

**IMPORTANCE OF FLOAT MANAGEMENT IN CONTRACTOR'S
EXTENSION OF TIME CLAIMS, A CASE STUDY**

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**İS PROGRAMLARINDA BOLLUK YÖNETİMİNİN YÜKLENİCİLERİN
SÜRE UZATIM TALEPLERİNDEKİ ÖNEMİ
ÖRNEK ÇALIŞMA**

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FOREWORD

I would like to express my deep appreciation and thanks for my Prof. Dr. Atilla DIKBAS.

This study is dedicated for my dear wife Gulsah.

May 2010

Emre BAYRAK

(Architect)

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ABBREVIATIONS

EOT	: Extension of Time
SCL	: Society of Construction Law
TIA	: Time Impact Analyses
W	: Window
PLN	: Planned
PLN-IMP	: Planned and Impacted
MEP	: Mechanical, Electrical, and Plumbing
DM	:Dubai Municipality
O	:Owner
C	:Contractor

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IMPORTANCE OF FLOAT MANAGEMENT IN CONTRACTOR'S EOT CLAIMS – A CASE STUDY

SUMMARY

Delays on construction project are common occurrences and, related to that contractors submit their extension of time and entitled damages as requirements of their contracts. The float allocation and its accurate usage are key points for success of contractors' extension of time claims. This study discusses the importance of float allocation on contractor's extension of time claims in two case studies on a high-rise building project.

On first case study, a forensic analysis has been introduced to demonstrate the delay events and accelerations on contractors' contract and internal programme those represent different risk assumptions by using time impact analysis method.

Analysis results indicate that no matter activity durations are increased by risk allocations or manipulation of contractor, float allocation and contingencies at activity durations may change the nature of contractors' extension of time claims. Such changes may result in changes in the quantification of delay analysis, may affect the validity of previous extension of time claims and may eliminate the right of valid extension of time claims in future.

The second part of study, a methodology is proposed to qualitative contractors own risks assumptions considering and analyzing the circumstances of case project. By the application of proposed methodology, the improvements, on management of float allocation and its reflection to programmes have been targeted. Additionally the impact of mismanaged float to the validity of extension of time claims can be minimized. Although the model has been developed for one case project, later improvements can be applied for adaptation of model on more complex projects.

İŞ PROGRAMLARINDA BOLLUK YÖNETİMİNİN YÜKLENİCİLERİN SÜRE UZATIM TALEPLERİNDEKİ ÖNEMİ - ÖRNEK ÇALIŞMA

ÖZET

İnşaat projelerinde gecikmeler sıklıkla olabilmektedir, buna bağlı olarak yükleniciler kontratlarının gerekliliği olarak süre uzatım ve ilişkili maliyet taleplerini hazırlamaktadırlar. Bolluk dağıtımı ve doğru kullanımı yüklenicilerin süre uzatım talepleri için çok önemli anahtar konuları oluşturmaktadır.

Bu çalışma yüklenicilerin iş programlarındaki bolluk dağıtımlarının süre uzatım talepleri üzerindeki etkisini, bir yüksek bina projesi üzerindeki iki örnek çalışma ile tartışmaktadır.

Birinci örnek çalışmada, yüklenicinin geçmiş bir yıllık dönemi içindeki gecikme ve hızlanma vakaları, pencere analiz tekniği kullanılarak, farklı risk kabullerinin yapıldığı sözleşme ve yüklenicinin dahili programında geçmişe dönük olarak analiz edilmiştir.

Bu analizin sonucunda, programlarındaki aktivite süreleri gerek yüklenici tarafından saptırılmış, gerek risk faktörü eklenerek arttırılmış olsun, bu durumun yüklenicilerin süre uzatım taleplerinin tabiyatını değiştirdiği görülmüştür. Bu değişiklikler analizlerindeki gecikme hesaplamalarında azalmalara, geçmişte teslim edilmiş taleplerin geçerliliğini yitirmesine ve gelecekte yapılması planlanan haklı süre taleplerinin oluşamamasına sebebiyet verebilmektedir.

İkinci örnek çalışmada ise örnek projenin şartları dikkate alınarak, yüklenicinin, kendi taşıdığı gecikme riskini nitelendirmek ve görselleştirmek amaçlı uygulanabilir bir model önerilmiştir. Bu modelin uygulanması ile iş programlarındaki bollukların proje yüklenicisi takımı tarafından daha iyi yönetebilenmesi ve iş programına dağıtılması amaçlanmaktadır. Bununla birlikte yanlış yönetilen bolluk sonucuna bağlı olarak, süre uzatım taleplerinin geçerliliğini yitirmesi de engellenebilir. Önerilen model sadece örnek proje için geliştirilmiş olsada, ileride daha karmaşık yapıya sahip projelerde kullanılmak üzere geliştirilebilir.

1. INTRODUCTION

1.1 Background

There is universal agreement that delay is a common occurrence in the construction industry worldwide (Al-Khalil, 1996; Chan and Kumaraswamy, 1997; Frimpong et al., 2003; Koushki et al., 2005; Arditi and Pattanakitchamroon, 2006).

Several studies have concentrated on issues of delay analyses and its combined concepts as ownership of float, concurrent delays, the migration of the critical path, productivity losses and resources allocation (Kraiem and Diekmann 1987; Galloway and Nielsen 1990; Arditi and Robinson 1995; Chehayeb et al. 1995; Alkass et al. 1996; Bordoli and Baldwin 1998; Finke 1997, 1999; Shi et al. 2001; Gothand 2003; Sandlin et al. 2004; Mbabazi et al. 2005; Al-Gahtani and Mohan 2005; Hegazy and Zhang 2005; Kim et al. 2005; Lee et al. 2005; Ibbs and Nguyen 2007). In addition developments in computer technology and advanced project planning softwares have improved the capabilities of delay analyses techniques over the past decade (Pickavance 2005)

“Delay and Disruption Protocol” published by the UK’s Society of Construction Law (SCL, 2002) and “Forensic Schedule Analysis” by US’s Association for Advancement of Cost Engineering International (AACEI, 2007) are the recent two practical guide for delay analyses.

However, related debates are still continues, even today’s most preferred techniques, such as “but for” and “window analysis” have important limitations and require improvements (Mohan and Al-Gahtani 2006). In addition, industry practitioners continue discussion on which schedule analysis technique is preferable (Arditi and Pattanakitchamroon 2006; Zack 2006).

1.2 Determination of Scope and Purpose of Study

The discussion of float concept and its relevant issues as acceleration, concurrency and mitigation are affecting the nature of delay analysis and EOT claims.

The current practice of apportioning float ownership, as “first come, first served” basis, is in benefit of the party who uses float first, to mitigate the potentially negative effect of delaying events and at the expense of other party who delays critical activities in the later stages of the project.

Although the ownership of float is not always recognised as the contractors’ (Pasiphol, 1994) itself, by preparation of tender or contract programmes, contractor becomes responsible for maintaining the preliminary distribution of float.

During this pre allocation period, contractors usually define their exclusive float and include it as contingency activities or by increased activity durations for their project risks or resource allocation. Moreover, this process may be repeated in revisions or updates of schedules.

In line with critical path, float in a project does have a dynamic nature. The amount and allocation of contractors’ float may change the nature of time claims if the project risks aren’t accurately been considered.

Contractors exclusive float allocation or usage should correspond to the contractors risk assumption as, the activities who bear the most risk should own the most float. (Khalid, 2009)

The research aims to highlight the importance and explain the complexity of float management and its effects on validity of extension of time claims. Purpose of this study includes;

- Demonstrate the effects of different risk assumptions on the validity of EOT claims by a forensic analysis on contractors’ case work programmes.
- Demonstrate a practical methodology for contractors to qualitative their exclusive risk for float distribution or time contingencies.

1.3 Objectives of the Study

The objectives of the study are defined as below;

- Overview the basics of float concept and related issues as acceleration, mitigation and concurrency.

- Compare and quantify the results of delay events demonstrated in different programmes with different risk assumptions.
- Qualitative and visualize contractors' delay risk on selected case study and overview the results

1.4 Content of the Study and Methodology

After reviewing the purpose, research objectives, and content of the study in Chapter 1, the thesis continues with the description of main terminologies for delay analysis in the construction industry at chapter 2. In this chapter, the float is the predominantly discussing point. Following issues as acceleration, mitigation, concurrency and delay types and analyses are described in term of their relation with float. In chapter 3, the case building and theoretical delay events in a certain period has been introduced. A forensic schedule analysis has been done on contractors two separate programmes representing its different risk assumptions. The results and findings have been discussed. In chapter 4, a methodology has been proposed to qualitative and visualize contractors delay risk. In chapter 5, the proposed methodology at chapter 4, is discussed in comparison with a similar methodology in literature.

In the conclusion part findings and conclusions are presented and the evaluation of possible ways for further analysis has been discussed.

As methodology: A literature review has been done on books, papers and accepted standards on delay related issues for representation of different approaches. "Delay and Disruption Protocol" published by the UK's Society of Construction Law (SCL, 2002) is accepted as a practical guide as it is widely used in construction industry. Time Impact Method has been used as a technique of forensic analysis at chapter 3, as it is advised by the SCL (2002). The schedules used in case study belongs to a real ongoing construction site, however delay events are created theoretically for the purpose of this study. The risk definitions and rankings are carried with interviews with current contractor team on board.

2. ISSUES RELATED WITH FLOAT AND DELAY

2.1 Introduction

This section is composed as three sections. In the first section, float concept has been discussed including its ownership and allocation approaches. In second section, the issues related with float as acceleration, mitigation and concurrency has been introduced.

For the classification of both section Prateapusanond (2003) studies classification has been edited with cooperating recent studies and SCL Protocol (2002) inputs.

In the third section firstly delay and its classifications has been explained and then the most common delay analyses techniques are introduced. Finally, recent researches (Ndekugri et al., 2008) (David Arditi and Thanat Pattanakitchamroon, 2008) on the usage, awareness and success of delay methodologies, are presented and their findings are discussed.

2.2 Float

In Construction management practice, float is an important issue as it determines the amount of time; an activity can be delayed before it becomes critical on path or paths of the project. The ongoing discussion, regarding its ownership and approaches for allocation, is changing the nature of EOT claims and related contractors strategies.

This section starts with definition and continues with the introduction of different ownership approaches in terminology, and followed by the introduction of approaches for float allocation and its usage as contingency.

2.2.1 Definition of Float

Float is defined as (Pickavance 2000) the amount of time between the early start date and the late start date, or early finishes date and the finish date of any activities in CPM Programme.

SCL Protocol (2002) very similarly defines it as “the amount of time which activities may be shifted in time without causing delay to a contract completion date”. There are two types of float; Protocol defines these types as;

- Total float is the amount of time that an activity may be delayed beyond its early start/early finish dates without delaying project completion date
- Free float is the amount of time that an activity can be delayed beyond its early start/early finish dates without delaying the early start or early finish of any immediately following activity

2.2.2 Ownership of Float

The question “who owns float?” has increasingly concerned contractual parties. And becomes the source of major disputes when the project delays (Prateapusanond 2003). Differences in the approaches significantly impacts the result of time and cost analysis. Main approaches discussed in the industry for float ownership are as follows;

- Contractor Owns
- Owner Owns
- Project Owns
- Joint Ownership

2.2.2.1 Contractor Owns

It has been supported (Finke, 2000) (Wickwire, Hurlbut and Lerman, 1974) that the contractor should be the owner of the float where the risk of project is been carried by contractor, especially in lump-sum contracts (Jerry and Hulan, 1990). Basis of this approach is that; since the contractor prepares work schedule and defines the float reservations, it should be his right to control it.

Eventually, the contractor has the right to manage the resources such as workforce, equipment and cash flow or manage the sequence of activities to achieve the project on time within the planned budget.

SCL Protocol (2002) expresses this approach as;

“Contractor may argue that it owns the float, because, in planning how it proposes to carry out the works, it has allowed additional or float time to give itself some flexibility, in the event that it has not it is not able to carry out the works as quickly as it planned if, therefore, there is any delay to the contractors progress will not result in the contract date being missed, but merely in erosion of its float”

With having float ownership; contractor may control the projects risks depending on schedule and related cost and will not play “schedule games” by Zack (1992) where he named it as a contractor tendency for schedule manipulation.

2.2.2.2 Owner Owns

It has been argued by Pasiphol (1994) that the project float belongs to the owner as he pays the cost associated with the project. Owner should have the flexibility for project changes without delaying completion date to manage its investment successfully.

Control of the float by owner may be a reasonable approach for cost-plus contracts when financial risks of project carried by the owner. By this way owner may use the float to minimize his project expenditures. (Jerry and Hulan, 1990)

2.2.2.3 Project Owns / First takes owns

This concept implies that the total float belongs not to any individual party, but shall be used for the benefit of project itself. Under this construct, total float is considered an expiring resource available to all parties involving in the project.

The practical application of the concept is based on “first come, first served” basis. The party who uses float first has right to mitigate the potentially negative effect of its delaying events and can forward the responsibility of project delay to following user of the path. This process may be continued until the path float drops to zero and becomes critical. After that point, the party who changes the float to negative will hold the total responsibility of project delay.

SCL Protocol (2002) states as a core principle that;

“Unless there is express to the contrary in the contract, where as remaining float in the time of an Employer risk event, an EOT should only be granted to the extent that the employer delay is predicted to reduce below zero the total float on activity paths affected by the employer delay” (SCL, 2002)

The principle states that an EOT claim can be granted if only the float on a path reduces to zero, therefore the parties may spend the float of path without causing any delay or damages until it the float finishes.

Consequently, the late-stage party will be also responsible for damages of work delays occur as a result of an extension of the project completion date. The misleading results of this approach arise when the owner consumes the contractor's entire float on a non-critical path bringing the contractor to develop a new critical path thus increasing his project risk with no compensation. In this situation contractor has to control schedule without having control on float.

2.2.2.4 Joint Ownership

Joint ownership of float concept is evaluated to replace or reduce the pitfalls of “the project owns the float” concept.

Details of that concept will be explained as below listed float allocation approaches in next section as;

- New Concept of Using float clauses in contracts
- Total float management

2.2.3 Float Allocation Approaches

Prateapusanond (2003) mentioned about four methods that can be used for allocating and controlling of float, these are listed as;

- Allocating float to individual activities along a path of activities;
- Trading total float as commodity;
- Calculating and using safe float;
- Using float clauses in contracts

Additional to these two newer concepts will be explained as;

- New concept of using float clauses in contracts
- Total Risk Approach

2.2.3.1 Allocating float to individual activities

Pasiphol and Popescus (1995) first approach is distributing of float to activities which are in same path. The allocation was depending on two criteria as quantitative and qualitative.

The quantitative allocation depends on numbers from activities. Three criteria is used as a weight factor for distribution on a path; uniform distribution, activity duration or activity direct cost.

The second criteria as qualitative are non-numeric factors for activity delays. These are mostly subjective factors that will be produced by project management team such as resource demand, labour strike, late material delivery, type of work and environmental permission.

Distribution process of total float continues until all activities on all paths are become critical. After the process is completed, all activities will perform with their allowable duration, which is a result of adding distributed float duration to their original durations.

The main disadvantage of approach is, its difficulty in practical application, especially in work schedules where the critical path has a dynamic nature.

2.2.3.2 Total float as commodity

The commodity approach is defined by De La Garza et al (1991). It introduces the float as a commodity that can be tradable between contractor and owner. The total float turns to a resource controlled by contractor but also available to all parties.

The approach gives flexibility to owners to purchase float from contractor based on a formula that agreed in project contract. The formula aims to guide the negotiations between parties especially while pricing change orders of project.

The calculation of daily value of a total float for an activity given as:

$$\frac{LateFinishCost - EarlyFinishCost}{TotalFloat} \quad (2.1)$$

2.2.3.3 Using Safe Float

This approach is been suggested by Gong and Rowings(1995) and updated by Gong (1997) The approach introduces a new concept as “safe float” which indicates the amount of float which can be used safely to reduce the risk of project delay caused by non-critical activities. As a result of the approach, parties will be aware of their range of using float, and related project delay risk will be minimized and float ownership will not considered as an issue.

This method indicates that usage of total float after a limit may increase the project risk and parties may face the associated cost of this result. However the practical implementation of the method can be complex and difficult especially considering the fact that the definition of the range of safe float is mostly related to the attitudes of project managers.

2.2.3.4 Using float clauses in contracts

The final and most popular approach is using float clauses in contract documents. Researchers such as Zack (1996), Ashley and Mathews (1984), Ibbs and Ashley (1986), Hartman, Snelgrove and Ashrafi (1997) and Sweet (1999) mentioned that well- prepared scheduling specifications are related with good and fair scheduling implementation.

Studies (Zack 1992; 1996; Person 1991; Wickwire, Driscoll, and Hurlbut 1991) have recommended that owners include such clauses in contract documents during contract preparation. Clauses that are currently in construction contracts to deal with the float ownership issue are;

- “Joint Ownership of Float”
- “No-Damages-For-Delay” Clauses
- “Nonsequestering of Float” Clauses

Joint ownership of float clause is designed to avoid from contractors’ delay claims supported by the “contractor owns the float” concept; it simply states “float is a jointly owned resource that expires as the project progresses and is consumed on a first-come, first-served basis.”

“No damage for delay” clause is required to improve and support “Joint Ownership of Float”. This clause should be included in the scheduling specification, as “no time extensions will be granted nor delay damages paid until a delay arises that is caused by the owner and causes the work to exceed the current adjusted contract completion date” (Zack 1996, p. 46)

The contractor can control the float in a project schedule by using preferential logics, artificial activity durations, or constraints during project updates or revisions (Zack, 1996), to avoid that, “nonsequestering of float” clause can be included in the

scheduling specification giving the owner authority to review and comment on any schedule submittal if float is affected.

2.2.3.5 New Concept of Using float clauses in contracts

This new concept suggested by Prateapusanond (2003), is a modification of using float clauses in contracts, to avoid pitfalls of the “first come, first served” float ownership method.

The new concept redefines the “Joint Ownership of Float” as “Preallocation of float” clause. In this clause, total float preallocation is defined by a predetermined percent by the owner and contractor such as 50-50 for equal allocation or any figure between 0 to 100 based on agreement between parties.

The amount of float by each party named as “allowable total float”. This amount will guide sharing the responsibility of project delays during any delay analyses. Opposite to “first come, first served” concept, parties agree on that any party that uses its float exceeding its allowable float will be responsible for the project delay if that delay appears on a critical path.

Prateapusanond (2003) advised a “Formulas Clouse” as an improvement, to calculate the responsibilities of parties, for a delay with respecting dynamic nature of float.

2.2.3.6 Total Float Management

The approach has been proposed by Al Gahtani and Mohan (2007). The study mentions that float ownership should correspond to the risk assumption and the party who bears the most risk should own the most float. The approach proposes to integrate several existing approaches to restructure the allocation of float between project parties.

Firstly, it defines how the float is divided between parties based on the levels of risk from project conditions and contract terms. Next, trades float as a commodity, so, if a nonowning party consumes float, that party must compensate the party who owns that part of float. Finally, the approach uses a day-to-day system to deal with the dynamics of float management that arises from schedule updates or revisions due to delay events.

2.2.4 Float Allocation and Contingency

Float can also be treated as contingency period; Pickavance (2000) states that float can be a contingency for completion, or contingency for resource planning. Contingency for completion usually appears as a finishing activity called “snagging” or “cleaning” or an unnecessary lag between activities.

SCL (2002) acknowledges that the contractor can make allowances for the possibility of its delay. It agrees that contractor can increase its activity durations where as it sees a potential risk or it can identify separate activities such as “contingency for ...”

2.3 Acceleration, Mitigation and Concurrency as Implications of Float

2.3.1 Acceleration

The contractor may fall behind the programme due to various reasons, such as slow release of design information, design changes, change in ground conditions, poor construction or project management. Such factors or employers’ instructions, may force contractors to accelerate their works and to complete the whole or the part of the works earlier than planned.

Acceleration is defined in SCL Protocol as:

“The execution of the planned scope of work in a shorter time than anticipated or the execution of an increased scope of work within the originally planned duration”.

Acceleration can be classified into three types (Kehui Zhang and Tarek Hegazy, 2005) as;

- Owner-directed,
- Owner-constructive
- Contractor voluntary.

2.3.1.1 Owner-directed Acceleration

Directed acceleration occurs with verbal or written instruction of owner (Kehui Zhang and Tarek Hegazy, 2005) to contractor for performing a work in a shorter time period than the original assumption or for performing in same time period for increased scope of work (Mohan,2008).

2.3.1.2 Constructive Acceleration

Constructive acceleration occurs in a condition when a contractor suffers from an excusable delay or increased scope of work to project and its EOT claim is not been recognized by owner. The indeterminate situation for completion date and applicability of liquated damages or other financial consequences for finishing later forces contractor to accelerate to complete works within original durations without a direct instruction by owner (Keane and Caletta,2008).

AACE International (2009) provides the following five criteria for constructive acceleration.

- The contractor is entitled to an excusable delay;
- The contractor requests and establishes entitlement to a time extension;
- The owner fails to grant a timely time extension;
- The owner orders the completion within a shorter time period than is associated with the requested time extension; and
- The contractor provides notice to the owner that the contractor considers this action an acceleration order.

2.3.1.3 Contractors Voluntary Acceleration

Contractor voluntary acceleration occurs when the contractor accelerates works himself without an instruction from owner to recover a non-excusable delay (Kehui Zhang and Tarek Hegazy, 2005) or to benefit financial consequences of early finishing.

2.3.1.4 Float Gained by Acceleration

Acceleration generates additional float on programme. In line with the opinions in float ownership and allocation discussion, the allocation and ownership of float gained by acceleration are also a discussion points. Moreover, the discussions may be complicated when dynamic nature of critical path of a programme is considered.

If there is no clause in the contract, for the ownership of the float, gained by acceleration, general float ownership clause works for its management. If general clause supports “whoever uses it first” methodology, the first claiming party is going to capture the float gained during acceleration.

Another opinion is suggested by Kehui Zhang and Tarek Hegazy (2005), considering acceleration as a negative delay, they propose that the parties as contractors or owners that accelerated the works or owned the acceleration by financing it, can use benefits of acceleration to cover their own delays. In line with this opinion, if a contractor accelerates his construction activities and generates float, he should have right to use this float, to decrease his own previous delays, or reserve this float for its possible future delays. Similarly, if the float generated by the owner such as a early design achievement, that float needs to be used by himself again.

The usage of float provided with an acceleration is also related with the source of acceleration finance. The usage of float produced by a owner financed acceleration should belong to owner (Kehui Zhang and Tarek Hegazy, 2005). On the contrary if the acceleration is carried by contractor voluntary to benefit from early completion of project, the generated float should be captured by the contractor.

2.3.1.5 Methods of Acceleration

In order to accelerate, the contractor may consider applying the methods like; re-sequencing activities, reducing lead-time for material delivery, adding resources and overtime working.

A sequence of activities driven by a resource constraint could be re-sequenced by addition of resources. Shortening the material lead-time will result acceleration in schedule if the critical path for the project passes through the procurement activities. Contractor may consider reducing the material lead-time by increasing the number of scheduled deliveries that may allow the work to proceed in parallel. Another option for contractor is to pay for the reduced lead-time or selecting a different vendor who could offer the shorter lead-time (Mohan,2008).

