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SCHEDULE DELAY IN CONSTRUCTION PROJECT USING TIME IMPACT ANALYSIS

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ABSTRACT

One of the most important problems in the Construction industry is delay. Delays occur in every construction project and the magnitude of these delays varies considerably from project to project. Some projects are only a few days behind the schedule; some are delayed over a year. So it is essential to define the actual causes of delay in order to minimize and avoid the delays in any construction project. There is a wide range of views for the causes of time delays for engineering and construction projects. Some are attributable to a single party, others can be ascribed to several quarters and many relate more to systemic faults or deficiencies rather than to a group or groups. The successful execution of construction projects and keeping them within estimated cost and prescribed schedules Inadequate or weak preparatory work before starting construction of any structure may cause serious problems during the construction period. Consequently, the cost of construction increases digressively, the construction duration of the project extends and the quality of construction is affected adversely. The necessity of construction schedules in achieving the aim of producing good quality construction work within the specified duration. Monitoring continuously the interactive relation concerning delays in construction schedules and contractor demands is a complicated process.. The main purpose of this study is to investigate the causes of construction schedule delays and the methods of schedule delay analyses. In the present study construction project of forum sujana mall in Hyderabad has been selected as a case study for analyzing project scheduling and time delays. The "Time Impact Analysis Method" (TIA) has been applied to the study, PRIMAVERA® software in used to determine the construction schedule delay and also to measure the impacts of these delays on the project completion duration; and to allocate responsibility amongst the project participants for preventing delay claims.

KEYWORDS: The "Time Impact Analysis Method" (TIA) has Been Applied to the Study, Planning, Designing, Estimating, Negotiating, Purchasing, Scheduling, Controlling, Accounting, Architects or Engineers, Clients, Subcontractors, Suppliers

GENERAL INTRODUCTION

Planning and control of resources within the frame work of a project is the main target of construction management. Construction management procedures help the managers about how the resources can be best used during construction process and aims for the timely and efficient application of the resources in construction projects. Many issues should be carefully thought in order to conduct a project successfully (Halpin, and Wood, 1998). The planning, designing, estimating, negotiating, purchasing, scheduling, controlling, accounting, etc. should be done carefully in the office before the work starts on the site to accomplish the objective of a quality project within budget and on schedule. Construction delays are wide spread in most projects around the world. Some delays may happen in the preconstruction phase which is defined as the period beginning from the initial conception of the project to the signing of the contract between the owner and the contractor; however some of them may happen in the construction phase that is the period when actual construction is under way. Project schedules are consistently dynamic and uncertain. Several controllable and uncontrollable factors can adversely affect the project schedule and cause delays. These delays definitely create negative impacts on project performance. Schedule delay in the completion of a construction project may be a major difficulty for contractors leading to costly disputes and adverse relationships between project participants. The challenge is to measure the net impact of construction delays accurately. Otherwise, there may appear delay claims between all parties involved in the construction process. The method of schedule delay analysis technique should be acceptable to all participants through the project.

SIGNIFICANCE OF THE STUDY

The construction environment is sensitive to disputes. Nearly each party in the construction industry is involved in a dispute today. The owner usually has disputes with contractors, construction managers, and designers. The contractor has disputes with architects or engineers, clients, subcontractors, suppliers, etc. Time is the key to construction disputes. Although these disputes originate from a variety of causes, delays remain their origin. Schedule delays are common in construction projects. Although many methods have been developed for analyzing and measuring schedule delays for construction projects. The “Time Impact Analysis Method” (TIA) is applied to this case study. It is used to determine the construction schedule delays, and also used to measure the impacts of these delays on the project completion duration.

OBJECTIVES OF THE STUDY

- To identify the qualitative and quantitative parameters of delay analysis.
- To Identity the most sensitive parameters causing delay in project.
- To analyze the project delay using Time Impact Analysis.
- To determine the liabilities of parties involved in delay and measure the impacts of construction delays on an as-planned project schedule.

