IRACST – Engineering Science and Technology: An International Journal (ESTIJ), ISSN: 2250-3498, Vol.2, No. 4, August 2012

Resource Management in Construction Projects – a case study

SK. Nagaraju
Lecturer, Department of Civil Engineering
Adama Science and Technology University (ASTU),
Adama, Ethiopia.
E-mail I.D: sknagaraju.ce@gmail.com

B. Sivakonda Reddy
Assistant Professor, Department of Civil Engineering
JNTUH College of Engineering (AUTONOMOUS)
Hyderabad, India.
E-mail I.D: bskreddy_246@yahoo.com

Prof. A. Ray Chaudhuri
Department of Civil Engineering
Adama Science and Technology University (ASTU),
Adama, Ethiopia.
E-mail I.D: amroyc@gmail.com

***Abstract*- Construction Project refers to a high stake endeavour aiming at time bound predetermined performance objective. Unless matching resources are planned and procured, no activity can be executed according to a prefixed time schedule. Project managers must take complex decisions under different scheduling needs (such as smooth resource utilization profiles and resource constraints) and under conditions of uncertainty that sometimes extend beyond task durations. The present study deals with resource scheduling for a fast track project with constrained durations.**

The study has been carried out in two phases. In the first phase, with the aid of PRIMAVERA software project schedule for various activities for the construction of a commercial building was prepared. Subsequently, requirements of resources were attributed to the activities based on Standard Schedule Rates (CPWD). The requisite data has been collected from the detailed drawings and prevailing site conditions.

In the second phase, a Resource Constrained Analysis was carried out by Resource Leveling for various activities by decreasing resources with increased duration to study the time-cost implications.

Keywords: Resource Management, Resource Leveling, PRIMAVERA.

I. INTRODUCTION

Construction projects contain numerous inter-dependent and inter-related activities. The fast changing environments of the present era impose numerous financial, legal, ethical, environmental and logistic constraints. They interact technically, economically and socially within the environment as well as with other organisation, structures and systems. These projects employ voluminous resources. But they have in-built difficulties, uncertainties and risks. These pose series of problems concerning resources, like how much they are required, 'where they are going to come from', 'when they should be inducted at site', where they should be housed', 'how to optimise their utilisation' and 'when to demobilise'.

In general, construction projects are of high value, and they employ huge resources of men, materials and machines. Major works involve heavy investments- say from a hundreds of crores of rupees to a few thousands of rupees, the use of high level technology and need an open ended model for effective management of resources.

Due to the resource-driven nature of construction management, Resource Management is really a difficult task. The construction manager must develop a plan of action for directing and controlling resources of workers, machines and materials in coordinated and timely manner in order to deliver a project within the frame of limited funding and time. Hence, aside from a technology and process focus, a resource-use focus must be adequately addressed in describing a construction method or operation in a project plan.

II. RESOURCE MANAGEMENT

A resource is an entity that contributes to the accomplishment of project activities such as manpower, material, money, equipment, time or space.

A. Importance of Resources in Construction Projects

The crucial factor in successful implementation of a construction project not only depends on the quality & quantity of work, but also largely depends on availability of resources. All activities involved in the project require certain amount of resources. Each activity is allocated with a specific resource and must be completed within the time limit, otherwise it may adversely effect the overall duration of the project.

The time and cost are directly dependent on the availability of resources. The time required may be determined by dividing the productivity associated with the resources used on the activity into the defined quantity of work for the activity. The best combination of resources to use for performing a construction activity is based on contractor's ability to identify the interdependencies of the various resources.

B. Methodology Adopted

This paper introduces a comprehensive framework for resource management particularly related to manpower as resource element in construction domain. This study is carried out in two phases. In the first phase, all the information and data needed to estimate resources were collected. The construction project schedule using the estimated resources was prepared in the form of Gantt chart and resources required for each activity are tabulated. The peak units required for a project day by day are shown in Resource histograms.

