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CRITICAL CHAIN PROJECT MANAGEMENT IN CONSTRUCTION PROJECT

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Abstract - Modern Construction industry has achieved broad development overall especially in couple of years. Construction is the second biggest monetary movement in India after agribusiness. Poor Planning in Construction Projects results in delay in completion and financial losses. Developed Countries have adopted Significant planning measures and technique to minimize or eliminate delays at construction projects. Lack of foresight in Construction Projects brings about defer in finish and monetary misfortunes. Countries have embraced Significant arranging measures and method to limit or take out delays at development projects. A real preparation and assets coordination between clients and labour force is expected to finish the undertaking in time period, which is a lot of ailing in Indian Construction projects. "Eliyahu M.Goldratt applied Theory of constraints (TOC) in project management and the outcome was a robust scheduling technique called critical chain project management (CCPM)." A detailed study was completed to figure out the reasons for delays and limit it with the Critical Chain Project Management techniques with preventive measures.

Key Words: Buffers, Critical Chain Project Management, Construction, Theory of Constraints

1.INTRODUCTION

The Critical Chain Management is a strategy to design and oversee plans where much consideration is paid to resources, risks and liabilities. It is based on standards of keeping them evened out and where start dates should be adaptable. This has the effect between this technique and more conventional ones like CPM in project management and PERT. Significant limitations in construction projects are time and cost overwhelm, inaccessibility of assets when required, less efficiency, deficiency of venture inside time period and even some of the time projects halted totally during its execution stage. It is important for the task mangers to meet the undertaking conveyance date to fulfill the requirements of the clients in the competitive market. In this way, it becomes obligatory for a task to be arranged and booked appropriately to deliver it on-time. The customary basic way strategy which is being utilized these days to be ineffective. To make a compelling and proficient planning technique, "Eliyahu M. Goldratt applied Theory of requirements (TOC) in project management and the outcome was a productive method called Critical Chain Project Management (CCPM). Basic chain technique doesn't depend predominantly on evaluations to decreased half of a typical length." Such a strategy permits project managers to kill vulnerabilities and depend on new thoughts - buffers - that act as essential focuses. Safety buffers are generally utilized here to even out down chances and guarantee permanency of a plan.

2. BACKGROUND

"Critical Chain Project Management (CCPM) was first introduced by Eliyahu Goldratt as a new method of managing projects at the International Jonah Conference in 1990. This method that in general originates from Theory of Constraints notions was introduced in the books with the title **The Goal** business novel in 1984, and **Critical Chain** in 1997 by Eliyahu Moshe Goldratt, the famous business guru of Israeli origin."

3. HUMAN BEHAVIOUR

Following major four important Human behaviors make project timeline longer than required.

Deliberate Padding

It occurs when afterward the work has been traditionally assessed different layers of the management will increment it much more. Manager feels they should safeguard their own presentation, in numerous estimates are not treated as "estimates" yet rather as "obligations". No one need to be late on obligations, so they are cushioning in their evaluations of what amount of time a given undertaking will require.

Student Syndrome

In this condition a characteristic develop in which the work is postponed as late as possible. This condition causes longer lengths since a portion of the time expected to finish a responsibility is lost when it is begun past the point of no return or in any event, when it is start "just in time."

Bad Multitasking

Bad multiple tasks happens when an individual is chipping away at more than one errand simultaneously. Performing various tasks is separated into two classes of good and bad. Bad performing multiple tasks is dealing with a

solitary undertaking before it is done in order to begin another.

Parkinson's Law

"Parkinson's Law states that the amount of work rises to fill the time available to complete it".

4. PROCEDURE

During CCPM technique the following procedure shall be carried out.

1. The aggressive half of the time assessment is determined for every activity.
2. Resource leveling is done for the activities and connections between the activities are anticipated consolidating both task conditions and the evened-out resource needs.
3. Critical Chain of both tasks and resources is recognized.
4. Re scheduling project activity is finished toward guarantee to critical chain remains same to complete the project.
5. The buffers presented toward the finish of the critical chain and taking care of each non-critical chain with the buffer sizing.
6. Buffer Monitoring & Management to be finished after consummation of the buffer addition.
7. Taking on and Calculation of appropriate buffer estimating with its management to finish prior as planned with of financial saving of the project.

5. BUFFER

In CCPM the buffers used for safety times required for the objective to mitigate risks & delays in project. Following are the three types of buffers mainly used in CCPM scheduling with the different buffer sizing methods.

