JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT OF CONSTRUCTABILITY PRACTICES IN PUBLIC BUILDING CONSTRUCTION PROJECTS IN THE CASE OF JIMMA TOWN

A Thesis submitted to School of Graduate Studies, Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Master of Science in Construction Engineering and Management

BY

ANDUAMLAK YILMA GIZAW

August, 2021

Jimma, Ethiopia

JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT OF CONSTRUCTABILITY PRACTICES IN PUBLIC BUILDING CONSTRUCTION PROJECTS IN THE CASE OF JIMMA TOWN

A Thesis submitted to School of Graduate Studies, Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Master of Science in Construction Engineering and Management

Advisors: Dr. GETACHEW KEBEDE

Engr. ABEBE ESHETU

August, 2021

Jimma, Ethiop

JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT OF CONSTRUCTABILITY PRACTICE IN PUBLIC BUILDING CONSTRUCTION PROJECTS IN THE CASE OF JIMMA TOWN

A thesis submitted to School of Graduate Studies, Jimma University, and Jimma Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Master of Science in Construction Engineering and Management

By Anduamlak Yilma Gizaw

APROVED BY BOARD OF EXAMINERS:

1. _____ _____ ___/___/___
   External Examiner Signature Date

2. _____ _____ ___/___/___
   Internal Examiner Signature Date

3. _____ _____ ___/___/___
   Chairman Signature Date

4. Dr. Getachew Kebede _____ ___/___/___
   Advisor Signature Date

5. Engr. Abebe Eshetu _____ ___/___/___
   Co-Advisor Signature Date

DECLARATION

I declare that this research entitled "ASSESSMENT OF CONSTRUCTABILITY PRACTICE IN PUBLIC BUILDING CONSTRUCTION PROJECTS IN THE CASE OF JIMMA TOWN" is my original work and has not been submitted as a requirement for the award of any degree in Jimma University or elsewhere.

ANDUAMLAK YILMA GIZAW ……. ……

NAME SIGNATURE DATE

As Master research Advisor, we hereby certify that we have read and evaluated this research prepared under my guidance, by Anduamlak Yilma Gizaw entitled "Assessment of Constructability Practice in Public Building Construction Projects in the Case Of Jimma Town" and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Construction Engineering and Management.

Advisor: Dr. GETACHEW KEBEDE …… …….……

NAME SIGNATURE DATE

Co - Advisor: Engr. ABEBE ESHET …….... …….

NAME SIGNATURE DATE

ABSTRACT

Constructability is a project management tool that optimizes construction knowledge and experience at various stages of the project to meet the project's ultimate goals. It is also utilized to solve a variety of difficulties in the pre-construction phase, such as cost, time, and quality defects. However, there is still a large integration gap between design and Construction in practice. One of the key problems in the developing countries' construction industry, mainly in Ethiopia, lack of integration of construction knowledge, resources, Technology, and experience during all stage of construction process.

This study aims to investigate concepts and practice of constructability, effects of Constructability on performance of Public Building Construction Projects and identify the barriers and remedial measures of constructability on public building construction projects during pre-construction phase. So, the study was carried out by collecting input data from questionnaires and interview with available concerned bodies on the active public building construction project sites to meet the specific objectives.

The research used both mixed approaches of Qualitative and quantitative types of research. The Target populations involved in this study were Client/Client's representative, consultants and contractors. The overall populations were well-known, limited in number, and well-suited to the study objectives. As a result, the study's sample included the entire population that was targeted. To analysis the data and to Rank the factors Relative Importance Index (RII) was used. The data was presented and analyzed by using descriptive statistics like graphs, charts and tables by Microsoft excel sheet version 2013.

This study identified practices and concepts, effects, barriers and remedial measurements of constructability in public building construction projects. As a result 'Lack of awareness of Constructability, Unwillingness to invest extra money in early project stages, Separate design management and construction management operations' are the most Client's concerned barriers. Whereas 'Lack of awareness of benefits and concepts of Constructability, Lack of mutual respect between designers and contractors' are Designer barriers. In addition, 'less early involvements of Contractors during designs, No knowledge of the latest construction methods and techniques are the most Contractor barriers.

However, the remedial measures to the identified top barriers of Constructability are also recognized, based on this the most evaluated remedial measures are 'the stakeholders must be aware of the benefits and concepts of Constructability, Allow enough time for constructability assessment before the project starts, Client must provide enough financial incentive for designer ,there must be mutual respect between designers and contractors, the parties must be aware of the latest construction methods and techniques'. In general, the practice and implementation of constructability, rather than following the conventional approach of construction management improves the project's performance.

Keywords: *Barriers, Constructability, Integration, Performance, Public Building*

ACKNOWLEDGMENT

First of all, I would like to say thanks to my Almighty God for helping me through in my work. I am deeply grateful to my Advisor Dr. Getachew Kebede and to my Co-advisor Eng. Abebe Eshetu for their patience: supervision, guidance, expert advice and support in order to complete this thesis. Without their constructive comments and valuable suggestions, this research could not have reached this stage.

Also, I'd like to express my gratitude to my brothers Anteneh Gebere and his families, as well as Ermiyas Gebeyehu, for their assistance in providing Wi-Fi internet and helpful research materials, which enabled me to conduct my research in this manner.

Mr. Muniter Muresa and Mr. Wondimagegn Gebeyehu (lecturers at Dilla University) deserve special thanks for their assistance from the beginning of title selection until the completion of this thesis; they generously offered their useful and constructive comments, expertise, and knowledge with me.

Finally, I would like to express my sincere thanks for all those who willingly participated to interviews and questionnaires from various organizations during the conduct of the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ASCE	American Society of Civil Engineers
BOT	Built Operate Transfer
BCP	Building Construction Project
CA	Constructability Analysis
CAs	Constructability Activities
CC	Constructability Concepts
CII	Construction Industry Institute
CIRIA	Construction Industry Research and Information Association
CPs	Constructability Principles
CPR	Constructability Practice
CPM	Critical Path Methods
CR	Constructability Review
DB	Design-Built
DBB	Design -Bid -Built
EPC	Engineering Procurement and Construction
JIT	Jimma Institute of Technology
OM	Operation and maintenance
PBCP	Public Building Construction Project
PDP	Project Delivery Process
PERT	Project Evaluation and Review Technique
RII	Relative Importance Index
TQM	Total Quality Management
US	United State
UCBP	University Capacity Building Program
VE	Value Engineering
VM	value Management

CHAPTER ONE

INTRODUCTION

1.1 Background

Construction industry, as one of the biggest industry, has several issues. Constructability is one of these problems; that is a management tool for optimizing construction knowledge and experience throughout various stages of a project in order to meet overall goals (Khan, 2019). As far as, development of appropriate techniques and tools are necessary to make project management efficient and to avoid waste in terms of time and resources (Materials, Equipment and others). Several tools, such as constructability, value engineering, and design review were developed to enhance design process quality and overall project performance (Al-Fadhli, 2020).

Moreover, the main reasons for project failure in developing countries like Ethiopia are lack of advance planning, a holistic approach, lack of comprehensive engineering and management strategy, inconsistency in monitoring and follow-up, coordination and communication lapses and above all, absence of a methodical approach (Ayalew, et al., 2016).Similarly, Ding, et al., (2020) construction industry is fragmented by various problems related with cost, time and quality. Therefore, having integrated contractual strategies for projects and developing a transparent and unambiguous contract is highly effective for proper implementation of constructability (Jadidoleslami, et al., 2019).

The word "Constructability" is grew in USA (1970s). The US, Construction Industry Institute (CII, US) defined constructability as "the optimum integration of construction knowledge and experience in planning, engineering, procurement and field operations to achieve overall project objectives" (Keerthana & Pradeep, 2019). Also, Constructability refers to utilizing knowledge and experience together to optimize construction in all phases of the project life cycle of initiating, planning and designing, executing, and closing (Mohsenijam, et al., 2020).Moreover an effective constructability program will begin during the planning phase and will continue conceptually to the end of construction Stage (Samuel & Oluseye, 2016). Also, Amade, (2016) It is normally identifies obstacles before a project is actually built to reduce or prevent error, delays and cost overruns.

Constructability is facilitating the construction of a project through integrating knowledge and experience to achieve the overall and common objectives of the project in all stages of it, but

practically there is still a significant gap between design, construction, and achieving the desired project objectives. This issue results in increasing project time and cost, poor relationships, and also increasing project waste and duplication. (Jadidoleslami, et al., 2018). Though, implementing constructability concepts in a construction project can bring many benefits such as reduced project cost and time, enhanced project quality, and improved site management (Ding, et al., 2020).

Constructability is a project management technique for reviewing the whole construction process and before project implementation, to reduce or prevent mistakes, delays and overflow costs, through identifying the obstacles (Jadidoleslami, et al., 2019). Also it is an effective technique that implements a detailed review of design drawings, documents, specifications, and construction processes by highly experienced engineers, working with original team of the project before construction mobilization (Al-Fadhli, 2020).

In addition, Fadoul, et al., (2021) the economic and time efficiency can be attained in the construction industry by applying the principles of Constructability. As a result, incorporating these principles into initial stages of projects, maximize outcomes for all stakeholders including designers, contractors, and clients.

Also Successful project management is both an art and a science which attempts to control corporate resources within the constraints of time, cost, and quality performance. The triangle of time, cost, and performance is a combination that should be continuously pursued by the project team member throughout the life cycle of the project (Shamsudeen & Biodun, 2016).

Similarly, Integration management is the most important knowledge area, which provide platform for processes, and activities that integrate, coordinate the various elements of project management in one chain. Just like that a strong and victorious construction project coordination and integration of the various elements are necessary for project's success (Salwa, et al., 2014).

What's more, Construction projects have often suffered from high fragmentation, large waste, poor productivity, cost and time overruns, and conflicts and disputes for a long time. Thus, many new and innovative management and procurement systems in construction are introduced such as partnering, joint venture, alliances, supply chain management and Total Quality Management (TQM) to meet these challenges. However, these construction management and procurement systems are meaningless without coordination, a vital managerial principle and activity, which provides the best cooperation among team members (Hai, et al., 2012).

Concepts of "constructability" and "buildability", "constructability" is more frequently used in Australia and Malaysia whereas "buildability" is adopted by Hong Kong and Singapore. The United States use both terms interchangeably. The literature shows that different countries adopt different terms. The researchers found that buildability concerns more on design whereas constructability encompasses wider scope and it embraces management functions/systems. (Ding, et al., 2020). The concept of buildability originated in the United Kingdom and is defined as the extent to which the design of a building facilitates ease of construction (Ansyorie, 2019).

In addition (Samuel & Oluseye, 2016)Constructability concept is more comprehensive than buildability concept as constructability covers the overall management systems in the building development, procurement and production process and site operations; while buildability deals only with the development of building designs and deliverables.

The purpose for using constructability technique is to improve performance of the building project process. But it faces many barriers, which constrain the effective implementation. The barriers for constructability review may classified within four main groups: Owner barriers, Designer barriers, Contractor barriers and Barriers relating waste and recycling management (Al-Fadhli, 2020).

This study aims to assess the general concepts of Constructability, identified its barriers and determined remedial measurements to the selected barriers of constructability on public building construction projects in the Jimma Town.

1.2 Statement of the Problem

Implementing constructability rather than conventional way of construction management methods, it will improve the, cost, time, quality and safety of the project. Also, it use to overcome problems interrelated to public building construction projects and improve performance projects and obtain significant results (Al-Fadhli, 2020).

Improving the productivity and quality of construction projects along with the minimization of cost and time are without affecting the quality is significant concerns in construction engineering and management (Mohsenijam, et al., 2020). Similarly, Jadidoleslami, et al., (2019) having integrated contractual strategies for projects and developing a transparent and unambiguous contract is highly effective for properly implementation of constructability. In Ethiopia, no further publications or researches which are carried out and published on the concepts of Constructability. Moreover, duplications and lack of constructability occur in public construction projects due to a lack of sufficient information from the start, poor coordination among project stakeholders, and

inaccurate schedule and cost estimates. As a result, they contribute to project delays, cost overruns, and poor project quality (Ayalew, et al., 2016).

There are still issues in Ethiopia's construction industry, particularly on public building construction projects, integrating construction knowledge, Resources, Technology, experience, information are the most common issues are throughout all stages of construction. So, the purpose of this research is to fill the gap of constructability concept, awareness and implementation among key stakeholders involved in public building construction projects in Jimma Town.

1.3 Research Questions

The research was aimed to answer the following questions:-

1. How constructability practice in Jimma Town's public building construction projects?
2. What are the barriers of Constructability to the implement in Public Building Construction Projects in Jimma Town?
3. What are the effects of Constructability on the performance of Public Building Construction Projects in Jimma Town?

1.4 Objectives of the Study

1.4.1 General Objective

The general objective of this research is Assessment of constructability Practice on public building construction projects during pre-construction phase in Jimma Town.

1.4.2 Specific Objectives

1. To examine the practices of constructability in public building construction projects.
2. To identify barriers of Constructability to implement in public building Construction projects.
3. To determine effects of Constructability on the performance of public building construction projects.

1.5 Significance of the Study

The Common separation way of construction and the design process have resulted in less efficient performance on the construction projects. Moreover, optimum uses of construction knowledge and experience, human resources, construction materials, Construction equipment, design Layout, Construction methods and information through construction process leads to improve wastage minimization, cost, time and quality of the project. Therefore, using Constructability principles as an alternative construction management method, make the project effective and will achieve successfully. So that, this study will able to contribute to construction industry of Ethiopia,

particularly in public building construction projects in several means and all construction project stakeholders will beneficial.

A further important aspect of this study is that it will raise knowledge about constructability practices among all construction stakeholders participating in public building construction projects, with the goal of utilizing it as an alternative construction project management tool to meet the project's objectives and very significant to create awareness among the construction industry's Participants to implement constructability concept to improve the performance of Public Building construction projects in Jimma Town. Also, Improve cultures of using an alternative Construction management method.

1.6 Scope and Limitation of the Study

Constructability, as management concept encompass all stages of construction projects. But Constructability is expected more at early stage of Construction. Therefore, this study focused only on pre-construction (conceptual planning, design and procurement) stage. Also, scientific Contract procedures and tangible data are anticipate more from Public Construction projects so that Public building construction projects in Jimma Town were scope of this study. The reluctance of the respondent's throughout data collection were the limitation of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 General Overview

The construction industry has complexity in its nature because it contains a large number of parties as clients, contractors, consultants, regulators and others. Thus, Construction projects suffer from many problems and complex issues in performance such as time, cost, quality and safety (Bekr, 2017). Construction project performance relies on different dimensions of project management. From those, integration management is paramount importance since effective project management starts with the integration of processes and people within a construction project (Demirkesen & Ozorhon.B., 2017). Process of construction project management begins with planning, followed by execution and control. (Yang, et al., 2020)

Construction Project Management is an integrated management approach that leading projects and the effective choice and use of project management tools and techniques. It seeks to push the boundaries of project management to take on board future needs and user issues. Also (Fewings & Henjewele, 2019) Integration of the construction project, meaning closer relations between the project team, the supply chain and the client. As well as, Integration refers to coordination among processes. And Integration management is one of the most important elements of project management, which encompasses all aspects of a project. Project integration management ensures the successful coordination among project activities (Demirkesen & Ozorhon.B., 2017).

According to Ding, et al., (2020), the Concepts of Constructability defined as "the optimum use of construction knowledge and experience in the conceptual planning, detailed engineering and procurement and field operations phases, to achieve the overall project objectives**.**

The components of integration management are determined as development of project charter, 'knowledge integration, process integration, staff integration, supply chain integration and integration of changes. From this Components, "Knowledge integration" refers to the exchange of knowledge among all stakeholders, project parties and sharing of previous and current knowledge, and input of all data into the current knowledge transfer system. The integration of knowledge and ideation in project group management is indicated as the key element of sustainable success (Demirkesen & Ozorhon.B., 2017). This point toward that the concept and principles of Constructability in general.

2.2 Overview of Ethiopian Construction Industry

In Ethiopia, the construction industry is the highest recipient of government budget in terms of government development program. Consequently, public construction projects consume an average annual rate of nearly sixty percent of the government's capital budget (Koshe & Jha, 2016).Also, the construction industry in Ethiopia is developing tremendously. Although its prominent role, the industry like others construction industry in developing countries is facing many performance challenges in implementing construction project. The industry performance in general is very low and characterize its deficiency as; in adequate capital base, old and limited number of equipment, deficiency in human resources with technical and managerial skills and very limited experiences and participation in private sector. Overall, as many studies indicate the performance of Ethiopian construction industry with respect to three constraints (time, cost and quality) is low in (Ayalew & Dakhli, 2016).

Insufficient data collection and survey before design, Lack of skilled professional in construction PM(project management) in the organization, Infective project planning, scheduling or resource management, Poor site management and supervision, Preparing Incomplete/un detailed BOQ and Unqualified/inadequate experienced Labour are the most frequent and most critical delay factors are in the construction projects (Koshe & Jha, 2016).These are major problems of Constructability implementation on sit.

2.3 Concept and Principles of Constructability in Construction Industry

According to Mohsenijam, et al., (2020) Constructability concepts are classified into three main groups:

- Conceptual Planning Phase Concepts
- design and procurement phase concepts and
- field operation phase concepts

Based on the constructability concepts (CC) established by the Construction Industry Institute (CII) and other relevant literatures, 23 constructability concepts (CC) were formulated to utilize a study in relation to the engineered construction phases.

