RESEARCHERID
THOMSON REUTERS

[Bhan* *et al.*, 6(8): August, 2017]
IC™ Value: 3.00

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

MONITORING OF CONSTRUCTION PROJECT THROUGH BUFFER MANAGEMENT

Ms. Arti Bhan[*1] & Prof. Ashish P. Waghmare[2]

[*1]Post Graduate Student, Department of Civil Engineering, DYPSOET, Pune, India
[2]Assistant Professor, Department of Civil Engineering, DYPSOET, Pune, India

DOI: 10.5281/zenodo.839157

ABSTRACT

Critical Chain Project Management is an effective method over Critical Path Method (CPM) for scheduling and monitoring the progress of a project. CPM leads to ineffective scheduling due to overestimation of duration and increases the overall project duration. The task estimates in CPM are based on guess work whereas CCPM reduces the duration of task to 50% to that of its original duration as uses the remaining 50% duration as buffer to protect the activity against delays. Also the availability of resources is not considered by the scheduler to develop optimal schedules. To overcome the shortcomings of CPM, a new project management methodology called "Critical Chain Project Management" (CCPM) was developed in 1990's by Dr. Eliyahu M. Goldratt after which various additions were given by different researcher to his research. CCPM is based on the philosophy of "Theory of Constraints" (TOC) which believes that every system has a constraint & without eliminating this constraint the system cannot progress. CCPM achieves its goal through buffer management. The developing countries like India mostly face the problems of project delays so CCPM can be applied to save the projects from time and cost overruns. This paper aims at the scheduling and monitoring the project using fever charts through buffer management.

KEYWORDS: CCPM, TOC, Buffer Management, fever chart.

I. INTRODUCTION

CCPM aims at delivering the projects faster as compared to traditional methods & achieves it through the process of waste reduction. The CCPM project planning & control process directly addresses uncertainty and variation in project activity duration. It focuses on developing and managing project performance to meet or exceed reduced activity times, thereby, reducing overall project duration. India is a developing country which is on a pace of transformation towards growth. It is necessary for any developing country to develop its infrastructure for continual improvement in its GDP as infrastructure sector and real estate sector contribute majorly towards it. With RERA coming into effect in India, it is very important for construction firms to complete their projects within the stipulated time failing which they will have to pay penalty for delays to their customers. The Critical Chain is the sequence of both precedence & resource dependent tasks that prevent a project from being completed in a shorter time given finite resources.

CPM has does not consider the availability of resources and allows the multi-tasking of resources which contributes to the delays. On the otherhand CCPM considers the resource availability and does not allow multi-tasking and thus overcomes the drawbacks of CPM.. It has been found that most of the project planners normally include excessive contingency time within each activity while planning for a project to keep project completion duration on a safer side. There are various reasons found by researchers for such inefficient planning like Student's syndrome, Parkinson's law, Murphy's law etc. In India mostly, CPM is most used for planning the construction projects. To efficiently plan the project, thus CCPM can be helpful in single and multi-projet environments and also for complex projects which are highly uncertain risks associated with them

CCPM is based on the philosophy of Theory of Constraints. This philosophy has mainly focused on finding the constraint first which acts as an obstruction towards on time completion. In CCPM this is achieved through Buffer Management. The Critical Chain method works on the principle of removing the individual securing of

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

each task & allocating them at them at the end of project. There are various types of buffers like Project Buffers, feeding buffers, resource buffers which prevent the Critical chain and the feeding chains from adding to the delays in project completion dates. The use of CCPM and TOC is not only restricted to the construction projects rather it finds its application to other fields also like production, software development. The study uses Fever Charts to monitor the project through buffer management. al goals.

II. TYPES OF BUFFERS

Buffers are designed quantities of time, sized and applied to a project schedule to protect what is important to the success of that project.

A. Project Buffer

The Project Buffer protects the promised due date from variation in the critical chain. A Project Buffer is inserted at the end of the project network between the last task and the completion date.

B. Feeding Buffer

To protect against this, feeding buffers are inserted between the last task on the feeding path and the Critical Chain. The feeding buffer protects the ability of the critical chain to maintain its relay race performance by buffering the variation of non-critical tasks and chains where they feed into or merge with critical chain tasks.

C. Resource Buffer

Resource Buffers act as serve as a wakeup call for the resources that one may need in order to be ready to run their leg when their predecessor is complete.

III. Methods to decide buffer size

There are various methods given by researchers to decide the size of buffers which can help in effective buffer management. Some of them are given below:

1 Cut and Paste method
2 Root Square Error Method
3 Adaptive Procedure with Density
4 Adaptive Procedure with Resource Tightness

For the present case, Cut & Paste method is use to calculate the size of and manage the buffer.

