Analysis Methods in Time-Based Claims

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Abstract: Assessing the impact of delay and resolving disputes are contentious issues since courts and administrative boards do not specify standard delay analysis practices. First, the advantages and disadvantages of widely used delay analysis methods, including the as-planned versus as-built, impact as-planned, collapsed as-built, time impact, and productivity analysis methods are summarized. Fifty-eight claim cases associated with time-based disputes in government work during the 1992–2005 period are extracted and analyzed to observe issues in time-based claims, including the reasons why they occur and the common practices in their resolution. The effects of various factors on the selection of a delay analysis method are examined. These factors include the type of schedule used, the schedule updating practice, the use of existing versus newly created schedules, and the availability of expertise, information, time, and funds. A project management system that makes use of regularly updated network schedules, and that maintains adequate project records should allow a scheduling expert to select a delay analysis method that would make a claim quite convincing.

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Introduction

A typical construction project suffers from high risks associated with schedule delays and time-based disputes, since time is of the essence of the construction contract. For example, the unique nature of construction makes the work susceptible to unforeseen site conditions and severe weather changes. In addition, a construction plan created for a project relies on the performance of owners, designers, contractors, subcontractors, and suppliers, as well as the coordination among them. A single event that deviates from the plan, such as a change in the scope of the project, can disturb the overall performance and can create turbulence among the parties. The volume of time-based disputes and litigation grows substantially as construction becomes larger and more complex.

Delay in construction can have a number of consequences in a project, such as late completion, lost productivity, acceleration, consequential damages, increased cost, and contract termination. The party experiencing damages from delays needs to be able to recognize the delays and the parties responsible for them in order to recover time and cost. However, delay situations are generally complex. A delay in an activity may not result in the same amount of project delay. A delay caused by a party may or may not affect the project completion date and may or may not cause damage to another party. A delay such as unusually severe weather conditions can be caused by none of the parties. A delay may occur concurrently with other delays, and all of them may jointly impact the project completion date. A delay may sometimes contribute to the formation of other delays.

Identifying delay impacts and allocating responsibility for delay events is more often argumentative because it involves one party's gain and the other party's loss. Delay analysis is one of the important parts of time-based dispute resolution, even though the outcome of a claim may be dependent on a multitude of factors. The analysis establishes the arguments in the entitlement of claims, and the result of the analysis plays a critical part in computing damage compensation. A number of methodologies have been developed to assess delays and their impacts, but courts and administrative boards have not specified any standard method to evaluate delay impacts. The parties may use any method in a level of detail that they see fit to prove the entitlement to compensation. Delay analysis can be conducted in a cursory manner or in such detail as to exceed the value of the underlying dispute. Each delay analysis method adopts a different approach to identify delay impacts and may yield different results. The most sophisticated delay analysis method using the highest level of detail does not guarantee success.

The ways to conduct delay analysis have been discussed extensively. Most of the literature relies on basic scheduling theories and individual experience (Bordoli and Baldwin 1998; Zafar 1996; McCullough 1999; Finke 1999; Bubshait and Cunningham 1998; Kartam 1999). Some studies refer to claim cases, but none of them present a significant number of claims to demonstrate the actual practices in claims management (Gasan 1996). The study reported in this paper was conducted to examine various aspects of time-based disputes focusing specifically on delay analysis and other relevant issues with which construction participants are concerned in the preparation of time-based claims. The study compiles quantitative and qualitative data from actual claim cases and attempts to identify effective practices in claims management. The objectives of the study include identifying the common reasons why time-based claims occur and assessing the factors that seem to be of importance to practitioners in the selection of a delay analysis method in time-based claims.

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Delay Analysis Methods

Bramble and Callahan (1987) define delay in construction as the time during which some part of the construction project has been extended or not performed due to an unanticipated circumstance. An incidence of delay can originate from within the contractor's organization or from any other source that interacts with the construction project.

There are six delay analysis methods often mentioned in the construction literature, namely, schedule review/discussion, as-planned versus as-built analysis, impact as-planned analysis, collapsed as-built analysis, time impact analysis, and the productivity method (Fruchtman 2000; Stumpf 2000; SCL 2002; Gothand 2003; Lovejoy 2004). The opinions of researchers and practitioners on the performance and effectiveness of these methods vary. For a thorough discussion of the opinions of a large number of researchers and practitioners relative to the merits of each of these methods, and the factors that affect the selection of the most appropriate one for given conditions, see Arditi and Pattanakitchamroon (2006). The accuracy of delay analysis depends not only on the analysis method, but also on a multitude of issues relative to concurrent delays, float ownership, theories for determining critical paths, and scheduling options. Again, for a thorough discussion of these issues, see Arditi and Pattanakitchamroon (2006). A brief description of the most commonly used six methods is presented below.

Schedule review/discussion is the least sophisticated method that involves arguing a claim with or without using a schedule, but relying mostly on the strength of the evidence and testimony. Some writers suggest that the "global impact method" is often a sensible choice in this respect, as it simply plots the delays and disruptions on a bar chart and determines their global impact on the project schedule by summing up the durations of all delay events (Harris and Scott 2001). The global impact method is an easy and inexpensive way to argue time-based claims when detailed calculations cannot be conducted. But the results of such an analysis are not acceptable to most analysts because it ignores the nature of each delay event and assumes that every delay has an equal impact on the project duration, which in turn can lead to a gross overstatement of the entitlement (Alkass et al. 1996). Accordingly, courts and administrative boards resist the use of the global impact method as well as other approaches based only on evidence and testimony.

The as-planned versus as-built analysis method is the comparison of a baseline or an as-planned schedule with the final or an as-built schedule. The method involves identifying the as-built critical path, comparing the as-built critical activities to the as-planned schedule, and considering the causes of actual delay events and activity sequences to determine the impact of delay on project completion (Fruchtman 2000). Variations of this method are also known as the net impact method (Baram 1994), the total time method (Stumpf 2000), and the critical path method (CPM) update review (Zack 1999).

The impact as-planned analysis method is the favorite method of CPM experts and has been used extensively after the 1960s for asserting delay claims against the owner (Wickwire et al. 1991). This approach uses only the as-planned schedule based on the theory that the earliest date that a project could have been completed can be determined by adding the delays into the as-planned schedule. The claimant simply adds to the as-planned schedule in the appropriate sequence new activities with durations that represent delay caused by the defendant (e.g., change in scope, disruption, suspension, etc.) to demonstrate the reason why the project was completed later than planned. The time extension sought by the claimant is the duration between the planned completion and the new impacted completion.