A. **Project Buffers**
B. **Feeding Buffers**
C. **Resource Buffers**

6. ADVANTAGES & DISADVANTAGES

The main advantages using CCPM method :

1. Safety buffers are accruing at the finish of the project in its place of providing them into individual activity and protects the critical chain against ambiguity.
2. Constraints are the main concern for the Project.
3. 50% probability estimates for the task completion
4. Initiate the tasks as quickly as predecessors completed, finish tasks as fast as possible.
5. It helps the project team to avoid Bad Multitasking, Student's syndrome & Parkinson's law.
6. Accelerates execution of the project due to non-rescheduling and having further chance to finish with in time frame.
7. Relay race the Scheduling and Late start Scheduling of Non-critical activities.
8. Allow a substantial reduction in capital needs.

The following disadvantages are perceived with CCPM method.

1. The commitment required from project associated team and other stockholders.
2. Losses occurred if the team is not foresighted.
3. The method needs to be endorsed by planning experts.
4. A new methodology so it's difficult to determine any long-term improvements

7. METHODOLOGY

The Project framework was carried out with the construction schedule for an **Ancillary Building (Power upgradation Substation) in a Commercial Complex Project based in New Delhi.** The initial baseline scheduling completed with basic planning tools using Microsoft office Project & Primavera P6.

Following are the four methods for buffers sizing.

I. Cut & Paste Method.
II. Root Squares Error Method.
III. Adaptive Procedure with Resource Tightness.
IV. Adaptive procedure with density

8. FLOW CHART

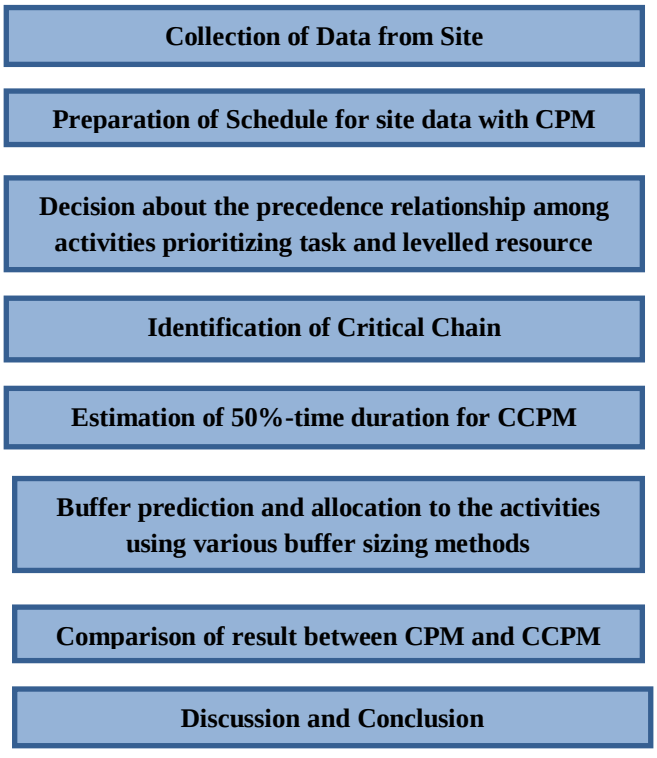

FIGURE 8.1 - FLOW CHART

9. RESULT

The details show the simulation of total duration required for the project using CPM and CCPM buffer sizing methods.

TABLE 9.1 - Project Duration

Sr. No.	CPM	C & PM	RSQ	APRT	APD
Total Project Duration (Workdays)	103	52.75	65	100.77	60.32

With reference to results, it's realized this CCPM method works better than Critical Path Method in terms of time duration and cost involves in project. Different buffering sizing methods used as "Adaptive procedure with density (APD)" method of shows as effective process as comparison to the results of all others method used in CCPM. In the "Root Squared Error method" the period of 52.75 workdays is less, the factor of uncertainty missing in this method, so the result is not precise. In the APD method gave lesser time period including the factor of uncertainty and so the result closer to the actual time duration. Therefore, application of APD method for buffer sizing in a project, gave an actual result by improving the scheduling and its implementation stages to complete the project within time frame with the allocated cost.

TABLE NO. 9.2 - Total Project Cost

Construction of Ancillary Building	
Total Project Cost	
Activity Description	**Amount**
Reinforced Concrete Structure Works	INR 1,04,29,500
Architecture & Finishes Works	INR 32,32,747
Fire Fighting System	INR 9,83,461
HVAC Works	INR 27,27,703
PHE Works	INR 17,00,000
TOTAL COST	**INR 1,90,73,411**

9.1 COST IMPACT CPM V/S CCPM

Resource cost was derived from the comparison of cost reduction after using CCPM on the original CPM schedule. The total cost benefit of INR 2,82,100 to be derived after the completion of Project.

