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Multiproject Scheduling in Construction Industry

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***Abstract*—**In this paper, supply policy and procurement of shared resources in some kinds of concurrent construction projects are investigated. This could be oriented to the problems of holding construction companies who involve in different projects concurrently and they have to supply limited resources to several projects as well as prevent delays to any project. Limits on transportation vehicles and storage facilities for potential construction materials and also the available resources (such as cash or manpower) are some of the examples which affect considerably on management of all projects over all. The research includes investigation of some real multi-storey buildings during their execution periods and surveying the history of the activities. It is shown that the common resource demand variation curve of the projects may be expanded or displaced to achieve an optimum distribution scheme. Of course, it may cause some delay to some projects, but it has minimum influence on whole execution period of all projects and its influence on procurement cost of the projects is considerable. These observations on investigation of some multistorey building which are built in Iran will be presented in this paper.

***Keywords*—**Construction Management, Supply Management, Resources Sharing, Multi-Project, Resource Procurement.

I. Introduction

In construction industry, most of owners and contractors have usually large ongoing construction portfolios rather than one-off construction projects. Although, every project has its own resources requirements but the type and quantity of resources vary considerably during the projects implementation. In addition, some market incertitude increase the projects delay risk. Nevertheless, general project management literature is heavily biased towards the single project paradigm, with little written on the multi-project environment [1], [2]. A single project paradigm does not accurately reflect the reality of many construction clients. Multi-projects have tended to be treated as monolithic projects [3], even though unique problems, particularly regarding their management, have been identified by several authors [4], [5]. In brief, there are enough differences between multi-projects and traditional projects to question the applicability of straight project management approaches.

The management of multi-projects is not simply an aggregate of single project efforts and as such requires unique approaches, techniques and tools. Use of common resources provides usually important constraints on the individual planning of these kinds of projects. Some of these limitations are: storage capacity, transportation, specialized and non-specialized manpower and even cash resources. The main target of this research is to minimize the overall cost of these resources for a group of projects without any delay on a whole.

Although, use of common storage and transportation system may provide some delays or modifications to the individual project planning, but it leads to great saving in material delivery cost [6]. When the projects are planned concurrently, some cases are met at which the demand for special resource is increased where at other periods the demand is at its lowest. Non-uniformity in demand distribution causes some difficulty in supply of resources. It is possible to bring the resources consumption to a proper level by suitable distribution of demand within whole duration of the projects. This investigation shows considerable reduction in volume of the necessary resources and total projects' expenditure.

II. Problem Description

Nowadays, the competition in construction industry is usually very strict and serious. Therefore, a methodology for optimal use of resources and for maximum reduction of any risk damages and delays could affect considerably projects delivery with competence. A construction project compounds of several activities each one requiring various kinds of resources and services during its execution. Ordinarily, the projects are scheduled using some software as like as MSF, PRIMAVERA, etc. which are based on activities precedence in essence. The activities of each project are distributed during a particular periods and each one demands some particular resources including construction materials and equipment. Although the quantity and quality of these resources are determined in advance but there is usually some flexibility to displace the activities leading to change in the periods of resource demands. Besides, the quantity and quality of some resources might be inconsistent to market delivery.

Encountering the resource restraints leads to some repeated modification and software performance improvement to consider the resource restrictions of single project. But, there are several reasons to merge the management of some projects in a higher level while each project has always its own management. Some of these reasons are as following:

a) The quantity of required resources is not economically feasible at some time intervals.
b) The quality of some services and resources delivery is not accessible with enough satisfaction.

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c) The market uncertainty and inflation affect considerably on the resource and service delivery of the projects as a whole.
d) Resource and service delivery for the projects in busy urban areas oblige some storage and transport facilities which add some supplementary constraints to be attended.

Transport and storage capacity are some examples of very expensive and severe constraints that affect considerably on whole cost of construction portfolios. These constraints could be more restrictive for the projects undertaken in the busy areas of grand cities. In one side the demand of these kinds of resources is very different during the execution of each project and in the other side, the supply possibilities has usually unpredictable. The market based restraints also provide essential and harmful effects on project delivery. On-time material delivery for all the projects' activities requires a plan of procurement consistent to all the projects' scheduling. Because of the difference on peak time of material needs and uncertainty of market response to instant delivery, some storage capacity is required and it obliges some prediction and material reservation. This will be more important when market shows irregular infatuation and the initial prediction of costs is being violated. Predicted and unpredicted traffic obstacles provide additional needs to resource storage. This research investigates the cost and delay sensitivity of projects portfolios delivery in respect to the shared and unshared storage and transportation capacity that has important influence on multi-project delivery in holding construction companies.

