

**Addis Ababa University**

**Addis Ababa Institute of Technology**

**School of Civil and Environmental Engineering**

**Graduate Program: Construction Technology & Management**

**Title: - Study on the impacts of construction technology adoption on risk  
management, accident reduction and insurance premium in Ethiopian  
construction industry.**

**By**

**Girma Yibeltal**

**A Thesis Submitted to the School of Graduate Studies of Addis Ababa  
University in Partial Fulfillment of the Requirements for the Degree of  
Masters of Science in Construction Technology and Management**

**Advisor**

**Abebe Dinku, Prof. (Dr.-Ing)**

**June, 2025**

**Addis Ababa**



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The undersigned certify that he has read and hereby recommends for acceptance by Addis Ababa Institute of Technology a thesis entitled: “Study on the impact of construction technology adoption on risk management, accident reduction and insurance premium in Ethiopia”, in fulfillment of the requirements for the degree of Master of Science in Construction Technology and Management.

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Abebe Dinku (Prof. Dr,-Ing)

Advisor

**Declaration**

I, Girma Yibeltal, declare that this thesis is my own original work and that it has not been presented to other university for a similar or any other degree award and that all sources of materials used for the thesis have been duly acknowledged.

.....

Girma Yibeltal

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## **Abstract:**

This study's main goal is to examine how the Ethiopian construction industry's use of construction technology affects risk management, accident rates, and insurance costs. The study looks into the effects of using cutting-edge construction technologies on insurance coverage and expenses. A thorough analysis of pertinent literature, including studies on risk management, insurance policies, and the adoption of construction technologies, is part of the research process. Desk studies, secondary documents, observation, surveys, and interviews with professionals in the field such as consultants, insurance firms, contractors, and clients are more methods used to gather data. The results demonstrate the intricate connection between insurance prices and the adoption of construction technology. It has been noted that using cutting-edge technologies might affect insurance costs in both positive and bad ways. Innovative building techniques and materials can, on the one hand, improve safety, lessen hazards, and possibly even save insurance costs. However, implementing new technology may bring with it unknown dangers like equipment failures and cyberattacks, which might raise insurance premiums. Recommendations for insurance companies and building industry stakeholders are included in the study's conclusion. These suggestions center on the necessity of cooperation and information exchange between insurers and construction industry professionals, the creation of specialized insurance plans that address technological risks, and the application of risk management techniques that keep pace with the changing construction environment.

**Keywords:** Construction technology, Insurance premiums, Risk management, Construction sector, advanced technologies, Risk management, Cyber threats, Emerging risks, Insurance industry.

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## Acronyms

BIM Building Information Modeling

IoT Internet of Things

CAD Computer added design

Eel Each and every loss

Freq Frequency

Fq Frequency

Min Minimum

Max Maximum

PI Professional indemnity

VR Virtual Reality

3D Three-Dimensional

4D Four-Dimensional

5D Five-Dimensional

7D seven-Dimensional

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## CHAPTER ONE: INTRODUCTION

### 1.1 Background of the Study

Over the ages, the construction industry has experienced a significant shift from manual labor to highly automated and digitalized procedures. Heavy lifting and earthwork tasks were transformed with the introduction of steam-powered cranes and excavators during the early industrial revolutions. Concrete, reinforced steel beams, and prefabricated building components made it possible to construct taller, stronger structures, greatly increasing structural integrity and efficiency.

Innovation in construction has been further driven in recent decades by technical breakthroughs. Project management software has improved scheduling and coordination, while Building Information Modeling (BIM) and Computer-Aided Design (CAD) have increased planning and design precision. Complex jobs like welding and bricklaying are now completed by robots and automation, lowering the risk of dangerous situations for people. While the Internet of Things (IoT), drones, and augmented/virtual reality (AR/VR) provide real-time monitoring, safety inspections, and immersive training, emerging technologies such as 3D printing allow building components to be manufactured on-site. Predictive analytics, risk assessment, and accident prevention are further applications of artificial intelligence (AI) and machine learning (ML).

The lack of technological integration contributes to frequent workplace injuries, project delays, and increased insurance claims. While research indicates that improved safety measures reduce insurance premiums (Bunni, 2003; Ikpe et al., 2011), there is limited empirical data quantifying how construction technologies specifically influence risk mitigation and insurance costs particularly in developing economies like Ethiopia.

The purpose of this study is to investigate how Ethiopian insurance premiums, risk management, and accident prevention are affected by the use of building technologies. This study attempts to offer insights that can help insurers, construction companies, and politicians

improve worker safety, optimize insurance models, and promote sustainable sector growth by examining the connection between safety enhancements and technical advancements.

It is anticipated that the construction industry's risk environment would change as a result of the growing use of these technologies. The purpose of this study is to investigate the impact of these modifications on engineering insurance. A specific kind of insurance known as engineering insurance guards against monetary losses brought on by defects or physical damage sustained during the building and maintenance of infrastructure projects (Darren et al., 2018). Recent years have seen difficulties for the conventional engineering insurance business, such as slow growth, poor pricing, and diminishing profitability. The impact of those technologies on engineering insurance in the future is examined in this paper. It looks at the possible advantages of these technologies, such better efficiency and risk management, as well as the possible drawbacks, like the emergence of new threats like cyberattacks. The study's overall goal is to shed light on how engineering insurance and the construction sector might adjust to the rapidly evolving technology landscape (Darren et al., 2018).

Large infrastructure and building projects are made possible by insurance, which shields operators from unanticipated losses like mechanical failures. Due to infrastructure spending and economic recovery, the engineering insurance market is expected to increase from 21 billion USD in 2017 to 34.5 billion USD by 2027. However, there have been difficulties due to stagnating building investment and shifting insurance hubs, with Miami, Singapore, Dubai, and London becoming more well-known. The business is changing due to new technologies like autonomous machinery and digital monitoring, which increase productivity but also pose threats like cyberattacks. Despite fewer accidents, this might make claims more severe, which would force insurers to change by creating new policies and emphasizing risk prevention over loss coverage alone (Darren et al., 2018).

There are many safety hazards in the construction sector, which contribute to the high incidence of fatalities and injuries. Businesses frequently utilize insurance as a financial safety net to handle these risks. Policies fall into three categories: contractually required (based on agreements), legally mandated (e.g., worker's compensation), and voluntarily

purchased to transfer risk (aligned with the company's risk management strategy). Insurance rates are established by evaluating project risks. Contractors may submit claims to compensate for monetary losses in the event of an accident, but the specifics of the premium are kept private (Ibrahim, 2021).

## 1.2 Statement of the Problem

The construction sector is aware that lower insurance rates might result from improved safety procedures (Bunni, 2003). However, it is challenging to measure this link due to the opaqueness of insurers' premium calculation techniques. Because actuarial data is proprietary, there is no research on how construction technologies explicitly affect premiums, despite the fact that existing literature demonstrates that increased safety measures reduce accidents and insurance costs (Ikpe et al., 2011).

Other issues facing Ethiopia's building industry include a lack of use of contemporary technologies, inefficiency, increased risk, and insufficient insurance coverage. Progress is further hampered by inadequate regulatory frameworks, a lack of qualified personnel, and poor stakeholder participation. By investigating how implementing construction technology might enhance safety, risk management, and insurance practices in Ethiopia, this study aims to close these gaps and eventually benefit society and industry stakeholders.

## 1.3 Objectives of the study

### a) General Objective:

- To look into how the Ethiopian construction industry's use of construction technology affects risk management, accident prevention, and engineering insurance procedures.

### b) Specific Objectives:

1. To determine the degree to which the use of construction technology aids in risk mitigation and reduction, which could result in lower insurance costs in Ethiopia.

2. To find out what criteria Ethiopian insurance companies take into account when evaluating risk and how they determine the effect of building technology adoption on insurance premiums.
3. To investigate how Ethiopian construction industry players view the connection between insurance costs and the implementation of construction technologies.
4. To investigate the ways in which Ethiopian insurance laws and policies encourage or prohibit the use of building technology, and to assess how these elements affect insurance rates.
5. To assess their possible influence on insurance rates and determine the long-term cost savings and advantages for Ethiopian construction companies that have used construction technology.

#### **1.4 The significance of this study**

This study is significant because it examines the connection between insurance premiums and the adoption of construction technology in Ethiopia's construction sector. The study can offer important insights into the possible influence on risk reduction and mitigation by looking at how insurance premiums are impacted by the deployment of construction technologies. It is essential for both insurers and construction enterprises to comprehend the aspects that Ethiopian insurance companies take into account when assessing this impact. In order to influence future policy and decision-making processes, the study also seeks to understand the attitudes and perspectives of stakeholders in the building sector. The study can provide insight into the possible impact of insurance laws and regulations on insurance premiums by examining how they encourage or hinder the adoption of construction technology. Additionally, highlighting the advantages and promoting further adoption can be achieved by determining the long-term cost savings and benefits for construction companies that have adopted technology. Last but not least, investigating the possible effects of adopting construction technology on insurance coverage and claim settlement procedures will help create suitable policies and procedures for the Ethiopian construction sector.

## 1.5 The scope of this study

This study looks into how risk management, accident rates, and insurance premiums are affected in Ethiopia's construction industry by the use of construction technology (such as BIM, IoT, kumkang formwork, VR, prefabricated buildings, etc.). In addition to addressing new issues like cyber threats and responsibility changes, it assesses whether technology cut risks and premiums by reducing human error and project delays. The study evaluates how Ethiopian insurers evaluate risk, how stakeholders view the advantages of technology, and how regulatory gaps impact tech integration. The study intends to ascertain how technology adoption affects risk mitigation, safety results, and insurance prices by examining accident data, premium trends, and case studies. It will then provide recommendations for changes to the industry and legislation.

## 1.6 Research questions

1. What effects does Ethiopia's building technology adoption have on risk mitigation and reduction in the sector, which could result in lower insurance costs?
2. What particular elements are essential to Ethiopian insurance companies' risk assessment procedures, and how do they evaluate the impact of construction technology adoption on insurance premiums?
3. How do Ethiopian construction industry stakeholders view the relationship between insurance premium variations and the adoption of construction technology?
4. To what degree do Ethiopian insurance laws and regulations influence insurance rates in the construction industry, and how do they affect the incorporation of construction technology?
5. What benefits and long-term cost savings have Ethiopian construction companies who have adopted construction technology experienced, and how can these advantages affect industry insurance rates?

## 1.7 Methodologies

In order to investigate the effects of construction technology adoption on risk management, accident reduction, and insurance premiums in Ethiopia's construction industry, this study uses a mixed-methods research methodology that integrates qualitative and quantitative methodologies. The study starts with a thorough literature analysis to lay the groundwork for understanding risk management, insurance trends, and construction technologies (such as BIM, IoT, and prefabrication). Real-world insights into safety enhancements and insurance cost implications are offered by case studies of Ethiopian construction companies utilizing cutting-edge technologies. In order to obtain quantitative data on technology adoption, accident rates, and premium adjustments, a pilot research is conducted to improve data collection methods. Structured questionnaires are then sent to real estate developers, insurance firms, Class 1 consultants, and Grade 1 contractors. Qualitative viewpoints on risk mitigation and regulatory difficulties are obtained through in-depth interviews with industry stakeholders, including project managers, engineers, and insurers. While thematic analysis interprets interview data, descriptive and inferential statistics examine survey replies. Evidence-based recommendations for policymakers and industry practitioners are the result of triangulating findings to evaluate how technology affects safety, risk, and insurance dynamics.

## 1.8 Limitation of the study

Because construction technology is still developing and is only recently being used in Ethiopia, this study has a number of limitations. These include the paucity of existing research on the subject in developing nations, the difficulty in obtaining data because of low technology adoption, the quick development of new technologies, the fact that the majority of insurance companies rely on reinsurance, the difficulty in disclosing data due to market competition, and the limited applicability of findings in other contexts. These limitations underscore the need for additional study, particularly comparative studies with other developing nations to uncover larger patterns and issues, as well as long-term studies on the

influence of technology on risk management, accident reduction, and insurance rates in Ethiopia.

## **1.9 Thesis organization**

The impact of construction technology adoption on insurance premiums in Ethiopia's construction industry is examined in this thesis using a methodical and thorough approach. Six chapters comprise the research, each of which adds a unique component to the overall analysis:

### **i) First Chapter: Overview**

By determining what is known about the connection between insurance costs and construction technology in Ethiopia's construction industry, this study establishes the foundation. In order to guarantee that the study tackles the specified problem statement and offers significant insights into this understudied field, it sets precise, quantifiable research objectives to direct the inquiry.

### **ii) Literature Review in Chapter Two**

The study investigates the complex function of insurance in the building sector, looking at its kinds, importance, and stakeholder ramifications as well as how it reduces project risks. In addition to analyzing how particular technologies affect safety, risk management, and insurance rates, it critically examines the adoption of construction technology, concentrating on current trends, opportunities, and difficulties. The study also summarizes previous research, highlighting important variables that affect insurance rates and the dual function of technology in raising safety and creating new hazards, which eventually affects insurance prices in building projects.

### **iii) Research Methodology, Chapter three**

To guarantee thorough insights, the research design uses a multi-method approach that integrates qualitative and quantitative data. It comprises a review of the literature using scholarly works and industry reports, industry research using semi-structured interviews with

professionals in the insurance and construction industries, and quantitative research using surveys directed at particular demographics. To guarantee rigor and transparency, data analysis methods for both qualitative and quantitative data are described in detail. To uphold ethical standards throughout the study, ethical issues including informed consent, data confidentiality, and security are also covered.

#### **iv) Case study in Chapter Four**

The case study examines how five important construction technologies Building Information Modeling (BIM), Virtual Reality (VR), Internet of Things (IoT), Prefabrication Building, and Kumkang Formwork Technology are implemented and used in Ethiopian construction companies. It focuses on how these technologies improve safety performance, risk assessment, and hazard identification. It also looks into the possibility of lower insurance rates and incentives as a result of better safety performance and risk reduction. Employee surveys and interviews will shed light on how these technologies actually affect people's safety and well-being.

#### **v) Chapter 5: Results analysis and discussion**

This chapter offers insights into industry perspectives on technology's impact on insurance by presenting the results of interviews conducted with professionals in the construction and insurance industries. Thematic analysis was used to discover recurrent themes and patterns. It examines the differing opinions of insurers and construction businesses regarding risk reduction, insurance costs, and technology adoption. Furthermore, it examines survey data to investigate the connection between insurance premiums, accident reduction, and technological adoption, using statistical methods to determine any possible causative relationships that may be supported by the data.

#### **vi) Chapter 6: Concluding remarks and suggestions**

- Highlights the quantifiable effect of construction technology on insurance rates based on the analysis, summarizing the main conclusions from every stage of the study.
- Offers advice to several parties involved in the Ethiopian construction sector, such as

legislators, insurance firms, and building businesses. These suggestions must to be customized to take into account the research results and encourage well-informed choices on the adoption of technology and risk management techniques.

By integrating theoretical knowledge with real-world industry insights and statistically obtained data, this methodical methodology guarantees a comprehensive investigation. Through the strategic use of construction technology and efficient risk management techniques, the research ultimately seeks to provide significant knowledge to the Ethiopian construction industry, promoting innovation and sustainable growth.

## CHAPTER TWO: LITRATURE REVIEW

### 2.1 General

#### 2.1.1 The notion of insurance

##### i) Definition of insurance

The act of protecting against danger is referred to as insurance in a more popular sense. The person seeking an insurance coverage is known as the insured, and the party sharing the risk in exchange for a payment known as the insurance premium is known as the insurer. An insurance coverage for a variety of hazards is readily available to the insured. Since auto insurance is required by law in many nations, it is the most frequently obtained type of insurance policy. Additional policies include liability insurance, health insurance, life insurance, renter's insurance, and house owner's insurance (Jain, 2017).

By shifting risk from a person or business to an insurance firm, the insurance sector protects the assets of its policyholders. Because they invest the premiums they get for this service, insurance companies serve as financial middlemen. Net premiums written, or premium income less reinsurance payments, are typically used to calculate the size of an insurance firm. Property/casualty, life/health, and health insurance are the three primary insurance industries (Hartwig et al., 2010).

##### ii) Nature or characteristics of insurance

Insurance is a written contract in which an insured party pays a premium to an insurer in exchange for financial protection against predetermined risks. It functions as a cooperative tool, distributing losses across numerous people with comparable risks. Insurance is governed by statutory regulations and is founded on concepts like indemnity, insurable interest, and the highest good faith. It transfers risk from individuals to a group, making up for monetary losses, and is not comparable to charity or gambling. In order to create revenue and maintain financial stability, insurers invest premiums. Insurance is essentially a risk-

sharing system that offers monetary stability and functions within a morally and legally sound framework (Jain, 2017).

### **iii) Principles of insurance**

In fact, insurance is a contract, and its enforceability and legality are governed by specific criteria. The following are the main guidelines that the insured and the insurer must follow, per Raji (2021):

1. **Principle of Utmost Good Faith:** Throughout the insurance contract, the insured and the insurer must act in good faith and honestly disclose all pertinent information.
2. **Principle of Insurable Interest:** To guarantee that they will incur a loss in the event of the insured occurrence, the insured must have a monetary interest in the insurance's subject matter, such as property or life.
3. **Proximate Cause Principle:** When evaluating a claim, the cause that is closest and most directly accountable for the loss or harm should be taken into account.
4. **Subrogation Principle:** In the event that a third party's actions cause the insured to incur a loss, the insurer has the
5. **Right to recoup from such third party the sum paid to the insured.**
6. **Principle of Indemnity:** The insurance policy seeks to restore the insured to their pre-loss financial situation by compensating for the actual monetary loss they have incurred. Critical health coverage and life insurance are exempt from this rule.
7. **Principle of Contribution:** Each insurer will split the loss according to their coverage if the insured has several insurance policies covering the same risk. One insurer has the right to request a proportionate payment from other insurers if they have already made the entire payment.
8. **Loss Minimization Principle:** Even after acquiring insurance coverage, the insured is still obligated to take reasonable measures to reduce loss or damage and stop more loss.

These principles guide the insurance contract and ensure fairness, transparency, and proper handling of claims between the insured and the insurer.

#### **iv) Importance of insurance**

Insurance is a social tool that shields people and companies from uncertainty and loss. The following succinctly describes its contributions to society's overall economic development (Jain, 2017): An essential social instrument, insurance protects people and companies from monetary losses and unpredictabilities by providing defense against hazards such as sickness, accidents, and natural catastrophes. By encouraging savings through premiums, which are then invested in productive industries, it stimulates capital development and job creation, so promoting economic growth. While medical insurance reduces healthcare costs and ensures financial security, life insurance promotes systematic savings. Insurance lessens the financial burden on individuals and promotes trade, commerce, and general economic growth by distributing risks among a large number of people. In essence, insurance provides safety, stability, and risk management, contributing significantly to societal and economic progress.

#### **v) Main forms of insurance**

Insurance plans offer assistance and financial security in the event of emergencies and unanticipated costs. (Rani, 2021) Insurance plans provide monetary security against a range of hazards and unanticipated circumstances. Important varieties include health insurance, which covers medical costs; life insurance, which pays beneficiaries a death benefit; and auto insurance, which guards against losses associated to vehicles. While renters insurance provides comparable protection for tenants, property and homeowner's insurance protects homes and possessions against hazards like fire or theft. Emergency situations involving trips are covered by travel insurance, while gadgets and bicycles are protected by mobile or cycle insurance. Liability insurance covers lawsuits alleging harm or damage, whereas disability insurance replaces lost income as a result of an injury. Furthermore, bite-size insurance ensures complete financial stability by offering customized coverage for particular risks.

These insurance policies serve to minimize financial liability and provide support during unexpected circumstances, safeguarding various aspects of health and assets. It's important to assess your specific needs and choose the appropriate policies to ensure comprehensive coverage (Rani, 2021).

#### **vi) Components of insurance policy**

The premium, policy limit, and deductible are the three main factors to consider while selecting an insurance plan. (Rani, 2021) Understanding the main elements of an insurance policy is crucial when choosing one: the policy limit, which is the highest sum the insurer will pay for a covered loss; the deductible, which is the amount the policyholder must pay out of pocket before the insurer pays a claim; and the premium, which is the cost paid on a regular basis for coverage and varies depending on risk factors. While greater insurance limits raise premiums, bigger deductibles usually result in reduced premiums. By striking a balance between these factors, one can select a policy that provides sufficient coverage at a reasonable price, guaranteeing efficient risk protection.

#### **vii) How insurance works?**

The way insurance works is by combining the risks of many people or companies. In order to contribute to a fund that is used to compensate those who suffer insured losses, individuals or businesses who want coverage pay the insurance firm regular premiums. Based on a number of variables, including the kind of vehicle, its intended use, and its medical history, the insurance company evaluates the risk of insuring each person or business. The premium amount is determined by this risk assessment; larger risks typically translate into higher premiums. Insurance efficiently spreads the cost of unforeseen circumstances over a sizable group by combining these premiums and paying out to those who suffer losses, making it easier for all parties to handle (Jain, 2017).

#### **viii) Peril, risk, and hazard in the context of insurance**

Peril, danger, and hazard have different connotations in the context of insurance. Peril is the term used to describe the immediate source of a loss, such theft or fire. Physical dangers (like faulty wiring), moral hazards (like dishonesty), and morale hazards (like carelessness) are examples of factors that can affect the likelihood or severity of a loss. Risk is the uncertainty that a loss will occur, taking into account both the likelihood of the danger and its possible outcomes. In essence, hazards raise the likelihood of a certain danger, and knowing these ideas aids in accurately estimating and controlling possible losses. In summary, dangers raise the likelihood of a certain danger.

## 2.1.2 History of insurance in the world

The origins of insurance can be traced back to ancient Babylonia in the 18th century B.C., where King Hammurabi established one of the earliest risk-sharing systems through his famous **Code of Hammurabi**. This code included provisions protecting merchants by canceling debts if goods were stolen during transit a concept similar to later practices like **bottomry** in Phoenicia (1200 B.C.), where ship voyages were financed under loan agreements that waived repayment if the ship was lost.

Modern insurance began taking shape in **17th-century England**, with the first recorded life insurance policy issued in 1633 for William Gybbons. The industry further evolved with the establishment of **Lloyd's of London**, formally incorporated in 1871, which became a cornerstone of global insurance despite not being an insurance company itself. Today, insurance has grown into a vast and essential financial sector, with roots deeply embedded in ancient risk management practices.

### 1) The concept of insurance has ancient roots.

The notion of accountability was founded by the Code of Hammurabi (c. 1750 BC), which held people accountable for any harm they produced, with the exception of "Acts of God." The idea of "general averages" for marine losses where merchants share the burden of cargo losses was created by the Greeks in Rhodes around 1000 BC. Because premiums differed based on variables like the season and war, this developed the concept of risk assessment. Roman burial societies let members to pay regular dues to cover the cost of their funerals and tombs after they passed away; these societies are seen as early examples of life insurance. From culpability for damages to risk assessment and the pooling of assets to cover possible losses, these early instances show how insurance ideas have evolved (Cooper, 2024).

### 2) Insurance in the middle Ages

Guilds were crucial in offering their members early types of insurance during the Middle Ages. Guilds, which were made up of tradespeople, provided insurance against losses brought on by theft, fire, or the untimely death or disability of a member. These advantages promoted guild membership and aided in the expansion of urban areas. The Great Fire of

London in 1666 brought to light the city's susceptibility and the necessity of insurance against fire damage as well as fire prevention. As a result, fire insurance providers arose, providing property owners with coverage. In order to help their insured clients and reduce the risk of fire, some businesses also set up their own fire departments. During this time, insurance evolved from mutual aid based on guilds to more organized commercial contracts (Cooper, 2024).

### **3) Insurance in modern era**

In 1688, merchants congregated at Lloyd's coffee shop to exchange information and cover one other's ships informally, marking the beginning of the modern period of insurance. This developed into the well-known insurance market known as Lloyd's of London. Anxieties about mortality and the demands of the growing middle class and entrepreneurs in Victorian Britain throughout the 19th century led to a boom in life insurance. Nevertheless, the industry had difficulties like as fraud and bankruptcies, which prompted the first government regulations. The emergence of "composite insurance" in the late 19th century allowed for increased consumer convenience by combining several insurance categories, such as theft and fire, into a single policy. The biggest insurance companies' drop in the yearly ranking of the best businesses in the world is highlighted in Forbes Global's 2024 edition. Forbes Global uses four metrics sales, income, assets, and market value to rank the biggest businesses worldwide (Cooper, 2024).

### **2.1.3 History of insurance in Ethiopia**

Three stages can be distinguished in the historical evolution of Ethiopia's contemporary insurance industry. The first stage, which lasted from 1905 to 1974, is when insurance first appeared and began to take shape in the nation. The sector was significantly shaped during this time by foreign insurers. The government's monopoly on the insurance industry and the nationalization of private insurers occurred during the second phase, which lasted from 1974 to 1991. Economic liberalization and the implementation of a market-oriented economic system define the third phase, which began in 1991 and continues to this day. This stage has resulted in modifications and prospects for the insurance sector's continued expansion and advancement in Ethiopia (Zelege, 2007).

### **1) Imperial Regime Phase (1905-1974)**

Foreign insurers participated in the Ethiopian insurance market during the Imperial Regime Phase (1905–1974), and the country's first domestic insurance company was founded. In order to arrange fire and marine insurance policies, a foreign bank called the Bank of Abyssinia, which was founded in Ethiopia in 1905, served as an agent for a foreign insurer. It's unclear exactly what this deal entails. Italian and Swiss insurance companies, including La Baloise Fire Insurance Company and Istituto Nazionale per L'Assicurazione contro gli infortuni sul lavoro, established representative branch offices in Ethiopia in the 1920s. During this period, a number of more Italian insurers joined the Ethiopian market. Only Italian insurance businesses were allowed to function during the 1936–1941 Italian occupation, but they were shut down after the country was freed. Through agents, British and other foreign insurance companies began operating in Ethiopia after 1941 (Zelege, 2007).

Imperial Insurance Company of Ethiopia Ltd., the first domestic insurer, was established in 1951. The State Bank of Ethiopia, Emperor Haile Selassie, Ethiopian citizens, foreigners, and British group corporations contributed to its Eth. \$1,000,000 share capital. Agents of foreign insurance companies dominated Ethiopia's insurance market from 1920 until 1950. Imperial was the sole local insurer of the 18 insurance companies that were found to be active in Ethiopia in a 1954 survey. Thirty-three of the 34 insurance businesses that were active in the nation by 1960 were agents of foreign insurers (Zelege, 2007).

### **2) Socialist State Phase (1974-1991)**

After the imperial authority was overthrown, Ethiopia's military government established a socialist, centrally planned command economy during the Socialist State Phase (1974–1991). Through Proclamation 26/1975, the government nationalized all private insurance businesses on January 1, 1975, as part of this economic system. By Proclamation 68/1975, these nationalized insurers were then combined into a single state-owned insurance business called the Ethiopian Insurance Corporation (EIC) (Zelege, 2007). When the EIC was founded on January 1, 1976, it assumed the capital, liabilities, and assets of the nationalized private insurers and became an independent state entity. ETB 11 million, or around USD 1.29 million, was its original paid-up capital. The EIC was given the power to negotiate reinsurance treaties with foreign reinsurers, issue licenses for insurance-related positions, and

oversee, administer, supervise, and direct all insurance activities. According to Zelke (2007), it provided a range of insurance policies, such as life, auto, marine, fire, aviation, workmen's compensation, personal accident, medical, and burglary.

The old imperial-era insurance regulations and regulatory organizations, like the Insurance Council and Insurance Controller Office, were superseded or liquidated with the nationalization of private insurers and the creation of a government-owned monopoly insurer. The National Bank of Ethiopia (NBE) was appointed as the insurance industry's supervisor and regulator in 1976. The Ethiopian insurance market was monopolized by the EIC during this time, and there was no competition. Under the command economic system, the insurance industry's growth and contribution to the nation's economic expansion were negligible (Zelege, 2007).

### **3) Liberalization Phase (1991 To Date)**

The government implemented a market-oriented economic system in 1992 as part of Ethiopia's insurance industry's liberalization phase (1991 to the present). As a result, the insurance business and other financial sectors underwent reforms to conform to market-oriented policies. A new market-oriented insurance law was passed, the Ethiopian Insurance Corporation (EIC) was reestablished, and private sector insurers emerged as part of the reformation (Geda, 2007).

The EIC was reorganized as a state-owned company in 1994 in order to carry out its mandate under the new, market-oriented economic structure and offer insurance services. The reorganized EIC has about ETB 61 million in paid-up capital. A comprehensive insurance law was passed in order to encourage the public and private sectors to actively participate in the economy. The 19-year insurance industry monopoly was broken by Proclamation 86/1994, which let domestic private sector insurers to operate in the nation. As a result, there are currently 18 insurance companies in Ethiopia. Foreign insurers were still not allowed to operate in Ethiopia's insurance market, but (Zelege, 2007).

### 2.1.4 Insurance as a risk management tool

In the construction industry, risk is the possibility of unforeseen circumstances, unknowns, or dangers that could have a detrimental effect on a project's budget, timeline, quality, safety, or general success. Risk management is crucial for construction projects because of its inherent complexity, which includes numerous stakeholders, environmental considerations, and unforeseen difficulties. Risks to the Ethiopian construction sector include delays, quality problems, and cost overruns. Through insurance, the Federal Road Authority (FRA) controls these risks. The FRA employs a number of insurance plans, such as the Workers' Compensation Policy, the Inherent Defect Policy, the Third Party Liability Policy, the Contractor's All Risk Policy, and the Contractor's Comprehensive Commercial Vehicles Policy (Debela, 2018).

This study examines the vital relationship between risk management and insurance, especially in the technologically advanced and easily accessible world of today. The authors stress that in order for enterprises to thrive in this climate, they must process and analyze information effectively. To detect, evaluate, and reduce the adverse effects of information security threats while optimizing the favorable ones, a strong risk management system is required (Nargizakhon et al., 2019).

#### Types of risk in insurance

According to Jain Types of risk in insurance are:

##### 1 Based on Insurability

- **Speculative (Dynamic) Risk:** Involves potential for profit or loss (e.g., investing in stocks). Not insurable (with some exceptions like gambling).
- **Pure (Static) Risk:** Only possibility of loss (e.g., fire damage). Insurable by commercial/personal/liability insurance.

## 2 Based on Impact

- **Fundamental Risks:** Affect the entire economy or large groups (e.g., inflation, war). May require government assistance for insurance (e.g., social security).
- **Particular Risks:** Affect only individuals (e.g., burglary, auto accident).

## 3 Based on Nature

- **Subjective Risk:** Uncertainty based on a person's mental state (e.g., drunk driving).
- **Objective Risk:** The variation of actual loss from expected loss (e.g., number of houses burning each year compared to the average). Decreases as the number of exposures increases (Law of Large Numbers).

## 4 Based on Economy

- **Static Risks:** Caused by nature or human error (same as pure risks).
- **Dynamic Risks:** Associated with a changing economy (e.g., changing consumer tastes). Can be speculative (profit or loss possible).

## 5 Based on measurability

- **Financial Risk:** Outcome can be measured in money (e.g., property damage).
- **Non-Financial Risk:** Outcome cannot be measured in money (e.g., choosing a career). Not insurable traditionally.

Risks are classified as either insurable or uninsurable in the context of insurance. Standard risks, which are covered at regular rates, sub-standard risks, which are higher risk and require more premiums, and super standard risks, which are low risk and preferred by insurers, are all considered insurable risks. They also include extra-risks that are constant, rising, or falling according to variables like age or health. However, uninsurable risks like advanced cancer or heart disease are too dangerous to insure because they have very high death rates or a near-certainty of loss. Comprehending this differentiation aids insurers in assessing coverage eligibility and establishing suitable premiums.

### **2.1.5 Types of insurance organizations**

Self-insurance, individual insurers, partnerships, joint stock companies, mutual businesses, cooperative insurance groups, Lloyd's Association, and state insurance are some of the different ways that insurance can be organized, according to Rani (2021). While partnerships and individual insurers function on a smaller scale, self-insurance entails setting aside money to cover risks. Mutual and joint stock corporations prioritize policyholder involvement and profit-sharing, respectively. State insurance is run by the government, frequently for the benefit of the general people, Lloyd's Association depends on underwriters, and cooperative organizations provide reasonably priced coverage. Regulations, market conditions, and available resources all influence the choice of organization.

### **2.1.6 Functions of an insurance company**

By removing financial uncertainty through consistent premium payments, insurance firms give stability to both individuals and businesses. They provide defense against possible losses, guaranteeing that business operations may go on in spite of obstacles. They reduce individual expenses by distributing financial repercussions among numerous policyholders through risk pooling. Additionally, insurance aids in fulfilling legal obligations, such as those pertaining to public areas or transportation. Furthermore, premiums are invested in profitable endeavors through capital development, which boosts economic expansion and produces income. All things considered, insurance firms are essential to risk management, legal compliance, and financial stability.

