行政院國家科學委員會專題研究計畫 成果報告

考量工率折減之時程延遲分析方法之建立
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行政院國家科學委員會補助專題研究計畫成果報告

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□國際合作研究計畫國外研究報告書一份

執行單位：中華大學營建管理研究所

考量工率折減之時程延遲分析方法之建立

摘要

時程延遲在營建工程專案經常出現，而致使延遲的履約爭議日益增加，在解決延遲的履約爭議時，經常無法使契約雙方獲得滿意的結果，究其原因，除了多數延遲的責任歸屬不易確認外，另外一主要原因乃是延遲分析之計算結果無法令雙方滿意。時程延遲分析的計算方式，已有學者提出數種模式(如 But-for Technique 、Windows Analysis 等)，然而國內外相關延遲分析技術的發展多數偏重於表面結果之分析，少數探究基本原因(如工率折減)之影響，因此分析方法之實用性仍有提升之空間。本研究分析、彙整國內外各種延遲計算方法之程序與優、缺點及所需要的文件，以瞭解各分析方法在解決工率折減延遲問題之成效，並針對各種可取得(包含商用工具)延遲分析工具之功能與優、缺點，及系統所需的資訊，與解決工率折減延遲問題之可能性進行分析。此外，本研究亦分析、彙整國內外遭遇工率折減問題案例及案例中所用之方法的分析程序、功能性、適用性及所需要的文件。最後，則以上述之分析結果為基礎，建構適用於國內且考量工率折減之時程延遲分析法，並以一實際案例驗證方法的可行性。本研究將所建構之方法命名為考量工率折減之崩塌竣工時程分析法。此方法以實際竣工網圖為分析基礎，除可大幅降低甲乙雙方對時程準確性之疑慮，也克服原規劃時程與實際竣工時程產生之差異太大及重建原規劃網圖曠日廢時之問題，並且於分析過程將工率折減因素納入考量，除可分析工率折減所導致之工期延遲天數，也可釐清業主與承包商甚至第三者各應負責之延遲天數。而此方法所使用之基準生產力是以工程性質類似或相同且未受影響之作業的每天每人平均生產力作為基準生產力，於分析過程並不考慮學習效應之差異性。本研究所建立之新式時程延遲分析方法，可解決各單位面臨工率折減時程延遲分析，卻無工具可用之困擾，同時提升時程延遲分析結果之效率與合理性。

關鍵字：工率折減、遲延分析、營建專案

Abstract

Schedule delays are commonly appeared in construction projects and result in delay claim progressively. The resolutions for most delay claims usually cannot satisfy both of the contract parties. The root causes of such circumstances are the responsibilities of most delays being hard to distinguish, and the calculation results of available delay analysis techniques being unacceptable. Several researchers have proposed various schedule delay analysis techniques i.e. But-for Technique, Windows Analysis, etc. However, previous research results mostly focused on surface data (final project completion date) and its consequent results, few looked into the root causes of the factors (i.e. lost productivity) which might impact the schedule. Thus, there is still a room to improve its practicality for available delay analysis methodologies. This study analyzed available schedule delay analysis methodologies to clarify their calculation processes, weakness and strengths, and the required data, to evaluate the ability of solving delay problem with lost productivity. Furthermore, this study evaluate available commercial project management software and schedule delay analysis tools to analyze their pros and cons, required data and the possibility to solve schedule delay problems of lost productivity. Based on reviewing available delay analysis methodologies considering lost productivity, this study developed a new schedule delay analysis methodology with considering lost productivity, termed as "but-for delay analysis method with considering lost productivity." The developed method used the as-built schedules as analysis baseline, and adopted daily average productivity in similar or same construction works that were not affected by any delay event as baseline productivity to calculate the schedule delay impact. In sum, the developed method can be used as a tool to resolve the problem of schedule delay with lost productivity.

Keywords: Lost Productivity, Delay Analysis, Construction Projects.

一、計畫背景

由於營建工程專案的施工項目及工程界面日趨繁多、施工環境亦日趨繁雜，且工程建設施工週期長、各工程間之條件狀況迥異，具有強烈的獨特性，導致影響營建工程專案不確定性因素的發生機率頗大，經常造成工程專案的進度落後。由黃慶隆[1]的研究當中發現，國內重大公共工程之進度落後情形，普遍嚴重，平均約 73.88%的專案發生延遲的現象，而較預定工期縮短者，僅約 17.14%；而吳卓夫等[2]在行政院公共工程委員會的委託研究報告當中，亦曾針對行政院列管之重大公共工程進行延遲發生頻率之統計，其成果顯示總計在 283 筆列管之重大公共工程建設的案例資料中，僅有 38 筆(僅佔 13%)案例資料並無發生任何進度落後，顯見即便是政府列管的重大公共工程，工程進度落後發生的比率依然高。當工程發生時程延遲，契約雙方除須界定延遲的責任歸屬外，更須明確計算逾期日數或求償日數，而延遲分析時，經常發現爭議的雙方各持己見，甚至各自利用不同的觀點與計算基準，提出有利於本身的成果，以作為爭取本身權益的依據。由吳家德[3]的論文研究中以國內公共工程為例，發現國內仲裁爭議以施工階段發生仲裁爭議的比例最高(約為 59.4%)，而其中又以工期延誤為最大之爭議因子(約為 13%)；而根據公部門仲裁失利之重要因子調查中發現，工期的核算是工程執行面上最大的失利因子，顯見工期核算在營建工程爭議發生時的重要性。因此合理延遲工期計算方式是處理工期爭議與分析時程延遲必須先解決的課題。