The projects portfolios describes a collective group of construction projects carried out under the sponsorship and/or management of a particular organization, with no inference to the manner in which they are organized or managed. In general, it focuses on the benefits or strategic aims of an organization; provides common purpose between projects; involves a number of projects run within groups, and exhibit some form of interaction between projects. In fact, it is a framework for grouping existing projects or defining new projects, and for focusing all the activities required to achieve a set of major benefits. These projects are managed in a coordinated way, either to achieve a common goal, or to extract benefits which would otherwise not be realized if they were managed independently.

III. Methodology

A general literature review was undertaken to establish previous researches, identify definitions, terminology and general construction trends. The scarcity of resources on the subject within construction-related disciplines dictated that literature from other disciplines formed the major proportion of the review.

In this study, we investigated the actual project scheduling and management planning of three multi-storey buildings executed in some busy areas of Tehran. All these buildings had a unique owner but each one had its own project manager and subcontractor. These projects were scheduled using the MSP software and modified successively during the project implementation. Although, each project had its own special problems in resource procurement, but there were some common problems that could be resolved or delighted by the initiative proposed in this study. This research concentrates on the resources whose delivery is affected considerably by transport obstacles or the resources for which some storage facilities could provide sufficient ease on the resource procurement. Looking for these kinds of resource leads some deep study on the quality and quantity of resources used by each activity including the appropriate using time intervals.

In fact, at the beginning, each project was analyzed and scheduled ordinarily and independently using the MSF software. Independent planning of the projects provided initial guess of resource demand and their delivery deadlines. These schedules were modified several times during the project execution to coincide the actual resource availabilities. The procedure could be summarized at the following steps:

Step1

Schedule separately all the projects under consideration using an ordinary technique as like as MSP or PRIMAVERA software. The activities on the critical lines and also the slack times of other activities for all the projects could be determined clearly.

Step2

Define a time interval and divide the maximum expected period of the project execution. Estimate the resource demand for each activity of all the projects in different time intervals.

Step3

Evaluate the influence of different resource scarcity on the delivery of every project. (Sensitivity Analysis)

Step4

Recognize the most vulnerable resources and classify them based on the market stability, feasible resource quantity, transport obstacles, etc.

Step5

Investigate the procurement possibilities of required resources and distinguish the most influenced ones by the transport and storage facilities.

Step6

Estimate the quantity selected resources with enough precision accompanied by time intervals of their demands. It will serve as initial guess for global resource demand. In fact, the decision variables may be the quantity of selected resources during the corresponding intervals.

Step7

Estimate the upper and lower bound on selected resources corresponding to the different time intervals using the scheduling diagrams of the concurrent projects. These bounds serve as technological constraints used in the optimization program.

Step8

The capacity of the storages and transport facilities, in centralized management, could introduce other constraints to be defined and formulated in respect to the decision variables.

Step9

Estimation and formulation of the direct and indirect cost of the storage and transport related to the resources provide objective function in the optimization program. All the mentioned cost refers to life cycle cost that includes all the related operational and capital costs.

Step10

Use the appropriate optimization program to find the decision variables at a cost total minimal.

Considering the quantity of resource allocation to each projects at each time intervals as decision variables, the sensitivity analysis provides approximation to formulate the objective function that could be some kind of simulated life cycle cost. Forever, the technological and behavioural constraint could be estimated satisfactorily. Required transport and storage capacity in different intervals could be formulated as functions of the decision variables. The details of this formulation were described in [6], [7].

However, the optimization program applied to this problem provides the quantity of the selected resources for each project in each interval. Therefore, the total demand of each resource at each interval would be realized. Thus, the procurement plan for resource delivery to the centralized storage and transport facilities are well recognized against lack of any resource deficiency for the projects. In addition to huge save for total resource delivery at any interval, it provides any challenge and competence for centralized procurement of resources which usually forgive considerable benefits.

IV. Sample Projects

Three real multi-storey buildings were investigated. They are selected based on the following criteria to improve the clearance observations and justification of the comparison at most:

a) The selected projects are some real cases under construction in the same period to provide similar social and economical conditions.
b) The selected projects use similar kinds of materials and equipment and also use similar construction technology.
c) All the cases are located in high populated business area of Tehran.
d) T he distance between the cases' sites are sufficiently far to present the transport effects of Tehran.

Some other criteria also are considered which are described in [6], [7].

