

**Assessing the impacts of subcontractor's schedule overruns in
building Construction.**



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A Thesis Submitted to the Department of Civil Engineering,

School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the

Degree of Master's in Civil Engineering (Specialization in

Construction Engineering and Management)

Office of Graduate Studies

Adama Science and Technology University

**June, 2024
Adama, Ethiopia**

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DECLARATION

I, the undersigned declare that this Master's Thesis entitled "**Assessing the impacts of subcontractor's schedule overruns in building Construction**" is my original work, prepared under the guidance of Dr. Lema Beresa. All sources of material used for organizing of this thesis have been dually acknowledged. Moreover, this research has not been organized by any other person in this or any other university or Higher Educational Institute for an award of a degree.

By: Bontu Shentema

Signature _____

Date _____

RECOMMENDATION

I, the advisor/supervisor of this research, hereby certify that I have closely advised/supervised the student while developing this research and read the draft research entitled “**Assessing the impacts of subcontractor’s schedule overruns in building Construction**” prepared under my guidance **Bontu Shentema**. Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures

Major Advisor/Supervisor

Signature

Date

APPROVAL SHEET

I/We hereby certify that all the correction and recommendation suggested by the board of examiners are incorporated into the final thesis entitled “**Assessing the impacts of subcontractor’s schedule overruns in building Construction**” by **Bontu Shentema**.

Advisor/Supervisor

Signature

Date

We, the undersigned, members of the Board of Reviewers of the thesis open defense by **Bontu Shentema** have read and evaluated the her thesis entitled “**Assessing the impacts of subcontractor’s schedule overruns in building Construction**” and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements of the degree of Master of Science in Construction engineering and management.

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Final approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

Department Head

Signature

Date

School Dean

Signature

Date

Office of Postgraduate Studies, Dean

Signature

Date

ACKNOWLEDGEMENTS

I would like to thank Almighty God and his mother, who gave me the commitment and tolerance to pass various obstacles and which has made it possible for me to reach this point.

My deepest gratitude goes to my advisor, Dr.Lema Beresa for his continuous support and guidance during this research. I would also like to thank the organizations, which participated in the research during the study, for their collaboration and willingness.

Finally, special thanks and love go to my family and friends, especially my mom workitu Ejo, for all the love, understanding, and encouragement mentally as well as financially throughout the research.

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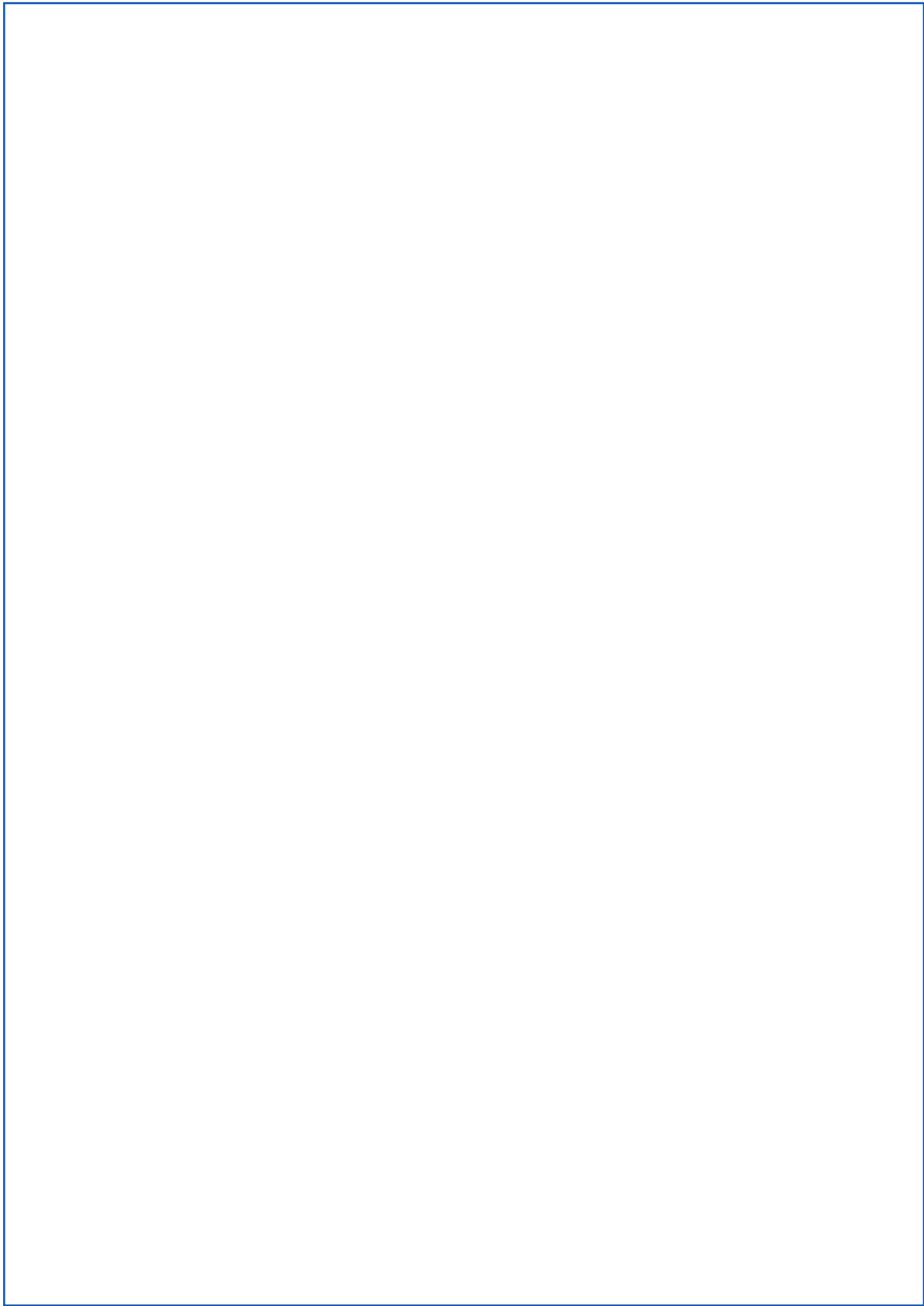
ACRONYMS

BIM	Building Information Modelling
FIDIC	International Federation of Consulting engineers
GCC	General Conditions of Contract
OCC	Oromia Construction Corporation
PPA	Power Purchase Agreement
WBS	Work Breakdown Structure

ABSTRACT

This study presents assessing the impacts of subcontractor's schedule overruns in building Construction. Subcontracting is a common practice in the modern construction industry. Subcontractors carry out a large part of the work done in construction projects. The objective of this research is to assess the impacts of subcontractor schedule overruns in building Construction. A well-executed schedule by subcontractors contributes to a project's timely, cost-effective, and high-quality completion as well as to higher profit margins and fewer claims. In this study questionnaire survey and literature review were used to collect relevant information from primary and secondary sources. Using a questionnaire survey the required data were collected from 48 respondents. The data gathered using the questionnaire was analyzed with the help of the Fuzzy logic toolbox of the MATLAB program software. It is appropriate for uncertain or approximate reasoning that involves human intuition which includes defining the input variables, defining output variables, defining the membership function, defining the rule base, and analyzing the design. The most critical factors of schedule delay of subcontractors were identified as frequent design and scope changes, shortage of skilled laborers and lack of experience, financial difficulties faced by contractors, and lack of information flow between parties. Most of the respondents surveyed in the study have agreed that schedule overruns of subcontractors have an impact related to cost, time, and quality respectively. The study recommends conducting background checks on subcontractors before hiring ensuring they have the necessary skills and experience for the job also assigning experienced supervisions to monitor subcontractor's work on site closely.

Keyword: subcontractors, schedule, time, cost, quality.



CHAPTER ONE

INTRODUCTION

1.1 Background of the study

There are various stakeholder parties involved that interact in construction projects, including the owners/governments, main contractors, architects, consultants, subcontractors, and suppliers, each having different responsibilities and diverse specified roles.(Tan et al., 2017).

A construction project is awarded to a general contractor or prime contractor or principal contractor or main contractor, which resorts their work out to specialize outside firm to carry out specific project activities. General contractors are responsible for managing the project such as contract administration with clients, project financing, material and equipment procuring, and monitoring the project progress. The general contractor's performance is strongly dependent on subcontractors. The ability of the general contractor and consultant to deliver the project within time, quality and cost depends largely on performance of subcontractors. Subcontractors are specialist in the execution of a specific job, they act as agents of the production system of the contractor company in supplying materials, manpower, equipment, tools or designs. A subcontractor is a construction firm that contracts with a general contractor to perform some aspect of the general contractor's work. In most construction projects, a vital role is played by subcontractors who are hired to perform specific tasks on a project. (Lew Yoke, 2012)

Because of the increased project complexity and the highly competitive nature of the construction industry, a construction project often is executed by several sub-contractors (for example dealing with foundations, steel erection, framework, reinforcing bars, and concrete). For instance, it is common for a semiconductor facility construction project to involve over 50 subcontractors working on the jobsite. Hence, effectively managing the numerous subcontractors involved in a construction project becomes a crucial challenge for the general contractor in ensuring timely project completion. Although subcontractor management has been recognized to significantly affect construction project duration, current practice and past research deal with subcontractor management and schedule control separately. Managing subcontractors does not simply involve asking them to allocate resources (labor, material, and machinery/equipment) into the jobsite whenever an activity is scheduled, and then pushing them to speed up the work without a clear consciousness of schedule risk. Factors (or uncertainties) such as weather, labor, site

conditions, material delivery, and equipment breakdown can influence the time performance of subcontractors, affecting total project duration. The work of each of the paths of a schedule network is usually performed in a continuous flow by various subcontractors to reduce interruption costs and maximize resource utilization rates. Thus, a network path can be treated as a working route of a subcontractor or several subcontractors (Wang & Liu, 2005)

The construction industry is facing schedule overruns when projects are becoming more complex and fast-paced i.e., design/build, security concerns, smart technologies, integrated systems, etc., while the shortage of talented design and project management professionals continues to deepen. The writers have noticed an increase in prime contractors and owners not fully understanding the scope of work and logical dependencies between subcontractor works that are critical to the success of such complex and fast-paced projects. Miscommunications and conflicts between prime contractors, subcontractors, and other project participants often result in costly litigation and dissatisfied customers (Dossick et al., 2016.)

Contractors and subcontractor play a vital role in endorsing the development of construction industry. Project productivity is mainly the result of coordination between project parties" especially main contractor and subcontractor. Which is the main participant on the construction. However, there are numerous issues that arise between main contractor and their subs which influencing relation between them. Identifying of those problems will develop good relationship between contractors and their subcontractors and it helps to improve performance of the two parties.(Yemsirach, 2020)

A construction schedule is a duration for completing a project. The schedule of a project is normally arranged to allow the building to be used by a date determined by the client. Time is one of the major factors that is used to measure the success of a project. Thus, the component of time may suggest to project managers and all stakeholders that the project was completed smoothly and on schedule. Therefore, project managers prefer contacts with reasonable amount of time to execute completely. The timely completion of a construction project is seen as the hallmark of the design and built industry However, construction delays have become a major component of construction projects as projects continue to experience delays even with the vast advancement in technology and management understanding (Ahiawodzie, 2018) .

1.2 Statement of the problem

Numerous construction projects are faced with late completion due to technical difficulties these delays may also attributed to the increasing complexity of projects and the underestimation of the complexity of a project subcontracting aspect of a project has been seen to yield good results when utilized effectively. The performance of a main contractor can be linked to that of the subcontractors there are situations where subcontractors disrupt the success of a construction project. There is a failure of construction projects in terms of time to subcontractors. The benefits of engaging subcontractors may not be realized if they are not properly managed.

It is a fact that when the time available to complete tasks or activities is perceived to be far shorter than that which is reasonably required, the productivity and quality of the work tend to suffer. The performance of the general contractor is strongly influenced by the performance of the subcontractors. For effective time performance, the successful execution of construction projects and keeping them within the prescribed schedule is very important to complete the project, within time, budget, and quality.

1.3 Objectives of the study

1.3.1 General Objective

The general objective of the study is to investigate the impacts of subcontractor's schedule overruns in building Construction.

1.3.2 Specific Objective

The specific objectives of the study are;

- Identify the key factors influencing schedule overruns of subcontractors in building construction.
- The impact of key factors influencing schedule overruns of subcontractors in building construction.
- Formulate strategies to minimize the impacts of schedule overruns of subcontractors.

1.4 Significance of the study

This research discuss the effects of subcontractors on project schedule overruns and the effects they have on schedule overruns in terms of time, budget, and quality. No matter how complex, large, or the size or the climate within which it is constructed, a project is deemed successful when it is finished on schedule, within budget, and with acceptable

quality. A well-executed schedule by subcontractors contributes to a project's timely, cost-effective, and high-quality completion as well as to higher profit margins and fewer claims.

1.5 Scope of the study

This study assess the impacts of subcontractor's schedule overruns in building Construction of projects in Oromia Construction Corporation (OCC). And factors influencing subcontractor schedule overruns related with time, budget and quality. This study is limited to only building construction firms in the Oromia Construction Corporation (OCC). This scope was selected due to the large number of construction companies in the Oromia Construction Corporation who have experience working as subcontractors.

Schedule overruns is known to be the top priorities of main contractors. Schedule overruns of subcontractors can occurs in various phases of a project, including planning, execution, and final delivery and it typically results from combination of different factors and those factors results in schedule overruns and impacted the project related to time, quality and cost . Time, cost and quality is considered a good and measurable indicator of project impact and therefore, among different key performance indicator of impact, Time quality and cost are considered in this research.

1.6 Organization and Contents of the document.

The research comprises of five chapters.

Chapter one is the introductory chapter, which provides basic information about the study, including background and statement of the research problem, research objectives and scope and limitations of the research.

Chapter two presents theories and discussions related to the major functions of key performance indicator, performance management, potential factors that leads to poor performance, emphasis on time and cost, the impacts of contractors' performance and managing project cost and time. A brief discussion on performance management trend is also included under this chapter.

Chapter three covers the research methodology followed in order to achieve the objectives of the study. It presents an overview of the research design, sources of data and research instruments, research population and sampling, sample size distributions and method of analysis.

Chapter four presents analysis of the research data obtained from the questionnaire survey and the case study is discussed accordingly.

The last chapter, which is chapter five, is devoted to the author's conclusions and recommendations.

1.7 Limitation of the Study

The major limitations of this study were time, due to that the study was limited to schedule overrun of subcontractors in Oromia Construction Corporation (OCC) only in building sectors

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Construction projects involve many parties, such as contractors, consultants, clients, suppliers, and sub-contractors. To transfer the risks, the contractors normally sublet the works to the sub-contractors, who are specialist agents in executing a specific task and supplying manpower, equipment, tools, and designs as well. Subcontractors help the contracting company's production system perform better. The relationship between the main contractor and sub-contractors is key to any successful construction project. The bad relationship between main contractor and the subcontractor lead to delays that is considered one of the most challenging problems for construction projects. Delays occurrence leads to an increase in the project's time and cost. Many subcontractors may work under the main contractor on large projects. The project can be finished on time and on budget if the subcontractor is capable and reliable. Despite its importance, little information is available about the effective relationship between main contractors and sub-contractors. In Egypt, subcontractors are responsible for more than 90% of the work in construction (Kshaf et al., 2022).

A construction project is awarded to a general contractor or main contractor, which resorts their work out to specialize outside firm to carry out specific project activities. A main contractor is a contractor engaged by the client and is responsible for all work on a construction site including the engagement of subcontractors to complete part of the works involved. Main contractors are responsible for managing the project such as contract administration with clients, project financing, material and equipment procuring, and monitoring the project progress (Yemsirach, 2020)

To begin, many main contractors work with a group of long-established subcontractors for each major trade of construction work, such as excavating, drainage laying, formwork, concreting, metalwork, etc., and the relationship may last for more than 10 years by a conservative estimation). Both the main contractor and the subcontractors are cooperative and have good performance records, which benefits both parties. In other words, both parties can gain mutual benefits from each other by treating the other as a long-term partner or teammate. Moreover, there are also many main contractors maintaining short-term or one-off business relationships with subcontractors possessing specific abilities or competences for specialized construction work Nevertheless, some of these short-term

business relationship subcontractors may be developed into long-term ones provided that their construction performance and cooperative abilities are satisfactory to the main contractor. (Tan et al., 2017).

Numerous construction projects are faced with late completion dates due to technical difficulties. These delays may also be attributed to the increasing complexity of projects and the underestimation of the complexity of a project. There is an increase in productivity when subcontractors are effectively managed. Therefore, subcontractor engagement and effective management in a construction project can affect the performance of a construction project in terms of time. Construction projects have become more complex due to their increasing size and use of modern technologies. Therefore, to stay more competitive, companies must focus on their core competencies. (Ahiawodzie, 2018)

Aggressive project schedules or targets and the reactive response of the construction site manager to delays often invite undesirable consequences on a project's cost and schedule as a result of the dynamic nature of schedule pressure. This situation is due mainly to a lack of understanding of the tradeoffs and the cause-and effect relationships of schedule pressure. We have demonstrated that the productivity, rate, and quality of work tend to decline as the schedule pressure increases above its normal level. (Nepal et al. 2015)

There are many attributes that affect the schedule performance either positively or negatively. In order to improve schedule performance in the complicated construction industry, it is important to identify the attributes (success/failure) responsible for schedule performance and understand the latent properties of these attributes by studying the critical success and failure factors. (Sinesilassie, 2017).

As Wang & Liu, (2005) said in the schedule control of the factor-based path model, management should typically focus on two types of paths – critical paths and near-critical paths which are very sensitive to factors. These paths should receive most attention since the lack of float time prevents the paths from reacting to changes caused by factors, such that even small variations in the duration of critical or near-critical paths directly affect the duration of the project.

2.2 Parties involves in construction project

A construction project normally involves many parties in order to provide good productivity of a construction project. The list of possible participants is extensive and can include owners, contractors, consultants, project managers, designers, shareholders, legal

authorities, employees, sub-contractors, suppliers, service providers, financial establishments, insurance companies, etc. Among them employer/client/, consultant, main contractor and subcontractor are parties directly involved in the construction industry.

2.2.1 Employer /Client/

Employer is the party that has the authority in making decisions especially on goals, objectives, and parameters as well as the time that the project can start to commence since they are the owner of the project. The employer is the initiator and financier to all the construction project.

