EVALUATION OF LABOUR EFFICIENCY FACTORS IN BUILDING CONSTRUCTION PROJECTS FOR CONCRETING ACTIVITY USING ANALYTIC HIERARCHY PROCESS (AHP)

ELIYAS MESGANU MARE

A THESIS SUBMITTED TO
THE DEPARTMENT OF CIVIL ENGINEERING,
COLLEGE OF CIVIL ENGINEERING AND ARCHITECTURE

OFFICE OF POSTGRADUATE STUDIES
ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

JUNE, 2025

ADAMA, ETHIOPIA

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DECLARATION

I hereby declare that this thesis entitled "**Evaluation of Labour Efficiency Factors in Building Construction Projects for Concreting Activity Using Analytic Hierarchy Process (AHP)**" is my own work and has not been submitted to any university for similar purpose. The references used in this proposal are duty recognized by proper citation

Name of Student	Signature	Date

RECOMMENDATION OF ADVISOR

I, the advisor of this research thesis, hereby certify that I have closely advised the student in the development of this thesis and have read the draft entitled "Evaluation of Labour Efficiency Factors in Building Construction Projects for Concreting Activity Using Analytic Hierarchy Process (AHP)" prepared under my guidance by Eliyas Mesganu Mare. Therefore, I recommend the submission of the thesis to the department for further review and evaluation.

Bahiru Bewket, PhD		
Advisor	Signature	Date

APPROVAL PAGE FOR THESIS

I/we, the advisors of this thesis entitled **"Evaluation of Labour Efficiency Factors in Building Construction Projects for Concreting Activity Using Analytic Hierarchy Process (AHP)"** developed by Eliyas Mesganu Mare, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Major Advisor	Signature	Date
Co-advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Eliyas Mesganu Mare have read and evaluated the thesis entitled**" Evaluation of Labour Efficiency Factors in Building Construction Projects for Concreting Activity Using Analytic Hierarchy Process (AHP) "**and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Construction Engineering and management

Chairperson	Signature	Date
Internal Examiner	Signature	Date
External Examiner	Signature	Date

Finally, 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
College Dean	Signature	Date
Office of postgraduate studies, Dean	Signature	Date

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ABSTRACT

This study aims to evaluate the key factors influencing labour efficiency in building construction projects, focusing specifically on concreting activities within the context of Addis Ababa, Ethiopia. The primary objective is to identify and prioritize these factors so that targeted interventions can improve productivity. A quantitative research approach was adopted, employing structured questionnaires designed with a pairwise comparison matrix and analyzed through the Analytical Hierarchy Process (AHP). Data were collected from construction industry professionals, including project managers, engineers, and site supervisors. To ensure the validity of results, the primary findings were triangulated with secondary data sourced from industry reports, scholarly articles, and similar urban construction contexts. The results reveal that manpower related factors such as skilled labour availability and supervision are the most significant determinants of productivity, corroborated by secondary data indicating widespread labour skill shortages and management inefficiencies in developing urban environments. Additionally, material quality and management practices emerged as critical components influencing operational efficiency. The triangulation of primary and secondary data confirms these factors' pivotal roles, providing a reliable basis for developing strategic recommendations. The insights gained from this research can guide stakeholders in implementing targeted strategies to improve labour performance, reduce project delays, and optimize resource utilization, thereby contributing to the overall enhancement of construction productivity in the region

Keywords: Labour productivity, Concreting Activities, AHP, Project efficiency, Construction Management, Resource Optimization, Construction Performance

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LIST OF ABBREVIATIONS

AHP = Analytical Hierarchy Process

LP = Labour productivity

GM= Geometric mean

CI = Consistency Index

CW = Criteria weight

WSV = weighted sum value

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CHAPTER ONE

INTRODUCTION

1.1 Background

The country's economic growth and prosperity are largely depending on the construction industry. Constructing something is complicated and requires many workers in different roles to work together to finish the project successfully. So, improving how productive workers are in construction is a key step to making projects successful.

As noted by Abdu et al. (2023), Construction is one of the most labour-intensive industries in developing countries. Therefore, understanding construction labour productivity is essential. Additionally, Chakkappan & G Das, (2016) emphasize that labour productivity is a crucial factor in estimating the duration of construction activities within the construction project management process. Ashebir A. et al. (2019) stated that the success of construction projects is greatly impacted by labour productivity. Companies in the construction industry have been negatively affected by low labour productivity.

According to Shamil G. (2016), the success of construction projects is largely determined by labour productivity, which significantly impacts various project outcomes. Improving worker productivity in the building construction industry is essential for achieving sustainable development goals and optimizing resource use. To finish tasks on time, within budget, and with the appropriate level of quality, efficient utilization of human resources is crucial. However, a number of factors can lead to uncertainties in the construction industry's productivity.

Himanshu A. et al., (2016) noted that numerous studies have explored ways to manipulate factors for increased productivity. To improve labour productivity, a thoroughly examination of specific details is crucial. Workers face a range of variables that can influence their productivity levels. Consequently, the primary focus of projects is labour productivity, which is defined as the amount of goods and services produced by the workforce within the given timeframe. This productivity is typically assessed by comparing labour costs to the output generated.

1.2 Statement of the problem

Labour productivity is very essential for success in building construction and it directly influencing project costs, schedules, and overall quality. According to recent studies and industry reports, projects with low labour productivity experience delays and cost overruns, which substantially impact overall project success. Low productivity levels leads to increased project durations and higher expenses, which can affect the financial viability and timely completion of the construction projects. Ineffective labour resource management and the inability to identify and address key productivity factors continue to challenge the sector, resulting in inefficient use of resources, cost overruns, and schedule delays. Therefore, understanding and evaluating the factors affecting labour productivity is essential for improving project performance and achieving successful construction outcomes.

1.3 Objectives

1.3.1 General Objective

The general objective of this thesis is to evaluate labour efficiency factors in building construction projects for concreting activity using AHP.

1.3.2 Specific Objectives

The specific objectives of this thesis include:

- To identify factors that affect labour productivity.
- To prioritize significant factors using the Analytical Hierarchy Process (AHP).
- To develop recommendations for optimizing workforce (labour) efficiency.

1.4 Research questions

This study addresses the following questions to achieve its objectives:

- What are the key factors influencing labour efficiency in building construction projects, specifically for concreting activities?
- How can the Analytic Hierarchy Process (AHP) prioritize these factors to determine their relative significance?
- What actionable recommendations can be derived from the AHP results to improve labour efficiency on-site?

1.5 Significance of the research

This research is for the construction industry as it provides insights and guidelines to enhance project productivity. It aims to enhance understanding of the key factors that influence labour productivity in building construction projects. By identifying and analyzing these factors, it seeks to clarify the underlying reasons of productivity variations. This knowledge will help project managers and stakeholders make informed decisions and implement effective strategies to optimize workers productivity.

Furthermore, the findings can serve as a practical reference for policymakers and industry professionals seeking targeted interventions to elevate labor efficiency, reduce delays, and control costs in concrete construction processes. The research thus contributes to advancing both academic understanding and practical management strategies in the context of construction labor productivity.

1.6 Scope of the study

This thesis (study) focuses on enhancing productivity of employees in construction sector, particularly in the context of building construction for concreting activity in Addis Ababa, Ethiopia. Through a comprehensive review and analysis of existing literature and research findings, the study intends to identify and investigate many elements influencing labour productivity in these projects.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Ethiopia has witnessed remarkable expansion in its construction industry in recent years. This sector is a key driver of economic development and urbanization, playing a crucial role in advancing infrastructure, generating employment opportunities, and increasing economic progress.

The construction industry in Ethiopia encounters numerous challenges, one of which is labour productivity. Construction workers must not only operate various equipment but also understand the roles of other skilled trade's people, as well as the materials, tools, and machines involved in their work. Addressing these issues is essential for ensuring the long term growth and development of the construction industry.

2.2 Labours in the Construction industry

Despite the introduction of new technologies, the construction sector remains largely dependent on human labour. The industry relies heavily on workers who engage in physical construction of buildings, infrastructures, and other structures. This group, known as construction labourers, includes both skilled and unskilled employees such as carpenters, electricians, plumbers, masons and excavators.

Tewodros W. L. (2019) highlights that the construction sector is characterized by a high demand for labour, especially during peak building seasons. This industry frequently faces Labour shortages, which can result in project delays and increased costs.

Shobhit C. et al., (2018) highlighted in their study that construction employees require a diverse set of skills and expertise beyond just physical labour. This includes safety training, project management skills, and an understanding of building standards and regulations. Given that many construction workers operate in hazardous environments, additional safety measures and training are essential.

To conclude, labour is a critical factor for success in construction projects. Providing construction workers with proper training, equipment, and support can boost productivity and decrease the likelihood of accidents and delays, as demonstrated in the study by Himanshu A. et al., (2016).

2.3 Productivity in the Construction industry

Productivity is a critical factor in the construction sector that greatly affects project success. According to Bartoschek P.M., et al., (2021), accurately calculating the time and costs needed to complete a project depends on the productivity rates of the construction trades. When productivity is low, it can lead to delays, cost overruns, a decline in job quality, resulting in dissatisfied clients and stakeholders. In the context of construction, productivity measures how efficiently resources such as personnel, materials, and equipment are used to complete a project.

Amanuel (2016) defines productivity as the relationship between the amount of work completed and the effort required to achieve it. Work is generally quantified by the physical output of the project

According to Dozzi S. P. &Abourizk S. M. (1993), two key indicators of labour productivity are the efficiency of labour utilization during the building process, and the relative efficiency of labour in completing tasks at a specific location and time.

Productivity is a crucial concept in economic analysis, serving as a key indicator of economic effectiveness. It defines how resources are pooled and used effectively to produce the desired results. In order to create a value from available resources like raw materials, labour, skills, capital equipment, land, managerial ability, and financial capital, a nation must have a good productivity. By making informed choices, countries can enhance production, increase value, and boost income for every hour worked (Policy Studies Institute, 2020).

2.4 Labours Productivity in the Construction industry

The construction industry plays a vital role in Ethiopia's economy. However, it has encountered challenges in recent years, particularly concerning low labour productivity. This issue has led to higher costs and delays in construction projects.

Labour productivity measures production efficiency by indicating the amount of output produced per unit of labour input. In the construction, it refers to the quantity of work that one worker or a group of workers can complete with in a specific time frame, typically measured in terms of the work accomplished per hour or day. Various factors can influence labour productivity in construction, including employee skill levels, the availability of tools and materials, project complexity, and the working environment, as noted in research by Tewodros W. L. (2019).

The success of every construction project is significantly influenced by the productivity of the labour force. In the Ethiopian construction sector, low worker productivity has adversely affected the success of companies. Productivity in this industry is typically measured as the amount of work completed per hour of labour. This metric indicates how efficiently a system employs labour, capital, and equipment to transform worker efforts in to usable output Ashebir A.etal. (2019).

Ahmed H. et al. (2013) concluded that 30% to 50% of a project's total cost is allocated to labour. Therefore, accurately estimating labour productivity rates for construction activities is essential for improving overall cost estimates.

The concept of labour productivity as described by Shobhit Chaturvedi et al. (2018) focuses on the construction sector and has been extensively researched by numerous scholars in the fields of operations management and civil engineering. It has been defined that two productivity metrics, partial factor productivity and total factor productivity, are mostly used in the industry. Total factor productivity is defined as the ratio of total output to total output, with inputs typically including labour, capital resources, materials, and equipment. In contrast, partial factor productivity is calculated by combining outputs with one or more inputs, depending on the set of inputs used.

Himanshu A. et al., (2016) note that prior research on labour productivity has concentrated on the construction sector. Some studies have examined manipulative techniques to enhance productivity. To boost labour productivity, it is crucial to thoroughly analyze true labour costs. Various factors affect the production levels of different labourers. For each project, the main concerns are productivity, cost, quality, and time. Increasing productivity is now a top priority

for corporation as they seek to efficiently convert resources into marketable products and evaluate the profitability of their ventures.

As seen from the studies, given the variety of factors influencing individual worker performance, it is imperative to comprehend the true cost of labour to increase labour productivity. Time management, quality, cost, and productivity are major issues in building projects. In the current business climate, firms place a high premium on productivity, recognizing that it is critical to use resources effectively to generate marketable goods and guarantee the success of their ventures

2.5 Importance of labour productivity

Labour productivity assesses how efficiently labour is used to produce goods and services. It is defined as the output produced by a worker or a group of workers within specific time frame. This measure is vital because it significantly influences economic growth and consistently garners attention from researchers. Due to its importance in the construction process, many studies have been conducted over the past three decades to explore the factors impacting labour productivity, as outlined by Ahmed H. et al. (2013).

