

Delay Mitigation in the Construction Industry

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Abstract— Project management is a process of planning, organizing, managing activities and resources to accomplish a defined objective within constraints on duration, resources or cost. Monitoring involves watching the progress of the project against time, resources and performance schedule during execution of the project. Whereas project controlling uses data from monitoring activities to bring actual to planned performance. As project become larger and complex, the ability to exchange information on timely basis is shrinking. The construction projects have become so vast and complex that the application of information technology has become inevitable. Companies started developing software for project management such as Primavera, Microsoft project, etc. This study involves monitoring and controlling the project using Primavera-P6. There is tremendous amount of information on project that is always changing. So there comes need of Primavera to overcome the failure due to lack of management.

The main objective of this paper is to identify the management tool that are practiced in the construction industry for mitigating delay. This paper comprises of three phases. Phase-I comprises of data collection, estimation, planning and scheduling. Data is gathered in form of responses from questionnaire survey and interviews with those involved in construction project. In second phase primavera tool is used. With usage of Primavera, comparison of planned and actual efforts are done which provides delay occurrence. Delay causes are found with analyzing delay time. Third phase includes study, analysis and mitigation of delay causes. Stakeholder management is done in accordance to causes of delay. Now once delay causes are found, it needs to be countered by providing mitigation plan so as to complete project on schedule or with minimal delay.

Keywords— Primavera software; Delay causes; Delay mitigation

INTRODUCTION

Project management is a process of planning, organizing and managing activities and resources to accomplish a defined objective within constraints on duration, resources or cost. The purpose of project management is prediction and prevention, NOT recognition and reaction. It is very common to see project failing to achieve its mission within specified time and cost. The factors contributing to overrun are inadequate project formation, poor planning for implementation and lack project management during project execution but the main cause of failure can be attributed to cost estimation and management failure. Construction delays are the rule, not the exception. Most construction work is performed out-of-doors. Weather, alone, can play havoc with schedules. Then, there are change orders, site problems, labor

disputes, shipping delays, supply backlogs, subcontractor problems, and accidents.

Always have a contingency plan for delays. As project become larger and complex, the ability to exchange information on timely basis is shrinking. There is a tremendous amount of information on a project that is always changing. The traditional project management system cannot meet the demands of today's projects. The construction projects have become so vast and complex that the application of information technology has become inevitable. Companies started developing software for project management such as Primavera, Microsoft project, etc.

Objectives of work:-

- To study causes of delay.
- Develop comparative study of planned and actual duration of project.
- Mitigation plan for the same

I. LITERATURE REVIEW

Pethe Sarang & Pramila Adavi published the paper in ASCE 2012 Project management concepts are no longer theoretical but have got converted to technology driven means.

Matthew J. Liberatore, Bruce Pollack-Johnson, and Colleen A. Smith. Published paper in ASCE 2001 Decision of using PM software depends on complexity of project. Construction professionals using more analytical techniques tends to choose the full featured software packages primavera over other packages while those who use fewer techniques to use Microsoft Project Plan MPP.

Andrew Fernans Tom, Sachin Paul Lecturer published paper in IJIRSET 2013. The main objective of this study was to understand the role of monitoring and control in the progress and timely completion of a construction project. This objective was achieved through revision of literatures and methodologies involved in monitoring and control. The case study proved to be a guideline in understanding the progress of construction work and also to identify the specific problems arising during the process. Results of this study show the drawbacks of the present project management system in construction project and the importance efficient planning, monitoring and controlling, as well as the need and effectiveness of project management software like Primavera P6 in a construction project.

H. Abdul-Rahman¹; M.A.Berawi²; A.R.Berawi³; O. Mohamed⁴; M. Othman⁵; and I. A. Yahya⁶ published paper in ASCE 2006 This research purpose is to identify causes for project delays and suggest mitigation to overcome effects of problem. Data for study have been gathered in form of questionnaire survey & interview of those involved in construction management like project manager of company. Study results implies delay incidents occur mainly during the construction phase of a project and one or more parties usually contribute to delay. Paper emphasis on having capable construction manager as well as skilled labourers to enable the industry to develop at a faster rate either nationally or internationally.

