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Leveling Resources for a Construction Project by Various Software based Leveling Tools

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Abstract: ***Resource management is the key factor of the project management in today's construction industry. Resources like material and labour have significant impact on construction projects, Project schedules obtained from network scheduling technique generally have unwished resource fluctuation that are clumsy, costly, inoperable and not fulfilling the max availability of resource at a particular time on construction sites. Resource leveling is essential in project management due to these undesirable and costly resource demands. Typically, schedules with improved resource profiles can be derived by shifting the activities within their float times considering the schedule of fixed duration found by various method like Critical Path method, Precedence diagram method ,etc. However, if the project time duration can be extended, It is commended to find a schedule with a extensive resource leveling so far as a longer duration permits for extra float time for overall activities. In the modern era of development a project has a large number of activities, resources and relation whose scheduling could not made possible by manual operation. In this paper, we compare different tools of two commonly used software packages to enable the project manager decisive.***

Keywords: Resource Leveling; Scheduling; Optimization; Project Management.

I. INTRODUCTION

There are many scheduling techniques, such as Gantt charts, Critical Path Method (CPM), and Program Evaluation and Review Technique (PERT) used in construction and research projects. Among these techniques, CPM has been extensively used by construction industry practitioners by the late 1950s. Regardless its popularity, CPM has a general shortcoming as it assumes that resources are unlimited However, in real life, resources are limited and several activities may concurrently require these limited resources, which in turn may lead to scarcity and idleness. Such halts in production may bring about severe delays as well as cost overruns resulting from shortage costs, waiting costs, penalties, etc. Therefore, resources should be utilized proficiently in order to prevent project failures. Several studies focus on resource management in CPM networks Studies on resource management in CPM networks in construction projects can be categorized according to two approaches. The primary approach, which is known as resource allocation or resource-constrained scheduling, Assumes that, If there are limitations on resources. The main objective of this approach is to minimize project duration along with constraints on resources In the last 30 years, There are lot of project management software packages has appeared in the market to assist the project management organizations, Despite the wide spread of these packages , the project managers are left indecisive as to how they select the most suitable or appropriate tools for their respective tasks.

II. OBJECTIVE

The objective of this paper is to identify a optimum schedule for any construction project having various resource constraints and this paper also present the model approach which is capable of directly measuring and comparing the results generated by various software based resource leveling tools, impact of resource fluctuation on construction productivity and project duration , the approaches are also capable of generating experimental schedules that maximizes the capacity of resource utilization in construction projects.

III. LITERATURE REVIEW

A number of resource leveling models and algorithms have been developed so far in order to reduce the level of fluctuation in resource utilization and their negative influence on construction productivity and finance .

Some major work published previously includes

Hani Gharaibeh (2014) author explains a comparison about project management software package on the basis of scoring model also tells about the efficiency of each software package and provided a score for each attribute which assist the user to understand how the software package executes.

T. Subramani (2015) explains about the Primavera P6 software and advantages of Primavera P6 software, he says that Primavera P6 is amazing software which is not only used by project planners but anyone involved in project, i.e. managers, engineers, schedulers, contractors can use Primavera P6software, focusing on the comparison of construction estimate methods application in project

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utility. Primavera permit users to generate project templates, which can be kept and used for the future project, also Primavera can also be used to group and look over multiple projects at the same time.

P. Thangam (2016) explains that, Past work was carried out was not done properly with lack of planning, scheduling and resource allocation. So that resources were in vain and their result in increasing time. After using primavera software in work, it gives reform in quality of construction with prescribed cost and time.

Unmesh. Y. Polekar (2015) says that in each year an immense amount of money wastes due to unfair resource management. This improper management of resources also causes increase in time duration. Using Primavera software, we can organize our project and diagnose potential problems. Primavera software is used for making project management smoother, especially when we encounter difficulties Planning the project means thinking about, and documentation.

B.S.K Reddy (2015) says that resource plays important role in any construction project. The performance of any construction project directly depends upon resource management. For the purpose of resource optimization and leveling author choose primavera p6 software in ongoing construction project in Dubai at UAE. The main objective of this paper is to minimize under allocation of resources. After using primavera software author concluded that there is 5.65% resource reduction in the project.

Muhammad Sajjad (2016) focusing on how to select appropriate software for project management purpose. In this paper author predicts which of the among software tools are best suitable for the project management purpose. Author also discusses the web based project management tools in this paper. Author compares multiple software packages regarding software's features.

For Result Comparison, we use Sum of squares method by Hegazy (1999) Few Researcher deal with extending the project duration beyond the CPM duration and looked on the effect of such extensions on resource profiles, however these studies only assume a predetermined extended duration and are not focused on finding the minimal duration that gives the best leveling as we are finding in our study.

IV. EXPERIMENTAL SETUP

To accomplish the above objectives, the author takes a case study of G+3 hospital building construction project to generate various schedules from different leveling tools available in Project Management Software Packages, In the following setup author takes two most commonly used software package named "Primavera P6" by Oracle Inc. And "Project 2013" by Microsoft Inc. . Both the Software have different approach to level the over allocated resources in order to fulfil the various constraints and dependencies in the project. To complete the above said work following System and softwares are required- A Computer System with Intel Core-i3 processor along with 4 gigabytes of RAM and 500 gigabytes of HDD(or higher configuration), "Primavera P6 Professional R16.2" or higher software by Oracle Inc. , "Project 2013" or higher by Microsoft Incorporation, "Microsoft Excel 2007" for Data calculation and management