The collapsed as-built schedule analysis method is defined by SCL (2002) as a method where the effects of events are "subtracted" from an as-built schedule to determine what would have occurred but for those events. The process includes recovering the final as-built schedule or creating an as-built schedule from appropriate information, removing the claimant's delay out of the as-built schedule, recalculating the schedule, and finally determining the impact of the defendant's delay remaining in the schedule. This approach is a method of choice for the contractor who lacks an acceptable schedule during the project (Fruchtman 2000). This analysis is popular in claim applications because it is easily understood by triers of fact (Zack 2001). It is also referred to as the "but-for" technique (Zack 2001).

The time impact analysis method is a procedure that utilizes network schedules and an analysis of the facts associated with each day to demonstrate the delay's effect on the project schedule (Wickwire et al. 1991). The basic processes involved in time impact analysis are described in detail by Gothand (2003) and include receiving the as-planned schedule, developing fragnets using delay events, inserting these fragnets into the as-planned schedule, and observing the impact of each delay event on total project duration. This process is repeated either every day, every time a delay event occurs, or every time the schedule is updated (e.g., every month). The impact of individual delay events are accumulated and used to justify remedies.

Sometimes, this method is referred to as "snapshot analysis" since the objective of the analysis is to obtain a snapshot picture of the project each time it experiences a major impact to the schedule, to account for the dynamic sequence of actual events, and to compare impacts between the snapshot periods (Baram 1994). When the timing of the snapshots is based on a series of regularly scheduled updates (e.g., every month) rather than delay events, the method is known as "window analysis" (Gothand 2003; Winter and Johnson 2000). This method is called "contemporaneous period analysis" when it starts with a validated as-planned schedule that is updated by using contemporaneous project documentation prior and subsequent to a delay event to get the impact of the delay (Zack 1999; Stumpf 2000). Time impact analysis is considered to be quite effective and some researchers recommend that it should be used in time-based claims, even if this is not specified in the contract (Baram 1994; Alkass et al. 1996; Gothand 2003).

The productivity method compares the productivity achieved in an activity against normal productivity rates. The intent is to seek damages on the grounds that site productivity has been negatively affected by a delay. However, historically speaking, courts and boards have often arbitrarily reduced claims based on published impact standards because of the uncertainty as to their accuracy. On the other hand, the "measured mile" method compares the productivity of a period that has been impacted by a negative event to the contractor's own normal productivity in similar work under normal, unimpacted conditions. The theory is that the difference is the amount of excess cost to the contractor as a direct result of labor inefficiencies and loss of productivity caused by the delay. Courts and boards do not object to the "measured mile" method as long as the contractor's productivity rates are based on reliable records segregated by activity and event.

Construction delay analysis has evolved in different directions. Many of the recent developments have involved the integration of computerized CPM schedules and as-built information from a project database. The systematic administration of construction claims is nowadays possible thanks to the advanced computer technology (Abdul-Malak et al. 2002). Time impact analysis and productivity analysis methods would benefit most from recent advances in computer technologies, as they require a great amount of input to accurately quantify the impact of delay. Eventually, delay can be measured on a daily basis (Livengood and Laush 2003).

Some researchers attempted to eliminate common flaws in existing delay methods. For example, Shi et al. (2001) and Lee (2003) have developed delay analysis methods based on the as-planned versus as-built comparison approach by incorporating a systematic methodology to scrutinize delay impact. On the other hand, a number of new methods other than the existing were proposed in contemporary literature (Spittler 2003; Gothand 2003; Alkass et al. 1996); however, none of them reported successful practice in time-based claims.

Methodology

The methodology of the study involves the analysis of objective evidence. The data used in the study came from published claim cases decided by courts and administrative boards. The decisions/opinions of courts and boards are normally disclosed to the public and are generally considered to be remarkably reliable for scholarly research. The claim cases in the study were compiled from the information posted on the Web sites of the United States Court of Federal Claims (USCFC) (http://www.uscfc.uscourts.gov/opinions.htm), the Court of Appeals for the Federal Circuit and Federal District Courts (CAFC/FDC) (LexisNexis.com), the Armed Services Board of Contract Appeals (ASBCA) (http://www.law.gwu.edu/asbca/), the Veterans Affairs Board of Contract Appeals (VABCA) (http://www1.va.gov/bca), and the General Services Administration Board of Contract Appeals (GSABCA) (http://www.gsbca.gsa.gov/decisns.htm). These sources contain many thousands of cases. However, many of the cases were beyond the scope of the research conducted in this study. Four criteria were, therefore, used to filter the cases for the study, including (1) construction projects; (2) government contracts; (3) time-based disputes; and (4) sufficient detail.

The file of a typical claim case summarizes the hearing conducted by courts or boards. The length of a case file varied from 10 to 180 pages, depending on the details and the issues that were documented. A case could contain multiple hearings docketed in separate motion summaries. A claim case could comprise multiple claim items seeking a solution to various issues. If a case decided by a board of appeals was appealed to the USCFC, the decision of the highest jurisdictional authority was used.

Each case file was divided into (1) an "Introduction" that contained basic information about the case, including names of parties involved in the case, a contract number for the project, previous proceedings and decisions, dates of hearing, etc.; (2) the "Finding of Facts" summarizing what actually happened during the performance of the project; and (3) "Discussions" that presented the opinions of the judges. Courts and boards decided claim issues based on the facts and evidence that the parties presented in the hearings. Facts and evidence contained delay analyses that supported the arguments of the parties to a claim case. The information categories used in the study and their brief descriptions are presented in Table 1.

The contracts involved in the cases ranged from a $118,569 roof repair project to a $105,978,000 new hospital building. The project duration of the cases varied between a 3.5-month renovation project and a 42-month railway project.

Reasons for Filing Time-Based Claims

The frequencies of the reasons why contractors filed time-based claims in the 58 cases can be seen in Fig. 1. The most frequently cited reason was differing site conditions. The nature of construction is closely related to existing site conditions. Contractors frequently encounter hidden conditions, such as underground soil conditions and utilities whose locations are difficult to foresee, before the work starts. Differing site conditions may significantly impact the time and cost of performing work.

For government work, the differing site condition clause (FAR 52.236.2) is mandatory for all fixed price construction contracts expected to exceed the small-purchase limitation of $25,000 (FAR 1B.10.6). According to this clause, the risk of differing site conditions is assumed by the owner. Such a clause benefits both the owner and the contractor because the contractor is able to rely upon the contract documents to submit a more precise and competitive bid without high contingency factors (Bramble and Callahan 1987). When they come across differing site conditions, contractors have the right to request a time extension if the conditions affect the time required for completion. However, whether a differing site condition affects the work performance is sometimes disputable. It is often the case that the parties are unable to settle the time and cost adjustment resulting from such conditions.

