IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 6 Ver. IV (Nov. - Dec. 2015), PP 61-71
www.iosrjournals.org

Delay Analysis of Projects and Effects of Delays in the Mining/Manufacturing Industries

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Abstract: *Delays are unique and one of the largest issues mining/manufacturing companies is facing today. Delays in mining/manufacturing projects have become a major concern across all parts of the world. Substantial value is destroyed and companies face significant corporate risk if these delays occur during project execution. However, despite the concern regarding the project delays, there has been very limited research conducted in this area.*

Delay in the completion of a project can be a major problem for contractor companies leading to costly disputes and adverse relationships amongst project participants. Projects can be delayed for a large number of reasons. The reasons are related to the various types of uncertainty associated with activities during the mining/manufacturing processes. The most common factor of delay are natural disaster like flood, earthquake etc. and some others like financial and payment problems, improper planning, poor site management, insufficient experience, shortage of materials and equipment etc. Delays will also result in several negative effects like lawsuits between house owners and contractors, exaggerated prices, loss of productivity and revenue, and contract termination. So, comprehensive study on these delays is important.

Present study works on identification of causes of delay in mining/manufacturing projects in Indian context. 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.

In most of the cases schedule delays also appear in these projects and result in delay claim progressively. Several studies have proposed various schedule delay analysis methodologies; however, most of the studies focus on the analysis of surface data (as-planned and as-built schedules), few of them on evaluating the effect of root causes, such as the problem of lost productivity. Lost productivity, one essential delay cause, is usually experienced by a contractor while accomplishing its works less than planned rate of production. We analyze the situations of schedule impacts caused by loss of productivity through the case study. In this study, it has been proposed to calculate the schedule impact from lost productivity. The study results will be a basis for developing comprehensive delay analysis methodologies for different mining/manufacturing Projects. It is hoped that the findings of the paper will help the stakeholders to act on critical causes and further try to reduce delay of their projects.

Keywords: *Mining delays, Effects of delays, Cost overruns, Mining/Manufacturing project, Relative importance index, Importance index, Delay analysis, Loss of productivity.*

I. Overview

Infrastructure projects in India are infamous for delays and cost overruns. Recently commissioned, Bandra-Worli Sea Link amply demonstrates the state of project delivery system in the country. The original cost estimate of the project, to be completed by 2004, was Rs. 300 crore. But due to delay in completion of the project by five years, the final cost of the project stood at Rs. 1600 crore. Indeed, very few projects get delivered in time and on cost. The delays and cost overruns have become hallmark of infrastructure projects in India. The quarterly reports of the Ministry of Statistics and Program Implementation (MOSPI) stand testimony to a saga of unfettered delays and cost overruns. Yet, the extents and the causes behind the time and the cost overruns have remained understudied. As a result, the types of the policy interventions required to rectify the malady have also remained unidentified. Delays and cost overruns have significant implications from economic as well as political point of view. Due to delays in project implementation, the people and the economy have to wait for the provisions of public goods and services longer than is necessary. Thus, delays limit the growth potential of the economy. Similarly, cost overruns reduce competitiveness of the economy. Services provided by infrastructure projects serve as input for other sectors of the economy. Cost overruns in these projects lead to an increase in the capital-output-ratio for the entire economy. Simply put, delays and cost overruns reduce the efficiency of available economic resources and limit the growth potential of the entire economy.

II. Introduction

Delays on projects are a universal phenomenon. They are almost always accompanied by cost and time overruns. The following research aims to establish the root causes of delays, delay analysis methodologies and impact of delays in the mining/manufacturing projects in India. Generally, mining projects are based on the establishment of infrastructure that supports mining and the workings that are developed as the ground is moved. Globally more research has been done in the area of construction projects. The effects of delays are only linked in some cases of research. The literature available from the construction industry is relevant to mining as the process of planning and execution of a project in mining is basically the same as any construction process.

Mining/manufacturing project activity is subject to high risks because of its size, uncertainty, complexity, and high costs. Large engineering projects are high-stakes games characterized by substantial irreversible commitments, skewed reward structures in case of success, and high probabilities of failure.

