ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.6

Applying the Theory of Constraints in Project Management

Priya Bhagdewani[1], Prof. A.K.Kanase[2], Prof. R.D.Shinde[3]
PG Student[1], Professor [2], HOD[3]
Department of Civil Engineering
RMD Sinhgad School of Engineering, Warje, Pune, Maharashtra, India[1, 3]
Sihgad Institute of Technology & Science, Narhe, Pune, India[2]

Abstract:
Theory of constraints (TOC) is about thinking in logical and systematic way similar to the Plan do check act (PDCA) learning loop. It is not only about analyzing the causes and effect but also verifying basic assumptions, exploring alternatives and process improvement. The goal of TOC is to maximize the efficiency, profitability, quality of work. This paper includes basic theoretical information about TOC. It basically helps in problem solving & implementing the solution for the same. TOC is majorly applied in manufacturing sector, including distribution, marketing, project management, and accounting. In short, any situation involving change to a system TOC is applied.

Keywords: Theory of constraints (TOC), process improvement, critical chain, project management, linear programming, Case study.

I. INTRODUCTION

In today's construction scenario, it is essential to grow with the new technology & concepts. Continuous improvement is the ultimate goal. Basically in India, where the proper system of work is not followed, TOC will helps in understanding to not limit the extent of any task to its optimization but to continuously approaching the new techniques so as the optimization will be continued till the end. **Theory of Constraints (TOC)** is an overall management philosophy introduced by Dr. Goldratt in his book titled *The Goal*. This title comes with the thought that any manageable system is limited to achieve the goals at certain context; where in reality there is always at least one constraint. Constraint is nothing but the point where the project or task fails to perform at it is expected. This paper will first briefly outline the background of TOC, and then the Practical application from the survey of real case, its applications and the findings. The main concept of TOC is that any organization has a constraint which dominates the entire system. To improve the system one should know how to tackle such constraints. Therefore, TOC is a tool allows learning and using the thinking processes that enable them to develop their own solutions to complex problems. This helps in analyzing the situation, finding the causes the obtaining the solution by applying different combinations of solutions.

OBJECTIVES OF RESEARCH:

- To Increase the profit
- Fast improvement
- To Improve the capacity
- To Reduce lead times
- To Reduce inventory

SYSTEMS AS CHAINS

Goldratt states that there is only one constraint in a system at a time limiting the Output of the entire system. When one constraint is strengthened, however, the system does not become infinitely stronger. The system is stronger than it was but still not as strong as it could be. Suppose there are three machines A, B & C. In this, machine B is the weakest constraint. Imagine that the manufacturer improves machine B & now, process C becomes the system constraint while the non constraints are everywhere else. If process improvements continue until all the machines perform at its best. At this point, internal constraints have been replaced by an external constraint. Overall, the theory of constraints emphasizes fixing the weakest link in the chain—the system constraint.

The weakest link in the chain is in fact the strongest one since it breaks it[1]…

II. LITERATURE SURVEY

The literature search has covered many blogs on TOC. In majority of papers, the methodology of TOC has been discussed theoretically. However it would also be useful to collect and analyze the actual reported data on the benefits of TOC, to verify & improve the process. The literature search identified several case studies and quantitative data on the application of TOC to different companies. The main application of TOC is in the manufacturing sector. However, there were several instances of application to administrative functions. The methodology of TOC is now stepping into construction sector. This methodology works as a problem solving tool. Drum Buffer Rope (DBR) system is used to optimize the results. Here, Drum is the activity, Buffer is controls the mechanism of process & rope is nothing but the arrival of resources at the unit.

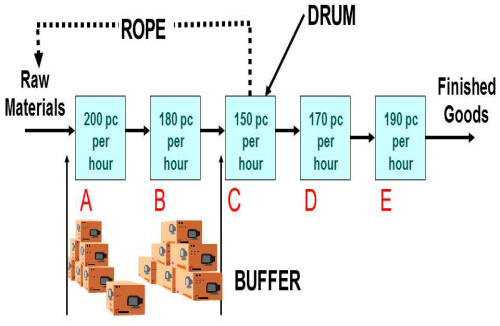


Figure.1. Drum Buffer Rope system

In our study, we firstly classified the constraints into five categories based on literature review. They are:
(1) Economic constraints,
(2) Legal constraints,
(3) Environmental constraints,
(4) Technical constraints, and
(5) Social constraints.

III. ASSUMPTIONS

TOC methodology operates on several assumptions:

- For any system, Speed and volume are the main determinants.
- Current processes are essential to produce the desired output.
- The product or service design is stable.