工程延遲的發生除了責任難以區分的問題外，延遲計算的計算方法及認定標準亦經常是承包商與業主間主要的爭議點，目前常見的分析方法並未有甲乙雙方都認同之方法。通常業主為了管控施工承包商之工程進度，大多會在契約條款中明訂逾期罰款之規定，一般工程所訂定之每日罰款金額約為契約總價之千分之一；而若每日罰金以總價千分之一計，工程費十億元之工程案每逾期一日，僅僅逾期罰款之金額即高達一百萬元，更遑論其他連帶增加的直接或間接工程費用，因此不論業主或是承包商為維護其自身權益與利益，除了在延遲原因的責任認定上各自據理力爭之外，對於延遲時間的計算亦是斤斤計較。然而，過去國內工程契約內容往往較為保護業主，同時有關延遲計算的方式，並未有明確的共識，以至於在延遲認定上經常存有爭議之問題，但隨著產業競爭國際化，誠信原則逐漸的受到各界重視，業主與承包商兩造在契約上的地位逐漸趨於平等，然而國內在延遲計算上並未有一套制式，或被認可的一套具共識的標準延遲計算方法，因此如何客觀、合理的計算出工程的延遲時間，以作為當工程不幸發生延遲時之索賠評估準則為時程管理的重要課題之一。然而前述國際上發展的延遲分析技術，僅著重於表面形態的分析層次(分析原規劃與竣工網圖之差異)，少數探究基本原因(如工率折減問題)之影響，因此各式延遲分析方法之實用性仍有提升之空間。

二、計畫目的

本研究計畫以國內外專家學者曾針對「延遲分析技術」一課題進行分析後所得之研究成果為基礎，針對營建工程面臨工率折減之延遲問題，進行更深入之分析，期望協助解決國內面臨工率折減延遲問題所遭遇的困難，本研究計畫主要目的可歸納為下列四點：

1. **分析國內外各種延遲計算方法之分析程序、方法優、缺點，及所需要的文件，以瞭解各分析方法在解決工率折減延遲問題之效益。**
2. **分析現有考量工率折減之時程延遲分析方法其分析程序、功能性、適用性及所需要文件。**
3. **分析各種可取得(包含商用工具)延遲分析工具之功能與優、缺點，及系統所需的資訊，與在解決工率折減延遲問題之可能性。**
4. **提出國內適用之工率折減延遲問題計算方法。**

三、文獻回顧

(一) *常用延遲分析技術比較*

於尹碧娟[4]之研究中曾針對 Global impact technique、Net impact technique、As-planned expanded technique、Collapsed as–built analysis、Snapshot analysis technique、Window analysis technique、Isolated delay type technique 等七種常見之延遲分析技術的分析程序，及分析結果的優缺點進行分析，其分析成果如表 1 所示；而比較的結果發現 Window analysis technique 與

Isolated delay type technique 是常見的時程延遲分析方法中較為精確且優異的兩種方法。

表 1 常見時程延遲分析技術之優缺點比較表

分析技術	優點				缺點		
	延遲分類	共同延遲	連續延遲	及時要徑分析	邏輯缺陷、漏項	分析耗時、昂貴	依比例分擔責任具爭議
Global impact technique							
Net impact technique							
As-planned expanded technique	●				●		
Collapsed as–built analysis	●						
Snapshot analysis technique		●	●		●		●
Window analysis technique	●		●	●	●	●	●
Isolated delay type technique	●	●	●	●	●	●	

尹碧娟[4]之研究中亦曾針對常見之時程延遲分析技術所需的文件種類進行彙整，彙整結果如表 2 所示；就分析的基礎文件、分析前需準備的文件以及分析時比對的文件需求而言，Window analysis technique 與 Isolated delay type technique 兩種方法所需具備的文件是最少的。

表 2 常見時程延遲分析技術所需文件整理表

分析技術	分析基礎文件		分析前需準備文件(參考計算用)			分析時比對文件		
	原規劃時程	實際竣工時程	原規劃時程	實際竣工時程	延遲歸責分類文件	原規劃時程	實際竣工時程	延遲分析用調整後時程
Global impact technique	●	●	●	●		●	●	
Net impact technique	●	●	●	●		●	●	
As-planned expanded technique	●		●	●	●	●		●
Collapsed as–built analysis		●	●	●	●		●	●
Snapshot analysis technique	●		●	●	●	●		●
Window analysis technique	●		●		●	●		●
Isolated delay type technique	●		●		●	●		●

Yang et al. (2007) 根據過去的相關研究成果，針對延遲的分析功能，包括：即時分析、共同延遲的處理、步調延遲的分析等，彙整目前較為熱門的延遲分析技術進行比較，如表 3 所示。發現 Window analysis technique 較其他延遲分析技術所能處理的延遲狀況較多，也能處理相對較為複雜的延遲狀況[5]。

表 3 時程延遲分析技術功能性比較整理表

延遲分析方法	功能			
	即時要徑分析	即時延遲資訊分析	共同延遲	步調延遲
As-planned vs. as-built method	×	×	×	×
Global impact technique	×	×	×	×
As-planned technique	×	×	×	×
Impacted as-planned technique	×	×	×	×
Net impact technique	×	×	×	×
Time impact technique analysis	○	○	×	×
But-for	×	×	○	×
Isolated delay type technique	○	×	○	×
Snapshot technique	○	○	○	×
Windows analysis	○	○	○	×

註：○ with the capability；× without the capability.