Therefore, a standard approach to mining/manufacturing project management, effective tools that can be utilized to meet the project objectives, and studies regarding risk factors associated with these projects, are required to be developed.

Mining/manufacturing 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 and is considered as common problem in construction as well as mining projects. To the owner, delay means loss of revenue through lack of production facilities and rentable space or a dependence on present facilities. In some cases, to the contractor, delay means higher overhead costs because of longer work period, higher material costs through inflation, and due to labor cost increases.

These projects subject to many variables and unpredictable factors such as performance of parties, equipment availability and maintainability, resources availability, environmental conditions, involvement of other parties, and contractual relations etc.

Mining project delays have an adverse effect on parties (owner, contractor, consultants) to a contract in terms of a growth in adversarial relationships, distrust, litigation, arbitration, cash-flow problems, and a general feeling of apprehension towards each other.

While increased mine mechanization and automation make considerable contributions to mine productivity, unexpected equipment failures and lack of planned or routine maintenance prohibit the maximum possible utilization of sophisticated mining equipment resulting delay and thus require a significant amount of extra capital investment. So, it is essential to define the actual causes of delay in order to minimize it.

Objective of the Study

The main objectives of this study include the following.

-   To identify the causes of delay formining/manufacturing projects in Indian context.
-   Tocalculate exact effective delay time in executing a turn-key Project by a job shop Industry.

III. Techniques Of Calculating Delays

III.A. Data Analysis Approaches

The following approach should be used for data analysis

III.A.1. Relative importance index technique: To determine the relative importance of the various causes and effects of delays. The same method is going to adopted in this study within various groups (i.e. clients, consultants or contractors). The four-point scale ranged from 1 (not important) to 4 (extremely important) will be adopted and will be transformed to relative importance indices (RII) for each factor as follows: RII = Where, W is the weighting given to each factor by the respondents (ranging from 1 to 4), A is the highest weight (i.e. 4 in this case), and N is the total number of respondents.

III.A.2. Importance index technique: In this technique, For each cause/factor two questions should be asked: What is the frequency of occurrence for this cause? And what is the degree of severity of this cause on project delay? Both frequency of occurrence and severity were categorized on a four-point scale. Frequency of occurrence is categorized as follows: always, often, sometimes and rarely (on 4 to 1 point scale). Similarly, degree of severity was categorized as follows: extreme, great, moderate and little (on 4 to l point scale).

Frequency index: A formula is used to rank causes of delay based on frequency of occurrence as identified by the participants. Frequency Index (F.I.) (%) = Σ a (n/N) * 100/4 Where, a is the constant expressing weighting given to each response (ranges from 1 for rarely up to 4 for always), n is the frequency of the responses, and N is total number of responses.

Severity index: A formula is used to rank causes of delay based on severity as indicated by the participants. Severity Index (S.I.)(%)= Σ a (n/N) * 100/4 Where a is the constant expressing weighting given to each response (ranges from I for little up to 4 for severe), n is the frequency of the responses, and N is total number of responses.

Importance index: The importance index of each cause is calculated as a function of both frequency and severity indices, as follows: Importance Index (IMP.I.)(%) = [F.I.(%)* S.I. (%)]/100

III.B Data accuracy check approach

Spearman's rank correlation factor is going to be used to check the accuracy of collected data. Spearman's rank correlation coefficient is a non-parametric test. Nonparametric tests are also referred to as distribution free tests. These tests have the obvious advantage of not requiring the assumption of normality or the assumption of homogeneity of variance.

Spearman's rank correlation coefficient r is used to measure and compare the association between the rankings of two parties for a single cause of delay, while ignoring the ranking of the third party. And it is calculated by the following formula: 1s'= 1− [(6 Σ d2) / (n3− n)]

Where r is the Spearman rank correlation coefficient between two parties, d is the difference between ranks assigned to variables for each cause, and n is the number of pairs of rank.

IV. Delay Analysis Methods

Delay analysis techniques can be classified into three separate categories: the Foresight Method, the Hindsight Method, and the Contemporaneous Method. The differences between these delay analysis techniques involve the baseline schedule used for measuring the delay, the point in time when the delay is measured, and the treatment, if any, of concurrent delay.

