



ADDIS ABABA UNIVERSITY

DESIGN MANAGEMENT PRACTICES IN BUILDING DESIGN PROCESS: IN
THE CASE OF ETHIOPIAN CONSTRUCTION CONSULTANT AND DESIGN
ENGINEERS

By

Samson Melesse Mamo

Advisor: Tadesse Ayalew (PhD)

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APPROVED BY BOARD OF EXAMINERS

Tadesse Ayalew (PhD)
Advisor

Signature

Date

Internal Examiner

Signature

Date

External examiner

Signature

Date

Chairman, Department Graduate Committee

*EiABC, Addis Ababa University
Addis Ababa, Ethiopia
August 2022*

DECLARATION

The Work Contained in this thesis, entitled “Design management practices in building design process, in the case of Ethiopian Construction Consultants & Design Engineers” has not been previously submitted for a degree or diploma at any other higher education institution. To the best of my knowledge and support of my advisor, the thesis contains no material previously published or written by another person except where due reference is made.

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TABLE OF CONTENTS

DECLARATION	III
ACKNOWLEDGEMENTS	IV
TABLE OF CONTENTS.....	V
LIST OF TABLE	VIII
LIST OF FIGURES	IX
LIST OF ABBREVIATION	X
ABSTRACT.....	XI
CHAPTER ONE	1
INTRODUCTION	1
1.1 Background of the Study.....	1
1.2 Statement of the Problem.....	3
1.3 Research gaps.....	5
1.4 Objectives of the Study	7
1.5 Research Questions	10
1.6 Scope of the Study	10
1.7 Significance of the Study	11
1.8 Limitations of the Study.....	12
1.9 Organization of the Research.....	12
CHAPTER TWO	14
LITERATURE REVIEW	14
2.1 Introduction.....	14
2.2 Theoretical Literature Review	15
2.2.1 The Design activity	15
2.2.2 The Design Process.....	16
2.2.3 Design as a creative process.....	17
2.2.4 Design as a management process.....	19
2.2.5 The process of building design	20
2.2.6 Theories of Design management and best practice.....	30
2.2.7 Managing design information production and flow.....	38

2.2.8	Design planning, monitoring and controlling	40
2.2.8.1	Planning and monitoring of design tasks	40
2.2.9	Design changes and control	48
2.2.9.1	Changes or variations.....	49
2.2.9.2	Design development.....	49
2.2.9.3	Requests for information from the Site.....	50
2.2.9.4	Design change control.....	50
2.2.9.5	Integration of design and construction.....	52
2.2.9.6	Design team experience	53
2.2.9.7	Design management hand books and checking manual.....	56
2.2.9.8	Design management handbook	56
2.2.9.9	Design management tools and the barriers to deploy	59
2.2.9.10	Design checking manual, and proposals in Ethiopia	60
2.2.9.11	Empirical studies.....	62
2.2.9.12	Global studies.....	62
2.2.9.13	Evidences from Ethiopia.....	63
CHAPTER THREE		65
RESEARCH METHODOLOGY		65
3.1	Study area.....	65
3.2	Research Philosophy	65
3.3	Research Approach	66
3.4	Research Design.....	67
3.5	Data Type.....	68
3.6	Data Source.....	68
3.7	Population and sampling design	68
3.8	Method of data collection	71
3.9	Method of data analysis	73
3.10	Validity and reliability test.....	74
3.10.1	Validity	74
3.10.2	Pilot test	74
3.10.3	Reliability test	75
3.11	Ethical Considerations	76

CHAPTER FOUR.....	78
RESULTS AND DISCUSSIONS	78
4.1 Introduction.....	78
4.2 Respondent profile	78
4.3 Level of Design management practices in building design	79
4.4 Applications of tools and techniques in design management	85
4.5 Discussions	104
CHAPTER FIVE	107
CONCLUSION AND RECOMMENDATION	107
5.1 Introduction.....	107
5.2 Summary of major findings	107
5.3 Conclusions.....	108
5.4 Recommendations.....	109
5.5 Recommendations for further research	110
REFERENCE.....	111
Annex.....	i
APPENDIX I – Questionnaire	i
Thank You!	v
APPENDIX II – Interview Questioners.....	vi

LIST OF TABLE

Table 1 Previous research category and their findings	7
Table 2 Design Management Handbook Contents	45
Table 3 Design Management Tools Standard format	46
Table 4 Number of Registered Consultants in Addis Ababa	57
Table 5 Sample Size Determination	59
Table 6 Respondents' Outlooks Index Factor.....	62
Table 7 Reliability Statistics Test Results	65
Table 8 Respondent profile.....	67
Table 9 Average annual number of building design.....	68
Table 10 Challenges of Design Management Process	69
Table 11 Challenges of Design Management Process by ANOVA	72
Table 12 Extent of use on the basics tools and techniques in the design management	74
Table 13 Applications of tools and techniques in design management	78
Table 14 Summary of document review and observation on, the applications of tools and techniques in design management Process	80
Table 15 Barriers for deploying tools and techniques	83
Table 16 On Difficult improvement areas	86
Table 17 Summary of Qualitative Interview	90

LIST OF FIGURES

Figure 1 Comparison of Performances with the International Good Practices	3
Figure 2 Types of interdependency in design activities.....	19
Figure 3 Relation ship in construction practice	31
Figure 4 IDEFO notation for design process maps.....	31
Figure 5 Prioritization and missing information identification from an ADePT matrix	34
Figure 6 Sample for a work package progress document.....	35
Figure 7 Change order control flow chart.....	39
Figure 8 Levels of Design management challenges	71
Figure 9 Level of applications of design management tools and techniques	82
Figure 10 Level of barriers for deploying tools and techniques	85
Figure 11 Level of difficulties for improvement area.....	89

LIST OF ABBREVIATION

ADePT	Analytical Design Planing Technique
ACE	Architectural Construction and Engineering
BIM	Building Information Model
CAD	Computer Aided Drafting
CDM	Collaborative Design Management
CE	Concurrent Engineering
DM	Design Management
DMH	Design Management Hand Book
DSM	Design Structure Matrix
ECEAA	Ethiopian Consulting Engineers and Architects Association
ICE	Integrated Concurrent Engineering
IDP	Integrated Design Planning
QFD	Quality Function Deployment
MoWUD	Minister Of Work and Urban Development
RIBA	Royal Institute of British Architects
RM	Responsibility Matrix
VE	Value Engineering

ABSTRACT

In recent times, the construction industry has been under pressure to improve efficiency in terms of quality improvement, timely delivery, and maintaining budget costs. The need for quality design solutions and effective processes has also incited significant emphasis in the industry. This study aimed to assess the design management practice in the building design process for Ethiopian construction consultants and design engineers in Addis Ababa. Accordingly, the study employed a quantitative research design. The study mainly used primary sources of data to collect the necessary information. It used three data collection methods, namely a questionnaire, an interview, and a document review. By employing descriptive statistics, this study found that challenges of design management practice included a lack of a structured and explicit design process and design information production and flow, as well as unimproved design planning, lack of design management tools and techniques and implementation by an inexperienced team. It mostly exhibited unsatisfactory level of design management disciplines, and various barriers included tools poorly deployed into industry practice, deficient resources in quality or quantity, and the inability to have a design checking system. There are also difficulties areas in terms of improvement needs on better managing design process include of having adequate design time increasing specialized design professions, to recognize design is as a process. Thus, the study concluded that these organizations created a low-level design management practice definition that involves setting high-level project milestones or gateways that the team can work towards. Accordingly, this study suggests that organizations must be cultured about the importance of the design process in delivering value to the whole project, how the way they work affects the design process, how they can contribute to the design and consequentially the whole project process. Therefore, implementation of a design management tool or practice must include and educate at all levels within an organizations and project team to ensure it is taken up in practice.

Keyword: *Design, Management, Practice, Challenges, Issues, Improve efficiency, Timely delivery*

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Several studies have pointed out that a large percentage of defects in building arise through decisions or actions in design stages. Also, it is widely known that poor design has a very strong impact on the level of efficiency during the production stage (Ferguson 2006). In recent years, the increasing complexity of modern buildings in a very competitive market-place has significantly increased the pressure for improving the performance of the design process in terms of time and quality. For instance, it has been fairly common to overlap the design and the production stages in order to reduce project duration and increase the flexibility of product design.

In Ethiopia 2008, with a delegation of FDRE Minister of Urban Development there was an initiative tried to prepare a design checking and project follow-up guideline (manual) by selected Ethiopian Construction Consultants and Engineers but it was not accepted. The design and documentation checking and project follow up were being conducted because of the desire of the government to have cost effective, functional and safe structures. Although the cause is noble, it also had its drawbacks as it was extremely time consuming, not cost effective and one of the major reasons for unbearable delays in project execution (FDRE, MOI, 2008). This after effect, is not an attribute of the requirement itself, but a result of the bureaucratic process set up, lack of adequate number and experience of checkers, the absence of clearly defined terms of reference for the checkers on what should be reviewed and incomplete and non-exhaustive existing checklists. Design checking is therefore, taken as an evil rather than a noble process. This trend needs to be reversed and render design checking and project follow-up an effective and dynamic process that would be undertaken by partnership of the parties involved in the project. To meet this end, a revised design checking and project follow-up guideline (manual) should have been prepared (FDRE, MOI, 2008).

Design is a complex process that continues to grow in complexity because of the dramatic increase in specialist knowledge. There are now several contributors to the design of a project from a wide variety of organizations (Gray and Hughes, 2001). This gives rise to design processes that consist of a continual exchange and refinement of information and knowledge. Due to this, the managing of building design phases might be one of the most challenging forms of management in this industry. It encompasses managing both outputs as drawings and creativity and it need enough room for creativity so that a building project can evolve to serve clients' needs (Vegard et al., 2015). As a result high level of collaboration, cooperation, and coordination within design and engineering processes has become inevitable as it is considering the escalation in complexity of construction project delivery (Ergo et al., 2019).

Consultant firms, being the key stakeholders of the construction design industry, are the primary agents for meeting the design demands made upon the industry. These firms in general, are project-based organizations which are mainly devoted in production of design and supervising projects. This output of design passes through sequential processes and needs to be managed and controlled. The discipline called design management plays a significant role in handling these processes. Design Management is an emergent professional discipline which separates the management function of a project's design phase from the design function. It is becoming increasingly important in modern construction projects (Gray and Hughes 2001). A simplified definition is to say that design management is about managing people and information (Emmitt and Ruikar 2013).

In this regard, (Stickdorn and Schneider 2010) advised a way to improve design process performance is to measure it by providing an understanding of practices that provide competitive advantage through which will address the ever-rising customer requirements and expectations for improvements in the cost, timing and quality of construction output. Accordingly, consultants need to have an appropriate design management approach which spans from the concept stage up to the completion stage and which integrates the works; defining the tasks ,managing information, evaluating information and presentation. Blomkvist (2010) also suggested that design management should be assessed its practices, key players and challenges in design service and development, and propose possible solutions to address these challenges. Thus, this study is intended to assess the design management practices and its challenges in the context of building design process.

1.2 Statement of the Problem

Despite its importance, relatively little research has been made on the management of the design process, in relation to the research time and effort which has been dedicated to production management and project management in general (Austin et al. 2004, Koskela et al. 2007). The relatively small cost of the design process compared to the production costs probably covers its true importance for the performance of construction projects (Austin et al. 2004).

To some extent, the fact that design management has been neglected is understandable. It involves thousands of decisions, sometimes over a period of years, with numerous interdependencies, under a highly uncertain environment. There are several defining features of the design process that have been noted that interact and make it difficult to manage. Primarily, the process is iterative and poorly defined which can be attributed to two key factors; first, it requires the production of incomplete outputs to develop understanding of both design problems and alternative solutions secondly, this is undertaken by a diverse team (e.g. Architects, Clients, Mechanical, Civil, Structural, Electrical, Environmental and Process Engineers, Quantity Surveyors, Estimators and Planners) representing different disciplines, educational backgrounds and goals. As a result, the process is one of significant co-ordination, negotiation, agreement, and compromise often under uncertainty and time-pressure to achieve success and failing to manage might lead to expected quality defects. (Pocock et al., 2006; Wong et al., 2007).

The learning curve is steep not least because many projects must now be delivered fast track while co-coordinating more specialists in the design of increasingly complex fabric and content of buildings (Austin et al., 2006). While historically, design was manageable with simple planning and management techniques, Gray and Hughes, (2001) and Baldwin et al (2009) note that such approaches to Design management are now inadequate as they have not evolved at the pace of industry changes. It needed to identify and develop approaches and tools capable of managing the building design process and get them adopted in the organizations.

Construction Design problems and mistakes in Ethiopia are generally evidenced within, Inadequate data source, Design quality problem (poor or decline in quality), Documentation problem, Lack of standardized documents, Ethical problems and HUMAN FACTOR, Negligence, Procurement system, Low service fee (Quality-Cost-Schedule “trade-off”) , Lack of partnership (Silesy B. 2018), these all problems are the responsibilities of Consulting office

owner, Professionals working with consulting office, and the implementing agencies (ECEAA Code of Ethics, 2009).

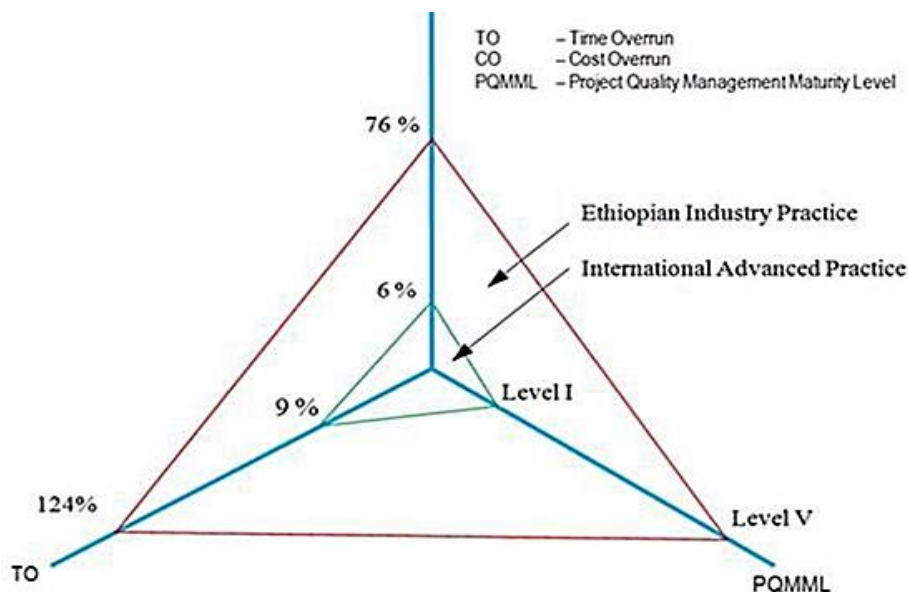


Figure 1 Comparison of Performances with the International Good Practices (Asmerom Taddese 2016)

The above figure is based on Material Project Information obtained from Construction Sector Transparency Initiative (CoST-Ethiopia), in 2016 the World Bank Governance Global Practice (GGP) Ethiopia Country Office (CO) has undertaken evidence based analytical work on the performance of construction contracts in a more quantitative ways with the identified gaps compared to global good practice in the industry such as, for example, the UK practice, is schematically exhibited in. The difference shows the gap between the construction industry of the Country and the good practice (Asmerom Taddese 2016).

Reasons for cost and time overruns of projects are attributed to design incompleteness, design changes, scope changes, changes in volume of work, poor initial estimation of completion time, force majeure and other reasons. Most of the reasons arise at earlier stages of the project cycle

(gaps in strategic project planning and preparation) thus showing more serious gaps related to project feasibility/planning, design and tender documents Equally important gap is associated with ineffective contracts implementation management that includes risks management and performance monitoring practices (Asmerom Taddese 2016).

Recent studies imply that design management tools and techniques application has great influence in design management. These tools and techniques are not a specific program and that offers an integrated platform to improve design, increase the speed of delivery for design and construction, and provide a flow of information without breaks. Nevertheless, due to the technological maturity and interoperability issues, industrial culture change requirements, lack of design management manuals, standards, and training and education needs, there is a common consensus that these tools and techniques are currently still immature for their full adoption over the construction life-cycle in the AEC industry (Zhiliang et al., 2011; Wong & Fan, 2013; Xu et al., 2014).

According to GTPII, by introducing construction project implementation techniques and tools (kaizen, integrated project management and information system), it is planned to bring about a significant shift in technological transfer and utilization. The enthusiasm for this study has stemmed from experience and observations. This research investigated the key challenges of design management in building design process in the Ethiopian Construction Consultant and design Engineers in Addis Ababa. Therefore, this study assessed the existing practices on design management processes and to identify tools and practices develops them to overcome implementation barriers, while making them capable of managing the design process and launch them to improve Design management practice within the organizations.

1.3 Research gaps

Numerous researchers acknowledge the challenges in the design phase globally (Hansen & Olsson, 2011; El. Reifi & Emmitt, 2013), and there is a consensus that the early stages of the design phase are important to improve the quality of the project (El. Reifi & Emmitt, 2013). Though, the research on this issue in building projects is limited, from the review of theoretical and empirical studies, it is understandable that there is lack of design management practices studies in Ethiopia. This creates a lot of gaps particularly in between design and construction. It

includes design errors and non-buildable solutions. This is because design work, compared to physical production, is different in the sense that is potentially infinite. There is always a better solution to be found (Hansen & Olsson, 2013). The design activities and their interdependencies differ from the activities in the construction phase, as they are more complex in their interdependencies and thus need another form of management. Design management is about organizing, planning, and managing the design process. It can also be described as a complex social situation where value can be a socially constructed phenomenon and making decisions can be inherently unpredictable (Kestle & London, 2012). This study, therefore, is engaged in bridging these gaps and to identify the role of design management. The management of the design process, to influence the key actors on how to solve the project with the best solutions possible and at the same time produces correct drawings for construction. This helps to continuous improvement of the design team in a pre-planned setting. Through the use of such kind of survey, it can be able to create a common understanding of what issues that needs to be improved in Ethiopia design management practices. Improving the design teams helps to close the gap of misalignment between design and construction, and helps to achieve success. This study will elaborate on how design culture including communication, collaboration and others, planning, information, design in action and monitoring and evaluation can help to improve the effectiveness of design management process, by aligning Ethiopian construction consultant and design engineers experience and current relevant literature.

In Ethiopia researchers, Silesy Ambachew (2018), assessment of Design management practice in National Consultant, Performance of Construction Consultants in Addis Ababa: A Study of Current Practices by Nuhamin Getachew (2018), Role of Building Information Modeling in Improving Building Design Process in Ethiopia. The case of Addis Ababa, by Belayneh Getachew (2016) and Design Management Using Building Information Modeling In Case of Projects in Addis Ababa by Betelihem Tesfaye (2018) have founds key challenges and issues which are summarized as:-

Table 1 Previous research category and their findings

Category of Research	Topics	Findings
1.Silesy Ambachew (2018),AAU	Assessment of Design management practice in National Consultant	<p>The finding revealed that national consultants face serious challenges with regard to practicing the design management theories in their design projects. The researcher shows that national consultants have a lower experience of evaluation of information at the early stages. In addition they also don't have enough information co-ordination between stages of the design process.</p> <p>The national consultants don't have a clear understanding and practice of value engineering by its methodologies and the researcher shows that the design review practice of national consultants don't have a consistent or standard way in which stages must be done.</p> <p>The results of the research indicated that, factors contributing to the inconsistent design management are unfamiliarity with defining tasks, ineffective managing and improper evaluation of information flow, inadequate planning, monitoring and controlling for project design process.</p> <p>The results revealed that consultants' design controlling process is not integrated with the management and evaluation of information throughout the design process with considering the time constraints.</p>
2. Nuhamin Getachew (2018),AAU	Performance of Construction Consultants in Addis Ababa: A Study of	The findings of the research show that there is a large room for improvement of consultancy services in Ethiopia. The results suggest that construction industry consultants in Addis Ababa generally perform at an average to below expected range.

	Current Practices	Most local consultants continue to face cost overrun, delay, quality problems and safety issues in projects they are involved in. These result, partly, from the gap between the duties of consultants and their actual performance on the ground such as poor contract administration and supervision, lack of commitment in enforcing health and safety and environmental requirements.
3. Belay Getachew (2016) ,AAU		
	Role of Building Information Modeling in Improving Building Design Process in Ethiopia. The case of Addis Ababa	<p>The researcher founds: -</p> <p>Design process is not as per the standard design frame work.</p> <p>Most consultants/designers do not provide design alternative to the client.</p> <p>Conventional design approach documents are fragmented and take longer time to prepare.</p> <p>Conventional design /Paper based approach result in omission of information and document errors.</p> <p>Engineering or critical assessment on the design process is given a very little attention.</p> <p>Projects go over budget, extended period and lesser quality caused by the poor building design management.</p> <p>Low design fee is the root problem identified poor building design management.</p> <p>Low design/professionals fee resulted in reduction of the details, limitation in having licensed software forced the experts to use cracked version, higher cost in establishing data base infrastructure.</p> <p>The majority of the professionals have at list the basic knowhow on BIM application; they rated the significance in encouraging way.</p>
4. Betelhem Tesfaye (2020), AAU		
	Design Management Using Building	The research indicates that the current design management practices follow the linear /successive design process which

	<p>Information Modeling In Case of Projects in Addis Ababa</p>	<p>criticizes to be error prone and less coordinated.</p> <p>Paper based, verbal and email communication ways are the common ways to communicate between the design team. Paper based communication is found to be the major ways of communication in category one consultants. It was found that the majority of consultants involve client at briefing stage only, this show the client role in the design process is not significantly considered.</p> <p>The current design management practice has limitations on design review for coordination since they use a 2D printed AutoCAD design and check for design clash. That error prone and time taking method found to be a drawback of the conventional way. The current practice also found to be difficult to consider constructability, maintainability and lifecycle cost of the building in depth.</p> <p>Very low project design fee is, ineffective design review procedures, predict the effect of design change within time and Fee, Unable to consider/model/analyze the existing site condition and Use of Poor technique to integrate designs are found to be the key challenges in design management.</p> <p>The research indicates that the design process using BIM follow the integrated design process which described as collaborative environment. The communication and collaboration between the design team during design is said to be live. The research indicates that BIM provides a better collaboration by providing a collaborative environment using server-based communication mode.</p>
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1.4 Objectives of the Study

1.4.1 Main Objective

- To assess the current design management practices in building design process.

1.4.2 Specific Objective

- To explore the practices of contemporary design management in building design process.
- To identify the key challenges and the successful implementation of tools and techniques in design management.
- To propose an improvement mechanism of design management in building design process.

1.5 Research Questions

1.5.1 Main Research Question

- What are the existing practices of design management in building design process?

1.5.2 Specific Research Question

- What are the key challenges and the successful implementation of tools and techniques in building design management process?
- How can improve Design management in building design process?

1.6 Scope of the Study

The purpose of this study was to evaluate contemporary design management practices and design management challenges in the building design process. The research focuses on building design management, specifically in the early stages of the design phase. To perform a thorough study of the research questions; there must be a limitation to the scope. "Early stages" refers to the stages of design where the activities are iterative with a high degree of interdependence across disciplines. Even though some of the publications address the whole lifecycle of building construction projects, the focus of this thesis is only on the early stages of construction. Thus, it

explored the challenges in terms of a structured and explicit design process, design planning, integration of design and construction, managing design information, tools and techniques, and design team experience. It also evaluates the design management process's effectiveness in terms of value and risk analysis, briefing workshops, room data sheets, collaborative working, technology clusters, responsibility matrixes, scope sheets, and appointment documents.

This study is also further restricted to building primarily for building projects in the study area (Addis Ababa). The high number of work divisions and items requires the collection and interpretation of a massive volume of information regarding resource design, productivity standards, and so on, which in turn demands the employment of an effective design management system. Another limitation of the study is that it will only investigate the internal challenges and issues of the design management process, despite the fact that there are external and other challenges that influence the process's effectiveness.

1.7 Significance of the Study

In the building design process, key technical and structural decisions are made for the project. Decisions made here influence the whole lifecycle of the building. Thus, having clear picture and information on the status of building design process, various stakeholders will be beneficiaries from such studies. In addition, this study will provide a clue to a better understanding of the most internal challenges and issues on the effectiveness of building design management practice. Besides, this study will contribute its effects to improve design management system in the country. Overall, this study is assumed to contribute much in the construction sector by revealing design management practices and systems for effective and efficient construction as well as proposing recommendations which are compatible with Ethiopian Construction Consultant and design Engineers in order to improve the sector's performance. Besides, it could be served as a reference material to researchers who are interested to conduct research in the area. The study would also provide directions for further research and development schemes that would benefit the construction industry and sector.

1.8 Limitations of the Study

The limitations of this study include the fact that it only focuses on local (non-foreign) consultants and among those, only the ones based in the city of Addis Ababa. The other limitation is that the data collected is prone to be affected by lack of transparency and limited availability of recorded follow up (post-construction) information for projects in the local construction industry. In addition, although the respondents were mostly top staffers of the consulting firms and fairly experienced, there may be a slight natural bias in their responses so as to present their firm as more practices than it actually may be. Although there is no evidence to suggest any major bias, it is worth anticipating such inclinations in this type of design management assessment research.