A. Case

As the first sample a private five-storey residential building with steel structure was investigated. It was built in a populated area of Tehran. It included more than 195 activities which were classified to five groups of activities. The project was scheduled for 315 days. Owing to some unpredicted conditions the last schedule extended to a period of 387 days [7]. The resource including; machinery, materials, cash, and human resource, actually used during the project implementation were estimated. It can be used in the multi-project planning thereafter. This kind of estimation guarantees the reliability of the comparison sufficiently.

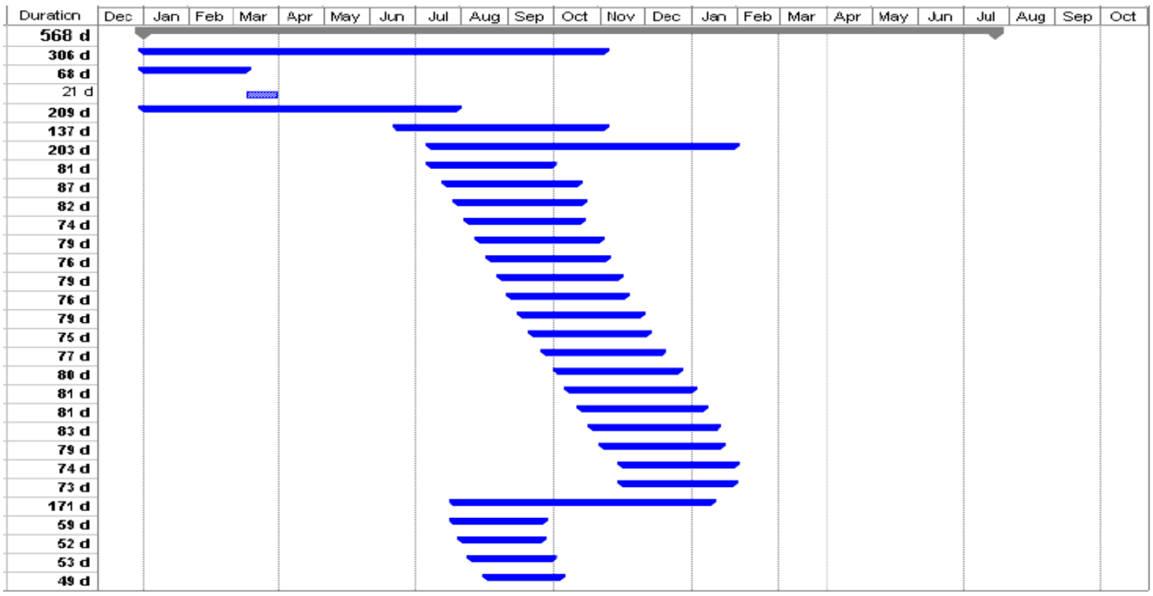

Fig. 1 Schedule of sample project (1)

Case two:

The second project is a seven storeys residential building belonging to the same owner and constructed in another populated area of the city. This building with more than 7000 square meter area, had a steel structure with composite floors. As like as the previous project all activities and required resources of this project were realized and classified carefully.

