EVALUATION OF DELAY ANALYSIS METHODOLOGIES ON LOST PRODUCTIVITY IN CONSTRUCTION PROJECTS

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Abstract

Schedule delays commonly appear in construction projects and result in delay claim progressively. Several studies have proposed various schedule delay analysis methodologies, however, most of the studies focused on the analysis of surface data (as-planned and as-built schedules), few of them on evaluating the effects of root causes, such as lost productivity. Loss of productivity is usually experienced by a contractor while accomplishing its works less than planned rate of production. Based on the literature review on lost productivity, this study further evaluated delay analysis methodologies, professional project management software and commercial delay analysis software to identify the capabilities of those methodologies and systems in dealing with the problem of lost productivity. Research results show that evaluated delay analysis methodologies, professional project management software and commercial delay analysis software cannot deal with the problem of lost productivity appropriately. That is, developing a comprehensive delay analysis method considering lost productivity is required.

KEYWORDS: Schedule Management, Delay Analysis, Delay Claim, Lost Productivity.

INTRODUCTION

Schedule delays commonly appear in construction projects and result in delay claim progressively. Most resolutions for delay claims usually cannot satisfy both of the contract parties, the owner and the contractor. Two main causes of such a circumstance are that the responsibilities of most delays are hard to identified, and the calculation results of available delay analysis methodologies/techniques are unacceptable for the contract parties. For solving the second cause, several studies have proposed various innovative schedule delay analysis methodologies or improved existed methodologies, i.e. global impact, net impact, adjusted as-built CPM (Critical Path Method), as-planned expanded, but-for, snapshot, time impact, windows, isolated delay type techniques and isolated collapsed but-for delay analysis methodology (Bubshait and Cunningham 1998; Arditi and T. Pattanakitchamroon 2006; Yang and Kao 2009). However, most of the methodologies focused on the analysis of surface

data (as-planned and as-built schedules), few of them on evaluating the effects of root causes. Lost productivity or loss of productivity is one of the most important delay causes among diverse causes of construction schedule delays. Lost productivity is usually experienced by a contractor while accomplishing its works less than planned rate of production. Recently more construction claims are including a loss of productivity component. But too often the claimed schedule impact and cost reimbursement amount is not properly substantiated or presented. Thus finding useful delay analysis methodologies and tools with the ability for dealing with the problem of lost productivity can help delay analysts to solve complex lost productivity problems. One of the most contentious areas in construction claims is the calculation or estimation of lost productivity (AACE, Inc. 2004).

The purpose of this study is to identify the capabilities of available delay analysis methodologies and tools for solving lost productivity problems. Therefore, the research methods of literature review and functionality review are employed. Rest of this paper is organized as follows. Basic definition for the problem of lost productivity is discussed firstly. After that, delay analysis methodologies, popular project management software and commercial delay analysis software are evaluated respectively. Conclusions for this study are finally made.

LOST PRODUCTIVITY

Definition

Productivity is commonly defined as the quantity of work produced or work output per unit of input or effort. Productivity measurement is typically expressed as a ratio or factor, as a percentage, or as a production rate. Productivity is lost on a project when the contractor's actual amount of labour or equipment hours is greater than the hours planned in its bid (Exponent Inc. 2010). In either case, lost of productivity is defined as the increased cost of performance caused by a change in the contractor's anticipated or planned working conditions, resources, or manner of performing its work (Finke 1997). Namely, lost productivity results in higher expenditure than planned conditions by the contractor. This circumstance usually comes with a dispute between the contractor and the owner. This paper discusses the delay problem caused by lost productivity.