The General Conditions of Contract for Construction Works (GCC 2004) states that "Employer" means the party named in the tender proposal who has called for tenders to build or construct erect or deliver the works and who will employ the contractor and the legal successors in title to the employer but not (except with the consent of the contractor) any assignee of the employer. "

According to FIDIC Red Book (2005) "Employer" means the person named as employer in the Contract Data and the legal successors in title to this person. "

According to PPA (2011) "Employer" means "Procuring Entity" as defined in the Public Procurement Proclamation. "

This is the main and very important project stakeholder, who conceives the project, approves the project charter and subsequently accords approvals and disburses the progress payment to the contractors. The involvement of the client in all phases of the project i.e. entire project life cycle is mandatory, in order to make the project a complete success. Unfortunately there are member of causes and reasons, over which the clients do not play their due role and input into the development and growth of the project. In the succeeding paragraphs, the authors have described the rundown of such factors. Timely funding on the project is very important in order to expedite the progress as per approved construction schedule and schedule baseline. Failure to ensure a smooth cash flow without any plausible reasons will halt and disrupt the project momentum. Most of the projects fail due to disruption in cash flows.(Tahir, 2013)

2.2.2 Consultant

Consultants consist of a team that was appointed by the client to design and supervise construction project. Consultant includes architect, engineer, quantity surveyor, electrical

and sanitary engineers and another related consultant. Consultants are in charge in project budgeting and management, to advice the client and give solutions (Syahidah, 2017).

In the construction industry of Pakistan, there is a general perception that consultants (both the design professionals and the architects) enjoy ultimate verdict and decision power for the constructability issues on the projects. It is unwise to say that contractors are the sole entities who are to be blamed for delay, failure or abandonment of construction projects. If objectively analyzed, consultants have direct influence and effect over success or failure of construction projects. Their professional or unprofessional actions do lay good or bad repercussions onto the contractors and the projects alike. For instance, when their will be clash and conflict among structural, public health works, electric and water supply drawings with architectural drawings, the ultimate problem will be shifted to the contractor. He may not be able to execute the drawings due to design errors, missing or insufficient data, and lack of integration of subsidiary plans.(Tahir, 2013)

2.2.3 Main Contractor

The General Conditions of Contract for Construction Works (GCC 2004) states that "Contractor means the person or persons, firm or Company whose tender has been accepted by the Employer and includes the Contractor's personal representatives, successors and permitted assigns. "

According to FIDIC Red Book (2005) "Contractor" means the person(s) named as contractor in the Letter of Tender accepted by the Employer and the legal successors in title to this person(s) " According to PPA (2011) „The term "Contractor" means "Supplier" as defined in the Public Procurement Proclamation. "

This is the prime stakeholders of any construction projects, who is the actual doer or executioner entity. He implements the vision of owner on ground. Instances have been seen and data in various publications reveals that most of the contractors, do not get mobilized immediately after award of the contracts. This is definitely an unnecessary and unwanted delay which shows a callous attitude towards performance of contract and the project.(Tahir, 2013)

Contractors are recommended to be attentive about construction materials and prices, so they are advised to purchase the construction materials at the commencement of work. Time schedule for material delivery to the site and usage of materials in the site must be prepared in order to avoid shortage or lack of materials. Qualified staff with appropriate

experience must be appointed to follow technical and managerial aspects of the project. The staff will be more effective if there are enough numbers of engineers, planning managers, technicians, and foremen, so the responsibilities would be shared between all of them. The quality of activities must be monitored continuously to set the required quality system in the different activities of the project so as to avoid any mistakes that may lead to rework of activities, and finally time and cost overruns project. (Syahidah, 2017).

2.2.4 Subcontractor

The subcontractor is usually appointed by the contractor or client to perform a part of the construction works by subcontracting the main contractors' work (Syahidah, 2017).

According to FIDIC Red Book (2005) "Subcontractor" means any person named in the Contract as a subcontractor, or any person appointed as a subcontractor, for a part of the Works; and the legal successors in title to each of these persons.

Subcontractors can contribute to the construction process for as much as 90% of total project value. In managing project subcontractors, a general contractor must determine the items of work to be subcontracted, select subcontractors, set subcontract agreements, and control the subcontractors during construction. (Wang & Liu, 2005)

2.3 Benefits of sub-contracting

Most construction companies engage the services of sub-contractors to execute specific, predetermined aspects of the construction project. Traditionally, sub-contracting firms perform the duties of a trade sub-contractor to the general contractor. (Syahidah, 2017).

There are numerous benefits in engaging the services of a sub-contractor on a construction project. The advantages originate as a result of the fact that, the subcontractor organization is specialized in that particular construction task. Furthermore, subcontracting firms are highly competent and are legally ready to execute the relevant work section and take responsibility for the related warranties. Subcontracting also saves time and increase productivity as task get done faster due to high specialty of sub-contractors. Quality of work is also highly ensured and a reduced cost. There are two avenues for cost savings. These are remuneration and performance of the work. Outsourcing work to an external party ensures that the work is well done and eliminates the possibility of rework. The birth subcontracting in the construction industry has influenced the industry and it has encouraged specialization and aided in the transfer of risk from the general contractor to the subcontractor

Subcontractor has become a great subject to all the practitioners in construction industry due to the common practice of subletting construction works into smaller packages in construction industry. Effective subcontractor selection and monitoring which can minimize the problem would determine the success of construction companies. (Lew Yoke, 2012)

2.4 Problems of sub-contracting

However, subcontractor related problems are still quoted as one of the main risks of construction project globally. Problems with subcontractors have been identified as one of the important causes contributing to delays in Malaysian construction industry. Subcontractor was quoted as one of the common causes of construction delays in construction industry. Several studies conducted in Malaysia shown that subcontracting practice is creating problems to the construction industry. There are many subcontractors working under the general contractors particularly for huge projects in Malaysia. But subcontractors are found to be among the top five reasons contributing to project delay. (Lew Yoke, 2012).

Lack of subcontractor skills are found to be one of the contributors to contractor in causing delay. Other than causing delay, coordination problems with subcontractor were quoted as factors that affect the construction labor productivity of residential projects. Despite interruption to work progress, role of subcontractor as partner of general contractor, material supplier and safety performance in construction project are also revealed. Subcontractors are identified as one of the risks associated with in partnering project in construction industry. (Raykar, 2016)

The importance of subcontractors' past safety performance was revealed as a criterion for soliciting bids for new work by the general contractors. Further, subcontractors are found crucial in material supply chain of Malaysian construction industry due to their role as the mediator between suppliers and main contractor. Subcontractor failure has been listed as one of the risks allocated to general contractor in construction contracts. (Lew Yoke, 2012)

Subcontracting is risky and can lead to low quality, delayed completion and unsafe practice. Another risk created by subcontractor is the possibility of them to breach contract and dispute with the general contractor. Hence, subcontracting has been listed as one of the significant factors causing delay. Payment issues, retainage withheld by general contractor, bidding issues, bonding issues, insurance issues, safety issues, partnering issues, and

productivity issues are among the issues needs to be investigated in subcontracting practices.

The problems do not limit to the general contractors, subcontractors also be inflicted with unfairness. An exploratory study participated by 28 subcontractors revealed the fact that subcontractors are often required to assume all risks and obligations stipulated between the owner and general contractor, without given the opportunity to examine them. Meanwhile, a study one in Scotland studied on the set-off, or more often called contra charge, shows that subcontractors has faced the problem to settle this obstacle with the main contractor fairly. Though some subcontractors are protected by the contract clauses, the subcontractors were found reluctant to use their contractual entitlements due to the fear of being denied opportunities to tender for the future jobs. (Ibironke & Elamah, 2011)

Problems of subcontractors, if ignored, can cause an immense impact to the construction project, and can extend into the operation of the general contractor's organization. Therefore, attention shall be given to the issues of subcontractor, which is the main participant in almost all the construction projects.(Lew Yoke ,2012)

2.5 Definition of schedule overruns

A construction schedule serves as a detailed timeline outlining all tasks and milestones within a construction project. It's an essential component of project planning, as it not only delineates the sequence of activities but also identifies the necessary resources and assigns responsibilities to the respective teams involved in the construction process.

Project delays are those that cause the project completion date to be behind schedule. According to Kaming et al., (1997), Time overrun is defined as the extension of time beyond planned completion dates traceable to the contractors. Thus time overruns can also be defined as the time increased to complete the project after the planned date which is caused by internal and external factors surrounding the project.

Delay, according to Alinaitwe et al., (2013), is defined as the completion of the works taking longer than expected or required under the contract. When a contract's development lags behind its planned course, a delay has occurred. It could be the direct outcome of one or more events and could be brought on by any party to the contract. A contract delay has negative consequences for both the owner and the contractor (in the form of lost profits or additional expenses) and frequently raises the contentious topic of delay accountability, which may lead to disputes that frequently end up in court.

According to Aibinu & Jagboro, n.d.(2016) described delay as to occur when the project is not completed within the initial, defined, or agreed-upon contract period. This has been caused by the contractor and the project owner jointly or severally. However, completing projects on time is an indicator of efficiency, but the construction process is subject to many variables and unpredictable factors, which result from many sources.

2.6 Factors Influencing Schedule Overruns

Time overrun is a very frequent phenomenon and is associated with nearly all projects in the construction industry. This trend is more severe in developing countries where time and cost overruns sometimes exceed 100% of the anticipated cost of the project (Kaming et al., 1997)

A construction project comprises two distinct phases: the preconstruction phase, the period between the initial conception of the project and the signing of the contract; and the construction phase, during which the contractor must complete construction subject to the conditions of the contract. There is no particular element in any project solely responsible for time overruns however; the construction phase holds a wider proportion of major troubles. Construction time overruns are integrated parts, none of them can be divided from the other, and this is seen by the costs construction time overruns leave behind.

According to Sweis,(2013)Presence of unskilled laborers, Shortage of technical professionals in the contractor's organization, Improper technical study by the contractor during the bedding stage, Poor planning and scheduling of the project by the contractor, Too many change orders from the owner, Slow decision making from owner, Delay in progress payments by the owner, Ambiguities and mistakes in specifications and drawings, Poor qualification of consultants, engineers and staff assigned to the project, Severe weather conditions on the job site.

According to Borse & Khare, (2016) in construction industry time and cost performance are the fundamental criteria for success of any project. Unfortunately construction industry facing poor performance leading to failure in achieving effective time and cost performance Time and cost overruns is a severe problems faced by large construction industries in India. It is resulted from various factors which had been identified. It was found that most significant factors causing time and cost overruns in Indian construction are material market rate, lack of planning, slow decision making, raising of fund, contract modification, project location, depends on the fresher's to bear the whole responsibility for time overruns and high transportation cost, change in material specification, escalation of

material price, frequent breakdown of construction plants and equipment's, and rework for cost overruns.

According to Enshassi et al., (2009) assigning part of the works to a new subcontractor, without informing the original subcontractor, the main contractor's financial problems, non-adherence to the conditions of the contract, delay in contract progress payments, and delay of the works behind the schedule are the most severe problems that affect the relationship between contractors and subcontractors. The factors caused by the subcontractor's group were ranked as the most important cause of problems. If these factors are addressed and monitored carefully, the relationship between contractors and subcontractors will be improved which may lead to disputes, delays, and cost overruns reduction.

The subcontractors should adhere to quality standards by using experienced labor, good materials, supervision of materials, implementing the engineer's instructions, and doing the remedial works. The subcontractors should also communicate with the contractor and the site engineers effectively and implement their instructions to avoid any problems. The subcontractors are advised to use all safety measures to help protect the task force. The owners are recommended to issue the financial payments for the contractor on time so that they can cover the payments for the subcontractors who in turn can purchase the required materials and pay for the task. Enshassi et al., (2009)

Construction schedule is the duration for the completion of a construction project (Chan and Chan, 2004). The inability for a contractor to meet the schedule stipulated in a contract document leads to delays. Construction delays are one of the most frequently occurring problems in the construction industry. Also indicated that, time overruns may lead to disputes, litigation and even complete abandonment of projects. The delays in a construction project may be caused by numerous factors. The factors are discussed below;

Competence of the construction manager

According to Jha and Iyer (2007), a competent construction project manager has technical capability and monitoring capabilities. He makes his people committed to the project through effective leadership. He effectively delegates authority to his subordinates which also acts as an 18 source of motivation for the workmen. Thus, if a construction manager can achieve all this, he effectively manages and controls the project schedule to avoid delays and setbacks.

A competent project manager possesses the capability to ensure the project to complete in budget and on schedule. He or she does so by doing regular schedule and budget updates. The previous experience of a project manager on similar projects makes him or her competent. It is not enough to possess the skills mentioned above unless the project manager exerts him or her for the project by getting involved in the project through regular schedule and budget update and taking active part in construction control meetings and possesses a thorough understanding of scope of work.(Sinesilassie , 2017)

Top management support

Owners support the project by taking appropriate action whenever the project faces operational difficulties. Top management extends support to the project by selecting a project manager with a proven track record at an early stage and by keeping short and informal lines of communication (Jha and Iyer, 2007). Also, a supportive top management backs up the project plan prepared by the site management team. Taking part in construction control meetings and making the resources available for the planned duration also show support for the project. Therefore, supportive top management critically affects the smooth flow of a construction project.

Monitoring and Feedback

Monitoring and feedback are a very critical factor in ensuring the successful execution of a construction project in terms of time. It is also seen from the literature review that monitoring, feedback, and coordination are given importance by most of the studies for the successful outcome of a project and identified as a key factor responsible for success of many projects.

Favorable working conditions

This factor comprises attributes like scope and nature of work, well defined in the tender, favorable social environment, favorable climatic condition at the site, and monitoring and feedback by client. Jha and Iyer (2007) indicated that, favorable social environment creates a cordial atmosphere to the non-local construction team at their locality. Generally, due to unemployment problems in certain underdeveloped areas, the locals expect their men to be appointed for work. Therefore, if they are not favored the locals tend to cause hindrances in the progress of work

Commitment of all project participants

Project participants include internal and external participants, such as project team, contractors as internal participants, and stakeholders like client, suppliers, etc. as external participants. Commitment refers to the willingness of these project participants towards a pooled effort. According to Jha and Iyer (2007), for the project to be successful not only internal factors are needed but external factors like political and economic environment are also needed. Delegating authority top management delegating to project manager, which in turn delegates down to other team members also shows the team commitment.

Competence of owner's advisory team

Making timely decisions, and regular monitoring and feedback on the progress of the project are some of the characteristics of a competent owner. The competence of the advisory team of the owner can have a huge say in the project performance in terms of schedule.

2.7 Effects of schedule overruns

According to Mukuka et al., (2015), the Effects of schedule overruns are the consequences that will occur when the causes of schedule overruns are not identified and worked on effectively. Extension of time, cost overruns, loss of profit, disputes, poor quality of work due to hurrying the project, creates stress to the client, acceleration losses, bad reputation with contraction team, claims and delay in getting profit by the client were the top ten identified effects of construction projects cost overruns in Gauteng, South Africa.

Time overrun: Time is the most crucial element in measuring project success and it is referred to the duration for completing the project. It is scheduled to enable the building to be used by a date determined by the client's future plans. (Mirawati et al., 2015)

Various factors have been identified by different researchers from the time aspect in different construction industries. Lack of materials, incomplete drawing, incompetent supervisors, lack of tool and equipment, absenteeism, poor communication, poor site layout, inspection delay and rework were found to be the most significant problems affecting project duration (time). (Ibironke & Elamah, 2011)

Time overruns occur when projects is not completed within the time the project plan specifies. This can occur due to many reasons. Time overruns leads to disruption of work and project productivity, disputes, late project completion, increase in time related cost and third party claims and abandonment or terminate of contract. (Raykar, 2016).

Most significant factors affecting time management in the Nigerian construction industry. They are lack of materials, rework, equipment, supervision delays, absenteeism and interface. Lack of material, weather, and physical site conditions, lack of proper tool and equipment, design, drawing and change orders inspection delay, absenteeism, safety, improper plan of work, repetitive work, changing crew size and labour turnover were found to be the most critical factors (Ibironke & Elamah, 2011)

Time overruns occur when projects is not completed within the time the project plan specifies. This can occur due to many reasons. Time overruns leads to disruption of work and project productivity, disputes, late project completion, increase in time related cost and third party claims and abandonment or terminate of contract.(Raykar, 2016).

When the stipulated completion time is pushed forward, the project is said to have experienced a schedule overrun. Schedule overrun refers to the late completion or late delivery, from the time specified or agreed by all parties of the construction project. The main causes for the schedule overrun are financial problems, late payments for the completed work and ongoing work, change orders, organizational changes, etc. Mukuka et al., (2015)

Cost overrun: Cost is the degree to which the general conditions promote the completion of a project within the estimated budget. Cost is not only confined to the tender sum, it is the overall cost that a project incurs from inception to completion, which includes any costs arise from variations, modification during construction period and the cost arising from the legal claims, such as litigation and arbitration. (Mirawati et al., 2015)

The ability to accurately predict the client's financial commitment to a project, which also forms the basis of the contractor's eventual revenue, has many advantageous implications. As a pre-warning indicator, alternative courses of actions can be examined and provision can be made for the preferred option. The client according to has the capital and related interests to consider often with no prospect of a financial return until full completion of the project. For large project, consisting of independent units and for situations where a number of projects are concurrently running, an indication of an overall cost that can be committed is crucial.(Ibironke & Elamah, 2011)

Cost overrun occurs when the expenses required to complete a project, or one aspect of a project, exceeds the amount which is budgeted. This cost overrun is common in construction projects and can happen for any number of reasons. Any delay in completion

of project makes the initial cost estimates obsolete leading to cost overruns. If budget overruns are not under control it can inhibit the desired growth thereby adversely affect the project completion.(Raykar, 2016)

When a project is completed at a cost higher than what was budgeted, it is said to experience a budget overrun. Critical factors that cause cost overruns in construction projects as changes in the scope of work on-site, incomplete design at the time of tender, contractual claims (extension of time with cost), lack of cost planning and monitoring of funds, delays in costing variations, and additional works. These critical factors in turn are the delay factors. cost overruns can be traced back to “root causes” that are often associated with the preliminary phases, project planning, or design, such root causes include; poor estimation of quantities, design variations or errors, project schedule changes, scope changes, unexpected site conditions, rising costs of materials and labor (largely due to inflation), and or unforeseen events. The following as the causes of cost overruns; increase in cost of labor, working force, materials and equipment and other factors. The main causes of the cost overrun are change orders, mistakes in the contract, changes in drawings etc. Mukuka et al., (2015)

Dispute and Claims: Disputes and claims arise because of the losses incurred through schedule overruns. Disputes normally come down in assessing three aspects of overruns: whose fault was it or who caused the overrun, how much delay occurred and, consequently, what monetary awards should be made. The Critical Path Method is primarily useful in addressing the second of these conditions and in some cases can be used to assist in determining at least a portion of the monetary awards. The main causes of disputes are slow or late payments for completed or ongoing work, client interference, neighbor issues, change in requirements, distribution of work, less communication within parties, subcontractor issues etc.