LITERATURE STUDY REVIEW

Planning is defined as Trying to anticipate what will happen and devising ways of achieving the set of objectives and targets, and point out that in planning concept there are always objectives to be reached in future. The planning is a process during which efforts and decisions are made to achieve the goals at the desired time in the desired way. Project planning has been also defined as “the process of selecting the one method and order of work to be used on a project from among all the various methods and sequences in which it could be done” Callahan *et al.* (1992). This process supplies detailed information used for time estimation and schedule; besides a baseline for project control. Mubarak (2005) states that project planning works for several functions such as: cost estimating, scheduling, project control, safety management, etc. According to Arıkan and Dikmen (2004) the main purpose of planning is to provide the primary duties of the manager, namely, direction and control. The second objective of planning is to organize all the relationships and information systems among the many parties involved in the construction project. The third function of planning as enabling project control and forecasting. Smith (2002) emphasizes the importance of careful and continuous project planning in the success of a realization of a project; and also notes that the activities of designers, producers, suppliers, workers and contractors, and their resources must be coordinated and integrated with the objectives of contractor. Oberlender (2000) the planning coordinates all works of the construction to reach a completed quality project. The basic benefit of project planning and scheduling as an effective tool of preventing some of the problems like delays in work, cost overrun or decline in productivity and principally puts in order the desired results of project planning and scheduling as indicated below:

- Finish the project on time.
- Continuous (uninterrupted) flow of work (no delays).

- Reduced amount of rework (least amount of changes).
- Minimize confusion and misunderstandings.
- Increased knowledge of status of project by everyone.
- Meaningful and timely reports to management.
- You run the project instead of the project running you.
- Knowledge of scheduled times of key parts of the project.
- Knowledge of distribution of costs of the project.
- Accountability of people, defined responsibility/ authority
- Clear understanding of who does what, when, and how much.
- Integration of all work to ensure a quality project for the owner.

Types of Construction Delays

General types of construction delays should be clearly examined before schedule delay analysis begins. Schedule construction delays are categorized in many ways. According to Trauner *et al.* (2009), there are four main groups of construction delays:

- Critical or noncritical
- Excusable or non-excusable
- Compensable or non-compensable
- Concurrent or non-concurrent

The diagram displayed in Figure 1 presents a general overview of how the construction delays can be categorized Firstly, if the delay is critical or noncritical and concurrent or non-concurrent should be determined in the process of analyzing delay effects on the project. All construction delays are either excusable or non-excusable as shown in the figure. Then, excusable delays are classified into compensable or non-compensable delays. This figure presents only one interpretation, since excusably and compensability of delays can change according to the contract. Kartam (1999) classified project delays into three main groups in terms of their origin, timing and compensability as shown in Figure 1. These groups are as given in the following:

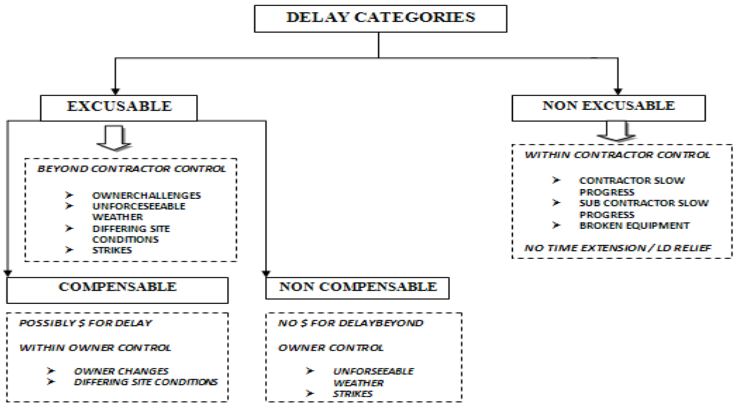

Figure 1: Flow Chart of Delay Categories (Trauner et al., 2009)

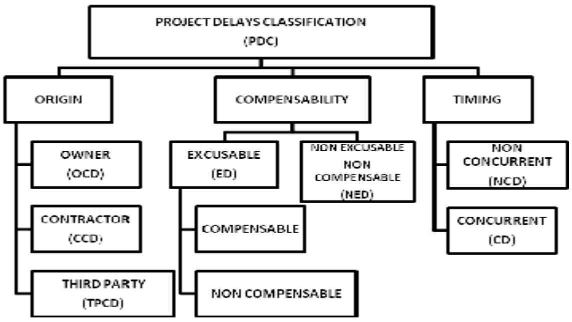

Figure 2: Project Delays Classification (Kartam, 1999)