The other main limitation is that this research doesn't involve the other major industry players due to time and money constraints. The contribution of clients and contractors as well as statutory bodies would have been relevant to this research. Moreover, this research hasn't particularly studied practicing professionals who work as freelance designers or consulting engineers. Moreover, the research focused only 5 projects for cases, most of the organizations are not ready to cooperate and not have full engagement on the research focusing area. Especially consultants in Governmental projects are not accepting due to the disclosed information. Thus, it was planned to convince and notified the respondents about the objective of the study.

1.9 Organization of the Research

Chapters in the study are outlined thus:

Chapter One – Introduction: this is the introductory chapter containing background of the research, statement of the research problem, the problem statement, the significance of the study, research objectives, research questions, the scope and limitation of the study and organization of the structure.

Chapter Two – Literature review: this chapter reviews relevant literature of previous research regarding Design Management practices and gives an overview of the complex nature of building design and its management and presents challenges and issues on building design

management process, theories and discussions related with the major design management disciplines, tools and techniques, barriers. A brief discussion and comprehensively reviewed on areas considered to be difficulties in terms of improvement needs on better design management.

Chapter Three – Research methodology: this chapter comprises the research method adopted in the study for achieving the intended research aim and objectives. Moreover, this chapter examines the research design, research population, sampling technique, instrument for data collection, and technique for data analysis and model formation.

Chapter Four – Data analysis and discussion of findings: this chapter contains the report on the elicited data, analysing the obtained results. Additionally, it includes a discussion of the research findings, represented in both graphical and tabular formats.

Chapter Five – Conclusion and recommendations: this final chapter, based on the analysis of the findings, draws overall conclusions and offers final recommendations in regard to the aim of the research.

CHAPTER TWO

LITRATURE REVIEW

2.1 Introduction

In recent times, the construction industry has been under pressure to improve efficiency in terms of quality improvement, timely delivery and maintaining budget cost. The need for quality design solutions and effective processes has also incited significant emphasis in the industry (Latham 2004, Egan 2008). The reflection of this in practice has however been a huge challenge, nevertheless we cannot continue with the 'business as usual' mind-set. Common sources of problems in construction projects include: inadequacy of design process management, escalated by inadequate briefing, technical incompetence amongst designers and inadequate communication. These problems are more significant than the ones ascribed to substandard workmanship and site management, which follows from late, incomplete or uncoordinated design information and poor build-ability. The most determinant decisions are taken at the start of any project. This is the time for conceptual innovation, creativity, allocation of resources, definitions and a period laden with uncertainties. The informed advice of relevant professionals is crucial to good decision making at this stage. Most of the information about the potential of the project lies within the design professionals who are considered the key stakeholders in this phase. At this design phase which is most associated with architects and engineers, concepts are formulated to represent the end product that achieves the objectives of the design. However, discrepancy is commonly noted between these concepts representation and the design requirement and within the untidy circumstances found in reality. This is due to variety of factors which makes projects complex and unique.

Traditional approaches to design management are inadequate and have evolved more slowly than the industry and society as a whole. They also posited that the institutionalization of project role has discouraged professionals from developing more appropriate skills of managing the integration and coordination of the fragmented process. On the other hand, management by professional with non-design background who may lack insight to the far reaching implication of their decisions have further compounded the ineffectiveness at this phase.

This thesis assesses the challenges for effectiveness of design management process and offers the opportunity to determine the effectiveness of methodology in practice. It is a fact that construction industry has been faced with the responsibility to improve efficiency. The bulk of the problems have been laid at the foot of design, in other words, studies have revealed the most of the failures have been attributed to design inadequacies, lack of innovation and general problems in the strategic design phase in the project life cycle. This thesis set out to explore design management process and its effectiveness. The results of this study were relevant to the consultants, designers, clients, the construction project team, especially design managers in practice, and the academia. The research analysed the challenges of design management process, practices of design management with tools and techniques, barriers to deploy tools and techniques and exploring the difficulty improvement areas of design management process. The aim of this research was to understand the most internal challenges and issues on the design management process and recommending the improvement areas on the practice.

2.2 Theoretical Literature Review

2.2.1 The Design activity

Much has been written about design and how designers do or should think, but there appears to be no absolute agreement on the nature of creativity or any universally applicable methodology for approaching design. Creativity can take an abstract form with or without obvious meaning, as in the work of the artist who produces extraordinary or unexpected work. It can also describe 'lateral thinking' as a means of solving problems, perhaps leading to innovatory solutions which had not been seen, noticed or recognized previously (Powell 2004).

Creativity may have nothing to do with innovation at all, but simply a competent, well-organized attempt to produce an obvious, workable solution to a problem which attracts little or no attention. At its most basic level, creativity can just be the act of making anything, which may be good, average or poor. Teachers and practitioners in different design disciplines all have their own ways and means, and ultimately the commissioned designer must respond to the specific challenges of creating the project in hand on his or her own (Ferguson 2006). Their techniques and styles are based on their own experience of success, and regretfully sometimes of failure. It is important to recognize the impact of success or failure of design on those for whom the design

is intended. For some products, it is appropriate that they should be innovative and fresh to momentarily ‘catch the eye’ of users, to become obsolete intentionally, maybe by mutual agreement as sales, fashion and technology dictate, but for others, a well understood, tried and tested solution will better satisfy long-term needs.

Building design falls somewhere between the two; innovation is fine so long as it is relatively practicable (it may be said to ‘work’), and something that works is fine so long as it is reasonably attractive. A critically acclaimed building can be a disaster to its regular occupants whilst an ordinary, unnoticed building can be the source of great pleasure. There are pros and cons to taking a conservative or a radical approach to building design depending on a variety of circumstances, but the success or failure of any building imposes significant long-term consequences on its users, which cannot be dismissed lightly (Koskela et al. 2007).

Before considering specific issues associated with new buildings, it may be helpful to consider what design may mean and what the process of design may involve (Lawson 2010). There are similarities in the ingredients of all forms of design and in the way that they can be handled to create a product. Very few products are designed in isolation in the hope that someone will like them. Even the artist working to satisfy him or herself achieving public recognition or professional acclaim, generally needs to sell their work or gain income from exhibitions. The aim of most commercial designers is to satisfy the consumers of their products, who select them because they are useful, attractive and/or economical. In a commercial context it is the consumer who judges the success or failure of the product and their level of expectation are crucial. Competition and market forces mean that product designers must have an even higher level of expectation than their consumers in order, if possible to continue to create better products than their consumers were anticipating.

2.2.2 The Design Process

Markus and Arch (2013) pointed out that most descriptions of the design process, both theoretical and empirical, recognize two patterns. One consists of an individual decision making process, usually performed by a designer, concerned with the creation of alternative solutions. The second one is a management process, divided into phases, which develop from the general and abstract to the detailed and concrete. A complete picture of the design method requires the

consideration of both patterns. These are discussed in the sections titled “Design as a Creative Process” and “Design as a Management Process” respectively

2.2.3 Design as a creative process

Designers are traditionally known by the solutions which they produce, rather than the kind of problem they deal with (Lawson 2010). In design, the problem is usually poorly defined, i.e. the clients sometimes are not able to make their needs explicit. Often, there is no way to develop an adequate solution from existing information, since the client requirements are vague. The solution does not necessarily come directly from the problem. The attention of the designer oscillates between the comprehension of the problem and the search for a solution (Cross 2004). Each designer approaches the design problem in a particular way. One of the traditional ways used by designers for dealing with the problem is to develop quickly a potential solution or a group of potential solutions, which are used as a way to define and understand clearly the problem (Cross 2004). From the outset of a new project, the designer’s preliminary work can be based on very limited information which may be sufficient to justify putting forward ideas for consideration. However, it is very unusual to find that the finished design materializes effortlessly, translating initial ideas into reality without any revision.

Designing is a continual process of selecting and organizing elements, trying to establish which are the most important and how they might all play their part in the creation of the new product, and inevitably ideas change as possibilities are added or discounted, as proposals are conceived and considered. Markus and Arch (2003) The aims of design can be summarized as follows: Identify all the relevant elements pertinent to the project, discover or understand how the elements interact with one another and plan or arrange the elements so that they fit together in an appropriate or meaningful way to create a competent product.

It can be argued that trying to meet these aims is a process demanding logic; an intellectual, rational review of the matter, but it is by no means clear that this is how all, or any designers work in practice. Much has been written about brainstorming, mind mapping and even day dreaming as ways in which unexpected, apparently illogical design solutions appear. However, in many cases, the design development process involves the following actions.

Analysis Analysis means splitting up the ‘whole’ into its constituent parts. In the example of the designing building shop front, it is useful to find out what the essential design criteria is for the major elements of function, appearance, cost, image and so on, which can each be analyzed in more detail to determine what they mean, or could mean in relation to creating the shop front.

Synthesis Synthesis is the re-assembly of the parts into a meaningful ‘whole’. The information gained through analysis can be used to suggest a possible design for the shop front.

Appraisal The proposal for the shop front can be checked to see if it matches the analysis, critically assessed by interested parties such as the client, the Planning Authority and other members of the design team.

Feedback Critical comments received following appraisal in the form of further information, advice, recommendations, approvals or instructions will either confirm that the proposal is acceptable, or that some elements must be analyzed again in more detail. Further examination of the elements leads to a new synthesis, a new design proposal which can be re-appraised and tested once more, leading to more precise feedback so that the design improves, becomes better, more practicable, economical or attractive until at some point it is accepted as being the right solution, or the best solution to proceed with under the prevailing circumstances.

For all but the simplest of design tasks, the process will not be in the progressive linear form of start, analysis, synthesis, appraisal, feedback, finish, completing each stage before moving on to the next one. It cannot even be categorically stated which comes first, as ideas and decisions are influenced by each action and there is constant need to go back and test solutions against requirements. As most building design contains compromise, a good designer tries to get as close to the center of the target as possible, or has to stop when time runs out (Lawson 2010). How close the designer can get to the center depends on ability, skill, conscientiousness, perseverance, inspiration or even sheer luck in taking the correct or best route and being able to recognize where they have already been.

It can be a good idea to keep a record of these routes so as not to go down the same dead-end again (Cross 2004). Or it might be that revisiting with a fresh piece of information enables the designer to unlock the gate to the next level. Sometimes though, a perfectly sound design proposal can be ignored in the search for a better one, which may not exist. One of the designer’s

key skills is being able to recognize the target and to know when it has been reached. To a large extent, the process of designing is a personal activity influenced by the way that the designer's brain works; how they think.

Some designer's work in the direction of 'analysis, synthesis, appraisal and feedback' which is a method of examining problems (Koskela 2012). They are 'problem solvers' concentrating on working out ways of putting the known elements together to create a product, which is then checked or tested to see if it is a satisfactory solution. For others, the process is predominately reversed in the direction of 'feedback, appraisal, synthesis and analysis', which is a way of testing solutions. These designers are intuitive, speculating or postulating an idea or possible solution straight away, in advance of the complications of detail, and then checking to see if the answer contains all the necessary elements, or satisfies the brief. Most designers will use a mixture of both methods as whilst a design solution can come purely from consideration of analyzed or perceived problems, it is quite common to find that a proposed design solution redefines the original problem, satisfying needs which were not initially identified or understood.

2.2.4 Design as a management process

In the building industry, design is traditionally regarded as a single stage in building projects. This is due to the fact that the participation of the design team tends to start relatively late in the project and finish as soon as the production stage starts. In the present study, design is regarded as a process which takes part of all stages of the building process, from inception to building operation. In fact, design is one of the most important processes in building projects, since it defines the product to be built and has many interfaces with several other processes. The way the design process is divided into stages varies considerably in different studies both in terms of content and the names given to each stage (Cross 2004). Mostly the design process is divided into seven stages: (a) Inception and Feasibility, (b) Outline Design, (c) Scheme Design, (d) Design for Legal Requirements, (e) Detail Design, (f) Production Monitoring, and (g) Feedback from Operation. Each design stage can be further divided into sub-processes, which successively transform information from client requirements and project constraints into product design. Generally, the design process is analyzed from the point of view of the New Production Philosophy (Koskela 2012), which means that there are four kinds of activities involved:

conversion, waiting, moving, and inspection. Only conversion activities are value adding. Waiting, moving and inspection activities are non-value adding and should be eliminated, rather than made more efficient. Part of the conversion activities are not value adding, since they cause rework, due to errors, omissions and uncertainty (Huovila et al. 2007).

This kind of rework should not be mixed up with the iterative process that occurs when a design alternative is generated, which is an inherent part of design as a creative process. Based on the view of design as a flow, Huovila et al. (2007) proposes a number of principles and methods for eliminating waste in the design process: 1. Reduce uncertainty, which is one of the main causes of rework, especially in the early stages of design. This can be done by increasing the effort in terms of clearly defining the project restrictions and the requirements of internal and external clients; 2. Reduce waiting time by decomposing adequately the design tasks so that they can be properly planned, and also allow the transfer of information to be made in smaller batches; 3. Reduce the effort needed for information transfer through team work, and by rearranging the design tasks.

2.2.5 The process of building design

Design is a creative and very personal activity. It is important, however, to understand how designers think when defining and realizing their objectives and their respective priorities. Only when the design is complete can the results of their intense intellectual activity be seen. This is at the heart of the problem of managing design. It is why managers of the design process must understand the methods by which a typical design is developed, and the characteristics of the designers, in order to achieve a level of understanding that allows them to be sympathetic to the process. Architectural design is in this discipline that most of the research into the creative aspects of design has been carried out. Many engineers would disagree with this view and suggest that they have made an equal contribution to the creative design process (Addis, 1996). While we recognize this, the characteristics of the creative process that are revealed and articulated here are applicable across the whole design team, not just to architects.

In essence, the architect takes the client's brief and uses design skills to develop a three-dimensional interpretation which other designers use as the basis for their own work. This is not a hard and fast rule, as on any project the formative or concept design stage is both interactive and

iterative between the many design disciplines as well as between the architect and the client. The input from the structural and services engineers, for example, can often have a strong influence on the eventual design solution.

Ashworth (2009) believes that excellence in building and construction is attained only where appearances, soundness of construction and usefulness have been developed together in a fully integrated manner. The design approach will also vary depending on the nature of the designer. Coles and Barritt (2012) suggest that during design development, everyone involved in the process has different ideas and many models will be created to represent parts or Improving building design management aspects of the building. The Architect will model solids and spaces, while the structural engineer will investigate the ground and suggest how to support the weight and the forces that may act upon the building. Services engineers model routes of pipes, ducts and cables, and equipment sizes and types needed. Cost consultants model the likely cost of the designers' proposals. The client may model what should happen in the completed building and how this activity will be financed and operated.

Since these models include different interests and viewpoints, they are never perfectly compatible at the beginning. Design development is largely the process of reconciling these different models, so that the builders will be given design documentation for one complete and coordinated model. This process is often made more complicated by the growth of the project organization over a period of time. Ideally, a full team of designers their specialist knowledge would be assembled at the outset. In practice, the various members of the design team join at different times and the process of developing and all the models, to make one integrated design for the building, can be long and unpredictable.

2.2.5.1 The process guides of designing building

Process models and frameworks are essential to allow all designers to understand their position, roles and responsibilities in relation to others; they are also essential for design managers, Emmitt and Ruikar (2013).

A number of well-known frameworks and models exist for the administration and management of projects, their suitability dependent on ensuring the best fit between the client, the aims of the project and the project participants' organizational needs. The best known is the RIBA Plan of

Work, developed by the Royal Institute of British Architects for use by architects. Other process models have been developed by others, such as the British Property Association and the generic process management protocol. With the uptake of BIM there will, no doubt, be the need for new process models that better reflect our digital working environments. Whatever process management tool is used it is crucial that all those working on the project are comfortable with it and understand the boundaries of their decision-making responsibilities; it also needs to be appropriate for the context of a given project. Early discussion about the process management tools being used can help to eliminate misunderstanding later in the project.

Models represent a rational (and often prescriptive) approach, although the reality is that considerable flexibility is required in practice. Frameworks help to give a degree of formality to sub-sets of work and help to formalize the interface of work and workers. The formality of the framework is such that it is sufficiently understood by those contributing to the process to enable informal interactions within and around the frame, i.e. it is interpreted liberally. It can be misleading to put too much emphasis on the framework model. It is more important that everyone understands the project, roles and responsibilities, which needs to be discussed at the outset of projects and re-visited at regular intervals during the course of the project.

Managerial frameworks should facilitate design work, communication, knowledge sharing and information flow. The process needs to be mapped and a suitable operating structure devised to manage the various activities in an efficient manner. It is a sensible policy to assemble the main actors, discuss how the project should be planned, and agree on the most appropriate framework in which to work collaboratively (a bottom-up approach). This tends to be a more effective approach than implementing a system and expecting everyone to be comfortable with it (a top-down approach). From the perspective of the architects, the model must allow space for spontaneity and creativity. Frameworks should be customized to suit the project context and as a minimum should contain: clearly defined stages, roles, tasks and responsibilities; value and risk management workshops at strategic intervals; project milestones; last responsible moment for decision making; control gateways to coincide with the end/start of different phases; learning opportunities and feedback loops, Emmitt and Ruikar (2013).

One of the best-known guides for managing design projects is the RIBA Plan of Work. This was first developed in the early 1960s by the Royal Institute of British Architects (RIBA) as a tool to help architects manage their projects, and has since been updated to reflect changes in how we build and more recently our attitude to our environment. The guide continues to be used extensively by architectural firms and has parallels with guides produced by architectural bodies in other countries. The Plan of Work has been criticized (mainly by non-architects) as being a linear model that promotes a segmented approach to the management of projects. Although this may appear to be the case when read literally, it fails to recognize the way in which architects use the model. The Plan of Work provides a familiar guide that helps designers navigate their way through highly complex and interwoven activities. The guide is not followed strictly, since design activity requires constant iteration and reflection as the design work develops. A fluid approach is possible because of the guide; forming a backbone to decision making and delivery of work to defined milestones.

The RIBA Plan of Work and similar frameworks give a formality to the process that is understood by other actors. The process is a number of sub-sets of formality (stages or phases) held together by a number of loose joints. It is the positioning and control of the joints that determine the framework of the work plan and the subsequent effectiveness of the process. The actors interpret formality differently, but there is enough common understanding to make the process work. Care is required when implementing new (unfamiliar) frameworks, as time is required for the actors to engage in communication and hence develop a common understanding. The main phases are the inception phase, the design phase, the detailing phase, the implementation phase and finally the post-occupancy phase, Emmitt and Ruikar (2013).

Other models developed by IDEF0 notation for design process maps, are also available that claim to be less linear, although these, too, break down functions into discrete work packages and/or areas of responsibility. Process models can help to illustrate, or model, a web of relatively complex activities under a generic framework applicable to all projects. These models are more suited to large and complex projects and application to small projects may be unnecessary and inappropriate. Emphasis tends to be on integration of activities, concurrent development of work packages, knowledge transfer and change management. Value management and value-based management models are based on the discussion and agreement of values via facilitated

workshops. Consensus and the creation of trust is a fundamental component of these models. Workshops start with team assembly and continue to project completion and feedback. Workshops encourage open communication and knowledge sharing while trying to respect and manage the chaotic nature of the design process. Cooperation, communication, knowledge sharing and learning as a group help to contribute to the clarification and confirmation of project values. Getting to know fellow actors and the development of trusting relationships is an essential feature of the model. The model is suited to partnering type arrangements and relies heavily on the skills of the process facilitator to drive the work forward.

Often the frameworks are implemented in a pure form, although it is also relatively common for architectural offices to take different elements from models to suit their work ethic. Flexibility and some degree of latitude for change is an essential requirement of good frameworks. Allowing some tolerance between well-defined stages or works packages is a familiar and effective way of allowing for some degree of uncertainty. For example buffer management techniques have proven to be successful in helping to manage the interface between different work packages.

2.2.5.2 The nature and types of the building design problem

One of the challenges for design managers is to first establish the type of problem they are dealing with and then apply the appropriate managerial frames to suit the context, Emmitt and Ruikar (2013). This is usually done in the early interactions with clients and may form part of the briefing process; and in the case of wicked problems form part of the design process. Managerial techniques such as value management can also assist in helping to identify function and value. Opportunities for designers to interact collaborate, communicate, discuss, negotiate, make decisions and learn must be included within the managerial framework.

Clients cannot always state their requirements clearly or fully at the outset because of the many different interests that have to be satisfied. In many cases each problem is 'owned' by a group of people, each with varying requirements and ambitions for its solution. Each party will have a different role to play in the initial decision-making processes that will inevitably lead to overlaps and gaps in the statement of requirements given to the concept designer. To help develop a

working brief that can be agreed by all parties, a designer will often pose solutions to the problem, largely to elicit where they fail and then, through a process of learning, offer a better description of the problem. External sources, such as Local Authority planners or environmental agencies, may well also have important inputs at this stage.

A successful outcome to the design process is often determined by the choice of starting point in relation to the definition of the client's problem. Assessing the level at which to start is important and is a matter of fine judgement. It requires a clear definition of the boundaries surrounding the problem, because starting at too low a level may lead to a misunderstanding of the real issues. For example, a designer trying to design the layout of a floor space for office use must know how many people are to work in the office and the type of tasks that they are going to perform.

This could then be extended to the way the office is organized and to considerations of the company structure and its philosophy on work, its workers, and many other matters. It is clear, however, that there would be no end to solving the problem if every eventuality had to be considered before taking any decision. At the same time it is equally important to allow the designer to stretch the boundaries of the problem to uncover all the factors that may influence the final design solution.

2.2.5.3 Complex process of design

Gray and Hughes (2001) indicate that two issues should always be addressed in design; the provision of accurate, fully coordinated, complete information and the timely provision of that information. The first is the responsibility of the lead designer and the second is management. Findings from research indicate that, for design, planning and control are substituted by chaos and improvising in design, (Koskela et al. 2007). Poor communication, lack of adequate documentation, deficient or missing input information, unbalanced resource allocation, lack of co-ordination between disciplines and erratic decision making have been pointed out as the main problems in design management (Ballard and Koskela (2008). Coles (2000) found that the most

Significant causes of design problems were poor briefing and communication, inadequacies in the technical knowledge of designers and lack of preplanning for design work. Common consequences included slow approvals from clients, late appointments of consultants and

inadequate time to complete design documents carefully. Koskela et al. (2007) explains that, to some extent the situation is understandable. The design effort is complex, with numerous interdependencies, singularly uncertain, with erratic decision-making by lay clients and authorities, and often carried out under time pressure.

In order to try to understand the difficulties of design management it is also important to understand the process in building design. The design process is often divided in several stages or phases. An example is the RIBA plan of work which has divided the construction process into the seven stages where stages 1 through 4 include design work (RIBA, 2013). The flow of information, focus points, planning and managing differ in these stages. A simplified definition is to say that design management is about managing people and information (Emmitt & Ruikar, 2013). People in this context are stakeholders in a building project and information being deliverables among stakeholders.

The final part of deliverables as drawings, models etc. are concrete and easier to manage than for instance ideas or evolving concepts from the creative minds of designers. “Design management is a complex social situation as value can be a socially constructed phenomenon and decision making to that end can be inherently unpredictable”(Kestle & London, 2012).

Brief stages and the implication that these can have on a project are attracting an increased focus hence they give inputs to the rest of a building process (Blyth et al., 2013). But this is an important and under researched area. The briefing period is also a complex stage to manage. If the management of the briefing phase is poorly conducted, it is likely that opportunities are missed out later in the design process (Tilley, 2005). On the other hand, Azlan-Shah and Cheong-Peng (2013) argue that good designers can improve the clients brief.

A briefing stage usually ends up in briefing documents, on which a project is based. In some projects, this process is short and very often only consists of a client and an architect. In this stage, the vast majorities of key decisions are made. Gilbertson (2006) argues that design cost is 20% of construction costs, yet maintenance and building operating costs are five times of construction costs and business operating costs can be as much a 200 times the construction costs. The research of Reifi and Emmitt (2013) revealed that the issues related to the design brief were responsible for almost 30% of the rework. Accordingly, they also discovered that the client

brief was the largest hindering of the design value by over 60%. This highlights the importance of the briefing stage.

In the early stages of the design phase, such as preparation, brief, concept design etc., processes are creative, iterative and innovative. These are processes which many solutions, thoughts and ideas are shared between stakeholders. These processes need to be open and to enable the best solution to arrive (Hansen & Olsson, 2011). The process has an iterative form (Kalsaas & Sacks, 2011) and each iteration will hopefully contribute to the end value of a project. Lawson (2007) defines design problems and design solutions as interdependent. Design problems cannot be comprehensively stated and there are no optimal solutions to design problems, and design solutions are unlimited in number. Thus, there is a need to control the design process, but also a major challenge. The design process can therefore be viewed as an endless reciprocal process versus the building production process is traditionally viewed as a strictly sequential process.