The additional resources and working overtime are the common solution for accelerations; however they need to be considered carefully from cost and productivity wise. Additional labor and working overtime may cause loss of productivity (Pickavance, 2000) and increase in costs for unit of work performed. Similarly usage of additional equipments may result with the decrease in productivity of equipment and higher costs for work unit productions.

If the contractor decides to accelerate, he has to consider factors like; obtaining his own management and labour support, the adequate support of subcontractors and

suppliers and primarily the support from the owner's team, designers, project managers and consultants (Keane and Caletta, 2008).

Moreover, contractor needs to pay attention for monitoring quality standards as well as securing the suitable quality and management level for additional labours (Keane and Caletta, 2008).

2.3.2 Mitigation

The contractor is obliged (SCL, 2002) to mitigate the actual or potential loss arising from delayed or disrupted contract works. Construction contracts usually require the contractor to mitigate delay in terms of reducing the effects of delay.

A way of mitigation is to modify the sequence of works to meet the original completion date; however, from the contractor side the revised sequence of works should be achieved without additional expenses. The contractor should identify the difference between actions to mitigate and usage of acceleration measures and, ensure that non-productive labour and plants are minimised during mitigation period. (Keane and Caletta, 2008).

The contractor needs to reflect the effect of his mitigation efforts in his revised work programmes with updates at regular basis as 3-6 month intervals. The effects of 'excusable' and 'non-excusable' delays should be included together with the proposed mitigation measures to recover or reduce the effects of excusable delays at programme updates (Kumar, Mohan, Douglas 1998).

2.3.3 Concurrency

There is no universally agreed definition of concurrent delay (Keane and Caletta, 2008). P203 as there are different views on the implementation of concurrency on analyses (SCL, 2002).

Concurrent delay is (Rubin et al. 1983; James, 1990; Keane and Caletta, 2008) defined in many researches as two or more delays that causes project delay occurring at same time.

SCL (2002) defines 'true concurrent delay' term as;

‘True concurrent delay is the occurrence of two or more delay event at the same time, one an Employer Risk Event, the other a Contractor Risk Event, and the effects of which are felt at the same time’

SCL (2002) also defines ‘concurrent effect’ term where delay events are occurred at different times but their impacts have been felt at the same time, to clarify the confusion with common usage of concurrent delay for the same situation.

The analysis of concurrent delay is very complex (Kim, 2005) due to the overlapping nature of events (Arditi, 1985) and difficulties of determining concurrent delays (Yates, 2006). The complexity increases during the identification of the responsibilities for associated costs as the liability for events between the owner, contractor and the events that are considered as neutral. (Keane and Caletta, 2008). Neutral events will entitle an additional time for the contractor without compensation. During these analyses acceleration or mitigation has also need to be taken into account.

2.4 Delay and Delay Analysis Techniques

2.4.1 Delay

Delay is a common (Al-Khalil , 1996; Chan and Kumaraswamy, 1997; Frimpong et al., 2003; Koushki et al., 2005; Arditi and Pattanakitchamroon, 2006) and costly (Alkass, 1996) problem encountered on construction sector as projects frequently suffers from it.

Construction delays can be classified in three ways; (Alkass et al. 1996; Bramble and Callahan 2000; Kumuraswamy and Yogeswaran 2003).

- Critical and noncritical
- Excusable and non Excusable
- Compensable and non-compensable

2.4.1.1 Critical non-critical

If the delay is on the critical path of the project, then it will cause delay on project completion date, which can be named as ‘critical’ delay (SCL, 2002), conversely a delay on the project but not in the critical path, can be called ‘noncritical’ delay.

2.4.1.2 Excusable and non Excusable

When the contractor is delayed by events, which are out of his control and entitled to extension of time, this is named as ‘excusable’ delay (Sweet, 1997).

Non-excusable delays are delays that result from the contractors or sub-contractor’s actions or inaction (Kraiem and Diekmann 1987; Alkass, 1996) due to events that under their control and that are foreseeable. Contractor will not be entitled for an extension of time and delay damages due to impacts of non-excusable delays (Alkass, 1996). Delays caused by contractors insufficiency for maintaining required resources such as manpower , staff or equipment are examples for non-excusable delays.

2.4.1.3 Compensable and non-compensable

A compensable delay is a delay where the contractor or subcontractor is entitled to have time extension and additionally its compensation (Lee, 1983). Related back to the previous classification, only an excusable delay can be classified as compensable or non-compensable. An example of an excusable compensable delay is a late design decision given by the owner.

A non-compensable delay can be occurred when the contractor has right for a time extension but not its compensation. Examples of non-compensable delays are events such as unprovoked strikes, or any ‘act of nature’ (Alkass, 1996).

2.4.2 Delay Analysis

Analysis of construction delays has become an essential part of the project’s construction life as introduction of flexible and feasible delay analysis techniques is very valuable especially when dealing with construction claims.

Delay Analysis is defined by Ndekugri (2008) as the investigation of project delay events for to define financial responsibilities of parties related to delay. Therefore, it first aims to determine how the delays affect the project activities and the project completion date and then distribute that affect to each party as time and cost compensations.

Work schedules that can be used in a delay analysis can be classified as below (Kraiem and Diekmann 1987; Alkass, 1996);

- As-planned schedule,

- Adjusted schedule.
- As-built schedule

The as-planned schedule represents contractor's original work plan to achieve contract requirements. During construction process it acts as a criterion for measurement of contractor's performance (Kraiem and Diekmann 1987). The schedule does not include and progress data and indicates original critical path of project with in original project duration.

The impact of schedule variances on a project are identified and quantified with adjusted schedules. The effects of different types of delays on project completion date can be determined on adjusted schedules (Kraiem and Diekmann 1987). The events that their impacts are reflected with impacted schedules, are change orders, construction changes, delays, contractor owned changes and accelerations (Alkass, 1996). The preparation of adjusted schedule is commenced with updating of as planned schedule with the impacts of delay events, once the update process has been completed the adjusted schedule will have a different critical path and project start/finish dates compared with the as planned schedule (Alkass, 1996).

The as-built schedule reflects the actual sequence of activities which is updated by project record, reports or through an inspection period (Kraiem and Diekmann 1987). The activities are shown with actual start and finish dates and actual durations. Similar to the as-adjusted schedule, as-built schedule may have a different critical path or project completion date from the as-planned schedule (Alkass, 1996). As the definition of SCL (2002) the as-built programme may be a bar chart record without any logic link inserted.

Several techniques using as built and as planned schedules for delay analysing are currently in use. Majors are summarised as below (SCL, 2002);

- As-Planned vs. As-Built,
- Impacted As-Planned,
- Collapsed As-Built,
- Window Analysis and Time Impact Analysis.

The following further describes them briefly

2.4.2.1 As-Planned vs. As-Built

The As-planned vs. as-built methodology compares the the original as-planned schedule with the as-built schedule. The delays and disruptions are mentioned on a bar chart (Alkass, 1996). The main advantages of this methodology are, its inexpensive, simple and easy to understand application (Lovejoy 2004), especially for simple projects, however it has major limitations such as failure to consider changes in the critical path and inability to deal with complex delay combinations (Stumpf, 2000; Zack, 2001).

2.4.2.2 Impacted As-Planned,

The Impacted As-planned methodology incorporates delay events as activities into original as-planned CPM programme. The delays are added to the baseline to demonstrate how a project completion date is impacted by those delays. The difference between the schedule completion dates, before and after the additions, are considered as the amount of project delay (Trauner 1990; Pickavance 2005). The major disadvantage of methodology is, its inability to reflect sequence changes, due to usage the original planned work sequence, even though the actual work sequence may been changed (Stumpf 2000; Zack 2001; Wickwire and Groff 2004)

2.4.2.3 Collapsed As-Built,

Collapsed As-Built methodology uses the as-built CPM programmes for to quantify the impacts of delays. Procedure starts with removing the delays from programme, chronologically or in a single shot. The programme created as result of the process is named as ‘collapsed’ as-built programme that aims to demonstrate project progress without delays (Ndekugri et al. 2008).

The difference between the completion date of collapsed as-built programme and the original as-built programme is counted as project delays caused by delays subtracted (Pickavance 2005). Although this methodology has an advantage of relying on a programme that shows what actually happened on site, it has limitations such as ignorance of changes on the critical path (Lovejoy 2004), inability to identify concurrency, redistribution of resources, acceleration (SCL,2002) and additionally requirement of great and subjective effort for identifying the as-built critical path. (Zack 2001; SCL,2002)

2.4.2.4 Window Analysis and Time Impact Analysis

The window analysis methodology is based on division of project duration to a number of time periods defined as ‘windows’. The factors as milestones, important changes in critical path, the effects delay events ; or the dates or periods of schedule updates or revisions may determine the boundaries of windows (Finke 1999; Hegazy and Zhang 2005). Initially, the first window is been updated with as-built information in cooperating the impacts of delays in the period, as the remaining part of schedule is still reflects the as-planned programme. The difference between the completion dates of the schedule, before the analysis and after the analysis of the first window is counted as the impact of these delays. This process is been repeated with other windows up to the end of required analysis period (Ndekugri et al. 2008).

As a result of this process, the methodology has ability to realize the effects of changes on project critical path. However due to amount of effort and time required for process, it is more expensive than the previous methods (Zack 2001).

Time Impact Analysis has a similar approach as Window Analysis as both analyses incorporate the delays into updated CPM programmes. Time impact analysis considers the chronologically added delay events as segments of analysis, instead of the time periods that contains delay events (Alkass et al. 1996). The difference at the completion dates of the schedule after in cooperating the delay event is recognised as delay that caused by specially analysed delay event (Ndekugri et al. 2008).

This technique is mentioned as the preferred technique for complex disputes related to delay and compensation of it, by Society of Construction Law (2002). SCL(2002) describes the method as follows;

‘Time impact analysis is based on the effect of delay events on the contractor’s intentions for the future conduct of the work in the light of progress actually achieved at the time of the delay event and can also be used to assist in resolving more complex delay scenarios involving concurrent delays, acceleration and disruption. It is also the best technique for determining the amount of extension of time that a contractor should have been granted at the time an employer risk event occurred. In this situation, the amount of extension of time may not precisely reflect the actual delay suffered by the contractor. That does not mean that time impact analysis generates hypothetical results – it generates results showing entitlement.’(SCL,2000)

2.4.3 Awareness and Usage of Methodologies

The common usage of these techniques, their awareness by practitioners, and their chance of acceptance during negotiations or in front of courts or boards are important factors for the success of a delay analyses and related claims.

A recent research has been done by Ndekugri et al. (2008) in United Kingdom reporting the current practice in the use of these methodologies. His findings regarding success, usage and awareness has presented at below tables

Table 2.1: Level of Success and Challenge to Claims Settlement Using the Methods (Ndekugri et al. 2008) p697

Methodology	Success		Challenge	
	Success index	Rank	Challenge index	Rank
Global	45.8	5	90.9	1
Net impact	54.1	3	75.3	2
As-planned versus as-built	80.3	1	67.6	3
Impacted as-planned	67.7	2	64.7	4
Collapsed as-built	49.6	4	54.1	5
S curve	27.1	8	52.0	6
Window analysis	30.9	7	48.5	7
Time impact analysis	37.9	6	46.9	8

Table 2.2: Obstacles Level of Awareness and Extent of Use of the Methods (Ndekugri et al. 2008) p697

Methodology	Awareness		Usage	
	Awareness index	Rank	Usage index	Rank
As-planned versus as-built	86.4	1	81.9	1
Impacted as-planned	79.6	3	70.2	2
Global	79.9	2	54.6	3
Net impact	72.9	4	51.7	4
Collapsed as-built	59.6	5	47.1	5
Time impact analysis	46.4	6	37.5	6
Window analysis	40.0	8	31.4	7
S curve	40.9	7	30.2	8

The result of study also includes non-CPM based techniques as Global, Net Impact and S-Curve, excluding these techniques, with in the CPM techniques, as-planned

versus as-built method receives the highest score and impacted as-planned is ranked at second. Similarly for the extent of use, as it can be observed from Table 2.2, the As-Planned vs. As-Built methodology is ranked at first, followed by the impacted as-planned technique.

The results indicating the simple techniques are used more common than the sophisticated methods in practice. Although sophisticated methods can be more reliable, the simple ones are easy to use and understand, do not require complete project records that are often not fully available, and require fewer resources which make them more economical, the simplistic methods are preferable.

Another recent study has been carried out by David Arditi and Thanat Pattanakitchamroon (2008) based on the analysis of 58 time-based claim cases.

His study indicates that the choice of methodologies are also related with the size of project as the time impact analysis appears to have been used mostly in large-scale projects however less sophisticated CPM methods, such as as-planned versus as-built were used mostly in small projects with few resources.

As a reliability criterion, his study indicates that the time impact analysis method is more acceptable by courts and boards than the other methods.

However even under the lights of these recent researches, to indicate a common rule for the success of delay analyses and related time claims are not very easy. There may be several other criteria affecting the process such as availability of resources, amount of expected income and cost of claim, the timing of claim, and the awareness of parties whom involved for evaluation of time claims. Predilection of parties for dispute solving going either through negotiations or under the judgement of boards or courts may also change the intentions while preferring a technique.

Consequently, Project team that should consider mentioned facts and chose the best fitting technique for their project conditions.

3. FORENSIC ANALYSIS

3.1 Introduction

The study in this chapter consists of the retrospective (Forensic) analysis of a certain period in relation to EOT requests made by the contractor and the review of contractor's reactions to delay events occurred in the same period.

Delay events and accelerations are retrospectively simulated on contractors both internal and contract programmes with considering his different risk assumptions on planned durations.

As it is discussed in section 2, increasing activity durations is a practise by contractors, as reflection of project risks or resource allocation. The purpose of this section is to demonstrate how impact of different risk assumptions and associated floats as increased durations, effect evaluation of EOT claims.

In selected period of analysis, delay trend of project has been substantially changed. This substantial change is the reason of selection of this period for analysis. In the figure 3.1, the delay trend is reflected as total float figures including the impact of accelerations and delay events by parties.

The first red chart bar in monthly time frames represents the excusable delay events on as built critical path and the second green bar represents the non-excusable delay events or accelerations by contractor. The excusable delay events were obtained from EOT claims submitted by the contractor.

The data shown as a bar chart in the top negative area presents the impact interpreted as a delay; oppositely the data in the lower positive area is considered as acceleration or float gain.

The project as a case building introduced in section 3.1 that is still under construction. The analysis covers one-year duration from November 2008 to November 2009.

The contractors' submitted and approved work programme, periodic updates and the adjusted schedules by delay events are the main sources for this study.

3.2 Applied Method

Steps used in the method can be summarized as below:

- Definition of Project
- Definition of Delay Events
- Determining the Analysis Techniques
- Baselines to be Used
- Determination of Analysis Windows
- Comparison and Visualization of Results
- Approval of As built critical Path
- Determination of problematic issues
- Discussing problematic issues

3.3 Description of Project

3.3.1 Description of Building

Case Building is a super tall skyscraper with 6 Basement and 101 floors currently under construction in, United Arab Emirates. It has mixed function of hotel rooms and residential units. Case project height is more than 400 meters and it is estimated to one of the tallest residential building in world.

Building is divided to functions as per floors as below;

Basement 6 to Level 6 ; Parking and Common Utility Rooms

Level 1 ; Entrance to Building

Level 6 to Level 13 ; Hotel Utilities

Level 15 to Level 32 ; Hotel Rooms

Level 34 to L100 ; Residential Units

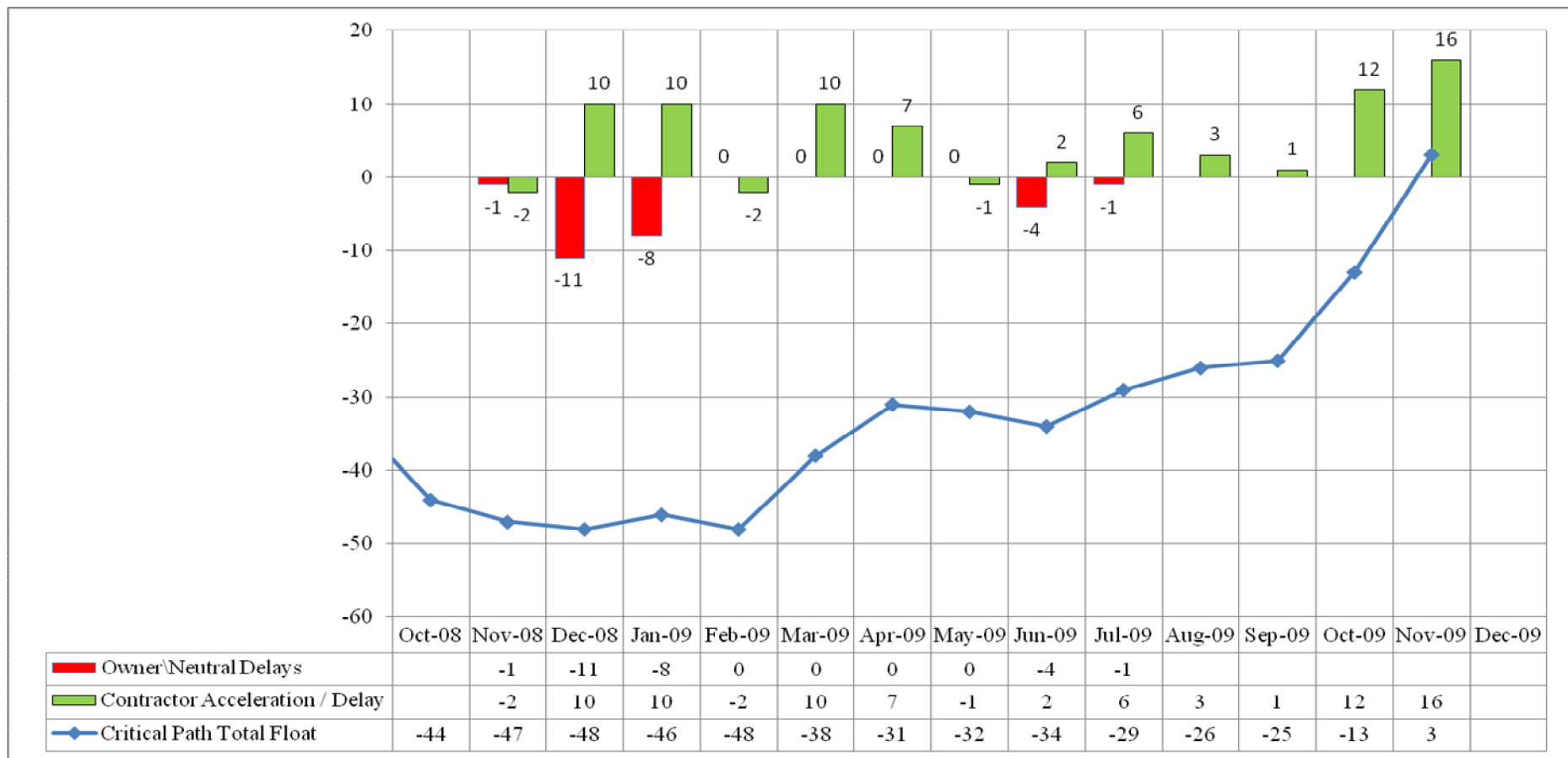


Figure 3.1 Delay and acceleration trend per month

Level 14,33,57,79 and 101 ; Mechanical Floors

L55, 56, 95 and 96 ; Apartment Utilities (Health Club)

Level 2 Elemental Project Description is described below;

General: Building Size; 55mx62m, 6 basement and 5 podium Floors, average 3m. Floor to floor height. 35mx37.5 m. 99 tower floors (13 floors 4.5m. floor to floor height and 86 floor 3m. floor to floor height. Total Built up area is 153.916 m2

Foundations: Concrete Raft foundation is 6 m. thick at tower and 4m. Thick at podium area sitting on 38 m. piles.

Basement Construction: Waterproofed concrete basement walls for 6 floors

Superstructure: Floor Construction; Post-Tension Concrete slab. Roof Construction; 41.5 m. height steel roof structure.

Exterior Construction: Walls (%7 of Façade Area); Lightweight Concrete blocks up to Level 12. %20 Windows , %20 Strict Curtain Wall System (Mostly L80 to L100 All faces and Ground to Level 6 Frond Façade , L6 to L14 Rear and Front), % 60 Composite Cladding Cover

Interior Construction: Core and apartment corridors; 15 cm lightweight concrete block work , Apartments and Hotel rooms; between the units 10 cm lightweight concrete block work both sides covered with steel stud and fire rated gypsum boards, With in the units ; steel studs with gypsum board.

Interior Finishes: Wall Finishes; Corridors and lobbies; graniti tiles on plaster or gypsum boards. Apartments dry areas; painting on gypsum board, wet areas; ceramic tiles up to ceiling height. Utility Rooms and parking; plaster and painting

Floor Finishes: Corridors and lobbies; graniti tiles. Apartments; Ceramic Tiles; Parking Areas and Electrical Rooms; epoxy paint.

Ceiling Finishes: Corridors, lobbies, partially Apartment areas; gypsum suspended ceiling and paint, Partially Apartments; ceiling plaster and paint. Utility Rooms and Parking Areas exposed concrete paint.

Conveying Systems: Passenger Elevators; 8 super speed elevator serving apartments (4 up to L78, 4 up to L101). 4 elevators for hotel Floors and 3 elevators serving from parking floors.

Service Elevators; one for full building, two for Hotel floors and 3 for parking areas

MEP Systems : FA System, Voice evacuation, Structural cabling, CCTV, Access Control System, SMATV, UPS, ATS, Video phone System, PA, Bus Bar, CO detection, VRV system, Chilled water system, Dry cooler system, Domestic hot water, Building Management System, metering system, Sprinkler system, FM 200, LPG system, energy recovery system, waste compacting and shut system

3.3.2 Description of the Contract

TAV (Tepe – Akfen Venture) Construction has been assigned as main contractor of the building. Contract scope includes all structural, shell, MEP and Conveying Systems of Building. All the interior construction and finishes except for Hotel rooms and partially utilities finishes are also in scope of the contract.

Nomination of some subcontractors such as Façade, Elevators, and Crown is going to be held by the client. Contract duration is defined as 38 months.

3.3.3 Construction Facts

Major quantities of project are;

Total Concrete Quantity:	130,000 m3
Total Rebar Quantity:	19,000 tons
Total Façade Quantity:	39,000 m2

Major systems selected by Contractor;

Wall Formwork System; Self Climbing

Slab Formwork System; Panel system

Tower Cranes; one internal climbing and one external crane

Hoists; 4 high speed hoists

Project has many challenges in relation to the nature of super tall buildings. Most of these challenges have impact on delay analysis. Case project has two important limitations due to its design and location. Firstly, construction area has very limited logistic support area for storage and equipment access since other towers and roads constructed around building are in the process of construction. Secondly, compared

to other super tall buildings above 400 m. Height, case building is one of the narrowest one. Its narrow structure causes limitations on the number of equipment resources such as hoist and garbage shuts on façade.