Critical Versus Noncritical Delays

While several authors (Mubarak, 2005; Kelleher, 2005; Levy, 2006) categorize delays into three groups as Excusable and Non-excusable, Compensable and Noncompensable and Concurrent and Non-concurrent; certain authors (Trauner *et al.*, 2009; Callahan *et al.*, 1992) add one more category to these three groups which is Critical and Noncritical delays. According to Trauner *et al.*, (2009) and Callahan *et al.*, (1992), the primary focus in any study of delays in a project is to see if the delay affects the progress of the entire project or the project completion date. The delays which result in extended project completion are considered critical delays, and delays that do not affect the project completion date are known as noncritical delays. Trauner *et al.* (2009) further claim that the issue of critical delays emerges from the Critical Path Method (CPM) scheduling. All projects have a critical path and if these critical activities on the path are delayed than the completion date of the project will be extended. The criteria determining the project completion date are as follows (Trauner *et al.*, 2009):

- The project itself
- The contractors plan and schedule (particularly the critical path)
- The requirements of the contract for sequence and phasing
- The physical constraints of the project- how to build the job from a
- Practical perspective.

Excusable versus Non-Excusable Delays

Construction delays are basically either excusable or non-excusable. Callahan *et al.* (1992) and Trauner *et al.* (2009) claim that whether a delay is excusable or non-excusable depends on the clauses in the contract. The standard construction contracts specify types of delay that will allow the contractor to an extension of time. For instance, in some contracts, unexpected or unusual weather conditions are not considered as excusable and so these contracts do not allow for any time extensions. According to Trauner *et al.* (2009) an excusable delay, in general, is owing to an unforeseeable event beyond the contractors or the subcontractor’s control. The authors further explain that delays resulting from the following issues are known as excusable:

- General labor strikes,
- Fires,
- Floods,
- Acts of God,

- Owner-directed changes,
- Errors and omissions in the plans and specifications,
- Differing site conditions or concealed conditions,
- Unusually severe weather,
- Intervention by outside agencies,
- Lack of action by government bodies, such as building inspection.

In another study, Levy (2006) adds two more excusable delays to the above list as:

- Illness or death of one or more of the contractors,
- Transportation delays over which the contractor has no control.

Moreover, Kelleher (2005) supplies the above list with two more delays as:

- Epidemics,
- Quarantine restrictions.

Mubarak (2005) defines non-excusable delays as “delays that are either caused by the contractor or not caused by the contractor but should have been foreseen by the contractor”. He also points out that a non-excusable delay does not entitle the contractor to either a time extension or monetary compensation. Trauner *et al.* (2009) enumerate some examples of non-excusable delays as follows:

- Late performance of subcontractors,
- Untimely performance by suppliers,
- Faulty workmanship by the contractor or subcontractors,
- A project-specific labor strike caused by the contractors unwillingness to meet with labor representatives or by unfair labor practices.

Compensable Versus Non-Compensable Delays

Callahan *et al.* (1992), Kartam (1999) and Mubarak (2005) claim that an excusable delay can be classified as “excusable compensable” and “excusable non-compensable”. As Mubarak (2005) states compensable delays are caused by the owner or the designer (engineer or architect). The contractor is typically entitled to a time extension or recovery of the costs related with the delay, or both. Factors which are specified in the contract resulting in delays such as differing site conditions, changes in the work, access to the site are some examples of compensable delays. According to Trauner *et al.* (2009) only excusable delays may be compensable. The non-compensable delays as those which despite being excusable do not entitle the contractor to any compensation. Many authors such as Barrie and Paulson (1992) and Mubarak (2005), point out that excusable noncompensable delays are normally beyond the control of either owner or contractor such as unusual weather conditions, natural disasters, wars, national crises, floods, fires or labor strikes. They add that usually the contractor is entitled to a time extension, but not additional compensation. Trauner *et al.* (2009) emphasize that if a delay is compensable or noncompensable basically depends on the issues of the contract. The contract determines the types of delays in detail and for which delay the contractor is entitled to time extension or monetary compensation.