V. METHODOLOGY

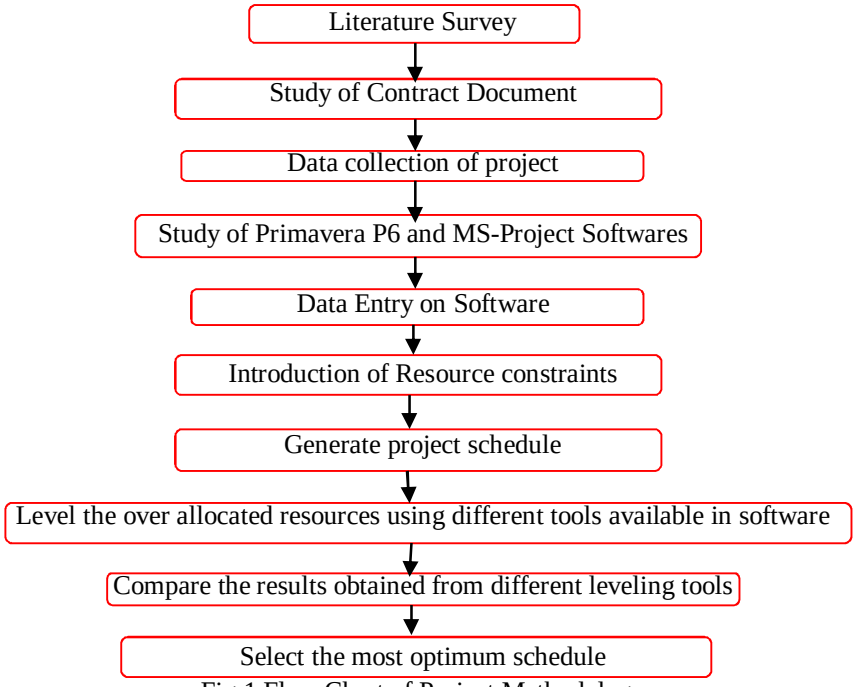


Fig.1 Flow Chart of Project Methodology

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VI. RESEARCH WORK

To generate an ideal schedule for any project, the primary step is to collect data available for the project and follow the below explained steps

1) *Creating EPS:* The EPS stands for Enterprise project structure, create the complete structure of the organization with its branches and sub branches which is executing the project using Primavera
2) *Creating New Project:* The project composes a plan for creating a product or service contains a set of different activities and respective information. The project is administered under respective divisions in EPS. That may be given planned start and finish dates.
3) *Work Breakdown Structure (WBS):* WBS factors have defined and manage the project elements. It helps to clearly identify the deliverables, report and summarize project schedule and estimated duration at different levels of detail. WBS is a hierarchy of any project work that must be intact to complete a construction project. Each project has its own project WBS hierarchy structure with top level WBS element being equal to that of each EPS node of the respective project.

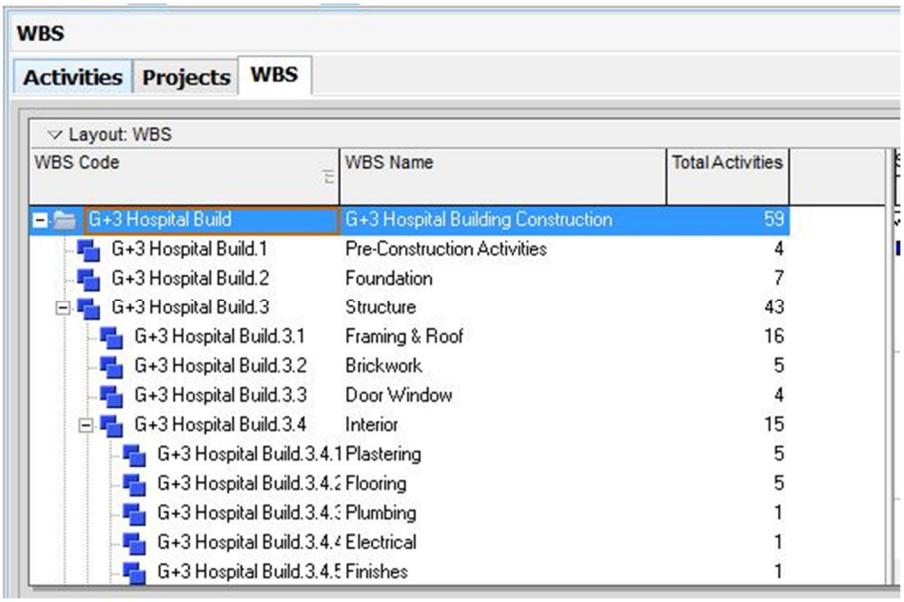


Fig. 2 Work Breakdown Structure

4) *Defining Activity:* The smallest sub divisions of a project are known as the activities. Activities are the fundamental and key work elements of a project and form the top to lowest level of a Work Breakdown Structure. The primary characteristics of activity includes Activity ID, activity name, duration, start and finish dates, activity calendar, activity codes, activity type, constraints, expenses, predecessor and successor relationships, resources, roles etc .

