POTENTIAL OF IMPLEMENTING "WINDOW DELAY ANALYSIS" FOR ROAD PROJECTS IN SRI LANKA – CLAIMS CONSULTANTS' PERSPECTIVES

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Dissertation submitted in partial fulfilment of the requirements for the degree Master of Science in Construction Law and Dispute Resolution

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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…….. ……...

Mr. Vijitha Disaratna Date

Dissertation Supervisor

DEDICATION

“This dissertation is dedicated to my beloved mother & father for their unconditional love”

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ABSTRACT

"Potential of Implementing 'Window Delay Analysis' for Road Projects in Sri Lanka – Claims Consultants' Perspectives"

An increased number of disputes with regard to the additional times and payments in respect of the construction delay claims, are presently experienced by the road construction industry of Sri Lanka.

The additional payment and time entitled to a claimant in respect of a delay, is generally computed utilizing an appropriate Delay Analysis Technique (DAT), the application and the outcome of which may vary from one another.

Previous researchers have identified that the DAT namely "Window Delay Analysis Technique (WDAT)" was the most appropriate DAT that can be used for road construction projects in Sri Lanka, which was also the minimally used DAT out of several methods practiced in the country.

Thus, the identification of the potential of implementing such highly recommended WDAT for road construction projects in Sri Lanka was of paramount importance, which was set as the aim of this study, which will also be towards the improvement of the practice of construction delay analysis in the country.

In the view of above, the areas such as "benefits of WDAT", "constraining factors for the implementation of WDAT", and "studying the contemporary practice of delay analysis and willingness of the practitioners to undertake WDAT", were explored as research objectives.

A preliminary study carried out revealed that the awareness of construction community of the DATs was very low, which led the researcher to reach the Claims Consultants in Sri Lanka, who were supposed to be the most suitable resource persons on this subject area.

Accordingly, this research problem was approached through the interviewing of four selected leading construction claims consultants in Sri Lanka, and by reviewing their eight sets of delay analysis documentations.

WDAT was identified to be a versatile and practical approach of applying the delay analysis, rather than a primary method of delay analysis, which can be effectively applied in cases of complicated delay situations to resolve them successfully.

The findings of this research revealed that the non-existence of a direct contractual requirement for its implementation, inherent limitations of applicability of the method, specific and compromised requirements of the claimants, the limited resources (budgets) of the claimant, the unawareness and the inexperience of the analysts, additional effort required on the part of the analyst, absence of prior preparedness and awareness, indirect discouragement of the analyst, and reluctance of the analyst to do his best, were the factors constraining the implementation of WDAT in Sri Lanka.

The researcher ultimately realized that there is a potential for WDAT to be developed more as a separate area of expertise, which could co-exist as a support service to the general "construction claims consultancy services".

Key words: *Construction Delay Analysis, Delay Analysis Techniques, Window Delay Analysis, Road Construction Projects, Sri Lanka.*

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LIST OF ABBRIVIATIONS

Abbreviation	Description
AACE	Association for the Advancement of Cost Engineering International
AACE RP	Association for the Advancement of Cost Engineering International Recommended Practice
ABCP	As Built Critical Path
ABCPA	As Built Critical Path Analysis
AHP	Analytic Hierarchy Process
APVAB	As Planned Vs As Built
ASCE	American Society of Civil Engineers
ASCII	American Standard Code for Information Interchange
CAB	Collapsed As Built
CPM	Critical Path Method
CSV	Comma Separated Values
CRE	Contractor's Risk Event
DA	Delay Analysis
DAT	Delay Analysis Technique
EOT	Extension of Time
ERE	Employer's Risk Event
IAP	Impacted As Planned
NE	Neutral Event
PDAT	Primary Delay Analysis Technique
RDA	Road Development Authority
SCLP	Delay & Disruption Protocol by Society of Construction Law
TIA	Time Impact Analysis
WDA	Windows Delay Analysis
WDAT	Windows Delay Analysis Technique

CHAPTER 01

INTRODUCTION TO THE RESEARCH

1.1 Background Study

The delays in completion of the Sri Lankan construction Projects result in time overrun, cost overrun, disputes, litigation, total abandonment and arbitration respectively in the order of their severity, which are detrimental to the parties to the Contract (Risath, Rifas, & Thamboo, 2011).

The local road construction projects experience 56% - 88% of average time overrun compared to the original (planned) project durations (Pathiranage & Halwatura, 2010).

It has been identified that the delay claims submissions occur in 50-70% of such delayed projects in Sri Lanka (Ramachandra, Rotimi, & Gunaratne, 2014). Furthermore, the same research has identified that only a 25-40% of such claims have been successful. They have further identified that the failure to establish a causal link in respect of a delay claim is the third major reason for the failures of such delay claims by the Sri Lankan Contractors, which is the role covered by the analysis of delays.

The payment and time entitled to a Claimant under a Contract, in respect of a construction delay, is generally computed utilizing an appropriate Delay Analysis Techniques (DAT) (Delay and Disruption Protocol, 2017), the applications and outcomes of which are varying from one another (Braimah, 2013b).

Previous researchers (Ekanayake & Perera, 2016) have identified that the DAT, namely, “Window Delay Analysis Technique (WDAT)”, as the most suitable DAT applicable for Road Construction Projects in Sri Lanka, which is also the minimally used DAT out of several methods practiced in the country.

Thus, the identification of what constrains the implementation of such mostly recommended Window Delay Analysis Technique (WDAT) is of paramount importance, which will be towards the improvement of the practice of construction delay analysis in the country.

1.2 Problem Statement

In accordance with Ekanayake and Perera (2016), the “Collapsed as Built” and “Window Analysis” are the mostly used techniques in other countries, whereas, in Sri Lanka, those were the least used. Furthermore, the “Window Analysis (WADT)” has been identified as the most appropriate DAT for road construction projects in Sri Lanka.

The same research has revealed that most of the local Contractors prefer to use the “As-planned Vs As built” and “Impacted As-Planned” methods in analysing delays in road construction projects considering their simplicity and low cost implementation.

The suitability of using various DATs, as developed by Perera and Sudeha (2013), has recognized that two former techniques practiced in the other countries is having the highest suitability grading, whereas, the two latter techniques practiced in Sri Lanka is having the lowest suitability grading.

The srilankan construction claims business is under increasing pressure to maintain higher standards to meet the required accuracy, legitimacy, credibility and competitiveness in their works, while rising to the international trends.

Hence, for obvious reasons, the above practice in Sri Lanka could not be a fair criterion in selecting a DAT, considering the demanding quality by the industry for such crucial analyses.

Despite, no such research has been undertaken to identify the potential of implementing the mostly recommended WDAT with which such an essential research gap could be filled.

Accordingly, the research problem was developed as “what is the potential of implementing WDAT for the road construction projects in Sri Lanka”.

1.3 Aim and Objectives

This research is aimed at identifying the potential of implementing the WDAT for the road construction projects in Sri Lanka.

To achieve the above aim, the following objectives were developed.

1. To identify what WDAT is, and how to perform the same.
2. To identify the benefits of the implementation of WDAT.
3. To identify what factors constrain the implementation of WDAT for the road construction projects in Sri Lanka.
4. To study the quality of the contemporary practice and test the willingness of the industry practitioners to undertake WDAT for the road construction projects in Sri Lanka.

1.4 Scope and Limitations

The scope of identification of the potential of implementing WDAT was limited to the areas of identification of, the benefits of WDAT, the factors constraining the implementation of WDAT and the willingness of the industry practitioners to carry out WDAT.

This research covers the perspectives of the construction claims consultants in Sri Lanka, and only the road construction projects implemented in the country were considered for this study.

The findings of this research are expected to finally give an insight to the construction community to device strategies to enhance the standard of the construction delay analysis practice in Sri Lanka.

1.5 Introduction to Research Methodology

The following methodology was adopted to carry out this study in a systematic manner to achieve the research objectives:

- **Literature Review**

  A comprehensive literature review was carried out to gain an in depth knowledge regarding existing position of the delays and DATs practiced globally as well as locally, and to identify the gaps therein. This review was then extended to study the WDAT in particular.

- **Semi-Structured Interviews**

  Semi-Structured Interviews were conducted in the view of identifying "the benefits of implementing WDAT" and "the factors constrain the implementation of WDAT" following a qualitative research approach.

- **Document Reviews**

  A review of interviewees' "construction delay analysis documentation" was carried out to test the quality and willingness of the industry practitioners to undertake WDAT following a qualitative research approach.

1.6 Structure of Dissertation

This dissertation comprises of five chapters as briefed below:

- **Chapter One: Introduction**

  The purpose of this chapter is to provide a brief introduction to the research, which basically focuses on exploring the research area by means of background of the research, problem statement, aim, objectives, limitations of the study and introduction of the research methodology.

- **Chapter Two: Literature Review**

  This chapter intends to explore the existing knowledge regarding the research area by referring to previous researches, books and other publications in order to understand the significance of the research problem. An especial effort has been taken to identify what is meant by a WDAT.

- **Chapter Three: Research Methodology**

  This chapter explains the methodology that has been adopted in achieving the objectives of the study by spelling out the requirements of the study, research approach and data collection and analysis techniques.

- **Chapter Four: Research Findings and Analysis**

  Chapter four focuses on the analysis of the data collected, with the purpose of presenting the findings through this study in a detailed manner.

- **Chapter Five: Conclusions & Recommendation**

  The final chapter of the research report emphasis on drawing out conclusions of the research with respect to the research problem identified.

  In addition, it also carries few recommendations on the possibilities for regularizing the practice of construction delay analysis in the road construction sector in Sri Lanka, and few suggestions for further research

CHAPTER 02

LITERATURE REVIEW

2.1 Introduction

The research problem was identified and a brief introduction to the research was given in Chapter One. Accordingly, this chapter intends to provide an in depth knowledge regarding the existing knowledge of the research area and to establish the research problem, with special reference to the previous researches carried out in Sri Lanka. The accomplishment of the Objective 1, which is to identify what WDAT is, is also expected under this chapter. The findings of the chapter are briefed in the summary hereunder.

2.2 Construction Delays

2.2.1 What are Delays and Disruptions

Trauner and Theodore (2009) have defined the Delay as “to make something happen later than expected; to cause something to be performed later than planned; or to not act timely” (p. 25).

Pickavance (2005) has stated that,

> Disruption is the difference between an intention and reality as to productivity, or achievement in relation to cost where the reality is derogation from the intent. Disruption is not delay. Although disruption may cause delay, and it may be caused by delay, delay is not a precondition of disruption and, indeed, disruption may be caused when the progress of the works is not delayed but accelerated. Pickavance (2005, p.10)

In contrast, the Disruptions have been identified in the following manner.

> Disruption, unlike delay, will always have a direct monetary consequences. There are many reasons why delay events may not have a direct impact on the critical path or delay damages. Disruption on the other hand, once established, has a direct measurable financial consequence, even if concurrent or co-contributory culpable factors are present.

In construction, ‘disruption’ may be defined as an interruption to the flow, continuity or sequence of planned work; a bringing of disorder to an activity or project. Disruption may be a cause of delay, and delay may be a cause of disruption, but they are not one and the same. (Keane & Caletka, 2015, pp. 7,135)

One of the main differences between delay and disruption in the context of construction delay analysis is that in the case of disruption the work activities or operations may not necessarily cause the construction completion date to be delayed; the works might be disrupted but the contract works could still be completed on time or indeed earlier than planned. In such circumstances, where the disruption was affecting non-critical activities, the contractor may well not have a claim for an extension of time, but rather a claim for the related costs of the reduced efficiency of labour and plant resources. (Keane & Caletka, 2015, p. 93)

2.2.2 Types of Construction Delays

Keane and Caletka (2015) stated that “Delays that affect the Project completion, or in some cases a milestone date, are considered critical delays, and in contrast, the delays that do not affect the Project completion, or a milestone date, are noncritical delays” (p. 26).

Delays could be further categorized in to the groups indicated in the Figure 2.1 below (Trauner & Theodore, 2009, p. 26).

An excusable delay, in general, is a delay that is due to an unforeseeable event beyond the Contractor’s or the Subcontractor’s control (Trauner & Theodore, 2009, p. 27).

General Labour strikes, Fires, Floods, Acts of God, Owner-directed changes, Errors and omissions in the plans and specifications, Differing site conditions or concealed conditions, severe weather, Intervention by outside agencies, Lack of action by government bodies are good examples for such delays. (Trauner & Theodore, 2009, p. 27)

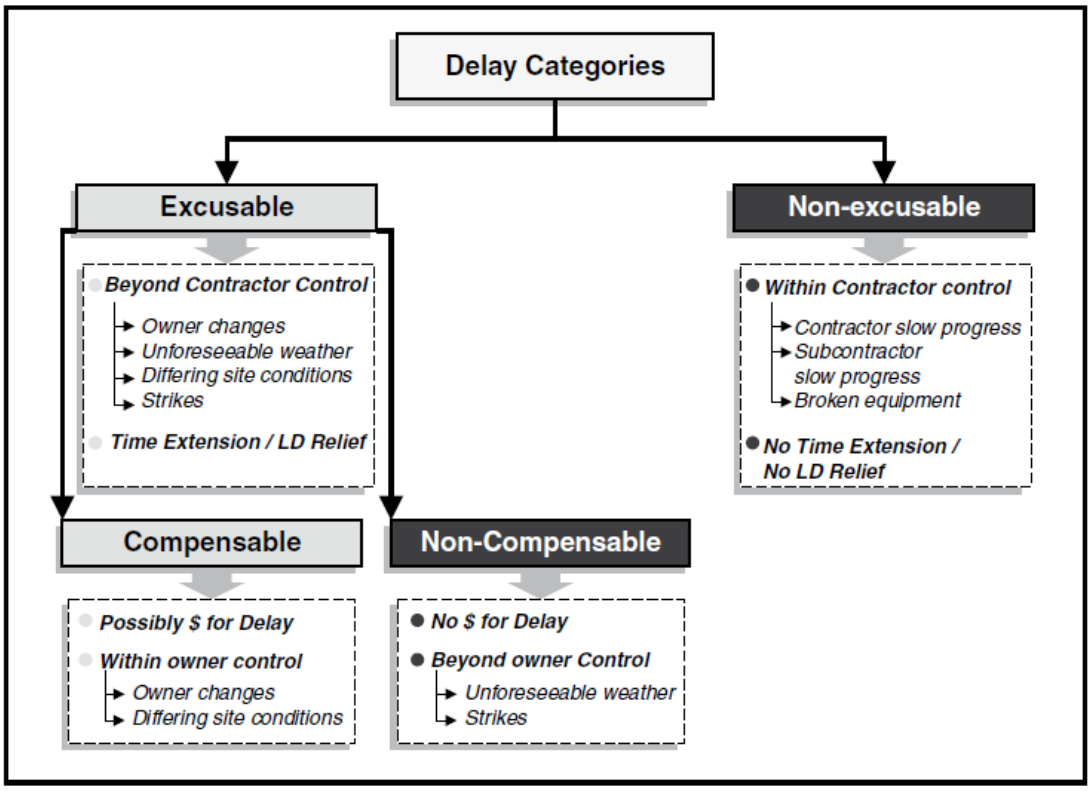

Figure 2.1: Categorization of Delays

Source: (Trauner & Theodore, 2009, p. 26)

In contrast, the Non-excusable delays are events that are within the Contractor's control or that are foreseeable (Trauner & Theodore, 2009, p. 27).

Late performance of Subcontractors, Untimely performance by suppliers, Faulty workmanship by the Contractor or Subcontractors, Project-specific labour strikes caused by either the Contractor's unwillingness to meet with labour representatives or by unfair labour practices are good examples for such delays. (Trauner & Theodore, 2009, p. 27)

Trauner and Theodore (2009) have further pointer out that,

> All non-excusable delays warrant neither additional compensation nor a time extension.
>
> A compensable delay is a delay where the Contractor is entitled to a time extension and to additional compensation, and only the excusable delays can be compensable.

