A STUDY ON REWORK DUE TO DESIGN CHANGES IN INFRASTRUCTURE PROJECTS IN MALDIVES

Aminath Zidhna

(158831H)

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Department of Building Economics

University of Moratuwa
Sri Lanka

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DECLERATION OF THE CANDIDATE AND SUPERVISOR

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DEDICATION

I dedicate this research to my loving Mother Fathimath Idrees

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ABSTRACT

Rework is experienced in every construction project and it impacts projects performance severely. Reduction of rework had always received special attention construction industry. Researchers have identified that a rework event may occur at any phase of the construction project. Rework due to design components are common in construction project. The aim of the research was to reduce rework due to design changes in infrastructure project in Maldives and overcome those causes.

In this research, 28 causes of design changes were identified from previous work of researchers. After identifying the causes, the causes classified in to 8 groups with a design changes classification model. The research indicated that changes to scope by the client and changes to design schedule by the client as the most likely causes of design changes in civil infrastructure projects in Maldives. Moreover, it was found that the client as the major source of design changes.

The research used a mixed method design approach as a research methodology. To investigate the causes of design changes, a survey questionnaire was developed to identify the most likely causes of design changes from construction professionals in Maldives. Furthermore, to explore the collected quantitative data the researcher approached construction professional's expert in the industry to understand and discovered the reasons for the causation of design changes and to identify activities to minimize the occurrence of the design change causes.

The mostly likely cause of design changes in infrastructure projects in Maldives was, changes to scope by the client. Also, the client related causes were found as the major contributing group to design changes in infrastructure projects in Maldives. Hence, client, design consultant and constructors should emphasize to study thoroughly project background, review design drawings and design documents in the designing phase.

Keywords: Rework, Causes, Design Changes, Infrastructure Projects

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List of Abbreviation

AGO	Auditor General office - Maldives
CBO	Congressional Budget Office - United States
MHI	Ministry of Housing and Infrastructure - Maldives
TPC	Total Project Cost
RII	Relative Importance Index
APCC	Australian Procurement and Construction Committee
CIDA	The Australian Construction Industry Development Agency
GDP	Gross Domestic Product
BOQ	Bill of Quantity
PLC	Project Life Cycle
COAA	Construction Owners Association of Alberta, USA
PTC	Project Total Cost

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CHAPTER ONE

INTRODUCTION

1.1 Background

Infrastructure is "The system of public works of a country, state, or region; also; the resources (such as personnel, buildings or equipment) required for an activity" (Merriam-Webster, 2017). These are known as capital goods which are not consumed directly but with a combination of other inputs like labor. The main purpose of these infrastructure is to provide a service; indeed, what matter is the service.

Every year the governments allocate and spend hundreds of billions of dollars for capital infrastructure development. According to United States (US) Congressional Budget Office (CBO) in 2014, in US, for transportation, drinking water and wastewater infrastructure, 416 billion dollars were spent. In 2013 the government of Maldives spend 4.2% of the total government spending on capital projects (AGO, 2016). Nevertheless, schedule overrun and cost overrun has become a common behavior in infrastructure projects (Shah, 2016) and the reason for this phenomenon is rework (Simpeh, Ndihokubwayo, Love and Thwala, 2015).

Rework has been defined by many researchers with respect to their study context. Terms like quality deviation (Davis, Ledbetter & Burati, 1989; Burati, Farrington, & Ledbetter, 1992), non-conformance (Abdul-Rahman, 1995), defects (Josephson & Hammarlund, 1999) and quality failures (Barber, Graves, Hall, Shearth & Tomkins, 2000) are interchangeable words for rework in construction industry. Love and Edward (2004) define rework as 'unnecessary effort of re-doing a process or activity that was incorrectly implemented the first time'. Fayek, Dissanayake and Campero (2003) define rework as "activities in the field which have been completed but were required to be repeated or undertaken again as a result of some impeding correction that was necessary to be carried out during the project regardless of source, or effecting a change order not due to change of scope by the owner". A mutually

agreed definition of rework among the researchers is hard to find, however, rework is repeat work but the definition depends on the context that the rework is done. (Taggart, Koskela and Rooke, 2014).

Rework in construction projects maybe due to many factors. According to Davis, et al. (1989) the five main sources that cause construction rework are; client related, design related, constructor related, vendor related and transporter related. Love, Smith and Li (1997) states the people, design and construction are the main causes of rework. Hwang, Thomas, Haas and Caldas (2009) reported that, many researchers have suggested that rework is often due to complicated characteristic of construction projects. Researchers agree that to address rework accordingly, it is necessary to classify and identify the root sources and causes of rework. The rework classification system adopted by Burati et al. (1992) boils down rework causes in to two phases; design and construction. Another rework causes classification system was adopted by Fayek et al. (2003) with five main causes; human resource capacity, leadership and communication, engineering and reviews, construction planning and scheduling and as the fifth one, material and employment supply. The design changes classification system developed by Yap, Abdul-Rahman and Wang (2016) list down five main sources for rework due to design changes.

Rework in construction projects are common and the consequences are severe. The actual causes of rework in construction industry is numerous and hard to weight their impact (Get It Right Initiative, 2016). In infrastructure projects in Australia, total rework costs were found to be 10.29% (Love, Edward, Watson & Davis, 2010). Forcada, Rusiñol, MacArulla & Love (2014) state that in civil infrastructure projects, the contract value increase by 16.5% due to rework and some of the rework were due to design changes. US Construction Industry Institute (CII) (2005), due to rework, the total cost of project increases by an average 5%. An audit carried out by Auditor General Office of Maldives (AGO, 2016) confirmed that, cost overrun of the completed infrastructure projects was MVR 124 million (8.06 million dollars). Some of the causes for the cost overrun in Maldives were identified as; changes to design due to faults identified in construction phase, later changes to scope of the projects,

poor quality of material, architectural design non-conformance to Male' planning regulation, missing design documents and late changes to design documents (AGO, 2016). Rework due to theses causes are not a desirable outcome since it increases the cost and schedule of project wasting limited resources.

From AGO (2016) report, it indicate, rework events are common in infrastructure projects in Maldives. It is important to identify the causation of rework to reduce rework events in infrastructure projects in Maldives. The study presented in this research, uses multiple stakeholders of construction professionals in Maldives who were involved in infrastructure projects to identify and to examine the likelihood of occurrence of the causes of design changes that lead to rework events. Forcada, Gangolells, Casals and Macarulla (2017), suggest that by identification of rework causes prior to the start of construction phase, could reduce rework.

1.2 Research Problem

Expansion of population, economies growth and more people becoming urbanized, increased the demand for infrastructure (systems and structures) in Maldives. Hence, the government of Maldives is concerned for the low performance in infrastructure projects due to rework which apparently hinder utilization of public fund appropriately, which result to a waste of limited resources (AGO, 2016). Therefore, it is necessary to identify the causes that leads to rework events in order to address the causes to reduce rework in infrastructure projects in Maldives. It is important to understand the actual reasons for the occurrences of the causes to reduce rework events. Also, identifying the activities that can be incorporate in to construction projects, can overcome the rework issue. Therefore, this research focus to investigate rework due to design changes. Furthermore, the research attempts to identify the reasons and activities to reduce rework due to design changes in infrastructure projects in Maldives.

1.3 Aim of the research

The aim of is this research is to investigate rework due to design changes in infrastructure projects in Maldives.

1.4 Objectives of the research

The objectives of this research are;

1. Review the concept of construction rework and establish the significance of design changes in leading to construction rework
2. Identify the causes of design changes that lead to rework in infrastructure projects
3. Investigate the reasons for causation of design changes that lead to rework in infrastructure projects in Maldives.
4. Identify activities to minimize causation of design changes that lead to rework infrastructure projects in Maldives.

1.5 Research methodology

A comprehensive literature review was carried out initially to understand the concept and current knowledge of construction rework, tools to identify causes of design changes to reduce rework in infrastructure with reference to books, journals, dissertation, websites and other publications. A mixed method approach was used to collect data from construction professionals in Maldives who were involved in infrastructure projects. In this research, the researcher used a questionnaire survey and expert interviews to collect primary data. Chapter 3 will explain the selected research approach and methodology in extra detail.

1.6 Scope and limitations

This research intent to investigate the rework in infrastructure projects in Maldives administered by the government. Hence, the research is based on rework with respect to design changes.

1.7 Chapters Breakdown

Chapter 1 provides an introduction to the background of the research, research aim, and research objectives. The need and justification of this research and an overview of in to the methodology is provided.

Chapter 2 is the of literature review, which provides in-depth literature findings on rework and design changes in construction industry and infrastructure projects. This chapter explore rework and design changes classification system adopted by different authors.

Chapter 3 describe the research methodology. There are various options in order to conduct empirical research. The chapter discuss the methods that is most appropriate for this research and why the specific approach selected.

Chapter 4 provide an analysis of data and research findings. To present the findings, charts and tables were utilized.

Chapter 5 provides the conclusions and recommendations. Furthermore, suggestions for further research were outlined.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The literature review in this chapter give an overview of construction industry performance and then provide a thorough review of relevant studies and publications to the research problem including causes of design changes, classification of design changes and impact of design changes on construction projects.

2.2 The Construction Industry

The construction industry belongs to a tertiary activity, with a main purpose of providing a service to the users. It is expected that the global construction output would grow at an average of 2.8% a year from 2017 to 2021 (Timetric, 2017). Construction industry increases the Gross Domestic Product (GDP) regardless whether a country is developed or under developed (Olanrewaju & Abdul Aziz, 2015). The industry contributes 5% to 10% to the GDP (Igor, 2010). According to Othman (2011), the industry count on to provide the essential building for housing, education, culture, medication, business, leisure and entertainment. Hence, the industry constructs the infrastructure structures that serve the citizens and facilities to perform their intended functions (Othman, 2011). This makes the industry intertwined with the government, since the government is the dominant infrastructure service provider in all the countries (Kenney, 2007). Therefore, these infrastructure impacts the social and economic development at national and international levels (Othman, 2011).

Infrastructure systems or public infrastructure assets are vital for every nation for the economic development and prosperity. (IVESTPODIA, 2017). The infrastructure includes physical components which could be systems and structures. For example, transport infrastructure is a structure and IT infrastructure is a technical system which

is also referred to as an infrastructure. These investments are high cost investment. Every year a portion from national budget is utilized for infrastructure development in order to provide a decent living for the citizens, to develop essential service building, to develop other infrastructure to facilitate smooth operation in that would be utilized by other industries too. In 2013, the government of Maldives spend 4.2% from total budget for infrastructure projects (AGO, 2016). The Australian government commit to spend over 75 billion dollars for country across transport infrastructure in the coming ten years. (Department of Infrastructure, Regional Development and Cities, Australia, 2016). The traditional approach, the government led and hierarchically provision has been replaced by the public-private partnership approach (Wiewiora, Keast & Brown, 2016). Wiewiora, Keast and Brown, (2016) it is believed, the changing delivery approach of infrastructure services would support to build infrastructure which is compatible with user's actual needs avoiding wasteful structures and systems.

In construction industry, projects often experience delay and cost overrun. It has become a norm and a culture that the industry has accepted this phenomenon (Simpeh et al., 2015). Rework has become a primary reason for delay, cost overrun, low performance or repeated failures in construction projects. (Love, Mandal &Li., 1999; Love., 2002; Love & Edward., 2004; Palaneeswaran, Love, Kumaraswamy & S.T. Ng., 2008; Jadhav & Patil., 2015; Forcada, et al., 2017).

2.3 Definition of Rework in Construction Industry

The Australian Construction Industry Development Agency (CIDA) (1995), define rework as "doing something at least one extra time due to non-conformance to requirement". Love and Edward (2004) define rework as "unnecessary effort of re-doing a process or activity that was incorrectly implemented the first time". Fayek et al. (2003) define rework as "activities in the field which have been completed but were required to be repeated or undertaken again as a result of some impeding correction that was necessary to be carried out during the project regardless of source, or effecting a change order not due to change of scope by the owner". The

rework definition can be expressed with consideration to the context, nevertheless it involves repeat work (Taggart et al., 2014). Therefore, it is important to understand the context of the terms used to describe rework to collect accurate, complete measurements and cost determinations to develop strategies to reduce rework occurrence (Mills, Love & William, 2009). However, for the purpose of the research, the operational definition for rework is the definition given by Love and Edward (2004), "unnecessary effort of re-doing a process or activity that was incorrectly implemented the first time".

Burati et al. (1992) reports that in construction projects, rework usually occur due to design component or construction component (refer Table 2.1).

a. Design Component

In construction projects the design component involves the development of the design and design related documents including working drawings, design technical specification, Bill of Quantity (BOQ) and schedule of work, (Abdul-Rahman, Chen & Hui, 2015).

b. Construction Component

In construction projects, the constructions component is referred as the fieldwork, the making of the actual structure represented on the design documents (Fayek et al., 2003). According to CII (2005) due to fieldwork rework, a 10% increase of cost in construction-phase is observed in major construction projects.

As most of the researchers agrees if design component carried out properly, projects can avoid rework due to design changes and furthermore, it would reduce rework in construction process (Li and young, Love, 2011 and Love et al 1999). Fayek et al., (2003) recommends to increase emphasis during design phase to avoid fieldwork rework. Li and Taylor (2011), if design errors, omission and changes are discovered during design phase, project rework cost can be minimized. This is because to correct the design and construction mistakes respect to the design, involves sizeable direct and indirect cost than to correct it during the design phases (Li & Taylor, 2011 and

Dell' Isolla, 1997). As a result, identifying design errors during design phase would reduce the overall cost of project (Li & Taylor, 2011).

In view of these findings by the researchers, as the design component plays a pivotal role in creating rework event in infrastructure projects, this research focus to study reduce rework in infrastructure projects due to design changes.

2.4 Definition of Design Changes

Abdul-Rahman et al. (2015) define design changes as "any changes on the design or construction of a project after the contract is awarded and signed". According to Li and Taylor (2010), design changes can be two types. Type one is, design that is not in initial scope but has to rework to meet the requirement of client or achieve the project function, and type two is, errors or omissions identified in design after the approval of final design. In this research, design refers to design drawings and technical specifications that are used infrastructure projects. Design change definition for this research is, any regular additions, omissions and adjustment to the design after the approval of design which effects original scope of the project, project cost, project schedule and quality of the project.

2.5 Impact of Design Changes in Construction Projects

The design changes can have massive negative impacts on construction projects (Love, 1999). Researchers have shown their interest finding ways to avoid rework due to design changes (Yup, Abdul-Rahman & Wang, 2016). Past researchers have identified several causes of rework in construction projects (Shah, 2016) and all the causes of design changes have been identified, that no new causes have not emerged during the recent years (Yup et al., 2016).

