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Study on Time Delay Analysis for Construction Project Delay Analysis

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***Abstract*— Time delay is one of the biggest problems facing in many construction buildings in India. Completing projects on time is the key factor of the project, but the construction process is subject to many variables and unpredictable factors, which result from many sources such as availability of resources, external factors, performance of parties and type of building. If there is a delay in project it leads to loss of productivity, increased cost, contract termination and disputes between contractor and owner. The aim of this project is to examine the causes and effects of delay on building construction project during construction phase and to provide control measures for time overrun in the project. A study carried out on construction schedule delays and various delay analysis techniques and methods in order to evaluate the causes of delay and their impacts in the construction project. Then a questionnaire survey is done to find the major causes of delay faced by Client, Contractor, Consultant and Project manager. Population sample of 35 was used in which 30 was deployed. From the survey and study identified 67 causes of delay under 9 major groups such as Project team, Owner, Contractor, Consultant, Architect, material, labour, equipment and external factors. Then a ranking method is done based on relative importance index method to find major cause of delay. It is found that the most common factors of delay which is repeated in most of the project are lack of funds to finance the project to completion, labour shortage, material shortage, lack of effective communication, lack of supervision and changes in drawings. The outcome of the project is to provide recommendation to control delay in the project during construction phase.**

Keywords— D*elay analysis technique, causes of delay, tools to evaluate delay in construction, delay control measure*

INTRODUCTION

In construction, delay could be defined as the time overrun either beyond completion date specified in a contract or beyond the date that the parties agreed upon for delivery of a project. It is a project slipping over its planned schedule. The delay in the project has an adverse effect on project success in terms of time, cost and quality. The objective of the project is

• To identify delay factors in construction projects

• To rank the delay factors according to the importance level on delays in project

•To find the tools to analysis and evaluate the time delay factors in the construction building.

•Recommendations to control delay during construction phase for construction project

I. STUDY ON DELAY ANALYSIS

A. Construction project planning

Planning explains “what” is going to be done, “how”, “where”, by “whom”, and “when” for effective monitoring and control of complex projects. The objective of project planning is to complete the construction within the specified time and budget. In construction project planning the steps need to be identified are as follows.

•Feasibility of the project
•Project management plan
•Identifying the constraints in the project (time, cost, resources)
•Project delivery method, stakeholders, funding sources
•Construction method
•Identifying risk in project
•Milestone, duration and budget
•Roles and responsibility
•Preparation of contract documentation

B. Project scheduling

Project scheduling covers only the issue of when? i.e. when works need to be done and completed. By doing project scheduling it helps to control and measure the project duration and provides information for timely decisions to be taken when there is a change in schedule. The results of doing a detailed project schedule are duration of the project and completion date can be easily tracked, helps to calculates the start or end of a specific activity, evaluate the effect of changes, improves work efficiency, predict and calculate the cash flow, resolve delay claims and it serves as an effective project control tool

C. Types of project scheduling

Selection of the most appropriate scheduling technique depends on the size and complexity of the construction Project, the preferences of the entity preparing the schedule, and the scheduling requirements of the Contract. The most common scheduling techniques used for construction projects are Gantt Charts or bar charts, linear schedules, program evaluation and review technique and Critical Path Method (CPM) schedules.

D. Progress monitoring

When updating a project, actual progress is recorded for each activity relative to the date of each update. This regular update will include progress on values for: dates on which activities started or finished actual percent of work completed within each task, actual resources expended on each task and actual cost expended on each task. There are six basic techniques for measuring the progress of a task in a CPM network as follows: Unit Measure, Incremental Milestones, Start/finish, Observational Assessment, Level of Effort/Cost Ratio and Equivalent Units

E. Classification of construction delays

The classification of delays is dependent upon the type and magnitude of the effect that an activity will have on the project and who is responsible for the delay among the stake holders. Hence they are classified into four categories such as Critical or noncritical, Excusable or non-excusable, Compensable or Non-compensable and Concurrent or Non-concurrent.

Critical Versus Non-Critical Delays

The delays that affect the project completion time or date are considered as critical delays. And the delays that do not affect the project completion time or date are noncritical delays. If certain activities are delayed in the construction project life cycle, the project completion date will be delayed. The determining which activities truly control the project completion date depends on the following: The project itself, the contractor‘s plan and schedule (particularly the critical path), the requirement of the contract for sequence and phasing and the physical constraint of the project.