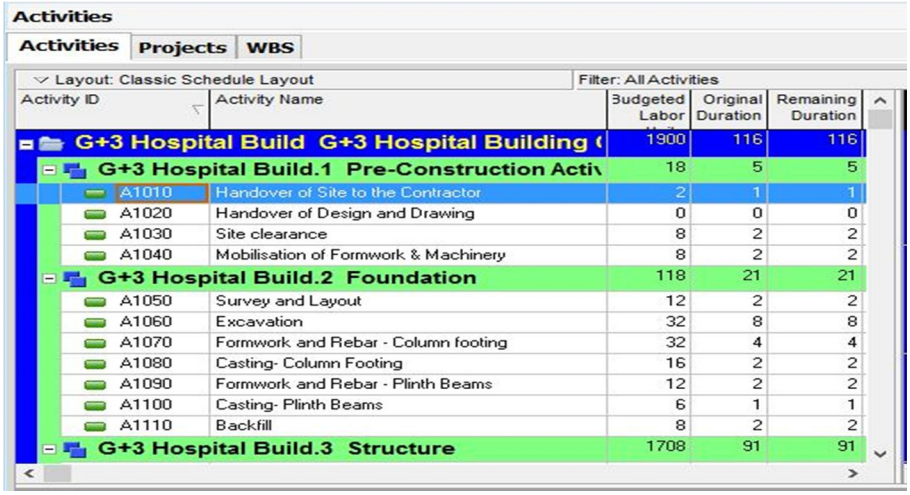


Fig. 3 Activity Table in Primavera P6

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5) *Relationship Between Activities:* By assigning succeeding, preceding activities with significant relationship to the overall project activities, forms a network schedule, the activities should be connected to each other. Types of relationship between activities are as follow-

a) Finish to start (FS) relationship
b) Start to start (SS) relationship
c) Finish to finish (FF) relationship
d) Start to finish (SF) relationship

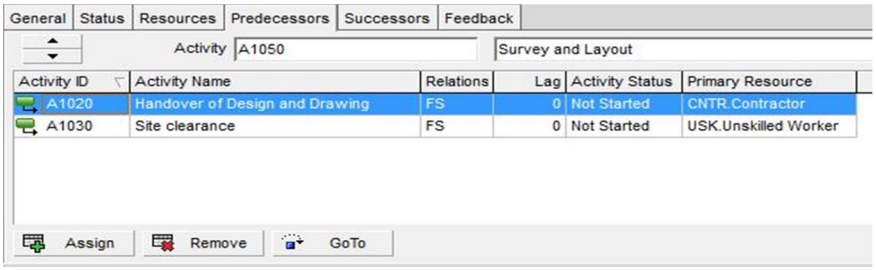


Fig. 4 Activity Details Showing Relationships

6) *Creating a Calendar:* The calendars define the available work hours in each calendar days. Also specify national holidays, organizations, and project- specific work/non a workdays and resource vacation days. The calendar can be created and assign it to each activity. We can easily modify each day work hours by referring calendar

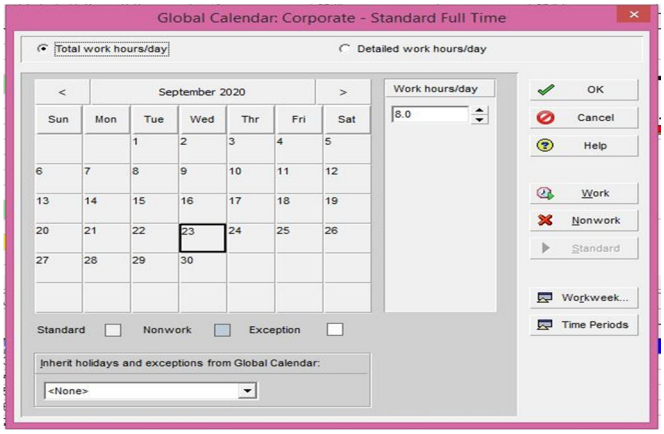


Fig. 5 Calendar in Primavera P6

7) *Activity Duration:* In planning stage of the work, the project duration is entered in the original duration field. It is defines as the time required to complete an activity. The actual duration can only be entered for the activities, which are completed.

8) *Creation of Resources:* Project resources are the people, capital, and/or material goods required for the successful execution and completion of a project. In primavera resources are of 3 types labour , Non-labour and Material

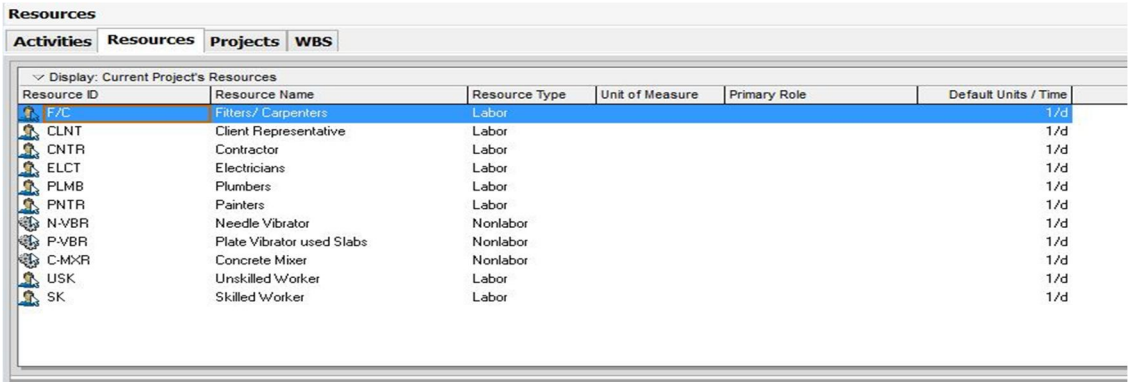


Fig. 6 Resource Chart in Primavera P6

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9) *Assigning Resources:* After creation, Resources can be assigned to respective activities
10) *Schedule Project:* Project can be scheduled on any specific dates, Scheduling alone assumes that all activities will be begin at their respective early start dates and all resources are available unlimited
11) *Creating Baseline:* A complete copy of the primary schedule is a simple baseline plan which provides a target against which a project's performance is tracked.
12) *Resource Loading Diagram:* It is a simple graph between Resource demand v/s Time of any specific resource , In primavera Resource Loading Diagram can be obtained by Resource Usage Profile Tab on Toolbar
13) *Over Allocation of Resources:* If the resource demand of any resource exceeds its maximum availability then it is known as over allocation of resources . To dissipate this over allocation, leveling of resource has to be done.