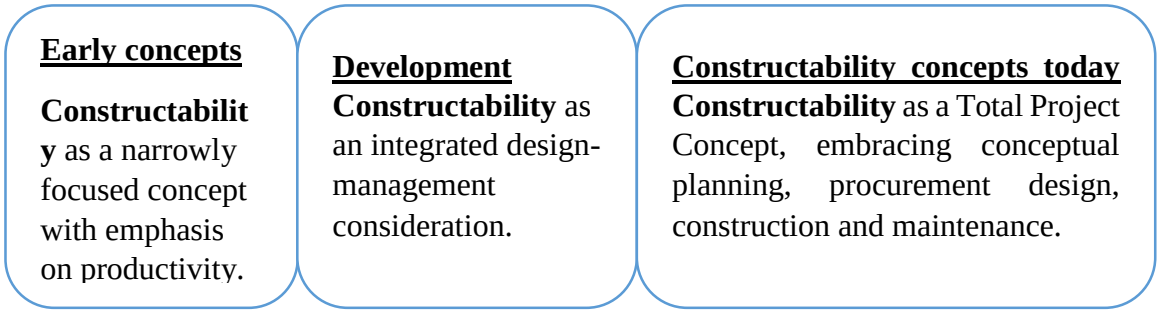

Figure 2.1 Development of constructability concepts (Griffith & Sidwell, 1995)

"Constructability is a system for achieving optimum integration of construction knowledge in the building process and balancing the various project and environmental constraints to maximize achievement of project goals and building performance overruns (Ansyorie, 2019).

Table 2. 1 CC in different Phase of Construction (Mohsenijam, et al., 2020)

1. Conceptual Planning Phase Constructability Concepts (CC)
CC (1) Constructability Programs are made integral part of project planning execution plans CC (2) A project team shall be formed to take consideration of constructability issues through all project phases CC (3) Project planning actively involves construction knowledge and experience CC (4) The construction method shall take into account the type and number of contracts required for the project CC (5) Overall project schedules are construction sensitive CC (6) Basic Design approaches consider major construction methods CC (7) Site layout should be studied carefully so that construction, operation, and maintenance can be performed efficiently
2. Design and Procurement Phases Concepts
CC (8) Design and procurement schedules are construction sensitive CC (9) The use of Advance information technologies to overcome the problem of fragmentation CC (10) Designs are configured to enable efficient construction CC (11) Design elements are standardized CC (12) Simplification of the project technical specifications

CC (13) Modularization, Preassemblies are prepared to facilitate prefabrication CC (14) Designs promote construction accessibility of personnel, material and equipment CC (15) Designs facilitate construction under adverse weather conditions
3. Field Operation Phase Concepts
CC (16) Innovative definitive sequencing of field tasks CC (17) Innovative uses of temporary construction materials/systems CC (18) Innovative uses of hand tools CC (19) Innovative uses of construction equipment CC (20) Contractor optional preassembly CC (21) Innovative temporary facilities directly supportive of field methods CC (22) Post-bid constructor preferences related to the layout, design and selection of materials CC (23) Evaluation, documentation, and feedback of issues of constructability should be maintained during the PDP

2.3 Awareness about Constructability Concepts in Ethiopia construction Industry

In Ethiopia, no more document or research which delivered and published on the concepts of Constructability. As far as, according to the researcher observation and interview data, the most important barrier is lack of awareness and willingness of stakeholder about constructability concept to the implement on Construction project. However, Ayalew, et al., (2016) declared that, less Constructability Practice is applying on Project Management is one of the factors for the poor construction project performance in Ethiopian Construction Industry, that leads to failure in achieving effective time and cost performance.

2.4 Role of Construction Project Parties in Constructability Enhancement

Every participant in Construction projects has their areas of specialization and they have confined themselves to their specific fields. They do not interfere in another team member's domain. The work is distributed and each one is bothered only about their share of responsibility (Khan, 2019).

2.4.1 Role of Client

As, Khan, (2019) The Client plays a crucial role in the design and construction process because he is the one who initiates the project and provides the most important resources for the project: the land and the finance, The Client can play a crucial role in saving the environment, by investigating and being vigilant on some of the issues such as:-

- Giving preference to Architects working on principles of constructability and environmental issues.
- Encouraging tenders from Contractors, with alternative solutions of safe construction methods/techniques related to environmental issues.
- Promoting and supporting the use of recycled materials and renewable resources of energy.
- Introducing the stakeholders at an early stage of the project so that their experiences and suggestions can be timely introduced in the project and maximum benefit achieved.

2.4.2 Role of Architect

The Architects are key role players in the project team because their design is to be executed on-site. The Architect can play important role by focusing on following issues:

- Insist on early involvement of the Contractor in the project.
- Explain the idea of constructability and its benefits to the team members.
- Break off the psychological barrier that the involvement of Contractor shall hinder his creativity.
- Open discussions and invite suggestions from team members.

2.4.3 Role of a Contractor

In the present scenario, the firms generally call Contractors for bidding only after the design stage is complete. The Bill of quantities is prepared and an estimate of approximate cost of the project is prepared. This methodology leaves less scope for the Contractor's involvement and contribution to the project in terms of sharing from his experience.

The Contractor can play an important role in the following ways:-

- He should be concerned about the environmental issues also and convince the Client/Project Manager at the initial stage about their implementation.
- The construction practices should not bring any damage to the environment.
- He should convince the team members regarding innovations possible in the construction methods and technology to gain maximum benefits for the project.
- He should break off the psychological barrier that they are not accepted as part of team, at the initial stage of the project.

2.4.4 Role of Financial Institutions

The financial bodies can play an important role in the promotion of constructability features and help in sustainable development by:-

- Buildings promoting and supporting constructability principles in their working can be given incentives.
- Additional funding can be provided for buildings which are designed to work on energy saving and increased efficiency parameters.
- Low interest rates can be provided exceptionally, for buildings managed on constructability issues and designed on sustainable features. Such features can be recognized, enlisted, and approved by the development authorities.

2.5 Constructability Practice and Project Delivery Processes

According to, Akpan, et al., (2014) Constructability could be improved upon by adopting certain procurement methods as inappropriate procurement systems could have negative effects on constructability. They went on to state that as a function of project management, procurement systems have wide-ranging effects on a variety of project parameters and that these parameters can in turn affect constructability. Also, Khan, (2015) the best type of contract was Build Operate Transfer (BOT) and Design Build (DB) as they had less number of constructability issues. By selecting the right contractual relationship of the involved parties and the degree of their involvement, constructability can be improved upon. Some of common project delivery methods in use today are (Akpan, et al., 2014):-

a) Design-Bid-Build (DBB)
b) Design and Build (DB)
c) Build Operate Transfer (BOT)
d) Engineering Procurement and Construction (EPC)

2.5.1 Design-Bid-Build (DBB)

This project delivery method is known as traditional method. The project delivery process is separated into design, bid and build phases in a linear manner which is contracts for design and construction are separated; (Zuber, et al., 2018). Moreover**,** under the traditional DBB procurement method, the architect or engineer designs everything whereas contractors have no involvement in the pre-contract stage (Akpan, et al., 2014).

In DBB no real integration between designers and contractors, the contractors were excluded from design responsibility. The lack of interaction was due to the nature of the traditional construction process conducted in sequential manner and constructed by segregated entities during the phase of

design and construction. This had resulted in recurrent claims, argument between project team members and cost and time overrun.

There are several problems arise in this method:-

- The project could be expensive due to none of significant development made for the design plans.
- Owner could not consider to change user functions as the design plans were locked before the procurement of the contractor and.
- Slight last minute changes in plans usually would cause conflict between all parties

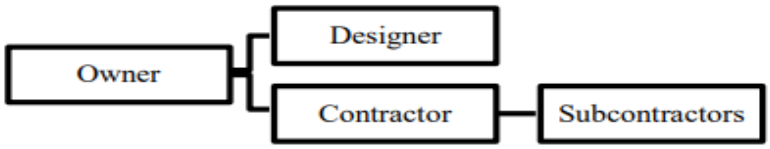

Figure 2.2 Design-Bid-Build; (Zuber, et al., 2018)

2.5.2 Design and Build (DB)

DB allows commencement of construction before completion of designs (Akpan, et al., 2014). In addition, a single entity signs the contract with the owner for the performance of design and construction services. By using this method, constructability could be enhanced because of the involvement of construction experts in the design stage. Clients could also enjoy single point responsibility of the DB contractors (Zuber, et al., 2018).

According to, Khan, (2019) Design and Build method as, the client deals directly with the contractor for the complete building and it is the contractor who is not only responsible for, but also coordinates the separate design and construction processes, including engagement of the design team who are, therefore, contractually linked with the contractor and the client.

This method encouraged team collaboration and enable early involvement of contractor to give input and took part in the budgeting, programming, financing, assessed the design for constructability and cost of construction (Zuber, et al., 2018).

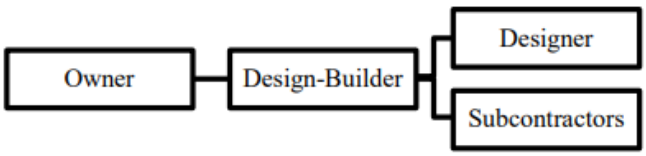

Figure 2.3 Design-Build; (Zuber, et al., 2018)

In addition, the construction process, while linked, is still separate from the design process, leaving the consultants free to concentrate on their own roles. The client may, however, directly appoint either in house staff or a separate consultant to check that the contractor is providing value for money and that content and quality are satisfying. (Khan, 2019)

2.6 Implementing and Role of CPs on the Building Projects life cycle

According to, Al-Fadhli, (2020) Contributions of constructability during the project phases as follows:-

- **Feasibility Phase**: focusing on generating alternatives that can be analyzed and expanded using the conceptual and design decisions in the manner of the financial and time considerations.
- **Early Design Phase**: As construction documents being developed the constructability team should make detailed constructability reviews on documents, such as: drawings, specifications, etc.
- **Procurement Phase**: When the overall design process is completed by 60% to 90%, the procurement process should be prepared, which includes subcontracts and bid packages, qualification of vendors, etc. The bidders are provided with complete and detailed comprehensive design so they may provide intelligent proposals that lead to a successful project.
- **Construction Phase**: Subcontractors who have constructability reviews can use their implementation experience well and make valuable suggestions. Such suggestions should be taken seriously to be analyzed, and assessed.
- **After Action Reviews**: Either the project has succeeded or not the participants try to put their possible bad experiences behind them to move on. There should be in either cases a formal review to document the constructability lessons that learned from that project.

The life-cycle of building is categorized as:-the conceptual planning stage, the design development stage, the field operations stage, and the maintenance stage. Role of Constructability in the Life Cycle of Buildings construction projects are as following (Khan, 2019):-

2.7 Benefits and processes of Constructability Principles

Continuous constructability studies during the planning and design phase can help to anticipate potential problems involving material compatibility, access issues, sequencing problems,

dewatering, weather or delivery issues, unnecessary complexity, new or proprietary installation methods and long-term performance. (Lawrence, 2003)

The important aspects of constructability are to minimizes or eliminate schedule delays and enhance cost control during the construction phase by ensuring that the construction process as fully coordinated and buildable as per the action plans developed during the pre-construction stage constructability practice will results in enormous amount of savings in the schedule and cost than the standard practices. (Kannan & Samuel, 2012). The qualitative and quantitative benefits of constructability (Khan, 2015).

The quantitative benefits may be stated as

- reduced engineering cost
- reduced schedule duration
- Reduced construction cost in terms of Labour, material, and equipment.

The qualitative benefits may be listed as

- Improved site accessibility
- improved safety
- reduced rework
- increased communication
- educed maintenance cost
- Increased focus on common goal
- Increased construction flexibility etc.

The benefits of constructability in design firms as: Better relationships with clients and contractors, being involved in fewer lawsuits, Building good reputation, Professional satisfaction, efficient design (Khan, 2015).

Construction project can divided into two phases:-**Pre-construction** phase and **Construction phase**. Pre-construction stage comprising of conceptual planning, design and procurement. The second stage is construction stage where actual physical construction of project begins on site (Zolfagharian, et al., 2012).

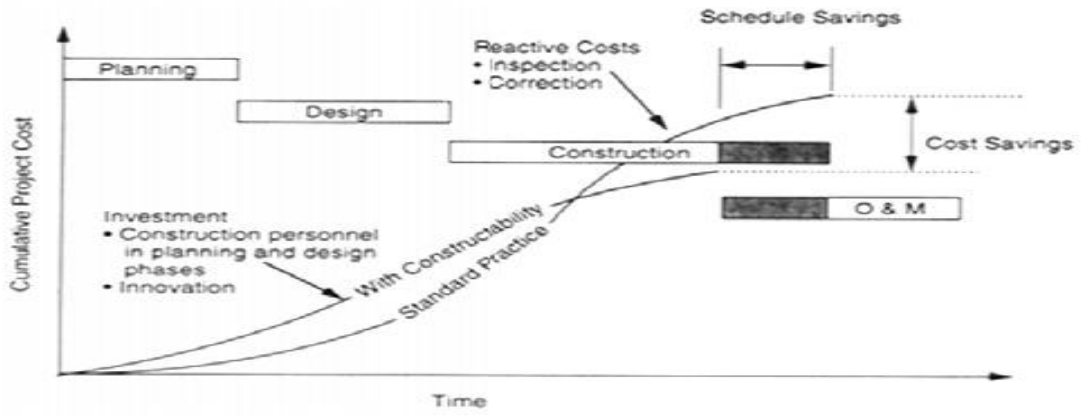

Figure 2.4 Importance of constructability on the cost-time relationship (Kannan & Samuel, 2012).

Constructability is a value management tool developed as an attempt to bring closer the design and construction activities to the level of integration. Constructability also have both discussed in their qualitative and quantitative benefits. The quantitative benefits may be stated as reduced engineering cost, reduced schedule duration, and reduced construction cost in terms of labor, material, and equipment. The qualitative benefits may be listed as improved site accessibility, improved safety, reduced rework, increased communication, reduced maintenance cost, increased focus on common goal, increased construction flexibility, etc. (Khan, 2019).

Systemic constructability is to obtain an optimal combination of construction knowledge and experience in the earlier phases of the project life cycle to achieve the overall goals of the project efficiently. One of the primary goals of the current practice of constructability is to incorporate information and skills of different parties involved in a project to reach a practical and efficient solution satisfying all project needs (Mohsenijam, et al., 2020).

According to, Maksimovic, (2014) in General Construction Process can be categorized as:-

Pre-construction phase

- Development of Plans and Specifications
- Financing, Budgets, Permits, Schedules
- Tendering and contracting works

Initial construction phase

- Site preparation works
- Building the foundations, structure and exterior envelope including roof
- Installing windows, doors, vertical transportation

Finishing phase

- Interior finishes applied and Exterior landscaping, planting and hardscape

During Post construction phase

- Testing and commissioning, close out, completion inspections, handover.

What's more, Zolfagharian, et al., (2012) the processes of constructability are based on the followings:-

- Organizing the design team
- Collecting data
- Identify the constraints
- Developing program
- Framing options evaluation
- Developing preliminary design
- Checking of options
- Final design process
- Developing bid package
- Procedure of bidding,
- Procedure of fabrications,
- Installation process

2.8 Constructability and Buildability Development

The Construction Industry Institute (CII) defines the term "Constructability" as "The optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives" (CII, 1986). Similarly, the Construction Industry Research and Information Association (CIRIA) defines term "Buildability" as, "The extent to which the design of a building facilitates ease of construction, subject to overall requirements for the completed building" (Fadoul, et al., 2017). Both concepts were originally presented in the late 1970s and early 1980s by the two different institutes. The idea behind constructability includes management's function, but buildability does not. (Amade, 2016).

The concept of "constructability" in the US or "buildability" in the UK emerged in the 1970s in an effort to stop the declining cost-effectiveness and quality of the construction industry buildability stresses on integration of design and construction to achieve the project goal by enriching the knowledge of designers in construction operations and involving construction expertise in the design process (Amade, 2016).

Table 2. 2 Concepts of "constructability" and "buildability" (Ding, et al., 2020)

	Definitions of "constructability"	**Definitions of "Buildability"**
1	The optimum use of construction knowledge and experience in the conceptual planning, detailed engineering, procurement and field operations phases to achieve the overall project objectives (Construction Industry Institute (CII) US (1986).	The extent to which the design of a building facilitates ease of construction, subject to the overall requirements for the completed building (Construction Industry Research and Information Association (CIRIA, 1983)
2	Constructability is a project management technique for reviewing construction processes from start to finish during the pre-construction phrase. It will identify obstacles before a project is actually built to reduce or prevent error, delays and cost overruns. (The Institution of Professional Engineers New Zealand Incorporated (IPENZ), 2008).	The extent to which a building design facilitates efficient use of construction resources and enhances the ease and safety of construction on site whilst the client's requirements are met.
3	Constructability, is the project management methods to evaluate the whole construction process. It is concept with relative, not absolute, value to increase optimization capacity of resources, such as workforce, time, cost, quality and working environment conditions	The extent to which the design of a building facilitates ease of construction as well as the extent to which the adoption of construction techniques and processes affects the productivity level of building works.

Constructability indeed encompasses methodological and decision-making aspects of indicative planning and operations performance evaluation: value engineering knowledge management, cost/benefit analysis, Total Quality Management (TQM) and object-oriented analysis. Whereas the implementation of buildability was promoted at a theoretical level to initiate a practical integration of design and construction for better deliverables and satisfaction of the project objectives. (Kifokeris & Xenidis, 2017).

According to, Franky, et al., (2007) the terms "buildability" and "constructability" had been defined by various researchers. With regard to "buildability" is "the ability to construct a building efficiently, economically and to agreed quality levels from its constituent materials, components and sub-assemblies" and "the extent to which decisions made during the whole building procurement process, in response to factors influencing the project and other project goals, ultimately facilitate the ease of construction and the quality of the completed project". Whereas "Constructability", "the integration of construction knowledge in the project delivery process and balancing the various project and environmental constraints to achieve project goals and building performance at an optimal level".

Also, Buildability is increasingly becoming a major requirement in building construction practice. The aim of buildability is to improve efficiency of the overall building process by developing construction sensitive designs. But the expected results from implementing constructability are efficient and effective construction of a building, with an economical project cost and at agreed quality specified by the clients (Mydin, et al., 2011).

