International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 05 | May-2018 www.irjet.net p-ISSN: 2395-0072

APPLICATION OF CRITICAL CHAIN PROJECT MANAGEMENT IN BUILDING CONSTRUCTION PROJECTS

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Abstract - *Many industries, including construction, have been using Critical Path Method (CPM) scheduling for a very long time. However, due to the increasingly competitive business environment, tighter time constraints are becoming the norm of the industry. As a result, more and more projects are slipping out of schedule. This eventually led to the development of a new project management technique, the Critical Chain Project Management (CCPM) Technique. It was developed by Eliyahu M Goldratt in 1997 based on the Theory of Constraints (TOC). The Critical Chain is the sequence of both precedence and resource dependent tasks that prevents a project from being completed in a shorter time, given finite resources. CCPM assumes that projects are plagued by uncertainty, that task times are overestimated as an attempt to avoid the undesirable effects of such uncertainty, but, in effect, such added safety time is actually wasted. In CCPM, this is countered through adequate buffer management. CCPM can be used in both single project and multi project environments. Through CCPM, the projects will get completed early with efficient resource utilisation. However it is not yet widely used in the construction industry. This paper shows the results of a study conducted in the field using the CCPM methodology.*

Key Words: critical chain, project management, critical path, buffer management, fever chart

1. INTRODUCTION

Project management deals with planning, organizing, and managing resources to bring about the successful completion of specific project goals and objectives. It is about making and keeping commitments under conditions of moderate to extreme uncertainty accompanied by significant levels of complexity and interdependencies. In most project management environments, it is expected that binding commitments will be made in three separate dimensions of a project before the project starts: (i) schedule or time, (ii) resource or budget, (iii) scope, quality or performance objectives. Falling short on any of these commitments can result in the project being deemed a failure, with attendant negative consequences to stake holders. Although each industry has its share of successfully concluded projects every year, evidence suggests that there is a high rate of project management failure across all industries. From numerous studies it has been found that only 44% of projects typically finish on time, projects usually complete at 222% of the duration originally planned, 189% of the original budgeted cost, 70% of projects fall short of their planned scope, and 30% are cancelled before completion. All this paved way to the development of the critical chain method of project management in the 1970's.

1.1 Critical Chain Project Management

Critical Chain Project Management (CCPM) was first introduced in 1997 by Dr. Eliyahu M Goldratt. It is based on methods and algorithms derived from Theory of Constraints (TOC). Application of CCPM has been credited with achieving projects 10% to 50% faster and cheaper than the traditional methods (i.e. CPM, PERT, Gantt, etc.) developed from 1910 to 1950's. The traditional statistics are mostly avoided through CCPM.

Dr. Eliyahu M Goldratt observed certain behavioral patterns in the workers that deterred the work flow. This included: 1) Procrastination or student syndrome, 2) Parkinson's law and the failure to report early completions, and 3) multi-tasking. The CCPM methodology was developed in order to eliminate these behaviors.

CCPM takes a different approach to handling risk than the traditional methods of project management. Traditionally the risk associated with a task is handled by the duration estimate of the individual task. Due to the Student Syndrome and Parkinson's Law this method has not proven to have the desired effect. By utilizing a pooled or aggregated risk methodology, task durations can be shortened to the task's average time to completion, and the variability of the tasks in actuality can be planned for and handled via buffers placed in locations that protect the project as a whole. Moreover, CCPM takes account of resource as well as precedence dependencies in determining the project duration. This solution allows project management to achieve its goal of making and keeping commitments while meeting the challenges of the project's complexity, interdependency, and uncertainty of the work environment.

1.2 Single Project Critical Chain

The basic steps of the process to create a single critical chain project schedule follow are:

1) Identify the critical chain

In CCPM, all activities are provided with duration, exclusive of the safety duration. Even though many methods of providing duration have been developed, in most cases, a 50-50 duration is given to the activities when using CCPM. The critical chain is identified as the

longest chain in the schedule considering both the precedence constraints and the resource constraints.

2) Exploit the critical chain

Any re-sequencing of tasks that can be done to reduce the project duration is done. Then the project buffer is added at the end of the critical chain. The project buffer is added to compensate for the safety time deducted from each activity in the above step.

3) Subordinate the other tasks, paths, and resources to the critical chain

Protect the critical chain by adding critical chain feeding buffers to all chains that feed the critical chain.

4) Elevate (shorten) the lead time of the project by using added resources for certain windows of time to break contention

5) Go back to step 1, identify the critical chain. Do not allow inertia to become the constraint

The figure 1 shows the CCPM technique being applied to a traditional plan.