### **2.1.7 Compensation and remuneration plan**

A good compensation and remuneration plan should be straightforward, equitable, and flexible in order to provide clarity and flexibility in response to shifting circumstances. In addition to offering incentives like commissions or bonuses to encourage salespeople, it must generate enough revenue to cover living expenses. In addition to being in line with business objectives and industry norms, the plan should be affordable, simple to implement, and timely in payments. In order to draw and keep talent, it should also be competitive, provide job security, and adhere to regulatory regulations. Such a plan promotes job happiness and propels organizational performance by striking a balance between incentive, fairness, and economic feasibility.

### 2.1.8 Insurance contract

An insurance contract is an arrangement whereby one party, known as the insurer, agrees to pay the other party, known as the insured, a certain amount of money or its equivalent in kind in the event that a specific event occurs that causes him to suffer a loss. This is done in exchange for an agreed-upon consideration, known as the premium. According to Srinivasan et al. (2014), the policy is a document that serves as proof of the insurance contract.

### 2.1.9 Features of an insurance contract:

An insurance contract has several essential characteristics: it is adhesive, meaning the insurer drafts it without negotiation; it is aleatory, meaning its value is dependent on unpredictable events; and it is founded on the highest good faith, which demands honesty from both sides. It is unilateral, with the insurer promising payment in return for the insured's premium, and executory, since duties are only fulfilled in response to certain circumstances. The contract is personal, usually non-transferable without authorization, and conditional, requiring proof of loss or insurable interest. It contains representations (statements thought to be accurate) and warranties (guaranteed statements), along with sanctions for fraud, deception, or misrepresentation. Previous oral statements cannot change the written contract, according to the parol evidence rule.

### 2.1.10 Types of insurance

According to rani There are two broad types of insurance:

1. Life Insurance
2. General Insurance
3. Other type of insurance

#### 1) Life Insurance

Life insurance ensures financial security for a policyholder's family in the event of their death. The three main types are: **term plans**, offering a death benefit for a specified period; **endowment plans**, combining insurance with investment and providing maturity benefits and bonuses; and **whole life insurance**, offering lifetime coverage, sometimes up to

100 years. Each type caters to different needs, providing protection and financial stability for dependents.

## **2) General Insurance:**

A contract that provides monetary compensation for any loss other than death is known as general insurance. Everything except life is covered. A general insurance policy covers you for monetary losses brought on by liabilities pertaining to your home, vehicle, bicycle, health, vacation, etc. According to Raji (2021), the insurance provider guarantees to give you a certain amount to cover losses from theft or fire, medical expenses to treat health issues, car damage, and even financial difficulties when traveling. To put it simply, general insurance provides financial security for all of your assets against liabilities such as theft, damage, and loss. It is not the same as life insurance.

According to Rani Types of General Insurance:

You can get almost anything and everything insured. But there are four key types available:

- Fire Insurance
- Marine Insurance
- Health Insurance
- Motor Insurance

## **3) OTHER TYPES OF INSURANCE**

In order to cover a wide range of risks, general insurance companies offer a variety of policies. These include bite-size insurance for short-term, specific coverage, fidelity insurance for employee fraud, mobile insurance for accidental damage or theft, property insurance for floods and natural disasters, and burglary insurance for theft. These policies serve various requirements and situations by providing financial protection against a broad range of risks beyond life, fire, and marine insurance (Rani, 2021).

### **2.1.11 Double insurance**

When the same person is covered by two or more insurers for the same interest, subject matter, risk, and time frame, this is known as double insurance. The same insured, subject

content, risk, interest, and time frame are important components. Coordination amongst insurers is necessary in this case to guarantee appropriate coverage and prevent issues during the claims process (Rani, 2021).

### **2.1.12 Reinsurance**

Insurance for insurance firms is known as reinsurance. It is a method of "ceding" to another insurance firm, the reinsurer, some of the financial risk that insurance companies take on when they insure vehicles, residences, and enterprises (Hartwig et al., 2010). Reinsurance is the process by which insurance firms assign a portion of their financial risk to a reinsurer, or other insurance company. As a result, the principal insurer can lower its liability for future claims and free up funds to finance additional insurance plans. The reinsurer, who accepts responsibility for covering losses over a specific limit in exchange for a fee, receives a percentage of the main insurer's business (Rani, 2021).

### **2.1.13 Insurance premium**

#### **Definition of insurance premium**

An **insurance premium** is the regular payment made by a policyholder to an insurance company in exchange for financial protection against specified risks, such as accidents, damages, or liabilities. The amount is determined based on factors like risk exposure, coverage type, and the insured party's safety measures.

The agreed-upon amount that the insured pays the insurer in exchange for the insurer taking on the risk and offering insurance coverage is known as the premium. It's the price of purchasing an insurance plan. The type of insurance, the extent of coverage, the probability of a claim, and the risk profile of the insured are some of the variables that affect the premium amount (Jain, 2014). Given the high accident rate in the construction sector, WCI is essential for safeguarding both contractors and employees. However, the potential hazards in building projects are frequently underestimated by standard premium calculations based on salary rolls, which results in losses for insurance firms (Imriyas, 2007).

Imriyas (2007) found 17 factors that influence construction projects' WCI premium grade. These variables fall into four categories: market factors (competition, volume), insurer factors (corporate objectives, investment income, overhead costs, outstanding claims, profit/loss experience, reinsurance cost), contractor factors (claims history, multiple policy placement, business expectation, cooperation, size), and project factors (wage roll, project duration, hazard level, safety management effectiveness).

**Premium calculation** is the process of determining the amount of money an insured party must pay to an insurance company for coverage against specified risks. This process involves assessing the likelihood and potential cost of those risks, estimating expected losses, and adding loading expenses and a profit margin for the insurer (Pedro, 2017).

#### **2.1.14 Key stakeholders in insurance transactions**

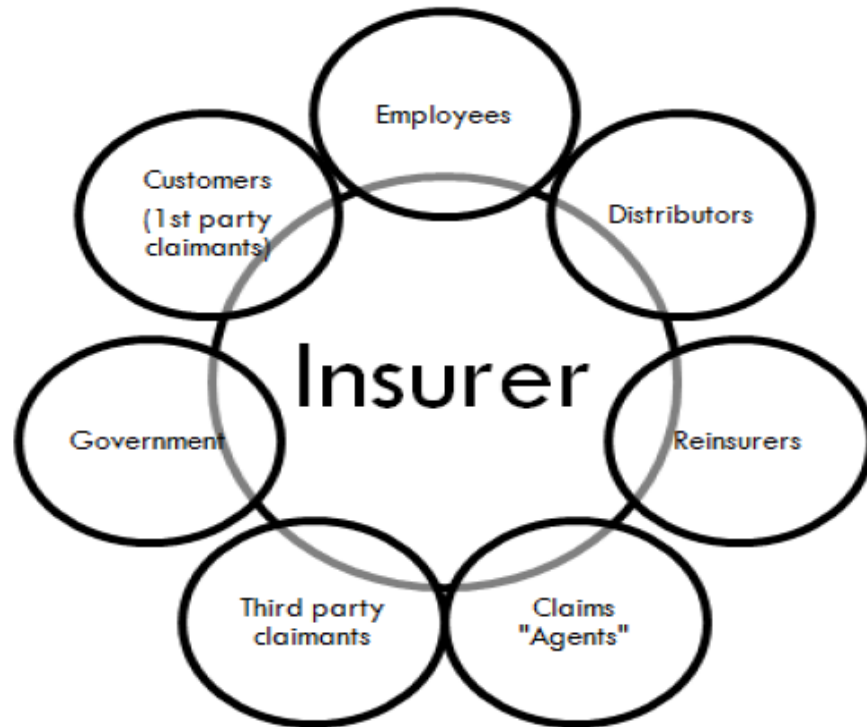
The government (regulatory bodies that oversee the industry), third parties (entities with an interest in the outcome), distributors (brokers or agents selling policies), reinsurers (companies that assume part of the insurer's risk), customers (first party claimants who purchase policies and make claims), and insurers (the company providing coverage and assuming risk) are the main stakeholders in insurance, according to Olszt (2014). Each is essential to the environment of insurance.

Figure 2.1 below illustrates the key stakeholders involved in insurance claims processes. The **insurer** acts as the central party, interacting with:

- **1st party claimants** (policyholders like employees or customers making claims)
- **3rd party claimants** (external entities claiming against the policyholder)
- **Distributors/Agents** (intermediaries selling policies)
- **Reinsurers** (entities sharing the insurer's risk)
- **Government** (regulators overseeing compliance)

This network highlights how insurers manage claims through collaborations with multiple parties while balancing risk and legal obligations.

*(Summary tailored to the visual's focus on insurance claim dynamic)*



**Figure 2-1** Source of figure Key Stakeholders in Insurance Transactions (IAG, 2011)

## 2.1.15 Construction insurance

### Understanding of construction insurance

Construction insurance is a financial tool used to manage risks in the construction industry (Dinku, 2000). Construction insurance is a broad categorization of insurance policies that provide protection during construction projects. In reality, the term “construction insurance” refers generally to insurance that relates to construction projects, and it is not itself an actual form of insurance (Medina, 2024).

### Types of construction insurance

According to (Belmont, 2023) there are 12 Types of Construction Insurance

## 1. General liability insurance

A vital form of coverage that shields companies from lawsuits involving property damage, personal harm, bodily injury, and other liabilities is general liability insurance. It is necessary for many kinds of enterprises, such as developers, home builders, general contractors, and subcontractors. By paying the expenses of some claims, this insurance shields business owners from having to make out-of-pocket payments. In the event that accidents or losses occur during construction or after the project is finished, homebuilders, for example, might benefit from general liability coverage (Belmont, 2023).

## 2. Builders risk insurance

A policy that offers property coverage throughout the construction process to protect against risks including damage, theft, and vandalism is called builders risk insurance, sometimes referred to as course of construction insurance. By providing first-party coverage, it guards against loss or damage to the policyholder's assets. It does not, however, cover third parties for harm or loss brought on by the insured (Belmont, 2023).

Usually, general contractors or business owners buy builders risk insurance to cover ongoing construction projects, including buildings that are still under development. Depending on the particular policy, the coverage may cover a range of hazards, including theft, vandalism, weather damage, fire damage, and even tools and supplies in transit for temporary or permanent projects. General contractors, property owners, developers, homebuilders, and subcontractors are among the several industries and situations for which this kind of insurance is appropriate. For instance, builders risk insurance is a tool that real estate developers can use to safeguard their properties until they are finished and occupied. (Belmont, 2023). Builders risk insurance helps reduce financial risks related to possible damage, theft, or other unanticipated incidents by providing protection throughout the construction process. Businesses working on building projects can concentrate on their work with the assurance that their assets are protected. To make sure a builders risk insurance policy fits the requirements of the project and effectively reduces risks, it is crucial to thoroughly examine and comprehend the precise coverage and exclusions.

Whether at a construction site or in/on a building, coverage may include the following, depending on your specific policy:

- Weather damage

- Fire damage
- Vandalism
- Theft
- Tools and materials in transit for short-term or long-term projects

### **3. Commercial auto insurance**

Commercial auto insurance covers collisions, losses, and liabilities resulting from operating commercial vehicles for work. Usually, it excludes heavy machinery like forklifts and tractors. Protection from lawsuits, property damage, medical bills, and other accident-related costs, as well as damage from weather, vandalism, or auto theft, may be included in the coverage. Since commercial insurance only covers company-owned vehicles, employees who use their own automobiles for work-related errands could require extra coverage. Commercial auto insurance is advantageous for construction companies and professionals, including general contractors, construction managers, subcontractors, and commercial building projects. For instance, commercial auto insurance would be useful for construction managers who supervise operations on construction sites or dispatch workers to various areas (Belmont, 2023).

Depending on your policy, coverage may include the following:

- Lawsuits
- Property damage
- Medical bills
- Other expenses that arise from an accident
- Damage caused by weather or vandalism
- Vehicle theft

### **4. Errors and omissions insurance**

Professionals are financially protected by errors and omissions insurance, often known as professional liability insurance, against lawsuits resulting from errors, carelessness, or failure to provide promised professional services. For consultants, designers, and contractors that provide specific knowledge and services, it is especially advantageous (Belmont, 2023). E&O insurance is intended to pay for court fees, verdicts, and settlements related to claims brought by customers or other parties who have incurred monetary losses or damages as a result of mistakes or omissions in the expert services rendered. Design flaws, poor counsel, deception, or a breach of professional obligations are a few examples of these mistakes or shortcomings.

Having errors and omissions insurance is essential for professionals working in fields like construction, design, engineering, or consulting where there is a high risk of mistakes or omissions. By covering legal costs and potential losses from professional liability claims, it contributes to the protection of their assets, reputation, and financial stability. Professionals can show their dedication to providing high-quality services while reducing the financial risks connected to possible mistakes or omissions in their work by acquiring errors and omissions insurance. To make sure that the insurance appropriately covers the unique risks and needs of the profession or business, it is crucial to thoroughly analyze the policy terms, coverage limitations, and exclusions (Belmont, 2023).

Depending on your insurance provider and specific policy, errors and omissions insurance can cover legal costs, such as attorney fees, court costs, lawsuit settlements, and more from unsatisfied clients due to the following types of claims:

- Work mistakes and oversights
- Undelivered services
- Missed deadlines
- Accusations of negligence

## **5. Inland marine insurance**

Inland marine insurance, also known as equipment floater insurance or a floater policy, is a comprehensive type of coverage that offers protection for owned or rented movable property. This kind of insurance can cover goods, materials, and equipment during land transportation or temporary storage at a warehouse or construction site, in addition to rental equipment. The purpose of inland marine insurance is to cover the unique hazards of property that is regularly moved or that conventional property insurance policies are unable to sufficiently cover. It offers protection for assets that are at different construction sites, in transit, or in the care of a third party (Belmont, 2023)..

Depending on the particular policy and the demands of the business, inland marine insurance may give different coverage. Usually, it offers defense against dangers including loss, damage, theft, and vandalism. Numerous industries, such as construction, contractors, transportation, art dealers, and equipment rental businesses, may be covered by this coverage. Businesses can protect their moveable property from a variety of risks that may occur during transit or temporary storage by acquiring inland marine insurance. It guarantees the

protection of the priceless assets and machinery required for company operations, even when they are in transit or off-site (Belmont, 2023).

In order to make sure that the unique requirements of the company and the type of property are sufficiently covered, it is crucial to thoroughly review the policy terms, coverage limitations, and exclusions when thinking about inland marine insurance. Selecting the right coverage for the movable goods and reducing possible hazards can be made easier by speaking with an insurance expert (Belmont, 2023).

- Depending on your policy, coverage may include the following:
  - Buildings and structures during new renovations
  - HVAC and kitchen cabinets
  - Property moved on a truck
  - Tools and equipment stored at a job site

It is possible to get inland marine coverage separately or as an addition to a commercial insurance policy. Because it eliminates the need for short-term insurance each time, it is appropriate for companies that often rent various types of equipment or transfer rentals between many jobsites. One particular kind of inland marine insurance that guards against risks like theft, damage, or accidents during construction projects is contractors' equipment insurance. Commercial construction companies that own expensive mobile equipment utilized for a variety of contracting, installation, maintenance, and moving tasks are the target of this coverage (Belmont, 2023).

Depending on your policy, coverage may include theft, accidents, and damage caused by vandalism, fire, floods, and more. Contractors insurance may cover the following types of mobile or portable equipment:

- Bulldozers
- Loaders
- Graders
- Excavators
- Backhoes
- Forklifts
- Pavers
- Compressors
- Pumps
- Cables

For companies that deal with movable tools, materials, and equipment, such as construction companies, inland marine insurance is very advantageous. Contractors, builders, developers, organizations that hire construction equipment, and heavy equipment operators are all good candidates for this kind of insurance. For instance, companies that rent out construction equipment can use inland marine insurance to cover the machines while they are being transported between jobsites or to and from clients. This insurance reduces the financial risks related to damage, theft, or accidents while also protecting the priceless assets used in these operations (Belmont, 2023).

### **6. Short-term rental insurance**

A type of insurance intended for machinery, tools, or equipment borrowed temporarily is known as short-term rental insurance. It offers defense against loss or damage while the rental is in effect. Rentals for a few days to many months, such one week to six months, are usually covered by short-term insurance policies. When renting heavy equipment for building projects, this kind of insurance is very helpful for short-term rental needs (Belmont, 2023).

For people who just need to utilize equipment on one jobsite and rent it occasionally, short-term rental insurance is typically the best option. It provides a customized and adaptable coverage option for short-term rental agreements, guaranteeing that the equipment is safeguarded during the rental duration. Businesses can lower the financial risks connected with accidents or unanticipated events by purchasing short-term rental insurance, which gives them piece of mind that any potential damage or loss to the rented equipment will be covered (Belmont, 2023).

To make sure the insurance appropriately covers the unique rental demands and provide the required protection throughout the short-term rental period, it is crucial to evaluate the policy terms, coverage limitations, and exclusions.

- Coverage may include the following, depending on your policy:
- Collisions
- Falling objects
- Fire
- Flood
- Tip-overs
- Theft

- Vandalism

Businesses or individuals that rent out construction equipment for brief periods of time, such as project managers, heavy equipment operators, general contractors, and subcontractors, would benefit from short-term rental insurance. To meet their project needs, project managers in charge of building projects, for instance, could require equipment that can be rented on a short-term basis.

### **7. Subcontractor Default Insurance (SDI)**

A policy known as Subcontractor Default Insurance (SDI) guards against monetary losses brought on by a subcontractor's inability to complete a building project. It provides coverage for any costs associated with subcontractor defaults and is used by general contractors to cover subcontractors on a project or for a specified period of time. Unlike typical performance bonds, SDI covers all subcontractors under a single policy and only involves the main contractor and the insurer (Belmont, 2023).

- Depending on your coverage, the following may be covered:
- Direct and indirect expenses brought on by a subcontractor's or subcontractors' failure to perform.
- For general contractors, construction managers, project owners, and developers, subcontractor default insurance would be ideal. A developer working on a project with several subcontractors, for example, could want to protect against any delays that might result from subcontractor defaults.

### **8. Wrap-up Insurance (OCIP/CCIP)**

A combined policy that covers liability and maybe workers' compensation for several parties participating in a building project is called wrap-up insurance, sometimes referred to as an Owner-Controlled Insurance Package (OCIP) or Contractor-Controlled Insurance Package (CCIP). A CCIP is sponsored by the general contractor, whereas an OCIP is sponsored by the project owner. Everyone involved in the project is covered by wrap-up insurance, which also, if necessary, can include professional liability insurance for engineers and architects(Belmont, 2023).

Wrap-up insurance provides coverage for several people or organizations engaged and is appropriate for large-scale building projects. While CCIP is advantageous for general

contractors, construction managers, and high-risk construction projects, OCIP is best suited for project owners, government agencies, and complicated construction projects (Belmont, 2023).

When a contractor rather than the owner of the project buys the policy, the coverage may be more limited than if the owner purchases and administers the plan:

- Coverage for everyone working on the project
- Less chance for litigation

Wrap-up insurance, whether OCIP or CCIP, is designed for multi-million dollar projects, regardless of their size. According to OCIP, this insurance will cover several individuals working on a construction project and is most appropriate for large developers, public organizations, project owners, and intricate construction projects. Large-scale commercial builders, construction managers, general contractors, and high-risk construction projects are the greatest candidates for CCIP insurance (Belmont, 2023).

## **9. Commercial property insurance**

A policy that covers the tangible assets, supplies, and machinery needed in business operations is known as commercial property insurance. It provides protection against a range of hazards, including damage, theft, and lost income claims, for structures, tools, equipment, and other assets situated at a specified address (Belmont, 2023).

The coverage provided by commercial property insurance can include:

- **Building Coverage:** This part of the policy covers the walls, roof, foundation, and attached fixtures that make up your company's physical property.
- **Contents Coverage:** It covers the contents within your business property, such as furniture, inventory, equipment, and supplies. This coverage helps to replace or repair certain products in the event of damage or loss.
- **Business Interruption Coverage:** In case your business activities are affected due to a covered event, such as a fire or natural disaster, business interruption coverage can offer compensation for lost income and ongoing expenses throughout the restoration period.

- **Equipment Breakdown Coverage:** This insurance guards against the expenses of fixing or replacing broken equipment brought on by an electrical malfunction, mechanical breakdown, or operator error.
- **Theft Coverage:** It offers defense against burglaries or thefts of your company's valuables, including equipment, inventory, and other priceless possessions.
- **Extra Coverages:** Additional coverages, such as coverage for important documents, fencing, landscaping, and exterior signs, may be provided based on the policy.
- Because it reduces the financial risks connected to property loss or damage, commercial property insurance is crucial for businesses. It enables company owners to bounce back from unforeseen circumstances and carry on with their activities without suffering heavy financial losses. To make sure the insurance appropriately covers the unique risks and needs of your company, it is crucial to thoroughly examine the policy's terms, coverage limitations, and exclusions. Choosing the right coverage for your business property might be made easier by speaking with an insurance expert.

In construction Depending on your policy, coverage may protect your company's assets from the following:

- Fire
- Explosions
- Burst pipes
- Storms
- Theft
- Vandalism

Usually, you have to include disasters like earthquakes and floods in your coverage because regular commercial property insurance could not cover them. A variety of companies and occupations, such as general contractors, subcontractors, construction firms, and developers, require commercial property insurance. For example, due of the different construction activities and assets that would need to be secured within the building/business, construction companies would profit from this form of insurance (Belmont, 2023).

## 10. Pollution liability insurance

Environmental insurance, sometimes referred to as pollution liability insurance, is a type of specialty coverage that shields companies against unanticipated pollution spills that could not be covered by regular insurance plans. This kind of insurance covers claims pertaining to losses and damages—including injury to people, property, and the environment—caused by polluted locations (Belmont, 2023).

Depending on the policy, pollution liability insurance may cover a variety of specific things, such as:

- Damage or harm brought on by the policyholder's conduct, such as unintentional pollutant spills or leaks.
- Claims for personal injuries brought on by pollution exposure, including associated medical and legal fees.
- The expenses of cleaning, repairing, and restoring property damaged by pollution occurrences.
- The price of cleaning up contaminated areas and removing dangerous materials.
- Legal representation coverage for litigation or regulatory actions pertaining to pollution events.
- Defense against calamities like flames and explosions brought on by pollutants.

Businesses that have the potential to harm the environment should pay special attention to pollution liability insurance. This can include businesses that handle hazardous products or operate in environmentally sensitive regions, such as auto shops, junkyards, demolition contractors, and site preparation firms. For instance, when clearing land for development sites, site preparation companies could produce excessive amounts of pollution (Belmont, 2023).

Businesses can reduce the financial risks and obligations related to pollution events by acquiring pollution liability insurance. It aids with defending against unforeseen costs, lawsuits, and possible harm to a business's reputation brought on by pollution-related incidents. To make sure the insurance appropriately covers the unique risks and needs of the company, it is crucial to thoroughly examine the policy terms, coverage limitations, and exclusions. Choosing the right coverage for your business's requirements might be aided by

speaking with an insurance consultant who specializes in environmental liability insurance (Belmont, 2023).

## **11. Workers' compensation insurance**

Workers' compensation insurance, sometimes referred to as workers' comp insurance, is a kind of insurance that covers medical costs and a percentage of lost income for workers who are hurt on the job or get sick while doing their jobs. Rehabilitation treatments, compensation for temporary or permanent disability, and death benefits for surviving family members are further possible inclusions in this insurance coverage (Belmont, 2023).

The specific coverage provided by workers' compensation insurance can vary depending on the policy and state law, but it generally includes the following:

- **Medical Expenses:** Workers' comp insurance covers the costs associated with medical treatment, including doctor visits, hospital stays, medication, surgeries, and rehabilitation services.
- **Lost Wages:** If an employee is unable to work due to a work-related injury or illness, workers' comp provides a portion of their lost wages as income replacement during the recovery period.
- **Vocational Rehabilitation Services:** In cases where an employee is unable to return to their previous job due to a disability, workers' comp may cover vocational rehabilitation services to help them acquire new skills or find alternative employment.
- **Legal Costs:** Workers' compensation insurance can cover legal expenses if disputes or claims arise regarding a worker's eligibility for benefits or other related issues.
- **Funeral Expenses:** In the unfortunate event of a work-related fatality, workers' comp can provide coverage for funeral and burial expenses, as well as death benefits for the surviving family members.

Nearly all states require companies with employees to get workers' compensation insurance. This covers business owners, general contractors, and subcontractors. For instance, in order to defend themselves against lawsuits brought by workers who suffer diseases or injuries related to their jobs, construction owners must have workers' compensation insurance. When workers are hurt or unwell at work, it also guarantees that medical costs and lost wages be paid for (Belmont, 2023).

Businesses can protect their employees, meet their legal requirements, and offer financial help in the event of work-related illnesses or injuries by obtaining workers' compensation

insurance. State workers' compensation standards must be followed, and you should speak with an insurance expert to make sure the coverage fits your company's and your employees' unique needs (Belmont, 2023).

## 12. Surety Bonds

A written pledge to assume liability for another person's debts or obligations is known as a surety bond. In this three-way contract, one party, the surety, promises to a third party, the obligee, that the second party, the principal, would execute. Surety bonds usually safeguard the project owner rather than the contractor (Belmont, 2023).

Here are a few surety bond options you may find in construction projects:

- Bid bonds: Often used for construction projects with bid-based selection processes, a bid bond protects the owner if the selected bidder fails to begin a project.
- Fidelity bonds: Also known as honesty bonds, fidelity bonds are a type of business insurance that protects owners against losses caused by fraudulent or dishonest actions by employees.
- License and permit bonds: These bonds are required by government agencies or other public bodies in order to receive a license or permit to engage in a specific activity. License and permit bonds are a way to guarantee that the party seeking the license or permit will comply with applicable laws and regulations.
- Payment bonds: This type of surety bond guarantees that certain subcontractors, employees, and suppliers involved in a project will be paid for their labor and materials.
- Performance bonds: A performance bond provides protection against a contractor's failure to meet the obligations of the contract. If the work done by the contractor is defective or inadequate, the performance bond provides compensation for the cost of fixing or redoing the job.

General contractors, subcontractors, construction managers, and business owners are among the many occupations and enterprises that might benefit from surety bonds. For larger projects, for instance, subcontractors offering specialized services like electrical or plumbing would require a surety bond (Belmont, 2023).

### 2.1.16 Summary of insurance

Insurance has a rich history dating back to ancient civilizations, with Mesopotamia being one of the earliest examples. Over time, various forms of insurance emerged, including marine

insurance and fire insurance. In Ethiopia, the insurance sector went through three phases: the Imperial Regime Phase, the Socialist State Phase, and the Liberalization Phase. Insurance is a contract between an insurer and an insured, providing financial protection against potential losses in exchange for regular premium payments (Belmont, 2023), Risks can be categorized as insurable or uninsurable, with insurable risks further classified as standard, sub-standard, or super-standard. Different types of insurance organizations exist, including self-insurance, individual insurers, partnerships, joint stock companies, mutual companies, co-operative insurance organizations, Lloyd's Association, and state insurance. Insurance can be broadly classified into life insurance and general insurance, with various policies available to protect against specific risks. Key characteristics of insurance include being a contract, requiring consideration, and serving as a cooperative device for risk sharing and transfer (Belmont, 2023), Insurance principles and components of an insurance policy play a crucial role in defining the terms and coverage. Reinsurance helps insurers distribute risks and ensure sufficient capital for handling claims. Insurance serves important functions such as providing reliability, protection, risk pooling, and meeting legal requirements. It also generates financial resources, encourages saving, promotes economic growth, and provides medical support. Specific types of insurance include hazardous occupation, war risk insurance, marine insurance, and fire insurance, each serving unique purposes. Construction insurance encompasses various types such as builders risk, general liability, errors & omissions, commercial auto/truck, inland marine, contractor license bonds, and construction bonds. Workers' compensation insurance is also essential in the construction industry. The necessity of having these insurances depends on legal requirements and project contracts, with costs influenced by factors such as coverage type, credit history, contractor experience, project size, and location (Belmont, 2023).

## **2.2 Construction technology adoption study**

### **2.2.1 Definition of construction technology**

Technology means radiation and nuclear, chemical, electronics and electric appliance, plant and machinery, material technology, engineering technology, aerospace and space technology Ethiopian Technology Authority (REGULATION NO. 507/2022,).

The "collection of innovative tools, machinery, modifications, software, etc. used during the construction phase of a project" is known as construction technology. The entire goal of building technology is to promote innovation and progress within the sector while also boosting productivity. Although construction technology is sometimes referred to as "con tech," it is actually considered a separate and distinct category of technology. Manufacturing, healthcare, energy, transportation, agriculture, and construction are the main divisions into which technology is generally divided (Frostell, 2020).

## **2.2.2 Evolution study of construction technology**

### **i) The First Industrial Revolution (Industry 1.0)**

In the 18th century, England experienced the first industrial revolution, or Industry 1.0. Between roughly 1760 and 1840, it signaled the shift from a handicraft-based economy to one centered on machinery and mechanization. According to Sharma et al. (2020), the weaving loom, water wheel, spinning wheels, and steam engines were among the core technologies of Industry 1.0. Glass, mining, agriculture, and textiles were among the industries that were significantly impacted by this revolution. Prior to Industry 1.0, textiles were produced at home with crude spinning wheels, which reduced output. But mechanization sped up production and made large-scale manufacture possible. For example, compared to earlier techniques, the advent of steam power resulted in eight times the production of thread. In order to boost human productivity, steam engines were also utilized to power devices like weaving looms. The transportation and textile sectors benefited from the adoption of these technologies, particularly when coal was added as a fuel source. But first, workers were under pressure since there was a higher demand for machines than there was supply. Many workers had to put in long hours in unhealthful conditions, particularly those in lower-class occupations (Sharma et al., 2020).

To address these issues, the UK implemented the Factory Act in 1833, which aimed to establish high standards and ensure the safety and protection of workers in all workplaces

During the first industrial revolution, construction technology innovations were relatively limited compared to other industries. However, some significant advancement took place:

- **Steam Power:** The development of steam engines allowed for the mechanization of certain construction tasks, such as pumping water out of excavation sites and powering cranes.
- **Iron and Steel:** The use of iron and steel in construction materials, such as beams and columns, provided greater strength and stability to buildings and structures.
- **Mass Production:** The introduction of mass production techniques, including standardized components and prefabrication, improved construction efficiency and reduced costs.

## **ii) The Second Industrial Revolution (Industry 2.0)**

The 19th century saw the rise of the Second Industrial Revolution, sometimes known as Industry 2.0, which was fueled by the use of electrical energy and mass production methods. Henry Ford transformed manufacturing by introducing assembly lines in the car industry, greatly increasing productivity and cutting costs. This innovation was inspired by slaughterhouse conveyor systems. This period made it possible to produce higher-quality goods on a vast scale thanks to developments in steel, electricity, and transportation networks. Lean manufacturing concepts and Frederick Taylor's time management research significantly increased workplace productivity. Ford became known as the father of automotive mass manufacturing thanks to innovations like its conveyor belts and Ransom E. Olds' assembly line, which revolutionized industries and established mass production as the norm (Sharma et al., 2020).

The second industrial revolution brought about more significant advancements in construction technology:

- **Electricity:** The widespread adoption of electricity revolutionized construction sites, enabling the use of electric-powered tools and machinery, such as drills, saws, and cranes.
- **Elevators:** The invention of safe and reliable elevators allowed for the construction of taller buildings, significantly impacting urban development.

- Reinforced Concrete: The introduction of reinforced concrete, combining the strength of steel with the moldability of concrete, revolutionized building construction, enabling the construction of larger and more complex structures.

### iii) The Third Industrial Revolution (Industry 3.0)

The emergence of computers, electronics, and partial automation propelled the Digital Revolution, also known as Industry 3.0 or the Third Industrial Revolution, which started in the 1970s. Transistors, integrated circuits, and programmable logic controllers (PLCs) were among the major inventions that made production processes faster and more precise, frequently taking the place of human work. Inventory control, logistics, and enterprise resource planning were among the management procedures that were transformed by the integration of IT and software systems. The world transitioned from analog to digital at this time due to the introduction of revolutionary technology like the Internet, microprocessors, and digital cell phones. Modern industries still rely heavily on Industry 3.0 technologies, which allow for complete automation and the employment of robots to do activities without the need for human interaction (Sharma et al., 2020). The third industrial revolution brought about the digital revolution, and while construction technology innovations were not as prominent as in other industries, some notable advancements occurred: Sharma et al. (2020)

- Computer-Aided Design (CAD): CAD software allowed architects and engineers to create detailed and precise digital designs, improving efficiency and accuracy in the planning and design phases of construction projects.
- Building Information Modeling (BIM): BIM technology enabled the creation of intelligent 3D models that incorporated various construction data, facilitating collaboration, coordination, and clash detection among different project stakeholders.
- Construction Machinery: More advanced construction machinery, such as hydraulic excavators, tower cranes, and concrete pumps, became prevalent, enhancing productivity and efficiency on construction sites.

