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A Methodology for Identifying Important Constraints in Construction Project Scheduling

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ABSTRACT: The occurrence of constraints is common in most construction projects, due to various reasons and causes delay before or during construction phase. As the delay results in time and cost overrun, analysis of these constraints makes it easy to give responsibility to the concerned party. This helps to avoid or minimize delays in future work. However, information of activities which are responsible for project delay and their magnitude provides the baseline for investigating the cause and assessing the responsibility for project delaying constraints. This paper describes the research methodology used for identifying important construction scheduling constraints and “constraint factors” by analytical methods referred to in available literature.

KEYWORDS: Constraints, Delay, Cost Overrun, Analytical methods.

I. INTRODUCTION

Constraints are defined as anything that limits a system from attaining higher performance towards its goal. Identifying and removing constraints from bottleneck activities help to reduce uncertainties in construction processes and increase the transparency of project management. Needs and constraints in a multi-party working situation bring complications in project management. Needs are diversified when the client is a large organization such as a public client or a corporate client. However, constraints in construction projects limit the achievement of high performance when we are unaware of the existence of the constraints, or, we tend to put more emphasis on the project goals. With the limited literature for the constraints in the construction working environment, it is important to identify the potential constraints in the construction project, which will help to decrease the unnecessary wastage and loss of both money and time because of inadequate planning. Controlling the constraints is thus a pre-condition for high performance of the project. Constraints are based on the idea that every system has at least one bottleneck which can be defined as any kind of situation that impedes the system to reach high performance level in terms of its purpose. Therefore this paper describes various statistical methods used to analyse these constraints.

II. ORGANISATION OF STUDY

The study is organised in the following steps:

- Review of literature and past studies related to planning and scheduling.
- To identify the project scheduling constraints, primary data is obtained from case studies and secondary data is obtained from literature review.
- Case studies are conducted to determine the 10 randomly selected project site performances with the help of cost performance index and schedule performance index. And constraints affecting the schedule of project sites are determined.
- Also, with the help of literature, constraints affecting the schedule of construction projects are studied.
- An initial list of 44 constraints are identified for the preparation of questionnaire survey.
- Data is collected from a diverse range of civil practitioners with the help of Google forms and direct filling of the forms from respondents.
- Data obtained is analysed by RII method and IMPI method.



- Ranking for each separate group of constraints by RII & IMPI is done.
- Results obtained after analysis are determined and conclusion is derived.

III. CLASSIFICATION OF CONSTRAINTS

After studying the constraints from literature review and case studies we have classified the constraints mainly in eight groups such as Cost, Client and Consultant related, Resources, Time, Knowledge and training, Management issues, Technology, Uncertainty.

