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Critical Success Factors in the Real-Time Monitoring of Construction Projects

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Abstract: Time management of construction projects is a very onerous task. Scheduling of construction projects is based on uncertainties. Projects face a time overrun ranging from few days/weeks to years. Identification of the factors which govern real-time monitoring of construction projects becomes very essential. This paper deals with the identification of critical factors with regard to the management aspects of the project that are responsible for the causes of delay at various stages. These factors include practical difficulties faced by the builders, project engineers and project managers. The factors identified to be critical are the. The proper management of these factors will definitely aid to achieve best project performance results.

Key words: Construction management, time management, project schedules, factor analysis, multiple regression.

INTRODUCTION

Scheduling of construction projects is based on uncertainties. Project Managers are very much responsible for the overall success of the project. They develop a schedule for directing and controlling resources in a coordinated and timely manner. Project schedules take into account certain factors by considering an activity as a whole as a critical activity. Construction planners determine the sequence of the activities to complete a project. They treat an activity as a whole and identify the critical activities that require to be completed without any flexibility in time.

While preparing the schedule the planners consider various factors that will help the completion favourably. They also identify the factors likely to cause delays. Delay in a particular activity due to various factors may cause delay in succeeding activities in a collection of activities. These factors may be called as critical factors in the monitoring of construction projects.

Critical success factors can be classified in to two groups which affect project performances at different phases of implementation. The first group is referred to as the strategic group that consists of factors like project mission, top management support, and project scheduling. The other group is the tactical group, which consists of factors like client consultation and personnel selection and training (Schultz *et al*., 1987).

There is no certainty in factors causing delay and only certain variables are monitored. Hence identification of critical factors causing delay which is an onerous task is absolutely essential (Jeffrey *et al*., 1997). Critical factors are those key factors or areas of activities in which favourable results are absolutely necessary for a project manager to achieve his target (Rockart, 1982).

Project Mission, top management support, project schedule, client consultations, technical tasks, client acceptance, monitoring and feed back, communication and trouble shooting are some the factors influencing the project (Pinto and Slevin, 1989). Another study identified project team commitment, client's and contractor's competencies, risk and liability assessment, end users needs and constraints imposed by them as critical factors (Chan *et al*., 2001). Role of project participants was said to have significant influence the project performance (Iyer and Jha, 2002).

All the research work and the techniques adopted in project management identify critical factors considering the activity as a whole. It is required to split up the activities and study the factors influencing each and every sub activities from the field oriented aspects. The practical difficulties faced during the execution of the work are to be studied and the project engineers must be suitably guided to prepare the schedule to take care of the difficulties. These factors will be the critical, real-time factors that are to be monitored throughout the project. Failure to do so will delay the project completion. The present study involves in the identification of such factors.

MATERIALS AND METHODS

Place of Study: The study was carried out as a part of research work for the award of the degree of Doctor of Philosophy (PhD). The duration of the study was three years since. The study was taken up in and around the City of Coimbatore in the State of Tamil Nadu, Southern India. The city of Coimbatore is an industrial city manufacturing pumps, textile accessories etc. It is also known for its textile industries and it was called as Manchester of South India.

Coimbatore is one of the major educational centres for engineering in this part of the country. There are a lot of Software companies coming up and as a result the growth in the infrastructural development is enormous. This potential growth in the construction industry prompted the author to take up the study in this part of the

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country. Sine the IT sector development is on the growing curve in the state, the data was collected from other major cities in the State also, with most data from Coimbatore.

Methodology of Study: The study involves two phases. The first phase involves the identification of various factors causing delay. This was done through personal interviews and discussions with the project managers, project engineers and builders who are directly involved in the progress of the project. These factors were analyzed and classified under 5 aspects, grouped under 2 stages: (1) Pre-tendering Stage and (2) Post-tendering Stage.