本研究則針對 Global impact technique、Net impact technique、As-planned expanded technique、Collapsed as-built technique、Snapshot analysis technique、Window analysis technique、Isolated delay type technique、Isolated collapsed as–built delay analysis 及 Effect-based delay analysis method[6]等 9 種延遲分析技術在分析過程中所考量之延遲因素(包括工率折減)，進行比較(如 4 所示)後發現，以 Effect-based delay analysis method 在分析過程中所能考量之延遲因素為最多，但這此延遲分析技術仍無法分析工率折減因素所造成的時程延遲。

表 4 延遲分析技術考量因素彙整表

考量延遲因素 / 延遲分析技術	區別延遲責任	考量共同延遲	考量連續延遲	考量步調延遲	及時要徑分析	及時延遲資訊分析	考量工率折減因素
Global Impact Technique	×	×	×	×	×	×	×
Net Impact Technique	×	×	×	×	×	×	×
As-Planned Expanded Technique	○	×	×	×	×	×	×
Collapsed As–Built Analysis	○	×	×	×	×	×	×
Snapshot Analysis Technique	×	○	○	×	○	○	×
Window Analysis Technique	○	○	○	×	○	○	×
Isolated Delay Type Technique	○	○	○	×	○	×	×
Isolated Collapsed As–Built Delay Analysis	○	○	○	×	×	×	×
Effect-Based Delay Analysis Method	○	○	○	○	○	○	×

四、排程與延遲分析軟體生產力相關功能分析

(一) *排程軟體生產力相關功能分析*

由於工率折減(損失生產力)在量化或計算的過程中必須具有實際生產力相關數據，才能進行所謂工率折減量化或計算，而目前又以 Microsoft Project、Primavera Project Planner(P3 與 P6)及 Open Plan 等 4 種一般性商業套裝軟體是較常被營建產業所使用，若上述這些軟體具備偵測或計算工率折減之相關功能，不但可減少工率折減發生的機率，也可提升日後時程延遲分析之效益。本研究針對前述常用的一般性商業套裝排程軟體，進行生產力相關功能之彙整及分析(如表 5 所示)，以瞭解目前常用的一般性商業套裝排程軟體在解決工率折減延遲問題之可能性。

表 5 排程軟體生產力相關功能彙整表

軟體名稱 / 功能	Project	P3	P6	OPP
資源分配	○	○	○	○
資源排程	○	○	○	○
資源撫平	○	○	○	○
資源平滑分配功能	○	○	○	○
資源用量分析(包括各式資源流量分析與各式資源圖表輸出等)	○	○	○	○
資源驅控工期(自動判定影響作業完成時間的資源)	○	○	○	○
追蹤資源進度	○	○	○	○
資源開銷率	○	○	○	○
估計資源需求	○	○	○	○
最佳化資源的專案計劃	○	○	○	○
計算加班成本	○	×	○	○
資源 RBS 之建立	×	×	○	○
非線性資源分配曲線(依資源性質設定不同耗用模式)	×	○	○	×
計算延遲任務之剩餘工時	○	○	○	○
檢視資源工作量及可用性	○	○	○	○
自訂欄位並設定公式	○	○	○	○
工率折減相關功能	×	×	×	×

註：○為具有該功能；×為不具有該功能

經本研究分析後發現，雖然這 4 種軟體可以記錄工率折減量化或計算時所需的資料(如作業開始與完成時間、作業所使用之人力與材料及設備、加班工時等)也有許多相對應之功能可進行與生產力有關的分析(如：資源撫平、資源用量分析及預估資源需求等)，但這 4 種軟體在計算或分析生產力相關數據的過程中並未將工率折減因素納入考量，而且這 4 種軟體也沒有任何可考量或計算工率折減之功能。目前唯一可解決之方式是透過自訂工率折減計算時所需之相關欄位並且設定其欄位的公式才能進行工率折減計算，但由於目前國內外對於工率折減並未有一套制式的計算方式，因此計算結果會因人而異，且不一定被業主或法院所接受。

(二) *延遲分析軟體生產力相關功能之彙整與分析*

相較於上述 4 種一般性商業套裝軟體而言，專業的延遲分析軟體最主要的功能是用來分析原規劃時程與實際竣工時程要徑之差異以及每個作業項目中所有資料的差異性，如：作業開始時間與結束時間之差異、成本之差異性、資源之差異性，甚至是分別計算出 NE、EN、EC 的值，但這些功能會隨著不同的分析軟體而有所不同。本研究將針對目前可取得之延遲分析軟體，如：Schedule Analyzer Professional 與 Primavera Claim Digger 進行系統分析及功能彙整，藉此釐清這兩種延遲分析軟體是否能夠進行工率折減相關數據之計算。

本研究根據上述兩種延遲分析軟體進行功能彙整及分析後發現，Claim Digger 雖然可以針對不同專案或專案中之不同作業項目進行詳細的分析比較(如：General Project Data、General WBS Data、Project Budget Data 、General Activity Data、Percent Complete 等)，但並無工率折減相關之分析功能。Schedule analyzer professional 亦是如此，雖然具有 Resource Checker 之功能，但此功能僅是分析經過資源撫平後的作業實際上使用資源的差異性，仍無法針對工率折減問題進行分析。

五、現有考量工率折減之時程延遲分析方法

(一) *方法一*

此方法為 OO 公司 OO 高級中學第一期校舍新建工程工期展延爭議調處案中使用的方法，其解決之方式係單純計算整體資源差異所造成的工期差異。此方法之計算邏輯為以計畫施工效率及實際施工效率為依據，計算出工率折減之數值，再以工率折減之數值為依據計算出應核給展延工期天數。經本研究分析，OO 工程股份有限公司所提出之工率折減時程延遲分析方法，其分析流程，如圖 1 所示。

