Stage-Wise Study of Construction Delay and Cost Overrun in Bridge Construction Projects

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Abstract- *Most of the bridge construction projects are reportedly failing across all the key performance measures including cost, time and quality performances. Construction delay and cost overrun is the important two problems faced by the bridge construction industries. The constructions of flyovers and bridges are complex and most of these works causes construction delay and cost overrun after the completion of works. These construction delay and cost overrun occur by several attributes caused by different stakeholders. The main objective of this study is to identify the stage–wise critical factors impacting schedule performance and cost performance across the design consultants, contactors and client perspectives who involved in public bridge works in Kerala. For the study, the bridge construction was divided to three stages and 22 attributes influencing construction delay and 25 attributes influencing cost overrun were identified from the literature survey. The impact of these attributes on construction delay and cost overrun were taken through questionnaire surveys. The critical factors were identified using Factor Analysis (FA). 42 respondents participated in the survey and the critical factors affecting construction delay and cost overrun were identified for each stages.*

I. INTRODUCTION

1.1 GENERAL

Infrastructure sector is a key driver for the Indian economy. This sector is highly responsible for propelling India's overall development and enjoys intense focus from Government for initiating policies that would ensure time-bound creation of world class infrastructure in the country. Infrastructure sector includes power, bridges, dams, roads and urban infrastructure development

During the last ten years the total capital formation by construction was about 44 per cent of the total investment and the contribution of construction to GDP was 5 per cent. There is strong evidence of inconsistent performance in over 60% of Indian construction projects especially across the key performance measures being cost, quality and schedule performances. While understanding of the intrinsic factors affecting all these key performance measures is still an area of investigation. This research focuses on the analysis of performance in terms of timely delivery of bridge construction projects within the estimated cost in Kerala. Infrastructure bridge Projects are complex process, which requires close cooperation and coordination among the stakeholders. There are many issues in bridge construction industry of Kerala which causes cost overrun and delay.

II. LITERATURE REVIEW

2.1GENERAL

Over the last few decades, there has been much research into the factors affecting cost performance and schedule performance at the construction phase of projects. Measuring the performance of any construction project in terms of success or failure though looks simple, in fact a very complex process. Modern construction projects even moderate in size are generally multidisciplinary in nature and they involve participation of designers, contractors, subcontractors, specialists, construction managers, and consultants. Researchers in the past have identified various causes or reasons for project success. Their works are area specific or project specific and are mostly from the developed countries and based on researchers experience on completed projects.

Doloi H. *et al*. (2011), using a selected set of 45 attributes, this research first identified the key factors impacting delay in Indian construction industry and then established the relationship between the critical attributes for developing prediction models for assessing the impacts of these factors on delay. A questionnaire and personal interviews have formed the basis of this research. Factor analysis and regression modelling were used to examine the significance of the delay factors. Doloi in 2012 had a study on cost overruns and failure in project management – understanding the roles of key stakeholders in construction projects

Chan D. W., Kumaraswamy M. MChan and Kumaraswamy conducted a survey to evaluate the relative importance of 83

potential delay factors in Hong Kong construction projects and found five principal factors: poor risk management and supervision, unforeseen site conditions, shown decision making, client-initiated variations, and work variations.

2.2LITERATURE SUMMERY

From the above selected literature review, it has been apparent that in most studies, priority has been given to identifying the critical causes based on perceptions of different parties in construction. However, quantification of the dependencies of one factor over others has not found widespread coverage. Currently only limited research has been found in public domain focusing the bridge construction project using the perceptions of clients, consultants and contractors impacting stage-wise schedule performance as well as cost performance. For instance steps taken to control a critical reason might trigger a situation where other factor becomes critical and cause even more delay and cost overrun than earlier anticipated. Hence it is important to identify the relationship between various factors of delay and cost overrun. The findings of this paper should benefit the bridge construction industry by highlighting the key factors impacting on the stage-wise schedule performance and cost overrun of the project and the associated responsibilities for effective management among the key project participants.Additionally, the results will provide guidance for further research in developing practical steps that can be implemented to reduce time overrun within the estimated cost during the whole development process.