Defective design/specification was the second most frequently cited reason for filing time-based claims. Design defects include errors and omissions, as well as lack of coordination between the various aspects of design. These problems affect contractors directly, who normally may not have the legal right to file a claim directly with the designer. In case such a problem increases a contractor's cost, the owner has to bear the cost and seek recourse against the designer. Certain areas such as site plans, foundation design, mechanical design, and design of renovation/rehabilitation projects seem to generate more design-related problems than others (Bramble and Callahan 1987).

The third reason that frequently led to time-based claims was change orders for extra work. Changes that are directed by the owner are named "constructive" changes. In general, the owner is responsible for the impact of a change order upon the contractor's time and cost performance. However, not all changes in the work will affect the contract duration. The contractor is responsible for proving that the time impact is attributable to a change order issued by the owner. Proving the impact of changes is often difficult. Even though entitlement to compensation may be justified, the owner and contractor may not be able to settle a time adjustment. In such cases, to facilitate the process of construction, the contract officer may issue a unilateral change order [FAR 43.103 (b)], which can be defined as a change order issued by the contract officer in accordance with his/her determination of an equitable price and time adjustment, but to which the contractor does not agree and does not sign. The contractor, therefore, pursues an equitable adjustment after the course of additional work. In some situations, owner delay in issuing a change order also leads to delay in the overall project completion.

Another reason that frequently resulted in time-based claims was uncertainty of weather. Even though a contractor is required to assume the risk of severe weather conditions during the project season and at the project location, delay caused by unusually severe weather is excusable under the standard federal construc-

Table 1. Information Categories Used in the Study

Information category		Description
Project information	Name of contractor	The name of the contractor who filed the appeal
	Date of decision	The year that the appeals decision is filed to the dockets
	Source of information	The name of the court or board that decides the appeals (USCFC, CAFC/FDC, ASBCA, VABCA, GSBCA)
	Project description	Brief description of the scope of the project
	Contract price	The price stipulated in the original contract
	Original project duration	Project end date minus project start date specified in the contract
Delay information	Causes of delay	The reasons why time-based claims occurred
	Remedy sought	• Remission of liquidated damages • Seeking compensation for consequential damages • Appealing termination for default
Project monitoring system	Scheduling technique used	• No schedule • Bar chart schedule • Network schedule
	Updating practice	• Project has no schedule • As-planned schedule exists • As-built schedule exists, but schedule is seldom updated • Project schedule is regularly updated
Delay analysis	Delay analysis method used	• Schedule review/discussion • As-planned versus as-built analysis method • Impact as-planned analysis method • Collapsed as-built analysis method • Time impact analysis method • Productivity analysis method
	Use of existing or newly created schedules	• Existing schedules processed at the time delay occurs • Existing schedules used after the fact • Newly created schedules
	Use of expert service	• No access to experts • Use of in-house staff • Use of expert advice