In the Pre-tendering Stage 23 factors were classified as Project Background Aspects. In the Post-tendering Stage four aspects were identified: (a) Planning/Scheduling Aspects consisting of 14 factors, (b) Technical Aspects consisting of 20 factors, (c) Execution Aspects consisting of 30 factors and (d) Management Aspects consisting of 19 factors.

The second phase involves identification of the most critical factors so identified in the first phase. This was done by circulating a questionnaire consisting of the factors identified in the first phase to the prospective respondents consisting of project managers, project engineers and builders requesting them to rate each factor based on the effect each factor has in causing the delay of the project.

The responses received were in the form of ratings on a 4 point Lickert Scale. They are: 1. No Effect, 2. Marginal Effect (where delay caused can be fully revived), 3. Significant Effect (where the delay caused can be partially revived), 4. Adverse Effect (where delay caused is beyond revival). The respondents background information such as their Role in the construction field, their experience, the type and size of the projects they handle and the class of their clients, were also collected.

It was decided to study each aspect separately so that the significance of important factors may not be lost. The study about the Management Aspects of the project is dealt in this paper. The 19 factors identified under this aspect are given in Table 1. The analysis was done using the software SPSS – Version 15 (Statistical Package for Social Scientists).

Descriptive Statistics of the responses were studied. Ranking of the factors based on the mean of the responses through descriptive statistics was done. A mean value of 2.5 was selected as the base and the factors with a mean of more than 2.5 were identified as critical. The criteria for selecting mean value is that, it is necessary to identify those factors which has significant and adverse effect on the completion of the project.

Test of Analysis of Variance (ANOVA) was done to study the difference in the perception of the importance of these factors by the three groups of respondents, namely Project Managers/Engineers, Consultants and Builders. Factors with less than 5% significance is said to have a different perception among the respondents.

To study which group of the respondents perceived differently, Post Hoc (Tukey's B) test was conducted for the factors whose significance value is less than 5%. The test compares the means of the group of respondents.

Factor Analysis by Principal Component Analysis Method was done to extract the critical underlying factors. For this purpose, the factor with highest mean value of response and less significance in the perception of the respondents was selected as the dependant variable.

Oblique rotation of the reference axes called Varimax Rotation with Kaiser Normalization Criterion was done since the initial factors were initially orthogonal. Factors with Eigen value greater than or equal to 1 were extracted and the initial 19 factors were grouped under the extracted factors based on their loading and the variance explained by each of them. The extracted underlying factors were given a common explanatory name.

The underlying factors extracted were subjected to Stepwise Linear Multiple Regression in order to find out the extent of cause and effect of these factors on the dependent variable.

RESULTS

Descriptive statistics identified 7 factors to have a mean value of more than 2.5. These factors are ranked according to their means and are shown in Table 2.

The ANOVA test indicated that only one factor, Factor No E17 – Approval of cost for additional items that is not mentioned in the tender – was said to have different perception by the respondents. The results of the Test of ANOVA for these factors are given in Table 3.

Post Hoc test indicated that the Builders perceive the factor differently. The reason may be that they are experiencing this problem during the execution of the works. The delay in finalization of specification and the rates for items which were not included in the tender will not allow the builder to proceed with the work. The result of the Post Hoc test is given in Table 4.

Factor analysis with Varimax Rotation with Kaiser Normalization Criterion, revealed that the 19 independent factors under the Technical Aspects of a construction project identified in this study can be grouped under FOUR underlying factors. The factor E08 – Cash flow in the project at all levels right from the client to site engineer was selected as dependent variable. The summary of the results of the Factor Analysis is shown in Table 5.

The underlying factors extracted were named as: (1) Role of Project Participants, (2) Planning, Monitoring and Feedback, (3) Decision Making, Approval and Implementation. The initial factors grouped under the extracted factors are shown in Table 6.