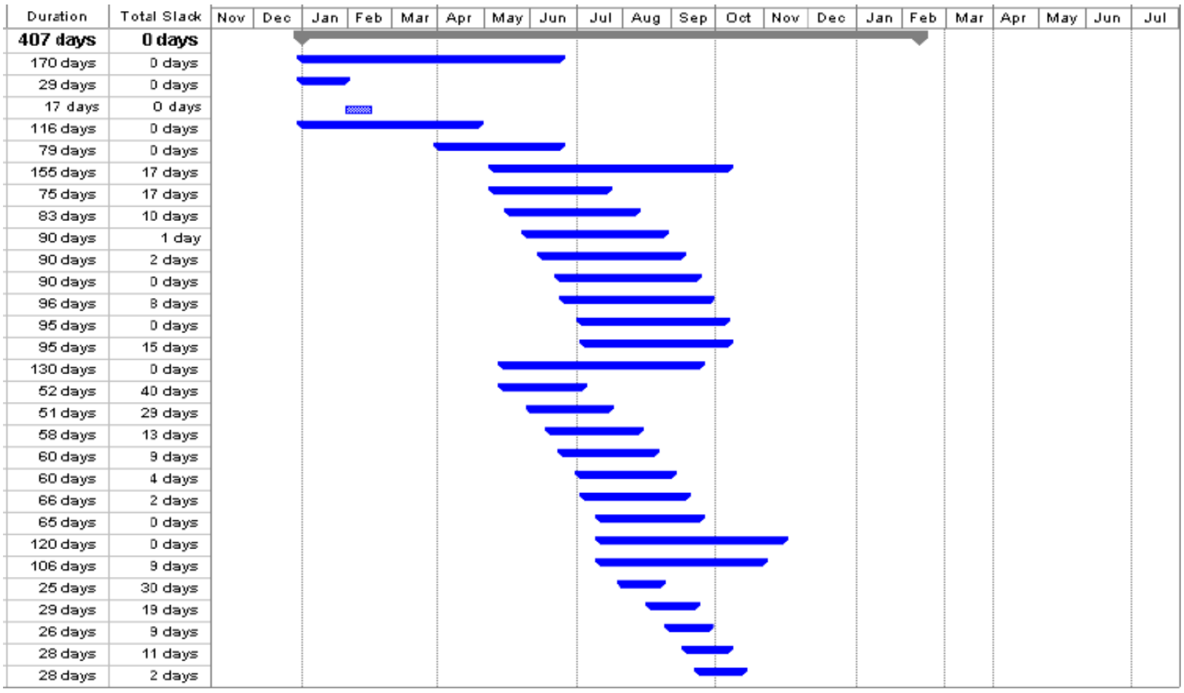

Fig. 2 Schedule of sample project (2)

Case three:

The third project under investigation is a 17-storey residential building constructed in a different populated area of Tehran. It compounds of further activities. The construction period of this project was longer than the else. It belongs to the same owner too. The quantities of all resources used for each unit volume of the activities were estimated consistent to reality.

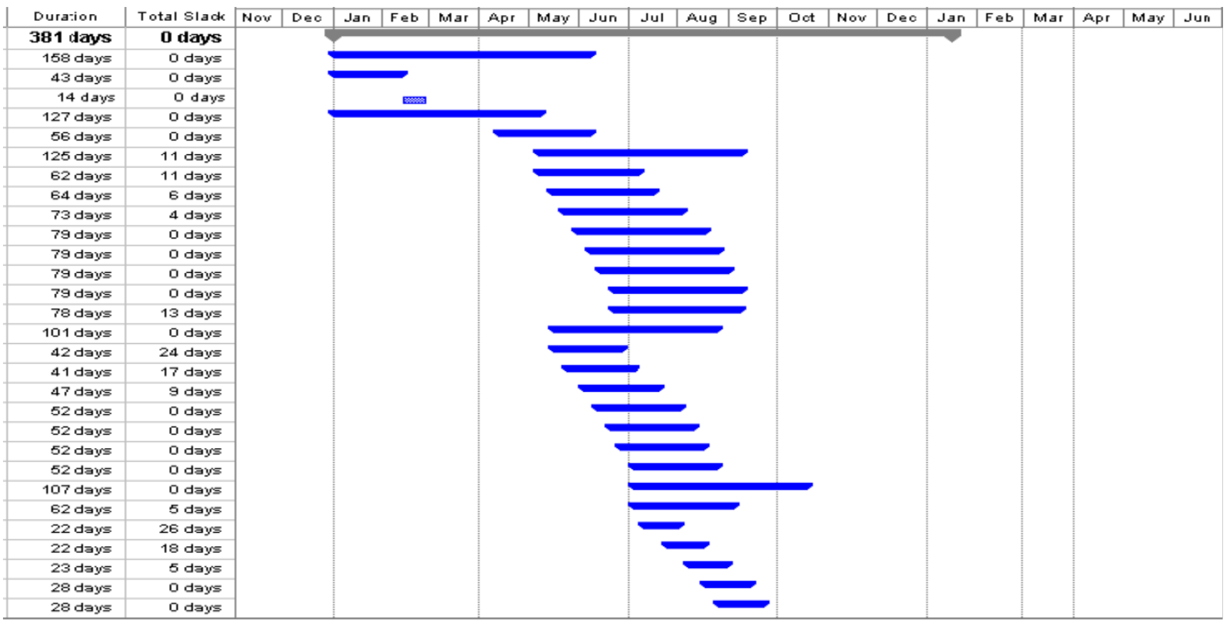

Fig. 3 Schedule of sample project (3)

V. Investigation and Discussion

In this research we used the data from three constructed project for a real justification of the methodology. We use the scheduling plan of the projects developed before project beginning. Although, the rate of resource usage by the activities of the three projects differ slightly, but they provide reasonable estimation of resource needs successfully used for multi-project procurement planning. A systematic careful investigation of the schedules and resources demands of the three projects permit composition of demands at different time sections concluding the global demands of resources. At this stage it will be possible to estimate the upper and lower bound of the quantity of these resources at each section. In fact, these bounds play the role of constraints in an optimal program looking for the optimal procurement plan. Considering the storage and transport capacity and cost at different time section provides the other constraints and also the objective function of this optimization problem. Application of the methodology presented at this article provides a global plan of management for all the projects that could be seen in Fig. 4.