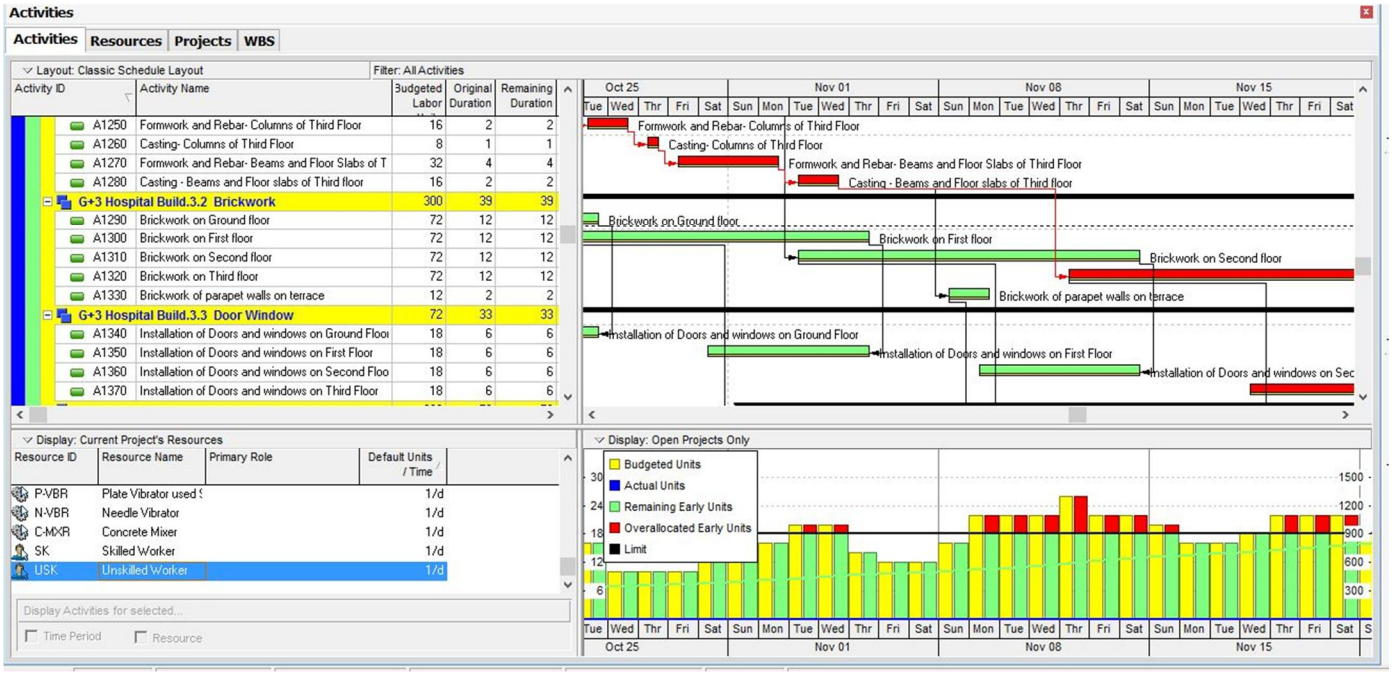


Fig. 7 Resource Loading Diagram showing over allocation of Resources

14) *Leveling Resources:* Leveling of over allocated resource can be automatically in software, where we has to select leveling tools to the level the project in consideration of various resource constraints

