

Influence of Constraints Analysis and Critical Chain Scheduling for the Improvement of Bridge Construction Projects

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Abstract— Constraints are encountered in every working environment whether it may be manufacturing industry, supply chain, construction industry etc. Construction companies are time bound endeavours meant to be realized within stipulated time. They have a particular goal to be achieved in time but constraints in the project create imbalance of sources and form barrier in completion of the project. Theory of constraints has application in manufacturing, project management, marketing and sales, finance and accounting, supply chain distribution. Critical chain project management (CCPM) is utilized in project management. CCPM uses schedule network analysis technique. It focuses on those activities having longest chain. Buffers are used throughout the TOC. Buffers are placed before the governing constraints, to ensure that the constraint is never starved. Buffer are placed behind the constraint to prevent downstream failure from blocking the constraints output. This concept of identifying the constraints and eliminating by using CCPM scheduling will be conducted on selected projects. First and foremost, field study and questionnaire survey is conducted for collection of basic information and to study current situation of the constraints in today's construction industry.

Keyword: Critical chain project management, Scheduling, Constraints, Bridge Construction.

1. INTRODUCTION

Delay in completion of infrastructure projects in India has become normal and frequent occurrence. Such delays are caused by a number of reasons such as contractual issues, shortage of manpower, delay in obtaining environmental clearances, delay in tendering, redundant laws and rules etc. The above number of reasons are actually the limiting factors (i.e. constraints). The effect of such delays not only lead to loss of profits and cost overruns but also to a compromise in the quality of

construction, disputes between contractors and buyers. On construction projects, as well as on other projects where a schedule is being used to plan work, it is not uncommon for delays to occur. It is what is being delayed that determines if a project or some other deadlines, such as milestone, will be completed late. Delays are categorized in four basic ways,

- i) Critical or noncritical,
- ii) Excusable or non-excusable,
- iii) Compensable or non-compensable,
- iv) Concurrent or non-concurring.

To successfully manage and eliminate those delays proper planning, execution and monitoring of a project is necessary. Project scheduling is a written or graphical representation of the contractors plan for completing a construction project that emphasizes the elements of time and sequence. The plan will typically identify the major work items (activities) and depict the sequence (logic) in which these work items will be constructed to complete the project. The project schedule should include every element of the project sequenced in a logical order from the beginning of the project through completion. In addition, the schedule should define specific time periods for each activity in the schedule. A project schedule is a valuable project control tool that is used by successful project managers to effectively manage construction projects. A contractor can use different types of schedules to depict its construction plan. The most common scheduling techniques used for construction projects are narrative schedules, Gantt chart, linear schedules, and critical path method schedules.

Construction project involves multi party participation. It may be a government project, or a private developer. Multi party participation brings numerous constraints as the needs are different. Different needs may lead to

constraints in project resulting in delay of work which can ultimately result into new constraints as the project will not be on schedule, which can bring cost consequences. The project manager or that particular engineer appointed for the project completion must handle the project on time, meet the client's needs, as well as make sure that the project will not be under any constraint, at present and also in future. It is necessary for the project manager to learn from the completed project and make sure that new projects are constraint free. Although new projects have different needs and a new structure which may give rise to a new constraint not encountered before, one can always identify potential constraints. Therefore, controlling and eliminating the constraint is the pre-condition before any new project is started.

2. STATE OF DEVELOPMENT

A lot of research works have been done on the Constraint analysis,

Livia Anastasiu et al. (2023) Critical Chain Project Management (CCPM) has emerged as a notable approach in recent years for improving time management in construction projects. This methodology focuses on optimizing project schedules, and its impact on construction projects has been explored through a review of literature from the past five years. However, a theoretical understanding alone may not be sufficient for promoting the adoption of CCPM in the sector. Therefore, an experimental study was conducted to assess the practical impact of CCPM on shortening the timeline of a construction project. The study involved the use of CPM for the planning phase and CCPM for the execution phase of finishing works (drywalls, carpentry, and painting) in three identical blocks of flats. At the completion of the project, an important economy of 36 days (around 20%) was achieved, and the project was completed in 151 days using CCPM compared to the planned 187 days using CPM. The research was limited to finishing works, and further studies are planned to explore the applicability of CCPM to other construction works. It is imperative to establish a continuous collaboration between researchers and practitioners in the construction industry, as research findings should be effectively applied in real-world scenarios.