Concurrent Delays

Mubarak (2005) states that a concurrent delay includes a combination of two or more independent causes of delay occurring within the same time frame. According to the author, a concurrent delay often includes an excusable delay and a non-excusable delay. Another definition made by Callahan *et al.* (1992) is that "more than one delay contributed to the project delay, not that the delays necessarily occurred at the same time". Although this type of delays seems like a simple issue, still there is no clear definition of concurrent delays. According to Trauner *et al.* (2009) concurrent delays are simply defined as "separate delays to the critical path that occur at the same time". Levy (2006) names this type of delays as overlapping delays. Nguyen (2007) also points out that simultaneous delays, commingled delays, and intertwined delays are other names used for concurrent delays. Levy (2006) further indicates that concurrent delays may be generated by the contractor or by the owner, but if it happens that both parties are responsible, and these delays overlap then neither party can be able to retrieve damages.

TOOLS TO QUANTIFY DELAY IMPACT

Bar Charts

Callahan *et al.* (1992) defines bar charts as "a collection of activities listed in a vertical column with time represented on a horizontal scale". Bar charts show duration, start and finish times of project activities in chronological order. Henry L. Gantt developed bar charts during World War I. This tool is widely preferred since it is simple, easy to prepare and has an easily understandable format. However, bar charts have many limitations. Wickwire *et al.* (2003) give a detailed list of disadvantages of this tool:

- Size limits a bar chart in what it can graphically present
- Bar charts do not show the interrelationships or interdependencies of one bar to another
- Bar charts do not show the available float or contingency time, nor can they show the delay impact of one bar on another
- Bar charts are not capable of accurately distributing or controlling manpower and project costs.
- Adding more detail to the bar chart makes it harder to read, understand, and maintain.

Consequently, bar charts cannot show the logical relationships among activities. When there are continuous relationships between many activities, a bar chart becomes difficult to prepare schedule correctly (Callahan *et al.* 1992).

Critical Path Method

The E.I. Du Pont de Nemours Company in conjunction with UNIVAC Applications Research Center of Remington Rand developed the Critical Path Methods between the years of 1956 and 1958. In 1961, CPM technique was first used in construction projects.

However, this tool was not used widely in the late 1960s (Callahan *et al*., 1992). In project management, the Critical Path Method (CPM) is a planning, scheduling and controlling tool and using this tool properly facilitates the completion of projects timely. Wickwire *et al.* (2003) describe CPM as "a graphic representation of the planned sequence of activities that shows the interrelationships and interdependencies of the elements composing a project." At first, CPM was introduced as a planning tool; however, later additional function of CPM appeared as proving delay claims. This function is the result of the ability of CPM as showing the picture of the project and changes.

Schedule Delay Analysis Techniques

There is a variety of schedule delay analysis techniques in construction industry. In figure 3 the different methods of schedule delay analysis are shown and are mentioned below are as follows:

- As-planned versus as-built,
- Impacted as-planned,
- Collapsed as-built,
- Window analysis, and

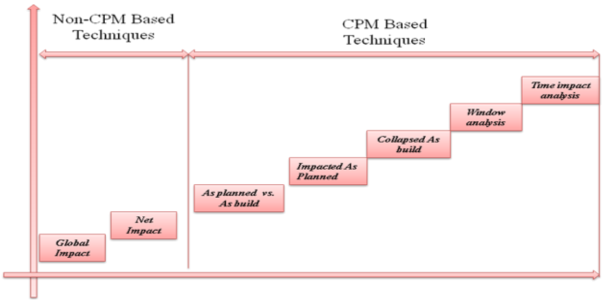

Figure 3: Schedule Delay Analysis Techniques (Nguyen, 2007)

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. In this manner, the method displays the net impact of all claimed delays on projects finish date (Nguyen, 2007). Figure 4 illustrates the as-planned versus as-built method where the as-planned schedule takes 10 days and as-built schedule takes 15 days. The difference between the two is 5 days which is total amount of delays recoverable. In other words, the difference between the two is regarded as delay to which a contractor is entitled to an extension of time as a means of an excusable delay activity.