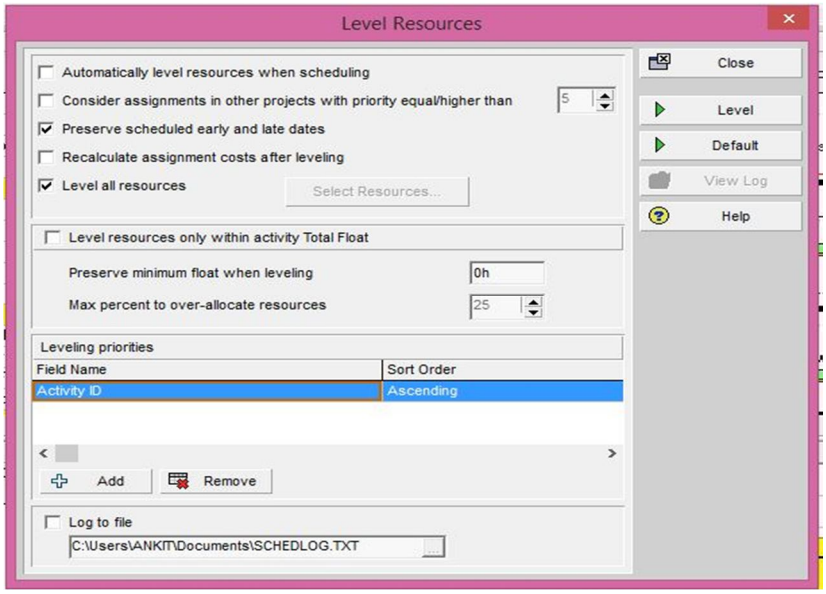


Fig. 8 Leveling Window in Primavera P6

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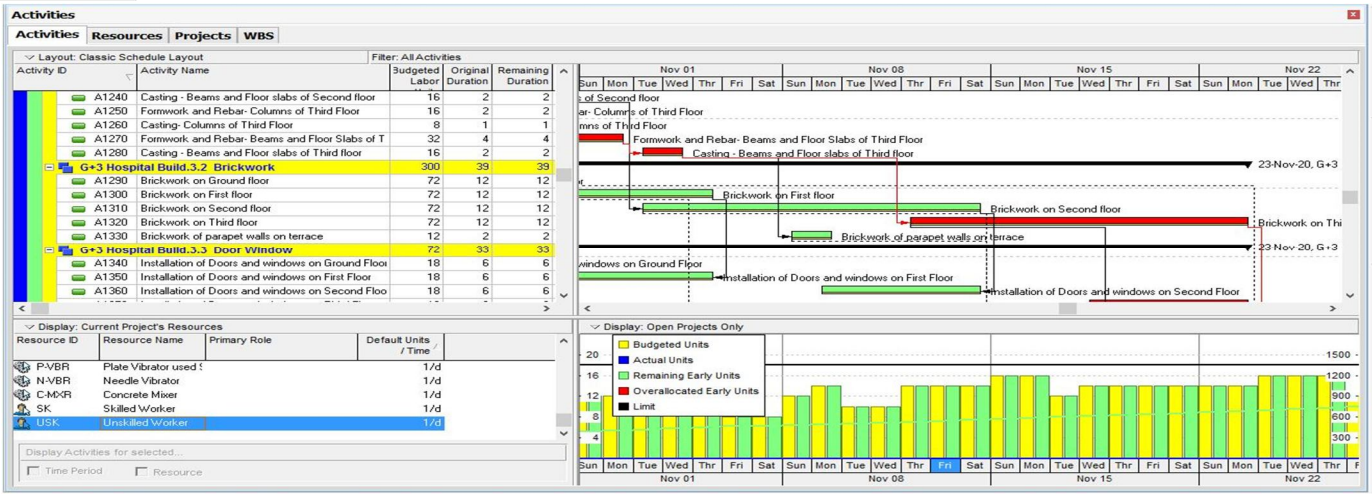


Fig. 9 Resource Loading Diagram After Leveling

Above explained procedure was also applied similarly on Microsoft Project Software to perform leveling operation in different iterations

VII. OBSERVATION AND RESULT

In this work, we took a case study of "G+3 Hospital Building Construction" Project which has total 59 activities, 11 resource types and was initially assumed to be completed in **116 days** but the resources having constraint of maximum availability per day. After Scheduling, it was found that two resources (R1.1- Unskilled Worker, R1.2 –Skilled Worker) has over allocated than its maximum availability, we gave equal Priority Level to each activity

To level these resources we use total 4 iterations on different tools available in Project Management Software Package as follows-

Table 1 Explanation of Software Tools to be used

S. No.	Software Name	Sheet Code	Leveling Tool/ Priorities/Order	Duration
1	Primavera P6	Primavera Lvl-1	Activity ID	131 days
2	Primavera P6	Primavera Lvl-2	Total Float & Early Start	133 days
3	MS Project	MS Project Lvl-1	ID Only	134 days
4	MS Project	MS Project Lvl-2	Standard	126 days