IV.A. Foresight Method

Commonly thought of as the simplest and easiest, the Foresight Method generally employs two approaches: Impacted As-Planned, where only the owner-caused delays are identified, and Adjusted As-Planned, where only contractor-caused delays are identified. In both approaches, the alleged delays are reviewed to determine where and how the revisions should be incorporated into the as-planned or baseline schedule. The result of these implanted activities is an adjusted project completion date, which demonstrates, either directly or indirectly, the owner's impact on the contractor's planned schedule of performance.

The Foresight Method is not generally favored by courts and boards, because it ignores the as-built history of the project; it produces theoretical results; it does not measure the effect of delay on actual performance; and it assumes that the as-planned schedule does not change.

IV.B. Hindsight Method

This method centers on an as-built schedule — a schedule depicting the dates that events actually occurred. Delaying events are normally depicted as distinct activities on the as-built schedule, which are invariably tied to the critical path. Typically, under this method, there are two approaches: As-Built Critical Path, which allocates time by determining the responsibility for the delays on the so-called critical path of the project, and Collapsed As-Built, which removes delays caused by one party to determine when the work would have been completed, if not for the delays of the other party.

The Hindsight Method has a number of disadvantages that include difficulty determining which work activities or delay events controlled the pace of the work; not considering what was critical at the time a delay occurred; not considering float through various paths at different periods of time; not accounting for concurrent delay; and not attempting to determine the individual impact of each delay.

IV.C. Contemporaneous Method

This third method hinges on the principle that in order to determine the impact of delaying events, the status of the project must be established at the time those events occurred. In essence, the schedule needs, first, to be updated at the time of the delay and, second, to be updated to incorporate any planning changes to coincide with the contractor's plan for pursuing the work. The goal of this method is to develop a freeze-frame picture of the project — identifying the delaying event, the impact of the delay, and the plan to complete the remaining work at the time the delay occurred.

Two approaches are commonly used as part of this method: Time Impact Analysis, which looks at a particular point in time and utilizes a series of chronological time slices to evaluate major scheduling variations that occurred during the project, and Window Analysis, which examines the critical path between two points in time and assesses the delay as it occurs.

Courts and boards hold that contemporaneous schedule updates should be considered in evaluating delay. The Contemporaneous Method is favored because it provides a baseline for measuring delay; the status of the project at the time a delay occurs; the impact of delaying events on remaining work; and insight into float, changes to critical path, and revisions to the plan to complete.

V. Time Impact Analysis

Time Impact Analysis for any asserted delay shall include a network analysis indicating how the Project Manager proposes to incarporate the delay into the project schedule. Each time Time Impact Analysis shall demonstrate the actual time impact of delay as of both the date upon which the delay commenced and the date upon which the delay terminated, reflect the scope and result of all measures which the Project Manager took to migrate the effect and impact of the delay, reflects the status of the work at both the commencement and cessation of the delay and provide the duration computations for all the affected activities. The activity durations used in the time impact analysis shall be those reflected by the latest project schedule update, unless such are otherwise adjusted by mutual agreement.

VI. Method for Data Analysis

The collected data was analyzed using an Importance Index (Ip.I). The Importance Index was computed using the following formula:

$$Ip.I = \sum_{I=1}^{5} a\,i\,x\,i \Big/ 100 \qquad (1)$$

Where Ip.I = importance index:

- ai = constant expressing the weight of the ith response, where i = 1,2,3,4,5;
- xi = level of the response given as a percentage of the total responses for each variable;
- i = response category index where i = 1, 2, 3, 4, 5; and
- W = the highest weight (5).

To assist respondents in identifying the level of effect of each variable that could cause delay,

Respondents were asked to rank on a scale of 1 (not at all or not relevant) to 5 (most relevant). Using these indices, the rank of the variables can be determined. These rankings were used for comparative importance of the variables as identified by the different group of contractors.