Causes for Lost Productivity

When a project encounters the problem of lost productivity, how to identify the causes actually caused the variance in construction productivity is a complicated task. Previous studies have tried to locate the causes, including project characteristics, site conditions, project execution, weather effects, supervision effects, management of time, local labor market conditions, and availability of tools and construction equipment (Klanaca and Nelsonb 2004). Furthermore, for assisting delay analysts in estimating lost labour productivity in construction claims, more complete causes of lost productivity are collected in a report of AACE International Recommended Practice (AACE, Inc. 2004). The listed common causes of lost productivity are absenteeism and the missing man syndrome, acceleration (directed or constructive), adverse or unusually severe weather, availability of skilled labour, changes, ripple impact, cumulative impact of multiple changes and rework, competition for craft labour, craft turnover, crowding of labour or stacking of trades, defective engineering, engineering recycle and/or rework, dilution of supervision, excessive

overtime, failure to coordinate trade contractors, subcontractors and/or vendors, fatigue, labour relations and labour management factors, learning curve, material, tools and equipment shortages, overmanning, poor morale of craft labour, project management factors, out of sequence work, rework and errors, schedule compression impacts on productivity, site or work area access restrictions, site conditions, untimely approvals or responses (AACE, Inc. 2004). Notably, although different delay causes exist and contribute to the delay of a project, a contractor should clearly prove the delay liability of loss productivity is not caused by him.

Impacts by Lost Productivity

When a project encounters the problem of lost productivity, more duration is required for completing original works. In general, if the problem exists in critical activities, project completion date is consequently extended, excepting work acceleration by the contractor. Notably, the problem of lost productivity usually results in the claims from the contractor. Contractors assert claims for loss of productivity when the anticipated means, methods, techniques, scheduling, or work sequence are altered by events or circumstances outside the contractor's control, and the contractor is entitled to relief for the loss (Klanaca and Nelsonb 2004).

Although the key to recovering and defending against lost productivity claims lies in the data collected by the contractor, to find useful methodology, tool, or software makes the contractor perform time-consuming delay analysis task easier in delay claims when required data is available.

EVALUATION OF DELAY ANALYSIS METHODOLOGIES

Available methodologies

Many delay analysis methodologies were proposed to help delay analysts to identify delay causes and to calculate the schedule impact caused by identified delay events on project duration. A previous study has reviewed eighteen delay analysis methods, and compared three process-based dynamic analysis methods (snapshot analysis method, windows analysis method and isolated delay type method) in detail (Yang and Kao 2009). This study just briefly introduces some advanced methods that are evaluated later.

As-planned expanded technique

This method individually considers claimant and defendant's viewpoint to add delay event to the as-planned schedule. The difference between the as-planned schedule and the expanded schedule is the final delay amounts.

But-for technique

The but-for technique, also termed as collapsed as-built technique, has two categories of analysis procedures. First, this method uses the as-planned schedule as a basis and then adds all delays up to form an updated completion schedule. The difference between the as-built schedule and the revised completion schedule is the final delay results (Alkass 1996). Second, this method uses the as-built schedule as a basis and then removes delays from the as-built

schedule to collapse the schedule. The difference between the as-built schedule and the collapsed schedule is the final delay results (Zack 2001).

Windows analysis method

This method, also termed the contemporaneous period analysis method, analyzes delay event(s) on a predefined time period (termed as a window) 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.

Isolated collapsed as–built delay analysis method

Similar to the but-for technique, this method analyzes delay event(s) backward from the as-built schedule, but incorporates the advantage of windows analysis method to analyze delay event in an extracted window (Yang and Yin 2009).

Ability to calculate lost productivity

Based on the reviews by previous studies (Bubshait and Cunningham 1998; Arditi and Pattanakitchamroon 2006; Mohan and Al-Gahtani 2006; Yang and Kao 2009) and this study, four methodologies (as-planned expanded technique, but-for technique, window analysis technique, and isolated collapsed as–built delay analysis) are selected for evaluating their abilities in lost productivity calculation. Table 1 shows the evaluation results. Although some of the four methodologies can deal with traditional delay problems, none of them can deal with the problem of lost productivity.