Tarek Hegazy, M.ASCE¹; and Wail Menesi, S.M.ASCE² published paper in ASCE 2008 This research introduces enhancements to a computerized schedule analysis model so as to yield accurate and repeatable results. Theoretical base for this method is traditional window analysis which presents improvements to the daily window analysis method. The resultant modified daily window analysis considers the multiple baseline and resource allocation effects on daily analysis. The model uses a daily window size in order to consider all fluctuation in the critical path and uses a legible representation of progress information to accurately a portion delays and acceleration along project parties. This research is useful for repeatable analysis of construction project in order to enable corrective actions and claim analysis.

Desai Meghal, Dr Bhatt Rajiv² published paper in IJETAE 2013 The paper presents the framework of causes of delays in residential construction projects. Total 59 causes were identified under 9 major groups. An approach is suggested to carry out ranking of these causes by two different techniques: Relative importance index and Importance index based on degree of severity and degree of frequency.

II. METHODOLOGY ADOPTED

The research methodology contains three phases. The first phase included a literature search from different journal papers, interviews, case study, estimation, planning and scheduling. The literature review was conducted through books, internet and international project management journals. Data is gathered in form of responses from questionnaire survey and interviews with those involved in construction project. For planning, estimation needs to be completed by taking residential building case study and estimating it followed by planning and scheduling. In second phase primavera tool is used. With usage of Primavera, comparison of planned and actual efforts are done which provides delay occurrence. Delay causes are found with analyzing delay time. Delay causes are considered from literature and site experiences. As the outcome of this phase, causes of delays for residential construction project were identified. Third phase includes study, analysis and mitigation of delay causes. Stakeholder management is done in accordance to causes of delay. These causes are categorized in nine main groups as: Project related, Owner, Contractor related, Consultant related, Design-related,

Material related, Labor related, Equipment related and External factors depending on their nature and mode of occurrence. Framework of the causes are given in appendix I. Now once delay causes are found, it needs to be countered by providing mitigation plan so as to complete project on schedule or with minimal delay. Mitigation plan is given in appendix I.

III. PHASE I

The first phase includes a literature search from different journal papers, interviews, case study, estimation, planning and scheduling.

IV. PHASE II

In second phase primavera tool is used. With usage of Primavera, comparison of planned and actual efforts are done which provides delay occurrence. Delay causes are found by analyzing delay time. Delay causes are considered from literature and site experiences. As the outcome of this phase, causes of delays for residential construction project have been identified.

A. *Role of Computer Technology in Civil Engineering*

The computer can play a useful and important role in the teaching and learning of civil engineering concepts and applications. Depending on the type of software used, the professor can design the course such that the computer can be used advantageously to increase the understanding of engineering concepts and to develop sound judgment in students. Since the development of faster and more affordable computers will be the trend, it is necessary that civil engineering schools should increase the awareness in students on the significant role computers play in education and in the industry.

B. *Primavera*

Project Management software (P6) is a powerful, interlinked software system designed to create and analyze the CPM schedules used in managing construction projects; which allows to link multiple schedules together. Primavera is the industry leading project and program management solution for projects of any size. Primavera helps to 1) Obtain early warning of project risks 2) Improve visibility into project performance. 3) Collaborate with the project team. 4) Reduction in manual efforts for planning. 5) Reduction in possibility of manual errors. 6) Effectively listing the dependent activities for next activity. 7) Effectively tracking of execution of activities. 8) Proposing solution to minimize the cost variance and schedule delay.