2.2.5.4 Interdependencies between design activities

Specific tools have been developed to assist in the understanding of the interdependencies between design activities and to deal with the iteration necessary to produce quality co-ordinated information. The Dependency Structure Matrix (DSM) has been included as a part of a multi stage approach called analytical design planning tool (ADePT) developed by Austin et al. (2009). From previous findings it is aimed at the detail design stages where, in the analysis of typical building designs the number of design tasks averages around 350 – 400, yet the number of information dependencies is over 2400. On larger projects, with over 750 design activities the design dependencies are over 2400. Clearly not only is it important to identify the design activities, but also the information interdependencies. The advantage of this approach seems to be the clear emphasis on the design stages order to meet the requirements of information interchange thereby the dependencies of one task on work done in another task can be anticipated. Subsequently there is an attempt to minimize the iterations commonly seen in design processes.

Bølviken et al. (2010) introduces the work of Thompson (2014) to describe the different processes of design and their interdependences. There are pooled interdependence, sequential interdependence and reciprocal interdependence. Bell and Kozolowski (2012) introduced a fourth dimension called intensive interdependence. Processes emerge at different times and at the same

time in the design phase. This also needs a form for coordination, which is described as coordination by standardisation, by plan and by mutual adjustment. “Design decision making is often negotiated amongst groups and teams, it is an iterative process” (Kestle & London, 2012).

Kalsaas and Sacks (2011) argue that it is important to understand dependencies in the design process in order to handle them. Andersen (2011) describes the coordination as negotiations, mutual adjustment and opinion based communication. Relations in a process follow different logics. One of the logics describes an “everlasting movement”, where everything is connected to each other (see Fig. 1). To be able to proceed, you must make a decision, regarding an element or structure, if not the process stops or it will not start. A concrete decision of a solution might then start a sequential process, yet a decision turning down a solution, might just set of a new reciprocal process. A second logic is to pursue decisions so that they again set of a chain of solutions and new decisions. Knotten et al. (2014) introduce the term reflective logic and sequential logic describing the logics of design process. The sequential logic is based on a sequential, linear, closed process. Activity A must be finished before activity B can start. These are the typical processes displayed in a Gant schedule, and they can be planed and managed by the management planning tools (Pinto, 2013).

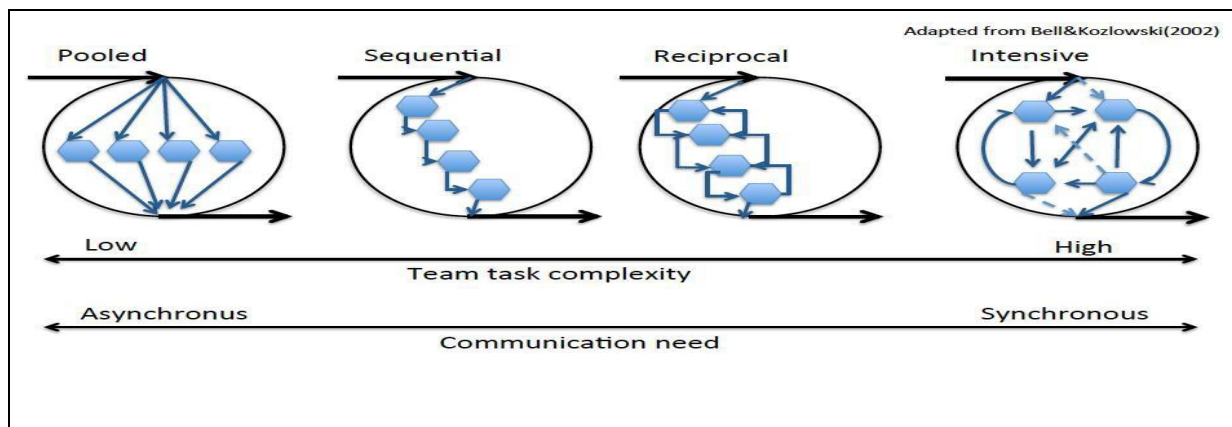


Figure 2 Types of interdependency in design activities

The reflective logic is dealing with reciprocal, iterative and intensive processes. Activity A needs input from activity B, before it can finish, yet activity B needs input from A before it can deliver its output to A. The design phase typically starts with a high amount of interdependencies and team task complexity as a design team is looking for the best solutions. As design problems are solved, interdependencies and team task complexity are reduced and consist of singular tasks (e.g. drawing completion). In turn, Alvesson and Sköldbberg (2009) describe reflective research to

consist of two characteristics, i.e. careful interpretation and reflection. This is coherent with Lawson's (2007) description of the process as analysis, synthesis and evaluation. Therein, a logic looks at a problem, tries to generate a solution and then evaluate the solution, before this might lead to a final solution.

2.2.5.5 Design problems solving

An efficient decision making process is the backbone to an effective problem solving strategy. Providing information and decisions at the last responsible moment will reduce quick and imperfect decisions being made. Users and clients tend to keep their options open for as long as possible to enable them to react to change, whereas designers and contractors want decisions frozen at the earliest opportunity. Blyth and Worthington (2011) suggest “A project programme should include a strategy for fixing decisions progressively through the project, but enable clients to keep options open on matters which cannot be decided early. If there are no clear decision points then there is confusion about what decisions might change.” Designing for construction projects is virtually always a wicked problem (Conklin and Weil 2007). The requirement documents are the supposedly definitive statement of the problem and to insist that they are specified up front and frozen until the project is complete is to ignore the fundamental nature of the design process. Because of the number of stakeholders, the dynamic nature of the problem formulation and changing constraints, it is not possible to reach an ideal solution for a wicked problem. “Design is not like solving a puzzle, where there are only a few possible solutions. Instead, there may be no limit to the alternative acceptable outcomes”, (Coles and Barritt 2012). To solve wicked problems it is necessary to confront a complex mass of information while unleashing creativity and opportunity driven thinking. Decisions, partial solutions and disagreement will flush out new aspects of the problem. Either time or money will run out, at that point, there will be a solution that is operationally optimal with respect to the resources provided and the approval of the stakeholders.

2.2.6 Theories of Design management and best practice

The twenty-first century construction sector is organizationally complex, with design activities distributed widely. It faces substantial and new challenges. In construction, there is a need for project management and control, but a culture of monitoring and measuring can drive out the iterative experimentation that is required in a design inquiry. Writers have articulated the difficulty faced by designers in a performance measurement culture (Allinson 2013) and have drawn attention to the different judgment- and measurement-based approaches to design quality (Gann and Whyte 2017). The judgment-based approach to design is prospective, concerned with the future; whereas the measurement based approach is retrospective, measuring the past and checking progress. It is this kind of design activity that has inspired management scholars to draw parallels between design and management seeing both as forms of reflective practice or inquiry (Boland and Collopy 2014). For those from a judgment-based approach, managing occurs through the activity rather than separately from it – those engaged in design activities act as design managers, rather than design management emerging as a separate profession. Hence Caudill's formation could be recomposed at project level by way of technical coalitions strategically 'designed' to respond to the reflective management tasks at hand. Computers offer great opportunities and also great threats to this collaborative culture. New digital tools for design, coordination and governance of large construction projects include centralized project archives that can be used to track design progress. These technologies are having a dramatic impact on the way design work is organized, for example enabling design work to be distributed globally over multiple offices to speed up its delivery. New practices that combine digital and physical ways of working are emerging (Harty and Whyte 2010) and their implications for design quality and for practices of design management need to be better understood. These technologies also herald a host of new intermediary roles, as document controllers, 3D CAD technicians and others become more salient in the coordination of professional design work.

Design management concerns itself with the design content of project outcomes and the effective management of the design process. Like design itself, design management is a multi-faceted subject. There are different and equally valid ways of approaching it, all of which are concerned with realizing potential and avoiding risks (Allinson 2010). Dumas and Mintzberg (2012) proposed four management models for design management. The 'cooperative design: Interactive

functions' is the model most effective with the growing level of complexity that exists in the process today. This model encourages interaction between the different contributors. Co-operative design is based on teamwork and reflects the ad hoc structure of most creative organizations.

Gray and Hughes (2001) suggest we view the task of managing the design as the responsibility of everyone on the project. Various professional institutions have published a formalized view of the main stages of design work, in an attempt to make it more controllable. The RIBA Plan of Work (RIBA 2013), for example, gives an impression that the work can be neatly wrapped up into stages, however Coles and Barritt (2012) claim, in many projects after construction starts, specialist contractors generate the majority of the production information which indicates overlaps in the process which are not seen in the professional model. The principles of lean construction are proposed in Koskela et al. (2010) where the following hypotheses are presented and justified through results from case studies: 1) There is an optimal sequence of design tasks. 2) Internal and external uncertainties tend to push the design process away from the optimal sequence. 3) Out of sequence design leads to low productivity, prolonged duration and decreased value of the design solution. 4) It is possible and worthwhile to enforce the realization of the optimal or near optimal sequence. They also observed the following as problems: The iteration needed from incomplete information, Lacking or delayed input from the client, Changes in design objectives, Unbalanced design resources, Late engagement of a design party and Earlier intentions not being taken into account in a later task

These deteriorate the design process and construction performance and eventually decrease the value provided for the customer.

2.2.6.1 Design, Professions and the boundaries of expertise

On the challenges of design management in construction is to immediately raise a number of questions. What is design? What is management? What is construction? Generally accepted answers to such questions stress the linearity of production processes. Design becomes associated with the work of professional actors, such as architects and engineers. Management is seen as a project management responsibility, the role of managers to monitor designers' progress and outputs. The term 'construction' is narrowly applied to a process of on-site assembly. In descriptions such as the conventional Royal Institute of British Architects

(RIBA) stages, work in design is passed into a construction stage after the main design work has been completed.

Based on such definitions, design management in construction has been explored in two main ways. First, it has been described as the management of the specialist professional expertise within consultant architecture and engineering firms at a pre-construction stage. Here researchers have discussed the commercial management of design firms (Winch and Schneider 2013; Emmitt 2017) and the differentiation and integration of design tasks into the conceptual design, interior layouts, façade, mechanical and electrical, structural and other subsystems. Second, it has been described as the management of vertical connections between phases of the design and construction process.

The architectural and engineering design professions have dominated discussion of design in the construction sector. From the beginning of architectural practice as a modern profession, architectural institutions have been active in the advocacy of a particular image of the building process that legitimates the social necessity of the architect's role (Kostoff 2014; Saint 2017). Since trades, contractors, and developers gained a strong operative and decisional presence, this image had to account for the actual spread of responsibilities without attaching it to a release of expertise. Authority 'on the subject' of architecture was connected with authority 'over the operations' of the building process (Tombesi 2009). This could only happen by promoting, as John Soane (2012), famously did in the late eighteenth century, a principle of non-compatibility between the production of advice (i.e., design) and the production of goods (i.e., construction), and by concentrating the 'design' function with architects insofar as they were professional.

Much writing in this vein refers to a triangle of practice, with trust relationships between a client in a commissioning role, design as a technical agency and construction management as a delivery function. Within this triangle of practice it was the ability to instruct and monitor the work of others that gave architects their professional status.

This implied a technologically exhaustive function, unfolding prior to construction and organized progressively, which was to be reflected in the technical dimension of the architect's work: define and organize the information necessary to envision the overall idea for the building, produce its various physical components, and determine the processes required for the implementation of the plan.

During the twentieth century this design function became increasingly distributed as processes of design and construction grew in complexity. In the twenty-first century relationships are now undergoing rapid change, due to new building types and forms of contracting, such as design and build, new tools and new approaches to delivery such as public-private partnerships and the increasing importance of a digital infra- structure for the delivery of project work (Whyte and Levitt 2010). As implied in the right-hand diagram of Figure 5, contracts are now available that facilitate official design assistance from several other parties, and procurement methods have been developed that parcel out the design effort in recognition of the actual distribution of technical expertise across the industry and overlay it with construction ,Bennett and Ferry (2010) and Pietroforte (2017).

Hence, current relationships can be seen as involving a polygon of practice, in which there are an increasing number of design roles involving subcontractors engaged in product engineering, testing and management. Yet, in many construction contexts, the theoretical skill to provide primary instructions, originally ascribed to the architect as main agent of the principal, has left an enduring mark on the way design is conceptualized ,a largely autonomous activity, closely associated with the work (and the services) of the architect plus

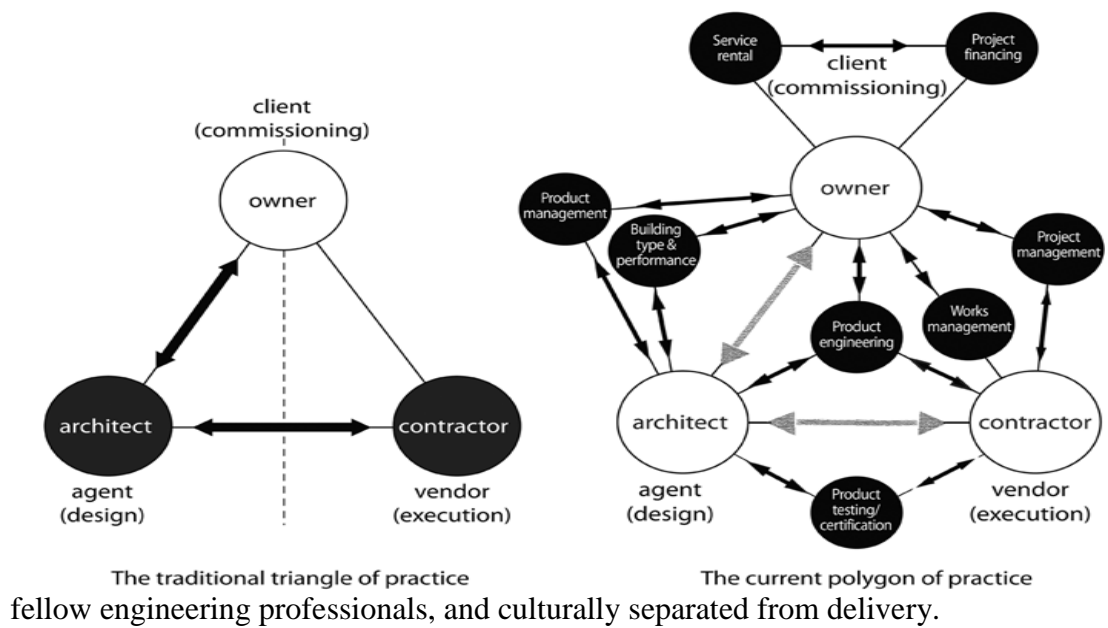


Figure 3 Relationships in construction practice. Tombesi and Whyte, 2011

2.2.6.2 Lean Design Management Practices in Construction Projects

The infrastructure life-cycle has several phases from the inception of the idea to the dismantlement of the facility, (PMI, 2017). Within this life cycle, the design phase is key because the decisions made during this phase can significantly affect the subsequent phase. In addition, the costs of changes in the design phase are negligible compared to the costs of changes in future phases, (AIA, 2007). Poor interactions within the work teams of the architecture, engineering and construction (AEC) industry can result in poor performances, Baiden, B.K (2006). Poor performance results from activities that do not add value and are considered project losses, such as reworks and waiting times, among others, Aziz, R.F et al. (2013) Therefore, it is essential to appropriately manage the design process.

Design management is the discipline of planning, organizing, and managing the design process to meet certain defined objectives, Knotten, et al. (2017). Although there is no tradition of integral management of the design process, in recent years; several options have been studied to evaluate its performance, Salvatierra, J.L et al. (2019). to implements integrated management systems and visual management tools, Heraklion, Greece, (2017). as well as to optimize this process, Knotten, et al. (2017).

Technological tools have great potential to improve the performance of projects, particularly in the design phase. However, the problems generated in the design of construction projects cannot be solved with technology alone but require an understanding of the social phenomena related to the processing of individual and collective information, Knotten, et al (2016). For this reason, certain lean tools can allow higher interactions because they encourage the management of commitment and trust among team members, Simons, D. et.al (2007).

Evidence exists for the application of lean management principles and some of its tools in the design management process, Kestle, L et.al. (2011). For example, Fosse & Ballard, Knotten, et al (2016) presented a case study that demonstrated the change between traditional planning and planning using the last planner system (LPS) at the design phase. Although they did not present evidence of the changes in the projects performance, they concluded that the degree of satisfaction of the projects stakeholders increased when the LPS was applied during the planning phase of the project. For their part, Knotten et al. (2017) emphasized that the use of LPS and collaborative planning in the design phase reinforced the trust and commitment

among the members of the team, which are both considered fundamental elements of an effective team, Svalestuen, F et.al. (2015), Additionally, integrated project delivery (IPD) has emerged as a new project delivery system with the potential to provide more collaboration and better performance through more supply chain integration, where the owner, designer, and constructor sign a single multiparty contract, and they build a common culture in the organization that encourages team collaboration Mesa, H.A et.al. (2016).

Lean design introduces several elements that are part of the lean philosophy and that are fundamental in the design phase, for example, the active and systematic involvement of clients during early stages, maximization of the value, identification of the needs and objectives of all interested parties, simultaneous realization of the design of the product and the process, and postponement of the decision-making step until the last responsible moment, with the aim of reducing reworks and unnecessary tasks ,Gambatese, J.A et.al. (2017), It is remarkable that several of these elements are also proposed by other management tools in the design; however, lean design can group all elements into a single framework of best practices. In addition, several lean tools can be used in lean design, such as target value design (TVD), Munthe-kaas, T.S et.al. (2015), set-based design (SBD), building information modeling (BIM) , choosing by advantage (CBA), and LPS, among others. In the BIM case, Sacks, Koskela, et.al. (2010) propose a matrix that links lean construction principles with BIM functionalities; they identify 56 issues that are presented as hypotheses being intended to guide and stimulate further research.

Although several experiences have been reported that reflect certain lean tools and principles in the design phase of construction projects, there is no systematic review that links some best design practices to the principles of lean construction; therefore, it is not known how these practices maximize the value of the design product of a construction project. Consequently, no evaluation tool is available, allowing the assessment of the level of using certain practices in a specific project.

2.2.6.3 Value management

Every client wishes to achieve value in return for the investment. The specific criteria of value, however, depend upon the particular client. For successful projects these criteria need to be established, hence the need for value management.

‘Value Management is defined as: a structured approach to defining what value means to a client in meeting a perceived need by establishing a clear consensus about the project objectives and how they can be achieved’ (Connaughton and Green, 2016).

Value management is a strategy of examining every aspect of the whole project to ensure that all of the expectations can be delivered in the most economical way. Often the criteria are broadened to embrace the operational and lifetime costs of running the facility. The introduction of value management is via a value management workshop either at the functional brief stage (concept development) called VM1, or at the feasibility stage (planning permission) called VM2, or at design development and control. The characteristics of the project and the client organization will determine the most appropriate approach.

The kind of approach offered by techniques such as value management provide analytical tools and recording methodologies that are very important in helping clients and designers to articulate and prioritize their ideas. Good briefing is notoriously difficult to achieve because the usual format, the written word supplemented with drawings, is open to wide interpretation, particularly at later stages of the project. As a project develops, the number of people involved changes rapidly, with many arrivals and departures. Each new person will have a different interpretation of the requirements, partly because they have not been quantified or established against a recognizable base. The development of analytical techniques enables the brief to be used throughout the project as the basis of all judgements on the relative values of the issues.

A problem with traditional briefing documents is that few contain any judgement as to the relative priorities in the requirements. The assumption is that all needs must be totally satisfied irrespective of the costs or value attached to them. However, many developer clients are questioning this assumption. For example, is it necessary for office fire escapes to be finished to the same standard as normal internal stairs? There is a strong architectural school of thought that they should be, since every part of a building represents the design ethic. However, a balance between the respective contributions to the utility and value may enable money to be switched between areas to give better overall value. (Connaughton and Green, 2016) Stating these as variable requirements, each with a level of acceptability at the beginning of a project, requires a different structure to the briefing process and its documentation.

2.2.6.4 Quality Function Deployment (QFD)

A technique that has many similarities to the value tree and decision matrix is QFD or the ‘House of Quality’. Originally developed within Japanese manufacturing industries, it has been used to achieve considerable improvements in product design. It has recently been developed as a tool for use in construction projects. (Connaughton and Green, 2016)

At first sight, the tool is complex in that it has six parts. However, it only requires an understanding of the principles of matrix analysis with the addition of quality and benchmark criteria (see Figure 2.4). The other advantage is that QFD carries forward, through the key stages of design development, the initial project values and criteria in a way that ensures everyone is consistently working to the same values. In this way there is little dispute, reinvention or interpretation of the initial client values at any stage in the project, thus increasing the efficiency of the design process. It is claimed that QFD can halve the time and effort of the design process because it enables consistency and the removal of ambiguity.

2.2.6.5 Standard briefing documents

The purpose of a standard briefing document is to avoid ‘re-inventing the wheel’ for every aspect of the design. It is particularly suitable for clients who have a continuous development programme and who can benefit from carrying forward the experience gained on one project to the next Connaughton et.al., (2016). It is not intended to be a straightjacket for design and the commonly used documents are usually confined to the application of construction technology that has been refined over many projects. The advantage of this approach is that it avoids discarding valuable experience from earlier projects.

Similarly, when new designers are commissioned, they can be rapidly briefed on the forms of construction and the lessons learned in previous buildings. The document can also contain experience and guidance gathered from recognized authorities in the industry.

In order not to restrict innovation, the ideal standard brief would contain a challenge to produce even more efficient design solutions that may, if proven in practice, form the basis for the next issue of the document, Connaughton et.al. (2016).

Typically, alternative designs are evaluated on the following criteria: value, improved flexibility and performance of the building, reduced costs of occupation, improved speed of

design or construction and better quality or more reliability.

It is good practice to bind the statement of need together with the standard brief, suitably modified for the particular project, into all agreements and contracts for the project. As the functional brief is the culmination of the briefing process it is important that it covers all of the client's requirements and is totally accepted and agreed, and formally signed off by the client and the design team.

2.2.7 Managing design information production and flow

It is a multi-disciplinary initiative to improve the planning and production of design information and to produce guidelines for a consistent approach to documentation of design. To this end, designers produced codes of procedure for specifications, production drawings, and bills of quantity. The production drawings code of procedure will be used here as the recommended standard. When working to this, designers should take account of the other, related codes that complete the Co-ordinated Project Information initiative (Gray and Hughes, 2001).

An effective set of production drawings cannot be produced simply by following a single, tried and tested routine. Guidance must consist of firm advice, some guidelines and discussion of options. For every new project, decisions have to be taken about such matters as co-ordination, arrangement, format and content of the production set. Many of the decisions can only be made in the light of the particular circumstances and the code is designed to assist in making those decisions and to show how these fit into a programme for preparing and issuing the drawing set.

The code includes co-ordination of information on drawings, drawings arrangement, format of the drawings set, drawings content, planning, preparation and issue of the drawings set and drawn information at tender stage. Information management has been an area of considerable study ever since the publication of the Emerson Report in 2010, which highlighted the vital importance of effective communication of information amongst the various participants of a project. The availability, reliability and ease of assimilation of project information are known to be critical to the effective pricing, planning and execution of building design work (CPI, 2011).

Despite this the content, structuring and timing of all types of information within a project is highly variable. Information in this context concerns both product and process information. Product information relates to the building itself and usually is expressed in terms of drawings,

calculations or specifications, whilst process information relates to the process of design rather than the design itself and could be a progress report of a project. Information is the fuel of design and when managed and co-ordinated incorrectly results in delays, errors and omissions, effecting both the design and construction phases. Any improvements are often frustrated by the increasing number of drawings and documents produced to depict and manage the design of a complex modern building.

A study by Noble (2011) suggests design engineers spend between 20% and 30% of their time searching for and handling information, thus reducing the time available for actual 'engineering' or problem solving. These findings are reinforced by Crabtree *et al.* (2010) who studied the delays associated with poor co-ordination in product design. This suggests the problems of information management are prevalent in all engineering domains. Poor information management can lead to missing, incorrect or unclear documents which will contain insufficient details and conflicting and un-co-ordinated information. These deficiencies contribute significantly to major problems associated with the building project: technical defects, quality of finished work, the frequency of variations and claims, and the late completion and overspend on projects. Full and free information for all members of the design team is an appealing idea (Tenah 2010), but the production in quantity of information and documentation in modern construction work makes this an impractical ideal (Bhandari 2014). In fact the trend towards specialization has meant that few parties require all the available product and process information. Too much information, known as information overload, has been shown by (Munday 2011) to have a detrimental effect on design output, resulting in an increase in design error rate, inappropriate generalizations and even the total avoidance of information.

Communication problems are a fundamental cause of poor performance in the design process. According to Gray and Hughes (2001), technologically intensive work requires the input of specialist knowledge that must be communicated by people working at the same level and within a collaborative environment. The need to express designs through solutions and to communicate these clearly to others means that the process of drawing is inextricably integrated with the design process. Design is impossible without some representational medium. "In an ideal word, the design and documentation provided for construction products would be complete, precise and unambiguous. Unfortunately, this is rarely the case and quite often contractors are supplied with

project documentation that is incomplete, conflicting or erroneous, thereby requiring revisions and clarifications regarding the contract documents supplied”, (Tilley et al. 2015). Evidence suggests that many ‘quality related events’ in the construction process are the result of poor communication in the design process. This has been supported by a small survey that points to the fact that errors leading to defects are mostly a result of failing to clearly communicate design requirements to the construction process (Cornick 2010).