In second phase, the actual resources available for the project were analyzed by Resource leveling with increased duration. The time-cost implications have been analyzed to alert the management.

III. PROJECT ATTRIBUTES

Project attributes presents the details of an ongoing project in terms of project schedule, manpower required for different activities to carryout resource constrained analysis. The costs incurred in the project are also presented.

A. Project Details

Name of the project : Construction of Commercial Building
Built up area : 47700 Sq ft
Number of Storey's : Ground + Five Floors
Floor to Floor height : 3.35m
Height of Plinth : 0.50 m above Ground Level
Depth of Foundation : 1.50 m below Ground Level.
External Walls : 250 mm thick including plaster
Internal Walls : 150 mm thick including plaster
Parapet Walls : 250 mm thick including plaster

B. Preparation of Estimates

Generally, for resource constrained analysis the man power requirements for various activities are very essential and these are to be calculated based on the quantities. These quantities required for man power study are calculated from the drawings.

C. Manpower Required

Manpower output is the output quantity i.e., the quantity of work which can be done per day per person considering all safety and quality measures as required by client. This was calculated based on the [2] and [12] and also considering views based on the experiences and thorough technical knowledge of many project managers, architects, engineers and many contractors who are experts and have been working in this field for many years. Some of the output constants for various types of activities are shown in Table I and Table II. The study is limited to these activities only under normal working and site conditions.

TABLE I. MANPOWER OUTPUT CONSTANTS FOR DIFFERENT LABOURS AS PER IS: 7272 (PART I – 1974)

Activity	Labour output per day
1. Unskilled (incl. Excavation, transportation)	
- Excavation	1.5 M^3
- PCC and Concrete	0.2 M^3
2. Carpenters (for all activities)	6.0 M^2
3. Barbenders (for all activities) (incl. Cutting, bending, fabrication, transportation etc.,)	0.2 MT
4. Masons (includes shifting of materials within the site, wetting in water and dressing in SSM)	0.9 M^3
- Size stone masonry	6.0 M^2
- Block Masonry	6.0 M^2
- Plastering	8.0 M^2
5. Painters (incl. Preparatory works as required)	10.0 M^2

TABLE II. MANPOWER REQUIRED FOR VARIOUS WORKS AS PER CPWD ANALYSIS OF RATES

Activity	Per Unit	Mason	Bhisti	Beldar
Plain Cement Concrete (PCC)	1 Cum	0.1	0.7	1.63
Barbending work	1 Ton	7.5	-	10
Shuttering work	4 Sqm	1	-	1
Reinforced Cement Concrete (RCC)	1 Cum	0.17	0.9	2
Masonry work	1 Cum	0.72	0.217	1.56
Plastering work	10 Sqm	0.67	0.93	0.86
Painting work	10 Sqm	0.54	-	0.54

D. Project Scheduling

The schedule contains different types of activities with different durations based on their nature of work and quantities calculated from drawings. From these quantities, man power required for various activities are calculated. Based on the quantities, manpower required and realistic durations in the current situations are taken in to account and durations are calculated. Based on the data obtained, network diagram is prepared and relations are assigned to the activities to calculate the critical path. Finally the total duration of the project is calculated by Primavera. After preparing the

schedule in Primavera software the total project duration is estimated as 507 working days (includes inception stage to completion stages).

E. Project Cost

The total cost of the project has been divided into two types namely, direct cost and indirect cost. Direct project costs are those expenditures, which are directly chargeable to and can be identified specifically with the activities of the project. These include labour cost, material cost, equipment cost, transportation cost etc. Direct Cost of the present Project is Rs. 41,176,035. The relation between time and cumulative direct cost is shown in Figure 1.