A non-compensable delay means that although an excusable delay may have occurred, the Contractor is not entitled to any monetary compensation resulting from such excusable delay.

The Concurrent Delays are the separate delays to the critical path that occur at the same time, which could be further sub-divided to "Concurrent Delays to the Same Critical Path" and "Concurrent Delays to Separate Critical Paths".

The concurrency argument is not just from the standpoint of determining the Project's critical delays but from the standpoint of assigning responsibility for damages associated with delays to the critical path. (p. 31)

In addition, there is another type of delay, namely "Pacing Delays", in which case one party expands the progress of a work so as to fill the time available for its completion, consuming the float created by a delay of the other party, based on the concept that "*why hurry up and wait*" (White, 2016).

The delays could be also categorised as, Contractor Risk Events (CREs), Employer Risk Events (EREs) and Neutral Events (NEs), based on the terms of a particular contract, the entitlements under which are briefed in the Figure 2.2 below (Keane & Caletka, 2015, pp. 87-89).

Type of event	ERE	CRE	Both CRE and ERE
Excusable	●		●
Non-excusable		●	
Compensable	●		
Non-compensable		●	●

Figure 2.2: Entitlements of the Contractor against Delays

Source: (Trauner & Theodore, 2009, p. 116)

2.2.3 Identifying Delays

Keane and Caletka (2015, pp. 87-89) have explained that a planned work scope could be delayed only in following three forms:

- Delay to commencement
- Extended duration
- Suspension during performance

Furthermore, as per Keane and Caletka (2015, p.87), the process of identifying delays can be undertaken by a delay analyst in two primary ways:

- One starts with an as-built programme and works backwards, identifying deviations from the as-planned schedule (these are the effects of delay events) and is therefore referred to as an 'effect-based' approach.
- The second develops a set of issues, events and potential delay events and attempts to measure the impact of these causes of delay on a baseline programme. Because this process relies on causes, it is known as a 'cause-based' approach.

They have further stated that:

> An 'effect-based' approach is heavily dependent on a reliable as-built programme, and a strong factual matrix. The 'cause-based' approach is heavily dependent on a reliable as-planned programme, or CPM updates, and clear cut 'events'.
>
> Because of the cost implications as well as the potential liability outcome, the approach to delay cause identification must be both systematic and pragmatic.
>
> Following the initial comparison of the as-planned versus as-built programme and initial interviews with project staff would provide valuable first indications of delay problem areas to an Analyst rather than going through each and every project document. Keane and Caletka (2015, pp.87-88)

In the course of this exercise, the delay analyst will require access to a wide range of records which may include categories of documents listed below in Table 2.1.

Table 2.1: Categories of Source Data for Delay Analysis

Tender documents:	
• Tender programmes	• Drawings issued for construction
Contract documents:	
• Contract form(s)	• Contractor's proposals
• Specifications	• Bills of quantities
• Employer's requirements	• Drawings issued for construction
Construction programmes:	
• Construction programme	• Revised programmes
• Subcontractor programmes	• Updated 'as-built' programmes
• Short-term programmes	• Information required by
Project and site records:	
• Programmes	• Requests for information (RFI)
• Project meeting minutes	• Labour returns
• Contractors' progress reports	• Drawing issue registers
• Subcontractors' reports	• Plant hire registers
• Photographs and videos	• Certificates (time and money)
• Site diaries or logs	• Confirmation of verbal instructions (CVI)
• Job correspondence	
Project documents:	
• Drawing revisions	• Design change orders
• Document/drawing transmittal sheets	• Project staff list and attendance record
• Instructions	• Computer discs and hard-drives
Claim related records:	
• Computer-aided 3D simulations	• Claim specific files/documents (e.g. previous claim submissions, time extension awards)
• Delay notices	
• Failure to release information notices	• BIM data

Source: (Keane & Caletka, 2015, p. 91)

2.2.4 Recording of Delays

In case the litigation or arbitration becomes necessary; the availability of the proper records is the key factor for the success of such cases (Downing, 2017).

As per Keane and Caletka (2015, pp. 89-90), it is a good practice to maintain an 'event analysis sheet' for each potential delay event which shall contain the details such as references to the,

- Documents
- Changes

- Contract entitlement clauses
- Programming information (including predecessors and successors)
- Actions required to quantify or verify the impact of the event

2.3 Analysis of Delays

2.3.1 The Requirement of Project Scheduling

As per Mubarak (2005), the following are the major objectives of scheduling

- To calculate the project completion date.
- To calculate the start or end of a specific activity.
- To expose and adjust conflicts between trades or subcontractors.
- To predict and calculate the cash flow.
- To evaluate the effect of changes.
- To improve work efficiency.
- To resolve delay claims.
- To serve as an effective project control tool.

2.3.2 The Requirement of the Delay Analysis

The failure to establish the link of cause and the effect in respect of a delay and disruption claim has been found to be the number one reason for the failure for Contractor's Claims, which is the role of a DAT (Braimah, 2008a).

Table 2.2 below summarizes the competing reasons contributing to the failure of such claims.

Table 2.2: Reasons for the failures in Contractor's Claims

Reasons	Contractors		Consultants		Overall	
	Frequency index	Rank	Frequency index	Rank	Frequency index	Rank
Failure to establish causal link	76.1	1	81.1	1	78.8	1
Inadequate supporting documentation on quantum	67.7	2	72.2	2	70.1	2
Insufficient breakdown of claim amount	62.0	3	70.1	3	66.2	3
Conflicting interpretation of contractual provisions	54.2	4	59.7	5	57.0	4
Contractual provisions not properly identified to support claim	46.6	5	63.0	4	55.1	5
Inadequate effort at mitigation	37.4	8	59.0	6	48.6	6
Lack of timely notice	42.3	6	53.3	7	47.9	7
Inadequate/incorrect notice	40.0	7	50.6	8	45.5	8
Test Statistics						
Kendall's W = 0.95						
$\chi^2_{critical}$ (=0.05) = 14.07; df = 7; χ^2_{sample} = 864.5						

Source: (Braimah, 2008, p.150)

2.3.3 The Use of CPM Techniques

The goal of delay analysis is to satisfy the burden of establishing 'cause and effect' (Keane & Caletka, 2015, p. 115).

CPM programming is the tool which identifies activities as being either critical or non-critical. The CPM programme allows float values of both critical and near critical work to be identified at a given point in time (Keane & Caletka, 2015, p. 112).

The importance of CPM Scheduling, have been further emphasized as given below.

> The CPM schedule therefore is the key to demonstrating those events which caused delays to the critical path and thus to completion, and those which did not. Hence, quantifying the impact of events must be based, in whole or in part, on sound CPM calculations.
>
> In most of the countries, the courts support the principle that a delay must be shown to be critical in order for it to be relevant for an award of time, or time-related damages
>
> Accordingly, various DATs have been evolved based on the framework of CPM scheduling for the analysis of construction delays. (Keane & Caletka, 2015, p. 112)

2.3.4 Construction Delay Analysis Guidance Available and Comparison

Delay and Disruption Protocol (SCLP, 2017) by the U.K. based "Society of Construction Law", AACE_Recommended_Practice-29r-03 (AACE RP, 2011) by the "Association for the Advancement of Cost Engineering International" and Standard for Schedule Delay Analysis by American Society of Civil Engineers (ASCE, 2017) are some of the useful guidelines available to an analyst. (Livengood, 2016)

His review summarizes that;

> Both SCLP (2017) and ASCE (2017) provide coherent discussions of underlying theoretical principals, while the AACE (2017) provides a much more detailed discussion of all the implications and assumptions that might be encountered while doing a forensic schedule delay analysis. The AACE RP (2011) guide also contains a specific section on issues associated with selecting a methodology, something generally absent from either SCLP (2017) or ASCE (2017). At the same time, ASCE (2017) provides excellent advice on best practices that all analysts should consider. The greatest shortcoming of the three guides is that none provide a detailed "how to" explanation of the different methodologies. (Livengood, 2016)

2.3.5 Delay Analysis Techniques (DATs) Available

As per SCLP (2017), the following are the typical DATs commonly available to an analyst.

- The impacted as-planned analysis method
- The time impact analysis
- The Time Slice Analysis
- The As-Planned Versus As-Built Windows Analysis
- The Retrospective Longest Path Analysis
- The Collapsed As-Built (Or But-For) Analysis

The frequently practiced DATs are tabulated in the Table 2.3 below.

Table 2.3: Delay Analysis Techniques Available

	Common name	Literature review	Alternative names used by different authors
Non-CPM based techniques	**S-Curve**	Rubin *et al.* (1999)	**Dollar-to-Time Relationship** (Trauner, 1990)
	Global Impact technique	Leary and Bramble (1988); Alkass *et al.*, (1995; 1996); Pinnell, (1998)	
	Net Impact	Leary and Bramble (1988); Alkass *et al.* (1995, 1996)	**Bar chart analysis** (Zack, 2001; Lucas, 2002) **As-built bar chart** (Bordoli and Baldwin, 1998)
CPM based techniques	**As-planned vs. As-built**	Stumpf (2000); Lucas (2002); Lovejoy (2004); Pickavance (2005)	**Adjusted as-built CPM** (Leary and Bramble, 1988; Alkass *et al.*, 1996) **Total time** (Zack, 2001; Wickwire and Groff, 2004) **Impacted as-built CPM** (Pinnell, 1998)
	As-Planned but for	Alkass *et al.* (1996); Pinnell, (1998)	
	Impacted As-planned	Trauner, (1990); Pinnell (1998); Lucas (2002); Lovejoy (2004) Pickavance (2005)	**What if** (Schumacher, 1995) **Baseline adding impacts** (Bordoli and Baldwin, 1998) **As-planned-plus delay analysis** (Zack, 2001; Chehayeb *et al*, 1995) **As-planned CPM** (Pinnell, 1998)
	Collapsed As-built	Pinnell (1998); Stumpf (2000); Wickwire and Groff (2004); Lovejoy (2004)	**But-for** (Schumacher, 1995; Zack, 2001; Lucas, 2002) **As-built but-for** (Pickavance, 2005) **As-built subtracting impacts** (Bordoli and Baldwin, 1998) **As-built-minus analysis** (Chehayeb *et al*, 1995)
	Window Analysis	Galloway and Nielsen (1990); Bordoli and Baldwin (1998); Finke (1999); Lovejoy (2004); Pickavance (2005)	**Contemporaneous Period Analysis** (Schumacher, 1995; Lucas, 2002) **Snapshot** (Alkass *et al.*, 1995; 1996) **Periodic update analysis** (Chehayeb et al., 1995) **Watershed** (Pickavance, 2005)
	Time Impact Analysis	Leary and Bramble (1988); Alkass *et al.* (1996); Pickavance (2005).	**End of every delay analysis** (Chehayeb *et al*, 1995) **Chronological and cumulative approach** (Wickwire and Groff, 2004)

Source: (Braimah, 2008, p.96)

2.4 Comparison of Commonly Used DATs

2.4.1 Level of Awareness of the Approaches

Table 2.4 below summarizes the results of a research done on the Contractors' and Consultants of UK Construction Industry over their awareness of various DATs, whereas in Sri Lanka no research of this nature has been reportedly conducted yet.

Table 2.4: Contractors' and Consultants' awareness of various DATs in UK Construction Industry

Approaches	Contractors		Consultants		Overall	
	Awareness index	Rank	Awareness index	Rank	Awareness index	Rank
As-planned *vs.* As-built	86.4	1	86.3	1	86.3	1
Impacted As-planned	79.6	3	77.6	3	78.6	2
Global	79.9	2	75.7	4	77.8	3
Net Impact	72.9	4	74.5	5	73.8	4
Collapsed As-built	59.6	5	70.3	6	65.1	5
Time Impact Analysis	46.4	6	78.2	2	62.9	6
S-curve	40.9	7	68.8	7	55.2	7
Window Analysis	40.0	8	67.2	8	54.0	8

Notes: Test Statistics: Kendall's $W = 0.87$; $\chi^2_{critical}$ ($\alpha = 0.05$) = 14.07; df = 7; χ^2_{sample} = 791.7.

Source: (Braimah, 2008, p.156)

It is observed that the practitioners even in United Kingdom are having the least awareness on WDAT similar to the situation in Sri Lanka.

It is observed that the concerned WDAT is having the lowest awareness among the construction community of UK.

2.4.2 Extent of Use

Table 2.5 below summarizes the results of a research done on the Contractors and Consultants of UK Construction Industry over the use of various DATs by them.

Table 2.5: Extent of Use of various DATs in UK Construction Industry

Approaches	Contractors		Consultants		Overall	
	Usage index	Rank	Usage index	Rank	Usage index	Rank
As-planned *vs.* As-built	81.9	1	56.3	2	65.7	1
Impacted As-planned	70.2	2	54.1	3	59.4	2
Collapsed As-built	47.1	5	63.0	1	54.8	3
Time Impact Analysis	37.5	6	52.5	4	48.2	4
Net Impact	51.7	4	39.7	6	45.7	5
Global	54.6	3	36.7	8	45.5	6
Window Analysis	31.4	7	48.9	5	40.2	7
S-curve	30.2	8	37.2	7	33.8	8

Notes: Test Statistics: Kendall's $W = 0.50$; $\chi^2_{critical}$ $(\alpha = 0.05) = 14.07$; $df = 7$; $\chi^2_{sample} = 455.0$.

Source: (Braimah, 2008, p.139)

Table 2.6 below summarizes the results of a similar research done on the Contractors', Clients' Consultants and External Claims Consultants of Malaysian Construction Industry over the use of various DATs by them (Muhamad, Mohammad, Ahmad, & Ibrahim, 2016).

It is observed therein that the External Claims Consultants in Malaysia tend to use "Time Impact Analysis" and "Window Analysis" mostly for their works.

Table 2.6: Extent of Use of various DATs in Malaysian Construction Industry

Methodology	Contractors		Clients' consultants		Overall (contractors + clients' consultants)			External claims consultants	
	Mean	Rank	Mean	Rank	Mean	Rank	Rank	Mean	Rank
S-curve	3.66	3	3.53	1	3.60	1	1	1.25	8
As-planned vs as-built	3.69	2	3.23	2	3.46	2	2	3.00	4
Time impact analysis	3.72	1	2.93	3	3.33	3	3	3.75	1
Impacted as-planned	3.00	4	2.35	4	2.68	4	4	3.50	2
Net impact	2.69	5	2.33	5	2.51	5	5	1.75	6
Window analysis	2.38	6	2.00	6	2.19	6	6	3.50	2
Collapsed as-built	2.28	7	1.95	7	2.12	7	7	2.25	5
Global method	2.22	8	1.95	7	2.09	8	8	1.50	7

Source: (Muhamad, Mohammad, Ahmad, & Ibrahim, 2016, p.127)

In contrary to the finding of the previous researchers (Ekanayake & Perera, 2016), it is observed that the WDAT has been rarely utilized by not only Sri Lankan practitioners, but also by the practitioners of United Kingdom and Malaysia.

However, it is worthwhile to note that there is a trend in the Claims Consultants of Malaysia to use WDAT at a relatively higher frequency, which could be compared with Claims Consultants of Sri Lanka.

2.4.3 Essentially Required Inputs

The inputs required for the implementation of each DAT are summarized in the Table 2.7 below.

Table 2.7: Inputs Required for the Implementation of Various DATs

Method of Analysis	Analysis Type	Critical Path Determined	Delay Impact Determined	Requires
Impacted As-Planned Analysis	Cause & Effect	Prospectively	Prospectively	• Logic linked baseline programme. • A selection of delay events to be modelled.
Time Impact Analysis	Cause & Effect	Contemporaneously	Prospectively	• Logic linked baseline programme. • Update programmes or progress information with which to update the baseline programme. • A selection of delay events to be modelled.
Time Slice Windows Analysis	Effect & Cause	Contemporaneously	Retrospectively	• Logic linked baseline programme. • Update programmes or progress information with which to update the baseline programme.
As-Planned versus As-Built Windows Analysis	Effect & Cause	Contemporaneously	Retrospectively	• Baseline programme. • As-built data.
Retrospective Longest Path Analysis	Effect & Cause	Retrospectively	Retrospectively	• Baseline Programme. • As-built programme.
Collapsed As-Built Analysis	Cause & Effect	Retrospectively	Retrospectively	• Logic linked as-built programme. • A selection of delay events to be modelled.