Arbitration: projects would have extra costs and time consequences related to the engagement of professional arbitrators in cases of disputes that go through arbitration.

Litigation: Disputes, due to schedule overruns, can lead to court cases for resolution especially when large penalties are at stake litigation as negotiations and going to court to solve the problems and it takes a long time to solve the problems. The main causes are late or no payments for completed work or on-going work and change orders.

Total project abandonment: schedule overruns in project execution could lead to total abandonment if issues leading to the overruns are not resolved timeously. Total abandonment of the construction project as stopping every work or suspending the project for a long time. The main causes of abandonment are organizational changes, regulatory changes, finances and payments and natural disasters. Many large construction projects are temporarily or permanently abandoned due to financial crisis, natural disasters and organizational changes.

Quality: Quality is defined as meeting the customer's expectations, or compliance with customer's specification in terms of appearance, performances, and reliability of the project for a given price range. Quality as meeting of the project's established requirements in term of materials and workmanship. (Mirawati et al., 2015)

The construction industry like any other production industry is faced with challenges that affect the performance and output of the endeavor. Identifying potential critical factors that affect the quality performance of small scale contractors before the commencement of projects will ensure client satisfaction at the completion of project. Identifying the potential critical factors will however not eliminate the problem of quality but to a large extent help project team to avoid such negative factors and strictly adhere to project specifications to reduce errors which will call for re-work by both consultants and contractors.(Oke, 2017)

The main contractor's success on projects relies on the temporary bounded interdependent services of the subcontractors. Because the services have not yet been performed, it remains difficult for the Main Contractor to accurately evaluate in advance the motives and intentions of the Subcontractor because their quality of resources, assets and capabilities are unknown Nevertheless, the main contractors is willing to compromise on technical know-how and co-operative skills, as long as the Subcontractor's quality is acceptable to achieve market-conform price. (White et al., 2014)

Quality Performance is a management tool that is aimed at giving necessary information to identify quality improvement opportunities for better performance and productivity that international construction projects performance is affected by more complex and dynamic factors than domestic projects. This is due to the fact that the former is frequently exposed to serious external uncertainties such as political, economic, social and cultural risks as well as internal risks from within the project.(Oke, 2017)

2.8 Strategies to minimize the impact of schedule overruns

Delays in construction projects are frequent regardless of the type of project. Delay in a construction project is defined as time overrun either beyond the date the contracting parties agree upon for delivery of the project or beyond the conclusion date specified in the respective contract. A project must be finished on time and fulfill the designated quality and cost requirements, as specified by the client's needs, to be considered successful. The main parameter for assessing a project's success is its timely conclusion.(Arantes & Ferreira, 2021)

This study used a survey to identify the main causes and the underlying causes of delays in the Portuguese construction industry with the aim of developing measures to mitigate those delays. Main causes of delays were slow decision-making, changes to orders, unrealistic time schedules and specifications in contracts, financial constraints on the part of contractors and the bidding and contract award processes. Six underlying causes of delay, namely, improper planning, poor consultant performance, inefficient site management, owner's influence, bureaucracy and sub-standard contracts. Finally, experts proposed a set of measures to mitigate delays considering the underlying causes and the ten top causes of delays. These results highlight the importance of the owner in avoiding delays in construction projects. As for the practical implications for the construction industry in Portugal, the owners should adopt bidding and contract award processes based on the most economically advantageous bid; improve their engineering and project management skills; promote the development of realistic plans and scheduling; select contractors with capable site managers, reliable equipment and dependable subcontractors and suppliers and select consultants with adequate experience and adequate skills. Moreover, BIM implementation is recommended for an effective flow of information. Finally, formal and legal instruments to manage the risks associated with project execution should be included in the project contract.(Arantes & Ferreira, 2020)

The present state of management in Malaysia construction industry. The implementation and use of a quality management system would provide logical and progressive sequence of work and prevent or mitigate delay in construction. The importance of coordinating the various management teams is required in the project environment and should be encouraged by all management of the functional groups involved. Depending on the contract type, the main participants will have to understand and commit their roles. The survey pointed out that there is some correlation between the type of contracts and delay

and the percentage of projects suffering from delay is relatively high.(Abdul-Rahman et al., 2017)

It is discovered that preventive measures are the most effective mitigation measures practiced in Malaysia, as they recorded the highest index coefficient in the SEM model. There are seven mitigation methods classified as preventive measures, namely a comprehensive contract document, competent project team, effective strategic planning, clear information and communication channels, ensuring timely delivery of materials, availability of resources and lastly, selection of a competent consultant and a reliable contractor. As preventive measures are predictions of problems to avoid the occurrence of delays through systematic precautions and past experience, construction players should emphasize evaluating past projects and strategic planning to enhance housing delivery performance.(Chai et al., 2015).

2.9 “Fuzzy” Definitions

Fuzzy means blurred, indistinct in shape or outline, frayed or fluffy. In modern mathematical society, fuzzy is defined as a branch of modern mathematics that was formulated by (Zadeh, 1965) to model vagueness intrinsic in human cognitive process and to solve ill-defined and complicated problems because of ambiguous, incomplete, vague, and imprecise information that characterize the real-world system. It is appropriate for uncertain or approximate reasoning that involves human intuitive thinking Zimmermann 2001 because much of our natural language is fuzzy in nature, for example, it was “very hot” yesterday; 100 is “much larger” than 10; I “like” watching TV; you drive “too fast,” please keep it “slower;” and he is not too “old.”((Chan et al., 2015).

According to Fayek & Lourenzutti, (2018)Construction management involves the development and application of techniques that will improve our ability to plan, structure, forecast, control and evaluate projects in order to deliver results that meet or exceed performance objectives, such as time, cost, productivity, quality and safety. Construction projects frequently represent large investments from numerous parties, but modelling and predicting the ways in which they will evolve is a difficult task. Decisions related to project planning, execution and investment, for example, can be quite complex. This complexity arises from the multiple interacting factors that affect each project and the fact that each project is unique, limiting the direct transfer of knowledge and data from previous projects that could be used to predict the ways in which a future project will unfold. Hence, there is a heavy reliance on experts to make decisions in the construction

industry, which causes a demand for modelling techniques that are able to capture and process subjectivity.

Fuzzy logic is widely used in problems that cannot be explained on the basis of Aristotelian Logic and because the parameters that are not taken into account in line with the 0-1 logic cause significant result changes in the equation, and because concepts such as "warm" are placed in the equation instead of just "cold" or just "hot".(Fuzzy Logic Toolbox™ User's Guide R2024a, 1995)

Today, computer technology is constantly evolving. Thanks to this emerging technology, it is possible to apply different and complex mathematical models. Artificial intelligence methods; It provides effective solutions in many design and analysis. Fuzzy logic method, which is one of these models, provides a starting point for important applications in artificial intelligence.(Büyükkaracıgan, 2022)

The Aristotelian logic used in the scientific world contains only 0 and 1 relations (open/closed). However, in Aristotelian logic, there is no near-hot, cold, or near-small-large. For brief information purposes, the weather temperature can only be given as cold and hot. However, there are also gray people, medium-height individuals, and warm weather in daily life in this respect, Aristotelian logic is not sufficient to explain the events that occur in daily life. Fuzzy logic is widely used in problems that cannot be explained based on Aristotelian Logic and because the parameters that are not taken into account in line with the 0-1 logic cause significant result changes in the equation, and because concepts such as "warm" are placed in the equation instead of just "cold" or just "hot".(Büyükkaracıgan, 2022)

2.10 Fuzzy Sets and Membership Functions

In several situations, concepts that are not precisely defined must be addressed. This lack of precision makes the processing of such concepts much more complex, since they do not have a clear boundary between true and false. For instance, if a \$200,000 house is considered expensive, a discount of \$10 in the price of the house will probably not change its classification, and the house will probably still be considered expensive, but maybe to a lesser degree. The classification of a person as tall will probably not change if his or her size varies by 1 cm. Dealing with these uncertain concepts, or fuzzy concepts, using classical set theory may lead to unrealistic situations where, for example, a house that costs \$199,999.99 is classified as having a low price while a house that costs \$200,000 is classified as having a medium price. This issue occurs because, in classical set theory, an

element either fully belongs or does not belong to a set. Such a requirement imposes a sharp boundary on uncertain concepts. On the other hand, fuzzy set theory, which can be seen as a generalization of classical set theory, provides a way to overcome such challenges by allowing an element to partially belong to a set. This capability is accomplished by using a membership function. Membership functions assign to each element a membership degree.(Fayek & Lourenzutti, 2018)

Membership functions assign to each element a membership degree, usually denoted by μ , between 0 (no membership) and 1 (full membership). By using membership functions, it is possible to capture the gradual transition between concepts. For instance, the price of a house is measured numerically in dollars; however, the concepts of low and medium prices are not precisely defined, presenting a gradual transition from one concept to the other. In other words, a price, say of \$150,000, can be considered a low price and a medium price at the same time but to different extents.(Fayek & Lourenzutti, 2018)

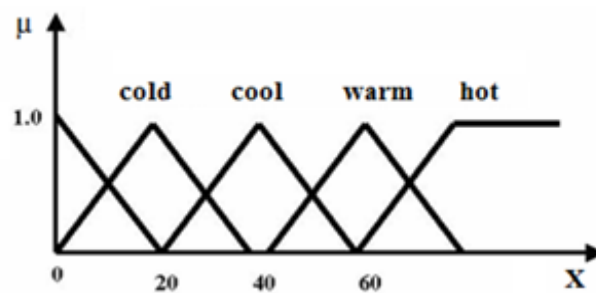


Figure 2.1 Fuzzy logic membership

2.11 Fuzzy Logic Toolbox of the MATLAB Software

Fuzzy Logic Toolbox software supports two types of fuzzy inference systems:

Mamdani fuzzy inference was first introduced as a method to create a control system by synthesizing a set of linguistic control rules obtained from experienced human operators. In a Mamdani system, the output of each rule is a fuzzy set. Since Mamdani systems have more intuitive and easier to understand rule bases, they are well-suited to expert system applications where the rules are created from human expert knowledge, such as medical diagnostics.

Sugeno fuzzy inference also referred to as Takagi-Sugeno-Kang fuzzy inference, uses singleton output membership functions that are either constant or a linear function of the input values.

The defuzzification process for a Sugeno system is more computationally efficient compared to that of a Mamdani system, since it uses a weighted average or weighted sum of a few data points rather than compute a centroid of a two-dimensional area.

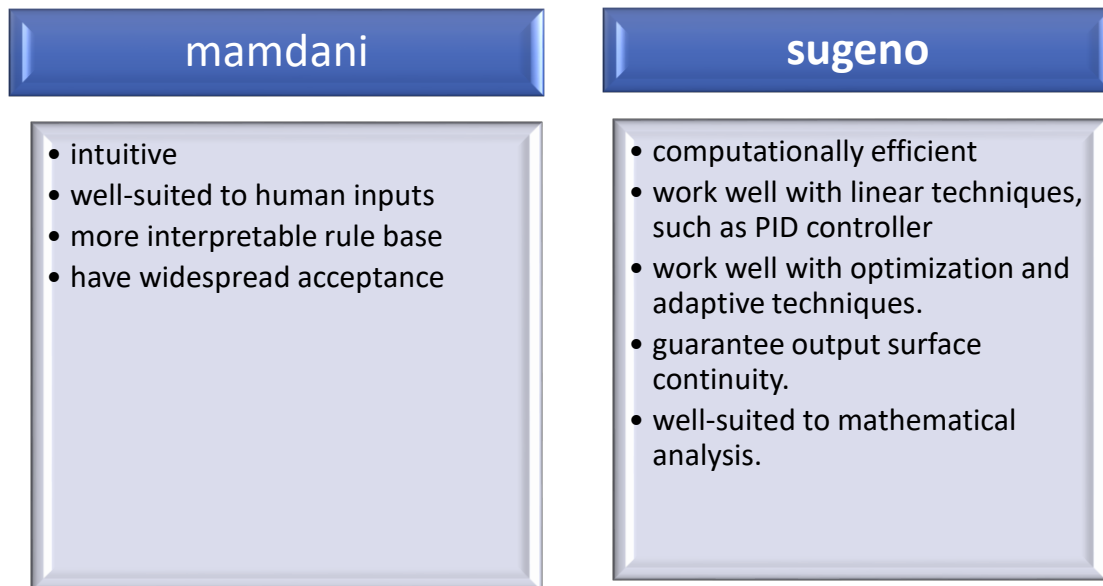


Figure 2.2 Advantage of mamdani and sugeno

2.12 Research gap

To thoroughly understand crucial concepts for this thesis, extensive literature has been reviewed. While many researchers focus on the impacts of schedule overruns from the perspective of main contractors, it's recognized that the performance of main contractors heavily depends on subcontractor performance. Therefore, this study aims to pinpoint the factors influencing schedule overruns among subcontractors and examine the consequential impacts. The research employs fuzzy logic methods for its analytical approach to derive precise values.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This section describes the procedures undertaken to achieve the research objectives. The procedures adopted, including all the information relevant to the data collection and where those data were obtained are discussed. In addition, data and information sources, research instruments, sample size, and method of analysis are presented.

3.2 Research Design

The strategy followed in carrying out the research was started with problem identification which has been done through unstructured literature review, archival study and informal discussion with colleagues and professionals in the sector; and then the research design was formulated.

Following this data and information sources were determined based on the formulated research design. On the basis of the data and information sources the research instruments were decided; and available documentary sources relevant to the research were reviewed. The review includes books, journal and articles, internet sources and archival document.

After a literature in-depth review, a questionnaire was designed and distributed to contractors to get their professional opinion based on their experience. The case study was mainly intended to collect values of time overrun and quantitative research method is selected to show their degree of appearance

The research design was developed to identify the impacts of subcontractor's schedule overruns in building Construction and major factors of schedule overruns.

This research was designed in order to address the problem identified in the previous chapters and achieve the objectives stated.

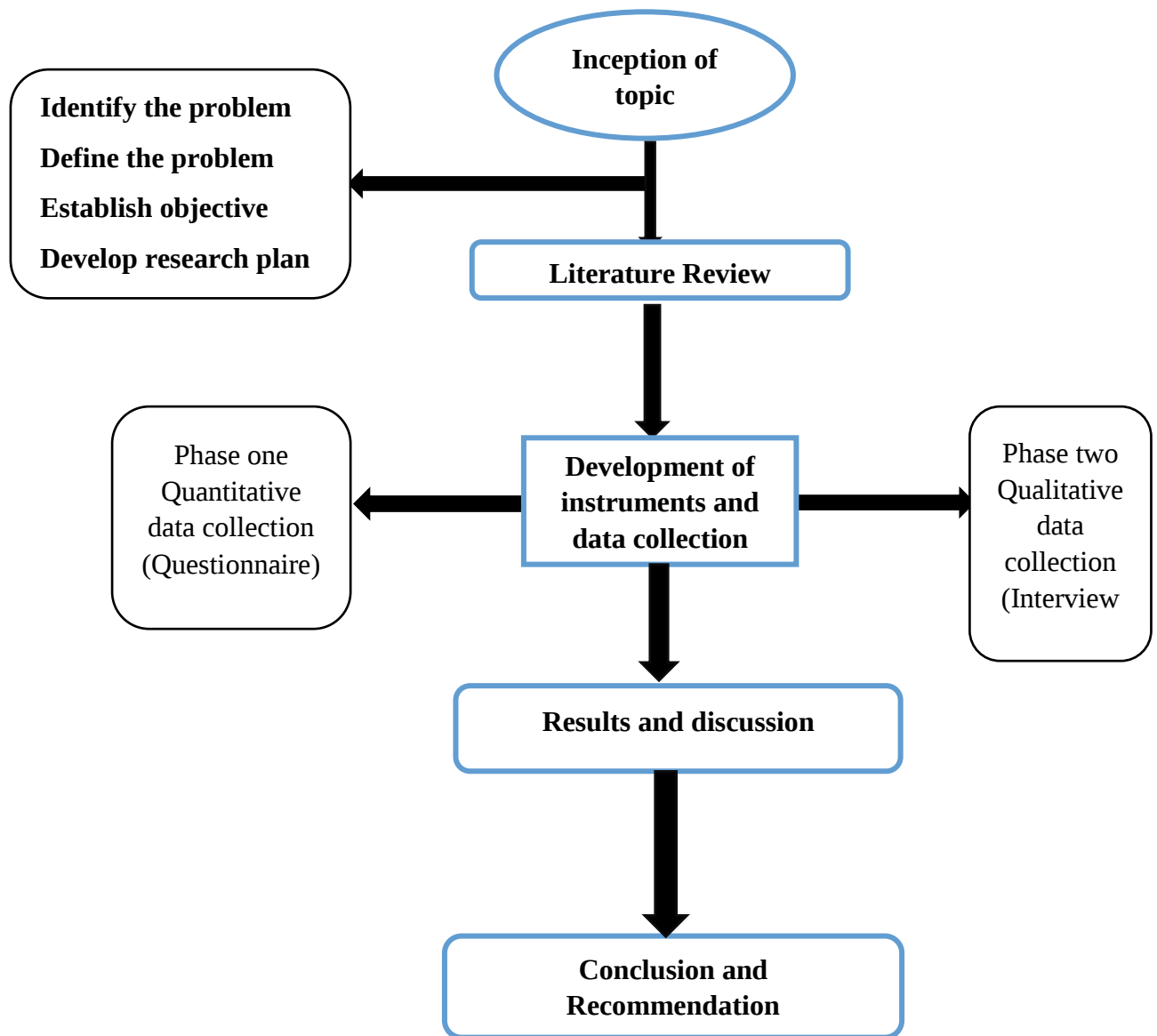


Figure 3.1 Research design

3.3 Source of Data and Data collection approach

The data collection approach revolves around determining the kinds of evidence required and where to obtain them, as well as establishing the methods of interpretation necessary to derive meaningful answers to the research questions at hand.

