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Utilization of Floats in Project Schedule Recovery

- *A Pilot Schedule Demonstration*

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Abstract: The time required for a construction project is vital attention as a delay in the schedule can lead to damages and financial impacts on the contract parties, mainly client and contractor. The main objectives of construction projects include completing the project on time. Moreover, the success or failure of a delayed project ultimately depends on the effectiveness of the appropriate actions taken at the right time to recover the project. Before these actions can be taken, however, organizations need to be able to recognize problems and prepare to take appropriate corrective measures. The Indian construction industry is also facing a lot of challenges in completing construction projects within the estimated time as well as cost. The basic technique utilized for assessing the effect of individual delaying events on the overall project duration is network analysis, also known as Critical Path Method analysis or CPM. The longest sequence of required construction activities to complete the project is its critical path. Delay to any of the critical path activities will extend the project duration. Several steps can be explored to recover the schedule such as re-sequencing activities or reducing other critical path activity durations. Also, the noncritical activities can be delayed without affecting the project duration within the available float. This paper outlines the process effectiveness of utilization of floats in the project scheduling as an attempt for schedule recovery.

Index Terms **- Float types, Allocation of floats, Utilization of floats, Schedule Recovery**

I. INTRODUCTION

Project float is defined as the time that an activity can be delayed without affecting the project completion date and a resource that provides flexibility in the contractor's operation (Yang, 2017). The float is an important element in the project schedule that can be used by contractors to change the start of noncritical activities for resource management purposes, and by owners to accommodate change orders. Arguments over the ownership of float in the project schedule are common, unless the contract document state otherwise, float belongs to whichever party uses it first (Pepoon, 2018). To reduce such ambiguities, the issues of float ownership, treatment, and use should be addressed and explicitly provided for in the contract documents. By following such a recommendation, both the owner and contractor know from the beginning their measure of the shared float - a "promise" on which they can rely throughout the project (Prateapusanond, 2007)

The success or failure of a delayed project ultimately depends on the effectiveness of the appropriate actions taken at the right time to recover the project. Before these actions can be taken, however, organizations need to be able to recognize problems and prepare to take appropriate corrective measures. The Indian construction industry is also facing a lot of challenges in completing construction projects within the estimated time and cost.

II. NEED IDENTIFICATION AND PROBLEM STATEMENT

According to Masood & Choudhry (2010), a time delay is a vital risk factor for construction projects because of complex nature and uncertain environments involving contractors, consultants, clients, and suppliers. Planning deficiency and consequent execution delays are likely to persist in construction projects (Iyer & Banerjee, 2016). Since time is money, and since time is of the essence in any construction project, there is a need to address the float consumption and the float allocation in construction projects (Haj, 2008). However, optimizing the cost of a time delay with the use of float is a less researched area. In real-time situations, unpredictable events often affect the schedules of construction projects, forcing contractors to alter the duration of specific activities (Lo & Kuo, 2013)

Projects do not get into trouble overnight. There are early warning signs, but most companies seem to overlook them or misunderstand them. Some companies simply ignore the tell-tale signs and continue hoping for a miracle. Failure to recognize these signs early can make the cost of downstream corrections a very costly endeavor. Hence, there is an immense need to address the issues affecting all the stakeholders by minimizing the impact delay in the project schedule (i.e. floats) and its consequent cost. When a project gets way off track, the cost of its recovery is huge and vast or even new resources may be required for corrections. The ultimate goal for getting the project back on track is to accomplish with reasonable benefits, value for the customer, and the stakeholders at the optimum cost.

III. OBJECTIVES

1. To develop an understanding of the concept of floats in construction scheduling.
2. To identify the parameters for float ownership, the purpose of incorporating in scheduling and clauses.
3. To assess the methods of using the float in project schedule recovery through examples and a pilot brief project schedule.

IV. RESEARCH METHODOLOGY

To address the research questions or meet the research objectives, the following research steps are proposed-

Step 1 - Desk research including collating and reviewing the existing literature related to float concepts in scheduling, its ownership, allocation, and effectiveness in construction projects.

Step 2 - Identifying and define the gap or problem area of utilization of floats in the scheduling of Indian construction projects.