TABLE NO. 9.3 - Cost Benefit (INR)

Resource Cost with CPM (INR)	**INR 17,11,700**
Resource Cost with CCPM (INR)	**INR 14,29,600**
Resource Cost Benefit (INR)	**INR 2,82,100**

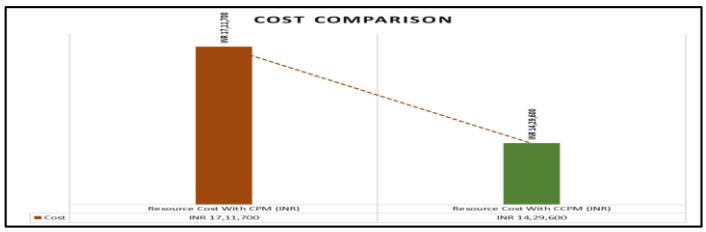

FIGURE 9.4 - Cost Comparison between CPM v/s CCPM

9.2 MANPOWER HISTOGRAM

Allocation of Resource applied to workforce and comparison made with the completion of project based on CPM duration v/s CCPM duration, as the project duration planned to be complete in shorten time by the applying of resource levelling at feeding buffer location.

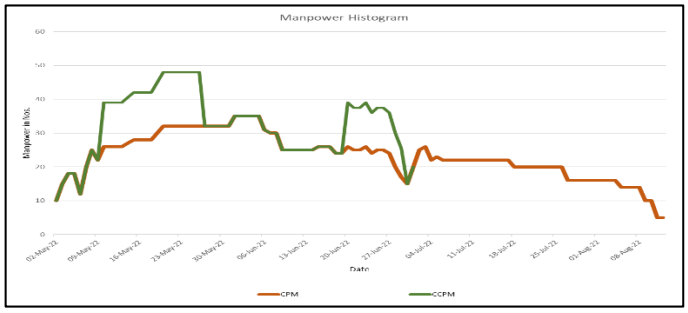

FIGURE 9.5 - Manpower Histogram

10. SPECIFIC OBJECTIVE

Objective of the CCPM in Construction project is to aware the construction sector about the evolving of CCPM techniques by its advantages over the CPM method by comparison of both methods in ongoing projects to be planned and planned properly to deliver the project within time frame.

11. FINANCIAL ASPECTS OF RESOURCE BUFFER

By adding of resource buffer, it helps to decrease the overall project duration by different time duration. Where the addition of resource buffers does not save any time in the project duration, there is no reason to introduce any buffer as it cost by hiring equipment and Manpower or they require expenditures on material earlier than required with comparison to Project schedule.

The major aspects of a construction project are to make a profit for the company. So, management decide to be spent small amount for resource buffers and make it small. As the delay of one day delay in a project end date might more cost the company as compared to the cost of a resource buffer required during project timeline. The contradictory situation is also possible, when resource buffers cost more than the penalties for delay in completion of the project are negligible. It is difficult for planner to determining the correct size of resource buffer. The cost of resource buffer must be compared to attain the financial benefits of an early finish, to avoid delays penalties in completion and the opportunity costs. The Planner should consider all aspects as above said before the finalization of the resource buffer.

12. FUTURE SCOPE

With the vibrant future scope of CCPM in construction industry till date it's not standardized, it has to adopt by the project management consultancy and construction Industry. Researchers made many suggestions for improvement in CCPM method with the objective of encouraging the CCPM technique in the construction project management field, but there are still several areas that require more attention in Indian Construction Industry. Trainings and updated techniques required to promote CCPM in project management. More research required in this subject to improvement of initial CCPM. As CCPM is resources-based scheduling more useful in project schedule. Many countries already used and preferred the CCPM for their large-scale infrastructure projects to complete with in project completion within time frame.

CONCLUSIONS

CCPM works improve the project schedule with comparison to earlier old methods. Project finish date is prevented from uncertainties by using Fever Charts to support the site managers and engineer to take timely protective actions to avoid the delays. Now these days CCPM introduced in software and production industry to get more productivity with cost control. It's recommended to use it in the construction industry to get the benefits of CCPM technique. It is purely displayed for the project that confidently complete on scheduled timeline within the agreed budget due to resource leveling & balance work done for the resource's allocation by CCPM technique before allocating precedence relations between the activities and provide the method for exclusion of idling of assigned resources during the projects.

By using this CCPM the schedule became more robust and easier to monitor. Project duration can be shortened by applying resource leveling. These details prepared based on Ancillary Building for Power upgradation substation with the completion of physical work at site as on date, in this the work completed with little buffer insertion. To understand the more benefit of using CCPM concept, management encouragement required to adopt CCPM in construction industry and handy software to be devolved for make it more convenient in the construction industry.

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