2.9 The Major Issues of Constructability on building construction

According to, Khan, (2015) some of the major issues have been extracted from the research of various authors and organized under various heads for detailed discussion. The issues have been taken which were common to most of the papers and the viewpoints gathered thereof are:- Integration, Coordination, Bidding Process, Construction driven schedule, Simplification of Design, Standardization of element, Prefabrication, Accessibility to Site, Adverse weather conditions, Specifications, Encouragement to Innovations, Past Lessons Learned Exercise & Reviews, Availability of Resources, Appraise Recycling, Waste Management, Employment of Advance Information Technology.

The major problems during planning and design stages of building construction phase are; lack of knowledge about constructability concepts, unwillingness to devote extra money for this in initial stages of projects, and shorten of team building and partnering (Zolfagharian, et al., 2012).

2.10 Factors Affecting Constructability on Building Construction Projects

Constructability can lead a project in better savings in cost, time and even some improvements in final expected quality which are all needed to finalize a project properly. Figure 2 illustrates the ability of constructability activities to influence total cost of a project. This figure shows that the ability to influence the total cost decreases as the project continues (Khan, 2015)

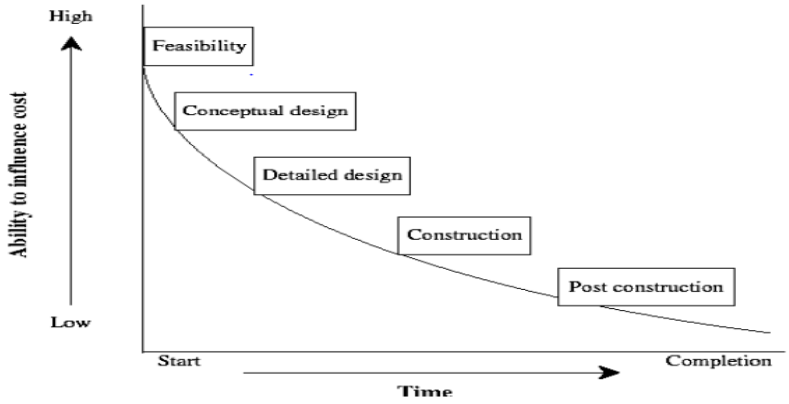

Figure 2. 5 Ability of CAs implementation to effect on total cost of projects

Also, Amade, (2016) pre-construction planning determines three important elements affecting design and plan sequence. They include:

- Choosing the right construction method and sequence so that designers can make provisions for them in their design
- Making sure that the design is constructible with at least one feasible way to execute the work
- Giving a firm assurance that all necessary resources will be made available when required, including accessibility, construction space, and information.

Constructability could be improved upon by adopting certain procurement methods as inappropriate procurement systems could have negative effects on constructability. Functions of project management, procurement systems have wide-ranging effects on a variety of project parameters and that these parameters can in turn affect constructability. Hence, by selecting the right contractual relationship of the involved parties and the degree of their involvement, constructability can be improved upon (Akpan, et al., 2014).

Also, Khan, (2019) Factors those are affecting constructability on building construction projects are:- Simplicity of Design, Communication, Standardization, Planning and Scheduling, Information, Award Of Works, Inspection And Meetings On Site, Sharing Of Knowledge. In general, the above factors if considering and taken well in advance of the construction projects, can lead to a reduction in delay of projects, increasing the constructability and hence reducing the maintenance during the life cycle of the structure.

- Simplicity and standardization of elements should be applied to the design.

- Information and better communication between designers and various constructional personnel involved in the construction process should be taken care of and that too, at an early stage.
- Proper planning and scheduling of various activities should be done by application of management techniques like CPM, PERT or by using software's like Primavera.
- Award of works is a critical and deciding factor.
- Cautious architectural design and inspection of site by the designer is important. Well thought of structural design by the civil and other services personnel like HVAC etc. need to be involved at design stage and they should be regular visitors to the site.
- Efficient contractors, skilled Labour/manpower should be selected.
- Study of proper building material properties and their life span should be identified before selection/ application.

Faulty, ambiguous, or defective working drawings, incomplete specifications, and adversarial relationships were found to be the three major factors that cause constructability problems. (Jadidoleslami, et al., 2019)

2.11 Constructability Analysis and Review

Constructability Analysis is as an analytical, creative and strategic organization function focusing on the most important factor to the overall success of a Construction Project. The use of constructability analysis provides an opportunity for input from the constructability review to the construction personnel to insure that efficient, economical, and quality solutions are reached. The necessary objectives that are to be considered for the efficient constructability analysis are as follows: (Kannan & Samuel, 2012).

- To evaluate and recognize the characteristics of the construction project
- To understand and apply the alternative project delivery systems like, design/build, design/build/operate/transfer system, design/bid/build/warranty system
- To understand and apply total quality management and value engineering concepts
- To define and apply the techniques of prefabrication, preassembly, and modularization techniques
- To define and apply a standard process to implement constructability
- To understand and apply the necessary start-up and commissioning processes
- To understand and apply the background concepts of maintainability and operability.

Moreover, constructability analysis (constructability review) is a process that utilizes experienced construction personnel with extensive construction knowledge early in the design stages of projects to ensure that the projects are buildable, while also being cost effective, biddable, and maintainable (Lawrence, 2003).The study of constructability showed that the traditional separation of construction and the design process have resulted in less efficient performance on the construction projects. It also shows that good achievement of constructability depends on both the designer and the contractor in charge (Kifokeris & Xenidis, 2017).

A Constructability review is a systematic process to ensure that a project possesses clear and feasible construction techniques. The Constructability Review Process starts at the inception of the project and continues throughout project development. The purpose of Constructability reviews during project development is to ensure that projects are biddable, buildable, cost-effective and maintainable (Sawyer, et al., 2017).

2.12 Relationship constructability and Value Engineering with Sustainability approach

Constructability and Sustainability are two complementary concepts. While constructability aims to utilize the construction knowledge and experience of construction professionals to improve project performance, sustainability integrates with constructability through efficient use of resources and minimize waste. Identified five areas that show the relationship connection between both concepts (Othman & Seoud, 2014).

1. Integrating organizational structures and contracting strategies.
2. Project management practices to manage both sustainability and Constructability.
3. Principles that reduce waste by simplifying the construction process and enhancing the level of sustainability.
4. Systems level design decisions that optimize performance of the entire facility.
5. Material selections that reduce physical waste and process waste.

Moreover, constructability concept is believed could be an effective approach in order to enhance the level of product/project design by allows the early involvement of professionals or construction expertise such as contractors and facility managers to share their knowledge and expertise in the initial stage of design in order to produce the design for ease of construction and maintenance towards green or sustainable construction in the future (Mohd, et al., 2011).

Constructability is a value management tool developed as an attempt to bring closer the design and construction activities to the level of integration, once achieved by master builder (Khan, 2019).Value management in construction project plays an effective role in reducing cost and improving the functionality or quality of the project.VM can be applied during the planning and design stage to achieve the best value for money and it has three subsets: - Value planning, Value engineering, Value analysis (Muthuckannal & Chitra, 2021).

Value planning: - It refers to the activities in the early phases of a project to define, clarify, and agree a clear understanding of Client objectives.

Value engineering: - The Value Engineering methodology can be concisely stated as a tool that helps construction industry improve cost effectiveness. Value engineering extends from detailed design to construction completion.

Table 2. 3 Relationship Constructability Concepts and Value engineering

	Constructability Concepts	**Value Engineering**
1	Constructability is focuses on optimizing the whole construction process	The main objective of value engineering is to reduce the facility life-cycle cost
2	Constructability is an effective technique that implements a detailed review of design, documents, specifications, and construction processes by highly experienced engineers and working with original team of the project before construction mobilization.	VE is a systematic and organized method to provide and enhance the value of goods or products by using an evaluation of function.
3	Constructability is not limited to design phase, but it should be processed during the whole lifecycle of the project.	Also Value engineering extends from detailed design to construction completion.
4	Constructability improve conceptual planning, procurement processes, construction methods, and also involving stakeholders in making the decisions, and achieve their satisfaction	Value engineering is important for enhancing project's value, effectiveness, communication and cooperation between different parties, costs saving, and documenting opportunities and issues.

2.13 Existing Barriers in Implementing Constructability

Constructability tries to improve construction companies' performance; however, implementing it faces many barriers. A barrier to constructability can be defined as any significant inhibitor that prevents effective implementation of the constructability program (Alalawi, et al., 2015)

The barriers are Classifying with three main groups:-managerial barriers (Managerial and strategic and organizational factors), engineering barriers (Executive and Technical and technology factors), and environmental barriers (cultural and legal factors) (Jadidoleslami, et al., 2018). But, Construction Industry Institute (CII, 1987) has classified barriers to constructability into various categories such as general barrier, owner barrier, designer barrier, and contractor barrier (Khan, 2015).

2.13.1 General barriers

General barriers are identified as follows: complacency with status quo "This is just another programme," "Right people" are not available, discontinuity of key project team personnel, no documentation of lessons learned, and failure to search out problems and opportunities.

2.13.2 Owner barriers

Owner barriers are identified as follows: lack of awareness of benefits, concepts, etc.; perception that constructability delays project schedule; reluctance to invest additional money and/or effort in early project stages; lack of genuine commitment; distinctly separate design management and construction management operations; lack of construction experience; lack of team building or partnering; disregard of constructability in selecting constructors and consultants; contracting difficulties in defining constructability scope; misdirected design objectives and performance measures; lack of financial incentive for designer; gold-plated standard specifications; limitations of lump-sum competitive contracting; and unreceptive to contractor innovation.

2.13.3 Designer barriers

Designer barriers are identified as follows: perception that they have considered it, lack of awareness of benefits, concepts, etc., lack of construction experience/qualified personnel, setting company goals over project goals; lack of awareness of construction technologies; lack of mutual respect between designers and constructors; perception of increased designer liability; and construction input is requested too late to be of value.

2.13.4 Contractor barriers

Can be listed as follows: reluctance of field personnel to offer pre-construction advice, poor timeliness of input, poor communication skills, and lack of involvement in tool and equipment development.

In addition, (Al-Fadhli, 2020) the barriers for constructability review classified as within four main groups:

- Owner barriers: Lack of knowledge of constructability, fear of project delays, fear of adding additional costs, and finally rejecting contractor's innovative ideas and alternatives.
- Designer barriers: Lack of awareness of advantages of implementing constructability, lack of construction experience, setting the objectives of the company before the objectives of the project, and finally budget constraints.
- Contractor barriers: Poor input timing, poor communication skills, and lack of participation in the development of equipment and tools.
- Barriers relating waste and recycling management: Lack of understanding of the significance of waste recycling management, and poor communication.

Barriers affecting Constructability Practices are :- (Windapo & Ogunsanmi, 2014)

External Factors

- Design
- Lack of open communication between designers & constructors
- Skilled Labour shortage
- Contractors are usually not involved until the designs have been completed
- Professional designers & constructors are engaged with separate contracts
- Highly competitive construction market
- Material supply shortage
- Building Codes do not require constructability
- Competitive equipment rental market

2.14 The Remedial Measurement to the Barriers of Constructability Implementation

Construction Industry Institute (ClI) introduced a list of barrier breakers, this includes seven steps to mitigate complacency with status quo (Alalawi, et al., 2015):-

- Designate a strong program champion
- Report constructability program benefits regularly
- Make constructability the responsibility of younger, more energetic individuals, who more frequently confront the status quo
- Establish funded programs that promote creativity and intelligent risk-taking

- Establish monetary awards for rewarding innovation and intelligent risk-taking
- Conduct training programs in shifting paradigms, promoting creativity, and promoting critical thinking
- Screen out personnel who regularly support the status quo

As (James & Steven, 1995) once barriers to constructability are identified within an organization or a project team, they may be mitigated or overcome with certain tactics, known as "barrier breakers." Such breakers should be both effective in combating the barriers and should be implementable or relatively easy to apply.

Also, the common approach of improvement is through reviewing constructability with different methodologies, such as using formalized constructability reviews at design and construction stages, early implementation of the review in the, conceptual planning stage, integration of constructability improvements into project development, integration of analytical review tools into the constructability review process, implementation of the constructability review process at different project stages, the in-house design-phase constructability review, and the carrying out of constructability review by an independent team with hands-on experience in similar projects. Also, improvement can be realized by implementing constructability programmes at various project stages (Franky, et al., 2007).

The seven most common barriers with barrier breakers encountered and identified are (James & Steven, 1995):-

1. Complacency/ Self-satisfaction with status quo.
    - Report constructability program benefits regularly
    - Establish funded programs that promote creativity and intelligent risk-taking
    - Conduct training programs in shifting paradigms, promoting creativity, and promoting critical thinking
    - Screen out personnel who regularly support the status quo
2. Reluctance to invest additional money and effort in early project stages.
    - Promote the attitude that constructability should be viewed as an investment opportunity with a corresponding downstream payoff.
    - Acquire promotional tools to sell the program to owners.
    - Include constructability as part of a standard bid response and in cost tracking/ control efforts.

- Establish formal commitment to the idea of constructability; then convince owners that constructability must start very early in the project process.

3. Limitations of lump-sum competitive contracting.
   - Owners and/or designers acquire in-house construction expertise for input during design.
   - Use only A/Es with strong constructability capabilities.
   - Understand the benefits and flexibility of negotiated contracts and acquire skills to effectively manage these; include constructability as a reimbursable service.
4. Lack of construction experience in the design organization.
   - Conduct in-house training on construction, constructability, field methods and problems, lesson learned, etc.
   - Close the "project loop" by getting feedback from the field and by tracking lessons learned.
   - Communicate construction issues from field engineers to office engineers and designers.
   - modify design management practices to elevate the visibility of constructability issues (e.g., include it on the agendas of routine project meetings)
   - Change attitudes; get designers to start viewing the field as a good source of information
5. Designer's perception that "we do it."
   - Find out what constructability is before you assess whether or not you are doing it.
   - Understand that value engineering alone does not address the full breadth of constructability issues.
6. Lack of mutual respect between designers and constructors.
   - Aggressively promote effective team building among project personnel.
   - Establish constructor presence in design office before pride of authorship begins.
   - Keep the team focused on common objectives and accepted procedures rather than personalities.
7. Construction input is requested too late to be of value.
   - Increase awareness of the necessity for early construction involvement.
   - Include constructability as an early activity in a formal activity flow plan or "roadmap"

- Include individuals with significant construction experience in the project team from the outset; expect active participation from these individual.

2.15 Summary of Literature review

Construction Project Management is an integrated management approach that leading projects and the effective choice and use of project management tools and techniques. It seeks to push the boundaries of project management to take on board future needs and user issue. Constructability is a project management technique for reviewing the whole construction process and before project implementation, to reduce or prevent mistakes, delays and overflow costs, through identifying the obstacles. Also it is an effective technique that implements a detailed review of design drawings, documents, specifications, and construction processes by highly experienced engineers, working with original team of the project before construction mobilization. Constructability concepts are classified into three main groups:

- Conceptual Planning Phase Concepts
- Design and procurement phase concepts and
- Field operation phase concepts

Construction Industry Institute (CII, 19

87) has classified barriers to constructability into various categories such as general barrier, owner barrier, designer barrier, and contractor barrier.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 The Study Area

This research was conducted in the South-Western part of Ethiopia, Oromia Regional State, Jimma Zone at Jimma Town, which at a distance of 345 km from Addis Ababa, the capital City of Ethiopia. Moreover, the geographical location of the Jimma Town is 7° 39′ 0″ N and 36° 52’ 30’’ E and elevation vary from 1700m-2000 m above sea level.

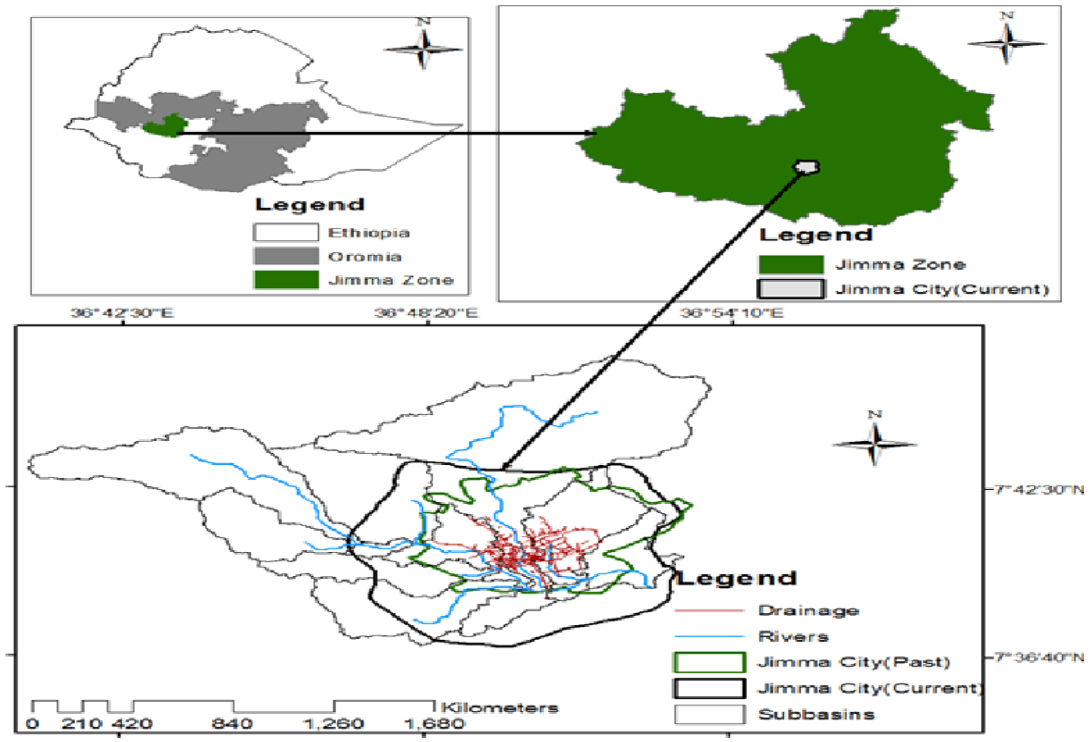

Figure 3.1 Map of Jimma Town (https://mapcarta.com/Jimma)

3.2 Research Design and Approach

This study was carried out by collecting input data from questionnaires and interview. To verify the research questions and objectives, the study used descriptive research design. Relative Importance Index (RII) was used to examine and ranked the collected data. The data were presented and analyzed by using descriptive statistics, Microsoft Excel sheets 2013 version and in order to clarify and demonstrate explanations used Tables, charts and figures and concluded based on result. The research used both mixed approaches of Qualitative and quantitative types of research. Qualitative Approach is less concerned with number and accurate measurement and more concern with the depth of data.