Jun-long Peng et. al. (2022) In order to solve the problems such as project duration delay caused by unreasonable buffer zone setting, a critical chain buffer

zone setting method is proposed based on fragility theory. Firstly, we propose that the construction process is brittle and the brittleness of the construction process was analyzed. Secondly, this paper introduces a risk-integrated impact rate to describe the uncertainty of the construction process and establishes a brittle risk entropy function. Then, it presents entropy models and modification models of project buffers and feeding buffers based on the original Root Square Error Method. Finally, an engineering project was selected as an example, and the simulation was carried out using the Monte Carlo simulation software Crystal Ball, and the resulting method was compared with three buffer zone calculation methods. The results show that the method can effectively reduce the construction period and is effective and practical when compared to the other three buffer calculation methods. The results of the study provide a new way of thinking about buffer settings based on existing critical chain project management methods

Anjay Kumar Mishra et. al. (2021) In this paper according to the authors saying, in the early days management of project was of short duration with more stable environmental conditions. Whereas modern projects have complex site nature, they consume more time, cash flow is not balanced and the contractual agreements are also complex. The authors undertaken project was a rural road project namely Sankosh - Tipling Road and Bhimdhunga-Lamindanda Road in Nepal having sufficient human resources available with Nepal construction firms. The undertaken project had many constraints resulting into delay of the project.

Avinash Adinath Chougule et. al. (2019) in this paper identified the constraints on infrastructure construction project. The scope of the paper was to study and identify the constraints in construction industry for residential building scheme. The major root causes of financial related problems that would lead to delays in project was identified. Opinions of the parties upon the actions that they undertake to manage the financial problem was investigated. Quantitative techniques were used to analyze causes in order to give suggestive recommendations to reduce the delay problems by considering case study. Study was carried out based on literature survey and questionnaire survey. Author concluded that identifying and removing constraints from bottleneck activities help to reduce uncertainties in construction process and increase the transparency of project management.

Hemaloshinee Vasudevan et. al. (2021) The author in this paper has studied the working of different construction companies and states the importance of quality management. According to the study quality management techniques has significant effect on organizational networking and organizational success ultimately improving the product quality, thereby reducing cost and increasing consumer satisfaction. Apart from the theory quality management is actually used in many industries across the countries. Finding the project constraints can led to better implementation of quality management. To overcome all the limitations affecting quality management author has mentioned the use of TOC procedure and methods. Activity based costing (ABC) is used by organization to handle the cost management methods such as target costing and theory of constraint. TOC and ABC was differentiated based on assumptions, resource capacity, Direct labor cost behaviour and cost operation, process / quality improvement, profit improvement and horizontal plan for mixed products and volume.

Marylin Mumbi et. al. (2020) Any project is said to be a successful project if it is completed within a defined schedule by implementing management skills, tools, resources. But the project nowadays stop at different stages due to many constraints. Author in this project mentions the progress of construction companies in Kenya which has always maintained an upward trend in growth. In 2013 and 2014 the construction industries in Kenya had contributed 4.8% and 7 % respectively to the gross domestic product (GDP). According to authors study the construction regulation authorities had eliminated those corrupted cases in construction filed which focuses mainly on material quality and contractor’s performance. And in order to neglect such cases building codes are revised to ensure relevance. The inspection units are bribed to avoid inspection of those construction projects which do not meet the building specifications. Author further states that in Kenya, it continues to face a number of challenges i.e nothing but the constraints. Author has conducted few studies on how those constraints can be eliminated or managed so that the expected project goal is achieved.

Saba Sultana et. al. (2019) In this paper author Saba Sultana used questionnaire survey with five point scale questions and some ranking form various parties involved in the construction project about the constraints they faced during the completion of the project in the company. The impact of a given constraint on the project

was to be ranked by the respondent. Later the questionnaire survey was analysed and recommendation for the administration was specified to have the constraints reported and to consider those constraints in the relevant plant and schedule just as the planning of the organizational structure. It was mentioned by the author that managers play a vital role in execution stage of project therefore its their duty to monitor the advancement and know about the constraints they experience. The author proposed that the manager should enable versatile management of the prevailing conditions. Author regarded the outcomes adequately demonstrated of how constraints in construction project would resemble.

3. FIELD OBSERVATION AND PIE CHARTS

i) Technical Constraints

Technical constraints are those limiting factors that restrict an activity to complete on time and are often based on practicality of building methods and standards. For example, for the construction of footing columns the excavation needs to be done properly by measuring and the ground must be levelled before excavation, as every activity depends on the previous one, errors in the footing it can create constraints.

