Material Constrained Scheduling in Construction Project

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Abstract: ***The effective construction project requires proper conceptual planning, execution and finishing of projects in a stipulated duration and committed cost. Most of the construction projects were completed with overrun cost and in extended time due to various reasons, especially due to improper allocation of resources which is found to be most critical. The overrun duration can be avoided by crashing the project schedule with considering the site related problems. By crashing the project schedule we may avoid the project over head cost occurring to the project .The method of study is analyzing the housing Project with respect to material related constraint and reducing the project duration and over head cost.***

Keywords: RepetitiveConstruction Projects, Project Scheduling, Resource Allocation.

1. Introduction

The Critical Path Method (CPM) has been widely accepted and used for construction scheduling problems over the recent decades. However, as for the management goal of the effective use of resources in construction projects, traditional CPM applications are difficult to implement since the CPM concept was originally devised to focus on project completion efficiency. Therefore, supported by the rapid development of computer techniques, further studies have been performed for solving the complexity of construction scheduling problems by using different techniques. The techniques adopted can generally be grouped into two categories (Moselhi and Lorterapong, 1993): optimization-based and heuristic-based. Optimization techniques such as mathematical programming and generic algorithm aim to produce optimal solutions. However, these techniques require strong assumptions regarding problem formulation and extensive computational efforts for real-life construction projects that generally include hundreds of activities. Heuristic models are based on decision rules for assigning priority with regard to resource allocation among various activities. Those heuristic models have been demonstrated to perform well over various problems, and are widely used in actual practice owing to their simplicity and efficiency in application. However, they cannot guarantee to find the optimal solution. (Chan et al.1996).In order to ensure project success, resource planning is a key topic in effective construction project scheduling.

2. Management of Construction Resources

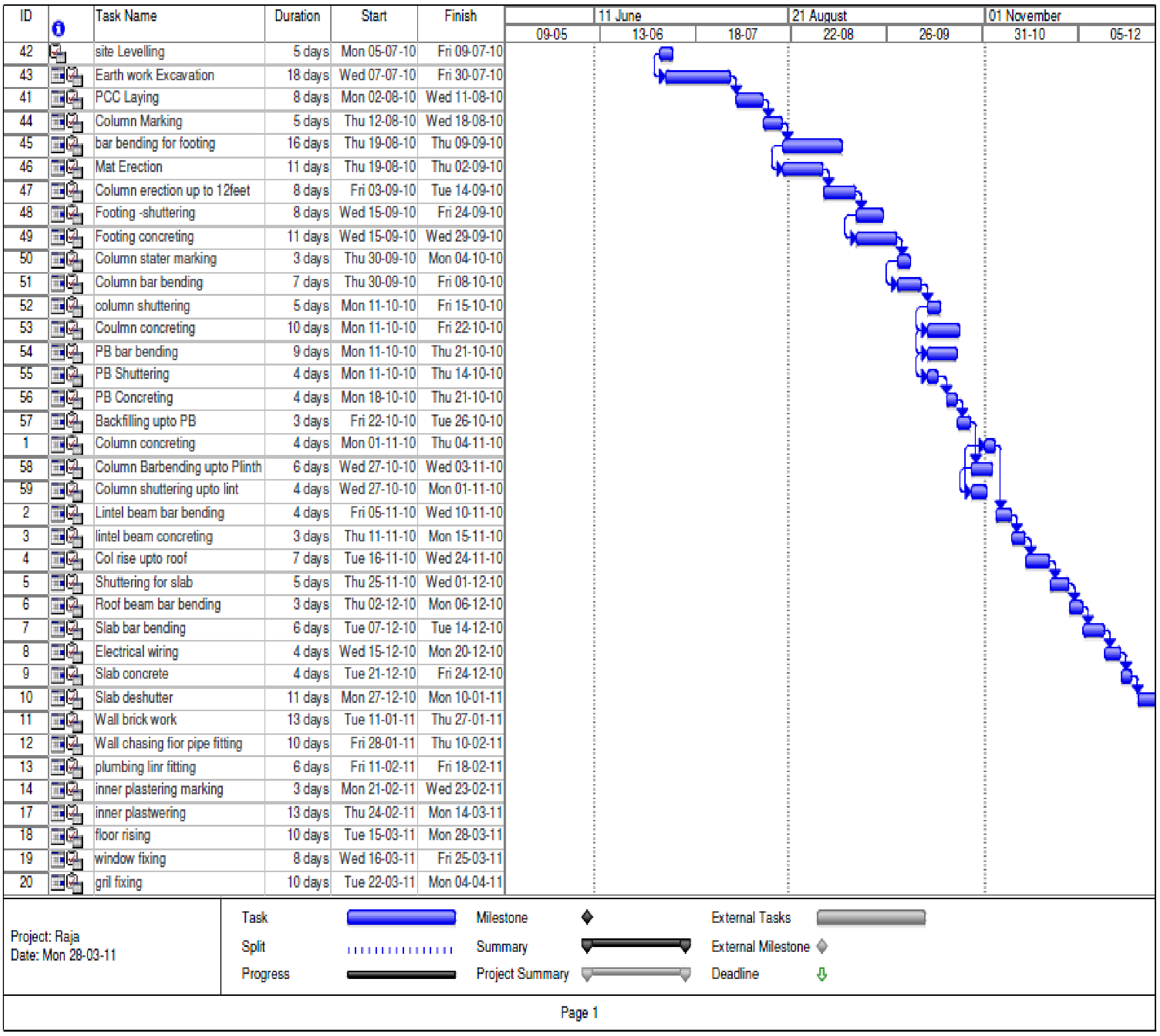
The traditional solution of the resource allocation problem commences with the CPM analysis of the project network. Each activity is assumed to require a fixed quantity of resources, and the activity once started cannot be interrupted. An overall project duration is determined based on the assumption that resources are in abundance. Then a search is made for a schedule of activities such that resource requirements are met. Resource allocation schemes were integrated into the CPM, subsequently, to reschedule project activities in a way such that resource needs could be matched throughout the project life. Usually, this is done heuristically by shifting some activities competing for limited resources to other time periods when resources become available. The schedule should maintain the dependence constraints between project activities.