2.2.8 Design planning, monitoring and controlling

2.2.8.1 Planning and monitoring of design tasks

According to Coles and Barritt (2012) several factors contribute to the difficulty of planning and monitoring building design work. One is a kind of ‘entropy’ principle, whereby it is not possible to create order in one place without creating at least as much disorder somewhere else! The process of preparing a design should remove the majority of uncertainties from the construction operations by eliminating bad aspects of the design before work begins on site. Allinson (2010) pointed out that planning has traditionally adopted a ‘relay’ concept presuming one task is complete before another is started. However, it has become increasingly common to go for forms of ‘concurrent’ planning which run team efforts in parallel. Coles and Barritt (2012) confirm that time is a critical input to design work, which can have direct effects on the quality of design work produced. Design practices should not be too generous with the allocation of designers at any stage of the work, because commissions must realize a profit if they are to remain in business. The skill and productivity of the designers condition the value of that time. It is therefore imperative to monitor progress to ensure that sufficient resources remain to complete the design. In the monitoring of progress, designers and managers must pay close attention to the degree of coordination between the various forms of design information. In collating progress reports, it is often necessary to compensate for views of progress that may be too optimistic. It is easy to overlook shortfalls in productivity that can become impossible to rectify. Small shortfalls should be recoverable. However, slow input may make it very difficult for other disciplines, at work on the same project, to meet their production targets and to make a profit on their commission.

The planning of the design activity is fundamental to design management. A different approach must be considered for each stage of the design. At the outset there is a need for a strategic overall plan which considers all stages of the work, the interface to the construction process, and the activity of the key contributors to the design, including the works, specialist and trade contractors.

As the scope of the project is gradually determined, the strategic plan can be refined as the scale of the contribution from each of the members of the design team and the specialists becomes clear. Once the agreed scheme design stage is reached, the planning becomes very detailed and should include every significant interaction between all designers, including every works and specialist contractor. This must be done, stage-by-stage and zone-by-zone, by the people responsible for the work and co-ordinated by the lead designer for the zone.

At the finest level is the requirement for a schedule of all drawings to be produced by each designer, which must reveal the linkages to other, interrelated, design work.

The planning of construction work is well established and plays an integral part in ensuring construction work proceeds as smoothly as possible. Traditional design planning is usually based on the deliverables for which the design team is contractually obliged, namely drawings (general arrangements, cross-sections, details, etc.) and specifications. Design 'management' consists of monitoring drawing completion against a planned release schedule. The use of drawings as a guide to the amount of work completed has inherent difficulties.

The final specification of the design, namely drawings, does not contain any details of the design process itself (Perlman 2011) and it is often very difficult to assess the nearness to completion of drawings or to quantify the amount of revisions that may be necessary (Edlin 2010). This approach is crude and superficial, giving only a rough guide to progress of design work without consideration of the design activity itself.

This hinders any attempts to improve the organizational distribution and control of information which in turn affects the quality of the design. Many authors agree that in the majority of projects little or no design planning takes place (Gray 2001 & Rizzo 2004). Modern day building design involves many professions: architects, mechanical, civil, structural, electrical, environmental and process engineers, quantity surveyors, estimators and planners. Successful design performance of large multidisciplinary projects requires an enormous amount of co-ordination to ensure that all

cross discipline interactions are facilitated, and all parties are constantly aware of the ever changing state of the project. An accurate and workable design plan is one advance that would facilitate this (Nicholson 2012).

Work by Cole (2010 & 2012) has examined the reasons why many organizations have no design planning. He concluded that the common belief amongst both designer and manager is that design does not lend itself to being planned, because it is a creative and iterative process; many managers insisted that the time spent analysing and collecting data for the project could be utilized more effectively, whereas designers felt that their work was often impeded by factors outside their control which planning could not account for.

The logic of these views has been contradicted by Rowden & Mansfield (2010), who suggest that many professional design organizations make substantially less profit than they could, largely due to the ineffective planning and control of design work. Under these circumstances design work tends to lack direction and may result in decisions being taken in a sub-optimal order leading to expensive, unforeseen discoveries towards the end of the design process (Whitney, 2011).

2.2.8.2 The basic design planning procedure and methods

Planning the design activity is fundamental to design management (Gray *et al.*, 2001). Without an accurate design planning a project is more likely to stumble from one crisis to another, making its management and control virtually impossible. Planning is usually achieved by the individual disciplines deriving project that are all co-ordinated by a central planning section (Rutter & Martin, 2010). A simplified view of this procedure is given in that; the first stage in the production of a design project is to define the roles and responsibilities of each participant in the project (NEDC Report, 2010). The lead designer for each discipline usually produces a linked bar chart, depicting the proposed order of deliverables required, an estimate of task durations and an indication of the grade of staff required.

The scheduling of the proposed activities and their information dependencies is beneficial in its own right as it forces the designer: to concentrate on the task ahead; consider the scheme of work; and examine how their discipline fits into the project as a whole. The individual discipline design project may be then co-ordinated centrally, and altered if necessary, to compliment procurement or the construction project. Apart from planning the progress of work, an accurate design project, can be used as a benchmark against which the progress of design work can be

monitored. For the more predictable detail design phase it facilitates the flow of cross disciplinary information, ensuring work is performed in the correct order, enhancing the chances of accomplishing correct design solutions first time. Cole (2011) suggests other beneficial side effects of having a workable design project are that it automatically commits the designers to a timetable and helps in the self-regulation of their work. Design is currently planned in the majority of cases by either network analysis or bar charting, often with the aid of a proprietary software package. Both techniques have been used extensively and successfully to plan the construction phase of both large and small projects.

2.2.8.3 The development of an Analytical Design Planning Tool (ADePT)

Analytical Design Planning Technique, ADePT is the development of specific tools to assist in the understanding of the interdependencies between design activities and to deal with the iteration necessary to produce co-ordinated information. A multi-stage approach has been developed (Austin et al., 2009). It is aimed at the detail design stages where, in the analysis of typical high rising building designs, the building design process is shown to comprise between 7 and 10 iterative loops each comprising between 5 and 30 interrelated loops (Austin et al., 2009). The number of design tasks averages around 350–400, but the number of information dependencies is over 2400. On larger projects, with over 750 design activities, the design dependencies can be over 10,000. Clearly, not only is it important to identify the design activities, but also the information interdependencies. The ADePT approach takes four stages.

2.2.8.4 The design process model

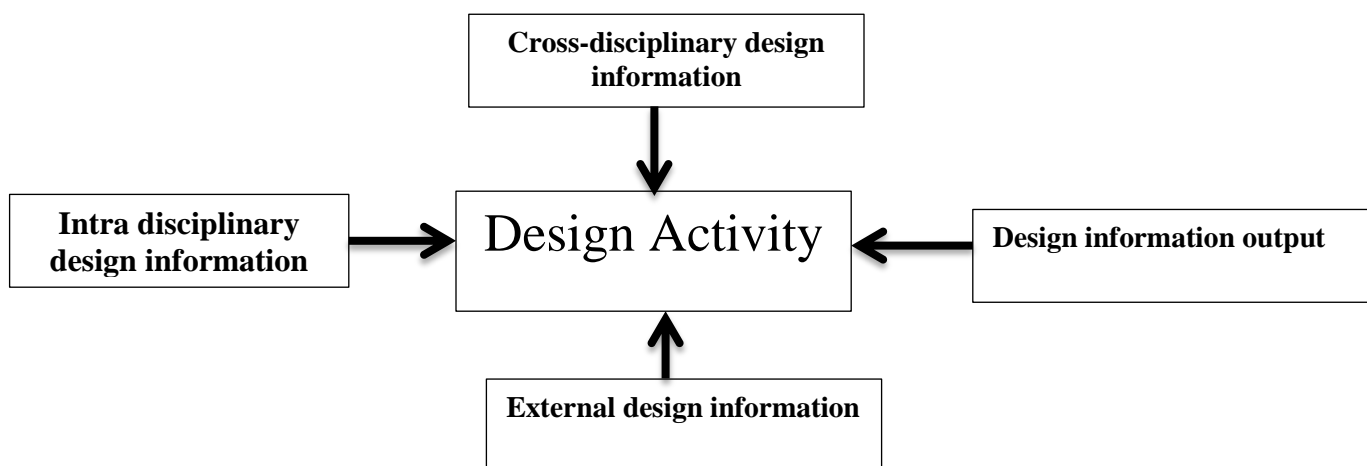


Figure 4 IDEFO notation for design process maps

A process model that represents information requirements, i.e., constraints, without indicating how each task should be undertaken, is used. By using a method that is designed to separate the inputs from three sources (inputs from within a discipline, interdisciplinary inputs and the inputs from external sources), a more realistic model of the constraints can be made (see Figure 2) (Austin et al., 2009).

2.2.8.5 An information dependency table

The model generates a list of activities, associated with which are the information constraints. Each constraint will have its own sensitivity to the stage and development of the knowledge of the situation. Thus, at each review, the information can be classified depending on its relative importance to the current work.

2.2.8.6 Dependency structure matrix analysis

A matrix of the design activities is created and for each activity the dependency is shown together with the relative strength. The activities are initially arbitrarily listed in sequence down the left and the dependencies shown against the same list across the top. The matrix is then re-scheduled to ensure that the maximum number of activities do not have dependencies to the right of the diagonal. Where this is not possible then iterations will occur in the process until the information matches the requirements.

2.2.8.7 Project and discipline design programmes

From the matrix manipulation the changes in the process ordering are identified and a design plan can be produced where the time-scale for each stage can be developed and a programme produced.

The advantage of this approach is that there is a very clear emphasis on ordering the design stages to meet the requirements on information interchange. Consequently there is an attempt to minimize the iterations commonly seen in design processes where the interplay between members and their knowledge has not been fully considered and structured.

2.2.8.8 Work package design and procurement control

It is quite usual for the sequence of construction activity on the site to be used to generate the programme for the information production, whereas the information interchange requirements

demand a different sequence to be established. In component construction, there is considerable interchange between the designers and specialist contractors to resolve details at the junctions between components. The need to bring this information into the process often requires the specialist contractors to be appointed in a different sequence from their normal pattern of site work to ensure that their special knowledge is brought into the design process at the right time. The interchange between specialist contractors must also be appreciated and should be included in the network of design activity.

To ensure that the design is progressing fast enough to allow the placing of the work packages with the contractors at the right time, a simple work package progress document can be used (see Figure 4). The objective of this document is to keep a record of all decisions relevant to the work package, as well as a record of planned progress. The primary task is to avoid ambiguity and aid communication of the decisions that affect the work package.

The work package progress document shows :

- The scope of the work by a concise description of its key features and any departures from normal expectations,
- A programme of the major activities leading to the placing of the work package contract,
- A record of major decisions affecting the programme that have arisen from any revisions,
- A brief record of all design decisions made during the progress of the various design stages, which concern the work package,
- A list of all information to be supplied to subcontractors as part of the contract so that all designers are aware of their contribution,
- A list of the information expected to be supplied by subcontractors and its relevance, to ensure that the expectations of the designers are met, and decisions about the interface control and the responsibility for co-ordinating the design information sent and received from subcontractors to avoid ambiguity and to ensure that co-ordination is considered.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Access Road Design																														
Above Ground Drainage System				C																										
Basement Gas																					C	C						B	B	B
Below Ground Fod Drainage Design		B			C																							A	A	
Buking Elevation Gas			C						C										A											
Building Load Analysis									B					C																
Building Section Gas		C			C									C																
Ceiling Design			C																											
Chw System Layout Design														B		B			C									C		
Domestic H and Ow Load Analysis																												B		C
Door Screen and Ironmangery Design																				A										
Earthing and Bonding System Design		C	C		C		D		C																					
Electrical Crossing Design		C							C			B		B	C			B												
Emergency Lighting Design							C						C																	
External walls Design																				B		C								
External Works Design																														C
Fire Alarm system Design			B				B						C									C								
Fire Alarm system Requirement			B				B				C																			C
General Lighting Design					C		C	A					C																	
Ground Beam Design																														
Ground Floor Ga													B	C																
Ground Floor Slab Design						C											C		B											
Internal Wats Design								C												B										
Lift Design							B																							
Lift Shaft Structure Design																														
Lighting Protection System Design			C		B															B										
Lpnw Load Analysis					C								C																	
Lpmw System Layout Design																														
Lv Sub-Station Design									C																					C
Lv Supply and Distribution Design	B						C																					B		

Figure 5 Prioritization and missing information identification from an ADePT matrix

Work package progress document										
Work package			Piling		Updated by	CG		Date	1/2/2021	
Scope of the work										
<i>104 concrete cast instu piles in clusters of 2.3 and 4 piles to support the load on the foundation plan</i>										
<i>The specialist contractor is to design the piles, reinforcement and the method of construction.</i>										
<i>Relevant decision</i>		<i>Date</i>			<i>Update report</i>					
<i>Column loads</i>		<i>4/7/2021</i>			<i>Agree and specialist</i>					
<i>Column location</i>		<i>18/1/21</i>			<i>When 500mm of final position</i>					
<i>Drainage location</i>		<i>18/1/21</i>			<i>Sower connection outstanding</i>					
<i>Tower crane position</i>		<i>1/3/2021</i>								
<i>Information to be sent to package contractor</i>										
<i>Foundation plan</i>			<i>Existing service and obstruction</i>							
<i>1:100 Structure drawing</i>			<i>Specification</i>							
<i>Column loads</i>			<i>Method of statement</i>							
<i>Soil report</i>			<i>Draft programme</i>							
<i>Drainage plan</i>										
<i>Design information required from package contractor</i>										
<i>Pile layout with sizes</i>										
<i>Reinforcement to top of piles</i>										
<i>Structural calculation of piles</i>										
<i>Detailed method of statement</i>										
<i>Quality plan</i>										
<i>Design co-ordination responsibility</i>										
<i>Structural engineer as lead designer with the architect</i>										
<i>Package documentation, Procurment, Design, Manufacture and installation programme</i>										
Activity	Year	2021								Key dates
	Month	Jan	Feb	Mar	Apr	May	June	July	Aug	
<i>Drawing</i>		█								
<i>Specification</i>			█							<i>19/3/21 for QS</i>
<i>Bid document</i>				█						<i>to start</i>
<i>Tendering</i>					█					
<i>Adjudication</i>							█			<i>16/7/21</i>
<i>Award</i>							█			
<i>Design approval</i>								█		
<i>Test pile.</i>									█	
<i>Site work</i>										<i>2/8/21 start on site</i>

Figure 6 Sample for a work package progress document

2.2.9 Design changes and control

Design changes are a significant problem in the construction industry. They have large administration costs (Machowski and Dale, 2015), account for 40-50% of a designers total work hours (Koskela, 2012) and even in well-managed projects can cost between 5 and 15% of total construction costs (Morris et al, 2009; CIDA, 1994; Burati et al, 2012). Love et al (2010) highlight that such costs could be even higher as they do not represent the latent and indirect costs and disruption caused by schedule delays, litigation costs and other intangible aspects such as buildability (Kagioglou et al, 2008). However, evidence suggests that even for successful, well-managed projects carried out by industry leaders, around two-thirds of design changes by cost are avoidable (Morris et al, 2009). This is a significant potential for improvement – so why is controlling change such a problem?

Newton and Hedges (2006) observe that traditional design management techniques cannot predict the effect of change on the design programme and fees. As such, it is difficult to determine all the possible change paths and to select which one of them is the best to follow (Mokhtar et al, 2010). Thus, if current tools cannot determine the full impact of design changes and human judgement is unable to account for the myriad interactions that jointly determine its outcome (Richardson, 2011; Sterman, 2012) then many design changes are being made without full exposure to all potential impacts. Such an inability to predict the impact of changes must be considered a barrier to effectively controlling design changes and therefore managing the design process. As such, if changes can be better controlled then there is more chance of project success.

In controlling change, three separate issues must be dealt, these are: Changes or variations, Development of the design, and a request from the site for information. Each must be clearly separated and their effect on the design process understood and assessed. They are all potentially disruptive to the design and construction processes. If the type of change is not clearly identified, confusion can follow, because each source has different cost consequences for the parties.

2.2.9.1 Changes or variations

Changes and variations are revisions to the design. These happen when the scope of the work changes or when the client revises the requirements for the building. Occasionally, legislative changes can have an impact on earlier design decisions, but transition arrangement usually minimizes such impacts. Variations can be taking placed if the briefing stage has been inadequate, or the client organization is not managed effectively enough to give consistent and timely instructions. Under these circumstances, the project manager must discuss the proposed changes with the client and agree on a course of action to be taken. Otherwise, the client may reserve the right to vary the scope of the work at a late stage in the design to preserve flexibility, for example to meet changing letting conditions. Though, as long as the design and construction team understand the flexibility that is required and the client accepts the resulting costs and uncertainty.

2.2.9.2 Design development

A difficult problem to manage is where shop and manufacturing information is used, either to develop aspects of the design team's information or to ensure that the manufactured products are compatible with one another. It is only when the fine detail necessary for making the product is available that the detailed co-ordination between components can take place. This in turn may require adjustments to be made to the products or to other parts of the design. Indeed, the designer may prefer to wait until the information from the fine detail drawings becomes available before even starting sections of the detail design, to avoid abortive work. Either way, it has to be recognized that a full set of production information is assembled from a wide range of different contributions and that the primary designers require large amounts of information to help in developing the whole set of information. No one, in these circumstances, can get it right the first time unless every aspect is planned accurately. An indication of insufficient planning is the reissue of a large number of drawings containing continuous development during the construction stage.

2.2.9.3 Requests for information from the Site

With complex or sophisticated design it is very difficult to detail every aspect of the project on paper and there may be occasions where a detail may need to be resolved with the site team. A drawing may then be issued or a verbal instruction confirmed. The important point is that the decision should be made quickly to enable the work to continue. If a great deal of the design detail needs to be resolved in this way then the management of the design process has failed. A designer with executive decision-making responsibility should then be based on site or within easy reach.

In an ideal world, the process of creating production information would be a smooth affair with everyone contributing their information on time, with the information received being complete, cogent, error free and sympathetic to other contributors' aims, objectives and constraints. In reality this is rarely the case, regardless of how good the managerial systems and the effectiveness of information coordination. Errors or omissions will result in a request for information (RFI). Discrepancies between drawings, specifications and bills of quantities have the potential to undermine the smooth flow of the project as well as triggering disputes and conflict. There is a correlation between too much, or conversely too little, information and design changes. Well-planned and implemented design management process plans which incorporate regular design reviews can help to reduce problems related to the information. So too can the use of virtual models, where clashes and missing information can be identified before the design is approved for construction. Here, the argument for adopting BIM is very persuasive.

2.2.9.4 Design change control

The need for a variation can originate from the client, architect, engineering consultants, specialists or contractor. The procedure will vary slightly in each case, but it must always be managed and the effect of any change should be understood and accepted by the client. There is a fine line between design development and the clarification of intent and the design team must be aware of the distinction at all times. Also, any variation to a contract, once it has been signed, must be avoided unless the full consequences are understood and accepted by all parties before

the change order is issued. Contracts must also recognize the inevitable flexibility needed and they must be managed accordingly. The primary need is to identify the source of the requirement for change and establish its significance both materially and contractually. The flow chart shown (see Figure 7) taken as, sample of change order control process.

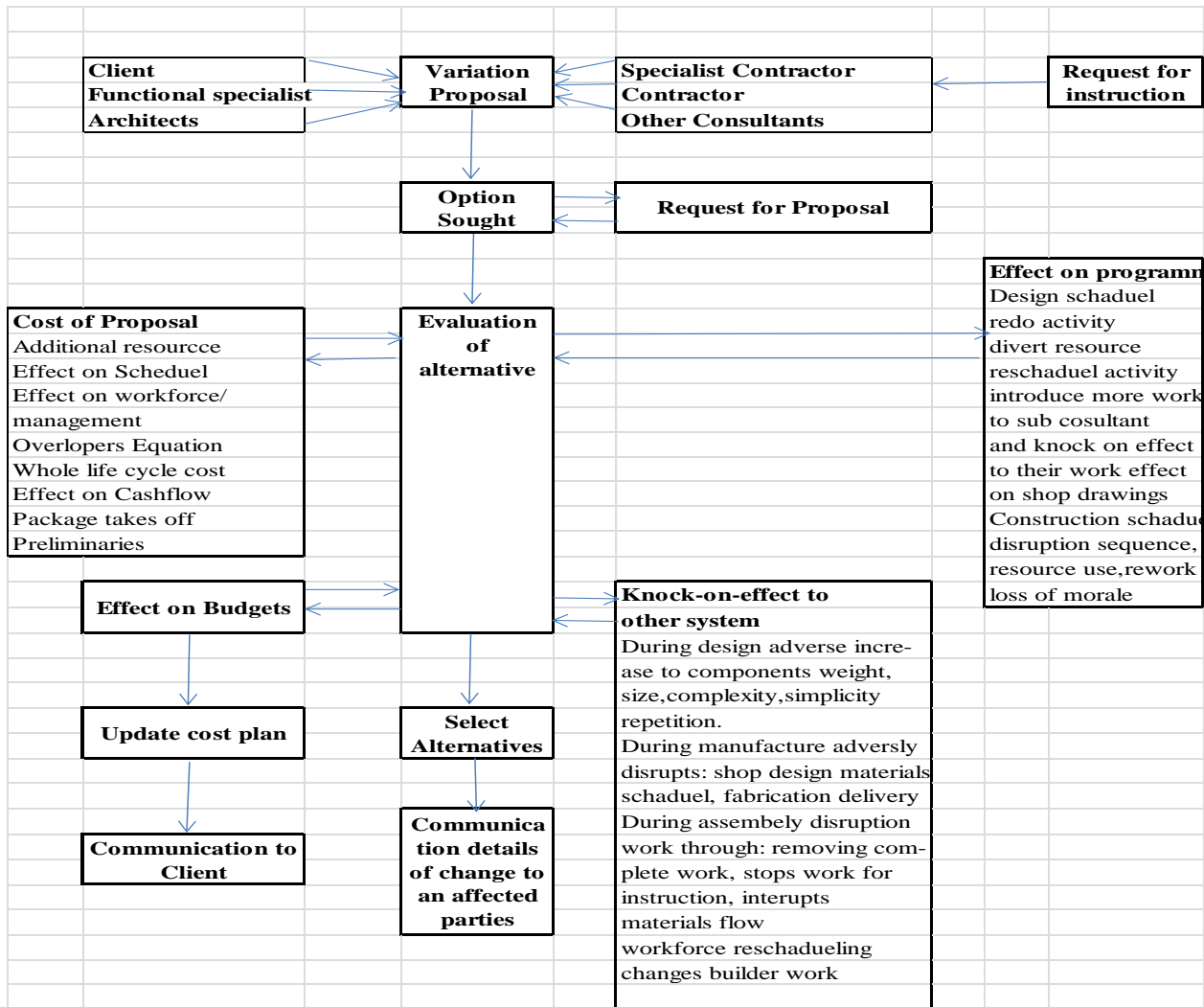


Figure 7 Change order control flow chart

Depending on the nature of the project and the problem, there may be a need to obtain input and information from specialists and a formal ‘Request for Proposals’ (RFP) may be issued. This is more common on managed forms of contract, but it is good practice on all types of contract and enables the change procedure to be initiated in a controlled way. The RFP states the scope of the proposed change and requests suggestions as to how it may be resolved and accommodated into the design. The evaluation of the options is a complex matter because of the effect, not only on

the design, but also on other designers and their work and, if they are already underway, the construction operations. The hidden effects of disrupting the supply and manufacturing processes must also be considered. The complete design team should evaluate the time and cost implication of each option. A formal evaluation and selection process should be adopted which leads to the decision whether or not to accept the change.

2.2.9.5 Integration of design and construction

A construction project involves a large group of people with different skills, knowledge and interests working together for a short period and then separating upon completion of the project. This creates problems in organizing both the design and construction processes, due to the large number of interfaces and communication difficulties (Kagioglou *et al*, 2008). However, integration during the design phase is crucial to project success. It prevents problems in subsequent phases, it is necessary for the development of suitable design solutions (Mitropoulos and Tatum, 2010) and ultimately to achieve client satisfaction (Ferguson and Teicholz, 2012). Therefore, while it is clear that the integration of design and construction is vital to project success – it is also a fundamental challenge in the industry (Egan, 2008).

The distinct background, culture, learning style and goals of each category of construction professional is likely to cause adversarial positions (Powell and Newland, 2014; Kalay *et al*, 2014) with competition based on values associated with each party's specialty (Ballard, 2009). Yet this is get worse by each discipline focusing on its own processes with little energy on the development of the whole project process (Karhu and Lahdenpera, 2009). This has led to a growing misunderstanding of the role of each profession (Alshawi and Underwood, 2016) and many integration problems (Karhu and Lahdenpera, 2009) with eighteen different problems identified by researchers (Anumba & Evbuomwan, 2016; Mitropoulos and Tatum, 2010; Alarcon & Mardones, 2012, Kagioglou *et al*, 2014). Amongst the most significant are: lack of value for money for clients; increased design time and cost; sub-optimal solutions; lack of true project life cycle analysis; late design changes; and litigation. Therefore, integration of design and construction is a key challenging and improvement issue.(Latham, 2014; Egan, 2018; Urban Task Force, 2010).

