OVERVIEW OF DISRUPTION CLAIM IN ROAD CONSTRUCTION INDUSTRY DURING LAST FIVE YEARS

Sandun Kuda Kurunduwage

119324 D

M.Sc/PG Diploma in Construction Law & Dispute Resolution

Department of Building Economics

University of Moratuwa

Sri Lanka

May 2016

OVERVIEW OF DISRUPTION CLAIM IN ROAD CONSTRUCTION INDUSTRY DURING LAST FIVE YEARS

Sandun Kuda Kurunduwage

119324 D

Dissertation submitted in partial fulfillment of the requirements for the degree Master of Science in Building Economics

Department of Building Economics

University of Moratuwa
Sri Lanka

May 2016

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.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature: Date:

The supervisor should certify the dissertation with the following declaration.

The above candidate has carried out research for the Masters Dissertation under my supervision.

Signature of the supervisor: Date:

Dedication……………….

To my beloved parents, Sister & Brothers

ACKNOWLEDGEMENT

This research has been completed with encouragement ideas and ready assistance from all the devote people. I must be sincere gratitude personally extended to them for the tremendous service rendered.

I wish to express my sincere gratitude to supervisor Dr. Gayani Karunasena for her invaluable guidance and encouragement during the pursuit of this work. Further, it is highly appreciated her honest criticisms in order to maintain the research aim and objectives.

As the head of Department and Course Cordinator, Dr. Yasangika Sandanayake encouraged and educated me on importance of completion research as a student. She expedites and fairly manage this master degree programme by scarifying her valuable time and avenues. Therefore, thank you very much again for your assistance.

In addition, I wish to sincere thanks for supports received from all contractors and leading professionals, for their kind co-operation and valuable answers for questionnaires towards the achievement of a prosperous dissertation. Further, it is very much helpful for me to seek industry patterns and practices prevailed in last five years.

I would further like to express my appreciation to my colleagues and friends, who provide me with experience, which eventually led me to inspiration to finish this study. Finally, I wish very special thanks for my family “for their love, beauty and patience, which are so important for creative human relations”. You help me in your own special way with completion of this research.

ABSTRACT

Sri Lankan construction industry has been increased dramatically during last decade, especially, road and highway construction is prominent among them. As per most of the project, it was observed that there were variations with anticipated work condition, plan with actual conditions. Sometimes, estimated project productivity could not be able to established due to various reasons. This is identified "Disruption events" which loses the Contractor's money unnecessary. In this research, it was focused to identify sources of disruptions, record maintenance and usage of disruption claim analysis methods in construction industry.

Questionnaire survey was carried out to identify status of disruption claim in construction industry during last five years. A five point Likert scale where 1 represents 'Not significant' and 5 represents 'Extremely significant' was used at questionnaire survey to identify the significance level among three main aspects such as sources of disruption, records maintenance at site and usage of disruption claim analysis methods.

Overtime concurrent operation, additional quantities of work, delays, dilution of supervision, joint occupancy, fast track construction, quality of craftsman, quality assurance/quality control practice, labour wages, weather and economic activity in the area were highest significance of causing disruption event in construction industry while stacking of trades, rework of already installed work changes to the plans and specification, management control, site access, and rework/errors were least impact. Further, it was found out that record keeping at site was significantly maintained through payment certificate, labour time sheets and daily report. However, it was identified that there was deficiency record maintenance of records such as correspondence, change order log, separate cost account for specific change orders, and record of change conditions caused by the owner even though those are important materials for substantiation of claim. According to the analysis, submission of disruption claims in construction industry with various types of disruption claim analysis methods was considerably lower level. Documentary evidence widely used methods of measured mile study, baseline productivity analysis and system dynamics modeling were least usage in industry. Mostly used method was total cost method which can be easily prepared at available data. Earned value analysis, comparison studies, industry based methods and modified cost methods were used comparatively lower level than the total cost method.

Eventually, Contractor suffers from disruptions events due to deficiency of contemporary records on hands. Therefore, it is recommended to establish one day before action plan, build specialized teams on particular work, independent team to grab the work norms and head office comments on project in order to answer disruptions early. Further, it is suggested to carry out further research to find out suitable method for record tracking system in construction industry.

Key words: Disruption, Disruption Claim methods, Construction, Sources of disruption

Table of Content

Chapter Three

Research Methodology

Chapter Four

Data Analysis

Chapter Five

Conclusions, Recommendations & Further Research

List of Tables

List of Figures

List of Abbreviations

NLR	New Law Report
SLR	Sri Lanka Law Report
AER	All England Law Report
CIDA	The Construction Industry Development Authority
ICTAD	Institute for Construction Training and Development
SCL	Society of Construction Law
AACE	American Association of Cost Engineering
SD	System Dynamics

CHAPTER ONE

Introduction

1.1. Background

A claim is basically an assertion for additional compensation in terms of time and/or cost on account of a change in the contract or otherwise. Being a unique combination of law and practice, claims evolve on commercial, contractual and technical issues, causing to a certain extent an imbalance in the total project delivery. It is, therefore, important that claims are resolved at the earliest practicable opportunity (Jayalath, 2013).

Construction claims are considered by many project participants to be one of the most disruptive and unpleasant events of a project (Ho and Liu, 2004). Today, construction projects are the subject of more claims than in any other time in history. The high competition has forced contractors to bid projects with minimum profits in order to stay in business. In addition to their multiparty nature, projects are becoming more complex and risky. This has placed an added burden on contractors to construct increasingly sophisticated and risky projects with less resources and profits. Under these circumstances, it is not surprising that the number of claims within the construction industry continues to increase (Ho and Liu, 2004).

Disruption is loss of productivity, disturbance, hindrance or interruption to a Contractor's normal working methods, resulting in lower efficiency. In the construction context, disrupted work is work that is carried out less efficiently than it would have been, had it not been for the cause of the disruption. If caused by the Employer, it may give rise to a right to compensation either under the contract or as a breach of contract (Darek., 2011). Disruption claims are categorized under contractor direct claims and considered as most complicated and difficult to analyze (Cushman et al., 2001).

Simply "disruption" can be defined as a prevention or hindrance to something intended, expected or proceeding, an interruption in continuity, dislocation, discontinuity or disorder (SCL, 2002).

Disruption claims often generate conflicts and contract disputes in the delivery of building and civil engineering projects. The quantification of losses resulting from disruption is possibly the most difficult area for anyone engaged in clearly identifying any additional payment that might be due (Davison and Mullen, 2009).

As depicted by Carnell (2005), there is very little written on disruption and disruption claims are acknowledged as very difficult to prove. The major challenges, the claiming party faces in preparing a disruption claim are to identify the root causes of the loss of productivity and quantifying the associated cost in labour and equipment productivity losses (Lee et al., 2005).

1.2.Research problem

In developing countries, construction of road and highway plays significant role in development of country economy. Government of Sri Lanka identified the situation and paid their attention to road sector and implemented vast project throughout the countries. However, it is a fact that loss of productivities was occurred during this trend due to various reasons such as variation, poor communication and instruction delay (Priyantha, 2011).

Contractor's claim submission for productivity loss (disruption claim) is not easy to proof and it requires to pass certain factors. For a successful disruption claim, and recover additional compensation for project inefficiencies, the contractor shall prove (1) liability, i.e., the owner was contractually responsible for the impact; (2) causation, i.e., the impact caused the labor overruns; and (3) Resultant cost increase, i.e., the impact actually caused a compensable loss (Klanac and Nelson, 2004).

Under these circumstances, most of the contractors suffer financial loss from disruption events when they fail to establish claim. In past five years, disruption related to road construction has been increased with the implementation of massive road projects throughout the countries. However, the significance level of disruption causes is still unknown among construction industry. Therefore, this study is carried out to identification significance of disruption causes toward road construction industry and educate contractors to concentrate of those causes in order to mitigate its effects on productivity loss.

1.3.Aim

To identify significance causes for the disruption claims in road construction industry during last five years

1.4.Objectives

- To understand the concept of disruption claim and its impact on the construction industry
- To examine/investigate the disruption claims in Sri Lankan construction industry
  - a) To identify occurrence of disruption claims during last five years
  - b) To identify the main sources for disruption claim
  - c) To identify the usage of disruption claim methods
  - d) To identify the required documents for preparation of disruption claim
- To identify practices to mitigate impacts of disruption claim occurrence

1.5.Methodology

The following methodologies was used to achieve the above objectives.

Literature Survey and Review

Literature review of relevant books, recent journals and seminar papers with related to disruption claim was referred in order to get ideas of the background for the research. Review court cases relating to civil and construction matters and refer various law reports (NLR, SLR, and AER).

Questionnaire Survey

Finding out significance level of disruption causes in construction industry during last five years are required to find facts and figures from industry. Therefore, most suitable method is questionnaire survey rather than interview methods. Hence, questionnaire survey was conducted as field survey to obtain field information from the 53 construction contractor's representatives who are directly involved in the civil/commercial disputes. However, 34 nos of contractor's representatives have responded and those details were analyzed in this research.

1.6.Scope and limitations

Clear identification of disruption among work activities is very difficult when there are many work activities coincide with each other. Building construction is a one of example. However, work activities in road construction are taken considerable time to complete one work activity (e.g. embankment). Hence, this survey was limited and considered only the disruption events in the road and highway projects spearheaded by contracting firms in the category of C1as per CIDA national grading system.

1.7.Structure of Study

Mainly, research is conducted in five chapters and their described important facts in details as follow;

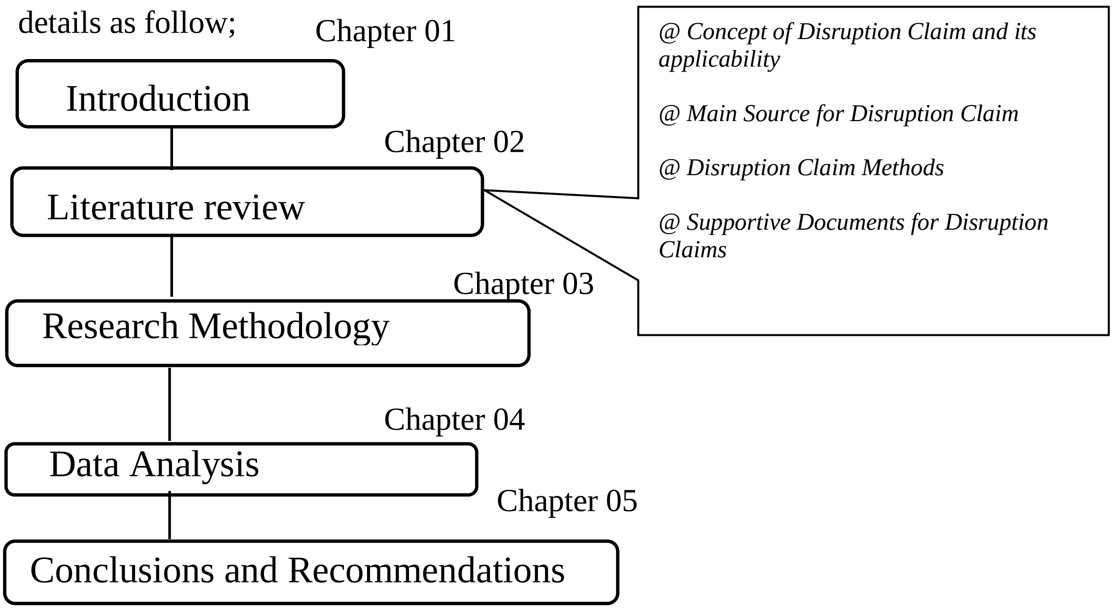


Figure 1.1-chapter breakdown

Structure of study was organized in five chapters. Under chapter one introduction is described background information for why importance of this research to carry out by the researcher. Chapter 02 - literature review, it is described available details on research topic and identify concept of disruption claims and its applicability in construction industry. Further, it was described sources of disruptions, analysis methods and required supportive documents to proof disruption claim. Chapter 03 described why researcher selected questionnaire survey other than other research methods. Data from research method was analyzed and presented in chapter 04. Finally, it was summarized the cursory view of research and proposed recommendations based on research finding. In addition, under the further research, it was opened and proposed to think researchers on new section to find out and develop the knowledge in respect to improvement of construction industry

1.8.Summary

Under this chapter, background information of the research was described to give indication to reader why researcher supposes to carry out this research. Further, importance of the research and organization of chapter break down as per research aim and objectives were described in brief under this chapter to make available easy reference for latter stages.