Step 3 - Further reviewing the literatures in the field of understanding the theory of over-allocation of resources and various task constraints in the scheduling, effective methods of utilization including sharing of floats and clauses pertaining to the pre-allocation of floats in the construction contracts. The step includes initially reviewing the existing body of literature to understand the scope of previous studies, as well as to realize what additional parameters are required in a pilot project schedule (e.g. inclusion of procurement) based on the real-time project that is currently operating under the CPM (Critical Path Method) scheduling technique.

Step 4 - Analyzing the methods of project schedule recovery with the effectiveness of floats demonstrated through a schedule of the pilot project schedule.

V. LITERATURE REVIEW

The literature is collated in the course of reviewing the definition of floats and its types, concept of lead and lags, floats in CPM (Critical Path method) for scheduling, phantom floats and concept pre-allocation of floats in CPM in project scheduling. In order to ensure the development of methodology of the application of the floats on the construction schedule, a literature review is performed on the available relevant literature in the form of key journals or publications. Other information sources include related textbooks and the internet. References in the obtained documents also lead to other significant references.

5.1 Floats and its types

Float represents the contingency and flexibility of the project schedule in terms of delaying or advancing the project activities (Chaudhari, 2019). Float is not "built into the schedule". Float is the amount of time that a particular work activity can be postponed or delayed before it begins to delay the Project. (Kim & Garza, 2003). In the Critical Path Method of scheduling, following types of the float can be calculated are total float (TF), free-float (FF), interfering float (INTF), and independent float (INDF). The four types of the float are defined (Ligtvoet, 2018) as following:

5.1.1 Total Float (TF)

The amount of time that an activity can be delayed or extended from its early start date without delaying the project finish date or disrupting a schedule constraint.
Total Float = Late Finish – Early Finish

5.1.2 Free Float (FF)

The amount of time that an activity can be delayed without delaying the early start date of any successor or disrupting a schedule constraint.

Free Float= Earliest Successors' Early Start – Activity's Early Finish

5.1.3 Interfering Float (INTF)

The amount of time that an activity can be delayed or extended from its early start date without delaying the project finish date. In case any activity is delayed for the amount of the Free and Interfering Float, its successor activities are critical. Also delaying an activity into interfering float will delay the start of one or more subsequent non-critical activities.
Interfering Float = Total Float – Free Float

5.1.4 Independent Float (INDF)

The maximum amount of time an activity can be delayed without delaying the early start of the succeeding activities and without being affected by the allowable delay of any predecessor activity.
Independent Float = Earliest Successors' Early Start – Earliest Predecessors' Late Finish -activity's duration

5.2 Lead and Lags

Lead is when the first activity is still running and the second activity starts. The balance of time for the first activity is known as Lead Time. Lead Time is the overlap between the first and second activities.

As per PMBOK Sixth Edition,

"Lead time is the amount of time whereby a successor activity can be advanced with respect to a predecessor activity."

"A lag time is the amount of time whereby a successor activity is required to be delayed with respect to a predecessor activity."

Float, lead and lag are used to optimally categorize and identify the dependencies and the associated constraints. The information pertaining to the float is useful in resource allocation when there are resource constraints.

5.3 Ownership of floats

The subject of float on the schedule for a construction project, and specifically its ownership and use, is an important and controversial aspect of risk allocation for the construction industry (Trauner, et al., 2011). According to Judson (2018), the issues pertaining to Project Float Ownership are appropriately navigated between the contractor, owner, and project. Also, when the parties share project float, they must take care to expeditiously exercise their right to it. Unless the contract documents state otherwise, float belongs to whichever party that uses it first, and the approach of sharing the float is a fair solution, although there will always be times when it seems rather inequitable (Pepoon, 2018).

The float ownership can be categorized into two major aspects: the ability to directly or indirectly influence the construction methodology and/or sequence once the project execution has started, and the entitlement of extension of time (EoT) and the application of liquidated damages (LDs). (Abdeldayem, 2010)

The best way to address ownership of float is through specific language in the contract between the Contractor and Owner. The risk of dispute can be minimized by drafting in a provision that specifically provides that one or the other party specifically owns the float (Kenney & Sams, 2017).

5.4 Float allocation and float utilization

Float is recognized as an expiring resource that doesn't belong to any party but at the same time, it is available to be used by the project parties on a fair basis (Haj, 2008). There are several approaches are used in the construction industry to allocate float. Besides the ownership approach (contractor, owner, and project), the other approaches for float allocation are bar approach, allocating float to individual activities along a path of activities, day by day approach, using safe float approach, contract risk approach, and total float traded as commodity approach.