Source: (SCLP, 2017, p. 34)

2.4.4 Strengths and Weaknesses

The Strengths and Weaknesses of the commonly used DATs are tabulated in the Tables from 2.8 to 2.12 below.

Table 2.8: Strengths and Weaknesses of Impacted As-Planned Technique

Strengths	Weaknesses
• Easy to understand • Least amount of variables in 'cause–effect' equation • Does not require as-built programme • Can be carried out contemporaneously • Does not require progressed programmes	• Does not account for changes to logic or durations of planned activities • Produces theoretical results based on a hypothetical question • Cannot identify true concurrent delay

Source: (Keane & Caletka, 2015, p.138)

Table 2.9: Strengths and Weaknesses of Time Impact Analysis

Strengths	Weaknesses
• Easy to understand • Can be carried out contemporaneously • Relies on contemporaneous intentions (accounts for changes to logic and duration of remaining activities from time to time) • Considers dynamic critical path • Does not require as-built programme • Can identify approximate concurrency	• Produces theoretical results based on a hypothetical question • Cannot identify actual concurrent delay • Labour intensive • Technically complex • Requires frequently prepared progress schedules

Source: (Keane & Caletka, 2015, p.150)

Table 2.10: Strengths and Weaknesses of the Collapsed As-Built Technique.

Strengths	Weaknesses
• Relies on as-built programme • Based on simple, easy to understand principles • Can isolate impact of EDE from CDE (when iterative applications are applied) • Only relies on as-built • Does not require progress updates • Does not require a baseline programme	• Reconstructing sufficiently detailed as-built is laborious • Constructing as-built logic is subjective • Does not calculate delay based on contractor's contemporaneous intentions, 'at the time' • Unable to distinguish pacing activities from critical delays • Can identify as-built periods of compensable delay • Cannot identify as-built (contemporaneous) critical path • Requires many subjective assumptions when recreating the CAB as-built model for analysis, in content and level of detail, as well as logic and durations of the as-built activities

Source: (Keane & Caletka, 2015, p.160)

Table 2.11: Strengths and weaknesses of the As-Planned Versus As-Built Technique

Strengths	Weaknesses
• Intuitive and easy to understand • Conclusions are readily supported by as-built records • Does not require frequently updated progress schedules • Does not require logical relationships or float to be expressly provided in as-planned programme • Can identify concurrency in the period work was actually carried out • Can identify critical delay in the period in which the work was actually carried out, and the period in which the costs were actually being incurred	• As-built sequence must relate to as-planned sequence for activity level variance method • Requires analyst to deduce the as-built critical path absent monthly progress updates • As-Built programme required • Constructing proper as-built programme could be resource intense and expensive

Source: (Keane & Caletka, 2015, p.170)

Table 2.12: Strengths and Weaknesses of Window Delay Analysis Technique

Strengths	Weaknesses
• Relies on readily available contemporaneous progress programmes • Relies on shifting critical path • Allows identification of multiple critical paths. • Intuitive and easy to understand • Conclusions are readily supported by as-built records • Can identify concurrency in the period work was actually carried out • Can identify both loss and gains achieved between progress updates • Can identify critical delay in the period in which the work was actually carried out, and the period in which the costs were actually being incurred	• Properly updated progress programmes required • Activity start, finish and float constraints may create gaps in the as-built critical path and require rationalisation when they affect the critical path • Early programmes may contain logical errors which were corrected in later contractor prepared updates • Requires reasonable level of planning expertise

Source: (Keane & Caletka, 2015, p.175)

2.4.5 Capabilities of Commonly Utilized DATs

The capabilities of the commonest DATs are indicated in the Figure 2.3 below.

Analysis technique	Capabilities			
	Real-time critical path analysis	Real-time delay identification	Identifying concurrent delays	Identifying Pacing delays
As-planned vs. as-built method	×	×	×	×
Global impact technique	×	×	×	×
As-planned technique	×	×	×	×
Impacted as-planned technique	×	×	×	×
Net impact technique	×	×	×	×
Time impact technique analysis	○	○	×	×
But-for	×	×	○	×
Isolated delay type technique	○	×	○	×
Snapshot technique	○	○	○	×
Windows analysis	○	○	○	×

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

Figure 2.3: Capabilities of Commonly Utilized DATs

Source: (Kao & Yang, 2009, p.411)

Accordingly, it is observed that the WDAT is having most of the functionalities wanted for an in depth analysis of a particular delay scenario.

2.4.6 Comparison of the outputs of DATs applied on a selected case

Case Studies conducted have revealed that the results arrived by the application of various DATs to analyse a same set of delays on a sample project has been significantly different from each other. Furthermore, the reasons for the above have been identified to be the difference in the approaches adopted by various DATs (Braimah, 2013b), (Maduranga, Palamakumbura, & Dissanayake, 2016).

2.4.7 Selection of the Most Appropriate DAT for a Particular Case

There are four main criteria for selecting which delay analysis methodology to be utilized for a given case (Barry, 2009).

- What does the contract require?
- Which approach is appropriate, correct, and sustainable?
- Does a lack of information preclude the use of any of the approaches?
- Do time/cost constraints eliminate certain options?

He has further stated that it is prudent to first establish the occurrence of delay and then trying to establish the cause (effect and cause approach) rather than making it other way around, which will also be towards a great assistance in the recovery of cost.

When a contract is silent on the DAT to be followed in an assessment of a delay, the terms of the contract must be the next first factor to be considered when choosing which DAT to be used (Keane & Caletka, 2015, p. 117).

> For example, if the contract terms state that the extension of time entitlement must be established by measuring delays to the ‘planned completion’ date rather than the ‘contract completion’ date, then a method which relies on contemporaneous programme projections is necessary.
>
> If the contract terms state that the extension of time entitlement must be established by events which ‘have caused delay’ to completion, then a form of retrospective analysis relying on an as-built programme of some sort is likely to be most

appropriate so that the delay will have a basis in fact rather than prospective CPM calculations.

If the contract requires that extension of time entitlement can be established based on the 'likely delay' to completion caused by an event, then methods of prospective analysis, which project 'what-if' scenarios of how the works might have been delayed, may be used.

Furthermore, when seeking to justify acceleration, it is recommended that more than one method of delay analysis is applied. A prospective method of delay analysis will assist in demonstrating what the delay 'would have been' if not for attempted acceleration, whereas a forensic method of analysis will assist in demonstrating what true delay was experienced, the combination of which will give a more acceptable solution. (Keane & Caletka, 2015, pp. 117-118)

2.5 Is Windows Delay Analysis Technique (WDAT) a Primary Method?

As per Quackenbush and Dillon (n.d.), a simplified version of the Army Corps of Engineers' technique known as the Multiple Time Impact Analysis ("Multiple TIA") approach began to be identified as the "Windows Analysis" technique since the early 1990's.

The delay analysis techniques are known by many generic titles and each method can be applied in several ways. The most widely known methods of delay analysis are subject to frequent misuse, but the name applied to a technique is not as important as the application of the chosen method (Keane & Caletka, 2015, pp. 7,135).

As per Keane and Caletka (2015), only the impacted As-planned, Collapsed as-built, As-planned versus as-built and Time impact analysis could be treated as the primary categories, and all other techniques shall fit in to one of these. Moreover, it has been stated that the "window" method could be implemented using any of the primary methods of above, which sometimes refers to as 'watershed' analysis too.

In a WDAT, the Windows, as well as, the primary methods of Delay Analysis used for separate Windows, could be selected by the analyst (Trauner & Theodore, 2009, pp. 140,141).

As per Trauner and Theodore (2009, p. 141) have emphasised that, though it has been frequently named as “Windows Analysis”, the same is a delay analysis approach only rather than a primary method of Delay Analysis.

Pickavance (2005) has stated that,

> "Windows" (and "Watersheds") are not methods of analysis in themselves: they are merely aspects of conducting the critical path analysis. In essence they represent the division of the overall construction period into smaller periods into which each new set of corresponding progress can be entered into the programme and analysed. Pickavance (2005, p.572)

Accordingly, it could be concluded that the WDAT is not a primary method of delay analysis, but a systematic useful approach to an analysis of delay, which essentially requires one of the primary DATs applied inside Windows.

2.6 Specialities of WDAT.

In accordance with Lane (as cited in Parry, 2015), as the WDAT focuses on sequential periods of project performance and on the contemporaneous critical path, the same has significant benefits over those which deal with the total project period as a whole.

A study done by Farrow (as cited in Parry, 2015) has identified that the WDAT considers the events at the times they arose and considers what the likely entitlement was at each window. The convenience of analysis is also there as only a limited number of activities are impacted (affected) in a single window, which makes this the most robust and extensive analysis.

As per Finke (as cited in Parry, 2015), in principle, there is no reason why WDAT should not be used to analyse any delay, as the essence of WDAT is not in what is analysed or how, but in the point at which it is analysed.

The entitlement obtained in one window is not negated by what happens in the next window. Hence, the WDAT appears to be the most reasonable and accurate option with which to conduct the analysis of compensable delays as well (Parry, 2015).

Hegazy (as cited in Parry, 2015) has suggested using windows of smaller size to capture and consider all variations in critical path(s), who also promotes a daily Analysis of Window.

Gibson (2008) has stated that the 'windows' method of analysis is considered to be the most reliable of the various retrospective analysis techniques. (p.199)

Skaik and Nair (2014) have stated that the WDAT is the best approach of delay analysis for a complicated situation, where concurrent delays of the parties are involved, once implemented with monthly windows using Time Impact Analysis (TIA).

By using an improved WDAT having widows of "one days", the special abilities that considers "the impact of resource allocations", "Contractor's acceleration", "the impacts of project rescheduling (Baseline Updates)" and thereby finally contributing to more appropriate apportionment of the delays among the parties to the Contract could be identified (Menesi, 2007, pp. 87-88).

The fact that the analysis is segmented into periods does not significantly increase or decrease the technical accuracy of this method, but, the segmentation is useful in enhancing the organization of the analysis process and enables prioritization. It also may add to the effectiveness of the presentation of the analysis (AACE RP, 2011).

The statement made by the Judge Toulmin below over the case *Mirant Asia-Pacific Construction (Hong Kong) Ltd v Ove Arup & Partners* held in the Technology & Construction Court gives an important insight to the construction community regarding the legal acceptability of WDAT (Gibson Consulting Limitted, n.d.).

“There may be more than one critical path.”

“It is important to look at activities at or near the critical path to understand their potential impact on the Project.”

“Windows analysis, reviewing the course of a Project month by month, provides an excellent form of analysis to inform those controlling the Project what action they need to take to prevent delay to the Project.”

“Without such analysis those controlling the Project may think they know what activities are on the critical path but it may well appear after a critical path analysis that they were mistaken.”

“Windows analysis is the most accepted method of critical path analysis. As Pickavance (referring to the book ‘Delay and Disruption in Construction Contracts’, by Keith Pickavance), makes clear at page 572 of his book, "Windows" (and "Watersheds") are not methods of analysis in themselves: they are merely aspects of conducting the critical path analysis. In essence they represent the division of the overall construction period into smaller periods into which each new set of corresponding progress can be entered into the programme and analysed.

“The term "Windows analysis" refers to the regular reviews and updates undertaken by the contractor, normally monthly. These periods of time would be described as monthly windows. Unlike previous monthly reviews, the planner would use sophisticated software programmes to plot which activity or activities were on and which were near to the critical path each month. The programmes would take into account those activities which had started early or had been delayed. Also built into the programmes would be the progress of those activities which had started since the previous monthly window. This would enable the Employer and the Contractor to analyse over the relatively short periods of time what changes had occurred, and identify what problems needed to be investigated and put right.”

“The analysis would also identify delay, enabling those concerned to investigate and, if appropriate, agree the cause at an early stage.”

Accordingly, it is verified that the WDAT is well superior amongst the other DATs along with its advanced features.

2.7 Basic Steps in Implementing a WDAT.

WDAT involves an interim assessment of delay on updated schedules at specific periods of the project. This method is also similar to the methods as referred to as “snapshot technique” and “contemporaneous period analysis” (Braimah, 2013b).

As identified by Braimah (2013b), the implementation steps of the WDAT are as follows:

> First, the total project duration is divided into a number time periods (windows or snapshots) usually based on major changes in planning or major project milestones. The schedule within each window is updated to reflect the actual durations and sequence at the time of the delay while the remaining as-planned schedule beyond the window period is maintained. Analyses are performed to determine the critical path and new completion date. This new completion date is compared with the as-planned completion date prior to this analysis to give the amount of delay during that window period. Analysis is then carried out for each “window” successively at the various updates to identify the overall impact. (Braimah, 2013b)

WDAT is retrospective analysis, which requires a Baseline Programme (a reliable fully linked critical path programme), regular programme updates, and a complete set of as-built data (Parry, 2015).

As per him, this technique requires the total project duration to be divided into digestible time periods, called windows, and to analyse the delays that occurred in each window successively with focus on the actual critical path(s) (p.93).

In a WDAT, The term ‘windows’ refers to the period of time being analyzed (Keane & Caletka, 2015, p. 7)

As per Hegazy and Zhang (as cited in Parry, 2015), usually, the selection of window size coincides with milestones, major programme updates, or major delay events.

At the completion of each window, it will be necessary to record the changes such as given below with respect to what was originally intended to encounter for such periods (Pickavance, 2005).

- Addition of a new activity
- Omission of an activity.
- Activities taken longer to complete
- Activities completed earlier
- Activities started later than planned
- Activities started earlier than planned.

If contemporaneous periodic updates are not available, it is then necessary to reconstruct the windows, which is undertaken by choosing various milestones through the project which dictate the course of the project or decisions which change the course in some way (Pickavance, 2005).

As per Alkass, Mazerolle and Harris (as cited in Parry, 2015), having identified a period of delay or mitigation in the window in question, the remaining task to assess the causative event or event could be done in a variety of ways, such as:

1. Detailed visual inspection (i.e. expert assessment).
2. Creating, impacting and analyzing so-called the fragnets (small critical paths that model a single programme activity in greater detail).

Parry (2015) states that the next step is to prepare a delay programme before the analysis proceeds, which will list the delay events alleged to give rise to the contractual entitlement.

Parry (2015) states that the next steps of this process shall be done as given below.

> For each of the window periods, the delay events that are alleged to have arisen in the period in question are impacted on the planned model and the impact on the date of completion is systematically recorded. The resultant project end date at the end of a window update will reflect the entitlement, at that time.
>
> The contractor's culpable delay events too could be impacted on the same model and time is analysed.
>
> Following the analysis, the progress records are imposed on the planned model and the programme time is analysed again. The resulting end date will represent the overall delay to completion actually occurring in that window period. This will allow for excusable delay events, compensable delay events, culpable delay events and contractor's mitigation due to changes in programme or faster progress. (pp. 98-99)

A more detailed steps of practically implementing a WDAT using a commercial software has been published by Keane and Caletka (2015, pp. 176-178), which is given below.

1. Identify the contractor's as-planned CPM programme.

2. Identify all contemporaneous CPM progress updates to completion.

3. Export the progress achieved each month, against each activity into a spreadsheet, database, comma separated value (CSV) or ASCII text file. This will include only progress data, including percent complete, actual start, actual finish and remaining durations.

4. Identify the periods requiring a 'half-step' update to evaluate loss/gain experienced due to 'progress only' (month 'n').