C. *Delays in Project*

Delay analysis is focus on a comparison of planned versus actual schedule performance. Delays give rise to disruption of work and loss of productivity, late completion of project, increased time related costs, and third party claims and termination of contract. It is important that general management keep track of project progress to reduce the possibility of delay occurrence or identify it at early stages.

D. Effects of Delay

Overtime: Suppose work is of 25 person days and it needs to be completed in 5 days so for its labor required would be 5 but labor arranged are only 4 then each labor would work extra for 2 hrs./day considering normal working hrs. Are 8 hrs. /day.

Over cost: while planning cost of cement is 'x' rupees but during construction cost of cement increases by 10 % so this 10% increase in cement cost would increase overall cost of project.

Abandonment: We have planned for project but the required approvals from government authorities like environmental, non-agricultural, etc. have been rejected in such cases the project would be abandonment.

Litigation: If the land is in disputes then we have to clear land ownership in the legal manner.

Lawsuits: If the land is in disputes then we have to clear land ownership in the legal manner.

Negotiations: There are some demands of a labor union which management have to negotiate with them in such a manner that work should not impacted with issues such as strike.

Disputes: Disputes in between Owner and Consultancies like Contractors.

E. Monitoring

Construction monitoring is a service which provides the client with independent verification (to the extent of the consultant's engagement) that the works have been completed in accordance with specified requirements. Most construction projects are unique, but unlike manufactured products which are often thoroughly tested and evaluated during construction and prior to being brought into service, the completed project is rarely tested against all design requirements. Factors influencing the level of construction monitoring for a project are: 1) The size of the project 2) The importance of the project 3) The complexity of the construction works 4) The experience and demonstrated skill in quality management of the constructor

F. Case study analysis

From studying and analyzing the project Actual vs. Planned duration/schedule in Primavera, it was found that there is variation in project actual duration with respect to project planned duration. Variation in duration/schedule can be seen in Fig. A given below. Reasons of such delay are found by Questionnaire survey with site Engineers and from journal papers. Causes of delay are as mentioned with their groups in terms of project, owner, contractor, consultant, design, material, equipment, labor and external in Appendix I.

G. Figures and Tables

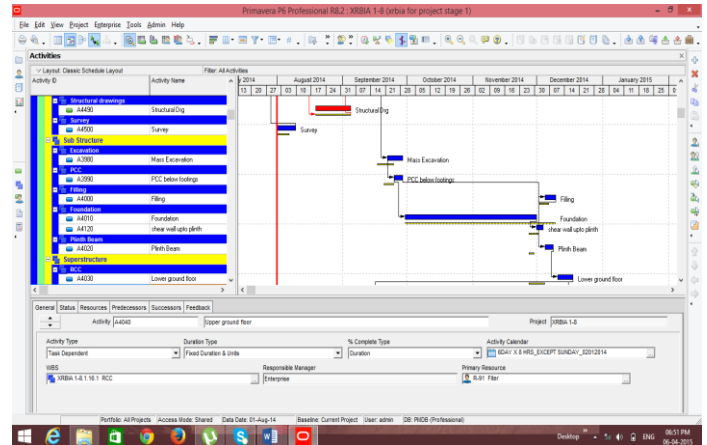


Fig A - Snapshot of primavera for showing the project is behind schedule

V. PHASE III

Third phase includes stakeholder management is calculated in accordance to causes of delay. These causes are categorized in nine main groups as: Project related, Owner, Contractor related, Consultant related, Design-related, Material related, Labor related and External factors depending on their nature and mode of occurrence. Framework of the causes are given in annexure I. Now once delay causes are found, it needs to be countered by providing mitigation plan so as to complete project on schedule or with minimal delay. Mitigation plan is given in annexure I.