IV. METHODOLOGY

1 Reduce the activity duration to calculate Aggressive duration or Average duration (T_{50}) from Safe duration (T_{90}).
2 The activity relationships are provided using the predecessor of respective activity to get network logic.
3 Allocate resources to all activity.
4 Find out the constraints of the project.
5 Remove the resource constraints before adding buffer to the project.
6 Introduce the buffers into the schedule.
7 Track the project and monitor the consumption of buffer through fever chart.

V. Data Collection

A. Case Study:

A case study from the real-world residential construction project is considered for this paper to validate the proposed CCPM framework. This section provides details of the study undertaken. Also, it is used to presents steps taken to implement the framework in the study. Table 1 gives the details of the schedule of Activities is based on CPM and has been modified in accordance with CCPM.

Table 1: Calculation of CCPM duration

Task Name	Duration of Activity in CPM (Days)	Duration of Activity in CCPM (Days)

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Site Cleaning	2	1
Line out works	2	1
Excavation	12	6
PCC	2	1
Footing	11	5.5
Stub Column	13	6.5
Plinth Beam	18	9
Plinth Filling	20	10
Floor PCC	18	9
First Slab		
Column	6	3
Beam bottoms marking & fixing	2	1
Beam Shuttering	3	1.5
Slab support works	4	2
Reinforcement works	4	2
Concreting	1	0.5
Second Slab		
Starters	1	0.5
Columns	4	2
Beam bottoms marking and fixing	2	1
Beam Shuttering	3	1.5
Slab support works	4	2
Reinforcement works	4	2
Concreting	1	0.5
Third Slab		
Starters	1	0.5
Columns	4	2
Beam bottoms marking and fixing	2	1
Beam Shuttering	3	1.5
Slab support works	4	2
Reinforcement works	4	2
Concreting	1	0.5
Ground Floor Masonary	21	10.5
First Floor Masonary	21	10.5
Second Floor Masonary	21	10.5
Ground Floor Internal Plaster	30	15
First Floor Internal Plaster	24	12
Second Floor Internal Plaster	24	12
External Plaster Internal Plaster	30	15

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

B. Removing Project Constraints:

After calculating the aggressive durations from the safe durations, the resource contentions are found which will prevent the project from completing within stipulated duration and can delay the project. In the present case the labour resources were acting as constraints for the project. To remove the resource contentions, resource levelling is done in MSP.

In the present case the labour resources were acting as constraints for the project. To remove the resource contentions, resource levelling is done in MSP.

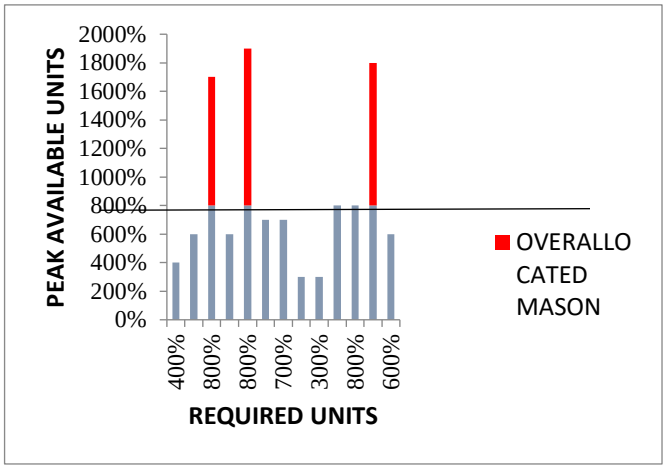


Fig 2: Resource Contention due to Mason Overallocation

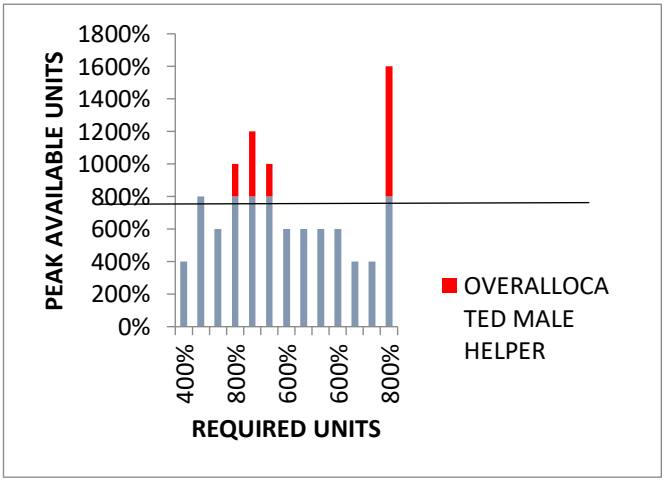


Fig 3: Resource Contention due to Male Helper Overallocation

After this, the critical chain and the feeding chain are identified and Project Buffer & Feeding Buffer is calculated using Cut & Paste Method of Buffer Management.