5. Import the progress achieved in month 'n' into the immediately preceding update programme (month n −1).

6. Recalculate month n−1 programme with the data date corresponding to month n. This is the ‘month-to-month’ progress-only update. Save the programme with an appropriate unique file name.

7. If subsequent programmes contain logic or duration revisions which were not agreed to, or are somehow suspect, the programme which received the progress data for month ‘n’ may also need to receive the progress data for month ‘n’+1 and so on. If so, repeat the process:

a) Import cumulative progress as of month n +1 into the programme n−1.

b) Recalculate the programme with the data date corresponding to month n +1, save the file and repeat the process as many times as necessary.

8. Tabulate the loss/gain to the project completion from each subsequent month-to-month update programme.

9. Tabulate the additional loss/gain in the corresponding contemporaneous programme update with the same data date. This loss/gain is the amount of delay that was not related to progress, but rather due to changes in sequences, durations made by the contractor on the programme.

10. Rationalize the additional loss/gain by researching and identifying the changes in logic/duration along the critical path which caused the additional loss/gain. (This can be done by way of manual review of the electronic programmes or by using commercially available scheduling comparison software such as ‘Claim Digger™’ or ‘PrimaPlan Project Investigator™’).

11. For the month-to-month programmes, determine which activities were on the ‘longest path’ which were either in-progress, or planned to commence in the period being analysed. These are determined to be ‘driving’ activities in the month-to-month update programme.

12. Compare and rationalise the variances of the float values for all of the driving activities in a ‘float map’ which tracks the gain/loss of float solely due to lack of progress in each driving activity through all of the available contemporaneous progress records.

13. Group all related driving activities in the float map and identify concurrent ABCPs by reference to sequences of unrelated activities which were competing for dominance on the driving contemporaneous critical path from time to time.

14. Identify the tasks which were sub-critical but predecessors to ‘driving’ critical activities along each path when concurrent ABCPs were dominant in that period.

15. Document the planned project completion date in each monthly update. (When concurrent critical paths were critical to ‘sections’ defined by the contract, then each sectional completion date should be monitored and documented.)

16. Identify the loss/gain achieved in each monthly update by reference to the projected project completion date.

17. Align the driving activities identified in the float map exercise with the loss/gain achieved to the completion date each month.

18. Investigate the cause of delay to the driving activity in each period that a measurable loss/gain is identified.

19. Assign or apportion responsibility for the loss/gain measured in each window by reference to the driving activity and causative events documented in the contemporaneous records.

20. Assign or apportion responsibility for the additional loss/gain reported due to changes to logic or duration noted above in step 10 above.

2.8 The Legal Acceptance of the DATs Globally.

As per Dale, Deluca, and D'Onofrio (2015), not all the DATs have been totally accepted or rejected by the Legal Tribunals.

They have also identified that the occurrence of the various DATs in the cases handled by Legal Tribunals from various jurisdictions of the world are as given in Figure 2.4 below.

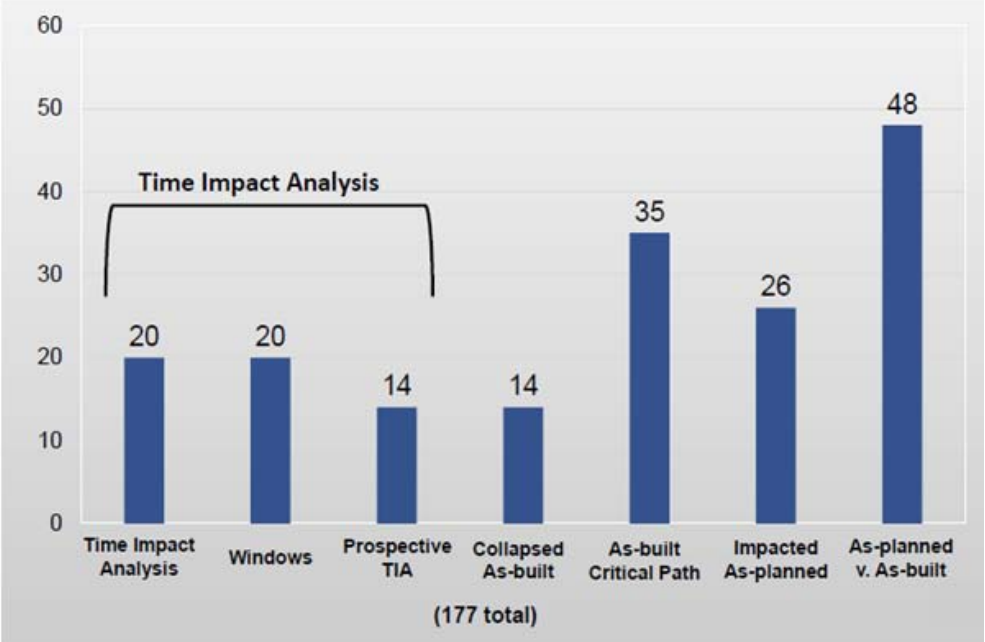

Figure 2.4: Frequency of Occurrence of DATs in Case Laws – All Global Jurisdictions

Source: (Dale, Deluca, and D'Onofrio, 2015)

Furthermore, they have similarly identified that the legal acceptance of the same has been as given below in Figure 2.5.

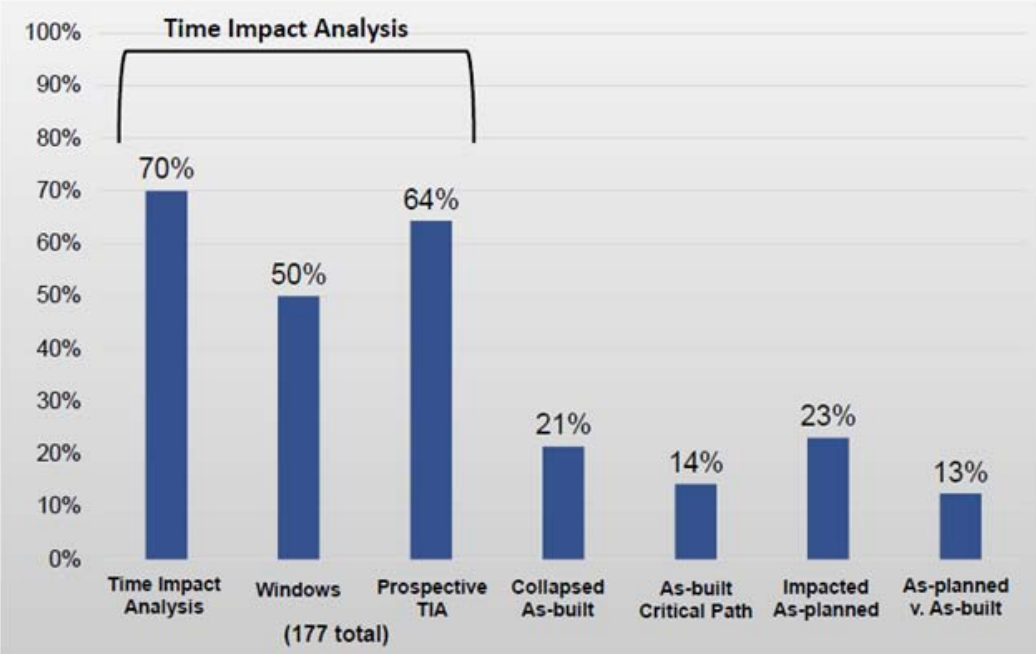

Figure 2.5: Frequency of Acceptance of DATs in Case Laws - All Global Jurisdictions

Source: (Dale, Deluca, and D'Onofrio, 2015)

In accordance with Sali, Anwar, and Idlan (2014), even thought almost all the Contract Forms carries a provision of Extension of Time (EOT), the relevant clause is generally not worded in a descriptive manner so that no legal determination could be easily made on the same.

However, they have identified the following as the minimum requirement in substantiation of a claim for EOT based on the English case of *John Barker Construction Limited versus London Portman Hotel Limited (1996)* in England.

- The assessment must be based on whether the delaying events are on the critical path;
- Whether they have affected the critical activities scheduled to be performed in the contract; and
- Calculate rather than make an impressionistic assessment of the time taken up by the delaying events.

2.9 Road Construction Industry of Sri Lanka

As per the Table 2.13 below, for the year 2015, the total estimated value of works done by all type of construction activities in Sri Lanka was Rs. 267,115 Million. The highest contribution (35.5%) to this total value has been made by the Roads & Railways construction activities, which was Rs. 94,755 Million. In accordance with Table 2.14 below, the construction of Roads alone will form a contribution of Rs. 78,614 Million, which is 29.3% of the total value (Department of Census and Statistics, Sri Lanka, 2016).

The above indicates that the Road Construction Industry has become a giant among the other disciplines of constructions.

Table 2.13: Values of National Works done – Construction Industries – Year 2015

Type of Construction Activity	Value of work done (Rs.)	%
Construction of buildings	87,357	32.7
Construction of roads and railways	94,755	35.5
Construction of utility projects	24,834	9.3
Construction of other civil engineering projects	34,524	12.9
Demolition and site preparation	1,124	0.4
Electrical, plumbing and other construction installation activities	9,880	3.7
Building completion and finishing	4,011	1.5
Other specialized construction activities	10,630	4.0
Total	**267,115**	**100.0**

Source: (Department of Census and Statistics-Sri Lanka, 2016).

Table 2.14: Values of National Works done – Construction of Roads – Year 2015

Type of Construction Activity		No. of Activities	Total Value of Contract (Rs.)	Value of work done (Rs.)
410 - Construction of buildings	41001 : Residential buildings	757	32,787,921,038	14,989,273,677
	41002 : Non residential buildings	1,494	60,939,299,396	44,257,041,142
	41003 : Both residential & non residential buildings	1,447	48,126,099,050	26,607,957,940
	41004 : Remodeling or renovating existing residential structures	664	1,811,071,943	1,502,433,228
	Group total	**4,362**	**143,664,391,427**	**87,356,705,987**
421 - Construction of Roads & Railways	42101 : Construction of roads	1,074	236,440,420,217	78,614,071,125
	42103 : Construction of bridges, tunnels	332	17,849,708,644	11,521,045,087
	42109 : Other construction related to roads & railways	65	4,686,750,369	4,620,118,414
	Group total	**1,471**	**258,976,879,229**	**94,755,234,627**

Source: (Department of Census and Statistics-Sri Lanka, 2016).

Researches undertaken purely on the road projects were very rare, and the author has therefore considered the reporting on general construction projects are applicable to the road projects as well, since the same is a subcategory of general constructions.

Accordingly, unless otherwise specifically referred to the wording “roads”, the contents below will be regarding all the construction projects in general.

2.9.1 Delays in Road Construction Projects of Sri Lanka

As per Risath, Rifas, and Thamboo (2011), the delays in project delivery is emphasized as a major misfortune in the construction industry of Sri Lankan.

Project delays often occur due to the dynamic and complex nature of the construction industry as per Ramachandra, Rotimi, and Gunaratne (2014).

As per Pathiranage and Halwatura (2010), the local road construction projects experience 56% - 88% of average time overrun compared to the original (planned) project durations.

As per Jayawardane and Jeyakanthan (2010), the delays in donor funded road projects have become inevitable, and an endemic problem in Sri Lanka hindering effective use of foreign aid granted for such projects, and 69% of the Projects (out of 24 examined) were experiencing delays.

2.9.2 Factors affecting time overruns in Sri Lankan Road Projects

In accordance with Risath, Rifas, and Thamboo (2011), the following factors are causing delays to the general construction projects in Sri Lanka.

Clients Related Delays are, Delay in revising and approving design documents, Change orders by owner during construction, Delay in approving shop drawing and sample materials, Slowness in decision making process, Poor communication and coordination, Conflicts between joint-ownership of the projects, Delay to furnish and deliver the site possession, Suspension of work by owner and Delay in progress payments.

Consultants Related Delays are Delay in approving major changes in the scope of work, Mistakes and discrepancies in design documents, Un-use of advanced engineering design software, unclear and inadequate details in drawings, Delays in producing design documents, Insufficient data collection and survey before design, Poor communication and coordination and Inadequate experience of consultant.

Contractor Related Delays are Delays in sub-contractors work, Poor communication and coordination, Inadequate contractor's work, Ineffective planning and scheduling of project, Conflicts in sub-contractors schedule in execution of project, Improper construction methods implemented, Frequent change of sub-contractors, Rework due to errors during construction, Conflicts between contractor and other parties, Difficulties in financing project, Delays in site mobilization and Poor qualification of the contractor's staff.

Material Related Delays are Delay in material delivery, Shortage of construction materials in market, Changes in material types during construction, Delay in manufacturing special building materials, Late procurement of materials and Damage of sorted material while they are needed urgently.

Labour Related Delays are Shortage of labors, Low productivity level of labors, working permit of labors and Personal conflicts among labors.

Equipment Related Delays are Lack of high-technology mechanical equipment, Low productivity and efficiency of equipment, Low level of equipment-operator's skill, Shortage of equipment and Equipment breakdowns.

Other Related Delays are Effects of subsurface and ground conditions, Weather effect on construction activities, Delay in providing services from utilities, Delay in obtaining permits from municipality, Traffic control and restriction at job site, Changes in government regulations and laws, Delay in performing final inspection and certification and Accidents during construction.

As per Jayawardane and Jeyakanthan (2010), the facts such as inadequate feasibility studies, errors and omissions in detail design, improperly harmonized procurement documents, shortcomings in contract documents occurred in pre-contract stage too have contributed to consequential delays during the execution stage of the Contracts. The same research revealed that 56% of the total project delays were caused by Variations and Extra Works caused by the design changes, omissions, and errors and inadequate feasibility studies.

2.9.3 Factors affecting cost overruns in Sri Lankan Road Projects

In accordance with Risath, Rifas, and Thamboo (2011), the prolongation of the completion of the works is one of the major causes for time and cost overruns.

With regard to the road construction projects, the delays in payments by the employers, the delays in relocation of existing utilities, the cost escalation, the design changes during construction and issues in connection with land acquisition have been the other critical cost overrun factors (Wijekoon & Attanayake, 2014).

2.9.4 Importance of the Mitigation of Delays

In accordance with Risath, Rifas, and Thamboo (2011), the delays in completion of the Sri Lankan construction Projects result in time overrun, cost overrun, disputes, litigation, total

abandonment and arbitration respectively in the order of their severity, which are detrimental to the parties to the Contract.

As per Dolage and Pathmarajah (2015), the construction project delays have undesirable effects on smooth functioning of projects, such as adversarial relationships among project participants, distrust, litigation, arbitration and cash-flow problems, which sometimes cause contracts to be abandoned or terminated.

As per Jayawardane and Jeyakanthan (2010), the delays in donor funded road projects have become inevitable, and an endemic problem in Sri Lanka hindering effective use of foreign aid granted for such projects.

It is obvious that, on top of all above, these causes will delay the intended use of such facilities by the public at the scheduled junctures placing all stakeholders in difficulty.

Hence, the mitigation of delays is of very high importance.

2.9.5 Contractors' Delay Claims and Reasons for failures in Sri Lanka

Ramachandra, Rotimi, and Gunaratne (2014) have identified, with 95% confidence level, that the delay claims submission occurs in 50-70% of such delayed projects in Sri Lanka. Furthermore, their analysis has confirmed that, with 95% confidence, only a 25-40% of such claims have been successful in Sri Lanka.

The same research has identified that the inadequate documents to substantiate the claims, delayed submission of the claim details by contractors, failure to establish link between cause and effects of the claims and failure to use appropriate delay analysis methods have been the top most reasons for the failures of the claims.

It is worthwhile to note that the failure to establish a causal link using an appropriate DAT in respect of a delay claim is the third major reason for the failures of the delay claims by the Sri Lankan Contractors, which, in fact, is the role of the analysis of delays.