Whereas, Quantitative approach is concerned with number and accurate measurement rather than the application of qualitative methods.

3.3 Study Variables

Variables are process of undertaking a research requires and the consideration of measurable factors that are subject to change due to circumstances. The manipulated variable which in some instances could be more than one in number is referred to as the independent variable while the variable which is expected to be affected by the manipulation is called the dependent variable.

3.3.1 Dependent variable

Dependent variable is the outcome variable, which is caused, in total or in part, by the Input variable. Thus, the dependent variable for this study was:-

- Constructability Practice

3.3.2 Independent Variables

An Independent variables are the input variables and they are factors and affect the output variables. Therefore, in this paper independent variables were;

- Awareness of Constructability
- Personnel experience
- Integration of the Parties
- Barriers of Constructability

3.4 Population and Sampling Method

3.4.1 Target population

The Target population involved in this study were stakeholders (Client, consultants and contractors) of Public building Construction projects in Jimma Town.

3.4.2 Sampling Method

In this study the participants were public building construction project stakeholder's clients/client' representatives, contractors, and consultants. There are 21 ongoing public building construction projects in Jimma Town. For the reason that of limited number of the projects 54 questionnaires were distributed to the professionals that are involved in active projects and 45 were collected. From this 22 from the side of Clients, 8 from the consultant and 15 from the side of Contractor. The overall population were well-known, limited in number, and well-suited to the study objectives. So in this study based on their limited number and availability used non-probability purposive sampling and included all population that was targeted.

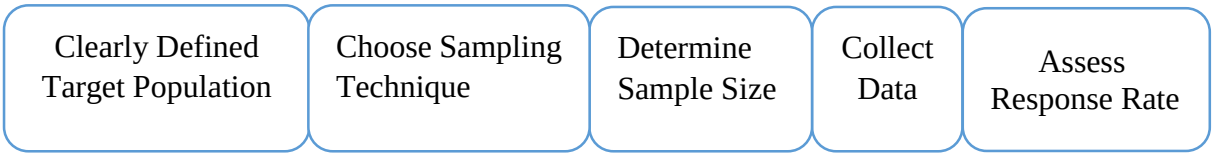

Figure 3.2 Sampling Process Steps

3.5 Sources of Data

The data for this study was gathered from both primary and secondary sources of data. Questionnaires and interviews were the primary data sources. Document review was a secondary source of data, which included books, journals, research papers, magazines, and so on.

3.6 Data Collection procedure

3.6.1 Questionnaire Survey

Questionnaires were the primary mode of data collection in this study. In addition, the questionnaires included both open-ended and closed-ended questions, with respondents providing replies to the required questions. Therefore, in order to meet the research's unique goals, the questionnaires were divided into six sections. Then it was conducted and given to the stakeholder on a physical level.

3.6.2 Interview

A face-to-face conversation with the respondent was conducted during the interview. The biggest issue in interviews was respondent willingness; most respondents were unwilling to provide information via interview. However, the four interviewees provided useful information in response to seven open-ended

interview questions. Literature study was necessary to organize the primary sources of data, particularly the questionnaire.

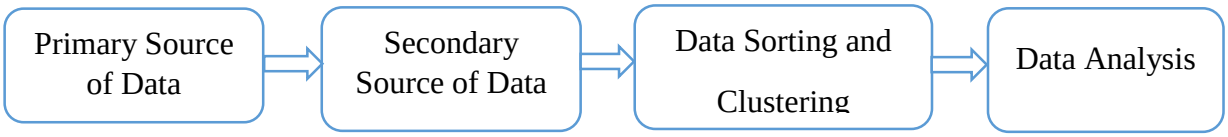

Figure 3.3 Data source and Collection Procedure

3.7 Data Presentation and Analysis

Data analysis is a process of putting facts and numbers together to address a research topic. The information for this study was acquired by a questionnaire and interview. The information was then sorted, grouped, processed, and displayed. The Relative Importance Index (RII) was used to examine and ranked the collected data. As a result, the data were presented and analyzed using descriptive statistics, Microsoft Excel sheets 2013 version, and in order to clarify and demonstrate explanations used Tables, charts and figures.

Relative Importance Index Technique is used to determine the relative importance of the various Factors and calculated by using the following formula (Rajgor, et al., 2019).

RII = ΣW / (A*N)……...…… (Equ. 1)

Where:-

W: Weighting given to each factor by the respondent,

A: the highest weight in the research,

N: Total number of respondents.

3.8 Reliability and validity of the Research

Data quality is very important issue with all types of data obtained from questionnaire survey, observation and interview. In this research the quality of data enhanced by confirmed reliability and validity of the research. Reliability is, the extent to which a measurement of a phenomenon provides stable and consist result. Hence, this study used Cronbach's Alpha coefficient to check quality of Reliability Test. Whereas, Validity is explains how well the collected data covers the actual area of investigation, in this study the validity has checked by correlation analysis. Formula that determines Cronbach's alpha is fairly simple and makes use of the number of variables or question items in the instrument (k) and the average correlation between pairs of items (r) (Smith & Samantha, 2018)

$$\alpha = \frac{Kr}{1+(K-1)*r} \quad \text{…… (Equ, 3)}$$

Where:-

α is Cronbach's Alpha coefficient

K is number of item/ number of variables

r is average correlation between pairs of items

An acceptable alpha value:-

0.9 to 1.0 Excellent	0.6 to 0.7 Questionable
0.8 to 0.9 Good	0.5 to 0.6 Poor
0.7 to 0.8 Acceptable	0.0 up to 0.5 Unacceptable

3.9 Ethical Consideration

Before beginning the research, the data has only been collected after receiving a formal letter from the Faculty of Civil and Environmental Engineering, chair of Construction Engineering and Management Stream. The study's goal and objectives were then explicitly explained to the company and the relevant stakeholders. Thus, the Data gathered after the participants' consent was gained, and the privacy of the research participants was maintained during this process. Moreover, during citation, any publications or concepts that were used as references or data sources for this study were given credit and recognition.

3.10 Plan for Dissemination

The study is primarily for academic purposes at Jimma University, and the findings were presented to the Jimma Institute of Technology, Faculty of Civil and Environmental Engineering, Construction Engineering and Management Stream. And it was distributed to Jimma University Technology Library, as well as to all relevant governmental and non-governmental organizations.

3.11 Research Methodology

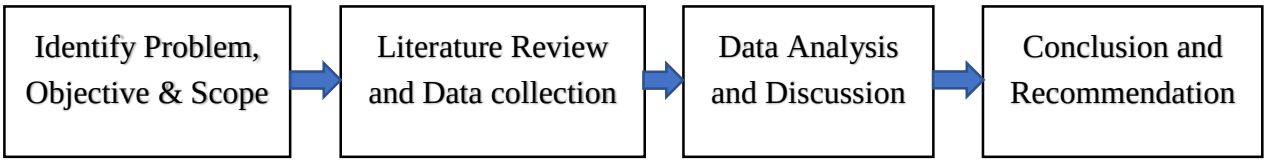

Figure 3.4. Research Methodology

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Basic Information about the Respondents

Fifty-four (54) questionnaires have been were distributed as planned, with 25 going to the client's representative, 8 to the consultant, and 21 to the contractors. Out of these, 45(83%) of the questionnaires were collected, including 22 (88%) from the Client's representative, 8 (100%) from consultants, and (71%) from contractors. Table 4.1 provides a detailed information provided by respondents.

Table 4. 1 Respondents' Information

Types of respondents Organization	Questionnaires Distributed	Questionnaires Returned	Response Rate in percentage (%)
Clients/ Client's Representatives	25	22	88%
Consultants	8	8	100%
Contractors	21	15	71%
Total	**54**	**45**	**83%**

4.2 Analysis on Constructability Practice on PBCP in Jimma Town

4.2.1 Awareness and practice of Constructability Concepts in Jimma Town

According to the results of this study's questionnaire survey, participants' awareness of constructability was dispersed. As shown in Figure 4.1, (74.1%) were aware of constructability, whereas (25.9%) were unfamiliar to the constructability.

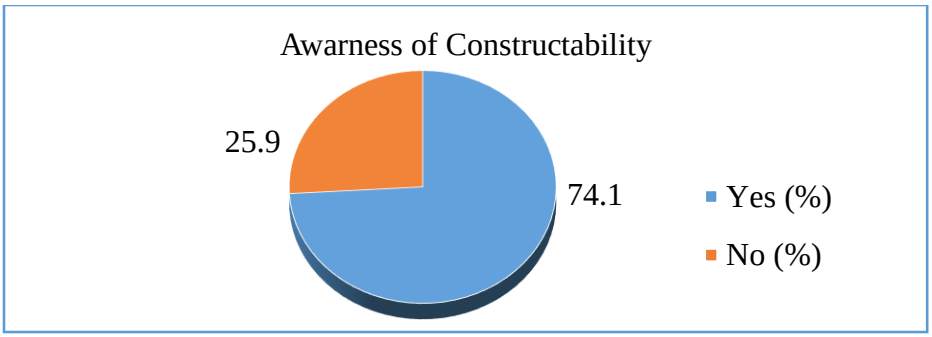

Figure 4.1 Awareness of Stakeholders on Constructability Concepts

Therefore, the result 74.1% was considerable amount and it indicate that, most participants were have aware of the term Constructability. However, practicing Constructability principle on Public Building Construction projects also gathered and analyzed as shown in Figure 4.2, according to the result, respondents (38.9%) were practicing constructability principle, whereas (61.1%) were no practicing

constructability principle on their Projects. This result demonstrated that, from the respondents the most Participants are respond Constructability Principles was not applied on their active building construction projects.

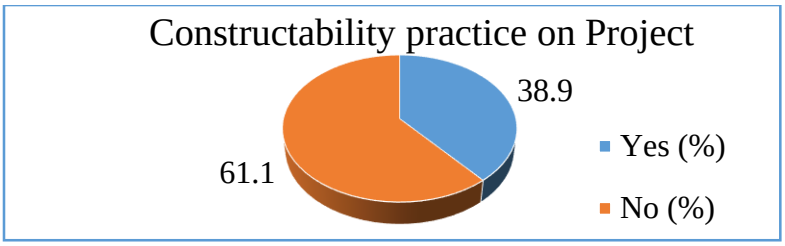

Figure 4.2, Constructability Practice on public building Construction Projects

As a result, while most respondents are aware of constructability. But, due to a unwillingness of Client's to spend some cost at early stages of a project, lack of knowledge and experience, unavailability of resources, improper construction Contract delivery methods, poor Communication between Consultant and Contractor, limited contractor involvement at earlier stage of the project and lack of team Coordination on the projects. Most stakeholders are not applying constructability. This study confirms study conducted by Amade, (2016) stated that, the level of awareness of constructability concepts and principles among industry professionals is somehow appreciable.

4.2.2 Organizational Category More Concerned Ensuring Constructability

In this study, the data was collected with Organization category based on Client, Consultant firm, Construction firm and Regulatory bodies, these are they find more concerned of ensuring Constructability on public building construction projects in Jimma Town. Thus, as shown on figure 4.3, on this survey questionnaires, the respondents respond the more concerned organization to ensure constructability on public building Construction project in Jimma Town were Client (21.6%), Consultant firm (51.0%), Construction firm (17.6%) and Regulatory bodies (9.8%)

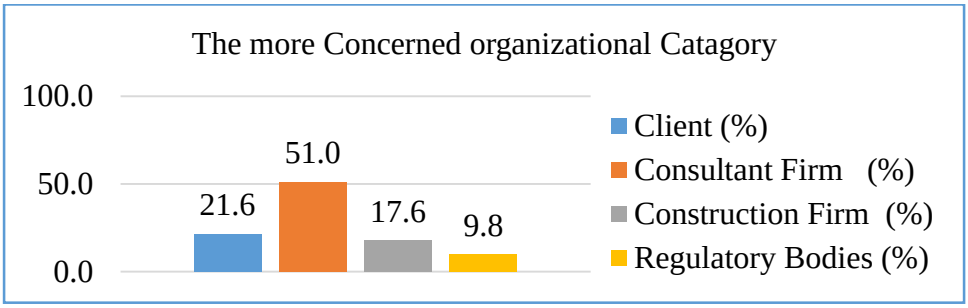

Figure 4.3 Organization category more concerned to ensure constructability

According to this result, the Percent indicated that, the Organization which are concerned more to ensure constructability on Public Building Construction projects in Jimma Town are Consultant Firms(51.0%) the first, Clients(21.6%) are the second, Construction Firms(17.6%) the third and Regulatory bodies(9.8%) are the fourth. So, based on the data, Consultant firms are the most concerned to ensure Constructability more. As, Mahame, et al., (2017) the majority of respondents with the rate of 47.66% think that design firms are the most concerned with ensuring the constructability of building construction projects. This was based on the fact a big number of construction projects are designed and supervised during its execution by the same firm known as consultant firm.

4.2.3 Effects of Constructability on Project Performance

Performance of Construction projects particularly public building construction projects are evaluated based on Time, cost and quality. These are constraints for the project performance and basic criteria to manage the projects. The use of integrated management systems in the construction industry used to minimized Cost and time and maintain the quality as well as for maximizing resources utilization of the project.

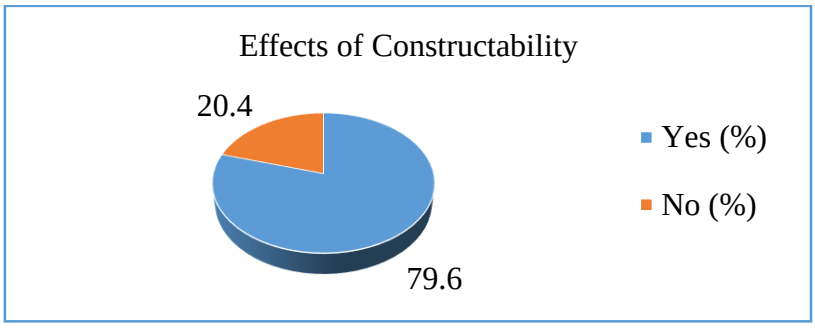

Figure 4.4 Effects of Constructability on the project Performance

So that, in this study in Public building construction projects in Jimma Town effects of Constructability practice related with cost, time, and quality are try to assessed and analyzed As presented in figure 4.4 Most of the respondents (79.6%) responded Constructability has great effects on the performance (cost, Time, and Quality) of the project but (20.4%) respondents were respond hasn't effects on the project performance.

This study supports study conducted by Samuel & Oluseye, (2016) specified that Constructability reduces overall project costs 4.3% on average, reduces project schedule 7.5% on average, improves project security and safety, increases project quality, and improves project team relationships. What's more (CII, 2019) identified Constructability during project development and implementation improves

cost performance by 6.1% and schedule performance by 7.1%, according to the latest benchmarking done by CII.

Also, this study confirms the study conducted by Fadoul, et al., (2017) stated that by saving total project cost, lower cost of bidding, reduced site Labour, and Increased cost effectiveness and by Better resources utilization, improved constructability saving 1-14% of total capital cost and on Time, Quality and Safety domain impact of Constructability, Reduced outage duration Higher quality of built products, Safer environment on site, Improvements in industrial relations, teamwork, communication and client satisfaction

4.2.4 Pre-Construction Phase of BCP Constructability principles apply most

From the inception to the end of project, the building construction projects divided in to Conceptual Planning phase, Design Phase, Contract Award phase and Construction Phase. In this study the data were gathered to analyze in which stage of building Construction Project Constructability Principles does apply furthermost. According to the survey, as specified on figure 4.5, the respondent responded Conceptual Planning phase (32%), Design Phase (56%) and Contract Award phase (12%).

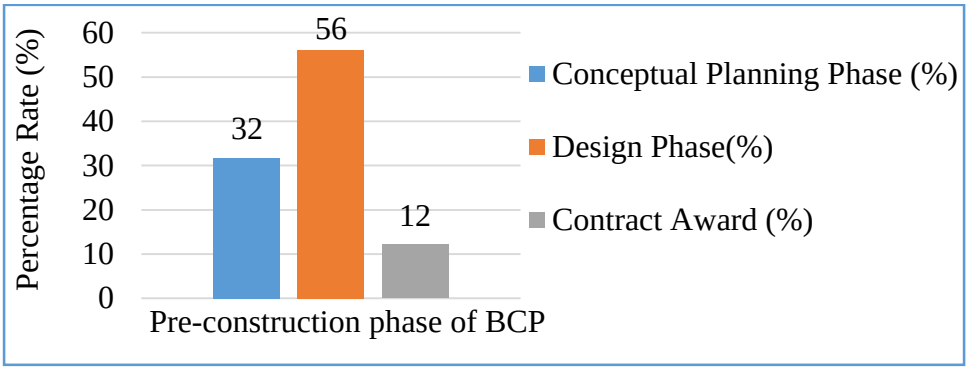

Figure 4.5 Pre-Construction Phase of BCP Constructability principles apply most

As a result, the most apply descending order of Constructability principles on Building Construction Project phase in Jimma Town are: - Design Phase (56%), Conceptual Planning phase (32%) and Contract Award phase (12%).This is demonstrated that, the most important stage of Constructability Principles was Design Phase (43%). This study argues study conducted by Zolfagharian, et al., (2012) stated that, Constructability is not only limited to design stage, but should be considered during whole project lifecycle and by project progressing, the influence of designer reduces while the effect of expenditure increases. Consequently, it is recommended to apply constructability at earlier design stages of project so as to achieve the objective of the construction projects.