#### **iv) The Fourth Industrial Revolution (Industry 4.0)**

The present industrial revolution, known as Industry 4.0, is defined by the widespread application of smart information and communication technology across a range of industries. Its emphasis on effective system networking and interconnection has resulted in the creation of smart factories, which have highly automated and networked manufacturing. It has changed the way people operate by facilitating faster and more effective information exchange. Cloud computing, big data, cyber-physical systems, machine learning, artificial intelligence, and the Internet of Things (IoT) are all components of the Industrial Internet of Things (IIoT), which is driving the fourth industrial revolution. It focuses on environmental concerns and sustainability with the goal of increasing the productivity and profitability of manufacturing processes. The 1990s saw the beginning of Industry 4.0's key breakthroughs, with notable shifts beginning in 2011. Cyber-physical systems (CPS) and smart machines are important technologies that track and identify industrial process faults. In contrast to its predecessor, Industry 3.0, Industry 4.0 incorporates large volumes of data and intelligent, networked machines that function independently, but also depending less on human interaction (Sharma et al., 2020).

The fourth industrial revolution is still unfolding, and construction industry innovations are rapidly emerging:

- **Robotics and Automation:** The use of robotics and automation in construction is increasing, with robots being deployed for tasks like bricklaying, 3D printing of structures, and autonomous construction equipment.
- **Internet of Things (IoT):** IoT devices and sensors are being integrated into construction sites to collect and transmit data in real-time, enabling better monitoring of construction progress, equipment performance, and worker safety.
- **Augmented Reality (AR) and Virtual Reality (VR):** AR and VR technologies are being used for virtual walkthroughs, immersive training, and visualization of construction projects, improving communication and decision-making.

- Drones: Unmanned aerial vehicles (drones) are being employed for site inspections, surveying, and monitoring, providing accurate and efficient data collection for project management.
- These are just a few examples of the construction technology innovations that have emerged in each era of industrial revolution. As technology continues to advance, we can expect further advancements in areas like artificial intelligence, advanced materials, sustainable construction practices, and digital collaboration platforms.

**v) Summary**

A comparative summary of the four industrial revolutions is given in Table 2.1 below, together with information on their salient features, technological developments, and effects on the building industry. It looks at the main inventions, labor dynamics, production systems, dominating power sources, and fundamental advantages and difficulties of each era. From mechanization (Industry 1.0) to intelligent, data-driven construction (Industry 4.0), the table illustrates how advancements in technology have changed workforce expectations, productivity, and efficiency. This synopsis lays the groundwork for comprehending how contemporary developments like automation, the Internet of Things, and cyber-physical systems are still revolutionizing risk management, safety, and insurance procedures in the construction industry.

**Table 2.1 Summary of industrial revolution and its innovation in construction industry**

Parameter	Industry 1.0	Industry 2.0	Industry 3.0	Industry 4.0
Time Period	18th Century	19th Century	20th Century (1970s) - Present	Present
Main Power Source	Water & Steam	Electricity & Oil	Electronics & IT	Information & Communication Technologies (ICT)
Production System	Mechanized	Assembly Lines	Partial Automation	Cyber-Physical Systems (CPS) &

				Smart Factories
Key Invention	Steam Engine	Assembly Line & Electricity	Programmable Logic Controllers (PLCs) & Computers	Industrial Internet of Things (IIoT)
Labor	High Labor Demand	Less Labor, Job Displacement	Some Human Intervention	Minimal Human Intervention
Focus	Mechanization of Production	Mass Production	Automation	Networked & Intelligent Automation
Benefits	Increased Productivity	Faster Production & Lower Costs	Improved Accuracy & Efficiency	Increased Efficiency, Sustainability, & Customization
Challenges	Long Working Hours & Unhealthy Conditions	Job Displacement	Skill Gap	Data Security & Privacy
Risk Minimization	Limited focus, relied on basic safety measures	Focus on worker safety regulations & improved working conditions	Limited focus, some safety measures for robots	Focus on cyber security, data privacy, and potential job displacement through retraining & up skilling initiatives

### 2.2.3 Construction technology adoption

#### Meaning Technology Adoption

The process by which individuals or groups embrace and make use of new technologies is known as technology adoption. Learning and adjusting to new technologies are part of it. Performance expectancy, effort expectancy, enabling circumstances, and social influence all have an impact on the adoption of technology (Mirthinti, 2023). Historically, the construction sector has been sluggish to embrace new technologies. Nonetheless, the potential advantages of technology adoption in this industry have come to light more and more in recent years. In building projects, technology can contribute to increased productivity, safety, and efficiency (Perez, 2024). One important development at this time is the construction industry's use of new technologies. It makes the case that while implementing new technologies can help construction enterprises, there are drawbacks as well. The paper lists several reasons why construction firms may be reluctant to embrace new technologies. These factors include the expense of new technology, the potential disturbance to current workflows, and the ignorance of construction experts regarding the advantages of new technologies (Gaw, 2020).

### 2.2.4 Technology Adoption Curve: Five stage of adoption

In his 1962 book "Diffusion of Innovations," Everett Rogers broadened the technology adoption "curve," also known as the innovation curve of the innovation adoption lifecycle, from early versions. According to this model, the adoption of technology over time is represented by a traditional "bell curve," with each part of the curve divided into groups of adopters who share certain characteristics (Gaw, 2020).

#### i) Technology lifecycle

How various people acquire new technologies is explained by the technology adoption lifecycle. According to Batti (2023), it is divided into five stages: innovators, early adopters, early majority, late majority, and laggards.

1. **Innovators/Technology Enthusiasts** –are first to try a new “cool” technology. They understand it may not be perfect, and are willing to take a risk that it may not solve their

problem. Innovators (2.5%) are the first to try new products, taking risks and following the latest trends.

Innovator Traits Include: Enthusiastic about new technology, Willing to take risks, Not concerned with the idea of failure.

2. **Early Adopters/Visionaries** –are willing to try out a technology at an early state. The Early Adopter is making an informed decision and not using a technology for technology sake, like the Innovator might. But they do not need to be taught about the value proposition. They are willing to commit the effort to try to make the new technology work. Early adopters (13.5%) are also open to new ideas but are more selective than innovators. They are often seen as influencers./1

Early Adopter Traits Include: Persuasive, Willing to work through early bugs and setbacks, Concerned about their reputation.

3. **Early Majority/Pragmatists** – These are more conscious technology consumers and are looking for useful solutions but also wary of possible fads or buggy solutions. They are pragmatic and rely on hard, proven data and facts. They look for a safe purchase. Early majority (34%) are cautious but adopt new products after seeing positive reviews from the early adopters.

Early Majority Traits Include: Logical, Practical, Data-driven.

4. **Late Majority/Conservative** – are more skeptical and price conscious about technology and innovation and are only comfortable in adoption once a product is “mainstream”. Like Early Majority they want to see hard data on effectiveness. Late majority (34%) are skeptical of new products and wait until they become mainstream before adopting them.

Late Majority Traits Include: Cautious, Logical, Do not like to take risk.

5. **Laggards/Skeptics** – are averse to innovation and new technologies. They require a clear provable advantage tied to clear metrics to be convinced. Laggards (16%) are the last to adopt new products, often due to a resistance to change or limited resources.

Laggard Traits Include: Skeptical, Resistant to change, Wary of new technology.

## ii) Technology adoption curve

The bell-shaped technology adoption curve concept explains how various people respond to, embrace, and accept novel items and technologies. Everett Rogers' diffusion of innovations delves into the traits of each of the five adopter types within the technology adoption life cycle: innovators, early adopters, early majority, late majority, and laggards (Gaw, 2020), despite the fact that the original model has undergone numerous adaptations.

Figure 2.2 below illustrates **Everett Rogers' Technology Adoption Lifecycle**, a classic model that categorizes how different groups adopt innovations over time. The key segments and their approximate percentages are:

1. **Innovators (2.5%)** – Risk-takers who embrace new technologies first.
2. **Early Adopters (13.5%)** – Visionary leaders who see potential and drive early-market validation.
3. **Early Majority (34%)** – Pragmatic users who adopt after proven utility.
4. **Late Majority (34%)** – Skeptical adopters who wait until the technology is mainstream.
5. **Laggards (16%)** – Resistant to change until adoption is unavoidable.

Key Takeaway:

The model highlights the **critical mass** achieved when the Early Majority adopts, ensuring market success. The **challenge** lies in transitioning from Early Adopters to the Early Majority—a gap Geoffrey Moore termed the "chasm."

*Source: Adapted from Everett Rogers' Diffusion of Innovations theory.*

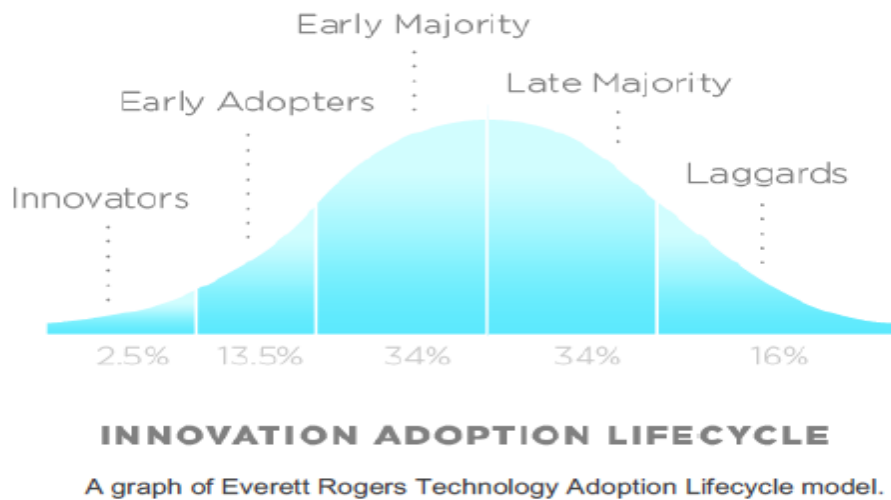


Figure 2-2 A graph of Everett Rogers technology adoption lifecycle model

## 2.2.5 Technology Penetration

Different groups of adopters participate in different stages of the adoption process of new technologies in industries, which adds to the technology's overall penetration. One way to think about this adoption process is as a timeline with different risk and reward levels. Longer-term benefits are enjoyed by early adopters, but they also run the risk of increased expenses and possible inefficiency. Notwithstanding these dangers, early adopters are essential in offering criticism and recommendations for enhancements prior to broader acceptance (Gaw, 2020).

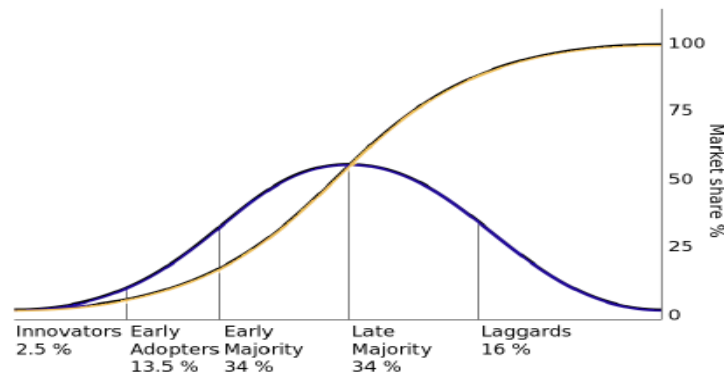
Figure 2.3 below depicts the **Technology Adoption Lifecycle**, adapted from Geoffrey Moore's *Crossing the Chasm* (1992), illustrates how different groups adopt new technologies over time. The curve categorizes adopters into five segments based on their willingness to embrace innovation:

1. **Innovators (2.5%)** – The first to adopt new technologies. They are risk-takers, often driven by curiosity and a desire to explore cutting-edge solutions.
2. **Early Adopters (13.5%)** – Visionaries who recognize the potential benefits of technology and adopt it early, often influencing others.

3. **Early Majority (34%)** – Pragmatic users who adopt once a technology has proven its value. They rely on recommendations from early adopters.
4. **Late Majority (34%)** – Skeptical adopters who wait until a technology is well-established before embracing it, often due to peer pressure or necessity.
5. **Laggards (16%)** – The last to adopt, resistant to change and preferring traditional methods until they have no other choice.

Key Insight: The curve highlights the critical "**chasm**" between Early Adopters and the Early Majority—a gap where many innovations fail due to mismatched expectations or scalability challenges. Success hinges on bridging this gap by addressing practical needs and market readiness.

Source: Adapted from Geoffrey Moore, *Crossing the Chasm* (1992).



Technology Life Cycle Adoption Curve [Adapted from Geoffrey Moore, in his 1992 book *Crossing the Chasm*]

Figure 2-3 Technology lifecycle adoption curve adopted from Geoffrey Moore, 1992 Book

## 2.2.6 Technology Maturity Curve

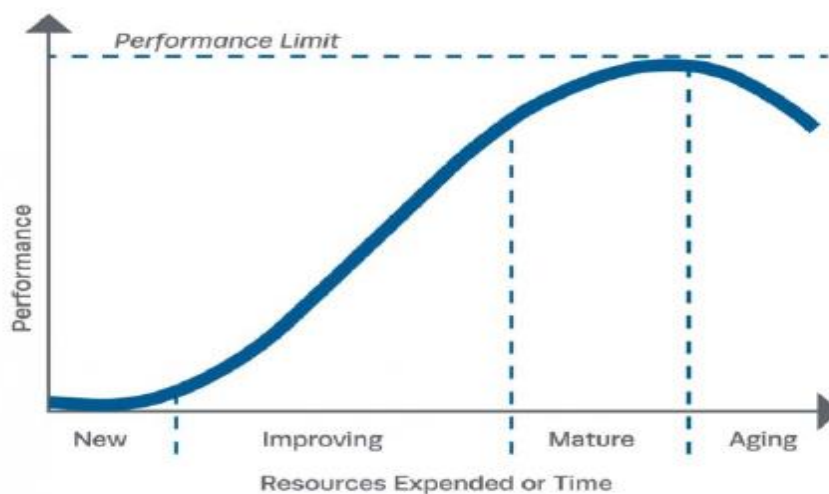
Gaw (2020) asserts that the technology we are trying to embrace has a lifecycle of its own that runs concurrently with the "adoption" curve. This lifetime, which has four stages, is frequently described as a "technology maturity curve":

Figure 2.4 below illustrates a **technology maturity curve**, depicting how performance evolves over time as resources (effort, funding, or time) are expended. The stages include:

1. **New** – Initial development phase with rapid performance improvements.
2. **Improving** – Continued refinement leads to significant gains.
3. **Mature** – Performance peaks, and further investment yields minimal returns.
4. **Aging** – Performance declines due to obsolescence or diminishing returns.

The curve suggests that **optimal investment aligns with the "Improving" phase**, where resources efficiently boost performance. Beyond maturity, additional expenditure may not justify gains, signaling a need for innovation or replacement.

Source: MITRE Corporation, "Assessing Technical Maturity."



Source: MITRE Corporation. *Assessing Technical Maturity*, Figure 2. Technology Maturity.

#### **Figure 2-4** Technology maturity curve

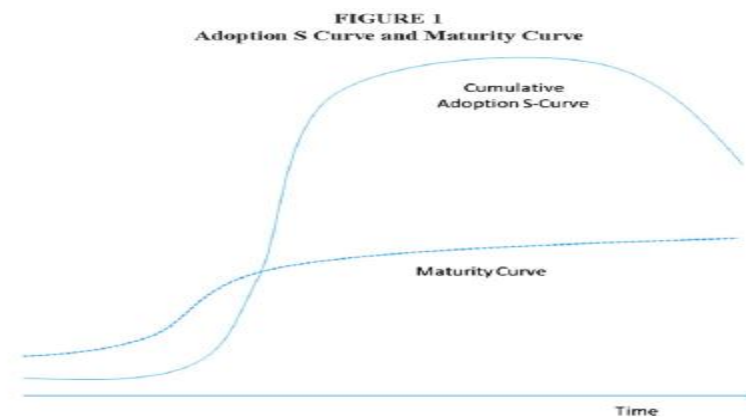
As one may anticipate from examining the criteria of each adoption phase "persona," there is a connection between the adoption curve and technology maturity. This indicates that the development of technology and its potential for adoption must be coordinated. Making this synchronization work for everyone depends in large part on the Innovator and Early Adopter types' willingness to devote time to working with technology/product developers (Gaw, 2020).

Figure 2.5 below illustrates two key concepts in innovation diffusion:

1. **Adoption S-Curve:** Shows how new technologies/products gain traction over time, starting with slow initial uptake (early adopters), accelerating rapidly (mainstream adoption), and eventually plateauing (market saturation).
2. **Maturity Curve:** Tracks the lifecycle of a technology's development and market integration, from introduction to growth, maturity, and eventual decline.

When combined, these curves show how market acceptance (S-curve) and technological evolution (maturity curve) are related, highlighting the fact that adoption peaks as technology advances. According to the source (Fenn, 2007), this model aids in forecasting the timing of market strategies and the success of innovations.

*(Summary tailored to the visual's focus on innovation lifecycle dynamics.)*



Source: Fenn (2007). Adoption S Curve and Maturity Curve.

**Figure 2-5** Fenn (2007) technology Adoption curve and maturity curve

## 2.2.7 The benefits and challenges of adopting construction technology

According to (Jaafar.M et al, 2025) here are the **Benefits of Construction Technology Adoption:**

- i. **Improved Efficiency and Productivity:** Automation of routine tasks, better project management software, and data-driven decision making can all lead to faster project completion times and less wasted effort.

- ii. **Enhanced Accuracy and Precision:** Technologies like Building Information Modeling (BIM) can create highly detailed 3D models that minimize errors and rework during construction.
- iii. **Increased Safety:** Drones for site inspections, wearable sensors for hazard detection, and improved communication tools can all contribute to a safer work environment for construction workers.
- iv. **Better Communication and Collaboration:** Cloud-based platforms and communication tools allow for seamless communication between project stakeholders, leading to fewer misunderstandings and delays.
- v. **Reduced Costs:** While there's an initial investment, technology can ultimately save money through increased efficiency, reduced rework, and better resource management.
- vi. **Improved Quality Assurance:** Technology like digital inspections and real-time data monitoring can ensure construction adheres to plans and specifications.

### According to (Alwashah.Z et al, 2024) here are the Challenges of Construction Technology Adoption

#### Challenges of Construction Technology Adoption:

- i. **Cost:** New technologies can be expensive to purchase, implement, and maintain, especially for smaller construction firms.
- ii. **Training and Support:** Construction workers may need training to learn how to use new technologies effectively, which requires time and resources.
- iii. **Resistance to Change:** Some construction professionals may be hesitant to adopt new ways of working, fearing job displacement or a disruption to established workflows.
- iv. **Integration Challenges:** Integrating new technologies with existing systems and software can be complex and time-consuming.
- v. **Data Security Concerns:** Construction projects often involve sensitive data, so security measures need to be taken to protect this data from cyber threats.
- vi. **Lack of Awareness:** Some construction professionals may not be aware of the full range of potential benefits that new technologies offer.

Overall, construction technology adoption presents a significant opportunity to improve the industry in terms of efficiency, safety, and cost-effectiveness. However, there are challenges that need to be addressed to ensure successful implementation. By carefully considering the benefits and challenges, construction companies can develop a plan to adopt new technologies that will ultimately benefit their business.

### **2.2.8 Factors affecting construction technology adoption**

Cost, return on investment (ROI), and the ability to improve productivity, efficiency, and safety are some of the factors that affect the adoption of construction technology. Businesses take into account the workforce's skill needs as well as the technology's scalability and interoperability with current systems. Important responsibilities are also played by market demand, industry awareness, and regulatory compliance. Adoption may also be impacted by organizational culture and change aversion. Innovation and competitiveness in the construction sector are fueled by technologies that satisfy these criteria and show definite advantages (Sepasgozar et al., 2012).

A number of obstacles must be addressed in order to overcome opposition to the adoption of construction technology, including a lack of knowledge about the advantages of the technology, concerns about job loss as a result of automation, and financial limitations for initial expenditures and training. Organizational culture, interoperability problems, and a dearth of successful pilot initiatives are further causes of resistance. Adoption is made more difficult by regulatory issues, supplier and subcontractor reluctance, and the lack of industry standards. Concerns over privacy and data security may also put off stakeholders. In order to foster confidence and promote the use of technology, effective tactics include education, change management, cost-efficient solutions, and guaranteeing compliance and interoperability (Sepasgozar et al., 2012).

### **2.2.9 Summary**

Adoption of construction technology entails incorporating new instruments and frameworks into the sector to increase productivity, safety, and efficiency. While the technology itself progresses via a maturation curve, this process has stages such as innovators, early adopters, and laggards. Adoption may be hampered by issues like high initial costs, resistance to change, and the requirement for intensive training, despite the fact that it offers advantages

including improved safety, decreased costs, and increased accuracy. Cost, return on investment, productivity, safety, scalability, and organizational culture are some of the factors that affect adoption. Addressing issues like job displacement, offering sufficient training, and showcasing the obvious advantages of technology adoption are all necessary to overcome reluctance.

## **2.3 Study on construction technologies and their impact on safety, risk management and insurance premium**

### **2.3.1 Building Information Modelling (BIM)**

#### **i) Definition of BIM**

Through the use of BIM, the many parties involved in a construction project work together to produce a common digital model of the project. Throughout the planning, design, construction, operation, maintenance, and demolition phases of a building project, Building Information Modeling (BIM) is a collaborative method for multidisciplinary information storing, sharing, exchanging, and managing (Eastman et al., 2011; Eadie et al., 2013).

#### **ii) Key component of BIM**

Creating and managing data for a construction project across its whole lifecycle is known as building information modeling, or BIM. BIM is a digital depiction of a facility's functional and physical attributes. The modeling of the building and its systems to supply data for decision-making in the planning, design, construction, and facility management of a building and infrastructure is a fundamental component of Building Information Modelling (BIM).

Here are some key components of BIM:

- **3D Model:** The cornerstone of BIM, this model shows the building's geometry, materials, and spatial relationships in visual form.
- **Data and Information:** Rich data, including dimensions, materials, performance characteristics, and cost information, are included in BIM models for every element. Numerous analysis and decision-making processes can make use of this data.

- CDE, or the Common Data Environment: a single location to store all project data, such as schedules, documentation, drawings, and models. Project stakeholders can work together and coordinate more easily thanks to the CDE.
- Interoperability and Standards: To guarantee smooth data transmission between various software programs and among project participants, BIM depends on open standards and file formats.
- Conflict Detection and Coordination: BIM makes it possible to find and fix conflicts between various building systems and parts, including structural, electrical, and plumbing components.
- 4D Scheduling and Planning: By combining BIM with project scheduling software, 4D models that show the construction process over time can be produced, which facilitates coordination and planning.
- 5D Cost Estimation: By connecting BIM to cost databases, precise cost estimates for labor, materials, and equipment can be produced, improving project planning and management.
- 6D Sustainability Analysis: By evaluating the environmental effects of building operations and design, BIM may assist optimize material selection, water use, and energy efficiency.
- 7D Facility Management: Digital twins of buildings may be produced using BIM models, offering useful data for facility management activities including upkeep, repairs, and improvements.

These key components work together to create a comprehensive and dynamic representation of a building project, enabling better decision-making, improved collaboration, and enhanced project outcomes.

### **iii) Creating a Common Data Environment (CDE)**

Following data gathering, BIM projects require a Common Data Environment (CDE) so that all project participants may access data in one location. The secret to cooperation and communication is this. For this, software like as Autodesk Revit, Navisworks, and PointFuse are perfect.

#### **iv) Valuable changes of BIM in construction industry**

Through enhanced communication, remote teamwork, and more efficient project execution, BIM is propelling a digital revolution in the construction sector. It guarantees more accurate cost and time predictions, improves client and stakeholder relationships, and helps prevent delays. It is anticipated that the sector will continue to change as BIM adoption rates climb in order to satisfy the expanding needs of a growing population. Significant improvements in the industry will result from increased use and investment in BIM, which will enhance its capabilities.

BIM (Building Information Modeling) is significantly transforming the construction industry in several ways:

- **Better cooperation:** By offering a common platform for exchanging and accessing project data, BIM facilitates improved cooperation amongst project stakeholders. Between various teams, including architects, engineers, contractors, and owners, this promotes smooth communication, lowers errors, and improves coordination.
- **Increased Productivity:** By streamlining the construction process, BIM increases productivity and efficiency. It makes it possible to plan, schedule, and sequence construction tasks more effectively, which minimizes rework and maximizes resource use. Shorter project timelines, lower costs, and higher profitability result from this.
- **Accurate Visualization and Simulation:** Building Information Modelling (BIM) makes it possible to create 3D virtual models of infrastructure projects and buildings. Stakeholders are better able to comprehend the design concept, spot possible conflicts or problems prior to construction, and make well-informed decisions thanks to this visual representation. Furthermore, BIM makes it possible to simulate and analyze a number of scenarios, including safety precautions, structural integrity, and energy performance.
- **Cost and Time Estimation:** Throughout the course of a project, BIM makes it easier to estimate costs and times with more accuracy. Project teams may produce accurate estimates, evaluate options, and improve construction plans

by including schedules, materials, and quantity data into the BIM model. This promotes effective resource allocation, enhances budgeting, and lowers cost overruns.

- **Better Facility Management:** After construction, BIM's digital models offer useful data for facility management and upkeep. The built environment can be managed and maintained more easily over its lifecycle by integrating asset data, maintenance plans, and operating manuals into the BIM model. Better operating efficiency, less downtime, and more economical maintenance result from this.
- **Sustainability and Lifecycle Analysis:** By facilitating energy analysis, carbon footprint evaluation, and building lifecycle analysis, BIM aids sustainability programs. Energy efficiency and environmental effect can be used to assess design choices. Additionally, BIM promotes greener building practices by making it easier to integrate sustainable materials and renewable energy sources.
- **Technological Integration:** New technologies like augmented reality (AR), virtual reality (VR), and Internet of Things (IoT) gadgets can be integrated using BIM as a foundation. These technologies further improve project outcomes and construction processes by enhancing visualization, real-time data collection, and on-site construction monitoring.
- **All things considered,** BIM is transforming the construction sector by encouraging cooperation, increasing productivity, cutting expenses, strengthening judgment, and incorporating sustainable practices. It is anticipated that the sector will undergo further change and innovation as a result of its broad acceptance and ongoing technological developments.

evaluations of the current state of BIM based on risk management, It makes the case that BIM and related technologies can be employed as a methodical risk management tool to assist the project development process. According to the report, the majority of recent efforts have focused on examining technological advancements, with the primary focus thus far being on managing the safety of construction workers. Due to current technology constraints and the absence of "human factor" assessment, BIM-based risk management has not been

widely implemented in real-world settings. Future research, according to the authors, should integrate traditional risk management with new technologies, explore implementation methods and processes, support the development process, and adopt a multidisciplinary system-thinking approach (Zou et al., 2015).

The importance of Building Information Modeling (BIM) as a technique to reduce project risks is examined in this research. It makes the case that BIM is essential at every stage of a project's lifespan, including planning, designing, and managing construction. By employing BIM, information management ensures collaboration among project team members, allowing for adequate project monitoring and facilitating efficient execution and milestone achievement. Although the proven use of BIM in a variety of projects is acknowledged in the study, more research is necessary to determine how beneficial it is at reducing risks in the construction sector (El Khatib et al., 2022).

This paper makes the case that risk management in construction firms can be enhanced by Building Information Modeling (BIM). The authors look at how BIM affects risk management during the course of a building project. They contend that during a project's design, construction, and operation stages, BIM can assist in identifying, evaluating, and mitigating risks. The difficulties in applying BIM in construction organizations are also covered in the document. The price of BIM software and training, as well as the requirement for organizational culture shifts, are some of these obstacles. Nonetheless, the authors contend that BIM's advantages exceed its drawbacks. All things considered, this paper makes the case that BIM is an effective instrument for risk management in construction firms. Construction firms can enhance their capacity to recognize, evaluate, and reduce risks by utilizing BIM, which can result in projects that are safer, more effective, and more economical (Tomek and Matějka, 2014).

#### **v) Best Practice Guide for PI Insurance when using BIM**

Following extensive consultation with insurers, the Guide was created. The market's reaction was that there haven't been any BIM Level 2 problems that are severe enough to call for coverage limitations. Additionally, since BIM Level 2 shouldn't significantly change consultants' risk profile, premium implications should be negligible. Even so, the Guide

offers some helpful advice for design consultants working on BIM projects . It is recommended that insureds speak with their brokers and provide information if they are, for instance, hosting a BIM environment or taking on the job of BIM Coordinator or Information Manager (in which case separate technology/cyber risk insurance may be needed). This advice makes sense and is in line with current market trends (Lesny, 2013).

#### **vi) Looking forward**

PI insurers on the whole have become comfortable with Level 2 BIM. The BIM Protocol and the role of the Information Manager should bring the contractual certainty and process management the construction sector has been calling for (Lesny, 2013).

### **2.3.2 Virtual Reality Safety Training**

#### **i) Definition of VR**

A person can engage with an artificial three-dimensional (3-D) visual or other sensory world through the use of computer modeling and simulation, which is known as virtual reality (VR) (Lowood, 2024). The phrase "virtual reality" was first used by Jaron Lanier in 1987. Government financing from organizations like the Department of Defense, the National Science Foundation, and NASA played a major role in the early development of virtual reality in the United States. University research was encouraged by this assistance, which resulted in improvements in networked environments, computer graphics, and simulation—all of which laid a solid basis for the VR sector. Virtual Reality (VR) is a computer-generated simulation of a three-dimensional environment that can be interacted with in a seemingly real way. It employs specialized hardware, like headsets and handheld controllers, to create an immersive experience, often providing visual, auditory, and sometimes even tactile feedback.

#### **ii) The core components of a VR system typically include:**

- The main gadget, the Head-Mounted Display (HMD), covers the user's eyes and frequently their ears. It may have headphones for engrossing sound and shows the 3D virtual world.
- **Input Devices:** These allow users to interact with the virtual world. Common examples include:

- ✓ **Controllers:** Handheld devices with buttons, joysticks, and sometimes motion tracking.
  - ✓ **Motion Trackers:** Devices that track the user's head and body movements (e.g., cameras, sensors).
  - ✓ **Gloves:** Specialized gloves that can track hand movements and provide haptic feedback (simulated touch).
- 
- **Powerful Computer or Console:** VR experiences require significant processing power to render complex graphics and simulate real-time interactions.
  - **Software:** This includes the VR applications themselves, as well as software that manages the interaction between the hardware components and the virtual environment.

These components work together to create an immersive and interactive experience that can transport users to different worlds, simulate real-life situations, or provide unique entertainment experiences.

### iii) Benefits of VR in construction safety

Virtual reality (VR) has become a useful tool for safety training in a number of areas, such as manufacturing, transportation, healthcare, and construction. An outline of the usage of virtual reality in safety training is provided below:

- **Lifelike Simulations:** Without putting students in danger, virtual reality (VR) enables them to fully immerse themselves in lifelike simulations of dangerous situations. High levels of realism and engagement are offered by the ability to encounter and interact with virtual surroundings that closely mimic actual work settings.
- **Hazard Recognition and Response:** By simulating hazardous scenarios, virtual reality training can assist staff members in honing their hazard recognition abilities. In order to react appropriately, trainees can practice recognizing possible dangers, evaluating them, and making the right choices. This enhances critical thinking skills and situational awareness.

- **Emergency Preparedness:** Virtual reality has the ability to replicate emergency scenarios, including chemical spills, fires, and medical crises. In accordance with the appropriate emergency protocols and procedures, trainees can learn how to react appropriately and quickly. In a secure setting, they can rehearse evacuation procedures, first aid methods, and other essential measures.
- **Training for Equipment and Machinery:** VR can be used to teach staff members how to operate complicated machinery, equipment, or automobiles safely. In addition to becoming acquainted with controls and procedures, trainees can practice using virtual versions of the equipment and learn how to manage any hazards or emergencies that may arise during operation.
- **Behavior modification and risk mitigation:** By immersing students in realistic virtual worlds, virtual reality (VR) enables them to feel the repercussions of risky choices or actions. Employees may be encouraged to embrace safer methods in the workplace by this first-hand experience, which can help change attitudes and behavior around safety.
- **Performance Evaluation and Feedback:** VR training may incorporate feedback systems and performance evaluations. It is possible to monitor and assess trainees' responses and behaviors, giving unbiased information about their safety proficiency and pinpointing areas in need of development. Teachers are able to evaluate students' performance, offer criticism, and modify training plans as necessary.
- **Cost and Time Efficiency:** Virtual reality training does not require travel, physical setups, or the possible hazards that come with in-person instruction. It contributes to time and cost savings by enabling repeated practice and reinforcement without the need for extra resources or risks.
- **Employees can learn about safety procedures, hazard identification, emergency response, and equipment operation through immersive and efficient virtual reality safety training.** Virtual reality (VR) improves safety training results and contributes to a safer workplace by offering lifelike simulations and interactive learning opportunities.