2.10 The Practice of DATs in Sri Lanka

2.10.1 DATs Used in Sri Lanka

As per Ekanayake and Perera (2016), As-planned v. As-built, Impacted as Planned, Time Impact Analysis, Collapsed as Built and Window Analysis are commonly used DATs in Sri Lanka in the ascending order of their frequency of usage.

They have also stated that only 87.5% of the delayed projects had used such a DAT, whereas others have not. As-planned v. As-built has been deployed by 53.4 % of such projects for the analysis of the delays.

2.10.2 The Framework to select the most suitable DAT for a given case

There is no single DAT appropriate for all kinds of delay cases, and the selection of the most appropriate DAT for a given case would remain to be rationally selected by the analyst (Perera & Sudeha, 2013).

With the complication of issues related to this subject area, and in consideration of the improvements of the quality of the analysis, the construction community is now towards the selection of the most appropriate DAT for a given case (Perera & Sudeha, 2013).

As per Perera and Sudeha (2013), the selection of most appropriate DAT for a given case shall be governed by the consideration of “Filter Factors” and “Utility Factors” indicated in the Table – 2.15 below.

Table 2.15: Factors Governing the Selection of a DAT

	Factors Identified	Utility factor	Filter factor
U_1	Record availability	√	
U_2	Nature of baseline programme	√	
U_3	The other party to the claim	√	
U_4	Applicable legislation	√	
U_5	The form of contract	√	
U_6	Skills of the analyst and familiarity with the project	√	
U_7	Size of the project	√	
U_8	Duration of the project	√	
U_9	Complexity of the project	√	
U_{10}	The amount in dispute	√	
U_{11}	Dispute resolution forum	√	
U_{12}	Time availability for delay analysis	√	
U_{13}	Cost of using the technique	√	
F_1	Nature of the delaying events		√
F_2	Baseline programme availability		√
F_3	The number if delaying events		√
F_4	Updated programme availability		√
F_5	Time of the delay		√
F_6	Reason for the delay analysis		√
F_7	Nature of the proof required		√

Source: (Perera & Sudeha, 2013)

Firstly, the “Filter Factors” shall be used for the primary screening of the DATs to identify the most suitable set of DATs, which will be a relatively simpler decision.

Secondly, in contrast to above, the secondary screening of the suitable DATs to identify the most suitable DAT (out of above selections) would be a more advanced decision considering the relative weightings of the “Utility Factors” as applicable to a certain DAT for its successful implementation.

Perera and Sudeha (2013) have also assessed the levels of suitability of frequently used primary DATs considering various influential factors as indicated in the Table 2.16 below.

Table 2.16: Suitability of DATs

Delay Analyzing Technique	Total Final Importance Score	Overall Ranking
Time Impact Technique	0.302	1
Collapsed As-built	0.249	2
As Planned vs As Built	0.215	3
Impact As-planned	0.123	4
Global Impact	0.111	5

Source: (Perera & Sudeha, 2013)

They have reportedly made use of an AHP Tool to analyse the data collected by their research in order to arrive at conclusions in the Table 2.16 above.

The abbreviation AHP refers to an Analytic Hierarchy Process (AHP), which is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then ("Analytic Hierarchy Process", 2018).

Subsequently, Ekanayake and Perera (2016), have identified that the DAT, namely, Windows Delay Analysis, as the most appropriate DAT for the road construction projects in Sri Lanka.

This has been decided considering the criteria, *Time Taken for Analysis, Cost of the Analysis, Workability of the Technique, Reliability of the Technique, Accuracy of the Technique, Acceptability of the Technique to the Relevant Parties, Acceptability to Courts and Tribunals, Complexity of the Analysis* and *Inputs from the Experts Required.* Sixty numbers of Engineers, Project Managers and Quantity Surveyors have participated in this survey, who have ranked each of above criteria on a five-point Likert scale.

They have also found out that the WDAT is the least used DAT in Sri Lanka, whereas the same is being frequently used in most of the other countries.

2.11 Summary

The existing knowledge on the subject area with special reference to the Sri Lanka context could be gathered, though very little was available.

The main objective of the literature review, which was to identify what the WDAT is and how to perform the same (Objective 1), was successfully accomplished.

May be due to the reason that the WDAT was a novel concept to the Sri Lankan construction industry, no literature could be sourced on related studies, and all the WDAT related literature inputs were of the foreign origin. This was reflecting the existing gap to be filled by new researches, which reconfirmed the value of undertaking this research.

Furthermore, the benefits of the WDAT in resolution of the construction delays in a meaningful manner were well realized, which was encouraging to proceed with the next stages of this study.

CHAPTER 03

RESEARCH METHODOLOGY

3.1 Introduction

Having already identified aspects and issues related to the research topic and the possibility of solutions using the existing literature under chapter two, the purpose of this chapter is to elaborate the path of achieving the aim and objectives of this research under a methodological approach.

Accordingly, the design of the research including the research approach and research techniques etc. related to this study will be discussed with the progression of this chapter.

3.2 Research Design

Kothari (2004) described research design as the conceptual structure within which the research is conducted, which also provides the blueprint for the collection and analysis of data. Similarly, Punch (2005) mentioned that the research design is the intermediate connector between research question and data. Moreover, Kagioglou, Cooper, Aouad, and Sexton (2008) found that research design identifying three key factors such as research philosophy, research approach and research techniques.

3.3 Research Approach

Kothari (2004) has emphasized that there are two basic types of research approaches that could be identified as *Quantitative* and Q*ualitative*.

Dawson (2002) has emphasized that Qualitative research could be utilized to explore attitudes, behaviours and experiences through such methods as interviews or focus groups, which attempts to get an in-depth opinion from participants.

Hancock and Algozzine (2006) have emphasized that qualitative approaches are more appropriate when, only a little is known of an issue, and the access to people who can participate in the research study is limited.

There is no evidence that a study has been undertaken to discover what causes constraining of the implementation of WDAT, and hence, a very little is known about this. At the same time, the number of competent persons that the necessary information could be collected from in this connection too is very rare.

Accordingly, the Qualitative research approach was selected for this research.

3.4 Research Techniques

An appropriate research technique should be identified to operate the research once after the selecting of research approach. Mostly, the techniques used for the research can be discussed under two broad types as data collection techniques and data analysis techniques (Yin, 2009). Semi-Structured interviews and Documentation Reviews were selected as the most suitable and reasonable data collection tools. Thematic and Comparative Analysis was used as the data analysis techniques.

3.4.1 Data Collection Method

Kothari (2004) has stated that there are two types of data collections that could be categorized as Primary Data Collection and Secondary Data Collection.

A researcher must judiciously select the method/methods for his own study, keeping in view the following factors such as 1) Nature, scope and object of enquiry, 2) Availability of funds, 3) Time factor, 4) Precision required in selection of an appropriate Data Collection Technique (Kothari, 2004).

Furthermore, Kothari (2004) has stated that there are several methods of collecting primary data, particularly in surveys and descriptive researches, the important ones being, (i) observation method, (ii) interview method, (iii) through questionnaires, (iv) through schedules, and (v) other methods.

3.4.1.1 Semi-Structured Interviews

In social research, there are many types of Interviews, namely, Unstructured, Semi-Structured and Structured interviews, being the most common ones.

Under the Semi-structured Interviews, the researcher wants to know specific information which can be compared and contrasted with information gained in other interviews, while maintaining the interview flexible so that other important information can still arise (Dawson, 2002).

Since the researcher was interested in extracting the common opinions of the interviewees by comparing and contrasting their opinions, by asking the same question from all interviewees, the Semi-Structured Interview technique was selected for this study.

Accordingly, the Semi-Structured Interviews method was selected for identifying "the benefits of implementing WDAT" and "what factors constrain the implementation of WDAT", in achievement of the Objective 2 and Objective 3 respectively.

3.4.1.2 Document Reviews

To study the quality of the contemporary practice and test the willingness of the industry practitioners to undertake WDAT was the other objective of this research, which could be assessed only by a careful scrutiny of the delay analysis documentation of such practitioners.

This was essentially required as this will reflect the real attempts and attitudes of the interviewees over this matter, irrespective of what they orally represented in the interviews.

Furthermore, documentary act as a method to cross validate information gathered from interviews since what people expresses sometimes are different from what people actually do (Bandula, 2012). Accordingly, documentation reviews could also be used to validate the data gathered from Semi-Structured Interviews.

Accordingly, the “Document Reviews” Technique was selected to gather the statistics about the interviewees’ “construction delay analysis documentation”, in achievement of the Objective 4.

Simple checklists were used to collect data from such documentation to capture the information such as “what was the primary DAT adopted by the analyst” and “what were the input data reasonably available to the analyst” etc.

3.4.1.3 Sampling

As per Kothari (2004), Sampling may be defined as the selection of some part of an aggregate or totality on the basis of which a judgment or inference about the aggregate or totality is made in general.

Since only a few professionals have been involved in resolving and managing construction delays (Institute of Dispute Management Professionals, 2013), the competent participants are to be carefully selected.

As the concerned WDAT is a novel and advanced technique to Sri Lanka, the competent professionals with both practical and theoretical knowledge have been identified to be limited, readily unknown and hidden.

The Snowball Sampling is a non-probabilistic sampling that could be used when the required sources of information is difficult to be accessed, may be due to their population is not readily identifiable and known. Under this method, after collecting information from one source, that source is requested to introduce other suitable sources building a sufficient sample base thereby (Fellows & Liu, 2015, p. 165).

Accordingly, Snowball sampling technique was used to gradually indentify suitable four (04) personal sources for gathering data.

Background of the Interviewees Participated

Three Experts (A, B and C) were successful owners of the well established Claims Consultancy Firms in the country, who were professionally qualified Quantity Surveyors.

The fourth Expert (D) was more a Construction Delay Analysis Expert running his own company, who was a professionally qualified Engineer.

All the interviewees were having sufficient foreign exposure as well in the business of Claims Management and Construction Delay Analysis.

They all were having over 15 years of post qualifying experience in construction claims consulting business, with specific skills on DATs.

This step helped thoroughly to identify and understand the current position and the barriers and challenges for performing WDATs in Sri Lanka.

As per Creswell (2003), the Intensity Sampling can be used to choose information-rich cases (but not extreme cases) that manifest the phenomenon intensely.

Owing to the nature of the study required under the Objective 4, a significant quantum of information was necessary in respect of a particular case of delay analysis. That is, in absence of a complete set of information, such a case could not be submitted for this analysis.

Furthermore, there are two major types of delay analyses approaches, namely, Prospective and Retrospective. The Prospective approach is applicable before the delaying effect has taken place, which attempts to predict the likely impact on the progress of the works. The Retrospective approach is applicable after the works have been completed, which seeks to demonstrate the actual impact on the works by a delaying event. Hence, the application of a particular DAT is dependent on the type of the delay analysis approach necessary (SCLP, 2017, p.34).

Accordingly, the primary DATs such as “Impacted As-Planned (IAP)” and “Time Impact Analysis (TIA)” are applicable prospectively, whereas, the “Collapsed As-Built (CAB)” and “As-Planned Vs As-Built (ASVAB)” are applicable retrospectively (SCLP, 2017).

Hence, any assessment on the quality of delay analysis shall be made addressing both above approaches.

Therefore, in the view of above, two sets of “delay analysis documentation” were sought from each participant for the evaluations.

Accordingly, Intensity Sampling technique was adopted to choose two "construction delay analysis" cases from each claims consultant, where one was for a Prospective DAT performed, whereas, the other was for a Retrospective DAT performed.

Furthermore, only the road construction projects having a contract sum of more than SL Rs. 500 million was considered to create comparability among the projects.

Accordingly, it was decided to study eight (08) cases of delay analysis, taking two (02) from each participant. The details of the road construction projects, pertaining to the examined delay analysis documentation, are summarized below in the Table 3.1 below.

Table 3.1: Details of the Road Construction Projects Analysed

Expert	Approach	Road Name	Stage of Analysis	Contract Sum/ Rs.	Case Ref. Number
A	Prospective	Madawachchiya - Kebithigollewa	Project ongoing	726 Mil	A1
	Retrospective	Madawachchiya - kebithigollewa	Project completed	726 Mil	A2
B	Prospective	Maditale-pathanawattha-tennapanguwa-kiriwehera	Project ongoing	714 Mill	B1
	Retrospective	Hulandawa Left - Kahambana	Project completed	771 Mill	B2
C	Prospective	Peradeniya - Badulla - Chenkalady	Project ongoing	843 Mill	C1
	Retrospective	Haputhale-Boralanda-Keppetipola	Project completed	2,445 Mill	C2
D	Prospective	Ratnapura - Ingiriya	Project ongoing	9 Bill	D1
	Retrospective	Ratnapura - Ingiriya	Project completed	9 Bill	D2

Authenticity of the documentation was assured before accepting them for the analysis.

This step was essential to ascertain the fact that the claims consultants were really willing to go for a reasonable standard of DAT when they are given the opportunity.

The guideline used by the researcher for Semi-Structured Interviews and Documentation Reviews are enclosed in the Appendix.

3.4.2 Data Analysis Techniques

There are three types of Qualitative Data Analysis Techniques as summarized in the Table 3.2 below.

Table 3.2: Qualitative Data Analysis Techniques

Technique	**When to Use**
Thematic Analysis	When the data is analysed by "theme". The themes emerge from the data, and the researcher doesn't impose.
Comparative Analysis	Data from different people is compared and contrasted, and the process continues until the researcher is satisfied that no new issues are arising. This is usually used in combination with Thematic Analysis.
Content Analysis	The process is much more mechanical with the analysis being left until the data has been collected, commonly by coding the content, and quantifying the data.

Source: (Dawson, 2002, pp.115-118)

The opinions of the participants expressed at the personal interviews were needed to be noted, compared and identified for similarities etc. in arriving at the conclusions.

Accordingly, the Thematic and Comparative Analysis technique was selected, that could be carried out manually as the number of interviewees was as small as four.

With regard to the document reviews undertaken in achievement of the Objective 4, the Table 2.7, which is reproduced below for convenience, indicates the required inputs for implementing each type of DAT.

Method of Analysis	Analysis Type	Critical Path Determined	Delay Impact Determined	Requires
Impacted As-Planned Analysis	Cause & Effect	Prospectively	Prospectively	• Logic linked baseline programme. • A selection of delay events to be modelled.
Time Impact Analysis	Cause & Effect	Contemporaneously	Prospectively	• Logic linked baseline programme. • Update programmes or progress information with which to update the baseline programme. • A selection of delay events to be modelled.
Time Slice Windows Analysis	Effect & Cause	Contemporaneously	Retrospectively	• Logic linked baseline programme. • Update programmes or progress information with which to update the baseline programme.
As-Planned versus As-Built Windows Analysis	Effect & Cause	Contemporaneously	Retrospectively	• Baseline programme. • As-built data.
Retrospective Longest Path Analysis	Effect & Cause	Retrospectively	Retrospectively	• Baseline Programme. • As-built programme.
Collapsed As-Built Analysis	Cause & Effect	Retrospectively	Retrospectively	• Logic linked as-built programme. • A selection of delay events to be modelled.

Source: (SCLP, 2017, p. 34)

Facts in the Table 2.7 above were used for ascertaining the best Primary Delay Analysis Technique (PDAT) that a particular Analyst could have gone for, with respect to the inputs that were reasonably available to him at the time of analysis, which will be then compared against the PDAT that the Analyst had actually chosen to implement.

The qualitative data obtained from the "delay analysis document review" were converted to quantitative data based on the suitability criteria of PDATs as assessed by Perera and Sudeha (2013).

Table 2.16, which is reproduced below for convenience, indicates the levels of the suitability of each type of PDATs.

Delay Analyzing Technique	Total Final Importance Score	Overall Ranking
Time Impact Technique	0.302	1
Collapsed As-built	0.249	2
As Planned vs As Built	0.215	3
Impact As-planned	0.123	4
Global Impact	0.111	5

Source: (Perera & Sudeha, 2013)

However, if an Analyst has incorrectly adopted a DAT (for example, the application of a DAT prescribed for Prospective approach has been incorrectly adopted for a Retrospective delay analysis), zero marks will be given, despite the marks available (Importance Scores) in the Table 2.16 above.

