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Multiple Resource Leveling using Re-Modified Minimum Moment Method to Construction Project

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Abstract: ***A Project Manager frequently comes across two types of situations time constraints and resource constraints. A project requires resource to execute the activities. These resources include labor, equipment and materials required to complete the work. In the ideal world, resources are unlimited but in the real world they are generally not unlimited and the project team needs to level out the consumption of resource. The purpose of this paper is to apply Re-modified minimum moment method for multiple resource leveling to a construction project and resource leveling by using primavera project management software for the same project and to determine the optimum solution. The method is based on critical path method. To achieve the objective, data of construction of a residential tower is taken. It has been observed that Re-modification minimum moment gives optimum solution than primavera software.***

Keywords: Resource rate**,** Resource Leveling, Re-Modified Minimum Moment Method, Primavera

1. Introduction

Resource leveling and resource availability constraints are typical real-life scheduling problems. Mostly two types of situations come across i.e. limited resource availability and limited duration. In time constraint problems, resources are assumed as unlimited but duration of project should not be extended and on the other side, in resource constraint problems resource availability is limited and project duration can be extended. By the use of resource leveling it provides the solution to both types of problems. The resource constraints problem requires shifting of critical and non-critical activity to minimize the fluctuations in day to day resource use whereas in time constraint problem shifting of only non-critical activities.

The aim of this paper is to apply resource leveling by Re-modified moment method to a construction project suggested by Abhay Tawalare.[4] Minimum moment method suggested by Harris[1] is one of the method used for resource leveling which proposed the procedure for leveling a single resource by preparing the resource histogram step by step until all activities have been located in time within the constraints of given network. Further, Hiyassat [2] proposed the modification to the traditional method to reduce the number of iterations and calculation. By applying modification minimum moment method the calculation part is reduced as compared to traditional method. Further, Hiyassat [3] proposed that the modified minimum moment method can also be applied for leveling multiple resource at same time due to which number of calculation are reduced. Abhay Tawalare [4] proposed a Re-Modification in modified minimum moment method in which calculation is reduced by change in selection criteria of activity which is to be shifted.

2. Literature Review

2.1 Minimum Moment Method

This method was proposed by Harris [1]. It assumes unlimited resources and limited project duration. According to this theory, when a given set of elements is arranged into a histogram over a fixed set of intervals, the minimum moment of the elements exist when the histogram is without peaks and valleys (i.e., rectangle).

The moment of an element is $1/2\sum(Y)^2$ about the axis 0-0.

Therefore total moment of the set is $M = 1/2\sum(Y)^2$.

The aim of the theory is to reduce, as much as possible, the differences between peaks and valleys in the resource histogram, by means of shifting non-critical activities. It should be noted that the statical moment of new position should have a lower value than the original one. The shifting of activities should within its free float available. A resource improvement factor (IF) is calculated for all activities on the last sequence step of network.

IF (activity, S) = R ($\sum x - \sum y - mR$)
Where, IF = Improvement Factor;
S = Number of days to be shifted;
$\sum x$ = sum of daily resources $x_1, x_2, \ldots, x_m$, to which m daily resource rates (R) are to be deducted;
$\sum y$ = sum of daily resources $w_1, w_2, \ldots, w_m$, to which m daily resource rates (R) are to be added;
m = minimum of either the days that the activity is to be shifted (S) or the activity duration (t);
R = Resource rate.

From this calculation the largest positive improvement factor is determined, and that particular activity is shifted. If the improvement factor is positive or zero, than only activity may be shifted otherwise shifting is not needed.

2.2 Modified Minimum Moment Method

In this method a modification over traditional minimum moment approach is proposed by Hiyassat [2]. Modification in terms of selection criteria of activity that has to be shifted.

According to this method that lie at the same sequence step, the selection of activity is to be shifted is based upon highest value of its product of resource rate (R) and free float (S).

After selecting the activity, the same improvement factor introduced by traditional method is calculated. In this method to calculate the improvement factor the value of R is dropped from equation as its value is constant for the same activity. Thus,

$$\text{IF (activity, S)} = \sum x - \sum y - mR$$

If the improvement factor for a given activity is negative then the activity cannot be shifted. Shifting of activity is allowed if only improvement factor is positive or zero. The selected activity is shifted to get maximum moment within its available free float.

The resource histogram and network diagram is updated for selection of next activity for shifting. The process continues up to first sequence step.

2.3 Re- Minimum Moment Method Modified

In this method Abhay Tawalare [4] proposed the Re-modification in modified minimum moment method by Hiyassat [2] in terms of selection criteria of the activity in sequence step of network.