CHAPTER TWO

Literature Review

2.1.Introduction

This chapter describes the details of disruption claims, applicability and sources of origin. Further, it is mentioned that the claim requirements to be attached and how disruption events to be analyzed with various methods.

2.2.Disruption claims

2.2.1. Disruption

"Disruption" is defined technically as Loss of productivity while increasing cost of performance caused by a change in the contractor's anticipated or planned working conditions, resources, or manner of performing its work (Schwartzkopf, 2004).

Disruption defines that any change in the method of performance or planned work sequence expected by the contractor at tender stage than actually performing in the manner. Further, disruption is a material alteration in the expected performance conditions at the time of bid from those actually encountered, resulting in increased difficulty and cost performance (Cushman *et al*., 2001).

Generally, disruption claim is also known as loss of productivity claim or as inefficiency claim (Klanac and Nelson, 2004). According to the Bunni (2005), inefficiency, loss of productivity of labour and uneconomic use of equipment come under the heading of disruption when they are caused by an event which is not the responsibility of the contractor.

Disruption is a cost increment of actual performance against the planned work performance, however, it does not require to change of initial scope or change initial estimated quantity. Disrupted work may still be performed using the planned resources, means and methods the disrupted work merely requires more man-hours to complete (Finke, 1998).

As per Society of Construction Law (2002, p.31), Disruption is lower efficiency in result of disturbance, hindrance or interruption on contractor's normal working methods. In addition, financial loss of lower efficiency can be compensated from Employer when he is fault under the Contract or as a breach of contract.

2.2.2. Disruption claim

Disruption claim is a claim of requesting compensation for disruptions in order to facilitate contractors in to same financial position which would has been in, if the disruptions would have not occurred (Klanac and Nelson, 2004).

As per Bunni (2005), disruption claim is addressed the possible effects of a claim events on the efficiency of the execution of some part or parts of the works which includes any reduction in the efficiency of the disrupted party's resources. The disrupted activity is disregard whether it is on critical or non-critical activity and result to delay ultimately (Davison and Mullen, 2009). In addition, disruption event is occurred when the rate of progress of the execution has to be accelerated, either to comply with the time for completion of the work or to be advance it.

According to Handling prolongation and disruption claims and Jayalath (2009), Claim submission for compensation events of disruption or loss of productivity due to act or omission of the Employer is a "disruption claim".

As per the Contract agreement, both parties shall fulfill the assigned rights and obligations while performing construction. The breach of rights and obligations are frequently made claimable situations. Therefore, as depicted in Cushman et al. (2001), disruption claims are based upon the following assumptions of rights and obligations;

1. The contractor is entitled to schedule the work at initial stage in the most efficient and cost effective way with available resources in order to meet project's plans and specifications.
2. The parties shall comply and fulfill rights and obligations as per agreement. Neither party will act or fail to act so as to prevent other party from exercising its right and/or performing its contractual obligations.

3. The contractor's schedule including methods and sequence of performance shall be realistic. It shall not be taken extraordinary efforts to others than schedule.

Disruption claim recovers damages of increased labour and man power costs resulting from inefficiency, increased labour costs from mobilize and demobilize work crews and increased plant and material cost, and so on.

Contractor evaluates the disruption event initially whether it is compensable or non-compensable under principles of disruption claim (Merritt, 2009). Non-compensable disruptions can be foreseeable under the contract. For an instance, adverse soil condition (Cushman et al., 2001). As stated by Carnell (2005), non-compensable disruptions are caused by the contractor's own actions, such as improper scheduling, inefficient material expediting, or the failure of a subcontractor or supplier to performance. Further, contractor cannot complain when its disrupted performance is based on unreasonable assumptions or its poor planning or performance.

Disruption event is compensable when it goes beyond the contractor's responsibility and risk under the contract. This can be recovered from specific contract provisions or otherwise general principles of contract law (Cushman et al., 2001).

Contractor submits disruption claims under a) increased preliminaries, b) head office overheads, c) loss of profit, d) loss of productivity or uneconomical working, e) increased costs resulting from inflation (Keating, 1991).

a) Increased preliminary

   Preliminaries are indirect work tasks such as procurement and usage of water, electricity, office rent and site overhead cost (Keating, 1991). In a disruption situation, claim for preliminaries are accounted cost of additional site supervision and management such as cost of indirect work, safety equipment, scaffolding etc. to enable the additional resources to perform the duties on site (Davison and Mullen, 2009).

b) Head office overheads

Any contract disruption event causes to increase cost of head office administration as there are administrative officers that to involve in issue of disruption to solve the issue. Therefore, part remuneration cost is linked with disruption event and disruption claim can be included those cost (Chappell, 2005).

c) Loss of profit

Contractor's loss of opportunity to earn profit due to the disruption is considered under the "Loss of profit". Disruption claim is forwarded to compensate this type of cost (Chappell, 2005).

d) Loss of productivity or uneconomical working

According to Cushman et al., (2005), contractor suffer loss due to the reduction of work scope than the planned resources for the original scope. Then, portions of labours and machineries are idle without having work scope. This cost is considered under disruption claim.

e) Increased costs resulting from inflation

Due to the disruption, contractor has to work in high inflation which cost of labourers and machineries are comparatively higher than the before of disruption. Disruption claim is addressed this issue (Chappel, 2005).

2.3.Sources of disruption

Effective management of resources (labour, equipment, etc) is a basic requirement for timely and on-budget completion of construction projects. The productivity of these resources is, however, highly influenced by myriad of factors, such as, mismanagement, inclement weather, change orders, differing site conditions, to mention a few (Hanna and Heale, 1994; Makulsawatudom and Emsley, 2001).

Further, as per Keane and Caletka (2008), there are many causes of disruption and factors that affect productivity that may arise during the course of a construction project. A decrease in efficiency is often associated with one or more secondary factors unrelated to the original excusable event, but which are implemented to negate or mitigate the effects of the root cause (Merritt, 2009).

According to Davison and Mullen (2009), sources of disruptions are shifting the location for performance, inadequate or defective specifications, incorrect contract drawings, differing site conditions, unusual severe weather, strikes, unavailability of materials, interferences from other contractors, failing to schedule and coordinate the work and failing to respond to request for information and submits in a timely manner. On many construction projects, the largest single area of cost overrun is in labour cost. This is not surprising because labour is frequently the largest variable cost for a contractor. This is an oversimplification of the problems because labour overruns on a project can and do result from a variety of causes. The major reasons for labour cost increases include schedule acceleration, changes in the work, project management, project characteristics, project location, and external conditions (Schwartzkopf, 2004).

Table 2.1: Summary description for source of disruptions (Schwartzkopf, 2004).

Issues	Reasons
1. Schedule acceleration	Overcrowding, Stacking of trades, Over time Concurrent operation
2. Change in work	Additional quantities of work, Learning curve, Scope changes, Delays, Engineering errors and omissions, Rework of already installed work Changes to the plans and specifications
3. Management characteristics	Material and tool availability, Management control, Project team, Dilution of supervision
4. Project Characteristics	Project size, Work type, Workforce size, Joint occupancy, Fast track construction, Site access, Site condition

5. Labour and Morale	Quality of craftsman, Quality assurance/Quality control practice, Rework and errors, Absenteeism, Craft turn over, Fatigue, Morale, Wages, Incentives
6. Project Location /External conditions	Weather, Area population, Commuting time, Availability of skilled labour, Economic activity in the area.

2.3.1. Schedule acceleration

Acceleration of a construction project occurs when the construction schedule for the project, or portion of the project, is shorter than what would be required to complete the work using normal sequences of construction on a normal working schedule. There are three traditional methods to accelerate a schedule; working overtime, working shifts, and overmanning (Hanna *et al.*, 2005).

2.3.1.1. Working overtime

Relationship between productivity and working additional hours is inverse, hence, it shows a decrease in productivity when number of hours worked per week increase and/or as project duration. Major reasons are fatigue, increased absenteeism, decreased morale, reduced supervision effectiveness, poor workmanship resulting in higher than normal rework, increased accidents, etc (Hanna *et al*,. (2005). Even though overtime work, initially, result in increasing output, if it is continued for a prolonged period, the output may actually decline for the reasons stated earlier (Horner and Talhouni,1995).

2.3.1.2. Overmanning

Effective productivity is achieved when there is a sufficient work space to work all without interference each other. However, there are more workers are assigned to work in a fixed working space, eventually, decrease the productivity as hindrance to work. In addition, when the workmen of several trades could be crowded or “stacked” in a limited work area, creating a situation in which the work cannot be carried in the most efficient sequence and thus cannot be done efficiently (AACE, 2004).

2.3.2. Change in work

Most of the construction projects vary from original design, scope, and definition irrespectively small or large. This can be because of technological advancement, statutory changes or enforcement, change in conditions, geological anomalies, non-availability of specified materials, or simply because of the continued development of the design after the contract has been awarded. These variations may include alterations to the design, alterations to quantities, alterations to quality, alterations to working conditions, and alterations to the sequence of work. However, it is a very difficult task to quantify the disruptive impact of change order (Finke, 1998).

2.3.2.1. Learning Curve

As stated by Norfleet (2004), it is generally accepted that a worker learns as he works. There is a typical learning curve while the labor crews become familiar with the project, its location, the quality standards imposed, lay down area locations, etc (Thomas *et al.*, 1986). Further, it is also wide recognition that the more often the worker repeats an operation, the more efficient he or she becomes. The result of that efficiency is a decline in direct labor input required to continue performing the operation. It can be further discussed as efficiency improves and the amount of direct labor input (hours) required to perform the operation decreases. As a result of that, the productivity of that worker increases at a corresponding rate during a given time period. This is to be expected and is typically included in as-bid costs (Eden *et al.*, 1998).

Norfleet (2004) stated that there are loss of productivity when resume the work after suspension as it takes considerable time period to adopt earlier efficiency level of workers.

