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Monitoring and Controlling RCC Work in Delayed Construction Projects

Nimesh Gujarati[1], Dr. B S Balapgol[2]

[1]Post Graduate Student (Construction and Management), DYPCOE, Akurdi, Pune-44, Maharashtra, India
[2]Principal, DYPCOE, Akurdi, Pune-44, Maharashtra, India

Abstract - *In construction sector, cost overruns and schedule delays are two most important problems which happen due to absence of well-established effective cost monitoring and controlling systems in projects. Effective monitoring and controlling systems enables project manager to monitor the actual project performance. EVM (Earn Value Management) is one of the reliable and well proved monitoring and controlling system which helps the client, project Managers and contractor to predict or Forecast the project performance. This study helps to forecast the project at periodic intervals and thereby finding the alternative solutions by applying controlling techniques to reduce the variances in the project. Crashing and Fast-Tracking are schedule compression techniques which are used to reduce the delay of project.*

Key Words: Cost Slope, Crashing, Fast Tracking, Scheduling, Rework, Crash Cost.

1. INTRODUCTION

The entire life cycle of a construction project comprises of initiating phase, planning phase, execution phase, and closing phase. Project management means applying knowledge, skills, tools and techniques to project in order to meet owner or stakeholder's needs and expectations. Project management involves project managers to understand the scope of project and enables him to answer question like "What will be at completion time and cost of project?" Risk curve shows that, risk involved in project is higher in the early stages and it gradually decreases towards the end. Project performance forecast is very important for project managers to find out variances in the project.

1.1 Earned Value Management

The traditional method of Project Monitoring differs from Earn value Management. In traditional method emphasis is given on comparison between planned and actual spending. While Earn Value Management focuses on three elements namely budgeted value of work scheduled (PV), budgeted value of work done (EV) and actual value of work done (AC). Earn Value Management proves to be one of the most important and efficient monitoring and controlling system which helps in providing accurate project forecasts. It acts as decision making tool and provides an early warning to the managers about the problems and helps in taking corrective actions. Various Earned Value Indices are used to find out project performances like Cost Performance Index (CPI), Schedule performance Index (SPI), Earn Value, Planned Value, Actual Cost, Cost Variance, and Schedule Variance, BAC(Budget at Completion) etc.[1][2].

Cost Variance (CV): It is the difference between Earned value (EV) and the Actual Cost of Work Performed (AC). A positive value of Cost Variance indicates that money spent is less than planned budget and vice-versa.

$$CV = EV - AC \quad (1)$$

Cost Performance Index (CPI): It is the ratio of Earned Value (EV) and to the Actual Cost of Work Performed (AC). If ratio is greater than 1, project is under budget and vice-versa.

$$CPI = EV \div AC \quad (2)$$

Schedule Performance Index (SPI): It is the ratio of Earned Value (EV) and to the Planned Value (PV). If the ratio is greater than 1, project is going ahead of schedule and vice-versa.

$$SPI = EV \div PV \quad (3)$$

1.2 Fast Tracking

Fast Tracking one of the "Schedule Compression Technique" that is used by many industries especially construction industries to accelerate the project progress. If the project is lagging behind the schedule, the respective delay in the project can be minimized by fast tracking the remaining project. In fast tracking we start the second of two sequential activities when first activity is approx. 66% complete i.e. by performing tasks in parallel. Fast tracking is applied by re-scheduling various activities within the project to be worked on simultaneously instead of waiting for each piece to be completed separately. But the fast tracking is done keeping in mind the risk associated with that activities being fast tracked. Because if the project is fast tracked without proper planning, it can cause the disruption of construction processes. In fast tracking, only normal duration of the project is reduced without changes made in number of resources needed for the particular activities. Fast-Tracking always involves high risk that could lead to increased cost and rework at later stage. The relation between fast tracking

and project predictability revealed that fast tracking has impact on project predictability in terms of unexpected outcomes which can be avoided by unrealistic goals, aggressive overlapping [3]. Poor handling of material can cause the loss of profit in construction firm. There is need for developing new approaches to material management in fast track construction to improve efficiency of production [4].