3. Objective

- Quantifying the resource constraints involved in housing projects in India.
- Fine tuning the resource -material traditional planning system
- Optimization of construction delays and reducing the overrun project duration.
- Generalize the scheduling of housing projects and reducing the over head cost of the project.

4. Project Schedule For The Housing Project

In critical path scheduling for the situation in which activity durations are fixed and known. Unfortunately, activity durations are estimates of the actual time required, and there is liable to be a significant amount of uncertainty associated with the actual durations. During the preliminary planning stages for a project, the uncertainty in activity durations is particularly large since the scope and obstacles to the project are still undefined. Activities that are outside of the control of the owner are likely to be more uncertain. For example, the time required to gain regulatory approval for projects may vary tremendously. Other external events such as adverse weather, trench collapses, or labor strikes make duration estimatesparticularly uncertain.



ID	Task Name	Duration	Start	Finish
42	site Levelling	5 days	Mon 05-07-10	Fri 09-07-10
43	Earth work Excavation	18 days	Wed 07-07-10	Fri 30-07-10
41	PCC Laying	8 days	Mon 02-08-10	Wed 11-08-10
44	Column Marking	5 days	Thu 12-08-10	Wed 18-08-10
45	bar bending for footing	16 days	Thu 19-08-10	Thu 09-09-10
46	Mat Erection	11 days	Thu 19-08-10	Thu 02-09-10
47	Column erection up to 12feet	8 days	Fri 03-09-10	Tue 14-09-10
48	Footing -shuttering	8 days	Wed 15-09-10	Fri 24-09-10
49	Footing concreting	11 days	Wed 15-09-10	Wed 29-09-10
50	Column stater marking	3 days	Thu 30-09-10	Mon 04-10-10
51	Column bar bending	7 days	Thu 30-09-10	Fri 08-10-10
52	column shuttering	5 days	Mon 11-10-10	Fri 15-10-10
53	Coulmn concreting	10 days	Mon 11-10-10	Fri 22-10-10
54	PB bar bending	9 days	Mon 11-10-10	Thu 21-10-10
55	PB Shuttering	4 days	Mon 11-10-10	Thu 14-10-10
56	PB Concreting	4 days	Mon 18-10-10	Thu 21-10-10
57	Backfilling upto PB	3 days	Fri 22-10-10	Tue 26-10-10
1	Column concreting	4 days	Mon 01-11-10	Thu 04-11-10
58	Column Barbending upto Plinth	6 days	Wed 27-10-10	Wed 03-11-10
59	Column shuttering upto lint	4 days	Wed 27-10-10	Mon 01-11-10
2	Lintel beam bar bending	4 days	Fri 05-11-10	Wed 10-11-10
3	lintel beam concreting	3 days	Thu 11-11-10	Mon 15-11-10
4	Col rise upto roof	7 days	Tue 16-11-10	Wed 24-11-10
5	Shuttering for slab	5 days	Thu 25-11-10	Wed 01-12-10
6	Roof beam bar bending	3 days	Thu 02-12-10	Mon 06-12-10
7	Slab bar bending	6 days	Tue 07-12-10	Tue 14-12-10
8	Electrical wiring	4 days	Wed 15-12-10	Mon 20-12-10
9	Slab concrete	4 days	Tue 21-12-10	Fri 24-12-10
10	Slab deshutter	11 days	Mon 27-12-10	Mon 10-01-11
11	Wall brick work	13 days	Tue 11-01-11	Thu 27-01-11
12	Wall chasing fior pipe fitting	10 days	Fri 28-01-11	Thu 10-02-11
13	plumbing linr fitting	6 days	Fri 11-02-11	Fri 18-02-11
14	inner plastering marking	3 days	Mon 21-02-11	Wed 23-02-11
17	inner plastwering	13 days	Thu 24-02-11	Mon 14-03-11
18	floor rising	10 days	Tue 15-03-11	Mon 28-03-11
19	window fixing	8 days	Wed 16-03-11	Fri 25-03-11
20	gril fixing	10 days	Tue 22-03-11	Mon 04-04-11

Figure 1: Project schedule for Housing Project

Fig 1 shows the project schedule of the housing project. Two simple approaches to dealing with the uncertainty in activity durations warrant some discussion before introducing more formal scheduling procedures to deal with uncertainty. First, the uncertainty in activity durations may simply be ignored and scheduling done using the expected or most likely time duration for each activity. Since only one duration estimate needs to be made for each activity, this approach reduces the required work in setting up the original schedule. Formal methods of introducing uncertainty into the scheduling process require more work and assumptions. While this simple approach might be defended, it has two drawbacks. First, the use of expected activity durations typically results in overly optimistic schedules for completion. Second, the use of single activity durations often produces a rigid, inflexible mindset on the part of schedulers. As field managers appreciate, activity durations vary considerable and can be influenced by good leadership and close attention. As a result, field managers may loose confidence in the realism of a schedule based upon fixed activity durations. Clearly, the use of fixed activity durations in setting up a schedule makes a continual process of monitoring and updating the schedule in light of actual experience imperative. Otherwise, the project schedule is rapidly outdated.

Table 1: Direct Cost for the Planned Project Schedule

Item	Unit	Qty	Rate/Unit	Amount in Rs
Cement	Bag	436	250	109000
Sand	Cft	2201	35	77035
Jelly	Cft	2869	25	71725
Steel	Kg	6020	35	210700
Brick	Nos	12000	6	72000
Wood	Sft	4362	7	30534
Tiles	Nos	1520	20	30400
Direct Cost = Rs 601394				

Table 1 shows the details about the direct cost for the housing project. For the calculation of direct cost major construction material items has been taken.