3.3.4 Construction Progress

The brief summary of the physical condition of the construction and its impact on the work schedule is presented next; At the beginning of the analysis period, 5 floor of basement floors were completed, however, when the baseline programme of the contractor is taken into account, 5 floor of basement floors and 6 floor of typical floors are planned to be completed. By 30th of November 2008, the end of the analysis period, structural slab progress of the contractor reaches up to 48th floor, whereas contractor's baseline schedule expects the physical progress to reach 47th floor by the same date.

In Figure 3.2 the physical conditions of the planned and actual critical path activities summarized in line of balance graph. At the beginning of the analysis period, the difference between planned and actual was -43 days. The delays that had occurred before the period of analysis, are excluded as the analysis begins with a condition of -43 days of delay by November 2008.

3.4 Delay Events

The delay events existing in analysis period are listed in order in Table 3.1. These listed excusable events can be caused by owner risk events or by natural events.

Delay Events c,d,f and g are caused by Engineer/ Client and as a result of new design requirements. Detailed explanation of these delay events is given while forming delay windows.

Neutral events are conditions which neither the client nor the contractor can avoid. These Events b,h,j are unexpected weather conditions. Event “a” occurred when the concrete supplier could not deliver concrete due to special circumstances. Event k is an accident that took place in the neighbouring construction site that affected site productivity.

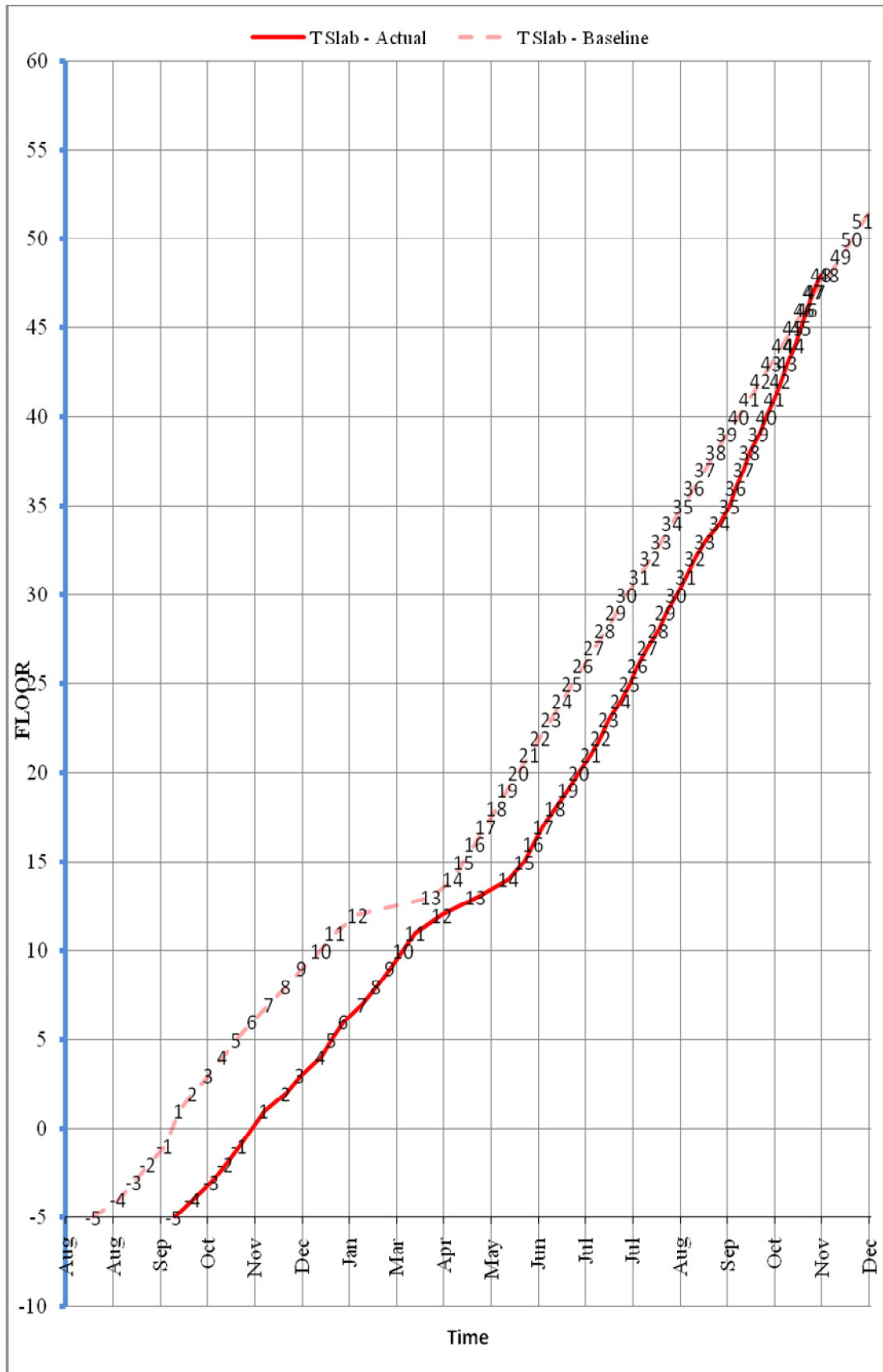


Figure 3.2. Line of Balance for Critical Path – Concrete Slab Works.

Table 3.1 List of Delay Events

Reference	Description
Event 02(a)	Concrete Batching Plant – Unforeseeable Closures
Event 02(b)	Unseasonably Heavy Rain
Event 02(c)	L01 (Ground Floor) Slab – New Requirement for Approvals
Event 02(d)	L02 Slab – New Requirement for Approvals
Event 02(e)	Unseasonably Heavy Rain
Event 02(f)	L03 Slab – New DM Requirement: Additional Lateral Reinforcement
Event 02(g)	L04 Slab – New DM Requirement: Additional Lateral Reinforcement
Event 02(h)	Unseasonably Heavy Rain
Event 02(j)	Unseasonably Heavy Rain
Event 02(k)	Accident – from Neighbouring Site

3.5 Analysis Technique

The Time Impact Analysis is chosen under the light of the criteria in Guidance Section 4 of SCL Delay and Disruption protocol as it was referred as the best technique for retrospective delay analysis by the protocol.

Windows analysis is also sometimes referred as a technique, but the term ‘windows’ simply refers to the period of time being analysed. Windows can be identified at regular intervals (e.g. weekly, monthly) as well as irregular periods determined by the completion of significant key tasks.

3.6 Definition of Baselines

The information available on the case is as follows

- Submitted and Approved Baseline (clause 14 contract programme)
- Contractors internal Baseline programme
- Contemporaneously (monthly) updated CPM programmes
- Contemporaneously (monthly) prepared as built programmes
- Delay event wise updated CPM and As built programmes

As listed above, contractor submitted the Contract Baseline programme and received approval of the engineer following the commencement of construction.

In the present study, this programme is referred as Contract programme. Contractor updated contract programme monthly, and incorporated the as built data into his programme.

The contractor has an internal programme different then the approved baseline programme. This schedule is referred to as internal programme in the current study. The differences between the contract schedule and internal schedule are as follows

- The approval of the engineer is required for the revisions in the contract programme to take effect. Contract programme, aside from being a project management tool is also a used as a commercial tool for EOT claims. These dissimilar usage intensions are considered during programme revisions and revisions and shape parties submittals and approvals.
- Internal programme is revised more frequently compared to contract programme and contains more detailed records.
- Contractor exclusive float is hidden as increased activity durations in contract programme.
- Potential impacts of learning curve on activity durations for repetitive activities are not considered contract programme

As explained in the aim of the study, the delay analysis method will be applied to both programmes. How the differences mentioned above affects the results of the analysis is going to be discussed further.

3.7 Definition of ‘Windows’

In a TIA using windows as a time period, windows can be defined;

- Relying on updated contemporaneous progress programmes a ‘contemporaneous update TIA’ or
- Updating each of those programmes with progress data up to the point immediately prior to the commencement date of each delay event. This is a ‘chronological event TIA’, which will result in one pre-impacted ‘base’ programme per delay event.

In this Study, a synthesis of the two methods is going to be applied, since the accuracy of analysis increases as the windows size get smaller. If the period between delay events extends more than one month, the contemporaneous progress updates will be used between delay event windows to calculate the impact of the acceleration measures in a manageable size as well as delay impacts.

3.7.1 Delay event windows

The date when the impacts of the delay event first interrupt the critical activities or when it is certain that it will interrupt the activities or the date on which the closest as-planned data exist, is accepted as the commencement date of the delay analysis window. When the impact of the delay event ends, this date will be accepted as the closing date of delay event windows.

This process will be repeated for every delay event by consisting windows for each delay. The data generated from as-planned, as-planned impacted and as-built programme is compared in while generating analysis results. The list of delay events and windows are provided at Figure 3.4 and table 3.2. Other assumption applied in analysis is listed below;

- When delay events that took place in the same period concurrently their analyses have been done is same window, as shown in the example of Window 2d, for Delay events 2d L02 Slab – New Requirement for Approvals and Delay event 2e Heavy Rain.
- Delay event 2j and 2k are windows are considered in monthly updates and will not be evaluated as separate windows.

The window analysis shown in Figure 3.3 is explained in detail for an example of excusable delay event.

The commencement date of the period referred as Window 2d is December 15th 2008 and the closing date is December 21st 2008. The 03PODOST30 Level 2 Concrete Slab activity which is in the contractor's critical path, is suspended by the Municipality on December 16th 2008, due to a design change that owner/engineer was responsible of was not fulfilled.

Table 3.2 List of EOT Claim Updates

Update ref	Update Type	Cut Date
W2A1	DE 2a As Planned	15-Nov-08
W2A2	DE 2a As planned-impacted	22-Nov-08
W2B1	DE 2a & 2b As Planned	1-Dec-08
W2B2	DE 2a & 2b As Planned-impacted	7-Dec-08
W2D1	DE 2d & 2e As Planned	15-Dec-08
W2D2	DE 2d & 2e As Planned-impacted	22-Dec-08
W2F1	DE 2f As Planned	27-Dec-08
W2F2	DE 2f As planned-impacted	1-Jan-09
W2G1	DE 2g As planned	1-Jan-09
W2G2	DE 2g As planned-impacted	13-Jan-09
W2H1	DE 2h As Planned	13-Jan-09
W2H2	DE 2h As planned-impacted	19-Jan-09
W2K1	DE 2K As Planned	17-Jun-09
W2K2	DE 2K As planned-impacted	6-Jul-09

The most reliable as planned data declared by the contractor before this impact had effect, was December 16th 2008, a date that was agreed on by both parties in a weekly meeting on December 15th 2008. Based on this, the beginning date of the analysis is December 15th 2008. The declaration in the meeting is shown as planned data in Figure 3.3.

As seen in the example, for the accuracy of analysis the activities are broken down to detailed pieces and delay events are added as listed below.

- Municipality Inspection Failed due to lack of lift study
- Meeting Held with Municipality / Decision of transferring the issue to next slab
- Municipality Inspection

Level 2 concrete slab that planned to be casted on December 16th 2008, was actually casted on December 21st 2008 which was 5 calendar days later than planned. This date is also accepted as the ending date of delay event impact and the closing date of delay event window.

The window analyses done for each delay event is provided in figure A.

3.7.2 Monthly Windows/Updates

Windows determined incorporating the updated programme information. The monthly programme updates are listed in table 3.3.

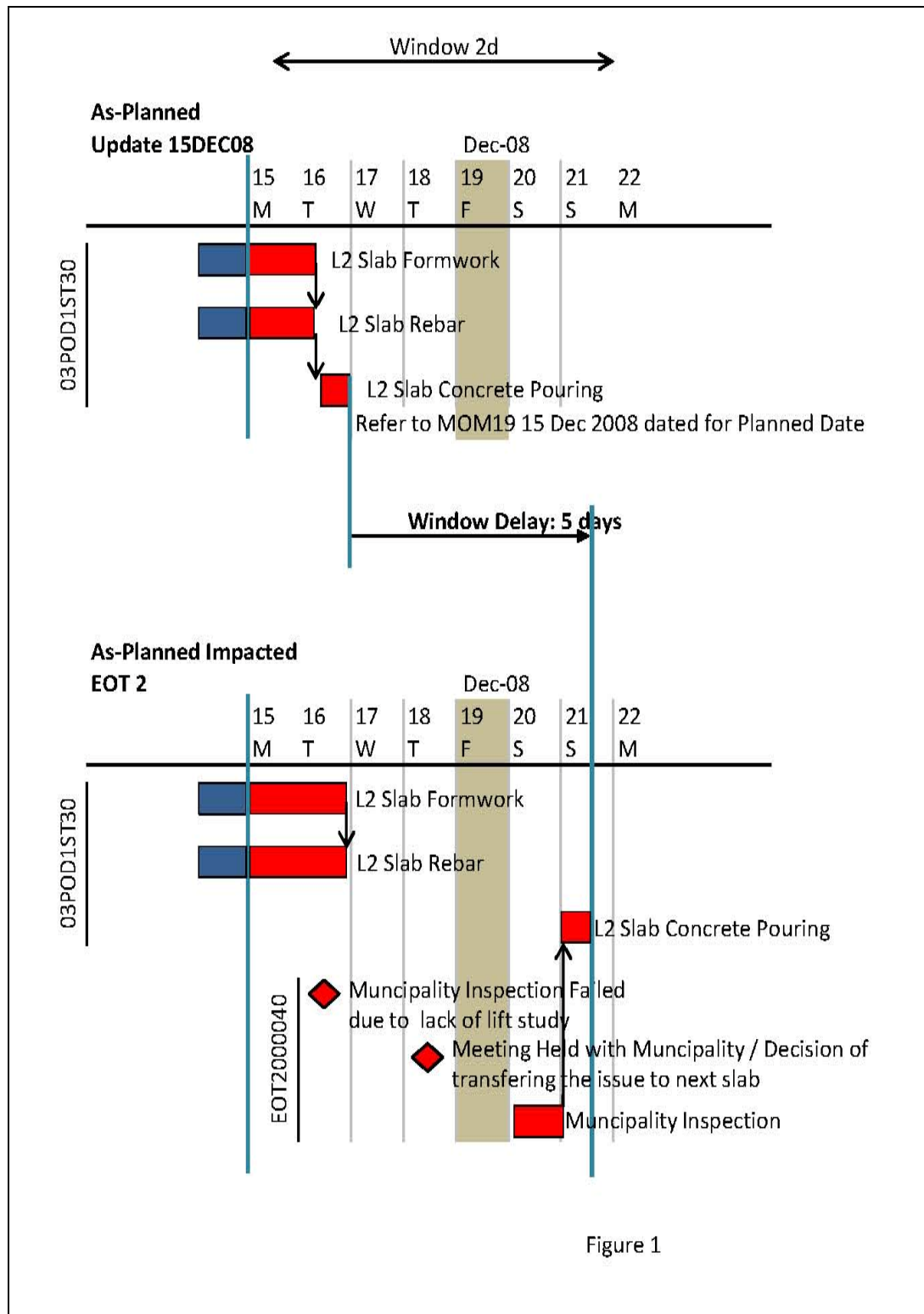


Figure 3.3. As-Impacted Analysis for Each Delay Event 02-d

3.7.3 Analysis Windows

As a result of displaying Delay Event and Monthly Update windows chronologically, the analysis windows below are determined as follows at table 3.4

Table 3.3 List of Monthly Updates

Update ref	Update Type	Cut Date
0810	October Monthly Update	1-Nov-08
0811	November Monthly Update	1-Dec-08
0812	December Monthly Update	1-Jan-09
0901	January Monthly Update	1-Feb-09
0902	February Monthly Update	1-Mar-09
0903	March Monthly Update	1-Apr-09
0904	April Monthly Update	1-May-09
0905	May Monthly Update	1-Jun-09
0906	June Monthly Update	1-Jul-09
0907	July Monthly Update	1-Aug-09
0908	August Monthly Update	1-Sep-09
0909	September Monthly Update	1-Oct-09
0910	October Monthly Update	1-Nov-09
0911	November Monthly Update	1-Dec-09

3.8 Determination of Critical Path

For a delay event to result with an EOT claim, the project finishing date should be delayed. This is a basic principle for the delay analyses. Thus SCL Delay and Disruption Protocol is indicated in the principle as follows.

“Float, as it relates to time; unless there is express provision to the contrary in the contract, where there is remaining float in the programme at the time of an Employer Risk Event, an EOT should only be granted to the extent that the Employer Delay is predicted to reduce to below zero the total float on the activity paths affected by the Employer Delay.”

The accurate determination of the critical path in the analysis is of major importance regarding the validity of the study. In the study the data below is considered while determining the critical path.

- Critical path on Contract programme
- Critical path on Internal programme
- As planned and as built critical paths in updates on contract and internal programme

3.8.1 Critical path on Contract programme

Critical path on contract schedule is summarized in figure 3.5. The first part of the path is passing through the substructure activities as 2.5 month of foundation and 3 month of basement constructions.

Tower Superstructure activities are the longest part of critical path that take 29 months duration. Then path continues with remaining lift works of subcontractors at motor room as 1 month. Testing and Commissioning works starts after, is the last activity in critical path. Another critical path crosses over the dismantling of formwork supports of 98th floor slab and the Finishing Works activities of the same floor and continues through the finishing works activities up to the 101st floor. Then it again links to the Testing and Commissioning process activities.

Due to the scope of contractors' works, major finishing works begins after 34th floor and continues up to floor 101. This works path will be considered as a near critical path.

Table 3.4 List of Case study Analysis Windows

Window No	Start	Finish	Start Update ref	Finish Update ref
W 1	01-Nov-08	15-Nov-08	0810	W2A1
W 2	15-Nov-08	22-Nov-08	W2A1	W2A2
W 3	22-Nov-08	01-Dec-08	W2A2	0811
W 4	01-Dec-08	07-Dec-08	0811	W2B2
W 5	07-Dec-08	15-Dec-08	W2B2	W2D1
W 6	15-Dec-08	22-Dec-08	W2D1	W2D2
W 7	22-Dec-08	27-Dec-08	W2D2	W2F1
W 8	27-Dec-08	01-Jan-09	W2F1	0812
W 9	01-Jan-09	13-Jan-09	0812	W2G2
W 10	13-Jan-09	01-Feb-09	W2G2	0901
W 11	01-Feb-09	01-Mar-09	0901	0902
W 12	01-Mar-09	01-Apr-09	0902	0903
W 13	01-Apr-09	01-May-09	0903	0904
W 14	01-May-09	01-Jun-09	0904	0905
W 15	01-Jun-09	17-Jun-09	0905	W2K1
W 16	17-Jun-09	21-Jun-09	W2K1	W2K3
W 17	21-Jun-09	29-Jun-09	W2K3	W2K5
W 18	29-Jun-09	06-Jul-09	W2K5	W2K7
W 19	06-Jul-09	01-Sep-09	W2K7	0908
W 20	01-Aug-09	01-Sep-09	0907	0908
W 21	01-Sep-09	01-Oct-09	0908	0909
W 22	01-Oct-09	01-Nov-09	0909	0910

3.8.2 Critical path on Internal programme

When the internal work programme of the contractor in Figure 3.6 is evaluated, the critical path again crosses over Tower Substructure and Superstructure Works.