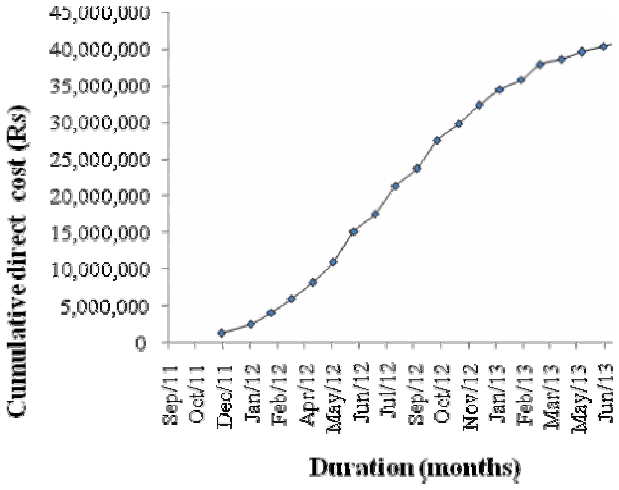

Figure 1. Duration (Months) Vs Cumulative direct cost (Rs)

Indirect costs on a project are those expenditures, which cannot be clearly allocated to the individual activities of a project, but are assessed as whole. The indirect cost includes the expenditure related to administrative and establishment charges, overhead, supervision, expenditure on a central store organization, loss of profit, loss of revenue, penalty etc. In this project indirect cost is taken as 10% of direct cost. Indirect Cost of the present Project is Rs. 41, 176, 03. So the total cost of project is Rs. 4, 52, 936, 39.

IV. RESOURCE CONSTRAINED ANALYSIS

In Resource Constrained Analysis an attempt has been made to generate resource histograms based on the manpower required for different activities. From the project schedule it is observed that, almost all the activities are critical except finishing works (Total float zero or minimum). Hence, any resource leveling needs to be achieved by enhancing the duration of the project under constrained resources. In view of this constraint, presuming that management allows the increase in the project duration, implications on project costs have been analyzed by increasing the project duration.

A. Procedure Adopted for Resource Leveling

1. The 'peak' and 'low' demands have been identified in resource histograms for Masons, Barbenders, Painters and Unskilled helpers for different days. These values have been obtained from resource histograms.
2. In order to illustrate the resource leveling procedure adopted in this study, only data and procedure pertaining to masons has been presented as an example.
3. In masons histogram the peak units in a day were 31 (and total project duration was 507 days) with a total man power units of 4920.5. The man power units are taken as fixed units.

   The three main parameters required to compute total man-hours are total duration, peak units, and total number of masons.

- Total duration for masons = Adding all individual durations of Activities involving masons namely, (Activity 1030, 1050, 1060, 1080 etc.)

  = 461 days

- Peak units = The maximum resources in any day.

  = 31 numbers

- Total masons for activities = Sum of all the individual resources of each Activity if corresponding duration

  = activity 1030 = 1.64 numbers

  = activity 1050 = 81 numbers

  Similarly, cumulative of all mason activities = 4920.5 numbers

- Total man-hours for masons = Total carpenters for all activities X 8 hrs/day

  = 4920.5 x 8 hrs/day

  = 39,364 hours

4. It can be observed that there was no over allocation in the histogram when 31 units were assigned for activities duration as per the original schedule.
5. In the first trial, assuming resource constraints for masons were reduced to 10% i.e., 27.9 masons were considered to be available. In these trails total masons required is taken as constant i.e. 4920.5 numbers, when change has been effected in from 31 to 27.9 units.
6. The reduction in peak units attempted for different activities namely, masons, bar benders, unskilled helpers and painters are shown in Tables III to VI.
7. In the project schedule substructure, superstructure and finishing work for 5th floor activities are critical.

8. For the above activities, the over allocation has been reduced by increasing duration without changing the man-hours.
9. However, in the above case overall man-hours allocated remained the same for completion of the activity and the duration was evenly distributed for all activities in all days.
10. The increased duration of masons and total project duration corresponding to resource constraints (peak units) is shown in Table III.