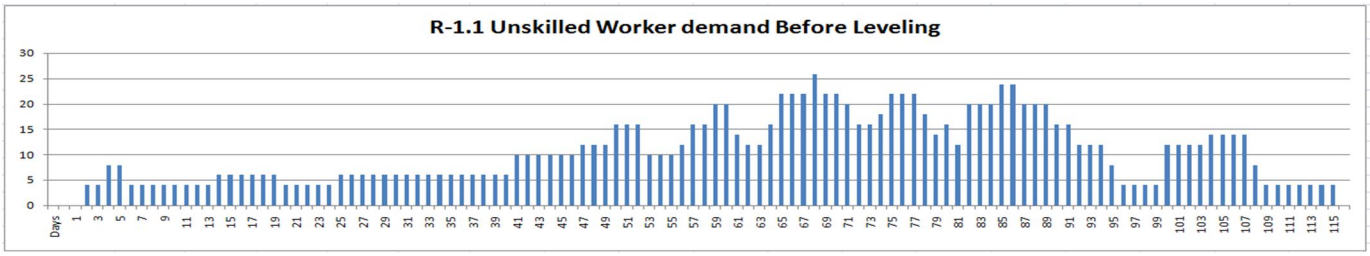


Fig. 10 Resource Loading Diagram of R-1.1 Unskilled Worker Before Leveling

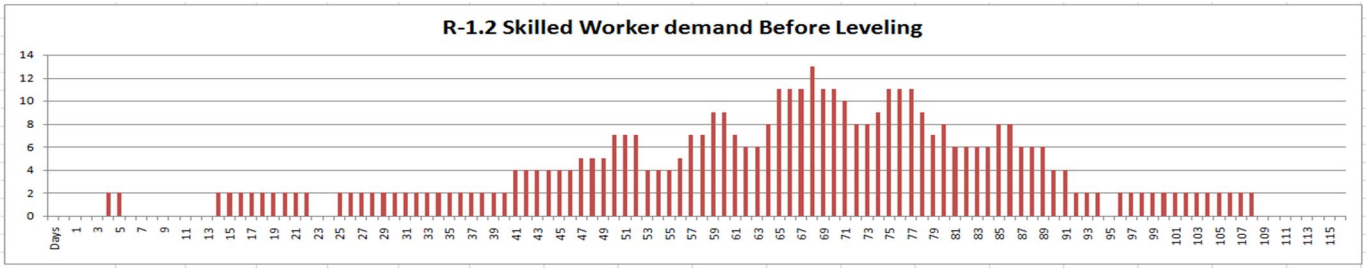


Fig. 11 Resource Loading Diagram of R-1.2 Skilled Worker Before Leveling

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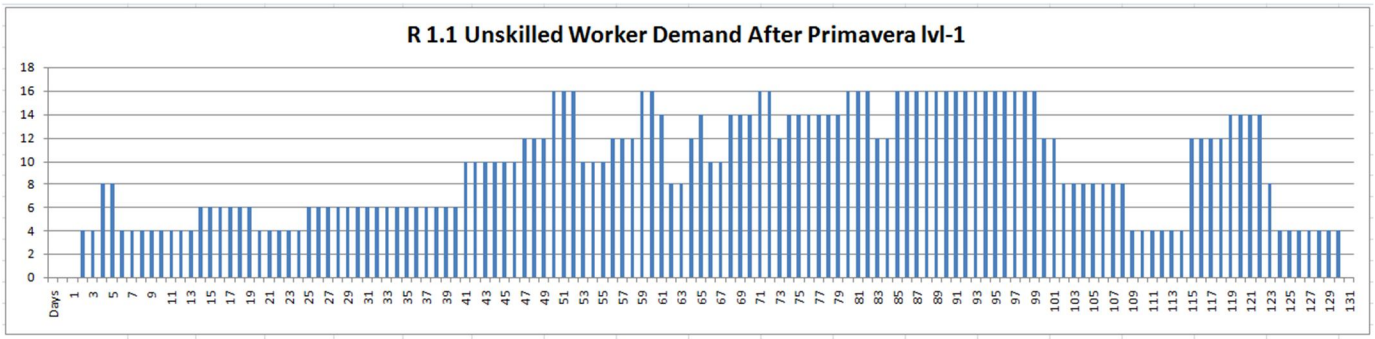