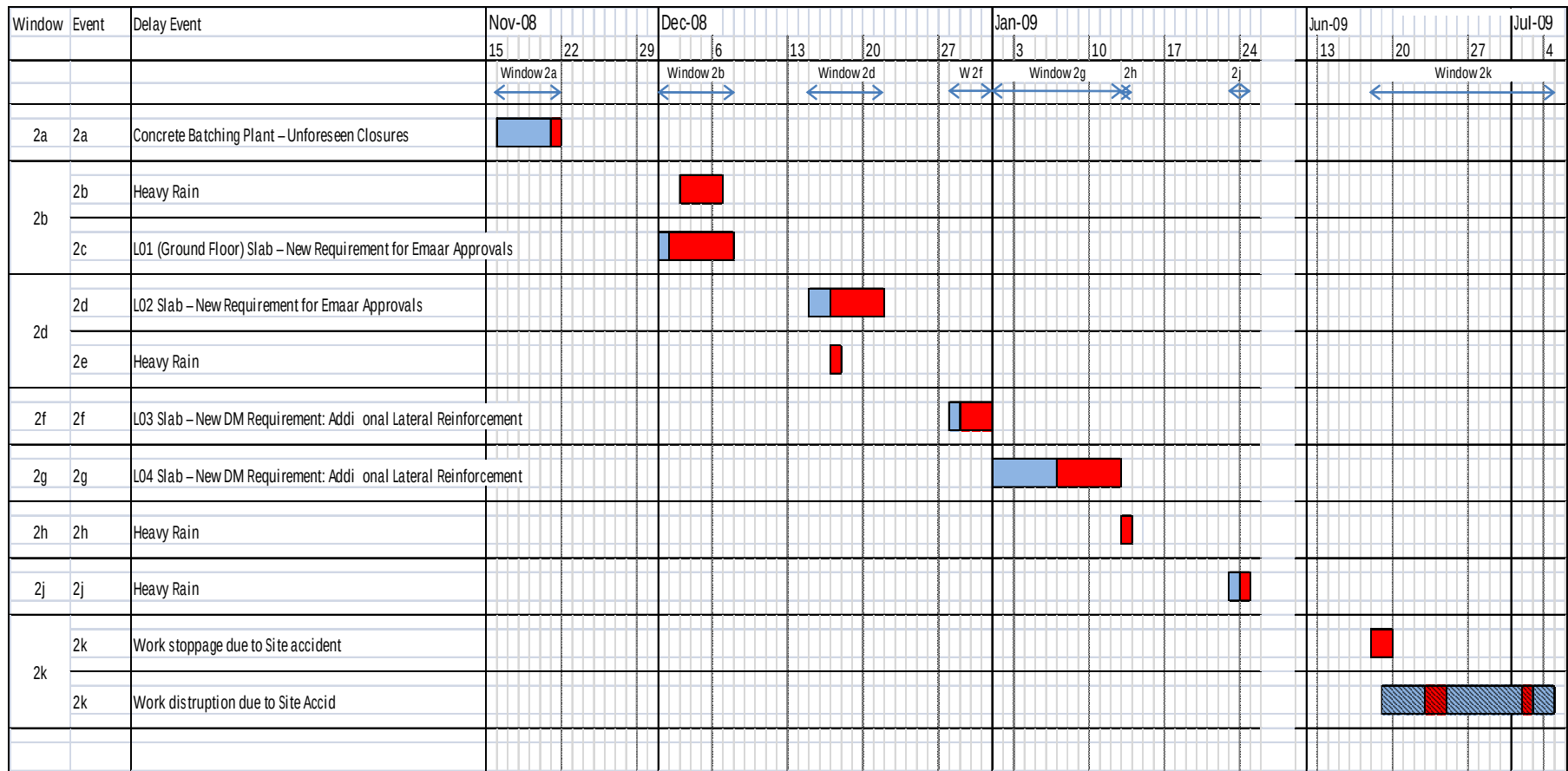


Figure 3.4. Delay Events and Window Definitions

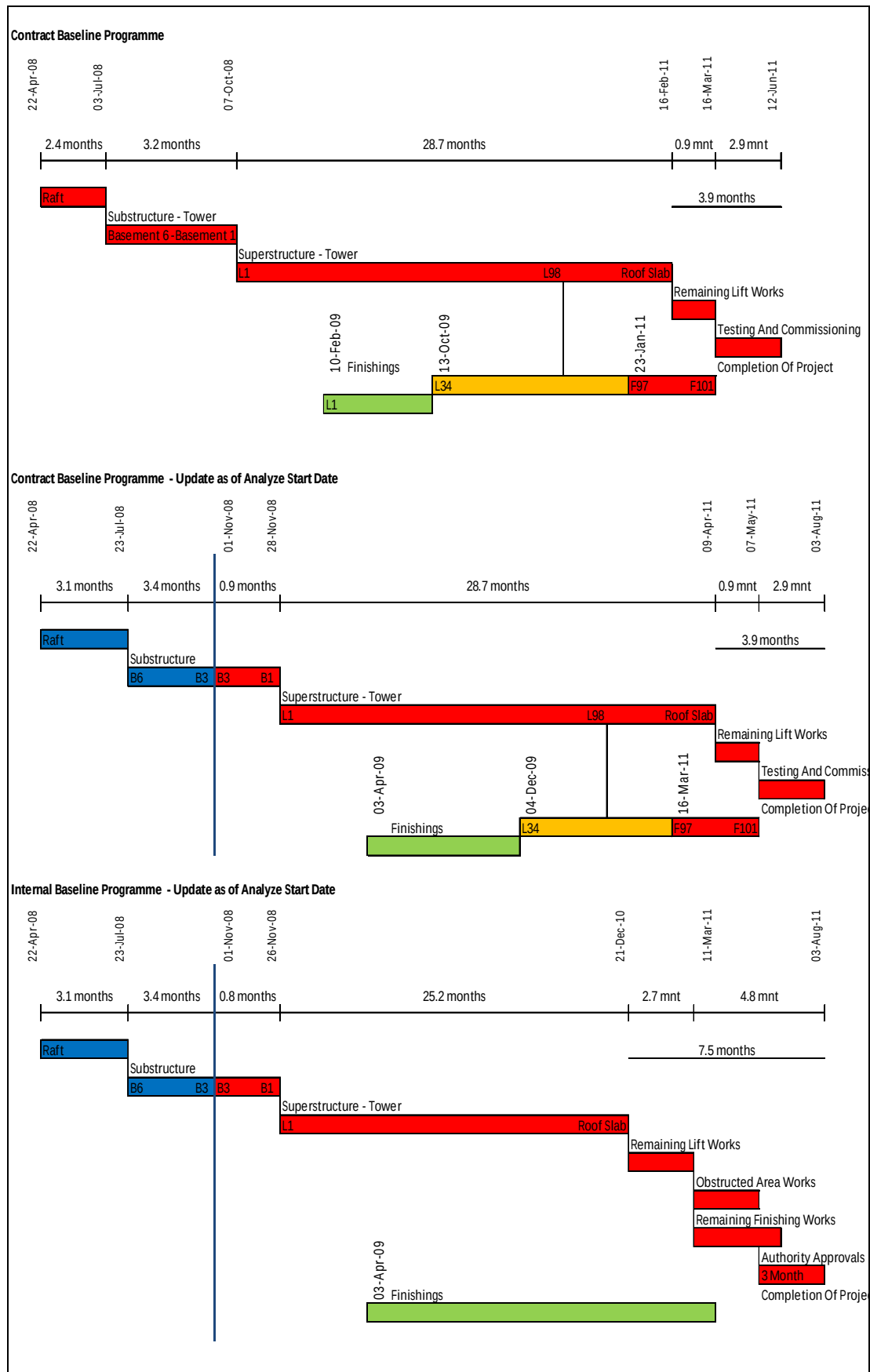


Figure 3.5.Contract Schedule Critical Paths

In actual programme the duration for Superstructure Works is approximately 3 and a half months shorter than contract programme

After determination of the Lift Works activities durations by receiving the correct work programme data from the liable subcontractor, contractor decides to revise its completion of superstructure works.

Lift subcontractor requires 3 month of time in order to complete the Lift Works construction after the completion of construction of Structural Works.

After handing over one of the lifts to contractor for temporally use of material delivery, the facade hoists on the building can be dismantled and facade works in obstructed areas can be completed. The authority approval processes can begin only after these works are completed and the process may take up to 3 months under optimal conditions. With considering these additional data, the duration needed after the completion of the structure is 7,5 months instead of 4 months stated in contract programme.

3.8.3 As planned and as built critical paths in updates on contract and internal programme

On the update on December 1st 2009, the ending date of the analysis, critical path vanishes compared to contract baseline. This path transforms into a positive float since the contractor operated faster than planned. However, internal programme update for the same date preserves the criticality of the original critical path. By accelerating on the critical path activities, the contractor has reduces -44 days of delay to -29 days.

As per this update tower substructure works and tower superstructure works, up to L49, can be defined as built critical path. It is observed that after various updates the original as-planned critical path is kept its stability, therefore the path can be acceptable as a reliable path for the purpose of further steps of analysis.

3.9 Analysis Results

This section of the study contains the comparison of the critical path values on each window update, following the definition of windows in Section 3.7 and determination of the critical path in Section 3.8.

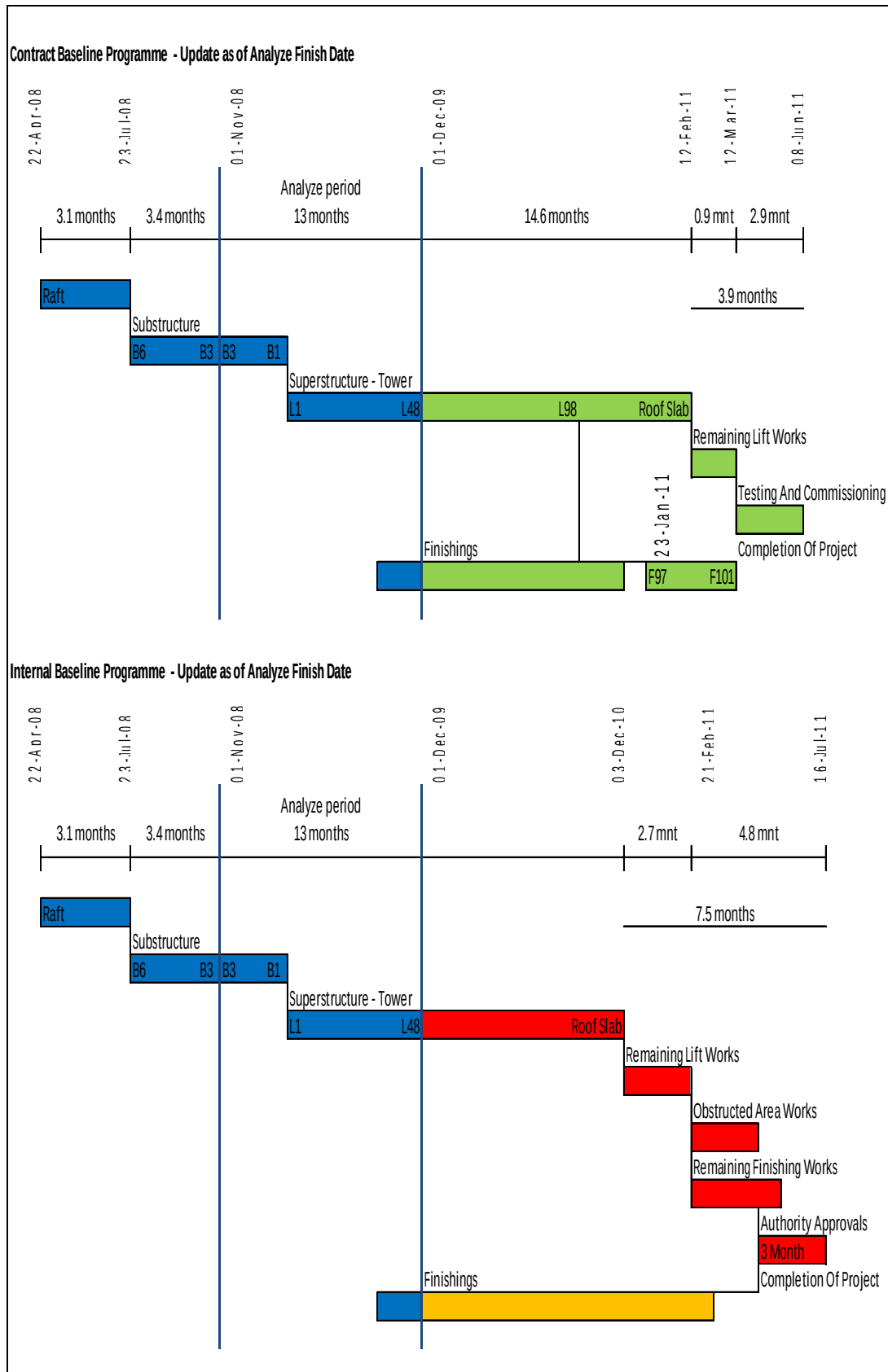


Figure 3.6.Contract Schedule and Internal Schedule

Table 3.5 Float Changes at Contract Programme

Win No	Start	TF	Ref	Update Type	Finish	TF	Ref	Update Type	Float Change	Delays By		
										O	C	N
W 1	01-Nov-08	-44	0810	October Monthly	15-Nov-08	-41	W2A1	DE 2a As Pln	3	0	3	0
W 2	15-Nov-08	-41	W2A1	DE 2a As Pln	22-Nov-08	-42	W2A2	DE 2a As Pln-imp.	-1	0	1	-2
W 3	22-Nov-08	-42	W2A2	DE 2a As Pln-imp.	01-Dec-08	-42	0811	November Monthly	0	0	0	0
W 4	01-Dec-08	-42	0811	November Monthly	07-Dec-08	-46	W2B2	DE 2a & 2b As Pln-imp.	-4	-4	0	
W 5	07-Dec-08	-46	W2B2	DE 2a & 2b As Pln-imp.	15-Dec-08	-45	W2D1	DE 2d & 2e As Pln	1	0	1	0
W 6	15-Dec-08	-45	W2D1	DE 2d & 2e As Pln	22-Dec-08	-49	W2D2	DE 2d & 2e As Pln-imp.	-4	-4	0	0
W 7	22-Dec-08	-49	W2D2	DE 2d & 2e As Pln-imp.	27-Dec-08	-46	W2F1	DE 2f As Pln	3	0	3	0
W 8	27-Dec-08	-46	W2F1	DE 2f As Pln	01-Jan-09	-46	0812	December Monthly	0	-1	1	0
W 9	01-Jan-09	-46	0812	December Monthly	13-Jan-09	-50	W2G2	DE 2g As Pln-imp.	-4	-4	0	0
W 10	13-Jan-09	-50	W2G2	DE 2g As Pln-imp.	01-Feb-09	-46	0901	January Monthly	4	0	5	-1
W 11	01-Feb-09	-46	0901	January Monthly	01-Mar-09	-49	0902	February Monthly	-3	0	-1	-2
W 12	01-Mar-09	-49	0902	February Monthly	01-Apr-09	-38	0903	March Monthly	11	0	11	0
W 13	01-Apr-09	-38	0903	March Monthly	01-May-09	-31	0904	April Monthly	7	0	7	0
W 14	01-May-09	-31	0904	April Monthly	01-Jun-09	-32	0905	May Monthly	-1	0	-1	0
W 15	01-Jun-09	-32	0905	May Monthly	17-Jun-09	-32	W2K1	DE 2K As Pln	0	0	0	0
W 16	17-Jun-09	-32	W2K1	DE 2K As Pln	21-Jun-09	-33	W2K2	DE 2K1 As Pln-imp.	-1	0	0	-1
W 17	21-Jun-09	-33	W2K2	DE 2K1 As Pln-imp.	29-Jun-09	-34	W2K3	DE 2K3 As Pln-imp.	-1	0	0	-1
W 18	29-Jun-09	-34	W2K3	DE 2K3 As Pln-imp.	06-Jul-09	-34	W2K4	DE 2K5 As Pln-imp.	0	0	1	-1
W 19	06-Jul-09	-34	W2K4	DE 2K5 As Pln-imp.	01-Aug-09	-31	0907	July Monthly	3	0	3	0
W 20	01-Aug-09	-31	0907	July Monthly	01-Sep-09	-26	0908	August Monthly	5	0	5	0
W 21	01-Sep-09	-26	0908	August Monthly	01-Oct-09	-25	0909	September Monthly	1	0	1	0
W 22	01-Oct-09	-25	0909	September Monthly	01-Nov-09	-13	0910	October Monthly	12	0	12	0
W 23	01-Nov-09	-13	0910	October Monthly	01-Dec-09	3	0911	November Monthly	16	0	16	0

Table 3.6 Float Changes at Internal Programme

W No	Start	Total Float	Ref	Type	Finish	Total Float	Ref	Type	Float Change	Delays By		
										O	C	N
W 1	01-Nov-08	-44	0810	October Monthly	15-Nov-08	-42	W2A1	DE 2a As Pln	2		2	
W 2	15-Nov-08	-42	W2A1	DE 2a As Pln	22-Nov-08	-43	W2A2	DE 2a As Pln-imp.	-1		1	-2
W 3	22-Nov-08	-43	W2A2	DE 2a As Pln-imp.	01-Dec-08	-44	0811	November Monthly	-1		-1	
W 4	01-Dec-08	-44	0811	November Monthly	07-Dec-08	-49	W2B2	DE 2a & 2b As Pln-imp.	-5	-5		
W 5	07-Dec-08	-49	W2B2	DE 2a & 2b As Pln-imp.	15-Dec-08	-48	W2D1	DE 2d & 2e As Pln	1		1	
W 6	15-Dec-08	-48	W2D1	DE 2d & 2e As Pln	22-Dec-08	-52	W2D2	DE 2d & 2e As Pln-imp.	-4	-4		
W 7	22-Dec-08	-52	W2D2	DE 2d & 2e As Pln-imp.	27-Dec-08	-51	W2F1	DE 2f As Pln	1		1	
W 8	27-Dec-08	-51	W2F1	DE 2f As Pln	01-Jan-09	-52	0812	December Monthly	-1	-2	1	
W 9	01-Jan-09	-52	0812	December Monthly	13-Jan-09	-57	W2G2	DE 2g As Pln-imp.	-5	-5	1	-1
W 10	13-Jan-09	-57	W2G2	DE 2g As Pln-imp.	01-Feb-09	-56	0901	January Monthly	1		1	
W 11	01-Feb-09	-56	0901	January Monthly	01-Mar-09	-63	0902	February Monthly	-7		-5	-2
W 12	01-Mar-09	-63	0902	February Monthly	01-Apr-09	-54	0903	March Monthly	9		9	
W 13	01-Apr-09	-54	0903	March Monthly	01-May-09	-51	0904	April Monthly	3		3	
W 14	01-May-09	-51	0904	April Monthly	01-Jun-09	-54	0905	May Monthly	-3		-3	
W 15	01-Jun-09	-54	0905	May Monthly	17-Jun-09	-52	W2K1	DE 2K As Pln	2	2		
W 16	17-Jun-09	-52	W2K1	DE 2K As Pln	21-Jun-09	-53	W2K3	DE 2K As Pln-imp.	-1		0	-1
W 17	21-Jun-09	-53	W2K3	DE 2K As Pln-imp.	29-Jun-09	-54	W2K5	DE 2K As Pln-imp.	-1		1	-2
W 18	29-Jun-09	-54	W2K5	DE 2K As Pln-imp.	06-Jul-09	-54	W2K7	DE 2K As Pln-imp.	0		1	-1
W 19	06-Jul-09	-54	W2K7	DE 2K As Pln-imp.	01-Sep-09	-51	0908	August Monthly	3		3	
W 20	01-Aug-09	-51	0907	July Monthly	01-Sep-09	-46	0908	August Monthly	5		5	
W 21	01-Sep-09	-46	0908	August Monthly	01-Oct-09	-44	0909	September Monthly	2		2	
W 22	01-Oct-09	-44	0909	September Monthly	01-Nov-09	-38	0910	October Monthly	6		6	
W 23	01-Nov-09	-38	0910	October Monthly	01-Dec-09	-29	0911	November Monthly	9		9	

Classification of delays are followed the terminology mentioned in the 2.4.1 Delay section. Owner impacted delays are within excusable delays and is going to be classified as compensable or non-compensable depending whether it is concurrent or not. Contractor impacted delays are non-excusable delays and neutral delays are going to be referred to as excusable compensable delays.

Graphical assessment of data extracted from contract schedule in Table 3.5, is shown in figure 3.7. The reflection of the Contractor's internal schedule values exhibited in Table 3.6 can be seen on figure 3.8. The main purpose of forming these tables is to determine and compare the time-related issues on internal and contract baseline programmes.

In Figures 3.7 and 3.8, Structural Works total float changes determined as the critical path of the project are shown in graphics and float changes for each Window that is represented with different colours according to their sources. A time line named as floor added to the table indicating the number completed structural floors for to monitor the physical progression of the project at each window period. Concurrently, the floor line trend indicates which structural activities are affected by delay events or accelerations in project.

All owner-impacted delays shown in the graphics, occurred in the first 6 monthly period, between November 1st 2008 and May 1st 2009. The critical path activities in this period contain the Structural Works construction between Basement 3 Slab up to Level 14 slab. This period of 6 months is divided into 13 windows and the windows 4, 5, 8 and 9 are defined as delay event windows. This period window including owner impacted delay events will be described as circumstance 1.

In the period between July 6th 2009 and December 1st 2009, contractor has acceleration actions. The critical path activities in this period contain from L21 slab to L48 concrete slab activities. This period window including contractors' voluntary acceleration will be described as circumstance 2 where acceleration, contingency and float distribution at activity durations are going to be major discussing points.

3.9.1 Circumstance 1

Contractor begins the period, inheriting a delay of -44 days from the previous term, as its EOT request is not been responded from the engineer..

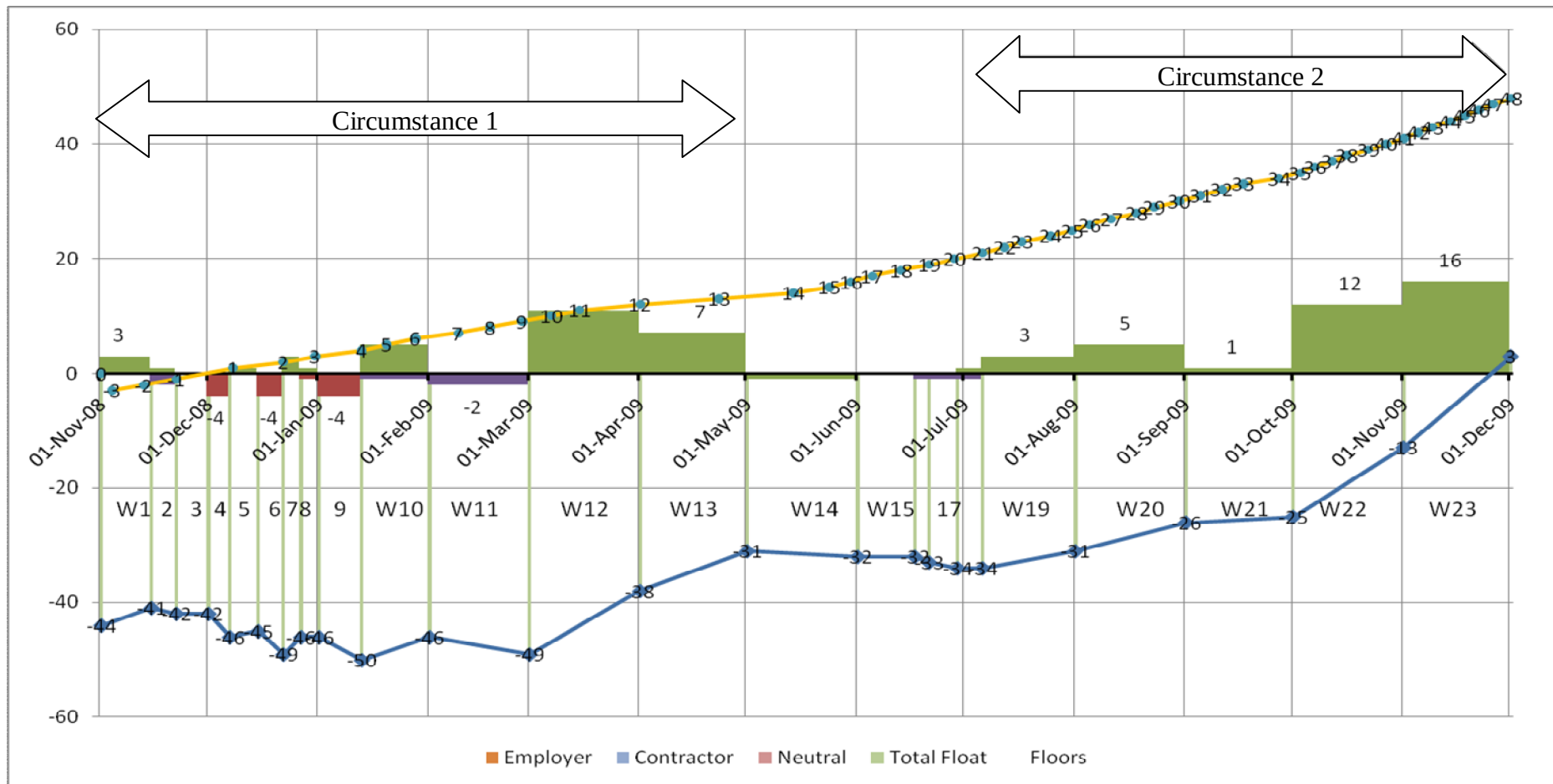


Figure 3.7. Contract programme Delay and acceleration trend per window

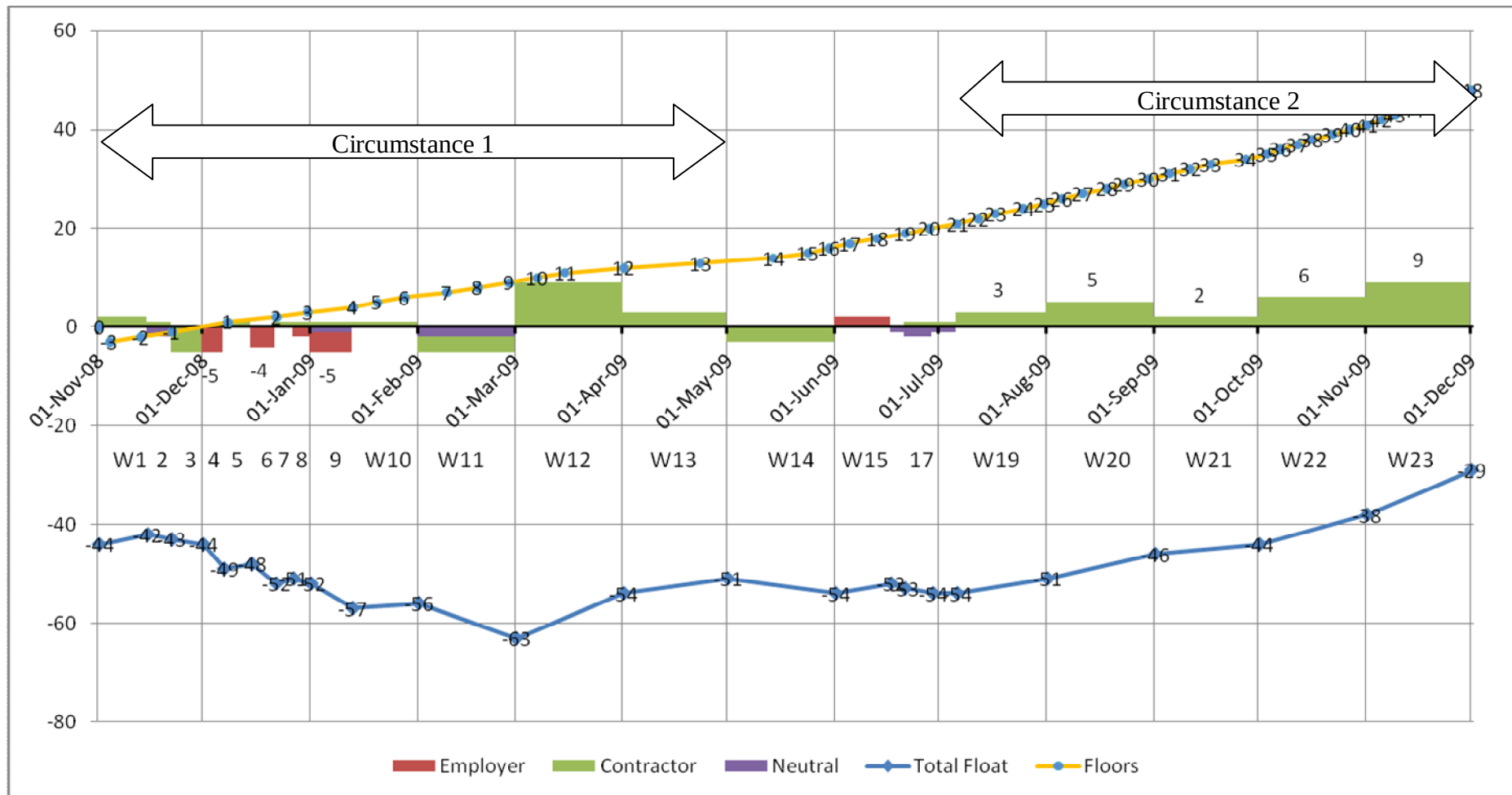


Figure 3.8. Internal programme Delay and acceleration trend per window

Window 1; from the beginning of the November until the mid-November, contractor performed faster than planned. In Window 2, between dates November 15 and 22, contractor encountered a concrete supply problem and B1 slab is impacted by a 2 days of delay, which then the contractor compensated by working on an off-day and recover one day of delay

In Window 3, although the contractor did not delay on contract programme for Level 1 slab, he deviated 5 days from his original goals in his initial programme. In Window 4, between dates December 1st and 6th, there were additional delays other than slab 1, due to a change in design. In the period between Slab level 3 and Slab level 4 to window 9, there were additional delays inflicted by employer-engineer. The detailed windows analysis of these delays is given in Figure A.