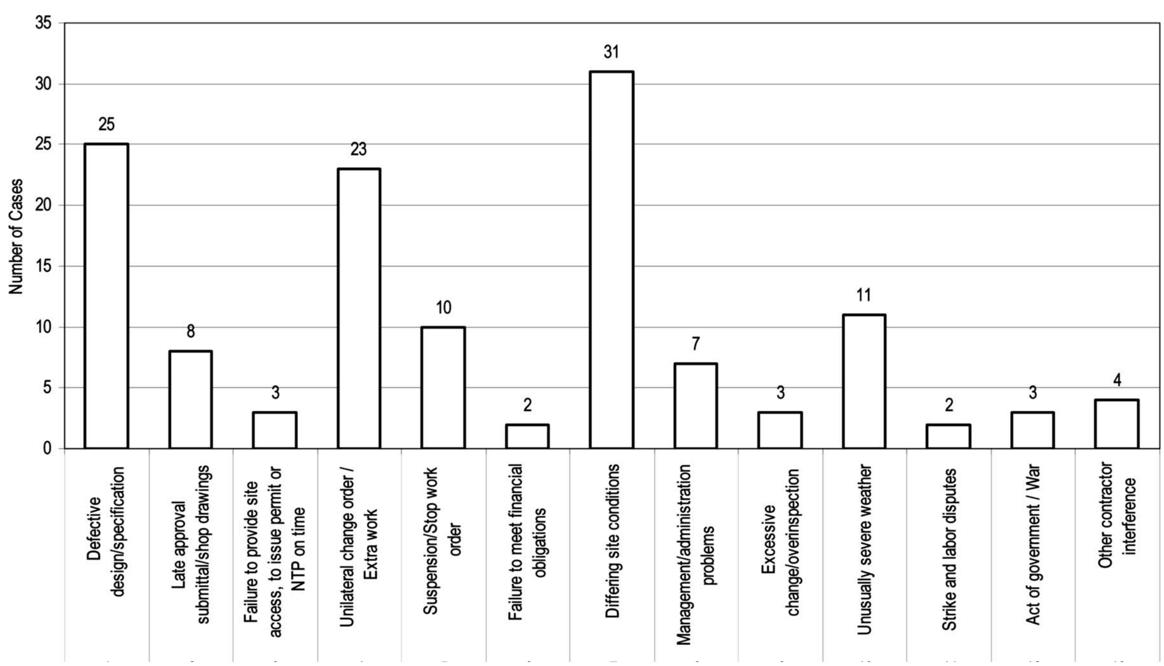

Fig. 1. Reasons for filing claims

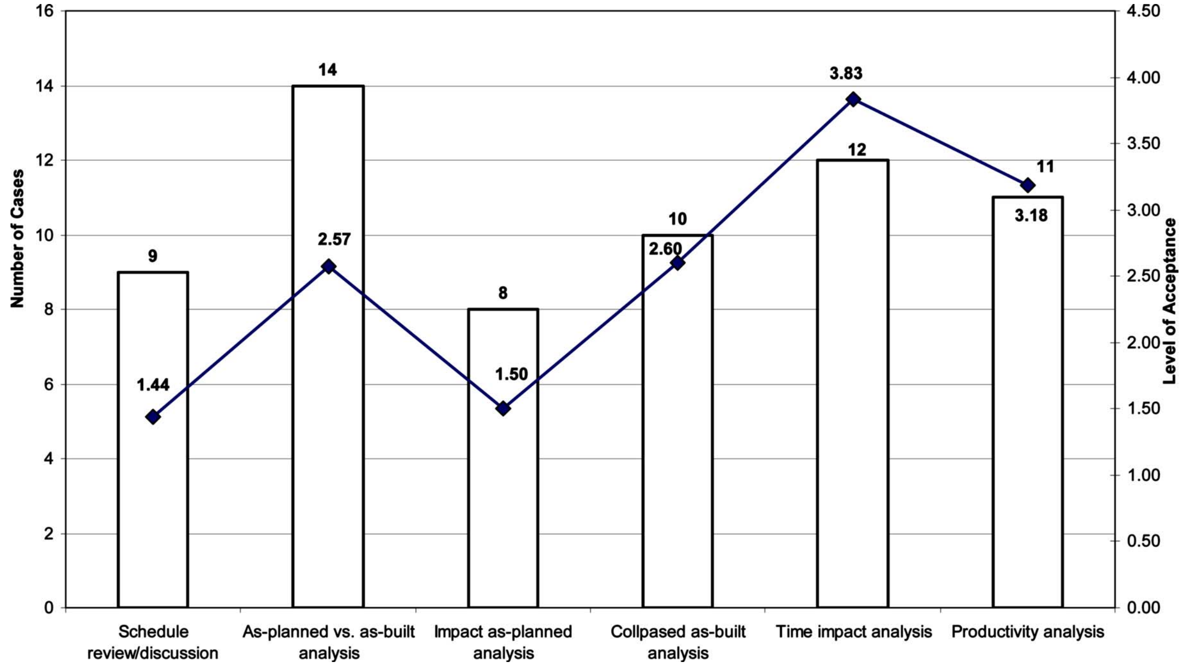

Fig. 2. Delay analysis methods used and acceptance index by courts/boards

tion contract (FAR 52.249-10). To be allowed an extension of time, the contractor is required to establish evidence that the severe weather deviated from the local climate significantly and that it caused delay in specific parts of the work. Disputable situations can arise when interpreting the days of unusually severe weather. In some cases, a consequence of bad weather, such as flood, could hinder the performance of work and the contractor may need time recovery from that delay, but negotiation at that time is always difficult.

The remedies sought by claimants in time-based claims included minimizing or eliminating liquidated damages charged by the owner for alleged contractor-caused delays, seeking consequential damages for owner-caused delays, and challenging the owner's decision to terminate the contract on the basis of contractor default. "Liquidated damages" is the amount of money the contractor pays the owner to relieve the loss to the owner caused by contractor-caused delay. The situation where the contractor contested "liquidated damages" on the grounds that the delays were actually caused by the owner or designer was the remedy sought in 47% of the cases. "Consequential damages" is the amount of money compensated to the contractor when an owner-caused delay hinders the contractor's performance or results in additional cost to the contractor. Disputes over "consequential damages" occurred in 34% of the cases. "Termination" describes the situation where the project experienced severe delays, making it unlikely to meet the final deadline and precipitating the issue of a termination for default by a contract officer. Even though cases of termination for default often make news items in trade magazines, contractors in only 19% of the cases wanted to reverse the termination by default decision by arguing that the delays were not caused by the contractor.

Selecting a Delay Analysis Method

The level of acceptance of delay analysis methods by courts and boards was measured by an acceptance index on a scale of 1 to 5 where "1" denotes methods that were found by courts and boards to be flawed, "3" denotes methods that were found to be somewhat acceptable but were used with data considered to be conflicting, inconsistent, or unreliable, and "5" denotes methods that were acceptable and that were used with credible data. The frequency of use of delay analysis methods, as well as their average acceptance indices, are shown in Fig. 2. The acceptance index of a method was calculated by dividing the sum of the acceptance indices recorded for each case by the number of cases where the method was used. The total number of cases in Fig. 2 is 64 rather than 58, because there were six cases where contractors used two-delay analysis methods.

The findings presented in Fig. 2 indicate that time impact analysis was the most recognized method by courts and boards (acceptance index=3.83) in measuring delay impact, which is consistent with the general understanding of the majority of construction professionals and researchers whose opinions are summarized by Arditi and Pattanakitchamroon (2006). Time impact analysis was highly regarded by courts and boards, because it presents a delay impact correlated to each delay event at the time it occurs. This concept is considered to be an accurate way to determine delay impacts (SCL 2002; Abdul-Malak et al. 2002). Fig. 2 also shows that time impact analysis was the second most widely used method. The frequent use of this method can be explained by its wide acceptance as the most efficient method available and its ability to use contemporaneous documents to evaluate the schedules. The fact that it is not the most widely used method is probably due to the high level of expertise, time, and effort required to conduct the analysis that may not be available in some cases.

The large majority of cases that made use of productivity analysis (i.e., the use of the measured mile method and of industry productivity factors) were set out to prove consequential damage claims by demonstrating that the disruption caused by delay events negatively affected site productivity. In order to establish entitlement to delay damages, the claimant is not only required to determine a critical path of the project and the causal link between the defendant's wrongful actions and the delay, but also bears the burden of demonstrating the extent of the harm to the claimant resulting from the delay. As a result, productivity analysis appears to have been quite well recognized by courts and boards (acceptance index=3.18), but it must be kept in mind that the use of this method was confined to arguing mostly consequential damage and sometimes acceleration claims.

It was surprising to see that the collapsed as-built analysis received a fair level of acceptance by courts and boards (acceptance index=2.60), ranking third among all the methods. It was also surprising to see that it was not used extensively either, even though Zack (2001) claims that it is commonly preferred in time-based claims over other methods. The unexpectedly low level of usage of this method compared to time impact analysis and the productivity method may be attributable to the fact that an as-built schedule had to be reconstructed in some of the cases, which requires considerable time and effort, not to mention reliable and available records. Recreated as-built schedules are also often seriously challenged by defendants for manipulation and bias.

The as-planned versus as-built method was the most widely used delay analysis method, probably because it is easy to use and because the rationale of the methodology is appealing. Some researchers encourage using this method because it requires only existing materials generated while monitoring the project and less effort to prepare the analysis (SCL 2002). The finding is consistent with comments from researchers (SCL 2002) that the as-planned versus as-built method produces fairly accurate results as it addresses concurrent delays (Fruchtman 2000), and prevents analysts from inputting biased information to later-adjusted schedules (Zafar 1996). The as-planned versus as-built method received a fair level of acceptance from courts and boards (acceptance index=2.57). It should be noted that the level of acceptance of this method depended on the way the method was detailed. For example, the as-planned versus as-built method is referred to as the "total time" approach when the analysis omits detailed comparisons of independent activities (Finke 1999; Alkass et al. 1996) and involves simply taking the original and extended completion dates, computing the overrun, pointing to a host of individual allegedly owner-caused delay incidents, and then leaping to the conclusion that the entire time overrun was attributable to the owner. Courts and boards routinely diqualified the "total time" theory.

