Application of Critical Chain Project Management to Construction Project by a Case Study

사례연구를 통한 건설프로젝트에 CCPM의 적용

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Abstract

The Theory of Constraints (TOC) is an approach and a philosophy that is used to develop specific management techniques. It was first popularized by the novel, The Goal, that applied the principles to operations management. Since 1997 it has found application in two areas within project management. The first application is scheduling of a single project to reduce project duration and simplify project control. there is a further application to allocate resources that are shared by concurrent project. It is the objective of this paper to explore the fundamentals of critical chain and to pursue an application of critical chain method to construction project by a case study.

Key Word: TOC, CCPM, Project management

1. Introduction

The engineering and construction industry faces formidable challenges. As a whole, the industry worldwide continues to perform unsatisfactorily. It suffers from low profit margin, persistent project overruns in schedule and budget, and is plagued with claims and counter-claims.[1]

The construction industry receives many criticisms. Mohamed[2] claims that the current practices and mechanism of the construction are inherently inefficient, which inevitably leads to wastes. De la Garza[3] thinks that the construction industry productivity has been static for almost two decades.

The Theory of Constraints (TOC) is an approach and a philosophy that is used to develop specific management techniques.[4] It was first popularized by the novel, The Goal[5], that applied the principles to operations management. Since 1997 it has found application in two areas within project management. The first application is scheduling of a single project to reduce project duration and simplify project control. This is the main theme of the novel Critical Chain[6]. Only towards the end of this novel there if some indication of a further application to allocate resources that are shared by concurrent project.

It is the objective of this paper to explore the fundamentals of critical chain and to pursue a application of critical chain method to construction project through a case study. The paper is organized as follows. Section 2 offers a short overview of the fundamentals of critical chain method. Section 3 discuss about domestic construction project case applying critical chain method. Section 4 provides overall conclusions and offers some suggestions for future research.

2. Critical chain method

Goldratt proposes a Critical Chain Project Management (CCPM) method, to overcome some of the problems inherent in the traditional project planning and scheduling methods, notably the basic Critical Path Method (CPM). The critical chain method, applying the Theory of Constraints (TOC), offers an enhanced approach to manage the associated risk and uncertainty in the project value chain and to achieve improved performance in project time management.

2.1 Critical chain approach

PERT deals with uncertainty in the same way for all activities, whether or not they are on the critical path. The approach of the critical chain method is to relocate the safety times in strategic positions. Time estimates may be reduced (if it is known they are inflated), but safety buffers of time at the end of the project, called the "project buffer" shown in Fig 1, are added. This will have the effect of reducing the length of the critical path. It should be noted that the decision to cut the overall safety time is subject to the level of confidence that concerned parties have in this process. the Goldratt Institute recommend that the first emphasis should be on finishing on time, before looking for a reduction in overall time: in the TOC language, they go for 'exploit' before 'elevate'.

The activities on the critical path need to be able to start when the previous activity on the path are completed. They should not be required to wait for any sub-critical activities. So "feeding buffers" are added at the end of the non-critical sub-paths shown in Fig 2. Resource buffer may be needed to

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deal with critical resources, in order to protect the critical chain for resource availability. It is argued that the drastic cut in activity times will have the benefit of removing procrastination, the "student syndrome", because those involved are concerned about whether or not they can finish the activity the on time.

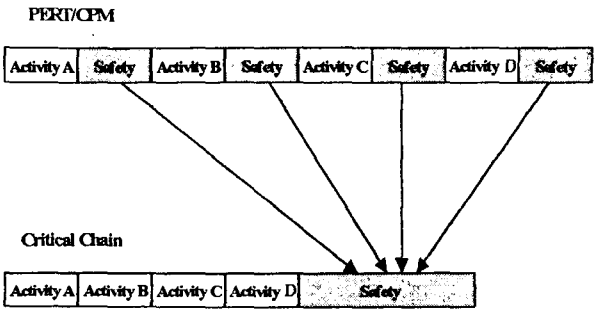

Fig. 1. Comparison between PERT/CPM and Critical Chain Method with regard to safety time[13)]