At the end of Window 9, when the delay at the critical path reached to a minus 50 days, Contractor has to make a decision to reduce the delay by acceleration or continue with planned performance and anticipate receiving an EOT. At this point contractor has an acceleration opportunity with reasonable costs and to gain 12 more workdays than, by purchasing additional formwork for the transfer beam between Level 12 and Level 13 construction that may arrive to site 2.5 months after his decision. Such effective acceleration may not be possible even contractor spends additional costs on regular floors. However If the contractor accelerates on that point, he will be also recovering other parties' delays and produce positive float to the project. On the other hand, the delay in contractor's internal programme is more than contract programme as -63 days, which indicates there are risks in the future that are expected, but not reflected to the contract programme.

As explained in Section 3.8., Critical path determination, the structural works of the project must be completed before the date stated in contract programme. In this condition, contractor is decided to create this extra float to reduce possible risks in future. It is observed in Windows 12 and 13; contractor used acceleration opportunity considering its costs, since the acceleration cost done at the right time, is less than the Liquidated damages due to the delays with considering the possibility of receiving the EOT claim and the possibility of occurrence of delay.

In Circumstance 1 period, time impacts below occurred, according to contract programme.

- Total Owner impacted Delay: 13 days
- Total Neutral Delay: 5 days
- Total Contractor Acceleration: 24 days
- End of Term Total Float: -38 work days

The same period according to updates made on contractor's internal programme is as follows;

- Total Owner Impacted Delay: 16 days
- Total Neutral Delay: 5 days
- Total Contractor Delay: 10 days
- Total Contractor Acceleration: 20 days
- End of Term Total Float: -54 work days

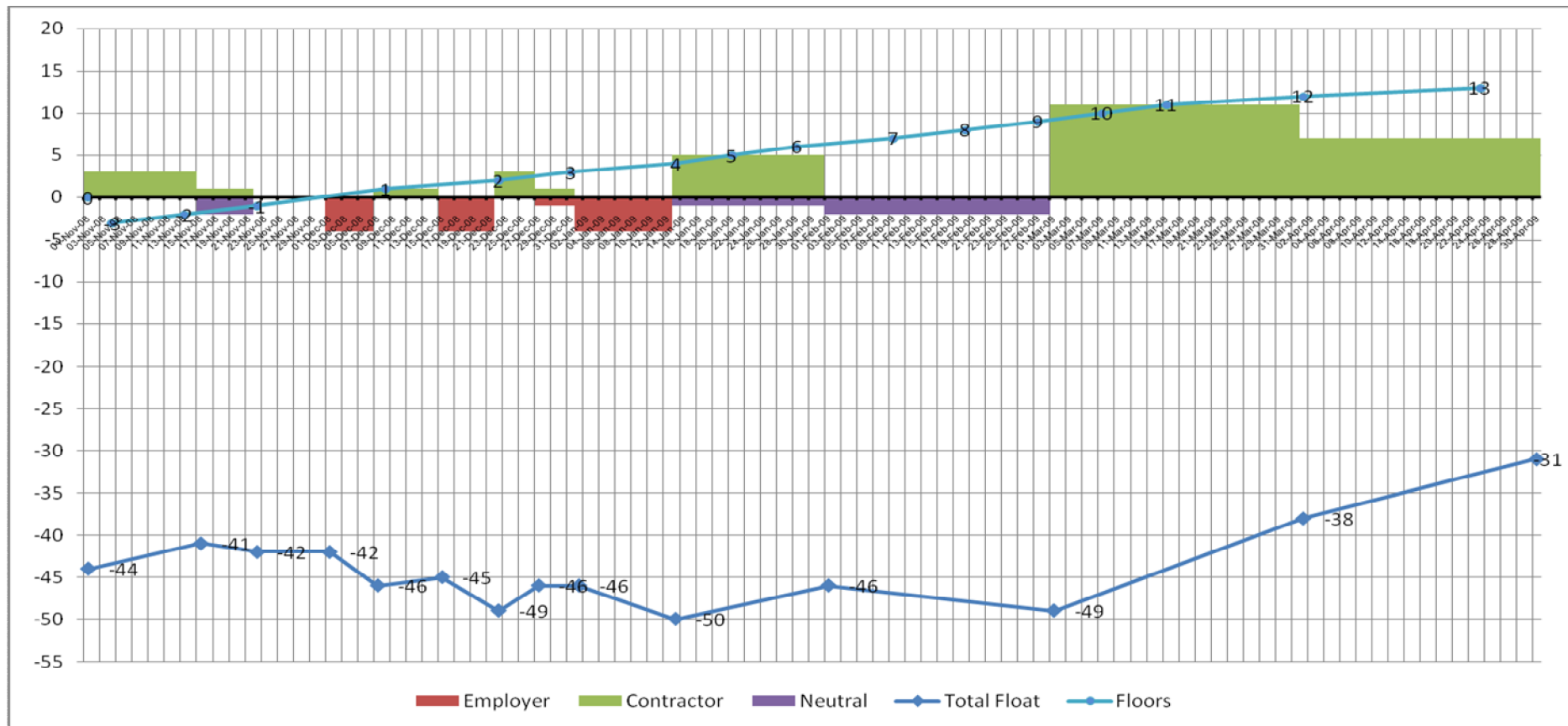
The figures indicate that there are differences in the calculations of assignments of delay responsibilities between the data obtained from contract and internal programme. The most important difference is the on the calculation of compensable excusable delay events where contractor has right to time and its compensation; there is 3 days difference which is to %19 difference between programmes.

The biggest variance is reported between is the total float figures which dedicate the expected completion of project. Such amount of difference may mislead contractors' project management strategy including all time and cost issues.

In terms of float sharing and ownership the misallocated float in contract programme is exposed during Circumstance 1 period and shared with project which works in "First comes, first owns" concept. On the other side although the initial programme has showing a later completion date, it still keeps contractor valuable exclusive float within its activities

3.9.2 Circumstance 2

In Circumstance 2 period the contractor's performance compared with previous periods and contractor continued to work on off-days. Acceleration intent begins on July 6th 2009, in window 19 and continues until the end of work window 23.



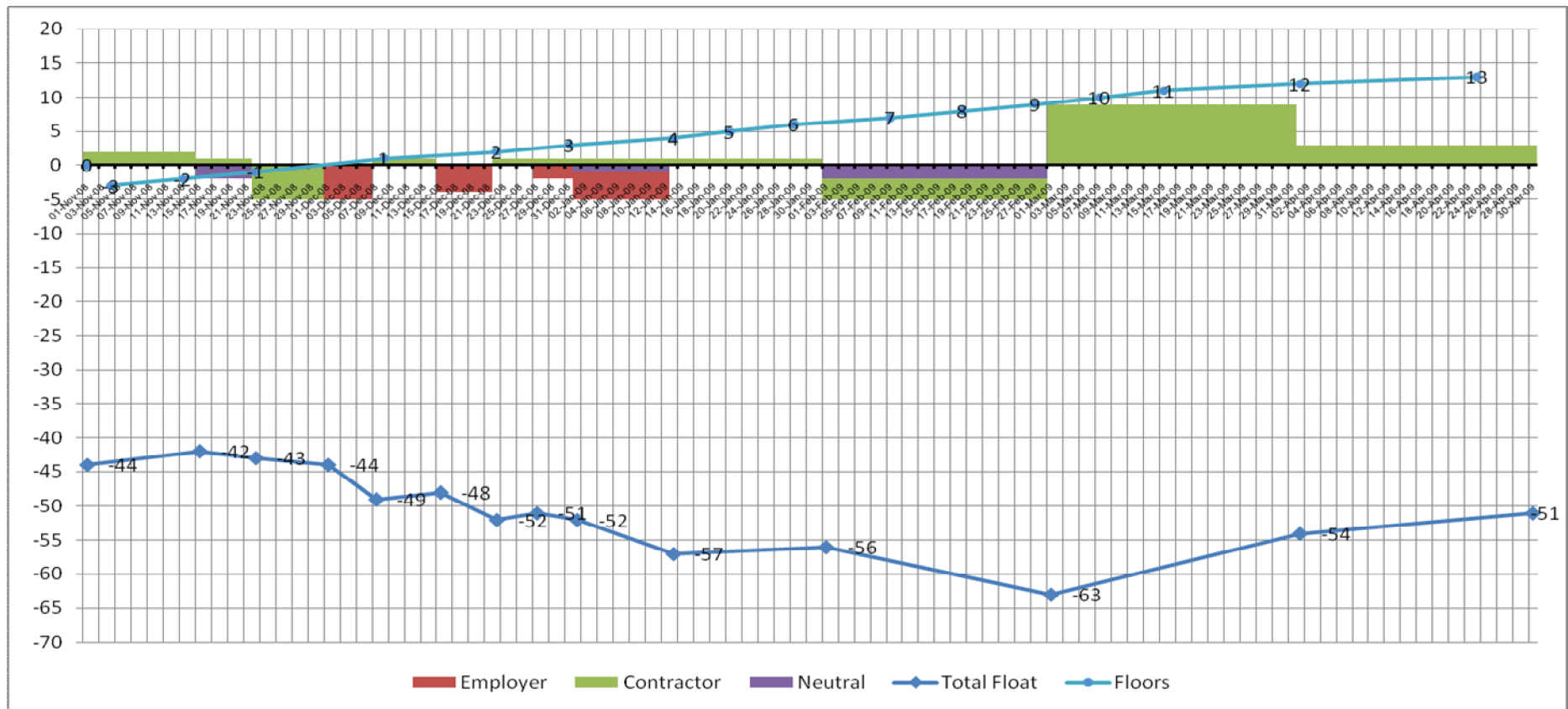


Figure 3.10. Circumstance 1 Internal programme Delay and acceleration trend per window

When figure 3.7 and figure 3.8 are compared, this intent can be seen on both contract and internal programmes. The main difference is the magnitude of acceleration.

In Circumstance 2 period, the delay event and acceleration and total float changes related to these are as follows;

- Total Contractor Acceleration: 37 days
- Beginning of Period Total Float: -34 days
- End of Period Total Float: +3 days

The same period according to updates made on contractor's internal programme is as follows;

- Total Contractor Acceleration: 25 days
- Beginning of Period Total Float: -54 days
- End of Period Total Float: -29 days

According to the contract programme, contractor recovered all delay events. 37 days of acceleration reported in the internal programme can be segregated to period as follows;

Since 25 days out of 37 days are reported in internal programme, the remaining period of 12 days is the contingency periods added to the activities by the contractor. This can be assessed as a faulty planning by the contractor or misplacing the float allocation due to misjudging the risk.

21 days out of 25 days, the contractor worked on weekends voluntarily. The remaining 4 days are the result of unexpectedly improved labour performance of contractor due to repetition of work.

Contractor could not sufficiently evaluate the learning curve effect on repetitive activities, both on contract and internal programmes although the acceleration has been achieved without extra cost. On the contrary, the contractor assumed that as the building goes up, the logistic problems would have more impact and contingency periods would be useful. However, on both updates, acceleration related to performance between Window 21 and Window 23 is in a rising trend in month. The amount of figures reported for contract programme is raises questions about the reliability of programme itself.

Contract programme, aside from recovering from all the delays, has given a 3 days of float to the project, for the benefit of the first party that claims. Considering that contractor cannot be slower than his existing optimum speed, especially when there is a delay risk for his internal programme, he may continue sharing its valuable float to the project with an increasing trend.

As a result that contractor may lose its entitlement for his previous submitted Extension of Time claims and associated costs. As there is no critical path in the contractors' contract programme current update and contractor's intension is to continue acceleration, total float the longest path of contract programme will be increased in future updates. If contractor do not properly reflects the changing conditions to its programme, he may lose his opportunities for future extension of time claims although he may suffer from these delays in his actual programme.

4. A PROPOSED METHODOLOGY FOR CONTRACTORS' RISK MAP

4.1 Introduction

The current practice of float ownership is “first come, first served” basis. Under this condition, it is contractors challenge to evaluate and place its exclusive float without effecting flexibility and credibility of his work programme.

Contractor can hide his float with increasing individual activity durations or can define a time contingency activity, which is recognized as an acceptable practice by SCL (2002)

However, both methods may have serious pitfalls. As it is discussed in chapter 3, the misplacement of float durations in activities may cause differences in contractors EOT claim entitlements. When it is defined as a contingency as an activity, its usage can be manipulated if consumption limits did not defined in per time unit or per construction phase

Whether it is by increased durations or by contingency activities, contractors exclusive float allocation or usage should correspond to the contractors risk assumption as, the activities who bear the most risk should own the most float.

The objective of this chapter is to obtain a visual contractors risk map to indicate the trend for allocation or usage of float in contractors future submittals. A methodology will be advised to qualitative the risk level of activities, based on subjective assumptions of project managing team to achieve objective.

4.2 Method

The below steps will be followed as in the study;

- Definition of Phases of Project
- Qualitative Risk Level for each Phase
- Combining with Work Programme

- Preparation of Risk Map for Float Allocation

The study starts with the definition of phases of project. The activities that have similar characteristics of constructability or resource demand and belong to same path or spiral of paths in work programme will be grouped and named as phases.

Second step is to qualitative the delay factors for each activity in a specific time period. The analytic hierarchy process (AHP) (Satty 1982) used by Popescu (1994) to qualitative factors for total float distribution has taken as a guide which will be explained in detail further.

The calculated risk factors then will be loaded to a work schedule to produce a graph for contractor risk event. To simplify the analyses original work programme has been summarized and transferred to an Ms Excel Chart at figure B.2

4.3 Phase Types

Construction activities have been grouped considering the similarities in below listed criteria.

- Work Sequence
- Equipment and logistic limitations
- Recovery / acceleration measures

Considering these facts a phase can represent a single path such as roof phase or group of paths which has a spiral nature such as finishing works phase. The phases are defined as fallows; (Figure 4.1)

- Start Phase
 - o Raft and Substructure
 - o Repetitive Phases
 - o Substructure
 - o Heavy Finish and MEP
 - o Sections (MEP Shaft , Lift, Facade
 - o Finish and MEP
- Finish Phase

- o Roof
- o Dismantle and Remaining Works

The major characteristics of phases has been summarized in table 4.1

4.3.1 Raft and Substructure

Raft and partially substructure works are always in the critical path of a tall building project. From many perspectives, it is unique and challenging phase for contractor and owner.

Ground conditions may create unexpected construction difficulties and the distribution of responsibility in case of a delay can be a dispute among parties.

From the contractor part, as the construction and management team is recently established and the performance of teams should be expected as minimum.

4.3.2 Structure Repetitive

Structure activities are concrete core wall, slab and wall activities which are fully or partially in critical path of project. Activities are in an invariable straight order as from downwards to upwards. Productivity depends on cycle time of one floor construction. Criteria that define cycle time of floor are type of formwork system, availability of crane, space constraint for manpower, manpower productivity, concrete type and its curing time.

It is not possible to allocate resource in multi locations and there is usually a limited space for mitigation after the system is settled, however there are possibilities of limited acceleration with increased or modified formwork sets or increased manpower.

4.3.3 Heavy Finish and MEP

These activities heavy block work and Mechanical first and 2nd fix items. They are dependent to crane and loading platform resource constraints remanding after structural works. They move as successor of structural activities. Although it is physically possible to work in multi levels and increase daily productivity; it can be preferred only without effecting structural works cycle.

4.3.4 Sections (MEP Shaft , Lift, Facade)

These activities include vertical activities such as;

- Lift shaft activities
- Mechanical and Electrical shaft activities
- Shelf activities such as cladding and windows

These activities working space is limited with volume of shaft or the dimensions and number of working platforms or cradles. The erection sequence is determined by the vertical movement abilities of cranes or platforms. These activities carry serious accident risk and safety regulations may also impact on their installation sequence and productivity.

Due to equipment, space and safety constraints, applicable acceleration or recovery measures are very limited and costly.

Lift and façade works are long lead items and delays are common for offsite procurement works which are not under control of contractor.

4.3.5 Finishing and MEP - Repetitive Nature

These activities include all the finishing and MEP activities excluding heavy partition and Mechanical second fix works.

This phase is acts more like a spiral of paths that are combined to each other that have a higher complexity level due to existing of multiple different trades. Although it is possible work in multi levels with increasing the number of teams the increase is limited with the logistic criteria such as capacity of crane and hoist and storage area.

4.3.6 Top Structure Roof

These activities include installation of;

- Parapets
- Roof Finishes
- Roof MEP and Window Cleaning System Units
- Roof Steel Structure

These activities are predominantly calculated as critical path activities, the sequence of teams is fixed with their physical connections and cannot be re-sequenced. Crane, scaffolding, and workspace are the limitations of work. Acceleration methods are very limited and costly which may be achieved only with advance work methods and additional special cranes.

The Erection of 41 meter height steel structure will be performed at 400 meter height and interfaces with other trades, can be defined as a remarkable contractor risk.

4.3.7 Dismantle and Remaining Façade & Finishing Works

These activities include installation sequenced as;

- Dismantle of Formwork Systems
- Dismantle of Tower Cranes and Hoists
- Remaining Facade works after dismantle of equipments
- Remaining Finishing Works after remaining Facade Works

All of these activities will be in critical path of project. The movement of teams are fixed as up to down for dismantling and down to up for remaining facade works and re-sequencing is not possible due to workspace constraints. The sequence of activities with is also physically fixed and cannot be re sequenced.

After dismantling of cranes and hoists, area of 2-3 meters width and 400 meter height will be remaining for each of equipments. Working in these limited spaces with a fixed sequence from up to down is depends on cradles. Additional cradles can be provided by only with advance installation methods to achieve an acceleration or recovery.

Another challenging part of this phase is reminding finishing works after remaining façade works. Even through the work, left in each level will be including only couple of rooms; these activities will proceed with a lower productivity rate compared with initial stages

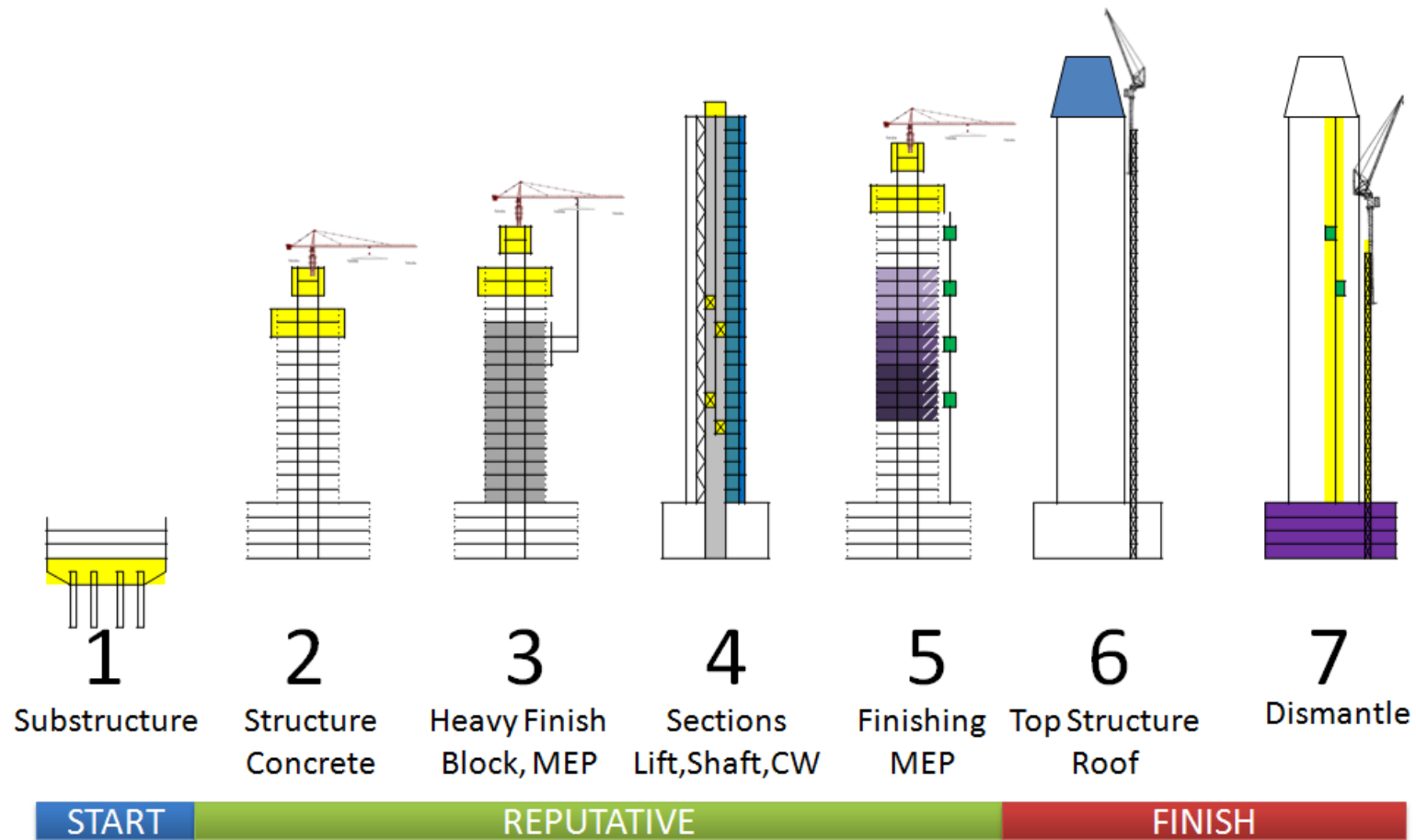


Figure.4.1 .Phase Types of Case Building

Table 4.1 Phase Types of Building

Criteria	Detail of Criteria	Substructure	Structure	Heavy Finish	Finish	Section	Roof	Dismantle
Ratio of Critical Activities		All	High	Medium	Medium	High	High	All
No of Different Teams		Less Than 5	Less Than 5	2	More than 15	3	5-8	More than 15
Work Direction		Down to Up	Down to Up	Down to Up		Down to Up	Fixed	Up to Down
Equipment/Logistic Limitations	Crane		Major				Major	Major
	Formwork System	Major	Major	Yes				
	Loading Platform			Major				
	Hoist			Yes	Major	Yes		
	Cradles/Scaffolding					Major	Major	Major
	Work Space		Yes			Major	Yes	Major
	Storage Area				Yes			
Recovery / Acceleration Measures	Re-Sequencing Teams (Floor Sequence)	Not Possible	Not Possible	Possible	Possible	Possible	Not Possible	Not Possible
	Re-Sequencing Activities	Not Possible	Not Possible	Possible	Possible	Not Possible	Possible	Possible
	Increase Manpower	Possible /Limited	Possible /Limited	Possible	Possible	Possible	Possible /Limited	Possible /Limited
	Additional Equipment	Not Possible	Required	Required	Not Required	Required	Not Possible	Required
	Advance Work Methods	Possible	Required	Not Required	Not Required	Required	Required	Required

4.4 Qualitative Risk Level for each Phase Type

The purpose of this step is to qualitative the delay risk factors for each phase or activities per a period.