Despite knowing the causes of design changes, construction companies have fail to reduce rework due to design changes (Yup et al., 2016). Yup and Abdul-Rahman (2015), such failures have created negative consequence in project organization and in the construction industry as a whole. The impacts can be recognized in terms of

cost and schedule (Love, 2002 and Shah, 2016), material waste (Bekr, 2014) and dispute (Forcada et al., 2014; Love & Edward 2004).

a- Schedule and Cost overrun

Constant design changes create a huge impact on project cost (Sidney, Skitmore & Love, 2014). A case study done on Australian residential apartment blocks found out that, rework caused the mean schedule overrun by 20.7% and most of the rework occurred due to poor contract documentation of design documents, omission, error and inconsistencies in design and contract document (Love, 2002). In 2016 an Audit was carried out by Auditor General Office (AGO) of Maldives, to examine construction capital projects from 2008 to 2013. The audit examines a sample of 50 projects valued as MVR 1.07 billion. From the selected 50 samples, 28 projects were completed by the time of the audit. The cost overrun of the completed infrastructure projects was MVR 124 million (AGO, 2016). Some of the causes of rework were due to constructability issues in design identified in construction phase, later changes to design due to change of scope of buy the client, poor quality of material in design specification, architectural design not conformance to Male' planning regulation, missing design documents and late changes to design documents due to inaccuracy (AGO, 2016).

A study done by Al-Hazim, Salem and Ahmad (2017) on Jordan infrastructure projects, confirmed that some of the factors that contribute escalation of cost and schedule overrun was due to rework created from mistakes in design and specification. It was estimated that rework cost overrun and schedule overrun was an average of 214% and 226% respectively (Al-Hazim et al., 2017).

b- Material Waste

Material wastage due to rework is one indicator that can weigh the magnitude of rework in construction project (Bekr, 2014; Koskela, 1992). Koshy and Apte (2012) defined waste as any losses produced by activities that generate direct or indirect

costs but do not add any value to the product from the point of view of the client. In a construction project, all material waste is not due to rework. For example, waste created in construction site due to demolition and land excavation are not construction waste (Bekr, 2014).

A clear analysis should be taken to identify the causes of material waste in order to find portion contributing to rework in construction project. Material waste in rework can be in two forms; direct and indirect (Koskela, 1992). Koskela (1992) states that direct form of material waste is which are damage during building process and the indirect material waste as a monitory loss where the material is not physically lost. In the survey carried by Bekr (2014) respect to waste material in Jordan construction industry, it was confirmed that the top three causes of waste material was due to changes to design, rework due to workers mistake and poor contract documentation.

c- Disputes.

Scope uncertainty and less involvement of contactors during design stage, increases the probability of rework due to design changes, ultimately leading to a dispute between client and constructors (Forcada et al., 2014). This increase the cost of the project as well jeopardize the image of the construction company limiting the future endeavors.

Australian Procurement and Construction Committee (APCC) (1997) call the causes, the symptoms of rework. Identifying and addressing the rework incidents is not a solution for rework (Burati et al. (1992). According to Burati et al. (1992) and APCC (1997), the most effective way of addressing rework causes is by identifying and classifying the root sources of the causes and focusing on to taking preventative measures to reduce rework in a proactive manner.

2.6 Classification of rework

The first step to avoid or minimize rework is to identify and classify factors or sources contributing to the causes of rework. (Hwang et al., 2009). Causes of rework in construction project are due to certain factors (Davis et al., 1989). Table: 2.1 shows rework classification system of Burati et al. (1992). Rework can occur in any stages in construction Project Life Cycle (PLC); either design phase or construction phase (Burati at el., 1992). He then subdivided these two phases in to 4 type deviations. They are change, error, omission and damage. The classification system of Burati et al. (1992) is an extended version of O' Conner and Tucker (1986), Farrington (1987) and Davis et al. (1989).

Table 2.1. Rework Classification System

Category	Type	Tertiary	Causes of Rework
Design	Change	Construction	A change is made at the request of the contractor.
		Client/client rep	A change made by the client/clients' representative to the design
		Occupier	Design changes initiated by the occupier
		Manufacture	A change in design initiated by a supplier/manufacture.
		Improvement	Design revision, modifications and improvements initiated by the contractor or subcontractor.
		Unknown	The source of the change could not be determined, as there was not enough information available. Discussion with the project manager does not reveal the cause.
	Error		Errors are mistakes made in the design.
	Omission		Design omission results when a necessary item or component is omitted from the design.
Construction	Change	Construction	A change in the methods of construction in order to improve constructability.
		Site condition	Changes in construction methods due to site conditions.
		Client/client rep	A change made by the client/client representative after some work has been performed on-site.
		Occupier	Occurs when a product or process has been completed.
		Manufacture	Process or product need to be altered/rectified
		Improvement	Contractor request to improve quality
	Error		Construction errors are the result or erroneous construction methods or procedures.

	Omission		Construction omissions are those activates that occur due to omission of some activities.
	Damage		Damage may be caused subcontractor or inclement weather.

Source: (Burati et al., 1992)

Love et al. (1999) and Fayek et al. (2003) too acknowledges the rework classification system by Burati et al. (1992), O' Conner and Tucker (1986), Farrington (1987) and Davis et al. (1989), but argues that other than design process and construction process, there are other factors that leads to rework in construction projects. Study done by Love et al. (1999), promotes to view projects in a system perspective. They explained the interrelationship among the sub-systems of a project. The three most important sub-systems are "human resource sub-system", "technical operational sub-system" and "quality management sub-system", where each subsystem compose of influencing factors that leads to occurrence of rework (Love et al., 1999). They concluded, the longer the rework event goes unnoticed, the impact on cost, schedule and quality of the project becomes higher.

The classification system (Causes and Effect) in Figure 2.1 was developed by Fayek et al. (2003) for Construction Owners Association of Alberta (COAA), USA. This fishbone diagram consists of five distinct sources of rework and four possible causes for each category.

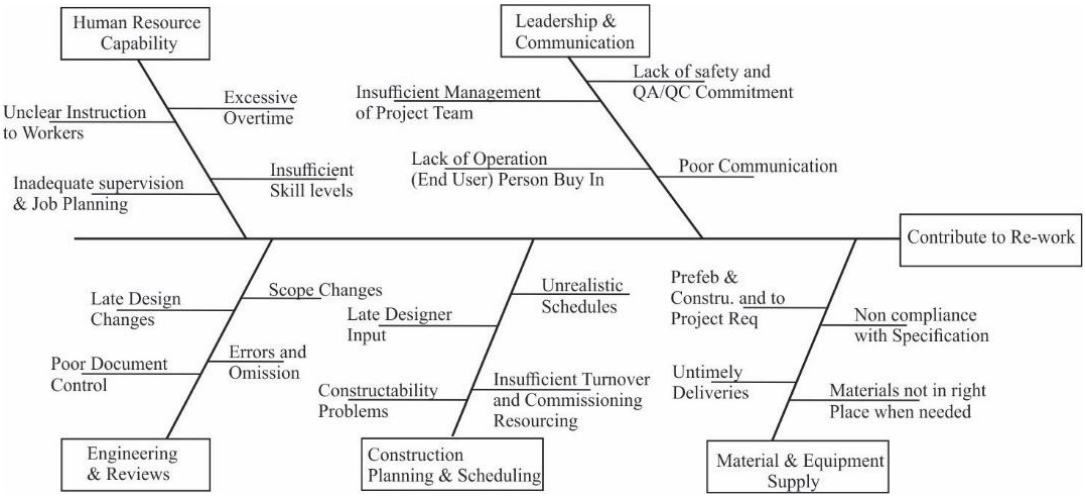

Figure 2.1: Fishbone Classification Model of the Causes of Rework

Source: (Fayek et al., 2003)

Fayek et al. (2003) used this fishbone diagram in a pilot study, to identify the most significant causes of field rework in Alberta Construction Industry. The study fortified, that the probability of rework occurrence in field is high due to factors related to design component. For example, late input to project design for a client request or due to constructability issue noticed in construction phase. Fayek et al. (2003) recommended that by practicing standard procedures like Value Engineering (VE) can minimize the impact of rework related to design component and can minimize constructability issues too. However, the work of Fayek et al. (2003) is remarkable because the findings provide a new perspective for the classification of rework causes for construction projects. Love and Edward (2004) acknowledges the work of Fayek et al. (2003) but group the root sources of rework in to people or parties of the construction project, which are client related, designer related and contractor related factors including subcontractor too.

As the rework classification systems developed by Burati et al. (1992), Fayek et al. (2003) and Love and Edward (2004) include “design” as one factor or a source that create rework in construction project. Consequently, from the work of these researchers in indicates, by giving considerable attention to the “design” component, rework can be reduced to a greater extent in construction projects.

2.7 Classification of Design Changes

Love, Holt, Shen, Li and Irani (2002) states that in construction project, design changes are created due to external and internal elements. Yap et al. (2016) developed the fishbone diagram in Figure 2.2 acknowledging the work of Love et al. (2002). This framework is a map to manage causes of design changes that leads to construction rework. The diagram consists of external and internal factors. The generic causes and effect diagram, classifies the causes of design changes in to five main sources namely; design related, client related, project related contractor related and external related. (Yap et al. 2016).

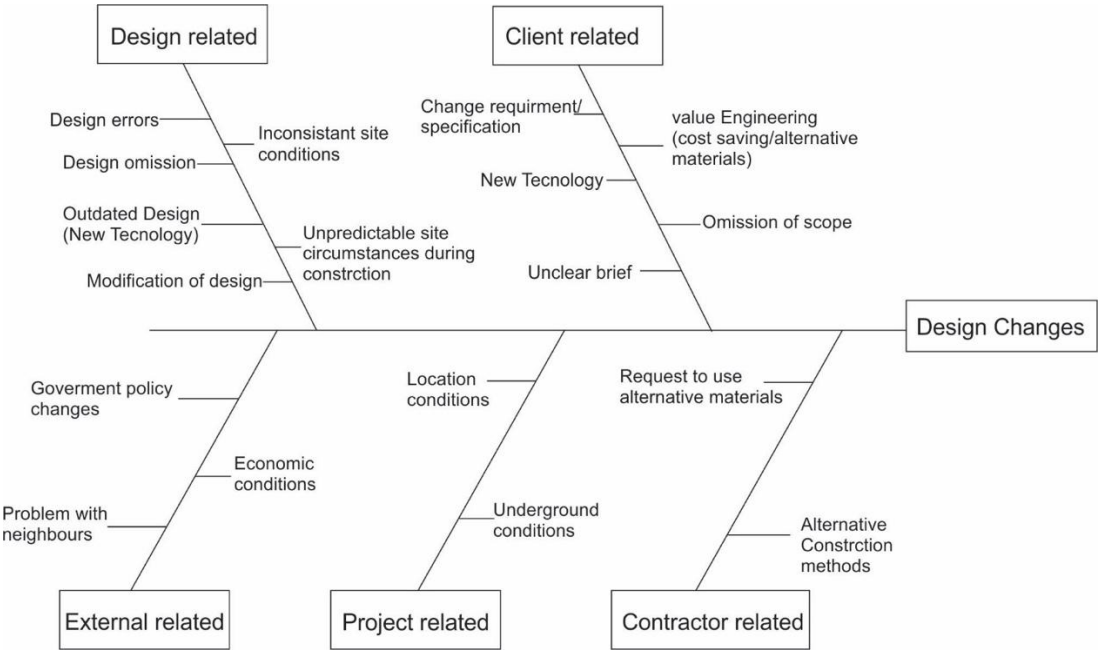

Figure: 2.2 Fishbone Design Changes Classification System

Source: (Yap et al., 2016)

Suleiman and Luvara (2016) researched to analyses the causes that leads to design changes and their effect during construction stage of building projects in Dar Es Salaam, Tanzania. They acknowledged the work of Burati at el. (1992) and Love and Edward (2004) and developed a more comprehensive list of sources of design changes grouping in to two categories; internal sources and external sources. The Table 2.2 summaries the identified sources under each category.

Table: 2.2 Internal and External Sources of Design Change

Categories	**Sources**
Internal	Client Related
	Design Consultant related
	Contractor related
	Project Management related
External	Environment
	Third Party
	Political and Economic

Source: (Suleiman and Luvara, 2016)

Suleiman and Luvara (2016) concluded that environmental related, third-party related and political and economic related as main sources of design changes. In contrast, Yap et al., (2016) list those sources as causes in their generic causes and effect diagram shown in Figure 2.2. Love and Edward (2004) identified that rework due to design changes raise due to subcontractors too, which was not included in Yap et al. (2016) and Suleiman and Luvara (2016) as a main source of design changes. The Table 2.3 exhibit the identified sources of design changes

Table: 2.3 Identified Sources of Design Changes

Author	Identified Sources							
	Client Related	Design Consultant Related	Contractor related	Project Management related	Political and Economic	Third-party	Environment Related Causes	Subcontractor
Suleiman and Luvara (2016)	✔	✔	✔	✔	✔	✔	✔	
Yap et al., (2016)	✔	✔	✔					
Love and Edward, (2004)	✔	✔	✔					✔
Fayek et al., (2003)		✔						

To provide a more holistic view of sources of design changes, the identified sources by Love et al. (2005), Suleiman and Luvara (2016) and Yap et al. (2016) were incorporated to develop the diagram in Figure 2.3, to classify the causes of design changes for the purpose of this research.

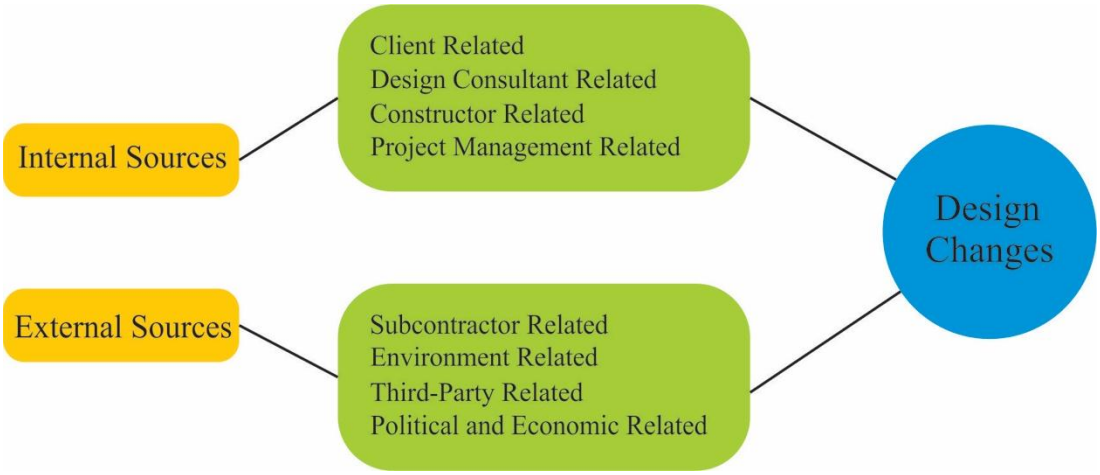

Figure: 2.3 Source of Design Change

Source: (Author derived)

This sources of design change diagram was used as a classification system to categories sources and categorize causes of design changes identified in the literature review of this research.