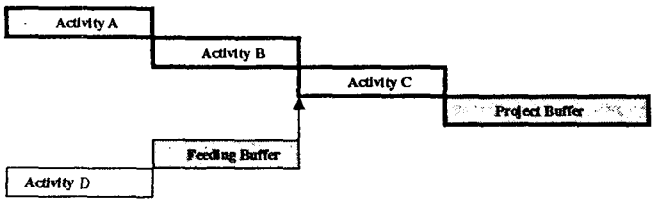

Fig. 2. Arrangements of buffers in the TOC approach to project management[13)]

3. A case study

We intended to study the application of CCPM to construction project by a domestic case. This case is river levee work and is divided into three areas(Area A, B, C). The main works are a bank protection construction and a poor subsoil improve -ment construction. The summary of this case (area A) is presented in Table 1.

Table 1. Summary of a case project (Area A)

Activity	Duration	Start Date	Finish Date	Budget	Rate
river levee costruction	70	2003-01-01	2003-03-11	₩4,410,000,000	100%
suface soil removal	18	2003-01-01	2003-01-18	₩89,523,000	2.03%
work road build	12	2003-01-06	2003-01-17	₩197,127,000	4.47%
structure demolition	18	2003-01-06	2003-01-23	₩32,634,000	0.74%
rubble pile	20	2003-01-11	2003-01-30	₩680,904,000	15.44%
poor subsoil improvement	18	2003-01-16	2003-02-02	₩1,064,133,000	24.13%
soil conveyance	20	2003-01-21	2003-02-09	₩975,051,000	22.11%
banking	20	2003-01-21	2003-02-09	₩417,627,000	9.47%
alignment arrangement	13	2003-01-31	2003-02-12	₩58,653,000	1.33%
revetment block	20	2003-02-10	2003-03-01	₩645,183,000	14.63%
joint plan	15	2003-02-20	2003-03-06	₩102,753,000	2.33%
appurtenant work	20	2003-02-20	2003-03-11	₩146,412,000	3.32%

3.1 Critical chain scheduling

Total Project was constructed the association of three areas with the same task. Resource capacity was constrained by a area's capacity. For critical chain scheduling, we made five scheduling charts in order(Fig 3~Fig 7). Firstly, scheduling chart applying CPM was made, which wasn't considered resource conflict problems. Secondly, scheduling chart was considered multitasking in order to solve resource conflict problems, but caused project duration to increase. Thirdly, scheduling chart was constructed three areas in sequence in order to solve resource conflict problems, but also caused project duration to increase . Fourthly, scheduling chart was performed resource leveling in order to solve resource conflict problems. Finally, scheduling chart was applied to critical chain method that safety buffer to each activity integrate as "project buffer" at project end. we assumed that safety buffer defined 30% to each activity and analyzed sensitivity ranged from 10% to 50% on safety rate in Section 3.3.