Popescu (1994) previously has used an AHP (Satty 1882) to qualitative factors for total float distribution. His proposed factors have been explained at chapter 2. These factors has been reviewed and modified as follows.

- Manpower Demand; The activities demand for more rare manpower resource are having more delay risk.
- Type of Work; the rarer applications which require specialist manpower are having more delay risk.
- Complexity of process, the activities that have more trades with having more handover process within them are having more delay risk.
- Equipment Demand; The activities demand for more equipment resource such as Mobile crane, hoist, or cradles are having more delay risk.
- Late Material Delivery; the activities that are having higher risk of late material delivery are having more delay risk.
- Insufficient Design; the activities which are having more complex drawing are having more delay risk.
- Wind; the activities that are on outside and higher floors are having more delay risk.
- Reputation; the activities that are repeated lesser are having more delay risk.

Table 4.2 provides the matrix of paired comparison for quantitative criteria for to compare each quantitative with others individually. As a result of this process priority will be settled which will be accepted as a weight factor as it is mentioned in the last column of table 4.2

In this process, the project management team needs to assign importance value for each pair of criteria. As an example from table 4.2 manpower demand criteria may cause two times higher compared with the equipment demand.

Table 4.2 Matrix of each qualitative factor calculation for each criterion priority

Criteria	Manpower Demand	Type of Work	Complexity	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	$\sum$	Pi	pi
Manpower Demand	1	0.5	0.5	2	0.5	0.7	0.5	4	0	0.877	9%
Type of Work	2	1	1	2	1	1	0.5	6	12	1.364	15%
Complexity of process	2	1	1	5	3	2	1	6	360	2.087	22%
Equipment Demand	0.5	0.5	0.2	1	0.5	0.5	1	4	0	0.688	7%
Late Material Delivery	2	1	0.3	2	1	1	0.5	4	3	1.13	12%
Insufficient Design	1.4	1	0.5	2	1	1	0.3	4	2	1.07	11%
Wind	2	2	1	1	2	3.3	1	6	160	1.886	20%
Reputation	0.3	0.2	0.2	0.3	0.3	0.3	0.2	1	0	0.255	3%
Total									537	9	100%

Table 4.3 The process of checking contingency

Criteria	Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Row Sum
pi	9%	15%	22%	7%	12%	11%	20%	3%	
Manpower Demand	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.7755
Type of Work	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.2	1.2029
Complexity of process	0.2	0.1	0.2	0.4	0.4	0.2	0.2	0.2	1.8801
Equipment Demand	0	0.1	0	0.1	0.1	0.1	0.2	0.1	0.6661
Late Material Delivery	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.9996
Insufficient Design	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.9429
Wind	0.2	0.3	0.2	0.1	0.2	0.4	0.2	0.2	1.7635
Reputation	0	0	0	0	0	0	0	0	0.2229

Below listed steps is summarizing the process for calculating pi as a weight factor between criteria as it is mentioned in the last column of table 4.2.

- The process of checking consistency (Table 4.3)
 - o Calculated pi factors are placed to top of rows for each criterion.
 - o Compared values from table 4.2 , and placed pi factors are multiplied in table 4.3 and a column indicating row sum has been added to end of table
 - o Last column numbers are divided by the criterion priority (pi) as shown in table 4.5

Table 4.4 Random Contingency of AHP Matrix (Satty, 1982)

Size of Matrix	1	2	3	4	5	6	7	8	9	10
Contingency	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 4.5 Calculation of Contingency

Criteria	Raw Sum of Table 4.3		Pi Value		Raw Sum /Pi Value
Manpower Demand	0.78	÷	0.09	=	8.27
Type of Work	1.2	÷	0.15	=	8.25
Complexity of process	1.88	÷	0.22	=	8.43
Equipment Demand	0.67	÷	0.07	=	9.06
Late Material Delivery	1	÷	0.12	=	8.27
Insufficient Design	0.94	÷	0.11	=	8.25
Wind	1.76	÷	0.2	=	8.75
Reputation	0.22	÷	0.03	=	8.17

- o The contingency of matrix is finally calculated from the following equation;

$$\lambda_{\max} = \frac{(8.27 + 8.25 + 8.43 + 9.06 + 8.27 + 8.25 + 8.75 + 8.17)}{8} = 8.433 \quad (4.1)$$

- o The contingency of matrix is 0.062 is less than 1.41 (Satty 1982), that mentioned at table 4.4 for a size of matrix as 8 criteria therefore the criterion priority is approved

$$Contingency = \frac{\lambda_{\max} - n}{n - 1} = \frac{8.433 - 8}{8 - 1} = 0.062 \quad (4.2)$$

After the approval process, the activities will be ranked with a number from 0 to 5 which represent the sensitivity of an activity to the delay due to an individual qualitative criterion in table B.

During ranking process project management team has considered following factors;

- Manpower Demand, Type of Work, Complexity of process criteria has been ranked differently for each phase of work, however within the same phase of works it has given as same for all floor levels
- Equipment demand criterion ranking also differs for each phase additionally ranking increases for activities in higher floor.
- Late material delivery criterion is assigned for initial activities at lower floor levels.
- Insufficient design criterion is assigned for initial activities at lower floor levels.
- Wind criterion is assigned for external works at higher floor levels.
- Reputation criterion is assigned higher for the activities which have repeated more independent from phase types.

Calculation of ranking for phase and floor are listed in table B.2, below section explanation has been given for structure and finishing phases. Figures for other phases has been presented at Figure B.1

Structure – Repetitive Nature

Figure 4.2 indicates risk ranking of structural elements. The x axis indicates risk ranking while y axis is indicates floor numbers. It is assumed that the initial activities are carrying highest risk in the construction of first floors and delays may be expected on these activities. As time passes due to reputation of work, delay risk of activities are getting decrease and requirement for float allowance goes down. However, after reaching 90th floor at 330 meters height from ground, due to conditions such as strong wind, work stoppages and productivity decreases are expected.

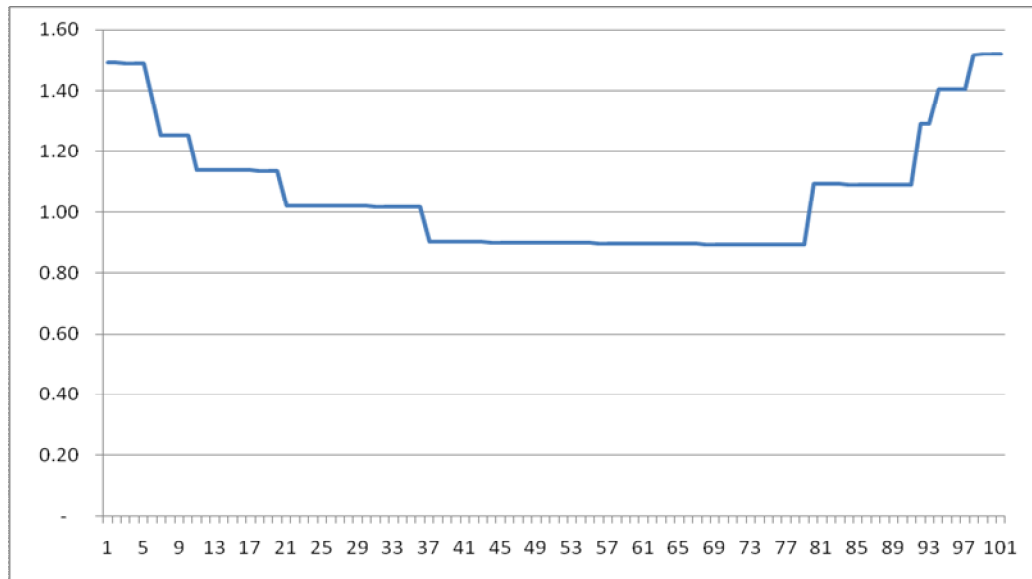


Figure.4.2 .Risk Trend per floor for Superstructure phase

Finishing and MEP - Repetitive Nature

Figure 4.3 indicates risk ranking of finishing phase. The finishing works commences from level 34 of the project. The highest risk is expected in the start of project due to possibility of late material deliveries and complexity of coordination of MEP systems with finishing items.

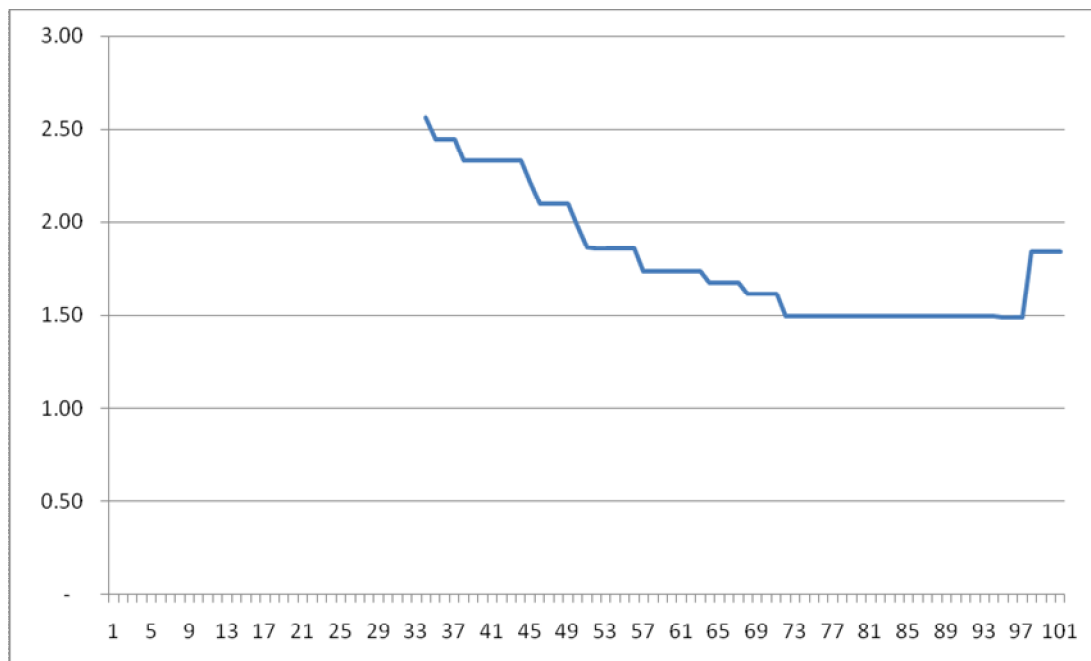


Figure.4.3 .Risk Trend per floor for finishing phase

The risk will continue decreasing as the repetitive works are repeated in following floors. The major concern about this phase is its high complexity level since it

consist of spiral of paths rather than a single alone path with cooperation of various trades. The risk level is again expected to be increase in the last floors where type of apartment changes and new trades needs to be introduced

4.5 Combining Ranking with Work Programme

The programme of building has been represented in figure B.2. In that programme;

- Week accepted as minimum unit for activities
- Required cycle time of an activity is defined as 1 week per floor which is indicated by superstructure works required progress
- Each handover process between the phases or within phase needs to be repeated with in cycle time to provide the continuity of trades and avoid idle time of resources.
- Original Durations are not modified with exclusive float of contractor.

Firstly, the delay risk factors calculated for activities is loaded to activities in schedule. Secondly to combine different risk factors for phases, new criterion named as density factor' has been introduced. The density factor is acts like a weight factor and is multiplied with loaded risk factors to reach to combined risk assumption value for project.

The density factor is formed as a combination of these criteria;

- No of teams in one floor; indicates the maximum number of teams can be allocated in one floor without decreasing the original productivity level. The assumption is that as long as a trade has a potential to increase its manpower efficiently without decreasing its planned productivity, the delay risk of this trade will be lesser.
- Possibility of working in Multi levels; indicates the maximum number of floors which a trade can increase its manpower without decreasing its original productivity level.

$$Density\ Factor = \frac{1}{no.\ of\ teams\ in\ one\ floor \times no.\ of\ accessible\ floors} \times 10 \quad (4.3)$$

As an example the assumed density factors for superstructure and block works phases are calculated as;

$$DensityFactorSuperstructure = \frac{1}{1 \times 1} \times 10 = 10 \quad (4.4)$$

$$DensityFactorBlockwork = \frac{1}{2 \times 5} \times 10 = 1 \quad (4.5)$$

4.6 Risk Map

The rankings for each phase and their density factor have been loaded to work programme in Figure B.2. And transformed to a excel chart in figure 4.4. In figure 4.4 X axis represents time as the number of weeks of project. The y axis represented the cumulated risk value of all phases weighted with their density factor. Each phase risk has been represented with a different colour and sequenced as per their sequence of work at construction process.

The brief summary of the graph as follows, at week 29 the risk level of superstructure works is maximised as it is the start week of repetitive floors construction, the majority of risk goes down up to week 49 as the work trades start to get experience and production increases at same. At week 57 a high risk phase as facade works and its impact is cumulated to risk level. With the commencements of phases of finishing at week 69 and lift at week 81 and it reaches a higher stable level between weeks 85 to 121. The aggressive increase trend commences at week 121 when the last floor of superstructure will be highly affected by extreme wind conditions. With the inclusion of last phases as roof and remaining works, which have very limited acceleration possibilities and congested with limited space, the project delay risk will reach its maximum level during entire project life.

Eventually, this risk graph can be used as a guide for the allocation of float in programme submittals or revisions. The float allocation can be preferred as distributing it to individual activities or as creating a contingency activity in the end of programme. The risk amounts presented by graph may indicate the amount and location of distribution or the permitted allowances for the usage of contingency activities.

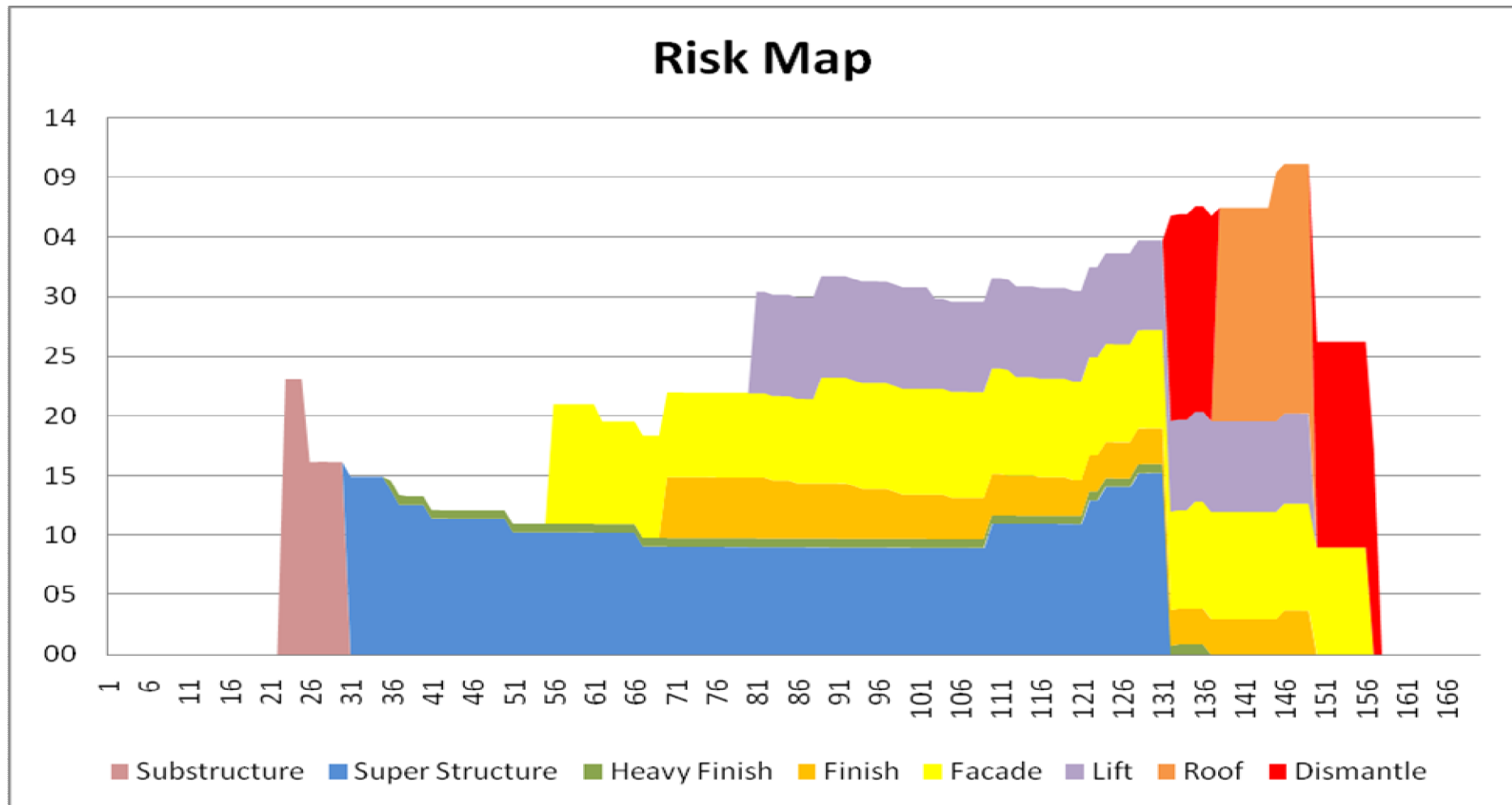


Figure 4.4 Risk Map of Project

5. DISCUSSION ON PROPOSED METHODOLOGY

Purpose of chapter is to discuss the proposed methodology for contractors' risk map by comparing the way of using common tools with Popescu(1994)'s float allocation approach that is explained in section 2.

Although there are fundamental differences between the approaches and the proposed study is not been developed as an alternative to Popescu's study, comparison and related discussion will improve the way of understanding of the proposed methodology at chapter 4.

The methodology proposed is developed for a specific case, building and conditions, according to the requirements of project management team. The practicability during execution of works and the visibility of report for easy understanding were the requirements expected from the process. Differ from to that, Popescu's study has been developed as a common solution as other methodologies mentioned at chapter 2 for various schedule types.

In terms of approach, Popescu's methodology proposes the way of distribution of float to activities at the end of process as a result; differ from that, proposed methodology provides a tool named as 'Risk Map' that can used as guideline for different types of float management applications.

Popescu prioritizes the float allocation on schedule paths based on criticality in line with total float figures, differ from that, in proposed method criticality has not been considered as the activities' criticality has been equalized by using a schedule that has already been optimized with the levelling of critical resources such as crane and hoists.

The classification called 'Phase Types' has been introduced that defines single or group of paths that acts independently or half-independently during project execution. The term 'half dependent' is used to define the works that has a hard link from predecessor works but at the same time their progress is dominantly determined by resource constraints. As an example to that condition is block work phase that has

predecessor link from concrete works and its progress generally depends on the availability of crane and loading platform on practical execution.

The common tool used in both methodologies is the AHP (Satty 1982) to qualitative non-numeric factors. Popescu used the AHP with a set of criteria that affect delay risks of an activity and utilized the calculated factors for distribution of float to individual activities. Proposed study modifies his criteria and similarly uses the calculated factors to represent the risks of an activity in a phase and furthermore loads them to activities without changing their duration.

As an improvement a factor called as density factor' has been introduced. The density factor combines different risk factor of phases and acts like a weight factor between them. It represents the recovery possibilities that depend on the resource increases.

In a CPM based schedule, there are usually two types of links; hard links such as physical constraints and soft links that represent sequences of work or teams or resource levelling. Although the stability of these both links is significantly different from each other, their impact to criticality and calculation of total float figure are same. The proposed density factors also aims to score the stability of these soft links in the programme. If in a phase the resource/sequence links can be easily broken or modified with providing additional resources, the delay risk of this activity will be proportionally accepted as reduced.

As it is mentioned, the model has been proposed for a specific case, it may not be easily applicable for more complex schedule networks where schedule optimization cannot be achieved easily. If the schedule nature is preventing optimization, the identification of phases cannot be efficiently done. However method of loading risk factors as a unit in to work programme can be developed for more complex schedules at future stages.

6. CONCLUSION AND RECOMMENDATIONS

In conclusion, float management in work programmes is a key element for contractor's time management and EOT claims.

To efficiently manage float and succeed on EOT claims, basic and first requirement is to establish a manageable and accurate baseline programme.

Since the float ownership is generally recognized as 'First come, first served' basis, contractor has to carefully analyse its exclusive float requirements while transforming its programme to a contract programme.

However this process can be manipulated by contractors own will as a part of "schedule games" or can be corrupted by not correctly analysing the risk of delay under their responsibility.

A manipulated programme may lose the reliability of claims and disputes may be arising between parties when contractor tries to defend original durations on delay analysis.