2.8 Causes of Design Changes

The design process or component is one of the major component in construction projects that creates rework (Love, 2002). Design changes has always been part of construction industry (Yap et al., 2016). Changes in design arise during design phase and construction phase due to various sources. (Yap et al., 2016). Burati at el. (1992) designs changes may be due to the request of contractor, client, occupier, manufacture or maybe due to errors, omission, improvement and unknown factors in the approved design. Also, design changes are due to main 4 causes: late design changes, poor document control, scope changes and error and omission in design (Fayek et al., 2003).

Mohamed, Nekooie and Al-Harthy (2012) conducted a case study on reinforced building projects. The case study concluded that, clients were the major source to the causes of design changes. Modification to the original design, addition of new

work/scope and unclear initial design brief were three major causes of design changes due to client. The second group was designer or design consultant, where inconsistent information, discrepancy with the contract document and insufficient details of existing site condition were the three major causes of design changes due to design team (Mohamed et al., 2012). The study identified, contractors were the least contributing source of design change (among the three groups) to initiate design changes.

Study done on Spain civil infrastructure projects by Forcada et al. (2017) confirmed that, design inconsistencies and tight design schedule by the client create undesirable consequences on project performance, resulting to multiple rework events. Forcada et al. (2014), most design changes are due to less involvement of contractors during designing phase. Nevertheless, involvement of a contractor could minimize rework due to design changes and can improve constructability of the design (Forcada et al., 2014). Study done by Love et al. (2010) infrastructure project identified the main causes for design changes are due to, poor use of IT by design team, lack of client involvement during design process and no better plan to manage documents. Also, a study done by Love and Sing (2013) identified that design revision, modifications and improvements initiated by the contractors to improve constructability and inconsistent information on design drawing are two causes of design changes.

The findings of Alaryn, Emadelbeltagi, Elshaat and Dawood (2014) on Kuwait public and private construction projects were similar to Mohamed et al. (2012) and Love et al. (2013) findings. Change of project scope by owner, error and omission on design, poor design and poor working drawings details were causes of design change and those causes would destructively impact the project cost and duration of individual activates leading to delay in payment due to unexpected cost (Alaryn et al., 2016).

However, design changes are widely accepted by the stakeholders of construction projects (Yap et al., 2016). But they continuously scan for solutions since it has a negative effect on Project Total Cost (PTC), schedule, quality and the image of the

company (Mohamed et al., 2012). The causation of design changes identified by the authors in the literature are provided in Table 2.4.

Table: 2.4: Causes of Design Changes

#	Causes	Authors											
		Burati (1992)	Fayek et al (2003)	Love, Edward, Watson and Davis (2010)	Forcada, Rusinol, MacArullaand Love (2014)	Love and Sing (2013)	Alaryn, Emadelbeltagi, Elshaat, Dawood (2016)	Forcada, Gangolells, Casals and Macarulla (2017)	Mohamed, Nekooie and Al-Harthy (2012)	Yap, Abdul-Rahman and Wang in 2016.	Suleiman and Luvara (2016)	Taggart, Koskela and Rooke (2014)	AGO (2016)
		1	2	3	4	5	6	7	8	9	10	11	12
1	Changes to scope changes (e.g. addition or decline)		✔		✔		✔		✔		✔		✔
2	Unclear initial design brief from client								✔		✔		
3	Owners change of design schedule due to financial problem (e.g. Unrealistic design schedules, instruction to modify design)	✔			✔		✔	✔	✔	✔	✔		
5	Low fee for design Consultant										✔		
6	Errors made in the design (e.g. mistakes)	✔	✔				✔			✔	✔		
7	Design omission (e.g. missing important component)	✔	✔				✔			✔			
8	Unskilled design consultant			✔									
9	Less involvement of client and design team during design process			✔									
10	Inconsistent information on design drawing (e.g. structural and architectural detail do not match)				✔	✔	✔		✔		✔	✔	✔
11	Design team/consultant not familiar with the regulations and construction permits										✔		✔
12	Design team/consultant lack										✔	✔	

#	Causes	Authors											
		Burati (1992)	Fayek et al (2003)	Love, Edward, Watson and Davis (2010)	Forcada, Rusinol, MacArullaand Love (2014)	Love and Sing (2013)	Alaryn, Emadelbeltagi, Elshaat, Dawood (2016)	Forcada, Gangolells, Casals and Macarulla (2017)	Mohamed, Nekooie and Al-Harthy (2012)	Yap, Abdul-Rahman and Wang in 2016.	Suleiman and Luvara (2016)	Taggart, Koskela and Rooke (2014)	AGO (2016)
		1	2	3	4	5	6	7	8	9	10	11	12
	of knowledge material availability												
13	Less involvement of constructors and during design process				✔						✔		
17	Design revision, modifications and improvements initiated by the constructors to improve constructability (e.g. constructors proposing alternative construction methods)	✔			✔	✔				✔	✔		✔
14	Changing construction techniques during construction phase to increase profit				✔						✔		
15	Constructors request to use available material									✔			
16	Unrealistic Construction schedule										✔		
4	Insufficient checking and correct planning documents (e.g. fail to review design documents before final approval, Discrepancy with the contract document, drawing and BOQ do not match)		✔						✔		✔		
18	Insufficient information of site conditions (e.g. Unforeseen ground condition)				✔		✔		✔	✔	✔		
19	Lack of communication among other parties involved within a construction project										✔		
20	Design revision, modifications and	✔							✔		✔		

#	Causes	Authors											
		Burati (1992)	Fayek et al (2003)	Love, Edward, Watson and Davis (2010)	Forcada, Rusinol, MacArullaand Love (2014)	Love and Sing (2013)	Alaryn, Emadelbeltagi, Elshaat, Dawood (2016)	Forcada, Gangolells, Casals and Macarulla (2017)	Mohamed, Nekooie and Al-Harthy (2012)	Yap, Abdul-Rahman and Wang in 2016.	Suleiman and Luvara (2016)	Taggart, Koskela and Rooke (2014)	AGO (2016)
		1	2	3	4	5	6	7	8	9	10	11	12
	improvements initiated by the subcontractor (e.g. Design change initiated by a manufacture)												
21	Material non-conformance to technical specification (e.g. Poor quality of material)												✔
22	Design changes initiated by the occupier	✔									✔		
23	Complains from neighborhood										✔		
24	Unforeseen bad weather conditions										✔		✔
25	Occurrence of natural disaster (e.g. flood)										✔		
26	Inflation and price fluctuation				✔						✔		
27	The sudden changes in policies and regulations										✔		
28	Change of market demand of the intended use of the building.										✔		

From the literature review 28 causes of design changes were identified. "Owners change of design schedule due to financial problem" and "Inconsistent information on design drawing" were most cited causes by the authors. In order to identify the root source of each cause, the causes were categorized under eight groups, which were the identified eight sources in Figure 2:3. Table 2.5 exhibit the causes under each group and code given for each cause.

Table 2.5: Causes (with code) under each group

#	Code	Causes of Design Changes
Group 1	**Client Related Causes**	
1	1a	Scope changes by client (e.g. addition).
2	1b	Unclear initial design brief from client (e.g. Unrealistic period to design, unclear function of design).
3	1c	Change of schedule due to financial problem of client.
4	1d	Low fee for design consultant.
Group 2	**Design Consultant Related Causes**	
5	2a	Errors made in the design by design consultant.
6	2b	Omission made in the design by design consultant.
7	2c	Unskilled design consultant
8	2d	Less involvement of client and design consultant during design phase
9	2e	Inconsistent information on design drawings and specification (e.g. structural and architectural detail do not match)
10	2f	Design consultant not familiar with the regulations and construction permits
11	2g	Lack of knowledge of material availability in the market
Group 3	**Constructor Related Causes**	
12	3a	Less involvement of constructors and design consultant during design phase
13	3b	Constructor changing construction technique/method to improve constructability
14	3c	Constructor changing construction techniques to increase constructor profitability
15	3d	Constructor request to use available material
16	3e	Unrealistic construction schedule
Group 4	**Project Management Related Causes**	
17	4a	Insufficient checking and correct planning and contract documents (e.g. fail to review design documents with client, drawing and BOQ do not match)
18	4b	Not able to collect sufficient information of site conditions (e.g. condition of underground)
19	4c	Lack of communication among other parties involved in the construction project
Group 5	**Subcontractor Related Causes**	
20	5a	Design change (e.g. revision, modifications and improvements) initiated by a manufacture/subcontractor.

#	Code	Causes of Design Changes
21	5b	Material non-conformance to technical specification (e.g. wrong material, poor quality)
Group 6	**Third-Party Related Causes**	
22	6a	Request of changes (e.g. floor space, entrance) by the occupier
23	6b	Complaints from neighbors
Group 7	**Environment Related Causes**	
24	7a	Unforeseen weather conditions (e.g. high probability of corrosion and erosion)
25	7b	Unforeseen natural disaster (e.g. storm surge)
Group 8	**Political and Economic Related Causes**	
26	8a	Unforeseen price fluctuation of materials and equipment.
27	8b	Sudden changes in government policies and regulations
28	8c	Change of market demand of the intended use of the building

Under each group two or more than two causes were listed. “Design consultant related” group received the highest number of causes from the total 28 causes. Hence, “subcontractor related causes”, Third-party Related Causes” and Environment Related Causes” group received the least (only two causes) causes.

Rework is the downfall of construction industry (Forcada et al., 2017) and design is the major contributing component to the cause of rework in construction projects (Love et al., 2010). Construction industry has done various research to avoid or reduce rework mainly focusing on design and on how to improve constructability of the design (Forcada et al., 2014). The division of design and construction professionals in construction industry is one reason for the failure of projects (Simpeh et al., 2015). Nevertheless, by integrating the knowledge of construction experts and design engineers can synergized value-added projects, since construction experts and design engineers are two complimentary parties that can add value, improve design functionality and constructability (Russell, Swiggum, Shapiro & Alaydrus, 1994).

2.9 Chapter Summery

Design changes are common in construction projects. Researchers have shown their interest and had carried out numerous studies on design related rework. In in order to address causes of design changes, classification systems or models were utilized to categories the identified causes of design changes. This allows to identify the root source of the causes of design changes.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The focus of this research is to reduce rework due to design changes in infrastructure projects in Maldives. In this research, a mixed method research design was utilized to investigate causes of design changes in infrastructure projects in Maldives. This chapter explains and discuss the research design which was used to collect the primary data and how it was analysed. This includes, the research approach, data collection methods and data analysis methods

3.2 Research Design

A research design is a plan or the overall framework used as a guide to collect, formulate and analyze the data needed for the research (Pandey and Pandey, 2015). The research design depends on the nature of the problems (Walliman, 2011). The argument presented by Leedy and Ormrod (2010) concerning the choice of research method is used as a basis, where consideration should be given to the nature of the data that will be collected in the resolution of the problem.

3.3 Research Approach

A mixed method approach of quantitative and qualitative methods was adoptedin this research as a research methodology. Figure 3.1 shows the research approach design for the subject under study.

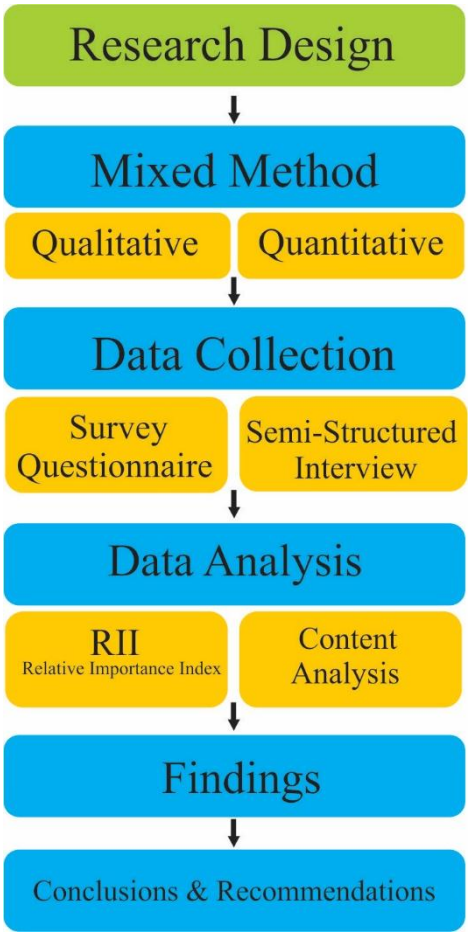

Figure 3.1: Research Design

A questionnaire survey and semi-structured interviews were used to collect the primary data and to analyse the collected data from these two tools, Relative Importance Index (RII) and content analysis was used respectively.

A quantitative research approach is about quantity or amount (Kothari, 2004) or it is called a scientific research or inquiry (Leedy & Ormrod, 2010). On the other hand, qualitative research is a holistic approach which result in discoveries (William, 2007), but cannot easily be reduced to numerical values (Leedy & Ormrod, 2010). The qualitative data gathered from qualitative method provide an insight of the quantitative data collected from quantitative method (Creswell & Clark, 2007). According to Creswell and Clark (2007) this approach is the explanatory design,

which is recognized as the most simple and straightforward of the mixed method designs. They further explain the benefit of the explanatory design as follows:

- The researcher applies two methods in two separate stages and gathers only one type of data at a time.
- The finding of the research can be explained in two separate stages, this allow the reader to understand the research result in clearer manner

3.4 Strategy of Inquiry

According to Tashakkori and Teddile (2003), mixed method inquiry opens a platform to explore different form of expression like, dialogue, perceptions understanding and valuing of respondents. In this research, both inquiry methods; questionnaire survey and interview were sequentially mixed. This approach of mixing is known as "Method Triangulation" (Tashakkori & Teddile, 2003). Method triangulation generate more comprehensive data, increase the validly of the collected data and capture a different perspective of the studied phenomena (Bekhet & Zauszniewski, 2012). Also, the reason for method triangulation was, the interview questions were based on the result of the survey questionnaire.