A. Mitigation plan for Delay

An analysis is needed to identify the impact of delay on time and cost followed by taking the appropriate action to mitigate delay and minimize the cost required. Mitigation efforts are necessary to minimize losses and this can be achieved by many procedures such as protection of uncompleted work, timely and reasonable procurement, and timely changing or cancellation of purchase orders. It is important to predict and identify the problems in the early stages of construction and diagnose the cause to and implement the most appropriate and economical solutions. This factor increases the probability of delay occurrences in construction projects and makes effective management important to reduce the diversions from the original program.

VI. CONCLUSION

Delays are known to cause losses to the developers. Identifying projects life cycles and when delay usually occurs will help to identify the cause of a delay in a construction project. With help of primavera tool the delay in schedule can be found by comparing planned schedule and actual schedule of project. Analyzing delay in schedule it was observed that major cause of delay was decision making by management for number of building floors. All parties involved in the project also agreed that delay occurs mostly during the construction phase. From questionnaire survey it was found that there are many other causes of delay during construction phase. Therefore, in order to solve these several causes of delay, the mitigation plan was suggested.

TABLE I. APPENDIX – I

Sr. No.	Causes of delay	Group	Mitigation plan
1	Legal disputes b/w various parts	Project	Amicable solution should be provided between parts. Appoint arbitrator to take final decision.
2	Ineffective delay penalties	Project	Monetary penalties should be effective on consultant/contractor for any delay in project and it should be in signed agreement.
3	Delay in progress payments by owner	Owner	It should be compensated by making advance payment to vendors/contractors.
4	Delay to furnish and deliver the site to the contractor by the owner	Owner	Motivate contractor by paying bonus so as to complete work as per rescheduled activities. Labors can be paid extra for extra work done to complete work on schedule.
5	Change orders by owner during construction	Owner	Owner should stick upon their orders. If orders needs to be changed then owner should plan it ahead so as not to impact on schedule.
6	Late in revising and approving design documents by owner	Owner	Prior execution of project, owner must have finalized drawings and documents.
7	Delay in approving sample materials	Owner	Prior to execution of project, material sample should be finalized as per its availability and need of project.
8	Poor communication and coordination by owner and other parties	Owner	Weekly review meetings should followed religiously by owner to track project progress.
9	Slowness in decision making process by owner	Owner	Decision process should be simpler and faster.
10	Rework due to errors during construction	Contractor	Work should progress as per plan. Engineer/Architect should monitor ongoing work so as to avoid any errors during execution of work. Timely monitoring work will reduce the need of rework.
11	Conflicts b/w contractor and other parties (consultant and owner)	Contractor	Owner should conduct weekly/monthly meetings so that alarming issues between contractors and other parties can be addressed.
12	Poor site management and supervision by contractor	Contractor	Qualified and experienced staff should be hired for site management and supervision.
13	Poor communication and coordination by contractor with other parties.	Contractor	Contractor should co-ordinate with subcontractor and other parties on weekly basis. Contractors should publish work schedule on regular basis.
14	Ineffective planning and scheduling of project by contractor	Contractor	Planning/Scheduling should be practical and achievable. Planning and schedule should be reviewed by experienced staff and owner.
15	Improper construction methods	Contractor	Consultant should provide timely guidance on work methodology to accelerate the