There are three basic approaches to research, quantitative approach, qualitative approach and mixed approach. Quantitative research is a study where purely quantitative data and analysis techniques are adopted. It involves the generating of numerical data or data that can be transformed into useable statistics to explain, predict, and/or control phenomena of interest. While the qualitative approach makes use of purely qualitative data and analysis. It attempts to maximize the objectivity, replicability, and generalizability of findings and is

normally interested in prediction. The mixed approach on the contrary adopts the combination of both quantitative and qualitative approaches.

This research involved both qualitative and quantitative characteristics. As a method of quantitative data collection, the questionnaire is a very flexible tool that has the advantages of having primary data, a structured format, easy and convenient for respondents, and quick to administer to a large number of cases covering large study areas. Besides the questionnaire, an interview which is a qualitative data collection instrument was also conducted to get individuals' perceptions and lived experiences. The one-to-one interview was conducted with selected individuals who represented major contracting parties and actively participated at different responsibility levels. In addition to the primary data secondary data are gathered from journals, previous related studies, and internet sources.

3.4 Design of the survey

3.4.1 Questionnaire design

One of the research instrument used in this research was questionnaire which was designed in such a way that it ensures to address the objectives of the study. The questionnaire was designed to be a close ended questions including with few comment spaces. These type of questions had a number of choices of possible answers and the respondents selected whatever they feel was most appropriate. The closed ended questions were also selected because they are easier to assess and answer considering how busy the respondents were. It is prepared based on the literature reviewed, interviewing experts and by referring to previous studies. For the addressing of all parties involved in construction, the questionnaires were prepared in English.

3.5 Population and Sampling

3.5.1 Research Population

The targeted construction sites for this study are Bishoftu poly-technic College, 2B+G+12 Oromia police commission, Sebeta municipality office B+G+5, Sululta town mini stadium, Jamo-3 fruit and vegetable shade project phase-1, Dukem municipality, Fiche integrated bus terminal and Remaining building works of B+G+6 at Adama which are under construction by Oromia construction corporation(OCC).

Table 3.1 sample size population

Oromia Construction Corporation Building project Around Addis Ababa					
Project name	Location	Project manager	Site engineer	Office engineer	Total
Bishoftu poly-technic college	Bishoftu	1	3	2	6
2B+G+12 Oromia police commission	A.A	1	10	5	16
Sebeta municipality office B+G+5	Sebeta	1	3	2	6
Sululta town mini stadium	Sululta	1	4	2	7
Jamo-3 fruit and vegetable shade project phase-1	A.A	1	2	1	4
Dukem municipality	Dukem	1	3	2	6
Fiche integrated bus terminal	Fiche	1	4	2	7
Remaining building works of B+G+6 at Adama	Adama	1	2	2	5
Total					57

3.5.2 Sample Size

A sample is a small portion of a population which give a fairly representative view of the whole population. The process of selecting just a small group of cases from out of a large group is called sampling.

The parties who participated in this study were only the main contractor which is Oromia Construction Corporation (OCC). There were around 50 building construction projects in Oromia Construction Corporation (OCC. From these sites, 8 projects were selected for this study out of the 50 building projects which are available around Addis Ababa. As a result, the study used the 8 projects under consideration as a target population. The researcher

believes they can supply sufficient information about the study subject by giving accuracy to the data to be gathered.

3.6 Methods of data analysis

Creating a FIS (Fuzzy Inference System) structure typically involves several steps. Fuzzy logic is a mathematical approach to dealing with uncertainty in systems, and a FIS is a framework for implementing fuzzy logic. Here are the general steps to create a FIS structure:



Figure 3.2 fuzzy inference steps

3.6.1 Define input variables

Identify the variables that will influence the system. These could be physical quantities, measurements, or other factors that impact the system's behaviour. Determine the range of values for each input variable and discretize them into linguistic terms. For example, if one input variable is "temperature," linguistic terms could include "cold," "warm," and "hot."(Fuzzy Logic Toolbox™ User's Guide R2024a, 1995)

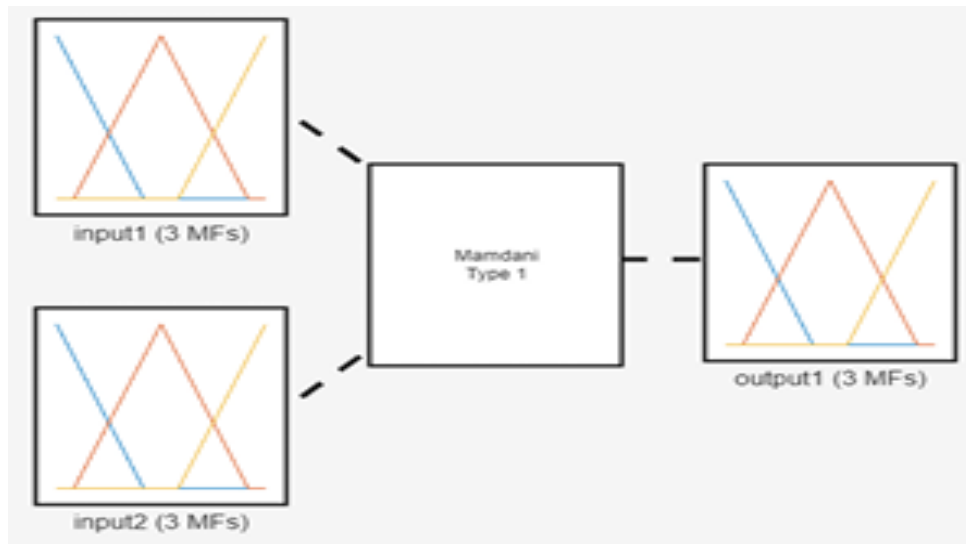


Figure 3.3 input variables

In the Property Editor, define the following properties for each input variable.

- Name — Input variable name. For this example, name the first input service and the second input food.
- Range — Input variable range. For this example, both inputs are rated on a scale from 0 through 10. Therefore, specify each variable range as [0 10]

PROPERTY EDITOR: INPUTS			
	Name	Range	Number of MFs
1	service	[0 10]	3
2	food	[0 10]	3

Figure 3.4 property editor

3.6.2 Define Output Variables

Identify the output variables of the system. These represent what you want the system to achieve or control. Determine the range of values for each output variable and discretize them into linguistic terms.

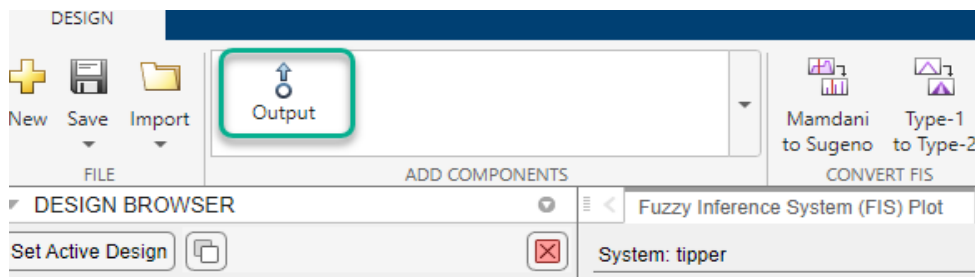


Figure 3.5 output variables

For this example, the template FIS already has one output variable. In the System Browser pane, click Outputs. The app displays the properties of the output variable in the Property Editor.

In the Property Editor, define the following properties for the output variable.

- Name — Output variable name. For this example, name the output variable tip.
- Range — Output variable range. For this example, specify the output variable range as [0 30]

PROPERTY EDITOR: OUTPUTS			
	Name	Range	Number of MFs
1	tip	[0 30]	3

Figure 3.6 output property editor

3.6.3 Define Membership Functions

Membership functions play a vital role in fuzzy logic by assigning membership degrees to elements, representing the degree to which an element belongs to a fuzzy set. These degrees typically range between 0 (indicating no membership) and 1 (indicating full membership). Membership functions enable the gradual transition between concepts, allowing for the representation of uncertainty and imprecision in linguistic terms.

By employing membership functions, fuzzy logic captures the gradual transition between different states or concepts. For example, consider the linguistic term "temperature" with fuzzy sets such as "cold," "cool," "warm," and "hot." The membership function for each set assigns degrees of membership to temperatures within a specified range. As the temperature changes, the membership degrees smoothly transition between the linguistic terms, reflecting the gradual change in perceived temperature.

In essence, membership functions facilitate the modelling of fuzzy concepts by quantifying the degree of belongingness of elements to fuzzy sets. This capability is particularly useful in domains where precise boundaries between categories are difficult to define, allowing fuzzy logic to effectively handle real-world complexities and uncertainties.

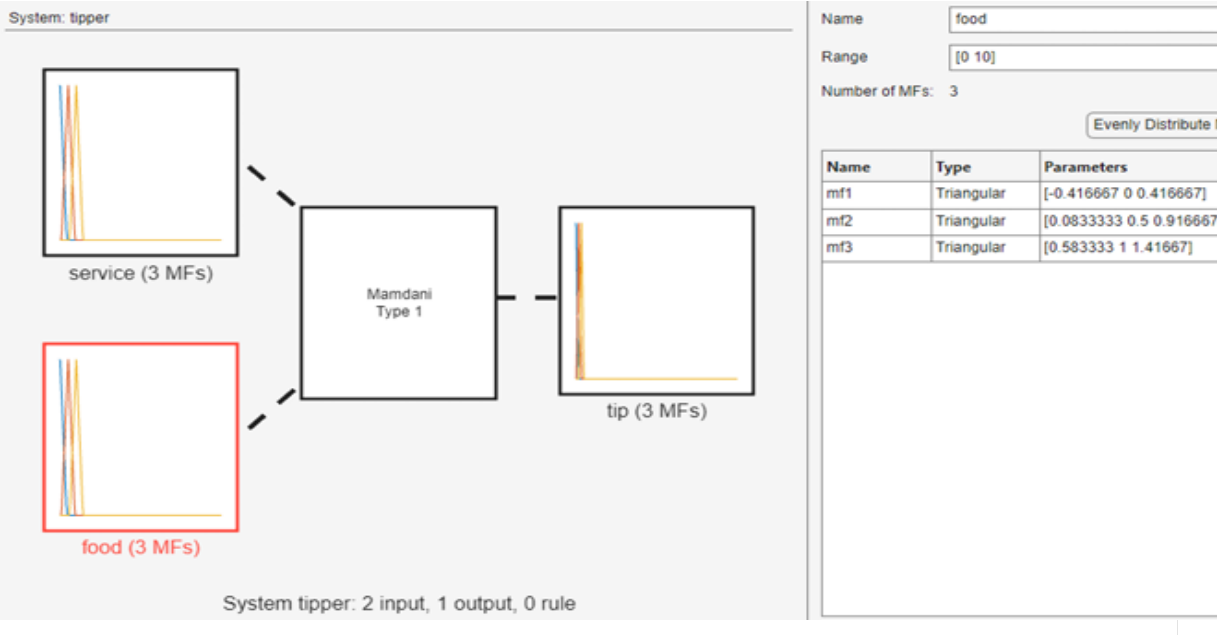


Figure 3.7 membership function

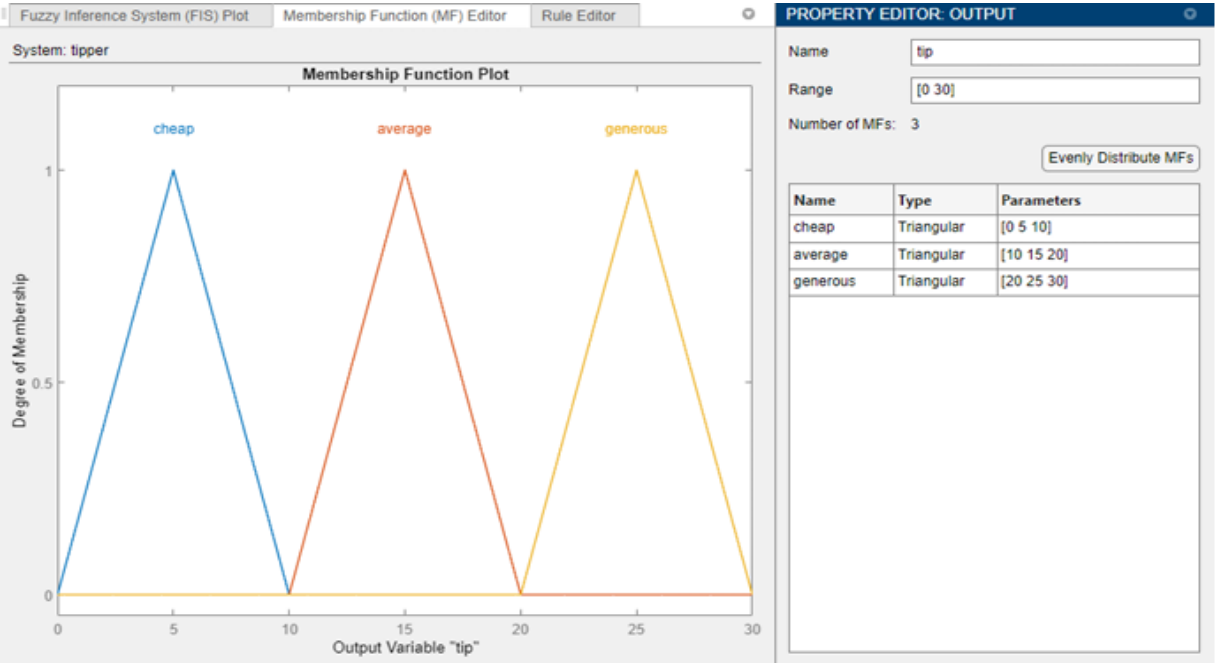


Figure 3.8 membership editor

To edit membership function properties, in the System Browser, select the membership function or the corresponding variable. Then, in the Property Editor, specify the following membership function properties.

- Name — Membership function name
- Type — Membership function type
- Parameters — Membership function parameters

3.6.4 Define Rule Base

Once you define the variables and membership functions for your FIS, you can define the if-then rule base for the system. For this example, use the following rules.

- If the service is poor or the food is rancid, then the tip is cheap.
- If the service is good, then the tip is average.
- If the service is excellent or the food is delicious, then the tip is generous.

Fuzzy Inference System (FIS) Plot Membership Function (MF) Editor Rule Editor			
System: tipper			
Add All Possible Rules Clear All Rules			
	Rule	Weight	Name
1	If service is poor or food is rancid then tip is cheap	1	rule1
2	If service is good then tip is average	1	rule2
3	If service is excellent or food is delicious then tip is generous	1	rule3

Figure 3.9 membership editor

Create a set of rules that represent the behavior of the system. These rules relate combinations of input variables to output variables.

Each rule typically takes the form of an IF-THEN statement. For example, "IF temperature is cold AND humidity is high THEN turn on the heater."

Determine the number of rules needed and ensure they cover the possible combinations of input variables adequately.

3.6.5 Analyze Design

Once you define your rule base, you can analyze your design using the following documents.

- Rule Inference — specify input values and view the inference diagram and resulting output value.
- Control Surface — Plot the output values for all combinations of two input variables.

- System Validation — Compare the outputs from each FIS design with the corresponding output value from the testing data.
- Error Distribution — for a given FIS design and testing data, view the output error for different combinations of inputs

For this study, analyze the FIS using the Rule Inference and Control Surface documents.

3.8.4.1 Rule Inference

In the Rule Inference document, you specify values for your input variables, inspect the inference process, and view the resulting output value

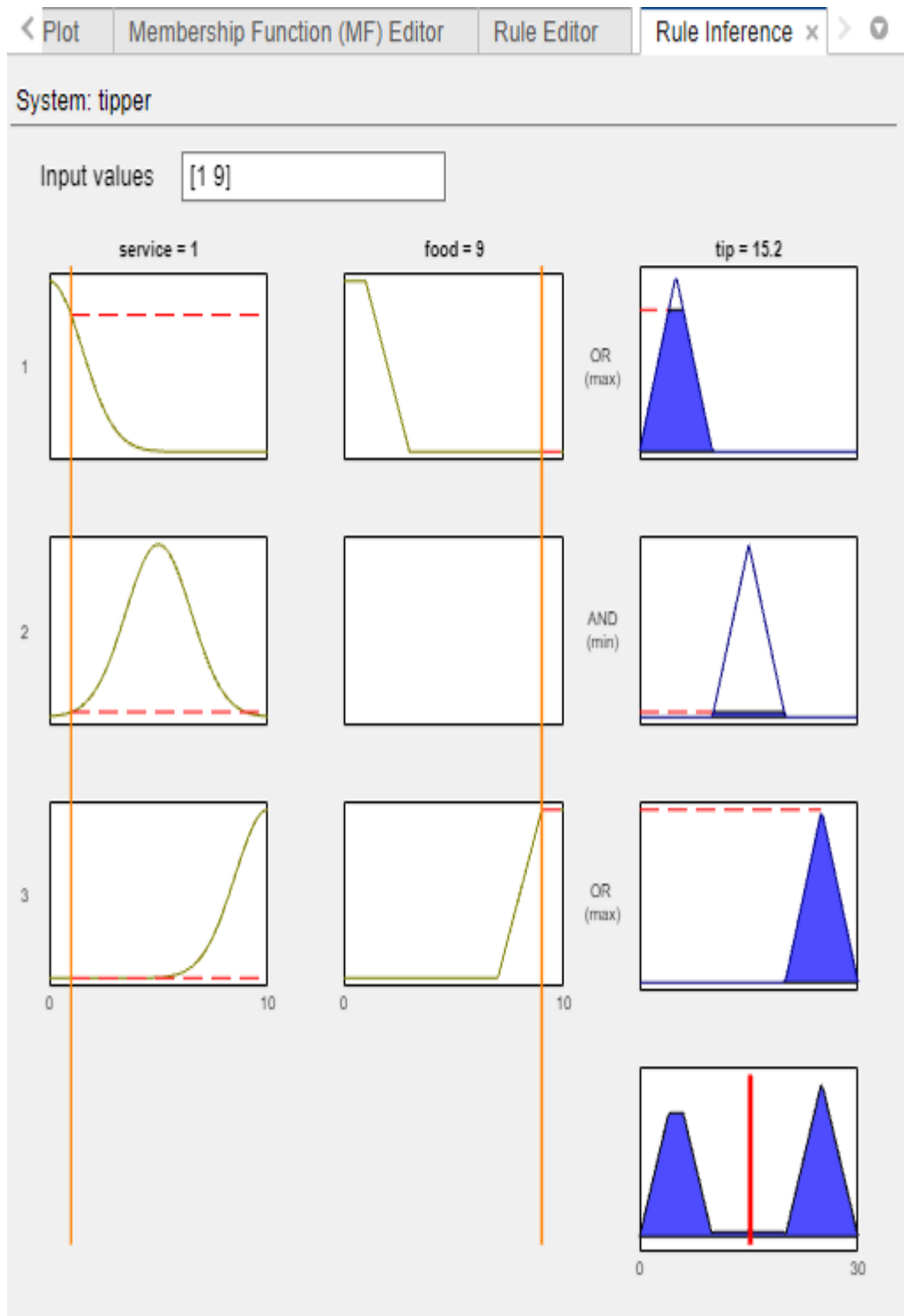


Figure 3.10 rule inference

3.8.4.2 Control Surface

The Control Surface document shows the FIS output value for all possible combinations of two input variables.