2.3.2.2. Defective engineering, engineering recycle and/or rework

Productivity is declined when there is an additional work requirement at ongoing work area due to the stagnation of work until receiving proper instruction to proceed work (AACE, 2004).

2.3.3. Management characteristics

Effective Management of required material, machinery and project team directly enhance the productivity.

2.3.3.1. Material, tools and equipment management

The major non-productivity categories such as; delay in material delivery, shortage of materials, tools or equipment and delay in survey work by foreman deprive potential benefit of construction productivity (Thomas et al., 1989). It was found that there was productivity loss ranged between 5.4% to 56.8%, due to mismanagement of material such as late or out of sequence deliveries, and fabrication error (Thomas and Sanvido, 2000).

2.3.3.2. Project management team

Proper project management is included planning and implementation of project at the outset in a proper manner. This is by focusing shortage of critical construction equipment or labor, and incorrect mix of labor crews. However, failure of proper project management causes productivity loss (Klanac and Nelson, 2004; AACE, 2004).

2.3.3.3. Dilution of supervision

Site supervision is weaken when increases of work scope with additional work due to the diversion of supervisory attention from the original contract work. For an instances, crews are split up to perform base scope work and changed work in multiple locations or when work is continually changed or re-sequenced. Then, site supervision is often unable to effectively perform their primary task to see that crews work productively as site supervision ends up spending more time planning and re-planning than supervising (Pickavance, 2005; AACE, 2004).

2.3.4. Project characteristics

Project characteristics such as project's size, its complexity, the schedule, the extent of revamp, the construction contract, the availability of labor, the location, and competing projects, influence on labour productivity. Therefore, change of project characteristic directly affects the productivity of the project (Klanac and Nelson, 2004).

2.3.5. Labour and morale

Productivity of the project depends on labour's efficient, however, there are many reasons behind the labour's efficiency such as fatigue, rework, and unsatisfactory morale.

2.3.5.1. Fatigue

Tiredness of working condition decreases the productivity of normal condition as slow down the work, carrying more mistakes than normal, sometimes, suffer many accidents and injuries while working (AACE, 2004).

2.3.5.2. Morale of labour

Morale of labours is changed with working conditions and productivity varies with same basis. For example, productivity decreases when there are circumstances as many rework, uncertainty about employment, dissatisfaction and lack of confidence of work (Pickavance, 2005).

2.3.5. Project location/External conditions

Productivity of project depends on external factors at project location. Adverse weather condition is a one of factor which can adversely influence on project. Productivity loss on construction of embankment in rainy season is a one of best example when it is necessary to complete project on time (Klanac and Nelson, 2004; Rayes and Moselhi, 2001). Procuring skill labour from project location is also one of challenge and most of available labour are belong to unskill category. Hence, expected productivity cannot be achieved under this circumstances (AACE, 2004).

2.4. Disruption claim analysis method

One of the most contentious areas in construction claims is the calculation or estimation of lost productivity. Unlike direct costs, lost productivity is often not tracked or cannot be discerned separately and contemporaneously. As a result, both causation and entitlement concerning the recovery of lost productivity are difficult to establish. Compounding this situation, there is no uniform agreement within the construction industry as to a preferred methodology of calculating lost productivity. There are, in fact, numerous ways to calculate lost productivity. Many methods of calculation are open to challenge with respect to validity and applicability to particular cases, thus making settlement of the issue on a particular project problematic (AACE, 2004).

The construction industry has developed and employed a number of methodologies for estimating loss of productivity. Based on the appropriate data input, these methods can be classified into three major groups (Nelson, 2011);

1) Project practice based approaches.
2) Industry based approaches
3) Cost based approaches
4) Other Quantifying Methods

Project practice based approaches describes two categories such as project specific studies and project comparison studies and applicability is decided by availability of records. However, industry based approaches come and play vital role, when there is no sufficient details to evaluate the disruption claim. In adverse situation of no record and proper industry norms, then cost based approaches are used to evaluate the disruption claims.

2.4.1. Project practice based approaches

Details record of project construction is required to analysis the disruption claim under this approach. There are two types of categories with different methods;

1) Project Specific Studies
    a) Measured Mile Study
    b) Baseline Productivity Analysis
    c) System Dynamics Modelling

   d) Earned Value Analysis
   e) Work Sampling Method
   f) Craftsmen Questionnaire Sampling Method
2) Project Comparison Studies
   a) Comparable Work Study
   b) Comparable Project Study

2.4.1.1. Project Specific Studies

In this category, when a dispute arises over lost productivity, calculations based upon contemporaneously created project documentation from the project in dispute, supported by personnel who were actually involved in the project and disputed work activities are the most credible. Accordingly, when calculating lost productivity, recommended practice is to utilize one of the following techniques, when possible. There are two primary methods for measuring completed work items. The percentage complete method rests upon periodic estimates of the percentage of work completed on a work item basis. For example, a monthly payment application may estimate backfill work 50% complete, underground conduit 32%, etc. The physical units of work completed method, however, is more detailed and more accurate. Under this method, the actual units of work are surveyed for completion on a regular or periodic basis and compared to the total known number of units to be installed or constructed. Any of the project specific studies below can use either of these calculations, depending upon contemporaneous project documentation maintained by field personnel.

2.4.1.1.1. Measured Mile Analysis

The measured mile approach is widely acknowledged as the most acceptable method for calculating lost productivity costs Zink (1990), Presnell (2003), Gulezian and Frederick (2003), Ibbs and Liu (2005) and Merritt (2008). The analysis compares identical tasks in impacted and non-impacted periods of the project to estimate the productivity loss caused by the impact of a known series of events (Zink, 1990). It is based on an extrapolation of actual work hours spent. The measured mile calculation might include comparison of similar work activities and achieve court acceptance. The attraction of the measured mile is that the actual contract performance rather than the initial estimate is used for the calculations. As such it compares actual performance on site with actual performance, not some theoretical planned performance.

A recent court decision has broadened the Measured Mile calculation to include comparison of similar work activities and least impacted periods versus impacted periods. If sufficient work on the project is complete in an unimpacted or least impacted period and the quantity of work is known then calculations can usually be performed to ascertain a baseline level of productivity for that part of the work. Physical units of work complete divided by hours expended to complete these work items determines productivity during the least impacted or unimpacted period. A similar calculation is then performed for the period of the impact. The productivity loss can then be calculated by subtracting the unit productivity rate during the impacted period from the unit productivity during the unimpacted period. It is noted that when performing a Measured Mile calculation, other variables, which could affect productivity but are unrelated to the claimed impacts, must be accounted for and removed from the impacted period calculation to the extent these variables occurred during the least or unimpacted period. These may include weather, project mismanagement, subcontractor-related problems, voluntary acceleration, etc. Numerous federal court cases have upheld use of the measured mile technique including E.C. Ernst, Inc. v. Koopers Company, Natkin & Company v. George A. Fuller Company, United States Industries, Inc. v. Blake Construction Company, Inc., Appeal of Batteast Company, Goodwin Contractors, Inc., and Clark Concrete Contractors, Inc. v. General Services Administration. Of the six methodologies listed in the project specific studies category the Measured Mile study is the method most often cited in court cases. It is probably the best of the recommended practices, assuming there is sufficient contemporaneous data to allow such an approach. This method appears to be recognized as the most credible in the legal system. Additionally, unlike some other methods, the Measured Mile study can be used after the impact has occurred or as a sampling technique, while the impacted work is in progress (AACE, 2004).

The below illustrates a non-disrupted period of excavation and a later disrupted period where the volume of excavation per unit of time has been adversely affected by operational and access restrictions imposed upon the Contractor.

There are several assumptions and prerequisites underlying the measured mile technique:

1) First, there must be a non-impacted or least impacted period, so-called "measured mile" period, for the specific type of work being assessed. The adverse factors affecting productivity during the measured mile period, if any, must be solely attributable to the contractor;

2) Second, the length of this period should be significant compared to the impacted period and the course of work. It would be unreasonable to extrapolate 2% of progress into 80% of expected costs;

3) Third, sufficient amounts of contemporaneous project data should be available for the analysis. At most the physical units of work completed have to be periodically recorded so that the cumulative labour hours can be plotted through the course of work.

4) Fourth, the project data are assumed to be error free. That is, the contemporaneous documentation must be accurately recorded by the contractor; and

5) Finally, all disruptions during the impacted period are due to Employer's actions or inactions. It is extended that other factors unrelated to the claimed impacts have to be accounted for and removed from the impacted period analysis to the degree these factors occurred during the measured mile period

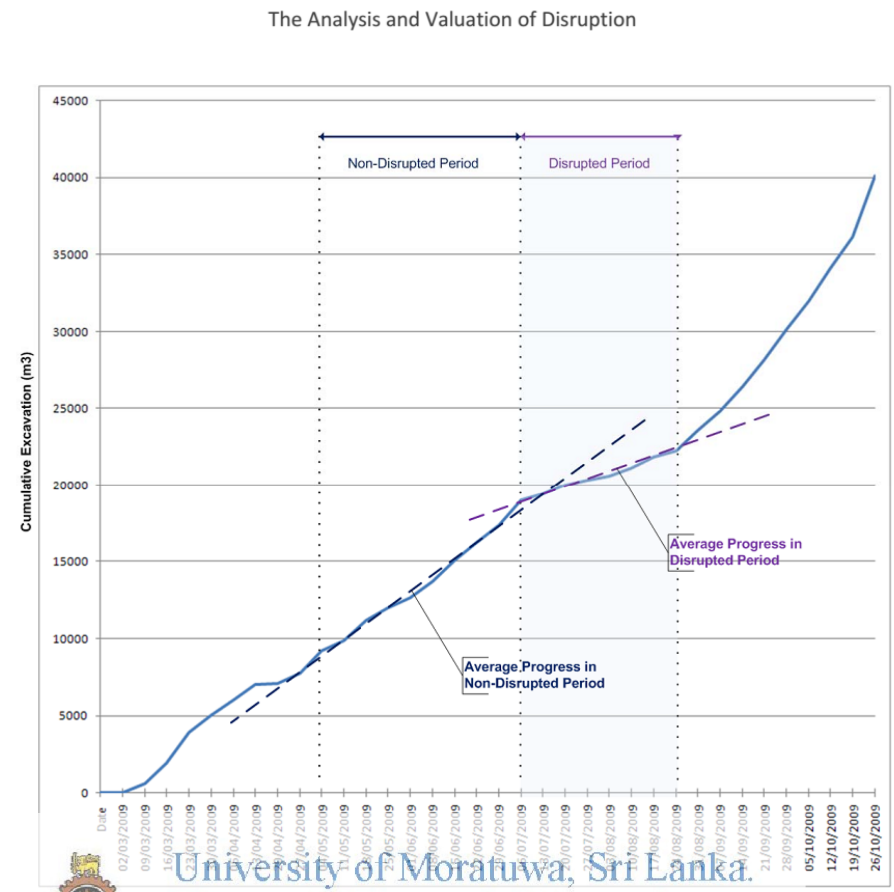


Figure 2.4.1 The Analysis and Valuation of Disruption

(Nelson, 2011)

Considerable limitations are embedded in these assumptions. The measured mile analysis becomes unreliable or even impossible when either a non-impacted period simply does not exist or that period is not sizeable. The fact that the analysis requires identical or substantially similar activities for comparisons can hamper its applicability as the method is inappropriate for unique and complex tasks. The reliability of the method is challenged if inaccurate contemporaneous project data is used for the analysis. Unfortunately reporting errors are commonplace in projects. Other limitations are more implicit. Projected cumulative labour hours can be extrapolated differently due to different options of the time frame. Gulezian and Samelian pointed out that:

1) Different time frame and segments selected within the measured mile period may produce different numbers; and

2) Variation of daily productivity is concealed to varying extents by the cumulating nature of the measure mile analysis.