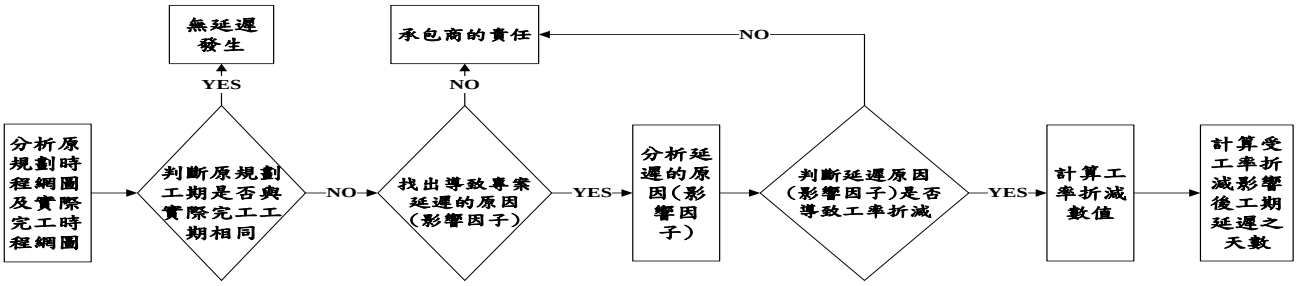

圖 1 方法一分析流程

(二) *方法二*

此方法由 Lee et al.[7]所提出，其目的主要為探討工率折減(損失生產力)造成工期延遲的影響程度，並且根據工率折減影響所造成之工期延遲天數與工率折減發生原因來分配業主、承包商或甚第三人各自應負之延遲天數。此方法之成果可區分為兩部分：其一，計算工率折減轉換成工期之計算邏輯；其二，將工率折減影響之工期納入延遲分析評估。此方法之計算邏輯，係在某個已延遲之作業項目中找出可能導致工率折減(損失生產力)的影響因子，並計算與比較該未受到影響因子影響期間及受到影響因子影響期間各種生產力數據(如每天每人平均生產力、受到影響因子影響期間之生產力損失總和與工作量損失總和以及所造成之工期延遲總和)之差異，再根據這些計算結果與工率折減發生原因來分配業主、承包商或甚第三人各自應負責之延遲天數。經本研究分析，Lee et al.[7]所提出考量工率折減之所造成延遲分析之方法論，其分析流程如圖 2 所示。

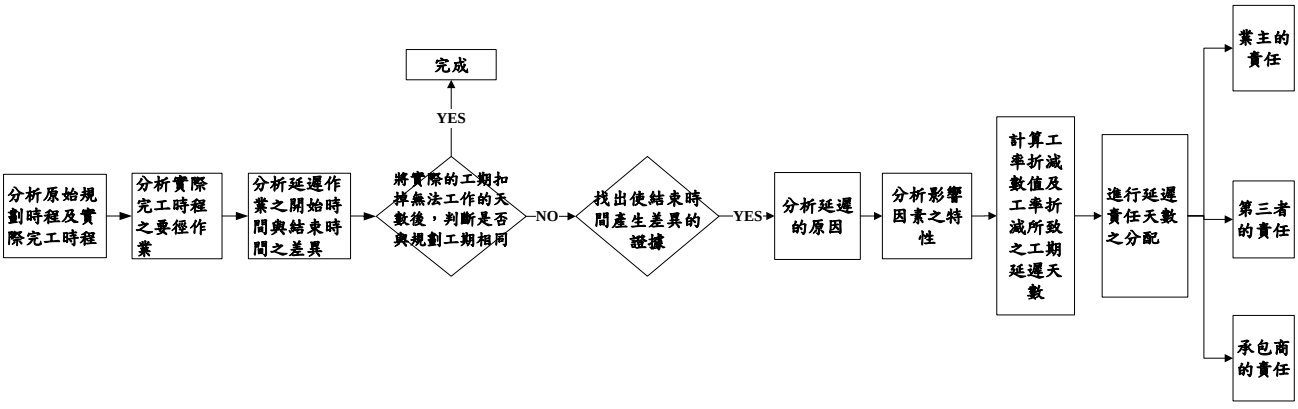

圖 2 方法二分析流程

(三) *方法三*

此案例為國內一工率折減爭議調處案例，該工程為西濱快速公路 OO 標新建工程，展延工期爭議事件，因雙方無法達成協議，因而申請履約爭議調解。該案例中所使用之分析方法，是由 OO 公司所提出。其目的最主要為證明因受到第三人因素影響(如強風)使得承包商無法出

工，導致其工率下降所造成的工期延遲。此方法之計算邏輯，係為統計受到第三人因素影響日數之總和，並以此為依據再運用三種計算準則(日數、半日數、半工作日數)計算其預期的工率、損失的工率、實際的工率，再根據這三種工率數值計算應可展延之日數。經本研究分析，OO公司所提出之工率折減時程延遲分析方法，其分析流程，如圖 3 所示。