In CCPM the project is monitored and controlled with the help of the buffer management system. It includes the fever chart, a graph between the % buffer used and the % chain complete. A Red/Yellow/Green convention is used to depict the overall status of each project at regular intervals and a trend chart is used to project whether or not the project's status is changing for the better or for the worst. Figure 2 illustrates how schedule risk for a single project can be tracked over time.

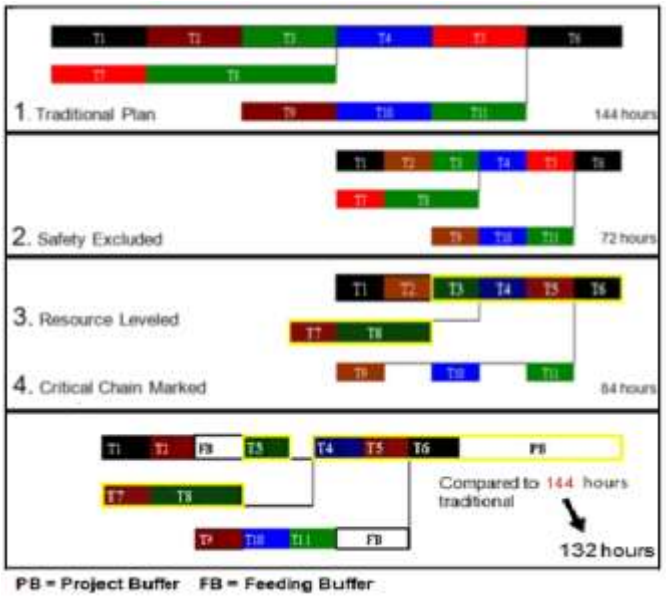


Fig -1 CCPM Schedule Preparation

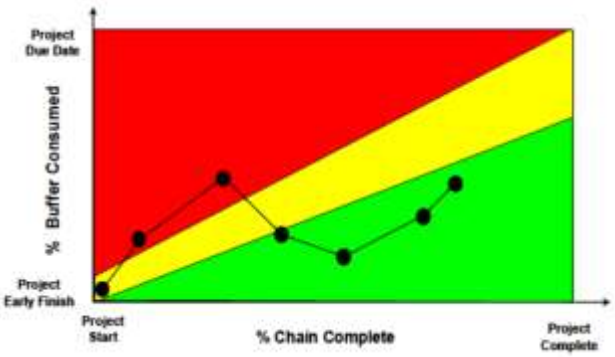


Fig -2 Fever Chart

2 LITERATURE REVIEW

Izmailov *et al.* studied the use of relatively new method of project management, Critical Chain Project Management (CCPM), comparing it with the traditional approach to project management. He observed that project progress and planning accuracy with the use of CCPM is frequently monitored not by the classical technique of earned value analysis, but by the percentage of the used buffers. Thus, the more time planned as a buffer is used, the greater the impact of uncertainty on the project in the form of realized risks. Tracking remaining project buffer for the task is used in CCPM to monitor the status of the task: when achieving the minimal threshold level of the buffer we need to apply some corrective actions. Similarly, the percentage use of the project buffer serves as a trigger for determining the feasibility of the promised completion date, and the indication of the success of the project.

He concluded that if an organization is actively using project management, including the use of a limited number of resources, and timing of projects are critical to the management, the use of critical chain project management may prove beneficial. [1]

Izmailov *et al.* also studied the core features of CCPM and delved into the problems faced while implementing CCPM. He observed that CCPM helps in accelerating the flow of work. It helps in getting the project completed early, with project duration reduced by 25-50%. Although these changes are easy to understand, its implementation is faced with many serious problems. It requires the appropriate support from senior department and cooperation with all other departments. [2]

Ghaffari and **Emsley researched** the current status of research on CCPM and potential areas of CCPM for future investigations. 140 papers were analysed and it was shown that there is still on-going research being conducted on the method and although with a slower pace, CCPM studies are still being published. Six categories of approaches towards CCPM (introductory, critical, improving, empirical, case-reporting and exploiting) were identified and their

contributions discussed, one of them being improving studies. Finally, the areas requiring future research were identified. [3]

Heptinstall published a case study of the 'win-win-win public works' initiative started in Japan in 2011, which encouraged the use of CCPM in its project management works. The contractors were asked to adopt the CCPM methodology. The use of CCPM increased as people found that CCPM allowed them to deliver better and faster projects, whilst also collaborating and working in harmony with other project members. It was then found that the project progress was hindered still, but by the government staff, and in particular the speed at which decisions were made throughout the project lifecycle- this became the next improvement target. The overall benefits included faster projects, improved collaboration, fewer disputes, increased staff motivation, higher profits and increased capacity. [4]