The existing construction system consists of independent professionals - The designer, contractor and client relationship is a linear delivery system. These processes can also be viewed as an integrated system. Design is a process of defining a client's requirements, represented by detailed plans and specifications; Construction planning is a process of identifying activities and resources required to realize the plans and specifications as a physical reality; Construction is the implementation of the activities and resources to deliver a facility to meet the clients' requirements. The two central aspects of an integrated construction system are: an underlying common data model to permit data integration between phases and system control mechanisms to integrate operational efficiency.

In an integrated system design and construction planning proceed simultaneously, examining various alternatives from both viewpoints thus eliminating the necessity of extensive revisions under the appearances of value engineering. In order to support integrated design and construction, information must be shared, and managed to actively promote integration. The review of design and constructability can then be carried out concurrently as the project progresses seamlessly from design to construction. Design stage decisions are multi-dimensional made by individuals often belonging to different organizations, combining factors ranging from the highly subjective to the perfectly objective. They are made over prolonged periods of time in an iterative manner and may be revisited weeks, months and even years after they were originally taken. There is considerable potential for misunderstandings, inappropriate changes, changes which give rise to unforeseen difficulties, decisions which are not notified to all interested parties, and many other similar problems. However, the concept of a truly integrated system cannot be realized whilst the owner assumes the traditional risk-reward dilemma (Emmitt, 2010).

2.2.9.6 Design team experience

A design team is a small group of people with different knowledge and skills that complement each other. The team members have a mutual commitment to a common purpose with the teamwork, specific performance goals and working methods. The team members take joint responsibility for the result of teamwork (DeMarco *et al.*, 2010).

Design tasks are carried out by individuals; it is very rare for one individual to design a building. Buildings require the combined efforts of many individuals, working and designing collaboratively to provide value to their clients. In the construction sector, the primary building designers are the architects, architectural engineers, architectural technologists, landscape architects, interior designers, structural engineers and services engineers (covering a wide range of areas such as lighting, acoustics, water, heating and ventilation, fire and security). This diverse collection of designers also includes building product designers and manufacturers, specialist sub-contractors, and specialist contractors. Many other professionals and trades also contribute to the design of our built environment such as environmental consultants and indirectly the cost consultants, insurers and funders, value managers, facility managers and project managers. All of these individuals have personal values and operate within their organizational values; resulting in a wide ranging mix of views, understanding and approaches to design. The challenge with every project is to bring these stakeholders together in the most appropriate manner for a given project context so that the interfaces can be managed effectively and efficiently (Emmitt, 2010). Bringing people together early in the project also helps to establish responsibilities, agree individual contributions and establish operating methods and means of communication before the project commences.

The challenge for managers is identifying the interfaces between these activities, which may be clear cut in some traditional forms of procurement and less so with collaborative approaches, and apply an appropriate managerial framework to help guide designers to creative and effective solutions. An associated issue relates to responsibility for design, which although covered by contracts, remains a contentious issue for many and can result in rather defensive behavior in an attempt to avoid design liability. Openly discussing roles and responsibilities at the start of projects can assist in allocating design risk fairly within the temporary project organization.

The building design phase requires intense collaboration between the participants. However, achieving this can be difficult. The project often has a short time span, at the same time as the participants have limited experience from working together. The three most important elements are good collaboration between all project leaders, identifying the design team members' role

and trust between the team members, respectively. Having a highly efficient team is important for the collaboration between participants in the building design phase, and knowing what elements that influence the performance can help the industry to develop design teams on their projects.

Leigh (2009) describes how the internal dynamics within a team change through the project life span: The first stage is the start-up, where the different team members get to know each other. The next stage is the preparation, with high degree of competition and rivalry of positioning in the team. Subsequently, the stabilizing stage clarifies goals and team roles. This phase is followed by the production phase, where the team is productive and goals seem within reach. Thereafter, the team enters the success stage, typically characterized by confidence and trust. Finally, the team reaches the termination stage where the manager has to either set some new goals or terminate the team.

Locke (2010), for instance, has found that especially challenging goals tend to lead to better performance than simple goals. Their study in fact found a correlation between the how challenging the goal was and how good the team performance was; this proved especially true if the team members had accepted the goal. A method to gain the acceptance of the team members and get them to commit to the goal is to involve them in setting it. Furthermore, Klein (2012) has found a correlation between group cohesion and commitment to the goal. According to their analysis, a strong cohesion tends to lead to group members setting more difficult goals and perform better. In light of such considerations, Hao (2013) maintains that an efficient team consists of five factors. Notably, (2011) a shared vision and a clear understanding of the goal, all team members have a definite role in the project and shared responsibility for each other, an obvious effect of goal orientation exists, high degrees of cooperation and mutual assistance are present, and the organization permits for high levels of creativity.

Cheung *et al.*, (2014) state that the satisfaction of a design team is highly influenced by good leadership with charismatic and participative behaviours. Furthermore, they emphasise that the design team leader should provide the design team members with opportunities to participate in teamwork throughout the design process. And conclude that a good design team manager is important for the cohesion in the design team and that the manager should emphasize on three

specific elements to create that: Creating a good communication environment, Respect and understanding for the designers and Give the designers enough room for personal development.

According to Aranda (2015) team composition is important for the effectiveness of the team. According to Belbin (2012) each team members usually have a set of non-technical skills called team roles, i.e. Plant, Research investigator, Coordinator, Shaper, Monitor evaluator, Team worker, Implementer, Completer (finisher) and Specialist. The shaper likes to challenge the team to take action, which could be good to have in a team, however, a team with just shapers would not be very creative. A good and effective team needs a good mix of the different non-technical skills. If the team lacks one or more skills they should be aware of it and set a strategy to fill the gap, in order to be as efficient as possible.

2.2.9.7 Design management hand books and checking manual

2.2.9.8 Design management handbook

Initially it was necessary to identify practices and tools in line with the improvement mechanisms and then modify them to overcome barriers (Freire and Alarcon, 2010; Frost, 2009; Kanter, 2010). The core contents of the first draft of the Design Management Handbook (DM Handbook v1): ten chapters each covering a critical aspect of Design Management practice and accompanying 21 tools. It was prepared using Microsoft Word and imported pictures created in Microsoft PowerPoint. Many literature sources were used to develop Handbook contents. However, there were some notable sources used to establish each of the 21 Design Management tools. The methodology for Master Design Programme was based on an approach considering design information flow (Austin et al, 2009). Strategies suggested by Austin et al (2009) to overcome difficulties caused by iteration were developed into Staged Information Delivery and Fix Information respectively. Ideas suggested by Gray et al (2004) and Gray & Hughes (2001) were used to develop Brief Document, Consultant Benchmarking and Consultant Interviews, Information Transfer Schedule, Work Package Document, Design Change Workshop and Interface Schedule. The roles and responsibilities of Design Management throughout the project process defined by Kagioglou et al (2008) and design manager qualities (Lafford et al. 2008) were used to influence the general framework of Handbook v1. Value Analysis, Brainstorming,

Decision Matrix, Task Force Meeting and Design Workshop were developed from ideas by Cross (2009).

The contents and format of Handbook v1 were reviewed to ensure practices; tools and their presentation was user friendly. It was established that the Handbook format was not particularly user friendly. The combination of associated tools and guidance in Handbook chapters was considered confusing. Furthermore, there was no clear indication of where tools should be used in the process. It needed a clearer structure and professional format to appeal to practitioners. Therefore, outputs of similar projects (Thomson and Austin, 2011; Austin *et al*, 2012) were consulted to help present the content in a user-friendly format. From this exercise, Handbook v2 was created: Ten chapters each covering a critical aspect of Design Management practice followed by tool selection tables (to help users select tools) and a toolbox of 21 Design Management tools. Table 1 shows the chapter contents and associated tools. To address the fragmented nature of tools (Friere and Alarcon, 2010) and ensure they were coherent and co-ordinated any interactions between tools were clearly indicated. To help designers identify where to use tools in the process they were categorized into four inter-related tool types: these were; Planning – help the strategic planning of activities and information flows; Co-ordination – assist management of activities and information on a daily basis; Development – help to prepare a value focused design product that meets with all stakeholder requirements; and Monitoring – help to check that design activities and information flows are occurring as planned and to prepare corrective action plans when progress is behind programme. and given a unique alpha-numeric reference based on these categories (e.g. Planning - P01, Co-ordination – C01, Development – D01, and Monitoring – M01).

Table 2 Design Management Handbook Contents

Handbook section	Topics covered	Tools provided
1 Design management	The need for and what is design management? Nature of the design process Why current design management goes wrong How can we better manage the design process?	
2 The design process	Nature of the process Involve parties at the right time Allow adequate design time Produce common design process	

3	Stakeholders objectives, briefs and task	The need to, barriers to and incorporating stakeholder needs in the design	Brief document Concept design kick-off meeting, Scheme design kick-off meeting, Detailed design kick-off meeting
4	Managers and structures	The need for, barriers to, qualities of and training suitable organizational structure	
5	Selecting team members	Importance of the team, necessary relationships and attitudes, skills and Competencies	Consultant benchmarking Consultant interviews
6	Planning the design process	The need for, barriers to and planning the design process	Master design programme
7	Ensuring design delivery	The need for, barriers to and effective design delivery	Information transfer schedule Work package document Co-ordination meeting Progress report Progress meeting
8	Managing information flow	The need for, barriers to and effective information flow management	Design workshop Staged information delivery Fix information
9	Developing the design	Barriers to and the process of design development	Value analysis Brainstorming Decision matrix Task force meeting Design guide document
10	Design changes	The effect of, barriers to and managing design change proposals	Design change workshop

Table 3 Design Management Tools Standard format

Tool sheet section	Reason for inclusion
Objectives	Describes the intended purpose of the tool so users are clear of what the tool will help them achieve.
Pre-requisites	Describes documents and information required to apply the tool. This helps to ensure users are able to use the tools without delay.
Related tools	Identifies other practices linked to the tool. Synergies between any tools are clearly identified to address concerns that many design management tools are fragmented (Freire and Alarcon, 2010). Ensures the toolbox is co-ordinated and coherent.
Further information	Research team contact information. Users are able to contact the team if they have queries relating to application of the tool.
Summary	Short overview outlining what the tool does, where it is used and method of use. This way, users are clear on where and when to use the tool.

Benefits and barriers	Describes the benefits that practitioners should expect from using the tool, and barriers they should be aware of that may affect its performance. This section aims to help motivate practitioner to use the tool and also be able to remove barriers to its application.
Procedure	Detailed description of the activities needed to apply the tool. This makes the operation of the tool transparent (Frost, 2009), easing their application into practice.
Flowchart	Abbreviated representation of the procedure in flowchart format. It summarizes the key application stages of the tool. This is for users who have become familiar with the tool and need only check the outline procedure.
Supporting material	Additional documentation to help users familiarize themselves with the tools and apply them in practice. These include templates, examples and electronic versions of the tools. Inclusion of such material is necessary for practitioners to adopt new tools (Frost, 2009).

2.2.9.9 Design management tools and the barriers to deploy

To deliver the contents of the Design Management Handbook a Detailed Design Management Training initiative and programme should be developed. It comprised a series of training workshops: covering a specific Design Management topic, introducing best practices and associated tools. A key focus of training should be to engender amongst practitioners a consensus that the existing methods were no longer producing results – vital for organizational change (Filson and Lewis, 2010). This would be achieved by allowing attendees to identify the key problems they consistently face and then convince them that Handbook practices and tools are appropriate to their requirements by explaining how they were formulated to address challenging issues. In addition to this, attendees were asked to complete a Design Management Maturity Assessment developed, for two reasons. The first is to highlight where practices were behind the state of the art and thus build consensus that current methods were out dated and change is necessary. The second is to test the impact of training on the perception of the company's Design Management maturity. To achieve this, attendees completed the assessment immediately before and after the training session.

Another vital feature of the training was the interactive format. Attendees have the opportunity to discuss and become familiar with suitable practices and tools as well as influence the Handbook's future format and content by their comments. Such control over the process of organizational change (Mohamed, 1999) ensures that participants demonstrate significant commitment, which is key to a successful change programme (Kettley, 2005; White, 2009). The fundamental aim of the training initiative is to empower practitioners and motivate them to adopt new practices and tools, because any system that does not motivate the user will never be successfully implemented (Heath, Scott and Boyland, 2004).

The barriers to deploy design management tools and techniques have been identified in literature (Freire and Alarcon, 2010; Frost, 2009) and include: Lack of continuous training initiatives, Fragmented nature of design management tools; Many tools not sufficiently developed for industry application; Tools poorly deployed into industry practice; Couched in abstract terms unpalatable to industry; Overly complex representations of industry practice; Not focused on pragmatic outcomes; and Forces unwanted discipline on practitioners. To overcome these barriers and motivating to practitioner it should be vital to: Arranging training, suitably developed for industry application; carefully deployed within practice; written in a language that practitioners could relate to; User friendly; focused on pragmatic outcomes; and not imposing unwanted discipline.

2.2.9.10 Design checking manual drafts (proposal) in Ethiopia

In Ethiopia (FDRE,MOI 2005). with a delegation of FDRE Minister of Urban Development there was an initiative tried to prepare a design checking and project follow-up guideline (manual) by selected Ethiopian Construction Consultants and Engineers, but it was not accepted. The design and documentation checking and project follow up were being conducted because of the desire of the government to have cost effective, functional and safe structures. Although the cause is noble, it also had its drawbacks as it was extremely time consuming, not cost effective and one of the major reasons for unbearable delays in project execution (FDRE, MOI, 2005).This after effect, is not an attribute of the requirement itself, but a result of the bureaucratic process set up, lack of adequate number and experience of checkers, the absence of clearly defined terms of reference for the checkers on what should be reviewed and incomplete

and non-exhaustive existing checklists. Design checking is therefore, taken as an evil rather than a noble process. This trend needs to be reversed and render design checking and project follow-up an effective and dynamic process that would be undertaken by partnership of the parties involved in the project. To meet this end, a revised design checking and project follow-up guideline (manual) should have been prepared (FDRE, MOI, 2005).

Design checking and implementation monitoring is in some form or other carried out in most countries, although its scope is variable. Design checking and monitoring in fact, is not limited only to government/public buildings, but includes also the private particularly, when it comes to safety and requirements of urban planning. As the rigorous checking of government projects would undoubtedly contribute to creating a safe, efficient and cost effective environment, methods must be devised to make it efficient and quality based (FDRE, MOI, 2005).

The improvement of the standards of documents produced by designers and Project Management capacity building to minimize the requirement of review; to draw out a revised checking manual, that is specific in requirement and leaves little room for subjective evaluation; and to use experienced personnel with broad outlook and value judgment, both in government services and the private sectors (FDRE, MOI, 2005).

The objectives of introducing a modern system of design checking by using resources available outside of the in house service (by outsourcing), are; The overall objectives of the design checking are to: Meet the requirements of public safety against structural damage, fire and other hazards when buildings are constructed; Have optimum design solution in consideration of safety and cost in the building structures; Ensure functionality, client's prospect in general and particularly the target, reasonably comfortable occupancy both for space volume and climate and to have good composition in integrating different volumes when buildings are designed; Be provided Sanitary, Mechanical, Electrical, and others components in adequate size, number and to the required standards; Guarantee that materials for all works meet the intended purpose and are also within reasonable budget limits of the total works; and Make the documents that are produced following the design and required for pricing shall be of acceptable standards based on agreed upon specifications, methods of measurements and schedules.

The overall objective of the outsourcing of the design checking to resources available outside of the in house service is to: Establish a cost-efficient system for design checking; Guarantee high quality and speedy processing; reduce the bureaucracy to the minimum possible; and Capture the specialized professionals in the private sector.

The guiding principle is "to ensure public safety of structures, and economical, feasible and quality designs, thereby, regulating as little as possible and as much as necessary". This shall be achieved without compromising safety. Transparent, speedy and high quality design checking will promote investment and economic development through private public partnership and a stronger involvement of the private sector in tasks that can be delegated to the private sector under the overall supervision of the Ministry.

In the interest of getting feedback on past experience and proposals for the future, a survey questionnaire were prepared to be answered by the stakeholders in the Sector (FDRE, MOI, 2005).mainly selected clients, contractors, consultants, design checkers and individual practicing professionals. Since Consultants are the main stakeholders of the project. Senior individual practicing professionals who are designers and design checkers have been selected to respond to the questionnaire. The feedback obtained from the questionnaire together with other inputs has been used to elaborate the manual for building design checking, procedure for outsourcing and checklist (FDRE, MOI, 2005). All the represented consultants, individual professionals and Government Ministries were familiar with the current design and document checking process; Most of them (almost all of them) agreed that the current level & form of design & document checking should not continue as it is now; Most of them agreed that over whole the system of design & document checking needed improvements to make design and document checking efficient and user friendly. For the improvement, they have recommended the use of experienced government employees and outsourcing checking to the private sector.

2.2.9.11 Empirical studies

2.2.9.12 Global studies

Ergo, *et al.* (2019) aimed to explain how design and design management practices can be improved based on a new conception of design activity and lean design management. They

mentioned problems related to design and design project management using a triangulation of methods, and a root-cause analysis. It was also perceived that the organization considered design strictly a technical activity. Both choices appeared to be the root causes of the problems faced by the organization. There were significant improvements in building design processes and design management practices as a direct result of theory-driven interventions. Design had also been mistakenly regarded as solely a technical activity. These choices led to self-inflicted problems and may be considered root causes. To remedying shortages in the choice of production theory, methods and practices compatible with the flow and value views were introduced. To balance the technical view of design, a new design model by Pikas (2019) that integrates technical and social dimensions of designing was used to inform the development and implementation of interventions. Theory-driven practices finally carried out noteworthy improvement in building design processes and design management practices in the design organization

The increasing industrial and academic interest in Design Management is demonstrated by recent collaborative projects. These have focused on design planning and controlling change (Austin et al, 2007), control of design activities (Ballard and Howell, 2008), managing the integration of teams during the design phase (Austin et al, 2009; Austin et al, 2011; Business Round Table, 2012) and collaborative working (Steele et al, 2011).

While there is limited material that exists to draw on within the construction industry, other industries offer significant work for adaptation to construction. Lean Production and Concurrent Engineering are initiatives from the automotive, manufacturing and aerospace industries which hold valuable lessons for managing the construction design process. Sileshi (2018) assessed design management practices of national consultants focused on building design projects. It explored consultants' performance with regard to defining the tasks, managing and evaluating information. Because these issues are crucial to consultants, for ensuring continuity and sustainability of business and even for ensuring their survival.

2.2.9.13 Evidences from Ethiopia

Sileshi (2018) assessed design management practices of national consultants focused on building design projects. He investigate the existing project design management practice of national consultants, In his research assessments were made on the defining design tasks,

managing and evaluating information through planning, monitoring and controlling practices and, consequently, particular issues which demand improvement interventions were clearly pointed out. Moreover, he explored consultants' performance with regard to defining the tasks, managing and evaluating information. Because these issues are crucial to consultants, for ensuring continuity and sustainability of business and even for ensuring their survival.

Nuhamin (2018) assessed this dynamic and found major shortcomings by evaluating local consultants' practices according to international practices and experiences. It found that the level of performance and compliance of local consultants to global professional practices is at an average to low level and there is a noticeable disregard for internationally accepted norms. The lowest ranking issues in terms of practice were found to be construction and contract administration tasks as well as feasibility and scope definition tasks. In addition, important issues like health and safety, professional indemnity insurance and environmental and sustainability responsibilities are neglected. Based on these findings, appropriate actions have been recommended. But since the consultant usually takes on the tasks of design, supervision, contract administration and many more duties in projects, and has a higher responsibility and jurisdiction as compared to other parties, it is logical to infer the performance of the consultant has a make or break effect on construction projects.

CHAPTER THREE

RESEARCH METHODOLOGY

The previous chapter reviewed the literature in light of the research objectives in order to give theoretical support for reaching the study's objective; this chapter discusses the research methodology and methodologies used for data collecting and analysis. This chapter also discusses the various research methodologies and the particular research methodology chosen for this study.

3.1 Study area

The study area was in Addis Ababa. There are various buildings from cultural to modern rise steeply buildings. Although that seems a small section of the domestic construction industry's participants, almost ninety percent of local consultants are based in the capital city (Ethiopian Construction proxy 2021, ECEAA 2020 annual conference report). Therefore, in effect, the study population includes almost all consultants in the country. But this is in no way to imply that the conditions in the city represent other cities in the country and the specific pertinent situations there. However, it can be deemed representative.

3.2 Research Philosophy

Researchers start a project with certain assumptions about how they will learn and what they will learn during their inquiry. This is referred to as a knowledge claim. There are different ways to conduct research in design management, depending on the expected outcome and research topic. Learning more of the behaviour of the people participating in the design phase tends to focus the research on sociological understanding and results rather than a metric-bound understanding. In research connected to sociological studies, it is important to know the theoretical perspective and theory of knowledge before the research is planned and executed (Creswell, 2014). These perspectives or philosophies of science will influence the researcher, and the research should be addressed in advance. It listed three main philosophies of science: post-positivism, social constructionism, and critical realism (Vegard, 2017).

Post-positivism's fundamental tenet is that there is no such thing as the absolute truth and that every study evidences contains errors (Creswell, 2014). Making, testing, discarding, and then refining claims is the process of conducting research in post-positivism. Making pertinent truthful assertions that can explain the current condition is the aim of research. The researcher must check the techniques and results for bias in order to ensure the research's objectivity.

Humans make sense of the world they live in using their experience of history and social perspective. All meanings arise from social interactions. As all these assumptions point out, this affects the researcher, as experience influences the interpretation of the findings (Creswell, 2014). Critical realists view experiments as the best way to generate elementary knowledge because it is possible to isolate and identify the mechanisms. The use of theory in research can be described in two ways: inductive or deductive. The inductive approach is to collect data and develop a theory based on the data and analysis, while the deductive approach is to develop a theory or make a hypothesis and use the research design to test it (Saunders et al., 2009). The knowledge claim of this study thesis is based on constructivism, since the focus is on humans and their meanings, behaviours, and interactions based on their interpretation of the world and society. The research has an inductive approach since its aim is to learn more about building design management from practitioners and contribute new knowledge.

3.3 Research Approach

To evaluate the current practices and difficulties of design management in the building design process, this study used a mixed-methods approach. It is understood to be a research strategy and technique of inquiry when it directs the direction of data collection and analysis, with a mix of quantitative and qualitative research methods used in both. The majority of the data analysis for this study was qualitative. As a result, this study gathered and analysed numerical data as well as evaluating the size, scope, frequency, and other characteristics of events. Emaculate, Tendayi, Trynos, and Elias (2010) employed primary and secondary data sources, such as questionnaires, interviews, the Delphi technique, and document analysis, to conduct a thorough case analysis of condominium housing on 103 sites in Addis Abeba City. Both qualitative and numerical data were generated. They sought to demonstrate the importance of design considerations in the provision of affordable housing through the IHDP and the degree to which the Addis Ababa

Administration had regarded design consideration in the provision of affordable housing as relevant.

The study was highly detailed and structured, and the results can be easily collected and presented statistically. When the approach to research is considered as the criterion of classification, research can be classified into three groups: qualitative, quantitative, or mixed. Qualitative research is more subjective in nature than quantitative research and involves examining and reflecting on less tangible aspects of a research subject, e.g., values, attitudes, and perceptions. Whereas the emphasis of quantitative research is on the collection and analysis of numerical data; it focuses on measuring the scale, range, frequency, etc. of phenomena. Moreover, mixed methods combine quantitative and qualitative data collection and analysis within a single study or investigation program (Creswell, 2014).

3.4 Research Design

One must consider the research questions in order to build the proper research procedure. The objective is to comprehend the design process and the participants better. It was stated that various research methodologies, including experiment, survey, archival analysis, history, and case study, have distinct relevant contexts for them. The three factors listed below will aid in choosing the most appropriate approach. The types of study questions asked, the degree of influence over the actual behavioural occurrences, and the proportion of time spent focusing on current rather than past events are as follows.

This study considered the practices and challenges of design management in building construction in Addis Ababa. Because the research was conducted to assess design management practices and challenges in building construction, it provided a detailed picture of design management practices and challenges in building construction in Addis Ababa. Actually, the study provided a complete picture of the practices and challenges of design management in building construction and explained the application of design management in building construction or mega projects. This is because the research conclusion could be useful for the economic development developers as well as for enhancing individual capacity and monitoring

ability and skill development in the countries concerned. Thus, this study appropriately employed a descriptive research design.

3.5 Data Type

In this study, the researcher combined quantitative and qualitative data. In order to better comprehend a research problem, data for this study was typically collected and analyzed by combining quantitative and qualitative data in a single study or series of studies. The integration of theoretical and practical viewpoints, which were previously hindered by quantitative and qualitative methodologies, is improved by this sort of study data. In order to pragmatically combine quantitative and qualitative research and make up for the paradigmatic flaws in the two different methodologies, researchers chose to use a mixed methodological approach.