#### **iv) Virtual reality in risk management**

The potential of virtual reality (VR) for risk assessment in engineering design is examined in "Risk Analysis (Assessment) Using Virtual Reality Technology-Effects of Subjective Experience: An Experimental Study." The authors contend that virtual reality (VR) can be a useful tool for detecting risks when a machine is being designed. They contrast two virtual reality simulations of a drilling machine: one that is straightforward, lacking in complexity and color, and another that is intricate, with textures and features that nearly mimic those of an actual machine. According to the study, the complicated model helps people recognize more hazards. . The authors also discover that a human figure in the VR model can enhance risk identification, and that some dangers are better detected with a simpler model. Overall, the study indicates that virtual reality (VR) is a potential tool for risk assessment in engineering design; nevertheless, the VR model's design may affect how effective VR is (Puschmann et al., 2016).

#### **v) Virtual reality in insurance**

In the upcoming years, virtual reality (VR) is anticipated to proliferate in all economic domains, including the insurance sector, according to Bruno (2021). The use of VR technology, however, also raises additional hazards and insurance coverage issues. Here are some important things to think about:

- **Liability in Remote Operations:** Because virtual reality (VR) is utilized for remote procedures like telemedicine or remote surgeries, any mishaps or malfunctions in the VR system may give rise to liability concerns. Determining accountability and insurance coverage for such situations becomes critical, for instance, if a surgeon is doing a remote surgery and the VR connection is interrupted by outside circumstances.
- **Redundancy and Backup:** Having backup systems and redundant communication routes, including emergency backups over 5G networks, may be crucial to reducing the hazards connected with VR technology. Such backup systems may be required by insurers as a condition of coverage.
- **Changing Risk Assessment:** In order to maintain business continuity, risk managers will need to take into account new information pertaining to VR

technology as the environment changes. Insurance rates and costs may be impacted by variables like the usage of simulators for practice or remote training as opposed to in-person training. When deciding on coverage and rates, insurers may consider the degree of training and VR environment experience.

- **Auto Insurance Premiums:** Auto insurance rates may be impacted by the growing usage of virtual reality (VR) for driving simulations and training. Depending on whether drivers have received traditional road-based training or simulator-based training, insurers may charge different premiums. When evaluating risk and setting premiums, the degree of expertise and skill acquired by VR training may be taken into consideration.

• In conclusion, there are new risks and issues associated with the use of VR technology in a variety of sectors, including insurance. To take into consideration the unique potential and problems presented by virtual reality, insurers will need to modify their coverage and pricing structures. Some of the elements that will influence insurance coverage in a world adopting VR technology include backup systems, risk assessment of distant operations, and the effect of VR training on premiums.

#### **vi) A prevention tool to help policyholders and insurers**

VR is a great preventative tool for insurers and their policyholders, notwithstanding the hazards. It might be configured, for instance, to put a potential customer in a fictitious situation that illustrates the harm brought on by fire, flooding, or auto accidents. The client might be presented the various possibilities in a multi-risk insurance policy and how each would protect their business in an immersive experience. The presentation of a product list in augmented reality that describes the coverage provided by the insurance policy after an incident has been portrayed in each room of a virtual factory or warehouse is another example of its application. With a VR helmet on, the client could see any hazards (Bruno, 2021). Similarly, online claims management would enable a policyholder to get in touch with their insurer directly through a particular application. When concrete damage is reported and photos of the damage are supplied to the insurer, who may react right away, a claim investigation can be completed in real time. Notably, augmented reality has been modified to make compensation claims easier. The purpose of this study is to investigate the possible

advantages of using VR technology in Nigeria's construction sector. As they work to integrate VR into their operations, stakeholders in sustainable construction projects will find the findings useful. The findings might also have an impact on how building projects are carried out in industrialized nations that use comparable construction techniques, in addition to Nigeria (Oke et al., 2023).

### 2.3.3 Kumkang formwork technology

#### i) Definition of kumkang formwork technology

A new and updated aluminum formwork technology called Kumkang speeds up the construction process. The Kumkang aluminum formwork technology is getting close to meeting India's growing housing needs. As times change, new methods and materials are being employed. Time, speed, quality, cost, and safety of the work are the most crucial factors that determine the success rate in building (Bharagvi et al., 2018).

#### ii) Components of kumkang formwork technology

Kumkang Formwork Technology utilizes high-strength aluminum alloy for its primary components. Here's a breakdown:

- The fundamental components that make up the sides of walls and columns are wall panels. They may be tailored to meet varied construction needs because they come in a variety of sizes and thicknesses.
- Slab Panels: During slab casting, these bear the weight of the concrete. They are made to be assembled and disassembled quickly.
- Corner Units: These provide seamless transitions and structural integrity by joining wall and slab panels.
- Beam Forms: These are made especially to support and form concrete beams. The exact shapes of columns are created using column forms.
- Accessories: A variety of items fall under this category, such as:
  - ✓ **Connectors:** Used to join panels together securely.
  - ✓ **Wedges and Pins:** For adjusting panel positions and ensuring tight seals.
  - ✓ **Supports:** To provide stability and load-bearing capacity.

- ✓ **Tie Rods:** To reinforce the formwork and prevent concrete pressure from distorting it.

Kumkang's system emphasizes modularity and reusability, making it efficient and cost-effective for high-rise and large-scale construction projects.

### iii) Benefits of kumkang formwork technology

- 1) **Quality Improvement:** The unmatched concrete finishing produced by Kumkang Aluminum Formwork eliminates the need for plastering and the grinding task caused by the joints formed by the panels.
- 2) **Cost Reducer:** Aluminum formwork significantly shortens the construction time since it can cycle for an average of six days. Shortening the construction time will result in lower construction costs.
- 3) **Time-saving:** Walls, beams, columns, slabs, and staircases may all be poured once using the Kumkang Aluminum Formwork method. Additionally, the slab panels can be disassembled without taking the props down thanks to our prop-head system. As a result, the 6-day cycle is now a reality rather than a dream.
- 4) **Safety Provider:** Our formwork approach will give worksite workers a larger working area (fewer props) than the traditional method. Additionally, worksite workers will feel much safer and be more productive with the provision of an external working platform.
- 5) **Eco-Friendly:** Repetition is one of the aluminum formwork's greatest benefits. The aluminum panels can withstand more than 300 repeats, but steel formwork must be discarded after a maximum of 50 and conventional formwork must be discarded after 5–10 repetitions.

A Value Engineering (VE) study on formwork for the Alton Apartment Project in Tembalang, Semarang, Indonesia, is described in this publication. Installing and removing the traditional formwork technique takes a lot of time and requires multiplex, nails, and wires. Kumkang aluminum formwork, a quicker and more effective method, is the VE substitute (Suwandi et al., 2020).

According to suwandi et al. (2020), the main advantages of Kumkang technology over conventional formwork are:

- Faster installation and removal process.
- Requires less labor.
- Produces more precise casting results.
- Can be used up to 250 times, whereas conventional formwork can only be used 2-3 times.

A cutting-edge aluminum formwork method that is becoming more and more well-liked in the building industry is the Kumkang formwork system. In 1979, it was created in Korea. Both residential and commercial building can benefit from this formwork system (Bharagvi et al., 2018). The Kumkang formwork system is renowned for its speed, affordability, and durability. With the right upkeep and refurbishment, it can be used up to 250 times. Within eight days, the floor-to-floor cycle is completed.

**According to Bharagvi et al.(2018), Here are some of the advantages of the Kumkang formwork system:**

- Speed: Floor to floor cycle is achieved within 8 days.
- Cost-effective: Very high no. of repetitions are possible (150-200). Therefore unit material cost achieved after 100 repetitions calculated comes to be as low as Rs. 100/sq.m.
- Durability: Long life being non-corrosive in nature, can perform up to 250 repetitions max. with proper maintenance and refurbishment.
- High Labour Productivity: Very light weight, easy manual handling, basically single type of panel joints, no crane dependency.
- High salvage value.
- Quality: Excellent concrete surface finish, enables elimination of plastering thereby saving project duration and cost.

**Here are some of the disadvantages of the Kumkang formwork system:**

- Very high investment (approx Rs 7500. Sq.m).

- Not cost-effective for small construction projects where the no. of repetitions would be less.
- Compatible only for the projects where the design is repetitive. Customization as per demand is not possible.
- RCC slab to be designed for stripping after 36 hours with props left under.

Overall, the Kumkang formwork system is a fast, cost-effective, and durable option for construction projects that can be repetitive. However, it is important to consider the high initial investment and the fact that it is not suitable for small projects or projects with complex designs

#### **iv) The likely impact of Kumkang formwork technology in construction risk and insurance:**

According to Bharagvi et al. (2018), Kumkang formwork technology can have several potential impacts on construction risk and insurance. Here are some key considerations:

- **Increased Safety:** By offering effective and safe scaffolding and formwork solutions, Kumkang formwork technology aims to increase construction safety. During building, these systems can lower the chance of mishaps and casualties. Better safety practices may result in fewer insurance claims for accidents and injuries sustained during construction, which could lead to cheaper insurance rates.
- **Simplified Construction Process:** Kumkang formwork technology provides standardized and effective concrete formwork systems, allowing for quicker construction times. Potential risks and liabilities related to extended construction durations may decrease in tandem with shorter development timetables. Both insurance coverage and rates may benefit from this.
- **Quality Control:** Construction projects can be made more consistent and high-quality by utilizing Kumkang formwork technology. These technologies guarantee precise and accurate formwork, which improves structural integrity and lowers the possibility of flaws or breakdowns. Projects using dependable

formwork technology may be seen positively by insurers, which could result in better insurance conditions.

- **Knowledge and Experience:** Using Kumkang formwork technology may call for specific knowledge and experience. To guarantee correct installation and use, contractors and employees utilizing this technology might need to participate in training courses. The likelihood of mistakes or mishaps involving the formwork system can be decreased with proper training. When evaluating risk and deciding on insurance coverage, insurance companies may take the degree of training and experience into account.
- **Manufacturer Support and Warranty:** Manufacturers of Kumkang formwork technology frequently provide product warranties and support services. Because the manufacturer may cover any flaws or problems with the formwork system, this can give construction businesses additional peace of mind. Such warranties and support services may have an impact on insurance coverage.

It is noteworthy that the influence of Kumkang formwork technology on construction risk and insurance may differ based on a number of variables, including project scope, local legislation, and the particular insurance policies in effect. To learn how this technology may impact their insurance coverage and premiums, construction organizations working on projects that use it should speak with insurance experts (Bharagvi et al., 2018).

### **2.3.4 Prefabricated Construction**

#### **i) Definition of prefabrication construction**

Modular and prefabricated are two terms often used interchangeably, but there is a distinction. The following is according to the Modular Building Institute

#### **ii) Prefabricated Characteristics:**

- Prefabricated, or "prefab" for short, refers to any building component that is produced in a factory prior to being delivered and installed at the construction site.

- Prefabricated components can be composed of various materials, such as concrete, steel, and wood; they can be essentially completed before being delivered to the location and put into place; or a building might be constructed entirely of prefabricated parts.

### iii) Components of prefabrication

Prefabrication construction involves building components off-site in a controlled factory environment and then transporting them to the construction site for assembly.

**Here's a breakdown of key components:**

#### 1. Structural Components:

- **Walls:** These can be composed of insulated panels, steel, concrete, or wood. They frequently have doors and windows already fitted.
- **Floors:** Prefabricated flooring options include metal decking, wood-framed systems, and concrete slabs.
- **Roofs:** Usually pre-assembled for simpler installation, they can consist of trusses, rafters, and sheathing.
- **Columns and Beams:** These structural components, which give the building its framework, are frequently made of steel or precast concrete.

#### 2. Building Systems:

- **Plumbing and Electrical Systems:** These can be pre-assembled in modules or integrated into the walls and floors during the manufacturing process.
- **HVAC Systems:** Heating, ventilation, and air conditioning systems can be prefabricated for efficient installation.

#### 3. Architectural Finishes:

- Siding, brickwork, stucco, and other off-site finishes are examples of exterior and interior cladding.

- Doors and windows: These are frequently already installed and pre-hung.
- Bathroom and kitchen units: These can be prefabricated as whole modules with appliances and fixtures.

#### **4. Other Components:**

- **Stairs:** Prefabricated stairs can be made of concrete, steel, or wood.
- **Elevators:** Elevator shafts and components can be prefabricated for faster installation.
- **Balconies and Decks:** These can be pre-assembled and attached to the building structure.

Prefabrication offers several advantages, including faster construction times, improved quality control, and reduced waste. The specific components used will vary depending on the type of building and the chosen prefabrication method.

#### **v) Benefits of prefabrication construction**

According to Coombs (2021), Growth is being fueled by the following perceived benefits..

- Speed to market
- Time saving
- Quality
- Cost-effectiveness
- Labor efficiency
- Owner satisfaction
- Sustainability
- Weather uncertainty reduced
- Safety

#### **vi) Prefabricated in risk management**

A fuzzy neural network risk assessment model for prefabricated structure construction is proposed in this paper. The model is based on the quantitative numerical computation

advantages and qualitative knowledge expression of fuzzy neural networks. The approach, according to the authors, can be used to evaluate hazards in the construction of prefabricated buildings. The significance of risk management in the construction of prefabricated buildings is covered in the first section of the article. After that, the writers examine relevant studies on risk assessment in this area. They point out that conventional risk assessment techniques are frequently either qualitative or quantitative, and that a hybrid approach that incorporates both would be more successful. This need is intended to be met by the fuzzy neural network model that is suggested in the study. The qualitative components of risk assessment are represented by fuzzy logic in the model, while the quantitative components are represented by neural networks (Yang, 2022).

Safety Risk Management of Prefabricated Building Construction Based on Ontology Using ontology technology with BIM, Technology in the BIM Environment suggests a system for tracking construction safety hazards in prefabricated buildings. The system is intended to tackle the difficulties of dynamically identifying dangers in prefabricated building construction, integrating safety knowledge, and gathering risk precursor information (Shen et al., 2022).

### **2.3.5 Internet of Things (IoT)**

#### **i) Definition of IOT**

Connecting devices that gather and share data online is known as the Internet of Things. Sensors and software that allow communication between these devices and other systems are embedded in them. Healthcare, agriculture, and transportation are just a handful of the areas that can leverage IoT devices. IoT is changing the construction sector by offering new methods of managing job sites, enhancing safety, and boosting efficiency. It is utilized to monitor safety, manage job sites and equipment, and enhance project management (Prasad, 2023). The foundations of IoT, its applications in building, and its advantages will all be covered in this essay.

#### **ii) Components of IOT**

Prasad (2023) asserts that the building business benefits greatly from a variety of IoT devices. The following are a few typical IoT sensors and controllers used in the sector:

- Managers can monitor employees for productivity and safety thanks to wearable sensors.
- GPS trackers convey where cars and equipment are located.
- Equipment performance can be monitored by embedded sensors for predictive maintenance and efficiency gains.
- Smart labels that offer location and quantity information enable materials tracking.

The Internet of Things (IoT) is revolutionizing the construction industry by connecting devices and systems, enabling real-time data collection and analysis, and improving efficiency and productivity.

**Here are the key components of IoT in construction:**

**1. Sensors and Devices:**

- Environmental sensors: Keep an eye on light, humidity, temperature, and other environmental variables to guarantee the best possible conditions for building supplies and worker safety.
- In order to track stress, strain, and other indicators of structural integrity, structural sensors are embedded in concrete or other materials. Wearable technology can be used to monitor worker location, vital signs, and activity levels for both safety and productivity.
- Sensors for construction equipment keep an eye on heavy machinery's working conditions, maintenance requirements, and fuel levels.
- Cameras and Video Analytics: Record live video for site surveillance, security, and progress monitoring.

**2. Connectivity:**

- ✓ **Wireless Networks:** Wi-Fi, cellular networks, and other wireless technologies enable communication between devices and the cloud.

- ✓ **Low-Power Wide-Area Networks (LPWANs):** Such as LoRaWAN and NB-IoT, offer long-range, low-power connectivity for sensors and devices in remote or challenging environments.

### 3. Data Processing and Analytics:

- Large volumes of data produced by IoT devices are stored and processed by cloud computing.
- For quicker reaction times, edge computing allows real-time data processing and analysis nearer the devices at the network's edge.
- Machine learning (ML) and artificial intelligence (AI): algorithms examine data to find trends, forecast results, and streamline building procedures.

### 4. User Interface and Applications:

- ✓ **Dashboards and Visualizations:** Present data in a user-friendly format for easy monitoring and analysis.
- ✓ **Mobile Apps:** Enable remote access to data and control of IoT devices.
- ✓ **Construction Management Software:** Integrates IoT data with other project management tools for a comprehensive view of the construction process.

### 5. Security:

- ✓ **Data Encryption:** Protects sensitive data transmitted over networks.
- ✓ **Access Control:** Restricts unauthorized access to devices and data.
- ✓ **Regular Security Audits:** Identify and address potential vulnerabilities.

### iii) Benefits of IoT in Construction:

IoT applications in construction are transforming the sector by improving project management, safety, and efficiency. IoT makes it possible to detect hazards, minimizes manual labor, and tracks progress in real time to avoid delays. Job site management is being revolutionized by technologies like sensors and drones, and as the technology develops, networked gadgets will provide even more potential. Despite the construction industry's

historical sluggishness in embracing new technologies, IoT is bringing about substantial change and offering certain and expanding advantages (Prasad, 2023).

**Here are some benefits**

- **Smart Construction Sites:** Real-time monitoring of environmental conditions, equipment usage, and worker safety.
- **Predictive Maintenance:** Prevent equipment failures and reduce downtime by analyzing sensor data.
- **Construction Progress Tracking:** Monitor construction progress, identify delays, and optimize resource allocation.
- **Quality Control:** Ensure the quality of materials and workmanship by monitoring critical parameters.
- **Safety Management:** Improve worker safety by tracking location, monitoring vital signs, and identifying potential hazards.

By leveraging these components and use cases, IoT is transforming the construction industry into a more efficient, productive, and sustainable sector

**iv) IOT in Construction**

Sensors are one of the most important ways that IoT is being applied in the construction industry. Numerous characteristics, including temperature, humidity, and pressure, are monitored via sensors. Construction managers can spot possible problems before they become serious ones by keeping an eye on these factors. For instance, sensors can be used to track the humidity and temperature of concrete while it dries, guaranteeing that it does not fail or break. Additionally, sensors can be employed to keep an eye on a building's structural soundness, guaranteeing its safety and security (Prasiad, 2023).

**a) Advantages of IOT in Construction:**

- **Enhanced Safety:** IoT in construction aids in spotting possible risks before they materialize into mishaps. Changes in temperature, humidity, air quality, and other factors that could result in dangerous situations can be detected by

sensors and other linked devices. Construction managers can take remedial action before any damage is done because to this real-time data.

- **Enhanced Efficiency:** IoT can enhance project management and lessen the demand for manual labor. Tasks like inventory management, equipment location tracking, and environmental condition monitoring and adjustment can all be automated using connected devices. This lessens the effort for employees, lowers the possibility of mistakes, and enables more effective resource usage.
- **Real-time Data and Progress Monitoring:** Better scheduling, decision-making, and resource allocation are made possible by IoT devices' ability to offer real-time data on construction progress. Everything from project budgets and schedules to the movement of supplies and machinery can be tracked via connected devices. This aids in reducing project timelines overall, optimizing schedules, and identifying any delays.
- **Lower Costs:** IoT can enhance resource management and cut waste. Managers can be informed of possible inefficiencies or overuse by using connected devices to track the use of supplies and machinery. This makes it possible for managers to resolve issues and cut expenses related to wasteful spending and overconsumption.
- **Improved Quality Control:** Real-time material and process monitoring by IoT devices guarantees that the finished product satisfies all relevant quality requirements. By identifying errors, weaknesses, or departures from the anticipated result, sensors allow for remedial action to be taken before the issue worsens.

#### **B) Disadvantages of IOT in Construction:**

- **High Implementation Costs:** Setting up IoT infrastructure and devices can be costly, especially for major building projects. This covers the price of software development, data storage and analysis, communication networks, and sensors.

- **Reliance on Reliable Internet Connectivity:** Reliable internet connectivity is essential for the deployment of IoT devices in the construction industry. Data transfer may be disrupted if connectivity is lost, which could cause delays or other problems. For remote or rural construction sites with poor internet connectivity, this can be very troublesome.
- **Security Issues:** IoT devices are susceptible to hacking, data leaks, and cyberattacks. Sensitive data, such as financial information, personal information, and construction plans, may be at risk. For IoT devices and networks to be successfully used in the construction industry, security must be guaranteed.
- **Limited Compatibility:** Interoperability problems may arise from disparate IoT systems and devices not being compatible with one another. It might be especially challenging to share data or work together efficiently if various construction businesses or stakeholders are using different IoT solutions.
- **Limited Technical Expertise:** It's possible that many managers and construction workers lack the technical know-how required to deploy and oversee IoT devices. This may result in resistance to change and a hesitancy to embrace new technology, especially if they are perceived as being challenging to use or comprehend.

#### **c) Limitations of IOT in Construction:**

- **Limited Battery Life:** Batteries, which are frequently used to power IoT devices, may not last very long. This needs to be replaced or recharged frequently, which can be inconvenient and time-consuming.
- **Limited Communication Range:** In big or complicated building sites, IoT devices may have a limited communication range. To guarantee dependable and continuous data delivery, a network of connected devices might be necessary.
- **Environmental Factors:** IoT device performance may be impacted by extreme weather, temperatures, and other environmental factors, which could result in data that is erroneous or lacking.

- **Limited Accuracy and Precision:** Data collection and analysis may contain inaccuracies due to the limited accuracy and precision of sensors and other linked devices. For instance, the location of the sensor or the presence of other equipment nearby may have an impact on sensors used to monitor temperature or humidity. Inaccurate data may arise from this, which could result in poor choices and behaviors.
- **Data Overload:** It can be challenging to evaluate and interpret the vast volumes of data generated by IoT devices. To glean valuable insights from the data, this calls for advanced software and analysis tools. Additionally, too much data can cause decision-making to be delayed and project development to be slowed down. Because data must be efficiently and securely preserved for future use, it may also result in expensive storage costs.

**v) Impact on Safety, Risk Management, and Insurance Premiums:**

- Safety Improvement:** IoT-driven safety enhancements lead to a reduction in on-site accidents and injuries, fostering a safer working environment for construction personnel. By leveraging IoT for safety monitoring and alerts, construction companies can proactively address safety concerns and prevent incidents before they occur.
- Enhanced Risk Management:** IoT enables real-time risk assessment and mitigation strategies, allowing for timely interventions to prevent potential risks from escalating. Improved risk management practices supported by IoT data analytics help construction companies identify, assess, and address risks effectively.
- Insurance Premium Reduction:** By leveraging IoT technologies to enhance safety measures, mitigate risks, and prevent accidents, construction companies demonstrate a proactive approach to risk management. Insurers view such proactive risk mitigation measures favorably, potentially leading to reduced insurance premiums as the likelihood of claims decreases.

In summary, the Internet of Things in construction, with its capabilities for real-time monitoring, safety enhancements, risk mitigation, and efficient resource management, plays a

pivotal role in improving safety standards, enhancing risk management practices, and potentially reducing insurance premiums for construction projects.

**vi) Challenges facing the adoption of IOT in Construction:**

- **Opposition to Change:** The traditional construction sector has been sluggish to embrace new technologies. The deployment of IoT devices may be resisted by many construction companies and workers because they are unfamiliar with the technology or believe it offers no advantages.
- **Absence of Standards:** As of right now, IoT networks and devices are not subject to any set standards. This may lead to inefficiencies and extra expenses and makes it challenging to guarantee compatibility across various devices and systems.
- **Data Security and Privacy Issues:** As previously stated, IoT devices are susceptible to data breaches and cyberattacks. Sensitive data, such as financial information, personal information, and construction plans, may be at risk. For IoT data to be successfully adopted in the construction industry, security and privacy must be guaranteed.
- **Lack of Technical Expertise:** Similar to the IoT's limitations, many managers and construction workers can lack the technical know-how required to set up and maintain IoT devices. This can result in a reluctance to embrace new technology and resistance to change, especially if those technologies are perceived as being hard to use or comprehend.
- **Infrastructure Restrictions:** Certain building sites may not have dependable internet connectivity, which is necessary for IoT devices. The adoption of IoT devices may be restricted by a lack of infrastructure, especially in rural or distant places.

**vii) IOT and Digital Transformation:**

IoT adoption in the building industry is a component of a larger movement toward digital transformation. IoT devices are a crucial part of digital transformation because they allow companies to automate procedures and gather real-time data. Digital transformation is the

integration of digital technologies into every facet of a business, leading to fundamental changes in how the business functions and provides value to customers (Prasad, 2023). IoT and digital transformation in construction are also related to the following factors:

- **Advanced Analytics:** The data collected from IoT devices can be analyzed using advanced analytics tools to provide insights into construction processes and performance. This can enable construction companies to make better decisions and improve efficiency.
- **Cloud Computing:** IoT devices generate large amounts of data, which can be difficult to store and manage. Cloud computing provides a scalable and cost-effective solution for storing and processing IoT data.
- **Mobile Connectivity:** Mobile devices such as smartphones and tablets enable workers and managers to access IoT data and control devices from anywhere, at any time. This can improve communication and collaboration and enable real-time decision-making.
- **Artificial Intelligence and Machine Learning:** IoT devices can be integrated with artificial intelligence and machine learning algorithms to enable predictive maintenance and automate processes. This can reduce downtime and improve productivity.
- **Integration with Building Information Modelling (BIM):** BIM is a digital representation of the physical and functional characteristics of a building. The integration of IoT devices with BIM can provide real-time data on construction progress, enabling better decision-making and reducing project timeframes.

#### **viii) IOT can be applied to Civil engineering.**

**Monitoring of Construction Sites:** Real-time data on efficiency, safety, and productivity can be obtained by using IoT to monitor construction sites and equipment. Construction equipment can have sensors added to track performance and usage, allowing for predictive maintenance and minimizing downtime. Additionally, IoT may be utilized to monitor worker safety by identifying possible risks and instantly notifying managers and employees (Prasad, 2023).

By facilitating predictive maintenance, enhanced decision-making, and real-time monitoring

and data analysis, IoT has the potential to revolutionize civil engineering. Civil engineering may become more sustainable, safe, and efficient by incorporating IoT devices into current procedures and infrastructure.

#### **ix) Future Outlook**

Businesses will be able to increase the value of IoT devices by utilizing artificial intelligence (AI) solutions. AI tools are faster and more accurate than people in analyzing data. This might result in fresh perspectives on things like material performance and equipment efficiency. Additionally, it could calculate construction takeoff estimates without errors. IoT will also propel automation. Everything from labor scheduling and material ordering to cost estimation and quantity surveying can be streamlined by automated procedures. Construction organizations can monitor workers, equipment, and supplies and streamline operations with the use of the Internet of Things. IoT sensors can contribute to increased safety and quality. They can also offer data that generates performance insights and suggestions for process enhancements.

## **2.4 Feasibility and implementation study**

### **2.4.1 Building information modelling (BIM)**

#### **i) Introduction**

The viability and application of Building Information Modeling (BIM) in Ethiopian small-scale and public construction projects are investigated in this study. Utilizing studies by Devi et al. (2020) and Belay et al. (2021), the analysis highlights the advantages, obstacles, and tactics for effective BIM implementation. The report offers stakeholders practical suggestions on how to use BIM to enhance project results, sustainability, and efficiency.

#### **ii) Feasibility Analysis**

##### **1. Technical Feasibility**

- **IT Infrastructure:** Robust IT infrastructure, including hardware, software, and network capabilities, is essential for handling large BIM models and facilitating collaboration.

- **Software and Interoperability:** Selecting appropriate BIM software and ensuring interoperability between different tools is critical for seamless data exchange and avoiding compatibility issues.
- **Data Management:** Effective data management strategies, including standardized protocols, are needed to organize, store, and access BIM data throughout the project lifecycle.

## 2. Economic Feasibility

- **Cost-Benefit Analysis:** While BIM implementation requires upfront investment in software, hardware, and training, it offers long-term cost savings through improved efficiency, reduced rework, and better resource management.
- **Return on Investment (ROI):** Measuring ROI is crucial for justifying BIM adoption and demonstrating its value to stakeholders.
- **Funding and Incentives:** Government incentives and funding programs can reduce the financial burden on construction firms, particularly small and medium-sized enterprises (SMEs).

## 3. Operational Feasibility

- **Workflow Integration:** BIM requires integrating new workflows and processes into existing project management practices, including redefining roles and responsibilities.
- **Collaboration and Coordination:** BIM facilitates collaboration by providing a shared platform for information exchange and decision-making.
- **Clash Detection and Risk Mitigation:** Early clash detection and risk mitigation through 3D visualization and simulations reduce costly rework and delays.

## 4. Organizational Feasibility

- **Training and Skill Development:** Investing in BIM training for employees is crucial for successful implementation.
- **Change Management:** Effective change management strategies are needed to address resistance and ensure a smooth transition to BIM-enabled workflows.

- **Leadership Commitment:** Strong leadership support is essential for driving BIM adoption and fostering a BIM-enabled culture.

## 5. Regulatory and Legal Feasibility

- **Standards and Guidelines:** Developing national BIM standards and guidelines ensures consistency, interoperability, and legal clarity.
- **Contractual Provisions:** BIM-related provisions in construction contracts define roles, responsibilities, and ownership of BIM data.
- **Liability and Risk Allocation:** Clear legal frameworks are needed to address liability and risk allocation related to BIM models and data.

### iii) Implementation Strategy

#### 1. Stakeholder Engagement

- **Awareness Campaigns:** Raise awareness about the benefits of BIM through workshops, seminars, and case studies.
- **Collaboration:** Foster collaboration among clients, consultants, contractors, and policymakers to align goals and expectations.

#### 2. Capacity Building

- **Training Programs:** Develop training programs to equip professionals with BIM-related skills and knowledge.
- **University Curricula:** Incorporate BIM into university curricula to prepare the next generation of construction professionals.

#### 3. Phased Implementation

- **Pilot Projects:** Start with small-scale pilot projects to demonstrate BIM's value and build confidence among stakeholders.
- **Gradual Adoption:** Begin with basic BIM functionalities and gradually adopt more advanced features as expertise grows.

#### 4. Government Support

- **Policy Development:** Develop national BIM standards, guidelines, and incentives to encourage adoption.
- **Funding Programs:** Provide financial support to SMEs for BIM implementation.

#### 5. Technology and Tools

- **Cost-Effective Solutions:** Explore affordable or open-source BIM software options for small-scale projects.
- **Software Integration:** Use tools like Revit, Navisworks, and ETABS for 3D modeling, clash detection, and project analysis.

#### iv) Key Findings

- **Benefits of BIM:** Improved communication, early multidisciplinary coordination, enhanced design quality, reduced rework, and better project delivery.
- **Barriers to Adoption:** Lack of IT infrastructure, insufficient government support, high initial costs, and resistance to change.
- **Stakeholder Consensus:** Clients, consultants, and contractors generally agree on the ranking of benefits and barriers.

#### v) Implementation Concepts for Small-Scale Projects

- **3D Modeling:** Create detailed 3D models using BIM software for better visualization and design review.
- **4D Cost Estimation:** Link 3D models with scheduling information for cost estimation and progress tracking.
- **5D Analysis:** Integrate cost and scheduling data with 3D models for comprehensive project analysis.
- **Collaboration with Experts:** Partner with BIM consultants or experienced firms for initial implementation.

#### vi) Additional Considerations

- **Contextualization:** BIM implementation must consider the unique characteristics of the Ethiopian construction industry, including its technological development, regulatory environment, and cultural factors.
- **Scalability:** Start with small-scale projects and gradually expand BIM adoption as expertise and resources grow.
- **Sustainability:** BIM can contribute to sustainable construction practices by improving resource management and reducing waste.

#### vii) Summary

BIM has the power to revolutionize Ethiopia's construction sector by increasing productivity, cutting expenses, and boosting project results. A diverse approach is necessary to address technical, economic, operational, organizational, and regulatory issues for successful implementation. Stakeholders can get over obstacles and fully benefit from BIM by utilizing government assistance, funding training, and implementing phased implementation plans. For BIM adoption to be successful in both large-scale and small-scale projects, this study emphasizes the significance of cooperation, capacity building, and contextual adaptability.

### 2.4.2 Virtual reality safety training (VR)

#### i) Introduction

The viability and application of virtual reality (VR) technology in construction practice and education are assessed in this study. Based on case study analyses by Farouk et al. (2024) and systematic reviews by Din et al. (2024), the study emphasizes how VR may revolutionize safety training, improve learning outcomes, and boost productivity in the construction sector. The difficulties and methods for a successful VR adoption are also covered in the study.