The impact as-planned analysis and schedule review/discussion were the least used methods and received the lowest level of acceptance by courts and boards (acceptance index=1.50 and 1.44, respectively). As far as impact as-planned analysis is concerned, claimants and defendants were probably aware of the flaws in the analysis, and that courts and boards have frequently rejected this method in the past (Wickwire et al. 1991). The low level of acceptance by courts and boards of impact as-planned analysis is consistent with the comments by researchers and practitioners cited by Arditi and Pattanakitchamroon (2006). This method, so criticized by the construction industry, was used only as a last resort when updated schedules and relevant records were not available. As far as the schedule review/discussion method is concerned, this method was one of the least used methods, since it has the disadvantage that the interpretation of project records and scheduling documents is quite subjective. Sometimes, schedule review/discussion was used when claimants were unable to conduct a formal delay analysis due to unavailability of expertise and/or project records.

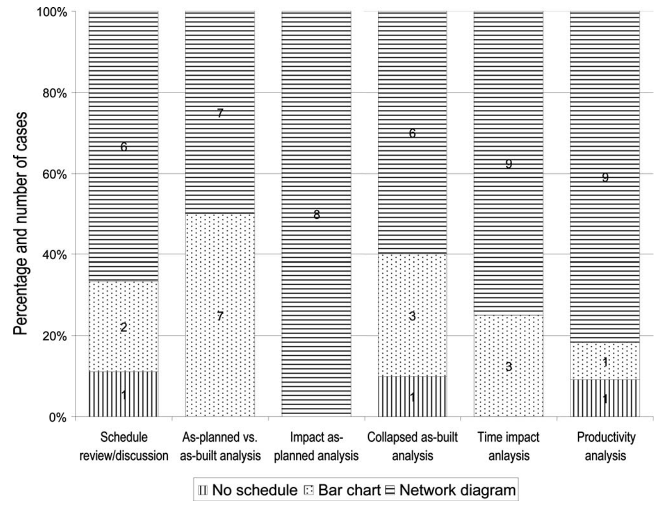

Fig. 3. Delay analysis methods by type of schedule used

Factors That Affect the Selection of a Delay Analysis Method

It was hypothesized that the selection of a delay analysis method depends upon a variety of factors, including type of schedule used, schedule updating practice, the use of existing versus recreated schedules, availability of expert advice, availability of information, amount of time, funds and effort allocated to the analysis, and timing of the analysis. Information was extracted relative to these issues from each of the 58 cases studied. The following interpretations are made in the light of the information collected.

Effect of Type of Schedule Used

The choice of a scheduling system used in a project generally depends on contract requirements. In government work, a schedules for construction contracts clause (FAR 52.236-15) is typically included in the specification. The clause comprises principal requirements for submitting a project's planned schedule for approval in the early stages of the construction and maintain regular updates (e.g., on a monthly basis). It was found that contractors relied on a network diagram to monitor project progress in 67% of the cases, and on a bar chart in 28% of the cases. No schedule was used in the remaining 5% of the cases. In recent years, the use of a network diagram has become standard practice in construction contracts due to its many advantages over bar charts. However, some contracts allow contractors to select their own scheduling system based on the nature of the work. A bar chart is acceptable if the contract does not require a network schedule.

Preparing a bar chart is less complicated than preparing a network diagram and it does not require expertise and complex computation. RS Means (2004) estimates an additional 0.05 to 0.1% increase in the total contract value for using a network schedule rather than a simple bar chart. Some contractors would not be willing to spend extra on network scheduling to monitor less complex projects. As a result, a bar chart is expected to be the scheduling system of preference in projects with small contract value and short duration.

It can be seen in Fig. 3 that when a bar chart schedule was used in a project, comparing as-planned versus as-built schedules was the preferred delay analysis method in filing time-based claims because this method relies on an observation technique

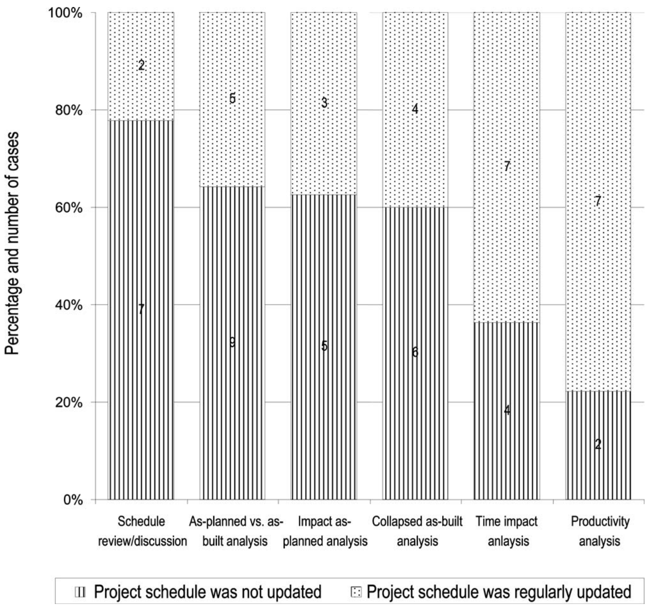

Fig. 4. Delay analysis method by updating practice

that does not require network schedules, as opposed to impact as-planned, collapsed as-built, and time impact analyses that work best with a network schedule. A bar chart has the advantage of being simple, practical, and easily understandable by the parties, but it limits severely the analyst's choice of the delay analysis method.

Delay analysis methods based on network schedules appear to be better accepted by courts and boards (acceptance index=2.59) when compared with bar chart-based analysis methods (acceptance index=2.13). Indeed, the as-planned versus as-built method conducted on a bar chart schedule was often denied by courts and boards because the analyst was unable to determine the impact of delay on a critical path. The advantages of network schedules, particularly in defining precedence relationships between activities and identifying a critical path, are well recognized by researchers and practitioners (Bramble and Callahan 1987; Wickwire et al. 1991) and is reflected in the fact that courts and boards prefer delay analyses based on network schedules.

Effect of Schedule Updating Practice

Maintaining project schedules involves incorporating the actual progress for each project period into the schedule to show how the work has proceeded, relative to the baseline plan that was originally adopted. Updating a schedule allows integrating changes into the schedule in a timely manner and mitigating delays in a proper time frame before their impacts become overbearing. An updated schedule reveals shifts in critical path and changes in activities' floats. Without an up-to-date schedule, it is impossible to prove the work was planned to finish accordingly. An updated schedule can be used as a basis for negotiating a contractor's claim for time extension and damages. For any type of schedule used, government contract requirements call for updating the schedule on a regular basis (e.g., monthly updates) to ensure that the owner is able to monitor the contractor's progress [FAR 52.236-15 (b), (c)]. The findings indicate that project schedules were not updated on a regular basis in 59% of the cases.