3.6 Data Source

In order to get the essential data, the researcher additionally used both primary and secondary sources of information. The researcher gathered data mostly through questionnaires and document reviews and conducted interviews with design managers to gain primary data. With regard to secondary data, the researcher used international and regional studies, literature, reports, manuals, and journals to gather supplemental information.

3.7 Population and sampling design

3.7.1 Population

This study employed a group of construction consulting firms, grades 1-3, in Addis Ababa, Ethiopia. Multiple sampling techniques were employed to select study participants, purposive sampling techniques and systematic random sampling. Primarily, The purposive sampling techniques were used to select 61 Grade 1,2 & 3 Consulting firms from the population (140 Consulting firms who are members of ECECAA and renewable license taken from EFDR Construction license registration office seating in Addis Ababa) owing to personal experience of the researcher and the need to make the study more manageable. Besides, the inclination of the study to focus largely on qualitative data in order to answer the basic questions had urged the investigator to confine to merely very limited number of firms with whom he had some degree of

acquaintance. Furthermore, purposive sampling gave the researcher prudent to choose key informants based on their familiarity to the issues. Thus, Architects, Structural Engineers, (practicing Architects & Structural Engineers), Design Managers (Technical Manager), Consulting firm owners, Team leaders of all the selected firms were target population of the study. Secondly, Systematic random sampling technique was also employed to recruit professional's respondents to fill the questionnaire. Table 5, shows the number of professionals in each firms and in each grade level and the required minimum sample size as well.

3.7.2 Sample population of consultants

According to the Registration of 2013EC EFDRCM, Construction Certificate license, on March 21, 2020, and registries received from the Ethiopian Consulting Engineers and Architects Association List, the population of the study consisted of consultants based in Addis Abeba. The result is depicted in Table 4 below.

Table 4 Number of Registered Consultants in Addis Ababa

	Grade-1	Grade-2	Grade-3
CA	7	3	5
CAE	14	13	4
CEG	8	6	1
Total	29	22	10

Where, CA=Consulting Architects, CAE=Consulting Architects and Engineers, CEG=Consulting Engineering (General),

Sample Size

A quota sample seeks to give proportional weighting to selected factors (strata) which reflects their weighting in which they can be found in the wider population (Singh and Masuku, 2014). Keeping that in mind, sample size for this study was determined based on the result of the sampling technique chosen i.e. quota sampling.

$$n_0 = \frac{z^2 p (1 - p) N}{z^2 p (1 - p) + Ne^2} \dots\dots\dots \{Equation 3.1\}$$

Where: n_o = sample size; z = confidence interval corresponding to a level of confidence; p = population proportion; N = population size; and, e = precision or error limit.

Preferring a confidence level of 95% (z becomes 1.96), $p = 50\%$ (percentage choice expressed as a decimal), $e = 5\%$ and with N being 61, sample size for consultants becomes;

$$n_o = \frac{1.96^2 \cdot 0.5 \cdot (0.5) \cdot 61}{1.96^2 \cdot 0.5 \cdot (0.5) + 61 \cdot (0.05)^2} = 53 \text{ Consultants}$$

3.7.3 Sample Size Determination

According to Cohen et al. (2005), there are three quota sample determination stages. Therefore, the following steps were taken accordingly.

- **Stage 1** – Identify characteristics which appear in the wider population which must also appear in the sample; divide the wider population into homogeneous and discrete groups (strata).
- **Stage 2** – Identify the proportions in which the selected characteristics appear in the wider population, expressed as a percentage.
- **Stage 3** – Ensure that the percentage proportions of the characteristics selected from the wider population appear in the sample (Cohen et. al., 2005).
- According to Zinabu et al. (2015) which cites Yamane T. (1967), sample size can be determined by using Eq. 3.1 below.

Accordingly, the following samples were determined by using sample size determination formula in the serious of steps. Primarily the total number of consultants in each strata (grade) were determined which are 25 grade-1, 19 grade-2 and 9 grade-3 Consulting organizations. And secondly the total number of professionals who responding the questionnaires were determined, which are 3 professionals for grade 1 and 2 consultants and 2 professionals for grade 3 consulting organizations.

Table 5 Sample size determination

	Grade-1	Grade-2	Grade-3	Total
Step 1: Total number of consultants in each strata (grade):	29	22	10	61
Step 2: Population Strata and Percentage Distribution	48 %	36%	16%	100%
Step 3: Quota Sample and Percentage Distribution	$48\% * 53 = 25$	$36\% * 53 = 19$	$16\% * 53 = 9$	53
Step 4: Total number of professionals in each strata (Consulting firms)	$25 * 3 = 75$	$19 * 3 = 57$	$9 * 2 = 18$	150

3.7.4 Response rate

Out of 150 distributed surveys, 124 had correct responses, resulting in a response rate of 82.6%. For a study, a response rate of 50% is considered satisfactory, 60% good, and 70% or higher exceptional. A response rate of 75% was appropriate and dependable for the study, as can be seen in the table below. Due to COVID 19 and its effects, the study therefore seemed to have good data efficiency in data collection

3.8 Method of data collection

3.8.1 Questionnaire

Both closed-ended and open-ended questions were used in the design of the research questionnaire for this study, and questions adopted the five-point Likert scale to limit the replies that survey participants may provide. In accordance with the study's aims, the questionnaire was created using data from the studied literature. The questionnaire was adapted from various studies; for example, Ergo, et al., (2019) for design management practices in building design process, Knotten et al., (2014) and Sileshi (2018) for barriers for deploying tools and techniques

used for the effectiveness of building design management process and design management tools and techniques for effectiveness of design management process.

The questionnaire for the study was designed in sections, with each section aiming to achieve a particular objective of the study. The first section of the questionnaire was used to elicit biographical information about survey respondents. The second section is divided into three sub-sections that address the first objective of the research, which is to examine respondents' perceptions of design management practices in the building design process. The second sub-section identifies the challenges of design management, specifically to address the second objective. The third sub-section of the questionnaire gives the anticipated improvement mechanisms for design management in the building design process.

3.8.2 In-depth interview

The most popular technique for gathering data in qualitative research is the in-depth interview, which has been called the "gold standard of qualitative research methods" and can be thought of as a "conversation with purpose." This is so that people's experiences, motivations, and points of view can be thoroughly explored. An interview is more than just a series of questions and responses. In this regard, managers and design engineers were interviewed in fifteen separate sessions. In order to examine and investigate the meanings in ways that addressed the study topics, special questions were created for this interview.

3.8.3 Document review

For this research, the most important documents are those that support evidence from other sources. Regardless of the study, documents can provide information that is useful for the researcher. However, documents must be viewed carefully since they might be selected to show one side, which is biased or incomplete (Creswell, 2014). The documents studied from the cases were design manuals, guide lines and companies design management framework, their organizational structure, design work flow chart and assignment scope sheets, meeting memos, company presentations, and other documents that were presented by the case companies. Meeting agendas and minutes give an overview of what was planned to be covered in the meetings. These also provided insight about the preparation of the design manager and how the meeting was executed, supporting the observations. The study selected five construction consultant companies, their techniques of design development starting from briefing phase,

planning technique, collaborative and coordination way, as they used a series of spreadsheets to summarize the integrated concurrent engineering (ICE) sessions. The spreadsheet included the design plan, decision plan, and action plan for the next. This provided easy access to information; however, not all participants were comfortable with the document and asked for traditional meeting minutes. The presentation of the working structures and processes presented by the companies in the cases also exemplified the design process in terms of how they perceived it or how they would like it to be. This worked as a reference in observations or interviews.

3.9 Method of data analysis

3.9.1 Data processing

Data analysis includes testing, tabulating, categorizing, and examining the results to address the purpose of a study (Yin, 2003). The quantitative data obtained from the structured questionnaire were analysed using Statistical Package for the Social Sciences (SPSS) 24 software and descriptive statistics, while the qualitative data gathered from interviewees were analysed using the qualitative content analysis method. Frequency tables, bar charts, and pie charts were drawn from the analysed quantitative data and presented accordingly.

3.9.2 Descriptive analysis

Descriptive statistics is the act of describing or summarizing quantitative data obtained in a study in a meaningful manner and understandable format (tables and charts, for example) (Lapan & Quartaroli, 2009). The descriptive statistics present a basic overview of each data variable by using descriptive statistical tools (O'Leary, 2013). It was explained that the purpose of statistical tools in data analysis is to provide an overall and straightforward picture of a large amount of data. It was identified as having three measures: mean, median, and mode. The study variables are broadly described with mean values and respective percentages of the respondents. This study adopted mean, percentage, and standard deviation in analysing the quantitative data obtained in the survey.

The frequency distribution, which shows the frequency of observation of each response to each variable under investigation, is used to analyse the results of some questions. In addition, rating

scales are one of the most common formats for questioning respondents on their views or opinions of an event or attribute. In the context of this specific research Participants were requested to measure respondents' attitudes to a particular question or statement and to specify the importance or level of influence of factors (research variables) by rating them on a five-point scale: (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree) or (1 = not used, 2 = rarely used, 3 = neutral, 4 = used, and 5 = highly used).

This statistical technique is intended to establish the respondents' perspectives or importance of the factors. Each of the factors has been assigned an importance index or severity index, to help rank them according to their importance, as follows.

3.9.3 Inferential analysis

The population group means differ from the means of the other groups, according to the research hypothesis. The assumption under consideration is that all demographic groupings' means are equal. We can adopt the standard social science threshold of 0.05 in this study because there was no clear justification given for fixing the level of significance to a certain probability. The null hypothesis is rejected and the research hypothesis is supported by the data if the likelihood of the test statistic is less than or equal to the probability of the level of significance (alpha error rate). If the null hypothesis is accepted, we can say that there were no differences in the population's means.

3.10 Validity and reliability test

To ensure data quality, the study verified both the relevance of items in the data collection instruments and their ability to produce consistent data. Presented in this section is a description of how the validity and reliability of the instruments were ensured.

3.10.1 Validity

The core of ensuring the quality of the data, according to Creswell (2014), is examining the validity and reliability of data collection devices before giving them to the real study subject. The degree to which the methods and tools used for data gathering are measuring what they are intended to assess is known as validity. An evaluation of an instrument's validity can include

determining if it achieves its intended goals. In quantitative research, validity relates to whether the measurement methods are reliable and effectively measuring the variables they are designed to.

The design substance and construct validity of the research were examined to assure its high calibre. Correct operational measures are established by construct validity for the topics under study. Construct validity is the topic of this text, which means it has to do with determining whether a measurement tool is appropriate for use in measuring the phenomenon under investigation. A panel of "experts" who are well-versed in the measure and the phenomenon can help with the application of construct validity in an efficient manner. Five construction experts and design engineers were consulted for this investigation, and the questionnaire received favourable results. Also referred to as formative validity, it describes the evaluation of the measure's usefulness in terms of giving data that can be utilized to enhance certain aspects of the research.

To ensure the validity of the research, many data sources were compared using the triangulation method to find a unifying theme. Five construction consultants and design engineers reviewed the produced questionnaire before the survey. To ensure content validity, the researcher used constructs from earlier studies. An extensive literature review was also done to make sure the content of measuring is relevant to the study. It was chosen to rely on the management, design, and consulting expertise of experts. In order to ensure the validity of the instrument, the researcher initially designed it with input from the subject experts and specialists.

3.10.2 Pilot test

A pre-test of the research tool (a questionnaire) was conducted among design managers and professionals in order to confirm its applicability. According to Neuman's (2002) analysis, the dissemination of pre-test or pilot study questionnaires would improve the dependability of research results. As a result of the data offered by design professionals through the use of interviews and questionnaires, the main questionnaire has to be adjusted in order to better serve the research's objectives. The questionnaire modification procedure included rephrasing research questions, eliminating irrelevant questions, including crucial questions, and overall revising the research questionnaire. The completed pilot study helped the researcher defend the relevance of

the study's topic and the relevance of the variables revealed in the questionnaire used for the investigation.

3.10.3 Reliability test

Research reliability refers to the ability of future researchers to undertake the same research project and generate the same results, interpretations, and claims. In other words, research is considered reliable if the findings of the study remain constant when conducted by another researcher under steady conditions (Silverman, 2016).

Table 7 Reliability Statistics Test Results

Reliability Statistics		
Variables	Cronbach's Alpha	N of Items
Challenges	.758	7
Applications	.698	36

Survey result, 2021/22

The purpose of conducting a reliability test is to minimize the errors and biases in a survey; the greater the degree of consistency and stability of an instrument, the greater the reliability of the instrument. For the purpose of this research, reliability was assured by testing scaled research questions using Cronbach's alpha coefficient, as it was noted that the closer the coefficient is to 1, the more reliable the survey instrument is. Tavakol and Dennick (2011) agreed that score values between 0.7 and 0.95 are standardized values for proving test reliability; thus, the optimal Cronbach's alpha value should be greater than 0.7. For this research, the results of the Cronbach's alpha coefficient tests were acceptable; they are almost 0.71 in terms of reliability test requirements.

3.11 Ethical Considerations

Respecting research ethics is very noteworthy for the positive results of the research. The researcher addressed ethical considerations of confidentiality and privacy for all individual respondents. Respondents participated on a voluntary basis. Participants were well informed as to the purpose of the study and consented verbally. Measures were taken to ensure the respect,

dignity, and freedom of each individual participating and to assure confidentiality in the study. In addition, participants were informed that the information they provide will be kept confidential and will not be disclosed to anyone else. Furthermore, data, results, methods and procedures, and publication status were truthfully reported.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The data analysis from the survey given to building design experts and the results of the interviews with architects and design team leaders are presented in this chapter. Descriptive statistics is the analysis method. Frequency distribution has been used to portray the data in tables, charts, and histograms. The chapter also discusses the questionnaire's response rate, the respondents' biographical data, and the typical yearly number of building design projects that are completed. Additionally, the tables offer a summary of the observations, the document review, and the interview part. The chapter then discusses the findings and their interpretation with regard to design management improvement techniques for the building design process.

4.2 Respondent profile

This part presents the respondents' profile about their field of specialization, involvement in design work and other related issues that related to this study.

Table 8 Respondents' Profile (N=124)

Respondents' Characteristics		Count	Column N %
Field of Specialization	Architects	53	42.7%
	Structural Engineers	28	22.6%
	Design team leaders	39	26.9%
	Other specialize	4	3.2%

Table 9 Respondents' average annual number of building designs executed or managed, over the past five years

Categories	Number of respondents	
Average annual number of building designs executed or managed, over the past five years	1-5 projects	20
	5-10 projects	34
	10-15 projects	23
	15-20 projects	25

	Over 20 projects	22
Total		124

4.3 Level of Design management practices in building design

A process-oriented method to managing a project's conception, development, and implementation is called design management in the construction industry. This indicates that it entails supervising and coordinating the work of designers, engineers, and architects who are especially tasked with coming up with the project's design (Machowski and Dale, 2015).

The difficulties of using design management techniques during the building design process are shown in Table 10 below. The respondents' assessments of the most challenges and problems affecting the efficiency of the design management process were investigated. Based on earlier studies like Seleshi (2018), the grand mean score was determined to be 3.89, which has been interpreted as a low level practice of design management. These included a lack of enhanced design planning (4.03), a lack of design management tools and techniques (3.92), a lack of an organized and explicit design process (3.89), a lack of design team experience (3.85), and a lack of controlling design information creation and flow (4.08).

Table 10 Challenges of Design Management Practices

Items	Mean	Rank
Lack of managing design information production and flow	4.08	1
Lack of design team experience	3.85	5
Lack of tools and techniques	3.92	3
Lack of structured and explicit design process	3.89	4
Lack of integration of design and construction	3.71	7
Lack of predict/understand the impact of design changes	3.77	6
Lack of improved design planning	4.03	2

Lack of managing design information production and flow; mean value scored as 4.08 was firstly ranked by respondents as the most challenges and issues on the effectiveness of design management process. Findings reveal that 41% of the respondents agreed, besides 42% of the respondents strongly agree that there is lack of managing design information production and flow is the most challenge and issue on the effectiveness of design management process. This may be as a result of lack of proper guidelines for a consistent approach to documentation of design and not cultivating the planning and production of design information. The surveyed organizations may also have improper codes of procedure for specifications, production drawings, and bills of quantity preparation.

Lack of improved design planning with mean value 4.03 was secondly ranked by respondents as the most challenges and issues on the effectiveness of design management process. Findings reveal that majority of them 46 % of the respondents are agreed, in addition 36 % of the respondents strongly agreed that there is lack of improved design planning.

This study also found that mean value score was 3.92; that was ranked thirdly by respondents as the most challenging issues on design management. The respondent's data reveal that 41% of them are strongly agreed and 35% of the respondents are agreed that there is lack of design managements tools and techniques. Historically, design was manageable with simple planning, management tools and techniques. Similarly, Silesy (2018) concluded that, factors contributing to the inconsistent design management are unfamiliarity with defining tasks, ineffective managing and improper evaluation of information flow, inadequate planning, monitoring and controlling for project design process.

Regarding on the lack of structured and explicit design process with mean value of 3.89 was found from the respondents as the most challenges of design management process. The respondent's data shown that 51% of them are strongly agreed and 29% of the respondents are agreed that there is lack of structured and explicit design process, it may be related to poorly defined and mere verbal communication cannot create sufficient understanding of a process between various parties and lack of engaging project stakeholders. This shows that there is lack of regular approach to the design process. In addition, the mean score for lack of design team experience was 3.85; it was fifthly ranked by respondents as the most challenges and issues on the effectiveness of design management process. Findings reveal that that 46% of the respondents strongly agreed and 31% of the respondents

are agreed that there is lack of design team experience. The building design phase requires intense collaboration between the participants. Bringing people together early in the project also helps to establish responsibilities, agree individual contributions and establish operating methods and means of communication before the project commences, because of project often has a short time span, at the same time as the participants have limited experience from working together.

On the lack of integration of design and construction, this study found that mean value score was 3.77; that was ranked by respondents as the most challenges on design management process. Findings reveal that 46% of the respondents strongly agreed and 31% of the respondents are agreed that there is lack of integration of design and construction is. This shows that the surveyed organizations followed fragmented phases in design and construction processes. This creates it could not able to prevents problems in subsequent phases. Thus, this organization could not able to develop suitable design solutions and unable to eventually to achieve client satisfaction. Betelhem (2020) advised that in an integrated system design and construction planning proceeds simultaneously, examining various alternatives from both viewpoints thus eliminating the necessity of extensive revisions under the appearances of value engineering.

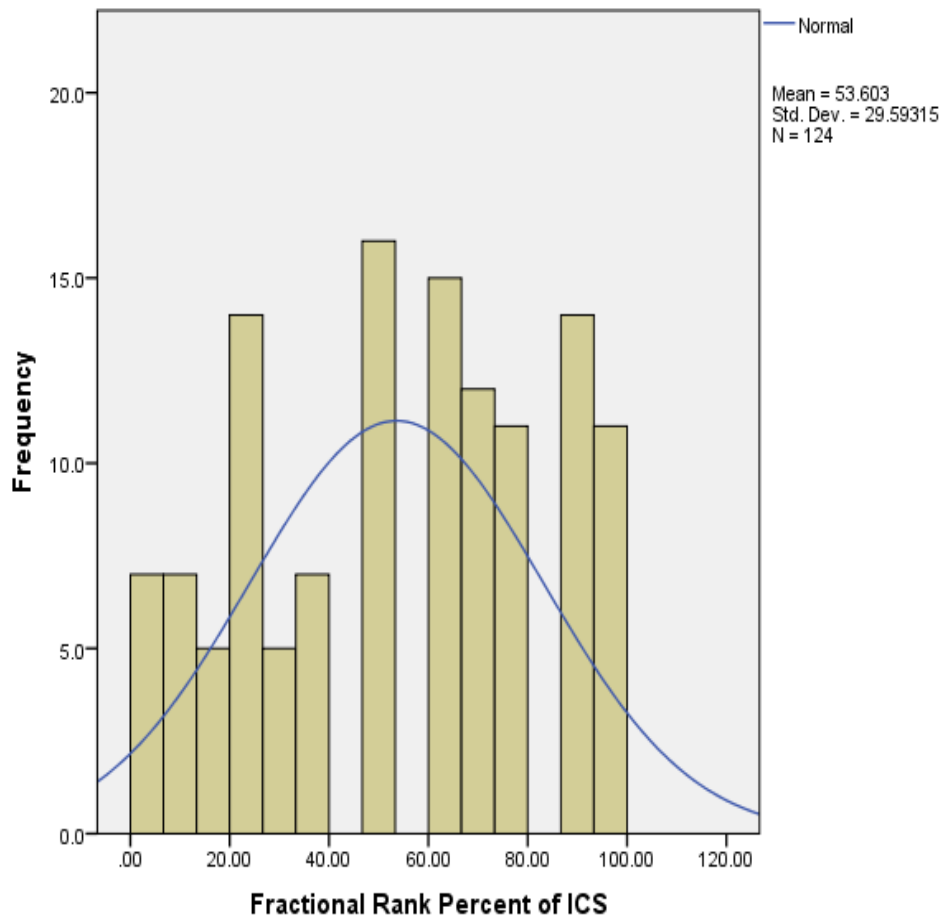


Figure 8 Levels of design management practices

The above figure, Figure 8 shows that the level of internal challenges and issues on design management process obtained or perceived by the respondents. The result shows that the overall perceived level of internal challenges and issues on design management process obtained from the respondents was almost 53.6 % for of the surveyed respondents which can be the prioritized point of focus for intervention. It shows that on average above half of the respondents strongly agreed that the internal challenges and issues on the effectiveness of design management process are thoughtful.

Figure 8 also shows that these companies have been in good position on understanding and predicts impact of design changes as well as on the challenges in the integration of design and

construction. In addition, these organizations have been assessed as using tools and techniques are not in good conditions. It has been ignored simple planning, management tools and techniques, unable to use more complex as a result of factors such as fast tracking and the increasing complexity of the fabric and content of buildings requiring enormous co-ordination effort. It may create poor communication, lack of adequate documentation, deficient or missing input information, poor information management, unbalanced resource allocation, lack of co-ordination between disciplines and uncoordinated decision making. In general, these organizations could not be able use or managing design information production and flow, improved design planning, design management tools and techniques, structure and explicit design processes and weak in design team experience.

4.3.1 Agreement among challenges of design management practice

A one-way ANOVA analysis revealed no statistically significant differences in the problems of design management methods among research participants who performed or managed projects during the previous five years and with professional experience ranging from 1–5, 5–10, 10-15, and 15-20 years (See Table 9).

Table 11 Challenges of design management practices by ANOVA

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
Lack of structured and explicit design process	Between Groups	9.099	3	3.033	2.598	.055
	Within Groups	140.094	120	1.167		
	Total	149.194	123			
Lack of improved design planning	Between Groups	6.891	3	2.297	1.636	.185
	Within Groups	168.496	120	1.404		
	Total	175.387	123			
Lack of managing design information production and flow	Between Groups	11.730	3	3.910	2.586	.056
	Within Groups	181.464	120	1.512		
	Total	193.194	123			
Lack of integration of design and construction	Between Groups	11.016	3	3.672	3.207	.026
	Within Groups	137.403	120	1.145		
	Total	148.419	123			
Lack of understand / predict	Between Groups	9.369	3	3.123	2.463	.066

impact of design changes	Within Groups	152.179	120	1.268		
	Total	161.548	123			
Lack of tools and techniques used in design management	Between Groups	6.952	3	2.317	1.838	.144
	Within Groups	151.266	120	1.261		
	Total	158.218	123			
Lack of design team experience	Between Groups	6.253	3	2.084	1.991	.119
	Within Groups	125.618	120	1.047		
	Total	131.871	123			

In order to look for differences between more than two populations, analysis of variance is utilized. It can be seen as a progression of the t-test that we used to compare the means of two populations. The one-way ANOVA is a common name for the particular analysis of variance test that we shall examine. The term "analysis of variance" is referred to as ANOVA. The adjective "one-way" denotes the existence of a single variable (also known as a factor) that determines group membership.

Table 11 demonstrates how this study used additional types of ANOVA analysis to compare means using more than one variable. The underlying premise of the study is that the population group means are distinct from those of the other groups. The assumption under consideration is that all demographic groupings' means are equal. We can adopt the standard social science threshold of 0.05 in this study because there was no clear justification given for fixing the level of significance to a certain probability. We reject the null hypothesis and come to the conclusion that our data supports the research if the likelihood of the test statistic is less than or equal to the probability of the level of significance (alpha error rate). If we fail to reject the null hypothesis, we can state that we found no differences among the means for the population groups for this characteristic. Therefore, this study indicated that for the bulk of the questions or items, there were no variations in the means for the population categories (between experienced and novice respondents). This demonstrated that the study's attempt to refute the null hypothesis—that all demographic groupings' means are equal.

4.4 Applications of tools and techniques in design management

To improve design management performance the understanding of the very nature of the design process must be improved and more use should be made of the tools and techniques that are available to manage the design process. This may be including with the specified tools and techniques that provide a common basis and reference point, beside this individual design manager can develop their own style and skill. And To identify the intended purpose of the tool and techniques so users are clear of what the tool and techniques will help them achieve or loose, additional documentation to help users familiarize themselves with the tools and apply them in practice. These include templates and electronic versions of the tools, Inclusion of such material is necessary for practitioners to adopt new tools.