A forensic analysis for a specific period has been introduced to demonstrate the possible impacts of a manipulated programme where it is explained in detail at chapter 2. Delay events and accelerations are retrospectively simulated on both contract programmes where activity durations are increased considering risks of delays and on internal programme of contractor, by using windows analysis method.

After comparison of as-planned and as-built programmes, it has been understood that contractor has loaded the float in its early activities in its contract programme by overestimating delay risks on these activities.

Furthermore, after the advance information has been provided by new subcontractors, it is recognised that contractor is also misplaced the float as it is much aggressively required in last phases such as roof and commissioning. Result of analysis indicates that; in the case period where the activity durations are manipulated or corrupted, the nature of EOT claims are changed. Calculation discrepancies occur between programmes as follows;

- Completion date of Project is estimated earlier in the Contract programme
- Amount of Accrued Excusable and non-excusable delays are calculated less in contract programme.
- Amount of Contractor acceleration is calculated more in the contract programme

These discrepancies are affected the validity of previous EOT claims and change the nature of valid EOT claims in future. Moreover, distribution of manipulated may corrupt the communication with subcontractors and mislead their operations.

Following actions will reduce the risk of corruption;

- Both contract and internal programmes required frequently to be updated and results needs to be compared with closely monitoring actual site performance.
- Contingency durations in activities need to be defined.

Contractor have right to increase the durations of the activities that carry delay risks, by defining these actions as "contingency" or "risk allowance". SCL protocol acknowledges such period increases in activities and alternatively recognises these allowance as separate activities as an acceptable application.

A practical approach has been suggested at chapter 4 by modification of method used by Popescu (1994) to qualitative factors for total float distribution. The suggested approach links float usage to contractors risk assumption whereas, the activities who bear the most risk should own the most float.

The proposed approach provides;

- A classification system called phases considering the similarities for limitations at work sequence, Equipment and logistic and Recovery / acceleration measures
- A value for to qualitative contractor risk for each activity for each construction phase
- Introduction of a factor called density factor will reflect recovery / acceleration capacity of construction phases allowing combination of different construction phases calculated risks.

- A visual risk graph linked to construction schedule will be produced to indicate the trend for allocation or usage of float.

It is concluded that due to the characteristic nature of high rise buildings such as stability in critical path the proposed method is much more applicable in high rise buildings construction

Contractors will have listed benefits from the application of proposed method.

- Project Management teams subjective facts will be organized in a practical manner.
- The risk map can be updated or revised as resultant of programme revisions or changes in resource allocation
- If the contractor prefers to include his float in activity durations, this risk map will guide for the timing and location of it.
- If the contractor prefers to include a separate activity in his programme as contingency, this risk map will guide the limitations of usage the contingency duration.

Future developments in application of methodology

- Delay risk criterion can be diversify for acceleration or recovery measures , and methodology may be developed for recognizing these measures as negative delay risk.
- Difficulty of and Possibility of success of an EOT claim may be introduced as a criterion and methodology can be developed for recognizing it.
- Construction types where as activity durations diversified and critical path has more dynamic nature than tall buildings, fundamental modifications needs to be improved to keep methodology practical.

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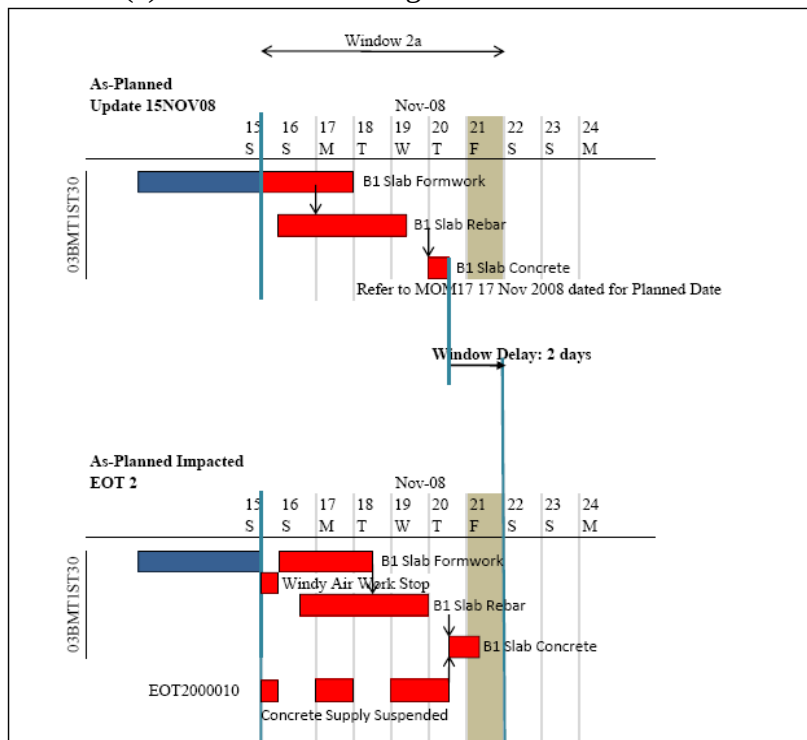
APPENDICES

APPENDIX A : Delay Analyses Windows

APPENDIX B : Calculations for Risk Map

APPENDIX A

Event 02(a) : Concrete Batching Plant – Unforeseeable Closure



Event 02(b) : Unseasonably Heavy Rain

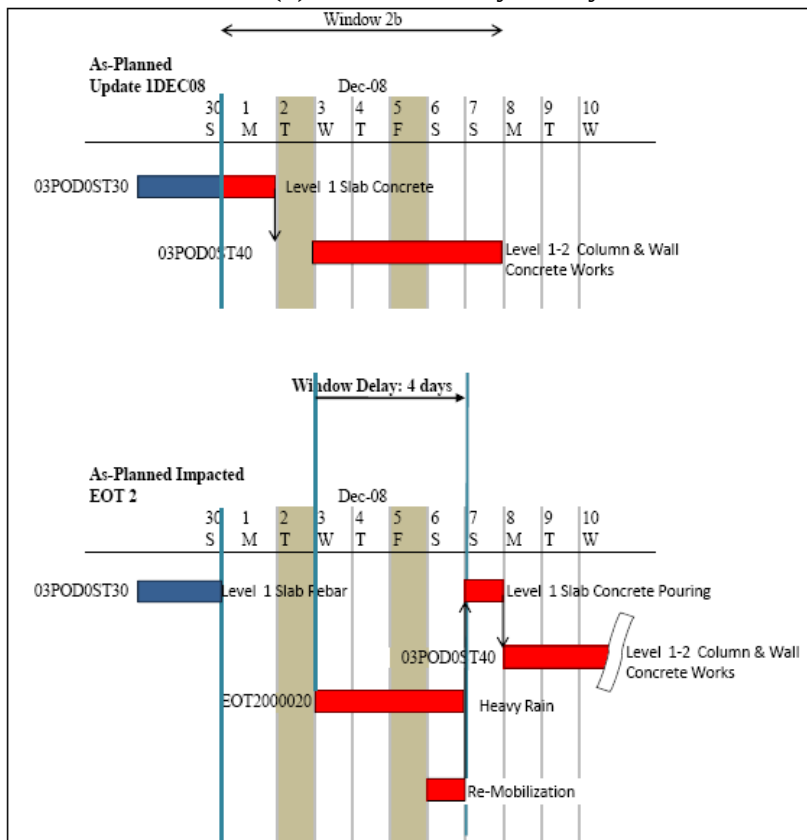
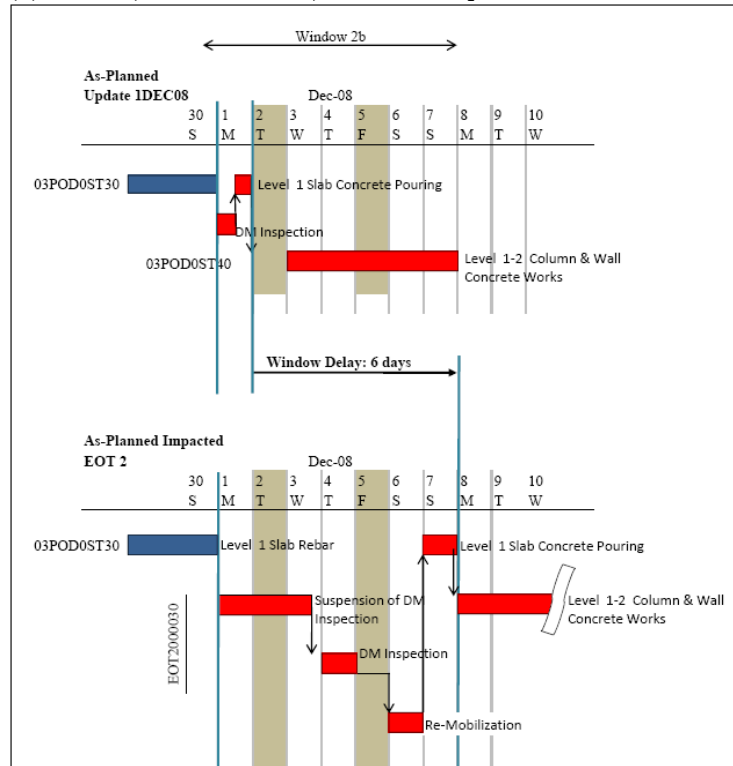


Figure A. Delay Analysis Windows Delay Analysis Windows

Event 02(c) : L01 (Ground Floor) – New Requirement for Emaar Approvals



Event 02(e) : Unseasonably Heavy Rain

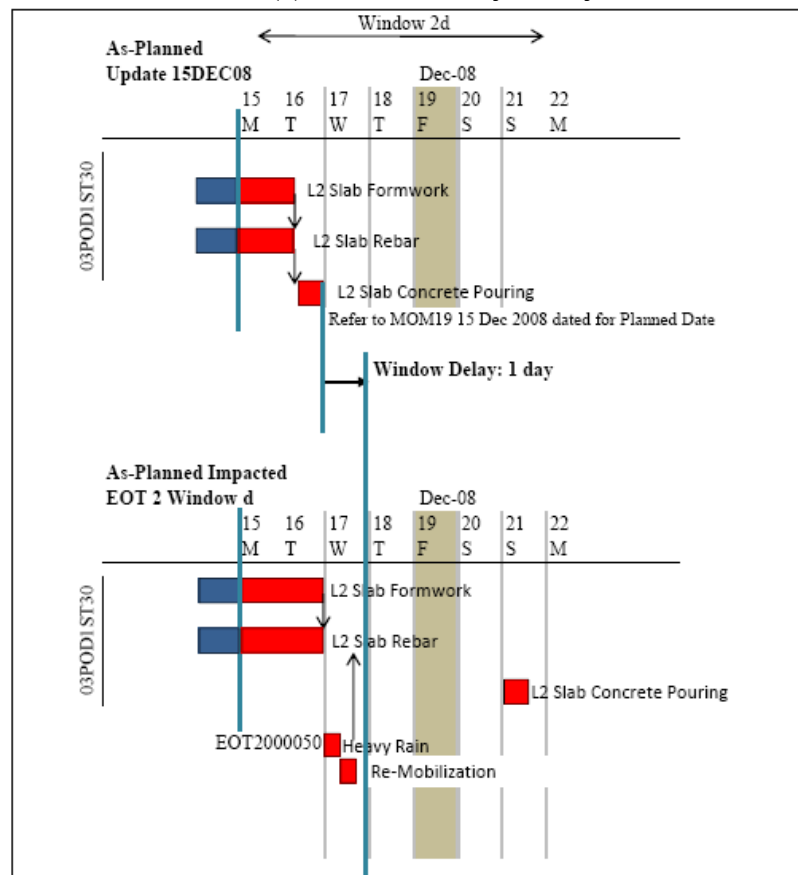
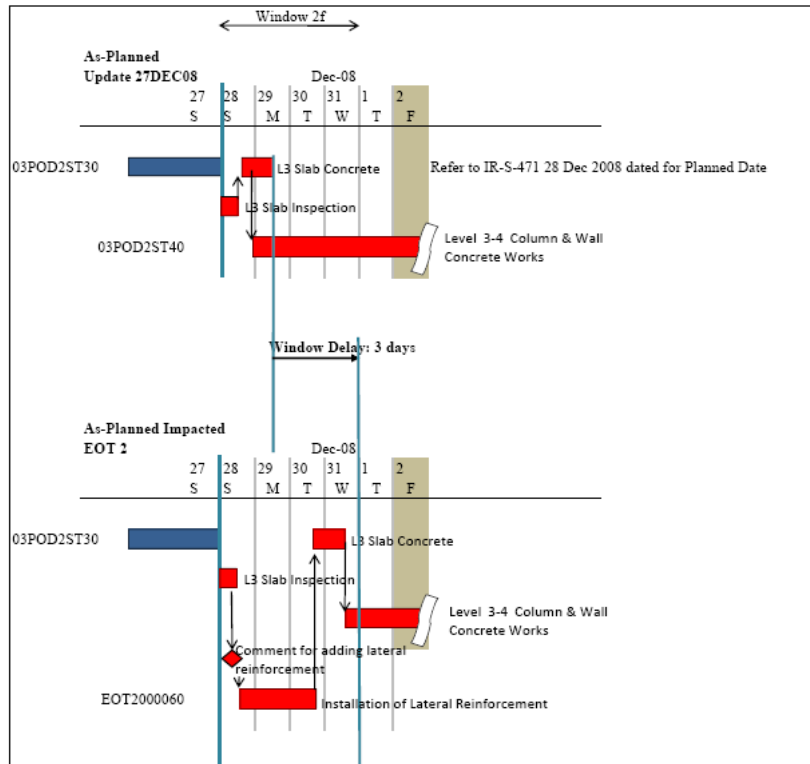


Figure A.Delay Analysis Windows Delay Analysis Windows (Continued)

Event 02(f) : L03 Slab –Additional Reinforcement



Event 02(g) : L04 Slab –Additional Lateral Reinforcement

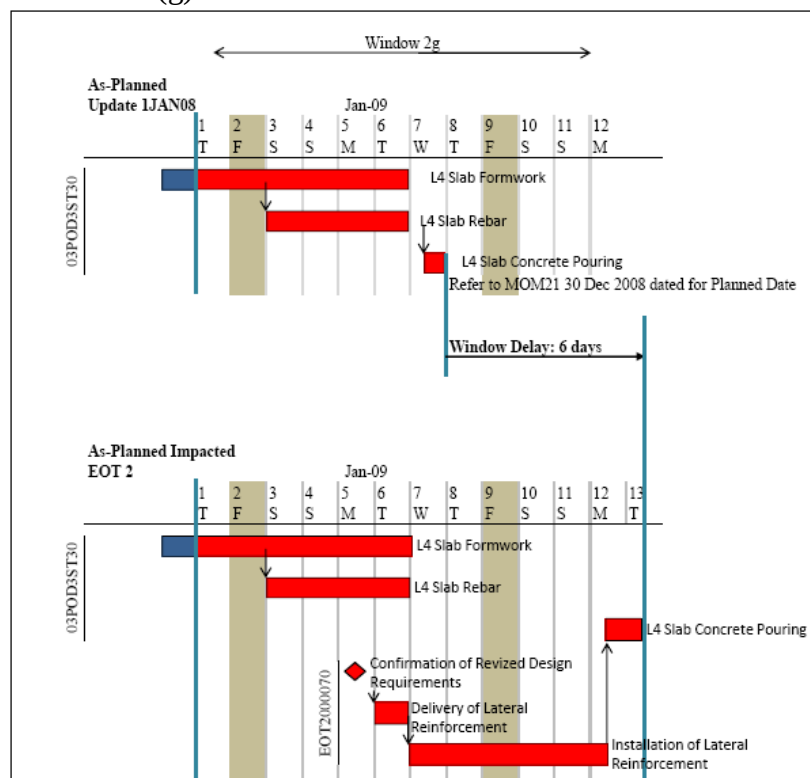
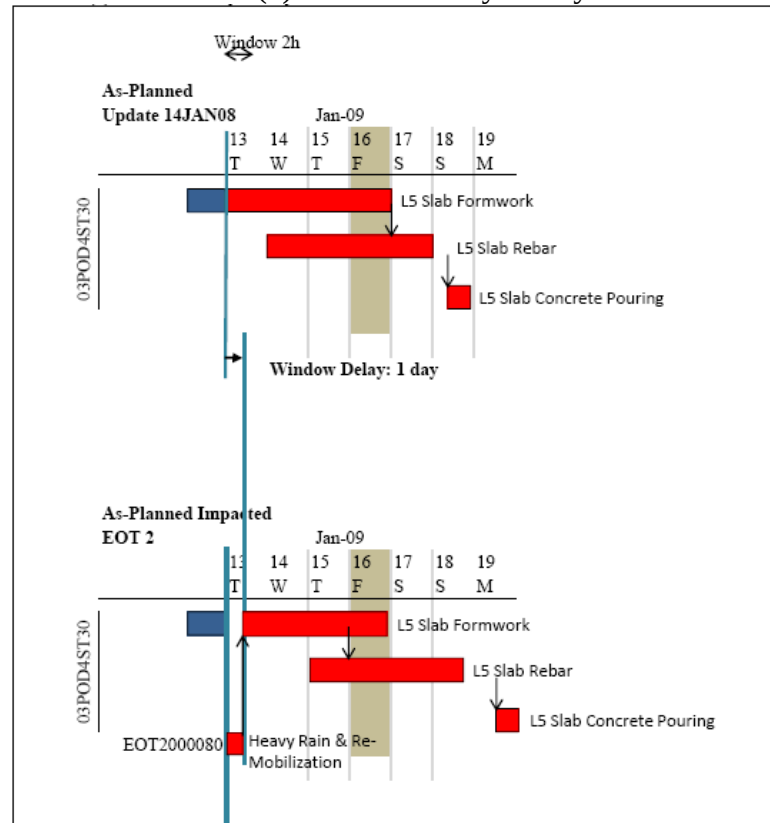


Figure A.Delay Analysis Windows Delay Analysis Windows (Continued)

Event 02(h) : Unseasonably Heavy Rain



Event 02(J) : Unseasonably Heavy Rain

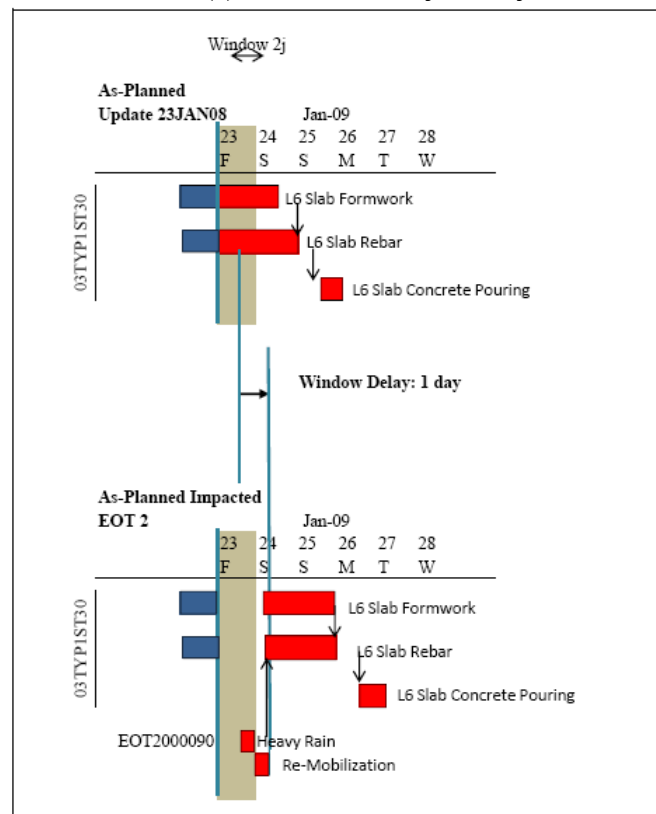


Figure A.Delay Analysis Windows Delay Analysis Windows (Continued)

Event 02(k) : Accident from Neighbouring Site

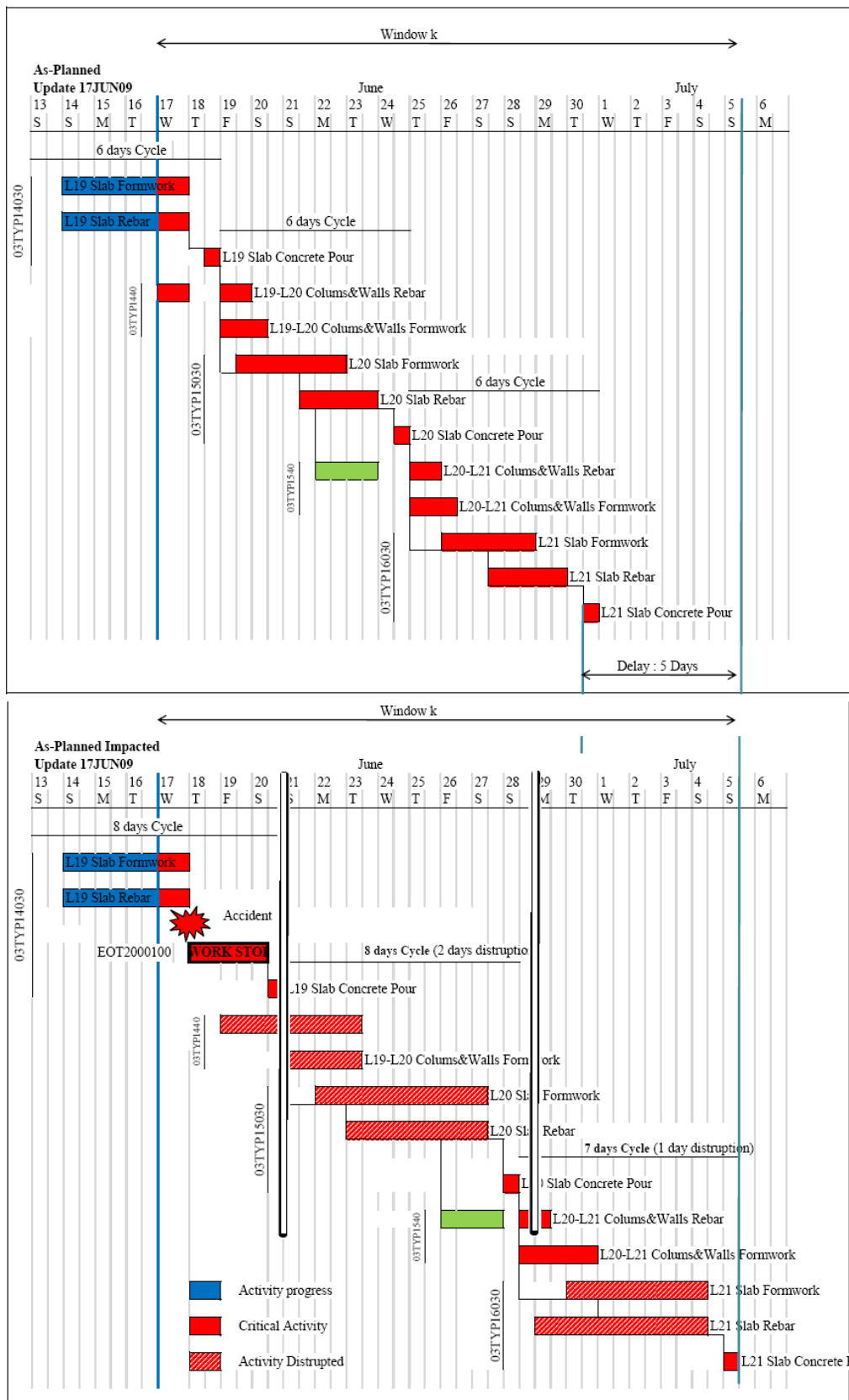


Figure A. Delay Analysis Windows Delay Analysis Windows (Continued)