Schedule performance of projects and the management of cost overruns is an ongoing topic for investigation across many countries. In this research, the bridge construction project is divided into three stages,

III. METHODOLOGY

In this study the stage-wise impact of various attributes on construction delay and cost overrun has been obtained by conducting a questionnaire survey. Questionnaire for this study is prepared based on literature review, face-to-face interviews, a pilot study and a questionnaire survey at various public work departments of Kerala. A survey of construction professionals representing various stakeholders involved in bridge construction projects in Kerala was conducted. Heterogeneity of respondents is an important criteria in capturing the impact of various attributes on any statistical analysis (Sambasivan and Soon, 2007). The survey was carried out among the internal stakeholders (client, consultant and contractor) of the selected construction projects. Statistical analyses of the responses from the respondents were also carried out to determine the relationship between various attributes.

The objectives of research is to identify the most critical factors impacting stage-wise schedule performance as well as cost performance across the design consultants, contractors and client perspectives. The objectives of works are as follows:

- Identification of attributes affecting project performance (time and cost) through a literature survey;
- Identifying the stage-wise ranking of the most critical attributes based on the Relative Importance Index (RII) for delay and cost overrun;
- Reducing the influencing delay attributes and cost overrun attributes into factor groups for each stages, identifying the latent properties of each factor and their effective management based on factor analysis;
- Investigating the influence of the factors on the schedule performance based on regression analysis;
- Analysis of the management of the influencing factors in relation to the role and responsibilities of the consultants, the contactors and the client in the project;

The first objective is important in order for clients, consultants and contractors to understand and attend to the underlying attributes impacting schedule performance and cost performance. By establishing the stage-wise relative positioning of the attributes in the order of their significance, the second objective attempts to create a better understanding of the clustered effects (e.g. factors) of these attributes for each stages on the schedule performance and cost performance in bridge projects. The factor are then analyzed in the contexts of effective management among the clients, the consultants and the contractors in optimal project delivery process. The second objective is particularly important for all the three parties to prioritize the factors in terms of their criticality for developing contractual arrangements and assume responsibilities in order to obtain the desired outcomes. The third objective, is to develop the stage-wise regression model to predict the effect of identified attributes on delay by regression analysis.Finally, through the fourth objectives, the resulting factors are analyzed with reference to the roles and responsibilities of all three key stakeholders with respect to the schedule management processes and their effective development and implementation in the construction projects.

3.1.2PREPARATION OF QUESTIONNAIRES

Through personal interviews with bridge construction professionals of Kerala, such as Kerala Public Work Department (PWD) Engineers, LSGD Engineers, Central PWD Engineers, Engineering consultant and Registered Government contractor's 22 delay attributes and 25 cost overrun attributes were identified. Though the list of 22 delay attributes and 25 cost overrun attributes may not be called exhaustive due to the vast magnitude and fragmented nature of construction industry, the list covered attributes pertaining to a large variety of construction projects. A survey was then framed to get respondents views on impact of these attributes on project schedule and cost. Questionnaire contains two sections. Section A contains questionnaire on the impact ratings of each attributes on schedule performance and cost performance of the project for each stages. Section B is the questionnaire about General Information of the given project and respondent. The relevant portion of the questionnaire is given in Appendix A. A five-point scale was used to measure the attributes influence on schedule performance and cost performance (Table 3.1.1).

Table 3.1.1 Likert scale

Impact Ratings	Description	Number
Very low	Very slight consequence on schedule performance/ cost performance of the project	1
Low	Slight consequence on schedule performance/ cost performance of the project	2
Medium	Moderate consequence on schedule performance/ cost performance of the project	3
High	Significant consequence on schedule performance/ cost performance of the project	4
Very high	Very high consequence on schedule performance/ cost performance of the project	5
Nil	Not applicable	0

3.1.3 DATA COLLECTION

Respondents are selected from a wide range of professionals engaged in Kerala bridge construction sector (contractors, clients and engineers). Table 3.1.2 shows a brief description of respondent's profile in terms of professional role and experience who participated in the study. Data's are collected from bridge construction professionals of Kerala, such as Kerala PWD Engineers, LSGD Engineers, Central PWD Engineers, Engineering consultants and Registered Government contractors through direct interviews and mailing The respondents includes 11 clients, 19 contractors and 12 consultants. Since the consultants were employed by the clients to take care of the client's interests, and that the consultant's responses were not significantly different from that of clients, they were merged with client's responses. Amongst the respondents, the highest proportion (45%) was from the contractors involved in construction activities followed by the clients (26%). Respondents from the roles of consultants were 29%.