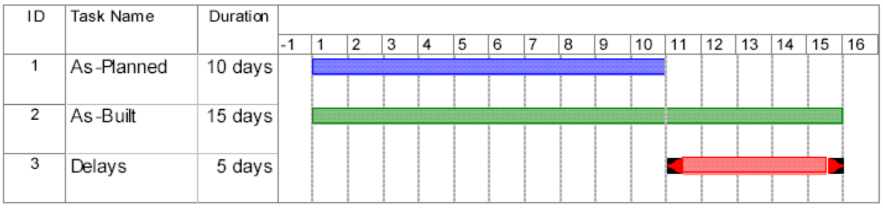

Figure 4: Diagram of as-Planned versus as-Built Method (Nguyen, 2007)

According to Ndekugri *et al.* (2008), the main advantage of this method is that it is inexpensive, simple and easy to use or understand, on the other hand its disadvantages are failure to consider changes in the critical path and incapability of managing complex construction delays.

Impacted As-Planned Method

The other names of this method are “what-if” or “adjusted-baseline” method. In this method the analyst specifies the asplanned 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. The period between the completion date presented on the as-planned programme and the one on the impacted as-planned programme is regarded as delay to which a contractor is entitled to an extension of time as a means of an excusable delay activity. The major weaknesses of this method as follows: firstly the impacted schedule does not show the project activities as they occurred, secondly the decision of placing which changes or impacts into the schedule is greatly subjective, and finally, and also most significantly, it does not reflect the dynamic nature of construction project and the critical path. This approach because of being simple and clean, however, this method is greatly inaccurate.

Collapsed As-Built Method

Another method of analysis is the collapsed as-built method, also called "the subtractive as-built or but-for 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 . If subtracting activities from the as-built schedule has an impact on the new schedule‟s end date, then the difference in time between the as-built and the collapsed as-built end dates is thought to be the delay caused by the subtracted or removed activities. The two different variations of this method are explained such as "unit subtractive as-built and gross subtractive as-built" methods. This method has many serious problems and their three primary weaknesses are explained as follows:

- "It requires the analyst to construct a CPM network diagram based on asbuilt information.
- It is extremely subjective and highly amenable to manipulation.
- With very little effort, the analyst can create an as-built schedule that supports a predisposed conclusion."

Window Analysis Method

Window analysis method is also called the contemporaneous period analysis and snapshot method. In contrast to previous methods which analyze construction delays by taking into consideration the whole project, window analysis method analyzes delays within certain time periods individually. This technique is based on CPM scheduling. 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. The selection of boundaries of window sizes is specified with major project milestones, significant modifications in the critical path, occurrence of major delay events and dates for the issue of schedule revisions.

Time Impact Analysis Method

Nguyen (2007) indicates that the time impact analysis method (TIA) is one of the most reliable techniques presently. Alkass *et al.* (1996) state that this method is a variation of the window analysis technique, also in this method, the analyst focuses on a specific delay or delay activity, whereas in the window analysis the analyst focuses on time periods (also known as window or snapshot). This method analyzes the impacts of delays chronologically, starting with the first delay, by incorporating each delay (sometimes using a fragnet- or subnet-works) into an updated CPM schedule. 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). TIA is more useable as a forward-looking took than as a backward-looking tool. This is partially due to the ability of the Owner to respond to the results of the analysis and optimize the cost of a delay. Never the less, TIA is an acceptable and useable tool for the determination of the effects of a past delay. Other analysis techniques such as Windows Analysis and As-Built Analysis are generally more accurate and reliable, but at the expense of more research and time required to complete. The Society of Construction Law (2002) recommends this method. Time

Impact Analysis is the most appropriate method for specifying the amount of time extension that the contractor should have been given at the time that an excusable risk appeared. However, in order to apply this method successfully, the daily records and diaries should be noted very meticulously and accurately.