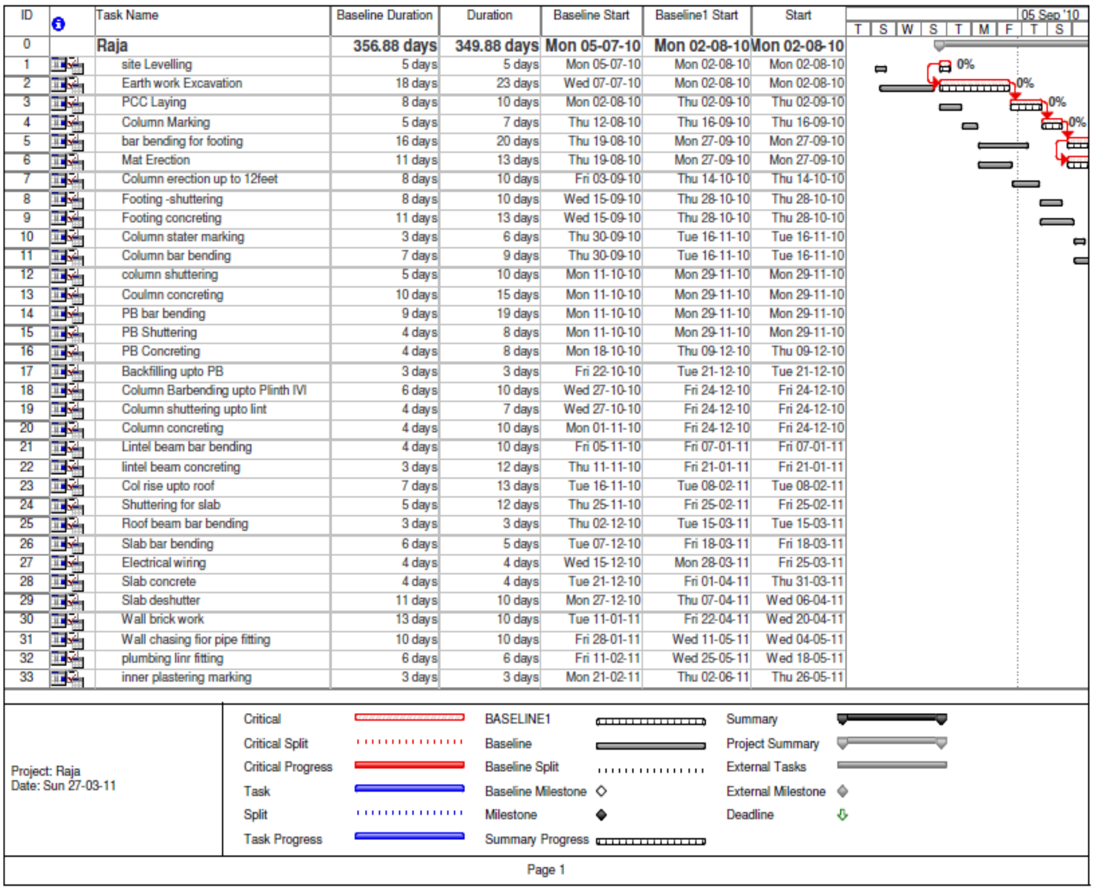
Table 2: Indirect Costs for the Planned Project Schedule

Description	% Increase	Amount
Overhead cost	10%	60139
Wastage of material	2%	12027
Stores over head cost	1%	6013
Rate variation, Transport, Maintenance	7%	42097
Indirect Cost Rs 120278		

Table 2 shows the details about the Indirect cost occurring to the material items for that stores maintenance charges, wastage of material, transportcharges, rate fluctuation cost difference .Indirect costs are overhead expenses incurred by the applicant organization as a result of the project but that are not easily identified.Generally, indirect costs are defined as administrative or other expenses that are not directly allocable to a particular activity or project; rather they are related to overall general operations and are shared among projects and/or functions. Examples include executive oversight, accounting, grants management, legal expenses, utilities, and technologysupport and facility maintenance.While the definition of direct and indirect costs is subject to some interpretation, Actual administrative and maintenance costs do not ordinarily increasein direct proportion to grant amount and in many cases may not increase at all.Therefore, we expect that larger grants will require a considerably lower amount of indirect costs than is typically the case for small grants.

5. Crashing of Real Time Project

The activity in the projects is crashed based on considering the constraints in construction site and the activity duration has been reduced.