Dr. Ghanim A. Bekr (2016) defines labour productivity as measurement of output per worker or output per labour hour. Although various definitions of productivity exist, they all focus on comparing input to output. Increasing labour productivity is essential for several reasons. First it drives economic growth. When labour productivity is high, businesses can produce more goods and services with the same of labour input, result greater profits for corporations and higher wages for employees. Second, enhancing labour productivity can lead to cost reductions. When labour productivity is high it results in larger earnings for corporations by producing more with the same input, businesses can lower production costs, enhancing their competitively higher employee compensation. Second, increasing worker productivity can lead in cost of reduction. By producing more with the same amount of labour input, businesses can lower production costs. This can make businesses more competitive and draw in new clients. Shobhit Chaturvedi et al., (2018) highlighted the significance of improving labour productivity for several reasons: It can drive economic growth, lower prices, and improve quality of life. Key factors influencing labour productivity include skill level, experience, motivation, work environment, and project

management, might influence labour productivity enhancement. By focusing on these elements, we can increase labour productivity and reap the associated benefits.

2.6 Factors influencing labour productivity

Understanding the factors that influence construction labour productivity is crucial for identifying ways to minimize project cost overruns and delays, ultimately enhancing productivity and overall project performance. This information will be particularly valuable for improving construction productivity in Ethiopia, as noted by Amanuel M. (2016).

Zeray S. (2019) proposed that understanding the factors influencing productivity can aid in developing strategies to eliminate inefficiencies and improve project performance. Recognizing the elements that affect construction labour productivity is crucial for minimizing cost overrun and delays, ultimately leading to better overall project outcomes. These insights will be instrumental in enhancing construction productivity in Ethiopia.

Numerous elements influence the building sector productivity. Key criteria affecting construction productivity are frequently mentioned in different studies, and many scholars have investigated the factors.

According to Amanuel M. (2016), a lot of factors influence the construction sector productivity. Extensive research has been undertaken on this topic, highlighting several key factors that are frequently cited across various literatures. These factors include supervision, resource availability, and project uniqueness, all of which play significant roles in determining productivity levels. Additionally, the organization of work, labour availability, and changes in technology are critical elements that affect construction productivity. Management practices, whether poor or good, alongside labour organizations, also contribute to the overall effectiveness of construction projects. Furthermore, aspects such as wages, the training and motivation of workers, weather conditions, and uncertainties related to the project environment can significantly impact labour productivity. The location of the project and the monitoring of performance are further factors that have been identified as influential in enhancing or hindering productivity within the construction sector

This study tried to see and include different aspects of each factor by incorporating manpower-

related and external factors. Hence political economic factors and technology-related factors were not considered in the study.

Ashebir A. et al. (2019) identified 32 characteristics that negatively affect labour productivity, emphasizing the top ten factors. Among these decision-making delays, material shortages, and payment delays, which significantly hinder productivity. Additionally, poor labour experience, order changes initiated by the client or consultant, and equipment shortages were found to be influential. Other notable factors include site accidents, a lack of inspiration among workers, poor workmanship, and a shortage of regular meetings with labour. The initial list of 32 factors was subsequently narrowed down to these ten key elements that specifically affect labour productivity.

Abdu, M., Arebu, T., & Kumar Gangwar, P. (2023) identified key motivational factors affecting labour productivity in the construction sector: rewards; good relationships; promotion opportunities; job security; the amount of salary; good supervision; and a good work environment. This study considered motivational factors which affect labour productivity in construction projects only. Hence, another aspect was not considered and included in this study.

As per Faiq Mohammed Sarhan Al-Zwainy et al., (2013), project managers face challenge of identifying factors that impact labour productivity in the construction. Understanding these elements allows for strategies to reduce inefficiencies and enhancing project performance. Defining activities to minimize cost overruns and delays is essential for improving productivity and outcomes. This requires a clear understanding of the factors that influence construction labour productivity. While surveys and studies have identified several of these factors, many issues remain unclear and warrant further research, even in the industrial nations. Additionally, productivity enhancement policies vary across countries. Furthermore, the key elements affecting productivity in emerging nations are not the same as those in developed nations.

After examining different research, it is clear that lowering project costs, cutting down on delays, and enhancing overall project performance all depend on an understanding of the variables affecting construction labour productivity. Researchers stress that to create methods for increasing efficiency, it is critical to understand the positive and negative factors affecting production. Research shows that for developing countries, skilled labour is essential to sustaining

economic growth and productivity, indicating the necessity of high-quality workforce development to bolster industry-led expansion.

The productivity of the construction sector is influenced by several elements and different research has revealed that labour productivity is adversely affected by various factors. It can be difficult for project managers to pinpoint the variables influencing worker productivity in the construction sector. To eliminate inefficiencies and improve project performance, methods that take these factors into account shall be developed.

Although research has discovered factors that affect productivity, there are still gaps in understanding, particularly in developed and developing countries where policies and essential components vary. Labour productivity in developed countries tends to be higher than in developing countries due to having more advanced services that leverage technology and innovation to increase productivity. On the other hand, in developing countries, labour productivity is often lower due to factors which discussed in this study.

The research reviewed in this literature review has identified the key factors that affect labour productivity in the construction industry of Ethiopia.

2.7 Approaches for Modeling

Different studies have employed various modeling approaches, which are crucial for assessing and enhancing labour productivity. Integrating the Analytic Hierarchy Process (AHP) represents a significant methodological choice. AHP provides a structured way to evaluate and prioritize factors affecting labour productivity, facilitating the identification of key variables and their relative importance. As a general measurement theory, AHP utilizes ratio scales based on discrete and continuous measurements, including paired comparisons that indicate the relative strength of preferences and sentiments (Saaty, 1987).

According to Emad Elwakil (2016), the analytic hierarchy process (AHP) mimics the human decision-making process. AHP's flexibility enables integration with modeling techniques such as multiple linear regression, fuzzy logic, and artificial neural networks (ANN), resulting in more comprehensive outcomes.AHP is founded on three main concepts: creating hierarchies, prioritizing tasks, and ensuring logical consistency. Prashik Ingle &Leeladhar Pammar (2020)

emphasize the advantages of AHP, including its ease to use, scalable hierarchy structure, adaptability to different problem sizes, and low data requirements. According to Esra Albayrak &Yasemin Claire Erensal (2003), the effective application of the analytic hierarchy process (AHP) depends on establishing a clear decision hierarchy. AHP employs a hierarchical structure to simplify complex problems and utilizes pair wise comparisons for multi-criteria decision-making. The process consists of three steps: designing the decision hierarchy, prioritizing, and calculating results. By organizing complex decision issues into hierarchical frameworks, AHP breaks down multi-criteria decision-making into interconnected elements, including criteria and alternatives, resembling a family tree structure.

The Analytical Hierarchy Process is one of the tool helps for making decisions. By taking both qualitative and quantitative aspects, it helps as to organize complicated issues into systems. Creating a hierarchy of an items and defining the problems are the first step in the process. Intermediate levels that show the criteria and sub-criteria that affected our choice come in the next place. The next step after creating hierarchies is to evaluate each criterion's weight in relation to others at the same level. According to Bhavya K. and Lekshmi M. G. (2022), this is done by pair wise comparisons using a nine-point scale.

Hamouda, H. & Abu-Shaaban N. (2015) demonstrated the effectiveness of the Analytical Hierarchy Process (AHP) in statistically examining the relationships among various factors. Their findings reveal that Labour productivity is significantly affected by job satisfaction and security, the lack of incentive schemes, skill and experience, drug use, overtime, and weather fluctuations across different sub-groups. Notably, the category of physical variables had the most substantial impact on onsite labour productivity across all key groupings. The study illustrates how the AHP model can help construction companies in the Gaza Strip enhance labour productivity, leading to time and cost savings. Furthermore, the AHP approach is user-friendly, allowing for continuous refinement of group preferences, including sub-criteria.

In general, the Analytic Hierarchy Process (AHP) offers key advantages that enhance decision-making and prioritization. It manages complex decision problems by breaking them down into smaller components, allowing for systematic analysis and comparison of criteria and alternatives, resulting in a transparent decision-making process. Moreover, AHP integrates qualitative and

quantitative factors, enabling decision-makers to weigh subjective judgments against objective data. The use of pair wise comparisons strengthens the assessment of relative importance and preferences, leading informed and rational outcomes. AHP's flexibility, systematic methodology, and ability to accommodate diverse criteria make it a powerful tool for addressing complex decision problems.

2.8 Summary of the study gap

The literature review provides a thorough analysis of Addis Ababa, Ethiopia's construction sector, emphasizing the critical role that worker productivity plays in promoting urbanization and economic growth. It highlights the complex relationship between productivity and stakeholder satisfaction, project success, and cost control in the construction industry. The review explores several productivity evaluation dimensions, such as job completion rates, labour efficiency, project timeframes, and resource use. It also highlights how critical it is to address issues with labour productivity to maintain the long-term expansion and viability of Addis Ababa's construction sector.

Even though the literature study offers insightful information about worker productivity problems in Addis Ababa's construction industry, there is still a significant knowledge vacuum about workable solutions and tactics for raising productivity levels. To enhance worker productivity, future research could concentrate on investigating cutting-edge strategies by examining critical factors.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

The research methodology aimed to the precise procedures and methods used to determine, rank, and examine the elements influencing labour productivity and to develop the optimization framework. Professionals in the building construction industry were the target audience for a survey questionnaire that was presented in a pair wise matrix format. Ethical considerations were carefully considered throughout the research process in order to protect participants and preserve the integrity of the data. Furthermore, each participant gave their informed consent, guaranteeing the privacy of their personal data.

3.2 Study Area

This research focuses on building construction projects in Addis Ababa, Ethiopia. This area was picked because of its substantial infrastructure investment and quick urban development. A wide variety of projects, including public infrastructure, commercial, and residential ones, define Addis Ababa's construction industry, offering a rich setting for analyzing labour productivity factors. Evaluating labour efficiency factors specifically helps to increase labour productivity in regional construction practices requires an understanding of the particular dynamics and challenges of the region.

3.3 Research Design and Approach

This study's research design is based on a quantitative research methodology, which enables methodical examination and analysis of numerical data. The research's primary goals are to determine, rank, and examine the variables influencing labour productivity in building projects.

Numerical data is collected and examined in quantitative research in order to identify patterns and connections. Because it enables the statistical analysis of various factors influencing labour productivity, it is particularly suitable for this study.

The following essential elements are part of the research work.

• Literature Review: To find pertinent factors influencing labour productivity, a thorough review of the body of existing literature was carried out. The study's design and data collection techniques were based on this review.

• Data collection: To collect information from experts in the construction sector, a structured questionnaire was created. This survey's objective was to collect quantitative data on a range of productivity-related topics.

3.4 Sources of the data

The existing literature, research, and academic papers which are focused on construction Engineering and Management, and related fields include notable examples such as the Journal of Construction management and economy, and the International Journals of Project Management. Surveys done with construction professionals, project managers, and workers provide useful information about individual project experiences, issues, and potential for improvement

3.5 Populations and Sampling

In order to select participants for this study based on predefined criteria, a non-probability sampling technique called purposive sampling was employed. This approach ensured that the sample would be highly relevant to the study's objectives and inquiries. Various construction project professionals, including project managers, site engineers, resident engineers, and office engineers, were among the participants.

3.6 Methods for collecting data

Data for this study were gathered using a selection of methods to ensure a comprehensive understanding of labour productivity factors.

3.6.1 Questionnaires

A structured questionnaire was developed in order to gather quantitative data from professionals in the construction sector.

Design of the questionnaire: Data on Demographics The questionnaire included questions about the participants' roles, education, experience, and backgrounds.

• Pair wise Comparisons: A pair wise matrix format was employed to allow participants to rank factors based on their significance. The questionnaires were delivered in person to ensure clarity and allow participants to ask questions. The participants had two weeks to complete the surveys and send them back.

3.6.2 Interview

In addition to the questionnaire, semi-structured interviews were conducted to gain understanding of the participants' perspectives and experiences. The interviews' semi-structured format allowed for flexibility in responses while still covering crucial subjects linked to labour productivity.

Table 3.1 Summary of selected under construction projects

No	Name of Project	Building Type	Scope	Location
1	Ambaye Commercial Building	Mixed Use Commercial Building	4B+G+24	Atlas
2	NB Real estate	Apartment Building	4B+G+24	Bole
3	Addis life real estate	Apartment Building	2B+G+24	Sar Bet
4	HA Building	Mixed Use Building	3B+G+23	Mexico
5	Sengatera Traders Union	Mixed-Use Commercial Building	3B+G+22	Mexico
6	Alehiwan Real estate	Apartment Building	2B+G+16	Jemo
7	Felek Trading	Mixed-Use Building	2B+G+15	Lebu
8	Oromia Media Complex Building Project	Mixed-Use Building	G+11+R	Dembele
9	Mihcat Construction and Cottage Industry	Mixed-Use Building	3B+G+10	Merkato
10	Radical Project	Mixed-Use Building	B+G+9	Filwiha
11	La Gare Central Core Mall	Apartment Building	G+8 (3Blocks)	Legehar
12	National quality insurance	Laboratory & Office Building	B+G+7 &B+G+8	Megenag na
13	Azeb Apartment	Apartment Building	B+G+5	Ferensay Legasion
14	ATR Residential Building	Residential Building	2B+G+4(4blocks)	Mekanis a
15	Helen Residence	Residential Building	B+G+3	BisrateG abriel

3.7 Data Analysis

To analyze the research data, statistical techniques were employed to identify patterns, correlations, and interactions between variables. This approach enabled a thorough evaluation of the factors influencing labour productivity, providing a solid foundation for the next stages of the research. Excel was the primary tools for data processing and analysis, serving as the platform for data management, cleaning, and basic statistical calculations.