Whether a work schedule was updated regularly throughout a project can constrain the selection of the most appropriate delay analysis method. Fig. 4 shows that analysts were able to use sophisticated delay analysis methods, such as time impact analysis and productivity analysis, in projects that keep up-to-date project schedules. Projects with no updated schedules were limited to only simple methods, such as schedule review/discussion, and as-planned versus as-built analysis. In some instances, and this explains the exceptions to the preceding statements, the analyst had to create new schedules that incorporated changes throughout the course of the project in order to recreate the chain of events leading to delay.

It was found that the delay analysis conducted by using complete updated information received higher acceptance by courts and boards (acceptance index=2.92) than the analysis that lacked updated information (acceptance index=2.12). This finding explains to a certain extent the reason why time impact analysis, which makes extensive use of updated schedules, has a higher acceptance index (3.83) when compared to schedule review/discussion and impact as-planned method (1.44 and 1.50, respectively) that do not require updated schedules.

Effect of Using Existing versus Recreated Schedules

A delay analysis is ideally conducted by using existing work schedules, because these schedules are considered to be part of contract documents. All project participants are expected to be familiar with these work schedules. It was found that while 55% of the cases relied on existing schedules to conduct delay analysis, either right after the delay event occurred or at the end of the project. Claimants used newly created work schedules in the remaining 45% of the cases. In some cases, an existing bar chart was converted into a network schedule, as recommended by Popescu (1991). However, the quality of the recreated schedule is very important, as the outcome of the analysis is heavily dependent on the logic and duration of the activities in the network schedule.

A newly created schedule is useful when submitting delay claims for several reasons. In some situations, the existing work schedules may not adequately represent the factual records of the project for reasons that may range from a schedule that has not been approved, schedules that contain errors/contradictions, to schedules that have never been updated. An analyst may not be the one who created the work schedules and does not have to rely on existing logic. In these circumstances, the newly created schedule can be a replacement of the existing erroneous schedule so that it reflects more faithfully the actual events that occurred in a project. As seen in Fig. 5, the analysis methods that require as-built and/or as-planned schedules often make use of newly created schedules because these schedules are considered to be more realistic, since they are based upon daily logs, project photographs, project correspondence, interviews with project personnel that worked in the field, and other contemporaneous project documents. On the other hand, creating a new schedule requires considerable effort and can be controversial. The owner's expert witness may find that changes of logic and durations are not warranted and that the network schedule was manipulated to present a contractor-biased view of the situation.

Judging from the acceptance indices, courts and boards appear to have no preference for the use of existing or recreated schedules. Indeed, the small difference between the acceptance indices of 2.40 for analyses conducted with existing schedules, and 2.54 for analyses conducted with recreated schedules show that this issue is not the most important factor in selecting delay analysis methods.

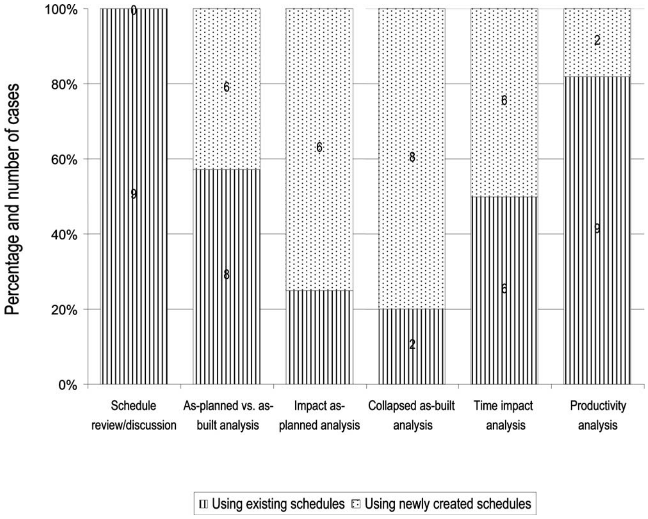

Fig. 5. Delay analysis method by use of existing versus newly created schedules

Effect of Availability of Expertise

The scheduling expert plays an important role in conducting delay analysis. Courts require certain credentials and experience of the expert who presents the delay analysis during the hearing. In many cases, owners also provide their own scheduling experts and analyses to counter the claims. The report and conclusion developed by the expert must be fair to all sides, firmly grounded to the facts of the project, and derived from complete and proper reviews of appropriate project data. It is to be expected that detailed and comprehensive schedule analysis conducted by the claimant's expert can prove that the owner somehow delayed, accelerated, augmented, or complicated the work, and thereby caused the contractor to incur specific additional costs. The majority of contractors (72%) did not hesitate to conduct full delay analysis by engaging the services of a scheduling expert who made use of sophisticated work schedules. In 12% of the cases, the contractor provided an elementary analysis conducted by in-house staff using existing schedules, while in the remaining 16% of the cases, the contractor did not provide any formal analysis. In construction litigation, contractors bear the burden of proof on their challenge to the contract officer's decision. A contractor must show liability, causation, and injury.

Fig. 6 indicates that filing a claim that makes use of a formal schedule analysis requires expert service. The hiring of a scheduling expert appears to be standard practice whenever productivity, time impact, collapsed as-built, or impact as-planned analyses are conducted. The contractor's in-house staff conducted few as-planned versus as-built analyses. In some instances, the contractor was unable to demonstrate delay impact by using any one of the delay analysis methods and had to rely only on schedule discussion/testimony. Yet mere evidential records are not enough to demonstrate the impacts of delay on the schedule and to deliver a clear assertion of damages. The more sophisticated the method, the more expertise appears to be needed. The cases that were supported by scheduling experts who used formal delay analysis methods were clearly better substantiations of the delay claims with an acceptance index of 4.14, whereas no analysis (1.44) or elementary analysis performed by in-house staff (1.57) were not favored by courts and boards.