They also argue that the measured mile does not necessarily reflect the productivity normally achieved by the contractor due to the smoothing effect of successive cumulative data and the nature of variation in unit productivity values. In addition, the two average productivity rates, which are readily calculated and compared for non-impacted and impacted periods, may mask the fact that a contractor generally does not attain a single rate of productivity throughout a time period.

2.4.1.1.2. Baseline Productivity Analysis

This approach was proposed in order to avoid some of the limitations and impractical assumptions of a current measured mile analysis. Similar to the measured mile method, baseline analysis relies on the contractor's actual performance of the project being analysed. A central point of this analysis is to establish the baseline productivity. It represents the best and most consistent productivity the contractor was able to achieve on the project. It represents the best and most consistent productivity the contractor was able to achieve on the project (Thomas and Zavrski, 1999).

This is used where unimpacted portion of the project cannot be found. From the claimant's perspective, this is a conservative measurement because the baseline productivity may still include some lost productivity. But because responsibility for that lost productivity cannot be easily measured and clearly assigned to the respective parties, the claimant uses the baseline period as a reference, even though some lost productivity may still be intertwined in the baseline rate (Ibbs and Liu, 2005a).

As concluded by Ibbs and Liu (2005a), compared to the measured mile method, the baseline method has certain advantages: The baseline method does not require records with the same level of detail as the measured mile method. Base line built up with isolating non continuous set of data points. Also in the cases where no measured mile is apparent or available, a baseline productivity rate can still be determined and used to measure change.

Although the baseline analysis solves several problems associated with the measured mile approach, it is still limited. The way of calculating the baseline productivity should be more scientific and straightforward, subject to properly dealing with the reliability of reported data, variation of productivity values, and casual linkages to disruptions and inefficiency. Some shortcomings are related to the establishment of the baseline sample are:

1) The baseline sample is identified according to the best daily output instead of the best daily productivity; and

2) The 10% requirement for the baseline sample size is arbitrary and not based upon scientific principles.

In addition, it is agreed that the baseline analysis is a cause and effect analysis, yet it is qualitative or very roughly approximate in nature. There has been no sound method for which damages induced by the owner and contractor are classified and quantified during a disputed period. Especially, multiple and/or simultaneous owner and contractor-caused disruptions are not uncommon in real life (Ibbs and Liu 2005a).

2.4.1.1.3. System Dynamics Modeling

System dynamics (‘SD’) modelling has been employed to understand the behaviour of various natural, social, and engineered systems. By using SD modeling quantification of cumulative impacts can overcome one of the major limitations of the measured mile and baseline analyses. As discussed earlier the two methods are not able to properly handle the multiple and/or concurrent disruptions caused by different project parties. SD models can correctly quantify owner-responsible delay and disruption impact costs and demonstrate the cause–effect relationship of the cumulative impacts (Ibbs and Liu 2005b).

A key feature of SD simulation modeling is that it allows and directs answering a pool of "what if" questions such as What if one particular category of disruptions had not occurred but all others had? What if the owner interventions had not occurred? (Cooper, 1980 cited Ibbs *et al*., 2007 and Eden *et al*., 2005).

As stated by Ibbs and Liu (2005b), the SD technique recognizes and models the interaction of work activities and graphically illustrates the mechanism by which disruption occurs, the results are accurate and persuasive.

One main reason is that SD simulation models are not readily understood due to the dynamic complexity and quantitative nature of those models. In addition, unless the SD model is properly validated, it is pointless, barely credible, and therefore useless. Validation of a SD model is problematic and time consuming and requires extensive expertise of the SD methodology. In some circumstances, it is assumed that the reasonableness of the original estimate in SD modelling can draw inaccurate and unpersuasive quantum of damages. Also, although the causal coefficients indicating the relationships between activities are very important to the accuracy of a SD model, they are not easy to estimate (AACE, 2004).

2.4.1.1.4. Earned Value Analysis

Productivity measurement is sometimes difficult when there is insufficient information concerning the physical units of work installed on the project. In these situations, a simplistic form of the earned value analysis method can be utilized to calculate estimated labor hours. The contractor's estimate or alternatively the value of payment applications, contract amounts or unit prices can be used to determine labor hours, when they were expended and, possibly, on what activities. Physical units of work completed multiplied by budget unit rates can be used to determine earned hours. The earned hours are then compared to the actual hours expended for the period of the impact and the difference between the two may be used to calculate the productivity loss experienced. Earned value measurement of contemporaneous project documentation, such as percentages complete from schedule updates or payment applications can assist with calculating labor productivity. In addition, the claimant may calculate the actual revenue per hour of labor versus the planned revenue per hour, as an alternative. Earned value analysis may also be utilized to calculate estimated labor hours (AACE, 2004).

When using the earned value analysis technique, it is cautioned that the budget used to generate the earned value metrics be carefully reviewed and verified for reasonableness. Any earned value analysis based upon an unreasonable budget is highly suspect (AACE, 2004).

2.4.1.1.4. Sampling Method

Two sampling methods used for estimating lost productivity are work sampling and craftsmen questionnaire sampling methods.

<u>Work Sampling Method</u>:

Work sampling is a method in which the claims analyst makes a large number of direct observations of craftsmen to determine what they are doing at various points in time. Work sampling is defined as "An application of random sampling techniques to the study of work activities so that the proportions of time devoted to different elements of work can be estimated with a given degree of statistical validity." From these observations the claimant determines, on a percentage basis, how much time is spent between direct work (pay item work); support work (moving tools and materials to the work location); or delays (time when no work is being performed). By performing a number of work sampling studies, the analyst can draw comparisons of productivity before and after known events, between work activities or crews, etc. Work sampling has been offered as a means of determining productivity loss but it can only be performed during the life of the project and is not compatible with a hindsight analysis effort. Although they can be used for lost productivity claims, their trustworthiness is not high as they are only a sampled measure of labour productivity. For instance, an assumption of work sampling that there is a positive relationship between productive time and labour productivity was found to be false (AACE, 2004).

<u>Craftsmen Questionnaire Sampling Method</u>:

Claims analysts estimating lost productivity frequently are not in the field, on the project, during the disruption period. However, when productivity loss is recognized by field project management staff, a questionnaire can be prepared and provided to craftsmen in the field. The questionnaire allows craftsmen to estimate the amount of lost productive time in the field on a daily or weekly basis, identifying the reason for the lost time. While, perhaps, not the most scientific of studies, this is contemporaneous documentation if administered properly. The claimant can then tie the results of such a survey to the entitlement and causation arguments (AACE, 2004).

2.4.1.2. Project Comparison Studies

AACE (2004) and Pickvance (2005), classifies the comparable work studies in two forms: Comparable Work Study and Project Comparison Studies.

2.4.1.2.1. Comparable Work Study:

There are two forms of this analytical technique. One form is for the contractor to estimate productivity loss on the impacted portion of the project. Once done, the analyst locates an analogous or similar work activity on the project, which was unimpacted (or least impacted) and calculates the productivity on this work. For example, a comparison of electrical conduit installation with fire sprinkler installation. The ratio of the two calculations then forms the estimated productivity loss. The difficulty in this method is determining what is analogous or similar work? If the productivity loss occurred during the installation of electrical conduit, is such work really analogous to installation of fire sprinkler piping? Factors such as size, length, weight, height above ground or off the deck, etc. must all be carefully considered and documented to successfully present such an analysis. The other form of a comparable work study is to calculate productivity during the impacted period on the project and compare this productivity to similar work, on the same project, performed by another contractor whose work was not impacted. Typically, the comparable work study is only performed when study of the same work before and after a known event is not possible and thus a measured mile analysis cannot be completed. Perhaps change orders concerning the electrical conduit were so pervasive from the outset of the work that the contractor was never able to achieve a measured mile plateau. In such situations, project owners are unlikely to allow a comparison of actual productivity with as-bid productivity, even if they are responsible for the changes. Hence, in its place, the contractor may be able to compare actual productivity on conduit installation with productivity on fire sprinkler installation to draw some conclusions.

2.4.1.2.2. Comparable Project Study:

In the event that the comparable work study cannot be performed, an acceptable alternative may be to calculate productivity on the project in dispute and compare this productivity to that achieved on another project with similar work. Of course, to do this successfully the contractor must demonstrate that the comparable project was of similar size and magnitude, similar location, similar weather and labor conditions, etc. The more similarity between the projects, the more likely it is that this method will be given credence. Less similarity between projects obviously leads to decreased chances of success.

2.4.2. Industry based approaches

This approaches consisted with two methods, specialty industry studies and general industry studies. In general, although the industry based methods are quick and inexpensive, their use in calculating lost productivity is not the first preference.

2.4.2.1. Specialty Industry Studies

In the event there is insufficient contemporaneous project documentation to allow preparation of one of the project specific or project comparison studies such as; Acceleration, Changes, Cumulative Impact and Rework, Learning Curve, Overtime and Shift Work, Project Characteristics, Project Management, Weather, or other circumstances to estimate. The claimant will, of course, be challenged to demonstrate entitlement and causation. In additional, the contractor will have to demonstrate that the project encountered a situation similar to that of the specialized study or studies relied upon (AACE, 2004).

2.4.2.2. General Industry Studies

Sometimes there is insufficient contemporaneous documentation to support a project specific study or a project comparison study, and further, the loss of productivity stemmed from numerous, non-specific causes. This is especially true when there is a lack of contemporaneous data from a project or when there is a surfeit of non-definitive data. In these situations, then, recommended practice is to employ one of the general industry studies (AACE, 2004).

2.4.3. Cost based approaches.

If it is possible to demonstrate entitlement and causation but there is insufficient project documentation to support damage calculations using any of the above techniques, recommended practice is to use one of the costing methods set forth below. These methods require analysis of the project job cost records. The purpose of such preliminary analysis is to determine actual direct labour hours and costs (having stripped out materials, installed equipment, supplies, field and home office overhead, small tools and consumables, etc.). Total cost and modified total cost methods are grouped into cost based methods.

Total cost method

A total cost claim occurs when a contractor attempts to recover its entire man-hour overrun (i.e., the difference between its planned and actual man-hours) on a given scope of work. Total cost claims are popular with contractors because they are easy to produce and they maximize a contractor's potential recovery. The method only be used if the contractor can first satisfy a set of four prerequisites:

As applied to loss of productivity claims, these four prerequisites are: (1) the planned productivity was reasonable; (2) the actual productivity was reasonable; (3) none of the productivity losses were non compensable; and (4) through no fault of the contractor, a more accurate accounting of the compensable losses of productivity is unavailable (AACE, 2004; Keane and Caletka, 2008).