Linear Multiple Regression of these factors with the dependent factor Frequent Changes in plans, designs and working drawings, revealed that the underlying factor Role of Project Participants was said to have a more cause and effect on the dependent variable Cash flow in the project at all levels right from the client to site engineer. The summary of the regression with coefficients for the regression model is shown in Table 7.

Table 1: List of Factors included under Management Aspects

Factor No	Factor Name
E01	Involvement and commitment of project participants – clients, consultants, architects, contractors/builders
E02	Involvement and commitment of project managers, project engineers, technical assistants, workers
E03	Delay in finalization of utility or change in the utility of the building
E04	Clearance of technical drawings after discussion among clients, architects, consultants, project engineers and builders
E05	Periodic discussion among project participants and timely delivery of the outcome or feedback at the site.
E06	Coordination between agencies involved in the project (material suppliers, equipment suppliers etc.)
E07	Controversies among project participants and hence suspension of work
E08	Preparation of Bill of Quantities and timely payment to builders
E09	Cash flow in the project at all levels right from the client to site engineer
E10	Proper planning in procuring materials and stacking
E11	Proper planning in organizing the equipments and machinery
E12	Approval from external agencies/authorities
E13	Timely decisions regarding problems identified at site
E14	Suspension of project due to pending decision regarding revised or increased project cost
E15	Authority to take decisions at site
E16	Approval for additional items in respect of specification and methodology of construction
E17	Approval of cost for additional items that is not mentioned in the tender
E18	Review and monitoring of construction program and the necessary feed back
E19	Responding to ideas of subordinates

Table 2 : Ranking of Critical factors identified through Descriptive Statistics

Factor No	Factor Name	N	Mean	Std. Devn
E09	Cash flow in the project at all levels right from the client to site engineer	60	2.75	.914
E08	Preparation of Bill of Quantities and timely payment to builders	60	2.58	.850
E14	Suspension of project due to pending decision regarding revised or increased project cost	60	2.57	.945
E01	Involvement and commitment of project participants – clients, consultants, architects, contractors/builders	60	2.57	.945
E07	Controversies among project participants and hence suspension of work	60	2.57	.963
E02	Involvement and commitment of project managers, project engineers, technical assistants, workers	60	2.55	.946
E06	Coordination between agencies involved in the project (material suppliers, equipment suppliers etc.)	60	2.50	.930

Table 3 : Results of ANOVA for the Background Information – Role in the Construction Field

Factor No	Factor Name	Sig
E01	Involvement and commitment of project participants – clients, consultants, architects, contractors/builders	.209
E02	Involvement and commitment of project managers, project engineers, technical assistants, workers	.636
E03	Delay in finalization of utility or change in the utility of the building	.648
E04	Clearance of technical drawings after discussion among clients, architects, consultants, project engineers and builders	.771
E05	Periodic discussion among project participants and timely delivery of the outcome or feedback at the site	.904
E06	Coordination between agencies involved in the project (material suppliers, equipment suppliers etc.)	.184
E07	Controversies among project participants and hence suspension of work	.431
E08	Preparation of Bill of Quantities and timely payment to builders	.782
E09	Cash flow in the project at all levels right from the client to site engineer	.320
E10	Proper planning in procuring materials and stacking	.501
E11	Proper planning in organizing the equipments and machinery	.713
E12	Approval from external agencies/authorities	.134
E13	Timely decisions regarding problems identified at site	.905
E14	Suspension of project due to pending decision regarding revised or increased project cost	.578
E15	Authority to take decisions at site	.630
E16	Approval for additional items in respect of specification and methodology of construction	.421
E17	Approval of cost for additional items that is not mentioned in the tender	.049
E18	Review and monitoring of construction program and the necessary feed back	.187
E19	Responding to ideas of subordinates	.720

Table 4: Results of the Post Hoc (Tukey's B) Test

Factor Name : Approval of cost for additional items that is not mentioned in the tender			
Respondent Group	N	Subset for alpha = 0.05	
		1	2
Consultants and Others	18	2.44	
Project Managers/Engineers	22	2.73	
Builders	20		2.15