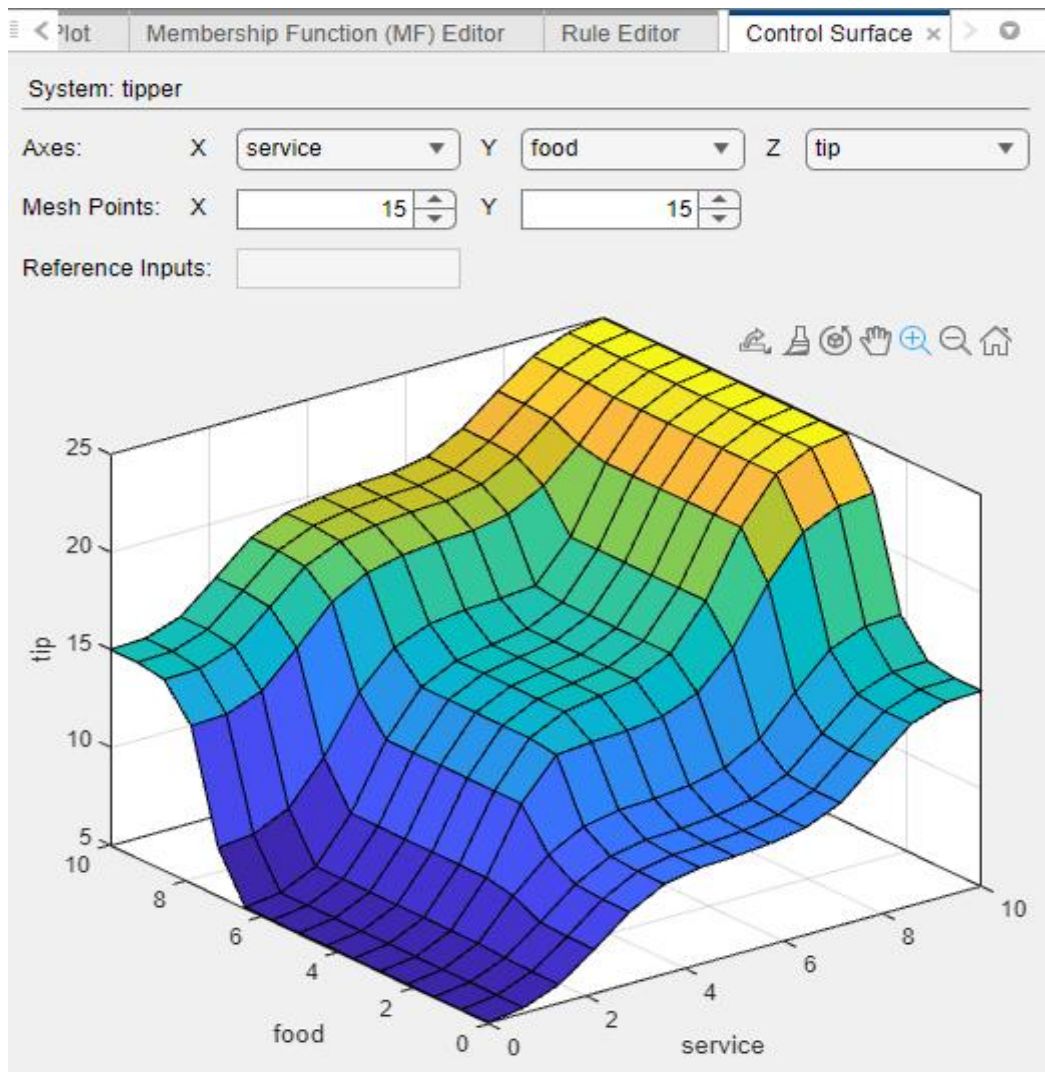


Figure 3.11 control surface

3.7. Ethical Consideration

Throughout the data collection process, ethical considerations were taken into account. The analysis tool began on the main page with a clear explanation of the study's aims and a statement that the participants' names were kept anonymous. Every chosen responder was informed that their participation in the study is entirely optional, and only those who grant written consent were allowed to take part. Throughout the research process, alternative scholars' contributions were acknowledged, and anybody who assisted the researcher in any way was treated with respect.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This research studied the major factors influencing schedule overrun and impacts of factors influencing schedule overruns on building project on Oromia Construction Corporation (OCC). This chapter presents the output of the analysis and discusses major findings. The data collected were analyzed using the fuzzy logic designer in MATLAB program software. The data analysis and discussion were carried out and organized according to the objectives of the research. The analysis output is presented in form of figures and tables. The major findings are discussed and the results are compared to the literature review.

4.2 Response Rate

A total of 57 questionnaires was sent to the three groups of respondents in the building construction projects of Oromia Construction Corporation (OCC). Out of 57 questionnaires, 48 questionnaires were collected which comprises 7 from project manager, 25 from site engineers and 16 from office engineer. This gives a response rate of 84.21% as shown in Table 4.1 shows summary of overall survey response.

Table 4.1 response rate

Group	Questionnaire Distributed	Questionnaire Returned	Percentage Returned (%)
Project manager	8	7	87.5
Site engineer	31	25	80.64
Office engineer	18	16	88.89
Total			84.21

4.3 Respondents' Profile

Based on the figure below the researcher gathered information on the level of education, position in the company and working experience in construction project since it help understand the organizations exposure and challenges.

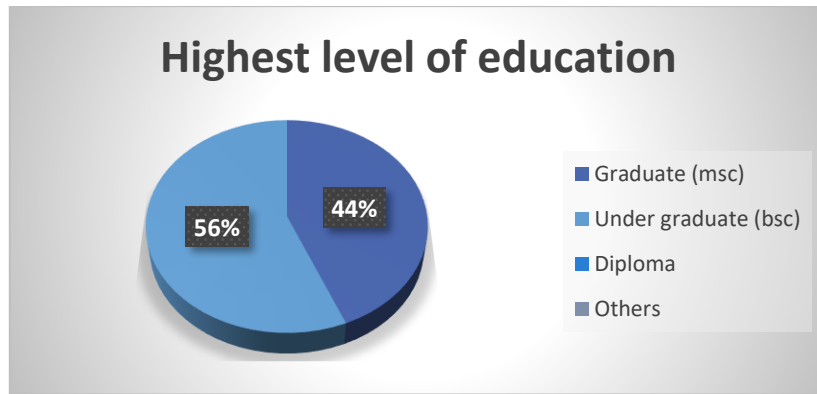


Figure 4.1 highest level of education

Out of the 48 respondents 56% of the respondents had under graduate (BSc) and 44% had graduate (MSc). The percentage distribution of the various professionals indicates that the majority of the questionnaires was completed directly by professionals involved in the road construction industry. The survey also shows that it was well represented by better qualified professionals in the construction management and these groups of respondents are expected to have plenty of knowledge on the subject matter.

Regarding the position the respondents' are working on the organization a majority of the respondents were working as site engineer (52%), 33 % were working as an office engineer, 15% as a project manager, as shown in figure 4.2.

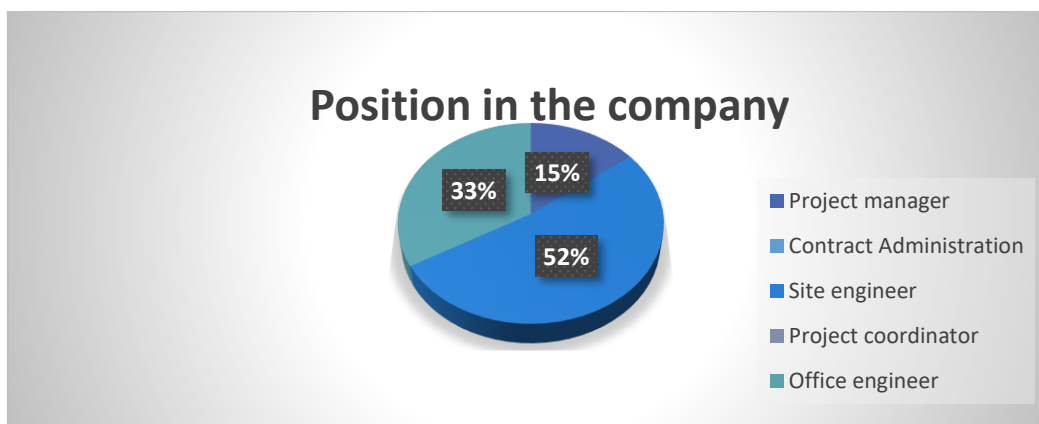


Figure 4.2 position in the company

Regarding the Professional experience of the respondents' a majority of the respondents had between 5-10 year experience (52%), whereas the second major respondents of a 3-5 year of experience (25%), the third respondent had between 10-15 year of experiences, the fourth respondent had between above 15 years of experience and the last respondent had below 3 years of experiences (4%) as shown in figure.

Based on the professional background and years of experience, it is safe to say that the respondents' for this study have a good understanding of the study matter, and could thus provide reliable answers to the questionnaire.

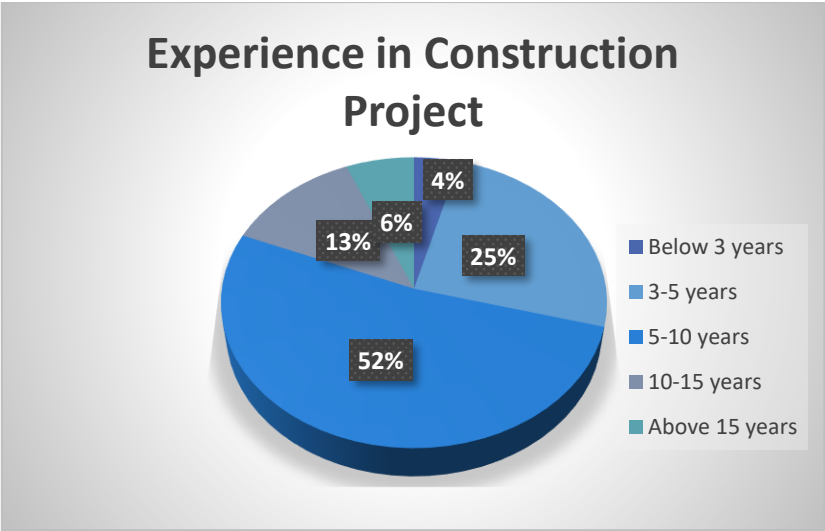


Figure 4.3 experience in construction project

4.4. Analysis of factors influencing schedule overruns of subcontractors.

In this section, analysis of respondents' understanding and views on construction local contractor performance cause and impact have been considered and discussed. The responses of the various contract groups to the questionnaire (Appendix A) were analyzed and discussed in subsequent sections.

Certainly! Schedule overruns of subcontractors can occur due to various factors, and identifying them is crucial for effective project management. Analyzing factors influencing schedule overruns in a project is crucial for identifying potential causes and implementing strategies to mitigate them.

Tables 4.2, 4.3, 4.4 and 4.5 show that responses by project manager, site engineer and office engineer on factors influencing schedule overruns of subcontractors related to main contractors, related to subcontractors ,related to consultant and related to client.. These factors were ranked accordingly.

4.4.1 Factors related to main contractors

In the table below it shows factors influencing schedule overruns of subcontractors related to main contractors.

Table 4.2 factors related to main contractors

Item no	Factors influencing schedule overruns of subcontractors related to main contractors	Mean	Rank
1	Poor site coordination.	2.6	5
2	Delay of shop drawing.	3.13	8
3	Delay of materials approval.	2.5	3
4	Delay in providing necessary materials and equipment for labor contract.	2.54	4
5	Lack of adequate planning and scheduling.	2.31	2
6	Financial difficulties faced by contractors.	2.15	1
7	Lack of clear communication.	2.85	7
8	Delay in effecting payment.	2.75	6

The table above shows the means score based on the response of the participants with respect to the factors related to contractors leading to schedule overrun of subcontractors are presented.

Financial difficulties faced by contractors mean score is 2.15 which is ranked as the first factors that cause schedule overruns of subcontractors from the others factors related to main contractors implying most of the respondents agreeing that financial difficulties faced by contractors mostly caused schedule overruns of subcontractors.

Lack of adequate planning and scheduling and delay of materials approval mean score is 2.31 and 2.5 respectively which ranked after financial difficulties faced by contractors implying that most respondents agreed that one of the causes for schedule overrun is the lack of adequate planning and scheduling and delay of materials approval.

Delay of shop drawing, delay in effecting payment and lack of clear communication mean score is 3.13, 2.85 and 2.75 respectively. Which ranked lastly that factors of schedule overruns of subcontractors less caused by delay of shop drawing, delay in effecting payment and lack of clear communication.

According to respondent's factors influencing schedule overruns of subcontractors related to main contractors is ranked lastly. Factors that causes schedule overruns of subcontractors which is 4.91. Factors influencing schedule overruns of subcontractors

related to consultant have less effect rather than factors related to subcontractors, consultant and clients.



Figure 4.4 rule inference for factors related to main contractor

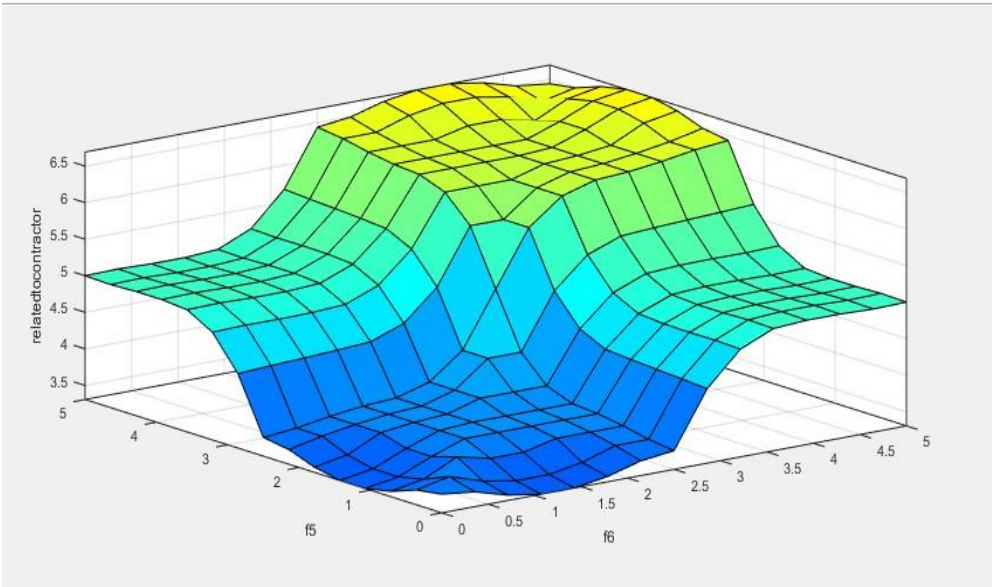


Figure 4.4 rule inference for factors related to main contractor

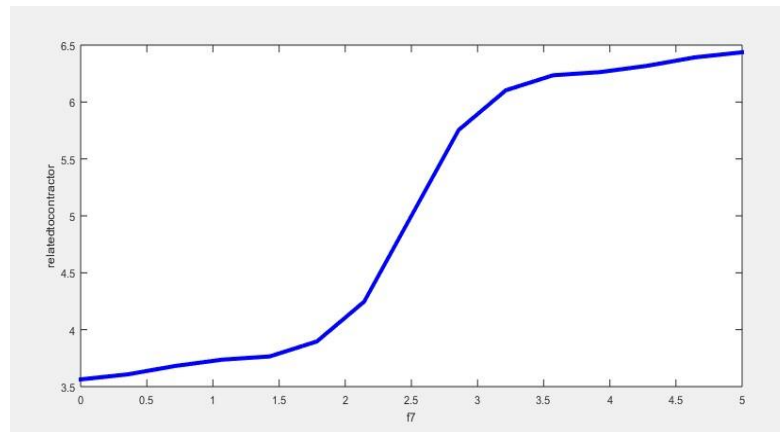


Figure 4.6 lack of clear communication

4.4.2 Factors related to subcontractors

In the table below it shows factors influencing schedule overruns of subcontractors related to subcontractors.

Table 1.3 factors related to subcontractors

Item no	Factors influencing schedule overruns of subcontractors related to subcontractors.	Mean	Rank
1	Shortage of skilled laborers and lack of experience.	2.04	1
2	Inaccuracy in sub contract cost	2.41	3
3	Unrealistic contract duration exposed	2.31	2

Shortage of skilled laborers and lack of experience mean score is 2.04 which implies most of the respondents agreed that schedule overruns of subcontractors are caused by shortage of skilled laborers and lack of experience of subcontractors which leads the project into schedule overruns.

Unrealistic contract duration exposed mean score is 2.31 which is ranked as the second position which implies that schedule overrun result due to Unrealistic contract duration exposed.

Inaccuracy in sub contract cost mean score is 2.41 which is ranked as a last place. Inaccuracy in sub contract cost have less effect in causing schedule overruns of subcontractors related to the other two factors.

According to respondent's factors influencing schedule overruns of subcontractors related to subcontractors is ranked as the first factors that causes schedule overruns of

subcontractors which is 4.11. most of schedule overruns of subcontractors caused by factors influencing schedule overruns of subcontractors related to subcontractors.