Modified cost method

The major difference between the total cost and modified total cost methods is that damages quantified by modified total cost calculation takes into account unreasonable estimates and/or inefficiencies due to contractor's problems (Klanac and Nelson 2004; AACE, 2004).

Total Labor Cost Owed = Total Labor Cost Expended – Acknowledged Contractor Problems – Total Labor Cost Paid

2.4.4. Other Quantifying Methods

There are other inefficiency estimations such as expert testimony and jury verdict. A considerable portion of lost productivity calculations is based primarily upon an expert's testimony. Although this method might work, it is extremely uncertain due to a lack of supporting analysis.

Jury Verdict

The jury verdict method affords courts or boards the discretion to award damages when those damages have not otherwise been shown with specificity. The jury verdict approach is not one that the contractor should use when making its claim. Rather, it is merely a tool available to the courts to utilize the evidence presented in order to award costs to the contractor when liability and causation are clear and other methods of calculating the lost productivity are not available (Cushman *et al.*, 2001).

2.5. Supportive documents for disruption claims

Measurement and allocation of responsibility for loss of productivity can be difficult. There are a number of reasons for this difficulty. Amongst them are the followings;

1. Lost productivity resulting from some action which is the responsibility of the owner, may not be easily detected or observed at the outset. Unless a contractor has a good productivity monitoring plan, well known to field project management staff, all that may be known at the outset of a problem is that the field crews are not completing work activities as planned, and project schedule, costs and cash

flow are suffering as a result. Hence, appropriate written notice to the project owner is often not promptly filed, kicking off more discrete and detailed project monitoring efforts.

2. Productivity is frequently not discretely tracked on construction projects in a contemporaneous manner. Unless a contractor uses some sort of structured earned value system for tracking output units and input units, there is no way to measure productivity contemporaneously. Thus, productivity losses can be difficult to prove with the degree of certainty demanded by many owners.

3. Lost productivity is, all too often, calculated at the end of a project during preparation of a claim or request for equitable adjustment. As a result, often times only a gross approximation or a total cost estimate can be made.

4. Complicating the issue even more, there are myriad ways to calculate lost productivity. There is no common agreement amongst cost professionals as to how such lost hours should be calculated. Notwithstanding this statement, there is general agreement among cost professionals that a comparison to unimpacted work on the project is generally preferred when there is sufficient data available.

5. The quality of some of the methods' results is not always repeatable, leading to low confidence in the resulting analysis. Often two methods are used to compare results as a check with seemingly wide variances observed that cannot be easily understood or reconciled.

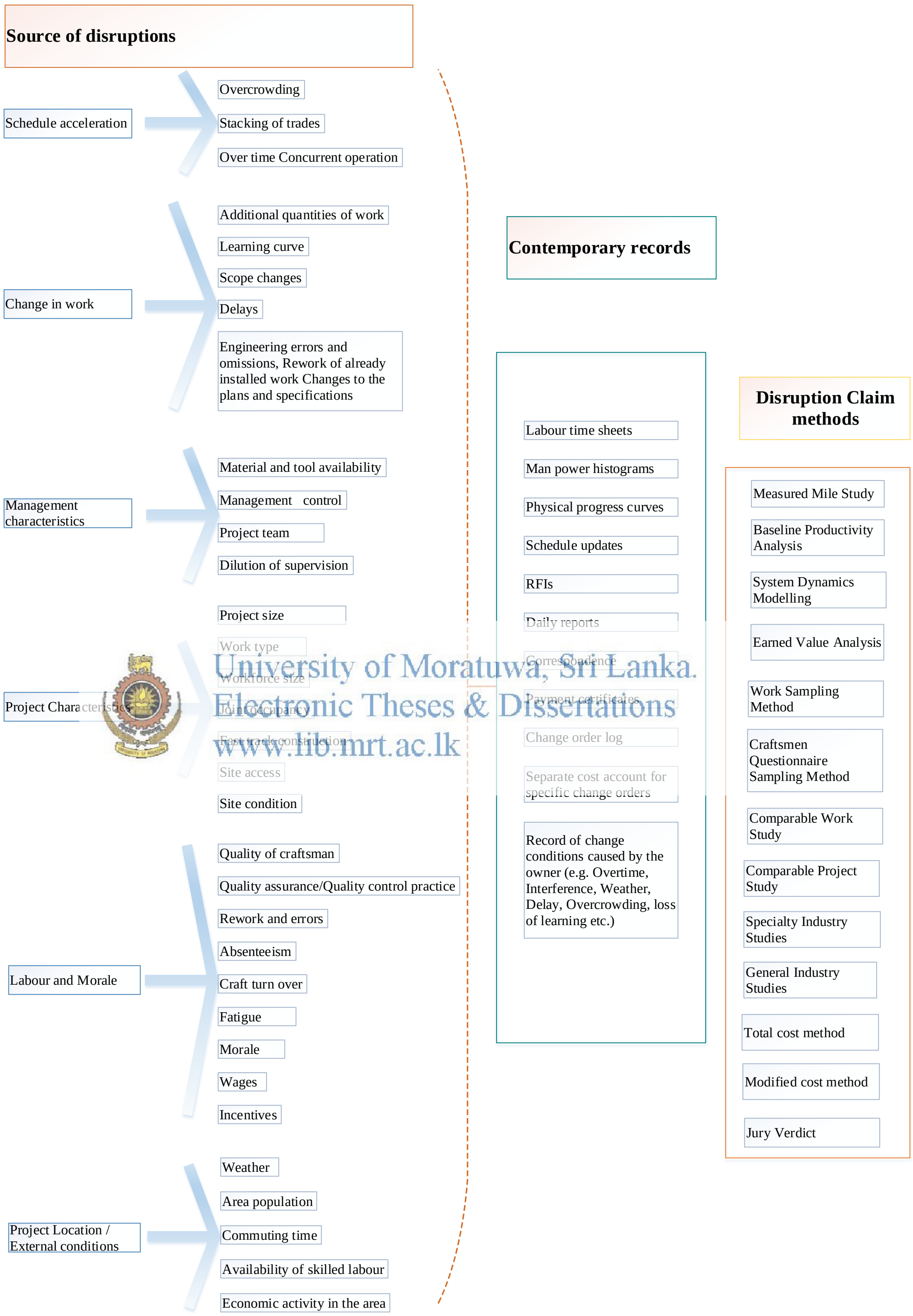
6. Finally, once lost productivity is calculated, it is still difficult to establish causation. Contractors tend to blame such losses on owners and ask to be compensated. Owners, on the other hand, often blame a Measurement and allocation of responsibility for loss of productivity can be difficult.

According to Braimahet al. 2007, following documents are used as effective documentary to success the disruption claims. They are;

a) Labour time sheets
b) Man power histograms
c) Physical progress curves
d) Schedule updates
e) RFIs
f) Daily reports
g) Correspondence
h) Payment certificates
i) Change order log
j) Separate cost account for specific change orders
k) Record of change conditions caused by the owner (e.g. Overtime, Interference, Weather, Delay, Overcrowding, loss of learning etc.)

According to Alwis 2010, most of the Contractors in Sri Lanka have less attitude to go for disruption claim even though they lose construction productivity because of repetitive tasks, stacking of trades and dilution of supervision and many more. Further, they identified sequence change, stop and start work and mental disruption due to non-continuous working as sources of disruption. It is important to note that the impact from each factors are vary from project to project, activity to activity and from crew to crew. In addition, many claims for loss of productivity fail because proper contemporaneous records do not exist. Project documents are important in demonstrating costs as well as causation.

Literature summary is as follows;



2.6. Summary

This chapter is described the disruption event in detail with identifying sources for the disruption events. There are many reasons for development of disruptions, however, some events can be claimable with constructing strong argument. According to above information, it is required that contemporary records when analyzing the disruption event with comprehensive claim methods such as measured mile, baseline productivity. Evidence shows that maintenance of contemporary record at construction industry is at a lower standard, hence, it is pointed that application of disruption claim analysis methods are at limited for certain methods.

CHAPTER THREE

Research Methodology

3.1. Introduction

This chapter outlines are described the methodology that was used by researcher. The discussion begins with reasons for the choice of overall methodology. Methodology contains Quantitative research approach and describe why it selected among other research approaches.

3.2. Approaches to Research

Research approach can be construed as a general plan of how researcher will go about answering the research question. (Tan, 2002). Furthermore, Smith, Thorpe, and Lowe, (2002) have stated that the research approaches help in organizing the research activities, including the collection of data, in ways that are more likely to achieve research aims. A simple method to choose the research approach is considering the starting word of the research question. If the research question starts with how / why qualitative approach would be appropriate whereas quantitative approach would be suitable if the question starts with who / what / where / how many / how much”. Apart from that method more logical methods can be descried as follows. Kumar (2011) have described qualitative approach is suitable if the researcher is interested in studying values, beliefs, understandings, perceptions, meanings, etc., whereas quantitative approach is suitable if the researcher focus to measure the magnitude of the variation (i.e. how many people have a particular value, belief?). Moreover, gathering factual data and studying relationships between facts and how such facts and relationships accord with theories and findings of any research executed previously are focused in a quantitative approach (Fellows et al., 2003; Yunus & Yang, 2011). The case study research is to investigate the contemporary phenomenon that has real-life context as well as when the boundaries between phenomenon and the context is not clearly defined (Yin, 2009). This research has quantitative approach since it deals with the numeric data to analysis the disruption event, and identify disruption claim in road construction projects in Sri Lanka during last five years.

3.3. Research Process

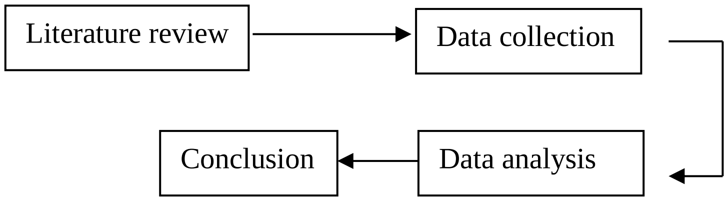


Figure 3.3; Research process

3.3.1 Literature review

A literature review report was a synthesis of information on a topic presented in an organized formal nature. Any investigation whatever the scale, which involve reading what other people have written about the area of interest in this specific research, gathering information to support or refute the arguments and writing about their finding. It is to provide evidence that the researcher has read certain amount of relevant literature and he also has some awareness of the current state of knowledge on the subjects (Bell, 1993 cited Yin). In firstly, identify the disruption events and claim situation in Sri Lankan construction industry. Therefore, books and journal papers are referred.

3.3.2 Research techniques for data collection

Data collection from the construction industry is carrying out to fulfill balance objectives which was remained under literature review. This research is focus to identify significance level disruption causes in construction industry during last five years. Therefore, questionnaire survey is recommended to follow as it is the best method available in research analysis.

3.3.2.1 Questionnaire

Questionnaire comprises with 1 to 5 Linkert scale and 1 represents the lowest value whereas 5 represents the highest values. Further, it is repeated for years of construction to collect data from construction industry during last five years. In addition, disruption sources identified under literature review were re-examined with industry experts to verify whether there are any other factors available at Sri Lankan context. However, it was found that listed disruptions are only applied in Sri Lankan road construction.