3.5 Data Collection Methods

In order to investigate the causes of design changes, secondary and primary data was collect. The secondary data is any data that is already available and analysed by someone else (Kumar, 2011). The researchers should be careful and should only collect data from the most suitable, adequate amount and only from reliable sources (Kothari, 2004). Secondary data could be published or unpublished data. By utilizing the secondary data, a preliminary literature review was produced, within the context of the problem under study. Hence, the sources and causes attributing to design changes and its classification was undertaken to help gain an insight into the proposed objectives.

In this research, under the mixed method approach, the primary data was collected using questionnaires survey and expert interviews. Preliminary interviews were held with three construction professional experts to develop the questionnaire survey. It was identified the causes of design changes were commonly used in Maldivian construction industry. For clarity, appropriateness of wording, and to convey the desired meaning, the term “contractors” was replaced by the term “constructors”, as the term constructors are more commonly used in Maldives.

3.5.1 Questionnaire Survey

More specifically, questionnaire survey method provides a tool to gather data over and beyond the physical reach of the researcher. In a questionnaire survey, a list of question are given to responder, who is presumed to have knowledge in the area (Singh, 2006) and the answers are recoded by the recipient him or herself (Kumar, 2011). A questionnaire was developed according to research objective, to quantify how the respondents would rank the causes of the design changes. The questionnaire is comprised of two sections, namely: profile of respondents and causes of design changes.

The first section (Section A) of the questionnaire is used to collect information of about the respondents. The information gathered includes the role or the current position of the respondents, experience in construction industry and type of projects that was involved.

The second section (Section B) is list of causes of design changes that the respondents were expected to rank with respect to the infrastructure projects in Maldives that they were involved. Kumar (2011), the responder interprets the questions themselves, so it is important to keep the question clear and easy to understand. Therefore, for clarity, the questionnaire survey in this research categorized 28 causes of design changes, to 8 group; client-related, design-related, constructor related, project management related, subcontractors related, environment related, and political and economic relates, to solicit respondents’ opinions about the

causes design change (refer Appendix A).

Gathering of data for the identified 28 causes was carried out using Likert-scale where; 5 = Very Likely, 4 = Likely, 3= Neutral 2 = Unlikely and 1 = Very unlikely.

3.5.1.1 Population Sampling Size

The study of the whole population is not possible and it is impracticable, therefore, a research cannot be undertaken without use of sampling, which makes it an indispensable technique of behavioral research (Singh, 2006). A selected number of cases in a population are referred to as the sample and to make the research findings more accurate and economical, it is necessary to select a sample which represent the whole population (Kothari, 2004). Singh (2006) further asserted, that the sample should be in enough to represent the whole population, nevertheless should consider the availability of time, energy and money. The first step in sampling for any research study would be to define the population. As this research focus on construction rework in infrastructure Maldives, the population for this research was construction professionals with experience in infrastructure construction projects in Maldives.

3.5.1.2 Sampling Techniques

Sampling can be either probability sampling or non-probability sampling. According to Kothari (2004), in probability sampling the probability of being selected in the sample is unknown. Non-probability sampling is also known as deliberate sampling or purposive sampling, where a particular unit of population purposively chosen which would represent the whole population (Kothari, 2004). In non-probability sampling, some members of the population do not have any chance or little chance of being sampled (Leedy & Ormrod, 2010). Purposive sampling was adopted as a sampling technique in this research.

In purposive sampling representative of the total population is selected. The idea is to select a sample with relation to some criterion, which can provide the most required information about the subject matter (Singh, 2006). As the research want to

investigate the causes of design changes in infrastructure projects in Maldives, the criteria used by this research to select the respondents were construction stakeholder belonging to client, design consultant and constructors who were involved in infrastructure projects in Maldives administered by the state. Table 3.1: exhibit the detail of selected respondent of infrastructure projects in Maldives.

Table 3.1: Detail of selected respondents for the questionnaire survey

Respondents	No. of forms distributed	No. of forms received
Client	20	12
Design Consultant	20	16
Constructors	10	4
Total	50	32

3.5.2 Semi-Structured Interviews

According to Burns (1997) an interview is "a verbal interchange, often face-to-face, though the telephone maybe used, in which the interviewer tries to elicit information, belief or opinions from another person". In order to collect a specific information, interviewer initiates the interview pertinent to the researcher's field of study. According to Wimmer and Dominick (2013), uncovering the perspective on a particular issue of the responder is a characteristic of a successful interview.

An interview is a distinctive research technique, with three specific purposes (Best, 1981);

a. First, as the principal means of gathering information with the objectives of the research under study.
b. Second, to test the hypothesis, suggest new ones, or as tool to identification of variables and relationships.
c. Third, in conjunction with other methods in a research under study.

In this research, semi-structured interview questions (refer Appendix B) were developed based on the findings of questionnaire survey. Each group comprises of one main question to identify the reasons for the causation of design changes respect to each group. Furthermore, under each main question, sub questions were asked on how to minimize occurrence of design changes causes respect to each cause identified under each group.

3.5.2.1 Selection of Interviewees

Qualitative research is to gain and develop understanding, discover meaning and explaining the phenomena experienced by the participants. Similarly, as the survey questionnaire, the population to collect the data is, construction professionals with experience in infrastructure projects in Maldives. As the purpose of the semi-structured interview questions are to understand and discover the perception and opinion of interviewees on the causes of design changes. Nevertheless, to extract the required amount of data, loads of time is required to interview each interviewee. Therefore, due to limitation of time availability, a sample size of four interviewees were selected to collect the primary data in the second stage.

Table 3.2 exhibit the background details of the interviewees selected for the expert interview

Table 3.2: Interviewees selected for the expert interview

Interviewees	Title	No. of years in Industry	Types of infrastructure projects involved
Interviewee one (I_1)	Project Managers (Policy maker)	10	Residency housing, harbor projects, schools, Mosques
Interviewee two (I_2)	Project Manager (Constructor)	20	Medical center, residency housing harbor projects, schools, mosques
Interviewee three (I_3)	Architect - (Private design firm)	8	Road, government office, quay Wall,
Interviewee four (I_4)	Quantity Surveyor (Constructor)	9	Residency housing, harbor projects, schools, Mosques, Road,

Moreover, for the expert interview, the researcher approached to four respondents which took part in the questionnaire survey. The reason was, these respondents would be familiar with the identified causes in the survey questionnaire. Therefore, it enables them to reflect back again to their reason for ranking the causes as they have and justify it with reasons for the causation of the design changes and recommend activities to minimize occurrence of causes of design changes,

3.6 Data Analysis

As the research approach for this research was a mixed method approach, the method of analyzing questionnaire survey and semi-structured interviews are explained in this section.

3.6.1 Relative Importance Index (RII)

Quantitative analysis involves mathematical operations which quantifies the results in numerical values (Singh, 2006). Quantitative data extracted from survey questionnaires was analyzed in two forms. First, the mean and standard deviation was calculated by Microsoft Excel. With the mean value, the researcher identified the position (very likely, likely, neutral, unlikely or very unlikely) of each cause received in particular to the score given by the 32 respondents. The standard deviation was used to determine the proportion of values that lie with the particular range of mean value.

Furthermore, to identify the most likely cause from among the 28 causes of design changes, RII method was utilized. The formula used was as following;

$$RII = (W_1 * n_1 + W_2 * n_2 + \ldots) / A*N$$

Where W = weights given to by each respondent for each cause, which ranges from 1 to 5.

n = number of responses under each option

A = highest weight given (i.e. 5)

N = total number of respondent

The responses by the respondents was drawn and presented in the form of pie charts and tables.

3.6.2 Content Analysis

The expert interviews were analysed using content analysis technique. The content analysis is design in a way to extract the objective by studying thoroughly the subject under study and qualities need to be examined. (Leedy & Ormord, 2010). In content analysis, data is categorized in to themes and sub-themes for easy understanding and comparison (Leedy & Ormrod, 2010). This allow the researcher to structure the collected data to achieve the research objectives. The advantage of content analysis is, the data can be reduced and simplified, also can measure using quantitative techniques. Krippendorff and Bock (2008), states that probability of human error is high in this approach due to misinterpretation of the gathered data, whilst generating not the expected conclusion.

From the questionnaire survey, the themes (the 8 group of design changes) and sub themes (causes of design changes) were extracted. For each theme and sub theme, semi-structured questions were asked to each interviewee. The raw data was collected and then tabulated under each theme and sub theme against each interviewee. By this approach it is easy to identify the number of reference given by each interviewee against each question.

3.7 Chapter Summary

This chapter serves as an outline of the research methodology adopted for this study. A mixed method approach was adopted in this research. Furthermore, in this chapter methods and techniques to collect primary and secondary data was outlined. This encompasses detail explanation of questionnaire survey and semi-structured

interviews and how the collected data was analysed.

CHAPTER FOUR

DATA ANALYSIS AND RESEARCH FINDINGS

4.1 Introduction

This chapter demonstrate the data analysis of questionnaire survey, semi-structured interviews analysis and discussion on research findings. Each group of design changes were analysed in order to obtain an overall ranking of the 28 causes to identify the most likely causes of design change and to identify the reasons for the occurrence of causes and activities to minimize the occurrence of these causes in infrastructure projects in Maldives.

4.2 Response Rate

To obtain the data, public and private construction companies which were involved in infrastructure projects of Maldives were approached. The data were obtained from self-administered questionnaires and a total of 50 questionnaires were distributed to construction professionals in Maldives. The questionnaires were distributed and collected in person. However, only 32 respondents dully completed and returned back. The respondents were; policy makers/ client (12), design consultant (16) and constructors (4). The respondent was involved in multiple projects in different capacities including, project managers, architect, quantity surveyor, consultant engineer, constructor and legal consultant.

Figure 4.1 shows the experience of the survey respondents in the construction industry ranged from 0-5 (34%), 6-10 (31%), 11-15 (16%), 16-20 (13%), and greater than 21 years (6%). Figure 4.2 shows types of the infrastructure projects the respondents were involved during their work experience in construction industry. Most of the responds (16%) were involved in “government office building” and “hospitals/ Medical Centre” projects.

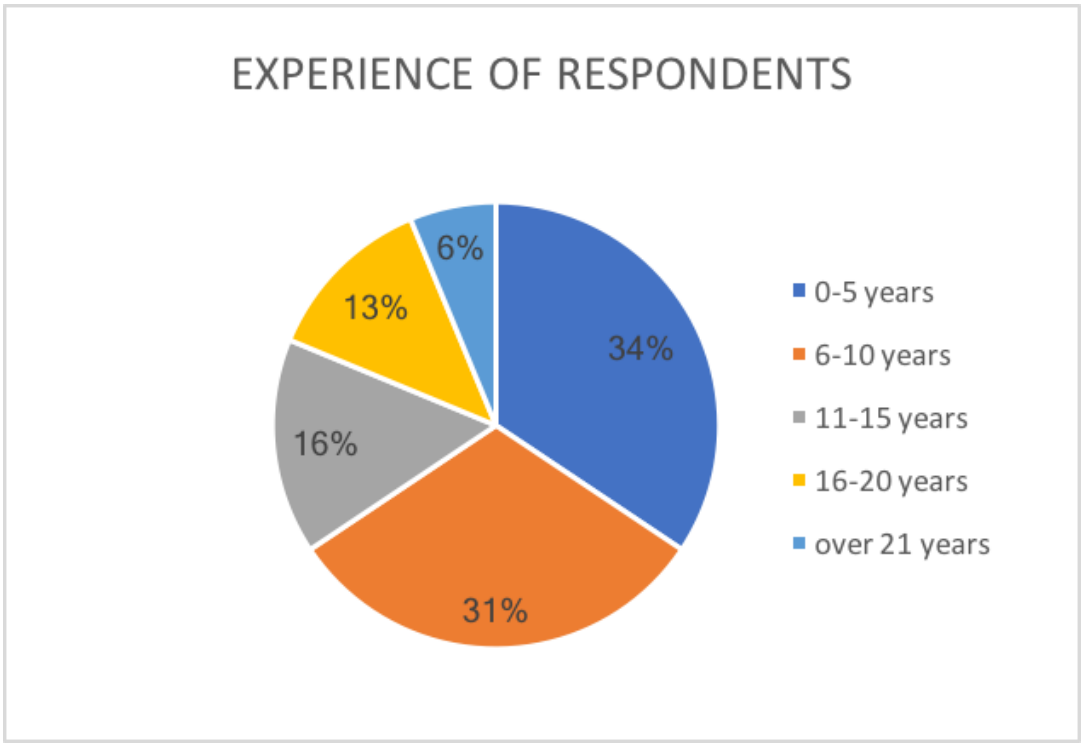

Figure 4.1 Experience of Respondents

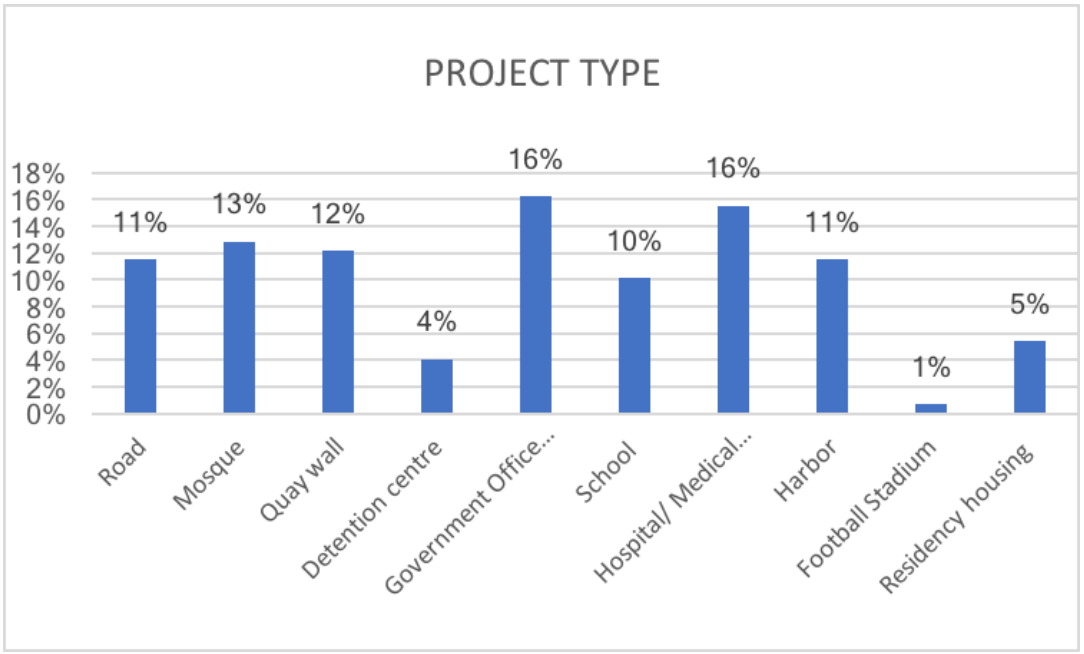

Figure 4.2 Project types

4.3 Data Analysis

In the questionnaire survey the respondents were asked to indicate their assessment on the likelihood of occurrence of design changes that might lead to rework events, using a Likert scale, where 1= very unlikely; 2 = unlikely; 3 = neutral; 4 = likely and 5 = very likely. With the aid of Microsoft Excel, mean and standard deviation of the responses were calculated. Hence, the causes were ranked by using RII calculation (refer section 3.7 for the RII equation).