C. Buffer Sizing using Cut & Paste Method:

After identifying the critical and the non-critical chain the Project Buffer and Feeding Buffer is calculated using C& PM. This method is very effective for scheduling as it neither under-estimates nor over-estimates the aggressive durations

Table 2: Buffer Duration

Sr.No.	Buffer	Duration (Days)
1	Project Buffer	83.5
2	Feeding Buffer	8.5

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

Also, Feeding Buffer is inserted in the schedule to protect critical Chain from delays due to delay in the feeding Chain. The resource contentions found in the schedule was also resolved through resource levelling tool.

VI. BUFFER MANAGEMENT

A. Tracking Feeding Buffer Consumption:

The Buffer consumption is tracked as the project progress to check the feeding buffer consumption on the following dates:

Table 3: Feeding Buffer Consumption

Status date after Rescheduling	FB Consumed (%)	%Feeding Chain Complete	Actual Completed Duration (Days)	Baseline Estimated Duration (Days)	%Project Complete
19/10/16	0%	0%	14.3	222.5	6.4
21/10/16	24%	9%	33.9	223.5	15.2
31/10/16	76%	86%	67.27	238.5	28.2

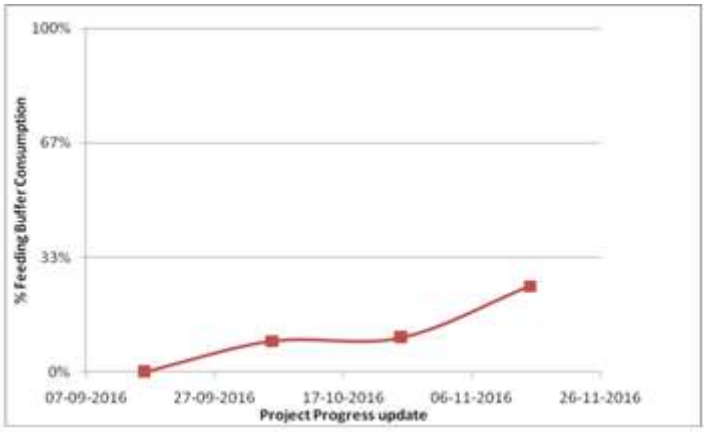


Fig 4: Feeding Buffer consumption as project progress

B. Tracking Project Buffer Consumption

After the consumption of feeding buffer due to delay in the feeding chain, the critical chain is protected from delays by the project buffer

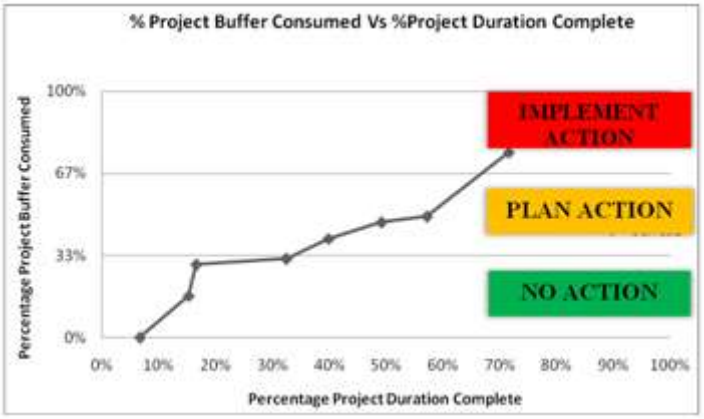
Table 5: Percentage PB Consumption

PB Consumed	PB Available	Percentage PB Consumed	Project Duration completed	Baseline Planned Duration	Baseline Estimated Duration	Percentage Project Duration completed
Days	Days	%	Days	Days	Days	%
0	84.5	0%	14.3	213.5	213.5	7%
14.3	84.5	17%	33.9	213.5	222.5	15%
25	84.5	30%	37	213.5	223.5	17%
27	84.5	32%	77.48	213.5	238.5	32%
33.9	84.5	40%	96.03	213.5	240.5	40%
39.5	84.5	47%	124.35	213.5	253	49%
41.5	84.5	49%	145.82	213.5	255	57%
63.5	84.5	75%	198.3	213.5	277	72%

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

VII. MONITORING PROJECT PROGRESS THROUGH FEVER CHART

After tracking the project , a fever chart is plotted which shows whether the project is on track or will be delayed due to excessive consumptions of buffer as the project progresses forward.