IV. RESEARCH METHODOLOGY

The Research Methodology follows below procedure-

- **Applied research:** gathering the knowledge for practical application focusing on solutions for specific problems.
- **Qualitative approach:** approximation between theory and factors, by means of analysis of sujectiveness and practical approach.
- **Explorative research:** bibliographic survey, interviews with people, analyzes the causes & effects.
- **Case study: d**irect observation of the reality with the use of logic; deeply analysis of the object

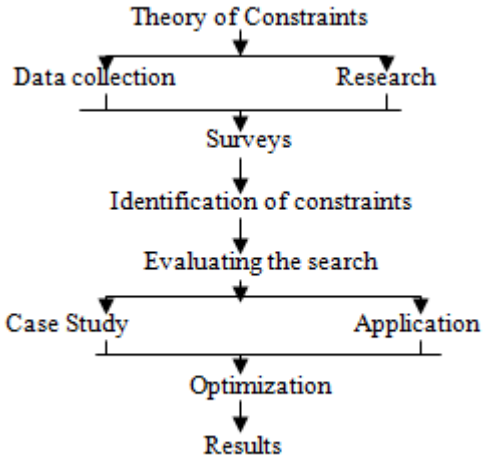


Figure.2. Flow Chart of Research

V. THEORY OF CONSTAINTS

In TOC, planning, execution and control should be done through the Constraint Management paradigm by means of a Continuous Improvement Methodology.

THE FIVE FOCUSSING STEPS OF TOC

Step 1: Identify the system constraint.
In the first step, one has to identify what part of the system constitutes the weakest link

Step 2: Decide how to exploit the constraint.
Exploiting means finding the causes & the ultimate changes or upgrades for the particular constraint.

Step 3: Subordinate everything else.
In this step, when the selected constraint is operated, rest of the non constraints is adjusted & hence results are evaluated. Then the performance is measured If the constraints gives the desired performance steps 4 is followed if not, the constraint is eliminated and step five is followed.

Step 4: Elevate the constraint.
This step is followed if Steps 2 and 3 were not sufficient in eliminating the constraint. At this point, the constraint is eliminated by involving major changes.

Step 5: Go back to Step 1
The whole procedure is repeated again to check the system performance. At the same time, changes related to subsequent constraints are observed properly with their impact on the constraints that are already broken, thus preventing solution inertia.

THEORY OF CONSTRAINTS AND LINEAR PROGRAMMING:

A CONCEPTUAL ANALYSIS

Linear Programming in Construction Management
LP can be used in construction management to solve the problems such as:

- Optimizing the use of resources.
- Determining most economic product mix.
- Transportation and routing problems.
- Personnel assignment.
- Determining Optimum size of bid.
- Location of new production plants, offices and warehouses

TOC is a conceptual adaptation, an evolution or a simplification of the Linear Programming (LP). This paper presents the logical foundation between these approaches, in order to further discuss the possible relations between them. Based on a numeric example and on the assumptions, this paper argues that, despite of searching optimizations in its origin, TOC currently presents few common points with LP.

FIELD PROGRESS REPORT

Case study- Ampco (Industrial Building at Chakan, Pune)
The purpose of this section is to describe the application of TOC on an ongoing Industrial project called AMPCO at Chakan, pune.
Typical situation at construction site:
o Low profit, low return of invest.
o Delivery time and time of commencement is longer than customer waiting.
o Delivery precision is not followed.
o Not enough time for good decision.

The possible conflict at any site can be determined well in advance with the experience & nature of work the various aspects of the project are to be list out & probable solutions or alternatives has to be decided prior to work. During application we can meet often with following problems:

o Resistance to change
o Disagreement on the issue
o Disagreement about problem solving
o Solution has sometimes unwanted risk
o Unspoken concerns

Research contribution

This paper describes the theoretical and practical knowledge about Theory Of constraints. Consequently, this article pointed to the possible problems and barriers at Ampco during application. This paper is based on an Industrial project called "AMPCO" at Chakan, Pune. It's a G+1 building. RCC frame structured building having flat slab carrying reinforcement in higher amount than conventional one. This project has been started 2 months back & is still at its construction phase. The main reason of such delay is improper planning, insufficient geological data, etc.