Such converted quantitative data, collected for both Prospective and Retrospective delay analysis approaches, were seperately analysed mathematically for central tendancy, in order to reflect the overall quality status of the delay analysis practice.

Mean, also known as arithmetic average, is the most common measure of central tendency and may be defined as the value obtained by dividing the total of the values of various given items in a series by the total number of items, which can be worked out as given below (Kothari, 2004, p.132).

$$\text{Mean (or } \bar{X}) = \frac{\sum X_i}{n} = \frac{X_1 + X_2 + \ldots + X_n}{n}$$

where $\bar{X}$ = Mean
$\sum$ = Symbol for summation
X_i = Value of the ith item X, $i = 1, 2, \ldots, n$
n = total number of items

3.5 Validation of Research findings by Experts

Once all information is gathered, synthesized, and reported, a researcher should confirm the findings of the study before disseminating a final report, and the most powerful strategy to confirm a report's findings is to share the results with those examined in the study (Hancock & Algozzine, 2006).

Accordingly, a draft of the research finding was distributed among the experts who participated in the interviews for their comments.

3.6 Research Process Flowchart

The process of this research "*Contemporary Practice of Construction Delay Analysis & Potential of Implementing "Window Delay Analysis" for Road Projects in Sri Lanka – Claims Consultants' Perspectives*" could be depicted as in Figure 3.1 below.

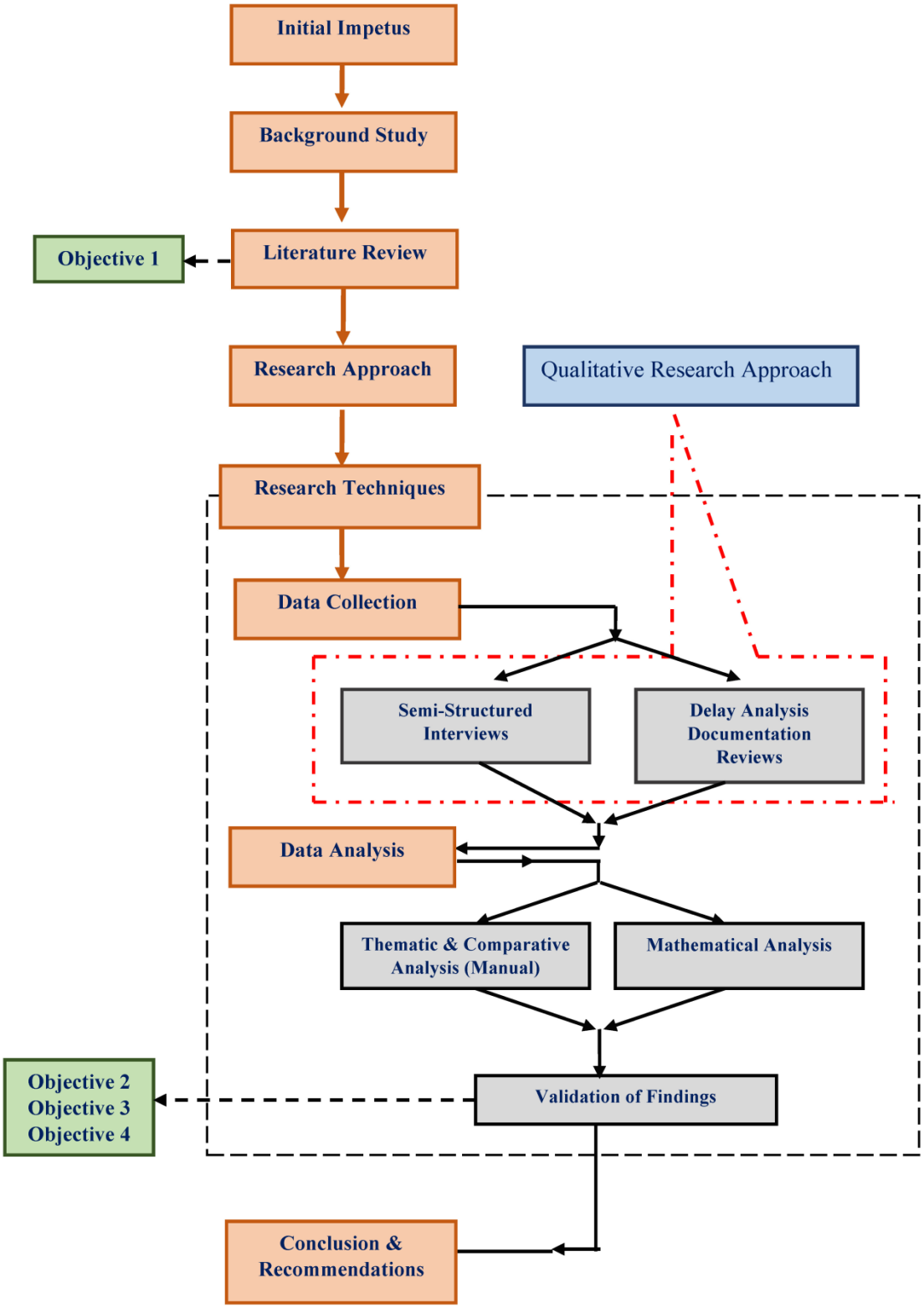

Figure 3.1: Research Process

3.7 Summary

This chapter basically elaborates the research problem solving mechanism that has been adopted under this research. The research process is discussed in here with the relevant research approach, techniques of data collection, analysis, validation and finally presenting the summary.

The brief of the important decisions made under this chapter in respect of the methodology of this research, are summarized in the Table 3.3 below.

Table 3.3: Brief of the Research Methodology

Objective	Research Approach	Sampling Technique	Data Collection Method	Data Analysis Technique
2 & 3	Qualitative	Snowball	Personal Interviews	Thematic & Comparative Analysis (Manual)
4	Qualitative	Intensity	Document Reviews	Mathematical Analysis

With the progression of this chapter, it was apparent that the objectives from 2 to 4 would be achieved at the last step of the research process, which is the data analysis, whereas, the Objectives 1 was already achieved through the literature review.

CHAPTER 04

RESEARCH FINDINGS AND DATA ANALYSIS

4.1 Introduction

The research methodology was described in the previous chapter, and this chapter presents the analysis of the data collected from this research.

The data collection was carried out in two stages in terms of “personal interviews” and “delay analysis documentation reviews”.

Four (04) numbers of participants (Claims Consultants) were interviewed, whereas eight (08) sets of delay analysis documentations, taking two (02) from each participant, were analysed.

The “thematic and comparative analysis (manual)” was used to draw the findings from data collected through the Personal Interviews.

A “mathematical analysis” was used to assess the central tendency of the data collected from the document reviews.

The expected final outcome of this chapter is to identify the benefits of the WDAT and the factors constraining the implementation of WDAT for the road construction projects in Sri Lanka, while studying the contemporary practice of construction delay analysing in the country and the willingness of the industry practitioners.

4.2 Responses and Analysis of the Interviews

4.2.1 Responses for Question – 1 and Analysis

In the view of achieving the Research Objective – 2, the following question was formulated and the interviewees were prompted to respond to.

Question – 1

In your opinion, what are the benefits in the implementation of WDAT?

Table 4.1: Responses and Analysis of Question – 1

Ref.	Expert -A	Expert -B	Expert -C	Expert -D
1	A method, the results of which could not be easily challenged. Level of accuracy is relatively high. In line with the common sense.	If implemented correctly, I agree that this is a very accurate method of delay analysis in principle under ideal conditions.	It is the general belief of the construction community that this is a relatively accurate method of deciding on time entitlements.	A method that identifies the most accurate time entitlements of parties as it considers the actual facts, rather than a mere modelling of the delay.
2	This reflects a good management Approach. That is, addressing small portions to analyse the overall picture thereby. Technically speaking, It also enables different DATs to be used in each window so that the analysis could be made more appropriate to the type of delay within such period (window), offering a flexible approach.	As its results are readily supported by the contemporary records, it is convenient to convince a party.	In fact, WDAT has nothing unique in it, but a procedure only. It is the DAT that we apply to solve a certain window, which decides the quality of the WDAT's outcome. Ex: TIA, As-Planned Vs. As-Built, As-Planned but for etc.	Consideration of Actual Critical Paths, Resource Considerations, Acceleration, Concurrency, Disruptions, Changes to the Baseline Programme, daily Basis Analysis, Prolongation could be easily related managed and captured.
3	When used retrospectively, this is an "As-Is" type analysis and the Court Decisions are more likely to accept this approach in principle when prompted to.	This DAT can be adopted for any type of a construction project.	Hence, in my opinion, the real meaning of so-called WDAT shall be demystified by the professionals first.	Once, completed accurately, the result of this analysis cannot be challenged as it has a strong basis.
4	For complicated delay situations, this method can be used to analyze only the selected areas of the schedule, hence simplifying the delay analysis process.		In fact, this is the typical practical approach to handle multiple number of delay events of any type.	The approach of Windows simplifies the complications, open to further developments, and supports the involvement of computers in to the scene. Hence, a versatile approach.

Ref.	Expert -A	Expert -B	Expert -C	Expert -D
5				There is high probability for the Claims to be success with WDAT, so that return to the Claimant as well as the Analyst is very high.

In the context of the Question 1, highly deviated and/or contradictory opinions were not observed.

Accordingly, considering the responses over the Question – 1, the following were concluded to be the advantages over the other DATs.

1. Having a relatively high degree of accuracy in respect of the time entitlement of the parties, if implemented correctly [*considering the thematic meaning of the responses, 1 of Expert - A, 1 of Expert - B, 1 of Expert - C, 1 of Expert - D*].

2. The simple step-by-step approach inspired by common sense [*considering the thematic meaning of the responses,* 1 and 2 of Expert - A]

3. Provide flexibility in choosing an appropriate DAT for separate windows, and number of windows [c*onsidering the thematic meaning of the responses,* 2 and 4 of Expert - A].

4. Capacity of handling of any number of delay events of any type in the same analysis. [Considering *the responses* 4 of Expert - C].

5. "As-Is" type of delay analysis, whose results are readily supported by the contemporary records, hence the ability to convince a party is very high [*considering the thematic meaning of the responses,* 3 of Expert - A, 2 of Expert - B, 3 of Expert - D]

6. Capacity to relate to and to capture Resource Considerations, Accelerations, Concurrency, Disruptions, Changes to the Baseline Programme and Prolongation etc., which are very important parameters of contractual importance in respect of a delay claim [*considering the thematic meaning of the response 3* of Expert - D].

7. The versatile approach by having “Windows”, which simplifies the complications, open to further developments, and supports the involvement of computers in the delay analysis [*considering the thematic meaning of the response* 4 of Expert - D].

8. Results in a very high probability of return to the Claimant as well as to the Analyst consequently [*considering the thematic meaning of the responses,* 5 of Expert - D].

4.2.2 Responses for Questions – 2 & 3 and Analysis

In the view of achieving the Research Objective – 3, the following two questions were formulated and the interviewees were prompted to respond to.

Question – 2

In your opinion, is there a “contractual obligation on the part of parties” and/or “a trend” requiring WDAT to be performed in Sri Lanka?

Table 4.2: Responses and Analysis of Question – 2

Ref.	Expert -A	Expert –B	Expert -C	Expert -D
	Straightforward Answer			
1	No	No	No	Not really
	For the Reasons			
2	Not stipulated in almost all the Contracts	Not a must under the general contracts	Contracts are silent on the DAT to be utilized	Contracts do not explicitly specify generally.
3	Not a requirement of the Parties	Clients never wanted us to do	It is an option out of several ways only	However, if we have done a real analysis, whatever the opposing party’s analysis could be challenged, and the Tribunals could be convinced for a better Analysis (like WDAT)

Ref.	Expert -A	Expert –B	Expert -C	Expert -D
4	Not a requirement of the Tribunals	Most of the Claimants do not want to do this as it identifies Concurrent Delays, during which the entitlement to cost becomes questionable.	If the Parties required, we can do it.	At a higher forum of dispute resolution, any Analysis shall provide a sustainable solution acceptable to common sense.
5	Not a requirement of Courts	Hence, there is no trend or requirement to carry out a WDAT.	Anyway, I have not seen a WDAT taken for a Road Project recently.	Whenever the suffering claimed by a Delay Analysis is very remote to what has actually happened, there is a possibility for challenging
6	Therefore, we hardly see such an analysis is done.			There is more priority for common law principles in an Arbitral or Litigating environment, rather than limiting to the provisions in the Contract itself.

Highly deviated and/or contradictory opinions were not found.

Accordingly, the following are concluded, considering the responses over the Question – 2.

1. There is no direct contractual obligation, or subsequent requirement of the parties to a contract, or a trend in the country, requiring a WDAT to be performed [considering the thematic meaning of the all responses of Experts A, B and C, and Response 1&2 of Expert – D]

1. However, the chances are not prevented for the WDAT to have its place amongst the other methods [*considering the thematic meaning of the responses, 3 to 6 of Expert - D*].

Question – 3

In your opinion, what factors (other than the contractual requirement) are constraining the implementation of WDAT for the Road Construction Projects in Sri Lanka?

Table 4.3: Responses and Analysis of Question – 3

Ref	Expert -A	Expert -B	Expert -C	Expert -D
1	This WDAT is generally applied for the delay events that are already occurred only (retrospectively). There is no particular application of WDAT in prediction of the future impacts (prospectively). This may prevent WDAT being used everywhere.	WDAT is a method, with an unnecessary level of accuracy considering the inputs required for the same.	In fact, WDAT has no unique analysis process built in to it, but a systematic approach only. That is, what we use inside a window even is essentially one of the following primary techniques. *Ex: TIA, As-Planned Vs. As-Built, As-Planned but for, As-Built-But for etc.*	In fact, this is a highly time and cost consuming exercise. This analysis is adopted only when there is a feasibility. That is, there should be a decent return against the high expenditure. There shall be sufficient time available for the analysis.
2	I however use DATs in a mix to suit the scenario considering their ability to convince the case. So, I am unable to accept we shall always go by a single DAT (Ex: WDAT) all the time.	A significant quantum of as-built data is required	A method that cannot be easily performed and the most rarely used method globally as well, in my opinion, due to inherent practical issues such as lack of needed inputs.	When there is **no** requirement for proving special scenarios such as, Entitlement for cost, acceleration, concurrency, change in Baseline Schedules, loss of productivity, pacing, disruption, etc. the method of DA could be compromised.

Ref	Expert -A	Expert -B	Expert -C	Expert -D
3	Need extra effort and prior preparedness to have the required inputs in place at the time of the analysis.	I mostly used the simplest "Impacted As-Planned" technique instead, and let the rivals to challenge if they require. So, I, as a practice, never use a Window Analysis in my submissions.	A method not viable if the needed inputs are not available. And, shall not be undertaken for the sake of doing it.	Most of the Sri Lankan Analysts have no expertise on this method. They equally do not know of its values and benefits.
4	Our extra effort is not rewarded or appreciated by the Clients. Hence, going this extra mile on our own need thinking twice.	I agree that this is a very accurate method of delay analysis in principle, but, the practicalities are more important to us as practitioners.	A method having a debatable procedures in performing	This could be tedious and laborious when the required data are not readily available and have to be ascertained using indirect information by the Analyst.
5	Parties want to conceal their faults and do not want to be very descriptive in any type of analysis. Accordingly, WDAT being more analytic may not be preferred by some parties.	Most of the cases come to us are after the completion of the Projects, and digging for details are very difficult by that.	There is no report of Courts insisting doing a WDAT, neither by any Tribunals.	Additional effort to implement as well as to convince the Parties is required. Additional graphical demonstrations are also needed
6	A method that shall be adopted when all inputs/resources are available only. So, the application could be limited.	Most of the Clients do not like this as the concurrent delay are highlighted in the process, during which the entitlements for cost is lost.	I have never done a Window Analysis in my life	The more the analysis is descriptive, more the stages to be agreed with the other party making this a difficult approach as a whole.