ID	Task Name	Baseline Duration	Duration	Baseline Start	Baseline1 Start	Start
0	Raja	356.88 days	349.88 days	Mon 05-07-10	Mon 02-08-10	Mon 02-08-10
1	site Levelling	5 days	5 days	Mon 05-07-10	Mon 02-08-10	Mon 02-08-10
2	Earth work Excavation	18 days	23 days	Wed 07-07-10	Mon 02-08-10	Mon 02-08-10
3	PCC Laying	8 days	10 days	Mon 02-08-10	Thu 02-09-10	Thu 02-09-10
4	Column Marking	5 days	7 days	Thu 12-08-10	Thu 16-09-10	Thu 16-09-10
5	bar bending for footing	16 days	20 days	Thu 19-08-10	Mon 27-09-10	Mon 27-09-10
6	Mat Erection	11 days	13 days	Thu 19-08-10	Mon 27-09-10	Mon 27-09-10
7	Column erection up to 12feet	8 days	10 days	Fri 03-09-10	Thu 14-10-10	Thu 14-10-10
8	Footing -shuttering	8 days	10 days	Wed 15-09-10	Thu 28-10-10	Thu 28-10-10
9	Footing concreting	11 days	13 days	Wed 15-09-10	Thu 28-10-10	Thu 28-10-10
10	Column stater marking	3 days	6 days	Thu 30-09-10	Tue 16-11-10	Tue 16-11-10
11	Column bar bending	7 days	9 days	Thu 30-09-10	Tue 16-11-10	Tue 16-11-10
12	column shuttering	5 days	10 days	Mon 11-10-10	Mon 29-11-10	Mon 29-11-10
13	Coulmn concreting	10 days	15 days	Mon 11-10-10	Mon 29-11-10	Mon 29-11-10
14	PB bar bending	9 days	19 days	Mon 11-10-10	Mon 29-11-10	Mon 29-11-10
15	PB Shuttering	4 days	8 days	Mon 11-10-10	Mon 29-11-10	Mon 29-11-10
16	PB Concreting	4 days	8 days	Mon 18-10-10	Thu 09-12-10	Thu 09-12-10
17	Backfilling upto PB	3 days	3 days	Fri 22-10-10	Tue 21-12-10	Tue 21-12-10
18	Column Barbending upto Plinth lVl	6 days	10 days	Wed 27-10-10	Fri 24-12-10	Fri 24-12-10
19	Column shuttering upto lint	4 days	7 days	Wed 27-10-10	Fri 24-12-10	Fri 24-12-10
20	Column concreting	4 days	10 days	Mon 01-11-10	Fri 24-12-10	Fri 24-12-10
21	Lintel beam bar bending	4 days	10 days	Fri 05-11-10	Fri 07-01-11	Fri 07-01-11
22	lintel beam concreting	3 days	12 days	Thu 11-11-10	Fri 21-01-11	Fri 21-01-11
23	Col rise upto roof	7 days	13 days	Tue 16-11-10	Tue 08-02-11	Tue 08-02-11
24	Shuttering for slab	5 days	12 days	Thu 25-11-10	Fri 25-02-11	Fri 25-02-11
25	Roof beam bar bending	3 days	3 days	Thu 02-12-10	Tue 15-03-11	Tue 15-03-11
26	Slab bar bending	6 days	5 days	Tue 07-12-10	Fri 18-03-11	Fri 18-03-11
27	Electrical wiring	4 days	4 days	Wed 15-12-10	Mon 28-03-11	Fri 25-03-11
28	Slab concrete	4 days	4 days	Tue 21-12-10	Fri 01-04-11	Thu 31-03-11
29	Slab deshutter	11 days	10 days	Mon 27-12-10	Thu 07-04-11	Wed 06-04-11
30	Wall brick work	13 days	10 days	Tue 11-01-11	Fri 22-04-11	Wed 20-04-11
31	Wall chasing fior pipe fitting	10 days	10 days	Fri 28-01-11	Wed 11-05-11	Wed 04-05-11
32	plumbing linr fitting	6 days	6 days	Fri 11-02-11	Wed 25-05-11	Wed 18-05-11
33	inner plastering marking	3 days	3 days	Mon 21-02-11	Thu 02-06-11	Thu 26-05-11

Figure 1: Crashed Real Time Project Schedule

Fig 1 shows the details about the crashed activity .The minimum time to complete a project is called theproject-crash time. This minimum completion time can be found by applying critical path scheduling with all activity durations set to their minimum values. This minimum completion time for the project can then be used in the time-cost scheduling problem described to determine the minimum project-crash cost. Note that the project crash cost is not found by setting each activity to its crash duration and summing up the resulting costs; this solution is called the all-crash cost. Since there are some activities not on the critical path that can be assigned longer duration without delaying the project, it is advantageous to change the all-crash schedule and thereby reduce costs.