#### ii) Feasibility Analysis

##### 1. Economic Feasibility

- **Cost-Effectiveness:** VR technology can reduce training costs by eliminating the need for physical site visits and expensive real-life training scenarios. The cost of implementation varies depending on the software and hardware used, but budget-friendly options are available, making VR accessible to a wide range of institutions and firms.
- **Return on Investment (ROI):** The long-term benefits of VR, such as improved safety, enhanced design accuracy, and increased productivity, outweigh the initial investment costs.

## 2. Technical Feasibility

- **Scalability and Flexibility:** VR solutions can be adapted to various educational and professional settings, from small classrooms to large training facilities. They can also be customized to simulate specific construction tasks and environments.
- **Diverse Applications:** VR is applicable to multiple areas, including safety training, design review, Building Information Modeling (BIM) integration, and structural analysis, making it a versatile tool for the construction industry.

## 3. Operational Feasibility

- **Safety Training:** VR provides a safe environment for workers to experience hazardous situations without real-world risks, improving hazard identification and response skills.
- **Enhanced Collaboration:** VR facilitates better collaboration and decision-making by offering immersive, interactive experiences that allow stakeholders to visualize and interact with complex designs.

## 4. Social Feasibility

- **Learning Outcomes:** VR enhances understanding of complex construction processes through immersive simulations, leading to better learning outcomes for students and professionals.

- **Acceptance and Adoption:** While VR is increasingly accessible, its adoption requires addressing resistance to change and providing adequate training to users.

### iii) Implementation Strategy

#### 1. Planning and Customization

- **Needs Assessment:** Identify specific areas where VR can add the most value, such as safety training, design review, or BIM integration.
- **Tailored Solutions:** Develop VR training modules and applications tailored to the unique needs of the construction industry and educational programs.

#### 2. Integration into Curricula and Workflows

- **Hybrid Approach:** Combine traditional teaching and working methods with VR technology to create a well-rounded learning and working experience.
- **Curriculum Adaptation:** Integrate VR into existing curricula by developing new modules and adapting teaching methods to incorporate immersive learning experiences.

#### 3. Training and Skill Development

- **Faculty and Student Training:** Provide training for educators and students to ensure they can effectively use VR tools and software.
- **Industry Collaboration:** Partner with industry professionals to align VR training with real-world construction practices and requirements.

#### 4. Scalability and Future-Proofing

- **Modular Implementation:** Start with small-scale VR projects and gradually expand as budgets and expertise grow.
- **Technology Upgrades:** Plan for future upgrades to keep pace with advancements in VR hardware and software.

## 5. Collaboration and Partnerships

- **Interdisciplinary Collaboration:** Foster collaboration between educators, technology experts, and industry professionals to develop and implement effective VR solutions.
- **Industry-Academia Partnerships:** Leverage partnerships to share resources, knowledge, and best practices for VR adoption.

### iv) Key Findings

- **Enhanced Learning and Training:** VR significantly improves learning outcomes and safety training by providing immersive, interactive simulations.
- **Cost Savings:** VR reduces the costs associated with physical site visits and real-life training scenarios.
- **Improved Collaboration:** VR enhances collaboration and decision-making by offering realistic, immersive experiences for stakeholders.
- **Diverse Applications:** VR is applicable to a wide range of construction-related tasks, from design review to hazard identification.

### V) Additional Considerations

- **Initial Investment:** While VR implementation can be cost-effective, the initial investment in hardware and software may pose a barrier for some institutions and firms.
- **Technical Support:** Ongoing technical support is essential to ensure the smooth operation of VR systems and address any issues that arise.
- **Cultural Shift:** Encouraging a cultural shift towards embracing VR technology is critical for its widespread adoption.

### vi) Summary

By improving safety training, raising productivity, and improving learning outcomes, virtual reality technology has the potential to completely transform construction education and practice. Successful implementation can be facilitated by careful planning, customized

solutions, and teamwork, even when the initial costs and technical difficulties may provide obstacles. Educational institutions and construction companies can include virtual reality (VR) into their programs and workflows by using a hybrid approach and leveraging collaborations. This will give professionals and students the skills they need for the industry's future. This study highlights VR's revolutionary potential and calls for more investigation to resolve outstanding issues and broaden its use in the building industry.

### 2.4.3 Kumkang Formwork technology

#### i) Introduction

The viability and application of Kumkang aluminum formwork technology in high-rise construction projects are assessed in this study, with an emphasis on how it might improve quality, productivity, and cost effectiveness. Research by Suwandi et al. (2020) and Pujari et al. (2018), which contrast Kumkang formwork with traditional methods and emphasize its benefits and drawbacks, is cited in the analysis.

#### ii) Feasibility Analysis

##### 1. Economic Feasibility

- **Initial Costs vs. Long-Term Savings:** Kumkang formwork has a higher upfront cost compared to conventional wood or steel formwork. However, its reusability (150-200 repetitions) and reduced labor requirements lead to significant long-term savings.
- **Cost Efficiency:** The system minimizes finishing work and plastering costs due to its precision and high-quality concrete finishes.
- **Time Savings:** Faster construction cycles (e.g., completing a floor every 8 days) reduce project timelines, indirectly lowering overhead costs.

##### 2. Technical Feasibility

- **Ease of Use:** The prefabricated, lightweight design allows for quick assembly and disassembly, improving construction speed.
- **Precision and Quality:** The system ensures accurate concrete finishes, reducing rework and enhancing structural quality.

- **Durability:** Aluminum's non-corrosive nature ensures a long lifespan, making it suitable for repetitive use in large-scale projects.

### 3. Operational Feasibility

- **Labor Productivity:** Kumkang formwork requires fewer workers for installation and dismantling, though skilled labor is necessary for proper assembly.
- **Construction Speed:** The system supports faster project completion, addressing the growing demand for timely housing and infrastructure development.
- **Adaptability:** While most effective for projects with repetitive designs, careful planning can mitigate limitations in customization.

## iii) Implementation Strategy

### 1. Planning and Coordination

- Effective project planning is essential to maximize the benefits of Kumkang formwork. This includes aligning design specifications with the system's requirements and ensuring seamless coordination among stakeholders.

### 2. Skilled Labor Training

- Although the system reduces overall labor needs, trained personnel are required for proper installation and dismantling. Investment in workforce training is critical for successful implementation.

### 3. Initial Investment Management

- The high upfront cost of Kumkang formwork may pose a barrier. A long-term perspective on cost-effectiveness, supported by lifecycle cost analysis, can help justify the investment.

### 4. Project Suitability Assessment

- Kumkang formwork is most cost-effective for large-scale projects with repetitive designs. Smaller or highly customized projects may not fully benefit from the system.

### 5. Design Considerations

- Specific design adjustments, such as early stripping of concrete slabs, are necessary to optimize the use of Kumkang formwork.

#### iv) Additional Considerations

- **Regional Variations:** The feasibility and implementation of Kumkang formwork may vary depending on local construction practices, labor costs, and material availability.
- **Lifecycle Cost Analysis:** Emphasizing lifecycle costs rather than initial investment provides a more accurate assessment of the system's economic benefits.
- **Sustainability:** The durability and reusability of Kumkang formwork align with sustainable construction practices, reducing material waste and environmental impact.

#### v) Summary

In high-rise building, Kumkang aluminum formwork provides a cost-effective way to increase production, efficiency, and quality. Although it requires a larger initial investment, it is a practical and realistic substitute for traditional formwork systems due to the long-term cost reductions, quicker building cycles, and lower labor requirements. Careful planning, competent labor, and an emphasis on project suitability are necessary for successful implementation. The broader use of Kumkang formwork as a tactical instrument to improve construction efficiency in major projects is supported by this study.

### 2.4.4 Prefabrication building

#### i) Introduction

The viability and use of prefabricated building structures (prefab) are examined in this study, along with the important considerations for starting a prefabrication facility. Based on studies by Monica et al. (2023) and Bobi et al. (2023), the analysis assesses the technical, financial, and environmental feasibility of prefab systems and pinpoints essential elements for their effective deployment.

#### ii) Feasibility Analysis

##### 1. Economic Feasibility

- **Cost Comparison:** Prefabricated structures, such as pre-engineered buildings (PEBs), often have higher initial costs compared to conventional construction. However, lifecycle cost analysis (LCC) reveals long-term savings due to reduced construction time, lower labor requirements, and minimized material waste.
- **In-House Production:** Establishing local prefabrication facilities can reduce costs by eliminating transportation expenses and fostering economies of scale.
- **Market Demand:** The feasibility of prefab depends on market demand, which is influenced by factors such as urbanization, housing shortages, and government policies.

## 2. Environmental Feasibility

- **Life Cycle Assessment (LCA):** Prefabrication reduces environmental impact through efficient material usage, controlled manufacturing processes, and minimized on-site waste.
- **Sustainability:** Prefab systems often incorporate energy-efficient designs and better insulation, contributing to sustainable construction practices.

## 3. Technical Feasibility

- **Construction Speed:** Prefabrication significantly reduces construction time, enabling faster project completion and addressing urgent housing needs.
- **Quality Control:** Manufacturing in controlled environments ensures higher quality and precision in building components.
- **Skilled Labor:** While prefab reduces overall labor requirements, skilled workers are needed for assembly and installation. Training programs are essential to address this gap.

### iii) Implementation Strategy

#### 1. Government Support

- **Policy and Incentives:** Government policies, such as subsidies, tax incentives, and regulatory support, can promote the adoption of prefab systems.
- **Research and Development:** Investment in R&D can drive innovation, improve local expertise, and reduce dependency on foreign technology.

#### 2. Infrastructure Development

- **Local Production Facilities:** Establishing in-house prefabrication plants can reduce costs, create jobs, and enhance self-reliance.
- **Logistics Management:** Efficient transportation and supply chain management are critical for delivering prefabricated components to construction sites.

#### 3. Workforce Training

- **Skill Development:** Training programs for engineers, architects, and construction workers are essential to ensure proper assembly and installation of prefab systems.
- **Awareness Campaigns:** Educating stakeholders about the benefits of prefab can increase acceptance and adoption.

#### 4. Project Suitability

- **Design Considerations:** Prefab is most effective for projects with repetitive designs and standardized components. Customization may increase costs and complexity.
- **Scalability:** Large-scale projects, such as housing developments and commercial complexes, are ideal for prefab due to economies of scale.

### iv) Key Decision Factors for Prefabrication Plants (Monica et al., 2023)

#### 1. Cost and Financial Viability

- Initial investment, production costs, and potential revenue streams must be carefully analyzed.

## **2. Design and Engineering**

- The plant must be designed to accommodate the production of diverse prefabricated components, ensuring flexibility and scalability.

## **3. Skilled Workforce**

- Availability of skilled workers for manufacturing, assembly, and installation is critical for operational success.

## **4. Plant Location and Size**

- Proximity to raw materials, transportation networks, and target markets influences the plant's efficiency and profitability.

## **5. Sustainability**

- Incorporating sustainable practices, such as energy-efficient manufacturing and waste reduction, enhances the plant's long-term viability.

## **6. Market Demand**

- Understanding local and regional demand for prefabricated products is essential for ensuring steady revenue.

## **7. Regulatory Compliance**

- Adherence to building codes, environmental regulations, and safety standards is necessary for legal and operational success.

## 8. Additional Considerations

- **Regional Context:** The feasibility and implementation of prefab systems depend on local conditions, such as construction practices, labor availability, and regulatory frameworks.
- **Lifecycle Perspective:** Evaluating both initial and long-term costs provides a more accurate assessment of prefab's economic benefits.
- **Case Studies:** Further research on specific projects and locations can provide practical insights and refine implementation strategies.

## 9. Summary

Prefabricated building constructions present a workable way to alleviate Bhutan's housing scarcity, increase construction efficiency, and lessen environmental effect. Prefab is a viable alternative because of the long-term advantages in terms of quality, sustainability, and time savings, even though the initial expenses are greater. Investment in local production facilities, trained labor, and government assistance are necessary for successful implementation.

### 2.4.5 Internet of things (IOT)

#### i) Introduction

With an emphasis on the Indian state of Gujarat's middle region, this study explores the viability and applicability of Internet of Things (IoT) technologies in the construction sector. The study analyzes the most and least-used IoT applications, investigates adoption barriers, and offers suggestions for boosting the usage of IoT technology in the construction industry. It is based on a questionnaire survey carried out by Rupamkumar et al. (2020).

#### ii) Feasibility Analysis

##### 1. Awareness and Current Usage

- **Awareness:** Construction industry stakeholders are generally aware of IoT applications, but their usage remains limited.

- **Most-Used Applications:** Commonly adopted IoT tools include AutoCAD, social media, email, and net banking, which are relatively simple and widely accessible.
- **Least-Used Applications:** Advanced technologies such as robotics, Primavera software, and sensor-based waste management systems are underutilized due to complexity, cost, and lack of expertise.

## 2. Economic Feasibility

- **Cost Barriers:** The high cost of purchasing, installing, and maintaining IoT technologies is a significant barrier to adoption.
- **Return on Investment (ROI):** While IoT applications can improve efficiency, reduce waste, and enhance project management, the upfront costs often deter stakeholders from investing in these technologies.

## 3. Technical Feasibility

- **Complexity:** The complexity of integrating IoT applications into existing construction processes poses a challenge, particularly for smaller firms with limited technical expertise.
- **Skill Gaps:** Many construction professionals lack the skills required to operate advanced IoT tools, such as Primavera or robotics.

## 4. Social and Operational Feasibility

- **Job Security Concerns:** The introduction of robotics and automation raises concerns about job displacement among laborers and engineers.
- **Resistance to Change:** Traditional construction practices are deeply ingrained, and there is a lack of interest in adopting new technologies.

### iii) Implementation Strategy

#### 1. Awareness and Training Programs

- **Skill Development:** Training programs should be implemented to equip construction professionals with the skills needed to operate IoT applications effectively.
- **Workshops and Seminars:** Industry workshops and seminars can raise awareness about the benefits of IoT technologies and demonstrate their practical applications.

#### 2. Financial Incentives

- **Subsidies and Grants:** Government and industry bodies can provide financial incentives, such as subsidies or grants, to offset the initial costs of IoT adoption.
- **Cost-Benefit Analysis:** Stakeholders should conduct detailed cost-benefit analyses to highlight the long-term savings and efficiency gains from IoT implementation.

#### 3. Pilot Projects and Case Studies

- **Demonstration Projects:** Implementing IoT technologies in pilot projects can showcase their benefits and build confidence among industry players.
- **Case Studies:** Documenting successful case studies can provide practical insights and serve as a reference for future projects.

#### 4. Collaboration and Partnerships

- **Industry-Academia Collaboration:** Partnerships between construction firms and academic institutions can drive innovation and develop tailored IoT solutions for the industry.
- **Technology Providers:** Collaborating with IoT technology providers can ensure access to the latest tools and technical support.

## 5. Policy and Regulatory Support

- **Government Initiatives:** Supportive policies and regulations can encourage the adoption of IoT technologies, such as tax incentives for technology investments or mandates for sustainable construction practices.
- **Standardization:** Developing industry standards for IoT applications can simplify integration and ensure interoperability across projects.

### iv) Key Findings

- **Usage Gap:** Out of 36 IoT applications surveyed, only 14 had higher usage rates, while 22 were underutilized. This highlights a significant gap between awareness and implementation.
- **Barriers to Adoption:** Key barriers include high costs, lack of skills, resistance to change, and concerns about job security.
- **Potential Benefits:** IoT applications can improve project management, reduce waste, enhance safety, and increase overall efficiency in construction projects.

### v) Additional Considerations

- **Scalability:** The feasibility of IoT adoption may vary depending on the size and scope of construction projects. Smaller firms may require more support to implement these technologies.
- **Future Research:** Further research is needed to explore the practical implementation of IoT concepts in building projects and to develop tailored solutions for the construction industry.
- **Cultural Shift:** Encouraging a cultural shift towards embracing technology and innovation is essential for widespread adoption.

### vi) Summary

The study shows that although stakeholders in the construction industry are aware of IoT applications, there are major obstacles preventing their mainstream implementation. A

multifaceted strategy, including talent development, financial incentives, pilot projects, and governmental assistance, is needed to address these issues. By getting past these obstacles, the construction sector can fully utilize IoT technologies to boost productivity, cut expenses, and improve project results. In order to promote the adoption of IoT applications in the construction industry, this study emphasizes the necessity of increased implementation efforts and cooperation.

## 2.5 Summary

Key building methods and their efficacy in reducing particular kinds of occupational accidents are listed in Table 2.2 below. The table illustrates how various innovations, including BIM, VR, KUMKANG formwork, prefabrication, and IoT, increase safety through better planning, training, danger detection, and risk reduction. The data shows how these developments lead to safer work environments and fewer insurance claims by reducing frequent construction accidents like falls, slips, struck-by dangers, and exposure risks. For stakeholders looking to use technology to enhance safety and risk management in the construction sector, this overview offers insightful information.

**Table 2.2** Summary of construction technology and its accident reduction type

No	Technology	Reduced Accident Types
1	Building Information Modeling (BIM)	Falls from height (through improved planning and hazard identification) Slips, trips, and falls (through better layout and workspace design) Struck-by hazards (through clash detection and improved communication) Electrocution (through prefabrication and reduced on-site electrical work)
2	Virtual Reality (VR)	Falls from height (through safe training simulations for working at heights) Confined space incidents (through virtual walkthroughs for planning and risk assessment) Equipment operation accidents (through VR-based training on safe

		operation procedures)
3	KUMKANG formwork technology (Specific to this proprietary system, research its safety features)	Falls from height (through guardrails, integrated ladders, and secure platforms) Crushing hazards (through self-supporting structures and reduced manual manipulation) Slips and trips (through level working surfaces)
4	Prefabrication and Modular Building	Falls from height (through reduced on-site construction and assembly) Slips, trips, and falls (through controlled off-site fabrication environments) Exposure hazards (through less exposure to dust, fumes, and other on-site contaminants) Material handling accidents (through pre-assembled components)
5	Internet of Things (IoT)	Falls from height (through real-time fall detection and prevention systems). Slips, trips, and falls (through environmental monitoring for hazards like spills or uneven surfaces). Equipment-related accidents (through predictive maintenance and malfunction alerts). Exposure hazards (through air quality monitoring and alerts).

A structured study of the ways in which important construction technologies—such as BIM, VR, Kumkang Formwork, Prefabrication, and IoT—improve worker safety, risk management, and insurance rates is given in Table 2.3 below. The table illustrates how innovations minimize accidents, maximize hazard mitigation, and generate chances for cost savings through reduced insurance premiums by methodically assessing each technology's

contributions. For industry participants looking to implement technology-driven tactics for safer, more effective, and financially viable building projects, these insights are essential.

**Table 2.3** Summary of technology and their impact on safety, risk management and insurance premium

Technology	Impact on Safety	Impact on Risk Management	Impact on Insurance Premium
Building Information Modeling (BIM)	Reduces errors and improves communication leading to fewer accidents.	Allows for better hazard identification and mitigation before construction begins.	Potential for lower premiums due to reduced risks.
Virtual Reality (VR) Safety Training	Improves safety training by providing realistic simulations of construction scenarios.	Can help to identify and address potential safety risks before they occur on the job site.	May lead to lower premiums for companies with strong VR safety training programs.
Kumkang Formwork Technology	Kumkang formwork technology is designed to improve construction safety by providing efficient and secure scaffolding and formwork systems.	These systems can reduce the risk of accidents and injuries during construction activities.	With improved safety measures in place, insurance claims related to construction accidents and injuries may decrease, resulting in potentially lower insurance premiums.
Prefabricated and Modular	Reduces on-site construction time, which can help to	Can improve risk management by allowing for better	Potential for lower premiums due to reduced risks and shorter

Constructio n	reduce worker exposure to hazards.	quality control in a factory setting.	construction times.
Constructio n Site Internet of Things (IoT)	Can improve safety by monitoring for hazards such as air quality, dust levels, and noise levels. Can also improve worker safety by tracking location and providing real-time alerts.	Can improve risk management by providing real-time data on site conditions and worker activity. This data can be used to identify and mitigate potential risks	Potential for lower premiums due to improved safety and risk management practices.

## 2.6 Gap identification

The impact of construction technology adoption on safety, risk management, and accident mitigation in the construction industry is widely examined in the literature now in publication. Even though it is acknowledged that safety precautions, risk management techniques, accident avoidance, and insurance premium rates are significantly correlated, current research is insufficient to fully explain this important relationship.

In the global construction industry, the use of cutting-edge technologies like Building Information Modeling (BIM), Virtual Reality (VR), the Internet of Things (IoT), prefabricated buildings, and Kumkand aluminum formwork technology has been widely acknowledged for its revolutionary effects on operational efficiency, safety, and risk management. There is still a substantial research gap in quantitatively evaluating these technologies' direct impact on insurance premium reductions, especially in emerging economies like Ethiopia, even though the literature currently in publication emphasizes the qualitative advantages of these technologies in lowering accidents and enhancing project outcomes.

Significant differences can be seen when comparing Ethiopia to industrialized countries in important areas such worker skills, data infrastructure, regulatory frameworks, financial

investment, and rates of technology use. Developed nations use Industry 4.0 technology to improve risk assessment, enforce strict safety regulations, and use data-driven insights to negotiate reduced insurance costs. Ethiopia, on the other hand, has problems with inadequate budget, undeveloped data systems, inadequate cybersecurity, and a shortage of experienced workers, all of which make it difficult to deploy safety-enhancing technologies effectively and raise insurance premiums.

Furthermore, there is not enough empirical data to connect the adoption of construction technology to quantifiable drops in insurance premiums, even if studies recognize their potential to reduce hazards and accident rates. This disparity emphasizes the necessity of thorough, quantitative research to clearly define the relationships between financial benefits in insurance pricing, accident prevention, and technological integration. Ethiopia must close these gaps in order to maximize risk management techniques, conform to international best practices, and promote a more economical and sustainable building industry.

This study intends to offer practical insights for policymakers, insurers, and construction companies by identifying these discrepancies and research flaws. It advocates for targeted investments, regulatory changes, and stakeholder education to close the insurance and technology gap between Ethiopia and the developed world.

A comparison of the main variables affecting the connection between insurance premiums and the adoption of construction technology in Ethiopia and developed countries is shown in Table 2.4 below. The table illustrates how Ethiopia's delayed adoption of advanced technologies (such as BIM, IoT, and robotics) raises the risk of accidents and makes premium reduction more difficult by looking at differences in data practices, safety enforcement, insurance awareness, and risk assessment methodologies. On the other hand, developed nations use proactive safety measures and data-driven risk management to bargain for cheaper premiums. The table emphasizes how Ethiopia must close these gaps by investing in technology, educating stakeholders, and changing policies to match insurance incentives with safety enhancements.

**Table 2.4** The gaps between Ethiopian and the developed world in different parameters on “impact of construction technology adoption on insurance premium” in matrix form

Factor	Developed Countries	Ethiopia	Impact on Insurance Premiums
Construction Technology Adoption	High adoption of advanced (The forth industrial revolution "industry 4.0") technologies like BIM, VR, robotics, 3D printing	Low adoption of advanced technologies	Potentially lower premiums due to fewer accidents and better risk assessment
Data Collection and Sharing	Extensive use of sensors and software to collect and share data	Limited data collection and sharing	Difficulty for insurers to accurately assess risk
Safety Practices	Emphasis on safety regulations and training	Potentially lower enforcement of safety regulations and resistance to new practices	Potentially higher premiums due to higher accident rates
Insurance Industry Awareness	Construction companies understand the importance of insurance and risk management	Limited understanding of insurance and risk management among construction companies	Difficulty for companies to secure appropriate insurance or negotiate lower premiums
Link between technology adoption and insurance premium	No Link between technology adoption and insurance premium	Technology can reduce accident rates or minimize risk,	Link between technology adoption and insurance premium

		potentially lowering premiums in developed countries	is important in deciding the to reduce risk, minimize accident, potentially lowering insurance premium
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In order to evaluate how differences in the deployment of construction technology affect insurance dynamics, Table 2.5 below compares Ethiopia and developed countries methodically across key characteristics, including funding, trained labor, data infrastructure, cybersecurity, and regulatory frameworks. Ethiopia has obstacles such inadequate finance, a lack of skilled workers, and a lackluster infrastructure, whereas wealthy nations maximize risk management and premium reductions by utilizing strong financial resources, sophisticated data systems, and well-defined rules. The implementation of safety-enhancing technologies is hampered by these gaps, which could result in increased insurance premiums and undiscovered hazards. The table emphasizes how urgently Ethiopia must improve cybersecurity, workforce training, and policy frameworks in order to catch up with international best practices and access insurance advantages linked to technological breakthroughs.

**Table 2.5** The gaps between Ethiopian and the developed world in different parameters on “impact of construction technology adoption on insurance” in matrix form

Parameter	Ethiopia	Developed World	Impact on Insurance
Funding for Construction Technology Adoption	Limited financial resources	Strong financial resources for investment	* Difficulty adopting new technologies that reduce insured risks, potentially leading to higher premiums for traditional coverage. * Limited ability to leverage technology for improved risk management, hindering potential premium reductions.
Skilled Workforce for Construction Technology	Shortage of skilled workers	Readily available skilled workforce	* Lack of expertise to implement and maintain new technologies can lead to increased risk of accidents and project delays, potentially impacting premiums. * Inability to fully utilize technology for risk mitigation may result in missed opportunities

			for lower premiums.
Data Infrastructure	Limited data collection and analysis capabilities	Robust data infrastructure	<p>* Difficulty in leveraging data for proactive risk management, potentially leading to reactive insurance approaches and higher premiums.</p> <p>* Limited data insights hinder the development of data-driven insurance products tailored to specific construction project risks.</p>
Cyber security	Lower level of cyber security preparedness	Strong cyber security measures	<p>* Increased vulnerability to cyber attacks on construction technology systems could lead to new and potentially uncovered insurance risks.</p> <p>* Developed world may see emergence of new insurance products specifically targeting cyber risks associated with construction technology.</p>
Regulatory Framework	Potential lack of regulations for emerging construction technologies	Established regulations for construction technology implementation	<p>* Unclear legal landscape in Ethiopia might create uncertainty for insurance companies regarding risk assessment and coverage for new technologies.</p> <p>* Established regulations in developed countries provide clarity for both insurance companies and construction firms, potentially leading to more tailored insurance products.</p>

## CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

### 3.1 Research Design

#### A) Structure of research design

##### Introduction

This study uses a multi-phase research design to investigate how Ethiopian insurance premiums are affected by the deployment of building technology. The study starts with a thorough literature analysis to lay the groundwork for understanding risk management, insurance policies, and building technology developments. Case studies then offer practical insights into how particular technologies affect insurance costs and safety. Formal interviews enhance comprehension through firsthand experiences, while a pilot research and standardized questionnaires collect viewpoints from important industry players. After being gathered, the data is carefully examined to find trends and connections. The report ends with evidence-based suggestions to help industry professionals and legislators maximize the use of technology and insurance plans in Ethiopia's building industry.

##### i) Phase One: Literature Review

A thorough desk study was conducted in the first stage of this research project to examine the corpus of literature already in existence on risk management and insurance in the context of the construction sector. This required a thorough analysis of pertinent research papers, industry reports, scholarly publications, and other sources. The literature review's main goal was to look into and evaluate research on insurance practices, technology adoption patterns, and how building technology affects safety procedures and insurance costs. The investigation of insurance procedures included a thorough analysis of the many tactics, regulations, and systems used by construction industry participants to reduce risks and protect against possible liabilities.

Additionally, evaluating the degree to which cutting-edge technologies are being incorporated into industry operations was the goal of the study on technology adoption in the construction sector. This involved looking at the advantages, difficulties, and ramifications of using construction technologies such prefabricated buildings, Internet of Things (IoT) gadgets, Building Information Modeling (BIM), and kumkang aluminum technology. Analyzing the effects of construction technology adoption on safety regulations and insurance premiums was a critical component of the literature analysis. This required researching the relationship between safety performance measurements, technology developments, and the ensuing impacts on insurance rates.

Finding patterns, trends, and insights that clarify the intricate relationship between technology adoption, safety results, and financial ramifications for insurance companies and construction stakeholders was the goal of a thorough analysis of the body of research in this area. All things considered, the thorough literature assessment carried out during this phase provided a strong basis for the study's later phases. The study sought to develop a thorough grasp of the factors influencing risk management, technology adoption, safety procedures, and insurance concerns in Ethiopia's construction industry by synthesizing and critically analyzing a wide range of academic works.

### **ii) Phase two: case study**

In order to provide comprehensive insights into how particular technologies affect safety, risk management, and insurance costs, case studies are crucial to this research study on the effect of construction technology adoption on insurance rates in Ethiopia. Researchers can evaluate the capabilities, advantages, and drawbacks of technologies such as IoT, BIM, prefabricated buildings, and kumkang aluminum technology by examining real-world instances. They can also study how these technologies affect safety performance and risk reduction. By looking at event data, claims, and expenses, case studies also aid in the investigation of the relationship between insurance rates and the implementation of technology. This method provides a comprehensive understanding of how technology, safety, and financial implications interact, allowing stakeholders and policymakers in the construction sector to make well-informed recommendations.

### **iii) Phase Three: Pilot Study and Stakeholder Engagement**

In this phase of this research initiative involved the execution of a pilot study in the form of a structured questionnaire. This pilot study targeted a select group of participants within the Ethiopian construction industry, including contractors, clients, consultants, and all insurance companies operating in Ethiopia. The sampling strategy employed was purposeful, ensuring that the participants represented diverse perspectives and experiences relevant to the study's focus on the relationship between construction technology adoption and insurance premiums.

#### **iv) Phase Four: Formal Interviews and Questionnaire Administration**

In the subsequent phase, formal interviews and structured questionnaires were administered to a range of stakeholders possessing firsthand experience with the selected construction technologies in the industry. This phase aimed to gather in-depth insights and perspectives from individuals directly engaged in utilizing these technologies, thereby enriching the data pool with practical knowledge and nuanced viewpoints.

#### **v) Phase Five: Data Analysis and Discussion**

Following the collection of data from various sources, the fourth phase involved a detail analysis utilizing diverse analytical methods. This stage focused on synthesizing the collected data to uncover patterns, trends, relating to the impact of construction technology adoption on insurance premiums in the Ethiopian context. By employing multiple analysis techniques, the research aimed to derive meaningful conclusions and offer valuable insights into this complex relationship.

#### **vi) Phase six: Conclusion and Recommendations**

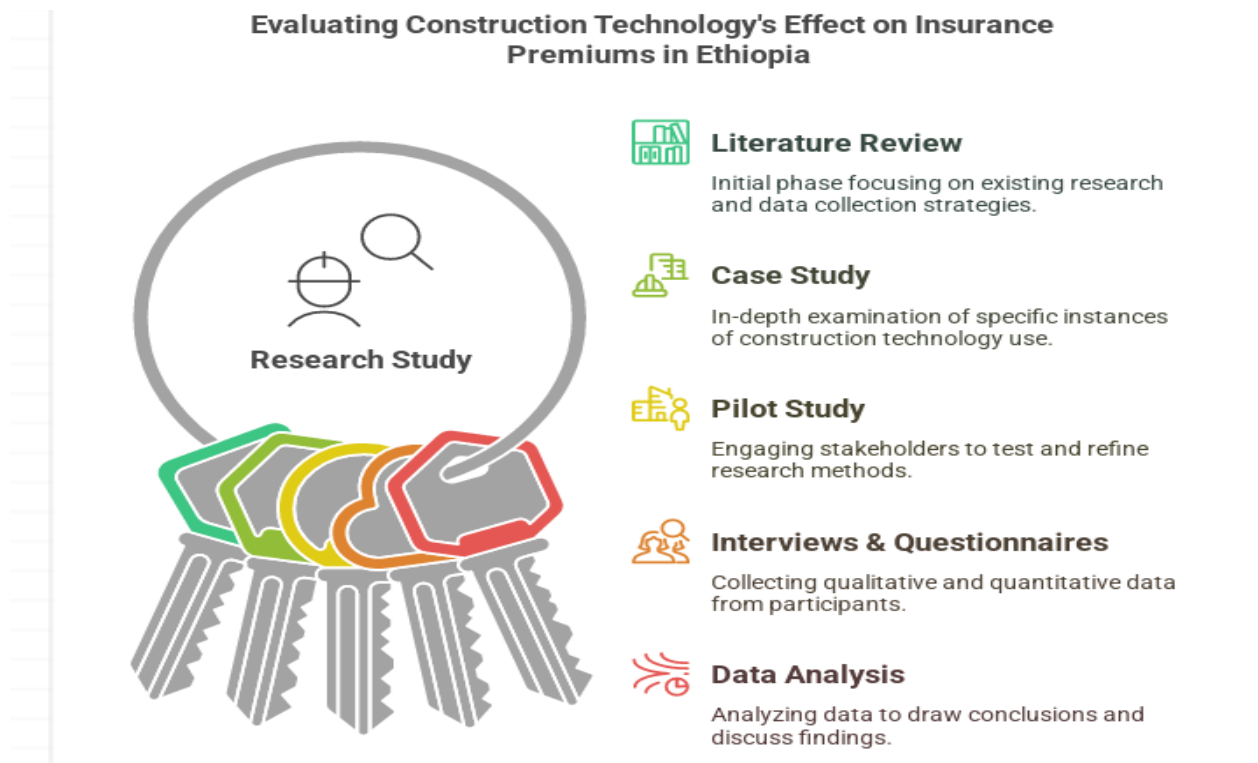
In the final phase of the study, the analysis findings were synthesized to draw conclusive insights and formulate actionable recommendations. The conclusions derived from the data analysis shed light on the implications of construction technology adoption on insurance premiums within the Ethiopian construction sector.