The following session explains the findings related to each group.

4.4 Ranking of Causes of Design Changes.

In order to indicate the most likely causes of design changes to least likely causes of design changes, each cause was given an overall rank respect to the RII value it obtained from RII calculation. The Table 4.3 shows all the 28 causes of design changes with the mean value, overall ranking and group ranking.

Table 4.1 Mean Score and Ranking of Causes of Design Changes.

#	Code	Causes	Mean	STDEV	RII	RII Rank
1	1a	Changes to scope by client.	4.28	0.68	0.856	1
2	1c	Changes to design schedule due to financial problem of client	4.03	0.93	0.806	2
3	6a	Request of changes (e.g. floor space, entrance) by the occupier	3.91	0.89	0.781	3
4	3d	Constructor request to use available material	3.88	0.91	0.775	4
5	3e	Unrealistic construction schedule	3.88	1.21	0.775	4
6	2a	Errors made in the design	3.84	0.92	0.769	5
7	7a	Unforeseen weather conditions (e.g. high probability of corrosion and erosion)	3.81	0.90	0.763	6
8	8b	Sudden changes in government policies and regulations	3.78	0.83	0.756	7
9	3b	Constructor changing construction technique/method to improve	3.75	0.80	0.750	8

#	Code	Causes	Mean	STDEV	RII	RII Rank
		constructability				
10	4c	Lack of communication among other parties involved in the construction project	3.75	0.92	0.750	8
11	2b	Omission made in the design	3.72	0.96	0.744	9
12	3c	Constructor changing construction techniques to increase constructor profitability	3.72	0.92	0.744	9
13	3a	Less involvement of constructor and design consultant during design phase	3.63	0.98	0.725	10
14	4b	Not able to collect sufficient information of site conditions (e.g. condition of underground)	3.63	1.10	0.725	10
15	8a	Unforeseen price fluctuation of materials and equipment.	3.63	1.01	0.725	10
16	8c	Change of market demand of the intended use of the building/structure.	3.56	0.84	0.713	11
17	1b	Unclear initial design brief from client (e.g. unclear function of design).	3.53	1.08	0.706	12
18	4a	Insufficient checking and correct planning and contract documents (e.g. fail to review design documents with client, drawing and BOQ do not match)	3.53	1.08	0.706	12
19	5b	Material non-conformance to technical specification (e.g. wrong material, poor quality)	3.53	1.02	0.706	12
20	5a	Design change (e.g. modification) initiated by a manufacture/subcontractor.	3.38	1.07	0.675	13
21	1d	Low fee for design consultant.	3.34	1.12	0.669	14
22	6b	Complaints from neighbors	3.34	1.07	0.669	14
23	2d	Less involvement of client and design consultant during design phase	3.31	1.18	0.663	16
24	2e	Inconsistent information on design drawings and specification (e.g. structural and architectural detail do not match)	3.19	1.03	0.638	17
25	2c	Unskilled design consultant	3.09	1.00	0.619	18
26	2g	Lack of knowledge of material availability in the market	2.75	1.08	0.550	19
27	2f	Design consultant not familiar with the regulations and construction permits	2.72	1.28	0.544	21
28	7b	Unforeseen natural disaster (e.g. storm surge)	2.38	0.91	0.475	22

From the survey result it indicate the most likely cause of design changes is "changes to scope by client" with a mean score of 4.28 (RII = 0.856).

The first two causes, "changes to scope by client" and "changes to design schedule due to financial problem of client" scored a mean value between 4 and 5. This indicates that the respondents agree that these two causes are very likely to cause design changes that might lead to rework events in infrastructure projects in Maldives. The causes ranked from 3rd to 18th scored a mean value between 3 and 4. Therefore, the respondents explicitly agree that these causes are likely to cause design changes that might lead to rework events in infrastructure projects in Maldives. However, only three causes; "lack of knowledge of material availability in the market", "design consultant not familiar with the regulations and construction permits" and "unforeseen natural disaster" scored below mean value 3. This indicates, the respondents agree, that these three causes are unlikely or less likely to cause design changes that might lead to rework events in infrastructure projects in Maldives. In addition, respondents ranked "unforeseen natural disaster" with a mean value of 2.38 (RII = 0.475) as the most unlikely cause of design changes that might lead to rework events in infrastructure projects in Maldives.

The followings section explains the findings related to each cause under each group.

4.4.1 Client Related Cause

The Table 4.2 shows client related causes as ranked by the respondents.

Table 4.2: Client Related Causes

Code	Causes	Mean	RII	Group Rank	Overall Rank
1a	Changes to scope by client.	4.28	0.856	1	1
1c	Change of schedule due to financial problem of client. (e.g. Unrealistic period to design)	4.03	0.806	2	2
1b	Unclear initial design brief from client (e.g. unclear	3.53	0.706	3	12

	function of design).				
1d	Low fee for design consultant.	3.34	0.669	4	14

"Changes to scope by client" was ranked at first, as a very likely cause of design change with a mean score of 4.28 (RII = 0.856). "Changes to design schedule due to financial problem of client" was ranked at second with a mean score of 4.03 (RII = 0.806). These two cases were also ranked as first and second in overall ranking and group ranking. This result indicates, the respondent tends to agree that these two causes are very likely to cause design changes that might lead to rework events, as their mean values are between 4 and 5. Causes ranked at third and fourth in this group scored a mean value between 3 and 4, which indicates, the respondents agree, that these two causes are likely to cause design changes that might lead to rework events in infrastructure projects.

4.4.2 Design Consultant Related Causes

With respect to design consultant causes, seven causes were identified. The result in Table 4.3 indicate, "errors made in the design" was ranked at first with a mean value of 3.48 (RII = 0.769), whilst, the cause was rank on fifth on the overall ranking. Causes ranked from first to fifth scored a mean value between 3 and 4. Therefore, it indicates, the respondents agree, that these causes are likely to causes design changes that might lead to rework events in infrastructure projects in Maldives.

Table 4.3: Design Related Causes

Code	Causes	Mean	RII	Group Rank	Overall Rank
2a	Errors made in the design	3.84	0.769	1	5
2b	Omission made in the design	3.72	0.744	2	9
2d	Less involvement of client and design consultant during design phase	3.31	0.663	3	15
2e	Inconsistent information on design drawings and specification (e.g. structural and architectural detail do not match)	3.19	0.638	4	16

2c	Unskilled design consultant	3.09	0.619	5	17
2g	Lack of knowledge of material availability in the market	2.75	0.550	6	18
2f	Design consultant not familiar with the regulations and construction permits	2.72	0.544	7	19

Nevertheless, "lack of knowledge of material availability in the market" and "design consultant not familiar with the regulations and construction permits" scored a mean value less than 3, indicating the respondents agree, that these two causes are unlikely to cause design changes that might lead to rework events in infrastructure projects in Maldives.

4.4.3 Constructor Related Causes

The Table 4.4 Shows five causes of constructor related causes. Among the five causes respondents ranked two causes, "constructor request to use available material" and "unrealistic construction schedule" with a mean value of 3.88 (RII= 0.775) at the first rank in this group. The two causes occupied the fourth rank in the overall ranking.

Table 4.4: Constructor Related Causes

Code	Causes	Mean	RII	Group Rank	Overall Rank
3d	Constructor request to use available material	3.88	0.775	1	4
3e	Unrealistic construction schedule	3.88	0.775	1	4
3b	Constructor changing construction technique/method to improve constructability	3.75	0.750	2	8
3c	Constructor changing construction techniques to increase constructor profitability	3.72	0.744	3	9
3a	Less involvement of constructor and design consultant during design phase	3.63	0.725	4	10

All the causes in this group scored a mean value between 3 and 4 indicating, that the respondents agree, these causes are likely to cause design changes that might lead to rework events in infrastructure projects in Maldives.

4.4.4 Project Management Related Causes

The Table 4.5 presents the survey result of project management related causes. "Lack of communication among other parties involved in the construction project" occupied the first rank with a mean value of 3.75 (RII = 0.750) followed by "not able to collect sufficient information of site conditions" (mean value 4.63) and "insufficient checking and correct planning and contract documents" (3.53) the second and third rank respectively.

Table 4.5: Project Management Related Causes

Code	Causes	Mean	RII	Group Rank	Overall Rank
4c	Lack of communication among other parties involved in the construction project	3.75	0.750	1	8
4b	Not able to collect sufficient information of site conditions (e.g. condition of underground)	3.63	0.725	2	10
4a	Insufficient checking and correct planning and contract documents (e.g. fail to review design documents with client, drawing and BOQ do not match)	3.53	0.706	3	12

The mean value of the all the three causes in this group is between 3 and 4, which indicates, the respondent tends to agree, that these causes are likely to cause design changes that might lead to rework events in infrastructure projects of Maldives.

4.4.5 Subcontractor Related Causes

The Table 4.6 represent the subcontractor related causes. Under this group two causes were identified. "Material non-conformance to technical specification" with

mean value of 3.53 (RII = 0.706) was ranked at first by the respondents, whilst it was ranked at twelfth in overall ranking.

Table 4.6: Subcontractor Related Causes

Code	Causes	Mean	RII	Group Rank	Overall Rank
5b	Material non-conformance to technical specification (e.g. wrong material, poor quality)	3.53	0.706	1	12
5a	Design change (e.g. modification) initiated by a manufacture/subcontractor.	3.38	0.675	2	13

The two causes scored a mean value between 3 and 4, which indicate the respondents tends to agree the causes are likely to design changes that might lead to rework events in infrastructure projects in Maldives

4.4.6 Third-Party Related Causes

Table 4.7 revealed the ranking of third-party related causes. “request of changes by the occupier” with a mean value of 3.91 (RII = 0.781) was ranked as most likely cause of design changes under this group. Also, this cause was ranked at the third in the overall ranking,

Table 4.7: Third-party Related Causes

Code	Causes	Mean	RII	Group Rank	Overall Rank
6a	Request of changes (e.g. floor space, entrance) by the occupier	3.91	0.781	1	3
6b	Complaints from neighbors	3.34	0.669	2	14

Furthermore, it indicates that respondent tend to agree the two causes are likely to causes design changes that might lead to rework events, since the mean value are between 3 and 4.

4.4.7 Environment Related Causes

The Table 4.8 shows the environment related causes that were identified. Both the causes scored a significantly different mean value. Respondent ranked "unforeseen weather conditions" at first with a mean value of 3.81 (RII = 0.763). This cause was on the sixth rank on the overall ranking.

Table 4.8: Environment Related Causes

Code	Causes	Mean	RII	Group Rank	Overall Rank
7a	Unforeseen weather conditions (e.g. high probability of corrosion and erosion)	3.81	0.763	1	6
7b	Unforeseen natural disaster (e.g. storm surge)	2.38	0.475	2	20

With a very low mean value (2.38) "unforeseen natural disaster" was ranked at the second in the group, indicating that the respondent highly agrees that "unforeseen natural disaster" is unlikely to cause of design changes that might lead to rework events in infrastructure projects in Maldives.

4.4.8 Political and Economic Related Causes

The Table 4.9 present the results of political and economic related causes. Under this group three causes were identified. With a mean value of 3.78 (RII = 0.756), "sudden changes in government policies and regulations" was ranked at first as a likely cause of design change. "Unforeseen price fluctuation of materials and equipment" and "change of market demand of the intended use of the building/structure" was ranked at the second and third rank respectively.

Table 4.9: Political and Economic Related Causes.

Code	Causes	Mean	RII	Group	Overall

				Rank	Rank
8b	Sudden changes in government policies and regulations	3.78	0.756	1	7
8a	Unforeseen price fluctuation of materials and equipment.	3.63	0.725	2	10
8c	Change of market demand of the intended use of the building/structure.	3.56	0.713	3	11

From respondent ranking it indicate the respondent tends to agree, that the three causes are likely to causes design changes that might lead to rework events in infrastructure projects in Maldives since the mean value of all three causes are between 3 and 4.

Furthermore, all the eight groups were analysed to rank in group wise. From the Table 4.10, it indicates that the "client related causes" is at first rank, followed by "constructor related causes" on the second rank. The respondent ranked "environment related causes" at eighth ranked, the lowest among the eight groups.

Table 4.10: Group Ranking

#	Groups	Group mean	Group RII	Group ranking
1	Client Related Causes	3.80	0.759	1
2	Constructor Related Causes	3.77	0.754	2
3	Political and Economic Related Causes	3.66	0.731	3
4	Project Management Related Causes	3.63	0.727	4
5	Third-Party Related Causes	3.62	0.725	5
6	Subcontractor Related Causes	3.45	0.691	6
7	Design Related Causes	3.23	0.646	7
8	Environment Related Causes	3.09	0.619	8

In the overall ranking of causes of design changes, from fifteenth to nineteenth (2^{nd}, 3^{rd}, 4^{th}, 5^{th} and 6^{th} lowest) design consultant related causes were ranked. Similarly, in group ranking also design consultant group was ranked at the second lowest by the respondents. One of the reason this result may be, that the respondents in the sample included was comparatively higher proportion of design professionals compared to clients and constructors.

4.5 Discussion on Questionnaire Survey Findings

The findings concluded that client related causes were more likely to cause design changes, which was similar to the finding of Mohamed et al. (2012). In the same study, design consultant was ranked as the second, whilst the survey carried out in this research, indicate that the design consultant related causes are less likely to causes design changes. This might be due to the higher proportion of design professionals responded to the survey compared to clients and constructors. The most likely two causes "change of scope by client" and "changes to design schedule due to financial problem of client" was also listed by Fayek et al. (2003), Mohamed et al. (2012) and Forcada et al. (2017) as most likely causes to cause design related rework in construction project. The causes at the third ranking, "unclear initial design brief from client" was also identified as one of major cause of design change by Mohamed et al. (2012) in their study. Cause ranked on the fourth (constructor request to use available material and unrealistic construction schedule) was major cause listed by Mohamed et al. (2012) under constructor. In the study done by Fayek et al. (2003) and Alaryn et al. (2014) (study done on Kuwait public and private projects) identified that "errors in design" is a major cause, whilst the respondent in this research ranked this cause at fifth, as a likely causes of rework due to design changes. The causes "unforeseen weather conditions" was stated in AGO audit report (Management of capital construction projects: Performance audit report, 2016) as a major cause that contributed to rework in construction projects in Maldives. However, this cause was ranked at sixth by the respondents as a likely causes of design change.