Fig. 12 Resource Loading Diagram of R-1.1 Unskilled Worker After Primavera Lvl-1

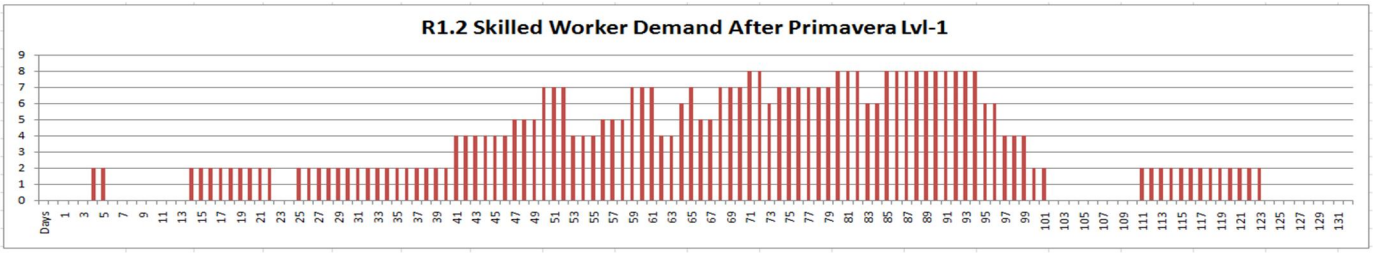


Fig. 13 Resource Loading Diagram of R-1.2 Skilled Worker After Primavera Lvl-1

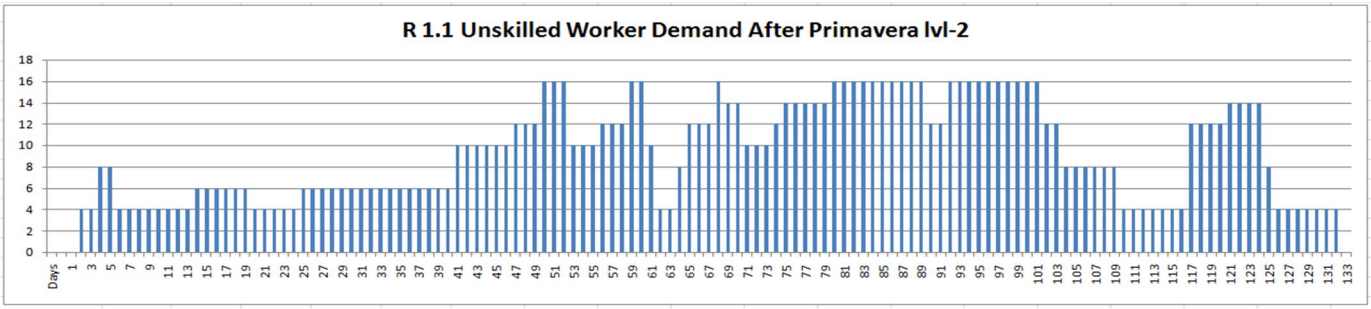


Fig. 14 Resource Loading Diagram of R-1.1 Unskilled Worker After Primavera Lvl-2

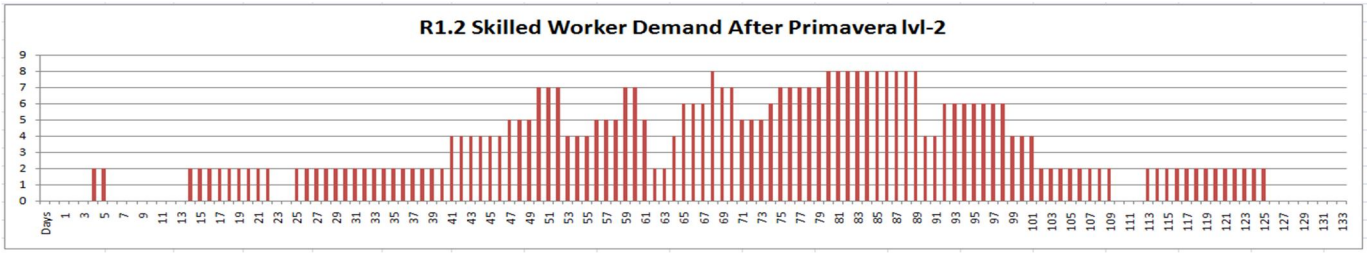


Fig. 15 Resource Loading Diagram of R-1.2 Skilled Worker After Primavera Lvl-2

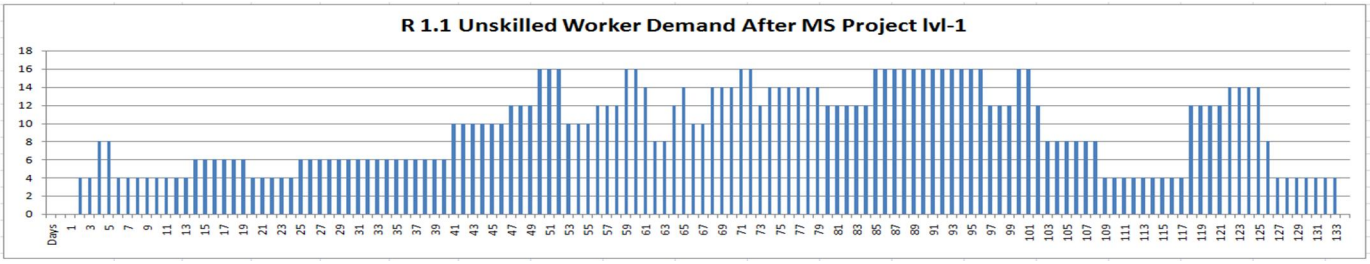


Fig. 16 Resource Loading Diagram of R-1.1 Unskilled Worker After MS Project Lvl-1

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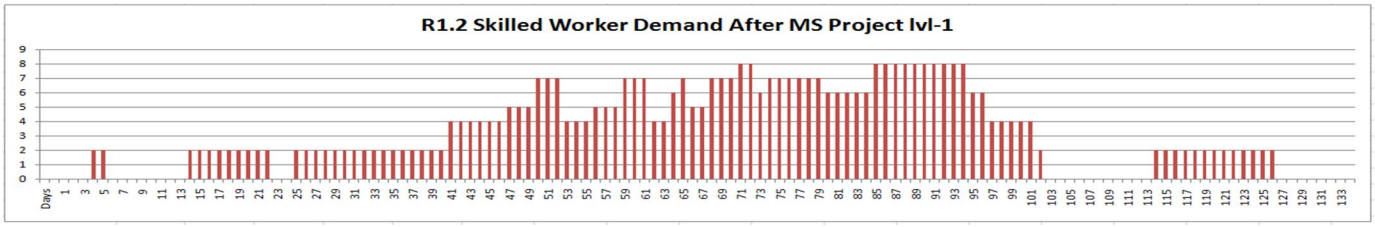


Fig. 17 Resource Loading Diagram of R-1.2 Skilled Worker After MS Project Lvl-1

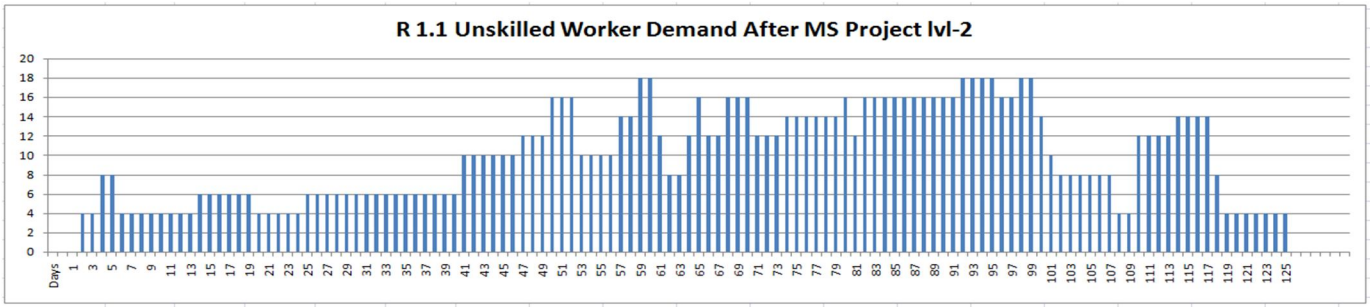


Fig. 18 Resource Loading Diagram of R-1.1 Unskilled Worker After MS Project Lvl-2

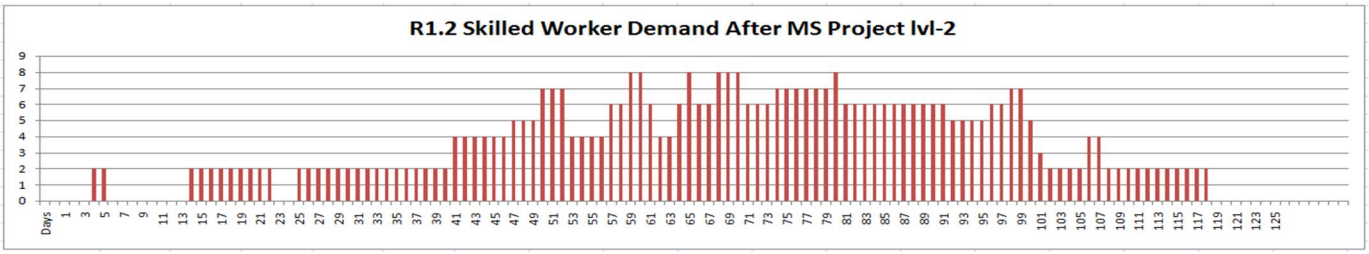


Fig. 19 Resource Loading Diagram of R-1.2 Skilled Worker After MS Project Lvl-2

To compare the resource level diagram results of different tools we use M_x Sum of square Method which Earlier used by (Hegazy 1999) in same context of comparing resource fluctuation,