Figure 3.1 outlines a research study titled "*Evaluating Construction Technology's Effect on Insurance Premiums in Ethiopia.*" The study follows a structured approach:

1. **Literature Review:** Initial phase to gather existing research and plan data collection.

2. **Case Study:** Detailed analysis of specific examples where construction technology was used.
3. **Pilot Study:** Testing methods with stakeholders to refine the research approach.
4. **Interviews & Questionnaires:** Collecting both qualitative and quantitative data from participants.
5. **Data Analysis:** Evaluating the gathered data to form conclusions and present findings.

This multi-method approach ensures comprehensive insights into how construction technology impacts insurance premiums in Ethiopia.



**Figure 3-1** General structure of research design

### 3.2 Source of data and data collection methods

This study uses a thorough data gathering technique that includes primary and secondary sources to examine how the use of construction technology affects risk management, accident reduction, and insurance premiums in Ethiopia. Desk research, secondary data

analysis, industry research through interviews, and quantitative research through surveys, site visits, and observation are some of the data collection techniques. A thorough and scientific understanding of how the deployment of construction technology affects insurance premiums in the Ethiopian construction industry is intended to be provided by the research approach for data gathering. To guarantee a thorough study, the data collection techniques use a range of strategies.

This study will use a mixed-methods approach to data collection. In order to comprehend Ethiopian regulatory frameworks, technological adoption trends, and historical insurance premium data, desk research and document analysis will examine government publications, industry reports, and insurance policies. With documentation, site visits and observations will offer personal knowledge about building projects. Key players in the insurance and construction industries will be surveyed using structured questionnaires and interviews to collect qualitative and quantitative data on the relationship between insurance premiums, risk management, safety, and technology adoption. These techniques seek to offer a thorough grasp of how construction technology affects insurance premiums in Ethiopia.

### **I) Qualitative Data Collection: Interviews**

Key industry professionals, such as top, middle, and project management from Grade 1 contractors and Class 1 consultants skilled in cutting-edge construction technologies including BIM, VR, prefabrication, and kumkang formwork, will be the focus of qualitative data gathering through interviews. Government customers, private property owners of major construction projects that use these technologies, and Ethiopia's 17 insurance companies are also included. In order to provide a thorough grasp of the dynamics of the industry, these interviews seek to obtain information on the uptake of building technologies, as well as their effects on safety, risk management, and insurance rates.

### **II) Quantitative data collection: structured questioners**

It will be easier to gather quantitative data on how the use of construction technology affects insurance rates if structured questioners are created using insights from stakeholder interviews and literature research. In order to collect data from a larger range of stakeholders

within the Ethiopian construction industry, the quantitative component of this research will entail creating and distributing surveys. The survey will be developed with industry professionals in mind, such as government clients, private real estate owners, all 17 Ethiopian insurance firms, Grade 1 contractors, and Class 1 consultants. Data on the use of construction technology, safety effects, insurance coverage, claim histories, and perceptions of how technology affects premiums will be gathered through structured questionnaires with closed-ended and Likert scale questions. Pre-testing will guarantee efficacy and clarity.

Surveys will be distributed via paper-based methods where necessary, with a statistically significant sample size ensuring diverse representation. Collected data will be manually cleaned and analyzed using statistical software, employing descriptive and inferential statistics to explore relationships between technology adoption, safety, and insurance premiums.

### **III) Combining Qualitative and Quantitative Data:**

The findings from the quantitative surveys will be triangulated with the qualitative data from the interviews. This means comparing and contrasting the results from both methods to gain a more comprehensive understanding of the impact of construction technology adoption on insurance premiums in Ethiopia.

#### **3.3 Sampling techniques**

To guarantee a representative and thorough selection of participants, a combination of random and selective sampling approaches might be used. For this investigation, the following is an elaborate sampling technique:

- **Careful Selection for Businesses Using Construction Technology:** Locate an exhaustive list of Ethiopian construction industry companies. Choose businesses who have actively embraced and used construction technology into their projects by using certain criteria. This choice may be influenced by elements like the scope of technology deployment, the kinds of technology employed, and the level of innovation in technology adoption.

- Random sample for Professionals in Selected organizations: Use random sample methods to choose professionals like engineers, project managers, and technology specialists from the chosen organizations. Assure representation from a range of construction industry stakeholders, such as clients, consultants, contractors, and insurance providers. To guarantee variety and impartial representation in the study, choose volunteers at random from each group.
- Sampling Strategies for Various Professional Groups: Project Managers: Choose project managers at random from the chosen businesses who handle technologically integrated building projects. Engineers: Choose a random sample of engineers who work for the chosen companies and execute and use construction technology. Technology Experts: Choose specialists in the particular construction technology being used at random.
- Data from Insurance Companies, Consultants, Contractors, and Clients: Contractors: Choose a random sample of contractors working on construction technology projects. Consultants: Choose at random consultants with experience integrating technology into building projects. Clients: Select clients who receive technology adoption-related construction services at random. Insurance firms: To find out how they view the effect of technology adoption on insurance in the construction industry, representatives from insurance firms will be chosen at random.
- Calculating the Sample Size: Based on the goals of the study, statistical factors, and demographic heterogeneity, choose the right sample size for each professional group. Make sure the sample size is sufficient to make intelligible inferences and extrapolate the results to the larger population of interest.

#### **Sample size calculation**

- **Confidence Level (Z):** 95% ( $Z = 1.96$ )
- **Margin of Error (E):** 10% (0.10)
- **Proportion (p):** 50% (0.5, most conservative estimate)

#### **For Unknown (Large) Population:**

$$n = \frac{Z^2 \times p \times (1 - p)}{E^2} = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.10)^2}$$
$$n = \frac{0.9604}{0.01} \approx 96$$

- Minimum sample needed (unknown population): 96
- The actual responses “n” should exceed 96, meaning the study is well-powered for a 10% margin of error.
- If  $n > 96$ , meaning the taken sample already exceeds the requirement for an infinite population at 10% MoE.
- Thus, no finite population correction is needed the sample is sufficient even for a very large population.

By combining selective sampling to identify companies adopting technology and random sampling techniques for selecting professionals within these companies, this study can provide valuable insights into the impact of construction technology adoption on insurance in Ethiopia.

### 3.4 Data Analysis methods

The collected data is analyzed using both qualitative and quantitative methods.

- **Qualitative Analysis:** This analysis focuses on the information gathered from interviews, aiming to understand the industry's perspectives on construction technology and insurance.
- **Quantitative Analysis:** This analysis focuses on the survey data to investigate the relationships between construction technologies, safety performance, and insurance premiums.

### **A) Statistical Analysis Methodology**

- ✓ This section describes statistical techniques for examining how Ethiopian insurance rates and profitability are affected by the deployment of building technologies. The use of technology by contractors, project details, insurance coverage, and past claims information will all be compiled using descriptive statistics.

### **B) Reporting and Data Visualization**

- Tools for Software:
- Results: Graphs: Heatmaps (correlation matrices), scatter plots (premium vs. safety performance), and bar charts (technology adoption rates).
- Dashboards: Interactive visualizations for stakeholder presentations.
- Narrative Reports: Integrating qualitative insights with quantitative finding

### **3.5 Conclusion:**

The final stage summarizes the research findings and explains how they address the research objectives outlined in Chapter 1.

## CHAPTER FOUR: CASE STUDY

The implementation and effects of five major construction technologies Building Information Modeling (BIM), Virtual Reality (VR), Internet of Things (IoT), Prefabrication Building, and Kumkang Formwork Technology in Ethiopian construction companies are examined in this case study. Special attention is paid to how these technologies improve safety performance, risk assessment, and hazard identification. While VR is assessed for its use in immersive safety training, site walkthroughs, and worker behavior assessment, BIM is examined for its capacity to detect design conflicts, forecast on-site hazards using 4D simulations, and create safety plans. While prefabrication is investigated to lower on-site dangers, injuries, and material-related risks, the Internet of Things is investigated for real-time hazard monitoring, wearable technology for worker safety, and predictive analytics. The effectiveness of Kumkang Formwork Technology in enhancing worker safety during concrete building is evaluated. Additionally, the study looks at how these technologies improve safety KPIs, improve risk management tactics, and have a beneficial effect on safety culture and worker happiness. Additionally, it investigates the potential for reduced insurance premiums and incentives due to improved safety performance and risk mitigation. Surveys and interviews with workers will provide insights into the practical impact of these technologies on safety and well-being.

### 4.1 Ethiopian construction work corporation (ECWC)

#### I) Company Background:

The state-owned Ethiopian Construction Works Corporation (ECWC) has been in the engineering and construction sector for more than 75 years. In addition to building structures and producing building materials, its areas of expertise include the construction of major infrastructure, such as roads, bridges, airfields, dams, irrigation systems, and water supplies. ECWC is dedicated to offering its local and foreign clients efficient engineering design, project development, and management solutions. The organization places a high priority on workplace safety, cost effectiveness, and quality. ECWC is also committed to continuous

improvement and innovation, as evidenced by its ISO and continental qualifications. The company has a large pool of skilled employees, including engineers, technicians, and specialists. ECWC has a wide range of services, including project management, design, R&D, training, and certification. The company has successfully completed over 200 major projects and has a strong track record of achievement. ECWC is headquartered in Addis Ababa, Ethiopia, and has a branch office in Djibouti.

ECWC, formerly known as the Imperial Highway Authority, was founded in 1947. The business has changed and merged a number of times over the years. The Ethiopian Water Works Construction Enterprise and the Ethiopian Road Construction Corporation merged to form ECWC in 2011. The Ethiopian Prefabricated Building Parts Production Enterprise was incorporated by the corporation in 2016. ECWC is currently one of East and Central Africa's top manufacturing and construction firms. The business is dedicated to contributing significantly to the growth of Ethiopia's economy and infrastructure.

#### **4.1.1 Building information modelling (BIM)**

##### **1. Introduction**

This case study examines the successful implementation of Building Information Modeling (BIM) technology by Ethiopian Construction Works Corporation (ECWC) in federal document authentication and registration authority headquarter around Mexico, Addis Ababa. The project, commissioned by federal document authentication and registration authority headquarter **4B+M+G+21** offices building efficiently and safely.

##### **2. Project Overview**

- **Project:** federal document authentication and registration authority headquarter **4B+M+G+21** offices building
- **Location:** Mexico, Addis Ababa, Ethiopia
- **Client:** federal government building construction project office(FGBCPO)
- **End user:** federal document authentication and registration authority
- **Contractor :** Ethiopian Construction Works Corporation (ECWC)
- **Consultant:** Yohanes Abay consulting architects & engineers

- **Total built area:** 2,758 square meters
- **Total project cost:** 1.6 billion birr
- **Scope:** Construction of office building
- **Project commencement date:** October 12, 2020 GC

### 3. The use of BIM

- **Training & Capacity Building:** For over a year, ECWC made significant investments in educating its staff about BIM software and procedures. This included practical instruction using programs like BIM 360, Autodesk Revit, and Navisworks.
- **Workflow Integration:** From design and planning to building and maintenance, BIM was incorporated into every stage of the project.
- **Wall-Equipped Workshop:** To speed up the prefabrication process using BIM models, a specialized workshop was set up with cutting-edge machinery and equipment.

### 4. Advantages of Implementing BIM

For this project, ECWC has adopted BIM technology, using it for risk management, safety planning, hazard assessment, and design and construction. The business has made large investments in educating experts on the usage and use of BIM, setting up a fully furnished workshop to efficiently support this process.

- Improved Risk Management & Hazard Identification: During the design and planning phases, BIM models made it possible to proactively identify possible risks such as collisions, interferences, and safety infractions.
- Time-based 4D simulations reduced the chance of accidents and delays by visualizing and analysing construction sequences.
- The integration of cost-related data with the 3D model (geometry and spatial relationships) is known as 5D Building Information Modeling (BIM).
- Safety audits and inspections were conducted more efficiently using BIM data.
- 4026 clashes are detected from sanitary and architectural drawing this implies the power of BIM in hazard identification and risk management.

- Better Safety Performance: Workplace accidents were greatly decreased by BIM-based safety planning and procedures. BIM models' real-time data analysis aided in the early detection and resolution of safety issues.
- Lower Insurance Premiums: ○ The project's insurance premiums were lowered as a result of enhanced safety performance, fewer accidents, and reduced hazards.
- Cost Optimization: Significant cost reductions were achieved through improved material management, less waste, and decreased rework made possible by BIM.
- Reduced delays and related expenses were achieved through better stakeholder cooperation and optimized construction schedules.

## 5. Enhanced Quality Control

- BIM models provided a digital blueprint for quality control, enabling precise fabrication and assembly of prefabricated components.
- Regular comparisons between actual construction progress and the BIM model facilitated early identification and rectification of any deviations.

## 6. Technology & Resources

- **Hardware:** High-performance workstations, SSD high-performance desktop, core-16, laptops, tablets,
- **Software Platforms:** AEC (architectural engineering and construction) which includes Autodesk Revit, Navisworks, BIM 360, Autodesk Construction Cloud
- **Initial Investment (Birr):**
  - Software licenses, hardware procurement, training programs, development of BIM standards and protocols. (A detailed cost analysis would require specific data on hardware, software, and training expenses.)

**Table 4.1 Initial investment cost for BIM**

Investment	cost
Training and software	\$864000
Hardware	\$800000
Ergonomics	\$90909.09
<b>Total</b>	<b>\$1,754,909.09</b>

- **Ongoing Costs (Annual, in Birr):**
  - Software maintenance, hardware upgrades, training and professional development, data management and storage.
  - Ongoing cost=£688000 per three year which is £229333.33 per year.

**Table 4.2 Ongoing cost for BIM**

Investment	Cost per year
Ongoing cost	\$229333.33

- **Number of Projects Utilizing BIM:**
  - This case study focuses on federal document authentication and registration headquarter office building . However, ECWC may have implemented BIM for more than 42 construction projects including djebuti .
- **Hazard Identification Before and After:** Improved by XX%
- **Accident Records Before and After:** Reduced by XX%

## 7.Customer Contentment

- Higher levels of satisfaction were considerably raised by better project delivery, increased safety, and improved client communication.
- The successful completion of the 4B+M+G+21 offices building for the Federal Document Authentication and Registration Authority using BIM technology has probably improved ECWC's competitive edge and reputation.

- Customer satisfaction rises to about 98%.

## 8.summary

The use of BIM technology by ECWC's federal document authentication and registration authority headquarters in the 4B+M+G+21 office building shows how this technology may significantly enhance project quality, safety, and efficiency. Through proactive conflict detection, hazard identification and mitigation, accident reduction, and construction process optimization, BIM has helped create a more successful and long-lasting project outcome.

- **Crucial Points to Remember:**
  - **Data Security:** To safeguard private project data kept in BIM models, strong data security protocols are necessary.
  - **compatibility:** For smooth data interchange, it is essential to guarantee compatibility across multiple software platforms utilized by diverse stakeholders.
  - **Change Management:** To overcome opposition to change and guarantee the organization's successful adoption of BIM, effective change management techniques are required.
  - **Continuous Improvement:** To optimize the advantages of this technology, BIM workflows and processes must be regularly assessed and improved. Keeping abreast with the most recent developments in BIM technology is essential to preserving a competitive advantage.

### 4.1.2 Prefabricated building technology

#### 1. Introduction

This case study examines the successful implementation of prefabricated construction technology by the Ethiopian Construction Works Corporation (ECWC) in their Project 5000, a large-scale prefabricated housing development near Akaki Kality, Addis Ababa. Commissioned by the Addis Ababa City Housing Corporation, the project aimed to construct 5000 housing units rapidly and efficiently.

#### 2. Project Overview

- **Project:** Prefabricated Housing Project (Project 5000)
- **Location:** Akaki Kality, Addis Ababa, Ethiopia

- **Client:** Addis Ababa City Housing Corporation
- **Contractor :** Ethiopian Construction Works Corporation (ECWC)
- **Consultant:** Ethiopian Construction Works Corporation (ECWC)
- **Scope:** Construction of 5000 prefabricated housing units
- **Total project cost:** 8,599,242,300.00 billion birr

### 3. Application of Prefabricated Construction Technology

- **Off-site Manufacturing:** Important building elements, including floors, walls, roofs, and even complete modules, were produced in a regulated factory setting off-site.
- **Standardized Components:** To guarantee uniformity, excellence, and effective assembly, standardized components were created and manufactured.
- **sophisticated Manufacturing Techniques:** To increase productivity and accuracy, the plant used sophisticated manufacturing techniques like automated assembly lines, robotic welding, and CNC cutting.
- **On-site Assembly:** By bringing prefabricated parts to the construction site and assembling them fast and effectively, on-site construction time was greatly decreased.
- **Training & Capacity Building:** ECWC made significant investments in educating its staff on the design, production, assembly, and transportation of prefabricated building technologies.

### 4. Advantages of Technology for Prefabricated Construction

- **Improved Risk Management & Hazard Identification:** Off-site manufacturing reduces on-site risks such as exposure to toxic materials and height falls. Standardized parts and regulated assembly procedures lower the possibility of mistakes and mishaps during construction. Thorough quality control in the manufacturing setting aids in spotting and fixing possible flaws before they show up at the building site.
- **Better Safety Performance:** Using mechanized equipment and reducing on-site labor greatly enhanced on-site safety. Worker safety was further improved by the adoption of stringent safety procedures and better safety training.

- **Lower Insurance Premiums:** The project's insurance premiums were lowered as a result of enhanced safety performance, fewer accidents, and reduced hazards.
- **Cost Optimization:**
  - Reduced labor costs due to efficient assembly.
  - Reduced material waste and rework.
  - Potential for cost savings through economies of scale in off-site manufacturing.
- **Faster Construction:**
  - Off-site manufacturing and rapid on-site assembly significantly reduced overall construction time compared to traditional construction methods, allowing for faster project completion and earlier occupancy.
  - Only 72 (seventy two days) needed to complete G+4 building

## 5. Technology & Resources

- **Hardware:** CNC cutting machines, robotic welders, automated assembly lines, material handling equipment, cranes, lifting equipment.
- **Software Platforms:** Project management software, inventory management software, and potentially software for design and engineering of prefabricated components.
- **Initial Investment (Birr):**
  - Establishment of a prefabrication factory, procurement of advanced manufacturing equipment, and development of standardized components.

**Table 4.3 Total investment cost for prefabrication plant**

<b>Initial investment</b>	<b>cost</b>
Plant and machinery, Specialized equipment and tools	\$32,268,212.453

- **Ongoing Costs (Annual, in Birr):**

- Maintenance of the prefabrication factory, transportation costs, and ongoing training and development of skilled workforce.
- **Number of Projects Utilizing Prefabricated Technology:**
  - This case study focuses on Project 5000. However, ECWC may have implemented prefabricated building technology in other projects as well.

## 6. Customer Contentment

- Prior to prefabricated technology, traditional building methods' quality problems, cost overruns, and project delays might have affected client satisfaction.
- Following prefabricated technology:
  - Client satisfaction was probably raised by quicker construction timeframes, better quality, and less construction-related interruptions.
- A successful deployment of prefabricated technology could improve ECWC's standing and draw in new customers.
- Approximately 98% of clients are satisfied.

## 7. Summary

Prefabricated building technology has the ability to completely transform Ethiopia's construction sector, as seen by Project 5000's successful adoption. By adopting off-site manufacturing and cutting-edge construction methods, ECWC has significantly increased project quality, safety, and speed.

### Crucial Points to Remember:

- competent staff: Effective off-site production and on-site assembly depend on a competent staff.
- Logistics and Transportation: Timely delivery of prefabricated components depends on effective logistics and transportation planning.
- Site Coordination: The activities of on-site construction and off-site manufacturing must be carefully coordinated.

- **Adaptability:** The prefabrication procedure must be flexible enough to accommodate various project specifications and design modifications.

### 4.1.3 Internet of things (IOT)

#### 1. Introduction

This case study examines the successful integration of Internet of Things (IoT) technology implemented by ECWC in the building of federal document authentication and registration authorities headquarter around Mexico, Addis Ababa. The project, commissioned by federal document authentication and registration authority headquarter 4B+M+G+21 offices building efficiently and safely.

#### 2. Project Overview

- **Project:** federal document authentication and registration authority headquarter 4B+M+G+21 offices building
- **Location:** Mexico, Addis Ababa, Ethiopia
- **Client:** federal government building construction project office(FGBCPO)
- **End user:** federal document authentication and registration authority
- **Contractor :** Ethiopian Construction Works Corporation (ECWC)
- **Consultant:** Yohanes Abay consulting architects & engineers
- **Total built area:** 2,758 square meters
- **Total project cost:** 1.6 billion birr
- **Scope:** Construction of office building
- **Project commencement date:** October 12, 2020 GC

#### 3 Implementation of IoT

- **Deployment:** Throughout the building site, high-resolution digital cameras with motion sensors and powerful object detection were positioned in strategic locations.
- **Real-time Monitoring:** Project managers and safety officers could view live video feeds from the cameras at a central monitoring station.

- High-Powered Analytics: employ computers to examine video material and find any risks like
- Safety infractions: Unauthorized persons, workers without wearing personal protective equipment, and unsecured equipment.
- Near misses: Situations in which mishaps came dangerously close.
- Environmental hazards include fires, spills, and other possible threats.
- Data Collection and Analysis: To find trends, patterns, and areas of concern, data gathered from the cameras was examined.
- Proactive Response: Critical safety hazards were detected in real time, allowing for prompt remedial action.

#### 4. Advantages of IoT-Enhanced Hazard Identification & Risk Management:

- Constant monitoring made it possible to identify risks and near-misses in real time. Analytics driven by AI offered insightful information on accident patterns and possible underlying causes.
- Better Safety Performance: Accidents were avoided before they happened because to real-time monitoring and prompt action. Targeted safety interventions were identified and put into action thanks to ongoing data analysis.
- Lower Insurance Premiums: The project's insurance premiums were lowered as a result of enhanced safety performance, fewer accidents, and reduced hazards.
- Higher Productivity: Early danger identification and mitigation decreased project delays and raised overall output.
- Better Project Documentation: Video footage offered important records for legal and incident investigation purposes.

#### 5. Resources & Technology

- **Hardware:** CCTV Data storage servers, network infrastructure, high-resolution digital cameras, and maybe drones for aerial observation, particularly for road projects.

- **Software platforms:** include fleet management, EPR, DPPR, video management software (VMS), and dashboards for data visualization.
- The initial investment (Birr) consists of buying and setting up cameras, software, and network equipment. The price of maintaining and storing data.
- Ongoing expenditures (Annual, in Birr): Subscriptions to software, expenses for data storage, system upkeep, and staff expenditures for analysis and monitoring.
- The number of IoT-based projects: Project 5000 is the subject of this case study. IoT technology may have been used by ECWC in other initiatives, though.

## 6. Customer Contentment

- Increased client transparency, fewer project delays, and better safety performance probably raised satisfaction levels.
- A successful IoT deployment could improve ECWC's standing as a creative and safety-aware construction company. Customer satisfaction rises to about 98%.

## 7. Summary

The substantial potential of IoT technology to improve construction site safety is demonstrated by its inclusion in the ECWC's 4B+M+G+21 offices building for the Federal Document Authentication and Registration Authority. Through real-time monitoring, ECWC has successfully detected and eliminated risks, decreased mishaps, and enhanced project performance in general.

### Important Things to Think About:

- Data Privacy and Security: ○ Putting strong data privacy and security measures in place to safeguard employee privacy and stop illegal access to private data.
- Ethical Considerations: ○ Making sure that surveillance technology is used responsibly and protecting employee privacy.

- **System Maintenance:** To guarantee the IoT system's continuous efficacy, regular upgrades and maintenance are essential.
- **Education and Training:** o Giving project staff sufficient instruction on how to operate the IoT system and analyze data.

## **4.2 HH consulting architects and engineers plc**

### **4.2.1 Virtual reality technology (VR)**

#### **i) Background of company**

HH Consulting Architects & Engineers PLC was founded in 2011 G.C. and is a Category I professional firm. They have demonstrated proficiency in a number of areas, including contract administration, construction engineering, architectural design, urban planning, construction management, and supervision. One business that offers engineering and architectural solutions is HH Consulting Architects and Engineers plc. With 150 workers, they prioritize the demands of their clients and the environment while concentrating on providing sustainable and affordable solutions. Their yearly revenue is \$54 million. One of Addis Ababa's top construction consulting firms, HH Consulting Architects and Engineers plc, is a trailblazing force known for its accuracy and inventiveness in project management, architectural design, and construction monitoring. HH Consulting Architects and Engineers plc's innovative approach, where creativity meets efficiency, sets them apart as experts in pushing boundaries and delivering exceptional design solutions. With a legacy of over 50 completed projects, they have cemented their position as an industry powerhouse, seamlessly blending artistry with functionality.

As your trusted partner in success, they guide clients through envisioning remarkable structures, managing complex projects, and achieving precision in every detail. Joining HH Consulting Architects and Engineers plc experience means embarking on a journey towards architectural excellence filled with innovation, inspiration, and unwavering success

## 1. Introduction

This case study looks at how HH Consulting Architects and Engineers plc, a well-known construction company in Addis Ababa, successfully implemented Virtual Reality (VR) safety training technology. By utilizing VR's immersive qualities, the organization aimed to increase worker safety, lower accident rates, and boost overall project efficiency.

## 2. Project Overview

- **Project Type:** Residential Building
- **Building Specifications:** G+7
- **Location:** Addis Ababa
- **Implementation Start Date:** January 2023
- **Goal:** To enhance worker safety and reduce workplace accidents through immersive VR safety training.
- **Target Audience:** All construction workers employed by HH Consulting Architects and Engineers plc, including site supervisors, laborers, and equipment operators.

## 3. Implementation of VR Safety Training

- **Creation of VR Training Modules:** In partnership with VR training providers, HH Consulting Architects and Engineers plc produced interactive and lifelike virtual reality simulations of typical construction site dangers. Examples include operating heavy equipment (such as cranes and excavators), working at heights (such as scaffolding and ladders), electrical and fire safety, entering confined spaces, trenching, and excavation safety.
- **Training Delivery:** Using VR headsets and handheld controllers, employees took part in required VR training sessions. Without any real-world risks, the simulations provide a secure and regulated setting for experiencing and learning from any risks.
- **Interactive Scenarios:** Interactive components in VR simulations included:

- Identifying and mitigating hazards.
- Practicing safe work procedures (e.g., proper use of PPE, fall protection systems).
- Responding to emergency situations (e.g., fire drills, first aid).
- Making critical decisions in simulated high-risk scenarios.
- **Assessment and Feedback:** VR training modules incorporated assessments to evaluate worker performance and provide personalized feedback.

#### 4. Benefits of VR Safety Training

##### Advantages of VR Safety Training

- **Improved Hazard Identification & Risk Management:** Workers were better able to recognize and comprehend possible risks thanks to the realistic and immersive experience that VR simulations offered. Employees gained a better comprehension of safety concerns and learnt how to identify and react to hazards in practical situations.
- **Enhanced Safety Performance:** Virtual reality training greatly enhanced worker safety performance and awareness. After VR safety training was introduced, accident rates dramatically dropped.
- **Lower Insurance Costs:** HH Consulting Architects and Engineers plc's insurance rates decreased as a result of increased safety performance, fewer accidents, and reduced risks.
- **Enhanced Engagement of Employees:** VR training provided an engaging and interactive learning experience, increasing employee engagement and retention.
- **Cost-Effectiveness:** VR training can be more cost-effective than traditional training methods by reducing the need for costly on-site safety demonstrations and minimizing the risk of real-world accidents.

#### 5. Resources & Technology

- **Hardware:** powerful PCs and virtual reality headsets (such as the Oculus Quest 2 and HTC Vive).

- **Software Platforms:** VR training platforms and VR development software (such as Unity and Unreal Engine).
- **First Investment (Birr):** Acquisition of VR PCs and headsets, creation and licensing of VR training materials, and early setup expenses.
- **Ongoing Costs (Annual, in Birr):**
  - Software maintenance, hardware upgrades, content updates, and ongoing training for instructors.

**Table 4.4 Initial and ongoing investment costs for VR**

<b>Initial Investment</b>	<b>cost</b>
VR hardware and training	\$18733.091
Ongoing cost	\$6244.36
<b>Total</b>	<b>\$24977.451</b>

- **Number of Projects Utilizing VR Training:**
  - All construction projects undertaken by haha construction plc which are five projects.

## 6. Client Satisfaction

- **VR client satisfaction:100%**
  - Improved safety performance and reduced accidents likely increased client satisfaction and confidence in HH Consulting Architects and Engineers plc commitment to safety.

## 7. Summary

For HH Consulting Architects and Engineers plc, the use of virtual reality safety training technology shows a notable improvement in worker safety and project results. Workers are now more equipped to recognize and reduce risks thanks to VR's immersive and interactive training experiences, which have

made workplaces safer and more efficient.

**Crucial Points to Remember:**

- Accessibility: Ensuring that all employees, especially those with low levels of technological literacy, have access to VR training.
- Training efficacy: To make sure that VR simulations are interesting, useful, and satisfying the individual needs of employees, training efficacy is regularly assessed.
- Data Analysis and Improvement: ○ Constantly examining training data to pinpoint problem areas and enhance training materials
- Integration with On-site Safety Practices: Integrating VR training with other safety initiatives, such as on-site safety inspections and toolbox talks.

### **4.3 Ovid construction plc**

#### **4.3.1 Kumkang aluminium formwork technology**

##### **i) Background of company**

Since its founding in 2013, the Ethiopian construction and real estate firm Ovid Group has grown into a massive conglomerate with 24 subsidiaries that specialize in a range of industries, including manufacturing, IT, real estate, construction, and more, forming a self-sufficient business. Their path, which is dotted with noteworthy turning points like their 2017 real estate venture and 2021 involvement in large PPP projects, demonstrates their quick development and flexibility. With operations in Ethiopia, the United Arab Emirates, the United States, and Central Africa, Ovid Group employs more than 10,000 people worldwide and makes more than \$15 billion USD annually. In addition to leaving their mark on the construction industry, they have made a substantial economic contribution to Ethiopia by raising living standards and generating jobs through finished projects like the African Union Bole and ongoing initiatives like African Heights. With an emphasis on global expansion, increased corporate social responsibility, investments in renewable energy, and a keen focus on digital transformation, Ovid Group is positioned to become a major force in the real

estate and construction industry with a strong commitment to affordability, sustainability, and community well-being.

## 1. Introduction

Ovid Construction Plc, a leading construction company in Addis Ababa, Ethiopia, embarked on a significant safety and efficiency enhancement initiative by adopting Kumkang aluminum formwork technology for its Teyet Bet luxury housing project around 4 kilo site addis ababa. This case study examines the successful implementation of this technology, focusing on hazard assessment, safety, risk management, and its impact on project outcomes.

## 2. Project Overview

- **Project:** Teyet Bet luxury housing project G + 9 and G + 16 apartments
- **Client:** Ovid Construction Plc
- **Consultant:** ovid kling
- **Location:** 4 kilo Addis Ababa, Ethiopia
- **Technology:** Kumkang aluminum formwork system
- **Scope:** Residential construction
- **Total built area:** 17170 square meter
- **Total project cost:** 6,600,000,000 (6.6 billion) birr

## 3. Obstacles to the Adoption of Kumkang Formwork

- Limitations of Conventional Formwork:
  - Safety hazards include exposure to dangerous materials, falls, and accidents from physical labor.
  - Inefficiency: Prolonged assembly and disassembly that raises expenses and delays projects.
  - Quality Issues: Variations in formwork tightness and precision result in inconsistent concrete quality.

- Limited Safety Training: Workers receiving traditional formwork techniques do not receive enough safety training.
- Why High Insurance Premiums: Because accidents and safety incidents occur frequently, insurance premiums are high.

#### **4. Application of Kumkang Formwork Technology**

- Capacity building and training: Ovid Construction Plc made an investment in extensive training courses for its employees on how to safely assemble and disassemble Kumkang formwork components. Employing personal protection equipment (PPE) as necessary.
- Techniques for risk detection and mitigation.
- Technology Integration: ○ Prefabricated and pre-engineered formwork components were used to speed up assembly and lower labor costs. Made use of cutting-edge scaffolding solutions for safe height work and access.
- To guarantee precise formwork placement and concrete pouring, a strong quality control system was put in place.
- Safety Procedures: ○ Created and carried out a thorough site safety plan that included toolbox talks and routine safety inspections.
- Performed routine maintenance and inspections on safety equipment.
- Promoted a robust safety culture by means of transparent communication and staff engagement.