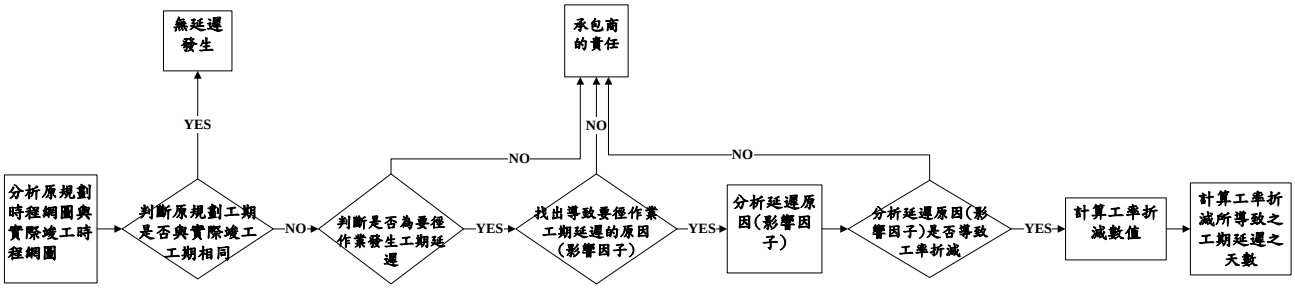

圖 3 方法三分析流程

(四) *方法分析所需資料及數據*

表 6 為方法一至方法三分析時所需資料及數據，由於三種方法在分析工率折減過程會隨著工程專案實際狀況而所有變化，並非任何一種專案都可適用於這三種方法，因此這三種方法分析時所需之資料也會隨著專案之實際狀況、可取得之相關資料、產生爭議的點及工率折減發生的原因而有所差異。由表 6 中可以發現，三種方法分析時所需之共同資料為原規劃時程、實際峻工時程及各作業項目受影響因子與未受影響因子影響之工期。就這三種方法而言，以方法一、二分析過程所需資料為最多。

表 6 有考量工率折減之時程延遲分析方法一至三分析所需資料及數據表

分析方法 / 所需資料及數據		方法一	方法二	方法三
時程部分	原規劃網圖	○	○	○
	實際峻工網圖	○	○	○
生產力部分	受影響因子與未受影響因子影響期間之總出工數		○	
	原規劃與實際之總出工數	○		
	受影響因子與未受影響因子影響期間之工作量		○	
	受影響因子與未受影響因子影響期間之每天每人平均生產力			
	原規劃、實際及損失之工率	○	○	○
成本部分	受影響因子影響期間所花費之成本總和	○		
	專案原規劃成本與實際峻工成本	○		
天候部分	逐日逐時氣象資料(風速/風向/豪雨等)		○	○

六、新時程延遲分析方法之建立與應用

(一) *新式延遲分析法之基本概念*

考量工率折減之崩塌竣工時程分析法之基本概念為：「以實際竣工網圖為基礎，分別運用業主與承包商觀點進行延遲分析，以業主觀點進行分析時，則於實際竣工網圖中移除不可原諒延遲，得到包含業主延遲責任之時程網圖，再將此網圖與實際竣工網圖進行比對，兩者之差異值即為未考慮工率折減情況下承商須負責之延遲天數。反之，以承商觀點進行分析時，則需先行計算出工率折減所致之延遲天數，因工程進行中因第三人或業主因素障礙，導致產值降低，係非可歸責於承包商，故工率折減影響所致之工期延遲應為可原諒延遲，再於實際竣工網圖中移除所有可原諒延遲(包含雙方先前所核定確認完成之可原諒延遲與工率折減所致之延遲)，得到包含承商延遲責任之時程網圖，再將此網圖與實際竣工網圖進行比對，兩者之差異值即為最終承商可向業主求償之延遲天數(可原諒延遲)。最後再將未考慮工率折減情況下承商須負責之延遲天數與最終承商可向業主求償之延遲天數進行比對，兩者之差異值即為最終承包商需負責之延遲天數(不可原諒延遲)。

(二) *新式延遲分析法之假設條件*

1. 新式延遲分析法所使用之基準生產力是以工程性質類似或相同且未受影響之作業的每天每人平均生產力作為基準生產力。
2. 新式延遲分析法於分析生產力數據時，假設生產力沒有學習效應(learning effect)之差異性。

3. 新式延遲分析法所分析之作業皆不考慮及計算其次作業之當量與生產力，僅針對該作業本身進行分析。
4. 新式延遲分析法僅適用於分析專案作業之工期已發生延遲的情況。
5. 實際案例中所使用之原規劃及實際峻工網圖的工期均為正確之工期。

(三) *新式延遲分析法之分析原則*

應用此項技術必須備有原規劃時程網圖、實際竣工時程網圖、延遲歸責分類完成之文件以及專案或作業項目實際生產力相關資料(如出工數、工作量)。考量工率折減之崩塌竣工時程分析法之分析流程如圖 4 所示。