The utilization of float can occur at various times throughout the preconstruction and construction phases of a project (Trauner, et al., 2011). The float associated with an activity can be consumed without affecting the project's critical path. In the planning phases of a project, float can be used to improve efficiency and productivity. Whereas in the project execution, the consumption of float can negatively influence these factors. (Trauner, et al., 2011).

VI. PILOT PROJECT

The concept of floats will be applied on a pilot project testing project to analyses the ways and methods of float utilization on a construction project schedule. Prior to pilot project testing, an example of a few activities with a network diagram is used to demonstrate the process of generation of floats and its optimum utilization. This example acts as a precursor to the pilot project demonstration.

6.1 Example (Network diagram)

A network of ten activities is considered as an example and the process of calculation of floats through the forward and backward pass has been carried out along with the identification of the critical path of the network. Further, similar resources are assigned to all the activities and a limit of the resources is set/constrained so that the overallocation of the same can be taken care of. While analyzing the resources in concurrence to the limit which was set, it was noticed that at a few instances (days/months), the resources were over-allocated. Henceforth, the float was utilizing to shift the activities within the available float and the resources were leveled. The snapshots for this process are below.

Table 6.1.1: List of activities with duration and cash as a resource

Activity	Predecessor	Duration	Total Cost	Monthly Cost
K		2	45000	22500
L	K	1	12000	12000
M	L	2	96000	48000
N	M	2	115000	57500
P	K	4	192000	48000
Q	L, P	6	289200	48200
R	Q	5	185000	37000
S	Q	4	144400	36100
T	S, Q	3	72000	24000
U	N, R, U	2	23600	11800

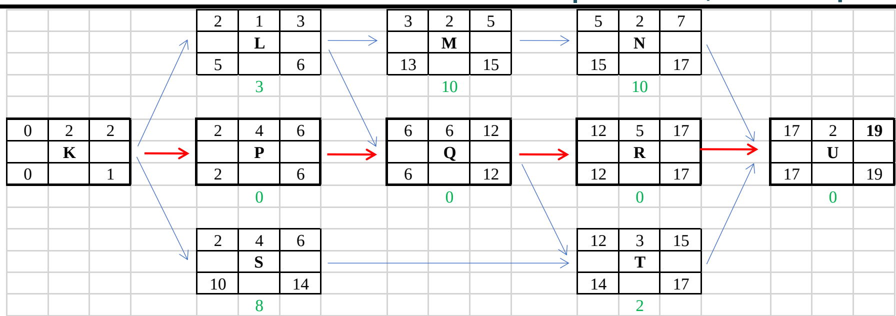


Figure 6.1.1: Network diagram of the activities with identified critical path

In this example, money (cash payout) is considered as a resource and a limit is set for the monthly expense for the project. The total value of the activity is equally divided into the monthly cost (cash payout) for explanation purposes. Several trial and error ways were tried to maintain the monthly limit of the cost. The cost will be replaced with the resources (human and equipment) in the pilot project demonstration.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
K	22500	22500																	
L			12000																
M				48000	48000														
N						57500	57500												
P			48000	48000	48000	48000													
Q							48200	48200	48200	48200	48200	48200							
R													37000	37000	37000	37000	37000		
S			36100	36100	36100	36100													
T													24000	24000	24000				
U																		11800	11800