Table 3.1.2 Respondents' profile

Category of stakeholder	Experience (years)			Total	% responses
	0-10	10-20	>20		
Client	5	5	1	11	26
Contractor	8	6	5	19	45
Consultant	7	4	1	12	29
Total	20	15	7	42	100

Table 3.1.3 List of bridges taken for case study

Sl. No.	Name of bridge	Actual Duration in months	Planned duration in months	Estimated cost
1	Kumarakodi Bridge	48	36	20,95,00,000
2	Kundaman Kadavu Bridge	33	24	8,75,11,990
3	Machel Bridge	16	12	4,58,35,901
4	Kandachira Bridge, Kollam	28	18	5,44,82,135
5	Thanni Bridge,	36	24	7,43,29,608

3.2 RANKING OF ATTRIBUTES

The next step was to rank the attributes in the order of their criticality. Chan and Kumaraswamy had an opinion that the mean and standard deviation of each individual attribute is not suitable statistics to assess the overall rankings because they do not reflect any relationship between them and accordingly they have used the Relative Importance Index

(RII) method to determine the relative ranking of the attributes. The RII is evaluated using the following expression:

$$RII = \frac{\sum W}{A \times N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.2.1)$$

3.4 REGRESSION ANALYSIS

Regression analysis is a statistical process for estimating the relationships among variables. Dependent variable is the impact of stage-wise delay on project which has been asked separately to every respondent focusing on a selected project. Thus the regression model framed to measure the overall impact of delay caused by individual attributes can be expressed generally as

$$y = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_j X_{ji} + e_i \quad \ldots\ldots\ldots \quad (3.4.1)$$

Where,

Y is dependent variable,

β_0 is constant and intercepts at Y axis;

β_1 to β_j are estimated regression coefficients;

X_1 to X_j are values of predictor or independent variables;

e_i is error which is distributed as normal random variable having zero mean at the common variance (Ref : Regression model).

Significance of the regression coefficients are tested using t-test ($P< 0.05$). Forward stepwise process is used to formulate the regression model. Since it may not be the best fitting model, predictor variables with significant correlation with dependent variable is identified using Spearman correlation and models are again formulated with forward pass backward stepwise and forced entry. The goodness of fit (predictive power of the model) of the regression model is assessed using coefficient of determination (R^2) where R is the correlation between observed Y values and the Y values obtained from the constructed regression model. Adjusted R^2 is the true value of R^2 in the population after adjusting the total number of independent variables and total sample size. Out of formed models, the optimum model is selected based on strength of correlation (R^2) which is a direct measure of % variance explained (Field, 2005). As the value of R^2 changes rapidly with the addition of new independent variables in the model, a good measure of strength in the model is adjusted R^2 values. The adjusted R^2 values and the change from R^2 values give the idea of how well the model generalizes the predictive strength of the dependent variable (Doloi, 2009). In an ideal case, values of R^2 and adjusted R^2 should be the same. The difference between R^2 and adjusted R^2 gives the predictive strength of the model, the lesser the difference is, the stronger the model (Field, 2005). The values of regression model for each stage is shown in the Table 3.4.1, Table 3.4.2 and Table 3.4.3 respectively.

Table 3.4.1 Results of regression analysis for stage 1

Factors	**β**coefficient	Standard Error	Sig.(p)	R^2/adj R^2
Constant	0.650	0.115	0.000	0.685/ 0.631
Factor 1 (Improper planning of client)	0.450	0.116	0.700	
Factor 2 (Insufficient site management)	0.527	0.116	0.000	
Factor 3 (Design issues and contractor's efficiency)	0.119	0.116	0.312	
Factor 4 (Irresponsibility of contractor and client)	0.029	0.116	0.800	
Factor 5 (Aggressive competition at tender stage)	0.223	0.116	0.050	
Factor 6 (Inadequate project formulation at the beginning)	0.001	0.116	0.996	

Table 3.4.2 Results of regression analysis for stage 2

Factors	**β** coefficient	Standard Error	Sig.(p)	R^2/adj R^2
Constant	0.450	0.117	0.000	0.673/ 0.617
Factor 1 (Insufficient management of client and contractor)	0.339	0.119	0.000	

Factor 2 (Improper planning of client)	0.386	0.119	0.000	
Factor 3 (capability of contractor)	0.273	0.119	0.028	
Factor 4 (Coordination)	0.128	0.119	0.290	
Factor 5 (Improper planning of consultant)	0.130	0.119	0.300	
Factor 6 (Material shortage)	0.122	0.119	0.300	