4.6 Findings from the Expert Interviews: Result from the Content Analysis

A structured interview session was carried out with respect to respondents ranking on the causes of design changes that might leads to a rework event in infrastructure projects in Maldives. Two project managers, one architect and a quantity surveyor was interviewed to collect their opinion on the impact of rework in Maldives, activities to prevent occurrence of design changes in infrastructure projects of Maldives. Furthermore, the interviewees were asked structured question, to collect their opinion for the reasons of causing design changes in each group and activities that can be incorporated in to construction projects process to reduce design changes that might lead to a rework event.

The following section explains the findings related to structured interview questions

4.6.1 The Impacts Due to Design Related Rework

The interviewees reported, the major impacts on construction projects due to design related rework, increases total project cost. Due to request of extra time to make the required changes to the design, it interrupts other activities in construction phase. The constructors have to rework consecutive activities two or more times and sometimes have to fully halt the construction phase until further notice to resume. Interviewees stressed some of the repercussion created due to rework events. For example, constructors forced themselves to meet the deadline to prevent construction schedule changes of other projects which they work concurrently or to be awarded in near future. Hence, this increase the probability of tarnishing the project quality and safety of building users.

Interviewees also reported, rework due to design changes are observed frequently in infrastructure projects in Maldives and it has created unhealthy environment among the design consultant, constructors, subcontractors, and client. The interviewees voiced differing perception of client and consultant. In situations like, delays in payment or not paying for making the late changes requested by the client, the clients were questioned with respect to their work integrity. In contrast incidents like constructors leaving the project unfinished even though the payment is done by the

client, the constructors were questioned with respect to their work reliability. Interviewees reported that to prevent such incidents, regulations are made more tighten on tendering procedure of construction projects, which ultimately has created a barrier to new comers to win projects and a bolster for old constructors including bad reputed constructors. Thus, this has opened rooms for bias and unfair selections of constructors and significant cases has been voiced by the public of unfairness in constructor selection. Furthermore, interviewees highlighted, the lack availability of living accommodation in capital Male City' and the skyrocketing rent as one the biggest social issue in capital Male' City. Escalation of project cost due to rework impact severely on users or occupants of the buildings. When the client passes the extra cost to recover due to rework to the occupants, the rent or down payment has always increased to a level where an ordinary person finds difficult to purchase or cope a decent living in those housing units.

4.6.2 Practices in Construction Industry of Maldives

The interviewees were asked, about the practices in Maldivian construction industry to prevent occurrence of design related rework. The interviewees reported that in Maldives, there are no specific regulation guidelines enforced by the state to reduce rework in infrastructure projects. Neither construction companies do not have to submit any obligatory reports with respect to design component with the intention to reduce design related rework and to improve the constructability of the design component. One of the architect highlighted, VE have been incorporated in to design phase of the construction project to improve the function and prevent rework due to design component. VE practices focus simply on the design function and to develop the design a team of experienced and construction field experts are gathered for VE process.

All the respondent unanimously agreed that to be on safe side and to prevent the occurrence of rework due to design changes, the current building code and construction related regulations provided by Ministry of Housing and Infrastructure can be followed.

4.6.3 Reasons and Recommended Activities to Reduce Causes of Design Changes

The reason for the causes and the recommended activities by the interviewee to incorporate in to construction process to reduce design related rework are explained below.

a- Client Related Causes: The client related causes were identified as the most contributing group to rework due to design changes. In Table 4.11 are the identified four reasons for the causation of client related causes.

Table 4.11: Reasons for the Causation of Client Related Causes.

#	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Lack of priority given to study the background of each project	✔		✔	✔	3/4
2	Client not clear about the function of the design until certain stages of the construction project is completed	✔	✔	✔		3/4
3	The urgency to execute certain projects, limits the required time to develop the most suitable design with sufficient technical specification documents		✔	✔	✔	3/4
4	Sudden changes to project scope due to political, economic or social pressure are cognitively made not estimating the magnitude and impact of rework	✔	✔	✔	✔	4/4

All the interviewees coincided with “sudden changes to project scope due to political, economic or social pressure are cognitively made not estimating the magnitude and impact of rework” as one reason for client related causes. Table 4.12 are client related causes and recommended activities that could minimize the occurrence of design changes that might lead to a rework event.

Table: 4.12 Recommended Activities to Reduce Client Related Causes

Cause	Activities	No. of Reference
Changes to scope by client.	Proper feasibility study of the project reflecting the opinion and concerns of the users or occupants	3/4
Unclear initial design brief from client (e.g. unclear function of design).	Collect all the necessary information relevant to design function in initiation phase of the project by client or appointed PM for the project	4/4
	Involvement of a PM from client side and a design consultant or an architect in the definition phase of the constructions project	2/4
	Proper record keeping of the client requirements by PM	3/4
Change of design schedule due to financial problem of client.	Identify the complexity of design, approximate price for the design by join effort of client, project management team and independent architect discussions	3/4
Low fee for design consultant.	Benchmarking similar projects and identifying range of fees allocated for design consultants	4/4

Interviewees recommended to carry out all the required statistical and analytical studies related to every aspect of the project prior to definition phase in order to make sound decisions to reduce client related causes. For example, four interviewees mentioned “Collect all the necessary information relevant to design function in initiation phase of the project by client or appointed PM for the project” can minimize “unclear initial design brief from client” cause. Also, four interviewees mentioned “benchmarking similar projects and identifying range of fees allocated for design consultants” can minimize “low fee for design consultant” cause.

b- Constructor Related Causes

The constructor consultant related causes were identified as the second most contributing group to design changes. Interviewees reported that constructors play a huge role in construction projects. The industry is one of the promising industry in Maldives and significant number of new constructors has entered to the industry over the past years. The interviewees identified 8 reasons for reasons for the causation of constructor related causes. In Table 4.13 shows the identified eight reasons by the interviewees for constructor related causes.

Table 4.13: Reasons for the Causation of Constructor Related Causes.

#	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Regulation preference for cheapest bidder	✔			✔	2/4
2	Selecting financially incapable constructors		✔	✔	✔	3/4
3	Assigning incapable project managers to projects	✔		✔		2/4
4	Selection of less experienced constructors respect to project type and complexity		✔	✔	✔	3/4
5	Selection of constructors with bad project portfolio for complex projects	✔	✔			2/4
6	Selection of constructors with bad project portfolio for complex projects		✔	✔	✔	3/4
7	Weak relationship between suppliers and constructors	✔	✔	✔		3/4
8	lowering quality of work and compressing construction schedule of current project due to the eagerness to start new projects in order to increase business profit	✔	✔	✔	✔	3/4

“Lowering quality of work and compressing construction schedule of current project due to the eagerness to start new projects in order to increase business profit” were mentioned by all the interviewees. In Table 4.14 are constructor related causes and recommended activities that could minimize occurrence of design changes that might lead to a rework event.

Table: 4.14: Recommended Activities to Reduce Constructor Related Causes.

Cause	Activities	No. of Reference
Constructor request to use available material	Invite interested constructors, subcontractors and suppliers to design briefing and provide heads up on expected materials and quantity, machineries and quality of the project	3/4
	Keep record of potential suppliers and subcontractors for future reference	4/4
Unrealistic construction schedule	Involvement of independent experienced PM from client side to review the construction schedule before awarding the project	4/4
Constructor changing construction technique/method to improve constructability	Involvement of independent and experienced PM from client side and assign design consultant in preliminary design briefings	3/4
Constructor changing construction techniques to increase constructor profitability	Involvement of independent and experienced PM from client side to review the construction methods before awarding the project	3/4
	Include criteria for constructor consultant who have done similar projects rather than focusing more on the cheapest tenderers	2/4
Less involvement of constructor and design consultant during design phase	Involvement of independent experienced PM from client side or potential constructors with assigned design consultant in preliminary design briefings	3/4

The interviewees were in an agreement that the project management should involve constructors and other parties more often in design briefings.

c- Political and Economic Related Causes

The political and economic related causes were identified at the third most likely group to cause design changes. In Table 4.15 shows the identified three reasons for the causation of political and economic related causes.

Table 4.15: Reason for the Causation of Political Economic Related Causes

#	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Weak relationship between state (client) and private construction companies	✔	✔		✔	4/4
2	Working papers on rules and building code goes unheard or unnoticed by constructors		✔	✔	✔	3/4
3	Lack of mediums to create awareness and provision of information of construction industry news	✔	✔	✔	✔	4/4

"Lack of mediums to create awareness and provision of information of construction industry news" is one reason which was mentioned by all the interviewees. In Table 4.16 are political and economic related causes and recommended activities that could minimize occurrence of design changes that might lead to a rework event.

Table 4.16: Recommended Activities to Reduce Political and Economic Related Causes

Cause	Activities	No. of Reference
Sudden changes in government policies and regulations	Introduction of blogs, industry publications, newsletter to provide latest updates on working papers and changing regulations by the state	4/4
Unforeseen price fluctuation of materials and equipment.	Involvement of subcontractors and suppliers in design and technical design specification briefing sessions	2/4
Change of market demand of the intended use of the building/structure.	Establishing and encouraging construction market researches and information provision to construction professionals	4/4
	Seminars and symposiums to share performance of the industry	4/4

The interviewees voiced different opinion about activities that can be incorporated in to construction process to reduce "unforeseen price fluctuation of materials and equipment". Only two interviewee recommended by involvement of subcontractors and suppliers in design and technical design specification briefing sessions can be reduced while the rest of the three respondents said the involvement of subcontractors and suppliers in design phase does not necessarily reduced the unforeseen price fluctuation because the price changes is tied to international market price of factors like transportation price and warehousing, which are not in control of suppliers and subcontractors.

d- Project Management Related Causes

As number of developments are going on in the capital island and other islands, competition among the constructors are strong to win more projects to soar their business. In Table 4.17 are the identified two reasons are for the causation of project management related causes.

Table 4.17: Reason for the Causation of Project Management Related Causes

#	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Lack of skilled project managers or professionals in construction project management field	✔	✔	✔	✔	4/4
2	Project management find difficult to manage the projects effectively when multiple projects are initiated concurrently	✔	✔	✔	✔	4/4

All the interviewees mentioned the two reasons for the occurrence of design changes in this group. In Table 4.18 are project management related causes and recommended activities by the interviewees to minimize occurrence of design changes that might lead to a rework event.

Table: 4.18: Recommended Activities to Reduce Project Management Related Causes

Cause	Activities	No. of Reference
Lack of communication among other parties involved in the construction project	Involvement of constructors, suppliers and occupants in design and technical design specification review sessions to collect their opinions	4/4
	Invite stakeholder parties to meetings to provide status of the project and collect their feedback and concerns	3/4
Not able to collect sufficient information of site conditions	Site conditions report as a mandatory report to be provided by project management in definition phase meetings	3/4
	Project management arranging site visits for design consultant to examine site conditions	4/4
	Project management to arranging site visits for the interested constructors during the tender process	4/4
Insufficient checking and	Review the design and contract documents with the	4/4

correct planning and contract documents	presence of client, design consultant, constructor consultant and project management before finalizing the design. (If the project procurement method is design-bid-build, can hire independent and experienced PM to the review session)	

The interviewees were in an agreement that the project management should provide the most updated information on time to time to make the accurate decisions by the stakeholders of the project.

e- Third-Party Related Causes

Interviewees attempt to answer this question reflecting rework incident witnessed by them. For example, projects brought down to a halt by the influence of users and occupants. In Table 4.19 are the identified two reasons for the causation of third-party related causes.

Table 4.19: Reason for the Causation of Third-Party Related Causes

#	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Due to disagreement with in the community for factors like size, location and design of the structure or building	✔	✔		✔	3/4
2	Lack of studies to identify, analyse and consider users, neighbors and public opinion.		✔	✔	✔	3/4

The interviewees were in agreement that every construction project is unique even though the function of the design is alike. This is because majority of the projects are executed in geographically separated islands. And the users, neighbors and occupant expectations varies. In Table 4.20 are third-party related causes and recommended activities that could minimize occurrence of design changes that might lead to a rework event.

Table 4.20: Recommended Activities to Reduce Third-Party Related Causes

Cause	Activities	No. of Reference
Request of changes by the occupier	Involvement of occupants with design consultant in initial design briefing held by client or client side project management	4/4
Complaints from neighbors	Arrangement of site visits project management for design consultant to meet existing neighbors of the site to collected first-hand information from them	4/4

It was clear from the interviewees recommendations, when involvement and consideration of the opinion of the users, occupants and neighbors prior to final design, design changes that might lead to rework events can be reduced significantly.

f- Subcontractor Related Causes

Interviewees revealed that subcontractor is one group that can impact the project schedule gently or severely. The group acquires information of other constructors, specialized knowledge and technical skills, which most constructors do not want to focus or invest on. In Table 4.21 shows the identified two reasons for the causation of subcontractor related causes.

Table 4.21: Reason for the Causation of Subcontractor Related Causes

#	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Lack of adherence to project schedule by subcontractors	✔	✔	✔	✔	4/4
2	Weak relationship and less involvement of subcontractors to identify the capacity (e.g. skill, financial, material availability, skilled labors) of subcontractors	✔	✔		✔	3/4

"Lack of adherence to project schedule by subcontractors" were mentioned by all the interviewees as reason for design changes. In Table 4.22 are subcontractor related causes and recommended activities that could minimize occurrence of design changes that might lead to a rework event.

Table 4.22: Recommended Activities to Reduce Subcontractor Related Causes

Cause	Activities	No. of Reference
Material non-conformance to technical specification	-Involvement of potential subcontractors (e.g. suppliers) final design briefing session held by client or client side project management	3/4
Design change initiated by a manufacture/subcontractor.	-Involvement of potential suppliers and subcontractors with design consultant in design briefing sessions held by client or client side project management	3/4

In general, the interviewees recommended, involvement and consideration of the opinion of the potential subcontractors, rework events due to design changes can be reduced significantly.

g- Design Consultant Related Causes

Design consultant related causes were ranked at the second lowest in group ranking. In Table 4.23 are the identified three reasons for the causation of design consultant related causes.