The assumptions are as follows:
1) The network logic is fixed.
2) No interruption is expected once the activity started up to its completion.
3) Resources applied to each activity remains constant throughout its completion.
4) The duration of each activity remains constant.
5) The project completion date is fixed.

The procedure proposed for resource leveling process is as follows:
1) In the network the activity on the last sequence step are examined.
   a) Activities having zero free float is passed over.
   b) Every activities having zero resource rate is shifted to the limit of the activity's free float to allow the preceding activities to be shifted.
2) Activities having positive resource rate values and free float are determined and arranged in ascending order according to values of R. The activity having highest value of R is selected for shifting.
   a) If there is tie in values of R for two or more activities, than the activities having largest value of free float(S) is selected.
   b) If still tied than the activities having the largest duration is to be selected for shifting.
3) For the selected activity in previous step, the improvement factor for all possible positions that the activity may occupy is calculated. If the largest improvement factor for the selected activity is positive or zero, the selected activity is shifted. If there is tie in the value of improvement factor at several of the possible activity positions, the activity with the greatest number of time units is shifted. In the case, if improvement factor is negative, no shifting takes place. The activity with the next largest value of (R) is considered.
4) If shifting occurs, the activity resource rate is subtracted from each of the daily resource sums at the position being vacated. This same rate is added to each of the daily sums at the position being occupied. The lags, free float, ESD, and EFD in the network are updated.
5) The next largest value of R is now selected, and steps 2–4 are repeated until all activities in the sequence step have been considered.
6) The next earlier sequence step is examined and algorithm steps 1–5 are repeated. This manner is continued until all activities have been considered and all possible shifting has taken place on every sequence step. This ends the forward cycle.
7) Beginning with the first sequence step, using back float instead of free float, and progressing to the next latest sequence step instead of the next earliest sequence step, algorithm steps 1–6 are repeated until all activities have been considered and shifted to an earlier time position, if possible. This ends the backward cycle and completes the leveling process.

3. Problem Statement

The data is collected from Construction of a residential tower at Pebbles II located at Bavdhan, Pune. The data collected only the work items involved in the projects. *Certain assumptions are to be followed as:*
1) Maximum number of availability of fitter per day is 40.
2) Maximum number of availability of carpenter per day is 30.

The scope of work is considered as follows:
1) Carpenter and fitter are only considered for resource levelling process.
2) As residential building consist of repetitive work activities, therefore resource levelling using Re-modified minimum moment method is applied for single floor to reduce the number of iterations in calculations.

The quantities are calculated from drawings collected through site. Also using these quantities labour requirement for various activities are calculated. Manpower constant is the quantity of work that can be done by one person in one day (i.e. working 8 hours). This output was computed by based on IS 7272:1974(Part I).

The construction project schedule involves various types of construction activities with different durations based on their nature of work. From drawing, quantities of activities are calculated and from this manpower required are calculated. Then durations are calculated based on quantities and manpower. Based on data collected, schedule is prepared in the form of Gantt chart. Finally using Primavera project management software (P6 Professional R8.2) total duration of project is calculated. As mentioned earlier Re-Modified minimum moment method is applied for a single floor.

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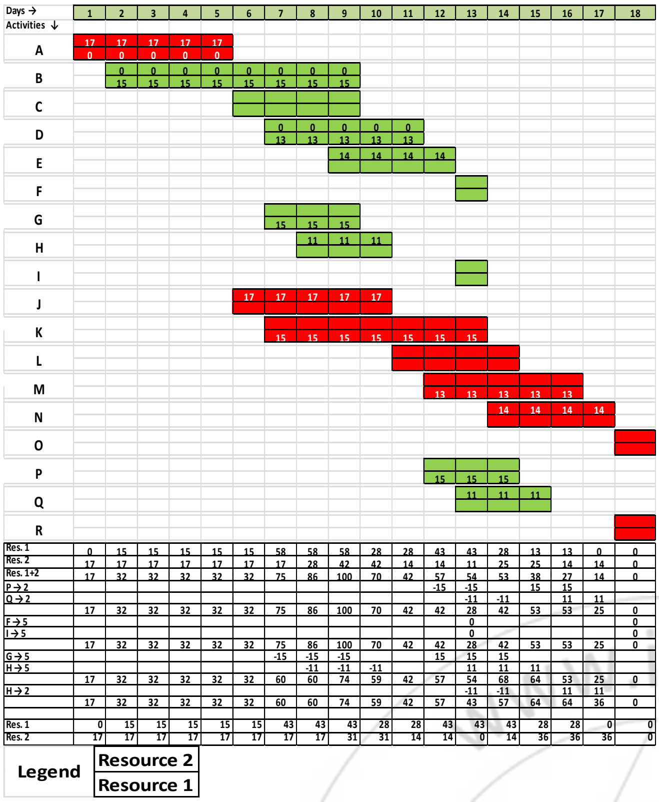