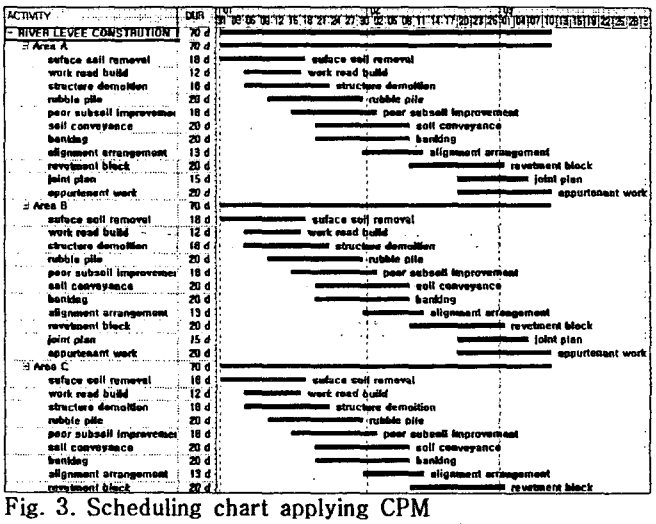

Fig. 3. Scheduling chart applying CPM

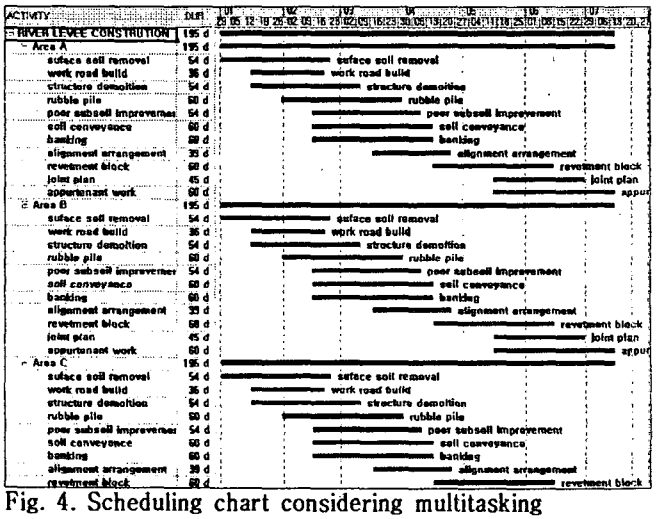

Fig. 4. Scheduling chart considering multitasking

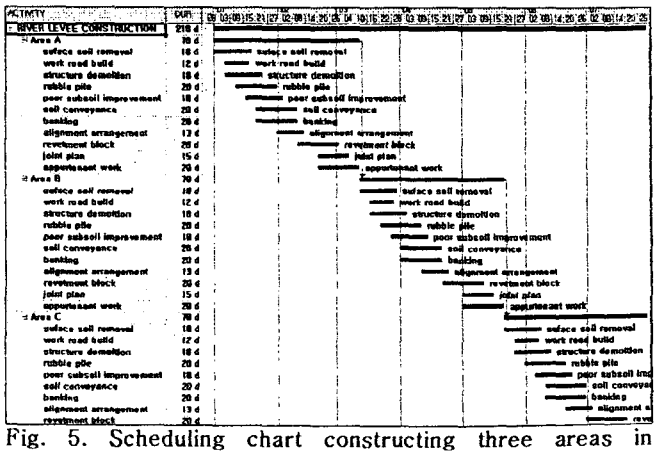

Fig. 5. Scheduling chart constructing three areas in sequence

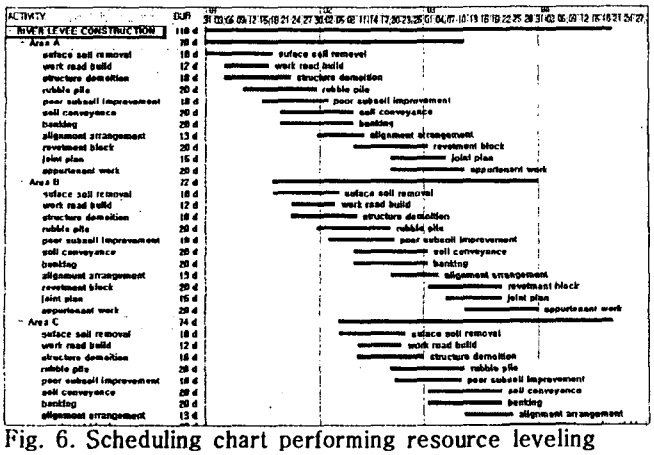

Fig. 6. Scheduling chart performing resource leveling

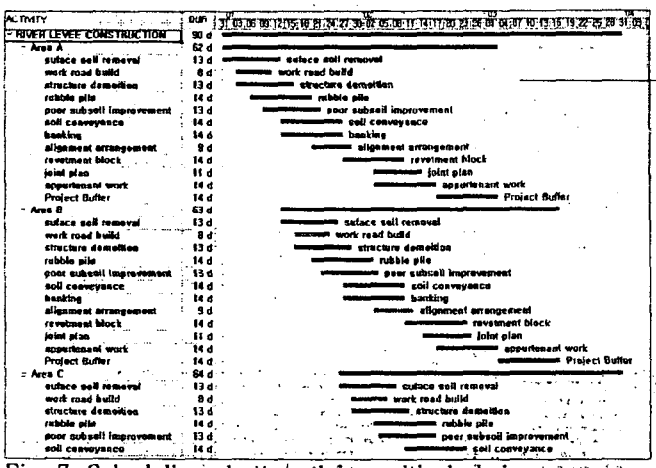

Fig. 7. Scheduling chart applying critical chain

3.2 Duration reduction and solving of resource conflict

Through making five scheduling chart, we intended to pursue a presented duration and resource subject. Fig. 8~9 was presented relationship between resource and duration about each scheduling chart. Scheduling chart applying CPM and Multitask respectively was shown resource conflict problem (300%) and resource under-allocation problem(33%). Remaining scheduling chart(Fig. 7, 8, 9) kept proper