Table 4.23: Reason for the Causation of Design Consultant Related Causes

#	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Lack of consideration in involving experienced project managers to review the constructability of the design	✔	✔	✔	✔	3/4
2	Less time given to recheck the design			✔	✔	2/4
3	less importance given to arrange review sessions with other engineers and consultant by under estimating the errors and omissions would occur	✔	✔	✔		3/4

"Lack of consideration in involving experienced project managers to review the constructability of the design" were mentioned by all the interviewees as reason for design changes. In Table 4.24 are the recommended activities that could minimize occurrence of design changes that might lead to a rework event.

Table 4.24: Recommended Activities to Reduce Design Consultant Related Causes

Cause	Activities	No. of Reference
Errors made in the design	Review the design with the presence of client, design and constructor consultant by project management. (If the procurement method is design-bid-build, can hire independent PM with experienced in construction industry to the review session)	3/4

	Check back to assure, requested changes by the consultants are made in design	3/4
	If the requested changes are not made, mention in design briefing reports, the reasons for not making the change for later reference	3/4
Omission made in the design	Involve independent and experienced PM and design consultant in final review meeting held by project management	4/4
	Check back to assure all corrections are made identified by independent PM and design consultant	4/4
Less involvement of client and design consultant during design phase	Arrange intermediate feedback sessions to meet design consultant and client	4/4
Inconsistent information on design drawings and specification	Arrange sessions to contrast and compare the design and specification with the presence of client, design consultant and constructor consultant	2/4
	If the project procurement method is design-bid-build, can hire an independent PM with experienced in construction industry to the review session	3/4
	Check back to assure, corrections are made in design drawings and specification	3/3
Unskilled design consultant	Identify complex and not complex designs.	2/4
	Including criteria to allocate marks for consultants who have done similar designs in prequalification and bid evaluation procedure	4/4

The activities recommended by the interviewees mostly mentioned to involve design consultant, constructor and client frequently before final design approval. “Involve independent and experienced PM and design consultant in final review meeting held by project management”, “check back to assure all corrections are made identified by independent PM and design consultant”, “arrange intermediate feedback sessions to meet design consultant and client” and “include criteria to allocate marks for consultants who have done similar designs in prequalification and bid evaluation procedure” were the activities mentioned by the four interviewees.

h- Environment Related Causes

The unanimous perception of the interviewees was, that the environment impact is a well aware factor respect to any industry. In Maldives, in construction industry also, designers and constructers are well aware of the surrounding environment and the impact it can create on the designs. In Table 4.25 shows the identified reasons for the causation of environment related causes.

Table 4.25: Reason for the Causation of Environment Related Cause

#	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Due to lack of studies of the uniqueness of each project location (island)	✔	✔	✔	✔	4/4

All the interviewees were coincided with "due to lack of studies of the uniqueness of each project location (island)" as one reason for design changes. In Table 4.26 are environment related cause and recommended activities that could minimize occurrence of design changes that might lead to a rework event.

Table: 4.26: Recommended Activities to Reduce Environment Related Causes

Cause	Activities	No. of Reference
Unforeseen weather conditions	Studying previous projects which was highly impact due to weather and analyzing the corrective measures taken	4/4
	Identifying new design solutions for tropical and archipelago surrounded by salt water	4/4

All the four interviewees recommended to study previous projects and identification of new design solution is a way forward to reduce "unforeseen weather conditions".

i- Causes that are less likely to causes rework due to design changes

In the questionnaire survey, the respondents "Design consultant not familiar with the regulations and construction permits", "lack of knowledge of material availability in the market" and "unforeseen natural disaster" as less likely to causes design changes that might lead to a rework event. The interviewee had a general perception for the three causes. Table 4.27 are the identified three reasons for the less likely causes.

Table: 4.27: Identified Reasons for Less Likely Causes

#	Causes	Reason	I_1	I_2	I_3	I_4	No. of Reference
1	Unforeseen natural disaster	Tide surges are seasonal and it impact are aware among the design consultant and constructors	✔	✔	✔	✔	4/4
2	Lack of knowledge of material availability in the market	The industry use similar materials since innovative construction techniques are significantly less in Maldives		✔	✔	✔	4/4
3	Design consultant not familiar with the regulations and construction permit	Only registered design consultant drawings are approved by MHI	✔	✔	✔	✔	4/4

The interviewees mentioned, that the Tsunami hit on Maldives islands on December 2004, impact on a high magnitude, whilst tide surges are seasonal. Furthermore, interviewees reported to be an approved design consultant, the

design consultant should fulfil a specific requirement and it is assumed that these design consultants would be familiar with building code and regulations. Therefore, it limits to a greater extent the occurrence of designs changes that would not matching the regulations. Table 4.28 exhibit the causes, reason and recommended activities by the responders to reduce causation of design changes that might lead to a rework event.

Table 4.28: Reasons, Causes and Recommended Activities to Reduce the Causation of Design Changes

Group	Reasons	Causes	Recommended Activities
Client Related Causes	• Lack of priority given to study the background of each project	Changes to scope by client	• Proper feasibility study of the project reflecting the opinion and concerns of the users or occupants
	• client not clear about the function of the design until certain stages of the construction project is completed • The urgency to execute certain projects limits the required time to develop the most appropriate design with sufficient technical specification documents	Unclear initial design brief from client (e.g. unclear function of design)	• Collect all the necessary information relevant to design function in initiation phase of the project by client or appointed PM for the project
			• Involvement of a PM from client side and design consultant in the definition phase of the constructions project
			• Proper record keeping of the client requirements by PM
	• Sudden changes to project scope due to political, economic or social pressure are cognitively made not estimating the magnitude and impact of rework	Change of design schedule due to financial problem of client	• Identify the complexity of design, approximate price for the design by join effort of client, project management team and independent architect discussions
		Low fee for design consultant	• Benchmark similar projects and identifying range of fees allocated for design consultants
Constructor	• Regulation preference for cheapest bidder	Constructor request to use	• Invite interested constructors, subcontractors

Group	Reasons	Causes	Recommended Activities
Related Causes	• Selecting financially incapable constructors	available material	and suppliers to design briefing and provide heads up on expected materials and quantity, machineries and quality of the project • Keep record of potential suppliers and subcontractors for future reference
	• Assigning incapable project managers to projects	Unrealistic construction schedule	• Involvement of independent experienced PM from client side to review the construction schedule before awarding the project
	• Selection of less experienced constructors respect to project type and complexity	Constructor changing construction technique/method to improve constructability	• Involvement of independent and experienced PM from client side and assign design consultant in preliminary design briefings
	• Selection of constructors with bad project portfolio for complex projects	Constructor changing construction techniques to increase constructor profitability	• Involvement of independent and experienced PM from client side to review the construction methods before awarding the project • Include criteria for constructor consultant who have done similar projects rather than focusing more on the cheapest tenderers

Group	Reasons	Causes	Recommended Activities
	• Selection of constructors with bad project portfolio for complex projects • Weak relationship between suppliers and constructors • lowering quality of work and compressing construction schedule of current project due to the eagerness to start new projects in order to increase business profit	Less involvement of constructor and design consultant during design phase	• Involvement of independent experienced PM from client side or potential constructors with assigned design consultant in preliminary design briefings
Political and Economic Related Causes	• Weak relationship between state (client) and private construction companies • Working papers on rules and building code goes unheard or unnoticed by constructors	Sudden changes in government policies and regulations	• Introduction of blogs, industry publications, newsletter to provide latest updates on working papers and changing regulations by the state
		Unforeseen price fluctuation of materials and equipment	• Involvement of subcontractors and suppliers in design and technical design specification briefing sessions

Group	Reasons	Causes	Recommended Activities
	• Lack of mediums to create awareness and provision of information of construction industry news	Change of market demand of the intended use of the building/structure	• Establishing and encouraging construction market researches and information provision to construction professionals • Seminars and symposiums to share performance of the industry
Project Management Related Causes	• -Lack of skilled project managers or professionals in construction project management field	Lack of communication among other parties involved in the construction project	• Involvement of constructors, suppliers and occupants in design and technical design specification review sessions to collect their opinions • Invite stakeholder parties to meetings to provide status of the project and collect their feedback and concerns
	• Project management find difficult to manage the projects effectively when multiple projects are initiated concurrently	Not able to collect sufficient information of site conditions	• Site conditions report as a mandatory report to be provided by project management in definition phase meetings • Project management arranging site visits for design consultant to examine site conditions • Project management to arranging site visits for the interested constructors during the tender process

Group	Reasons	Causes	Recommended Activities
		Insufficient checking and correct planning and contract documents	• Review the design and contract documents with the presence of client, design consultant, constructor consultant and project management before finalizing the design. (If the project procurement method is design-bid-build, can hire independent and experienced PM to the review session)
Third-Party Related Causes	• Due to disagreement with in the community for factors like size, location and design of the structure or building • Lack of studies to identify, analyse and consider users, neighbors and public opinion	Request of changes by the occupier	• Involvement of occupants with design consultant in initial design briefing held by client or client side project management
		Complaints from neighbors	• Arrangement of site visits project management for design consultant to meet existing neighbors of the site to collected first-hand information from them
Subcontractor Related Causes	• Lack of adherence to project schedule by subcontractors • Weak relationship and less involvement of subcontractors to identify the capacity (e.g. skill, financial, material availability,	Material non-conformance to technical specification	• Involvement of potential subcontractors (e.g. suppliers) final design briefing session held by client or client side project management
		Design change initiated by a manufacture/subcontractor	• Involvement of potential suppliers and subcontractors with design consultant in design briefing sessions held by client or

Group	Reasons	Causes	Recommended Activities
	skilled labors) of subcontractors		client side project management
Design Consultant Related Causes	• Lack of consideration in involving experienced project managers to review the constructability of the design • Less time given to recheck the design • Less importance given to arrange review sessions with other engineers and consultant by under estimating the errors and omissions would occur	Errors made in the design	• Review the design with the presence of client, design and constructor consultant by project management. (If the procurement method is design-bid-build, can hire independent PM with experienced in construction industry to the review session) • Check back to assure, requested changes by the consultants are made in design. • If the requested changes are not made, mention in design briefing reports, the reasons for not making the change for later reference
		Omission made in the design	• Involve independent and experienced PM and design consultant in final review meeting held by project management. • Check back to assure all corrections are made identified by independent PM and design consultant
		Less involvement of client and	• Arrange intermediate feedback sessions to

Group	Reasons	Causes	Recommended Activities
		design consultant during design phase	meet design consultant and client
		Inconsistent information on design drawings and specification	• Arrange sessions to contrast and compare the design and specification with the presence of client, design consultant and constructor consultant • If the project procurement method is design-bid-build, can hire an independent PM with experienced in construction industry to the review session • Check back to assure, corrections are made in design drawings and specification
		Unskilled design consultant	• Identify complex and not complex designs. • Including criteria to allocate marks for consultants who have done similar designs in prequalification and bid evaluation procedure
Environment Related Causes	• Due to lack of studies of the uniqueness of each project location (island)	Unforeseen weather conditions	• Studying previous projects which was highly impact due to weather and analyzing the corrective measures taken • Identifying new design solutions for tropical

Group	Reasons	Causes	Recommended Activities
			and archipelago surrounded by salt water

4.7 Discussion on the result of the Expert Interview Analysis

To reduce the rework due to design changes interviewees have recommended to incorporate various activities in initial and design phase of the construction project. Simpeh et al. (2015) mentioned (refer section 2.6.) the division of design and construction professionals in construction industry is one factor for the failure of projects. Whilst, Russell et al. (1994) advised, integrating the knowledge of construction experts and design engineers can improve design and constructability of the design. Also, to reduce rework due to design changes, the interviewees recommended and advised to meet design consultant and constructors frequently with presence of project management. For example, the interviewees recommended to held discussion sessions to share their opinion on the design and design related documents before the approval of the final design which was similar to activities was recommended by Fayek et al. (2003) to minimize the impact of rework related to design component. Furthermore, the interviewees highlighted that, weak relationship and less involvement of stakeholders (client, design consultant, constructors, subcontractors, project management, occupants) in initial and design phase of the construction project as one major reason for the occurrence of design changes in infrastructure projects in Maldives.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

With this chapter, the research is concluded with the research result in order to achieve the aim and objectives of the research. Furthermore, this chapter gives an over view of the research.

5.2 Overview of the research

Construction industry is one of the promising industry. Nevertheless, rework has been a major challenge for decades in the industry. Rework due to design changes are common and a big concern in this industry. In this research, the aim was to investigate the causes of design changes that create rework events in infrastructure projects in Maldives. The research was initiated to examine the causes of design changes that lead to rework events in infrastructure projects of Maldives. During the research, four objectives were accomplished to achieve the aim of the research. A mixed method approach was used in this research as a research methodology.

5.3 Conclusions

In order to achieve the aim of the research, four objectives were accomplished. The section below explains the findings in relation to each of the objectives.

1. Review the concept of construction rework and establish the significance of design changes in leading to construction rework

From the literature review the researcher identified several definitions of rework respect to the context of construction work. For the purpose of research “unnecessary effort of

re-doing a process or activity that was incorrectly implemented the first time" was referred as the definition of rework. Furthermore, "any regular additions, omissions and adjustment to the design after the approval of design which effects original scope of the project, project cost, project schedule and quality of the project" was the design changes definition used in this research. Also, rework due to design component and rework due to construction component were identified as two types of rework via literature review. Furthermore, the research discovered the impact the on the construction projects due to construction rework. It was identified rework impacts the project schedule and cost. Furthermore, from the literature review it was evident rework escalate the material waste and increase the probability of occurrence of dispute among the stakeholders of the project.

2. Identify the causes of design changes that lead to rework in infrastructure projects in Maldives.

The literature review found 28 causes of design changes in infrastructure projects that were carried out in different countries. Furthermore, to classify the causes of design changes to their root sources, a classification model was derived by the researcher from the findings of literature review.

Based on questionnaire survey, conducted among 32 construction professionals in Maldives, the study revealed that the most likely cause of design changes is "changes to scope by the client". The second likely cause of design changes was "change of design schedule due to financial problem of client". Furthermore, "client related causes" were identified as the major group contributing to design changes followed by "constructor related causes".

3. Investigate the reasons for causation of design changes that lead to rework in infrastructure projects in Maldives

The study found out multiple reasons for the causation of design changes in each group. It was discovered that one of the major reason to initiate design changes by client that leads to rework events in Maldives was due to, “sudden changes to project scope due to political, economic or social pressure that are not cognitively made by estimating the magnitude and impact of rework”. Furthermore, the reason “environment related causes” received the lowest rank to cause design changes in infrastructure projects in Maldives was due to “environment changes are seasonal and it impact are aware among the design consultant and constructors”.