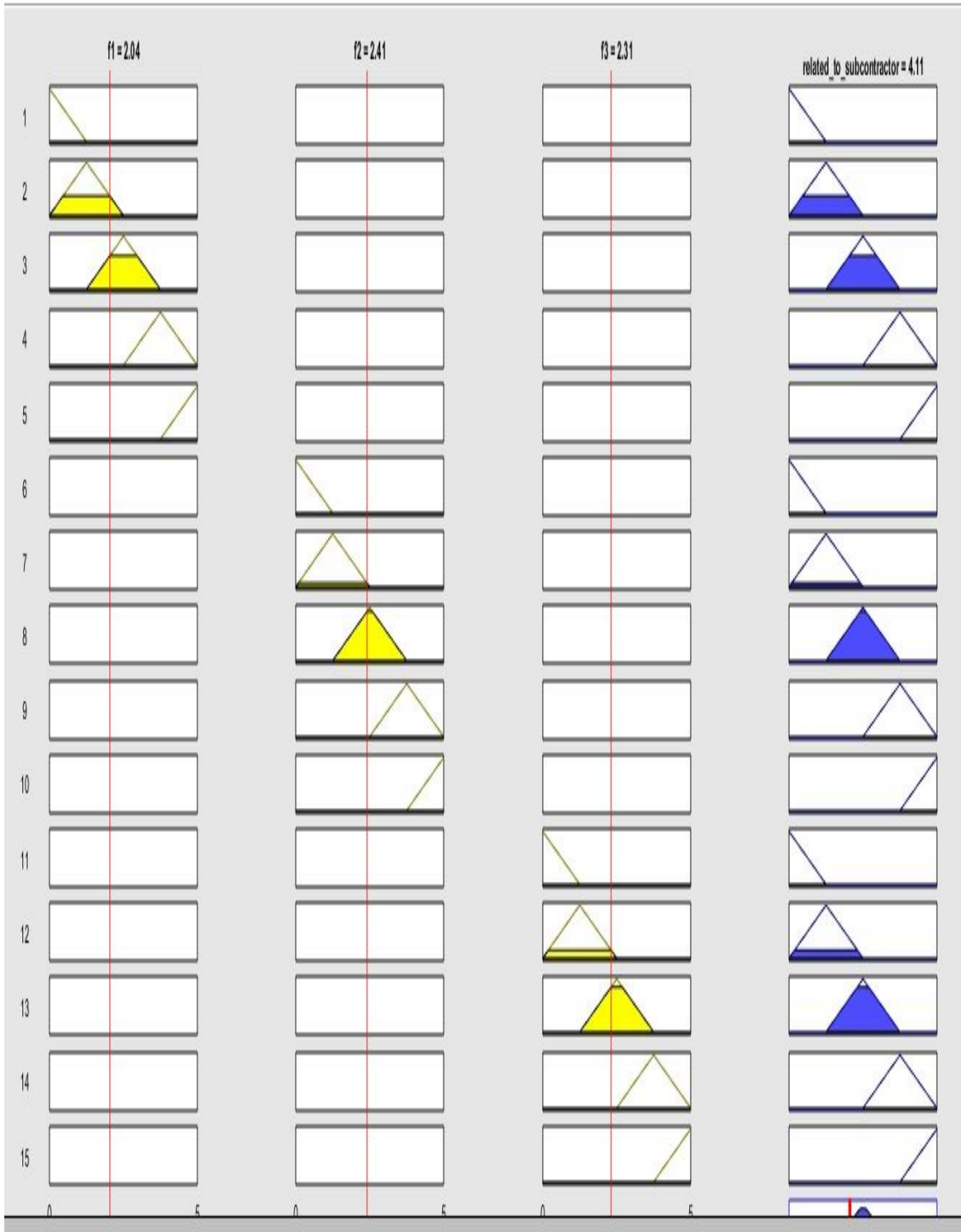


Figure 4.7 rule inference for factors related to sub-contractors

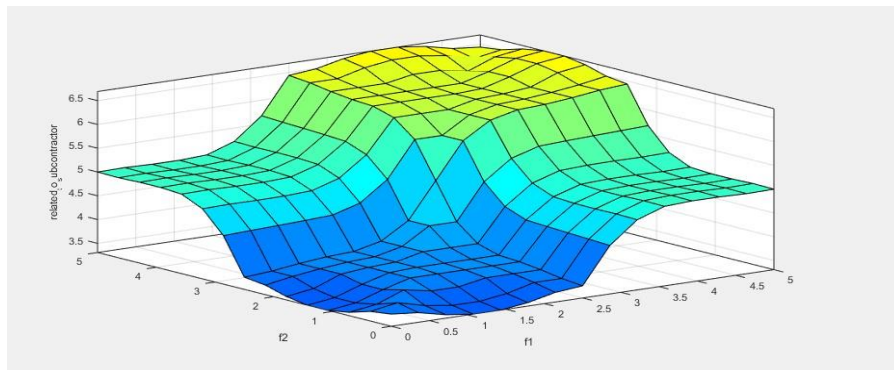


Figure 4.8 control surface for factors related to subcontractors

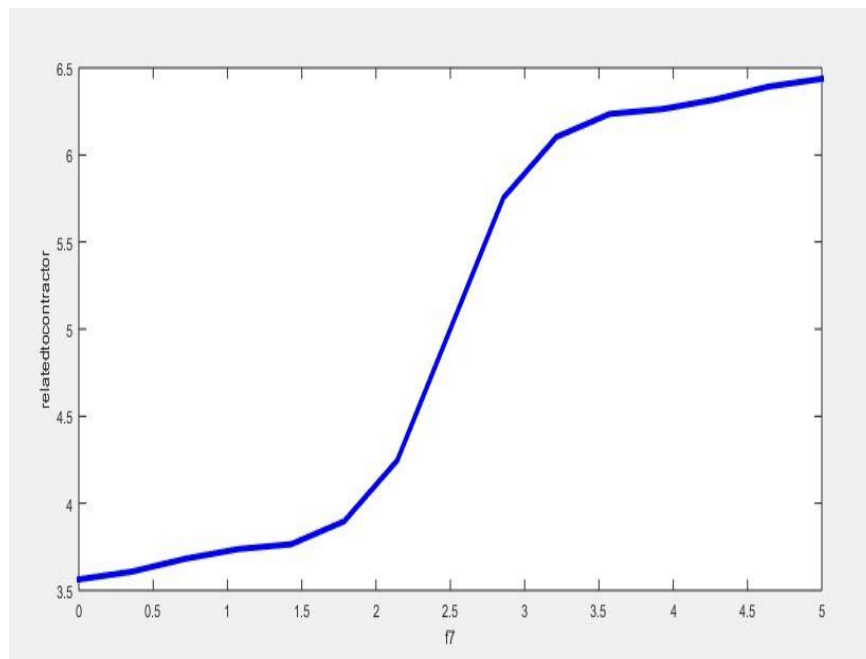


Figure 4.9 factor related to subcontractors

4.4.3 Factors related to consultant

In the table below it shows factors influencing schedule overruns of subcontractors related to consultant

Frequent design and scope changes mean score is 1.94. Frequent design and scope changes are ranked as first position which implies factors related to consultant mostly related to design and scope changes most of the respondents agreed that schedule overrun resulted due to frequent design and scope changes.

Lack of information flow between parties mean score is 2.23 which is ranked as a second factors that causes schedule overruns of subcontractors. Which implies most of the respondents agree that lack of information flow between parties faced by the consultant is one of the factors for schedule overrun.

Delay of shop drawing and delay of material approval mean score is 2.33 and 2.31 respectively which implies most of the respondents agree that cause of schedule overrun could be caused as a result of delay of shop drawing employed by the consultant and delay of material approval employed by the consultant

Lack of inception and supervision mean scores is 2.70 which is lastly ranked from others factors which implies most of schedule overruns factors are less likely be caused by lack of inception and supervision .

Table 4.4 factors related to consultant

Item no	Factors influencing schedule overruns of subcontractors related to consultant.	Mean	Rank
1	Lack of inception and supervision.	2.7	5
2	Frequent design and scope changes.	1.94	1
3	Lack of information flow.	2.23	2
4	Delay of shop drawing.	2.33	4
5	Delay of material approval.	2.31	3

According to respondent's factors influencing schedule overruns of subcontractors related to consultant is ranked as the second factors that causes schedule overruns of subcontractors which is 4.46. Factors influencing schedule overruns of subcontractors related to consultant have an adverse effect rather than factors related to main contractors and clients.

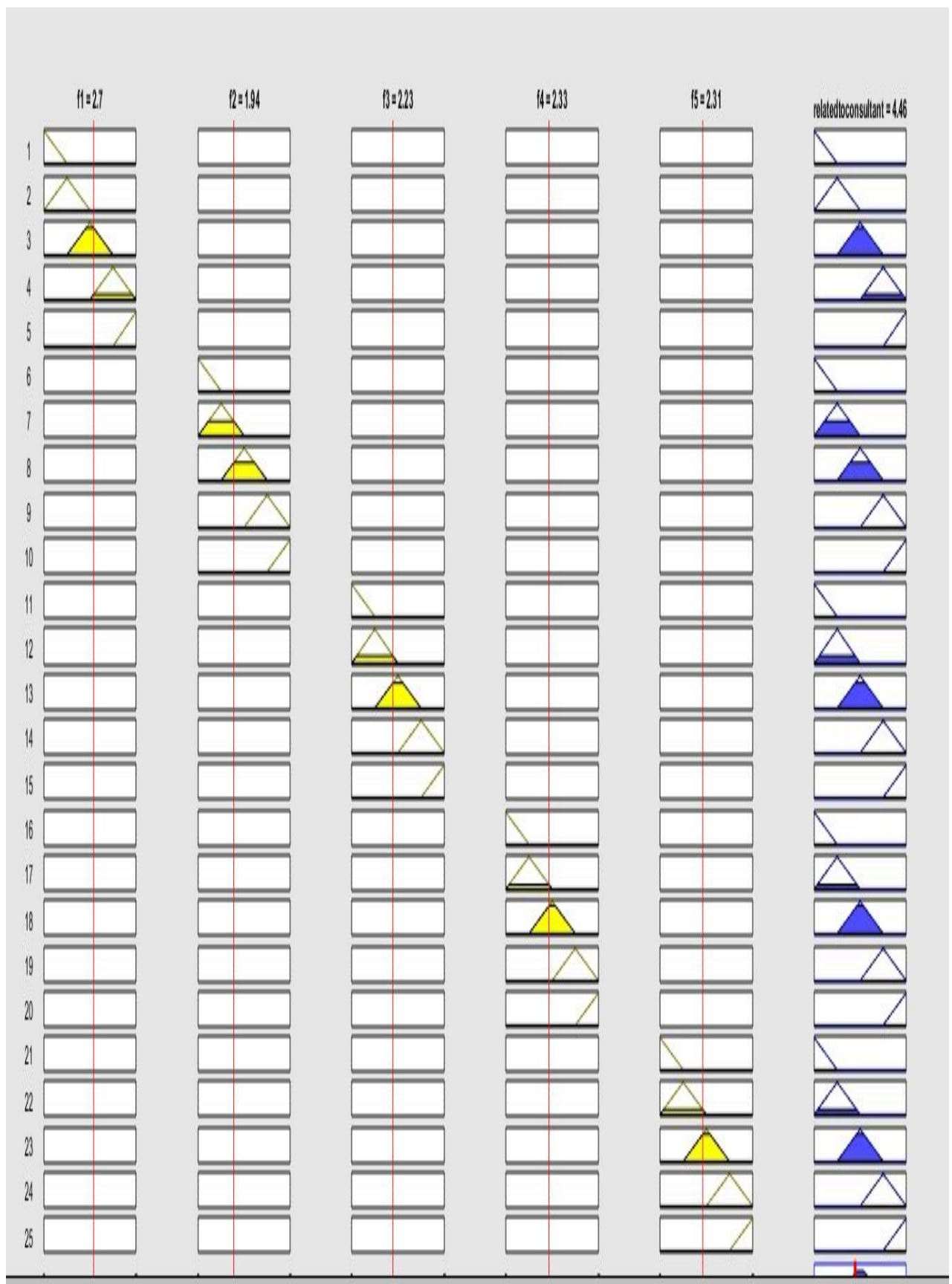


Figure 4.10 rule inference related to consultant

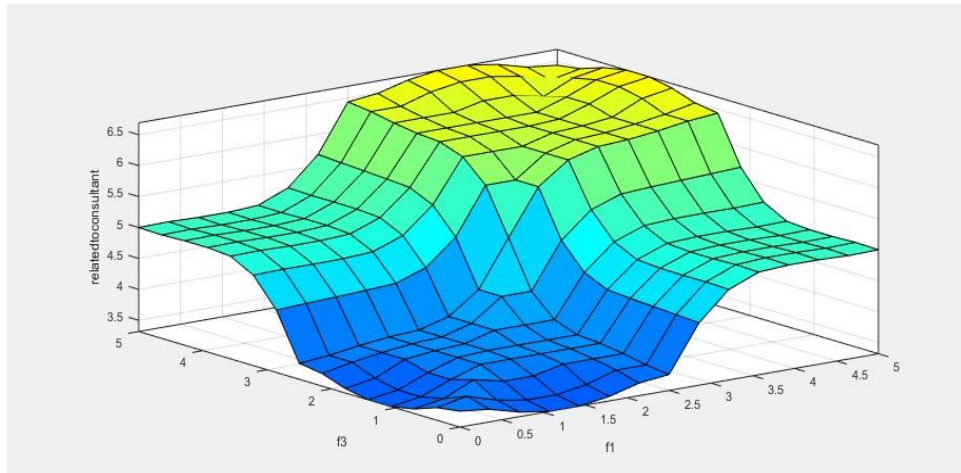


Figure 4.11 control surface related to consultant

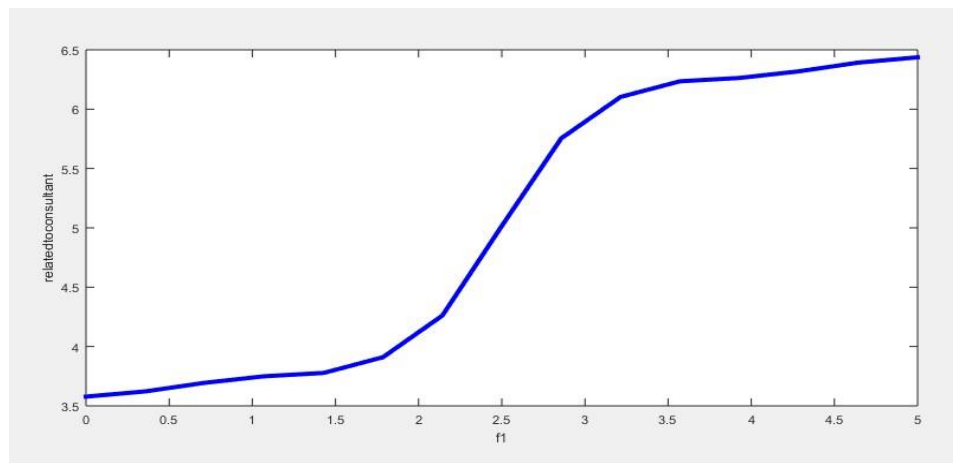


Figure 4.12 lack of inception and supervision

4.4.4 Factors related to client

In the table below it shows factors influencing schedule overruns of subcontractors related to client.

Financial difficulties faced by owners ranked first position the mean score is 2.25 which implies most of the respondents tend to agree that schedule overrun resulted due to financial difficulties faced by owners.

Slow decision making and delay in effecting payment ranked second and last position respectively the mean score is 2.36 and 2.56 which implies most of the respondents agree that schedule overruns of subcontractors are more likely to be caused by slow decision making then delay in effecting payment

Table 4.5 factors related to client

Item no	Factors influencing schedule overruns of subcontractors related to client.	Mean	Rank
1	Slow decision making	2.36	2
2	Financial difficulties faced by owners	2.25	1
3	Delay in effecting payment.	2.56	3

According to respondent's factors influencing schedule overruns of subcontractors related to client is ranked the third position which is 4.58.