Table 3: Crashed Activity Details

Activity ID	Activity	Schedule Duration	Crashed Duration
26	Slab Barbending	6	5
29	Slab Deshuttering	11	10
30	Wall brick work	13	10
35	Outer Plastering	18	15
36	Inner Plastering	13	11
39	Grill Fixing	10	8
40	Floor chasing & Cleaning	16	14
41	Toilet wall Tilling	16	14
42	Toilet floor Tilling	14	12
43	Floor Tilling	23	20
44	Skirting	7	6
45	Door Fixing	23	21
47	Electrical wiring	21	18
48	French Door Fixing	16	15
50	Two coat Putty	23	20
51	Two coat paint	19	17
52	One coat paint to wall	23	21
58	Flat Cleaning	8	6
59	Outer area Paint	11	10

Table 3 shows the details about the crashed activity in the housing project with original activity duration and crashed activity duration.Heuristic approaches are also possible to the time/cost tradeoff problem. In particular, a simple approach is to first apply critical path scheduling with all activity durations assumed to be at minimum cost. Next, the planner can examine activities on the critical path and reduce the scheduled duration of activities which have the lowest resulting increase in costs. In essence, the planner develops a list of activities on the critical path ranked in accordance with the unit change in cost for a reduction in the activity duration. The heuristic solution proceeds by shortening activities in the order of their lowest impact on costs. As the duration of activities on the shortest path are shortened, the project duration is also reduced. Eventually, another path becomes critical, and a new list of activities on the critical path must be prepared. By manual or automatic adjustments of this kind, good but not necessarily optimal schedules can be identified. Optimal or best schedules can only be assured by examining changes in combinations of activities as well as changes to single activities. However, by alternating between adjustments in particular activity durations (and their costs) and a critical path scheduling procedure, a planner can fairly rapidly devise a shorter schedule to meet a particular project deadline or, in the worst case, find that the deadline is impossible of accomplishment.

Improving the Scheduling Process:
Despite considerable attention by researchers and practitioners, the process of construction planning and scheduling still presents problems and opportunities for improvement. The importance of scheduling in insuring the effective coordination of work and the attainment of project deadlines is indisputable. For large projects with many parties involved, the use of formal schedules is indispensable. The network model for representing project activities has been provided as an important conceptual and computational framework for planning and scheduling. Networks not only communicate the basic precedence relationships between activities, they also form the basis for most scheduling computations.

Table 4: Direct Costs for the Actual Project Schedule

Item	Unit	Qty	Rate/Unit	Amount in Rs
Cement	Bag	436	270	117720
Sand	Cft	2201	38	83638
Jelly	Cft	2869	27	77463
Steel	Kg	6020	38	228760
Brick	Nos	12000	8	96000
Wood	Sft	4362	9	39258
Tiles	Nos	1520	22	33440
				Direct Cost Rs 676279

Rather than concentrating upon more elaborate solution algorithms, the most important innovations in construction scheduling are likely to appear in the areas of data storage, ease of use, data representation, communication and diagnostic or interpretation aids. Integration of scheduling information with accounting and design information through the means of database systems is one beneficial innovation; many scheduling systems do not provide such integration of information. With regard to ease of use, the introduction of interactive scheduling systems, graphical output devices and automated data acquisition should produce a very different environment than has existed. In the past, scheduling was performed as a batch operation with output contained in lengthy tables of numbers.

Updating of work progress and revising activity duration was a time consuming manual task. It is no surprise that managers viewed scheduling as extremely burdensome in this environment. The lower costs associated with computer systems as well as improved software make "user friendly" environments a real possibility for field operations on large projects.

Table 5: Indirect Costs for the Actual Project Schedule

Description	% Increase	Amount
Over head cost	10%	67627
Wastage of material	2%	13525
Stores over head cost	1%	6762
Rate variation, Transport, Maintenance	7%	47339
		Increased cost Rs 135253

6. Conclusion

Crashed duration of the project is seven days, Total cost difference in Planned Vs Actual can be saved by crashing the project schedule. By crashing the project schedule the over head cost of the material for the excess duration can be reduced. Resource allocation substantially influences project time performance. Impractical allocation may account for the project delay. Performing a schedule analysis without considering resource allocations may increase the owner's or contractor's risk of assuming delay responsibility which is not his or her fault. This paper has proposed steps to reduce the overhead cost due to increase in project time duration. The delay analysis considers impacts of resource allocation. A delay analysis that includes the resource allocation used on the project is more trustworthy. As such, this research is useful to both industry professionals and researchers.

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