Research Methodology

The Time Impact Analysis method was selected to analyze the construction delays in the work-schedule of the case-study construction project in order to determine the delays and apportion the responsibility of such delays amongst all parties. The TIA is typically associated with the modeling of the effects of a delay event. It requires a Critical Path Method (CPM) schedule that is able to show the pure CPM calculation differences between a schedule that does not include a delay and one that does include an activity modeling the delay event. The difference for project completion, between the non-impacted schedule and that of the schedule with the impact, is considered to be the impact of the delay for time duration.The aim was to identify construction delays, to quantify their net impacts on the project completion date and to allocate responsibility to all parties. Accurate allocation of liability is very important in schedule delay analyses in order to prevent delay claims amongst project parties. From the literature survey it was seen that the TIA would be the most appropriate technique to be used in this study. Therefore, for the successful application of this method, the daily records and diaries had been noted meticulously during the construction process. This method of analyzing a delay is recommended by the Society of Construction Law Delay and Disruption Protocol. This methodology is both prospective (forward looking) and a dynamic one. Figure 4. Shows the detailed procedure of the methodology is represented in a flow chart.

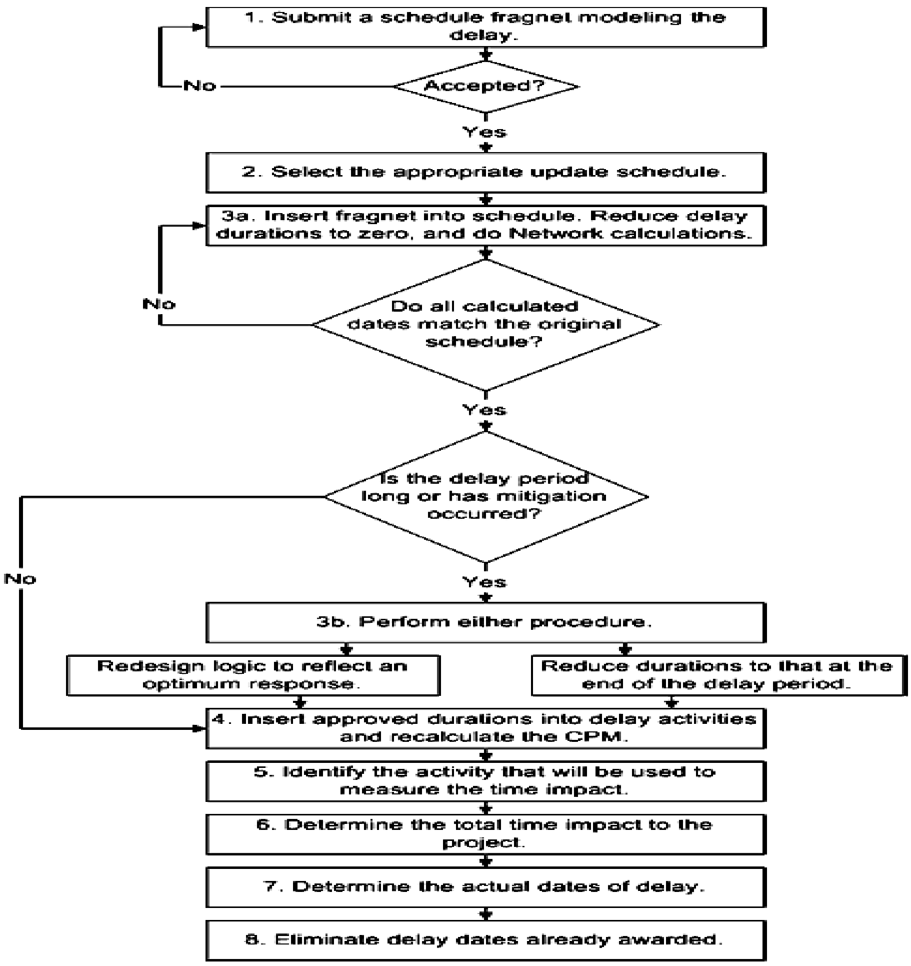

Figure 5: Time Impact Analysis Flow Chart (Arditi and Pattanakitchamroon, 2008)