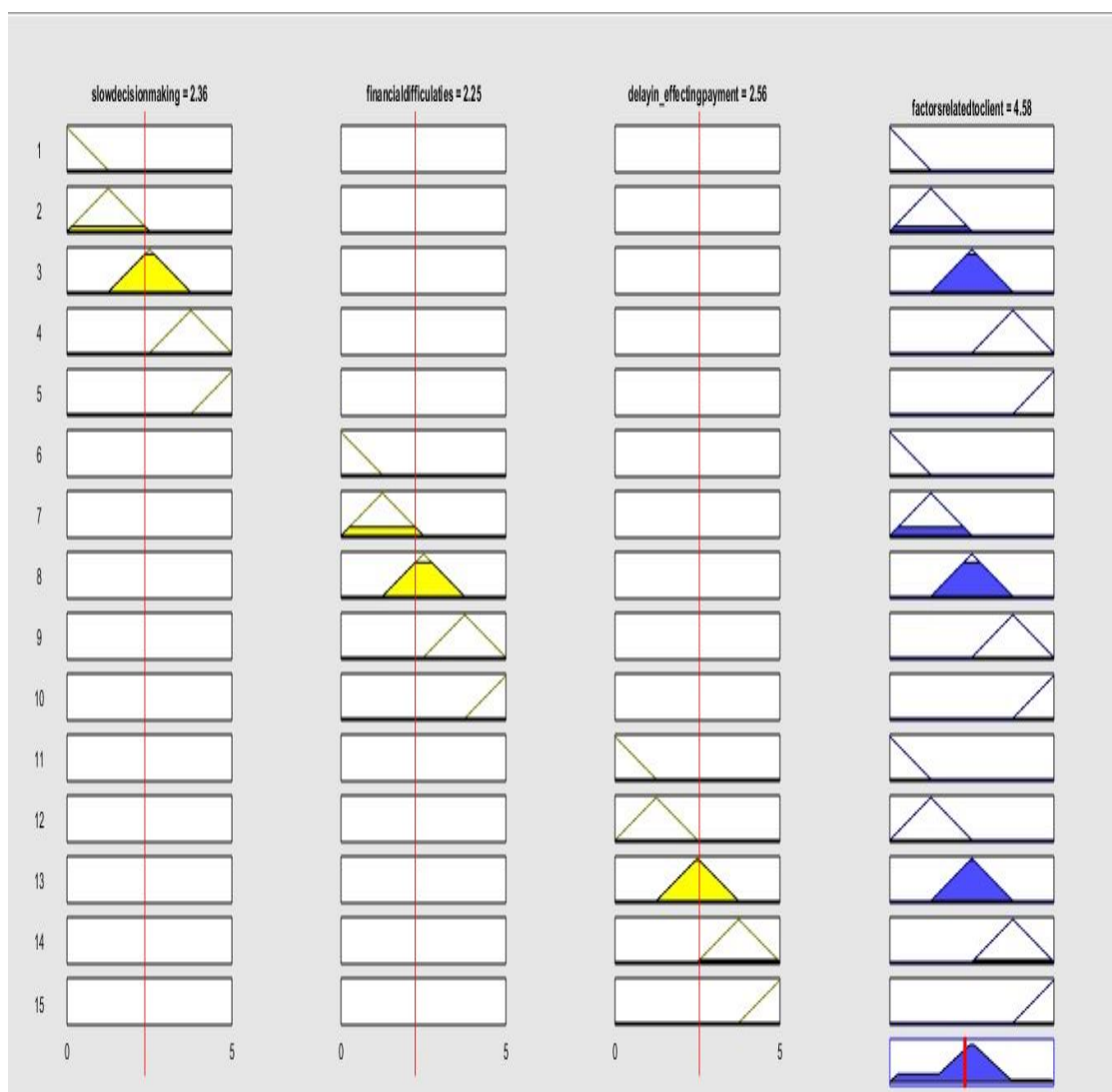


Figure 4.13 rule inference related to client

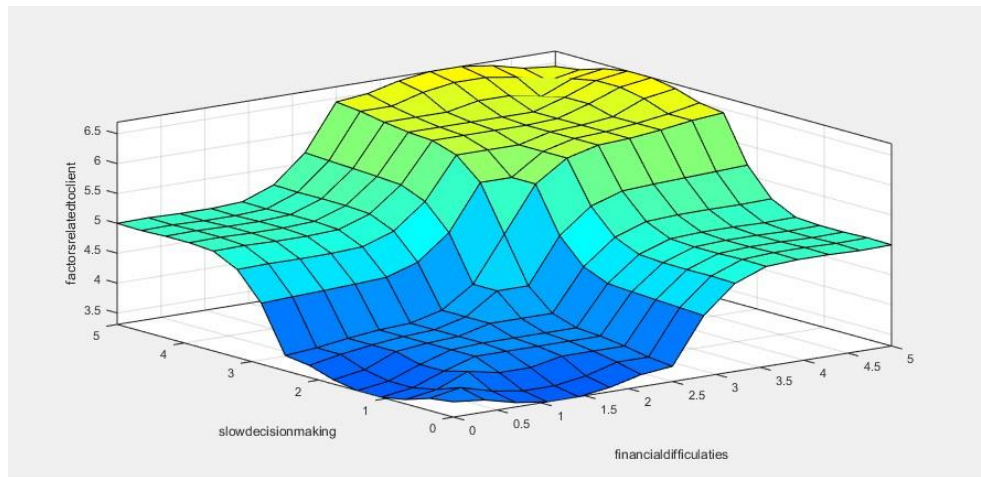


Figure 4.14 control surface related to client

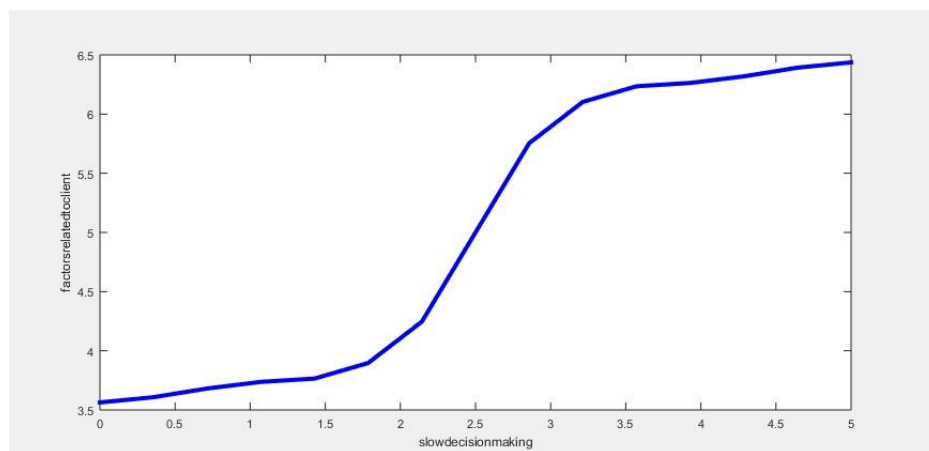


Figure 4.15 slow decision making

4.5 Analysis of impacts of key factors influencing schedule overruns of subcontractors

4.5.1 Impact related to time

In perspective of respondents change in project scope ranked the first position which have high impact in schedule overruns of subcontractors related to time the mean score is 2.04 which implies most of the respondents tend to agree that schedule overrun result due to change in project scope .

Lack of adequate planning and scheduling ranked the second position after change in project scope the mean score is 2.19 which implies most of the respondents believe schedule overruns of subcontractors impacted by lack of adequate planning and scheduling

Financial difficulties faced by contractors, delay in providing necessary materials and equipment for labor contract and lack of clear communication ranked after change in project scope and lack of adequate planning and scheduling respectively. The mean score

is 2.39, 2.44 and 2.66 and which implies most of the respondents agree that impact for schedule overrun of subcontractors impacted by this factors.

Delay in effecting payment ranked the last position in impacting schedule overruns of subcontractors related to time as respondent's perspective which shows delay in effecting payment have less impact compares to the others factors related to time.

Table 4.6 impact related to time

Item no	Impacts of key factors influencing schedule overruns of subcontractors related to time.	Mean	Rank
1	Lack of adequate planning and scheduling.	2.19	5
2	Change in project scope.	2.04	1
3	Delay in providing necessary materials and equipment for labor contract.	2.44	4
4	Financial difficulties faced by contractors.	2.39	3
5	Lack of clear communication.	2.66	5
6	Delay in effecting payment.	2.79	6

According to respondents the impacts of key factors influencing schedule overruns of subcontractors related to time is ranked the second position after impacts related to cost. Impacts of schedule overruns related to time have high impact compares to quality which is 4.74.

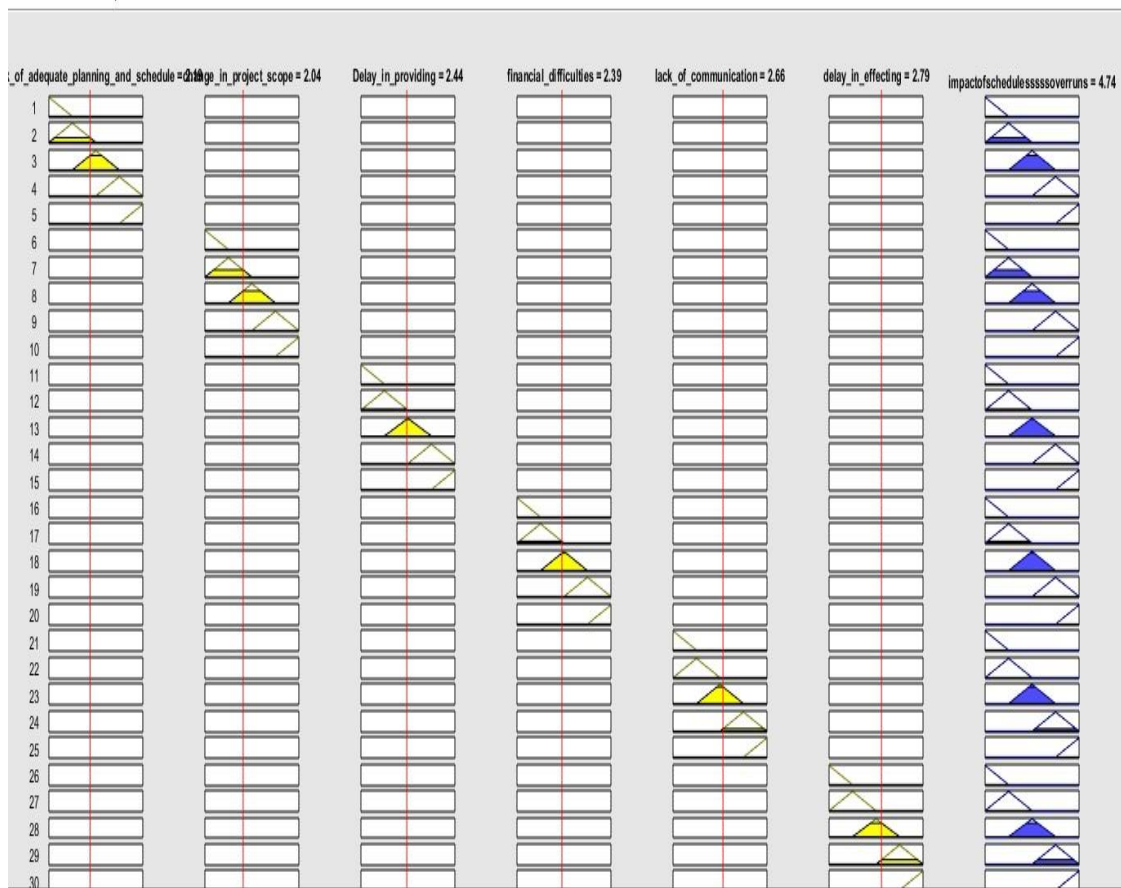


Figure 4.16 rule inference related to time

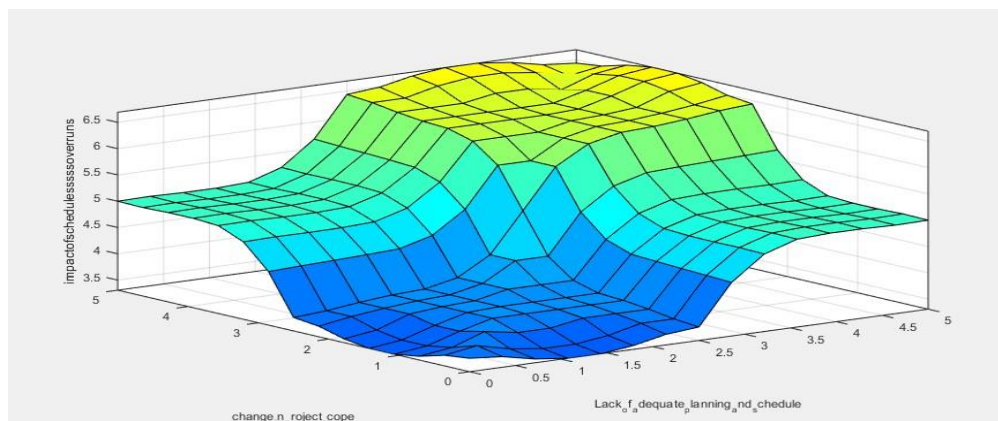


Figure 4.17 surface control of impact related to time

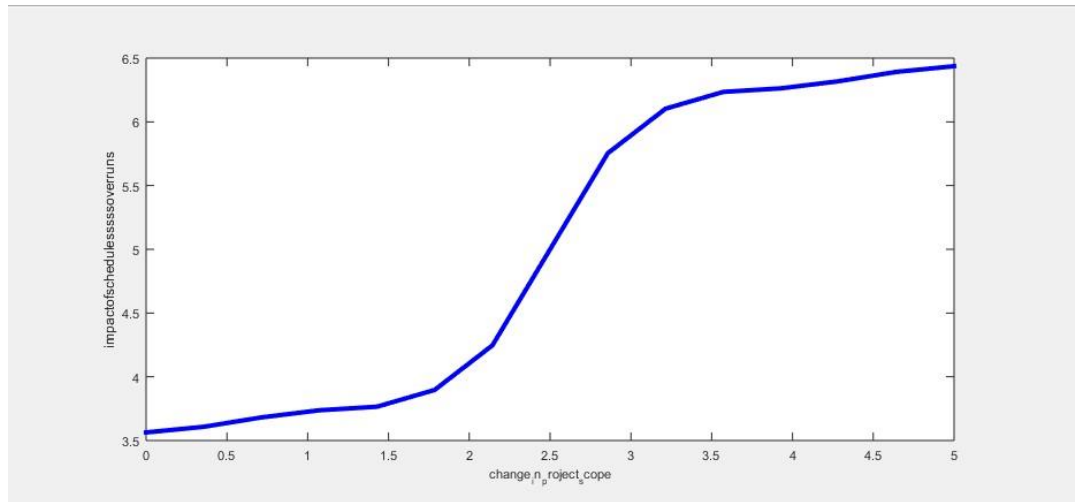


Figure 4.18 change in project scope

4.5.2 Impact related to cost

Frequent design and scope changes and mistakes during construction execution mean score is 2.02 and 2.06 which implies most of the respondents agree that schedule overruns of subcontractors impacted by frequent design and scope changes and mistakes during construction execution.

Inadequate monitoring and control the mean score is 2.27 which implies most of the respondents tend to agree that schedule overrun may impacted by inadequate monitoring and control.

According to respondents lack of resource availability ranked in the last position which shows compare to the factors resource availability have less impact on the schedule delay of subcontractors related to quality.

Table 4.7 impact related to cost

Item no	Impacts of key factors influencing schedule overruns of subcontractors related to cost.	Mean	Rank
1	Frequent design and scope changes.	2.02	1
2	Inadequate monitoring and control.	2.27	3
3	Lack of resource availability.	2.54	4
4	Mistakes during construction execution.	2.06	2

According to respondents the impacts of key factors influencing schedule overruns of subcontractors related to cost have high impact with respect to time and quality which is 4.21 hence, it have a high impact mitigate measures recommended to decrease the impacts of schedule overruns of subcontractors.

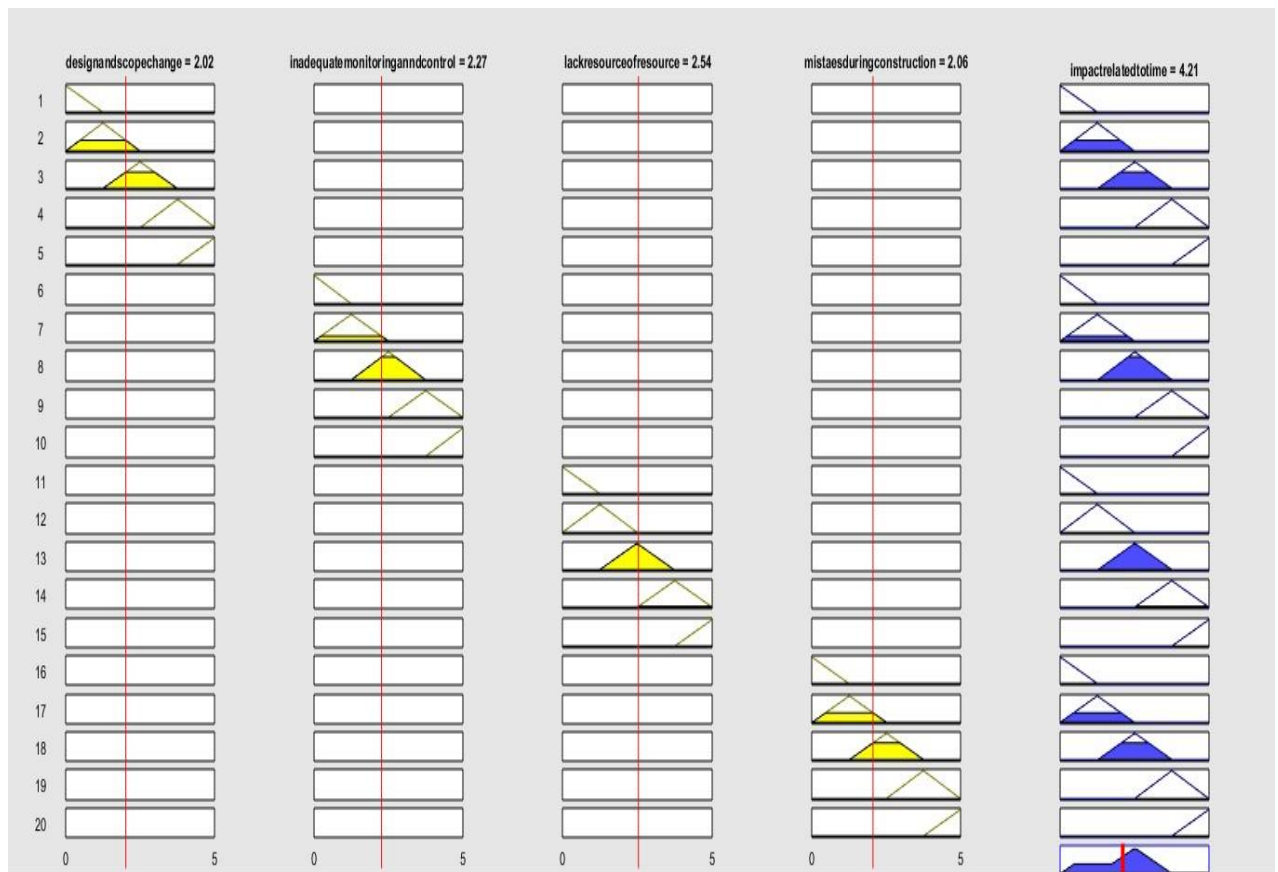


Figure 4.19 rule inference related to cost

4.5.3 Impact related to quality

Shortage of skilled laborers and lack of experience the mean score is 2.27 which implies most of the respondents agree that impact of schedule overruns of subcontractors are to be caused by shortage of skilled laborers and lack of experience.

Lack of clear communication, mistakes during construction and poor site coordination have impact related to quality respectively. Which implies most of the respondents tend to agree that impact of schedule overrun may result due to this factors.

Table 4.8 impact related to quality

Item no	Impacts of key factors influencing schedule overruns of subcontractors related to Quality.	Mean	Rank
1	Shortage of skilled laborers and lack of experience.	2.27	1
2	Lack of clear communication.	2.48	2
3	Mistakes during construction.	2.54	3
4	Poor site coordination.	2.58	4
5	Inaccuracy in sub contract cost.	2.94	5

Impacts of key factors influencing schedule overruns of subcontractors related to Quality ranked as shortage of skilled laborers and lack of experience, lack of clear communication, mistakes during construction, poor site coordination and inaccuracy in sub contract cost ranked respectively and the impact of schedule overruns of subcontractors related to quality from the result become 5.34 which shows the impact related to quality have less impact with respect to time and cost from respondents perspective.