Table 1: Abilities of Delay Analysis Methodologies

Methodologies	Identifying concurrent delays	Identifying serial delays	Real-time delay identification	Real-time critical path analysis	Considering lost productivity
As-planned expanded technique	×	×	×	×	×
But-for technique	×	×	×	×	×
Window analysis technique	○	○	○	○	×
Isolated collapsed as–built delay analysis	○	○	×	×	×

EVALUATION OF PROJECT MANAGEMENT SOFTWARE

As the concept and knowledge of project management are accepted in diverse industries, project management software has great development recently. Now, hundreds of project management systems have been developed. In Taiwan, three project management systems, the Primavera Project Planner (P3), the Microsoft Project and the Deltek Open Plan, are usually chosen for managing construction projects. This study evaluates the latest version of

those project management systems, i.e., Oracle Primavera P3 and P6, Microsoft Project 2007 and Deltek Open Plan 3.1.

Table 2 shows the evaluation results. It is clear that all systems have complete functions for resource management. Regarding to the productivity calculation, all of them provide no information. Notably, although evaluated project management systems do not provide a pre-programmed function to calculate activity or project productivity, they can record complete planned and used resources. Complete resource information makes productivity calculation workable. Therefore, to develop a program for calculating productivity can make available project management systems able to deal with the problem of lost productivity.

Table 2: Abilities of Project Management Software

Abilities	Microsoft Project	Primavera P3	Primavera P6	Deltek Open Plan
Resource scheduling	○	○	○	○
Resource allocation	○	○	○	○
Resource levelling	○	○	○	○
Resource smoothing	○	○	○	○
Resource profiling	○	○	○	○
Resource-driven duration calculation	○	○	○	○
Resource usage tracking	○	○	○	○
Resource breakdown structure	×	×	○	○
Non-linear resource assignment	×	×	○	○
Productivity calculation	×	×	×	×

EVALUATION OF DELAY ANALYSIS SOFTWARE

A previous study compared two delay analysis software systems, the Primavera Claim Digger and the Schedule Analyzer Professional, to identify their system requirements, functions and employed analysis methodologies (Yang 2005). Based on the research results by Yang (2005), this study further evaluates the function for lost productivity calculation. This study evaluates the systems of Primavera Claim Digger embedded in Oracle Primavera P6 and Schedule analyzer professional version 3.05.

Table 3 shows the evaluation results. Two professional delay analysis systems do not provide a function to calculate delay value that considers lost productivity. Although the evaluated professional delay analysis systems have employed advanced delay analysis methods, they focused only on the surface data, i.e. as-planned and as-built schedules.

Table 3: Abilities of Delay Analysis Software

Feature	Primavera Claim Digger	Schedule analyzer professional
Compatible scheduling system	Embedded in P6	P3, P6
Employed analysis technique	Time impact technique, Windows technique	But-for technique, Windows technique
Calculation of lost productivity	None	None
Others	Data comparisons for general activity data, costs, units, durations, dates, percent complete, constraints, added/deleted assignments, general resource assignment, added/deleted expenses ,general expenses, relationships, activity code assignments, etc.	As-built critical path identification, schedule re-building, as-planned/as-built schedule development, work schedule development, resource usage checking, etc.

CONCLUSIONS

Schedule delays commonly appear in construction projects and result in delay claim progressively. Recently, schedule delay due to lost productivity is one of hottest topics in delay claims. Although various schedule delay analysis methodologies, professional project management software and commercial delay analysis software are available, delay analysts still have difficulties in calculating delay impacts from lost productivity. Based on the evaluation of delay analysis methodologies, professional project management software and commercial delay analysis software, this study concludes that available delay analysis methodologies and project management systems, even professional delay analysis software, cannot deal with the problem of lost productivity in delay analysis. It is required to develop a comprehensive delay analysis method considering lost productivity to help delay analysts to solve complex lost productivity problems in delay analysis. Research results by this study are the basis for developing a comprehensive delay analysis method considering lost productivity. Based on the research findings, this study proposes the potential research topics including developing a comprehensive delay analysis method considering lost productivity and improving project management systems to record all information about planned and actual productivity information.

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