Excusable and Non-Excusable Delays

Delay that is due to an unforeseeable event beyond the contractor‘s or the subcontractor‘s control. Normally, based on common general provisions in public agency specifications, delays resulting from the following events would be considered excusable: General labor strikes, fires, floods, act of God, owner-directed changes, errors and omissions in the plans and specifications, differing site conditions or concealed conditions, unusually severe weather

Non-excusable delays are events that are within the contractor‘s control or that are foreseeable. These are some examples or non-excusable delays: Late performance of sub-contractors, untimely performance by suppliers, faulty workmanship by the contractor or subcontractors, a project-specific labor strike caused by either the contractor‘s unwillingness to meet with labor representative or by unfair labor practice

Compensable and Non-Compensable Delays

Compensable delay is caused by the owner or the owner's agents. A compensable delay is a delay where the contractor is entitled to a time extension and to additional compensation such as payment for the delay.

Non-compensable delay is caused by third parties or incidents beyond the control of both the owner and the contractor where the contractor is normally entitled to a time extension but no compensation for delay damages

Concurrent or Non-concurrent.

Concurrent delays are two or more parallel and independent delays to the critical path of a project. Concurrent delays can be on the same critical path or on a parallel critical path

F. Delay Analysis Techniques

Delay analysis is a analytical process that should be employed with project documentation along with collected data from project site. The selection of delay analysis depends on the variety of factors and the available records. There are five commonly used delay techniques.

1. Impacted as-planned method
2. Time impact analysis method
3. Collapsed as-built or but-for analysis method
4. Windows analysis method
5. As-planned versus as-built (Total time) method

Impacted as-planned method

According to Trauner et al. (2009), in this method the analyst specifies the as planned schedule, and inserts into this schedule the changes which caused project delays. These changes are the only determined delays recorded during construction process which may have affected the project duration. Trauner et al. (2009) point out the major weaknesses of this method as it does not reflect the dynamic nature of construction project and the critical path.

Time impact analysis method

The analyst determines the amount of project delay resulted from each of the delaying activity successively by calculating the difference between the project completion date of the schedule after the addition of each delay and that prior to the addition (Ndekugri, Braimah, and Gameson, 2008).

Collapsed as-built or _ ‘but-for’ analysis method

In this method, the analyst studies all contemporaneous project documentation and prepares a detailed as-built schedule instead of an as-planned schedule as mentioned in the what-if method. The analyst subtracts or removes activities which affected the project from the as-built schedule (Trauner et al. 2009).

Windows analysis method

Window analysis method is also called the contemporaneous period analysis and snapshot method. In this method, the basic concept is that the total project duration of CPM schedule is divided into digestible time periods or windows (e.g., monthly) and the delays that occurred in each windows of time are analyzed successively by focusing on the critical paths (Hegazy and Zhang, 2005).

As-planned versus as-built (Total time) method

Basically, the main concept is that the as-planned versus as-built method compares two schedules, which is why it is also called “the total time method or net impact method”. In this method the assumption is that one party (contractor) causes no delays and other party (owner) causes all delays.

G. Programme updates

It is used to document the performance of the employer, the professional team, designers, and the contractor and their ability to meet commitment dates. Programmes are updated to communicate actual project status from time to time, keep the programme relevant as a useful management tool, record actual performance of all parties' alike, record changes to the original plan and support forensic or prospective delay analysis. When no frequency is specified, it is unlikely that a contractor will submit updated CPMs to the employer until extensions of time are granted or significant changes to scope or sequence are incorporated into the project. The minimum data required to properly update a programme would be percentage complete, remaining duration (%), actual start, and actual finish.

H. Records

Once the program update is done then changes need to be recorded. When good record keeping procedures are established and maintained, contract administrators are often able to access key information quickly and in a timely enough manner to respond to crises and manage problems at the time they arise. Many standard forms require contractors to provide notice of an intention to make a claim for time and/or money within a reasonable time after the event which gave rise to the claim. Records can be inspected by the employer's representative from time to time. For each delay event an 'event analysis' needs to be done.

II. QUESTIONNAIRE SURVEY

The Survey is designed based on the objective of the study to find out the causes of delays in construction projects and effect of the delays on overall project. The Survey is framed in such a way that the personal view of different people involved in different projects (Architect, Consultant, Owner, Project manager, Contractor) is collected and analyzed. This questionnaire consists of 63 causes of delay on which a detailed analysis will be carried out by using statistical concept. These causes are classified into nine groups according to the sources of delay: Factors related to Project, Owner, Contractor, Consultant, Architect/design-team, materials, equipment, manpower (labor), and external factors.

A. Questionnaire format

Respondents are asked to fill What is the frequency of occurrence for this cause?. The frequency of occurrence was categorized as follows: always, often, sometimes and rarely (on 4 to 1 point scale). Respondents are required to fill the respective places with only scale points (1, 2, 3 and 4) of their opinion.