The respondents were required to rate the extent of use and approaches of the design management disciplines, by using tools and techniques for effectiveness of design management process A five (5) point Likert scale was adopted, where: Highly used=5, Used=4, Neutral=3, Rarely used=2 and Not used=1. As presented on Table 12.

Table 12 Extent of use on the basics tools and techniques in the design management disciplines

Items	Highly Used		Used		Neutral		Rarely Used		Not Used	
	N	%	N	%	N	%	N	%	N	%
Customer engagement										
Value & Risk management analysis	16	12.9%	26	20.97%	5	4.03%	15	12.1%	62	50%
Briefing workshop	13	10.48%	24	19.35%	0	0%	19	15.32%	68	55%
Room data sheet	20	16.13%	20	16.13%	2	1.61%	19	15.32%	63	51%
Collaborative Working										
ICT (CAD)	66	53.23%	58	46.77%	0	0%	0	0%	0	0%
BIM	7	5.65%	11	8.87%	3	2.42%	29	23.39%	74	60%
Technology clusters	15	12.10%	21	16.94%	2	1.61%	20	16.13%	66	53%
Consultant staff appointment										
Responsibility Matrix	20	16.13%	24	19.35%	0	0%	15	12.10%	65	52%
Scope sheet	16	12.90%	34	27.42%	0	0%	12	9.68%	62	50%
Appointment document	18	14.52%	26	20.97%	1	0.81%	13	10.48%	66	53%
Design Team Leadership										
Assigning Design Team Leadership	10	8.06%	14	11.29%	1	0.81%	20	16.13%	79	64%
Defining the Design Process										
Using Architects Plan of work	19	15.32%	21	16.94%	2	1.61%	16	12.90%	66	53%

published by the RIBA

Integrated Design Planning										
Using techniques, such as ADePT	12	9.68%	20	16.13%	2	1.61%	26	20.97%	64	52%
Information transfer schedules	8	6.45%	20	16.13%	3	2.42%	24	19.35%	69	56%
Work package documents	16	12.90%	20	16.13%	0	0%	20	16.13%	68	55%
Process Control										
Using Integrated Design Programme	12	9.68%	15	12.10%	9	7.26%	12	9.68%	76	61%
Design Development and Control										
Value analysis, using Value Tree	16	12.90%	20	16.13%	5	4.08%	10	8.06%	73	59%
Value analysis, by Decision matrix	14	11.29%	16	12.90%	6	4.84%	12	9.68%	76	61%
Quality Functional Deployment (QFD)	9	7.26%	14	11.29%	3	2.42%	19	15.32%	79	64%
Standard briefing document	23	18.55%	19	15.32%	0	0%	16	12.90%	66	53%
Commercial control										
By sharing the cost plan with the design team	5	4.03%	15	12.10%	2	1.61%	28	22.58%	74	60%
By exploring the key cost drivers of the design project	16	12.90%	13	10.48%	2	1.61%	15	12.10%	78	63%
Adapting the best value solution by the design team	21	16.94%	28	22.58%	0	0%	11	8.87%	64	52%

Customer engagement

Any design process revolves around the client, and this component tries to make sure that the customer and stakeholders are appropriately included in the project. The tools, techniques, and processes used should guarantee that briefing material is provided to the design team consistently and on time, and that it is appropriately documented. An evaluation of surveyed consultants' approaches to the design management discipline of customer engagement utilizing techniques like Value & Risk Management analysis has been conducted. 33% are used, 28% are occasionally used, and 37% are not used by the majority. 27% of people utilize briefing workshops, 24% use them occasionally, and 49% don't use them at all. Using the data sheet for the room, we can see that 47% are not utilized, 28% are rarely used, and 25% are used

Collaborative Working

This approach relates to ensuring that the necessary project culture, protocols and processes are in place to promote collaborative working between members of the design and project teams.

An assessment has been done that, from surveyed consultants the respondents approaches to the design management discipline of collaborative working by using Techniques such as ICT(CAD) 43% are used, 38% are rarely used and the remaining 29% are not used. On the BIM 21% are used, 25% are rarely used and the remaining 44% are not used. By Technology Cluster 31% are used, 45% are rarely used and the remaining 24% are not used.

Consultant staff Appointment

Approving scopes of works of each of the design team members and defining the role of the Lead Consultant is essential in setting the project off on the right basis.

The survey results indicate that the respondents' approaches to the design management discipline on consultant staff appointment by using Techniques such as Responsibility matrix 42% are used, 31% are rarely used and the remaining 27% are not used. By Scope sheet 44% are used, 35% are rarely used and the remaining 21% are not used. By Appointment document 47% are used, 38% are rarely used and the remaining 15% are not used.

Design Team Leadership

Design Team Leadership in the context of Design Management aims to ensure effective performance. Design team performance by guiding and influencing how the team interacts to draw on the strengths of its constituent parts (the individual members). An assessment has been done that, from surveyed consultants the respondent's approaches to the design management discipline on Design Team leadership, 28% are used, 24% are rarely used and the majorities 48% are not used by assigning an experienced & qualified Lead designer.

Defining the Design Process

It is crucial that the design process is defined, both in terms of the high-level project stages, and the detailed scope of each of the design team members involved. Creating a high-level design process definition involves setting high level project milestones or gateways that the team can work towards. There are a number of well recognised definitions or descriptions of the building design process, such as the Architect's Plan of Work published by the RIBA. An assessment has been done that, from surveyed consultants the respondent's approaches to the design

management discipline on Defining the design process, 26% are used, 29% are rarely used and the majorities 45% are not follow by using Architects Plan of work published by the RIBA.

Integrated Design Planning

Planning design is often ignored as the design process is poorly understood and poorly defined, making the planning of the process virtually impossible. Planning of design must be based on a detailed definition of the design process and a detailed understanding of the information flow between all parties.

An assessment has been done that, from surveyed consultants the respondents approaches to the design management discipline on Integrated design planning by using Techniques such as Analytical Design Planning Techniques (ADePT), 34% are used, 26% are rarely used and the majorities 40% are not used. By using Information Transfer schedule 27% are used, 25% are rarely used and the majorities 48% are not used. By using work package document 24% are used, 28% are rarely used and the majorities 48% are not used.

Process Control

It is essential that the Consultants and Design Engineers control the completion of activities, the associated production of information, and the release of Design Deliverable in line with the Integrated Design Programme. The survey results indicate that the respondent's approaches to the design management discipline on Process control 26% are used, 29% are rarely used and the majorities 45% are not follow the process control by using ,Integrated Design Programme Techniques and tools.

Design Development and Control

Ensuring that the design being developed is technically compliant is clearly the responsibility of the design team. However, it is essential that the Design Manager has an understanding of these requirements and ensures that technical reviews and audits take place at key intervention points within the design process. An assessment has been done that, from surveyed consultants the respondents approaches to the design management discipline on the Design development and control by using Techniques such as Value analysis, like Value Tree, 24% are used, 26% are

rarely used and the majorities 50% are not used. by Value analysis, like Decision matrix 25% are used, 28% are rarely used and the majorities 47% are not used, by using Quality Functional Deployment (QFD), 20% are used, 18% are rarely used and the majorities 62% are not used, by using Standard briefing document, 21% are used, 15% are rarely used and the majorities 64% are not used.

Commercial Control

To ensure project success, it is essential that design is developed in line with agreed affordability criteria. All too often, however, a lack of commercial awareness amongst the design team members leads to unrealistic and unworkable solutions being produced.

An assessment has been done that, from surveyed consultants the respondents approaches to the design management on commercial control discipline using Techniques such as by sharing the cost plan with the design team, 4% are used, 5% are rarely used and the majorities 91% are not used, by exploring the key cost drivers of the design project 13% are used, 10% are rarely used and the majorities 77% are not used, by adapting the best value solution by the design team 10% are used, 14% are rarely used and the majorities 76% are not used.

4.4.1 Agreement among uses of tools and techniques in design management

In this study ANOVA test was used. In the ANOVA test, the probability is obtained from the “F” distribution instead of the normal curve distribution. The test statistic is also referred to as the F-ratio or F-test because it follows the f-distribution.

One factor analysis of variance, also known as ANOVA, gives us a way to make multiple comparisons of several population means. Rather than doing this in a pairwise manner, we can look simultaneously at all of the means under consideration. To perform an ANOVA test, we need to compare two kinds of variation, the variation between the sample means, as well as the variation within each of our samples.

We combine all of this variation into a single statistic, called the F statistic because it uses the F-distribution. We do this by dividing the variation between samples by the variation within each sample. The way to do this is typically handled by software or simple excel spread sheet however, there is some value in seeing one such calculation worked out.

Table 13 Applications of tools and techniques in design management

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
Customer engagement	Between Groups	8.496	3	2.832	1.881	.136
	Within Groups	180.690	120	1.506		
	Total	189.185	123			
	Total	193.548	123			
Collaborative Working	Between Groups	.806	3	.269	.216	.885
	Within Groups	149.129	120	1.243		
	Total	149.935	123			
Consultant staff Appointment	Between Groups	.944	3	.315	.312	.817
	Within Groups	121.144	120	1.010		
	Total	122.089	123			
Design Team Leadership	Between Groups	8.389	3	2.796	1.943	.126
	Within Groups	172.732	120	1.439		
	Total	181.121	123			
Defining the Design Process	Between Groups	1.176	3	.392	.260	.854
	Within Groups	181.017	120	1.508		
	Total	182.194	123			
Integrated Design Planning	Between Groups	6.732	3	2.244	1.741	.162
	Within Groups	154.687	120	1.289		
	Total	161.419	123			
Process Control	Between Groups	1.736	3	.579	.540	.656
	Within Groups	128.458	120	1.070		
	Total	130.194	123			
Design Development and Control	Between Groups	2.552	3	.851	.796	.498
	Within Groups	128.190	120	1.068		
	Total	130.742	123			
Commercial Control	Between Groups	.949	3	.316	.528	.664

Within Groups	71.849	120	.599		
Total	72.798	123			
Total	170.798	123			

Survey result, 2021/22

Table 13 shows how this study was comparisons of means using more than one variable are possible with other kinds of ANOVA analysis. Thus, this study found that no differences among the means for the population groups (between experienced and inexperienced respondents) for the majority of the questions or items. This showed that research participated were no difference among their responses on customer engagement, collaborative working, consultant staff appointment, design team leadership, defining the design process, integrated design planning, process control, design development and control and commercial control.

Table 14 Summary of document review and observation on, the applications of tools and techniques in design management Process

R.Q. No.	Effectiveness of Design Management Process		The Most Internal Challenges and Issues on The Effectiveness of Building Design Management Process; in Ethiopian Construction Consultants and Design Engineers				
			Consultant A	Consultant B	Consultant C	Consultant D	Consultant E
2	Applications of Design Management Tools and Techniques;	Customer engagement	Consistent and timely briefing information is delivered to the customer but, this information is not properly documented.	Timely briefing information without value consideration is delivered to the customer.	Timely briefing information with value consideration is delivered to the customer, agreed approvals and sign off processes and ensuring commitment from the customer as the project proceeds are well documented.	Any customer engagement information is not properly documented.	Timely briefing information is delivered to the customer by briefing workshops.
		Design Team Leadership	Not assigned properly by considering specialist knowledge, qualifications, experience.	Assigned properly by considering specialist knowledge.	Assigned by considering experience only.	Assigned by considering experience only.	Assigned by considering experience & qualification.
		Defining the Design Process	Not defined properly and within standard.	Not defined properly and within standard.	Not defined properly and within standard.	Not defined properly and within standard.	Not defined properly and within standard.

2	Applications of Design Management Tools and Techniques;						
		Consultant staff appointment	Using simple tools such as responsibility matrices, scope sheets, flow chart	Using simple tools such as responsibility matrices, scope sheets , flow chart	Using simple tools such as responsibility matrices, scope sheets	Using simple tools such as responsibility matrices, scope sheets	Using simple tools such as responsibility matrices, scope sheets
		Integrated Design Planning	Planning of design not based on a detailed definition	Planning of design not based on a detailed definition	Planning of design not based on a detailed definition	Planning of design not based on a detailed definition	Planning of design not based on a detailed definition
		Design Development and Control	Only use for Design Change & Control	Only use for Design Change & Control	Only use for Design Change & Control	Only use for Design Change & Control	Only use for Design Change & Control
		Commercial control	No Controlling System & techniques	No Controlling System & techniques	No Controlling System & techniques	No Controlling System & techniques	No Controlling System & techniques

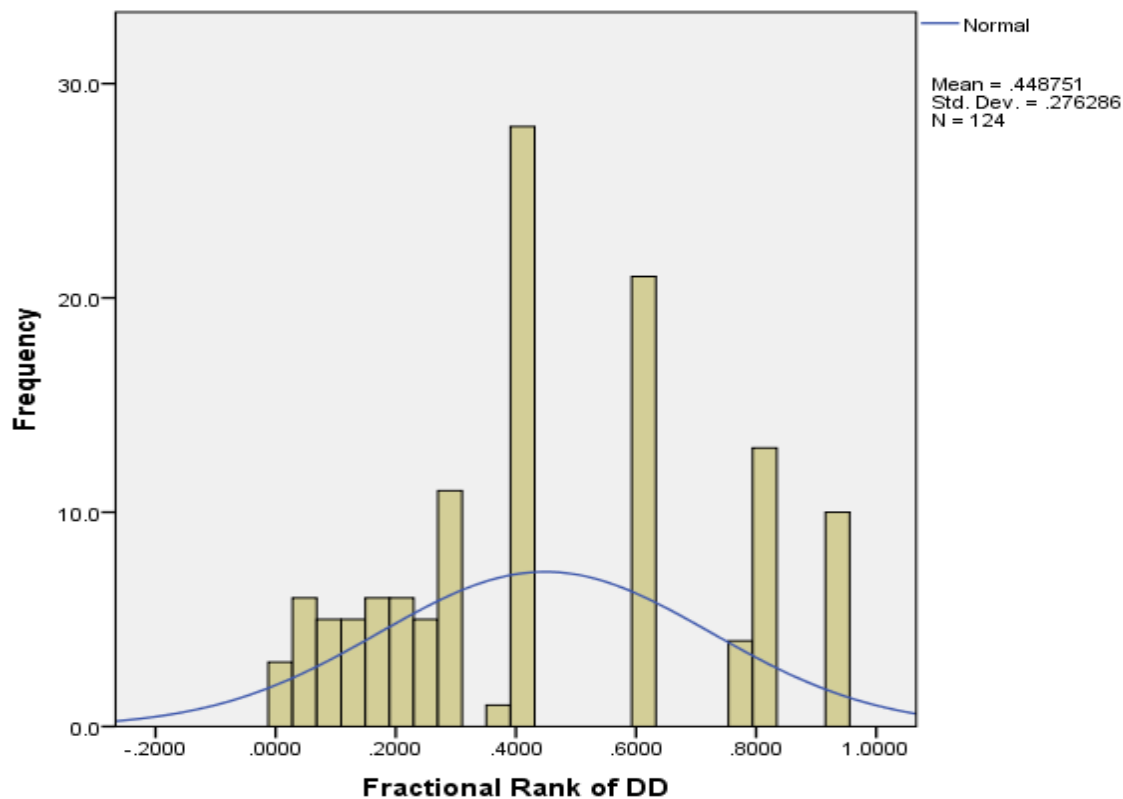


Figure 9 Level of applications of design management tools and techniques

The above figure, figure 9 shows that the level of applications of design management tools and techniques in surveyed organizations perceived by the respondents' staffs. The data shows that the overall perceived level of application with design management tools and techniques was almost 44.8 % for of the surveyed respondents which can be the prioritized point of focus for high intervention. It shows that on average more than half of the respondents strongly agreed that the organization have a gap on application with design management tools and techniques.

4.5 Barriers for Deploying Tools and Techniques

The barriers that have been identified in literature are included fragmented nature of design management tools; many tools not sufficiently developed for industry application; tools poorly deployed into industry practice; couched in abstract terms unpalatable to industry; overly complex representations of industry practice; not focused on pragmatic outcomes; and no design

checking or 2nd or 3rd party review, no system of design checking. The following table shows the result of the assessment.

Table 15 Barriers for deploying tools and techniques

Barriers	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	Std. Deviatio	Rank
Fragmented nature of design management tools	10	8%	25	20%	7	6%	44	35%	14	11%	3.39	1.146	7
Many tools are not sufficiently developed for industry application	12	10%	24	19%	4	3%	47	38%	13	10%	3.58	1.029	6
Tools poorly deployed into industry practice	12	10%	13	10%	3	2%	56	45%	16	13%	3.76	1.031	3
Design team experience	14	11%	6	5%	5	4%	55	44%	20	16%	4.04	0.769	1
Deficient resources in quality or quantity (e.g. tools, equipment, staff, or financial)	7	6%	12	10%	7	6%	53	43%	21	17%	3.83	1.095	2
Inadequate training/ inexperience, lack of knowledge	12	10%	21	17%	5	4%	46	37%	16	13%	3.6	1.126	5
No Design checking or 2nd or 3rd party reviews, No system of design checking	10	8%	15	12%	6	5%	50	40%	19	15%	3.68	1.213	4

Survey result, 2021/22

The perceptions of the respondents were explored on the barriers for deploying tools and techniques used for the effectiveness of building design management process, as presented in Table 15. The respondents were requested to rank the extent to which they agree with the identified barriers. Fragmented nature of design management tools with mean value 3.39 was ranked as 7th by respondents as the barriers for deploying tools and techniques. Findings reveal that 50% of the respondents agreed and only 12 % of the respondents strongly agreed that the fragmented nature of design management tools is the barriers for deploying tools and techniques. And this shows that this does not a barrier for effective design management in surveyed organizations. Similarly, many tools are not sufficiently developed for industry application, with mean value 3.58 was ranked as 6th by respondents as the barriers for deploying tools and techniques. Findings reveal that 62 % of the respondents preferred to the category of agree. This shows that several design tools are sufficiently developed for industry application; it is not considered as the main barriers for deploying tools and techniques.

Inadequate training/ inexperience, lack of knowledge in (building bye laws, codes, constructability, availability and suitability of materials, engineering design techniques), with mean value 3.60 and was ranked 5th by respondents as the barriers for deploying tools and techniques. This shows that there is adequate training, experience and knowledge in (building bye laws, codes, constructability, availability and suitability of materials, engineering design techniques) in the surveyed organizations. Similarly, No Design checking or 2nd or 3rd party reviews, No system of design checking was not highly indicated as a barrier for design management. This is because it's mean score 3.68 was ranked 4th by respondents. It shows that it is not as such a main barrier for deploying tools and techniques.

Design team experience with mean value 4.04 was ranked as 1st by respondents as the barriers for deploying tools and techniques. Findings reveal that almost 21 % of the respondents strongly agreed and 70 % of the respondents agreed that the design team experience are the barriers for deploying tools and techniques. Likewise, deficient resources in quality or quantity (e.g. tools, equipment, staff, or financial) with mean value 3.83 was ranked 2nd by respondents as the barriers for deploying tools and techniques. Findings reveal that 25% of the respondents strongly agreed, and 55 % of the respondents agreed that the deficient resources in quality or quantity. This shows that there is a shortage of tools, equipment, staff, and financial in design management in surveyed organizations; and the study found that these are the barriers for deploying tools and techniques. Third, tools poorly deployed into industry practice with mean value 3.76 was ranked 3rd by respondents as the barriers for deploying tools and techniques. Findings reveal that 16 % of the respondents strongly agreed, and 65 % of the respondents agreed indicating the tools poorly deployed.

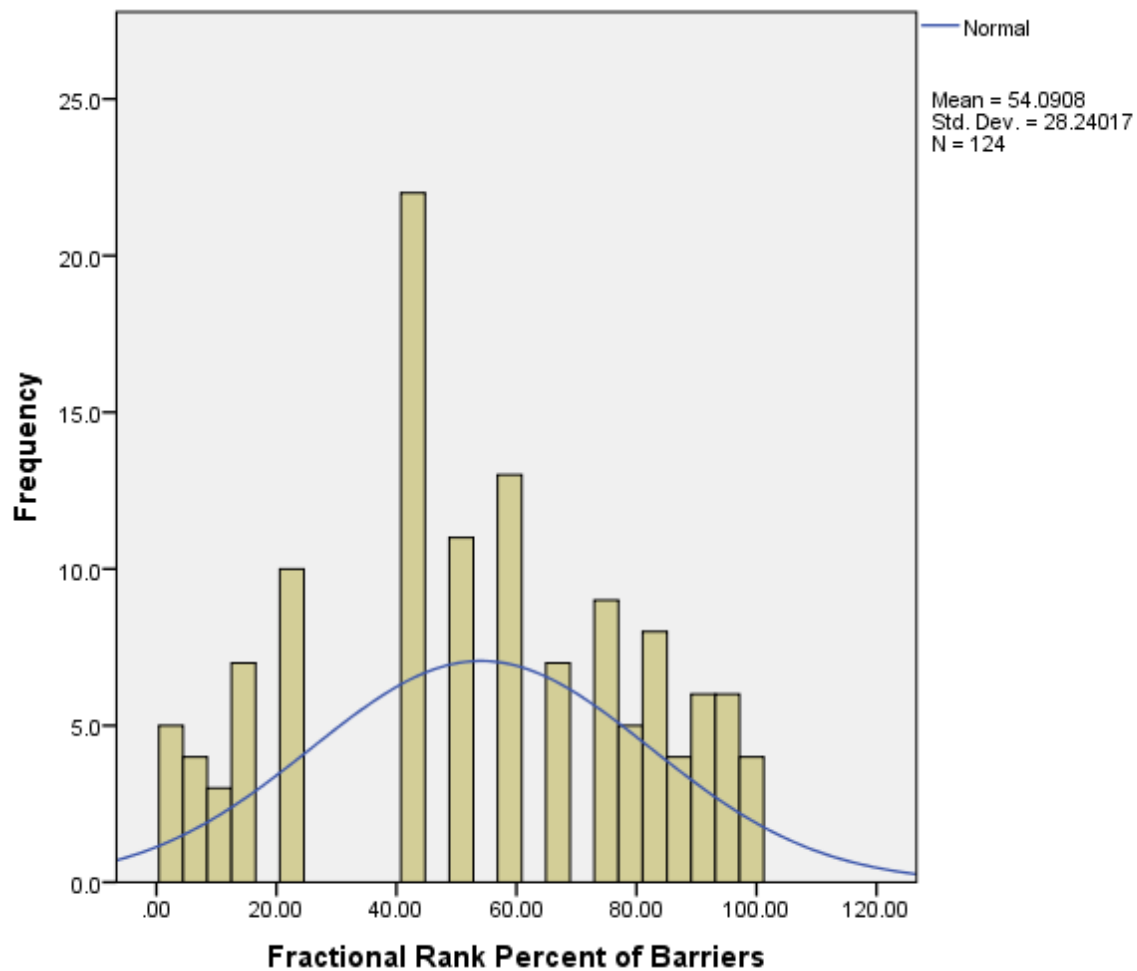


Figure 10 Level of barriers for deploying tools and techniques

The above figure shows that the level of barriers for tools and techniques in design management in surveyed organizations perceived by the respondents' staffs. The result shows that the overall perceived level of design management barriers was almost 54.09 % for of the surveyed respondents which can be the prioritized point of focus for intervention. It shows that on average more than half of the respondents strongly agreed that the organizations fashioned with varies design management barriers. Emmitt (2016) described design management as managing people and information. There is also the focus of traditional project management approaches, as highlighted the focus of time, cost, and quality as important for design management.

4.6 Difficulty areas in terms of improvement needs on better managing the Design process

The researcher identified, that the significant areas considered to be difficult in terms of improvements that can be made in the design management process are: - increasing specialism with in design, recognition that design is a process, contractor at the heart of design process, time; team approach; assigning design manager and understanding.

Table 16 On Difficult improvement areas

Difficult improvement area	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Mean	SD	Rank
	N	%	N	%	N	%	N	%	N	%			
Increasing Specialism within Design	12	10%	16	13%	2	2%	46	37%	24	19%	3.76	1.129	8
Recognition that Design is a Process	13	10%	19	15%	6	5%	42	34%	20	16%	3.84	1.129	7
Adequate Design Time	17	14%	19	15%	5	4%	38	31%	21	17%	3.96	0.83	5
Contractors at the Heart of the design Process	17	14%	18	15%	8	6%	36	29%	21	17%	3.98	0.675	3
Information at Briefing stages and the Briefs	18	15%	18	15%	7	6%	38	31%	19	15%	3.98	0.71	3
Design team approach and working in team	16	13%	20	16%	3	2%	37	30%	24	19%	3.94	0.794	6
Assigning Competent design Managers	17	14%	21	17%	7	6%	32	26%	23	19%	4.1	1.115	1
Design Tasks and Information Interdependency	16	13%	24	19%	4	3%	34	27%	22	18%	4.04	1.178	2
Grand Mean											3.95		

Survey result, 2021/22

The perceptions of the respondents were explored on the design management trends or practices, which are difficulties, in terms of Improvement needs on better managing the design process, as presented in Table 16.