APPLICATION OF TOC-

Planning is the most important aspect of any project & this paper shows how TOC can be applicable to the construction sector to eliminate the delay, identify its cause and solution to it. Example- for Bar bending, If there are 4 nos. of bar benders, then also delay is causing due to on time assembling of reinforcement bar then we have to identify the weakest or slowest person in this procedure. After that, instead of incorporating extra recourse one shall see the solution to strengthen the existing bar bender by training or single task procedure or allocating him the bars at first stage. TOC mainly focuses on such small links in a chain as small delay can result into the overall delay of project. To avoid such delays, the schedule shall be made not only for the overall project but also for weekly purpose. Then the observations are to be made. Regular meetings, approaching the vendors can help in fast delivery of project.

SCOPE OF TOC-

TOC is not only limited to overcoming such delays but also for continues improvement as there is always a constraints in any project. The five steps of the Continuous Improvement Methodology of TOC are to be used in such matters. Also, LP helps in problem solving technique.

TOC Methodology has to consider following aspects-

- **Internal:**
  1. Process constraints
  2. Lead time
  3. Policy constraints
  4. No overtime

- **External:**
  1. Material constraints
  2. Insufficient materials
  3. Market Constraints
  4. Demand constraints

Observations on site & causes of delay-

Before starting of any project, a lot of documentation is to be done. It involves environmental clearance certificate from MPCB, NOC's from different departments, approvals from MSRDC, MIDC, etc. These approvals takes time hence it's a time consuming activity. After discussing with client (If any), these approvals are made. Simultaneously drawings are to be prepared. Now, The drawings are primary requirements without which one can't start the work of approval process. Once the preliminary drawings are prepared & approvals are made excavation process is started. In Ampco, after getting approval, trial pits were excavated. Then it was noticed that Hugh amount of black cotton soil Is there at site. So, Geological survey was made, which caused 10 days delay in consulting & further excavating the whole WBC at about 3 to 5m depth took a lot of time. This type of ignorance of not doing Geological survey by trial pit method is regularly in practice in India. If TOC would have been applied in this area, one should have done the pit excavation prior to approval or at the same time documentation was made. Resulting in saving time, cost & delay wouldn't have occurred. Another example is of Using appropriate excavating tool. For removing such a big amount of WBC, JCB is more suitable as pokland is to be used for hard rock plus it costs more. Averagely, 15-20 m3 of material can be removed by a JCB in one working day.

Question 1: An aggregate crushing plant has two crushers A & B. Both the crushers produce two sizes of metals, 6mm(X) and 10mm(Y). The requirements for each product are provided in the table below.

Resource	Required per unit of Product X	Required per unit of Product Y
Crusher A	3 brass	5 brass
Crusher B	4 brass	3 brass

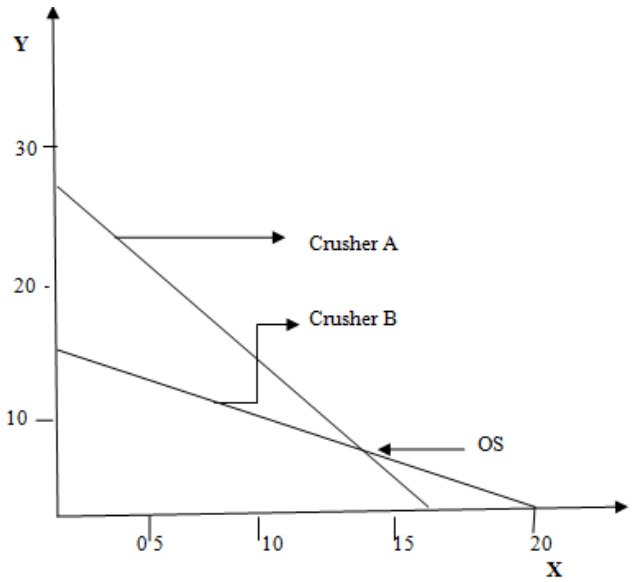
Weekly capacity is 80 hours for plant A and 60 hours for plant B. Throughput per brass at is Rs.1100 for X and Rs.1300 for Y. Assume that the company can produce as much of X and Y as it can produce. Determine the maximum throughput of X and Y that can be produced.

Solution: Where there are no demand constraints. The plant A constraint is 3X + 5Y = 80 so the company can produce 26.67 brass of X (80/3) or 16 units of Y (80/5) or some combination of X and Y on the line connecting those two points on the graph. The plant B constraint is 4X + 3Y = 60 so the company can produce 15 units of X (60/4) or 20 units of Y (60/3) or some combination of X and Y on the line connecting those two points on the graph.

We can find the solution by checking the throughput at each of the corner points.

1.16Y@Rs.1400=Rs.22,400
2.15X@Rs.1100=Rs.16,500
3.14Y@Rs.1400+8X@Rs.1100=Rs.28,400

The last point represents the solution since it produces the greatest throughput.