Case Study Descriptions

This case study is conducted for analyzing construction schedule delays in order to recommend steps to eliminate or minimize their negative effects on construction completion duration and to apportion responsibility of delays amongst all project participants. A delay analysis was carried out on an under-construction project of a forum sujana mall in Hyderabad which had suffered many delays during its construction. Information on the case study project is presented in more detail in the following paragraphs. The reason for choosing this project was that all the related data and materials like *as*-planned schedule of the project, project reports and diaries, official correspondences, project change orders, time extension requests, the construction contract and all other related bid documents could be easily obtained from the related construction and consulting companies. Also, this project suffered many delays caused by the owner and the contractor, as well as by the project architects and the project consultant. Consequently, the as planned schedule of the project was revised many times. Details on the identity of the project participants and the project are not given in this thesis for ethical reasons. In this project, a official contract was signed between the contractor and the owner. The owner had assigned a consulting company to oversee the project and deal with the contractor. The scope of work consisted of the completion of the forum sujana mall building as per the activities determined in the as-planned schedule, in compliance with the technical specifications of the contract. This as-planned schedule was attached to the official contract.

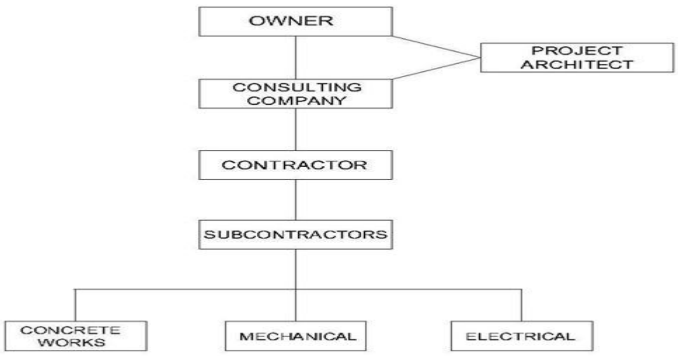

Figure 6: Working Diagram of the Case Study Project

The working diagram of the case study project is presented in original as-planned schedule was prepared according to this division of work items. However, some disputes, delays and failures occurred which prevented adherence to the as-planned schedule.

Determination of Delays

Impacts of construction schedule delays on the duration of the case study project were analyzed by the help of Time Impact Analysis method. The results of application of the selected method and the discussions are given in this section under respective headings, presented with figures and tables. In application of the TIA method, the accuracy of records which were used in the delay analysis was very important. To provide reliability of schedule delay analysis, inaccurate and unreliable records should not be used during the analysis process. Project changes, changing site conditions, official correspondences between project participants, time extension requests of the contractor were approved under the control of parties. Therefore, these records did not require any reliability control. In this study, only approved records were collected and analyzed, as well interviews with the project parties were conducted at the construction site. After these steps, it was noticed that there had been many problems during the whole construction process inevitably resulting in delays in the as-planned schedule.

SUMMARY

The aim of the study is to investigate the causes of construction schedule delays and the methods of schedule delay analyses. In this study construction project of forum sujana mall in Hyderabad has been selected as a case study for analyzing project scheduling and time delays.

The reason for selecting the Time Impact Analysis (TIA) method was that it can display the progress of construction works step by step with the help of PRIMAVERA® software. The main advantage of this method is that the situation of construction on the updated dates could be pictured clearly. The necessity for the delay analysis is to reflect the actual process of the construction in order to reach an accurate analysis of construction schedule delays. The delayed events are entered into the as-planned schedule respectively to observe the changes on the project. These delays were caused due to organizational deficiencies of the owner, the bureaucracy of the provincial municipality, the lack of detail drawings during the municipality application, the lack of experience of the contractor, problems in material procurement, unforeseeable weather conditions and shortages of qualified employees of the subcontractors. This TIA technique is the most realistic and the best technique for determining amount of time extension caused by construction schedule delays.

CONCLUSIONS

- It is observed from the delay analysis that, the total of 58 parameters were identified and analyzed.
- The delays due to the critical activities extended the project duration by 273 days i.e. (9 months) it is approximate 29.1 % of the estimated construction period. On the other hand, the delays due to the noncritical activities did not impact the total duration.
- After re- scheduling of the complete project the delay was reduce to 6 months.

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