    Total duration for masons = Adding all individual durations of Activities involving masons namely, (Activity 1030, 1050, 1060, 1080 etc)

    = 469 days
11. Similarly, the procedure was carried out for barbenders, masons, painters and unskilled helpers. Details have been presented in Table III to VI respectively.
12. The effected change in all the resources namely masons, barbenders, unskilled helpers, and painters were reflected in the main schedule.
13. It was observed that the total project duration was increased to 515 days, with the same total man-hours for all the different activities.
14. The same procedure was carried out for masons, bar benders, unskilled helpers and painters for another 4 trials reducing resources as shown in Tables III, IV, V and VI respectively.
15. The reduction in resources of different activities has resulted in increase in total project duration from 507 days to 515, 518, 538, 566 and 620 days respectively. The cost implication for increased durations is shown in Figure 6.

B. Decreased resource constraints for different trials

The decreased resource constraints for masons, bar benders, unskilled helpers and painters of different trials are shown in Tables. The Figure 5 shows decrease in resource constraints to the % increase in project duration.

TABLE III. CHANGE IN MASONS DURATION FOR DIFFERENT RESOURCE CONSTRAINTS

Resource Constraints	31	27.9	24.8	21.7	18.6	15.5
Duration for Masons	461	469	472	492	520	574
Total Increased duration	507	515	518	538	566	620

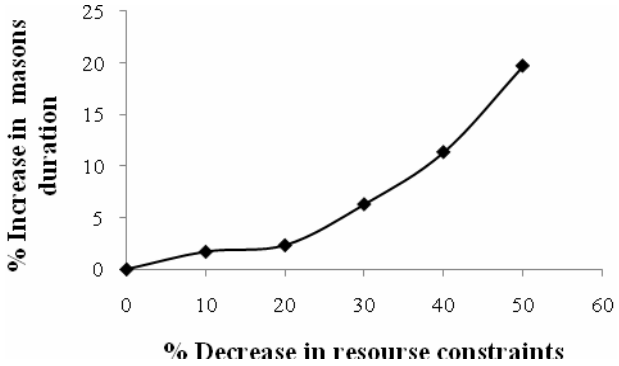

Figure 2. % Decrease in Resource Constraints Vs % Increase in Masons duration

TABLE IV. CHANGE IN BARBENDERS DURATION FOR DIFFERENT RESOURCE CONSTRAINTS

Resource Constraints	15	13.5	12	10.5	9	7.5
Duration for Barbenders	306	314	317	326	332	348
Total Increased duration	507	515	518	538	566	620

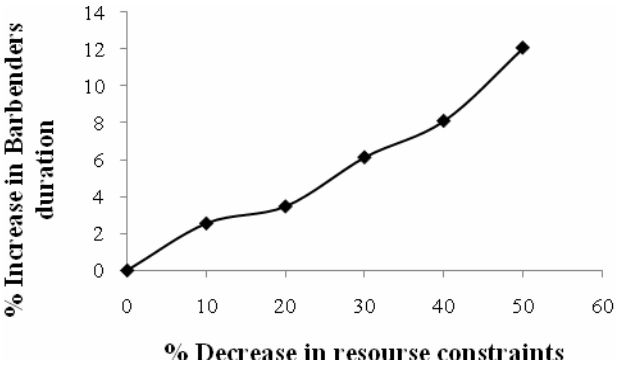

Figure 3. % Decrease in Resource Constraints Vs % Increase in Barbenders duration

TABLE V. CHANGE IN UNSKILLED HELPERS DURATION FOR DIFFERENT RESOURCE CONSTRAINTS

Resource Constraints	143	128.7	114.4	100.1	85.8	71.5
Duration for Unskilled Helpers	505	513	516	536	564	618
Total Increased duration	507	515	518	538	566	620