3.7.1 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) was essential in the data analysis phase in Excel. It provided a structured way to prioritize and rank factors influencing worker productivity through detailed comparisons, enhancing our understanding of their significance. AHP offered insights into the hierarchy of these factors, assigning weight and assisting in the evaluation of labour efficiency factors.

3.7.2 Initial AHP Factors

The factors influencing labour productivity, sourced from a variety of literature, were utilized as input for the study. Seventy-Seven (77) initial factors were identified from the in-depth literature review. Hence, to proceed with the analysis, the factors needed to be categorized into groups. Therefore, based on their meaning and implication, those factors were categorized into 6 different main factors and 14 sub-factors. Initial factors used in AHP are listed herein after fewer than 6 main categories.

Table 3-2 Factors from Category 1

#	Main and sub Categories	Description	Factors affecting LP
A	Manpower Factors	Factors related to the workforce, skilled professionals, and overall labour Engagement.	
	I - Labour-related factors	Factors pertain to aspects directly related to the workforce	Availability of labours
			Absence of sufficiently skilled labours
			Poor labour experiences
			Labour discipline which dugs addiction
			The absence of a labour outline that shows the hierarchy of labours
			Poor relationships among labours
			Number of workers on site
			Absence of incentive scheme for labours
			Labours age
			Labours working on weekends frequently
	II - Supervisor-Related Factors	Considerations related to supervisors or managers overseeing the workforce	Incompetence of the Work supervisors
			Delays in the decision making by supervisors
			Unclear instruction given by work supervisors
			Poor follow-up of work by supervisors
			Changing supervisors frequently
			Insufficient frequency of site inventories (usage, loss, theft, and breakage)

Table 3-3 Factors from Category 2

#	Main and sub Categories	Description	Factors affecting LP
B	Facility Factors	Include considerations related to the physical infrastructure and Resources needed for carrying out tasks efficiently.	
	I - Material-related factors	Focus on materials used in construction projects	Material shortage
			High increment in the price of materials
			Delay in delivery of the material
			Poor quality of the material
			Material inappropriateness for the purpose
			Poor material management techniques
			Low quality of transportation of the material
			Comparatively distant Material storage of the location
			Having a big size of construction site
	II - Equipment related factors	Concern about the equipment and machinery used in construction activities	Lack of equipments and tools
			Frequently damage to the equipments
			Inappropriate type of construction equip
			Inappropriate size of construction equip
	III - Technology-related factors	Involve the use of technology in construction projects to improve efficiency and productivity	Inadequate usage of technologies to communicate
			Poor usage of software for overall project management
			Lack of technology advancements in machinery

Table 3-4 Factors from Category 3

#	**Main and sub Categories**	**Description**	**Factors affecting LP**
C	Working condition factor	Focus on aspects of the work environment that impact employee health, Safety and well-being.	
	I - Health and safety-related factors	Address the health and safety aspects of the work environment	Absence of safety tools
			Violation of safety rules and regulations
			High occurrence of an Accidents during construction (small and large)
			Not hiring a safety officer on the site
	II - Motivation related factors	Relate to elements that influence motivation levels among workers	On time payment to labours
			Performing based payment
			Inadequate transportation facilities
			Unfair amount of wage concerning the activity
			Providing Free lunch

Table 3-5 Factors from Category 4

#	**Main and sub Categories**	**Description**	**Factors affecting LP**
D	Technical factors	Considerations related to the technical aspects of a project	
	I - Work plan Related Factors	Involve aspects related to project planning and scheduling adapting to changes.	Lack of a working schedule
			Poor implementation of the schedule
			absence of updated schedule
	II - Design-related factors	Focus on the design aspects of construction projects in compliance with building codes	Delay in delivery of drawings
			Delivering Incomplete drawings
			Ambiguous and incomplete specification
			Not conducting frequent revisions of drawing/design

	III - Project-related factors	Encompass broader project considerations and overall project management practices.	Complexity and scope of the project
			Inappropriate site layout (Temporary Offices)
			Congestion of site
			Poor site accessibility
			Location of the project
			Poor site security
			Shortage of water and/or power supply
			Contract type of the project
			Project objective not well defined
			Correction/rectification of works
			Changes in the scope of the project

Table 3-6 Factors from Category 5

#	**Main and sub Categories**	**Description**	**Factors affecting LP**
E	Organizational Factors	Elements within an organization that influence its functioning and Performance.	
	I - Management Related Factors	Involve organizational management aspects	Poor resources management
			absence of training for labours
			Absence of a financial motivation system
			Not conducting periodic meetings with Workers
			Unfair method of recruitment
	II - Stakeholders related factors	Pertain to stakeholders involved in the construction project	Financial difficulties of the owner/payment delay
			Absence of communication between parties (Owner, Consultant and Contractor)
			Improper owner interference with the work
			Absence of general support to the contractor

Table 3-7 Factors from Category 6

#	**Main and sub Categories**	**Description**	**Factors affecting LP**
F	External factors	Influences outside of the organization that can impact its operations and Performance.	
	I - Environmental and Natural factors	Include environmental considerations.	Subjecting to Earthquake
			Unsuitable Weather conditions
			Differing site conditions from the pre-analysis report
			Hydrological conditions
			Landscape of the site
	II - Political and Economic Factors	Encompass political and Economic influences	Unstable political conditions
			Government's taxation policies
			Inflation in every aspect of living expenses
			Economic fluctuations of the country

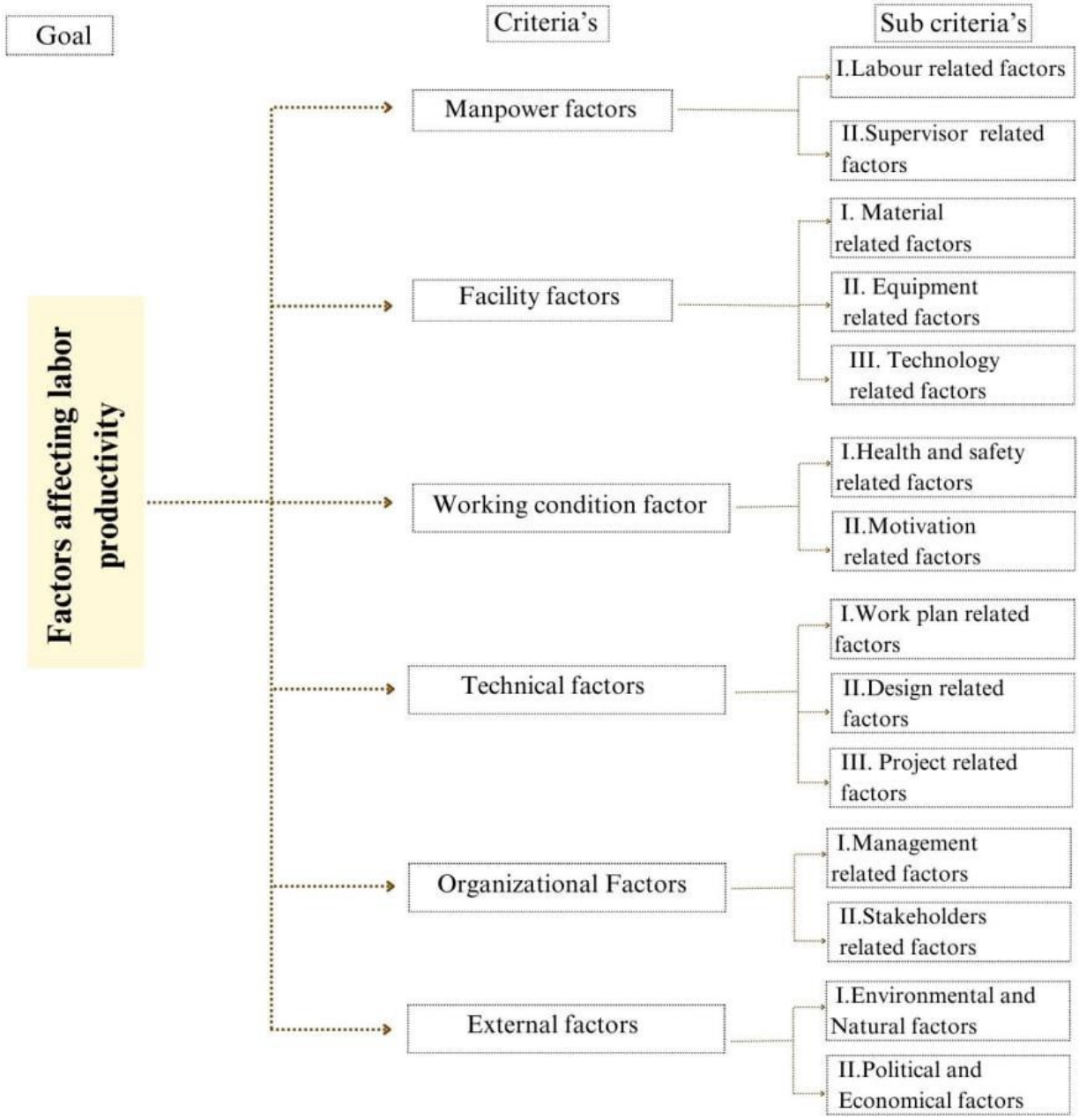
Professionals were then given a questionnaire to assess and evaluate each element within its respective categories, allowing them to provide numerical values ranging from 1 to 9 to each cell in the matrix. (Refer to Appendix I). The pair wise comparison enabled a thorough evaluation of the RI and influence of the parameters, offering significant insights into their importance and prioritization.

Table 3-8 the fundamental scale (Saaty, 1987)

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities make equal contributions to the objective.
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and demonstrated as dominant in practice.
9	Extreme importance	The evidence favoring one activity over another has the highest possible level of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed

Based on the importance comparison scale, a pair wise matrix questionnaire was distributed and collected effectively from 40 professionals.

3.7.3 Constructing Structural Hierarchy



The decision hierarchy structure which comprising the goals criteria, and sub-criteria, is created after a survey was finish. The attached structure is listed the first-line goal of the study, the second-line criteria, and the third sub-criteria components which was followed in conducting the research. Complex decision problems are categorized into hierarchies by the AHP.

3.7.4 Prioritizing

Thomas L. Saaty, a renowned University Professor at the University of Pittsburgh, where he taught at the Joseph M. Katz Graduate School of Business, provided the theory that was used to determine the intensity of importance on an absolute scale. Prioritization takes place based on the

weights given by the respondents.

To conduct the overall Analytic Hierarchy Process (AHP), the following steps were followed.

To calculate the geometric mean for all of the cells using the respondent's comparison will be

Equation 1 $GM = (x_1 \times x_2 \times x_3 \ldots \times x_n) \wedge (\frac{1}{n})$

Where: GM- Geometric mean

$x_1, x_2, x_3 \ldots x_n$, are the individual values

n is the total number of values

Construction of a pair wise matrix using the geometric value and putting all values of the cells in decimal numbers will be

	X_1	X_2	X_3
X_1	1.00	0.69	0.32
X_2	1.44	1.00	0.80
X_3	3.10	1.15	1.00

Example: - Matrix 3 x 3

Calculate the summation of each column (sum vertically)

Equation 2 …….. $cij = \sum_{i=1}^{n} cij$

Where:*cij* – each cell

	X_1	X_2	X_3
X_1	1.00	0.69	0.32
X_2	1.44	1.00	0.80
X_3	3.10	1.15	1.00
Sum	5.55	2.84	2.12

Normalizing the matrix: - a total sum of 1.0 or 100% for each column, pair-wise comparison matrices' entries was divided by their corresponding column total sums.

Equation 3 Normalized cell $= cij \div \sum_{i=1}^{n} cij$

Where: cij – each cell

	X_1	X_2	X_3
X_1	0.18	0.24	0.15
X_2	0.26	0.35	0.38
X_3	0.56	0.40	0.47

Calculating criteria weight: - average of each raw

Equation 4 $CW = Sum \div n$

	X_1	X_2	X_3	Weight
X_1	0.18	0.24	0.15	0.19
X_2	0.26	0.35	0.38	0.33
X_3	0.56	0.4	0.47	0.48
				1

Where: CW – Criteria weight of raw

n is the total number of variable

Checking consistency: the data must be consistent for the criteria weight to be accepted. Consistency and the internal coherence of decision-makers are correlated when comparing judgments in a pair wise comparison matrix. The most important metric for examining pair wise comparisons is this one.