APPENDIX B

Table B. Risk Weight Assignment to Activities

		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
Substructure	-6	3	1	3		1	5		5	1.92
	-5	2	1	2	0.0	1	5		5	1.61
	-4	2	1	2	0.0	1	5		5	1.61
	-3	2	1	2	0.0	1	5		5	1.61
	-2	2	1	2		1	5		5	1.61
	-1	2	1	2	0.0	1	5		5	1.61
Structure	1	2	1	2		1	4		4.9	1.49
	2	2	1	2	0.0	1	4		4.8	1.49
	3	2	1	2	0.0	1	4		4.8	1.49
	4	2	1	2	0.0	1	4		4.7	1.49
	5	2	1	2	0.1	1	4		4.7	1.49
	6	2	1	2	0.1	1	3		4.6	1.38
	7	2	1	2	0.1		3		4.6	1.25
	8	2	1	2	0.1		3		4.5	1.25
	9	2	1	2	0.1		3		4.5	1.25
	10	2	1	2	0.1		3		4.4	1.25
	11	2	1	2	0.2		2		4.4	1.14
	12	2	1	2	0.2		2		4.3	1.14
	13	2	1	2	0.2		2		4.3	1.14
	14	2	1	2	0.2		2		4.2	1.14
	15	2	1	2	0.2		2		4.2	1.14
	16	2	1	2	0.2		2		4.1	1.14
	17	2	1	2	0.2		2		4.1	1.14
	18	2	1	2	0.3		2		4.0	1.14
	19	2	1	2	0.3		2		4.0	1.14
	20	2	1	2	0.3		2		3.9	1.14
	21	2	1	2	0.3		1		3.9	1.02
	22	2	1	2	0.3		1		3.8	1.02
	23	2	1	2	0.3		1		3.8	1.02
	24	2	1	2	0.3		1		3.7	1.02
	25	2	1	2	0.4		1		3.7	1.02
	26	2	1	2	0.4		1		3.6	1.02
	27	2	1	2	0.4		1		3.6	1.02
	28	2	1	2	0.4		1		3.5	1.02

Table B. Risk Weight Assignment to Activities (Continued)

		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	29	2	1	2	0.4		1		3.5	1.02
	30	2	1	2	0.4		1		3.4	1.02
	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
	31	2	1	2	0.5		1		3.4	1.02
	32	2	1	2	0.5		1		3.3	1.02
	33	2	1	2	0.5		1		3.3	1.02
	34	2	1	2	0.5		1		3.2	1.02
	35	2	1	2	0.5		1		3.2	1.02
	36	2	1	2	0.5		1		3.1	1.02
	37	2	1	2	0.5				3.1	0.90
	38	2	1	2	0.6				3.0	0.90
	39	2	1	2	0.6				3.0	0.90
	40	2	1	2	0.6				2.9	0.90
	41	2	1	2	0.6				2.9	0.90
	42	2	1	2	0.6				2.8	0.90
	43	2	1	2	0.6				2.8	0.90
	44	2	1	2	0.7				2.7	0.90
	45	2	1	2	0.7				2.7	0.90
	46	2	1	2	0.7				2.6	0.90
	47	2	1	2	0.7				2.6	0.90
	48	2	1	2	0.7				2.5	0.90
	49	2	1	2	0.7				2.5	0.90
	50	2	1	2	0.7				2.4	0.90
	51	2	1	2	0.8				2.4	0.90
	52	2	1	2	0.8				2.3	0.90
	53	2	1	2	0.8				2.3	0.90
	54	2	1	2	0.8				2.2	0.90
	55	2	1	2	0.8				2.2	0.90
	56	2	1	2	0.8				2.1	0.90
	57	2	1	2	0.8				2.1	0.90
	58	2	1	2	0.9				2.0	0.90
	59	2	1	2	0.9				2.0	0.90
	60	2	1	2	0.9				1.9	0.90
	61	2	1	2	0.9				1.9	0.90
	62	2	1	2	0.9				1.8	0.90
	63	2	1	2	0.9				1.8	0.90
	64	2	1	2	1.0				1.7	0.90

Table B. Risk Weight Assignment to Activities (Continued)

		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
	65	2	1	2	1.0				1.7	0.90
	66	2	1	2	1.0				1.6	0.90
	67	2	1	2	1.0				1.6	0.90
	68	2	1	2	1.0				1.5	0.90
	69	2	1	2	1.0				1.5	0.90
	70	2	1	2	1.0				1.4	0.89
	71	2	1	2	1.1				1.4	0.89
	72	2	1	2	1.1				1.3	0.89
	73	2	1	2	1.1				1.3	0.89
	74	2	1	2	1.1				1.2	0.89
	75	2	1	2	1.1				1.2	0.89
	76	2	1	2	1.1				1.1	0.89
	77	2	1	2	1.2				1.1	0.89
	78	2	1	2	1.2				1.0	0.89
	79	2	1	2	1.2				1.0	0.89
	80	2	1	2	1.2			1	0.9	1.09
	81	2	1	2	1.2			1	0.9	1.09
	82	2	1	2	1.2			1	0.8	1.09
	83	2	1	2	1.2			1	0.8	1.09
	84	2	1	2	1.3			1	0.7	1.09
	85	2	1	2	1.3			1	0.7	1.09
	86	2	1	2	1.3			1	0.6	1.09
	87	2	1	2	1.3			1	0.6	1.09
	88	2	1	2	1.3			1	0.5	1.09
	89	2	1	2	1.3			1	0.5	1.09
	90	2	1	2	1.3			1	0.4	1.09
	91	2	1	2	1.4			1	0.4	1.09
	92	2	1	2	1.4			2	0.3	1.29
	93	2	1	2	1.4			2	0.3	1.29
	94	2	1	2	1.4		1	2	0.2	1.41
	95	2	1	2	1.4		1	2	0.2	1.41
	96	2	1	2	1.4		1	2	0.1	1.41
	97	2	1	2	1.5		1	2	0.1	1.41
	98	2	1	2	1.5		2	2	0.0	1.52
	99	2	1	2	1.5		2	2		1.52
	100	2	1	2	1.5		2	2		1.52
	101	2	1	2	1.5		2	2		1.52

Table B. Risk Weight Assignment to Activities (Continued)

		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
Heavy Finish	1	1	1	1			2		5.0	0.83
	2	1	1	1	0.0		2		4.9	0.83
	3	1	1	1	0.0		1		4.9	0.71
	4	1	1	1	0.1		1		4.8	0.71
	5	1	1	1	0.1		1		4.8	0.71
	6	1	1	1	0.1		1		4.7	0.71
	7	1	1	1	0.1		1		4.7	0.71
	8	1	1	1	0.1		1		4.6	0.71
	9	1	1	1	0.2		1		4.6	0.71
	10	1	1	1	0.2		1		4.5	0.71
	11	1	1	1	0.2		1		4.5	0.71
	12	1	1	1	0.2		1		4.4	0.71
	13	1	1	1	0.2		1		4.4	0.71
	14	1	1	1	0.3		1		4.3	0.71
	15	1	1	1	0.3		1		4.3	0.71
	16	1	1	1	0.3		1		4.2	0.71
	17	1	1	1	0.3		1		4.2	0.72
	18	1	1	1	0.3		1		4.1	0.72
	19	1	1	1	0.4		1		4.1	0.72
	20	1	1	1	0.4		1		4.0	0.72
	21	1	1	1	0.4		1		4.0	0.72
	22	1	1	1	0.4		1		3.9	0.72
	23	1	1	1	0.4		1		3.9	0.72
	24	1	1	1	0.5		1		3.8	0.72
	25	1	1	1	0.5		1		3.8	0.72
	26	1	1	1	0.5		1		3.7	0.72
	27	1	1	1	0.5		1		3.7	0.72
	28	1	1	1	0.5		1		3.6	0.72
	29	1	1	1	0.6		1		3.6	0.72
	30	1	1	1	0.6		1		3.5	0.72
	31	1	1	1	0.6		1		3.5	0.72
	32	1	1	1	0.6		1		3.4	0.72
	33	1	1	1	0.6		1		3.4	0.72
	34	1	1	1	0.7		1		3.3	0.72
	35	1	1	1	0.7		1		3.3	0.72

Table B. Risk Weight Assignment to Activities (Continued)

		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
	36	1	1	1	0.7		1		3.2	0.72
	37	1	1	1	0.7		1		3.2	0.72
	38	1	1	1	0.7		1		3.1	0.72
	39	1	1	1	0.8		1		3.1	0.72
	40	1	1	1	0.8		1		3.0	0.72
	41	1	1	1	0.8		1		3.0	0.72
	42	1	1	1	0.8		1		2.9	0.72
	43	1	1	1	0.8		1		2.9	0.72
	44	1	1	1	0.9		1		2.8	0.72
	45	1	1	1	0.9		1		2.8	0.72
	46	1	1	1	0.9		1		2.7	0.72
	47	1	1	1	0.9		1		2.7	0.72
	48	1	1	1	0.9		1		2.6	0.72
	49	1	1	1	1.0		1		2.6	0.72
	50	1	1	1	1.0		1		2.5	0.72
	51	1	1	1	1.0		1		2.5	0.72
	52	1	1	1	1.0		1		2.4	0.72
	53	1	1	1	1.1		1		2.4	0.72
	54	1	1	1	1.1		1		2.3	0.72
	55	1	1	1	1.1		1		2.3	0.72
	56	1	1	1	1.1		1		2.2	0.72
	57	1	1	1	1.1		1		2.2	0.72
	58	1	1	1	1.2		1		2.1	0.72
	59	1	1	1	1.2		1		2.1	0.72
	60	1	1	1	1.2		1		2.0	0.72
	61	1	1	1	1.2		1		2.0	0.72
	62	1	1	1	1.2		1		1.9	0.72
	63	1	1	1	1.3		1		1.9	0.72
	64	1	1	1	1.3		1		1.8	0.72
	65	1	1	1	1.3		1		1.8	0.72
	66	1	1	1	1.3		1		1.7	0.72
	67	1	1	1	1.3		1		1.7	0.72
	68	1	1	1	1.4		1		1.6	0.72
	69	1	1	1	1.4		1		1.6	0.72
	70	1	1	1	1.4		1		1.5	0.72
	71	1	1	1	1.4		1		1.5	0.72

Table B. Risk Weight Assignment to Activities (Continued)

		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
	72	1	1	1	1.4		1		1.4	0.72
	73	1	1	1	1.5		1		1.4	0.72
	74	1	1	1	1.5		1		1.3	0.72
	75	1	1	1	1.5		1		1.3	0.72
	76	1	1	1	1.5		1		1.2	0.72
	77	1	1	1	1.5		1		1.2	0.72
	78	1	1	1	1.6		1		1.1	0.72
	79	1	1	1	1.6		1		1.1	0.72
	80	1	1	1	1.6		1		1.0	0.72
	81	1	1	1	1.6		1		1.0	0.72
	82	1	1	1	1.6		1		0.9	0.72
	83	1	1	1	1.7		1		0.9	0.72
	84	1	1	1	1.7		1		0.8	0.72
	85	1	1	1	1.7		1		0.8	0.72
	86	1	1	1	1.7		1		0.7	0.72
	87	1	1	1	1.7		1		0.7	0.72
	88	1	1	1	1.8		1		0.6	0.72
	89	1	1	1	1.8		1		0.6	0.72
	90	1	1	1	1.8		1		0.5	0.72
	91	1	1	1	1.8		1		0.5	0.72
	92	1	1	1	1.8		1		0.4	0.72
	93	1	1	1	1.9		1		0.4	0.72
	94	1	1	1	1.9		1		0.3	0.72
	95	1	1	1	1.9		1		0.3	0.72
	96	1	1	1	1.9		1		0.2	0.72
	97	1	1	1	1.9		1		0.2	0.72
	98	1	1	1	2.0		2		0.1	0.84
	99	1	1	1	2.0		2		0.1	0.84
	100	1	1	1	2.0		2		0.0	0.84
	101	1	1	1	2.0		2			0.84
Finish	1	2	1	4	2.0	4	5		3.0	-
	2	2	1	4						
	3	2	1	4						
	4	2	1	4						
	5	2	1	4						
	6	2	1	4						

Table B. Risk Weight Assignment to Activities (Continued)

		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
	7	2	1	4						
	8	2	1	4						
	9	2	1	4						
	10	2	1	4						
	11	2	1	4						
	12	2	1	4						
	13	2	1	4						
	14	2	1	4						
	15	2	1	4						
	16	2	1	4						
	17	2	1	4						
	18	2	1	4						
	19	2	1	4						
	20	2	1	4						
	21	2	1	4						
	22	2	1	4						
	23	2	1	4						
	24	2	1	4						
	25	2	1	4						
	26	2	1	4						
	27	2	1	4						
	28	2	1	4						
	29	2	1	4						
	30	2	1	4						
	31	2	1	4						
	32	2	1	4						
	33	2	1	4						
Finish	34	2	1	4	2.0	4	5		5.0	2.56
	35	2	1	4	2.0	4	4		4.9	2.45
	36	2	1	4	2.0	4	4		4.9	2.45
	37	2	1	4	2.0	4	4		4.8	2.45
	38	2	1	4	2.1	4	3		4.8	2.33
	39	2	1	4	2.1	4	3		4.7	2.33
	40	2	1	4	2.1	4	3		4.7	2.33
	41	2	1	4	2.1	4	3		4.6	2.33
	42	2	1	4	2.1	4	3		4.6	2.33

Table B. Risk Weight Assignment to Activities (Continued)

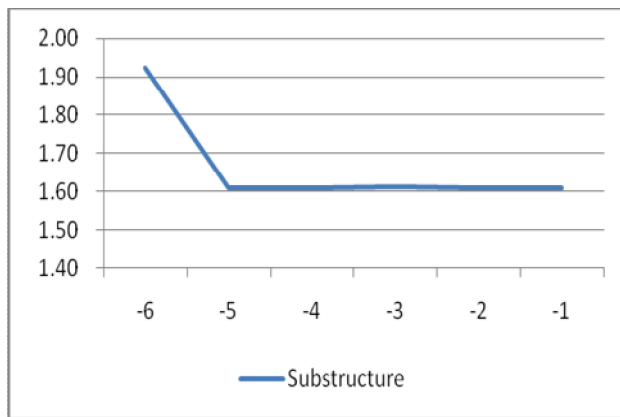
		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
	43	2	1	4	2.1	4	3		4.5	2.33
	44	2	1	4	2.2	4	3		4.5	2.33
	45	2	1	4	2.2	4	2		4.4	2.22
	46	2	1	4	2.2	3	2		4.4	2.10
	47	2	1	4	2.2	3	2		4.3	2.10
	48	2	1	4	2.2	3	2		4.3	2.10
	49	2	1	4	2.2	3	2		4.2	2.10
	50	2	1	4	2.2	3	1		4.2	1.98
	51	2	1	4	2.3	2	1		4.1	1.86
	52	2	1	4	2.3	2	1		4.1	1.86
	53	2	1	4	2.3	2	1		4.0	1.86
	54	2	1	4	2.3	2	1		4.0	1.86
	55	2	1	4	2.3	2	1		3.9	1.86
	56	2	1	4	2.3	2	1		3.9	1.86
	57	2	1	4	2.3	1	1		3.8	1.74
	58	2	1	4	2.4	1	1		3.8	1.74
	59	2	1	4	2.4	1	1		3.7	1.74
	60	2	1	4	2.4	1	1		3.7	1.74
	61	2	1	4	2.4	1	1		3.6	1.74
	62	2	1	4	2.4	1	1		3.6	1.74
	63	2	1	4	2.4	1	1		3.5	1.74
	64	2	1	4	2.5	0.5	1		3.5	1.68
	65	2	1	4	2.5	0.5	1		3.4	1.68
	66	2	1	4	2.5	0.5	1		3.4	1.68
	67	2	1	4	2.5	0.5	1		3.3	1.67
	68	2	1	4	2.5		1		3.3	1.61
	69	2	1	4	2.5		1		3.2	1.61
	70	2	1	4	2.5		1		3.2	1.61
	71	2	1	4	2.6		1		3.1	1.61
	72	2	1	4	2.6				3.1	1.50
	73	2	1	4	2.6				3.0	1.50
	74	2	1	4	2.6				3.0	1.50
	75	2	1	4	2.6				2.9	1.50
	76	2	1	4	2.6				2.9	1.50
	77	2	1	4	2.7				2.8	1.50
	78	2	1	4	2.7				2.8	1.50

Table B. Risk Weight Assignment to Activities (Continued)

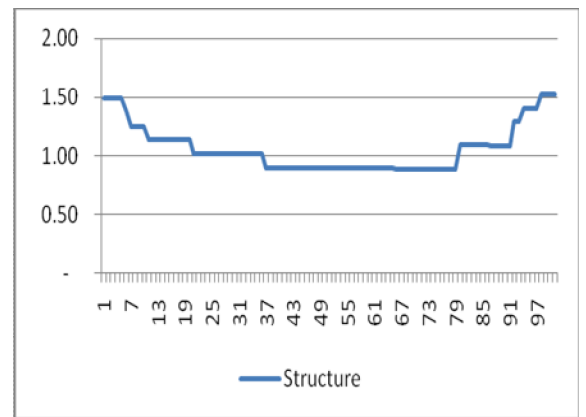
		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
	79	2	1	4	2.7				2.7	1.50
	80	2	1	4	2.7				2.7	1.50
	81	2	1	4	2.7				2.6	1.50
	82	2	1	4	2.7				2.6	1.50
	83	2	1	4	2.7				2.5	1.50
	84	2	1	4	2.8				2.5	1.50
	85	2	1	4	2.8				2.4	1.50
	86	2	1	4	2.8				2.4	1.50
	87	2	1	4	2.8				2.3	1.49
	88	2	1	4	2.8				2.3	1.49
	89	2	1	4	2.8				2.2	1.49
	90	2	1	4	2.8				2.2	1.49
	91	2	1	4	2.9				2.1	1.49
	92	2	1	4	2.9				2.1	1.49
	93	2	1	4	2.9				2.0	1.49
	94	2	1	4	2.9				2.0	1.49
	95	2	1	4	2.9				1.9	1.49
	96	2	1	4	2.9				1.9	1.49
	97	2	1	4	3.0				1.8	1.49
	98	2	1	4	3.0	1	2		1.8	1.84
	99	2	1	4	3.0	1	2		1.7	1.84
	100	2	1	4	3.0	1	2		1.7	1.84
	101	2	1	4	3.0	1	2		1.6	1.84
Lift	-6									
	1	3	3	3	2.0	3	2			2.13
	14	3	3	3	2.0	3	1			2.01
	79	3	3	3	2.0	2	1			1.89
	101	3	3	3	2.0	2	1			1.89
Facade	1									
	6	2	3	3	2.0	3	5		5	2.51
	14	2	3	3	2.0	3	2		4	2.14
	34	2	3	3	2.0	2			3	1.76
	57	2	3	3	2.0	1		3	2	2.22
	79	2	3	3	2.0			3	1	2.07
	101	2	3	3	2			4		2.25

Table B. Risk Weight Assignment to Activities (Continued)

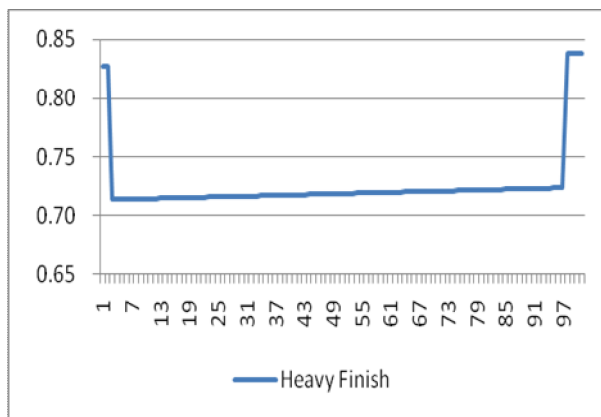
		Manpower Demand	Type of Work	Complexity of process	Equipment Demand	Late Material Delivery	Insufficient Design	Wind	Reputation	Risk Factor
Phase	Floor	0.09	0.15	0.22	0.07	0.12	0.11	0.20	0.03	
Dismantle	101	2	3	5	3		1	4		2.88
Roof	101	3	3	5	4	2	1	5		3.49



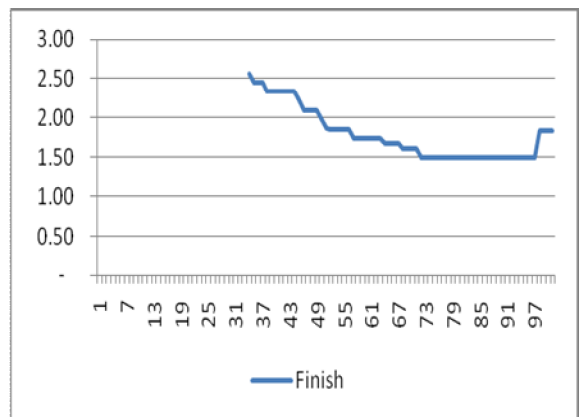
(a)



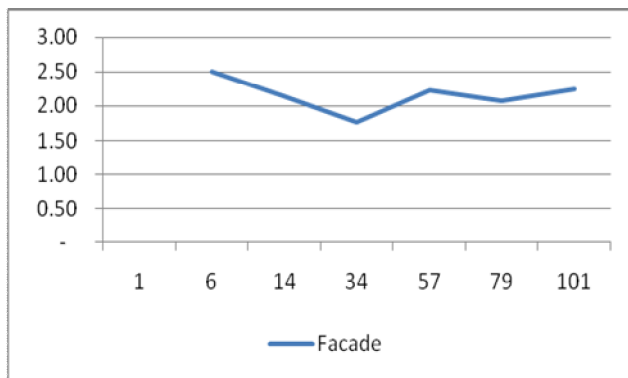
(b)



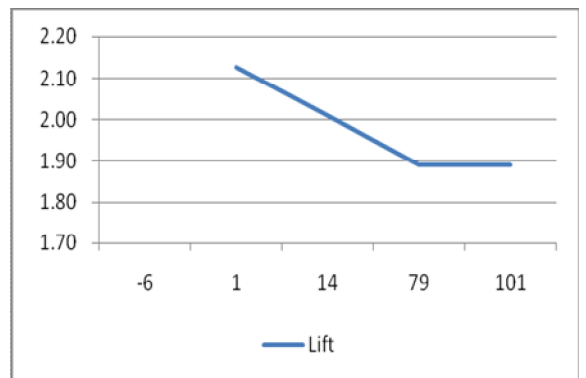
(c)



(d)



(e)



(f)

Figure B.1. Risk level per floor for phases (a)Substructure-(b)Superstructure-(c)Heavy Finish-(d) Finish-(e)Facade-(f) Lift

[illegible]

Figure B.2. Schedule with Risk factors (Continued)

[illegible]

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