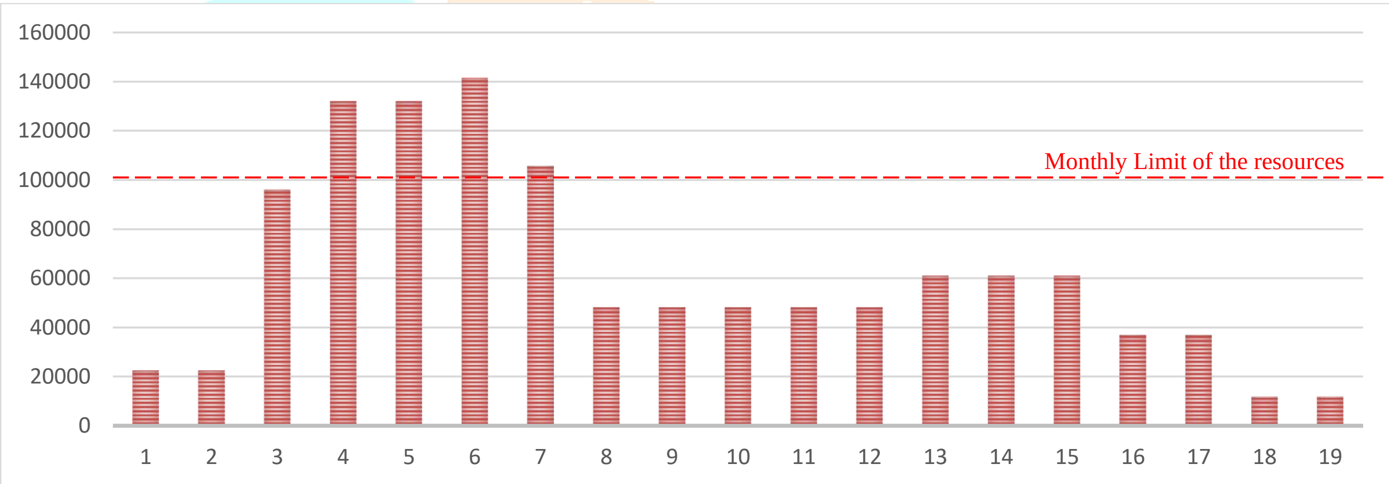


Figure 6.1.2: Resource graph with over allocation (with respect to the set limit)- adopted from Prof. Koshy Varghese(IITM)

As the activities B, C, D, H and I are non-critical, these activities can be shifted within the limit of the float available, so that the limit of the cash should not exceed the set limit which is fixed per month. After exploring various trial options (with trial and error method), the desired outcome was able to achieved. Below is the snapshot for the same.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
K	22500	22500																	
L			12000																
M					48000	48000													
N													57500	57500					
P			48000	48000	48000	48000													
Q							48200	48200	48200	48200	48200	48200							
R													37000	37000	37000	37000	37000		
S								36100	36100	36100	36100								
T															24000	24000	24000		
U																		11800	11800

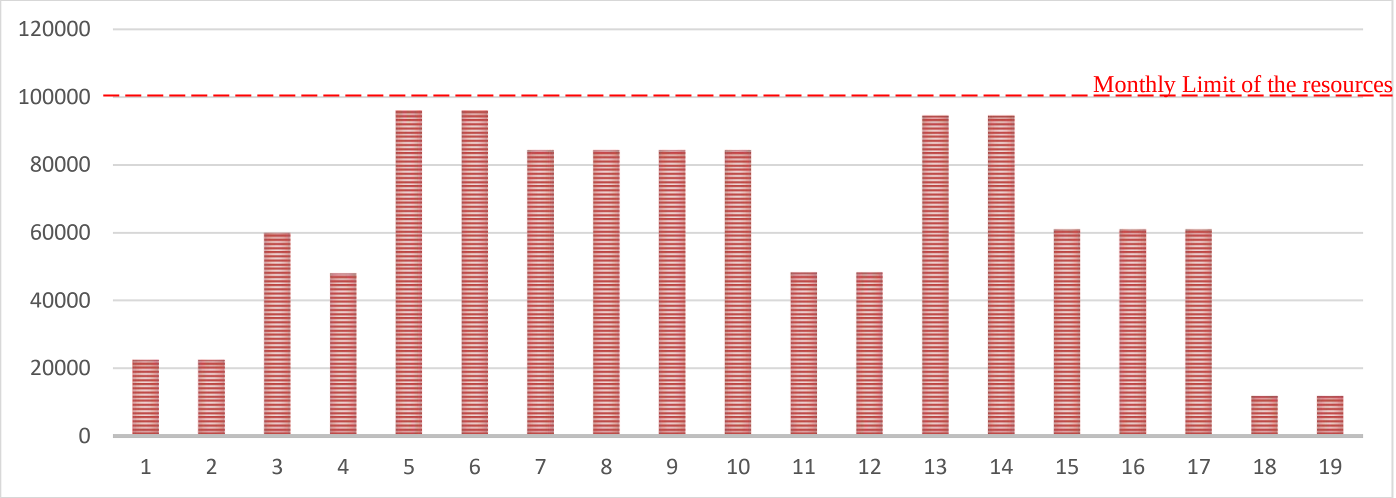


Figure 6.1.3: Resource graph levelled using the floats of the corresponding activities