This questionnaire survey was conducted among the 53 construction contractors representatives those are directly involved in the civil/commercial disputes to obtain field information as field survey. However, 34 nos of contractor has responded and those details were analyzed in this research

3.4. Data Analysis

Data analysis was done through questionnaire analysis by analyzing the data of questionnaire by using the Relative Importance Index (RII).

The Relative Importance Index (RII) was adapted to rank the significance of disruption level according to impact level of each attribute. RII method transforms the findings of 5-point likert scale in such a way that facilitates ranking the sinificance (Tam et al., 2000). Accordingly, RII was calculated using the following formula:

$$RII = (\sum W)/(A*N)$$

Where,

W= weighting given to each dimension by the respondents

A=Highest weight in the scale

N=Total number of respondents

3.5. Conclusion and Recommendation

Based on the findings and objectives of the research, it is concluded research summary. This includes narratives version of factors considered in literature review to examine field information and final result of questionnaire after data analysis. Further, significance levels of disruption cause and claim methods differ from availability records are considered when making recommendations. These recommendations are suggested to implement in construction industry to mitigate impacts disruption causes. This will be helpful to strengthen contractor's financial viability. In addition, it is proposed to follow further research on this in order to educate industry on disruption events and establishment of proper methods to be followed by day to day site working.

3.6. Summary

The methodology and research instruments that applied are expected to provide input to analyze the disruption claims in construction industry during last five years. This is systematical and scientific way to evaluate all inputs and design the outputs based on provided objectives under the research. Quantitative research method of questionnaire was applied as a research method to this research. Conclusion and recommendation was made through the result and output of data analysis.

CHAPTER FOUR

Data Analysis

4.1. Introduction

This chapter is described about research findings on disruption events and disruption claim in Sri Lankan construction industry during last five years in detail after analyzing of data which was gathered through questionnaire survey. This analysis is interconnection with literature review and research objectives.

4.2. Occurrence of disruption events

Last five years, occurrence of disruption events were examined through questionnaire survey. As per Figure 4.2.1. Disruption Occurrence during last five years shows that there is dramatic increase of disruption occurrence. Major reason is that rapid development of road construction after the war and sudden cessation of projects.

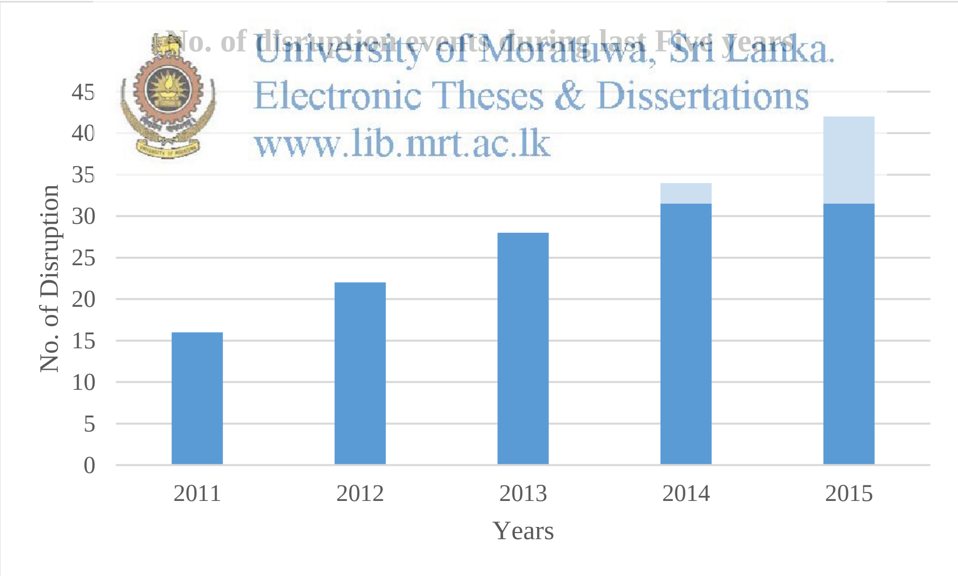


Figure 4.2.1. Disruption Occurrence during last five years

Furthermore, improper initial design, unavailability of proper feasibility report and other necessary report are major causes to increase disruptions. This situation was significantly impact when the Contractor seeks answers on productivity losses due to sudden cessation of projects.

4.3. Sources of disruption

Significance levels were examined under the six sub-headings; a) Schedule acceleration, b) Change in work, c) Management characteristics, d) Project characteristics, e) Labour and morale and f) Project location/External conditions.

4.3.1 Schedule acceleration

Schedule acceleration is required when the construction schedule for the project, or portion of the project, is shorter than what would be required to complete the work using normal sequences of construction on a normal working schedule. There are three methods to accelerate a schedule; overcrowding, stacking of trades and working overtime concurrent operation. As per received responses, Table 4.3.1 shows the level of significance of those three methods;

Table 4.3.1: Schedule acceleration

	Level of significance	
	RII	Rank
Over time Concurrent operation	82%	1
Overcrowding	61%	2
Stacking of trades	43%	3

Table 4.3.1. Schedule acceleration shows that Over time concurrent operation is widely disrupted to the project productivity. Usage of road while construction is one of reason for increasing of overtime concurrent operation. Overcrowding and stacking of trades are lower significance in road sector as there are enough locations to carry out operation without crowding.

4.3.2 Change in work

Civil construction is unique and final product cannot be expected as a line product (e.g. making a cake). It is always subject to changes. These changes are categorized as; additional quantities of work, learning curve, changes, delays, engineering errors/omissions and rework of already installed work. Table 4.3.2 shows the average level of significance against parameters listed above.

Table 4.2.2: Change in work

	Level of significance	
	RII	Rank
Delays	86%	1
Additional quantities of work	83%	2
Engineering errors/omissions	67%	3
Changes	60%	4
Learning curve	59%	5
Rework of already installed work	37%	6

Additional quantities of work and delay are the major significance factors for change in work as per Table 4.3.2. Change in work. Those factors cause disruption event frequently than the other. Rework of already installed work is the lowest factor while learning curve, changes, engineering errors and omissions are at medium significance for occurring disruptions.

4.3.3 Management characteristics

Supervision and proper management of labour, material and machinery is essential task to project success. Shortage of labour, material and machinery is severely affected on project productivity. Therefore, management and supervision through project team is important to reduce disruptions within the project. Hence, four management characteristic are deeply evaluated from questionnaire survey such as; material and tool availability, management control, project team and dilution of supervision. Average level of significance for management characteristics is shown on Table 4.3.3 as follows;

Table 4.3.3: Management characteristics

	Level of significance	
	RII	Rank
Dilution of supervision	87%	1
Project team	63%	2
Material and tool availability	58%	3
Management control	45%	4

Table 4.3.3. Management characteristics shows that management control is the least significance level to cause disruption in construction industry, impact dilution of supervision affects severely. Major reason is that management at ground level is played massive role in controlling labour, material and machinery toward the anticipated project progress. Material and tool availability, project team are medium significance level to cause disruptions.

4.3.4 Project characteristics

Difficulties and time for completion of project depends on project characteristics. Emerge of disruptions and effect to the project productivity are varied base on project characteristics. Therefore, certain factors are reviewed through questionnaire survey in order to identify the significance level related to cause disruption in construction industry. Those considered factors are project size, work type, work force size, joint occupancy, fast track construction, site access and site condition. Table 4.3.4 shows the average level of significance against parameters listed above.

Table 4.3.4. Project characteristics

	Level of significance	
	RII	Rank
Fast track construction	89%	1
Joint occupancy	81%	2
Workforce size	66%	3
Work type	61%	4
Site condition	59%	5
Project size	56%	6
Site access	38%	7

Fast track construction and joint occupancy are the major significance factors for project characteristics as per Table 4.3.4. Project characteristics. Those factors cause disruption event frequently than the other. Site access is the lowest factor while project size, work type, workforce size, and site condition are at medium significance for occurring disruptions.

4.3.5 Labour and Morale

Most of the construction projects, the largest single area of cost overrun is in labour cost. This is not surprising because labour is frequently the largest variable cost for a contractor. This is an oversimplification of the problems because labour overruns on a project can and do result from a variety of causes. Therefore, nine factors were examined in construction industry to identify the effects on disruption events. Those factors are quality of craftsman, quality assurance/quality control practice, rework and errors, absenteeism, craft turn over, fatigue, morale, wages and incentives. Average level of significance for labour and morale is shown on Table 4.3.5 as follows;

Table 4.3.5: Labour and Morale

	Level of significance	
	RII	Rank
Quality assurance/Quality control practice	86%	1
Quality of craftsman	82%	2
Wages	78%	3
Fatigue	69%	4
Absenteeism	63%	5
Incentives	61%	6
Craft turn over	56%	7
Morale	54%	8
Rework and errors	41%	9

Table 4.3.5. Labour and Morale shows that rework and error is the least significance level to cause disruption in construction industry, rather than quality of craftsman, quality assurance/quality control practice and wages are at the considerable significance level. Quality assurance and controlling process are prevention methods to identify unclouded areas initially without effect its damage to the project. Most of construction organization follows ISO standard and road specification while handling the project. Therefore, proper controlling quality control system, adverse effect of causing disruption event in respect to labour can be mitigated successfully. However, responses received from construction industry, it was observed that absenteeism, craft

turn over, fatigue, morale and incentives are affecting medium significance in construction industry.

4.3.6 Project Location/External conditions

Bottom layers of road construction, especially on soil involving activities such as embankment and shoulder construction requires dry weather conditions to compact the soil layers to prescribed limit under the specification. Further, functioning of existing road network while construction and finding competent human resources are considerable factors on project productivity. Therefore, identified factors under the literature were included in questionnaire survey to validate as per the industry. Those factors are weather, area population, commuting time, availability of skilled labour and economic activity in the area. Table 4.3.6 shows the average level of significance against parameters listed above.

Table 4.3.6: Project Location/External conditions

	Level of significance	
	RII	Rank
Weather	84%	1
Economic activity in the area	78%	2
Availability of skilled labour	68%	3
Area population	65%	4
Commuting time	62%	5

Weather and economic activity in the area are the major significance factors for project characteristics as per Table 4.3.6. Project Location/External conditions. Those factors cause disruption event frequently than the other. Area population, commuting time and availability of skilled labour are at medium significance for occurring disruptions.

4.4. Maintenance of Site records

Substantiation claim position depends on availability of relevant contemporary records at site to submit with claim. Acknowledgement of Engineer and properly documentation at claimable situations are expected from experience contractors. These records are evidences for representation of actual site picture to third parties. Therefore, it is important to verify whether there is availability of those records at site in order to process disruption claim. Hence, it is requested from respondent to provide significance of record maintenance at site in respect to records of labour time sheets, man power histograms, physical progress curves, schedule updates, RFIs, daily reports, correspondence, payment certificates, change order log, separate cost account for specific change orders and record of change conditions caused by the owner. Table 4.4 shows the average level of significance in record maintenance at site.