In order to verify it, the denormalized matrix cell is multiplied by the criteria weight, the sum of each raw is computed for the weight sum calculation, and the weighted sum is divided by the criteria weight to determine the ratio.

	X_1	X_2	X_3	W. SUM	Weight	Ratio
X_1	0.19	0.23	0.15	0.57	0.19	2.99
X_2	0.28	0.33	0.38	0.99	0.33	3.00
X_3	0.60	0.38	0.48	1.45	0.48	3.04

Then, the consistency index is calculated based on the largest eigenvalue of the matrix, known as Lamda Max (λmax). The average λmax was computed by dividing the weighted aggregate values of each variable by their respective criteria weights.

Equation 5 $\lambda \max = \sum (\frac{wsv}{cw}) \div n$

Where, WSV – is the weighted sum value (Summation of raw)
CW – is the criteria weight

n – is the number of variables

The consistency ratio (CR) evaluates the consistency and reliability of the compassion matrix when scoring based on criteria weight. Saaty's rule of thumb only accepts judgment matrices with a consistency ratio of less than 0.1 (CR < 0.1). Saaty, R. W. (1987). The consistency ratio is calculated using a Randomized Index (RI) and the Average Consistency Index (CI).

Calculate consistency ratio – check if CR = CI/RI < 0.1 then the matrix is reasonably consistent

Table 3-9 Summary of Matrix size

Timsing	Matrix size
Two	3x3
Five	4x4
Three	5x5
Two	6x6
One	9x9
One	10x10
One	11x11

In summary, in this study a total of 15 matrices were formulated.

3.8 Validity and Reliability

A consistent research analysis approach was employed to ensure the reliability of the data collected in the study. Reliability refers to the degree of consistency with which an instrument measures an attribute. An instrument demonstrates higher reliability when it produces less fluctuation in repeated measurements of an attribute.

In this research, Cronbach's coefficient alpha was utilized to measure internal consistency and assesses the reliability of the questionnaire. Cronbach's alpha values typically range from 0 to 1.0, with values closer to 1 indicating higher internal consistency among the items in the instrument.

3.9 Research Ethics

The primary goal is to ensure that research and related activities adhere to all applicable laws, regulations, and ethical standards of the country or region in where the research is conducted. Participants received clear information about the risks involved, allowing them to make informed decisions regarding their participation. Furthermore, all potential participants informed about how their confidentiality will be protected during data collection and publication of results

CHAPTER FOUR
RESULT AND DISCUSSION

4.1 Introduction

This chapter presents an overview of the study's participant profile and response rate of the questionnaire. It then discusses the statistical and technical results, as well as the analysis of factors influencing labour productivity.

4.2. Respondents background

The research involved administering a questionnaire to 47 selected professionals to prioritize factors affecting labour productivity using a pair wise comparison matrix. This method enabled a thorough exploration and ranking of these factors, resulting in a valuable data set for detailed analysis and insights.

Table 4-1 Summary of Questionnaire Distribution and Response Rate

Study population	Sample size	Total questionnaire distributed	Completed and qualified responses	Response rate
No	15 projects	47	40	85 %

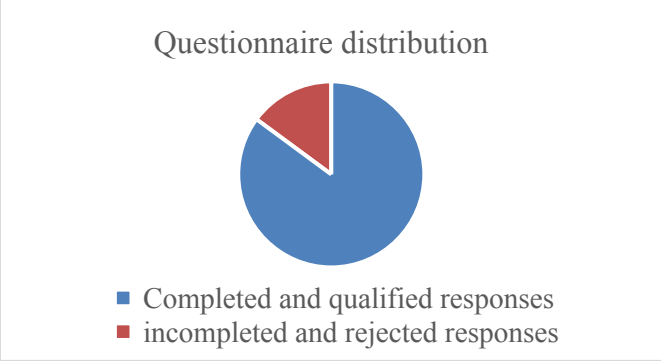


Figure 4.1 Distribution of Questionaries

General Information about Respondents

Type of firm the respondents engaged.

A total of 40 respondents were participated from different types of firms.

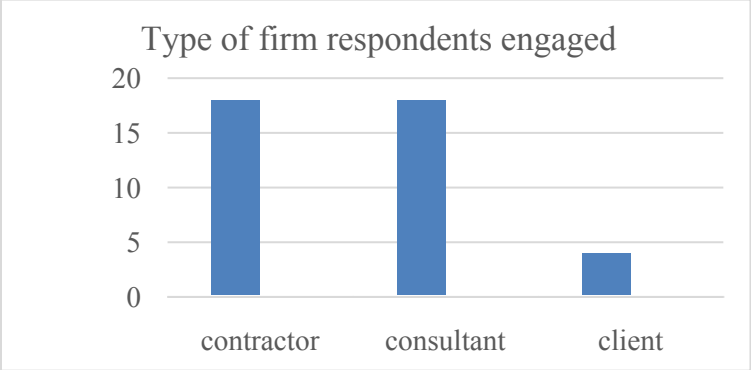


Figure 4-2 Type of firm engaged by participants

The educational level of respondents

Table 4-2 Educational levels of respondents

Description	BSc	MSc
Contractor	12	6
Consultant	4	14
Client	2	2

Current position in the firm site engineers, 11 Project Managers, 14 Resident engineers, and 5 Project coordinators participated

Checking Reliability

The reliability of the instrument equals 0.872 therefore it is acceptable because of Cronbach's Alpha coefficient is close to one. The method was used to test the validity and reliability of

respondents' perspectives on factors affecting labour productivity in building construction projects.

Table 4-3 Reliability statistics

Cronbach's Alpha	N of Items
.872	21

4.3 Conducting Analytic Hierarchy Process

one of the specific objectives of this research was to identify the significance of variables and prioritize using the Analytical Hierarchy Process (AHP). This requires a thorough statistical study in Excel.

Table 4-4 Statistical results for the Category 1

	#	**Factors Affecting Labour Productivity**	**Criteria weight**	λ max =	**CI**	**CR**
Manpower factors	I - Labour-related factors					
	1	Availability of labours	6.3%	10.4	0.044	0.03
	2	Absence of sufficiently skilled labours	16.7%			
	3	Poor labour experience	15.9%			
	4	Labour discipline (including being addicted to drugs)	9.0%			
	5	The absence of a labour outline showing hierarchy of labours clearly	9.1%			
	6	Poor relationship between labours	9.1%			
	7	Number of workers on site (Overcrowded labour force)	9.7%			
	8	Absence of incentive scheme for labours	8.6%			
	9	Labours age (elders)	9.1%			
	10	Labours working weekends frequently	6.5%			
	II - Supervisor Related Factors					
	11	Incompetence of Work supervisors	13.7%	6.04	0.008	0.006
	12	Delays in decision-making by supervisors	21.5%			
	13	Unclear instruction given by work supervisors	16.6%			
	14	Poor follow-up of work by supervisors	19.0%			
	15	Changing supervisors frequently	13.8%			
	16	Insufficient frequency of site inventories (usage, loss, theft, and breakage)	15.4%			

Each factor within these categories is assigned a specific criteria weight, which indicates the relative importance of that factor in influencing labour productivity within the context of the analysis conducted using the Analytic Hierarchy Process (AHP) methodology.

Factors such as "Absence of sufficiently skilled labours" with a weight of 16.7% and "Poor labour experience" with a weight of 15.9% are highlighted as significant labour- related factors impacting productivity. Similarly, supervisor-related factors like "Delays in decision-making by supervisors" with a weight of 21.5% and "Poor follow-up of work by supervisors" with a weight of 19.0% are identified as crucial considerations affecting labour productivity in the analysis.

These weights assigned to each factor play a key role in prioritizing and understanding the impact of different aspects on labour productivity, providing insights for decision- making and improvement strategies in the context of the analyzed data

Table 4-5 Statistical results for the Category 2

	#	Factors Affecting Labour Productivity	**Criteria weight**	λ max =	**CI**	**CR**
Facility factors	I - Material-related factors					
	17	Shortage of material	9.8%	9.23	0.028	0.02
	18	High increment in the price of materials	10.8%			
	19	Delay in delivery of material	15.5%			
	20	Poor quality of material	15.0%			
	21	Material inappropriateness for the purpose	8.8%			
	22	Poor material management	12.0%			
	23	Low quality of transportation of the material to the site	8.1%			
	24	Comparatively distant Material storage location	10.7%			
	25	Having the large size of the construction site	9.3%			
	II - Equipment related factors					
	26	Lack of equipment and tools	36.5%	4.114	0.038	0.04
	27	Frequent damage to equipment	21.2%			
	28	Inappropriate type of construction equipment	22.7%			
	29	Inappropriate size of construction equipment	19.6%			
	III - Technology-related factors					
	30	Inadequate usage of technologies for communication	19.2%	3.01	0.004	0.007

	31	Poor usage of software for overall project management	32.9%			
	32	Absence of technological advancements in machinery	47.9%			

Within the material-related factors category, factors like "Delay in delivery of material" with a weight of 15.5% and "Poor quality of material" with a weight of 15.0% are highlighted as significant considerations impacting labour productivity. Similarly, in the equipment-related factors category, "Lack of equipment and tools" is identified as a crucial factor with a weight of 36.5%.

Moreover, technology-related factors such as "Absence of technological advancements in machinery" with a weight of 47.9% and "Poor usage of software for overall project management" with a weight of 32.9% are emphasized as key aspects affecting labour productivity within the analysis.

Table 4-6 Statistical results for the Category 3

	#	**Factors Affecting Labour Productivity**	**Criteria weight**	λ max =	**CI**	**CR**
Working Condition Factor	I - Health and safety-related factors					
	33	Lack of safety tools	42.2%	4.06	0.02	0.024
	34	Violation of safety rules and regulations	20.1%			
	35	High occurrence of Accidents during construction (small and large)	14.5%			
	36	Not hiring a safety officer on the site	23.3%			
	II - Motivation related factors					
	37	On-time payment to labours	23.6%	5.23	0.06	0.052
	38	Performing based payment	24.7%			
	39	Inadequate transportation facilities for labours	15.5%			
	40	Unfair amount of wage concerning the activity	22.2%			
	41	Providing Free lunch	14.1%			

Within the health and safety-related factors category, "Lack of safety tools" is identified as a critical factor with a weight of 42.2%, highlighting its significant impact on labour productivity. Similarly, in the motivation-related factors category, factors like "On-time payment to labours" with a weight of 23.6% and "Performing-based payment" with a weight of 24.7% are emphasized as important considerations affecting productivity.

Table 4-7 Statistical results for the Category 4

	#	**Factor**s Affecting Labour Productivity	**Criteria weight**	λmax	**CI**	**CR**
Technical factors	I - Work plan Related Factors					
	42	Absence of a working schedule	27.3%	3.04	0.022	0.037
	43	Poor implementation of the schedule	33.9%			
	44	Lack of updated schedule	38.8%			
	II - Design-related factors					
	45	Delay in delivery of drawings	17.5%	4.05	0.02	0.02
	46	Delivering Incomplete drawings	24.3%			
	47	Ambiguous and incomplete specification	26.6%			
	48	Not conducting frequent revisions of drawing/design	31.7%			
	III - Project-related factors					
	49	Complexity and scope of the project	7.4%	11.4	0.04	0.003
	50	Inappropriate site layout (Temporary Offices)	5.5%			
	51	Congestion of site	7.4%			
	52	Poor site accessibility	7.3%			
	53	Location of the project	7.6%			
	54	Poor site security	6.2%			
	55	Shortage of water and/or power supply	14.1%			
	56	Contract type of the project	9.1%			
	57	Project objective not well defined	12.0%			
	58	Correction/rectification of works	10.8%			
	59	Changes in the scope of the project	12.4%			

Within the work plan-related factors category, "Absence of a working schedule" is identified as a significant factor with a weight of 27.3%, highlighting its substantial impact on labour productivity. Similarly, in the design-related factors category, factors like "Ambiguous and incomplete specification" with a weight of 26.6% and "Not conducting frequent revisions of drawing/design" with a weight of 31.7% are emphasized as important considerations affecting productivity.

Table 4-8 Statistical results for the Category 5

	#	Factors Affecting Labour Productivity	Criteria weight	λmax	CI	CR
Organizational Factors	**I - Management Related Factors**					
	60	Poor resources management	14.8%	5.02	0.004	0.003
	61	Lack of training for labours	16.0%			
	62	Lack of a financial motivation system	26.9%			
	63	Not conducting periodic meetings with labours	20.5%			
	64	Unfair method of recruitment	21.7%			
	II - Stakeholders related factors					
	65	Financial difficulties of the owner/payment delay	23.1%	4.08	0.028	0.031
	66	Lack of communication between parties (Owner, Consultant and Contractor)	30.7%			
	67	Improper owner interference with the work	28.7%			
	68	Lack of general support to the contractor	17.4%			

Within the management-related factors category, "Lack of a financial motivation system" is identified as a significant factor with a weight of 26.9%, emphasizing its impact on labour productivity. Similarly, in the stakeholders-related factors category, factors like "Lack of communication between parties" with a weight of 30.7% and "Improper owner interference with the work" with a weight of 28.7% are highlighted as crucial considerations affecting productivity.