Ref	Expert -A	Expert -B	Expert -C	Expert -D
7	Generally, as a best practice, prior agreement of the Parties over the DAT to be used is required before its implementation. Accordingly, if the parties fail to agree upon WDAT, its implementation would not be materialized.	WDAT is a method, with an unnecessary level of accuracy exceeding the expectations of the Parties to the Contract.		
8	Unfortunately, there is an emerging trend that the final award to a claimant is concluded mostly in a very informal manner having direct negotiations between the parties, which would be a business decision, in which case our analysis will only be limited to a mere paperwork, which discourages us to deliver a quality product while taking much effort. Most of the Tribunal Members too are in support of this system.	Only the academic professionals would urge implementing a WDAT, being unnecessarily debatable over the selection of other DATs, whereas many others would not so.		
9	We have done few Window Analyses in Sri Lanka, and those also were for one or few Windows of the full Programme only, but not in a successive-windows manner, covering the entire project.	Anyway, we are used to take an approach, where we select the impacted portion of the Time Programme (a window) only for the convenience of analysing, and apply a DAT, which cannot be considered as a perfect WDA in our opinion.		
10	We have done few WDAs when we were working in Dubai. I personally do not like to take part in the Road Construction Project as this sector is presently highly corrupted, and has no place for quality and genuine works.	WDAT, if implemented for few windows only, may indicate critical delays along the free floats as well, whereas, they are actually not so.		

In the context of the Question 3, highly deviated and/or contradictory opinions were not observed.

Accordingly, the followings were concluded as the factors constraining the implementation of WDAT in Sri Lanka (in addition to the two major reasons identified under the Research Question – 2), considering the responses over the Question – 3.

1. Inherent limitations of applicability of the method [c*onsidering the thematic meaning of the responses*, 1 of Expert - A, 2 of Expert - D, 4 of Expert – D, 10 of Expert - B].

2. Due to the specific and compromised requirements of the Claimant [c*onsidering the thematic meaning of the response* 2 of Expert - D].

3. Due to the limited resources (budgets) of the Claimant [considering the thematic meaning of the response 1 of Expert - D].

4. Due to the unawareness and the inexperience of the Analysts [considering the thematic meaning of the response 3 of Expert - D].

5. Additional effort required on the part of the Analyst in terms of analysing and convincing [considering the thematic meaning of the responses, 3 & 6 & 7 of Expert - A, 1 & 4 &5 & 9 of Expert - B, 2 & 4 & 6 of Expert - C, 1 & 3 & 4 & 5 & 6, 4 & 5 & 6 of Expert – D].

6. Absence of prior preparedness and awareness required for gathering the required inputs then and there [considering the thematic meaning of the responses, 2 of Expert - B, 3 of Expert - C, 6 of Expert – A, 4 of Expert – D].

7. Indirect discouragement of the analyst, by emerging trend of informal settlement of the disputes and corruption, which lead to leave the hardly earned analysis-results to be mere paperwork only [considering the thematic meaning of the responses, 8 & 10 of Expert - A].

4.3 Delay Analysis Documentation Reviews and the Findings

In order to achieve the Research Objective 4, reviews of the road construction project delay analysis documentations of the Interviewees were required to ascertain whether the claims consultants are in an attempt of producing a quality delay analysis to their clients.

Accordingly, these document reviews were undertaken, taking two cases from each Expert, one with a prospective DAT, and the other one with a retrospective DAT.

4.3.1 Analysis of the Data from the Delay Analysis Documents of Expert – A

Two delay analysis cases from Expert - A were sought and studied, and the summary of the findings are tabulated below.

Table 4.4: Results of the Document Review of Expert - A

Case Ref. Num.	Type of Analysis	Inputs that were reasonably available to the Expert	The ideal PDAT that could have been performed	The PDAT that was actually perform ed	Observati ons on the quality of attempt to analyse.
A1	Prospective	•Logic linked baseline programme. •Update programmes or progress information with which to update the baseline programme. •A selection of delay events to be modelled.	TIA	IAP	Below the expected
A2	Retrospective	•Logic linked as-built programme. •A selection of delay events to be modelled.	CAB	IAP	Below the expected

Note: No WDAT has been utilized by the Analyst

4.3.2 Analysis of the Data from the Delay Analysis Documents of Expert – B

Two delay analysis cases from Expert - B were sought and studied and the summary of the findings are tabulated below.

Table 4.5: Results of the Document Review of Expert - B

Case Ref. Num.	Type of Analysis	Inputs that were reasonably available to the Expert	The ideal PDAT that could have been performed	The PDAT that was actually performed	Observations on the quality of attempt to analyse.
B1	Prospective	•Logic linked baseline programme. •A selection of delay events to be modelled.	IAP	IAP	Up to the expected
B2	Retrospective	•Logic linked as-built programme. •A selection of delay events to be modelled.	CAB	APVAB	Below the expected

Note: No WDAT has been utilized by the Analyst

4.3.3 Analysis of the Data from the Delay Analysis Documents of Expert – C

Two delay analysis cases from Expert - C were sought and studied and the summary of the findings are tabulated below.

Table 4.6: Results of the Document Review of Expert - C

Case Ref. Num.	Type of Analysis	Inputs that were reasonably available to the Expert	The ideal PDAT that could have been performed	The PDAT that was actually performed	Observations on the quality of attempt to analyse.
C1	Prospective	•Logic linked baseline programme. •Update programmes or progress information with which to update the baseline programme. •A selection of delay events to be modelled.	TIA	IAP	Below the expected
C2	Retrospective	•Logic linked as-built programme. •A selection of delay events to be modelled.	CAB	IAP	Below the expected

Note: No WDAT has been utilized by the Analyst

4.3.4 Analysis of the Data from the Delay Analysis Documents of Expert – D

Two delay analysis cases from Expert - D were sought, studied, and the summary of the findings are tabulated below.

Table 4.7: Results of the Document Review of Expert - D

Case Ref. Num.	Type of Analysis	Inputs that were reasonably available to the Expert	The ideal PDAT that could have been performed	The PDAT that was actually performed	Observations on the quality of attempt to analyse.
D1	Prospective	•Logic linked baseline programme. •Update programmes or progress information with which to update the baseline programme. •A selection of delay events to be modelled.	TIA	TIA	Up to the expected
D2	Retrospective	•Logic linked as-built programme. •A selection of delay events to be modelled.	CAB	CAB**	Up to the expected

*Note: ** WDAT has been utilized*

4.3.5 Summary of the Delay Analysis Documentation Review and Conclusion

A total of 8 numbers of "road construction delay analysis" cases were studied thoroughly, inquiring the Analysts for further clarifications when necessary.

The efforts of the Analysts were evaluated as per the levels of the suitability of each type of primary DAT, as identified by Perera and Sudeha (2013), based on an assessment of the Total Final Importance Score, which was already explained and indicated under the section "3.4.2 – Data Analysis Technique".

An assumption is made hereby that the above identified ranking of PDATs, which, in fact, was for the Building Construction Industry, will be equally applicable to the Road Construction Projects as well.

Only the Expert – D has carried out a comprehensive WDAT, whereas all other Experts have not completed any WDAT.

The Expert – D had been able to secure SL Rs. 1.8 Billion monetary award for project prolongation by Arbitration to his client having utilized this WDAT for the evaluation of extension of time (EoT), which had been not defendable by the Respondent.

The analyst has successfully based his analysis on the daily contemporary records such as daily progress sheets, site instructions, testing records, meeting minutes, correspondence, logs etc. in establishing the claimant's entitlement for EoT for completion.

The Expert – D further added that they could recover the cost of Arbitration as well as the cost of Analyst.

The researcher well realized the degree of concentration and dedication that a comprehensive WDAT would require by inspecting the overall documentation of Expert – D, who has been specifically serving as a Delay Analysis Expert rather than a Claims Consultant.

The evaluation on the usage of DATs for Prospective delay analysis has been summarized in the Table 4.8 below.

Table 4.8: Summary - The Case of Prospective Analysis of Delays

Expert	Case No	PDAT that could have been performed		PDAT that has been actually performed	
		DAT	Score	DAT	Score
A	A.1	TIA	0.302	IAP	0.123
B	B.1	IAP	0.123	IAP	0.123
C	C.1	TIA	0.302	IAP	0.123
D	D.1	TIA	0.302	TIA	0.302
Total Socre		(A)	1.029	(B)	0.671
Overall % Drop in the Expected Standard of Delay Analysis (Central Tendancy)		(A-B) / A x 100		**35**	

Accordingly, it was observed that there has been an average drop of **35%** in the expected level of standard/quality in respect of the prospective analysis of delays by the practicing claims consulting community in Sri Lanka.

The obvious and common deficiency in above prospective analyses has been identified as the practice of mere impacting of the Original Baseline Schedules without any consideration of the actual status of the progress immediately before the event of delay.

The evaluation on the usage of DATs for Retrospective delay analysis has been summarized in the Table 4.9 below.

Table 4.9: Summary - The case of Retrospective Analysis of Delays

Expert	Case No	PDAT that could have been performed		PDAT that has been actually performed	
		PDAT	Score	PDAT	Score
A	A.2	CAB	0.249	IAP	0
B	B.2	CAB	0.249	APVAB	0.215
C	C.2	CAB	0.249	IAP	0
D	D.2	CAB	0.249	CAB**	0.249
Total Socre		(A)	0.996	(B)	0.464
Overall % Drop in the Expected Standard of Delay Analysis (Cental Tendancy)		(A-B) / A x 100		**53**	

** *WDAT has been utilized*

Accordingly, it was observed that there has been an average drop of **53%** in the expected level of standard/quality in respect of the retrospective analysis of delays by the practicing claims consulting community in Sri Lanka.

The obvious and common deficiency in above Retrospective analyses has been again identified as the practice of mere impacting of the original baseline schedules without any consideration of the actual as-built progress status by the time of the project completion.

It was also inappropriate to apply the DAT of "Impacted As-Planned" for Retrospective delay analyses, which is prescribed for Prospective type of delay analysis by SCLP (2017).

4.4 Validation of the Outcomes of the Research by the Experts

The author received no adverse comments in respect of any content of the draft of the research findings, which was previously distributed among the experts who participated in the interviews for their comments.

4.5 Summary

This chapter explains what the data were collected and how such data were analysed in the view of accomplishing the objectives of this research.

Author could successfully identify and interview four (04) suitable claims consultants.

The interviewing was commenced by inquiring the benefits of implementing WDAT from the Interviewees. Thereafter, the constraints to the implementation of WDAT were also explored.

The comparative and thematic analysis was carried out manually to arrive at the common opinions of the participants.

The analysis of the eight (08) sets of "delay analysis documentation" prepared by the Interviewees was finally carried out, which were mathematically analysed for central tendency.

A comprehensive WDAT has been carried out by one participant only, who has been specifically serving as a Delay Analysis Expert rather than a Claims Consultant.

Findings of this research were validated with the participants themselves, which are summarized in the next chapter.

The accomplishment of the research objectives was satisfactory to the author.

CHAPTER 05

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter is compiled to provide a summary of the way how this research was carried out and to highlight on its outcomes. Accordingly, this chapter summarizes the overview of each chapter and the success of the researcher's attempt to achieve the objectives of this research in particular. The general recommendations and the directions for further research evolved out from the findings of this research are suggested at the end of this Chapter.

5.2 Summary of the Research Study

This research was undertaken as there was a research requirement to find out what factors contribute to significantly constraint the implementation of the mostly recommended Windows Delay Analysis Technique (WDAT) for the road construction projects in Sri Lanka.

Identification of the quality of the contemporary practice of construction delay analysis in Sri Lanka, and the willingness of the practitioners to carry out a quality delay analysis was another objective of this research.

A comprehensive literature review was conducted to gather the existing knowledge on the WDAT, including the identification of what this WDAT really is, and the advantages of same over the other DATs.

Having set the aim and objectives, the requirement for in depth information was realized, and the qualitative research approach was appropriately selected.

Due to the scarcity of capable professionals in the industry and the time constrains prevailed, the numbers of Interviewees were limited to only four (04), who were gradually identified following a snowball sampling.

Semi-Structured Interviews were conducted, and the analysis of the data collected was done using thematic and comparative analysis, which was conveniently carried out manually.

A total of eight (08) cases of "construction delay analyses", taking two (02) cases from each expert, were reviewed and the results were mathematically analysed for central tendency.

Finally, this study arrived at its conclusions and recommendations successfully.

5.3 Conclusions

Out of four Experts interviewed, the researcher was able to identify only one Expert, who has carried out a comprehensive WDAT, whereas, the main focus under this research was on the WDAT and related matters. This was in line with the finding of the previous researchers Ekanayake and Perera (2016) that the concerned WDAT was having the minimum frequency of implementation.

WDAT was identified to be a versatile and practical approach of applying the delay analysis, rather than a primary method of delay analysis that can be effectively applied in cases of complicated delay situations to resolve them successfully.

For the features such as, *high degree of accuracy, simple step-by-step approach inspired by common sense, flexibility in choosing an appropriate primary DAT for separate windows, capacity of handling any number of delay events, the results being readily supported by the contemporary records, "capacity to relate to and to capture Resource Considerations, Accelerations, Concurrency, Disruptions, and Changes to the Baseline Programme and Prolongation etc.", the versatile approach by having "Windows" and very high probability of return to the Claimants as well as to the Analysts*, the WDAT have been attractive to the practitioners.

However, it was discovered that there exist no direct contractual requirement for the WDAT to be implemented for typical Sri Lankan Road Construction Contracts, which was identified as one of the main factors constraining the implementation of WDAT.

In addition, the other reasons such as, i*nherent limitations of applicability of the method, specific and compromised requirements of the Claimants, the limited resources (budgets) of the Claimants, the unawareness and the inexperience of the Analysts, additional effort required on the part of the Analyst, absence of prior preparedness and awareness required for gathering the required inputs then and there* and *indirect discouragement of the Analysts* have contributed to further constrain the implementation of WDAT in the Sri Lankan road projects.

However, it was well realized that the strong position that a properly carried out WDAT could take among the other methods of delay analysis. That is, especially at higher forums of justice, the opportunity for implementation of WDAT to establish a case is not really negated by the typically available contractual provisions.

As identified through the delay analysis document reviews, the quality of the attempts of the Experts on the "Prospective Delay Analysis" and "Retrospective Delay Analysis" were respectively 35% and 53% below the best practice standards. This evaluation was based on the suitability criteria of DATs identified by the previous Researchers (Perera & Sudeha, 2013), and Delay & Disruption Protocol by Society of Construction Law (SCLP, 2017).

Hence, it was ascertained that the reluctance in the analysts to do their best at a delay analysis, and the tendency to go for convenience, could be another untold reason for the drop in the implementation of WDAT among the other told reasons.

The researcher also noticed the seriousness of the dedication and preparedness required for implementing a comprehensive WDAT, for which the industry could not rely upon the ordinary claims consultants to fulfil along with their many other commitments.

Hence, the researcher ultimately realized that there is a potential for WDAT to be developed more as a separate area of expertise, which could co-exist as a support service to the general "construction claims consultancy services".

5.4 Recommendations

The Contract Drafters are recommended to have the “provision for extension of time in the contacts” drafted in a more descriptive manner, in order to compel the analysts to perform the kind of the DAT required, as appropriate, without being vague on the analysis requirement.

The Contractors are advised to be claims-conscious, maintaining good contemporary records on a daily and activity basis from the very first day in this complicated construction environment, which will enable a conducive background for the implementation of any DAT when the requirement arise. Contractors should also be prepared to provide sufficient resources for above purpose and deploy the right Experts when required in order to secure their entitlements.