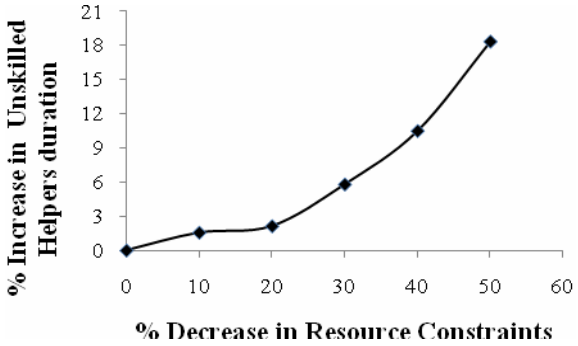

Figure 4. % Decrease in Resource Constraints Vs % Increase in Unskilled Helpers duration

TABLE VI. CHANGE IN PAINTERS DURATION FOR DIFFERENT RESOURCE CONSTRAINTS

Resource Constraints	35	31.5	28	24.5	21	17.5
Duration for Painters	25	25	25	25	25	25
Total Increased duration	507	515	518	538	566	620

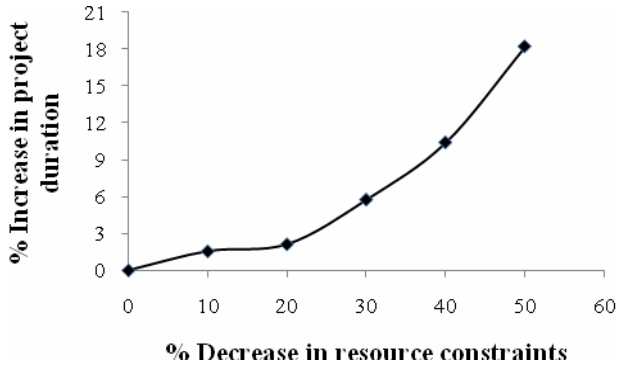

Figure 5. % Decrease in Resource Constraints Vs % Increase in Unskilled duration

C. Cost for increased durations

The Cost for the increased durations is shown in Table VII and is obtained as shown below.

Total Indirect cost = Rs. 4117603.5

Average Indirect cost per month = Rs. 205880.17

Indirect per day = Rs. 6862.67

TABLE VII. COST FOR THE INCREASED DURATIONS

Increased Duration in days	**Increased cost in Rs.**	**% increase in cost**
507	45293639	0
515	45348540	0.121
518	45424029	0.167
538	45636772	0.468
566	46041670	0.887
620	46817152	1.684

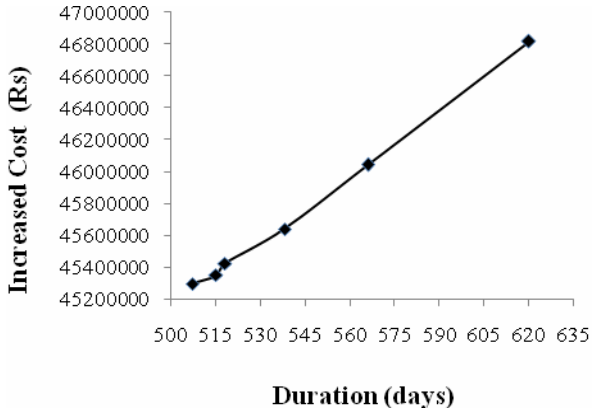

Figure 6. Cost for the increased durations

V. CONCLUSIONS

The nature of the construction industry is unique in characterized by complex deployment pattern of resources resulting in risk and uncertainty inherent in every phase of the project life cycle. In fact a state-of-the art resource management is essential for a construction project to succeed in fulfilling its project objectives. Allocation of resources for activities is necessary in construction domain to complete the project within the scheduled time. Resource leveling is needed in construction projects to avoid the difficulties associated with the large variations in resource usage.

The paper presents a project schedule with time constrained due to the client's requirement. All the activities of the schedule are critical (total float zero). The only option to increase schedule time is possible by resource leveling.