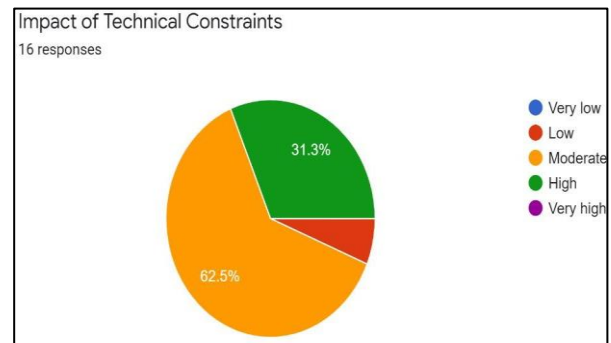


Fig 1 Level of impact of technical constraint

From the questionnaire survey conducted it was observed that 62% individuals agreed that the level of impact of technical constraint was moderate and 31.3% of individuals agreed that the level of impact was high.

ii) Economical Constraint

Economical constraints are not just related to budget, but also to the cash flow through the supply chain and allocation of resources. People are more likely to invest in luxury goods and services if they are confident about the future all of which provides additional work for the construction industry.

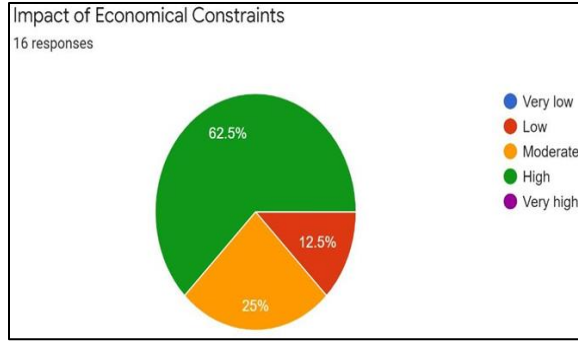


Fig 2 Level of impact of Economical Constraint

From the questionnaire survey conducted it was observed that 62.5% individuals agreed that the level of impact of economical constraint was high and 25% of individuals agreed that the level of impact was moderate, and 12.5% individuals agreed that the level of impact was low

iii) Legal Constraints

Legal constraint refers to regulations and guidelines that are administering the projects in construction industry. Legal contracts are a part of nearly every step in construction process, from initial planning through project completion.

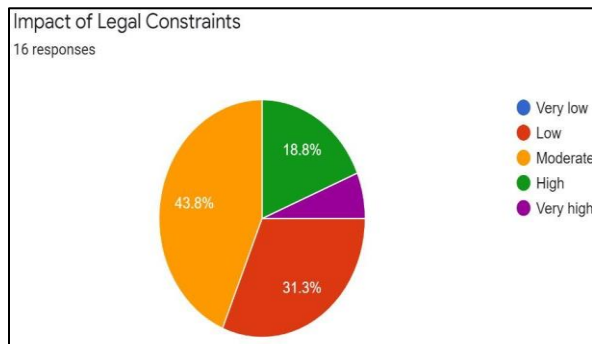


Fig 3 Level of impact of Legal constraint

From the questionnaire survey conducted it was observed that 43.8% individuals agreed that the level of impact of legal constraint was moderate and 31.3% of individuals agreed that the level of impact was low and 18.8% of individual agreed that the level of impact was high.

iv) Time Constraints

Time constraint is the obstacles on the start and end time of each activity in a projects basic way. When it comes to time constraints, proper scheduling is essential. For the project to achieve its purpose, to reach its objective, and to deliver its value, the project team should declare it done on a set date.

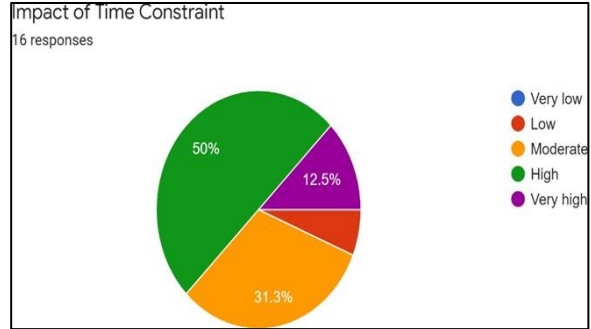


Fig 4 Level of impact of Time constraint

From the questionnaire survey conducted it was observed that 50% individuals agreed that the level of impact of time constraint was high, 31.3% of individuals agreed that the level of impact was moderate and 12.5% of the individuals agreed that there is very high level of impact.

v) Management Constraints

Management constraint refers to the hierarchical structure of an organization that can affect the project. This can include particular shift patterns, overtime requirements, resources allocation between projects, safety procedures, working practices, environmental and social policies, and agreements with unions and so on.