Table 4.4: Record maintenance at Site

	Level of significance	
	RII	Rank
Payment certificates	94%	1
Labour time sheets	67%	2
Daily reports	39%	3
Physical progress curves	34%	4
RFIs	31%	5
Schedule updates	29%	6
Change order log	27%	7
Man power histograms	25%	8
Correspondence	24%	9
Record of change conditions caused by the owner	23%	10
Separate cost account for specific change orders	20%	11

Table 4.4. Record maintenance at site shows that contractor record maintenance on special claimable case is at lower stage. As per responses, the lowest significance recorded as “Separate cost account for specific change orders”. Further, maintenance of correspondence, change order log, record of change conditions caused by the owner and man power histograms are at comparative lower significance level of record maintenance at site. Simultaneously, other records of physical progress curves, schedule updates, RFIs, and daily reports are at lower significant maintenance level. However, maintenance of payment certificate and labour time sheets are at higher significant level.

4.5. Usage of Disruption claim methods

Identification of disruption event separately from other work activities is quite difficult when many work activities are carried out simultaneously. Even though, it is possible to grab, then substantiation a disruption event depends on availability of contemporary records. However, there are eight disruption claim analysis methods and they require certain records to proceed the claim. Therefore, later part of questionnaire survey is focused on usage of those methods in construction industry during past five years. Table 4.5. shows the significance of usage of disruption methods of measure mile study, baseline productivity analysis system dynamics modeling, earned value analysis, comparison studies, industry-based methods, total cost method and modified cost method in detail.

Table 4.5: Usage of Disruption claim methods

	Level of significance	
	RII	Rank
Total cost method	69%	1
Industry-Based Methods	48%	2
Earned Value Analysis	46%	3
Modified cost method	38%	4
Comparison Studies	35%	5
Measured Mile Study	20%	6
Baseline Productivity Analysis	20%	6
System Dynamics Modeling	20%	6

Significance of usage of measure mile study, baseline productivity analysis and system dynamics modeling are minimum level. Those methods require detail of records to proceed the claim. However, as per Table 4.4, it shows that there is a deficiency of contemporary record availability at site to proceed the claim submission under these methods. Impact, other disruption analysis methods are also at the considerably lower level. According to above Table 4.5. Usage of Disruption claim methods. It reveals that there is less tendency in applying disruption claim against the project productivity losses in construction industry during last five years.

4.6 Summary

This chapter described the research findings and analysis base on received responses from questionnaire survey. During the last five years, disruptions has been increased dramatically in construction industry due to implementations of massive numbers of road projects within country. Subsequently, this situation was uplifted in case of sudden cessation of most of the project. However, significance levels of disruption occurrence, contemporary record keeping and claim application for disruption event is not acknowledged in the construction.

There are six identified major causes of disruptions were analyzed and found out their significance levels in construction industry. Acceleration by overtime operation, fast track construction and joint occupancy are at higher significance level in disruption occurrence. Furthermore, supervision of construction, engineering errors, additional work scope handling and delay in work make considerable impact on disruptions occurrence. In addition, major issues of poor workmanship and quality control system are deprived the anticipated productivity levels. Successively, adverse weather is played huge role to increase significance level of disruption occurrence.

Under these circumstances, industry has been failed to record these events in proper manner to establish claimable situations. Especially, correspondences against disruption events, RFIs, construction schedule update and maintenance with As-planned programme are at lower level. Therefore, claim submissions on disruption events with detailed substantiation methods such as measured mile study, baseline productivity analysis, system dynamics modeling is considerably neglectable. However, submission of total cost method is easy and used widely in construction industry even though it is not enough to substantiate the claims objectively.

CHAPTER FIVE

Conclusion, Recommendation & Further Research

5.1 Introduction

This chapter is summarized the principal findings and provides conclusions and recommendations. Three stages were used to describe chapter.

- Conclusion & Summarize of findings
- Recommendation
- Future research directions

5.2. Conclusions

Disruption is referred to loss of productivity while carrying out work. This is quite difficult to proof that even its shadow is visible. The main difficulty is that identify the sole disruption event from others. There are many sources behind disruption occurrence, however, some of them are lower significance of causing disruptions. Some are severely affected on project productivity. To claim those disruption events, contractor has to proceed with disruption analysis claim methods, but those methods require certain limits of records to initiate and calculate the amount. However, availability of contemporary record is now questionable.

According to the literature review, sources of disruption were identified under six sub-heading; a) Schedule acceleration, b) Change in work, c) Management characteristics, d) Project characteristics, e) Labour and morale and f) Project location/External conditions. On contractor's perspective, some of them above can be claimable which are directly passed the responsibility upon Employer or Engineer. By questionnaire survey, it was deeply reviewed and checked the significance level of occurrence in sources of disruption. Overtime concurrent operation was the highest significance level in schedule acceleration out of other factors of overcrowding and stacking of trades.

Highest significance in change in work category was additional quantities of work and delays. Learning curve, changes and engineering errors/omissions were second significance factors when rework of already installed work at the bottom level.

Management of project in a way to keep momentum of productivity level is a challenging task. Success depends on controlling of disruption occurrence while having management. Four factors were identified in literature survey as sources for disruption occurrence such as material/tool availability, management control, project team and dilution of supervision. Significance level of those factors were examined through questionnaire survey. It was recorded that dilution of supervision was the highest significance level in disruption occurrence other than material/tool availability, management control and project team.

Productivity varies with the project character and some of them are severely affected on project success. This aspect was examined through questionnaire survey and it was observed that joint occupancy and fast track construction are major significance level on disruption occurrence which ultimately cause productivity losses. Site access is minimum level of significance when project size, work type, workforce size and site condition are medium level significance in disruption occurrence.

Labour component of project play a significant role to complete project in timely and quality. However, there are many aspects of labour can be intervened with project productivity. Significance level of disruption occurrence was examined through questionnaire survey and it was identified that highest significance level are Quality of craftsman quality assurance/quality control practice, and wages. The lowest significance level of disruption occurrence on labour component is rework and errors. In addition, absenteeism, craft turn over, fatigue, morale and incentives are comparative higher significance level rather than rework.

One of determination factor for project success is that effect of external factors to the project. Some of them are severely affected on project productivity such as weather and economic activity in the area. Others; area population, commuting time and availability of skilled labour are comparatively lower effect on project productivity. Substantiate a claim is required evidences to proof the claim event. This may be a record that everyone can accept without any doubt. In literature, those records were identified, however, availability of those record at site is still questionable. Therefore, questionnaire survey was used to identify the what extent availability of those record at site. Under this survey, it was observed that the most availability record at site is payment certificates next to labour sheets, and daily report. Contrastingly, at lower availability records at site are correspondence, change order log, separate cost account for specific change orders, record of change conditions caused by the owner, and man power histograms. In addition, physical progress curves, and RFIs are also comparative lower availability at site.

Contractor suffer monetary losses from productivity loss due to various disruption causes. However, it is very difficult to compute and analyze of this loss from out of disruption events. As per details of disruption claim analysis method were described in literature survey, main reason is that most of disruption analysis method are required contemporary records to evaluate claim. Questionnaire survey was identified that maintenance of the most records at site are lower level which ultimately face huge difficulty in analysis of disruption claim. At this stage, usage of disruption analysis method in construction industry during last five years is questionable. Therefore, questionnaire survey was conducted in order to identified industry usage of those methods. According to the responses, most of the methods are at minimum level. Measured mile study, baseline productivity analysis and system dynamics modelling are the lowest usage. Total cost method is highest practice in the industry whereas earn value analysis, comparison studies, industry-based methods and modified cost method are medium usage. Total cost method is popular due to it is just presentation of actual cost and request a claim in whole and other method is required various documents to proceed the claim as submission elements.

In conclusion, there are many factors behind the productivity lose in construction industry and some of them are severely affected on project. Complex nature of individual identified of each disruption event and its effect to the project productivity loss, it is very difficult task to prepare proper claims. Even though, if it is identified, there is not adequate records at site to substantiate the case. During last five years, industry failed to maintain records at certain level that it requires from claim proceedings. Furthermore, it is hard to submit a claim, yet there are many comprehensive disruptions claim analysis methods are available. Hence, detailed disruption analysis methods of measured mile study, baseline productivity analysis and system dynamics modelling are at significant lower level usage in the industry. However, simple method of total cost method is practiced widely in order to process disruption claims.

5.3. Recommendations

It is a fact that Contractor is not paid for productivity loses, even though faults upon the Engineer or Employer. Based on the research findings, I propose following recommendations as mitigation measures.

- Project manager should establish daily planning systems one day before construction at site and incorporate daily views of supervisors and engineers in to that when the site is at acceleration programme, otherwise occurrence of disruptions and mitigation actions are very hard to control.

- Scope monitoring with original scope, recording of instruction of Engineers and delay events should be undertake by contract division and pass the responsibility upon especially project manager, quantity surveyors. They should provide early warnings and keep record the relevant records as per situations.

- Establish a team base system for particular work. For instances, earth work team, base construction team, asphalt team. This team comprises with site engineer, technical officers, supervisors and labours. They will specialize on particular work while they are handling same work again and again. Afterward, they will circulate among projects. This will be benefitted to industry to improve productivity level. Further, performance based assessment of their working and appreciation with monetary values are motivation factors to success this method.

- Establish an independent group with associate with site staff to grab the independent information to find out work norms. This will helpful to early identification of disruption events.

- Involvement of head office is essential to get their third comments and independent views. This will be great opportunity to find out early advices from their experiences.

5.4. Further research

This research identified that the industry is not ready to maintain proper record keeping system within their project implementations. This gap is still questionable, therefore, following suggestions are made for carrying out another research to find out best ways to improve industry.

- Identify a suitable method for record tracking system to capture contemporary record in record version. This can be check list to fill by site officers to verify that they have maintain the record properly.

- Identify a suitable method to document maintenance system when claim arise and it can be easily referred at claim submission stage.

Reference

- Alwis K.A.P.P., 2010. *Why there is a less number of disruption claims in the Sri Lankan construction industry?* Dissertation (B.Sc.). University of Moratuwa.
- Association for the Advancement of Cost Engineering (AACE) International, 2004. Estimating lost labor productivity in construction claims. AACE International Recommended Practice No. 25R-03.
- Braimah, N. and Ndekugri, I., 2008. Contractors and consultants' perceptions on construction project delay analysis methodologies. September 2008 COBRA Conference, Dublin, Ireland.
- Braimah, N., 2008. An investigation into the use of construction delay and disruption analysis methodologies. Ph.D. University of Wolverhampton.
- Bunni, N. G., 2005. The fidic forms of contract. 3rd ed. Great Britain: Blackwell Publishers.
- Carnell, N. J., 2005.Causation and delay in construction disputes. 2nd ed. Great Britain: Blackwell Publishers.
- Chappell, D. J., Smith, V. P. and Sims, J., 2005.Building contract claims. 4th ed. Great Britain: Blackwell Publishers.
- Cushman, R.F., Carter, J.D., Gormer, P.J. and Coppi, D.F., 2001. Proving and pricing construction claims [online]. Available from: http://www. Google books.lk [Accessed 12th November 2015].
- Davison, R. P. and Mullen, J., 2009. Evaluating contract claims. 2nd ed. Great Britain: Blackwell Publishers.
- Derek Nelson., 2011. The Analysis and valuation of disruption. *Journal of Hill International.*
- Derek Nelson., 2011. The Analysis and valuation of disruption. *Journal of Hill International.*
- Easterby-Smith, M. Thorpe, R. and Lowe, A., 2002. Management research: an introduction. London: Sage Publications.