Table 4-9 Statistical results for the Category 6

	#	Factors Affecting Labour Productivity	**Criteria weight**	λmax	**CI**	**CR**
External factors	I - Environmental and Natural factors					
	69	Subjecting to Earthquake	10.9%	5.12	0.032	0.028
	70	Unsuitable Weather conditions (too cold, heavy rainfall, too hot)	24.0%			
	71	Differing site conditions from the pre-analysis report	20.2%			
	72	Hydrological conditions	21.3%			
	73	Landscape of the site	23.6%			
	II - Political and Economic Factors					
	74	Unstable political conditions	26.1%	4.07	0.023	0.026
	75	Government's taxation policies	17.3%			
	76	Inflation in every aspect of living expenses	29.0%			
	77	Economic fluctuations of the country	27.6%			

Within the environmental and natural factors category, "Unsuitable Weather conditions" is identified as a significant factor with a weight of 24.0%, highlighting its impact on labour productivity. Similarly, in the political and economic factors category, factors like "Inflation in every aspect of living expenses" with a weight of 29.0% and "Economic fluctuations of the country" with a weight of 27.6% are emphasized as crucial considerations affecting productivity.

Table 4-10 Statistical Result for the Main Factors

	#	**Factors Affecting Labour Productivity**	**Criteria weight**	λmax	**CI**	**CR**
Main Factors	1	Manpower factors	21.4%	6.14	0.027	0.022
	2	Facility factors	22.0%			
	3	Working condition factor	19.2%			
	4	Technical factors	18.1%			
	5	Organizational Factors	10.7%			
	6	External factors	8.6%			

As shown in the tabular summary above, the matrices all satisfy CR = CI/RI < 0.1, so the data are reasonably consistent.

4.4 Factor Reduction

The factors should be reduced to a possible number. In order to do, the concept of Priority weight aggregation was used. The consistency analysis catalyzes priority weight aggregation, where multiplying the sub-factor weight by the complementary main factor weight of the same category determines the aggregated weight of each sub-factor according to Emad Elwakil (2016).

Equation 6 $ASW_{ij} = W_i * SW_{ij}$

Where: ASWij - Aggregated weight of the sub-factor, Wi - the weight of the main factor, and

SWij - the weight of sub-factor j in the ith factor.

Based on the main six factors' criteria weight value, only four of them are more than 80% of the total factors.

Table 4-11 Main factors after Factor Reduction

Manpower factors	21.4 %
Facility factors	22.0 %
Working condition factor	19.2 %
Technical factors	18.1 %

From 77 total factors collected from different literatures, using AHP, the factors are reduced to 21 Sub factors.

Table 4-12 Category 1 aggregate sum Calculation

		A	B
A	Manpower factors = Criteria Weight = 21.45	Criteria weight	Agg. Sum = A * Main factor Wt
	I - Labour related factors		
1	Availability of labours	6.3%	1.34%
2	Absence of sufficiently skilled labours	16.7%	3.59%
3	Poor labour experience	15.9%	3.41%
4	Labours discipline (including being addicted to drugs)	9.0%	1.92%
5	Absence of labour outline showing hierarchy of labours clearly	9.1%	1.96%
6	Poor relationship between labours	9.1%	1.96%
7	Number of workers on site (Overcrowded labour force)	9.7%	2.08%
8	Absence of incentive scheme for labours	8.6%	1.84%
9	Labours age (elders)	9.1%	1.96%
10	Labours working weekends frequently	6.5%	1.39%
	Aggregate sum Bench mark = Average of Aggregate sum		2.14%

		A	B
A	**Manpower factors = Criteria Weight = 21.45**	Criteria weight	Agg. Sum = A * Main factor Wt
	II - Supervisor Related Factors		
11	Incompetence of Work supervisors	13.7%	2.93%
12	Delays in decisions making by supervisors	21.5%	4.61%
13	Unclear instruction given by work supervisors	16.6%	3.563%
14	Poor follow up of work by supervisors	19.0%	4.08%
15	Changing of supervisors frequently	13.8%	2.97%

16	Insufficient frequency of site inventories (usage, loss, theft, and breakage)	15.4%	3.30%
	Aggregate sum Bench mark = Average of Aggregate sum		3.57%

Table 4-13 Factor reduced in Category 1

#	**Factors Affecting Labour Productivity**	**Criteria Weight**
A	**Manpower factors**	
	I – Labour-related factors	
1	Absence of sufficiently skilled labours	16.74%
2	Poor labour experience	15.91%
	II - Supervisor Related Factors	
1	Delays in decision making by supervisors	21.48%
2	Poor follow-up of work by supervisors	19.03%

Based on the detailed breakdown of factors affecting labour productivity within the Manpower factors category, the absence of sufficiently skilled labours at 16.74% and poor labour experience at 15.91% highlight the critical impact of skilled workforce availability and experience on productivity. Moreover, delays in decision-making by supervisors at 21.48% and poor follow-up of work by supervisors at 19.03% underscore the significance of supervisor efficiency in influencing operational efficiency and overall productivity.

Addressing these factors through targeted training programs for skill development, supervisory training initiatives, and performance monitoring systems can lead to enhanced productivity, streamlined operations, and improved organizational performance.

Category 2 of aggregate sum Calculation

Table 4-14 Factor reduced in Category 2

B	**Facility factors**	**Criteria Weight**
	I – Material related factors	
1	Poor quality of material	12.49%
2	Poor material management	12.13%
3	Delay in delivery of material	12.09%
	II - Equipment related factors	
1	Lack of equipment and tools	36.49%
	III - Technology-related factors	

1	Absence of technological advancements in machinery	47.87%

Here, poor quality of material at 12.49%, poor material management at 12.13%, and delay in delivery of material at 12.09% underscore the importance of material-related factors in influencing productivity. Additionally, the lack of equipment and tools at 36.49% and absence of technological advancements in machinery at 47.87% within equipment and technology-related factors highlight the critical role of proper equipment availability and technological advancements in enhancing operational efficiency and overall productivity.

Addressing these factors through improved material quality control, efficient material management practices, timely delivery processes, equipment provision, and technological upgrades can lead to optimized productivity levels, streamlined operations, and improved performance outcomes.

Category three

Table 4-15 Factor reduced in Category 3

C	**Working condition factor**	**Criteria Weight**
	I - Health and safety-related factors	
1	Lack of safety tools	42.18%
	II - Motivation related factors	
1	On time payment to labours	23.55%
2	Unfair amount of wage forth activity	22.21%
3	Performance-based payment	24.67%

The lack of safety tools at 42.18% under Health and safety-related factors emphasizes the critical importance of ensuring a safe working environment to enhance productivity. Furthermore, Motivation related factors such as on-time payment to labours at 23.55%, unfair wage distribution for activities at 22.21%, and performance-based payment at 24.67% highlight the significant impact of fair compensation and motivational incentives on workforce performance and overall productivity.

Addressing these factors through the provision of necessary safety tools, timely payment practices, fair wage distribution, and performance-based incentives can contribute to a safer, more motivated workforce, leading to improved productivity levels and better organizational outcomes.

Category Four

Table 4-16 Factor reduced in Category 4

D	**Technical factors**	**Criteria Weight**
	I Work plan Related Factors	
1	Poor implementation of the schedule	33.94%
2	Lack of updated schedule	38.75%
	II - Design-related factors	
1	Not conducting frequent revisions of drawing/design	31.68%
2	Ambiguous and incomplete specification	26.57%
	III - Project-related factors	
1	Shortage of water and power supply	14.11%
2	Changes in the scope of the project	12.45%
3	Project objective not well defined	12.02%
4	Correction/rectification of works	10.83%

Poor implementation of the schedule at 33.94% and lack of an updated schedule at 38.75% under Work Plan Related Factors highlight the importance of efficient scheduling practices in optimizing productivity. Additionally, Design-related factors such as not conducting frequent revisions of drawing/design at 31.68% and ambiguous and incomplete specifications at 26.57% underscore the significance of clear and up-to-date design processes in enhancing operational efficiency. Moreover, Project-related factors including shortage of water and/or power supply at 14.11%, changes in the project scope at 12.45%, project objectives not well defined at 12.02%, and correction/rectification of works at 10.83% emphasize the impact of project management aspects on productivity levels. Addressing these technical factors through improved scheduling methods, clear design processes, effective project management practices, and adequate resource allocation can lead to enhanced productivity, streamlined operations, and improved project outcomes

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study aimed to Evaluate labour efficiency factors in building construction projects, particularly concreting tasks. Through a comprehensive investigation, we identified several key factors influencing worker productivity and employed the Analytical Hierarchy Process (AHP) to prioritize them. The finding revealed that manpower, facility, working conditions, technical aspects, organizational elements, and external factors all significantly affect labour productivity. By establishing these priorities, we devised a structured strategy that enables construction managers to focus their resources and efforts on the most critical areas. This prioritization is essential, as it facilitate stargeted interventions that can result in substantial improvements in labour efficiency.

In conclusion, this study highlights the various factors that affect labour productivity in the construction industry. By applying the study, stakeholders such as project managers, labours, and clients can make educated decisions that target specific areas for improvement. This proactive approach enhances operational efficiency, and helps to minimize project delays and costs. Finally, the successfully implementation of this study is expected to lead to better project outcomes, fostering a more productive and competitive construction environment.

5.2 Recommendation

To enhance labour efficiency in building construction, it is critical to develop tailored training programs that prioritize elements impacting productivity. Additionally, establishing effective communication channels is essential; regular updates and feedback among team members can prevent misunderstandings and ensure alignment on project goals, fostering a collaborative work environment.

Conducting regular performance assessments helps identify ongoing issues and opportunities for improvement, enabling project managers to make timely adjustments to strategies and processes. Moreover, utilizing advanced construction management software and tools facilitates for real-time monitoring of labour efficiency and resource allocation, streamlining operations and improving decision-making.

Involving all key stakeholders including labours, supervisors, project managers, and clients in discussion about productivity challenges regarding productivity can provide valuable insights and help ensure that solutions are both practical and effective. Furthermore, cultivating a culture of continuous improvement by encouraging feedback and sharing best practices will contribute to lasting gains in labour efficiency and overall project success. By adopting these comprehensive approaches, construction firms can improve labour efficiency in concreting processes, leading to better project outcomes and increased competitiveness in the industry.

REFERENCES

Abdu, M., Arebu, T., & Kumar Gangwar, P. (2023) Study of Motivational Factors Affecting Construction Labour Productivity in the Working Environment. *Ann. For. Res 66(1)*, pp. 4305-4319

Ahmed H. et al. (2013) A Framework for Construction Labour Productivity Improvement In Egypt. *AEI*, pp. 1007-1017

Ashebir A. et al. (2019) A Study on Factors Affecting Labour Productivity on Construction Projects in Wolaita Zone. *IRJET, 8(12),* pp. 817-822

Amanuel, M. (2016). A study on factors affecting labour productivity on building construction projects in Addis Ababa, Ethiopia. Addis Ababa University.

Al-Zwainy, F.M.S., Abdulmajeed, M.H., &Aljumaily, H.S.M. (2013).Using Multivariable Linear Regression Technique for Modeling Productivity Construction in Iraq. Journal of Civil Engineering, 3, 127-135

Bartoschek, P. M., &Kirchev, F. K. (2021).Labour productivity influence in the construction industry. Jonkoping International Business School.

Bhavya K., Lekshmi M. G. (2022) Analysis of Labour Productivity in the Construction Industry Using Analytical Hierarchy Process and Linear Regression Method. *IJRASET, 10(7)*, pp. 1770–1776.

Dozzi, S. P. & Abourizk, S. M. (1993). Productivity in Construction National Research Council Canada

Dr. Ghanim A. Bekr (2016) Study of Significant Factors Affecting Labour Productivity at Construction Sites in Jordan: Site Survey. *Journal of Engineering Technology, 4(1),* pp. 92-97

Esra Albayrak & Yasemin Claire Erensal (2003) Using analytic hierarchy process (AHP) to improve human performance: An application of multiple criteria decision making problem. *Journal of Intelligent Manufacturing, 15*, pp. 491-503

Hamouda, H., & Abu-Shaaban, N. (2015) Enhancing labour productivity within the construction industry through analytical hierarchy process, the case of Gaza Strip. *Universal Journal of Management, 3(8),* pp. 329-336

Himanshu A., Sohit A., Dr.Mukesh P. (2016) A Case Study on Labour Productivity.

IRJET, 3(12), pp. 664-667

Policy Studies Institute. (2020). Ethiopia Productivity Report. Addis Ababa: Policy Studies Institute.