4.2.5 Effects of Contract delivery method on Constructability Practice

The delivery method of a construction project requires a coordination of the efforts of the owner, designers/consultants and contractor in an acceptable contract form. As indicated on the figure 4.6, the effects of construction contract delivery methods on Constructability practice assessed. Accordingly, the respondents responded (71.7%) contract delivery methods have effects on Constructability practice and (28.3%) answered no effects.

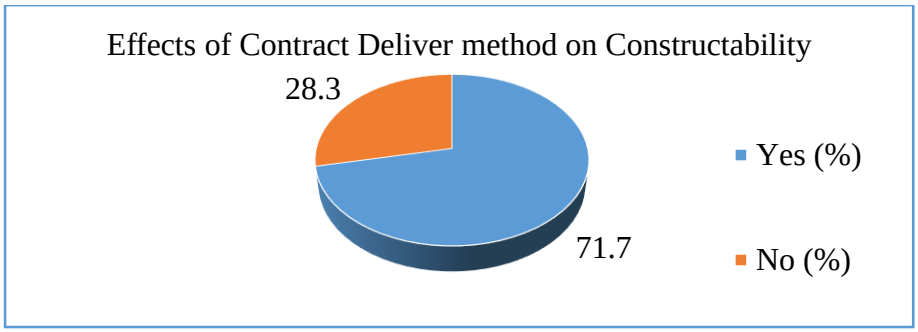

Figure 4.6 Effects of Construction Contract delivery methods on Constructability

This result, (71.7%) presented that, construction Contract delivery methods are have great effects on the practice of the Constructability. Based on the data most of the public building projects those are active in Jimma Town are practicing Design bid Build delivery method. This study supports study conducted by Akpan, et al., (2014) indicated that the selection of project delivery method determined the type of constructability input for the respective projects. The traditional design-bid-build (DBB) project delivery system is disposed to all of this, wherein most circumstances, insufficient time is available for design before tender/construction, resulting in a high number of errors and problems. So that, individuals consider the DBB isn't good for constructability. Also, Alalawi, et al., (2015) new contracting systems like design-build push design companies to implement constructability as a procedure in the design process. But, in characteristic of the DBB system is the separation of the design and the construction phase and, hence, also the separation of the contracts the client has to agree upon with a design and a construction organization.

4.2.6 Other method used instead of "Constructability"

In Modern Construction industry, there are so many methods used to manage construction projects depend on their characteristics, complexity and Environment.. As a result, as shown in Figure 4.7, (24.1%) used other method other methods instead of Constructability, whereas, (75.9%) were answered didn't used any other.

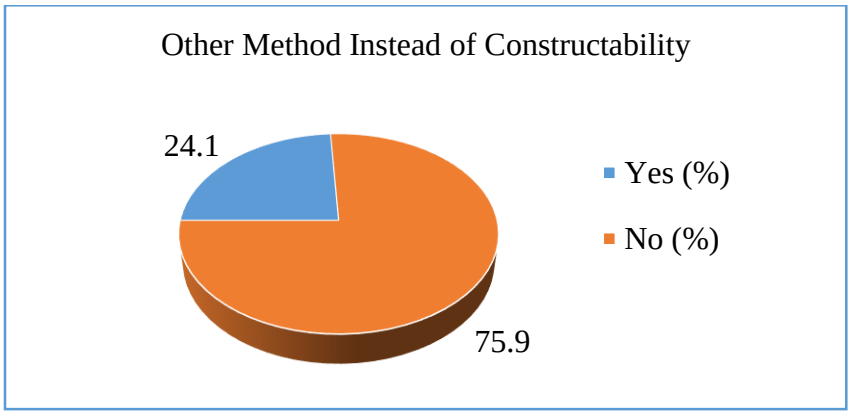

Figure 4.7 Other methods instead of Constructability

The result 75.9% indicate that, the most respondents were answered there is no any other methods instead of Constructability. However, 24.1% of respondents said "Yes" and Instead of "Constructability," the most respondents commonly used "Master Schedule," "Program Evaluation and Review Technique (PERT)," and "Microsoft project software (MS-project)". This study argues study conducted by Ayalew, et al., (2016) identified that using Lean construction, which is the outcome of the application of a new form of production management, is one strategy for improving performance in the construction industry by improving workflow reliability, planning, and control. Ethiopia's construction industry has struggled to achieve project objectives such as cost, time, and quality. As a result, there are numerous advantages of lean construction in terms of enhancing the construction industry's performance. Also, Kifokeris & Xenidis, (2017) stated that the Master schedule, Hybrid value engineering (HVE), Total quality management (TQM), cost/benefit (C/B) analysis supportive are alternative methods of Construction management

4.2.7 Summary of Analysis on Constructability Practice in Jimma Town

The overall Constructability Practice on public building construction projects in Jimma Town summarized as follow. According to the collected data most respondents are aware of constructability. But, in most project utmost stakeholders are not applying constructability due to a unwillingness of Client's to spend some cost at early stages of a project, lack of knowledge and experience, unavailability of resources, poor Communication between Consultant and Contractor, limited contractor involvement at earlier stage of the project and lack of team Coordination on the projects.

The Organization which are concerned more to ensure constructability on Public Building Construction projects in Jimma Town are Consultant Firms(51.0%) the first, Clients(21.6%) are the second and Construction Firms (17.6%) are the third. Based on the data, Consultant firms are the most concerned

to ensure Constructability more. The use of integrated management systems in the construction industry used to minimized Cost and time and maintain the quality as well as for maximizing resources utilization of the project. Most of the respondents (79.6%) responded as Constructability has great effects on the performance (cost, Time, and Quality) of the project but (20.4%) respondents were respond as hasn't effects on the project performance.

what's more, the most apply descending order of Constructability principles on Building Construction Project phase in Jimma Town are: - Design Phase (56%), Conceptual Planning phase (32%) and Contract Award phase (12%), This is demonstrated that, the most apply stage of Constructability Principles is Design Phase. As indicated on the result 75.9%, the most respondents were answered there is no any other methods instead of Constructability. On the other hand, 24.1% of respondents said "Yes" and Instead of "Constructability," the most respondents commonly used "Master Schedule," "Program Evaluation and Review Technique (PERT)," and "Microsoft project software (MS-project)."

4.3 Constructability Principles during Pre-Construction phase

As a method of construction project management, Constructability practice commenced at the project's conceptual planning phase and gone to through construction process. So, many researchers have enumerated 23 Constructability principles throughout all Construction project phases, which are Conceptual planning phase, design and procurement phase and field operation phase. However, due to the scope of study, in this study concentrated on only 15 of the principles, which are only relevant to the pre-construction phase.

4.3.1 Constructability Principles during Conceptual Planning Phase

Construction Project planning phase involves further development of the project in detail, outlining the activities, tasks, and timeframes are created to meet the overall project's objective. In this study the for conceptual planning period the 7 principles are assessed and ranked by using the Relative importance Index, as shown in the figure 4.13 and Table 4.4. The Rating point of responses was by using five point Likert Scale :-(1=Strongly Disagree, 2= Disagree, 3 =Moderately Agree, 4=Agree, 5=Strongly Agree). During Conceptual period , principles of Constructability on Building Construction projects in Jimma Town are measured and ranked as indicated Table 4.4:-

Table 4. 2 Relative Importance Index of CPs during Conceptual Planning Phase

No.	Constructability Principles during Conceptual Planning Phase	RII=∑W/(H*N)	Rank
1	Clarification of Constructability to the stakeholders	0.833	1
2	Site layout should be studied carefully	0.830	2
3	Major construction methods should be discussed and analysed in-depth	0.796	3
4	Formation of Team Including Client, Engineer and Contractor	0.793	4
5	Master project schedule and the construction completion date should be construction-sensitive	0.781	5
6	Construction methods should be taken into consideration when choosing the type and the number of contracts required	0.770	6
7	Use alternative contracting strategy e.g. design build, project management etc.	0.767	7

During the conceptual period, the RII of the Principles of Constructability were considered and ranked as followed. The relative importance index is represented as RII, whereas the rank is denoted by R. thus, based on the data, the most important Principles of Constructability through the Conceptual phase in public building construction projects in Jimma Town are Discussed as:-Clarification of Constructability to the stakeholders (RII=0.833, R=1), Site layout should be studied carefully (RII=0.830, R=2), Major construction methods should be discussed and analysed in-depth (RII=0.796, R=3),Formation of Team Including Client, Engineer and Contractor (RII=0.793, R=4), Master project schedule and the construction completion date should be construction-sensitive (RII=0.781, R=5), Construction methods should be taken into consideration when choosing the type and the number of contracts required (RII=0.770, R=6), Use alternative contracting strategy e.g. design build, project management etc. (RII=0.76, R=7). All principles are significant through Conceptual planning period, however, based on Relative importance index, during the Conceptual planning phase in public building construction projects in Jimma Town. 'Clarification of Constructability to Stakeholders, Careful Study of Site Layout, and Major Construction Methods Should Be Discussed and Analyzed in-Depth' are the most key aspects to consider during the Conceptual Planning phase of a project to improve constructability and achieve overall project objectives. This study confirms study conducted by Adi &

Daniel, (2019) specified the top four Principles of Constructability during Conceptual planning period that are "Basic Design approaches should consider major construction Methods, Constructability Programs are made integral part of project planning execution, Overall project schedules are construction sensitive and Site layout should be studied carefully" so that construction, operation, and maintenance can be performed efficiently.

4.3.2 Constructability Principles during Design and Procurement Phase

The design development stage is an exciting time during the construction management process. The architect, engineer, owner, and project manager are all involved in the design stage of a project. Also, throughout procurement the project formally transfers from design into construction and it is very vital stage to select highly qualified contractors. Figure 4.14 show that relative importance index of the Constructability Principles (CPs) during Design and procurement stage of project. This Chart validated the relationship of the principles during Design and Procurement period in over-all.

The Design and Procurement stage of Constructability principles on Building Construction projects in Jimma Town are discussed and ranked the essentiality by using Relative Importance Index as indicated on Table 4.5. The Rating point of responses was by using five point Likert Scale (1=Very Low, 2=Low, 3=Average, 4=High, 5=Very High).

Table 4. 3 Relative Importance Index of CPs during Design and Procurement Phase

No	Constructability Principles During Design Phase	RII=ΣW/ (H * N)	Rank
1	Design simplification to enable efficient construction.	0.804	1
2	project technical specifications should be simplified and configured	0.793	2
3	Project design should take into consideration the accessibility of construction personnel, materials and equipment	0.785	3
4	Use Advanced information technologies	0.781	4
5	construction schedule must be discussed and developed prior	0.781	4
6	Consider factors of fabrication, transport, and installation in modular/pre-assembly designs.	0.763	6
7	Project elements should be standardized	0.733	7
8	Design should facilitate construction during adverse weather conditions	0.711	8

As presented on the table 4.5, principles of Constructability during Design and procurement Period of the projects are: - Use Advanced information technologies (RII=0.781, R=4), Design simplification to enable efficient construction. (RII=0.804, R=1), project elements should be standardized (RII=0.733,

R=7), Consider factors of fabrication, transport, and installation in modular/pre-assembly designs. (RII=0.763, R=6), Project design should take into consideration the accessibility of construction personnel, materials and equipment (RII=0.785, R=3), Design should facilitate construction during adverse weather conditions (RII=0.711, R=8), construction schedule must be discussed and developed prior (RII=0.781, R=4), Project Technical Specifications should be simplified and configured (RII=0.793, R=2) are the evaluated principles of Constructability during Design and procurement Period of the project by using RII.

According to the result the most essential Principles during Design and procurement period of project are 'Design simplification to enable efficient construction (RII=0.804, R=1), Project Technical Specifications should be simplified and configured (RII=0.793, R=2). Project design should take into consideration the accessibility of construction personnel, materials and equipment (RII=0.785, R=3), Use Advanced Information Technologies (RII=0.793, R=4), Construction Schedule must be discussed and developed prior (RII=0.781, R=4) are the top five principles which are very essential for the period of design and procurement stage of the project. This study argues study conducted by Mohsenijam, et al., (2020), presented (1) Design elements are standardized, (2) Designs facilitate construction under adverse weather conditions and consider an increase of prefabricated elements, (3) the Project Technical Specifications are simplified and configured to achieve efficient construction without sacrificing the level or the efficiency of the project performance, (4) Design and procurement schedules are construction sensitive and considered in project sequencing are list as the most essential Principles among the all principles of Constructability during Design and Procurement period.

In addition Adi & Daniel, (2019) stated that Design elements are standardized (40.8%), Modularization and Preassemblies are prepared to facilitate prefabrication (25.7%), Designs facilitate construction under adverse weather conditions (14.1%), Designs are configured to enable efficient construction, (12.1%), Design and procurement schedules are construction sensitive (10.5%) are discussed as the most top Five Principles that are essential during Design and Procurement period

4.3.3 Summary of Constructability Principles during Pre-Construction phase

Construction Project Phase can be categorized as Pre-construction phase, Construction Phase and Closeout Phase and Pre-construction phase can be broken into Conceptual planning stage and Design and Procurement stage. This research focused on Pre-construction Phase only. Thus, Summary of Constructability Principles during Per-Construction phase are presented as following:-

Throughout Conceptual planning period the 7 principles are assessed and ranked by using the Relative importance Index, so, the most important Principles of Constructability through the Conceptual phase in public building construction projects in Jimma town are Discussed as:-Clarification of Constructability to the stakeholders (RII=0.833, R=1), Site layout should be studied carefully (RII=0.830, R=2), Major construction methods should be discussed and analysed in-depth (RII=0.796, R=3),Formation of Team Including Client, Engineer and Contractor (RII=0.793, R=4), Master project schedule and the construction completion date should be construction-sensitive (RII=0.781, R=5), Construction methods should be taken into consideration when choosing the type and the number of contracts required (RII=0.770, R=6), Use alternative contracting strategy e.g. design build, project management etc. (RII=0.76, R=7).

based on Relative importance index, during the Conceptual planning phase in public building construction projects: - Clarification of Constructability to Stakeholders, Careful Study of Site Layout, and Major Construction Methods Should Be Discussed and Analyzed in-Depth are the top three important Principles of Constructability and the most key aspects to consider during the Conceptual Planning phase of a project to improve constructability and achieve overall project objectives.

According to the result, the most essential Principles during design and procurement period of project are 'Design simplification to enable efficient construction (RII=0.804, R=1), Project Technical Specifications should be simplified and configured (RII=0.793, R=2). Project design should take into consideration the accessibility of construction personnel, materials and equipment (RII=0.785, R=3), Use Advanced Information Technologies (RII=0.793, R=4), Construction Schedule must be discussed and developed prior (RII=0.781, R=4) are the top five principles which are very essential for the period of design and procurement stage of the project.

4.4 Contractors' Involvement in CPc during pre-construction phase

Early Contractors' involvement is a type of construction contract where the principal contractor is engaged at an early stage in a project to offer input into the design phase. It is in contrast to the design–bid–build Construction Delivery method, where the contractor is only brought onboard at the end of the design phase.

4.5.1 Contractors' Involvement in CPc during Conceptual Planning phase

Participation of contractors' at initial stage of Construction project have many significant and improved constructability. In this study, assessed the Constructability principles where the Contractor is involved

during Conceptual Planning period, the Rating point of responses was by using five point Likert Scale(1=Very Low, 2=Low, 3=Average, 4=High, 5=Very High).

Table 4. 4 RII of Contractors' Involvement on during Conceptual Planning Phase

No	Contractors' Involvement on CPc During Conceptual Planning Phase	RII=∑W/(H*N)	Rank
1	Selection of major construction method and materials	0.619	1
2	Preparation of schedule, estimates and budget	0.611	2
3	Suggest structural systems	0.596	3
4	Execution of feasibility studies	0.570	4
5	Advice owner in the contracting strategy	0.541	5
6	Advice owner in the establishment of the project goals and objectives	0.478	6

As table 4.6 indicated that, the involvements of Contractors' during Conceptual period of the project were evaluated and ranked by Using RII. Thus, the result show that, the most essential descending order of Constructability principles that are contractors' involve during Conceptual Planning period are: - Selection of major construction method and materials (RII=0.619, R=1), Preparation of schedule, estimates and budget (RII=0.611, R=2). Suggest structural systems (RII=0.596, R=3), Execution of feasibility studies (RII=0.570, R=4), Advice owner in the contracting strategy (RII=0.541, R=5), Advice owner in the establishment of the project goals and objectives (RII=0.478, R=6). This indicated that during the Conceptual planning period in public building Construction projects in Jimma Town Involvements of Contractors' on 'Selection of major construction method and materials , Preparation of schedule, estimates and budget and Suggest structural systems' are well . However, through 'Execution of feasibility studies, Advice owner in the contracting strategy and Advice owner in the establishment of the project goals and objectives" the Involvements of Contractors' were low with Compare other. This study supports study conducted by Saghat, et al., (2010) stated based on the calculated Means for the first six constructability activities of conceptual planning phase, it is obviously clear that the only percentages which are more than 50% belongs to participants contribution in preparation of schedule, estimates and budget and also selection of major construction methods and materials . Then frequencies of contractors who have been involved in these activities are more than the other activities as well. This process shows that these activities have this potential to be among the Critical Constructability Activities.