4. Propose activities to minimize the causation of design changes that lead to rework in infrastructure projects in Maldives.

Finally, from the research, activities that can be incorporated in to construction projects to reduce rework due to design changes was identified. The identified activities clearly suggest that the collaboration of design consultant, constructors and clients could reduce rework to a greater extent. Furthermore, from the expert recommendations it was clear, that with consideration of the needs and concerns of users and occupants, occurrence of design changes could be minimize in infrastructure projects in Maldives.

5.4 Recommendations

The research only examines causes of design changes that leads to rework event in infrastructure projects in Maldives. The findings of this research the recommendation for the client, design consultant and constructor are as follow;

a. Client

The fact that “changes to scope by the client” was the main causes of design changes and main group causing design changes in infrastructure projects in Maldives, clients can reduce rework by;

- Conducting a proper background study for each project even the functions of the projects are similar.
- Conducting proper feasibility study of the project by reflecting the opinion and concerns shared by the users or the occupants of the structure.

b. Constructors

Constructor group were ranked at second that causes design changes in infrastructure projects in Maldives. Constructors can reduce design related rework by;

- Understand the project requirement and study the design and design related documents properly before accepting or signing the project contract. The purpose is to check whether they are technically and financially capable of delivering the project without sacrificing the client’s requirement and design functions.

c. Design Consultant

Design consultant group received a low rank in causing design changes in infrastructure projects in Maldives. However, “errors made in design” and “omissions made in design” where identifies as likely causes of design changes. Therefore, design consultant can reduce design related rework by;

- Collecting opinion from experience construction project managers to assure the constructability of the design before approval of final design.
- Reviewing the design and design related documents with the presence of client, independent construction manager and if possible with the presence of a user or occupants.
- Practicing standards procedure like Value Engineering to improve the functionality and constructability of the design in designing phase.

5.5 Further Research

This researched was only focused on the causes of design changes, a further study is needed to establish a comprehensive view of the impact of the causes on project schedule and cost and waste. Also, a further study can be done, in same context to identify the causes of rework due to construction component.

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Appendices

Appendix A

Survey Questionnaire

Dear Sir/Madam

Questionnaire for dissertation on "Reduce design related rework in infrastructure projects in Maldives"

The aim of this survey is to obtain the perception of construction practitioners in Maldives about the causes of design changes which creates rework in infrastructure projects of Maldives. It is a research study undertaken by an MSC student towards fulfilling a Master's Degree within the Department Building Economics situated at the University of Moratuwa, Sri Lanka.

For the purposes of the survey, design refers to design drawing and specification that are used in construction project. Design changes is defined as *"any regular additions, omissions and adjustment to the design after the award of contract which effects original scope of the project, contract cost, contract schedule and quality of the project".*

Relate the answers that you provide to **infrastructure projects** that you have been involved with. It is very important that each question is read carefully and that all questions are answered. The survey should take about 5-10 minutes to complete.

The survey has been distributed to purposively selected construction organization/practitioners. You are assured that the information obtained from this survey will be kept strictly confidential and will be only used for research purposes. Data will not be made available to any third party or used in any published material.

Thank you
Yours faithfully,
Aminath Zidhna
Email: aminathzidna@gmail.com

SECTION A: PROFILE OF THE RESPONDENT

5 What is your professional background?

- ☐ Architect
- ☐ Consultant Engineer
- ☐ Project Manager
- ☐ Constructor
- ☐ Quantity Surveyor
- ☐ Others (please specify)

.....

6 How long have you worked in the construction industry?

- ☐ 0-5 Years
- ☐ 6-10 Years
- ☐ 11-15 Years
- ☐ 16-20 Years
- ☐ Over 21 Years

7 Which of the following types of infrastructure projects have you been involved with?

- ☐ Road
- ☐ Government office building
- ☐ Mosque
- ☐ School
- ☐ Quay wall
- ☐ Hospital/Medical Center
- ☐ Detention Centre
- ☐ Harbor
- ☐ Others (please specify)

.....

SECTION B: CAUSES OF DESIGN CHANGES

Please indicate the likelihood of occurrence of design changes of the following causes of design changes in infrastructure projects of Maldives.

Indicate your answers by ticking (✔) in the given scale

CAUSES OF DESIGN CHANGE

	Likelihood of occurrence of design changes				
	Very likely	Likely	Neutral	Not likely	Very unlikely
1. **Client-related**					
a. Changes to scope by client.	☐	☐	☐	☐	☐
b. Unclear initial design brief from client (e.g. unclear function of design).	☐	☐	☐	☐	☐
c. Change of design schedule due to financial problem of client.	☐	☐	☐	☐	☐
d. Low fee for design consultant.	☐	☐	☐	☐	☐
2. **Design consultant-related**					
a. Errors made in the design	☐	☐	☐	☐	☐
b. Omission made in the design	☐	☐	☐	☐	☐
c. Unskilled design consultant	☐	☐	☐	☐	☐
d. Less involvement of client and design consultant during design phase	☐	☐	☐	☐	☐
e. Inconsistent information on design drawings and specification (e.g. structural and architectural detail do not match)	☐	☐	☐	☐	☐

f.	Design consultant not familiar with the regulations and construction permits	☐	☐	☐	☐	☐
g.	Lack of knowledge of material availability in the market	☐	☐	☐	☐	☐
3.	**Constructor consultant-related**					
a.	Less involvement of constructor and design consultant during design phase	☐	☐	☐	☐	☐
b.	Constructor changing construction technique/method to improve constructability	☐	☐	☐	☐	☐
c.	Constructor changing construction techniques to increase constructor profitability	☐	☐	☐	☐	☐
d.	Constructor request to use available material	☐	☐	☐	☐	☐
e.	Unrealistic construction schedule	☐	☐	☐	☐	☐
4.	**Project management-related**					
a.	Insufficient checking and correct planning and contract documents (e.g. fail to review design documents with client, drawing and BOQ do not match)	☐	☐	☐	☐	☐
b.	Not able to collect sufficient information of site conditions (e.g. condition of underground)	☐	☐	☐	☐	☐
c.	Lack of communication among other parties involved in the construction project	☐	☐	☐	☐	☐
5.	**Subcontractor-related**					
a.	Design change (e.g. modification) initiated by a manufacture/subcontractor.	☐	☐	☐	☐	☐
b.	Material non-conformance to technical	☐	☐	☐	☐	☐

	specification (e.g. wrong material, poor quality)					
6.	**Third-party-related**					
a.	Request of changes (e.g. floor space, entrance) by the occupier	☐	☐	☐	☐	☐
b.	Complaints from neighbors	☐	☐	☐	☐	☐
7.	**Environment-related**					
a.	Unforeseen weather conditions (e.g. high probability of corrosion and erosion)	☐	☐	☐	☐	☐
b.	Unforeseen natural disaster (e.g. storm surge)	☐	☐	☐	☐	☐
8.	**Political and economic-related**					
a.	Unforeseen price fluctuation of materials and equipment.	☐	☐	☐	☐	☐
b.	Sudden changes in government policies and regulations	☐	☐	☐	☐	☐
c.	Change of market demand of the intended use of the building/structure.	☐	☐	☐	☐	☐

Thank you for your cooperation and assistance.

Appendix B

Interview Guideline

Section A: Interviewee personal information

1. What is your current position/title?
2. How many years you have been in that position/title?
3. How many years you have been in construction industry?
4. What are the other positions/titles worked before?
5. What are the types of infrastructure you were involved?

Section B: The purpose of the questions in this section was to get an overview of the interviewee respect to impact of design changes and practices that can be followed to reduce rework due to design changes.

1. What are the major impacts on construction projects in Maldives due to design changes?
2. Are there any current guidelines provided by the relevant authorities to reduce rework in constructions projects?
3. What are the practices employed by your organization to prevent or reduce design related rework in construction projects?

Section B: The questions in this section was based on to identify respondents' opinion on how the causes of design changes can be reduced.

Question 1: Client Related Causes

1. Client related causes was identified as the most likely causes of design related rework in infrastructure projects in Maldives. In your opinion, what maybe the reason for this?

Sub-questions

a. Changes to scope by client and changes to design schedule due to financial problems of client was identified as two most common under client related causes for design changes. How do you think these causes can be reduced?
b. How can causes like unclear initial design brief from client and low fee for design consultant can be reduced?

Question 2: Constructor Consultant Related Causes

2. Constructor related causes was identified as the second most likely causes of design related rework in infrastructure projects in Maldives. In your opinion what maybe the reason for this?

Sub-questions

a. Constructor request to use available material was identified as the most common cause under constructor related causes for design changes. How do u think this cause can be reduced?
b. How do u think unrealistic construction schedules and constructor request to change construction techniques to improve constructability or increase their profitability can be reduce?
c. How do u think cause like less involvement of constructor and design consultant during design phase can be reduced?

Question 3: Political and Economic Related Causes

3. Political and economic related causes was identified at third rank as a likely design related rework in infrastructure projects in Maldives. In your opinion what maybe the reason for this?

Sub-question

a. Sudden changes in government policies and regulations was identified as the most common cause under political and economic related causes for design changes. How do u think this cause can be reduced?
b. How do u think cause like unforeseen price fluctuation of materials and equipment can be reduced?

Question 4: Project Management Related Causes

4. Project management related causes was identified at fourth rank as a likely cause of design related rework in infrastructure projects in Maldives. In your opinion what maybe the reason for this?

Sub-questions

a. Communication among other parties involved in the construction project was identified as the most common cause under project management related causes for design changes. How do u think this cause can be reduced?
b. How do u think cause like insufficient information of site conditions and inaccuracy in design related documents can be reduced?

Question 5: Third-party Related Causes

5. Third-party related causes were identified at fifth rank as a likely cause of design related rework in infrastructure projects in Maldives. In your opinion what maybe the reason for this?

Sub-question

a. Request of changes by the occupier was identified as the most common cause under third party related causes for design changes. How do u think this cause can be reduced?
b. How do you think cause like complain from neighbors can be reduced?

Question 6: Subcontractor Related Causes

6. Subcontractor related causes was identified at sixth rank as a likely cause of design related rework in infrastructure projects in Maldives. In your opinion what maybe the reason for this?

Sub-question

c. Material non-conformance to technical specification was identified as the most common cause under subcontractor related causes for design changes. How do u think this cause can be reduced?

a. How do you think cause like request of design changes by subcontractor can be reduced?

Question 7: Design Consultant Related Causes

7. Design consultant related causes was identified at seventh rank as a likely cause of design related rework in infrastructure projects in Maldives. In your opinion what maybe the reason for this?

Sub-question

a. Errors made in design was identified as the most common cause under design consultant related causes for design changes. How do u think this cause can be reduced?

b. How do you think causes like omission made in design and communication gap between client and design consultant during design phase can be reduced?

c. How do you think causes like inconsistency of information on design drawings and technical design specifications can be reduced?

Question 8: Environment Related Causes

8. Environment related causes was identified as the least likely cause of design related rework in infrastructure projects in Maldives. In your opinion, what maybe the reason for this?

Sub-question

a. Unforeseen weather condition was identified as the most common cause under environment consultant related causes for design changes. How do u think this cause can be reduced?

Question 9: Causes identified as very unlikely to causes design changes
9. Lack of knowledge of material availability in the market, design consultant not familiar with the regulations and construction permits and unforeseen natural disaster was identified as very less likely causes of design changes. In your opinion, what maybe the reason for this?

Appendix C

Respondents Score Sheet

Respondent/ Causes	1a	1b	1c	1d	2a	2b	2c	2d	2e	2f	2g	3a	3b	3c	3d	3e	4a	4b	4c	5a	5b	6a	6b	7a	7b	8a	8b
1	4	3	3	4	3	4	3	4	2	2	3	4	3	4	4	5	4	4	4	3	4	4	4	5	4	5	4
2	5	5	5	3	4	4	2	2	4	2	2	4	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4
3	4	3	3	4	4	4	2	2	4	2	3	4	4	5	5	4	4	4	4	4	4	3	3	5	4	4	3
4	5	4	3	4	5	5	2	4	5	3	2	4	3	3	4	3	5	5	5	3	5	4	4	4	1	4	3
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27	4	5	5	5	5	5	4	5	2	4	2	4	4	3	4	5	3	4	4	3	2	5	3	5	2	5	3
28	4	4	4	4	5	5	3	4	2	2	3	4	5	5	2	5	3	2	2	1	5	5	2	4	1	4	4
29	4	4	5	3	5	5	4	4	3	5	3	4	4	5	2	5	3	2	4	3	4	4	4	4	2	3	4
30	5	5	5	5	5	5	5	3	4	5	2	5	4	3	3	5	2	3	2	1	5	4	1	4	2	3	3

31	3	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	2	2	2	2	2	2	2	3	3	2	2
32	4	2	4	4	2	2	2	1	2	1	2	2	4	4	4	2	4	3	2	2	2	4	2	2	2	2	3
Total	137	113	129	107	123	119	99	106	102	87	88	116	120	119	124	124	113	116	120	108	113	125	107	122	76	116	121	
Count (N)	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	
Not answered	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	
No. of 5	13	7	12	5	8	7	2	5	2	5	3	4	5	7	8	15	8	7	5	5	6	8	4	5	0	5	6	
No. of 4	15	9	11	11	14	13	11	12	13	3	4	19	16	12	15	4	7	13	19	9	11	16	11	20	4	16	15	
No. of 3	4	11	7	7	7	8	7	4	7	6	9	2	9	10	6	7	11	6	3	13	9	5	11	4	9	6	9	
No. of 2	0	4	2	8	3	4	12	10	9	14	14	7	2	3	3	6	6	5	5	3	6	3	4	2	14	4	2	
No. of 1	0	1	0	1	0	0	0	1	1	4	2	0	0	0	0	0	0	1	0	2	0	0	2	1	5	1	0	
Total	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	
% of 5	41	22	38	16	25	22	6	16	6	16	9	13	16	22	25	47	25	22	16	16	19	25	13	16	0	16	19	
% of 4	47	28	34	34	44	41	34	38	41	9	13	59	50	38	47	13	22	41	59	28	34	50	34	63	13	50	47	
% of 3	13	34	22	22	22	25	22	13	22	19	28	6	28	31	19	22	34	19	9	41	28	16	34	13	28	19	28	
% of 2	0	13	6	25	9	13	38	31	28	44	44	22	6	9	9	19	19	16	16	9	19	9	13	6	44	13	6	
% of 1	0	3	0	3	0	0	0	3	3	13	6	0	0	0	0	0	0	3	0	6	0	0	6	3	16	3	0	
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	