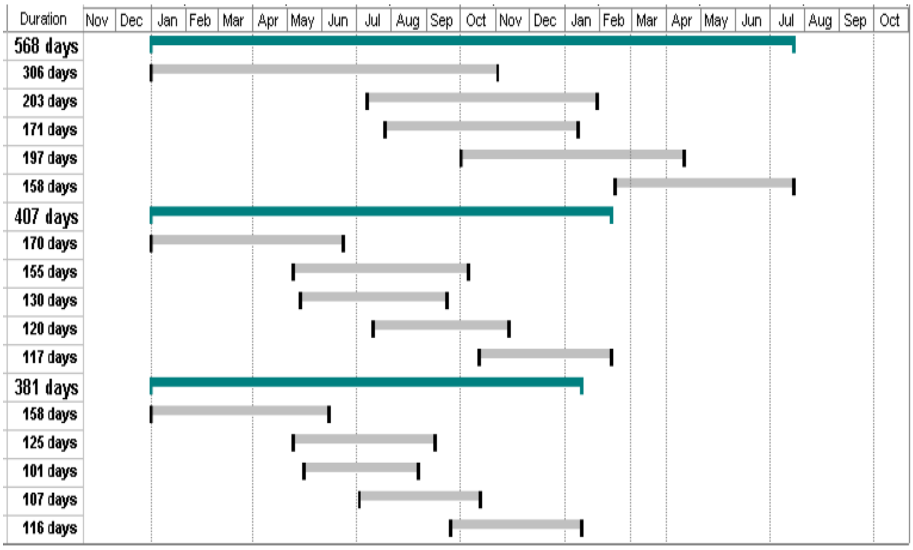

Fig. 4 Concluded schedule of the three projects

Use of this methodology presents considerable save for global planning of three projects. This investigation shows that only five resources have considerable effect on the life cycle cost. The following figure shows that only a few number of resources are affected considerably by centralized storage and transport facilities. Therefore, it does not need to involve all resources in the centralized procurement. Investigation of the resources needs at different periods of the project execution shows considerable decrease in whole resource needs. It could be seen in Fig. 5.

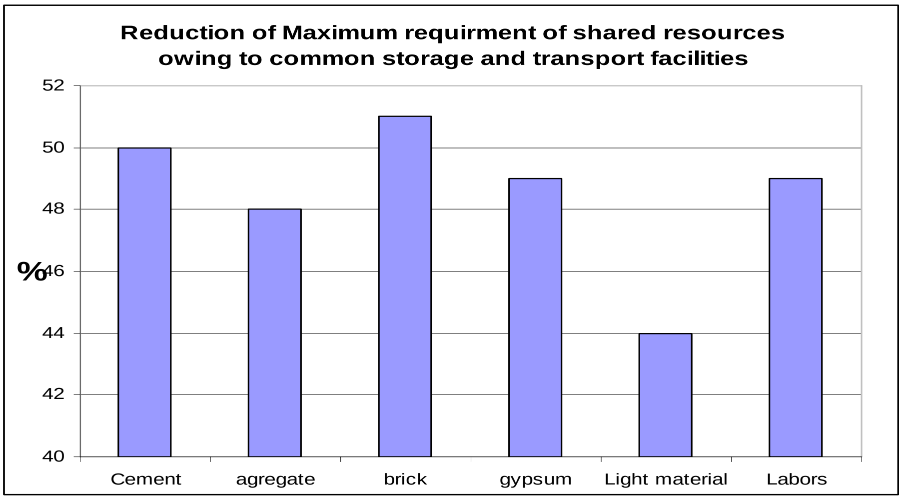

Fig. 5 Decrease on resources demands after application of multi-project procurement

VI. Conclusion

This procedure provides the required quantity of the selected resources to every project with satisfaction. Also, the total demand of all important resources at each time interval would be known for whole of projects under super management of the holding company. Consequently, the procurement plan for resource delivery to the centralized storage and the required transport facilities could be designed clearly.

This model provides great challenge and competence for procurement of resources in addition to huge save on the whole resource delivery at any interval, and also considerable benefits on whole multi-project delivery.

Owner and contractors can use the procedure of multi-project procurement to satisfy project activities requests with delay minimal. In fact, centralized management of the storage and transport facilities, even at small size, provide grand opportunity to prevent any deficiency on project delivery.

Although this procedure has focused on storage and transport affected resources, but it could be applied to other kinds of resources as like as cash request or skilled and unskilled labors requirement.

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