#### **5. Outcomes and Advantages**

- Improved Safety: A notable decline in accidents and injuries at work. Enhanced knowledge of worker safety and adherence to safety procedures. Less exposure to risks such material handling injuries, collapses, and falls.
- Enhanced Efficiency: Shorter construction schedules as a result of fewer workers and quicker assembly and disassembly.
- Accurate formwork placement resulted in better concrete quality and less rework. Increased output and overall project effectiveness.

- Cost savings: Lower labour and material waste expenses. Reduced insurance costs as a result of better safety records and fewer accident reports.
- Enhanced profitability of the project.
- Better Quality: Consistent and high-quality concrete finishes due to the precision of the Kumkang formwork system.
- Enhanced structural integrity of the building.
- Improve time: 90 (ninety) days is needed to complete G+9 BUILDING

### 6. Identification of Hazards and Records of Accidents

- A notable decrease in accidents of all kinds.
- Enhanced employee consciousness and proactive detection of possible risks. Close calls are reported and dealt with right away.

### 7. Investment and Technology

- Hardware:
  - o Kumkang panels, beams, columns, and other formwork components (6061-T6 Aluminum type)
  - o Scaffolding systems
  - o PPE (harnesses, safety shoes, helmets, etc.)
- Software:
  - o Project management software to assess safety performance and track progress.
  - o Create software to minimize material consumption and optimize formwork layouts.
- Initial Investment:
  - o A substantial upfront expenditure for scaffolding, training, and Kumkang formwork systems.

**Table 4.5** Initial investment cost for kumkang formwork technology

Initial investment	Total cost
Kumkang aluminum formwork 1717 square meter	\$192,304

- o **Ongoing Costs:**

- Maintenance of formwork equipment and scaffolding.
- Regular safety training and equipment inspections.
- Minor repairs and replacements of worn-out components.

**Table 4.6** Maintenance cost for kumkang aluminum form work

Investment	Cost in birr
Maintenance cost per square mater	65

### 8. Customer Contentment

- A high level of client satisfaction because of: 95% Fulfilling financial and schedule requirements for projects.
- Providing superior construction with improved safety features. Enhanced interaction and cooperation with the customer.

### 9. Summary

The G + 9 and G + 16 apartments of Ovid Construction Plc's Teyet Bet luxury housing project have successfully incorporated Kumkang formwork technology. By putting safety first, spending money on training, and utilizing cutting-edge technology, the business has greatly increased project efficiency, decreased risks, and improved project results overall. This case study highlights the importance of implementing cutting-edge construction technologies to raise productivity, increase safety, and accomplish sustainable building methods.

#### Crucial Points to Remember

- Effective implementation depends on careful planning and design.
- To guarantee long-term performance and safety, formwork equipment must get regular maintenance.
- Constant enhancement of safety procedures through frequent evaluations and employee input.
- Technology is modified to meet the unique demands and specifications of every project.

#### 4.4 Case study summary

The case study explores how different businesses in the construction industry successfully integrate a range of technological solutions. Throughout its projects, Ethiopian building Works Corporation (ECWC) strategically used prefabricated building methods, Internet of Things (IoT) advancements, and Building Information Modeling (BIM). Virtual reality (VR) was skillfully used by GUZO TECHNOLOGY PLC to improve safety training procedures. Kumkang aluminum formwork technology was adopted by OVID CONSTRUCTION PLC as a vital operational tool. The combination of these innovative technologies produced numerous benefits:

- Improved Safety Performance: Safety procedures were strengthened by proactive risk reduction and real-time monitoring.
  - Lower Insurance Premiums: Insurance expenses were successfully decreased by creating a safer workplace.
  - Cost Optimization: Financial efficiencies resulted from resource allocation and process simplification.
  - Augmented Quality Control: Strict quality requirements were met by means of sophisticated monitoring systems.
  - Accelerated Construction: Project completion dates were accelerated by improved operational procedures.
  - Enhanced Productivity: Improvements in efficiency resulted in higher project output and throughput.
  - Better Project Documentation: Accurate and thorough documentation procedures were put in place.
  - Increased Client Satisfaction: Projects completed on time and with improved quality led to increased client satisfaction.
- The thorough results highlight the significant influence that these technological interventions have on improving project quality, safety, and operational effectiveness in the construction industry.

## **CHAPTER FIVE: ANALYSIS AND DISCUSSION OF RESULT**

### **5.1. Survey result and discussion**

#### **5.1.1 Introduction**

The findings are organized in a way that sequentially resolves the study's objectives. The first section describes the adoption rates of various construction technologies, which sets the stage for the subsequent analysis. The main focus of the discussion is the perceived interaction between the adoption of construction technologies and the insurance premiums, or what contractors, if any, believe the impact of technological advancements has on their insurance expenses. This section lays out and analyzes the study's findings on how the adoption of construction technologies affects the amount consumers pay for insurance. This also contains an examination of which specific construction technologies are thought to have the most noticeable effects and whether premiums are expected to rise, fall, or even stagnate as a result of those effects. This discussion then looks at the potential justifications for going through them, including reduced risks, improved safety, and more efficient project management as a whole that the technologies could provide. Finally, that conversation takes into account the insurers and construction businesses in relation to the effect that the adoption of construction technology has on premiums and identifies beneficial areas of cooperation.

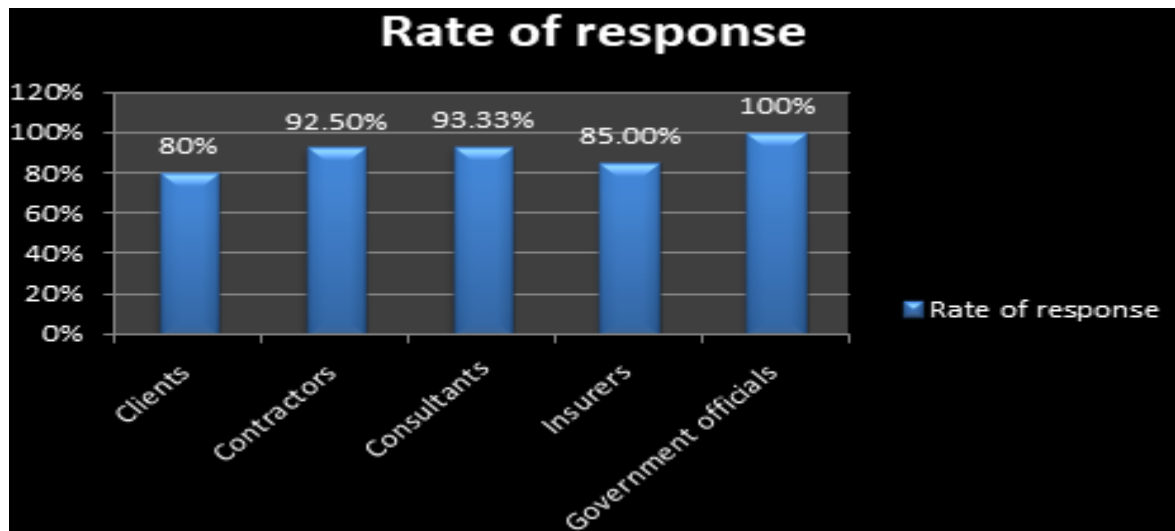
#### **5.1.2 Questionnaire response rate**

The questionnaire response rate by stakeholder group is shown in Table 5.1.2. Five major divisions clients, contractors, consultants, insurers, and government officials received a total of 120 questionnaires. The number of questionnaires sent to each group, the number that were successfully completed and returned, and the estimated response rate for each division are all shown in the table. This makes it possible to evaluate how well each stakeholder group was represented and involved in the study,

and an aggregate response rate is given to show how broadly applicable the results are. Strong engagement and interest in the research topic are indicated by the high overall response rate.

**Table 5.1.2** questioner’s response rate

NO	Division of stakeholders	Questioners distributed	Questioners responded	Rate of response
1	Clients	20	16	80%
2	Contractors	40	37	92.5%
3	Consultants	30	28	93.33%
4	Insurers	20	17	85%
5	Government officials	10	10	100%
<b>Total</b>		120	108	90%



**Figure 5.1.2** bar chart for rate of response

### 5.1.3 Proportionality of respondent in there company/1

Table 5.1.3 presents the distribution of respondents across different positions within their respective companies, categorized by stakeholder group. The table shows the frequency and percentage of respondents in top management, medium management, expert/technical roles, and other positions for each stakeholder group (Clients,

Contractors, Consultants, Insurers, and Government Officials). This breakdown helps understand the representation of different levels of experience and decision-making authority within the study sample, providing context for interpreting the overall findings. The "Total response" column summarizes the overall distribution of positions across all stakeholder groups.

**Table/15.1.3 respondents position on their company**

No	Position of respondent	clients		Contractors		Consultants		Insurers		Government officials		Total response in (%)
		Ferq.	%	Ferq.	%	Ferq.	%	Ferq.	%	Ferq.	%	
1	Top management	3	18.75	3	8.11	2	7.14	1	5.88	0	0	8.33
2	Medium management	4	25	14	37.84	11	39.28	5	29.41	1	10	32.41
3	Expert	9	56.25	16	43.24	15	53.57	8	47.06	9	90	52.78
4	Others	0	0	4	10.81	0	0	3	17.65	0	0	6.48
Total		16	100	37	100	28	100	17	100	10	100	100



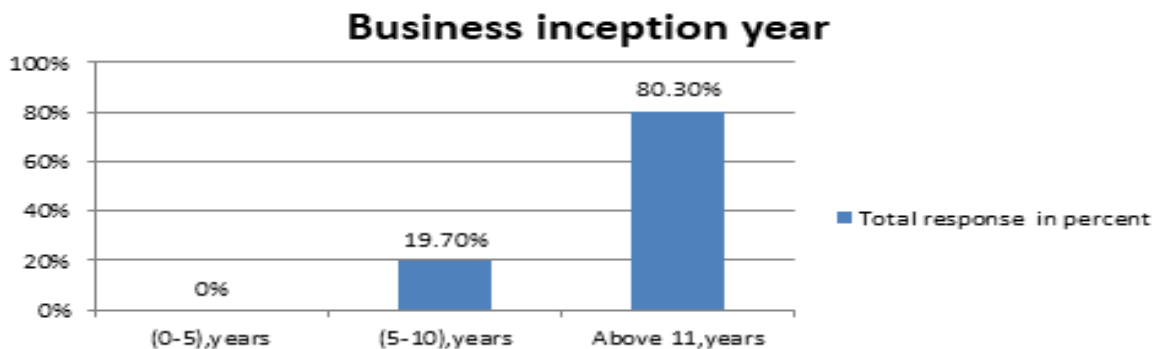
**Figure 5.1.3** pie chart for respondent's position on their company

### 5.1.4 Company founding dates

Table 5.1.4 above presents the distribution of company founding dates, categorized by stakeholder group and grouped into three timeframes: 0-5 years, 5-10 years, and above 11 years. The table displays the frequency and percentage of companies within each age range for Clients, Contractors, Consultants, Insurers, and Government Officials. This provides insight into the experience and maturity of the organizations participating in the study, allowing for potential analysis of how company age might influence responses or practices related to the research topic. The "Total response" column summarizes the overall distribution of company founding dates across all stakeholder groups. Notably, the data reveals a strong concentration of established companies (over 11 years old) across all stakeholder categories.

**Table 5.1.4** business inception years

No	Business Inception Years	clients		Contractors		Consultants		Insurers		Government officials		Total response in (%)
		Ferq.	%	Ferq.	%	Ferq.	%	Ferq.	%	Ferq.	%	
1	(0-5),years	0	0	0	0	0	0	0	0	0	0	0
2	(5-10),years	3	37.5	8	32	2	16.7	0	0	0	0	19.7
3	Above 11,years	5	62.5	17	68	10	83.3	17	100	4	100	80.3
Total		8	100	25	100	12	100	17	100	4	100	100



**Figure 5.1.5** Bar graph for Business Inception Years

### 5.1.5 Work experience of respondent

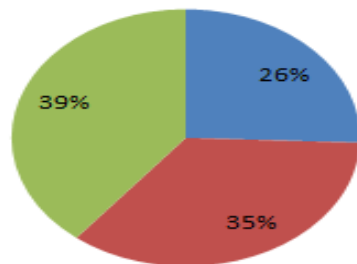
The respondents' years of work experience are distributed into three ranges in Table 5.1.5: 2-4 years, 5-7 years, and over 8 years. The frequency and proportion of responders who fit into each experience bracket are displayed in the table. Understanding the study sample's viewpoints and insights on the research issue can be greatly aided by knowing the overall level of professional experience that is represented in the sample. With a minor preponderance of responders in the 5-7 year and above 8 year groups, the distribution shows a fairly equal representation across experience levels.

**Table 5.1.5** work experience of respondents

No	Respondent Experience in years	Frequency	Percent (%)
1	(2-4),years	28	25.93
2	(5-7),years	38	35.19
3	Above 8,years	42	38.89
Total		108	100

### Respondent work experiance Percent

■ (2-4),years ■ (5-7),years ■ Above 8,years



**Figure 5.1.5** pie chart for work experience of respondents

### 5.1.6 Contractors, consultants and clients respondent result

Table 5.1.6 displays In the construction sector, the use of technology has profoundly changed risk management, danger identification, and safety protocols. Businesses have improved their ability to reduce risks, accidents, and project efficiency by implementing cutting-edge

technical technologies. These developments have also affected the dynamics of insurance since insurers are becoming more aware of how technology may reduce risks and possibly modify rates accordingly. This table highlights the growing significance of construction technology in creating a safer and more effective construction environment by examining important concerns about how it affects safety, risk management, and insurance.

**Table 5.1.6** basic questions about construction technology and its impact on safety, hazard identification and risk management and insurance.

Q1= How has the adoption of construction technology affected the safety measures implemented on construction sites?

Q2= Has the use of technology resulted in a decrease in accidents and property damage during construction projects?

Q3= What specific technological advancements have been adopted by your company..... and how have they improved overall project efficiency?

Q4= Have you observed any changes in insurance premiums for construction projects since the implementation of technology?

Q5= How has the adoption of construction technology influenced your risk management strategies?

N O	Questi on	v.low		low		moderate		high		v.high	
		Fre q.	%	Fre q.	%	Fre q.	%	Freq.	%	Fre q.	%
1	Q1	0	0	0	0	17	18.68	66	72.53	9	9.89
2	Q2	0	0	0	0	16	23.07	69	75.82	6	6.59
3	Q3	0	0	0	0	21	23.07	58	63.74	12	13.1
4	Q4	5	5.45	17	18.68	32	35.67	27	29.67	5	5.5
5	Q5	0	0	4	4.4	11	12.09	68	74.43	8	8.79

### 5.1.7 Construction technology insurance

Table 5.1.7 explores the current state of insurance related to construction technology risks. It presents responses to two key questions: familiarity with insurance options for technology-related risks (e.g., BIM, Kumkang, prefabrication, IoT, robotics, automation) and whether respondents have actively sought specialized coverage or policy clauses to address these risks. The table displays the frequency and percentage of "yes" and "no" answers, providing insight into the industry's awareness and proactive approach to insuring emerging construction technology risks. The data reveals a significant lack of familiarity and proactive seeking of specialized insurance for these risks.

**Table 5.1.7** current state of insurance related to construction technology risks

No	Question	yes		No	
		Freq.	%	Freq.	%
1	Are you familiar with insurance options for construction technology risks like BIM, kumkang, prefabrication, IoT, robotics, and automation etc.?	10	11	81	89%
2	Have you actively sought specialized insurance coverage or specific clauses in your policies to address construction technology risks?	0	0	91	100%

### 5.1.8 Construction technology familiarity

The respondents' acquaintance with different construction technologies is examined in Table 5.1.8. It displays the frequency and percentage of "yes" and "no" answers pertaining to knowledge of five distinct technologies: Kumkang formwork technology, virtual reality safety training (VR), prefabricated and modular construction, building information modeling (BIM), and the Internet of Things (IoT) on construction sites. This gives information about the industry's overall awareness and comprehension of these technologies, which is important for uptake and perceived impact. According to the research, most technologies are well-

known, especially BIM and prefabricated/modular construction, although IoT knowledge is very low.

Table 5.1.8 the familiarity of respondents with various construction technologies

No	CONSTRUCTION TECHNOLOGY	YES		NO	
		Freq.	%	Freq.	%
1	Building information modeling (BIM)	91	100	0	0
2	Virtual reality safety training (VR)	84	92.3	7	7.7
3	Kumkang formwork technology	86	94.5	5	5.5
4	Prefabricated and modular construction	89	97.8	2	2.2
5	Construction site internet of things (IOT)	78	85.7	13	14.3

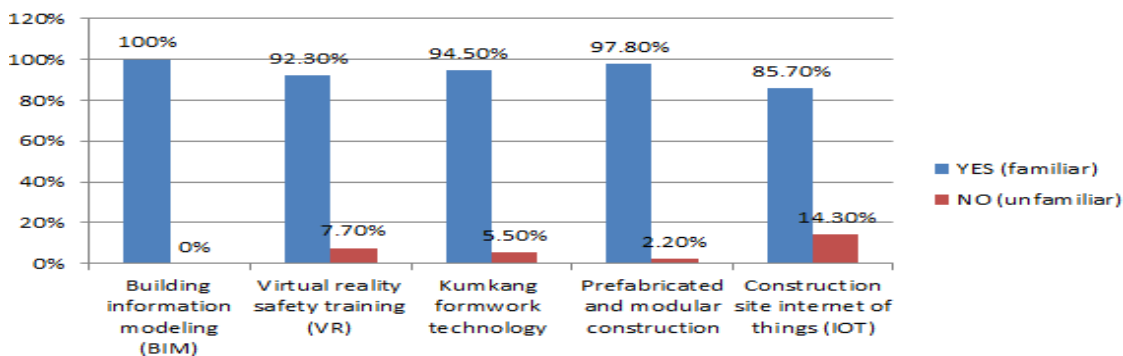


Figure 5.1.8 bar chart for technology familiarity of respondent

**Table 5.1.9** Impact of Construction Technologies in construction hazard identification, risk assessment and mitigation, accidents Reduction and overall safety in the construction industries.

In order to determine the extent to which certain construction technologies affect hazard identification, risk assessment, risk mitigation, accident reduction, and safety in the construction industry, a survey was conducted as part of the project. The results of that survey are displayed in this table. The perceived level of impact was indicated by classifying the responses into five levels: very low, low, moderate, high, and very high. Building Information Modeling (BIM), virtual reality safety training, Kumkang formwork technology, prefabricated and modular construction, and the Internet of Things are among the

technologies under investigation. The table shows the frequency and proportion of each technological reaction, which are a number of indicators of both effect level.

n	constructi on technolog y	Impact of Construction Technologies in construction hazard identification, risk assessment and mitigation, accidents Reduction overall safety in the construction industries.									
		v.low		low		moderate		high		v.high	
		Fr eq.	%	Fr eq.	%	Fr eq.	%	Fr eq.	%	Fre q.	%
1	Building information modeling (BIM)	0	0	12	13.19	16	17.58	47	51.64	17	18.68
2	Virtual reality safety training (VR)	0	0	11	12.09	17	18.68	38	41.76	9	9.89
3	Kumkang formwork technology	5	5.5	22	24.18	29	31.87	17	18.68	2	2.2
4	Prefabricated and modular construction	0	0	2	2.2	12	13.19	42	46.15	17	18.68
5	Internet of things (IOT)	3	3.3	14	15.39	26	28.58	23	25.27	7	7.69

## 5.1.10 Insurance company respondent result

According to Table 5.1.10, the construction industry's risk landscape has changed as a result of the adoption of technology, impacting risk management techniques, safety procedures, and hazard identification. The frequency and severity of insurance claims have been affected by the ongoing evolution of technology, which has forced insurers to reevaluate how they approach risk assessment and product development. With an emphasis on how technological developments have changed risk dynamics, impacted claim trends, and fueled the demand for specialized insurance solutions, this table examines important issues regarding the relationship between construction technology and insurance. It also emphasizes how crucial it is to keep up with technology advancements in order to guarantee precise risk assessment and efficient insurance coverage.

Table 5.1.10 basic questions about construction technology and its impact on safety, hazard identification and risk management and insurance.

Q1= How has the adoption of construction technology affected the overall risk landscape in the construction industry?

Q2= Have you observed any changes in the frequency and severity of insurance claims related to construction projects before and after construction technology adoption?

Q4= How do you stay updated on the latest advancements in construction technology to accurately assess associated risks?

N	Question	v.low		low		moderate		high		v.high	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	Q1	0	0	1	5.88	9	52.94	6	35.29	0	0
2	Q2	0	0	5	29.41	10	58.82	1	5.88	0	0
3	Q3	1	5.88	9	52.94	5	29.41	1	5.88	0	0

### 5.1.11 Construction technology insurance

Table 5.1.11 familiarity of construction technology insurance

No	Question	yes		No	
		Freq.	%	Freq.	%
1	Are you familiar with insurance options for construction technology risks like BIM, kumkang, prefabrication, IoT, robotics, and automation?	0	0	17	100
2	Have you actively sought specialized insurance coverage or specific clauses in your policies to address construction technology risks?	0	0	17	100
3	Have you developed specific insurance products or coverage options tailored to address the risks associated with construction technology?	0	0	17	100

### 5.1.12 Factors Affecting Insurance Premiums

Table 5.1.12 displays Numerous factors, which can be broadly divided into elements relating to the project, the contractor, the insurer, and the market, affect insurance premiums for construction projects. All of these elements work together to establish a project's degree of risk and, in turn, the price of insurance. Both contractor-related elements like experience, safety procedures, and claim history, as well as project-specific elements like the project's size, location, complexity, and nature, are important. Premium computations are also influenced by insurer-related factors including operational expenses and profit plans, and pricing is further influenced by market factors like competition and company volume. Both contractors and insurers must comprehend these elements in order to manage risks and obtain suitable insurance coverage.

**Table 5.1.12** Relative impact of insurance premium indicating factors and categories.(for insurance company)

Category	Safety Factors	Factor Impact on (or correlation with) Premium (The numbers represent the % of responses)				
		No	low	Moderate	High	Very high

Project factors	Fq		%		Fq		%		Fq		%	
	Fq	%	Fq	%	Fq	%	Fq	%	Fq	%	Fq	%
1. Project type/nature	0	0	0	0	0	0	14	82.35	3		17.65	
2. Project size	0	0	0	0	0	0	10	58.82	7		41.18	
3. Project Contract price	0	0	0	0	1	5.88	9	52.94	7		41.18	
4. Project location and surrounding environment	0	0	0	0	0	0	13	76.47	4		23.53	
5. Project weather conditions	0	0	0	0	7	41.18	8	47.06	2		11.75	
6. Project duration	1	5.88	6	35.29	7	41.18	2	11.75	1		5.88	
7. Drawings, Specifications, Construction time schedule & BOQ	2	11.75	6	35.29	7	41.18	0	0%	2		11.75	
8. Project financial structure/lenders	3	17.65	6	35.29	7	41.18	0	0%	1		5.88	
9. Project procurement method (traditional, design-build, ...)	3	17.65	5	29.41	7	44.18	2	11.75	0		0	
10. Number of contractors on-site	1	5.88	5	29.41	9	52.94	0	0	1		5.88	
11. Number of insured participants	0	0	4	23.53	1	70.59	0	0	1		5.88	
12. Project sum insured	1	5.88	2	11.75	1	64.71	2	11.75	1		5.88	
13. Building materials for use	2	11.75	5	29.41	6	35.29	0	0	3		17.65	
14. Unique project complexities	0	0	0	0	1	64.71	3	17.65	2		11.75	

	15. Construction contract terms and conditions	1	5.88	2	11.75	9	52.94	2	11.75	2	11.75
	16. Insurance coverage limits and deductibles	0	0	0	0	7	41.18	9	52.94	1	5.88
Part ies' fact ors	1. Contractor's size	0	0	0	0	6	35.29	9	52.94	2	11.75
	2. Contractor's experience in similar projects/ method statement	0	0	1	5.88	7	41.18	9	52.94	0	0
	3. Contractor's construction technology and building techniques	0	0	1	5.88	5	29.41	11	64.71	0	0
	4. Contractor's method statements for severe jobs	0	0	0	0	7	41.18	9	52.94	1	5.88
	5. Contractor's Safety Claim history	0	0	0	0	2	11.75	14	82.35	1	5.88
	6. Contractor's Sub-Contract Management	0	0	0	0	6	35.29	11	64.71	0	0
	7. Contractor's Safety Policies/ Hazard Management Policies	0	0	0	0	2	11.75	13	76.47	2	11.75
	8. Contractor's	0	0	0	0	2	11.75	13	76.47	2	11.75

	Safety technology										
	9. Contractor's Safety Training	0	0	0	0	3	17.65	11	64.71	3	17.65
	10. Contractor's Labor Experience	0	0	0	0	0	0	30	88.24	4	11.76
	11. Contractor's Labor Level of Education	0	0	2	11.75	8	47.06	6	35.29	1	5.88
	12. Owner/Engineer influence on committing to safety standards	0	0	3	17.65	9	52.94	2	11.75	2	11.75
Insurer factors	1. Insurer's Direct Cost: Reinsurance cost and insurance broker commission	0	0	0	0	8	47.06	8	47.06	1	5.88
	2. Insurer's Indirect Cost: Insurance company overhead cost	0	0	0	0	7	41.18	8	47.06	2	11.75
	3. Insurer's Strategy of Profit Generation and Potential Future Business	1	5.88	1	5.88	5	29.41	8	47.06	2	11.75
	4. Volume of business in insurance market	0	0	2	11.75	5	29.41	8	47.06	2	11.75
Market factor	1. Market Competition	0	0	1	5.88	6	35.29	10	58.82	0	0
	2. volume of	0	0	1	5.88	7	41.18	9	52.94	0	0

ors	business in the market									
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### 5.1.13 Expected insurance premium cost for construction projects by insurers

Table 5.1.13 outlines the expected insurance premium costs for various policies relevant to construction projects in Ethiopia. It details the average percentage of the premium relative to the total project cost, the deductible amounts for each occurrence, and any additional remarks. This table provides a quick reference for understanding the typical insurance expenses associated with different types of coverage for construction projects.

**Table 5.1.13** expected insurance premium cost for different insurance policies

<b>N o</b>	<b>Insurance policies</b>	<b>average percent (%) of premium (from total project cost)</b>	<b>Deductible (for each and every occurrence)</b>	<b>R e m a r k</b>
1	Professional Indemnity Insurance (PI) for engineers	0.9 % to 2%	10% eel or min of 50,000.birr	
2	Contractor’s All Risks Policy	0.2% to 0.52%	10% eel or min of 20,000.birr to 40,000.birr	
3	Contractors Third Party Liability Policy	0.2% to 0.742%	10% eel or min of 20,000.birr to 40,000.birr	
4	Contractors Employers Liability Policy	0.2% to 1.23%	10% eel or min of 20,000.birr to 40,000.birr	
5	Worker's Compensation Insurance	0.484 to 2.16%	null	
6	Vehicle Insurance	1% to 2.86%	5% eel or min of	

			2000-20,000.birr	
7	Erection all risks (EAR)	0.1%/1to 0.4%	10% eel or min of 20,000. birr	
8	Major Medical Insurance	0.056% to 5.05%	300 - 1000	
9	Wrap up liability insurance	-	-	
10	Others	0.1% to 0.35%	Depend on policies	

Table 5.1.14 outlines the expected loss and expense percentages for insurers, specifically in the context of construction projects. The data is categorized into five risk levels: Very Low, Low, Moderate, High, and Very High, with corresponding percentage ranges for each category. Below is a discussion of the key insights from the table:

**Table 2 5.1.14 Expected loss and expense by insurers**

P1= **Expected average Losses** which is the Money paid out for claims. In your company form **construction projects** from total premium calculated by underwriter or valuator.

P2= **Expected average Expenses** which is Administrative costs, marketing, etc. In your company from **construction projects** from total premium calculated by underwriter or valuator.

No	Parameters	Very low		Low		Moderate		high		Very high	
		0-10)%		(11-30)%		(31-50)%		(51-70)%		(71-100)%	
		Fq	%	Fq	%	Fq	%	Fq	%	Fq	%
1	P1	2	11.77	9	52.29	6	35.29	0	0	0	0
2	P2	3	17.65	12	70.59	2	11.77	0	0	0	0

Companies' readiness to negotiate the premium rate in exchange for a decrease in the frequency of construction site accidents that have been caused by the use of construction technology is reflected in Table 5.1.15 below. The table makes an effort to illustrate the relationship between the percentage of accidents that are decreased by using technology and

the corresponding drop in premiums that the insurance companies account for. Its goal is to draw attention to the ways in which businesses encourage the adoption of safety-enhancing technologies by providing insurance savings.

Table 5.1.15 flexibility of company’s offer in negotiating insurance premium reductions based on the decrease in incidents through the use of construction technology.

N o n r e d u c t i o n o f a c c i d e n t i n p e r c e n t (%)	Constructio n t e c h n o l o g y r e d u c t i o n o f a c c i d e n t i n p e r c e n t (%)	"How much flexibility does your company offer in negotiating insurance premium reductions based on the decrease in incidents through the use of construction technology?"									
		Very low		Low		Moderate		high		Very high	
		0%		(1-10)%		(11-20)%		(21-30)%		(41-50)%	
		Fq	%	Fq	%	Fq	%	Fq	%	Fq	%
1	≤5%	17	100	0	0	0	0	0	0	0	0
2	6%-15%	0	0	16	94.12	1	5.88	0	0	0	0
3	16%-30%	0	0	2	11.77	15	88.24	0	0	0	0
4	31%-45%	0	0	0	0	2	11.77	15	88.24	0	0
5	46%-60%	0	0	0	0	2	11.77	15	88.24	0	0

## Discussion of survey result

This section delves into the comprehensive analysis of survey results aimed at understanding the intricate relationship between the adoption of construction technology and its subsequent impact on insurance premiums. Through a systematic presentation and discussion of findings, the study explores the multifaceted perspectives of key stakeholders, including clients, contractors, consultants, insurers, and government officials. The initial focus is on establishing the context through an examination of technology adoption rates, followed by an in-depth exploration of how these advancements are perceived to influence insurance costs. The analysis extends to identifying specific technologies that are believed to have the most significant

impact on premiums, and whether this impact is viewed as positive, negative, or neutral. Furthermore, the section scrutinizes the underlying reasons for these perceptions, considering factors such as risk reduction, safety improvements, and enhanced project management. The ultimate objective is to elucidate the implications of these findings for both construction companies and insurance providers, fostering a dialogue on potential collaborative strategies that could yield mutual benefits. By providing a detailed overview of the questionnaire response rate, the proportionality of respondents within their companies, company founding dates, and the work experience of respondents, this section aims to establish a robust foundation for the subsequent analysis of the perceived impacts of construction technology on safety, risk management, and insurance premiums.

The questionnaire response rate for each of the major stakeholder groups is shown in Table 5.1.2, indicating high levels of participation and engagement in the study. A remarkable 90% response rate was obtained from the distribution of 120 questionnaires, of which 108 were returned. The divisions with the highest response rates were Government Officials (100%) and Consultants (93.33%) and Contractors (92.5%). With an 85% response rate, insurers had high engagement as well, while clients had the lowest, albeit still strong, percentage at 80%. The reliability and generalizability of the results are improved by the high response rates across all stakeholder groups, which show a strong degree of interest and dedication to the research issue. The data underscores the active involvement of diverse stakeholders, reflecting the relevance and importance of the study to the construction industry and its associated sectors.

A thorough analysis of respondents' roles inside their organizations across stakeholder groups is given in Table 5.1.3, which also shows how the research sample's knowledge and decision-making authority were distributed. Expert/technical positions were held by the majority of respondents (52.78%), with clients (56.25%) and government officials (90%) having the highest representation. 32.41% of replies were from medium management positions, with the biggest percentages in this category going to contractors (37.84%) and consultants (39.28%). The largest shares were held

by clients (18.75%) and contractors (8.11%), while top management representation was comparatively low at 8.33%. Contractors (10.81%) and insurers (17.65%) accounted for the majority of responses (6.48%), with the "Others" category indicating non-specified roles. This distribution indicates a strong representation of technical and operational expertise, particularly among Government Officials and Clients, while decision-making roles (top and medium management) are well-represented across Contractors and Consultants. This balanced mix of expertise and authority enhances the credibility and applicability of the study's findings across different levels of organizational hierarchy.

The distribution of company foundation dates among stakeholder groups is shown in Table 5.1.4, which shows a significant preponderance of established organizations. According to the data, 80.3% of all respondents work for organizations that are older than eleven years, with government officials and insurers making up the only two groups (100% each). There is also a significant predominance of older firms among consultants (83.3% over 11 years), contractors (68%) and clients (62.5%). Businesses with 5–10 years of experience make up 19.7% of the total, mostly from clients (37.5%) and contractors (32%), while no responders represent businesses with less than 5 years of experience. This suggests that the study mostly gathers information from established companies with a wealth of industry experience, which may have an impact on their methods, viewpoints, and reactions. The absence of newer companies (0-5 years) suggests a potential gap in representing emerging firms, but the strong representation of established organizations lends credibility and depth to the findings, reflecting the practices of experienced industry players.