VII. Effect Of Delays In Project

The delay causes a cost overrun and time overrun of the Project. The time and cost are directly related to each other. When the time of execution of project is delayed it leads to failure of guarantee/warranty of the items/equipments, failure of service period of equipments, damage of equipments due to weather condition and this will lead to non timely execution of job. The critical review under taken in this area of time delay and main (**Internal reasons**) attribute are:

- Unforeseen ground conditions at client premises
- Change in scope of the Project
- Customers poor decision making at different stages of Project
- Contractors cash flow and financial difficulties faced by contractor
- Ineffective planning and scheduling by contractor
- Delay in procurement of Materials
- Improper storage of materials at site
- Absence of sound project management of project
- Problems with subcontractor

External reasons

- Political scenario
- Economic condition
- Government rules and regulations
- Market trend

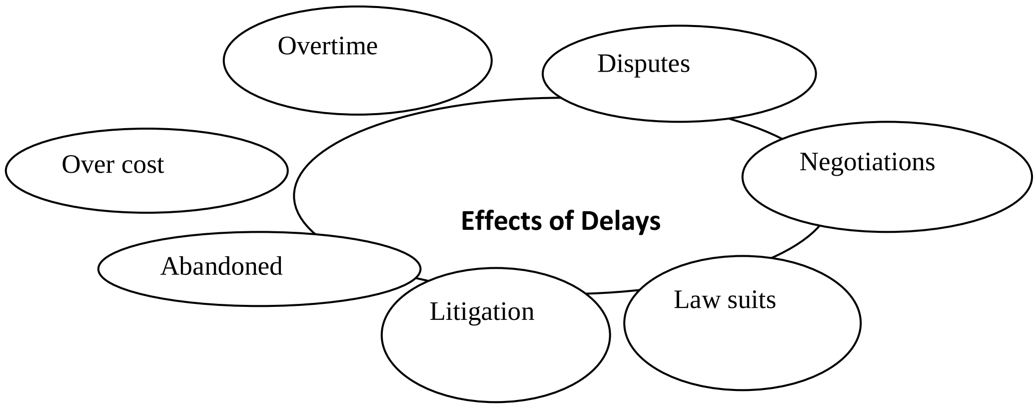

Fig. 1 Effect of delay in Mining/Manufacturing project

The application of sound project management practice provides a project stakeholder with the means to meet their objective. It can be achieved by using following methodology

- Analysis of contemporaneous project documentation
- Analysis of Project Management requirement stated in the contract
- Analysis of clarity of those requirement
- Development of cause and effect relationship between project problems and ensuring damages
- Allocation of the responsibility for Project management problems to delay and damages calculation.

VIII. Delay Calculating Methodologies

Delay work out is made by identifying the delay factor/event which affects the completion of a Project. In general common factors that are observed and are categorically placed as under:

a) Delay from client/customer side
b) Delay from consultant side
c) Delay due to constrains of contract
d) Delay due to subcontractor

These can be interrelated with each other and shown in fig.2- (Causes of delay in a project).

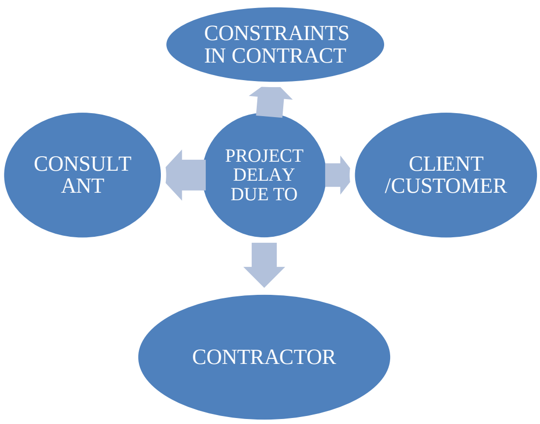

Fig. 2 Showing the different causes of Project Delay

In this study, we have chosen the contemporaneous method. It is prepared, based on "Observational" point of view. In this method the contractor prepares a network analysis before the work starts which shows the detailed plan and the implementation process. This network analysis is thoughtfully prepared by someone who understands all the facets of the entire project. It will include appropriate inputs from the various areas and the final form is shared with customers for their comments and possible approval.