1.3 Crashing

Crashing is also one of the important "Schedule Compression Technique" in which the scheduled duration is shortened for the least incremental cost by adding resources. When the crashing approach is used, any additional costs associated with rushing the project are reviewed against the possible benefits of completing the project on a faster timeline. Additional items to consider when using the crashing approach includes adding more resources for the project, allowing additional overtime, paying extra to receive delivery of critical components more quickly etc. Crashing involves activities whose cost slope value is less to shorten the project duration.

$$U_i = \frac{Cc - Cn}{Tn - Tc} \quad (4)$$

Where,
U_i = Cost Slope of the Activity
C_c = Crash Cost of the Activity
C_n = Normal Cost of the Activity
T_n = Normal Duration
T_c = Crashed Duration

There are two type of cost involved in the project which are project direct cost and project indirect cost. Project direct cost includes labour cost, material cost, equipment cost and subcontractor cost. In short it is a cost that is required for a specific activity. Project overhead costs are called as indirect cost. It is distinguished into two, project overhead and general overhead.

Project overhead includes cost of site utilities, supervisors, and accommodation of project staff, parking facilities, office, workshops and stores. General overheads include cost of the head office expenses, managers, directors, design engineers etc. Generally, Project overall indirect cost ranges between 2%-15% of the contract direct cost. Crashing can be applied to the critical activities only and crashing of non-critical activities will not cause any reduction in project completion time [5]. A simulation based methodology was adopted in which crashing is done in two phases: phase I involved crashing before start of project and phase II included dynamic crashing which is applied throughout the project life [6]. Linear programming technique was used for crashing of project by researcher [7].

2. OBJECTIVE

The primary objective of this study is to find out project performance periodically using EVM as performance measurement tool and also aims at suggesting various alternative solutions by controlling techniques to bring back the delayed project back on scheduled time.

3. METHODOLOGY

a) First of all, each and every major activity involved in the RCC work is being listed down.
b) Quantities of activities are calculated by referring drawings of the case studies.
c) All the resources are noted down along with their company's rates/unit after consulting with site supervisor.
d) By using standard labour output and resource constant, number of resources is being calculated for each and every quantity.
e) All the above data (i.e. - quantities, resources, standard durations etc.) is fed in Primavera software and activities are linked as per their relationships with each other.
f) After giving start date and after feeding all data in primavera "baseline of the project" is set.
g) Now the actual duration or actual progress of the work is noted down by consulting with site supervisor and following their DPR (Daily Progress Report).
h) Project is tracked for one month as per the actual progress of the work.
i) After finding out the status of project at the end of month, monitoring and controlling processes are adopted to the project for the remaining part of project.
j) Fast tracking and Crashing are adopted as schedule compression techniques to bring back the project on the scheduled time.
k) Depending on the risk associated with the two alternative solutions produced by Crashing and Fast Tracking, best one is selected keeping in mind scheduled time as a constraint.
l) Now the selected solution is applied to the project and again tracked for the next month and same procedure is followed as described above.

4. CASE STUDY

The case study is a commercial plus residential project in Nasik city. RCC cost covers the larger portion of any project cost. Monitoring and Controlling of only RCC work is taken into consideration while carrying out this study. The project is tracked for monthly basis and solutions are proposed to minimize the delays. This study takes into considerations constraint of completing the project on scheduled time. Indirect cost is assumed to be 3.5% of project cost. PRIMAVERA is used for tracking the actual progress of work

against the baseline scheduled work. Fast-Tracking and Crashing are schedule compression techniques used to fulfill the objective of this study.

Table -1: Project Actual Progress after January'16

Sr. No.	Parameters	Original Planned Schedule	Actual Project Tracked
1	Original Duration (Days)	153	161
2	Budgeted Total Cost (Rs.)	8902477	8937377
3	Indirect Cost (Rs.2037/day)	311661	327957
4	Total cost (Rs.)	9214138	9265334
5	Variance-BL Project Duration (Days)	0	-8
6	Cost Variance (Rs.)	0	(34900)
7	Schedule Variance (Rs.)	0	(990648)
8	Cost Performance Index	0	0.99
9	Schedule Performance Index	0	0.7

Table -2: Project Fast-Tracked after January'16

Sr. No.	Parameters	Original Planned Schedule	Actual Project Tracked	Fast Tracking after 31st Jan
1	Original Duration (Days)	153	161	153
2	Budgeted Total Cost (Rs.)	8902477	8937377	8937377
3	Indirect Cost (Rs.2037/day)	311661	327957	311661
4	Total cost (Rs.)	9214138	9265334	9249038
5	Variance-BL Project Duration (Days)	0	-8	0
6	Cost Variance (Rs.)	0	(34900)	(34900)
7	Schedule Variance (Rs.)	0	(990648)	(990648)
8	Cost Performance Index	0	0.99	0.99
9	Schedule Performance Index	0	0.7	0.7