- 1) **Cost:** Cost or budget is the amount of money invested in the project to achieve the desired result. A project's overall cost is also a major constraint for the contractor or project manager, as they need to find ways of completing the project without exceeding the allocated budget. Cost management is an ongoing task during the completion of a project, as the project manager needs to identify any potential issues that may raise the cost of completing the project on time.
- 2) **Client & Consultant related:** Client / owner related issues are responsible for time overrun as those effects fail to provide project information to constructors. The time overrun caused by the owners or clients such as delay in payment, slow decision making and delay in handing over the site may result in extension of time and cost escalation due to inflation, raw material supply delays, and sometimes improper planning and poor communication among the stakeholders
- 3) **Resources related:** Resource planning has prime importance in any construction project. Resources are categorized under three types such as materials, manpower and equipment / plant and machineries. In a typical project, material costs around 60% to 70% of total budget. Consequently, material planning includes quantifying, ordering, and scheduling. Productivity will be affected if the material planning is not done properly causing the time overrun in the project at a higher level. There has been a terrible lack of specialized persons to manage with the rapid growth in construction projects. In view of this, skilled manpower is not really skilful, but gained their experience from job site and learn skills through trial and error. Hence, it is quite difficult to assign the proper specialized person on a particular task which leads to insufficient number of labours. Requirement of more labours becomes essential to produce high quality work. However, implementation of Training institutions are limited even though that could produce construction workers in India.
- 4) **Time related:** Most projects have a clear deadline that needs to be respected by the project manager. Delivering a project on time is usually a crucial measure of its success, as any delay typically involves higher cost and the need to revisit any plans that the project's stakeholders have after its completion. The project manager needs to use their experience and knowledge to estimate how long the project will take until completion, which includes anticipating possible delays, setbacks, risks, and other unforeseen events.
- 5) **Knowledge / training:** Knowledge or training related constraints include lack of education/knowledge training, incompatibility of planning methods with project, poor or slow decision making regarding activity criticality, lack of effective leadership, Inaccurate or unrealistic/poor estimate for effort, duration & activity relationships, deficiencies of understanding /awareness of concepts, activity criticality & related resources, Insufficient expertise of professionals, Incorrect perception of professionals.
- 6) **Management issues:** Management reputation is also an important imponderable issue. Management support is more important reputation to build the overall performance of the organization. According to strategic planning, implementation of advanced technology, feeding the knowledge of previous project experience, developing the centralized and decentralized system as per requirement in the project, monitoring and controlling the resource scheduling, suggesting the calendar schedule for preparing proper scheduling to scheduler in advance are the topmost trends to bring out the project without management issues.
- 7) **Technology related:** Absence of new technology and software for planning and scheduling, limitations of scheduling tools such as PERT & CPM, lack of high technology equipment's are the technology related constraints.
- 8) **Uncertainty:** uncertainty constraint includes uncertainty value / unforeseen bottlenecks, absence of schedule contingency, rework, climatic factors, changes in government regulations, complexity of project.



IV. METHODOLOGY

To identify the constraints, practical case study is conducted. 10 project sites were randomly selected to evaluate the performance of the project using performance indicators such as scheduled performance index and cost performance index. The most commonly used performance efficiency indicators are cost variance & schedule variance of project.

$$\text{Schedule variance (SV)} = \text{EV} - \text{PV}$$

$$\text{Cost variance (CV)} = \text{EV} - \text{AC}$$

Where, EV – earned value, PV – planned value, AC – actual cost.

Schedule performance index (SPI): Measure of the schedule efficiency of the project.

$\text{SPI} = \text{budgeted cost of work scheduled (BCWS)} / \text{Actual cost of work scheduled (ACWS)}$

Cost performance index (CPI): Measure of the cost efficiency of the project.

$\text{CPI} = \text{Budgeted cost of work performed (BCWP)} / \text{Actual cost of work performed (ACWP)}$

Data required for the calculating performance indicator was collected from the sites and indices were found. The status of the project was determined depending on the average value of CPI & SPI. If the average value of CPI & SPI ≥ 1 , "GREEN" = on track, 0.85 but < 1 , "YELLOW" = slightly behind schedule/budget and < 0.85 "RED" = need immediate attention. After knowing the performance indices the constraints at the site for scheduling were studied and find out.

Constraint factors for scheduling in construction projects were also identified from literature review. The data collected to determine the most influential factors on management of the project was done through a survey by explorative questionnaire with the help of Google forms and direct filling the questionnaire form by the respondents involved in daily activities of construction firms in Amravati region of Maharashtra. The questionnaire is designed so that respondents can give the rank to their answers based on their opinions. The analysis of this data is made by a method named relative importance index (RII) method as well as important index (IMPI). Factor rating is used as 1-5 point likert scale method. It's a type of psychometric responses for surveying and this type of likert scale is widely used in the market research. Likert scale method is allowed by the respondents to responses of their level agreement of the questionnaire survey. In this study the Likert scale is used to rate their opinion about constraints in the project scheduling.