Frequency of Occurrence
Always (4): Generally occurs in all the projects (70%-100%).
Often (3): Occurs in 5 to 7 projects out of 10 projects (50%-70%).
Sometimes (2): Occurs in 1 to 5 projects out of 10 projects (10%-50%).

Rarely (1): Occurs only 1 time out of 10 projects (>10%).
The questionnaire format is provided in appendix

B. Respondent's profile

The questionnaires were distributed to Owners, Project Manager, Architect, Consultants and Contractors of Indian construction industry. The respondents involved in the survey had several years of experience in handling various types of projects. The characteristics of the respondents participated in survey are summarized below. Population sample of 35 was used in this survey. A total sample of 31 was deployed.

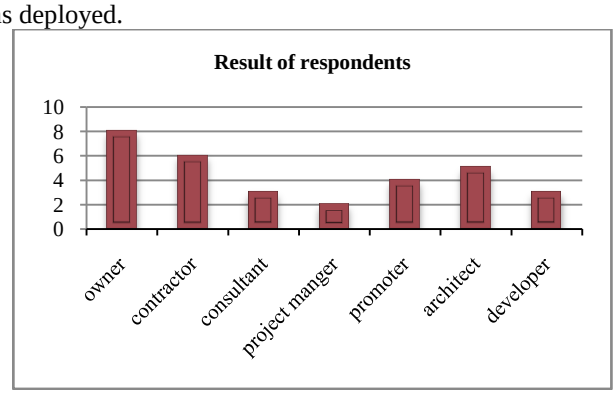

Fig. 1. Result of respodents

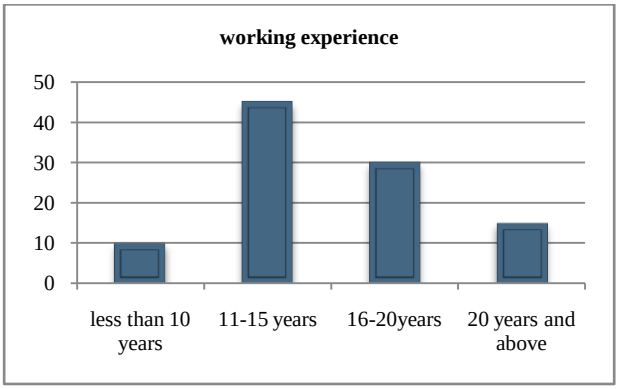

Fig. 2. Working experience

III. QUESTIONNARIE SURVEY RESULTS

The collected responses from different categories of people involved in construction project gives the major causes of delay factor faced in the construction process. The mean of each group of question is calculated using Relative Importance Index to calculate the ranking and the percentage of delay cause in the building. The final result showing the contribution of different factors on the delay of a construction project is shown below

TABLE I. RANKING FOR DELAY CAUSES

No	Cause Of Delay	Points	Rank %	Group
1	Very short original contract duration	20	17	Project team
2	Legal disputes between parties	55	46	
3	Inadequate definition of substantial completion	50	42	
4	Ineffective delay penalties	35	29	
5	Types of construction contract	40	33	
6	Types of project bidding	55	46	
7	Payment delay	70	58	Owner
8	Delay in delivering the site	57	48	
9	Change order	80	67	
10	Late approval of design document	51	43	
11	Late approval of sample material	54	45	
12	Lack of communication	82	68	
13	Late decision making	40	33	
14	Conflicts between partners	30	25	
15	Unavailability of incentives for contractor for finishing ahead of schedule	45	38	
16	Suspension of work	20	17	
17	Financing difficulty	72	60	Contractor
18	Conflicts with sub-contractor	50	42	
19	Rework	70	58	
20	Poor site management and supervision	60	50	
21	Poor coordination with labor and subcontractor	65	54	
22	Ineffective planning and scheduling	60	50	
23	Improper construction method	40	33	
24	Delay in sub-contractor work	45	38	
25	Lack of knowledge	50	42	
26	Frequent change of subcontractor	45	38	
27	Poor qualification of technical staff	52	43	
28	Site mobilization delay	52	43	
29	Inspection and testing delays	52	43	Consultant
30	Approval delay	45	38	
31	Poor communication	62	52	
32	Conflict between consultant & architect	45	38	
33	Lack of experience	45	38	
34	Errors in design document	50	42	Architect
35	Delay in producing design documents	65	54	
36	Inadequate details in drawing	51	43	
37	Insufficient data collection & survey	45	38	
38	Misunderstanding of owners requirement	45	38	
39	Unused advanced design software	52	43	
40	Shortage of material	70	58	Materials
41	Change in specification	60	50	
42	Late delivery	65	54	
43	Damaged of required material	45	38	
44	Delay in manufacturing	54	45	
45	Late procurement	60	50	
46	Lack of material availability	54	45	
47	Shortage of equipment	61	51	Equipment
48	Equipment break down	62	52	
49	Poor operator skill	50	42	
50	Low productivity & efficiency	52	43	
51	Lack of high technology equipment	65	54	
52	Shortage of labor	71	59	Labor
53	Personal conflicts	50	42	
54	Lack of knowledge	60	50	
55	Lack of communication	72	60	
56	Lack of skilled labor	80	67	
57	Poor soil condition	45	38	External Factors
58	Delay in obtaining permits	76	63	
59	Climatic factor	75	63	
60	Unavailability of utilities	44	37	
61	Accidents during construction	42	35	
62	Changes in government regulation	65	54	
63	Delay in final inspection	60	50	