Effect of Information Available and Time/Funds/Effort Allocated to the Analysis

The contracts involved in the 58 cases were grouped into three categories based on their durations. Contracts of less than 12-

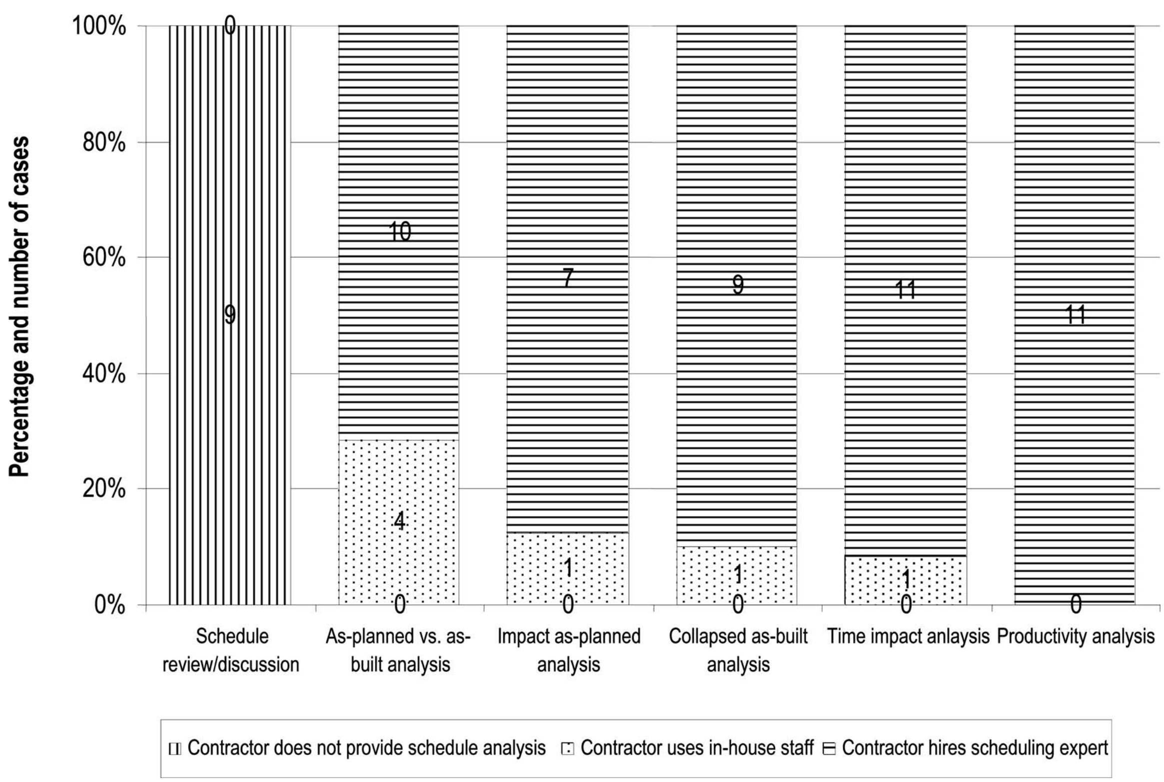

Fig. 6. Delay analysis methods by quality of expertise and data used

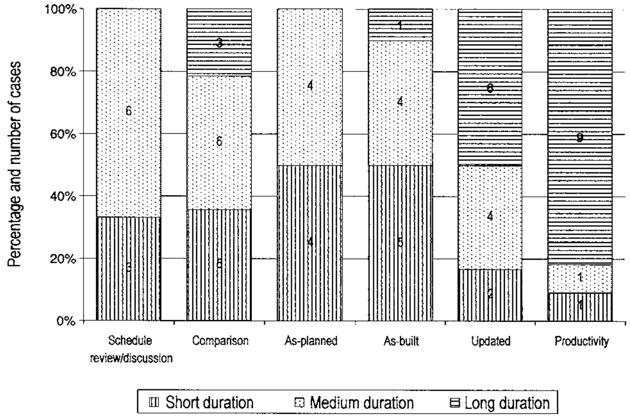

Fig. 7. Delay analysis methods by project duration

month duration were labeled "short duration," 12–24 months "medium duration," and longer than 24 months "long duration." Fig. 7 presents the delay analysis methods used broken down by contract duration. It can be observed that the elaborate analysis methods (i.e., time impact analysis and productivity analysis) were used more often in long-duration projects, which mostly tend to be large-scale projects with large contract values. Indeed, when the projects are grouped into three categories based on their contract value, and are labeled "small contract value" for projects of less than \$1m, "medium contract value" for projects \$1m–\$10m, and "high contract value" for projects larger than \$10m, one can observe a reasonable correlation between project duration and contract value. It appears that projects of long duration and large contract value can justify more costly and involved methods of analysis, because more funds and well organized documentation are likely to be available in such projects. In small-scale short-duration projects, where administrative requirements and management are rather simple, the contractor might prefer using simple analysis methods, such as impact as-planned and schedule review/discussion. The selection of the analysis method appears to be dependent on the degree of detail and the accuracy that the analyst can deliver, given the time constraints and budget limitations.

Effect of the Timing of the Method

A chronological analysis of the methods was conducted to see if there is a predominant method used in recent years and to compare the relative frequencies of use of the methods over the years. To this end, the yearly percentages of usage (number of cases using a method divided by the total number of cases using this method) were plotted against the years 1989 to 2005. A distribution that has a steep increase followed by a tapering off, indicates that this method was used significantly more in early years than in recent years. Conversely, a distribution that starts off rather flat and then picks up slope, shows that this method has become more popular in recent years. The results are presented in Fig. 8.

Comparing the 50 percentile values of the methods gives a good idea of the chronological differences between the methods. As seen is Fig. 8, it looks like the impact as-planned method has lost its popularity, presumably because courts of law do not accept this method as credible evidence any more. Even though the differences between the remaining methods are rather small, the time impact analysis method appears to be the method that is most favored in recent years, presumably because it has become easier with advancing computer technologies and ease in data storage.