- Eden, C., Williams, T. and Ackerman, F., 1998. Dismantling the learning curve the role of disruptions on the planning of development projects. *Journal of project management*, 16(3), 131-138.
- Eden, C., Williams, T. and Ackermann, F., 2005. Analysing projects cost overruns comparing the measured mile analysis and system dynamic. *Journal of project management*, 23, 135-139.
- Fellows, R. and Liu, A., 2003. Research methods for construction. 2nd ed. Great Britain: Blackwell publishers.
- Finke, M.R., 1998. A better way to estimate and mitigate disruption. *Journal of construction engineering and management*, 124(6), 490-497.
- Gulezian, R. and Samelian, F. Z. (2003) The Productivity Baseline. AACE *International Transactions*. AACE International, Morgantown, WV. EST.02.1- EST.02.4.
- Handling Prolongation and disruption claims Procurement practice guide, 2008. New South Wales government procurement system for construction, December 2008 .
- Hanna, A. S. and Gunduz, M., 2004. Benchmarking change order impacts on productivity for electrical and mechanical projects. *Journal of building and environment*, 40, 1068-1075.
- Hanna, A. S., Taylor, C. S. and Sullivan, K. T., 2005. Impact of extended overtime on construction labor productivity. *Journal of construction engineering and management*, 131(6), 734-739.
- Ho, S. P. and Liu, L. Y., 2004. Analytical model for analyzing construction claims and opportunistic bidding. *Journal of Construction Engineering and Management*, 130 (1), 94-104
- Horner, R.M.W. and Talhouni, B.T.,1995. Effects of accelerated working, delays and disruption on labour productivity. Charted Institute of Building.
- Ibbs, W. and Liu, M., 2005 a. Improved measured mile analysis. *Journal of construction engineering and management*, 131(12), 1249-1256.
- Ibbs, W. and Liu, M., 2005 b. System dynamic modeling of delay and disruption. *Journal of cost engineering*, 47(6), 12-16.

- Jayalath, C., 2009. Arguing construction claim. Colombo 10: S. Godage and Brothers (Pvt) Ltd.
- Jayalath, C., 2009. Dealing with disruption claims in nutshell [online]. Available from: http://www.articlesbase.com/authors/dr.-chandana-jayalath/172670.html [Accessed 21th October 2015].
- Jayalath, C., 2013. Arguing construction claims. 1st ed. Colombo: S. Godage & Brothers (Pvt) Ltd.
- Keating, D., May, A., Williamson, A. and Uff, J., 1991.Keating on building contracts. 5th ed. Great Britain: Sweet and Maxwell Publishers.
- Klanaca, G.P. and Nelson, E.L., 2004. Trends in construction lost productivity claims. *Journal of professional issues in engineering education and practice*, 130(3), 226-236..
- Lee, H. S., Ryu, H. G., Yu, J.H. and Kim, J. J., 2005. Method for calculating schedule delay considering lost productivity. *Journal of construction engineering and management*, 131(11), 1147-1154.
- Merritt, D., 2009.Factors to consider when preparing a disruption claim [online]. Available from: http://cmguide.org/archives/1867 [Accessed 21th October 2015].
- Norfleet, D.A., 2004. Loss of Learning in Disruption Claims. AACE International Transaction CDR.10.
- Pickavance, K., 2005. Delay and disruption in construction contracts. 3rd ed. Great Britain: MPG Books Publishers.
- Prentice M. O., 2005. Successful delay and disruption claims: presenting the claim [online]. Available from: http:// www.mop.ie [Accessed 24th July 2015].
- Priyantha T.H.S., Gayani Karunasena and V.A.K. Rodrigo., 2011. Causes, Nature and Effects of Variations in Highways. *Built - Environment - Sri Lanka - Vol. 09 - 10, Issue 01 – 02.*
- Rayes, K. E. and Moselhi, O., 2001. Impact of rainfall on the productivity of highway construction. *Journal of construction engineering and management*, 127(2), 125-131.

- Schwartzkopf, W., 2004. Calculating lost labour productivity in construction claims [online]. Available from: http://www. Google books.lk [Accessed 10th November 2015].
- The Society of construction law, 2002. Delay and disruption protocol [online]. Available from: http://www.scl.org.uk [Accessed 26th July 2015].
- Thomas, H. R. and Sanvido, V. E., 2000. Role of the fabricator in labor productivity. *Journal of construction engineering and management*, 126(5), 358-365.
- Thomas, H. R., and Završki, I., 1999. Construction baseline productivity: Theory and practice. *Journal of construction engineering and management,* 125(5), 295-303.
- Thomas, H. R., Mathews C.T. and Ward J. G., 1986. Learning curve models of construction productivity. *Journal of construction engineering and management*, 112(2), 245-258.
- Yin, R. K., 2009. Case study research-design and methods. 3 rd ed. New York: Sage Publications.
- Yogeswaran, K., Kumarasawamy, M.M. and Millar, D.R.A., 1998. Claims for extensions of time in civil engineering projects. *Journal of construction management and economics*, 16, 283- 293.
- Zink, D. A. (1990) The measured Mile: Proving Construction Inefficiency Costs. *Journal of Cost Engineering*, Vol. 28, No. 4, pp. 19-21.

Appendices

QUESTIONNAIRE SURVEY

ANALYSIS OF DISRUPTION CLAIM IN CONSTRUCTION INDUSTRY DURING LAST FIVE YEARS

Dear Sir/Madam,

I am sandun K.K., following M.Sc. in Construction Law and Dispute Resolution, in Department of Building Economics, University of Moratuwa. My research based on above topic is conducted under the supervision of Dr. Gayani Karunasena, Senior lecturer, Department of Building Economics, Faculty of Architecture, University of Moratuwa. The result of this survey would be essential for the successful completion of my dissertation.

Completion of the questionnaire would take approximately 15 minutes and all the questions can be answered with minimum effort. Further, I personally assure that all information obtained would be treated to the strictest confidential and only intended for the use of the analysis in this study. All the data will be considered on aggregated basis and no individual data will be published.

I would be much obliged to you if you could kindly allocate some time to read this questionnaire and participate by being one of my respondents to help me in this research. Your contribution is highly appreciated.

Thank you.

Yours faithfully,

....

Sandun K.K.
M.Sc Student,
Department of Building Economics,
Faculty of Architecture,
University of Moratuwa.
T.P. 0718194689
E-mail: Sandunkk@yahoo.com

Dr. Gayani Karunasena
Senior Lecturer,
Department of Building Economics,
Faculty of Architecture,
University of Moratuwa.
T.P. 0112650738
E-mail: gayanik@uom

…../…../2015

General Information

1. Name of Respondent: …………………………………………………
2. Position within organization: ………………………………………….
3. Name of the organization: …………………………………………….
4. Organization:

   Civil Engineering Construction ☐ Building Construction ☐

5. Years of Experience in claim preparation:

   0 - 5 years ☐ 10 - 15 years ☐

   5 - 10 years ☐ More than 15 years ☐

Please state the actual numbers of disruption occurrence during last five years						
No	Years	**2011**	**2012**	**2013**	**2014**	**2015**
1	How many disruption events were occurred during a year?					

"**Loss of productivity** is defined technically as "**Disruption**" while increasing cost of performance caused by a change in the contractor's anticipated or planned working conditions, resources, or manner of performing its work".

Causes for disruption are sources for disruptions.

Finding out the significant of disruption events frequently occurrence of and its significant in construction industry during last five years.

Please state the significant of each causes by ticking (√) in the applicable places from 0 to 5.																										
No.	**Disruption sources**	**2011**					**2012**					**2013**					**2014**					**2015**				
		1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
		Not significant	**Slightly significant**	**Significant**	**Very significant**	**Extremely**	**Not significant**	**Slightly significant**	**Significant**	**Very significant**	**Extremely**	**Not significant**	**Slightly significant**	**Significant**	**Very significant**	**Extremely**	**Not significant**	**Slightly significant**	**Significant**	**Very significant**	**Extremely**	**Not significant**	**Slightly significant**	**Significant**	**Very significant**	**Extremely**
1	**Schedule acceleration**																									
1.1	Overcrowding																									
1.2	Stacking of trades																									
1.3	Over time Concurrent operation																									

Please state the significant of each causes by ticking (√) in the applicable places from 0 to 5.

No.	Disruption sources	2011					2012					2013					2014					2015				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely
2	**Change in work**																									
2.1	Additional quantities of work																									
2.2	Learning curve																									
2.3	Changes																									
2.4	Delays																									
2.5	Engineering errors and omissions																									
2.6	Rework of already installed work Changes to the plans and specifications																									
3	**Management characteristics**																									
3.1	Material and tool availability																									
3.2	Management control																									
3.3	Project team																									
3.4	Dilution of supervision																									
4	**Project Characteristics**																									
4.1	Project size																									
4.2	Work type																									
4.3	Workforce size																									
4.4	Joint occupancy																									
4.5	Fast track construction																									

Please state the significant of each causes by ticking (√) in the applicable places from 0 to 5.

No.	Disruption sources	2011					2012					2013					2014					2015				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely
4.6	Site access																									
4.7	Site condition																									
5	**Labour and Morale**																									
5.1	Quality of craftsman																									
5.2	Quality assurance/Quality control practice																									
5.3	Rework and errors																									
5.4	Absenteeism																									
5.5	Craft turn over																									
5.6	Fatigue																									
5.7	Morale																									
5.8	Wages																									
5.9	Incentives																									
6	**Project Location /External conditions**																									
6.1	Weather																									
6.2	Area population																									
6.3	Commuting time																									
6.4	Availability of skilled labour																									
6.5	Economic activity in the area																									

Finding out the significant maintenance of site documents which can provide as evidence of disruption claim or apply with disruption claim analysis calculations in construction industry during last five years.

Please state the significant of each causes by ticking (√) in the applicable places from 0 to 5.

No.	Maintenance of Site records	2011					2012					2013					2014					2015				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely
1	Labour time sheets																									
2	Man power histograms																									
3	Physical progress curves																									
4	Schedule updates																									
5	RFIs																									
6	Daily reports																									
7	Correspondence																									
8	Payment certificates																									
9	Change order log																									
10	Separate cost account for specific change orders																									
11	Record of change conditions caused by the owner (e.g. Overtime, Interference, Weather, Delay, Overcrowding, loss of learning etc.)																									

Finding out the significant usage of disruption claim analysis methods in order to calculate disruption entitlement under disruption events in construction industry during last five years.

Please state the significant of each causes by ticking (√) in the applicable places from 0 to 5.

No.	Usage of Disruption claim methods	2011					2012					2013					2014					2015				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
		Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely	Not significant	Slightly significant	Significant	Very significant	Extremely
1	Measured Mile Study																									
2	Baseline Productivity Analysis																									
3	System Dynamics Modeling																									
4	Earned Value Analysis																									
5	Comparison Studies																									
6	Industry-Based Methods																									
7	Total cost method																									
8	Modified cost method																									