resource capacity level(100%) and especially scheduling chart applying critical chain was shown the largest project duration reduction(95 days) relat -ively among scheduling charts keeping proper resource capacity level(100%).

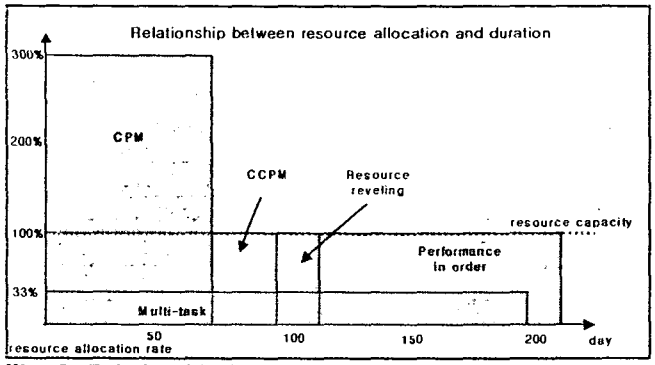

Fig. 8. Relationship between resource and duration

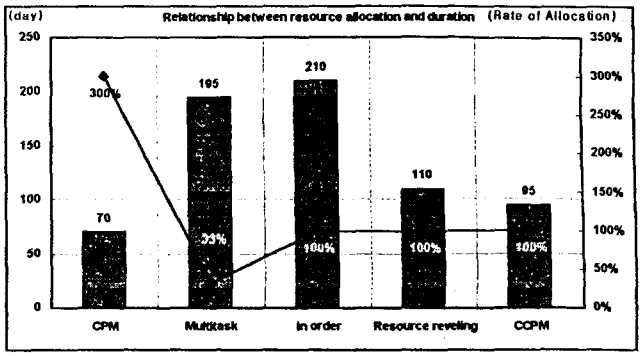

Fig. 9. Relationship between resource and duration

We compared critical chain scheduling with critical path scheduling on resource efficiency problem(Fig 10~Fig 11). Critical path scheduling is existed much unused times between resources. because of the unused times, unnecessarily much cost might be spent. For reducing unused times resource scheduling management is performed and critical chain scheduling considers resource conflict in advance in contrast to PERT/CPM

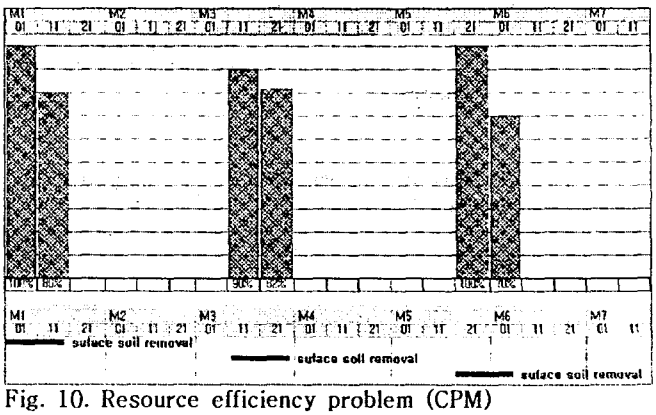

Fig. 10. Resource efficiency problem (CPM)