Table 2 Comparative results by Least Square Method

	R-1.1 Unskilled Workers	R-1.2 Skilled Workers	Duration
	$\sum M_x$	$\sum M_x$	
Unlevelled	18230	3060	116
Primavera Lvl-1	14752	2552	131
Primavera Lvl-2	14632	2378	133
MS Project Lvl-1	14432	2496	134
MS Project Lvl-2	15400	2380	126

In the above result Iteration no.4 that is “MS Project Lvl-2” gives minimum project duration along with almost minimum $\sum M_x$ for R-1.2 Skilled Worker, Thus it the most optimum tool for the above case study.

VIII. CONCLUSION

In this paper, we apply different leveling tools available in Software Based Project Management Packages to examine the best leveling tool to level resources fulfilling the constraints and condition for the above-explained case study of a construction project, As we know Indirect cost associated with any project has a straight relationship with the duration, thus to optimize the project cost-efficiently, the project should be leveled and scheduled with minimum duration along with fulfilling all the constraints

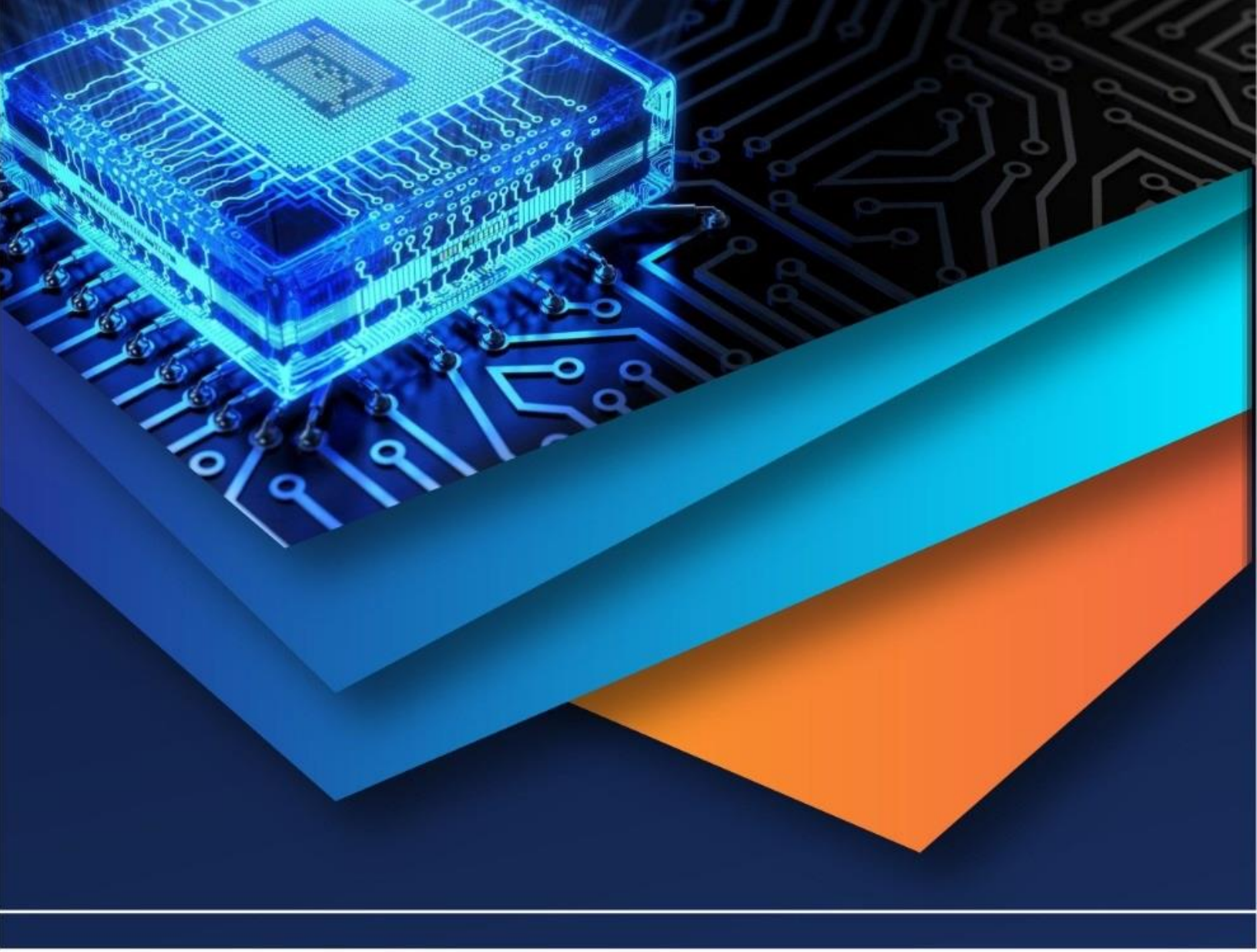
The tools available in both softwares have their unique features and importance like we can add more than one tools for leveling in Level operation, we can split the activities to be levelled in the MS-Project unlike in Primavera

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