A. *Highest percentage of delay group*

From the above finding and analysis using ranking method the group which is more responsible for the delay in the project is find out. According to the survey result it is found that resources are the main reason for the delay in the project along with external factors it is then followed by Contractor, then Owner and the others.

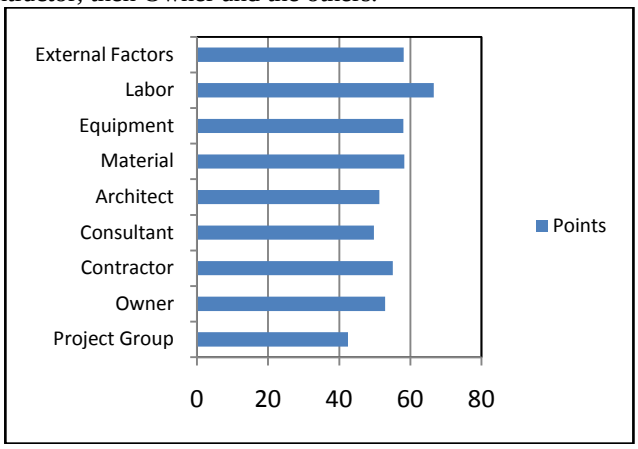

Fig. 3. Highest percentage of delay group

B. Template to evaluate time delay

The tools to evaluate and analysis time delay factors are CPM and PERT. The collected data from the tools should be filled in template for event analysis.

TABLE II. EVENT ANALYSIS SHEET

DESCRIPTION		FORMULA	VALUE
Planned quantity	PQ		
Planned duration	PD		
Planned productivity	PP		
Total budget	TB		
Cost per unit	C	TB/PQ	
Actual quantity	AQ		
Actual duration	AD		
Actual productivity	AP		
Planned value	PV, BCWS	(AD*TB)/PD	
Actual cost	AC, ACWP	C*AQ	
Earned Value (EV)	BCWP	*EV = PV x(AP/PP)*	
Cost Variance	CV	EV-AC (BCWP -ACWP)	
Cost Variance %	CV%	CV/EV	
Cost Performance Indicator	CPI	EV/AC	
To Complete Cost Performance Indicator	TCPI	(TB-EV)/(TB-AC)	
Schedule Variance	SV	EV-PV (BCWP- BCWS)	
Schedule Variance %	SV%	SV/PV (SV/BCWS)	
Schedule Performance Indicator	SPI	EV/PV	
To Complete Schedule Performance Indicator	TSPI	(TB-EV) / (TB - PV)	
Budget At Completion	BAC = TB		
Estimate At Completion	EAC	AC +(BAC- EV)	
Variance At Completion	VAC	BAC - EAC	
Planned % Completed		PV / BAC	
% Completed Actual		AC / EAC	

C. Recommendations

From the survey it is found that contractor has the highest percentage of cause of delay followed by owner and then consultant. So recommendation to control major causes of delay are listed below