QUANTITATIVE METHODS

1) Relative Importance Index Method

Relative Importance Index is the mean for a factor which gives its weight in the perceptions of respondents. The Relative importance index is a method that is used for evaluating the relative importance of the defined parameters. In this study, the RII method is selected to find the relative importance of the varied constraints in construction project scheduling using Likert scale. The five –point scale ranged from 1 =very low, 2=low, 3=average, 4=high, 5=very high, is adopted and transformed to relative importance indices (RII) for each factor as follows:

$$\text{RII} = \Sigma \text{W} / (\text{A} * \text{N})$$

Where,

W = Weightage given to each factor (ranging from 1 to 5)

A is 5 (the highest weight) and

N is the Total number of Respondents

The RII value had a range from 0 to 1 (0 not inclusive),

The higher the value of RII indicates that the more important is the constraint factor to the Construction industry.

2) Cronbach's α Reliability test

In a statistical test, Cronbach's Alpha was used as an estimation of the reliability of psychometric test. In statistics, Cronbach's Alpha is a coefficient of internal consistency. It is commonly used as an estimate of the reliability of a psychometric test for a sample of examinees. It was first named alpha by Lee Cronbach's in 1951, as he had intended to continue with further coefficients. Standard Cronbach's Alpha formula is.

$$\alpha = k/k-1 * [1 - (\Sigma S^2_y / S^2_x)]$$

S^2_y = sum of item variance

S^2_x = variance of total score

α = Cronbach's alpha

Where, Cronbach's α



Table 1: Cronbach’s α value

Cronbach’s α value	Reliability
0.9 and above	Excellent
0.80to0.89	Good
0.70 to 0.79	Acceptable
0.60 to 0.69	Questionable
0.50 to 0.59	Poor
Below 0.50	Unacceptable

3) Importance Index Technique –In this technique, for each cause/factor two questions were asked: What is the frequency of occurrence for this cause? And what is the degree of severity of this cause on project delay? Both frequency of occurrence and severity were categorized on a five-point scale. Frequency of occurrence is categorized as follows: 1= hardly ever,2=rarely,3=sometimes,4=often ,5=always . Similarly, degree of severity was categorized as 1=very little effect 2= little effect, 3= moderate, 4=great, 5=extremes

i. Frequency index: A formula is used to rank constraint based on frequency of occurrence as identified by the participants.

$$\text{Frequency Index (F.I.) (\%)} = \frac{\sum a (n/N) * 100}{5}$$

Where, a is the constant expressing weighting given to each response (ranges From 1 for hardly ever up to 5 for always), n is the frequency of the responses, and N is total number of responses.

ii. Severity index: A formula is used to rank constraint based on severity as indicated by the participants.

$$\text{Severity Index (S.I.) (\%)} = \frac{\sum a (n/N) * 100}{5}$$

Where a is the constant expressing weighting given to each response (ranges from 1 for very little up to 5 for extreme), n is the frequency of the responses, and N is total number of responses.

iii. Importance index: The importance index of each cause is calculated as function of both frequency and severity indices, as follows:

$$\text{Importance Index (IMPI) (\%)} = \frac{[F.I. * S.I.]}{100}$$

VII. FUTURE SCOPE

1. With the help of this study one can understand the various Constraints and their effects which can be more or less on the project.
2. The study of Commercial and Infrastructure projects may give different constraints views.
3. More research to be done on various construction project sites to identify their performance status and complex factors causing delay and find solutions to it.
4. By elaborate study and considering more numbers of case studies one can attain more accurate results.

VIII. SUMMARY

Present study outlines the constraints in construction projects schedule. Basedon literature study and from case study, 44 constraints were identified under 8 major groups. Furthermethodology is suggested to work out by two techniques: Relativeimportance index and Importance index as a function of severity index and frequency index. SurveyQuestionnaire is prepared based on these techniques. It is proposed to carry out ranking of these constraints from two different techniques in the present study. The study is limited to collecting responses and case study, which could vary for infrastructure projects, and larger projects.A study of infrastructure projects and large project could give quite a different picture. Some limitations are subject to geographical location of the site.Moreover, there is usually reluctance on part of the project authorities to reveal the data. More number of samples would give a clearer picture.



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