In such way Linear programming can be used to solve different problems. Another example to show the application of TOC is as follows-

Example: If a site needs to order 60m3 of concrete from RMC Plant for the work, normal practice is to hire a single vendor for supplying a particular material. Here the constraint is cost. To find the best optimum solution to minimize the overall cost of the project, one should focus on material inventory. Consider two RMC plants which are at equal distance from site. Plant a processes fast & delivers on time. Plant B processes the same quantity in longer period than plant A. But Plant a charges more than plant B & transportation cost is same for both. Now assume that the site requires 40m3 of total requirement on urgent basis. One can order 40m3 from plant A & remaining 20m3 from plant B. As the remaining concrete can arrive late, ordering from Plant B make sense & result in cost saving.

VI. CONCLUSION

To have a good understanding of the identified constraints at the planning stages, the documentation plays a very important role. Based on experience & assumptions, one can list out the probable causes of delay & identify the root for the same. At the implementation stage, the management should keep track of the progress and be aware of the constraints they encounter initially. The management should ensure that enough resources like money, facilities, staff and equipments are allocated to decrease the limitations from the constraints encountered. After studying the basic concept of TOC, the application of it can be done by simple Linear programming method. So far this paper has focused on maximizing throughput as the end goal. Actual Process is to elaborate start to finish length of the project, the overall delays occurred and reasons so as for the next project same mistakes shall not happen. However, short cycle times results in high. In short, for maximum profit, the bottleneck tool should always run at full capacity. That's one reason why *Just in Time* isn't really compatible with mass customization and mass construction processes. Goldratt's approach *should* be flexible enough to work even in a low cycle time environment, simply by redefining the constraints.

VII. FUTURE SCOPE OF WORK-

This paper describes the theoretical and practical knowledge about Theory of constraints. Consequently, this article pointed to the possible problems and barriers at Ampco during application. Results from this research give an impulse for next Working out about continues process improvement at Ampco. At present, goal is to identify the way to Incorporate TOC by identifying the scope, cost estimation, project management, proper planning and scheduling. Another advantage of this is we can identify the future constraints and plan to overcome them well in advance. It can also be helpful to overcome the barriers not only on Ampco but also to other sites too. Such barriers could be material procurement, resource allocation, etc. Identifying the probable constraints prior to the work helps in planning the tasks as per the analysis and saving money. Well in this case, Ampco has the following probable future constraints-

1. PEB design- PEB drawings, certification and approval from authority shall be done on prior basis as RCC design is totally dependent on it. Even though the design is ready, it takes time for the certification and approval. Also, after getting the approval, it takes 20-30 days for a manufacturer to cast and transport the material at site. So, one should take this thing in mind and order according to that so as the delay shall not occur.
2. Material allocation, its procurement, availability in market- material management is one of the most important tasks in any project. Its inventory control, testing, procurement, availability, etc things shall be taken care of.
3. Finishing works- as finishing works takes a lot of time, finishing works like flooring, painting shall be done on priority basis And for that proper resource management is required.
4. Fire NOC- Fire NOC form PMRDA or MIDC need to be taken for industrial works. It included casting of fire tanks, fire hydrants, etc. all the drawings should be prepared and approval shall be made.
5. MEP Design- Electrical and plumbing layout is prepared and approval shall be made from respective authorities.

VIII. REFERENCES-

[1]. The goal: a process of ongoing improvement By Goldratt, Eliyahu.

[2].http://en.wikipedia.org/wiki/Theory_of_Constraints

[3].Applying the theory of constraints in the course of process improvement by Michal MARTON, Iveta PAULOVÁ

[4]. Brazilian Journal of Operations & Production Management (Volume 7, Number 2, 2010, pp. 81-100)

[5].A Review of Goldratt's Theory of Constraints (TOC) – lessons from the international literature (Steven J. Balderstone and Victoria J. Mabin School of Business and Public Management Victoria University of Wellington New Zealand)

[6].Critical chain: the theory of constraints applied to project management by Graham K. Rand (Department of Management Science, The Management School, Lancaster University, Lancaster LA1 4YX, UK International Journal of Project Management 18 (2000) 173±177)

[7].Goldratt EM. Critical chain. Great Barrington, MA: The North River Press, 1997.

[8].Applying the Theory of Constraints to Supply Chain Collaboration by Togar M. Simatupang Institute of Information Sciences & Technology Massey University Private Bag 11222 Palmerston North New Zealand

[9]. http: //www.l ean- manufacturing- japan. com/scm-terminology / dbr-drum-buffer-rope-theory.html