Lechler *et al.* studied how CCPM is different from other project management approaches. It is concluded that the philosophy behind the critical path and critical chain approaches is remarkably different resulting in a different mindset for managers and a different set of management practices. The main difference is the application of the Theory of Constraints (TOC) in the critical chain case. As a result, critical chain focuses at improving the systems performance by laying out specific policies many of which are focused on resource management especially in multi-project environments that are not explicitly addressed by critical path. [5]

Leach published a textbook on CCPM that elaborately describes the CCPM technique. The Theory of Constraints is also described. It is the best book on CCPM that discusses CCPM in single as well as multi project environment with good examples. [6]

Herroelen and **Leus** highlight the merits and pitfalls of the CCPM scheduling approach. The CCPM scheduling mechanism is tested in a full factorial experiment performed on a set of benchmark problems. It was observed that the 50% rule for buffer sizing may lead to a serious overestimation of the required buffer protection. Regularly updating the baseline schedule and the critical chain provides the best intermediate estimates of the final project duration and yields the smallest final project duration. [7]

3 OBJECTIVES

The objectives of this study are:

- To study the effects of using CCPM in project management
- To study how the buffer management in CCPM helps in decision making, compared to the traditional CPM method

4. SCOPE

The study is limited to single project environment; multi project environment is not considered. The study ranges only over three months of the construction project.

5. METHODOLOGY

The methodology of the project is given in figure 3.

6. RESULTS

For conducting this study the site selected was that of a 10-storied office building in the city.

6.1 Pre- Implementation

Before implementation, the first step was to make the team aware of the CCPM methodology. For this purpose, a detailed class was taken on CCPM at the site. The workers were encouraged to work fast and report the work on time. They were closely watched and monitored so that the work may not be delayed.

6.2 Project Schedule Preparation

Critical path method was used to prepare the schedule at the site by the project manager. MS Project was the concerned software used. The initial project schedule is given in figure 4. The total project duration was found to be 627 days.

Fig -3 Methodology

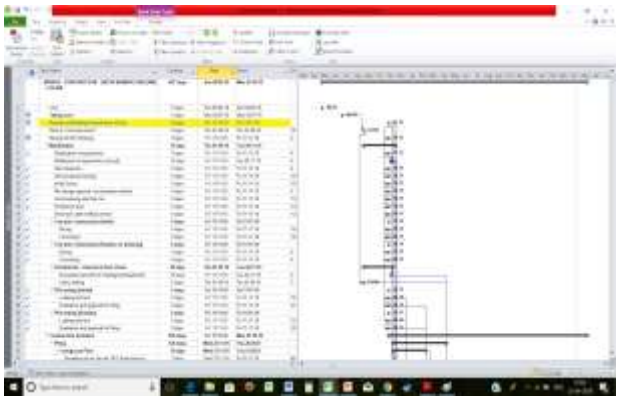


Fig -4 CPM Schedule; Duration = 627 Days

The next step was to prepare the CCPM method and prepare the corresponding schedule. The MS Project software itself with the ProChain add-on (for implementing CCPM) was used for this purpose. The schedule preparation required finding the focussed duration or the most optimistic duration for all tasks. It was calculated with proper guidance. The CCPM schedule initially prepared is shown in figure 4. In the CCPM schedule, the total duration was reduced to 600 days.

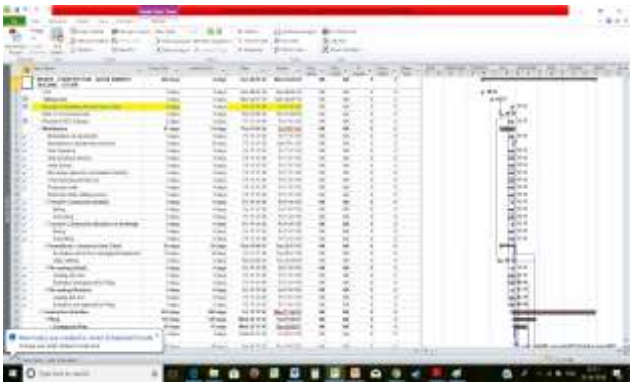
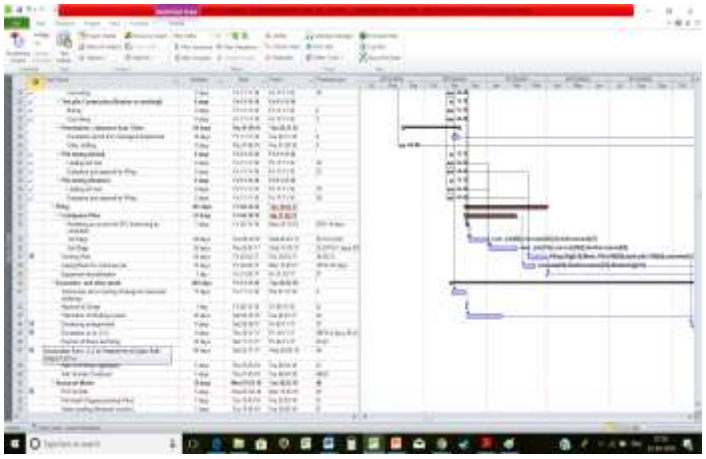