Table 3.4.3 Results of regression analysis for stage 3

Factors	**β** coefficient	Standard Error	Sig.(p)	R^2/adj R^2
Constant	0.285	0.139	0.000	
Factor 1 (Improper planning of client and contractor)	0.222	0.141	0.050	0.537/ 0.458
Factor 2 (Insufficient management by contractor and nature of project)	0.273	0.141	0.000	
Factor 3 (Client Efficiency)	0.004	0.141	0.977	
Factor 4 (Lack of resources and project formulation)	0.110	0.141	0.034	
Factor 5 (Capability of contractor)	0.247	0.141	0.009	
Factor 6 (Improper planning and scheduling)	0.420	0.141	0.322	

The final regression model for impact of delay at each stage can be expressed as:

- Impact of Delay at 1st stage = 0.650 + 0.527 (Insufficient site management) + 0.223 (Aggressive competition at tender stage)
- Impact of Delay at 2nd stage = 0.450 + 0.339 (Insufficient management of client and contractor) + 0.386 (Improper planning of client) + 0.273 (Capability of contractor)
- Impact of Delay at 3rd stage = 0.285 + 0.222 (Improper planning of client and contractor) + 0.273 (Insufficient management by contractor and nature of project) + 0.110 (Lack of resources and project formulation)

3.5 CONCLUSION

Focusing on the three major industry groups namely, consultant, client and contractor, this research investigated the stage-wise critical factors affecting schedule performance and cost performance across infrastructure bridge construction projects. Based on descriptive analysis, 22 selected attributes associated with schedule performance and 25 selected attributes associated with cost performance in stage-wise project were ranked using the relative performance index as perceived by the client's, consultant's and contractor's in bridge construction projects. By performing the stage-wise factor analysis, all 22 attributes of schedule performance and 25 attributes of cost performance further reduced to key factors. These factors are again discussed with the clients, consultants and contractors to find the actual reasons of occurrence of these factors and their solutions. Influence of these factors on schedule performance is further validated using the regression analysis. Based on the regression analysis, stage-wise regression model to predict the effect of identified factor on delay. The stage 1 has two significant factors which affect delay, insufficient site management and aggressive competition at tender stage. The stage 2 has three significant factors which are insufficient management of client and contractor, improper planning of client and capability of contractor. The third stage has also three significant factors improper planning of client and contractor, insufficient management by contractor and nature of project and lack of resources and project formulation.

One of the key findings that project planning and control measures play a significant role in overall schedule performance and cost performance in the bridge construction projects. It shows a clear shift of the industry wide perception of schedule performance being heavily reliant on the competency of contracting parties alone. The emphasis on the

technical planning and controlling skills of the contracting parties for effective management of schedule and cost performance clearly adds a new dimension on the current body of knowledge in the field where contractor's performance in terms of financial strengths, relevant experience, firm size etc. was reported to be closely linked to achieving the time and cost targets in most projects

It has been revealed that for all stages the implementing appropriate construction methods and effective reporting and monitoring procedures among the project parties are not up to mark, a common standard can be established for managing onsite construction works which potentially reduces numerous mistakes and errors in the downstream construction phase. Programming and sequencing of work during the onsite construction stages need to be regularly updated and forecasted in order to limit changes of delays. Design efficiency in terms of extent and clarity of pre-contract design at the initial stage of project creation is found to be highly necessary in order to produce realistic project time and cost. Failure to provide a complete detailed scope and design for the project will result in discrepancies in contract documentation and the likelihood of mistakes during construction. An experienced contractor with sound workforce and cash flow during construction can provide a significant expertise to better control the project.

Communication and personal rapport between all project participants can lead to a reduction in unnecessary paper work and therefore greatly reduce the time. Public interferences in construction works are commonly seen in Kerala. It should be predicted during the planning stage itself. Shortage of funds from the Government is the main problem in infrastructure works in Kerala. Delay in bill payments to the contractor makes financial constraints to the contractor which makes further delay of work. Extreme weather conditions of the region should be considered during planning phase of the project

Stage-wise analysis was carried out in this study and variation of each factors were identified. Under the current scenario of rapid urbanisation and progress in construction industry, it is necessary that these significant factors must be considered and well integrated in the main stream construction processes in order to improve the industry performance across bridge construction projects in Kerala. Although some researches have already been conducted on this topic in India and many factors have been identified and pointed out as critical ones to the schedule and cost performance of construction projects, evidently it have not yet been sincerely implemented by the practitioners in the construction industry in Kerala.

The project professionals can concentrate on significant key factors instead of handling all the factors simultaneously in order to maintain prepared schedule and estimated cost of the project.

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