Figure 1: Levelling Combined Resource

In the above figure, result obtained from Re-modified minimum moment method is represented. The upper part of the figure shows the bar chart in which red colour indicates critical activity and green colour indicates non-critical activity. The lower part of the figure shows the several adjusting steps taken during the levelling process. As mentioned earlier that only two resources are considered for levelling. Therefore carpenter and fitter are denoted as resource 1 and resource 2 respectively. The comparison between results of actual and after levelling is based on $\sum Y^2$ values of before levelling and after levelling. The value of $\sum Y^2$ before levelling is 46437 and after levelling is 41165.

And resource levelling using Primavera by applying different priority rules which are applicable to this project, such as activity Id, free float, total float, early start, early finish, late start, and late finish are calculated. Some of daily resource histograms are represented.

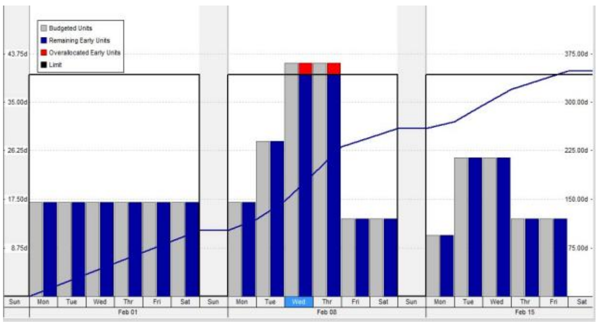

Figure 2: Daily Resource Histogram For Fitter Before Levelling.

In the graph shown above, red colour represents over allocation of fitters. Among all the results evaluated from the priority rules, select the optimum result obtained.

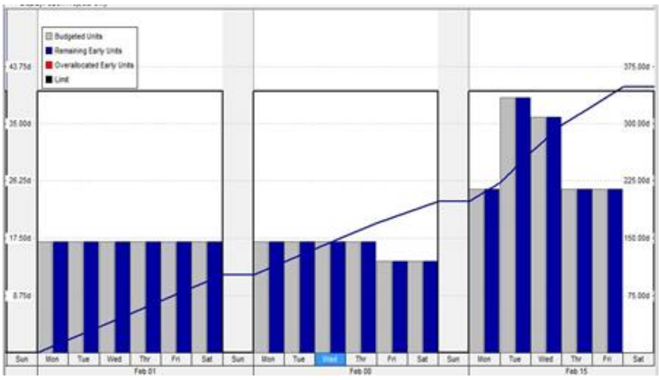

Figure 3: Daily resource histogram of fitter after levelling

In the above figure, daily resource histogram for fitter after levelling is represented. Among all priority rules mentioned earlier, late start gives the optimum solution. To identify which gives optimum solution, statical moment is calculated for every result obtained after levelling.

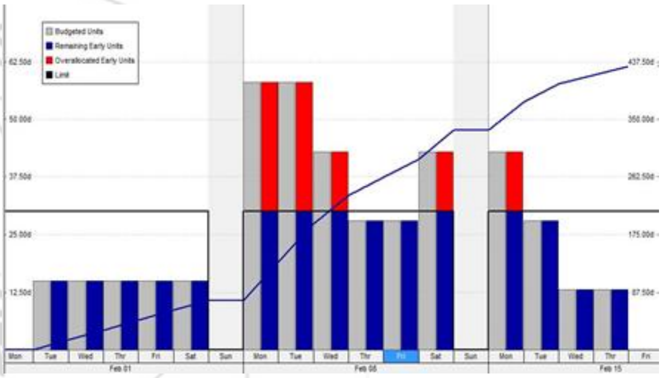

Figure 4: Daily Resource Histogram for Carpenter Before Levelling

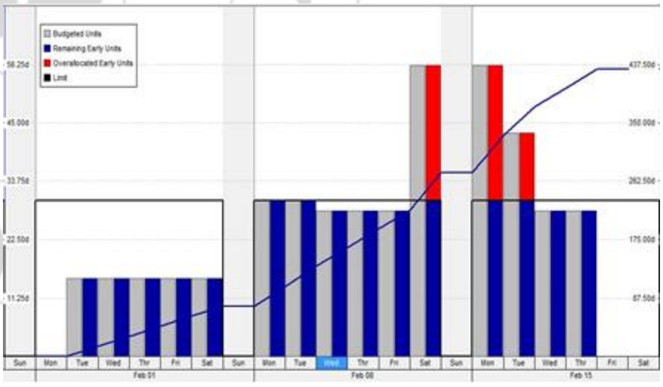

Figure 5: Daily Resource Histogram for Carpenter After Levelling.