Fig -5 CCPM Schedule; Duration = 600 Days

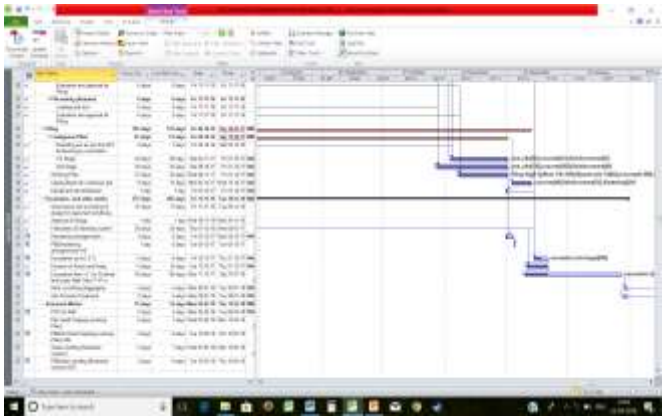
5.3 Monitoring the Schedule Using CCPM

The schedule was monitored and constantly updated in the CCPM software. It was observed that it was more easy and understandable to use the CCPM method of project monitoring and control than the CPM method. At a certain time the project progress can be checked by observing the fever chart.

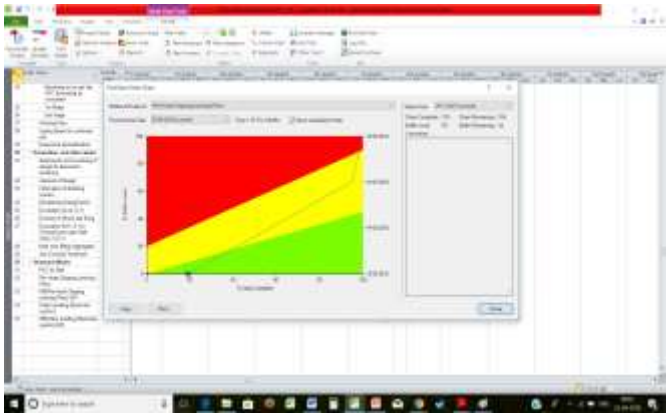
The progress check for the project on 29-11-2017 is as shown in figure 6.



(a) Before Updation



(b) After Updation



(c) Corresponding Fever Chart

Fig -6 (a), (b), (c) and (d) Schedule Details as on 29-11-2017

It was observed here that the current status of the project is alright, as can be seen from the corresponding fever chart. The project is in the green and yellow zones and the project buffer consumption is also low.

6 CONCLUSIONS

It was observed that:

- The schedule became more robust and easy to monitor while using CCPM
- The schedule got shortened and the project duration got shortened by 5 %
- This study was conducted over a small project duration, in which time the work occurred smoothly with little or no buffer consumption. To understand the concept better and to encourage management to adopt this method, a longer monitoring and control time is necessary.

REFERENCES

[1] Izmailov Azar, Korneva Diana, Kozhemiakin Artem (2016), "Project Management Using the Buffers of Time and Resources", Procedia - Social and Behavioral Sciences, vol. 235, 24 Nov, pp. 189 – 197

[2] Izmailov Azar, Korneva Diana, Kozhemiakin Artem (2016), "Effective Project Management with Theory of Constraints", Procedia - Social and Behavioral Sciences, vol. 229, 19 Aug, pp. 96 – 103

[3] Ghaffari Mahdi, Emsley Margaret W (2015), "Current status and future potential of the research on Critical Chain Project Management", Surveys in Operations Research and Management Science, vol. 20, Dec, pp. 43 – 54

[4] Ian Heptinstall (2012), "Construction Procurement and Project Management in Japan's Public Sector", PM World Journal, vol. 1, issue 1, Aug 2012

[5] Lechler Thomas G, Ronen Boaz, Stohr Edward A (2005), "Critical Chain: A New Project Management Paradigm or Old Wine in New Bottles?", Engineering Management Journal, vol. 17 no. 4, Dec

[6] Leach Lawrence P, "Critical Chain Project Management", Second Edition, Artech House effective project management library, 2005

[7] Herroelen Willy, Leus Roel (2001), "On the Merits and Pitfalls of Critical Chain Scheduling", Journal of Operations Management, pp. 559 – 577