4.4.2 Contractors' Involvement on CPc during Design and Procurement phase

During the interviews and observations, it was discovered that the majority of the public building construction projects in Jima Town use the DBB construction contract delivery system, which is considered to be one of the obstacles to Contractor involvement during the Design and Procurement phase. But in this Study analyzed and ranked the principles of Constructability that applying During Design and Procurement phase as table 4.7. Also, the Rating point of responses was collected using five point Likert Scale (1=Very Low, 2=Low, 3=Average, 4=High, 5=Very High).

Table 4. 5 RII of Contractors' Involvement during Design and Procurement Phase

No	Contractors' Involvement on CPc During Design and Procurement Phase	RII=∑W/(H*N	Rank
1	Analyze/revise specifications to allow easy construction	0.648	1
2	Advice design team about sources of materials and engineered Equipment	0.644	2
3	Preparation of schedule, estimates and budget	0.633	3
4	Analyze, designs that facilitate construction under adverse weather conditions	0.615	4
5	Review and advice accessibility of personnel, material and Equipment	0.611	5
6	Analyze the design to enable efficient construction	0.596	6

Table 4.7 presented that, the Essential order of Contractors' Involvement throughout Design and Procurement Phase in Constructability Practice by Using RII are:- Analyze/revise specifications to allow easy construction (RII=0.648, R=1), Advice design team about sources of materials and engineered Equipment (RII=0.644, R=2), Preparation of schedule, estimates and budget (RII=0.633, R=3), Analyze/promote designs that facilitate construction under adverse weather conditions (RII=0.615, R=4), Review and advice accessibility of personnel, material and Equipment (RII=0.61, R=5) , Analyze the design to enable efficient construction (RII=0.596, R=6). Therefore, according to the result, to enhance Constructability, Analyze/revise specifications to allow easy construction (RII=0.648, R=1), Advice design team about sources of materials and engineered Equipment (RII=0.644, R=2), Preparation of schedule, estimates and budget (RII=0.633, R=3) are the most essential principles in Contractors' Involvement throughout Design and Procurement Phase in Constructability Practice. This study supports study conducted by Adi & Daniel, (2019) stated that the selected project delivery method controls contractors' involvement during the design phase that permits or prevents early construction inputs. Generally, three main delivery methods are utilized by at present: Design-Bid-Build (DBB), Design-Build (DB), and Construction Manager/General Contractor

(CM/GC). Consequently, DB and CM/GC delivery methods allow the incorporation of contractors 'perspectives into the design process, while DBB delivery method has limited input from contractors. The main philosophy of DBB is that, the design has to be 100% completed before the construction gets started, and before the contractor gets procured into the project

4.4.3 Summary of Contractors' Involvement on CPc during pre-construction phase

Early Contractors' involvement is a type of construction contract where the principal contractor is engaged at an early stage in a project to offer input into the design phase. It is in contrast to the design–bid–build Construction Delivery method, where the contractor is only brought onboard at the end of the design phase.

Participation of contractors' at initial stage of Construction project have many significant and improved constructability. Contractors' involvements during Conceptual Planning period are: - Selection of major construction method and materials (RII=0.619, R=1), Preparation of schedule, estimates and budget (RII=0.611, R=2), Suggest structural systems (RII=0.596, R=3) the most adopting factors during the Conceptual planning period in public building Construction projects in Jimma Town. However, through 'Execution of feasibility studies, Advice owner in the contracting strategy and Advice owner in the establishment of the project goals and objectives" the Involvements of Contractors' were low with Compare other. Also, to enhance Constructability, "Analyze/revise specifications to allow easy construction (RII=0.648, R=1), Advice design team about sources of materials and engineered Equipment (RII=0.644, R=2), Preparation of schedule, estimates and budget (RII=0.633, R=3) are the most essential principles in Contractors' Involvement throughout Design and Procurement Phase in Constructability Practice in Jimma Town. But, during "Analyze/promote designs that facilitate construction under adverse weather conditions (RII=0.615, R=4), Review and advice accessibility of personnel, material and Equipment (RII=0.61, R=5) and Analyze the design to enable efficient construction (RII=0.596, R=6)" involvements of Contractor is very less.

4.5 Barriers to implementing Constructability

Any significant inhibitor that prevents effective implementation of the constructability program that is barrier to constructability. In this study the barriers of Constructability assed and evaluated by categorized: - Client/owner Barriers, Designer barriers and Contractor barriers.

4.5.1 Client/Owner Barriers

The Barriers in implementing Constructability under category of the Clients are discussed and ranked by using RII as indicated on figure 4.8. R is represent the Ranks of the Barriers.

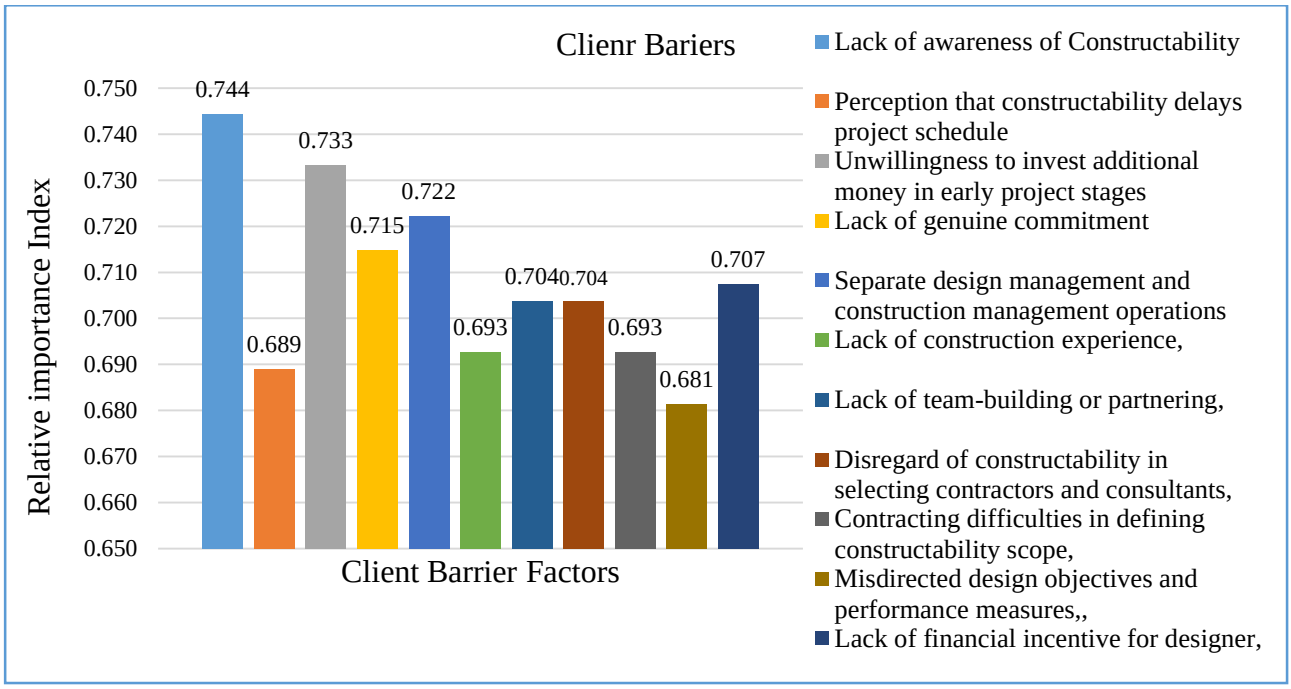

Figure 4.8 Client/Owner Barriers to the implementing Constructability

As indicated the descending order of the barriers concern the project clients are: - Lack of awareness of Constructability (RII=0.744, R=1), Unwillingness to invest additional money in early project stages (RII=0.733. R=2), Separate design management and construction management operations (0.722, R=3), Lack of genuine commitment (RII=0.715, R=4), Lack of financial incentive for designer (RII=0.707, R=5), Lack of team-building or partnering (RII=0.704, R=6), Disregard of constructability in selecting contractors and consultants, (RII= 0.704, R=6), Lack of construction experience (RII=0.693, R=8), Contracting difficulties in defining constructability scope, (RII=0.693, R=8), Perception that constructability delays project schedule (RII=0.689. R=10) and Misdirected design objectives and performance measures (RII=0.681=11) are the ranked order of the clients' concern barriers.

Thus, the result show that, all factors are the essential barriers but Lack of awareness of Constructability (RII=0.744, R=1), Unwillingness to invest additional money in early project stages (RII=0.733. R=2), Separate design management and construction management operations (0.722, R=3), Lack of genuine commitment (RII=0.715, R=4), the most Client's concerned Barriers to the implementation of Constructability. This study argues the study conducted by Adi & Daniel, (2019) stated that "Perception that constructability delays the project, Lack of commitment on design and construction scopes, the

selected project delivery method, the extra cost associate with constructability at early stage of the project" are stated as the major barriers of project's client for the implementation of Constructability.

4.5.2 Designer Barriers

The Barriers in implementing Constructability under category of the Designer also discussed and ranked by using RII as indicated on figure 4.9.

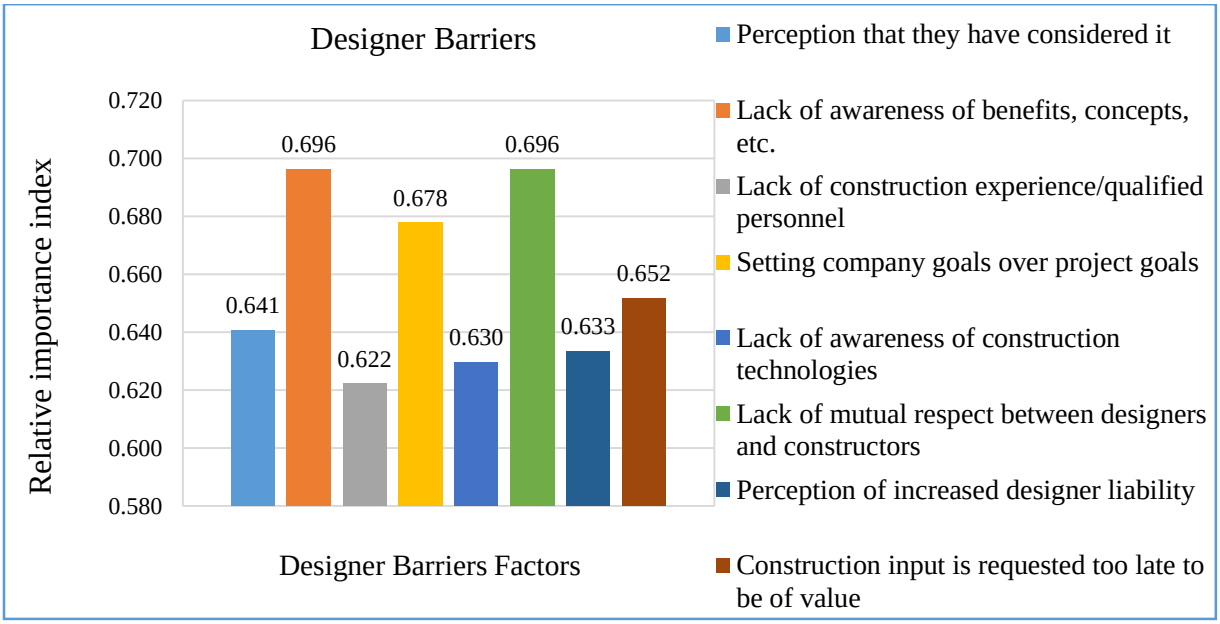

Figure 4.9 Designer Barriers in the implementing Constructability

As presented on the figure 4.9, Lack of awareness of benefits and concepts of Constructability (RII=0.696, R=1), Lack of mutual respect between Designers and Contractors (RII=0.696, R=1), Setting company goals over project goals (RII=0.678, R=3), Construction input is requested too late to be of value (RII=0.652, R=4), Perception that they have considered it (RII=0.641, R=5), Perception of increased designer liability (RII=0.633, R=6), Lack of awareness of construction technologies (RII=0.630, R=7), Lack of construction experience/qualified personnel (RII=0.622, R=8).

Based on the result, the most top Designers' barriers for the Implementation of Constructability are: - Lack of awareness of benefits and concepts of Constructability (RII=0.696, R=1), Lack of mutual respect between designers and constructors (RII=0.696, R=1), Setting company goals over project goals (RII=0.678, R=3). This study argues the study conducted by Mahame, et al., (2017) specified that "Lack of construction Experience/qualified personnel, Lack of financial incentive for the designer, Lack of knowledge of construction technologies and methods" are stated as the mainly affected barriers for the implementation of Constructability in Designer.

4.5.3 Contractor Barriers

The major barriers affecting contactors' constructability practices on the public building construction projects examined and summarizes in Figure 4.10.

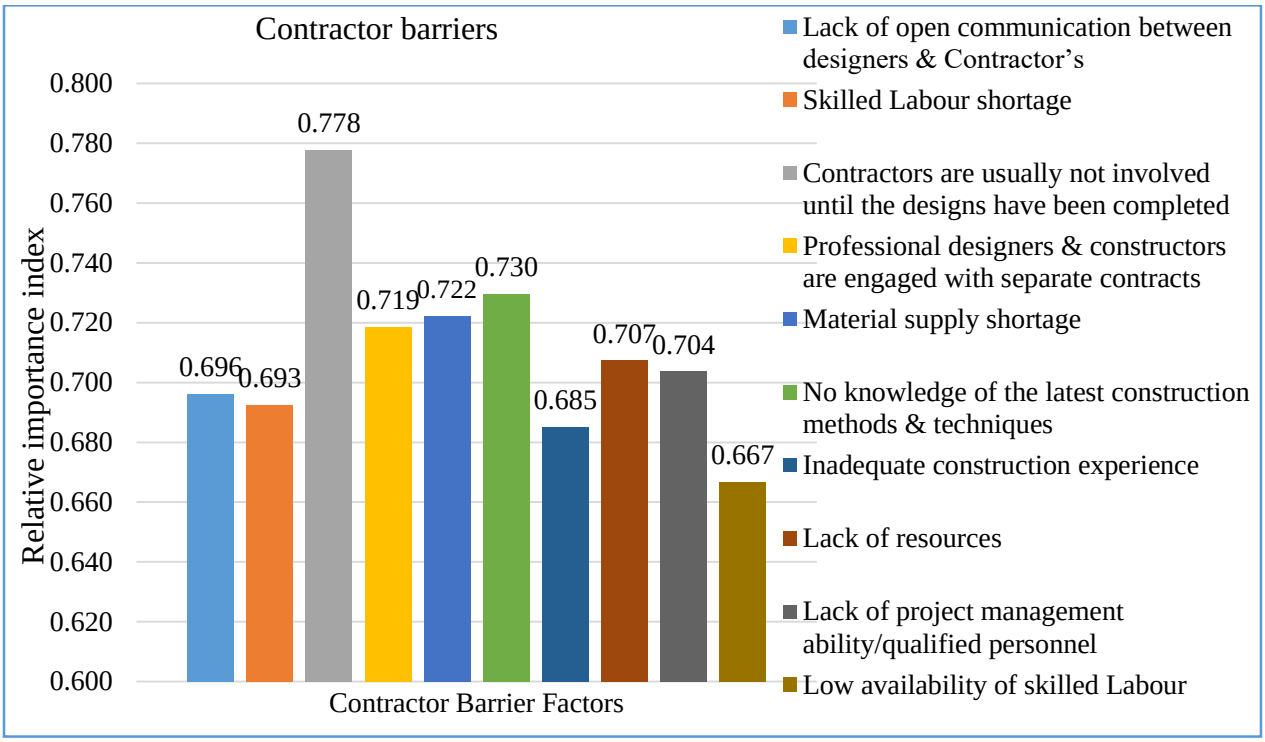

Figure 4.10 Contractor Barriers in the implementing Constructability

As shown on Figure 4.18, the major barriers affecting contactors' constructability practices examined and Ranked by using RII are:- Lack of open communication between designers & Contractor's (RII=0.696, R=7) Skilled Labour shortage (RII=0.693, R=8), Contractors are usually not involved until the designs have been complete (RII=0.778, R=1), Professional designers & constructors are engaged with separate contracts (RII=0.719, R=4), Material supply shortage (RII=0.722, R=3), No knowledge of the latest construction methods & techniques (RII=0.730, R=2), Inadequate construction experience (RII= 0.685, R=9), Lack of resources (RII=0.707, R=5), Lack of project management ability/qualified personnel (RII=0.704, R=6), Low availability of skilled Labour (RII=0.667, R=10).

Based on the result, the most top contactors' barriers for the Implementation of Constructability are:- 'Contractors are usually not involved until the designs have been complete (RII=0.778, R=1), No knowledge of the latest construction methods and techniques (RII=0.730, R=2), Material supply shortage (RII=0.722, R=3)'. This study argues the study conducted by Jadidoleslami, et al., (2018) "lack of attention to constructability has been identified as a significant problem during construction

projects implementation, lack of quantitative evaluation of constructability effects on the traditional construction approaches, lack of coordination in the construction projects performance" are stated as Contractors' obstacles/barriers to the constructability implementation.

4.5.4 Summary of the Barriers to implementing Constructability

Any significant inhibitor that prevents effective implementation of the constructability program that is barrier to constructability. In this study the barriers of Constructability assed and evaluated by categorized: - Client/owner Barriers, Designer barriers and Contractor barriers.

According to the analyzed, Lack of awareness of Constructability (RII=0.744, R=1), Unwillingness to invest additional money in early project stages (RII=0.733. R=2), Separate design management and construction management operations (0.722, R=3), Lack of genuine commitment (RII=0.715, R=4), are the most Client's concerned Barriers to the implementation of Constructability.