The resource type for this schedule is considered manpower (labour) only. The presented schedule increases the day by day cost due to sudden requirement of labour and hence, this result has an impact on the overall project cost and the cost is very steep. If the resource constraints are decreased about 10% to 50%, it causes the total duration of project to increase about 2% to 18.23 %.

For the decrease in the resource constraints, it is observed that there is an increase in duration for resources namely masons, barbenders and unskilled helpers by 19.7%, 12.07% & 18.28% respectively. But there is no increase in duration of painters because it is an independent activity in total project. The increased duration results in increase in the indirect cost

of the project and finally enhances the total project cost. The percentage increase in duration is about 18.23% causing percentage increase in project cost about 1.684%.

ACKNOWLEDGMENT

The authors are indebted to Mr. A. Kameshwarao, Senior Manager in Abir Infrastructure Pvt Ltd. and Ms. M. G. Prasanna, Assistant Engineer in Andhra Pradesh Municipal Department for providing real time data of the project in the pursuit of this case study. The authors would like to thank Mr. Bogale Tessama at the Adama science and Technology University for his English language editing.

REFERENCES

[1] Dho Heon Jun, Ph.D.1 and Khaled El-Raye - Multiobjective Optimization of Resource Leveling and Allocation during Construction Scheduling © ASCE, Journal of Construction Engineering and Management, Vol. 137, No. 12, December 1, 2011.

[2] Central Public Work Department, Analysis of Rates 2010, Published by Director General (Works) CPWD, New Delhi.

[3] Khaled El-Rayes and Dho Heon - Optimizing Resource Leveling in Construction Projects, Journal of Construction Engineering and Management © ASCE, Vol. 135, No. 11, November 1, 2009.

[4] User's Guide for Primavera Project 2009.

[5] Jonathan Jingsheng Shi, and Daniel W. Halpin, Enterprise Resource Planning for Construction Business management, Journal ofConstruction Engineering and Management © ASCE, Vol. 129, No. 2, April 1, 2003.

[6] Ming Lu and Heng Li, Resource – Activity Critical Path Method for Construction Planning, Journal of Construction Engineering and Management © ASCE, Vol. 129, No. 4, August 1, 2003.

[7] D.K.H. Chua, M. ASCE, and M. Li, Resource – Interacted Simulation Modeling in Journal of Construction Engineering and Management © ASCE, Vol. 128, No. 3, June 1, 2002.

[8] Sou – Sen Leu and Tzung – Heng Hung, An Optimal Construction Leveling and Scheduling Simulation Model, Can. J. Civ. Eng. Vol. 29, 2002.

[9] S.Seetharaman, Construction Engineering and Management, Umesh Publications, First Edition, 1997

[10] Tarek Hegazy - Optimization Of Resource Allocation and Leveling Using Genetic Algorithms, Journal of Construction Engineering and Management © ASCE, Vol. 125, No.3, May/June, 1999.

[11] Said M. Easa - Resource Leveling In Construction By Optimization, Journal of Construction Engineering and Management © ASCE, Vol. 115, No. 2, June, 1989.

[12] Indian Standard Recommendations for Labour output Constants for Building Work, IS : 7272 (Part I) – 1974.

AUTHORS PROFILE

First Author

Name: Shaik Nagaraju

Designation: Lecturer in Department of Civil Engineering

University: Adama Science and Technology University (ASTU), Adama, Ethiopia.

E-mail I.D: sknagaraju.ce@gmail.com

Mobile No: +251-926654367.

Second Author

Name: B. Sivakonda Reddy

Designation: Assistant Professor in Department of Civil Engineering

University: JNTUH College of Engineering, Hyderabad Andhra Pradesh, India.

E-mail I.D: bskreddy_246@yahoo.com

Mobile No: +91-9392029625.

Third Author

Name: A.Ray Chaudhuri

Designation: Professor in Department of Civil Engineering

University: Adama Science and Technology University (ASTU), Adama, Ethiopia.

E-mail I.D: amroyc@gmail.com

Mobile No: +251-931288204.