Basically this method produces a contemporaneous running commentary on job progress, where all the participants know status and update of the project. When the network is final, the customer reviews at appropriate regular intervals usually each month and observed the work status and accordingly delay activities are marked. The chart is again marked with start dates, percentage completion and completion dates for the affected activity, forecasting jobs, future work schedule and completion etc. It also focuses on possible causes of delays. We describe our points of delay as categorized above and have taken main reasons of delay by the four factors (customer, consultant, contractor, constraints in contract). Apart from these main reasons there may be other reasons which are also responsible for project delays but are not taken in consideration because of their low weight-age in delay calculation.

A) Delay from client/customer

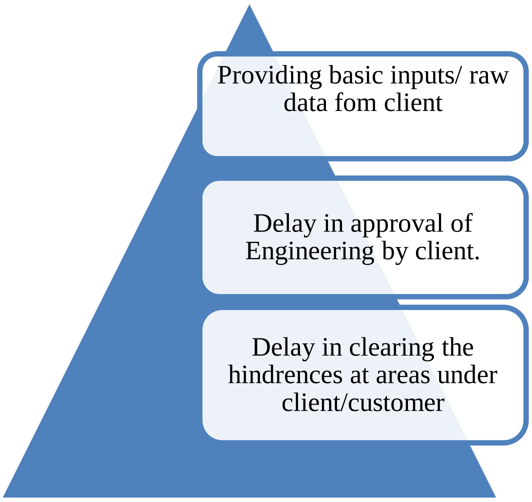

Fig. 3 Different reasons of delay due to client

B) Delay from consultant

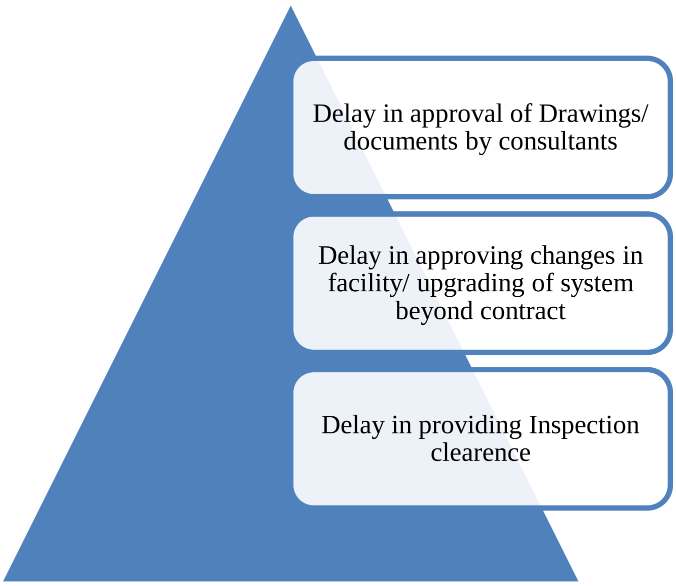

Fig. 4 Different reasons of delay due to consultant

C) Delay due to constrains of contract

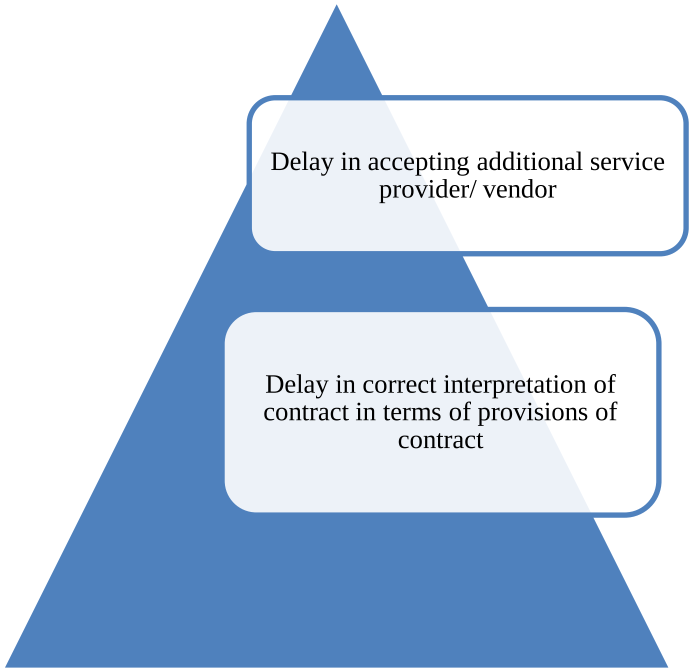

Fig. 5 Different reasons of delay due to constrains of contract

D) Delay due to Contractor/Sub-contractor

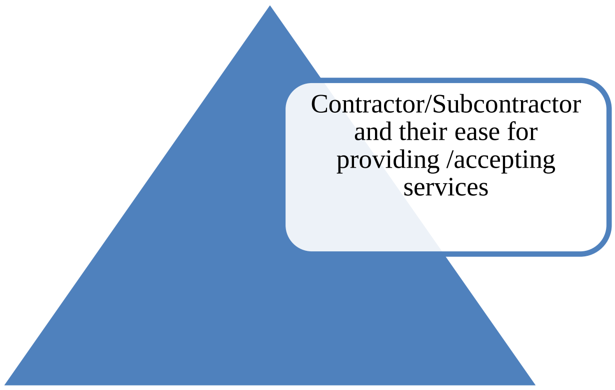

Fig. 6 Different reasons of delay due to contractor/sub-contractor

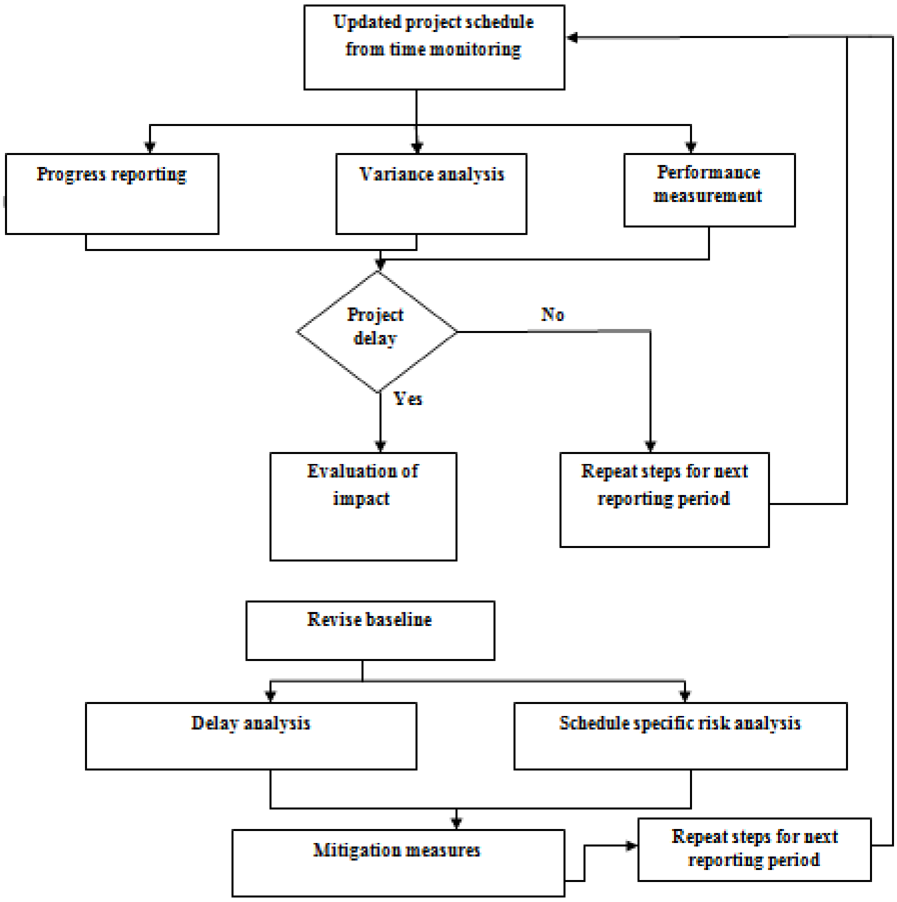