Jisha Chakkappan, Lakshmi G Das (2016) Labour Productivity Analysis Using Multi-variable Linear Regression Technique. *International Research Journal of Engineering and Technology, 3(9)*, pp. 870-872

Saaty, R. W. (1987). The Analytic Hierarchy Process-What It Is And How It Is Used (Vol. 9, Issue 5).

Zeray, S. (2019). Factors affecting employee productivity in the construction sector: The case of Defense Construction Enterprise. Addis Ababa University.

Appendix 1: Summary of factors affecting labour productivity

Factors Affecting Labour Productivity	Description and Hindering effects	Source
Availability of labours	The presence of an adequate number of workers to carry out tasks on the construction site efficiently.	Ashebir A. et al. (2019), Nguyen Van Tam et al., (2021), Dr. Ghanim A. Bekr (2016)
Absence of sufficiently skilled labours	Lack of workers with the required expertise and qualifications to perform tasks effectively	Bhavya K.& Lekshmi M. G. (2022), Muhammad I. et al. (2020), Jisha Chakkappan, Lakshmi G Das (2016), Dr. Ghanim A. Bekr (2016)
Poor labour experience	Insufficient relevant work experience among the workforce, impacting work quality and efficiency.	Ashebir A. et al. (2019), Hamouda H., & Abu-Shaaban N. (2015)
Labour discipline (including being addicted to drugs)	Issues related to worker behavior and conduct, including drug addiction	Nguyen Van Tam et al., (2021)
The absence of a labour outline showing the hierarchy of labours clearly	Lack of a structured hierarchy or clear organizational chart defining the roles and responsibilities of labours.	Ashebir A. et al. (2019), Jisha Chakkappan, Lakshmi G Das (2016)
Poor relationship between labours	Lack of teamwork, communication, or collaboration among workers leads to conflicts, delays, and inefficiencies.	Ashebir A. et al. (2019), Tewodros W. L. (2019), Abdu M...et al., (2023)
Number of workers on site (Overcrowded labour force)	Too many workers relative to tasks, cause congestion, coordination issues, and reduced productivity.	Himanshu A. et al., (2016), Bhavya K.& Lekshmi M. G. (2022), Muhammad I. et al. (2020), Tewodros W. L.(2019), Abdu M..et al., (2023)
Absence of incentive scheme for labours	Lack of motivational programs or rewards for workers to boost morale, engagement, and performance.	Himanshu A. et al., (2016), Muhammad I. et al. (2020), Hamouda, H., & Abu-Shaaban, N. (2015), Tewodros W. L. (2019), Abdu M..et al., (2023)
Labours age (elders)	Consideration of workers' age, including physical limitations, experience levels, and adaptability to new technologies.	Nguyen Van Tam et al., (2021), Tewodros W. L.(2019)

Labours working weekends frequently	Workers frequently work weekends leading to fatigue, decreased morale, and potential productivity issues.	Ashebir A. et al. (2019), Bhavya K.& Lekshmi M. G. (2022), Nguyen Van Tam et al., (2021), Muhammad I. et al. (2020), Hamouda, H., & Abu-Shaaban, N. (2015), Tewodros W. L.(2019)
Incompetence of Work supervisors	Supervisors lacking the necessary skills, knowledge, or experience to effectively lead and manage construction activities, potentially leading to errors, delays, and inefficiencies.	Bhavya K.& Lekshmi M. G. (2022), Muhammad I. et al. (2020), Hamouda, H., & Abu-Shaaban, N. (2015), Dr. Ghanim A. Bekr (2016)
Delays in decision-making by supervisors	Situations where supervisors take too long to make critical decisions, causing project delays, impacting workflow, and hindering progress.	Ahmed H. et al. (2013), Himanshu A. et al., (2016), Ashebir A. et al. (2019), Bhavya K.& Lekshmi M. G. (2022), Muhammad I. et al. (2020)
Unclear instruction given by work supervisors	Instances where supervisors provide ambiguous or unclear instructions to workers, leading to misunderstandings, errors, and inefficiencies in task execution.	Muhammad I. et al. (2020), Tewodros W. L.(2019)
Poor follow-up of work by supervisors	Supervisors' failure to adequately monitor, track, and follow up on the progress and quality of work performed by labours, potentially results in subpar outcomes and rework.	Ashebir A. et al. (2019), Tewodros W. L.(2019)
Changing supervisors frequently	Involves a high turnover of supervisors on a construction site, leading to inconsistency, lack of continuity, and potential disruption in work processes and communication.	Hamouda, H., & Abu-Shaaban, N. (2015), Muhammad I. et al. (2020)
Insufficient frequency of site inventories (usage, loss, theft, and breakage)	Inadequate monitoring and tracking of materials on-site, including usage, loss, theft, and breakage, can lead to inventory discrepancies, project delays, and increased costs.	Bamfo-Agyei et al., (2023)
Shortage of material	A lack of essential materials required for construction activities, causes interruptions, delays, and inefficiencies in work progress.	Ahmed H. et al. (2013), Bhavya K.& Lekshmi M. G. (2022), Muhammad I. et al. (2020), Jisha Chakkappan, Lakshmi G Das (2016), Tewodros W. L.(2019), Dr. Ghanim

High increment in the price of materials	Significant increases in material costs	Bhavya K.& Lekshmi M. G. (2022)
Delay in delivery of material	Situations where materials are not delivered on time as scheduled	Ahmed H. et al. (2013), Bhavya K.& Lekshmi M. G. (2022)
Poor quality of material	Substandard or inferior quality of materials used in construction activities, leading to rework, project delays, safety risks, and potential long-term structural issues.	Ahmed H. et al. (2013), Ashebir A. et al. (2019), Bamfo-Agyei et al., (2023), Tewodros W. L.(2019)
Material inappropriateness for the purpose	Using materials that are not suitable or designed for the specific construction task or application, leads to inefficiencies, rework, and potential safety hazards.	Bamfo-Agyei et al., (2023)
Poor material management	Ineffective handling, storage, tracking, and utilization of materials on-site, resulting in wastage, delays, inventory discrepancies, and increased project costs.	Ahmed H. et al. (2013), Abdu M..et al., (2023)
Low quality of transportation of the material to the site	Issues with the transportation process of materials to the construction site, including delays, damage, or inefficiencies in logistics, impacting project timelines and costs.	Bhavya K.& Lekshmi M. G. (2022), Bamfo- Agyei et al., (2023)
Comparatively distant Material storage location	The storage location for materials is far from the construction site, leading to logistical challenges, increased transportation time, and potential delays in access to essential materials.	Ashebir A. et al. (2019), Muhammad I. et al. (2020), Tewodros W. L.(2019)
Having a large size of construction site	Construction projects with extensive or oversized sites can result in logistical complexities, coordination challenges, increased material handling distances, and potential inefficiencies.	Bhavya K.& Lekshmi M. G. (2022), Tewodros W. L.(2019)
Lack of equipment and tools	A shortage or inadequate supply of essential tools and equipment required for construction tasks leads to delays, inefficiencies, and compromised work quality.	Ahmed H. et al. (2013), Ashebir A. et al. (2019), Rahul S. Chaudhari et al. (2022),Nguyen Van Tam et al., (2021), Jisha Chakkappan, Lakshmi G Das(2016)

Frequent damage to equipment	Regular instances of tools and equipment being damaged or malfunctioning during construction activities, resulting in downtime, repair costs, and disruptions to workflow.	Bamfo-Agyei et al., (2023), Tewodros W. L.(2019), Dr. Ghanim A. Bekr (2016)
Inappropriate type of construction equipment	Using equipment that is not suitable or optimized for the specific construction task at hand, leads to inefficiencies, safety risks, and subpar work quality.	Bamfo-Agyei et al., (2023)
Inappropriate size of construction equipment	Using equipment that is either too large or too small for the intended construction tasks, resulting in inefficiencies, reduced productivity, and potential safety hazards.	Bamfo-Agyei et al., (2023)
Inadequate usage of technologies for communication	Underutilization or ineffective use of communication technologies on-site, hindering efficient information sharing, coordination, and collaboration among project stakeholders and teams.	Argaw T. G. & Ajibade A. A. (2017)
Poor usage of software for overall project management	The inadequate or ineffective utilization of software tools designed for managing various aspects of a project, such as scheduling, resource allocation, task tracking, and communication.	Argaw T. G. & Ajibade A. A. (2017)
Absence of technological advancements in machinery	the lack of modern or advanced technology integrated into construction machinery and equipment, which could potentially improve efficiency, productivity, and safety on the construction site	Argaw T. G. & Ajibade A. A. (2017)
Lack of safety tools	Insufficient availability or utilization of proper safety equipment and tools necessary to ensure the well-being and protection of workers on the construction site.	Bhavya K.& Lekshmi M. G. (2022), Nguyen Van Tam et al., (2021), Muhammad I. et al. (2020), Tewodros W. L.(2019)
Violation of safety rules and regulations	Not adhering to established safety guidelines, protocols, and legal regulations designed to prevent accidents and injuries in the construction industry.	Ashebir A. et al. (2019), Tewodros W. L.(2019)
High occurrence of Accidents during construction (small and large)	A significant number of both minor and major accidents happen frequently on the construction site, posing risks to the workers' health and safety.	Shobhit C. et al., (2018), Tewodros W. L.(2019)

Not hiring a safety officer on the site	The absence of a dedicated safety officer responsible for overseeing and implementing safety measures on the construction site to prevent accidents and ensure compliance with safety standards.	Ashebir A. et al. (2019), Tewodros W. L.(2019)
On-time payment to labours	The timely disbursement of wages to labours for their work, which is essential for maintaining a motivated workforce and ensuring financial stability for workers.	Himanshu A. et al., (2016), Ashebir A. et al. (2019), Bhavya K.& Lekshmi M. G. (2022), Muhammad I. et al. (2020), Jisha Chakkappan, Lakshmi G Das (2016), Tewodros W. L.(2019)
Performing based payment	Compensating workers based on their performance or output rather than fixed wages, which can impact motivation, fairness, and financial security for labours.	Jisha Chakkappan, Lakshmi G Das (2016)
Inadequate transportation facilities for labours	A lack of proper transportation arrangements for labours to commute to and from the construction site, which can affect their accessibility, safety, and overall well-being.	Tewodros W. L.(2019)
Unfair amount of wage concerning the activity	the issue of workers receiving wages that are perceived as unfair or inadequate based on the nature of their work or the prevailing industry standards, leading to dissatisfaction and potential labour issues	Nguyen Van Tam et al., (2021), Muhammad I. et al. (2020), Tewodros W. L.(2019), Abdu M..et al., (2023)
Providing Free lunch	offering complimentary meals to workers, which can contribute to their well-being, satisfaction, and overall morale on the construction Site.	Abdu M..et al., (2023)
Absence of a working schedule	The lack of a structured and organized timetable outlining tasks, deadlines, and milestones for the construction project, can lead to inefficiencies and confusion among workers.	Shobhit C. et al., (2018)
Poor implementation of the schedule	even if a schedule exists, it is not being effectively executed or Followed, resulting in delays, cost overruns, and disruptions to the project timeline.	Shobhit C. et al., (2018), Dr. Ghanim A. Bekr (2016)
Lack of updated schedule	The issue of not regularly updating the project schedule to reflect changes, progress, and new developments, which can lead to miscommunication and inefficiencies.	Shobhit C. et al., (2018)

Delay in delivery of drawings	The late provision of essential drawings needed for the construction process, which can cause setbacks, hinder progress, and impact overall project timelines.	Tewodros W. L.(2019)
Delivering Incomplete drawings	providing drawings that are lacking crucial details or information Necessary for construction, leading to misunderstandings, errors, and rework.	Tewodros W. L.(2019)
Ambiguous and incomplete specification	Unclear or insufficient project specifications that can result in misunderstandings, variations, disputes, and delays during the construction process.	Himanshu A. et al., (2016), Bhavya K.& Lekshmi M. G. (2022)
Not conducting frequent revisions of drawing/design	Neglecting to review and update drawings or designs regularly, which can lead to discrepancies, outdated information, and potential errors in the construction process.	Himanshu A. et al., (2016),
Complexity and scope of the project	The intricate nature and extensive requirements of the construction project, which can pose challenges related to planning, coordination, resource allocation, and execution.	Himanshu A. et al., (2016), Ashebir A. et al. (2019), Tewodros W. L.(2019)
Inappropriate site layout (Temporary Offices)	An unsuitable arrangement or design of temporary offices on the construction site, which can impact workflow efficiency, communication, safety, and overall project management.	Himanshu A. et al., (2016), Tewodros W. L.(2019)
Congestion of site	Overcrowding or limited space available on the construction site, which can lead to inefficiencies, safety hazards, and logistical challenges in carrying out construction activities.	Muhammad I. et al. (2020), Jisha Chakkappan, Lakshmi G Das (2016), Tewodros W. L.(2019)
Poor site accessibility	Difficulties in accessing the construction site due to inadequate roads, pathways, or transportation infrastructure, which can hinder the movement of personnel, equipment, and materials.	Himanshu A. et al., (2016)
Location of the project	The specific geographical location of the construction project, which can influence factors such as logistics, availability of resources, environmental considerations, and overall project feasibility.	Nguyen Van Tam et al., (2021), Jisha Chakkappan, Lakshmi G Das (2016), Shobhit C. et al., (2018), Dr. Ghanim A. Bekr (2016)
Poor site security	insufficient measures in place to protect the construction site, equipment, materials, and personnel from theft, vandalism, or	Nguyen Van Tam et al., (2021)