The Delay Analysts are recommended to be adequately educated and be updated about WDAT and to adopt the same wherever possible as the results of such analysis are always having a very strong basis and hence could not be easily challenged by the opposing parties, leading to a very high possibility for such Claims to be success.

It is worthwhile to note that the claimants could usually recover the cost of delay analysis too through Arbitral Awards, which suggests the analysts as well as the claimants that their hard effort towards WDAT is having its rewords.

The construction community is recommended to be adequately aware about the consequences of the application of various DATs, and to go for the highly accepted WDAT whenever possible considering the success stories of those who have practiced the WDAT.

The construction regulatory bodies are also suggested to set at least minimum standards for construction delay analyses, as appropriate, in their levels of involvement.

The author expects all above recommendations to be towards the improvement of the practice of construction delay analysis in the road construction projects of Sri Lanka.

5.5 Limitation of the Study

Certain limitations were encountered during the research process which is discussed below in order to facilitate the reader to understand the context of the research.

This research study was limited to the experiences on the road construction projects in Sri Lanka. Only four competent interviewees could be identified, out of which only one has done a meaningful Window Delay Analysis.

Moreover, the document reviews were limited to only eight considering the scarcity of the relevant cases and complete documentations.

Since most of the Srilankan road construction delay analysis cases are handled by one of the above selected experts, the conclusions of this study could be generalized to the Sri Lankan context.

5.6 Directions for Further Research

Further researches are encouraged on the following areas, which will be towards the continual improvement of the practice of construction delay analysis in Sri Lanka.

- Maintenance of Contemporary Records for the future implementation of WDAT.
- The concept of Daily Windows Analysis in place of the Traditional Windows Analysis.

REFERENCE LIST

Analytic Hierarchy Process. (2018). Retrieved January 15, 2018, from Wikipedia: http//en.wikipedia.org/wiki/Analytic_Hierarchy_Process.

Bandula, K. A. (2012). *Analysing costs and beneftis of transport infrastructure project: A case study on Hambantota international airport*. (Unpublished undergraduate disseratation). Sri Lanka, University of Moratuwa.

Barry, D. (2009). *Beware the dark arts! delay analysis and the problems with reliance on technology.* Society of Construction Law. Retrieved from https://pdfs.semanticscholar.org/99ca/7115f76723ab467c01097f5e22b083f14f07.pdf

Braimah, N. (2008, August). *Disruption analysis methodologies (Unpublished Doctoral Dissertation).* Retrieved from https://core.ac.uk/download/pdf/1932701.pdf

Braimah, N. (2008). *The improvement of delay analysis in the UK construction (Doctoral thesis, Wolverhampton University).* Retrived from https://wlv.openrepository.com/wlv/bitstream/2436/38824/3/Braimah_PhD%20thesis.pdf.

Braimah, N. (2013a). Approaches to delay claims assessment employed in the UK construction industry. *Buildings*(3), 598-620. doi:10.3390/buildings3030598

Braimah, N. (2013b). Construction delay analysis techniques—a review of application issues and improvement needs. *Buildings*. doi:10.3390/buildings3030506

Creswell, J. W. (2003). *Research design - qualitative, quantitative and mixed methods approaches.* California: Sage Publications, Inc.

Dale, W. S., Deluca, R. L., & D'Onofrio, R. M. (2015). *Navigating the maze of schedule delay analysis methods*. Thomson Reuters. Retrieved from https://www.constructionsuperconference.com/wp-content/uploads/2016/12/E26_Navigating-the-Maze-of-Schedule-Delay-Analysis-Methods.pdf

Dawson, C. (2002). *Practical research methods - a user friendly guide to mastering research techniques & projects.* United Kingdom: How To Books Ltd.

Department of Census and Statistics, Sri Lanka. (2016). *Survey of Construction Industries - 2016*. Retrieved from http://www.statistics.gov.lk/industry/SCI_Final_Report_2016.pdf

Dolage, D. A., & Pathmarajah, T. (2015). Mitigation of delays attributable to the contractors in the construction industry of Sri Lanka - consultants' perspective. *Engineer, XLVIII*(01), 21-30. Retrieved from https://engineer.sljol.info/articles/abstract/10.4038/engineer.v48i1.6845/

Dolage, D. A., & Rathnamali, D. L. (2013). Causes of time overrun in construction phase of building projects. *Engineer, XXXXVI*(03), 09-18. Retrieved from https://engineer.sljol.info/article/10.4038/engineer.v46i3.6780/galley/5279/download/

Downing, R. E. (2017). *The Impact of poor contemporaneous project records on claims preparation and expert analyses.* Retrieved from Long International, Inc.: http://long.intl.com

Ekanayake, E. M., & Perera, B. A. (2016). Appropriate delay analysis techniques to analyse delays in road construction projects in Sri Lanka. *Built Environment Project and Asset Management, November 2016, Vol. 6, Iss 5*, 521 - 534.

Fellows, R., & Liu, A. (2015). *Research methods for construction* (4th ed.). United Kingdom: John Wiley & Sons, Ltd.

Gibson Consulting Limitted. (n.d.). *Guidance from the court on delay analysis.* Retrieved from http://gibsonconsulting.co.uk/wp-content/uploads/DR-05-Guidance-from-the-Court-on-Delay-Analysis.pdf

Hancock, D. R., & Algozzine, B. (2006). *Doing case study research - a practical guide for begining researchers.* New York: Teachers College Press.

Jayawardane, A. K., & Jeyakanthan, J. (2010). *Mitigating delays in donor funded road projects in Sri Lanka.* Retrieved from https://engineer.sljol.info/articles/10.4038/engineer.v45i1.6950/galley/5438/download/

Kagioglou, M., Cooper, R., Aouad, G., & Sexton, M. (2008). Rethinking construction: The generic design and construction process protocol. Engineering, Construction and Architectural Management, 7(2), 141-153. doi:10.1046/j.1365-232x.2000.00148.x

Kao, C. K., & Yang, J. B. (2009). *Comparison of windows-based delay analysis methods*. *International Journal of Project Management, 27*(4), 408-418. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0263786308000781

Keane, P. J., & Caletka, A. F. (2015). In *Delay analysis in construction contracts* (2nd ed., pp. 7,135). United Kingdom: Blackwell Publishing Ltd.

Keane, P. J., & Caletka, A. F. (2015). *Delay analysis in construction contracts, 2nd Edition.* United Kingdom: Blackwell Publishing Ltd.

Kothari, C. R. (2004). *Research methodology - methods & techniques* (Second Revised Edition ed.). New Delhi: New Age International (P) Ltd. Publishers.

Law, S. o. (2017). *Delay and Disruption Protocol.* Leicestershire. Retrieved from https://www.scl.org.uk/sites/default/files/SCL_Delay_Protocol_2nd_Edition.pdf

Livengood, J. (2016). Retrieved from https://www.navigant.com/-/media/www/site/insights/construction/2016/3peerreviewedguidesforensicscheduledelayanalysisif.pdf

Maduranga, J. A., Palamakumbura, A. P., & Dissanayake, P. B. (2016). Preparation of extension of time (eot) claims and delay analysis techniques used in the construction industry. In *Proceedings of the 7th International Conference on Sustainable Built Environment.* Retrieved from http://www.civil.mrt.ac.lk/conference/ICSBE_2016/ICSBE2016-94.pdf

Menesi, W. (2007). *Construction delay analysis under multiple baseline updates.* Retrieved from https://www.researchgate.net: https://www.researchgate.net/publication/245283509_Delay_Analysis_under_Multiple_Baseline_Updates

Mubarak, S. (2005). *Construction project scheduling and control.* Pearson Prentice Hall, USA.

Muhamad, N. H., Mohammad, F., Ahmad, A. C., & Ibrahim, I. H. (2016). Delay analysis methodologies (dams) in delivering quality projects: contractors and consultants' perceptions. *ELSAVIER, 222*, 121-131. Retrieved from https://www.sciencedirect.com/science/article/pii/S1877042816302750#!

Parry, A. (2015). *The improvement of delay analysis in the UK construction (Doctoral thesis). Northumbria University. Retrived from http://nrl.northumbria.ac.uk/27294/.*

Pathiranage, Y. L., & Halwatura, R. U. (2010). Factors influencing the duration of road construction projects in Sri Lanka. *Engineer - Journal of the Institution of Engineers, Sri Lanka, October 2010. 17-30.* doi: 10.4038/engineer.v43i4.6997. Retrieved from

https://www.researchgate.net/publication/278032614_Factors_Influencing_the_Duration_of_Road_Construction_Projects_in_Sri_Lanka

Perera, B. A., & Sudeha, H. M. (2013, December). A framework to select the most suitable delay analysis technique for building construction through a consideration of utility factors. *Built Environment Project and Asset Management, 3*(2), 521-534, doi: 10.1108/BEPAM-08-2015-0039. Retrieved from https://www.researchgate.net/publication/309728505_Appropriate_delay_analysis_techniques_to_analyse_delays_in_road_construction_projects_in_Sri_Lanka

Pickavance, K. (2005). *Delay and disruption in construction contracts, third edition.* London: LLP.

Quackenbush, D., & Dillon, S. M. (n.d.). *Shattering the windows schedule analysis method.* Retrieved from www.quackan.com/images/shattering.docx

Punch, K.F. (2005). *Introduction to social research: Quantitative and qualitative approaches* (2nd ed.). London: Sage publications Ltd.

Ramachandra, T., Rotimi, J. O., & Gunaratne, S. (2014). Reasons for contractors' delay claims failures in Sri Lanka. *Association of Researchers in Construction Management*, 475-484. Retrieved from https://www.researchgate.net/publication/286060192_Reasons_for_contractors'_delay_claims_failures_in_Sri_Lanka

Risath, A. L., Rifas, K. M., & Thamboo, A. J. (2011). *Construction project delays in Eastern Province of Sri Lanka: perspectives of contractors and consultants.* Retrieved from http://www.seu.ac.lk/researchandpublications/symposium/6th/IntSym%202016%20proceeding%20final%202%20(1)%20-%20Page%20252-261.pdf

Roger, G. (2008). *Construction delays: extension of time & prolongation claims*. New York: Tylor & Francis.

Sali, N. E., Anwar, N. V., & Idlan, R. (2014, December). Legal advances on evaluation of Contractor's right to extension of time. *International Journal of Law & Legal Studies, 1*(3), 050-057. Retrieved from http://internationalscholarsjournals.org/download.php?id=913325842699782170.pdf&type=application/pdf&op=1

Skaik, S., & Nair, K. P. (2014). *Examining the viability of windows impact/update method for delay analysis in construction disputes.* Retrieved from

https://www.researchgate.net/publication/262241839_Examining_the_Viability_of_Windows_ImpactUpdate_Method_for_Delay_Analysis_in_Construction_Disputes

Trauner, & Theodore, j. (2009). In *Construction delays : documenting causes, winning claims, and recovering cost* (2nd ed., p. 25). London: Elsevier Butterworth-Heinemann.

White, A. E. (2016). *Pacing - why hurry up and wait.* Retrieved from https://www.navigant.com/-/media/www/site/insights/construction/2015/pacingwhyhurryupandwait_ifh14.pdf

Wijekoon, S. B., & Attanayake, A. M. (2014). *Study on the cost overruns in road construction projects in Sri Lanka .* Retrieved from http://dl.lib.mrt.ac.lk/bitstream/handle/123/8969/SBE-12-111.pdf?sequence=1&isAllowed=y

Yin, R. K. (2009). Case study research: Design and methods (4th ed.). California: Sage Publications.

APPENDIX

M.Sc in Construction Law and Dispute Resolution

University of Moratuwa

RESEARCH QUESTIONNAIRE/ DOCUMENT REVIEW GUIDELINE

Research Title: Potential of Implementing 'Window Delay Analysis' for Road Projects in Sri Lanka– Claims Consultants' Perspectives.

Study Background: It has been discovered by the previous researchers that CAB and WDAT (using TIA inside) have been the mostly used techniques in other countries, whereas, in Sri Lanka, those were the least used.

It has been further identified that most of the local Contractors prefer to use the APVAB and IAP methods in analysing delays in road construction projects considering their simplicity and low cost implementation.

The suitability of using various DATs developed by researchers, has recognized that two former techniques practiced in the other countries is having the highest suitability grading, whereas, the two latter techniques practiced in Sri Lanka is having the lowest suitability grading.

The srilankan construction claims business is under increasing pressure to maintain higher standards to meet the required accuracy, legitimacy, credibility and competitiveness in their works, while rising to the international trends.

Hence, it is obvious that the above practice in Sri Lanka could not be a fair criterion in selecting a DAT, considering the demanding quality by the industry for such crucial analyses.

In this context, the identification of the potential of implementing WDAT for Sri Lanka has become highly important.

Interview Guideline: Section A: Background of the Claims Consultant

Section B: Opinions of the Claims Consultant on Window Delay Analysis

Section C: Construction Delay Analysis Documentation of the Claims Consultant

Confidentiality: Confidentiality of data / information provided in this document is fully assured.

Thanks Giving: Thank you in advance for your valuable time, guidance and support to my mission success.

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QUESTIONNAIRE

Abbreviations

DAT – Delay Analysis Technique

PDAT – Primary Delay Analysis Technique

WDAT – Window Delay Analysis Technique

CAB – Collapsed As Built

IAP – Impacted As Planned

APVAB – As-Planned Vs As-Built

TIA – Time Impact Analysis

Note: Please put "√" in appropriate cage where necessary.

SECTION A: BACKGROUND OF THE CLAIMS CONSULTANT

1. Overall experience as a Claims Consultant.

i. Below 05 Years ☐
ii. 05 – 10 Years ☐
iii. 10 – 15 Years ☐
v. Above 15 Years ☐

2. Experience in construction delay analysis.

i. Below 05 Years ☐
ii. 05 – 10 Years ☐
iii. 10 – 15 Years ☐
v. Above 15 Years ☐

3. Highest educational level achieved.

i. National Certificate ☐
ii. National Diploma ☐
iii. Higher National Diploma ☐
iv. Bachelors ☐
v. Masters ☐
vi. PHD ☐

4. Having foreign working experience?

Yes ☐ No ☐

5. Professionally qualified?

Yes ☐ No ☐

6. Having a registered consultancy firm?

Yes ☐ No ☐

SECTION B: OPINIONS OF THE CLAIMS CONSULTANT ON WINDOW DELAY ANALYSIS (WDAT)

Q.1 - In your opinion, what are the benefits in the implementation of WDAT?

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Q.2 - In your opinion, is there a "contractual obligation on the part of parties" and/or "a trend" requiring WDAT to be performed in Sri Lanka?

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Q.3 - In your opinion, what factors (other than the contractual requirement) are constraining the implementation of WDAT for the Road Construction Projects in Sri Lanka?

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SECTION C: CONSTRUCTION DELAY ANALYSIS DOCUMENTATION OF THE CLAIMS CONSULTANT

1. Name of the road construction project.

2. Contract Sum.

3. Reasonably available inputs to the analyst.

CASE 1 **Prospective Delay Analysis**	**Y / N**	**CASE 2** **Retrospective Delay Analysis**	**Y / N**
Baseline programme.		Baseline programme.	
Logic linked baseline programme.		Logic linked baseline programme.	
Update programmes or progress information with which to update the baseline programme.		Update programmes or progress information with which to update the baseline programme.	
A selection of delay events to be modelled.		A selection of delay events to be modelled.	
As-built data.		As-built data.	
Logic linked as-built programme.		Logic linked as-built programme.	
Any other information (specify)		Any other information (specify)	
Type of PDAT Actually Performed by the Analyst? ◯ IAP ◯ APVAB ◯ CAB ◯ TIA **Has the Analyst taken Window approach?** Yes ☐ No ☐		**Type of PDAT Actually Performed by the Analyst?** ◯ IAP ◯ APVAB ◯ CAB ◯ TIA **Has the Analyst taken Window approach?** Yes ☐ No ☐	