Moreover, 'Lack of awareness of benefits, concepts, etc. of Constructability (RII=0.696, R=1), Lack of mutual respect between designers and constructors (RII=0.696, R=1), Setting company goals over project goals (RII=0.678, R=3)' and 'Contractors are usually not involved until the designs have been complete (RII=0.778, R=1), No knowledge of the latest construction methods & techniques (RII=0.730, R=2), Material supply shortage (RII=0.722, R=3)' are the most top Designers' and Contractors' barriers for the Implementation of Constructability respectively.

4.6 Remedial Measurements to the Barriers of Constructability Practice

Many barriers exist for implementing constructability on public building construction projects, and many researchers have assessed and evaluated solutions or remedial measures for these barriers. In this study, some of the remedies are evaluated and ranked using RII as shown in Figure 4.11.

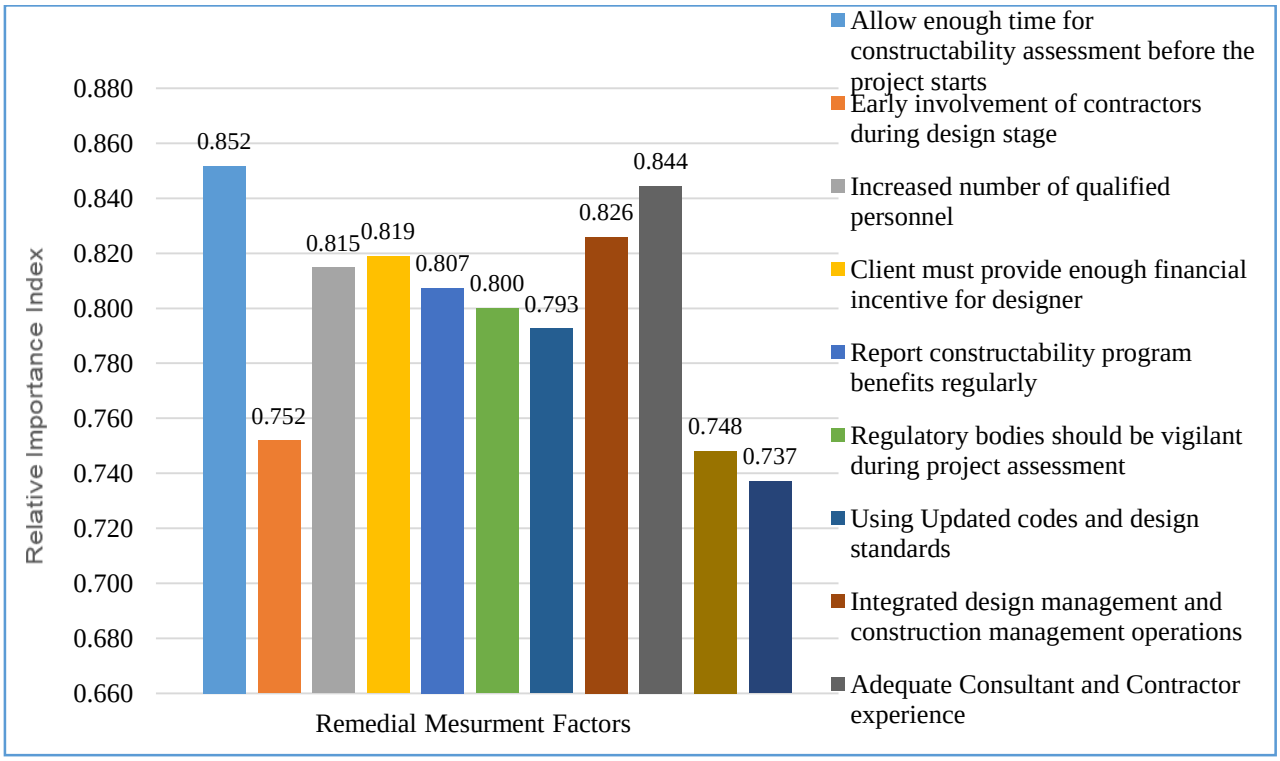

Figure 4.11 Remedial Measurements to the Barriers of Constructability Practice

As presented from figure 4.18, based on the RII, from the evaluated barriers:- 'Allow enough time for constructability assessment before the project starts (RII=0.852, R=1), Adequate Consultant and Contractor experience (RII=0.844, R=2), Integrated design management and construction management operations (RII=0.826, R=3), Client must provide enough financial incentive for designer (RII=0.819, R=4), Increased number of qualified personnel (RII=0.815, R=5) and Report constructability program benefits regularly (RII=0.807, R=6)' Regulatory bodies should be vigilant during project assessment (RII=0.800, R=7), Using Updated codes and design standard (RII=0.793, R=8), Early involvement of contractors during design stage (RII=0.752, R=9), Modify design management practices to elevate the visibility of constructability issues (RII=0.748, R=10), Disseminate cost-benefit data to disprove the

low-bid economy mentality(RII=0.737, R=11).are the most remedial measures that are the most essential solution to the barriers of Constructability.

Based on this Study, to achieve the objectives of the research, the top five Constructability Barriers and their Remedial measurements are categorized with Client Barriers, Designer/Consultant barriers and Contractor barriers as shown Table 4.9.

Table 4. 6 The most Barriers of Constructability and their Remedies under Category of the Parties

Category of Barriers	Client/owner Barriers	Consultant/Designer barriers	Contractor barriers
Top Five Barrie of Constructability	Lack of awareness of Constructability (RII=0.744, R=1)	Lack of awareness of benefits and concepts of Constructability (RII=0.696, R=1)	Contractors are usually not involved until the designs have been complete (RII=0.778, R=1)
	Unwillingness to invest additional money in early project stages (RII=0.733. R=2)	Lack of mutual respect between designers and constructors (RII=0.696, R=1)	No knowledge of the latest construction methods & techniques (RII=0.730, R=2)
Remedial Measurements of the Top Five Constructability Barriers	Allow enough time for constructability assessment before the project starts (RII=0.852, R=1)	Report constructability program benefits regularly (RII=0.807, R=6)	Early involvement of contractors during design stage (RII=0.752, R=9),
	Client must provide enough financial incentive for designer (RII=0.819, R=4),	Integrated design management and construction management operations (RII=0.826, R=3)	Adequate Consultant and Contractor experience (RII=0.844, R=2)

This study supports the study conducted by Mahame, et al., (2017) stated that the most needed solution that would help participants to apply constructability principles which are “increased number of qualified personnel within all parties concerned/regarded, client must provide enough financial incentive to the designer, encourage early involvement of contractors during the design stage, selecting

sustainable materials and efficient building System, regulatory bodies should be vigilant during the assessment of constructability of projects and allowing enough time for constructability assessment before the project starts" are the most stated solutions for the Constructability Barriers with the building construction project.

4.6.3 Summary on Remedial Measurements to the Barriers of Constructability

Based on the result, the highest barriers for the Implementation of Constructability are 'Lack of awareness of benefits and concepts of Constructability, Lack of mutual respect between designers and constructors, Contractors are usually not involved until the designs have been complete, Unwillingness to invest additional money in early project stages, No knowledge of the latest construction methods & techniques This meant that in order to implement Constructability on a project, the stakeholders must be aware of the benefits and concepts of Constructability, Allow enough time for constructability assessment before the project starts, Client must provide enough financial incentive for designer ,there must be mutual respect between designers and contractors, the parties must aware of the latest construction methods & techniques:-these are the best mitigation measures for the implementation of the Constructability on public building Construction projects in Jimma Town.

4.7 Analysis of Interviewed Data

In this study, in addition to questionnaire survey interview data were assessed and evaluated. There were seven interview questions that were categorized throughout the conversation as follows: Constructability practice, any other approaches connected to Constructability, Barriers and Solutions, and Constructability practice enhancements on Public Building Construction Projects.

The practice of constructability in public building construction projects is extremely rare in Jimma Town. But most of the respondents responded as organization have a long-term plan for adopting the setting out of an effective constructability practices as an alternative Construction management.

Also, if there any other principles, techniques and tools effectively implemented on your project questions, most of the respondents answered, "Master Schedule and construction Related software like MS-Projects and primavera are listed. Furthermore, the Constructability Principle has a direct relationship with Construction/Contract Delivery techniques, according to the respondents. The majority of ongoing projects in Jimma Town use DBB contract delivery methods. Moreover, during interview some barriers hampering to the implementation of constructability principles in public building construction projects are mentioned by the respondents that are: 'poor Communication among

the parties, Lack of Contractors competency, Lack of Consultant and Contractors' Knowledge and experience and Poor Government policy" are the most enumerated barriers.

According to the interviewees, role of Client, Consultants and Contractors to the improvement Barriers of Constructability on the Projects were responded: - "Clients must provide, conceptual plan from design up to final construction phase, provide Constructability Practices Team from the beginning, employ Experienced Consultant and should give brief job description to the Consultant and Contractor. On the other hand, with concern of Consultants:-Must provide detailed design and contract document and provide necessary information during Design and procurement, include professional knowledge and experience on the client Conceptual plan and proposal and should always meet and discuss with client and contractor. What's more, improve Constructability the Contractors:- should construct the project with the aspect of agreement, performed based on Time, cost and Quality, should add professional experience on Design and discuss the design before start Executing" are the most responded solutions to the improvement of the Constructability on Public Building Construction projects in Jimma Town.

4.8 Result of Reliability and validity of the Research

Table 4.7 Reliability and validity of the Research

	Section of Questionnaires	Cronbach's α
1	Constructability Principles during pre-construction phase	0.84
2	Contractors' Involvement on Constructability Practice during pre-construction phase	0.85
3	Barriers in implementing Constructability Practice	0.86
4	Remedial Measurement to the Barriers of Constructability Practice	0.98
	Total Sum	3.53
	Average	0.88

The Alpha value for this study was 0.88, with a range of 0.8 to 0.9 Good. As a result, the closer the alpha value is to one, the stronger the internal consistency of the items in the instrument under consideration.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

According to the findings, the majority of respondents (74.1%) are aware of the word constructability, yet most project stakeholders (61.1%) do not practice constructability due to a variety of issues. Consultant Firms (51.0 %), Clients (21.6 %), and Construction Firms (17.6 %) are the top, second, and third organizations, respectively, that are most concerned with ensuring constructability on public building construction projects in Jimma Town. Based on the data, Consultant firms are the most concerned to ensure Constructability more. Moreover, the most common stage for applying the Principles Constructability in Jimma Town is at the Design Phase (56%). However, majority of researchers agree that it is during the Conceptual planning phase.

This research focused on Pre-construction Phase only. Thus, Summary of Constructability Principles during Per-Construction phase are presented. Throughout Conceptual planning period the 7 principles are assessed and ranked by using the Relative importance Index. The most important Principles of Constructability through the Conceptual phase in public building construction projects in Jimma Town are discussed. Based on Relative importance index, during the Conceptual planning phase in public building construction projects : - Clarification of Constructability to the stakeholders (RII=0.833, R=1), Site layout should be studied carefully (RII=0.830, R=2), Major construction methods should be discussed and analysed in-depth (RII=0.796, R=3),Formation of Team Including Client, Engineer and Contractor (RII=0.793, R=4), are the most important Principles of Constructability and the most key aspects to consider during the Conceptual Planning phase of a project to improve constructability and achieve overall project objectives.

In addition, 8 principles of Constructability during Design and procurement Period of the projects are assessed. From these according to the result, the most essential Principles during design and procurement period of project are, ‘Design simplification to enable efficient construction (RII=0.804, R=1), Project Technical Specifications should be simplified and configured (RII=0.793, R=2). Project design should take into consideration the accessibility of construction personnel, materials and equipment (RII=0.785, R=3), Use Advanced Information Technologies (RII=0.793, R=4), Construction Schedule must be discussed and developed prior (RII=0.781, R=4) are the most principles which are very essential for the period of design and procurement stage of the project.

Early Contractors' involvement is a type of construction contract where the principal contractor is engaged at an early stage in a project to offer input into the design phase. It is in contrast to the design–bid–build Construction Delivery method, where the contractor is only brought onboard at the end of the design phase. Participation of contractors' at initial stage of Construction project have many significant and improved constructability, in this study involvements of Contractors' categorized under during Conceptual Planning and Design and Procurement period. Contractors' involvements throughout Conceptual Planning period during 'Selection of major construction method and materials (RII=0.619, R=1), Preparation of schedule, estimates and budget (RII=0.611, R=2), Suggest structural systems (RII=0.596, R=3) the most adopting factors during the Conceptual planning period in public building Construction projects in Jimma Town. However, through 'Execution of feasibility studies, Advice owner in the contracting strategy and Advice owner in the establishment of the project goals and objectives" the Involvements of Contractors' are very low with Compare other. Also, to enhance Constructability, "Analyze/revise specifications to allow easy construction (RII=0.648, R=1), Advice design team about sources of materials and engineered Equipment (RII=0.644, R=2), Preparation of schedule, estimates and budget (RII=0.633, R=3) are the most essential principles that Contractors' Involved throughout Design and Procurement Phase in Constructability Practice. But, during 'Analyze/promote designs that facilitate construction under adverse weather conditions (RII=0.615, R=4), Review and advice accessibility of personnel, material and Equipment (RII=0.61, R=5) and Analyze the design to enable efficient construction (RII=0.596, R=6)' the involvements of Contractors' were very less.

In this study the barriers of Constructability are evaluated by category of Client Barriers, Designer barriers and Contractor barriers. According to the analyzed, Lack of awareness of Constructability (RII=0.744, R=1), Unwillingness to invest additional money in early project stages (RII=0.733. R=2), Separate design management and construction management operations (0.722, R=3), Lack of genuine commitment (RII=0.715, R=4), are the most Client's concerned Barriers to the implementation of Constructability. Moreover, 'Lack of awareness of benefits and concepts of Constructability (RII=0.696, R=1), Lack of mutual respect between designers and constructors (RII=0.696, R=1), Setting company goals over project goals (RII=0.678, R=3)' are the most Designers barriers. Whereas 'Less involvements of Contractors at design stage (RII=0.778, R=1), No knowledge of the latest

construction methods and techniques (RII=0.730, R=2), Material supply shortage (RII=0.722, R=3)' are the most Contractors' barriers for the Implementation of Constructability respectively.

Based on the result, 'Lack of awareness of benefits and concepts of Constructability, Lack of mutual respect between designers and Contractors, less involvements of Contractors during designs, Unwillingness to invest additional money in early project stages, No knowledge of the latest construction methods and techniques' are the highest barriers for the Implementation of Constructability. This meant that in order to implement Constructability on a project, the stakeholders must be aware of the benefits and concepts of Constructability, Allow enough time for constructability assessment before the project starts, Client must provide enough financial incentive for designer ,there must be mutual respect between designers and contractors, the parties must aware of the latest construction methods and techniques are the best mitigation measures for the barriers of Constructability on public building Construction projects in Jimma Town.

The researcher concludes that constructability practice is an effective construction management strategy that enhances project performance by lowering project time and expense while also improving the quality and safety of public building construction projects.

5.2 Recommendation

To enhance Constructability Practice on Public building Construction projects, the Stakeholders in order to bring significant change should take their belong responsibilities and pay role for the implementation of Constructability.

A. For the Client/ client's representative

Client must build a Constructability Team from the start of the project and provide some incentive to the designer in order to meet the project's objectives and improve Constructability. In addition, the client should select a competent and experienced consultant and contractor.

B. For Consultants

Constructability principles are considered by the consultant throughout design and procurement and are incorporated in the document. During the project's design phase, professional knowledge and experience must include into the client's conceptual plan and proposal.

C. For Contractor

For improve of the project performance contractor should add professional experience on Design and discuss the design before start Executing. Also, the Contractor must use Constructability Principles as an alternative construction management method.

D. For government/Regulatory bodies

Regulatory bodies should encourage the researchers and Construction Project stakeholders to adopt Constructability as an alternative construction management technique and offer a consistent training, workshop, and seminar to raise awareness on it.

E. For another Researcher

Further specific research is needed to improve the implementation of constructability and to support the Ethiopian construction industry's'. Particularly in the construction and operation phases of projects further investigation is needed and better support it with Building Information Model (BIM)

REFERENCES

Adi, S. & Daniel, T., (2019). An Extensive Content Analysis of Constructability for Transportation Projects. Greater Montreal, https://csce.ca/elf/apps.

Akpan, E., Amade, B., Okangba, S. & Ekweozor, C., (2014). Constructability Practice and Project Delivery Processes in the Nigerian Construction Industry. Journal of Building Performance, 5(1), pp. 10-21.

Al-Fadhli, K., (2020). Value Engineering and Constructability Assessment Relating Infrastructure Projects. Iraq, IOP Publishing Ltd.

Amade, B., (2016). Constructability Tools and Techniques in Use in the Nigerian Construction Industry. PM World Journal , 5(3), pp. 1-19.

Ansyorie, A. M., (2019). Concepts of constructability for project construction in Indonesia. Indonesia , IOP Publishing.

Ayalew, T. & Dakhli, Z., (2016). The Future of Lean Construction in Ethiopian Construction Industry. International Journal of Engineering Research & Technology (IJERT), 5(02), pp. 107-113.

Ayalew, T., Dakhli, Z. & Lafhaj, Z., (2016). Assessment on Performance and Challenges of Ethiopian Construction Industry. Journal of Architecture and Civil Engineering, 2(11), pp. 1-11.

Ayalew, T., Dakhli, Z. & Lafhaj, Z., (2016). The Future of Lean Construction in Ethiopian Construction Industry. International Journal of Engineering Research & Technology (IJERT), 5(02), pp. 107-113.

Bekr, A., 2017). Factors Affecting Performance of Construction Projects In Unstable Political and Economic Situations. ARPN Journal of Engineering and Applied Sciences, 12(19), pp. 5384-5395.

CII, 2019. Construction CII's Impact.

Demirkesen, S. & Ozorhon.B., (2017). Impact of integration management on construction project management performance. / International Journal of Project Management 35 (2), pp. 1639-16544.