	Unauthorized access, posing risks to safety and project continuity.	
Shortage of water and power supply	A lack of adequate water and/or power resources essential for construction activities, which can impact productivity, efficiency, and the overall progress of the project.	Tewodros W. L.(2019), Dr. Ghanim A. Bekr (2016)
Contract type of the project	The specific type of contract governing the construction project, which can influence aspects such as project delivery, risk allocation, payment terms, and overall project outcomes.	Himanshu A. et al., (2016)
Project objective not well defined	The goals, requirements, and desired outcomes of the construction project are unclear or ambiguous, leading to confusion, misalignment, and potential challenges in project execution.	Himanshu A. et al., (2016), Tewodros W. L.(2019)
Correction/rectification n of works	The need to address and rectify errors, defects, or non-conformities in construction work to ensure compliance with specifications, quality standards, and client expectations.	Himanshu A. et al., (2016), Muhammad I. et al. (2020), Hamouda, H., & Abu-Shaaban, N. (2015), Dr. Ghanim A. Bekr (2016)
Changes in the scope of the project	Modifications or additions to the original project scope, which can impact timelines, costs, resources, and overall project management if not properly managed and communicated.	Himanshu A. et al., (2016), Bhavya K.& Lekshmi M. G. (2022)
Poor resources management	inadequacies in the allocation, utilization, and optimization of resources such as labour, materials, equipment, and finances on the construction site, leading to inefficiencies, waste, and potential delays in project delivery	Ahmed H. et al. (2013)
Lack of training for labours	The absence of adequate training programs or opportunities provided to labours, which can impact their skills, safety awareness, and overall performance on the construction site.	Ahmed H. et al. (2013), Ashebir A. et al. (2019), Muhammad I. et al. (2020), Hamouda, H., & Abu-Shaaban, N. (2015)
Lack of a financial motivation system	The deficiency of a structured system to incentivize and reward labours financially for their performance, productivity, or achievements, which can affect morale and motivation.	Ashebir A. et al. (2019)
Not conducting periodic meetings with labours	The failure to hold regular meetings with labours to discuss progress, issues, safety concerns, and feedback, which can hinder communication, teamwork, and project coordination.	Ashebir A. et al. (2019), Rahul S. Chaudhari et al. (2022), Muhammad I. et al. (2020)

Unfair method of recruitment	Using biased or unjust practices in the recruitment process for labours, which can lead to dissatisfaction, disputes, and inefficiencies in the workforce?	Muhammad I. et al. (2020)
Financial difficulties of the payment delay	the financial challenges faced by the project owner, leading to payment delays to contractors and suppliers, which can disrupt cash flow, strain relationships, and impact project progress.	Tewodros W. L.(2019)
Lack of communication between parties (Owner, Consultant and Contractor)	the absence of effective communication channels and collaboration among key project stakeholders can result in misunderstandings, conflicts, delays, and compromised project outcomes	Tewodros W. L.(2019)
Improper owner interference with the work	the inappropriate involvement or micromanagement of the project owner in the construction process, which can disrupt workflows, hinder decision-making, and lead to conflicts with contractors and consultants	Tewodros W. L.(2019)
Lack of general support to the contractor	a deficiency in providing necessary resources, guidance, and assistance to the contractor from the project owner or other parties Involved, which can impact project delivery and contractor performance.	Tewodros W. L.(2019)
Subjecting to Earthquake	The vulnerability of the construction site or structure to earthquakes, posing risks to safety, structural integrity, and overall project resilience in seismically active regions.	Hamouda, H., & Abu-Shaaban, N. (2015)
Unsuitable Weather conditions (too cold, heavy rainfall, too hot)	Adverse weather conditions such as extreme cold, heavy rainfall, or excessive heat can impact construction activities, worker safety, material quality, and project timelines.	Ashebir A. et al. (2019), Rahul S. Chaudhari et al. (2022), Bhavya K.& Lekshmi M. G. (2022), Nguyen Van Tam et al., (2021), Hamouda, H., & Abu-Shaaban, N. (2015), Shobhit C. et al., (2018), Bamfo-Agyei et al., (2023), Tewodros W. L.(2019)
Differing site conditions from the pre-analysis report	conditions on the site that differ from what was anticipated in the pre- analysis report, which can affect the planning and execution of the construction project	Hamouda, H., & Abu-Shaaban, N. (2015)

Hydrological conditions	Conditions related to water on the construction site, such as availability, drainage, potential flooding, or other aspects that can influence the design and development of the project.	Nguyen Van Tam et al., (2021), Hamouda, H., & Abu-Shaaban, N. (2015)
Landscape of the site	The natural and geographical features of the environment where the construction takes place, which can impact the design, logistics, and integration of the project with the surrounding area.	Hamouda, H., & Abu-Shaaban, N. (2015)
Unstable political conditions	The presence of political instability in the region where the construction project is taking place, which can create uncertainty, regulatory changes, and additional risks for project execution.	Muhammad I. et al. (2020), Shobhit C. et al., (2018), Tewodros W. L.(2019)
Government's taxation policies	the tax policies established by the government that can affect costs, financial feasibility, and profitability of the construction project	Ashebir A. et al. (2019), Nguyen Van Tam et al., (2021)
Inflation in every aspect of living expenses	widespread price and cost increases in the economy, which can Impact budgets, construction costs, and financial planning of the project.	Muhammad I. et al. (2020)
Economic fluctuations of the country	changes in the national economy, such as fluctuations in interest rates, economic growth, market demand, and other factors that can influence the viability and success of the construction project	Muhammad I. et al. (2020), Hamouda, H., & Abu-Shaaban, N. (2015)

Based on the definition and scopes each factor cover, all were categorized in different sub categories for further analysis

Appendix 2: Questionnaire

MSC THESIS RESEARCH QUESTIONNAIRES

RESEARCH TITLE – DESIGNING AN OPTIMIZATION FRAMEWORK FOR LABOUR EFFICIENCY IN BUILDING CONSTRUCTION PROJECTS FOR CONCRETING ACTIVITIES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

DEPARTMENT OF CIVIL ENGINEERING

(CONSTRUCTION ENGINEERING AND MANAGEMENT)

Dear Respondents,

I am doing a research study as part of my MSc program in Construction Engineering and Management on Designing An Optimization Framework for Labour Efficiency in Building Construction Projects for Concreting Activities. The goal of the study is to evaluate significance of factors that affect labour productivity in construction projects and it can be used to increase labour productivity.

Your participation in this study is vital because it will provide significant insights into the factors that influence labour productivity. The questionnaire is designed to collect information about your experience and understanding about the issue. I understand how valuable your time is, and I appreciate your willingness to participate in this study. All responses will be kept confidential and will only be used for this research purposes only. Your participation in this study is voluntary, and you may withdraw at any time without consequences.

Thank you in advance for your time and participation in this study. If you have any questions or issues, please contact me.

Phone no. +251 911938503

Email address: eliyasmesganu@gmail.com

Sincerely,

Eliyas Mesganu Mare

Section 1: General Information

1. Education Level

Certificate ☐ BSc degree

Diploma ☐ MSc degree

Other ☐

If other, please specify …….

2. Type of firm you are engaged in

Main Contractor ☐ Client

Sub Contractor ☐ Consultant

Other ☐

If other, please specify …….

3. Your current position in the firm

Project Manager ☐ Office Engineer

Project Coordinator ☐ Quantity surveyor

Site Engineer ☐ Resident Engineer

Other ☐

If other, please specify …….

4. Total Years of experie c e

3-5 years ☐ 13 - 15 years

6 - 8 years ☐ More than 15 years

9 - 12 years ☐

5.Are you currently involved in building construction projects?

Yes ☐ No

6. Current progress/status of the project as per the schedule)

Ahead of schedule ☐ Behind schedule

Within schedule ☐

7. What is the nature of the construction project you are working on?

Please specify scope of the project …….

SECTION 2 - FACTORS AFFECTING LABOUR PRODUCTIVITY

A comparison table is provided here to list the elements influencing labour productivity. Please give a value from the scale listed below to indicate the relative preference or level of effect of one criterion or alternative compared to another.

1 - Equal effect

3 - Moderate effect of one over another 5 - Strong effect of one over another

7 - Very strong effect of one over another 9 - Extreme effect of one over another

2, 4, 6, and 8: Intermediate values to express the strength of effect between the two adjacent judgments

Sample explanation how to fill the next pages

#	Factors affecting Labour	Level of effect compared to one																Factors affecting Labour
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
A	Manpower factors																		Manpower factors
	I - Labour related																		I - Labour related
	Availability of labours																		Absence of sufficiently skilled labours

If Availability of labours has great level of effect over Absence of sufficiently skilled labours - then mark on one of the box from 9 to 1 based on the labels above

If Absence of sufficiently skilled labours has great level of effect over Availability of labours - then mark on one of the box from 1 to 9 based on the labels above

For example - If you marked on 3 on left side, means Availability of labours has moderate effect over Absence of sufficiently skilled labours

For example - If you marked on 3 on right side, means Absence of sufficiently skilled labours has moderate effect over Availability of labours

N.B. Please only mark on one box in a raw.

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
A	**Manpower factors**																		**Manpower factors**
	I - Labour related factors																		**I - Labour related factors**
	Availability of labours																		Absence of sufficiently skilled labours
	Availability of labours																		Poor labour experience
	Availability of labours																		Labours discipline (including being addicted to drugs)
	Availability of labours																		Absence of labour outline showing hierarchy of labours clearly
	Availability of labours																		Poor relationship between labours
	Availability of labours																		Number of workers on site (Overcrowded labour force)
	Availability of labours																		Absence of incentive scheme for labours
	Availability of labours																		Labours age (elders)
	Availability of labours																		Labours working weekends frequently
	Availability of labours																		Marital status of labours
	Absence of sufficiently skilled labours																		Poor labour experience
	Absence of sufficiently skilled labours																		Labours discipline (including being addicted to drugs)
	Absence of sufficiently skilled labours																		Absence of labour outline showing hierarchy of labours clearly
	Absence of sufficiently skilled labours																		Poor relationship between labours
	Absence of sufficiently skilled labours																		Number of workers on site (Overcrowded labour force)
	Absence of sufficiently skilled labours																		Absence of incentive scheme for labours
	Absence of sufficiently skilled labours																		Labours age (elders)
	Absence of sufficiently skilled labours																		Labours working weekends frequently
	Absence of sufficiently skilled labours																		Marital status of labours
	Poor labour experience																		Labours discipline (including being addicted to drugs)
	Poor labour experience																		Absence of labour outline showing hierarchy of labours clearly
	Poor labour experience																		Poor relationship between labours
	Poor labour experience																		Number of workers on site (Overcrowded labour force)
	Poor labour experience																		Absence of incentive scheme for labours

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Poor labour experience																		Labours age (elders)
	Poor labour experience																		Labours working weekends frequently
	Poor labour experience																		Marital status of labours
	Labours discipline (including being addicted to drugs)																		Absence of labour outline showing hierarchy of labours clearly
	Labours discipline (including being addicted to drugs)																		Poor relationship between labours
	Labours discipline (including being addicted to drugs)																		Number of workers on site (Overcrowded labour force
	Labours discipline (including being addicted to drugs)																		Absence of incentive scheme for labours
	Labours discipline (including being addicted to drugs)																		Labours age (elders)
	Labours discipline (including being addicted to drugs)																		Labours working weekends frequently
	Labours discipline (including being addicted to drugs)																		Marital status of labours
	Absence of labour outline showing hierarchy of labours clearly																		Poor relationship between labours
	Absence of labour outline showing hierarchy of labours clearly																		Number of workers on site (Overcrowded labour force)
	Absence of labour outline showing hierarchy of labours clearly																		Absence of incentive scheme for labours
	Absence of labour outline showing hierarchy of labours clearly																		Labours age (elders)
	Absence of labour outline showing hierarchy of labours clearly																		Labours working weekends frequently
	Absence of labour outline showing hierarchy of labours clearly																		Marital status of labours
	Poor relationship between labours																		Number of workers on site (Overcrowded labour force)
	Poor relationship between labours																		Absence of incentive scheme for labours
	Poor relationship between labours																		Labours age (elders)
	Poor relationship between labours																		Labours working weekends frequently
	Poor relationship between labours																		Marital status of labours
	Number of workers on site (Overcrowded labour force)																		Absence of incentive scheme for labours
	Number of workers on site (Overcrowded labour force)																		Labours age (elders)
	Number of workers on site (Overcrowded labour force)																		Labours working weekends frequently
	Number of workers on site (Overcrowded labour force)																		Marital status of labours