6.2 Pilot Schedule

To demonstrate the concept of utilization of float in scheduling, a schedule of a project with two buildings (A and B) with four floors each is prepared. Following will be the process followed for preparing the schedule:

- Creation of WBS with proper linkages and logical relationships
- Application of required constraint to the activity or milestone. This might create negative float in case of delay or missing any milestone It can be noted that ff there is no constraint, then the schedule will automatically shift the dates of the activities and milestones as per the duration of the delay.
- Identification the critical and non-critical activities with the same type of task and resources (for effective utilization of float)
- Assessment of the amount of float which can be transferred/distributed from non-critical activity to a critical activity
- Examination of the change in the critical path

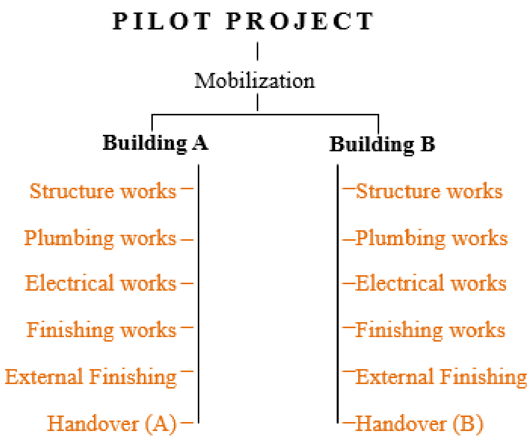
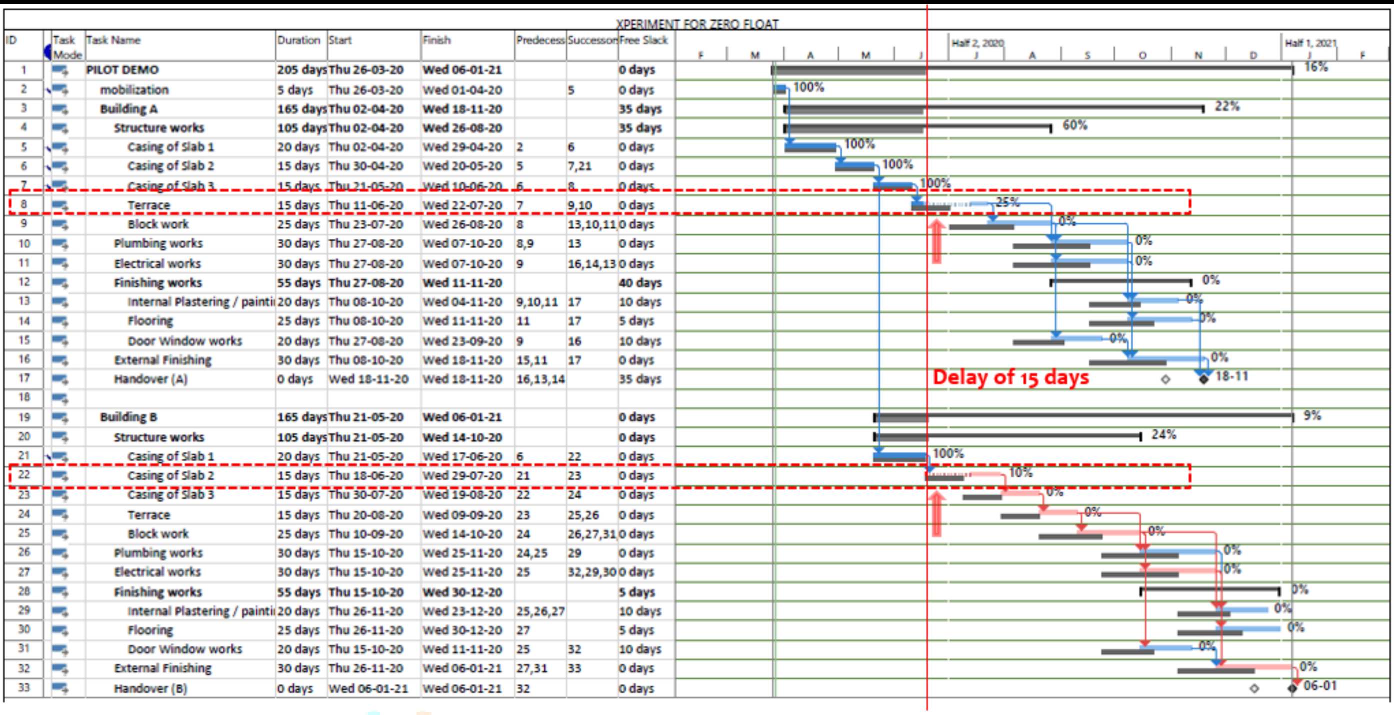