Table 5 :Summary of the Results of Factor Analysis

Extracted Factor Name	Percentage of Variance Explained	Cumulative Percentage of Variance Explained
Role of Project Participants	28.165	28.165
Planning, Monitoring and Feedback	25.095	53.260
Decision Making, Approval and Implementation	14.914	68.174

Table 6 : List of Initial Factors included under Underlying Extracted Factor

Extracted Factor Name	Initial Factors Included
Role of Project Participants	Involvement and commitment of project participants – clients, consultants, architects, contractors/builders
	Involvement and commitment of project managers, project engineers, technical assistants, workers
	Delay in finalization of utility or change in the utility of the building
	Periodic discussion among project participants and timely delivery of the outcome or feedback at the site.
	Coordination between agencies involved in the project (material suppliers, equipment suppliers etc.)
	Controversies among project participants and hence suspension of work
	Preparation of Bill of Quantities and timely payment to builders
Planning, Monitoring and Feedback	Proper planning in procuring materials and stacking
	Proper planning in organizing the equipments and machinery
	Approval from external agencies/authorities
	Review and monitoring of construction program and the necessary feed back
	Responding to ideas of subordinates
Decision Making, Approval and Implementation	Timely decisions regarding problems identified at site
	Suspension of project due to pending decision regarding revised or increased project cost
	Authority to take decisions at site
	Approval for additional items in respect of specification and methodology of construction
	Approval of cost for additional items that is not mentioned in the tender

Table 7 : Coefficients for Regression Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.522	0.319		1.635	0.107
	Role of Project Participants	0.890	0.123	0.689	7.246	0.000

A regression model equation which is not a functional equation but a *cause and effect* model was written as follows:

Cash flow in the project at all levels right from the client to site engineer = 0.890(Role of Project Participants) + 0.522(constant)

The initial factors which are included under the underlying factor Role of Project Participants are, (i) Involvement and commitment of project participants – clients, consultants, architects, contractors/builders, (ii) Involvement and commitment of project managers, project engineers, technical assistants, workers, (iii) Delay in finalization of utility or change in the utility of the building, (iv) Periodic discussion among project participants and timely delivery of the outcome or feedback at the site, (v) Coordination between agencies involved in the project (material suppliers, equipment suppliers etc.), (vi) Controversies among project participants and hence suspension of work, (vii) Preparation of Bill of Quantities and timely payment to builders

DISCUSSION

The role of the project participants is very vital in the successful time management of a construction project. The involvement and commitment of the key project participants – clients, consultants, and builders will ensure smooth progress of the project. The periodic discussions among them and the timely delivery of the outcome will enable the project to progress without any delay. The involvement and commitment of the other project participants such as project managers, project engineers, site engineers, subcontractors, supervisors and the laborers will ensure the progress of the work at the site, coordination among activities. The project managers and the engineers in consultation with the builder, maintain the inventory of the resources at site.. When the project runs smoothly without any delay then next is the timely payment to the builders. This will be possible only when the bills of quantities is prepared, checked and approved by the project engineer for payment. And further on timely approval from the consultant, the payment will be released by the client and the payment made to all those involved in the work. Lest the builder will be running overdraft and will at one stage may be forced to suspend the work for want of payment. When the cash flow in the project is smooth right from the client to the last technician, each and every person involved in the project will have a commitment to the project performance and the project will be running successfully.

CONCLUSION

The Management aspects of the project play a very important role in the successful completion of a construction project. The Role of Project Participants is vital in this regard. The critical factors identified in the analysis above should be monitored by the project managers. The project manager should liaison between the clients, consultants and the project engineers and builders. At the scheduling stage the factors should be given due considerations. During the progress of the work the monitoring of the project should be done with special attention to these factors as these are the factors which causes delay if not monitored at the appropriate stages. So effective monitoring of the critical factors identified in this study will ensure successful completion of the project.

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