Sr. No.	Causes of delay	Group	Mitigation plan
	implemented by contractor		work progress.
16	Delay in site mobilization	Contractor	Consultant should monitor site mobilization and ensure that it should be within time limit.
17	Delay in performing inspection and testing by consultant	Consultant	Consultant should timely inspect the site
18	Delay in approving major changes in the scope of work by consultant	Consultant	Scope of Work should be finalized by taking meetings so as to avoid any delay in approval process. Work schedule should be planned in accordance to that.
19	Inflexibility (rigidity) of consultant	Consultant	Before project execution, owner should ensure that consultant is aware of his responsibilities & expectations set by owner. A signed legal agreement should be in place for the same.
20	Late in reviewing and approving design documents by consultant	Consultant	Design document schedule must be strictly adhered by consultant and design engineer. In case of any delay made by consultant and design engineer, owner should schedule meeting and make the project expectations clear to them.
21	Conflicts between consultant and design engineer	Consultant	Design documents walkthrough should be arranged prior to project execution so as to have common understanding of project design.
22	Mistakes and discrepancies in design documents	Design	Design documents should be reviewed by consultant.
23	Delays in producing design documents	Design	Design document schedule must be strictly adhered by consultant and design engineer. In case of any delay made by consultant and design engineer, owner should schedule meeting and make the project expectations clear to them.
24	Unclear and inadequate details in drawings	Design	Drawing should be clear and self-explanatory. Drawing should be reviewed and approved by consultant.
25	Complexity of project design	Design	Provide additional details and try to reduce complexity of design. Consultant should have walkthrough from Design Engineers so as to understand the design and reduce complexity in it by redesigning.
26	Insufficient data collection and survey before design	Design	Consultant should provide complete data needed for designing to Design Engineers.
27	Misunderstanding of owner's requirements by design engineer	Design	Requirement gathering should be properly done by having repeated meetings and reviews with Owner/Client.

Sr. No.	Causes of delay	Group	Mitigation plan
28	Changes in material types and specifications during construction	Materials	It's part and parcel of project but can be avoided by taking fast decisions and having backup plan. Backup plan (like vendors list) would avoid any delay in delivery of material.
29	Delay in material delivery	Materials	Delivery schedule should be adhered with proper planning like having material in place before execution and making advance payments for booking material in case of scarcity. Backup plan like material vendors list should be handy.
30	Damage of sorted material while they are needed urgently	Materials	Sufficient material should be in store, considering the material damage.
31	Delay in manufacturing special building materials	Materials	Material specification should be provided early.
32	Late procurement of materials	Materials	Material should be procured as per the need of project and availability in market. If there is scarcity of material in market then it should be booked in advance by making partial payments.
33	Late in selection of finishing materials due to availability of many types in market	Materials	Consultant should technically evaluate the material by having pros and cons. Owner and consultant should then take decision on material as per project need, its cost and technically feasibility. This process should be completed before start of project execution.
34	Shortage of equipment	Equipment	Equipment's should be made available by contractor as per schedule and project status.
35	Low level of equipment-operator's skill	Equipment	Skilled labors should be hired by contractor for usage of equipment's
36	Low productivity and efficiency of equipment	Equipment	Equipment selection should be done as per its productivity and need of project. Skilled labors should be hired for using equipment.
37	Shortage of labors	Labor	Equipment's should be used to maximum so as to reduce dependency on labors.
38	Unqualified workforce	Labor	Skilled labors should be hired for work. Trainings should be provided to unskilled labors.
39	Low productivity level of labors	Labor	Contractor should sort out difficulties faced by labors during work and motivate them by providing incentives for good work.
40	Personal conflicts among labors	Labor	Contractor should handle conflicts by having proper communication.
41	Delay in obtaining permits from municipality	External	Documents should be complete. Process of approvals should be started early
42	Rain effect on construction	External	Activities should be planned and prioritized by considering

Sr. No.	Causes of delay	Group	Mitigation plan
	activities		the impact of weather conditions due to seasonal change.
43	Unavailability of utilities in site (such as, water, electricity, telephone, etc.)	External	Basic utilities on site should be considered during planning and arranged before start of project execution.
44	Effect of social and cultural factors	External	While planning consideration of labors social & cultural factors should be done.
45	Accident during construction	External	Safety precautions should be strictly followed on site. First aid kit should be available on site. Labors insurance should be done.
46	Differing site (ground) conditions	External	Soil investigation should be properly done prior to start of planning. This also helps structural Engineer as well.
47	Changes in government regulations and laws	External	Consultant should timely check the changes in government regulations/laws and act in accordance to that.
48	Delay in performing final inspection and certification by a third party	External	Inspection should be done on time by third party and certificate should be provided.

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