Table -3: Crashing calculation for crashing after January'16

Activity Crashed	No. of Days Crashed	Project Duration (Days)	Normal Cost (Rs.)	Indirect Cost (Rs.)= Project Duration X Rs.2037	Crash Cost (Rs.)	Total Cost= (N.C+ I.C + C.C)
Tracked till 31st JAN	-	161	8937377	327957	0	9265334
A1540, A1570	1	160	8937377	325920	(1x800)+ (1x800)= Rs.1600	9264897
A1660, A1690	1	159	8937377	323883	1600+ (1x800)+ (1x800)= Rs.3200	9264460
A1780, A1810	1	158	8937377	321846	3200+ (1x800)+ (1x800)= Rs.4800	9264023
A2350, A2380	1	157	8937377	319809	4800+ (1x800)+ (1x800)= Rs.6400	9263586
A2470, A2500	1	156	8937377	317772	4800+ (1x800)+ (1x800)= Rs.8000	9263149
A2410, A2170	1	155	8937377	315735	4800+ (1x800)+ (1x800)= Rs.9600	9262712
A1590, A1600	1	154	8937377	313698	9600+ (1x800)+ (1x1100)= Rs.11500	9262575
A1710, A1720	1	153	8937377	311661	11500+ (1x800)+ (1x1100)= Rs.13400	9262438

Table -4: Project Crashed after January'16

Sr. No.	Parameters	Original Planned Schedule	Actual Project Tracked	Fast Tracking after 31st Jan	Crashing after 31st Jan
1	Original Duration (Days)	153	161	153	153
2	Budgeted Total Cost (Rs.)	8902477	8937377	8937377	8937377
3	Indirect Cost (Rs.2037/day)	311661	327957	311661	311661
4	Crash Cost (Rs.)	-	-	-	13400
5	Total cost (Rs.)	9214138	9265334	9249038	9262438
6	Variance-BL Project Duration (Days)	0	-8	0	0
7	Cost Variance (Rs.)	0	(34900)	(34900)	(34900)
8	Schedule Variance (Rs.)	0	(990648)	(990648)	(990648)
9	Cost Performance Index	0	0.99	0.99	0.99
10	Schedule Performance Index	0	0.7	0.7	0.7

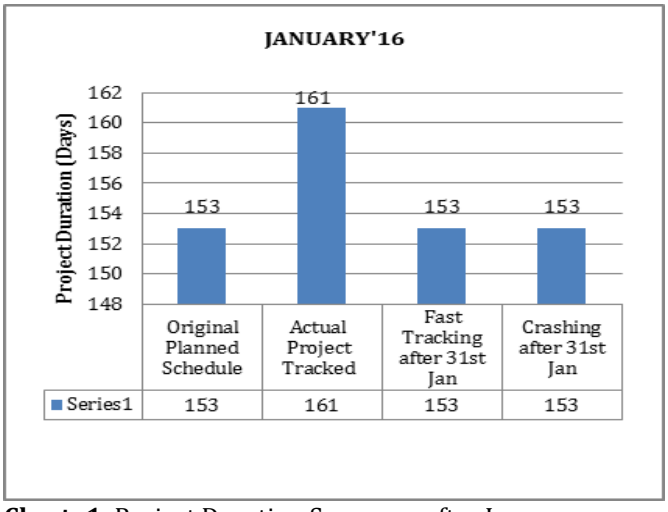

Chart -1: Project Duration Summary after January

Table -5: Summary of Project after February'16

Sr. No	Parameters	Actual Project Tracked	Proposed Solution Tracked	Fast Tracking after 29th Feb	Crashing after 29th Feb
1	Original Duration (Days)	166	158	153	153
2	Budgeted Total Cost (Rs.)	8977577	8977577	8977577	8977577
3	Indirect Cost (Rs.2037/day)	338142	321846	311661	311661
4	Crash Cost (Rs.)	-	-	-	8000
5	Total cost (Rs.)	9315719	9299423	9289238	9297238
6	Variance-BL Project Duration (Days)	-13	-5	0	0
7	Cost Variance (Rs.)	(75100)	(75100)	(75100)	(75100)
8	Schedule Variance (Rs.)	(894548)	(845279)	(845279)	(845279)
9	Cost Performance Index	0.98	0.98	0.98	0.98
10	Schedule Performance Index	0.81	0.82	0.82	0.82