Fig. 7 Typical flow chart for delay control

IX. Delay Time Calculation

In context to calculate the delay we have to define few terms used in the study

a) Date of Occurrence: This refers to the date when an activity started by the contractor based on agreed chart.
b) Date of Cessation: This refers to the date on which the said activity is completed.
c) Weight age: We adopt the principle that a activity which is the root of other activity gets delayed will delay all other related activity. So 100% weight age is awarded to such root activities. The activities which are not falling under root activity and is not affecting the total project weight age calculation may be derived from time allocated for completion of their portion of work in comparison to total time of completion of project. The weight age is calculated in percentage only.

Table 1 Calculation of delay

Sl. No.	Nature of Hindrance	Date of Occurrence (As per approved chart) A	Date of Cessation (As per approved chart) A'	Date of Cessation (As per actual completion) B	Gross period of delay (No. of days) C	Weig ht age (in %) D	Effective period of delay (No. of days) E= C x D	Gross time allotted as per appro ved Chart	Project Contr actual time allotted (Days)
1	Delay due to Client								
1.A	Providing basic input i.e. coordinates for wagon tippler complex	05.10.08	28.11.08	14.01.09	102	100	102	47	910
1.B	Variation in soil data provide at various junction house	21.09.08	23.01.09	19.04.10	447	100	447	130	910