In the above figure, daily resource histogram for carpenter before levelling and after levelling is represented. At the same time, for comparing the results obtained by primavera using late start as priority rule statical moment is also calculated. Therefore value of $\sum Y^2$ is calculated as 41356.

4. Conclusion

In this paper Re-modified minimum moment method is applied for leveling multiple resource simultaneously and resource leveling through primavera project management software is carried out. As calculation of resource leveling is heuristic method. Both the results are compared on the basis of value of $\sum Y^2$ obtained after resource levelling, to find the optimum method among them. From the above analysis it is found that Re-modified minimum moment method gives more optimum solution than primavera software.

5. Appendix

The following presents the calculations for the example shown in figure 1.

I.F. (Activity, S) = $\sum x$ - $\sum y$ – mR

Where, IF = Improvement Factor;
S = Number of days to be shifted;
$\sum x$ = sum of daily resources $x_1, x_2, \ldots, x_m$, to which m daily resource rates (R) are to be deducted;
$\sum y$ = sum of daily resources $w_1, w_2, \ldots, w_m$, to which m daily resource rates (R) are to be added;
m = minimum of either the days that the activity is to be shifted (S) or the activity duration (t);
R = Resource rate.

According to outlined procedure, the last sequence step is considered: Considering activity P and Q.

Resource rate of activity P is greater than Q, therefore I.F. is calculated for activity P,
I.F. (P, 1) = 56 – 13 – 1*15 = 28;
I.F. (P, 2) = 56 +43 – 13 - 13 – 2*15 = 43

Activity P is shifted by 2 days, and the network is updated. With this all activities in this in this sequence step are considered. Next sequence step is considered.

The activities having zero resource rate is shifted to the limit of the activity's free float to allow the preceding activities to be shifted.

Therefore activity F is shifted by 5 days, and the network is updated. Next activity is considered.

Considering activity G and H.

Resource rate of activity G is greater than H, therefore I.F. is calculated for activity G,

I.F. (G, 1) = 75 – 53 – 1*15 = 7;

I.F. (G, 2) = 75 + 100 – 53 – 55 – 2*15 = 37;

I.F. (G, 3) = 75 + 100 + 85 – 53 – 55 - 28 – 3*15 = 73;

I.F. (G, 4) = 75 + 100 + 85 – 55 – 28 – 92 – 3*15 = 90;

I.F. (G, 5) = 75 + 100 + 85 – 28 – 42 – 53 – 3*15 = 92;

I.F. (G, 6) = 75 + 100 + 85 – 42 – 53 – 53 – 3*15 = 67;

I.F. (G, 7) = 75 + 100 + 85 – 53 – 53 – 25 – 3*15 = 84;

As I.F. value is greatest at free float 5, therefore Activity G is shifted by 5 days, and the network is updated. Next activity is considered.

Considering activity H,
I.F. (H, 1) = 54 – 53 - 1*11 = - 10;
I.F. (H, 2) = 54 + 68 - 53 – 25 – 2*11 = 22;

As value of I.F. is maximum at free float 2, therefore activity H is shifted by 2 days. This completes the leveling process.

References

[1] R. B. Harris, "Packing Method for Resource Leveling (PACK)," Journal of Construction Engineering and Management, vol. 116, no. 2, June 1990.
[2] M. A. Hiyassat, "Modification of Minimum Moment Approach in Resource Leveling," Journal of Construction Engineering and Management, vol. 126, no. 4, July/August 2000.
[3] M. A. Hiyassat, "Applying Modified Minimum Moment Method to Multiple Resource Leveling," Journal of Construction Engineering and Management, vol. 127, no. 3, May/June 2001.
[4] Abhay Tawalare, Rajesh Lalwani (2013), "Resource Leveling in Construction Projects using Re- Modified Minimum Moment Approach", World Academy of Science, Engineering and Technology 62 2012
[5] IS: 7272 (Part I) – 974 "Recommendation for Labour Output Constants for Building Work Part I North Zone (Sixth Reprint February 2001)
[6] A. Kastor a, K. Sirakoulis, "The effectiveness of resource leveling tools for Resource Constraint Project Scheduling Problem", Science Direct International Journal of Project Management 27 (2009) PN 493–500
[7] A Guide to the Project Management Body of Knowledge (PMBOK Guide). (2013). PMI.

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