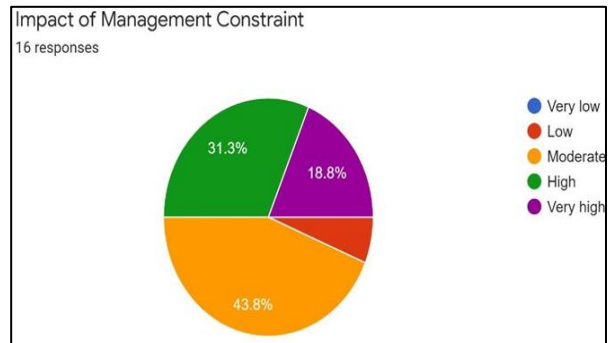


Fig 5 Level of impact of Management constraint

From the questionnaire survey conducted it was observed that 43.8% individuals agreed that the level of impact of management constraint was moderate, 31.3% of individuals agreed that the level of impact was high, 18.8% of individuals agreed that the level of impact is very high and 6.3% individuals agreed that the level of impact is low.

vi) Social Constraints

Projects that are funded by the public are normally subjected to social constraint. Whenever and wherever there is a construction work it involves local people.

Public participation is seen as an act of involvement for the purpose of influencing decisions. In addition to better decision making, the other purposes of participation are the principles of fairness and equity, the right of citizens to be informed and to express their views on governmental decisions.

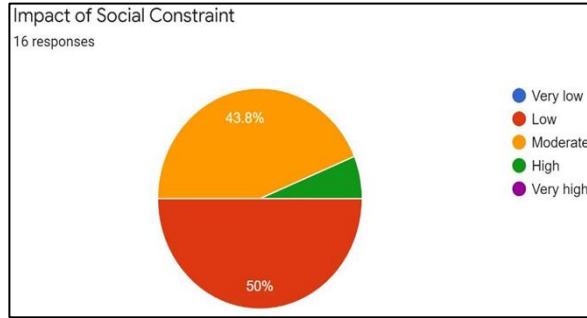


Fig 5 Level of impact of Social Constraints

From the questionnaire survey conducted it was observed that 43.8% individuals agreed that the level of impact of social constraint was moderate and 50% of individuals agreed that the level of impact was low.

vii) Environmental Constraints

Limiting factors that concerns air, water, ground pollution or contamination, usage of hazardous materials, carbon emissions are often under environmental constraints. In planning and design stage of project, the responsible people need to go the environmental department to apply for the approval/justification for the project.

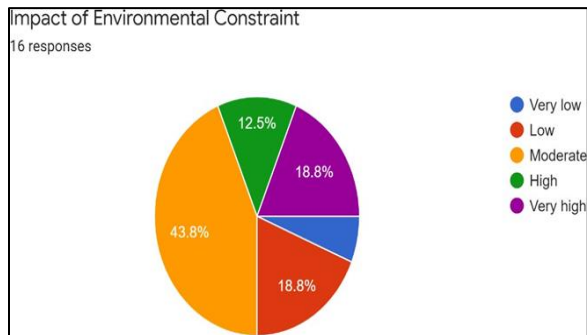


Fig 5 Level of impact of Environmental Constraints

From the questionnaire survey conducted it was observed that 43.8% individuals agreed that the level of impact of environmental constraint was moderate and 18.8% of individuals agreed that the level of impact was very high, 18.8% of the individuals agreed that the level of impact was low and for the 12.5% of the individuals the level of impact is high.

4. CONCLUSION

This research is solely discussed in terms of a literature review. The study's findings suggest that in the early days management of project was of short duration with more stable environmental conditions. Quantitative techniques were used to analyse causes in order to give suggestive recommendations to reduce the delay problems by considering case study.

- Authors concluded that identifying and removing constraints from bottleneck activities help to reduce uncertainties in construction process and increase the transparency of project management. The overall project consists of many critical and non-critical activities which has a clear time frame, giving a unique result in the form of products, services achievements and extending according to a predetermined plan.
- From the questionnaire survey conducted it was observed that the level of impact of economical constraint and time constraint is high.
- From the questionnaire survey conducted it was observed that the level of impact of technical constraint, Legal constraint, Management constraint, Social Constraints and Environmental Constraints is moderate

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