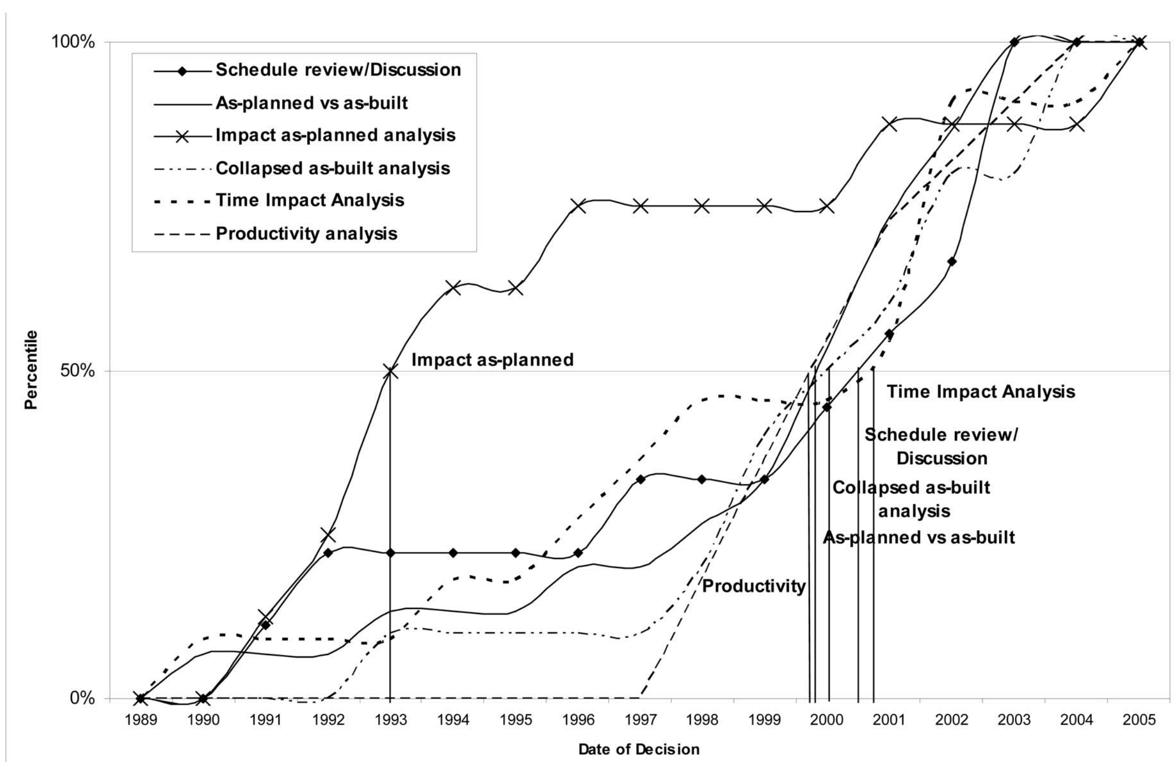

Fig. 8. Chronological analysis

Conclusions and Recommendations

Delay analysis in construction litigation is a controversial issue. Delay analysis methods have been developed to provide fair resolutions for all parties concerned and play an important role in time-based claim resolution. Although some of the methods are widely accepted as yielding accurate results for assessing delay impacts, it would be fair to state that they do not assure the claimant's success in contractual disputes. Because a standard delay analysis method is not specified by courts and boards for universal use, claimants can use the method of their choice to support their claims. They can use a formal method or simply an informal discussion of delay events and their consequences.

The study has analyzed data obtained from 58 time-based claim cases. The study indicates that the most frequent problems that cause time-based disputes in construction projects are differing site conditions, defective designs and specifications, and change orders. These problems can lead to project delays, disruption, and termination if they are not dealt with adequately. It is often the case that one delay event affects other portions of the work, as a claim usually involves multiple events that are caused by a single or concurrent problems. Disputes arise in a construction process because of unanticipated delay events, as well as the fact that preconstruction documents are often incomplete.

The delay analysis methods commonly used in the construction industry include schedule review/discussion, as-planned versus as-built schedule comparison, impact as-planned analysis, collapsed as-built analysis, time impact analysis, and the productivity method. These methods use different approaches to evaluate delays and disruptions, and calculate their impacts. The study found consistent practices in construction litigation where contractors bear the burden of proof to the claims. The claimants appear to have selected their analysis methods based on the type of schedule used, the schedule updating practice, whether existing or newly created schedules are used in the analysis, the availability of expert advice, the availability of information, and the amount of time/funds/effort allocated to the analysis. It also looks like improvements in computer technologies and changes in the practices of courts of law favor one or more of the methods against the others.

The time impact analysis appears to have been used mostly in large-scale projects and to rely on analyses conducted by expert consultants using regularly updated network schedules to recreate delay events faithfully along the project's time frame. It requires considerable data and effort, which may not be available in some construction projects where the transient nature of the project as well as time and budget limitations, do not sometimes allow scheduling data to be well documented. The study indicated that the time impact analysis method is received more favorably by courts and boards than the other methods because it is methodologically sound and provides extensive detail. This is particularly true in recent years as computer technologies have improved, allowing the storage of large quantities of data, access to a large amount of information, and the speedy assessment of work schedules. The study also clearly indicated that projects where regular schedule updates were not conducted, experienced difficulties in using time impact analysis. It follows that project managers should prepare for potential claims by engaging in practices that generate adequate information at all stages of a project.

The productivity analysis method involves mostly comparing the productivity of a delay-impacted activity to the productivity of a normally performed activity. It does not involve schedule manipulation and is generally used in situations that involve the recovery of consequential damages. The "measured mile" method is well accepted by courts and boards, is mostly used in larger projects, relies on reliable and accurate project records, and requires specialist help. Productivity analysis can be of great help when calculating delay-related damages rather than delay impact on a schedule.

The less sophisticated methods, such as schedule review/discussion, and as-planned versus as-built were used mostly in small projects with few human and financial resources and relied often on in-house expertise to conduct a simple discussion of evidence or a simple schedule comparison. The as-planned versus as-built method was the most selected in the 58 cases, presumably because it is simple and easy to understand. The study showed that analysts were likely to use the as-planned versus as-built analysis method when only a bar chart was available.

Collapsed as-built analysis is considered to be an effective method by the published literature, but it received little recognition from courts and boards and was little used by claimants in the 58 cases considered in this study. It looks like this low level of acceptance and use was caused by the controversial practice of creating new as-built schedules using contract records.

The analysis based on only an as-planned schedule failed to convince judges that the delay impacts actually affected the project duration as presented. This is evidenced by the trend observed in the chronological analysis to the effect that this method lost all popularity in recent years. The difficulty of this task is exacerbated by the fact that a delay does not necessarily result in the same amount of time shift in the project duration. The critical flaws of the impact as-planned method were recognized by all parties and resulted in this method being the least used method.

The analyst is expected to present the linkage between alleged delay and project performance. The use of a network schedule is consistently accepted by courts and boards to be an effective tool to monitor a construction project and determine cause and effect relationships of project delays regardless of the size of a project. The good practice of maintaining construction records allows dealing with time-based claims effectively. Hiring scheduling experts to conduct delay analysis is of great help, particularly when using the more sophisticated delay analysis methods.

The outcomes of claims decided by courts and boards are not only dependent on the body of evidence provided in the cases, but also on the delay analysis method because the delay analysis method plays an important role in demonstrating the impact of factual events that took place during the course of the project. The system that maintains project records adequately and the selection of the most appropriate analysis method facilitates the resolution process and makes claims more convincing.

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