VIII. CONCLUSION

CCPM has delivered successfully in the software & production industry which work in a highly uncertain environment. As the projects are getting complex and the environment is highly uncertain, CCPM in construction projects can be a great boon to the construction industry to deliver the projects within time. While on the other hand the traditional methods fail to achieve the targets within time.

As the progress is monitored through Fever Charts which are very easy to understand, it can be easy for the management to take necessary actions from time to time to protect

In the Phase-I of the project i.e. till the initial 7% actual completion, the buffer consumption was nil. From the fever chart it is evident that the progress line lies in the first one-third of the fever chart which means that the schedule was going as planned.

In the Phase-II i.e. 30% to 75 % actual completion , there was huge consumption of buffer and the fever chart show that the project lies in the last one-third part of the project. It is an indication for the project team to make a mitigation plan to bring back the project in the second or first one- third of the fever chart to complete the project within time.

Fever charts are very easy to understand and can help the managers to take quick and necessary action to complete their project time and reduce delay.

CCPM is based on systematic approach and takes into consideration, the critical resources, it can be used in a multi-project environment which is mainly activity focused..

IX. REFERENCES

[1] Francois Retief, “Overview of Critical Chain Project Management,” Critical Chain Symposium, Management Planning Systems, 2002Graham K. Rand, “Critical Chain: The Theory Of Constraints Applied To Project Management”, International Journal of Project Management, Pp.173 To 177,2000.
[2] Goldratt EM, “Critical Chain”, Great Barrington, MA: The North River Press, 19.
[3] Goldratt, E.M., The Goal. Second ed., North River Press, New York (1992)
[4] Herman Steyn, “Project Management Application Of The Theory of Constraints beyond Critical Chain Schedulling”, International Journal of Project Management, Pp. 75-80,2001.
[5] HoseinIranmanesh, FatemehMansourian and SamanehKouchaki, “Critical Chain Scheduling: A New Approach for Feeding Buffer Sizing,” in International Journal of Operation Management, Vol 25,No. 1, Pp. 114-130, 2016.
[6] JunguangZhanga, Xiwei Song and EstrellaDíaz, “Critical Chain Project Buffer Sizing Based On Resource Constraints,”, International Journal of Production Research”, Pp. 1-13, 2016.

[7] Junguang Zhang, SaikeJia and Estrella Diaz, "A New Buffer Sizing Approach Based On the Uncertainty Of Project Activities", Concurrent Engineering: Research & Applications", vol. 23(1) Pp 3-12, 2015.
[8] Lawrence P. Leach ,Artech House Boston, London, 2005.
[9] Leach, L.P., Critical Chain Project Management. Artech House Professional Development Library (2000)
[10] M.Ghaffari&M.W.Elmsley, "Current Status and Future Potential of the Research on Critical Chain Project Management", PM World Journal, VOL IV, Issue ix-September, Pp 1-25, 2015.
[11] Newbold R.C, Project Management in the Fast Lane-Applying the Theory of Constraints. The St.Lucie Press, Boca Raton (1998)
[12] Oya i. Tukel , Walter O. Rom and Sandra DuniEksioglu, "An Investigation Of Buffer Sizing Techniques In Critical Chain Scheduling", European Journal of Operation Research, Pp. 401-416, 2006.
[13] P.M. Chawan, Ganesh P. Gaikwad, Prashant S. Gosavi , "CCPM: TOC Based Project Management Technique", International Journal of Engineering Research and Applications, Pp. 1048-1052, 2012.
[14] Rob Newbold, "Schedulling for success with Critical Chain", ProChain Solutions, Inc, Pp 1-14,2010.
[15] Shurrab M, "Traditional Critical Path Method versus Critical Chain Project Management: A Comparative View", International
[16] Journal of Economics & Management sciences, vol 4 Issue 9, Pp. 1-6, 2015.
[17] Thomos G. Lechler, Boaz Ronen and Edard A. Stoh, "Critical Chain: A New Project Management Paradigm Or Old Wine In New Bottles?",Engineering Management Journal, VOL. 17 No. 4 Pp. 45-58, 2005.
[18] TzviRaz, Robert Barnes and DovDvir, "A Critical Look At The Critical Chain Project Management," Project Management Journal, Pp. 24 -32, 2003.
[19] http://www.goldratt.com
[20] http://www.ProChain.com.
[21] http://geometricglobal.com/
[22] http://google.com/
[23] https://books.google.co.in.

CITE AN ARTICLE

Bhan, Arti , and Ashish P. Waghmare. "MONITORING OF CONSTRUCTION PROJECT THROUGH BUFFER MANAGEMENT." *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY* 6.8 (2017): 171-77. Web. 5 Aug. 2017.