Figure 6.2.1: WBS (Work Breakdown Structure) of the Pilot Project Schedule

A schedule in Microsoft Project software is developed for the above WBS, with an induced delay of 15 days where the buildings were in progress with the civil activities. The finish dates of both the buildings are automatically shifted by 15 days. The finish milestone and the activities are not critical as the finish milestone of building A was not constrained. If the finish milestone of the buildings or the project was constrained (say, must finish on), then there would be the generation of negative float in the activities.

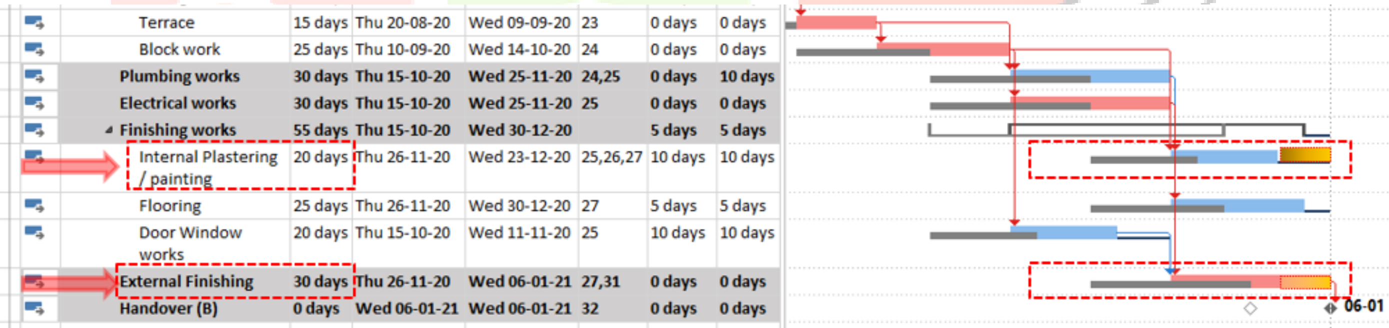


ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Free Slack
1	PILOT DEMO	205 days	Thu 26-03-20	Wed 06-01-21			0 days
2	mobilization	5 days	Thu 26-03-20	Wed 01-04-20		5	0 days
3	Building A	165 days	Thu 02-04-20	Wed 18-11-20			35 days
4	Structure works	105 days	Thu 02-04-20	Wed 26-08-20			35 days
5	Casing of Slab 1	20 days	Thu 02-04-20	Wed 29-04-20	2	6	0 days
6	Casing of Slab 2	15 days	Thu 30-04-20	Wed 20-05-20	5	7,21	0 days
7	Casing of Slab 3	15 days	Thu 21-05-20	Wed 10-06-20	6	8	0 days
8	Terrace	15 days	Thu 11-06-20	Wed 22-07-20	7	9,10	0 days
9	Block work	25 days	Thu 23-07-20	Wed 26-08-20	8	13,10,11	0 days
10	Plumbing works	30 days	Thu 27-08-20	Wed 07-10-20	8,9	13	0 days
11	Electrical works	30 days	Thu 27-08-20	Wed 07-10-20	9	16,14,13	0 days
12	Finishing works	55 days	Thu 27-08-20	Wed 11-11-20			40 days
13	Internal Plastering / painti	20 days	Thu 08-10-20	Wed 04-11-20	9,10,11	17	10 days
14	Flooring	25 days	Thu 08-10-20	Wed 11-11-20	11	17	5 days
15	Door Window works	20 days	Thu 27-08-20	Wed 23-09-20	9	16	10 days
16	External Finishing	30 days	Thu 08-10-20	Wed 18-11-20	15,11	17	0 days
17	Handover (A)	0 days	Wed 18-11-20	Wed 18-11-20	16,13,14		35 days
18							
19	Building B	165 days	Thu 21-05-20	Wed 06-01-21			0 days
20	Structure works	105 days	Thu 21-05-20	Wed 14-10-20			0 days
21	Casing of Slab 1	20 days	Thu 21-05-20	Wed 17-06-20	6	22	0 days
22	Casing of Slab 2	15 days	Thu 18-06-20	Wed 29-07-20	21	23	0 days
23	Casing of Slab 3	15 days	Thu 30-07-20	Wed 19-08-20	22	24	0 days
24	Terrace	15 days	Thu 20-08-20	Wed 09-09-20	23	25,26	0 days
25	Block work	25 days	Thu 10-09-20	Wed 14-10-20	24	26,27,31	0 days
26	Plumbing works	30 days	Thu 15-10-20	Wed 25-11-20	24,25	29	0 days
27	Electrical works	30 days	Thu 15-10-20	Wed 25-11-20	25	32,29,30	0 days
28	Finishing works	55 days	Thu 15-10-20	Wed 30-12-20			5 days
29	Internal Plastering / painti	20 days	Thu 26-11-20	Wed 23-12-20	25,26,27		10 days
30	Flooring	25 days	Thu 26-11-20	Wed 30-12-20	27		5 days
31	Door Window works	20 days	Thu 15-10-20	Wed 11-11-20	25	32	10 days
32	External Finishing	30 days	Thu 26-11-20	Wed 06-01-21	27,31	33	0 days
33	Handover (B)	0 days	Wed 06-01-21	Wed 06-01-21	32		0 days