1.C	Change in voltage level from 6.6 to 11kv incoming feeder LTSS buildings	29.01.09	19.03.09	13.05.10	470	51.64	243	50	910
2	Delay due to consultant								
2A	Delay in Approval of Basic Engineering Drawings of Structural Design of Gallery & Trestle for Conv. No. 11	11.05.10	25.05.10	22.08.11	469	51.51	242	14	910
2B	Delay in issue of Inspection certificate/ Inspection waiver certificate/ Dispatch clearance	05.04.12	19.04.12	14.11.12	223	24.50	55	14	910
3	Delay due to Constrains of Contract								
3A	Delay in approval of additional vendors due to non availability of vendors in contract	18.06.09	2.07.09	11.12.09	177	19.45	35	14	910
3B	Change in size of Area Repair Shop	01.02.09	10.03.09	18.08.09	198	21.75	43.08	38	910
4	Delay due to contractor								
4A	Delay by Yard Equipment manufacturer in supply of equipments	10.01.09	04.07.10	18.01.11	738	81.09	598	541	910
4B	Delay by Utilities Sub Contractor in supply of equipments(Fire fighting, water systems)	05.01.09	27.06.10	23.04.11	839	92.19	773	539	910
					Total Delay		2538 days or 6.95 Years		

So, a total delay of project is 2538 days or 6.95 years. Apart from total delay, the delay caused due to consultant and customer is 1167 days or 3.19 years.

A pie chart is made based on the above calculation and shown below:

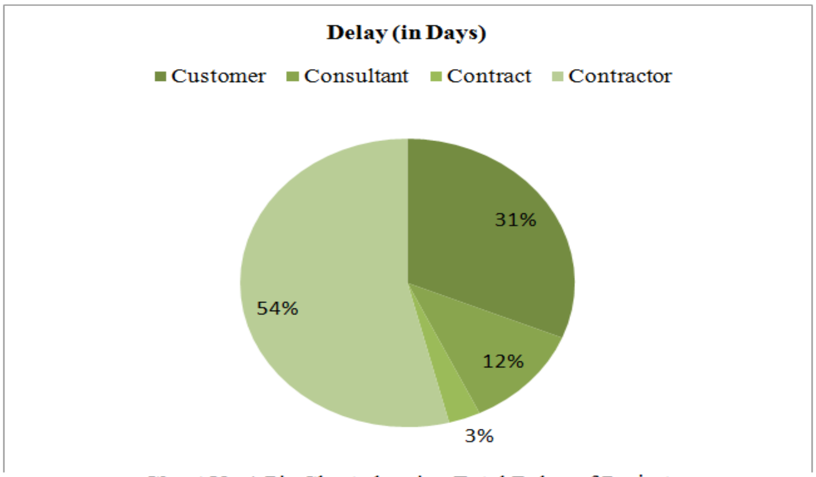

Chart No.1 Pie Chart showing Total Delay of Project

X. Extra Claim

When this delay analysis is accepted by customer, the claims are generally made in the following categories:

- Extra Wages and salaries
- Project Management cost
- Site activity cost
- Misc Item extra cost during project overrun

The extra claim is tabulated as:

Table 2 Extra claim

Sl. No.	Category	No. of worker	Minimum wages per day(Rs)	No. of working days per month	No. of month	Total wages/salaries to be paid (Rs)
1	Skilled	20 nos.	221	26	83.4	9,584,328
2	Semi Skilled	10 nos.	210	26	83.4	4,55,3640
3	Un Skilled	20 nos.	202	26	83.4	8,760,336
4	Management Staff	25 nos.	@ 1200000/month	30	83.4	100080000
					Total	122,978,304

1. Extra Wages and salaries: This consists of extra wages and salaries of workers, supervisors and engineers during overtime or in case of extension of a project.

2. Project Management cost: This consists of bank guarantee charges towards customers for extra period. The project completion is considered for 910 days or 30 months. The project management costs also includes cost of record keeping, retrieving records as and when required and providing all support to other departments and cost incurred in terms are tours. This figures comes to around 200 00000 for a period of 83.4 months (Table2).

Table 3 Site activity cost

Sl. No.	Category	No. of persons	Rent/cost of Establishment per month	No. of month	Total amount to be paid (Rs)
1	Site Guest House	10	25,000	83.4	2,085,000
2	Site office	15	2000	83.4	166800
3	Office boy wages	2	12000	83.4	1,000,800
4	Office Expenditures	15	10000	83.4	834000
5	Vehicle cost	5	35000/vehicle	83.4	14,595,000
6	Fatal damage		100000 for total period		100000
				Total	18,781,600

3. Site Activity cost: The extra time for a site establishment must be included in a project. The unexpected cost which is paid due to unforeseen reasons attributes to hike this cost against this category. This can be shown in Table 3.

4. Misc Item extra cost during project overrun: This is basically procurement of items which are purchased in emergency situation due to sudden damage of parts or, scarcity of parts. Total cost incurred during delay periods are tabulated below.

Table 4 Misc Item extra cost during project overrun

Sl. No.	Description	Amount incurred	Total amount
1	Emergency purchase of fasteners	10,0000	10,0000
2	Purchase of hydraulic parts for wagon tippler	25,098780	25,098780
3	Purchase of couplings of motor damaged due to wear out	10,087100	10,087100
4	Purchase of electrical switches	54980735	54980735
5	Purchase of High mast parts	40987600	40987600
		Total	131,254,215

Now we add all the extra cost (1+2+3) = 122,978,304 + 200 00000 + 18,781,600+ 131,254,215
Grand Total = Rs 293,014,119
This is the total extra cost incurred due to Project over run of 83.4 months.

XI. Conclusions

The study was carried out to investigate various reasons of delay in execution of a mining/manufacturing project. Results show that less than 50% delay is attributable to customer and client and more than 50% of problems are attributable to contractor. Also this study helps in identifying various reasons and factors causing delay from customer, consultant and contractor's end. Also it helps in highlighting flaws of contract.

The importance of delay causes in mining/manufacturing project in India has been identified clearly. Although this research was conducted in the commercial sector in India, the results may also be applicable for similar projects in other developing countries. The identification of important delay causes helps a contractor in seeking extra time for completion from the customer. If the contractor wins in explaining the reasons of delay and gets a contractual extension of time than the customer is bound to pay extra claim to contractor. The contractor gain or loss is huge in terms of its credential in the market in terms of a successful presentation of delay analysis.

Further methodology is suggested to work out critical causes from available ones by two techniques: Relative importance index and Importance index as a function of severity index and frequency index. Survey questionnaire must be prepared based on these techniques. It is proposed to carry out ranking of causes of delay from two different techniques in the next phase of research.

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