Increasing Specialism within Design with mean value was scored as 3.76; it was ranked as 8th by respondents. Findings reveal that 21 % of the respondents strongly agreed and 57 % of the

respondents agreed that the Increasing Specialism within Design is not as such a difficulty improvement area. This shows that it is an ease improvement area, on the design management trends and practices. It creates the complexity of modern day materials, systems and solutions require more clear in the surveyed organizations. It meant the organization collected specialist knowledge meaning that designers have had to move from being generalists to specialists.

On the recognition that design is a process with mean value 3.84 was found that ranked as 7th. Findings also reveal that 26 % of the respondents strongly agreed and 56 % of the respondents agreed that the recognition that Design Process is an ease improvement areas.

On the Design team approach and Working in Team with mean value 3.94 was ranked 6th by respondents as the difficulty improvement areas, on the design management trends and practices. Findings reveal that 17 % of the respondents strongly agreed, and 68 % of the respondents agreed that the recognition that design team approach and working in team are not as much difficulty improvement areas, on the design management trends and practices. Obviously, primarily the design process is about the successful integration of different organizations and disciplines into one team. This is not possible without the correct people. It is common in design processes that the interplay between members and their knowledge is not fully considered and structured.

On the adequate design time with mean value 3.96 was ranked by respondents as the difficulty improvement areas, on the design management trends and practices. Findings reveal that 18 % of the respondents strongly agreed, and 70 % of the respondents agreed that the recognition that adequate design time is difficulty improvement areas. Adequate design time, budget and resources to carry out the design properly prior to construction starting on site would ensure more certainty. This appears to be an industry wide problem and change can come from clients recognizing the philosophy that good design pays.

On Contractors at the Heart of the design Process, the study found a mean value of 3.98 that was ranked 3rd by respondents as the difficulty improvement areas, on the design management trends and practices. Findings reveal that 15 % of the respondents strongly agreed and 74 % of the respondents agreed that the recognition that Contractors at the Heart of the design Process is difficulty improvement areas. In Design-Build procurement, along with the accumulative use of

private finance to fund public procurement has controlled to the contractor being involved much earlier in the project process.

A mean score of 3.98 was also found on the Information at Briefing stages and the Briefs with that was ranked 3rd by respondents as the difficulty improvement areas, on the design management trends and practices. Findings reveal that 16 % of the respondents strongly agreed and 72 % of the respondents agreed that the recognition that Information at Briefing stages and the Briefs are difficulty improvement areas. This shows that there is no a clear means for communicating the design and task objectives across the interfaces between one stage and the next. The basic steps in the process of initiating a project and setting a brief for it cannot embrace all of the permutations necessary on every project. Nor is there a specific time-scale, as this will depend upon the organization initiating the project.

The highest mean score (4.10) was found on assigning competent design Managers with mean as the difficulty improvement areas, on the design management trends and practices. Findings reveal that 43 % of the respondents strongly agreed and 41 % of the respondents agreed that the recognition that assigning competent design managers is difficulty improvement areas, on the design management trends and practices. The essence of a professional service is the application of knowledge, skill and judgment that is primarily in a client's best interest. It shows that design professionals have executed their tasks and activities without appropriate support, preparation and adequate time.

Design Tasks and Information Interdependencies with mean value 4.04 was ranked 2nd by respondents as the difficulty improvement areas, on the design management trends and practices. Findings reveal that 42 % of the respondents strongly agreed and 40 % of the respondents agreed that the recognition that design tasks and information interdependencies is difficulty improvement areas, on the design management trends and practices. It is clear that no real consideration is given to determining the optimum sequence of design tasks and the interdependencies to produce the required co-coordinated information in many design projects. This is one of the main challenges of managing design process.

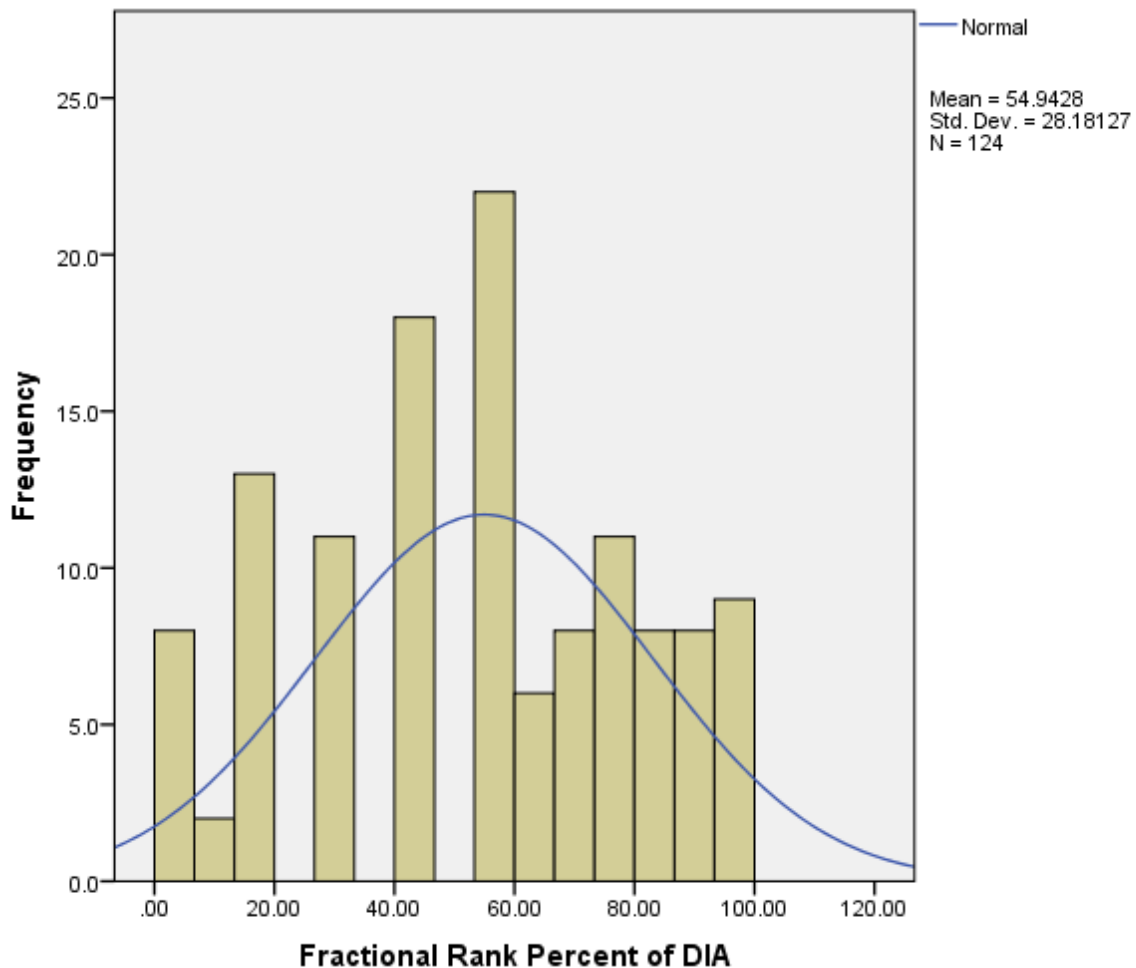


Figure 11 Level of difficulties for improvement area

The above figure shows that the level of difficulties for improvement area in surveyed organizations perceived by the respondents' staffs. The data shows that the overall perceived level of difficulties for improvement area was almost 54.94 % for of the surveyed respondents which can be the prioritized point of focus for intervention. It shows that on average more than half of the respondents strongly agreed that the organization formed with varies difficulties for improvement area.

Table 17 Summary of Qualitative Interview

S.No.	Effectiveness of Design Management Process		The Most Internal Challenges and Issues on The Effectiveness of Building Design Management Process; in Ethiopian Construction Consultants and Design Engineers, Summary				
			Consultants Group A	Consultants Group B	Consultants Group C	Consultants Group D	Consultants Group E
1	Internal Challenges and Issues;	On a Structured and Explicit Design Process	We understand the process, but not Implemented well, even the RIBA Plan of work can be used.	We are aware of all the standard process, but we didn't have a confidence to manage and implement	We understood the RIBA and all other types of Design process, but we are implementing in a low level because of we have no adequate design time.	We engender common design process only	We understood in detail a standard process and definition but we applied the major stages of design process only
		On an Improved Design Planning	Simple design planning is followed, with an input of time only , by using simple planning tools	We have low confidence in preplanning design, because the iterative nature and unbalanced resource allocation	We have not an improved design planning, because of lack of adequate documentation, design produced information, planning software	Simple planning technique have been used, like networking method , because inadequacy in design technical knowledge	Due to lack of coordination between disciplines and an interface management we didn't have an improved design planning, we have used simple design planning techniques
		On the Managing Design Information Production and Flow	Design information is not produced timely, and not distributed to all parties/teams with consideration of needs.	Design information produced in inconsistent approach and distributed not based on issues perception.	Design information is produced, distributed, and managed for only major design activity.	Design information is produced and distributed without fully co-ordinated and in complete information.	Design information is produced and distributed without Value consideration and timely provisions.

3	Barriers for deploying tools and techniques	Tools poorly deployed into industry practice	Deficient resources in quality or quantity	Project design fee is very low	The design team has less team spirit	Hired junior professional	
		Many tools are not sufficiently developed for industry application	Inadequate training/inexperience, lack of knowledge	Unaffordable permanent team	Expensive data base infrastructure	Used cracked version, or equivalent available software	
		Fragmented nature of design management tools	No Design checking or 2nd or 3rd party reviews	Can't access to a licensed software	No place who provide the training	Design team experience	
		Design team experience					
4	Difficulties Design management trends/practices, in terms of improvement need on better managing design	Increasing Specialism within Design	Adequate Design Time	Working in Teams	Increasing Specialism within Design	Adequate Design Time	
		Adequate Design Time	Erratic decision making	Assigning Competent design Managers	Inadequacies in designers' technical knowledge	Assigning Competent design Managers	
		Working in Teams	Inadequacies in designers' technical knowledge	Adequate Design Time	Adequate Design Time	Erratic decision making	
		Assigning Competent design Managers					

4.7 Discussions

The study founds challenges and issues of design management process that discourage the efficiency and quality of the design management process on. The findings from the data analysis were used to indicate the possible improvement areas and to do on that further study. It can be concluded that these surveyed organizations executed poor information management can lead to missing, incorrect or unclear documents which contained insufficient details and conflicting and un-co-ordinated information. These organizations have also lack of support integrated design and construction, information's are not shared and managed to actively promote integration.

The implementation of a design management tool and techniques has been disrupting at all levels within an organization and project team has been also unable to ensure it is taken up in effective design management process. Similarly, Vegard (2017) examined the current literature concerning building design management, describing the challenges of the building design process and the challenges of its management. The building design process is described as challenging since there is usually more than one solution to a design problem, and a proposed solution might trigger new problems to solve. The design tasks are highly interdependent in different ways. The dependencies can be described as pooled, sequential, reciprocal, and intensive and require different coordination and management approaches.

The barriers that have been identified in the surveyed organizations included used poor tools, having inexperience design team, deficient resources in quality or quantity and no design checking by third party. This showed that these organizations operated under fragmented, insufficiently developed, poorly deployed and couched in abstract terms. It can be decided that it was inclined to be overly complex and force practitioners into unwanted discipline. This indicated that these organizations could not able to defining the tasks properly to provide a clear means for communicating the design and task objectives across the interfaces between one stage and the next. In addition, it could not able to integrate different organizations and disciplines into one team. The essence of a professional service is the application of knowledge, skill and judgment that is primarily in a client's best interest.

This study also found that a low level reaction on properly use and approaches of the design management disciplines. It shows organizations can't be ensuring that consistent and timely briefing information is delivered to the design team and that this information is properly documented. In addition, it was found that it can't be ensured an effective performance through design team interaction that to draw on the strengths of its constituent parts (the individual members). Moreover, it can be created a low-level design process definition that involves setting high level project milestones or gateways that the team can work towards. Further, the focuses was on backward looking performance and progress reporting and it attempted to use tools and techniques like, value analysis using, Quality Functional Deployment and Standard briefing document. Similarly, it was also found that much of the time is spent in managing the information in the design phase. With a more effective information management, some of this time can be reduced and used in more value creating activities

Design Information Production flow management; providing a structured and explicit design process; Design planning; Design team experience, Integrating design and construction; and the ability to understand and predict the impact of design changes are the key areas overcoming the challenges and issues for improving fundamentals of design management process. The organizations do not recognize the iterative nature of the process and to improve Design Management performance there is a need to improve understanding of the very nature of the design process and available tools should be used to manage the design process.

The organizations undertake Design management in an inconsistent manner using approaches based on personal experience and preference rather than a structured approach. To be able to manage a process effectively it must be repeatable. The inconsistent way in which design is approached from project to project therefore makes effective Design Management challenge.

The organizations use few Design management tools and they are applied inconsistently across projects. The organizations operate with an unstructured design process. This has led to the use of varying terminology to describe process stages and tasks. Companies implementing a structured design process should expect to experience the benefits of a common language to describe the process and an understanding of the tasks and responsibilities of each project party.

When there is spending time searching for and handling information reducing the time available for actual 'engineering' or problem solving. And the delays associated with poor co-ordination in product design. This suggests the problems of information management are prevalent in all engineering domains. Poor information management can lead to missing, incorrect or unclear documents which will contain insufficient details and conflicting and un-co-ordinated information. Full and free information for all members of the design team is an appealing idea, but the production in quantity of information and documentation in modern construction work makes this an impractical ideal, this is the main challenge for design management in building design process.

When there is a lack of improved design planning in the consulting firm, they can't measure the skill and productivity of the designers condition the value of that time. It is therefore imperative to monitor progress to ensure that sufficient resources remain to complete the design. In the monitoring of progress, designers and managers must pay close attention to the degree of coordination between the various forms of design information. In collecting progress reports, it is often necessary to compensate for views of progress that may be too optimistic. It is easy to overlook shortfalls in productivity that can become impossible to rectify.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter summarizes the finding of the study with respect to its aim and objectives and is the closing chapter of the study, which includes a summary of findings, presents the conclusion, makes recommendations, and suggests areas for further research toward the improvement of the building design management process among Ethiopian construction consultants and design engineers.

5.2 Summary of major findings

The key challenges of design management practices in building design process included a lack of managing design information production and flow, a lack of improved design planning, a lack of tools and techniques, a lack of a structured and explicit design process and lack of design team experience. The overall perceived level of challenges obtained from design management practice was almost 53.6% for the surveyed respondents, which can be the prioritized point of focus for intervention.

The use and approaches of the design management disciplines and techniques that included the way to customer engagement, collaborative working, an appointment of consultant staff, assigning design team leadership, applying IDP, mechanisms of design development, the process and commercial control. The extent of use on these design management disciplines was almost 44.8% for the surveyed respondents, which can be the prioritized point of focus for high intervention.

The barriers to successful implementation of tools and techniques that have been identified in the surveyed organizations included tools poorly deployed into industry practice, an inexperienced design team, deficient resources in quality or quantity (e.g., tools, equipment, staff, or financial), no design checking or 2nd or 3rd party reviews, and no system of design

checking. The overall perceived level of barriers was almost 54.09 per cent for the surveyed respondents, which can be the prioritized point of focus for management intervention.

Finally this study identified that the significant areas that reflected difficulty in terms of improvements need on better managing design process included; the design tasks and information interdependency, assigning competent design manager, information at briefing stage and the briefs, contractors at the heart of design process and adequate design time. The overall level of these difficulties has been almost 54.94% for the surveyed respondents, which can be the prioritized point of focus for intervention.

5.3 Conclusions

The Consulting Company operate with an unstructured and explicit design process. This has led to the use of varying terminology to describe stages and tasks in the process. If companies were to implement a more structured design processes they might expect to experience the benefits of a common language to describe the process and an understanding of the tasks and responsibilities of each project party. From this it can be concluded that an unstructured design process can't provide significant benefit by aligning the processes of project parties and providing an explicit road map to help manage each project.

The challenge with every consulting firm is to bring the design team together in the most appropriate manner for a given project context so that the interfaces can be managed effectively and efficiently. Bringing people together early in the design project also helps to establish responsibilities, agree individual contributions and establish operating methods and means of communication before the project commences. Lack of design team experiences also another challenges of design management practices.

Improving design management practice within a design and construction organization is a long-term activity and must also overcome a range of barriers; not least the underlying company and construction industry culture. And Lack of leadership from senior management and the lack of agreed design management processes are the critical barriers throughout the design process.

In General this study concluded that the most significant challenges to the effectiveness of the building design management process included a lack of managing design information production and flow, a lack of improved design planning, a lack of design management tools and techniques, a lack of design team experience and a lack of a structured and explicit design process.

5.4 Recommendations

- Consulting firms should overcome the key challenges and difficulties area in terms of improving Design management practices which included:-by managing Design information production and flow; by providing a structured and explicit design process; an improved Design planning; with in Design team experience, Integrating design and construction; and the ability to understand and predict the impact of design changes.
- Design management while typically the role of one management function can be significantly affected by the actions of others. Organizations must be cultured about the importance of the design process in delivering value to the whole project, how the way they work affects the design process, how they can contribute to the design and consequentially the whole project process. Therefore, implementation of a design management tool or practice must include and educate at all levels within an organizations and project team to ensure it is taken up in practice.
- The design consultants should properly apply various design management techniques or introduce programming methods to Ethiopia's design-construction industry, including a technologically advanced project management system. In addition, it should integrate design information between each design process stage and develop a high-tech design system and a highly standardized design online library, develop a system or design reviewing manual that integrates resources, costs, time, and quality, and develop a system for controlling professionals' productivity and the coordination of information through them.
- The government should be involved in improving construction technologies that should be fundamentally changed for a better understanding of the science of materials and improved manufacturing processes. It may be involved in reducing taxes for construction

technologies, and professional tax exemptions may be applied for more competent designers and for those who are willing to challenge the conventional application of materials for aesthetic, cost, or production reasons.

- To improve design management performance, the understanding of the very nature of the design process must be improved, and more use should be made of the tools that are available to manage the design process. A structured approach to design management has been devised to benefit parties involved in managing the design process.
- Within large design and consulting organizations, a training initiative should be developed. The experiences would be explored to determine their relevance and impacts on other organizations.
- A design management auditing process should be developed to ensure projects are deploying design management practices and tools.

5.5 Recommendations for further research

A suggestion for additional study would be to initiate a debate about design management practices in the construction sector by conducting a survey on professional development in design management and the function of professional design managers. This is because design management employs a systematic managerial approach, and while though this thesis focuses on team members at the organizational level, future research may look at issues such as interpersonal power and ethics. There is still a need to investigate how the personal behaviour of the design manager influences the building design management process. In addition, future studies may be involved in the behaviour and improvement of the design team, including the behaviour of the design manager. Case study research should be conducted in consulting firms as part of a design management education and training initiative. It aims to disseminate an understanding of the nature of the design process and provide tools focused on the key needs of organizations. Further investigation is recommended to develop design management tools to control the costs of the designed facility.

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Annex

APPENDIX I – Questionnaire

(Questionnaire Survey)

Dear participant,

I am currently working a research on Design management practices in building design Process; In The Case of Ethiopian Construction Consultants and Design Engineers, as a partial fulfilment for my MSc study in Construction Management at the EiABC, Addis Ababa University. This research is aimed to investigate the challenges and issues on the effectiveness of building design management Process and to recommend improvement on the design management process in Construction Consultants and Design Engineers.

It is therefore important to identify challenges and issues on the effectiveness of building design management process in Ethiopia and offers the opportunity to determine the effectiveness of methodology in practice after analysing, subsequent recommendation of the possible solutions towards minimizing or overcome the challenges.

To successfully conduct this research, it is mandatory to look into the issues from different perspectives by involving professionals who have experience in the Ethiopian construction consultants and design engineers. In this respect, you are the one who can give the correct information; hence I kindly request you to respond to the questions.

I would like to confirm you that your response will be kept strictly confidential and it will be used exclusively for the purpose of this research. Besides, your quick response is vitally important in order to finalize the research timely and I would appreciate if you complete and return it within one week of your receipt of same.

Thank you very much for your time and cooperation, and looking forward to receiving your response.

Yours faithfully,

Samson Melesse

EiABC, Addis Ababa University, School of Graduate Studies,

My Address - Tel: +251911561904, E-mail: Samcot2014@gmail.com

PART I - General Information

I. Respondents' Personal Information

1. Gender

a) Male b) Female

2. Age

a) 24 -30 b) 31-40 c) 41-50 d) 51 & above

3. Educational Level

a) First Degree b) Master Degree c) PHD and above

4. Field of Specializations

a) Architect b) Structural c) Design M. d) Other specialize

5. Work experience

a) 1- 5 year b) 5-10 years c) 10-15 years d) 15-20 years
e) above 20 years

II. Design management Information

6. Average annual number of building designs executed or managed, over the past five years.

Below 5 projects 5-10 projects 10-15 projects
 15-20 projects Over 20 projects

PART II – Questionaries’

1. The followings are the key challenges of Design management practices in building design process in the Ethiopian Construction Consultants and Designers Engineers. Kindly “tick as appropriate”, using the scale below: Where 5=Strongly agree, 4=Agree,3=Neutral, 2=Disagree, 1=Strongly disagree.

Key challenges of design management	5	4	3	2	1
Lack of Structured and Explicit Design Process					
Lack of Improved Design Planning					
Lack of Integration of Design and Construction					
Lack of Managing Design Information Production and Flow					
Lack of Understand / Predict Impact of Design Changes					
Lack of Tools and Techniques used in Design Management					
Lack of Design Team Experience					

2. The followings are design management tools and techniques for effectiveness of design management process; To what extent have, the following approaches, tools and technique are used in the Ethiopian Construction Consultant and Design Engineers? Kindly “tick as appropriate”, using the below scale; Where 5=Highly used, 4=Used, 3=Neutral,2=Rarely used, 1=Not used. 5 4 3 2 1, if there is others please mention it.

Disciplines of Design Management ,Using Tools and Techniques;	5	4	3	2	1
Customer engagement					
→Value & Risk management analysis					
→Briefing workshop					
→Room data sheet					
Collaborative Working					
→ICT (CAD)					
→BIM					
→Technology clusters					

Disciplines of Design Management ,Using Tools and Techniques;	5	4	3	2	1
Consultant staff appointment					
→Responsibility Matrix					
→Scope sheet					
→Appointment document					
Design Team Leadership					
→By assigning an experienced & qualified Lead designer					
Defining the Design Process					
→Using Architects Plan of work published by the RIBA					
Integrated Design Planning					
→Using techniques, such as ADePT					
→Information transfer schedules					
→Work package documents					
Process Control					
→Using Integrated Design Programme					
→Others					
Design Development and Control					
→Value analysis, using Value Tree					
→Value analysis, by Decision matrix					
→Quality Functional Deployment (QFD)					
→Standard briefing document					
Commercial control					
→By sharing the cost plan with the design team					
→By exploring the key cost drivers of the design project					
→Adapting the best value solution by the design team					

3. The followings are barriers for deploying tools and techniques used for the effectiveness of building design management process in the Ethiopian Construction Consultant and Design Engineers. Kindly “tick as appropriate”, using the scale below: Where 5=Strongly agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly disagree.

Barriers	5	4	3	2	1
Fragmented nature of design management tools					
Many tools are not sufficiently developed for industry application					
Tools poorly deployed into industry practice					
Design team experience					
Deficient resources in quality or quantity (e.g. tools, equipment, staff, or financial)					
Inadequate training/ inexperience, lack of knowledge in (building bye laws, codes , constructability, availability and suitability of materials, engineering design techniques)					
No Design checking or 2nd or 3rd party reviews, No system of design checking					

4. Areas considered to be Difficult in terms of Improvement Needs on Better Managing the Design Process, in the Ethiopian Construction Consultant and Design Engineers ,Kindly “tick as appropriate”, using the scale below: Where 5=Strongly agree, 4=Agree, 3=Neutral, 2=Disagree, 1=Strongly disagree.

Difficult improvement areas	5	4	3	2	1
Recognition that Design is a Process					
Adequate Design Time					
Briefing stages and the Briefs					
Working in Teams					
Assigning Competent design Managers					
Design Tasks and Information Interdependencies					
Increasing Specialism within Design					
Contractors at the Heart of the design Process					

Thank You!

APPENDIX II – Interview Questioners

I am Samson Melese, from Addis Ababa University. I am currently working a research on the challenges of design management in building design Process; In The Case of Ethiopian Construction Consultants and Design Engineers.

Can I precede my questions? Thank you!

1. Please state and brief me on, The Challenges of Design Management in Building Design Process, in the Ethiopian Construction Consultants and Designers Engineers?

2. Do you brief me on, how the Ethiopian Construction Consultants and Designers Engineers approaches on the applications of Tools and Techniques for building design process, which has been helpful for the effectiveness of Design Management?

3. What are the barriers to the successful deployment of tools and techniques, with in the Ethiopian Construction Consultants and Designers Engineers?

4. Do you brief me about, Areas considered to be Difficult in terms of Improvement Needs on Better Managing the Design Process in the Ethiopian Construction Consultants and Designers Engineers?

Thank you again!