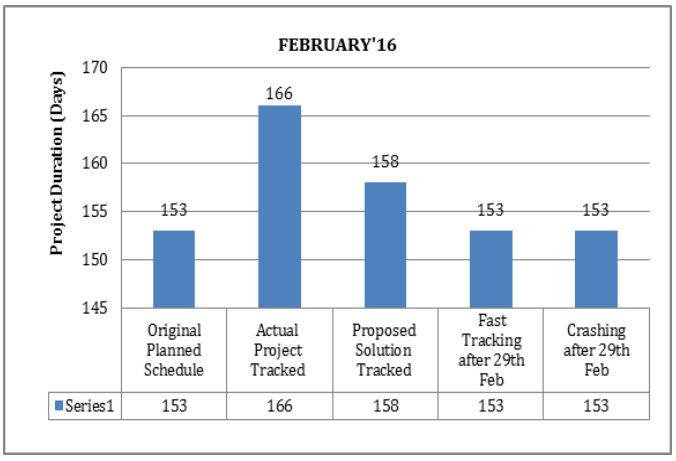

Chart -2: Project Duration Summary after February

Table -6: Summary of Project after March'16

Sr. No.	Parameters	Actual Project Tracked	Proposed Solution Tracked	Fast Tracking after 31st March	Crashing after 31st March
1	Original Duration (Days)	175	164	158	153
2	Budgeted Total Cost (Rs.)	9038177	9038177	9038177	9038177
3	Indirect Cost (Rs.2037/day)	356475	334068	321846	311661
4	Crash Cost (Rs.)	-	-	-	25700
5	Total cost (Rs.)	9394652	9372245	9360023	9375538
6	Variance-BL Project Duration (Days)	-22	-11	-5	0
7	Cost Variance (Rs.)	(135700)	(135700)	(135700)	(135700)
8	Schedule Variance (Rs.)	(1467630)	(1186073)	(1186073)	(1186073)
9	Cost Performance Index	0.97	0.97	0.97	0.97
10	Schedule Performance Index	0.77	0.82	0.82	0.82

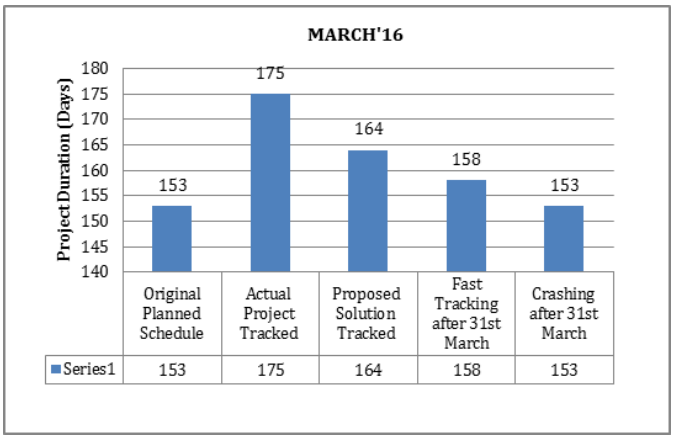

Chart -3: Project Duration Summary after March

5. RESULTS

By tracking project for the month of January, it is seen that project is 8 days delayed. Schedule compression techniques Fast-Tracking and Crashing are used to find out alternatives to bring back project back on scheduled time. There is restriction of completing the project on scheduled time. So keeping this in mind and increase in cost, best option is selected as a proposed solution. Similarly for the month of February and March the delay comes out to be 5 and 11 days respectively. Fast Tracking is again proposed solution for the month of February also. But in the month of March the delay of 11 days has been fully minimized by crashing and it is seen that it can't be fully minimized by Fast Tracking. So Crashing comes out to be the proposed solution after March.

6. CONCLUSION

By using schedule compression techniques like Fast-Tracking and Crashing, the delayed projects can be brought back on scheduled time. While applying schedule compression techniques, Fast-Tracking should be applied first because the increase in project cost is minimum as compared to Crashing. After that Crashing should be applied till there is no room for Fast –Tracking in the project. These solutions will act decision making tool for the higher authority or top management. Earned Value Management is one of most efficient project performance measurement tool.

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