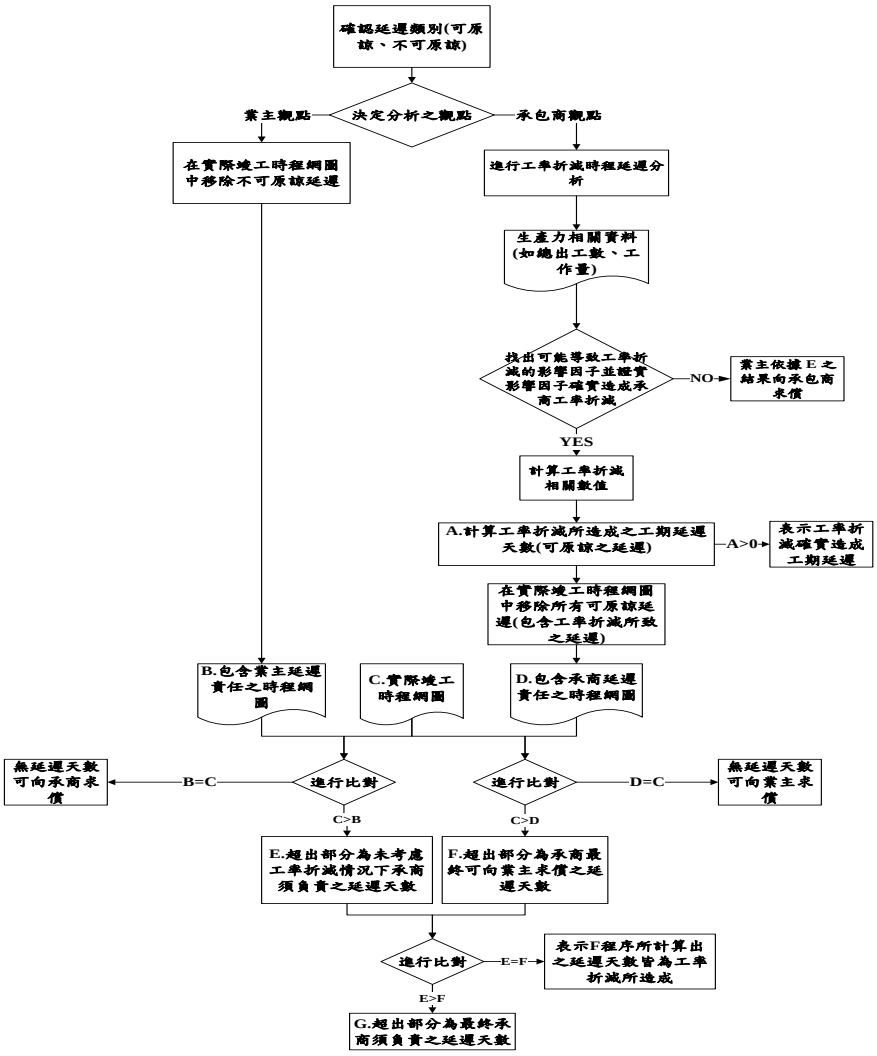

圖 4 考量工率折減之崩塌竣工時程分析法分析流程

(四) *案例驗證*

1. 案例說明

此案例為國內某一專案工程於施工期間，受第三人因素影響而遭遇工率折減之實際案例，由於該案例之排水箱涵工程中編號 B009 箱涵進行開挖及 PC 澆置作業時分別受到自來水管線、台電高壓管線、網路管線及瓦斯管線等四種管線及既有地下之鋼筋混凝土結構物(現場情況差異)等妨礙影響，使得承包商於作業時發生工率折減現象，進而導致該作業工期之延遲。而屬於同性質同尺寸之箱涵，排水箱涵編號 C063 箱涵進行開挖及 PC 澆置作業時並未受到任何管線或第三因素妨礙，該作業之工期並未發生延遲情況，再加上 B009 與 C063 排水箱涵工程皆位於該案例之要徑上(上述兩個箱涵工程為該案例中已完成之工程)，因此本研究將以上述兩個排水箱涵中的開挖及 PC 澆置作業為例，運用本研究所建立之新式時程延遲分析法進行分析，計算工率折減影響所造成之工期延遲天數，並釐清業主與承包商於此延遲事件中各應負責之延遲天數。

表 13 B009 排水箱涵原規劃時程與竣工時程對照表

ID	作業名稱	原規劃資訊				竣工資訊			
		工期(天)	前置作業	開始時間	結束時間	工期(天)	實際開始時間	實際結束時間	延遲(天)
—	B009箱涵4K+089.6～4K+149 L59.4*W4*H3	55d	—	97/11/6	97/12/30	70d	97/11/6	98/1/14	15d
2	開挖&PC	11d	—	97/11/6	97/11/16	26d	97/11/6	97/12/1	15d
3	底版 SEC 1/3	5d	2	97/11/17	97/11/21	5d	97/12/2	97/12/6	0d
4	底版 SEC 2/3	5d	3	97/1122	97/11/26	5d	97/12/7	97/12/11	0d
5	底版 SEC 3/3	5d	4	97/11/27	97/12/1	5d	97/12/12	97/12/16	0d
6	側牆及頂版 SEC 1/3	8d	3	97/12/22	97/12/29	8d	97/12/7	97/12/14	0d
7	側牆及頂版 SEC 2/3	8d	6,4	97/11/30	97/12/7	8d	97/12/15	97/12/22	0d
8	側牆及頂版 SEC 3/3	8d	7,5	97/12/8	97/12/15	8d	97/12/23	97/12/30	0d
9	進水孔 SEC 1/3	5d	6	97/11/30	97/12/4	5d	97/12/15	97/12/19	0d
10	進水孔 SEC 2/3	5d	9,7	97/12/8	97/12/12	5d	97/12/23	97/12/27	0d
11	進水孔 SEC 3/3	5d	10,8	97/12/16	97/12/20	5d	97/12/31	98/1/4	0d
12	回填	10d	11	97/12/21	97/12/30	10d	98/1/5	98/1/14	0d

