, but it leaves full liability on the contractor to follow up on the design process on site, which might cause variation in design. This conflicting situation is not necessarily due to lack of skill at the contractor's end, but also due to the difference in perception of the same documents by different personnel.

The second attribute, "design review is necessary only if any discrepancies arise at site during construction", extends the concern of the second attribute from a different

view. The responsibility of designer does not end with the handing over of final designs for execution. It is part of the designer's responsibility to follow up on the accuracy and quality of design being followed at the execution phase, and decide whether the final production is up to expectation as per the design. Carelessness in such a duty could raise discrepancy, whereas a timely review could avoid factors leading to discrepancies.

4 CONCLUSIONS

This research concentrated on stakeholders' perspective in large infrastructure construction projects in India. As evident from a survey of their viewpoints, unorganized design management is an influential factor for cost over-runs in any Indian design-build construction project. Thus, the proper design management can contribute in cost cutting. The essence of this study is that the three key stakeholders, namely designer, client and contractor, have a significant impact on design management. Pre-design phase consideration, including an appropriate set out of requirements, process, execution, and delivery of design, is important to avoid discrepancies and alterations at each phase of design process. This finding clearly highlights the importance of appropriate strategies, processes, and an initial follow-up of design in order to save money.

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