Figure 6.2.2: Schedule with the induced delay of 15 days

While analyzing the schedule for the utilization of float for an attempt to schedule recovery, an important aspect is noted that as the building A is having non-critical activities, hence the use of float in these activities will not make a remarkable difference in the schedule recovery.

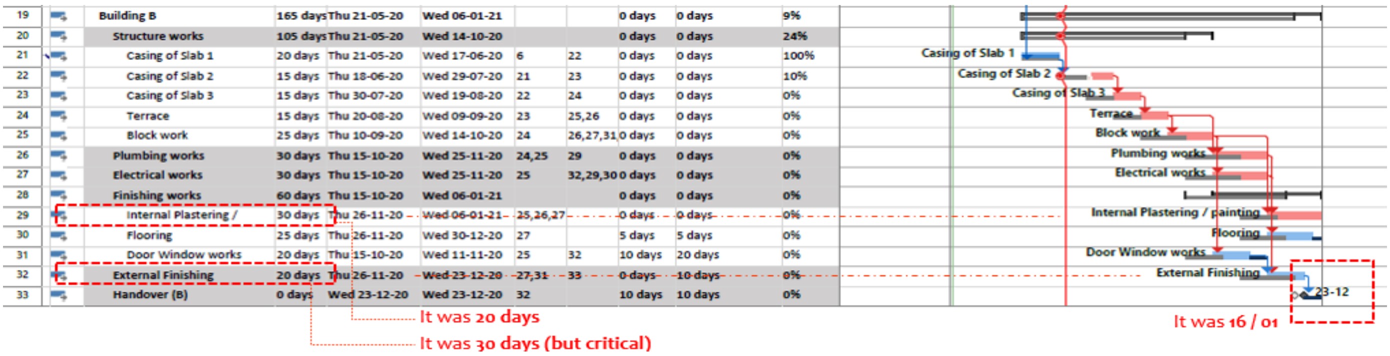
During the study, it was explored that the utilization of float is possible by effectively using the resources or reallocating them from one activity to another as per the best possible solution for the schedule recovery. Hence, the utilization of float is explored for the activities of building B (with critical activities) and the next step was to identify the activities with the same kind of work and resources. In this pilot schedule example, the similar activities are for finishing works e the maximum available float is 10 days (the snapshot of the Gantt chart of the schedule) with the internal finishing activity.