表 14 C063 排水箱涵原規劃時程與竣工時程對照表

ID	作業名稱	原規劃資訊				竣工資訊			
		工期(天)	前置作業	開始時間	結束時間	工期(天)	實際開始時間	實際結束時間	延遲(天)
—	C063箱涵6K+176.5～6K+321.5 L145*W4*H3	106d	—	97/8/21	97/12/4	106d	97/8/21	97/12/4	0d
2	開挖&PC	27d	—	97/8/21	97/9/16	27d	97/8/21	97/9/16	0d
3	底版 SEC 1/8	5d	2	97/9/17	97/9/21	5d	97/9/17	97/9/21	0d
4	底版 SEC 2/8	5d	3	97/9/22	97/9/26	5d	97/9/22	97/9/26	0d
5	底版 SEC 3/8	5d	4	97/9/27	97/10/1	5d	97/9/27	97/10/1	0d
6	底版 SEC 4/8	5d	5	97/10/2	97/10/6	5d	97/10/2	97/10/6	0d
7	底版 SEC 5/8	5d	6	97/10/7	97/10/11	5d	97/10/7	97/10/11	0d
8	底版 SEC 6/8	5d	7	97/10/12	97/10/16	5d	97/10/12	97/10/16	0d
9	底版 SEC 7/8	5d	8	97/10/17	97/10/21	5d	97/10/17	97/10/21	0d
10	底版 SEC 8/8	5d	9	97/10/22	97/10/26	5d	97/10/22	97/10/26	0d
11	側牆及頂版 SEC 1/8	8d	3	97/9/22	97/9/29	8d	97/9/22	97/9/29	0d
12	側牆及頂版 SEC 2/8	8d	11,4	97/9/30	97/10/7	8d	97/9/30	97/10/7	0d
13	側牆及頂版 SEC 3/8	8d	12,5	97/10/8	97/10/15	8d	97/10/8	97/10/15	0d
14	側牆及頂版 SEC 4/8	8d	13,6	97/10/16	97/10/23	8d	97/10/16	97/10/23	0d
15	側牆及頂版 SEC 5/8	8d	14,7	97/10/24	97/10/31	8d	97/10/24	97/10/31	0d
16	側牆及頂版 SEC 6/8	8d	15,8	97/11/1	97/11/8	8d	97/11/1	97/11/8	0d
17	側牆及頂版 SEC 7/8	8d	16,9	97/11/9	97/11/16	8d	97/11/9	97/11/16	0d
18	側牆及頂版 SEC 8/8	8d	17,10	97/11/17	97/11/24	8d	97/11/17	97/11/24	0d
19	回填	10d	18	97/11/25	97/12/4	10d	97/11/25	97/12/4	0d

2. 分析結果

根據上述之計算結果可得知 B009 箱涵之開挖及 PC 澆置作業延遲的 15 天中，有 14.49 天是因為承包商實際執行該作業時受到地下管線妨礙及現場情況差異所引起之工率折減而導致的工期延遲，通常國內承包商遭遇管線妨礙所採用之處理方式大致上可分為(1)採管線遷移作業。(2)採現地保護方式作業。若採用遷移方式，則需等待相關單位會勘且同意後才可進行遷移，從等待相關單位會勘至完成管線遷移這段期間，承包商係現場必須停工且管線遷移作業時間長，導致工期延誤時間無法掌控。反觀，若採用現地保護，承包商無須停工且可繼續施作，但承包商通常為避免破壞既有管線而必須降低施工速度，進而造成工率產生折減現象。但此過程工率折減並非承商本身錯誤所造成，而是受到地下管線與現場情況差異等妨礙所引起的，因此由工率折減所造成之 14.49 天延遲應為可原諒之延遲，也就是最終承包商可向業主求償之延遲天數，而剩餘之 0.51 天即為不可原諒之延遲，也就是承包商最終需負責之延遲天數。

七、結論與建議

(一) *結論*

1. 延遲分析技術之分析與比較

本研究針對各種時程延遲分析方法之分析流程、優缺點、及所需文件清單所進行之整理與歸類，可作為延遲分析所用之標準，由於此些分析的方法係一般性的方法，對於跨國專案有相當程度的實用性。也可提升日後各項時程延遲分析技術相關研究之研究效率。但目前各

種時程延遲分析方法仍無法考量工率折減問題，亦無法合理計算工率折減造成之延遲天數問題。

2. 排程軟體及延遲分析工具之分析與比較

本研究所完成各種可取得輔助時程延遲分析工具(包含商業化的工具)之系統功能、特性比較及所需資訊清單，可使當需要實用輔助工具時，做為系統選擇之依據，增加選用之效益。但目前各種排程軟體與延遲分析工具仍無法偵測工率折減問題，亦無分析工率折減之功能。

3. 工率折減問題案例所用之方法分析

由於國內業界對於工率折減之觀念仍屬萌芽階段，再加上目前國內多數有關時程延遲之研究重點皆著重於時程延遲原因分析以及時程延遲分析技術之分析或改進，尚未有任何研究針對工率折減問題進行詳細之分析。因此由本研究所分析之工率折減問題案例中所使用之方法以及所整理之方法所需相關資料，可作為日後承包商遭遇工率折減問題時之參考資料，也可作為後續相關研究之參考。

4. 新式延遲分析方法之建立

目前國內業界並無一普遍可接受的時程延遲分析方法，且目前的延遲分析技術，並無法解決更深入的延遲問題，例如因工率折減所造成的延遲衝擊，再加上由於多數營建工程專案提出之原規劃時程網圖皆不完整，造成無法作為遲延分析時之基礎。然而，依據會議記錄、施工紀錄及工程日報等相關文件，重新建構詳細完整適合延遲分析之實際竣工時程網圖確實比原規劃時程網圖來的容易及精確。根據上述之考量，本研究所建立之考量工率折減之崩塌竣工時程分析法以目前國內業界所能接受、國外最常為仲裁工程爭議法庭採用之崩塌竣工時程分析法與現有功能性、適用性較佳之工率折減時程延遲分析法所結合而成，此方法以實際竣工網圖為分析基礎，除可大幅降低甲乙雙方對時程準確性之疑慮，也克服原規劃時程與實際竣工時程產生之差異太大及重建原規劃網圖曠日廢時之問題，並且於分析過程將工率折減因素納入考量，先行釐清工率折減所導致之工期延遲天數，再進行時程延遲分析，如此一來，不但可清楚分析出工率折減所導致之工期延遲天數，也可釐清業主與承包商最終應負責之延遲天數。而此方法亦已透過國內一實際遭遇工率折減之案例驗證了方法的可行性。本研究所建立之國內營建工程環境適用之延遲計算方法可解決各單位面臨工率折減時程延遲分析，卻無工具可用之困擾，同時提升時程延遲分析結果之效率與合理性。

