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Critical path effect based delay analysis method for construction projects

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Abstract

Assessing schedule delay's impact on total project duration to distribute delay liability remains a controversy. None of existing delay analysis methods is perfect because including an element of assumptions, subjective assessment and theoretical projection. Windows-based delay analysis methods are excellent in identifying and measuring construction schedule delays. Based on a previous study identifying potential problems in available windows-based delay analysis methods, this study proposes an innovative windows-based delay analysis method, called the effect-based delay analysis method (the EDAM method). The EDAM method performs delay analysis using extracted windows and determines delay impacts by considering the effects of delays on the critical path(s). According to its application to hypothetical cases and comparisons with other methods, the EDAM method is efficient in delay analysis and effective in solving concurrent delays and determining schedule shortened. The proposed EDAM method is a good alternative for schedule delay analysis for construction projects.

Keywords: Delay analysis; Claim; Schedule analysis; Construction project

1. Introduction

Construction projects generally have highly complicated situations during execution, involve many project stakeholders and interfaces, and are influenced by many external factors. Therefore, schedule delays in construction projects are common and affect total project duration in unpredictable ways. Delay information and evidence are usually recorded and represented in different records, documents and schedules during the construction phase. Selecting a suitable delay analysis method and analyzing delay information accurately are essential tasks in any delayed construction project. Current delay analysis methods analyze delay liabilities based on delay information and evidence. Various analysis methods have been developed, such as global impact, as-planned, impacted as-planned, net impact, time impact, collapsing, isolated delay type, snapshot, window analysis and isolated collapsed but-for (Bordoli and Baldwin, 1998; Gothand, 2003; Hegazy and Zhang, 2005; Kim et al., 2005; Mbabazi et al., 2005; Ng et al., 2004; Yang and Yin, 2009; Zack, 2001). Farrow (2007) had clearly claimed that none of the delay analysis methodologies is perfect because they all include an element of assumptions, subjective assessment, and theoretical projection.

Generally, a delay analysis method attempts to discover delay information derived from as-planned and as-built schedules, those are the bases for resolving delay disputes and claims. However, existing delay analysis methods still have the following shortcomings: (1) concurrent delays cannot be recognized or calculated by some of existing methods; (2) the critical path method cannot be executed in analysis and critical path changes cannot be considered; (3) the relative cost of float consumption is not considered; (4) analysis is not contemporaneous with delay timing; and (5) most methods focus only on the delayed activities, and ignoring the effects of time-shortened activities on total project duration (Arditi and Pattanakitchamroon,

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2006; Bordoli and Baldwin, 1998; Gothand, 2003; Mbabazi et al., 2005; Ng et al., 2004; Yang and Yin, 2009). Furthermore, Arditi and Pattanakitchamroon (2006), in discussing how to select a delay analysis method, concluded that selecting a feasible analysis method depends on a variety of factors, including information availability, time of analysis, methodology capabilities, time, funds and effort allocated for analysis. Based on a empirical study in UK, six group factors (project characteristics, contractual requirements, characteristics of baseline program, cost proportionality, timing of the analysis and record availability) influencing the selection of delay analysis methodologies were identified (Braimah and Ndekugri, 2008). In summary, although some advanced delay analysis methods have been developed, including a few commercial systems, existing delay analysis methods cannot satisfy the practical requirements of delay analysis. That is, practitioners still require an alternative method for complex cases.

Windows-based delay analysis methods perform delay analysis according to some extracted time frames, called windows. Traditional windows-based method, the windows analysis method, has been recognized as the most creditable delay analysis method (Gothand, 2003; Kim et al., 2005). US courts have generally accepted some types of windows-based method, as they can calculate the impact of various delays, namely, the non-excusable delays (NE delays) and excusable delays (ED delays). Based on the viewpoint of a contractor, excusable delays are further divided into excusable compensable delays (EC delays) and excusable non-compensable delays (EN delays) (Zack, 2000; Mohan and Al-Gahtani, 2006). For above delay types, analysis results generated by windows-based methods provide a clear liability allocation to contract parties. This information is valuable for dispute resolution.

For a complex construction project, three types of delays (NE, EC and EN delays), might exist simultaneously. While the information for identifying all types of delays is available, the allocation of total project delay to above delay types provides more clear delay liability identification. Furthermore, for a contractor, to allocate all delays into these delay types improves its ability to get possible delayed-related expenditure back although the situations for compensable/non-compensable depend primarily on the terms of the contract (Trauner et al., 2009). It is beneficial to a contractor to distinguish compensable and non-compensable delays. Namely, a perfect delay analysis method is targeted to identify these delay types accurately.

To provide an alternative delay analysis method for resolving concurrent delays and liability distribution problems and for overcoming the time-consuming drawback of analyzing delays in a day-by-day manner, this study proposes a novel windows-based delay analysis method, called the effect-based delay analysis method (EDAM), which is a systematic analysis method that considers the impact of delays on the critical path(s) of a project.

2. Available windows-based delay analysis methods

Several windows-based delay analysis methods have been developed in the past two decades. All windows-based delay analysis methods can be divided into two categories: (1) performing delay analysis starting backward from an as-built schedule and (2) performing delay analysis starting forward from an as-planned schedule. The popular methods in the category of starting forward from an as-planned schedule include the windows analysis method (called traditional windows analysis (TWA) hereinafter), the modified windows analysis (MWA) method, the delay analysis method using delay section (DAMUDS) method and the daily windows delay analysis (DWDA) method. The TWA method performs delay analysis using extracted schedule windows, rather than by analyzing delay events in a one-by-one manner forward from the as-planned schedule or backward from the as-built schedule. The MWA method improves analytical processes by the TWA method and uses algorithms to calculate delay liability. The DAMUDS method tries to overcome two limitations in existing methods, namely inadequate accounting of concurrent delays and inadequate accounting of time-shortened activities. The DWDA method calculates clear delay liabilities to the contractor and owner based on day-by-day delay analysis of critical path(s) along the project duration.

Kao and Yang (2009) compared the above four windows-based delay analysis methods using an illustrative case. They determined that the four methods are dynamic delay analysis methods that perform real-time critical path analysis. The TWA and MWA methods are less reliable than the DAMUDS and DWDA methods, since they may lose essential information when the analysis period is long and may be unable to detect critical path changes. The DWDA method analyzes delay information in a day-by-day manner that is the same as as-built situations, but requires considerable effort during analysis. The DAMUDS method is more efficient than the DWDA method even though both yield the same analysis results. Detailed compared information can be found elsewhere (Kao and Yang, 2009).

Other windows-based methods belonging to the category of starting backward from an as-built schedule, such as the isolated collapsed but-for delay analysis method (Yang and Yin, 2009), have been developed for facilitating delay analysis problems by similar approaches. However, these methods perform delay analysis moving backward from an as-built schedule, not forward from an as-planned schedule. The approaches of using as-planned schedule or as-built schedule may derive different final analytical results. This study does not compare the results by the methods belonging to the category of starting backward from an as-built schedule to those by the developed EDAM method.

3. Problems in windows-based delay analysis methods

3.1. Unable to identify critical path changes

In general, whether an activity is on a critical path is an important signal when identifying its delay impact on total project duration. During the construction phase of a construction project, many situations e.g., change order, activity appending or deleting by different site conditions, and critical path changes, affect the outcome of delay analysis. In