Terrace	15 days	Thu 20-08-20	Wed 09-09-20	23	0 days	0 days
Block work	25 days	Thu 10-09-20	Wed 14-10-20	24	0 days	0 days
Plumbing works	30 days	Thu 15-10-20	Wed 25-11-20	24,25	0 days	10 days
Electrical works	30 days	Thu 15-10-20	Wed 25-11-20	25	0 days	0 days
Finishing works	55 days	Thu 15-10-20	Wed 30-12-20		5 days	5 days
Internal Plastering / painting	20 days	Thu 26-11-20	Wed 23-12-20	25,26,27	10 days	10 days
Flooring	25 days	Thu 26-11-20	Wed 30-12-20	27	5 days	5 days
Door Window works	20 days	Thu 15-10-20	Wed 11-11-20	25	10 days	10 days
External Finishing	30 days	Thu 26-11-20	Wed 06-01-21	27,31	0 days	0 days
Handover (B)	0 days	Wed 06-01-21	Wed 06-01-21	32	0 days	0 days

Figure 6.2.3: Schedule highlighting the activities with a similar type of resources

As an attempt, the resources of internal finishing activity can be shifted to the external finishing activity by increasing the duration of internal finishing activity. This option can reduce the duration of the external finishing activity by ten days by using the resource of another noncritical activity as that activity was containing a float of ten days.



19	Building B	165 days	Thu 21-05-20	Wed 06-01-21			0 days	0 days	9%
20	Structure works	105 days	Thu 21-05-20	Wed 14-10-20			0 days	0 days	24%
21	Casing of Slab 1	20 days	Thu 21-05-20	Wed 17-06-20	6	22	0 days	0 days	100%
22	Casing of Slab 2	15 days	Thu 18-06-20	Wed 29-07-20	21	23	0 days	0 days	10%
23	Casing of Slab 3	15 days	Thu 30-07-20	Wed 19-08-20	22	24	0 days	0 days	0%
24	Terrace	15 days	Thu 20-08-20	Wed 09-09-20	23	25,26	0 days	0 days	0%
25	Block work	25 days	Thu 10-09-20	Wed 14-10-20	24	26,27,31	0 days	0 days	0%
26	Plumbing works	30 days	Thu 15-10-20	Wed 25-11-20	24,25	29	0 days	0 days	0%
27	Electrical works	30 days	Thu 15-10-20	Wed 25-11-20	25	32,29,30	0 days	0 days	0%
28	Finishing works	60 days	Thu 15-10-20	Wed 06-01-21			0 days	0 days	0%
29	Internal Plastering /	30 days	Thu 26-11-20	Wed 06-01-21	25,26,27		0 days	0 days	0%
30	Flooring	25 days	Thu 26-11-20	Wed 30-12-20	27		5 days	5 days	0%
31	Door Window works	20 days	Thu 15-10-20	Wed 11-11-20	25	32	10 days	20 days	0%
32	External Finishing	20 days	Thu 26-11-20	Wed 23-12-20	27,31	33	0 days	10 days	0%
33	Handover (B)	0 days	Wed 23-12-20	Wed 23-12-20	32		10 days	10 days	0%

Figure 6.2.3: Schedule showing the utilization of float and change in the finish milestone of building B

In this particular option, the activity of internal finishing will now become critical and hence it is recommended that the available float should be utilized carefully with respect to the criticality of the activities. Several options for utilizing the float can be explored as per the requirement. One more option would be to use five days of float which will make both the activity non critical. During the exploration of the options of effective utilization of float, it was noticed that the critical path might also change after the utilization of float.

VII. CONCLUSION AND INFERENCES

This study concluded with a thorough insight pertaining to the process of analyzing the appropriate ways to utilize the floats in schedule recovery and assess the effectiveness of floats demonstrating through an example of the network diagram and a pilot schedule. The major inferences are:

The floats in project scheduling can be used to balance resource loads by shifting activities, to distribute/transfer the resource of one activity to another without increasing any number of resources, in project decisions, to balance sub-contracted work – the time of mobilization and demobilization can be structured properly and assessment of extension of time, if required. Besides, the knowledge of available float can be effectively utilized to identify the priority of critical activities v/s non-critical activates based on the calculated floats, the criticality of an activity/activity chain – a lot of times total float is defined not as zero but in a particular range.

In this pilot schedule study, a total of ten days is recovered from the schedule milestone finish date. The activity itself was of 30 days, which means approximately 30 % of that particular activity could be reduced by using the float leading to the schedule recovery. As far as the overall duration of this building completion is concerned, 10 days comprised of approximately 7 to 8 % of the total duration. This is achieved just using the float of one activity (total number of activities in building Bare 12, where only 3 activities have float).

A proper linking of activities and logical relationships is used to generate realistic float. Unrealistic float is mostly a result of hanging activates and hence the same is avoided this pilot project. Floats available in a similar type of WBS are likely to be consumed or utilized up to some extent.

VIII. ACKNOWLEDGMENT

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