Ding, C., Salleh, H. & Kho, M., (2020). Constructability Research Trends: A Review and Future Directions Chu Sheng Ding. International Journal of Sustainable Construction Engineering and Technology, 11(1), pp. 7-17.

Fadoul, A., Tizani.W. & Osorio-Sandoval, C., (2021). A Knowledge-Based Model for Constructability Assessment of Buildings Design Using BIM. Switzerland, s.n.

Fadoul, A., Tizani, W. & C.A., O.-S., (2021). A Knowledge-Based Model for Constructability Assessment of Buildings Design Using BIM. Nottingham, Springer.

Fadoul, A., Tizani, W. & Koch, C., (2017). Constructability Assessment Model for Buildings Design. Nottingham.

Fadoul, A., Tizani, W. & Koch, C., (2017. Constructability Assessment Model for Buildings Design. UK, International Workshop on Intelligent Computing in Engineering.

Fewings, P. & Henjewele, c., (2019). Construction Project Management : An integrated Approach. 3rd ed. England : Routledge.

Franky, W., Patrick, T., H.W., E. & Shen, L., (2007). A study of measures to improve constructability. International Journal of Quality & Reliability Management ·, 24(6), pp. 586-601.

Griffith, A. & Sidwell, T., 1995. Constructability in Building and Engineering Projects. 1st ed. london : MACMILLAN PRESS LTD.

Hai, K., Yusof, A., Ismail, S. & Wei, F., (2012). A Conceptual Study of Key Barriers in Construction Project Coordination. Journal of Organizational Management Studies , 7(2), pp. 2-14.

Hamed.T., (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. International Journal of Academic Research in Management, 5(2), pp. 18-27.

JadidAlEslami, S., Saghatforoush, E., Zare, R. & A, (2018). Constructability obstacles: an exploratory factor analysis approach. International Journal Of Construction Management, 21(3), pp. 1-14.

Jadidoleslami, S., Saghatforoush, E. & Heravi, A., (2019). A practical framework to facilitate constructability implementation using the integrated project delivery approach: a case study. International Journal of Construction Management, pp. 1-15.

Jadidoleslami, S., Saghatforoush, E., Heravi, A. & aPreece, C., (2018). Evaluating the Existing Barriers in Implementing Constructability. Civil Engineering Journal, 4(12), pp. 2864-2875.

James, T. O. & Steven, J. M., (1995). Overcoming Barriers to Successful Constructability Implementation Efforts.]ourlUll of Performance of Constructed Facilities, 9(2), pp. 117-128.

Kabir, S., (2016). METHODS OF DATA COLLECTION. In: Basic Guidelines for Research: An Introductory Approach for All Disciplines. Bangladesh: Book Zone Publication, pp. 201-275.

Kannan, R. & Samuel, G., (2012). Constructability – The Paradigm Shift in the Construction Engineering and Management. International Conference on Emerging Technological Trends in Advanced Engineering Research, pp. 1-6.

Keerthana, S. & Pradeep, T., (2019). Constructability Risk Assessment in Construction Projects. International Journal of Engineering and Advanced Technology (IJEAT), 9(2), pp. 2249-2258.

Khan, S., (2015). An Overview of Constructability: A Management Tool for Architects. http://journal.sapub.org/arch, 5(5), pp. 125-136-9.

Khan, S., (2019). Constructability: A Tool for Project Managemen. 1st ed. Nrw York: CRC Press Taylor & Francis Group.

Kifokeris, D. & Xenidis, Y., (2017). Constructability: Outline of Past, Present,and Future Research. Journal of Construction Engineering and Managemen, III(2), pp. 1-13.

Koshe, W. & Jha, N., (2016). Journal of Civil, Construction and Environmental Engineering. Investigating Causes of Construction Delay in Ethiopian Construction Industries, 1(1), pp. 18-29.

Mahame, C., Marie Judith Kundwa, J., M. & Bigirimana, T., (2017). Assessment of Constructability of Building Construction Projects in Rwanda. International Journal of Research in Engineering Technology , 2(6), pp. 94-107.

Maksimovic, I., (2014). Construction Administration & Construction Management, Berlin: ICSC.

Mengistu, D., (2013). Research paper Writing Principles and Concepts. 2nd ed. Addis Ababa : Meega Puplishing and Distributed P.L.C.

Mohd, N. et al., (2011). The Experiences of Malaysian in Industrialised Building System (IBS) To Enhance Constructability and Sustainability In Construction Project. Journal of Technology and Operations Management, 6(6), pp. 1-12.

Mohsenijam, A., Mahdavian, A. & Shojaei, A., (2020). Constructability Concepts, Significance and Implementation. Tempe,Arizona, https://www.researchgate.net/publication/.

Mohsenijam, A., Mahdavian, A. & ShojaeiI, A., (2020). Constructability Concepts, Significance and Implementation. Tempe, Arizona, Researchgate.

Muthuckannal, A. & Chitra, G., (2021). Value Management In Construction Projects. Issn (Print): 2393-8374, (ONLINE): 2394-0697,, 8(3), pp. 42-46.

Mydin, H. et al., (2011). Buildability Attributes at Design Phase in Malaysian Building Construction. International Journal of Sustainable Construction Engineering & Technology , 2(1), pp. 24-43.

Othman, A. A. & Seoud, A., (2014). Constructability for Sustainability: A Waste Elimination Approach in Construction Projects. Covenant Journal of Research in the Built Environment (CJRBE), 2(2), pp. 99-116.

Oyebanji, A. & Olayemi, J., (2017). RESEARCH VARIABLES: TYPES, USES AND DEFINITION OF TERMS.. In: A. Atanda, A. Ayeni & A. JaiYeobe, eds. Research in Education. Ibadan: s.n., pp. 43-55.

Rajgor, M. et al., (2019). RII & IMPI: Effective Techniques for Finding Delay in Construction Project. International Research Journal of Engineering and Technology (IRJET), 03(01), pp. 1173-1177.

Saghat, E., Hassim, S., Jaafar, S. & Trigunarsyah, B., (2010). Critical Constructability Activities In Building Projects. Tehran, https://www.researchgate.net/publication/265856501.

Saghat, F. E., Trigunarsyah, B., Too, E. & Heravitorbati, A., (2011). Effectiveness of constructability concept in the provision of infrastructure assets. Brisbane., QUT Digital Repository.

Samuel, O. & Oluseye, O., (2016). Constructability Concepts and Enhancement Capabilities of Construction Site Team Members in Obafemi Awolowo University,le-Ife, Nigeria. Civil and Environmental Research, 8(3), pp. 13-19.

Sawyer, K., Haddix, M. & Long.B., (2017). Constructability Review Guideline, s.l.: s.n.

Shamsudeen, M. & Biodun, N., (2016). Effects Of Design Errors on Construction Projects. International Journal of Scientific & Engineering Research, 7(2), pp. 1099-1114.

Smith, T. & Samantha, S., (2018). Reliability and Validity of the Research Methods Skills Assessment. International Journal of Teaching and Learning in Higher Education, 30(1), pp. 80-90.

Windapo, O. & Ogunsanmi, O., (2014). Evaluation Of The Barriers To The Use Of Appropriate Constructability Practices On Construction Projects. Journal of Construction Project Management and Innovation, 4(1), pp. 734-754.

Yang, X., Yu, M. & Zhu, F., (2020). Impact of Project Planning on Knowledge Integration in Construction Projects. J. Constr. Eng. Manage , 146(7), pp. 1-11.

Zolfagharian, S. et al., (2012). A Conceptual Method of Constructability Improvement). International Journal of Engineering and Technology, 4(4), pp. 456-459.

APPENDIX: A

QUESTIONNAIRES FOR CONSTRUCTION STAKEHOLDERS.

DATE ……

Research Tittle "Assessment on Constructability Practice in Public Building Construction Projects during Pre-Construction Phase-In the Jimma Town" as part of Partial Fulfillment of the Requirement for the Degree of Masters of Science in Construction Engineering and Management.

Objective of the questionnaire survey:

Dear respondent,

The word "**constructability**" defined as "the optimum integration of construction knowledge and experience in Conceptual planning, Design and procurement and field operations period to achieve overall project objectives". One of the key problems in Ethiopia construction industry particularly in Public Building construction projects are integration of construction knowledge, experience, resources, technology and Advance information through all construction Stage of Projects. The aim of this Study is to assess practice of Constructability, Identifying barriers for the implementation and determine the remedial measurement to the Top five identified barriers of Constructability Practice on public building construction projects during pre-construction period in Jimma Town.

Thanks in advance for your co-operation!
Anduamlak Yilma Gizaw

Jimma University Jimma Institute of Technology School of Graduate Studies Faculty of Civil and Environmental Engineering Construction Engineering and Management Stream.

Phone no.: 09 11 48 72 56 Email: yilmaandu@gmail.com

Advisor: Dr. Getachew Kebede

Co-Advisor: Eng. Abebe Eshetu

Section I: Respondents Profile

Mark your answer by ticking the response for the following questions.

1. Company name: ……
2. What your firm's role in the project? Client ☐ Consultant ☐ Contractor ☐

3. If it is Consultant/Contractor, please Specify the Grade ……
4. Position: - Project Manager ☐ Office Engineer ☐ Site Engineer ☐ Contract Administrator ☐Resident Engineer ☐ Site Supervisor ☐ Project Coordinator ☐ other, please specify……..
5. Level of education:-Diploma ☐ Bachelor's Degree ☐ Master's Degree ☐ Doctorate's Degree ☐ other, please Specify……
6. Level of experience in years:- 0-5 ☐ 5-10 ☐ 10-15 ☐ 15-20 ☐ > 20 ☐

Section II: Constructability Practice

1. Have you aware of , the concept "**Constructability**" Yes ☐ No ☐
2. Is practicing on your Building construction Projects? Yes ☐ No ☐
3. If your answer for above question is "No" Why? Please Specify it……
4. Which organization category do they find more concerned of ensuring **Constructability** of building construction projects? Client ☐ Consultant firm ☐ Construction firm ☐ Regulatory boards ☐ any other Specify it ……..
5. In your Building Construction Project practicing **Constructability, is** saving **Cost, Time, and Increase Quality**? Yes ☐ No ☐
6. If your answer for above question is "Yes".
    a. **Cost** Please, quantify it……
    b. **Time** Please, quantify it……
    c. **Increase Quality** Please, quantify it……
7. At which phase of building construction project does **Constructability** principles apply most? Conceptual planning ☐ Design phase ☐ Contract award ☐ Construction Phase ☐ any other…….
8. With your experience, is Contract delivery method affect **Constructability** Practice? Yes ☐ No ☐
9. If your answer for above question is "yes", How, please Specify it ……
10. Any other method used instead of "**Constructability**" Yes ☐ No ☐
11. If your answer for above question is "yes", please Specify it ……

Section III: Constructability Principles during pre-construction phase

Please choose the appropriate choice by putting (√). The Scale of agreement is represented by:-

1= Strongly Disagree, 2= Disagree, 3 = Moderately Agree, 4= Agree, 5=Strongly Agree

No.	Constructability Principles during pre-construction phase	Scale of Agreement level				
		1	2	3	4	5
	A. During Conceptual Planning Phase					
1	The project constructability programme should be discussed and documented within the project execution plan, through the participation of all project team members.					
2	A project team that includes representatives of the **owner, engineer** and **contractor** should be formulated and maintained to take the constructability issue into consideration from the outset of the project and through all of its phases.					
3	Use alternative contracting strategy e.g. design build, project management etc. as a way to have construction knowledge input early in a projects.					
4	The construction methods should be taken into consideration when choosing the **type** and **the number of contracts** required for executing the project.					
5	The **master project schedule** and **the construction completion date** should be construction-sensitive and should be assigned as early as possible.					
6	In order to accomplish the field operations easily and efficiently**, major construction methods** should be discussed and analysed in-depth as early as possible to direct the design according to these methods.					
7	Site layout should be studied carefully. Through considering both permanent and temporary facilities					
	B. During Design and Procurement Phase					

8	The construction schedule must be discussed and developed prior to the design development and procurement schedule.					
9	The use of **Advanced information technologies** will overcome the problem of fragmentation into specialized roles in the field, and enhance constructability.					
10	Designs, through design simplification by designers and design review by qualified construction personnel, must be configured to enable **efficient construction.**					
11	Project elements should be standardized to an extent that will never affect the project cost negatively.					
12	The project technical specifications should be simplified and configured to achieve efficient construction without sacrificing the level or the efficiency of the project performance.					
13	Consider factors of fabrication, transport, and installation in **modular/pre-assembly designs.**					
14	Project design should take into consideration the accessibility of construction personnel, materials and equipment to the required position inside the site.					
15	Design should facilitate construction during adverse weather conditions.					

SEC. IV. Contractors' Involvement on Constructability Practice during pre-construction phase

Please choose the appropriate choice by putting (√). The Scale of agreement is represented by:-

1=Very Low 2=Low 3 =Average 4=High 5=Very High

No.	Contractors' Involvement on Constructability Practice during pre-construction phase	Scale of Agreement level				
		1	2	3	4	5
	A. During Conceptual Planning Phase					
1	Advice owner in the establishment of the project goals and objectives					
2	Execution of feasibility studies					
3	Advice owner in the contracting strategy					
4	Suggest structural systems					
5	Selection of major construction method and materials					
6	Preparation of schedule, estimates and budget					
	B. During Design and Procurement Phase					
8	Analyze the design to enable efficient construction					
9	Review and advice accessibility of personnel, material and Equipment					
10	Analyze/revise specifications to allow easy construction					
11	Advice design team about sources of materials and engineered Equipment					
12	Analyze/promote designs that facilitate construction under adverse weather conditions					
13	Preparation of schedule, estimates and budget					

Section V: Barriers in implementing Constructability Practice

Please choose the appropriate choice by putting (√). The Scale of agreement is represented by:-

1= Strongly Disagree, 2= Disagree, 3 = Moderately Agree, 4= Agree, 5=Strongly Agree

No.	Barriers of Constructability Practice	Scale of Agreement level				
		1	2	3	4	5
	A. Client/Owner Barriers					
1	Lack of awareness of Constructability					
2	Perception that constructability delays project schedule					
3	Unwillingness to invest additional money in early project stages					
4	Lack of genuine commitment,					
5	Separate design management and construction management operations					
6	Lack of construction experience,					
7	Lack of team-building or partnering,					
8	Disregard of constructability in selecting contractors and consultants,					
9	Contracting difficulties in defining constructability scope,					
10	Misdirected design objectives and performance measures,,					
11	Lack of financial incentive for designer,					
	B. Designer Barriers					
12	Perception that they have considered it					
13	Lack of awareness of benefits, concepts, etc.					
14	Lack of construction experience/qualified personnel					
15	Setting company goals over project goals					
16	Lack of awareness of construction technologies					
17	Lack of mutual respect between designers and constructors					
18	Perception of increased designer liability					

19	Construction input is requested too late to be of value					
	C. Contractor Barriers					
20	Lack of open communication between designers & Contractor's					
21	Skilled Labour shortage					
22	Contractors are usually not involved until the designs have been completed					
23	Professional designers & constructors are engaged with separate contracts					
24	Material supply shortage					
25	No knowledge of the latest construction methods & techniques					
26	Inadequate construction experience					
27	Lack of resources					
28	Lack of project management ability/qualified personnel					
29	Low availability of skilled Labour					

Section VI: Remedial Measurement to the Barriers of Constructability Practice

Please choose the appropriate choice by putting (√). The Scale of agreement is represented by:-

1 = Strongly Disagree

2 = Disagree

3 = Moderately Agree

4 = Agree

5 = Strongly Agree

No.	**Remedial Measurement to the Barriers of Constructability Practice**	**Scale of Agreement level**				
		1	2	3	4	5
	A. Remedial Measurements					
1	Allow enough time for constructability assessment before the project starts					

2	Early involvement of contractors during design stage					
3	Increased number of qualified personnel					
4	Client must provide enough financial incentive for designer					
5	Report constructability program benefits regularly					
6	Regulatory bodies should be vigilant during project assessment					
7	Using Updated codes and design standards					
8	Integrated design management and construction management operations					
9	Adequate Consultant and Contractor experience					
10	Modify design management practices to elevate the visibility of constructability issues					
11	Disseminate cost-benefit data to disprove the low-bid economy mentality.					

If there are any other Remedial Measurements Please specify them.

…….

……..

……

Thank you so much!!! Anduamlak Yilma Gizaw

Email yilmaandu@gmail.com 0911487256

APPENDEX B

Part VII: Interview questions

Title: - "Assessment of Constructability Practice on Public Building Construction Projects during Preconstruction Phase in the Jimma Town"

INTRODUCTION:

The purpose of the interview is to gather key information from the, client, Engineers/ consultant and contractors, in order to assess constructability practice, barriers for implementation and determine the remedial measurement to the Top five identified barriers on public building construction.

Project Name: _____
Name of the organization: _____
Client/Consultant/ Contractor._____.
Respondent's Name (optional): _____
Position/role: _____
Date and time: _____

The following questions are about assess concept and practice, barriers for implementation and determine the remedial measurement to the Top five identified barriers of constructability practice on public building construction projects during pre-construction period in the Jimma Town.

1. Does your organization have integrated constructability principles as part of the Construction management Method?
2. Does your organization demonstrate a long-term plan for adopting the deployment of an effective constructability practices?
3. Does the organization use constructability practices for Minimize Cost and time of project?
4. What are the principles, techniques and tools effectively implemented on your project?
5. What are the barriers hampering to the implementation of constructability principles in the organization?
6. In your perception Constructability Principle Has direct relation with Construction/Contract Delivery methods?
7. In your perception what is role of Client/Consultants/Contractors/Regulatory bodies to the improvement of Constructability on the Projects?

Thank you so much!!! Anduamlak Yilma yilmaandu@gmail.com 0911487256