TABLE III. RECOMMENDATIONS FOR MAJOR CAUSES OF DELAY CAUSES

Causes of delay	Recommendations
Weather condition	Conducting detailed and perfect surveys towards the field condition and previous weather data
External factors	Monitor the work done by the earlier contractors to make sure that delays outside your control are recognized and documented.
Lack of funds	Optimize cash flow in accordance with the requirements and make sure fund needed for project is available to execute the project
Deviation of scheduling	Develop detailed and accurate schedule to facilitate easy and controlled scheduled execution
Lack of communication	Planning and applying Management Information System(MIS)
Poor decision making process	Conduct routine/regular coordination meeting and develop a procedure regarding decision making.
Lack of coordination / Wrong delegation of authority	Develop a good, simple and easy to understand system to regulate coordination procedures and responsibility of units. Make organization chart with detail job description which includes responsibilities and roles of each function
Lack of inspection	Provide separate technical staff or site manager for periodic inspection and monitoring work process which includes starting late, late submission of drawings, mistakes or errors, resource availability, etc. then proper record has to be maintained to detect risk and mitigate.
Improper planning	Understand the level of supply and demand to produce detail planning and schedule. Implement automatic machine work to avoid shortage of labor such as automatic plastering machine, wall painting, precast concrete wall, etc.
Lack of knowledge	Contractor needs to aware of new technology and techniques to reduce time duration for activity or labor force
Lack of facilities at site	Site management should be properly done to ensure proper resource; basic facilities for worker are available to increase productivity by doing detail study in site condition.
Poor selection of vendors	Consider supplier daily capacity and material quality for selecting vendors to avoid delay and conflicts.
Labor shortage	Early workforce planning is essential for owners and contractors to effectively manage project labor risks. Then providing incentives/awards for workers like best employer of the year/ month so that productivity and quality of work will be increased.
Skilled labor shortage	Providing training and upgrade skills to use new technology and techniques for unskilled labors to increase productivity and efficiency of the worker.

D. Conclusion

The major causes of delay which is found repeating in almost every project are external factors, financial difficulties, shortage of labor, insufficient labor productivity, owner interference and improper planning. After analyzing the data it is clear that the contribution of Contractor in delay of the construction project is high then followed by client then consultant side and others. Resource allocation is the main criteria for doing schedule planning to allocate duration for each activity included in the project so that delay in the construction project can be reduced.

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APPENDIX

Name	Date
Designation	Location
Work Experience	
Email Id	

No	Cause of delay	Always	Often	Some times	Rarely	Group
1	Original contract duration is too short					**Project team**
2	Legal disputes between parties					
3	Inadequate definition of substantial completion					
4	Ineffective delay penalties					
5	Types of construction contract					
6	Type of project bidding					
7	Delay in progress payment by owner					**Owner**
8	Delay to furnish and deliver the site to the contractor by owner					
9	Change order during construction					
10	Late in approval design document by owner					
11	Delay in approving shop drawings and sample material					
12	Lack of communication between owner and contractor					
13	Slowness in decision making process					
14	Conflicts between joint ownership of the project					
15	Unavailability of incentives for contractor for finishing ahead of schedule					
16	Suspension of work by owner					
17	Difficulties in financing project by contractor					**Contractor**
18	Conflicts in subcontractor schedule in execution of the project					
19	Rework due to errors during construction					

20	Conflict between contractor and other parties					
21	Poor site management and supervision					
22	Poor communication and coordination with labor and subcontractor					
23	Ineffective planning and scheduling of project by contractor					
24	Improper construction method implemented by contractor					
25	Delay in subcontractor work					
26	Lack of knowledge					
27	Frequent change of subcontractor because of their inefficient work					
28	Poor qualification of technical staff					
29	Delay in site mobilization related to subcontractor					
30	Delay in performing inspection and testing by consultant					**Consultant**
31	Delay in approving major changes in the scope of work by consultant					
32	Inflexibility of consultant					
33	Poor communication between consultant & others					
34	Late in reviewing & approving design document by consultant					
35	Conflict between consultant and architect					
36	Inadequate experience of consultant					
37	Mistakes in design document					**Architect**
38	Delay in producing design documents					
39	Unclear and inadequate details in drawing					
40	Insufficient data collection & survey before doing					
41	Misunderstanding of owners requirement					
42	Unused of advanced design software					
43	Shortage of material					**Materials**
44	Change in material type & specification during consultant					
45	Delay in material delivery					
46	Damaged of sorted material while they are need urgently					
47	Delay in manufacturing special building material					
48	Late procurement of material					
49	Lack of selected material availability in market					
50	Shortage of equipment					**Equipment**
51	Equipment break down					
52	Low level of equipment operator skill					
53	Low productivity & efficiency of the equipment					
54	Lack of high technology mechanical equipment					
55	Shortage of labor					**Labor**
56	Low productivity level of labor					
57	Personal conflicts among labor					
58	Lack of knowledge					
59	Lack of communication					
60	Lack of skilled labor					
61	Poor soil condition					**External factors**
62	Delay in obtaining permits					
63	Climatic factor					
64	Unavailability of utilities in site (water, electricity, telephone)					

65	Accident during construction					
66	Changes in government regulation and law					

67	Delay in performing final inspection and certificate by third party					