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Absence of incentive scheme for labours																		Labours age (elders)
	Absence of incentive scheme for labours																		Labours working weekends frequently
	Absence of incentive scheme for labours																		Marital status of labours
	Labours age (elders)																		Labours working weekends frequently
	Labours age (elders)																		Marital status of labours
	Labours working weekends frequently																		Marital status of labours
	II - Supervisor Related Factors																		**II - Supervisor Related Factors**
	Incompetence of Work supervisors																		Delays in decisions making by supervisors
	Incompetence of Work supervisors																		Unclear instruction given by work supervisors
	Incompetence of Work supervisors																		Poor follow up of work by supervisors
	Incompetence of Work supervisors																		Changing of supervisors frequently
	Incompetence of Work supervisors																		Insufficient frequency of site inventories (usage, loss, theft, and breakage)
	Delays in decisions making by supervisors																		Unclear instruction given by work supervisors
	Delays in decisions making by supervisors																		Poor follow up of work by supervisors
	Delays in decisions making by supervisors																		Changing of supervisors frequently
	Delays in decisions making by supervisors																		Insufficient frequency of site inventories (usage, loss, theft, and breakage)
	Unclear instruction given by work supervisors																		Poor follow up of work by supervisors
	Unclear instruction given by work supervisors																		Changing of supervisors frequently
	Unclear instruction given by work supervisors																		Insufficient frequency of site inventories (usage, loss, theft, and breakage)
	Poor follow up of work by supervisors																		Changing of supervisors frequently
	Poor follow up of work by supervisors																		Insufficient frequency of site inventories (usage, loss, theft, and breakage)
	Changing of supervisors frequently																		Insufficient frequency of site inventories (usage, loss, theft, and breakage)
B	**Facility factors**																		**Facility factors**
	I - Material related factors																		**I - Material related factors**
	Shortage of material																		High increment on the price of materials

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Shortage of material																		Delay in delivery of material
	Shortage of material																		Poor quality of material
	Shortage of material																		Material inappropriateness for the purpose
	Shortage of material																		Poor material management
	Shortage of material																		Low quality of transportation of the material to the site
	Shortage of material																		Comparatively distant Material storage location
	Shortage of material																		Having large size of the construction site
	High increment on the price of materials																		Delay in delivery of material
	High increment on the price of materials																		Poor quality of material
	High increment on the price of materials																		Material inappropriateness for the purpose
	High increment on the price of materials																		Poor material management
	High increment on the price of materials																		Low quality of transportation of the material to the site
	High increment on the price of materials																		Comparatively distant Material storage location
	High increment on the price of materials																		Having large size of the construction site
	Delay in delivery of material																		Poor quality of material
	Delay in delivery of material																		Material inappropriateness for the purpose
	Delay in delivery of material																		Poor material management
	Delay in delivery of material																		Low quality of transportation of the material to the site
	Delay in delivery of material																		Comparatively distant Material storage location
	Delay in delivery of material																		Having large size of the construction site
	Poor quality of material																		Material inappropriateness for the purpose
	Poor quality of material																		Poor material management
	Poor quality of material																		Low quality of transportation of the material to the site
	Poor quality of material																		Comparatively distant Material storage location
	Poor quality of material																		Having large size of the construction site

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Material inappropriateness for the purpose																		Poor material management
	Material inappropriateness for the purpose																		Low quality of transportation of the material to the site
	Material inappropriateness for the purpose																		Comparatively distant Material storage location
	Material inappropriateness for the purpose																		Having large size of the construction site
	Poor material management																		Low quality of transportation of the material
	Poor material management																		Comparatively distant Material storagelocation
	Poor material management																		Having large size of the construction site
	Low quality of transportation of the material to the site																		Comparatively distant Material storagelocation
	Low quality of transportation of the material to the site																		Having large size of the construction site
	Comparatively distant Material storage location																		Having large size of the construction site
	II - Equipment related factors																		**II - Equipment related factors**
	Lack of equipment and tools																		Frequent damage of equipment
	Lack of equipment and tools																		Inappropriate type of construction equipment
	Lack of equipment and tools																		Inappropriate size of construction equipment
	Frequent damage of equipment																		Inappropriate type of construction equipment
	Frequent damage of equipment																		Inappropriate size of construction equipment
	Inappropriate type of constructionequipment																		Inappropriate size of construction equipment
	III - Technology related factors																		**III - Technology related factors**
	Inadequate usage of technologies for communication																		Poor usage of software for overall project management
	Inadequate usage of technologies for communication																		Absence of technological advancements for machineries
	Poor usage of software for overall project management																		Absence of technological advancements for machineries
C	**Working condition factor**																		**Working condition factor**
	I - Health and safety related factors																		**I - Health and safety related factors**
	Lack of safety tools																		Violation of safety rules and regulations
	Lack of safety tools																		High occurrence of Accidents during construction (small and large)

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Lack of safety tools																		Not hiring safety officer on the site
	Violation of safety rules and regulations																		High occurrence of Accidents during construction (small and large)
	Violation of safety rules and regulations																		Not hiring safety officer on the site
	High occurrence of Accidents during construction (small and large)																		Not hiring safety officer on the site
	II - Motivation related factors																		**II - Motivation related factors**
	On time payment to labours																		Giving performance based payment
	On time payment to labours																		Inadequate transportation facilities for labours
	On time payment to labours																		Unfair amount of wage with respect to the activity
	On time payment to labours																		Providing Free lunch
	Giving performance based payment																		Inadequate transportation facilities for labours
	Giving performance based payment																		Unfair amount of wage with respect to the activity
	Giving performance based payment																		Providing Free lunch
	Inadequate transportation facilities for labours																		Unfair amount of wage with respect to the activity
	Inadequate transportation facilities for labours																		Providing Free lunch
	Unfair amount of wage with respect to the activity																		Providing Free lunch
D	**Technical factors**																		**Technical factors**
	I - Work plan Related Factors																		**I - Work plan Related Factors**
	Absence of working schedule																		Poor implementation of the schedule
	Absence of working schedule																		Lack of updating schedule
	Poor implementation of the schedule																		Lack of updating schedule
	II - Design related factors																		**II - Design related factors**
	Delay in delivery of drawings																		Delivering Incomplete drawings
	Delay in delivery of drawings																		Ambiguous and incomplete specification
	Delay in delivery of drawings																		Not conducting frequent revisions of drawing/design

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Delivering Incomplete drawings																		Ambiguous and incomplete specification
	Delivering Incomplete drawings																		Not conducting frequent revisions of drawing/design
	Ambiguous and incomplete specification																		Not conducting frequent revisions of drawing/design
	III - Project related factors																		**II - Project related factors**
	Complexity and scope of the project																		Inappropriate site layout (Temporary Offices)
	Complexity and scope of the project																		Congestion of site
	Complexity and scope of the project																		Poor site accessibility
	Complexity and scope of the project																		Location of the project
	Complexity and scope of the project																		Poor site security
	Complexity and scope of the project																		Shortage of water and/or power supply
	Complexity and scope of the project																		Contract type of the project
	Complexity and scope of the project																		Project objective not well defined
	Complexity and scope of the project																		Correction/rectification of works
	Complexity and scope of the project																		Changes in the scope of the project
	Inappropriate site layout (Temporary Offices)																		Congestion of site
	Inappropriate site layout (Temporary Offices)																		Poor site accessibility
	Inappropriate site layout (Temporary Offices)																		Location of the project
	Inappropriate site layout (Temporary Offices)																		Poor site security
	Inappropriate site layout (Temporary Offices)																		Shortage of water and/or power supply
	Inappropriate site layout (Temporary Offices)																		Contract type of the project
	Inappropriate site layout (Temporary Offices)																		Project objective not well defined
	Inappropriate site layout (Temporary Offices)																		Correction/rectification of works
	Inappropriate site layout (Temporary Offices)																		Changes in the scope of the project
	Congestion of site																		Poor site accessibility
	Congestion of site																		Location of the project
	Congestion of site																		Poor site security
	Congestion of site																		Shortage of water and/or power supply
	Congestion of site																		Contract type of the project
	Congestion of site																		Project objective not well defined

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Congestion of site																		Correction/rectification of works
	Congestion of site																		Changes in the scope of the project
	Poor site accessibility																		Location of the project
	Poor site accessibility																		Poor site security
	Poor site accessibility																		Shortage of water and/or power supply
	Poor site accessibility																		Contract type of the project
	Poor site accessibility																		Project objective not well defined
	Poor site accessibility																		Correction/rectification of works
	Poor site accessibility																		Changes in the scope of the project
	Location of the project																		Poor site security
	Location of the project																		Shortage of water and/or power supply
	Location of the project																		Contract type of the project
	Location of the project																		Project objective not well defined
	Location of the project																		Correction/rectification of works
	Location of the project																		Changes in the scope of the project
	Poor site security																		Shortage of water and/or power supply
	Poor site security																		Contract type of the project
	Poor site security																		Project objective not well defined
	Poor site security																		Correction/rectification of works
	Poor site security																		Changes in the scope of the project
	Shortage of water and/or power supply																		Contract type of the project
	Shortage of water and/or power supply																		Project objective not well defined
	Shortage of water and/or power supply																		Correction/rectification of works
	Shortage of water and/or power supply																		Changes in the scope of the project
	Contract type of the project																		Project objective not well defined
	Contract type of the project																		Correction/rectification of works
	Contract type of the project																		Changes in the scope of the project
	Project objective not well defined																		Correction/rectification of works

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Project objective not well defined																		Changes in the scope of the project
	Correction/rectification of works																		Changes in the scope of the project
E	**Organizational Factors**																		**Organizational Factors**
	I - Management Related Factors																		**I - Management Related Factors**
	Poor resources management																		Lack of training for labours
	Poor resources management																		Lack of a financial motivation system
	Poor resources management																		Not conducting periodic meetings with labours
	Poor resources management																		Unfair method of recruitment
	Lack of training for labours																		Lack of a financial motivation system
	Lack of training for labours																		Not conducting periodic meetings with labours
	Lack of training for labours																		Unfair method of recruitment
	Lack of a financial motivation system																		Not conducting periodic meetings with labours
	Lack of a financial motivation system																		Unfair method of recruitment
	Not conducting periodic meetings with labours																		Unfair method of recruitment
	II - Stake holders related factors																		**II - Stake holders related factors**
	Financial difficulties of the owner/payment delay																		Lack of communication between parties (Owner, Consultant and Contractor)
	Financial difficulties of the owner/payment delay																		Improper owner interference to the work
	Financial difficulties of the owner/payment delay																		Lack of general support to the contractor
	Lack of communication between parties (Owner, Consultant and Contractor)																		Improper owner interference to the work
	Lack of communication between parties (Owner, Consultant and Contractor)																		Lack of general support to the contractor
	Improper owner interference to the work																		Lack of general support to the contractor
F	**External factors**																		**External factors**
	I - Environmental and Natural factors																		**I - Environmental and Natural factors**
	Subjecting to Earthquake																		Unsuitable Weather conditions (too cold, heavy rainfall, too hot)
	Subjecting to Earthquake																		Differing site conditions from the pre analysis report

#	Factors affecting Labour Productivity	Level of effect																	Factors affecting Labour Productivity
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
	Subjecting to Earthquake																		Hydrological conditions
	Subjecting to Earthquake																		Landscape of the site
	Unsuitable Weather conditions (too cold, heavy rainfall, too hot)																		Differing site conditions from the pre analysis report
	Unsuitable Weather conditions (too cold, heavy rainfall, too hot)																		Hydrological conditions
	Unsuitable Weather conditions (too cold, heavy rainfall, too hot)																		Landscape of the site
	Differing site conditions from the pre analysis report																		Hydrological conditions
	Differing site conditions from the pre analysis report																		Landscape of the site
	Hydrological conditions																		Landscape of the site
	II - Political and Economical Factors																		**II - Political Factors**
	Unstable political conditions																		Government's taxation policies
	Unstable political conditions																		Inflation in every aspect of living expenses
	Unstable political conditions																		Economic fluctuations of the country
	Government's taxation policies																		Inflation in every aspect of living expenses
	Government's taxation policies																		Economic fluctuations of the country
	Inflation in every aspect of living expenses																		Economic fluctuations of the country
G	**Main Factors**																		**Main Factors**
	Manpower factors																		Facility factors
	Manpower factors																		Working condition factor
	Manpower factors																		Technical factors
	Manpower factors																		Organizational Factors
	Manpower factors																		External factors
	Facility factors																		Working condition factor
	Facility factors																		Technical factors
	Facility factors																		Organizational Factors
	Facility factors																		External factors
	Working condition factor																		Technical factors
	Working condition factor																		Organizational Factors
	Working condition factor																		External factors
	Technical factors																		Organizational Factors
	Technical factors																		External factors
	Organizational Factors																		External factors