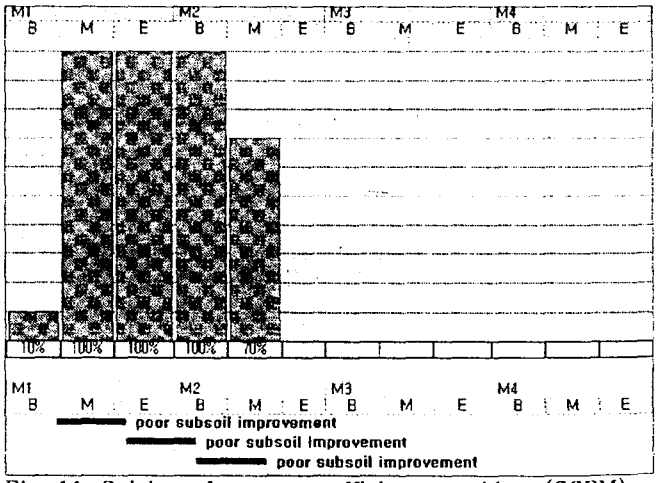

Fig. 11. Solving of resource efficiency problem (CCPM)

3.3 Sensitivity analysis

We performed sensitivity analysis about safety rate in each activity. Because safety rate can't be defined closely, we analyzed it range from 10% to 50% on safety rate in each activity. Then through being variation of safety rate, we analyzed the

variation of total project duration and cost saving. through the variation of safety rate in each activity, total project duration and cost saving respectively changed within ranging from 108 days to 77 days and from ₩1.4 billion to ₩6.6 billion. It is important subject to determine optimal safety rate all projects and requires continuous endeavor for it.

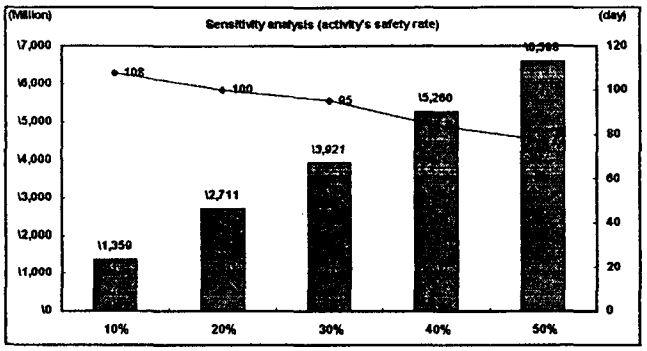

Fig. 12. Sensitivity analysis on safety rate in each activity

4. Conclusions

Results exploring the fundamentals of critical chain and studying a application of critical chain method to construction project with a domestic case study are as follows:

An application of critical chain was taken better improvement about inherent problems of CPM that are especially the uncertainty of duration estimate on individual activity and resource conflict problem.

In contrast to PERT/CPM, which may be characte -rized as dealing solely with certain technical aspects of project management, the application of the critical chain method focuses very much on how *senior management deal with human behaviour, both* in terms of construction the project network, and in managing it afterwards. As far as the technical aspects are concerned, if satisfying the milestones is not creates performance for your company but simply a tracking tool, inserting buffers at the appropriate points in the project network by identi -fying the critical chain is actually a better tool.

Further research can be directed in the areas listed later:
1) Application of TOC approach to other areas of project management.[1)4)]
2) The practical approach for scheduling multi-project sharing multi-resource.

5. References

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요 약

제약이론은 특정한 관리기술을 개발하는데 사용되는 접근방법이며, 철학이다. 운영관리상에 적용되었던 소설 "The Goal"에 의해서 처음으로 널리 보급되었다. 1997이후로 프로젝트관리의 두 가지 영역에서 적용되어 왔으며, 그 첫 번째 적용은 단일프로젝트에 대한 공기단축과 프로젝트 통제관리의 간소화를 위한 공정관리분야이며, 두 번째 적용은 동시에 수행되는 여러 프로젝트에 의해서 공유되는 자원의 효과적 관리이다. 이 논문은 프로젝트 관리에 적용된 제약이론인 애로사슬(Critical chain)의 원리에 대해서 연구하고, 국내의 건설프로젝트에 적용하는 것을 목적으로 한다.

Keywords : 제약이론, 애로사슬 프로젝트관리