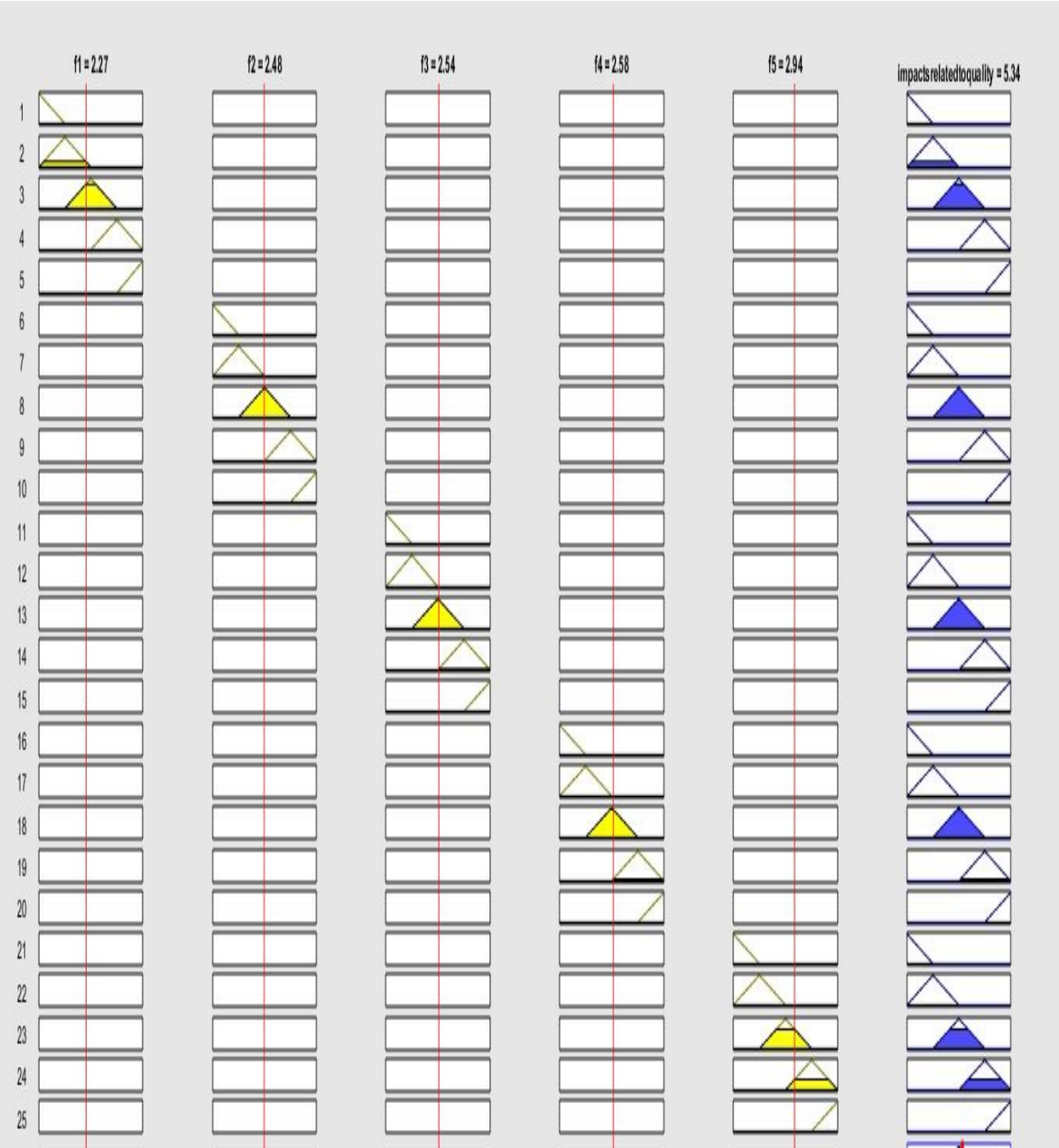


Figure 4.20 rule inference related to quality

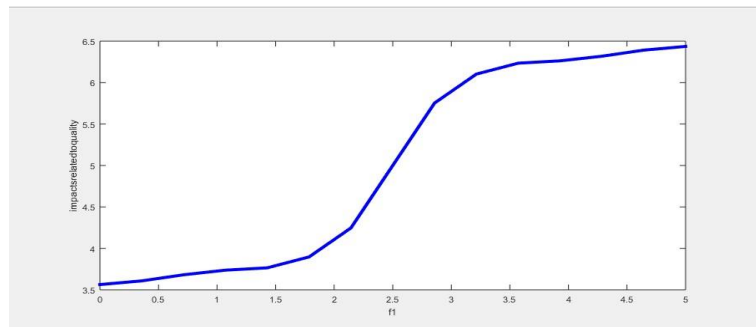


Figure 4.21 Shortage of skilled laborers and lack of experiences

As shown in the table 4.9 below, there are five major impacts influencing schedule overruns of subcontractors related to time, cost and quality.

Frequent design changes, mistakes during construction execution and inadequate monitoring and controlling was ranked 1, 2 and 5 from main contractor's perspective respectively which is resulted from impacts influencing schedule overruns of subcontractors related to cost. Hence, the main contractor's response shows that impact related to cost ranked as a first place. Which shows the impact resulted from cost have adverse effect on the schedule overruns of subcontractors.

Lack of adequate planning and scheduling and Shortage of skilled laborers and lack of experience was ranked 3 and 4 which resulted from impacts influencing schedule overruns of subcontractors related to time and quality respectively. The respondents agree lack of adequate planning and scheduling and Shortage of skilled laborers and lack of experience are common impact related to time and quality.

Table 4.9 impacts of schedule overruns

Item no	Impacts influencing schedule overruns of subcontractors	Mean	Related to time	Related to cost	Related to quality
1	Frequent design and scope changes	2.02		√	
2	Mistakes during construction execution	2.06		√	
3	Lack of adequate planning and scheduling	2.19	√		
4	Shortage of skilled laborers and lack of experience	2.27			√
5	Inadequate monitoring and control	2.27		√	

4.6 Strategic measures to minimize the impacts influencing schedule overruns of subcontractors

Frequent design and scope changes

Detailed planning and design phase conduct site investigation and feasibility studies and invest time in planning and design phases to minimize changes during construction. Effective communication between clients, designers, contractors, etc. use collaborative tools and platforms for sharing design changes promptly. Proactive risk management: identify potential change risks early in the project and develop mitigation plans. Invest time upfront in defining project scope comprehensively and accurately. Involve key stakeholders, including subcontractors, in the scope definition process to ensure alignment and minimize ambiguity. Clearly document scope boundaries, deliverables, and acceptance criteria to minimize scope creep.

Establish a formal change management process to evaluate, approve, and implement design and scope changes systematically. Require thorough impact assessments, including evaluations of schedule, cost, and resource implications, before approving changes. Ensure all changes are documented, communicated, and integrated into project plans promptly. Use flexible contractual arrangements, such as cost-plus or time-and-materials contracts, to accommodate scope changes more easily. Negotiate contract terms that allow for variations in scope, provided they are properly documented, approved, and compensated.

Mistakes during construction execution

Comprehensive training provide regular training and certification for all workers, emphasizing safety, quality standards, and specific project requirements. Quality control implements a robust quality control program with regular inspections and testing of materials and workmanship. Collaboration and coordination foster a collaborative environment where team members work together to solve problems.

Provide clear specifications, standards, and guidelines for construction activities to subcontractors. Communicate project requirements, technical specifications, and quality expectations upfront. Use detailed drawings, plans, and specifications to minimize ambiguity and reduce the likelihood of mistakes. Implement robust supervision and quality control measures to monitor subcontractor activities and identify mistakes early in the construction process. Assign experienced supervisors or quality inspectors to oversee subcontractor workmanship, adherence to specifications, and compliance with quality

standards. Conduct regular inspections, audits, and walkthroughs to detect errors and deviations from the approved plans.

Conduct thorough root cause analysis to understand the underlying factors contributing to construction mistakes. Identify systemic issues, process deficiencies, communication breakdowns, or training gaps that may be causing errors. Address root causes systematically to prevent future mistakes and improve overall construction quality.

Lack of adequate planning and scheduling

Allocate sufficient time and resources to the initial planning phase and develop a comprehensive project plan that includes all aspects of the project scope, resources, timelines, and risks create a detailed WBS to break the project into manageable tasks and sub-tasks Conduct regular schedule reviews to monitor progress and make necessary adjustments.

Develop an integrated master schedule that aligns subcontractor schedules with the overall project timeline. Coordinate activities, dependencies, and milestones across multiple subcontractors to ensure seamless integration and minimize conflicts. Use project management software to facilitate schedule integration and communication. Implement robust performance monitoring and control processes to track subcontractor adherence to schedules and milestones. Monitor key performance indicators, such as schedule variance, progress productivity, and milestone achievement. Conduct regular progress reviews and inspections to identify early warning signs of schedule overruns and take corrective actions proactively.

Establish clear communication channels and coordination mechanisms to facilitate information exchange and collaboration among subcontractors. Hold regular meetings, conference calls, and coordination sessions to review schedules, resolve conflicts, and align activities. Foster open communication and transparency to address issues promptly and prevent schedule overruns.

Shortage of skilled laborers and lack of experience

Pre-qualification and vetting conduct background checks on subcontractors before hiring ensuring they have necessary skills and experience for the job. Supervision and oversight: maintain close supervision and oversight of subcontractors work to ensure quality standards met. Regular feedback provide regular feedback to subcontractors on their performance and areas for improvement.

Foster a culture of collaborative problem-solving where subcontractors work together to address labor shortages and skill gaps. Encourage subcontractor cooperation, resource sharing, and knowledge exchange to overcome challenges collectively. Facilitate joint planning sessions, brainstorming workshops, and peer learning forums to identify innovative solutions and best practices.

Invest in technology solutions and automation tools to augment labor productivity and efficiency. Implement construction management software, robotics, and digital tools to streamline workflows, optimize resource allocation, and minimize manual labor requirements. Train subcontractor laborers in the use of technology to enhance their effectiveness and productivity.

Offer recruitment incentives, competitive wages, and retention bonuses to attract skilled laborers and retain experienced personnel. Collaborate with subcontractors to develop attractive compensation packages, benefits, and career advancement opportunities. Recognize and reward top-performing laborers to foster loyalty and retention.

Establish apprenticeship and mentorship programs to transfer knowledge and skills from experienced workers to new hires. Pair junior laborers with seasoned professionals to facilitate on-the-job training, skill development, and knowledge transfer. Encourage cross-training and skill diversification to build a versatile workforce.

Inadequate monitoring and control

Assess current systems evaluate existing monitoring and control mechanism to identify gaps or weakness. Implement technology utilize technology such as monitoring software, sensors, and data analytics. Establish protocols develop standardized protocols and procedure for monitoring and control processes to ensure consistency and effectiveness.

Hold regular performance reviews and progress meetings with subcontractors to discuss schedule performance, identify challenges, and collaborate on solutions. Use these meetings to review project plans, update schedules, and adjust resource allocations as needed. Encourage open communication and constructive feedback exchange to foster accountability and collaboration.

Establish clear escalation procedures and channels for addressing schedule-related issues and concerns. Define escalation paths for escalating unresolved issues to higher

management levels or project stakeholders. Ensure subcontractors are aware of escalation procedures and empowered to escalate issues promptly when necessary.

Implement stringent quality control and assurance measures to ensure subcontractor work meets specified quality standards and requirements. Conduct quality inspections, tests, and reviews to verify compliance with design specifications, industry standards, and contractual obligations. Address quality issues promptly to prevent rework and schedule delays.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter is the final chapter which is divided into two sections. The first section contains a conclusion from the findings, and in the last section recommendations are forwarded based on the established finding and conclusions that could be useful and viable for the construction industry.

5.2 conclusion

This paper was conducted to determine the factors and impacts of key factors influencing schedule overruns of subcontractors in Oromia Construction Corporation (OCC) projects through examining the perceptions of 48 engineers with different work experience levels. After a careful literature review, several factors and impacts affecting schedule overruns were identified and ranked by the study. Furthermore, the top five factors impacting the schedule overruns of subcontractors were identified and treated by mitigate measures for impacts influencing schedule overruns of subcontractors.

- Most of the respondents surveyed in the study have agreed that schedule overruns of subcontractors have impact related to cost, time and quality respectively.
- Main causing factors for schedule overruns of subcontractors related to main contractors identified from this study are: - Financial difficulties faced by contractors, Lack of adequate planning and scheduling, Delay of materials approval, Delay in providing necessary materials and equipment for labor contract, Poor site coordination and etc. in order of their significance.
- Main causing factors for schedule overruns of subcontractor's related to subcontractors identified from this study are: - Shortage of skilled laborers and lack of experience, unrealistic contract duration exposed and inaccuracy in sub contract cost, in order of their significance.
- Main causing factors for schedule overruns of subcontractor's related to consultant identified from this study are: - Frequent design and scope changes, Lack of information flow and Delay of materials approval. In order of their significance.
- Main causing factors for schedule overruns of subcontractor's related to client identified from this study are: - Financial difficulties faced by owners, slow decision making and Delay in effecting payment in order of their significance

- Five major impacts influencing schedule overruns of subcontractors related to time, cost, and quality identified from this study are: - Frequent design and scope changes, mistakes during construction execution, lack of adequate planning and scheduling, shortage of skilled laborers and lack of experience and inadequate monitoring and control in order of their significance.

5.3 Recommendation

Pursuant to the Study's findings, Schedule overrun of subcontractors is one of the primary challenges in Oromia Construction Corporation (OCC), and it has a substantial impact on productivity, quality of the works, budget, ease of management of the project and so much more.

Based on the results of the study presented in the preceding chapter, the researcher proposed the following list of action items. These suggestions are a series of solutions for reducing schedule overruns of subcontractors in construction project and minimizing its impact on the performance of schedule overruns.

- As consultant are mainly responsible for frequent design and scope changes ,they are suggested to have experienced professionals in the area.it also recommended to conduct comprehensive sessions with the client to understand all requirement and expectations before starting the design process and perform detailed feasibility studies to ensure that the proposed designs are practical and within budget.
- As main contractors are mainly responsible for mistakes during construction executions, they are suggested to have robust quality control and quality assurance.it also recommended to develop clear and detailed project specifications and drawing that outline quality requirement and creates a quality management plan that includes procedures, standards and responsibilities for quality control.
- As Contractors are mainly responsible for the project planning and scheduling performance of projects, they are suggested to select subcontractors within proven track record of successful project planning and execution. It is also recommended that contractors to build their capacity in the way of having a better project management system in the company also hold joint planning sessions involving clients, consultant, and subcontractors to develop realistic and detailed project plan and schedule.

- Conduct background checks on subcontractors before hiring ensuring they have necessary skills and experience for the job also assign experienced supervisions to monitors subcontractors work on site closely.
- Inadequate monitoring and controlling by consultants in in construction leads to various project issues, including delays, cost overruns, and quality problems to mitigate this risk, its essential to implement robust monitoring and control mechanisms.

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APPENDIX-QUESTIONNAIRE

My name is **Bontu Shentema**. I am currently doing research for the completion of my Master's degree in Construction Engineering and Management from **Adama Science And Technology**. I am conducting academic research entitled "**Assessing the impacts of subcontractor's schedule overruns in building Construction: The case of projects in Oromia Construction Corporation (OCC)**" for the partial fulfillment of the MSc Program. The main goal of this study is to identify the key factors influencing schedule overruns of sub-contractors and the impact of key factors influencing schedule overruns in building construction: The case of project in Oromia Construction Corporation (OCC).

As a result, this questionnaire is designed to collect information from relevant informants using a questionnaire solely for academic purposes. Your response is extremely valuable and contributes to the research's success. Furthermore, the names of the institutions and professionals who took part will be kept confidential and anonymous.

Due to the research time limitation, I humbly request that you complete and return the questionnaire within a week so that I can carry out the research on time.

Thank you so much for your time and cooperation!!!

Bontu Shentema

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Engineering and Management

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Section I -General Information

Dear Respondent

I would like to thank you in advance for your time and cooperation. The purpose of this questionnaire is to collect data for the requirement of MSc in Construction Engineering and Management. The researcher requests that you answer the question completely and truthfully. The information you provide will be kept confidential and will not be used for any other purpose other than the intended research. So, please respond as honestly and objectively as possible.

The questions below are related to your organization and yourself. Please tick the box corresponding to your answer (please tick one) and also fill the blank spaces provided.

1. What is your highest level of education?

Graduate (MSC) ☐ Under Graduate (BSC) ☐ Diploma ☐

If other, please specify _____

2. What is your position in the company?

Project Manager ☐ Contract Administration ☐ Site Engineer ☐

Project Coordinator ☐ Office Engineer. ☐

If it is other, please specify _____

3. How long have you been working in construction projects?

Below 3 ☐ Years ☐ 3-5 Years ☐ 5-10 Years

10-15 Years ☐ above 15 ☐ Years

Section 2: On the table below there are numbers of factors influencing schedule overruns of subcontractors identified from literature review.

(Tick (X or v) in the blank space provided)

Each scale represents the following rating: (1) = Strongly Agree, (2) = Agree, (3) = Neutral, (4) = Disagree, (5) = Strongly Disagree

2.1, factors influencing schedule overruns of subcontractors

No	Factors influencing schedule overruns of subcontractors	1	2	3	4	5
A, Related to main contractors						
1	Poor site coordination.					
2	Delay of shop drawing.					
3	Delay of materials approval.					
4	Delay in providing necessary materials and equipment for labour contract.					
5	Lack of adequate planning and scheduling.					
6	Financial difficulties faced by contractors.					
7	Lack of clear communication.					
8	Delay in effecting payment.					
B, Related to sub-contractors						
1	Shortage of skilled labourers and lack of experience.					
2	Inaccuracy in sub-contract cost.					
3	Unrealistic contract duration imposed					
C, Related to consultant						
1	Lack of inception and supervision					
2	Frequent design and scope changes					
3	Lack of information flow between parties.					
4	Delay of shop drawing.					
5	Delay of materials approval					
D, Related to client						
1	Slow decision making					
2	Financial difficulties faced by owners.					
3	Delay in effecting payment by owners.					

Section 3: On the table below there are numbers of impacts of key factors influencing the schedule overruns of sub-contractors identified from literature review.

(Tick (X or v) in the blank space provided)

Each scale represents the following rating: (1) = Strongly Agree, (2) = Agree, (3) = Neutral, (4) = Disagree, (5) = Strongly Disagree

3.1 The impacts of key factors influencing the schedule overruns of sub-contractors.

No	The impact of key factors influencing schedule overruns of sub-contractor	1	2	3	4	5
A, Related to time						
1	Lack of adequate planning and scheduling.					
2	Change in project scope.					
3	Delay in providing necessary materials and equipment in labour contract.					
5	Financial difficulties faced by contractors.					
6	Lack of clear communication.					
7	Delay in effecting payment.					
B, Related to cost						
1	Frequent design and scope Change.					
2	Inadequate monitoring and control					
3	Lack of resource availability.					
4	Mistakes during construction execution.					
C, Related to quality						
1	Shortage of skilled labourers and lack of experience.					
2	Lack of clear communication					
3	Mistake during construction.					
4	Poor site coordination.					
5	Inaccuracy in sub-contract cost.					