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國科會補助專題研究計畫項下出席國際學術會議心得報告

日期: 99 年 7 月 12 日

計畫編號	NSC 98－2221－E－216－046－		
計畫名稱	考量工率折減之時程延遲分析方法之建立		
出國人員 姓名	楊智斌	服務機構 及職稱	中華大學營建管理研究所教授
會議時間	99 年 6 月 25 日至 99 年 6 月 27 日	會議地點	Bratislava, Slovakia (斯洛伐克)
會議名稱	(中文)第 27 屆(2010 年)國際營建自動化與機器人研討會 (英文) The International Symposium on Automation and Robotics in Construction (ISARC 2010)		
發表論文 題目	(中文)延遲分析方法於營建專案工率折減應用之評估 (英文) Evaluation of Delay Analysis Methodologies on Lost Productivity in Construction Project		

一、參加會議經過

本人隨同國內他校營建管理之教師與博士生於台北出發經維也納後，經由陸路轉至斯洛伐克(Slovakia)的首都布拉提斯拉瓦(Bratislava)參加此研討會，研討會舉辦地點為 Hotel Crowne Plaza, Bratislava (位於斯洛伐克總統府對面)，研討會報到日為 6/24，論文發表從 6/25 至 6/27 日止，計有二天半。論文發表之場次安排請見附件。或許此次的研討會舉辦地點位於東歐的斯洛伐克，因此出席的國際人士並未如同以往的踴躍。研討會，主辦單位除了制式的論文發表外，亦安排經由多瑙河到 Devin Castle，以及 Red Stone Castle 的參觀。本人參與發表的論文被安排於 6/25 下午與 6/26 下午。整體而言，此次的研討會除了論文發表之外，亦與他國的學者有一些交談與互動，對於日後的研究將有所幫助。

二、與會心得

此次研討會主辦單位 Slovak University of Technology (SUT) in Bratislava，有別於傳統此研討會在 keynote speech 邀請具有聲望之學者進行前瞻性演講，而改以學校的校長與土木學院院長進行學校簡介之安排，雖然參與者可能會有些失望，但無疑對於學校是一種非常特殊且有意義的宣傳。此外，此次所有發表者中，台灣之發表者佔有相當之比例，顯示國內在營建工程與管理領域在國際上相關學術活動十分活耀，且占有一定之分量。而政府部門若能輔導國內學術單位積極爭取相關學術活動在台舉辦，除能提升台灣之能見度外，亦能提升台灣營建工程與管理領域之地位，對於國內日後營建工程與管理領域將更能奠立更好的學術交流基礎。此外由研討會所發表之論文，亦可以看到一些國際上有關 BIM(Building Information Modeling)的研究成果與趨勢，國內營建工程與學術界亦有意朝此一領域發展，相信此次研討會的資料應能提供國內學術界重要參考訊息。

主辦單位安排 Devin Castle 以及 Red Stone Castle 的參觀，由此兩城堡的參觀，不難發現斯洛伐克政府希望透過古蹟的保存與維護，擴展觀光資源，發展無煙囪產業，此部分值得國內多加學習。

三、考察參觀活動(無是項活動者略)

趁參加此次研討會之便，本人與國內其他學校(包括本校、中央、台科大、交大、淡江、中原)之教師一同參訪捷克、斯洛伐克、奧地利當地有關之建設項目，收獲頗豐。

四、建議

此次研討會主辦單位 Slovak University of Technology (SUT) in Bratislava 之土木學院(Faculty of Civil Engineering)建築技術系(Department of Building Technology)幾乎以最少的資源與人力安排此一國際性研討會，雖然活動精簡但精緻，相信對於參與安排之人員將能獲得非常好的學習經驗。因此，本人認為舉辦國際學術研討會所需投入的資源與所獲得的效益，十分可觀。國內過去幾年積極推動會展產業(MICE，國內外會議(Meeting)、獎勵旅遊(Incentive Travel)、國際會議(Convention)及展覽(Exhibition))，若能由政府積極補助並推動學術單位爭取國際研討會到台灣舉辦，並結合 MICE 產業投入，除能提升原有領域之學術地位外，亦能帶動 MICE 產業之發展。

五、攜回資料名稱及內容

ISARC 2010 研討會論文集一冊。

六、其他

無。

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

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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

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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

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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.

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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

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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.

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Resource breakdown structure	×	×	○	○
Non-linear resource assignment	×	×	○	○
Productivity calculation	×	×	×	×

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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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無研發成果推廣資料

98 年度專題研究計畫研究成果彙整表

計畫主持人：楊智斌	計畫編號：98-2221-E-216-046-
計畫名稱：考量工率折減之時程延遲分析方法之建立	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	1	0	100%		完成一計畫成果報告
		研討會論文	1	0	100%		研究論文被 2010 營建工程與管理學術研討會評為佳作論文
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	3	0	100%	人次	一碩士生畢業論文與本計畫相關
		博士生	1	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	1	0	100%		發表於 ISARC 2010 研討會，此研討會為 ISTP index 研討會。
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	無

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：■已發表 □未發表之文稿 □撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：(以 100 字為限)

已發表國際學術研討會論文(ISARC 2010)，國際期刊論文撰寫中。

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）(以 500 字為限）

此計畫之研究成果可做為解決工率折減延遲分析之基礎，讓學術研究得以更深入分析，讓產業界得以有輔助性工具可以參考使用。