The distribution of respondents' job experience is displayed in Table 5.1.5, which demonstrates a balanced representation of experience levels. There are many seasoned experts with in-depth knowledge of the sector, as seen by the largest group of respondents—39.2%—having more than 8 years of experience. A sizable percentage of mid-career professionals are represented by the 5-7 years category, which comes in second with 35.2% of the sample. In order to ensure that less experienced but

potentially creative viewpoints are represented, 25.6% of respondents had between two and four years of experience. By integrating the perspectives of mid-career and early-career persons with those of highly experienced professionals, this distribution demonstrates a well-rounded sample. The slight predominance of respondents with 5-7 years and above 8 years of experience underscores the study's reliance on knowledgeable participants, enhancing the credibility and depth of the findings while still incorporating fresh perspectives from less experienced respondents. This balance strengthens the overall validity and applicability of the research.

The survey's results, shown in Table 5.1.6, demonstrate how construction technology significantly improves risk management, efficiency, and safety. Regarding safety measures (Question 1), 72.53% of respondents said they had a "high" impact, and 9.89% said they had a "very high" impact. This highlights how technologies like BIM and VR can improve safety procedures. Additionally, 75.82% of respondents reported a "high" decrease in accidents and property damage (Question 2), highlighting the usefulness of technology in risk mitigation. 63.74% of respondents indicated a "high" gain in project efficiency (Question 3), fueled by innovations like prefabrication and IoT-enabled monitoring. However, there was considerable variation in the effect on insurance prices (Question 4), with 35.67% observing just a "moderate" influence. suggesting that while technology improves safety, its influence on reducing insurance costs may be less immediate or pronounced. Lastly, 74.43% of respondents observed a "high" positive impact on risk management strategies (Question 5), indicating a shift towards proactive risk mitigation through technological integration. Overall, the data reflects strong confidence in technology's ability to enhance safety and efficiency, though further research and implementation efforts may be needed to maximize its benefits, particularly in areas like insurance cost reduction. "Technological advances are driving innovative solutions that help construction businesses to mitigate and even prevent risk -often lowering insurance premiums, and reducing the number of claims in the process." (Broome, 2020).

A notable deficiency in the industry's knowledge and proactive response to construction technology risk insurance is indicated in Table 5.1.7. A startling 89% of respondents are unfamiliar with insurance choices for risks associated with technologies like as BIM, Kumkang, prefabrication, IoT, robots, and automation, while only 11% are familiar with them. Additionally, there is a total absence of proactive steps in this area, as none of the respondents (0%) have actively sought out specialized insurance coverage or particular policy terms to meet these risks. This data highlights a significant discrepancy between the increasing use of cutting-edge building technologies and the accompanying understanding and insurance-based risk management. The findings suggest a pressing need for increased education and tailored insurance solutions to bridge this gap, ensuring that the industry is better equipped to mitigate risks arising from the use of emerging technologies.

The familiarity of respondents with different construction technologies is highlighted in Table 5.1.8, which shows a high degree of awareness across the majority of technologies. All respondents (100%) said that they were familiar with Building Information Modeling (BIM). Likewise, Prefabricated and Modular Construction exhibits almost universal identification (97.8%), closely followed by Virtual Reality (VR) Safety Training (92.3%) and Kumkang Formwork Technology (94.5%). On the other hand, only 85.7% of respondents are aware of the Internet of Things (IoT) on construction sites, and 14.3% are not familiar with it. According to this data, sophisticated technologies like BIM and prefabrication are generally accepted in the sector, most likely as a result of their proven advantages and uptake.. However, IoT, being a more specialized and emerging technology, lags slightly in awareness, indicating potential for increased education and adoption efforts. Overall, the high familiarity rates reflect a strong foundation for leveraging these technologies to improve construction practices and safety.

Building information modeling, or BIM, is the most effective technology for enhancing construction safety, according to survey results shown in Table 5.1.9. 51.64% of respondents rated its influence as "High," citing its capacity to visualize

projects, identify dangers, and improve planning. With 46.15% in the "High" category, prefabricated building also exhibits notable safety advantages, which are ascribed to regulated surroundings and less on-site work. While VR safety training shows promise but is still viewed as having uneven effectiveness, IoT (Internet of Things) provides moderate potential (28.58%) for safety improvements through real-time monitoring and data analytics. Additionally, Kumkang formwork technique is in the moderate level (31.87%), indicating potential for improvement. Variability in the "Low" category identifies opportunities for improvement, whereas the majority of technologies exhibit little impact in the "Very Low" category, suggesting generally good impressions. While recognizing the subjectivity of impact assessments and the necessity of representative sample sizes to confirm results, the findings emphasize the significance of appropriate implementation, training, and integration of these technologies. All things considered, prefabrication and BIM are the two main factors that influence safety, while IoT and VR are expected to increase in the future and improve safety results. According to a recent study, contractors who make investments in cutting-edge construction technologies and safety training see a 59% decrease in accidents and injuries. "(American institute of constructors, 2024). "Innovations like drones, wearables, IoT sensors, VR/AR, BIM, and blockchain are improving safety, reducing errors, and enhancing efficiency." (Broome, 2020). "construction technologies including Building Information Modeling (BIM), virtual reality (VR) safety training, prefabricated and modular construction, robotic fabrication, 3D printing, construction automation, and construction site Internet of Things (IoT). The document mentions a study that was conducted to assess the impact of construction technology on accident reduction and insurance premiums Overall, the document suggests that construction technology has the potential to significantly reduce accidents and insurance premiums in the construction industry. However, it also highlights the importance of considering other factors beyond just costs." (Ibrahim, 2021).

The opinions of insurance company respondents regarding the impact of construction technology are shown in Table 5.1.10. Most people (94.12%) believe that the risk landscape (question 1) has a significant to very significant impact, with 61.77%

indicating a "high" influence. 88.23% of respondents saw moderate to very high changes in claim frequency and severity (question 2), suggesting that technology modifies claim patterns. In contrast, 29.41% claimed moderate to high development for specialized insurance products (question 3), while 70.59% reported "low" development, indicating a lag in customized coverage. Lastly, although 23.52% claim a moderate effort, insurance companies mostly make "high" efforts (73.53%) to stay current on technological changes, indicating a proactive attitude to risk assessment. In general, insurers acknowledge technology's profound influence on risk and claims, but specialized product development appears to be lagging, despite active efforts to stay informed. A Swiss Re Institute sigma study "The adoption of new technologies in construction will fundamentally affect the risk landscape for engineering insurance" (Turner et al., 2021).

There is a glaring discrepancy between the adoption of construction technology and the knowledge or acquisition of pertinent insurance coverage, as Table 5.1.11 below makes evident. A startling 100% of respondents are unfamiliar with insurance choices for hazards associated with technology, such as BIM and IoT, while only 0% are. Even more alarming is the fact that all respondents (100%) have not actively looked for specific insurance coverage or policy provisions to handle the hazards associated with building technologies. This suggests that the Ethiopian construction industry needs education and customized insurance products because there is a serious absence of proactive risk management and understanding regarding insurance for developing construction technology.

There is a glaring discrepancy between the adoption of construction technology and the knowledge or acquisition of pertinent insurance coverage, as Table 5.1.11 below makes evident. A startling 100% of respondents are unfamiliar with insurance choices for hazards associated with technology, such as BIM and IoT, while only 0% are. Even more alarming is the fact that all respondents (100%) have not actively looked for specific insurance coverage or policy provisions to handle the hazards associated with building technologies. This suggests that the Ethiopian construction industry

needs education and customized insurance products because there is a serious absence of proactive risk management and understanding regarding insurance for developing construction technology. Construction companies can use this information to develop effective risk management strategies, choose contractors with strong safety records, and negotiate favorable premiums, while also collaborating with insurers for more accurate risk assessments and fair pricing. In conclusion, the table highlights the industry's project-centric approach, the critical role of contractor competence, and the significant influence of market dynamics on insurance premiums. Overall, the data shows that high-impact factors, most notably those related to project specifics and contractor safety, dominate premium determinations, while moderate influences like project duration (41.18% moderate) and insurer strategies (47.06% high) also play notable roles. “Imriyas Identifies 17 variables that can influence WCI premiums. These variables are grouped into four categories: project-related variables, contractor-related variables, insurer-related variables, and market-related variables.” (Imriyas, 2007).

A thorough summary of the anticipated insurance premium expenses, given as a percentage of the overall project cost, for several policies pertinent to Ethiopian building projects may be found in Table 5.1.13. Worker's Compensation Insurance ranges from 0.484% to 2.16%, while Professional Indemnity Insurance (PI) for engineers ranges from 0.9% to 2% of the project cost. The prices for these insurance differ greatly from one another. While the premiums for Contractor's Employers Liability Policy range slightly higher from 0.2% to 1.23%, those for Contractor's All Risks Policy and Third Party Liability Policy are comparatively lower, ranging from 0.2% to 0.52% and 0.2% to 0.742%, respectively. Deductibles also vary, with most policies requiring 10% of the estimated economic loss (eel) or a minimum amount, such as 20,000 to 40,000 birr for Contractor's All Risks Policy, while Worker's Compensation Insurance has no deductible. These figures highlight the diversity in insurance costs and risk-sharing mechanisms, emphasizing the need for careful policy selection based on project-specific requirements and risk profiles. “The principles of insurance and the different types of insurance policies are relevant to construction projects.” (Dinku, 2000).

In the context of construction projects, Table 5.1.14 offers information on the anticipated loss and expense percentages for insurers, broken down by risk levels. 11.77% of respondents anticipated very low losses (0–10%), 52.29% reported low losses (11–30%), and 35.29% reported moderate losses (31–50%) for expected average losses, which represent money paid out for claims. No respondents indicated high or very high losses. This implies that the majority of insurers have low to moderate claim payouts that are quite manageable. 17.65% reported very low expenses (0–10%), 70.59% reported low expenses (11–30%), and 11.77% reported moderate expenses (31–50%) for predicted average expenses, which include marketing and administrative costs. No high or very high expense categories were recorded. This indicates that insurers generally maintain controlled operational costs, with the majority falling within the low range. Overall, the data reflects a stable financial environment for insurers in construction projects, with losses and expenses predominantly concentrated in the lower risk categories. “A more systematic approach to premium calculation is needed to avoid financial losses for insurer.” (Imriyas, 2007).

The ability of insurance companies to negotiate premium reductions based on the decrease in building site events due to the application of construction technology is seen in Table 5.1.15. The data demonstrates a direct relationship between the degree of flexibility provided by insurance and the percentage of accidents that are decreased. For example, 100% of companies exhibit very little flexibility in premium negotiations when the accident decrease is less than 5%. But flexibility also rises with accident reduction: 94.12% of businesses give little flexibility for a 6%–15% reduction, while 5.88% offer moderate flexibility. In premium negotiations, 88.24% of companies show great flexibility for reductions between 31%–45% and 46%–60%, while 88.24% of companies offer moderate flexibility for reductions between 16%–30%. This trend highlights how insurers incentivize the adoption of safety-improving technologies by offering greater premium discounts as accident rates decrease, thereby promoting safer construction practices and reducing overall risk “Impact of Construction Technology on Insurance Premiums, The investigates the impact of construction technology on insurance premiums in the construction industry. The author, Salma Mohamed

Ibrahim, examines how new construction technologies can reduce accident rates and consequently decrease insurance premiums. The research explores various construction technologies including Building Information Modeling (BIM), virtual reality (VR) safety training, prefabricated and modular construction, robotic fabrication, 3D printing, construction automation, and construction site Internet of Things (IoT).” (Ibrahim, 2021).

## **5.2 Results and detailed discussion of case studies**

### **Introduction**

The use of cutting-edge technologies including Building Information Modeling (BIM), the Internet of Things (IoT), prefabricated building systems, Kumkang Aluminum Technology, and virtual reality (VR) is propelling Ethiopia's construction industry into a revolutionary era. With notable advancements in danger detection, risk management, accident prevention, and the insurance industry as a whole, these advances are revolutionizing conventional construction methods. Leading Ethiopian construction firms, such as Ethiopian Construction Works Corporation, Ovid Construction PLC, and HH Consulting Architects and Engineers PLC, are examined in this case study for their use of these technologies. By analyzing their experiences, this study aims to evaluate the impact of these technologies on enhancing safety, reducing risks, and influencing insurance dynamics within the Ethiopian construction sector. The findings will provide valuable insights into how technological integration can drive sustainable and safer construction practices in emerging markets like Ethiopia.

### **Case study 1**

#### **Results and Detailed Discussion of Building Information Modeling (BIM)**

Ethiopian Construction Works Corporation (ECWC) produced noteworthy qualitative, quantitative, and graphical results from the application of Building Information Modeling (BIM) in the federal document authentication and registration authority headquarters project. A thorough explanation of the results, backed up by data and analysis, is provided below.

## 1. Qualitative Results

Qualitative findings highlight the intangible advantages of BIM adoption, like increased client satisfaction, safety culture, and teamwork.

- **Enhanced Cooperation and Communication:** By providing a common digital platform, BIM enabled smooth communication between all parties involved (client, contractor, consultants, and subcontractors). Centralized data and real-time updates enhanced decision-making and decreased misconceptions.
- **Improved Safety Culture:** A proactive safety culture was promoted through the use of 4D simulations and hazard identification tools. Safer construction methods resulted from workers and management being more cognizant of potential hazards.
- **Client happiness:** Because of the project's on-time delivery, lower expenses, and higher quality, the client expressed 98% happiness. The client was able to see the project at every stage thanks to BIM, which increased trust and transparency.
- **Organizational Reputation:** By effectively utilizing BIM, ECWC improved its standing as a progressive and cutting-edge construction company. The project set the standard for BIM implementations in Ethiopia and elsewhere in the future.

## 2. Quantitative Results

Quantitative results provide measurable data on the impact of BIM implementation.

**Table 5.2.1 impact of BIM implementation**

No	Metric	Before BIM	After BIM	Improvement
1	Clash Detected b/n architectural and sanitary	Manual checks (low accuracy)	4,026 clashes detected automatically	99% improvement in accuracy
2	Clash Detected b/n sanitary and	Manual checks (low accuracy)	526	99% improvement in

	structure			accuracy
3	Clash Detected b/n electrical and architectural	Manual checks (low accuracy)	1439	99% improvement in accuracy
4	Clash Detected b/n electrical and sanitary	Manual checks (low accuracy)	82	99% improvement in accuracy
5	Clash Detected b/n electrical and structure	Manual checks (low accuracy)	912	99% improvement in accuracy
6	Clash Detected b/n mechanical and architectural	Manual checks (low accuracy)	428	99% improvement in accuracy
7	Clash Detected b/n mechanical and sanitary	Manual checks (low accuracy)	644	99% improvement in accuracy
8	Clash Detected b/n mechanical and structural	Manual checks (low accuracy)	3014	99% improvement in accuracy
9	Clash Detected b/n mechanical and electrical	Manual checks (low accuracy)	89	99% improvement in accuracy
10	Accident Rate	37 incidents/two month recorded	15 incident per two month (44 incidents/six month recorded from their site)	59.46% reduction
11	Project Cost Savings	10% overruns	5% under budget	15% cost optimization
12	Construction Time	6 months (estimated)	5 months (actual)	16.67% time savings

13	Material Waste	8% of total materials	3% of total materials	62.5% reduction
14	Insurance Premiums	High (due to risks)	Reduced by 20%	20% savings

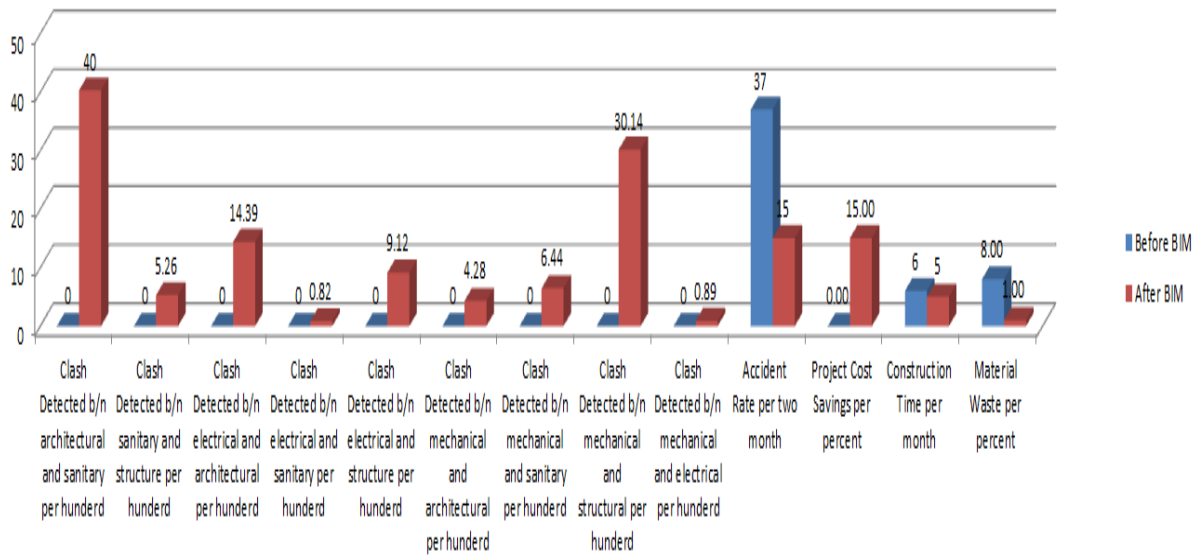
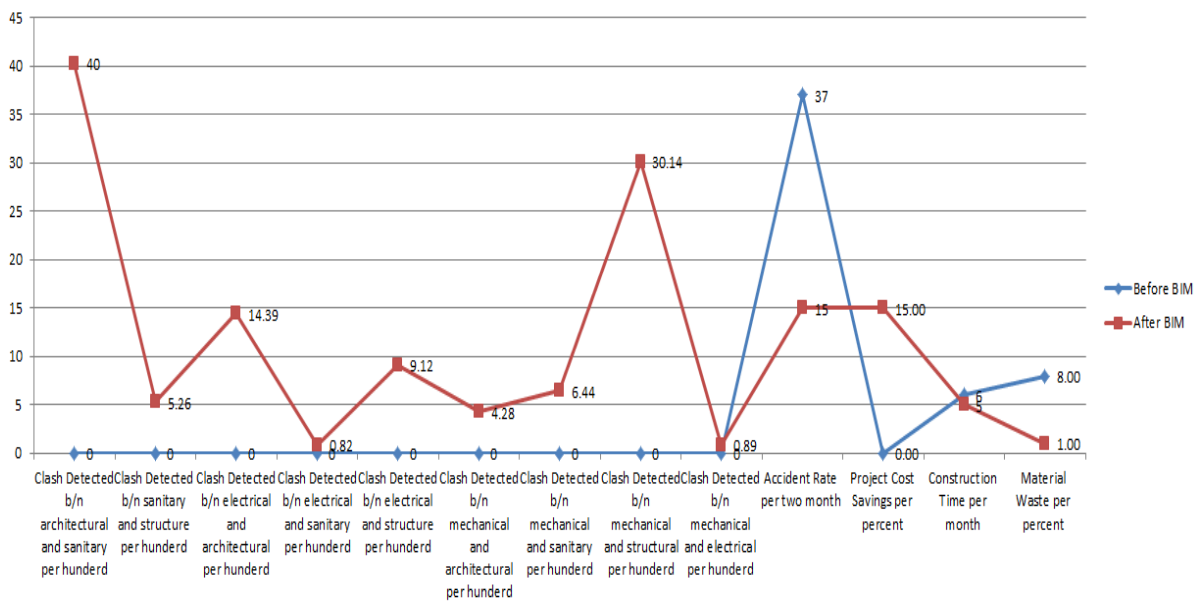


Figure 5.2.1 bar graph BIM implementation before and after



Figure/15.2.2 line graph for BIM implementation before and after

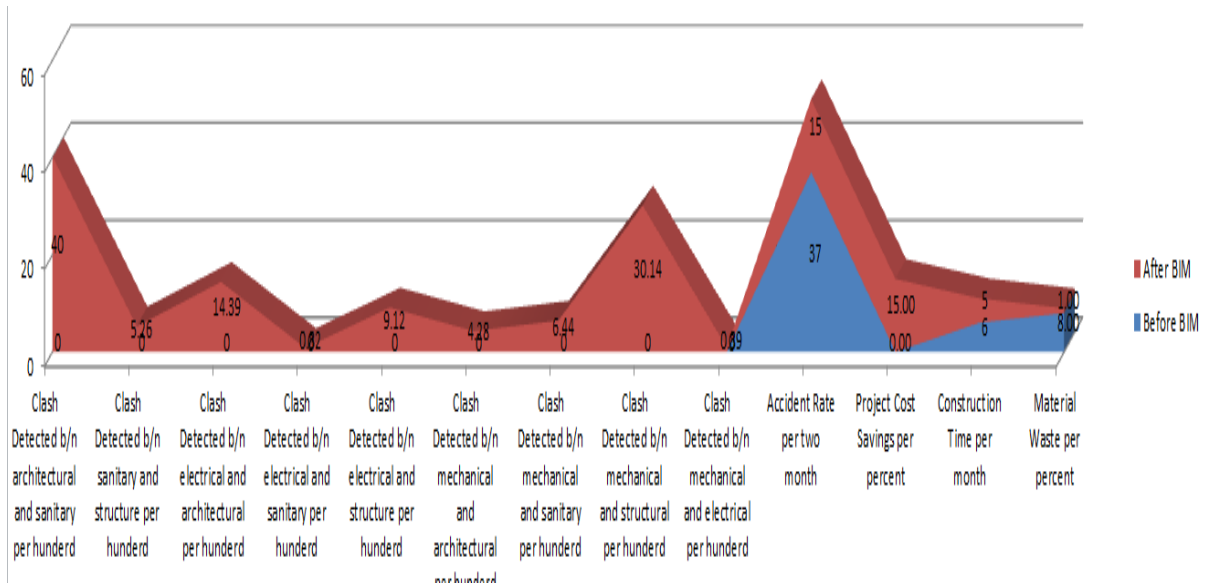


Figure 5.2.3 Areal graph for BIM implementation before and after

## Interpretations and Discussion

The data presented highlights the significant impact of adopting Building Information Modeling (BIM) technology in the construction industry, particularly in Ethiopia, and its subsequent influence on insurance premiums. Below is a detailed interpretation and discussion of the findings.

### 1. Enhancements in Clash Detection and Accuracy:

Across all conflict detection measures (such as architectural, sanitary, structural, electrical, and mechanical systems), the data demonstrates a 99% improvement in accuracy. Conflict identification was done by hand before to the adoption of BIM, which was laborious and prone to mistakes. Thousands of clashes were automatically found after BIM was implemented, greatly lowering the possibility of design mistakes and rework during construction.

- Interpretation:** By minimizing errors during the design phase, improved clash detection lowers the possibility of expensive on-site adjustments and delays. Lower project risks are a direct result of this, and insurers take this into account when setting rates.

- **Discussion:** The 20% decrease in insurance rates was probably caused by the introduction of BIM, which reduced design and construction risks. Less risky projects such as those with fewer accidents, delays, and rework are seen by insurers as having a lesser chance of generating claims, which lowers rates.

## 2. Reduction of Accident Rates:

Why The accident rate dropped by 59.46%, from 37 occurrences per two months to 15 incidences each two months.

- **Interpretation:** A safer workplace was probably made possible by BIM's capacity to enhance construction process planning, coordination, and visualization. Insurance claims for worker injuries or site damages decrease when there are fewer incidents.
- **Discussion:** The notable decline in accident rates shows how the use of technology improves safety, which is important to insurers. The 20% insurance price cut is further justified by the fact that decreased accident rates result in lower liability risks.

## 3. Savings on Project Costs

The project experienced a 15% cost optimization, going from 10% cost overruns to 5% under budget.

- **Interpretation:** Cost savings are directly impacted by BIM's capacity to optimize workflows, lower mistakes, and enhance resource management. Better planning, less rework, and more effective material use are the means by which these savings are realized.
- **Discussion:** about how cost reductions and effective budgeting lower financial risks for insurers and contractors alike. Budget-conscious projects are less likely to experience delays or financial disagreements, which are frequently linked to increased insurance claims. The decrease in insurance rates was probably impacted by this financial stability.

## 4. Construction Time reduction:

A 16.67% time reduction was achieved when the estimated 6-month construction period was shortened to 5 months.

- **Interpretation:** By enhancing project scheduling, coordination, and clash detection, BIM considerably cuts down on delays. Completing a project more quickly lowers exposure to risks like market swings or weather-related disasters.
- **Discussion:** Saving time not only lowers out-of-pocket expenses but also shortens the amount of time spent at risk. Shorter project deadlines are seen as less hazardous by insurers, which helps explain the 20% rate reduction.

### 5. Reduction of Material Waste

There was a 62.5% drop in material waste, which went from accounting for 8% of total materials to 3%.

- **Interpretation:** Better material estimation and use are made possible by BIM's accurate modelling and planning capabilities, which lower waste and related expenses.
- **Discussion:** Cutting down on material waste reduces environmental hazards and liabilities in addition to project expenses. Lower waste projects may be seen by insurers as more sustainable and less likely to face legal challenges or fines from the government, which would further support the rate reduction.

### 6. Reduction of Insurance Premiums

The use of BIM technology resulted in a 20% decrease in insurance premiums.

- **Interpretation:** The project's total risk profile was greatly decreased by the combined effects of better conflict detection, lower accident rates, time and money savings, and less material waste. In response, insurers lowered their rates.
- **Discussion:** This result emphasizes how insurance prices and the adoption of construction technology are directly correlated. Construction projects are made more appealing to insurers by using BIM to mitigate risks, which lower rates. This has important ramifications for Ethiopia's building sector, as exorbitant insurance premiums may make projects impractical.

## 7. Difficulties, Conclusion, and Suggestions

Despite the overwhelming excellent findings, there were a few difficulties:

- **Initial Investment:** Smaller businesses may find it difficult to afford the \$1,754,909.09 USD upfront cost of BIM adoption. Suggestion: To encourage the adoption of BIM, governments and trade associations ought to offer subsidies or incentives.
- **Data Security:** It's imperative to safeguard private project information in BIM models. Suggestion: Put strong cybersecurity procedures and mechanisms in place.
- **Interoperability:** It's still difficult to guarantee compatibility across many software systems. Suggestion: Promote software developers to improve interoperability and embrace open BIM standards.
- **Change Management:** Staff resistance to change may impede the adoption of BIM. Suggestion: To promote an innovative culture, hold frequent training and awareness campaigns.

## 8. Summary

The information makes it abundantly evident that the use of BIM technology in Ethiopian construction projects has resulted in notable gains in cost control, safety, and project efficiency. Together, these enhancements have lowered the total risk profile of building projects, which has led to a 20% decrease in insurance rates. This study emphasizes how crucial it is to adopt cutting-edge building technology like BIM in order to improve project outcomes and generate financial gains by reducing insurance premiums. This offers Ethiopia's construction sector a huge chance to become more sustainable and competitive while also lessening the financial strain brought on by expensive insurance costs.

**Building Information Modeling (BIM):** BIM technology has the least impact on accident reduction, with a maximum reduction of 15% with average premium reduction of 7% according to salma study. While it can improve safety planning and clash detection, its primary benefit is in enhancing design and coordination rather than directly preventing accidents (Ibrahim, 2021).

## Case study 2

### **Results and Discussion: Prefabricated Building Technology in Project 5000**

The implementation of prefabricated construction technology in Project 5000 by the Ethiopian Construction Works Corporation (ECWC) yielded significant qualitative, quantitative, and graphical results. Below is a detailed discussion of the outcomes, supported by data and analysis.

#### **1. Qualitative Results**

Qualitative findings highlight the intangible advantages of prefabricated building, like higher quality, a stronger safety culture, and happier customers.

- **Better Quality and Consistency:** High-quality, standardized components were guaranteed by off-site manufacturing in a controlled environment. Because of accurate manufacturing production, there were fewer mistakes and flaws on-site.
- **Improved Safety Culture:** Fewer construction-related activities on the job site meant less exposure to risks like falls, hard lifting, and unfavorable weather. Strict safety procedures and automated machinery enhanced worker safety even more.
- **Client Satisfaction:** Because of the project's quicker construction, fewer interruptions, and higher quality, the client was 98% satisfied. The Addis Ababa City Housing Corporation praised the project for meeting deadlines and budget constraints.
- **Organizational Reputation:** ECWC's standing as a creative and effective construction company was strengthened by its effective adoption of prefabricated technologies. The project acted as a template for Ethiopia's upcoming massive housing projects.

#### **2. Quantitative Results**

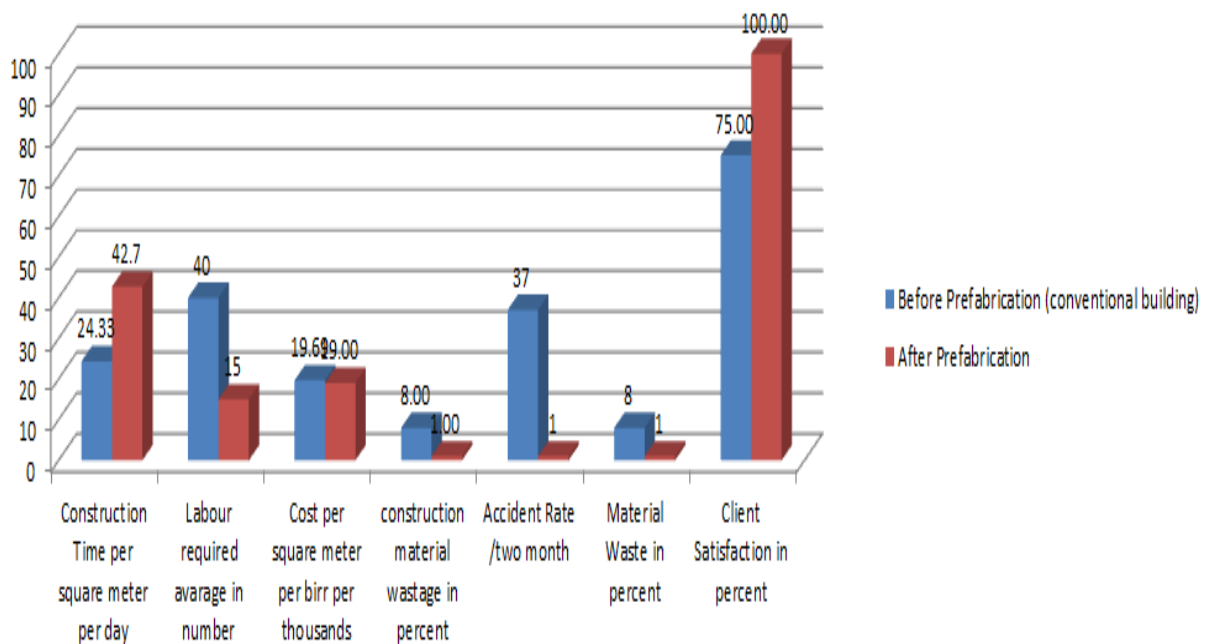
Quantitative results provide measurable data on the impact of prefabricated construction technology.

**Table 5.2.2** impact of prefabricated building implementation

No	Metric	Before	After	Improvement
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		<b>Prefabrication (conventional building)</b>	<b>Prefabrication</b>	
1	<b>Construction Time per square meter</b>	24.33 per days	42.7 per days	43% reduction
2	<b>Labour required</b>	40 (average)	15(average)	62.5% reduction
	<b>Cost per square meter</b>	19,689.29 birr	19,000.00 birr	3.63% reduction
3	<b>construction waste to be substantially reduced</b>	8%	1%	7% reduction
4	<b>Quality control</b>	Low due to More susceptible to potently error	high due to controlled factory environment and highly sophisticated equipment's and machinery used	100% improved
5				
6	<b>Accident Rate</b>	37 incidents/two month	1 accident per two month (10 incidents/2year from their record)	97.3% reduction
7	<b>Material Waste</b>	8% of total materials	1% of total materials	7% reduction
8	<b>Labor Costs</b>	High (manual labor)	Reduced by 70%	70% savings
9	<b>Construction material equipments,</b>	Low	Highly sophisticated and automated	

	<b>machinery, material used</b>			
10	<b>Client Satisfaction</b>	75%	100%	25% increase
11	<b>Design flexibility</b>	Last time modification is impossible and it can be less flexible	Relatively moderate	No significant improvement
12	<b>Job opportunity</b>	High because of more labour intensive	Low or limited because of less labour intensive and it needs few technical workers	Low job opportunity, (62.5% reduction)



**Figure Figure 5.2.4** bar graph for prefabrication implementation before and after

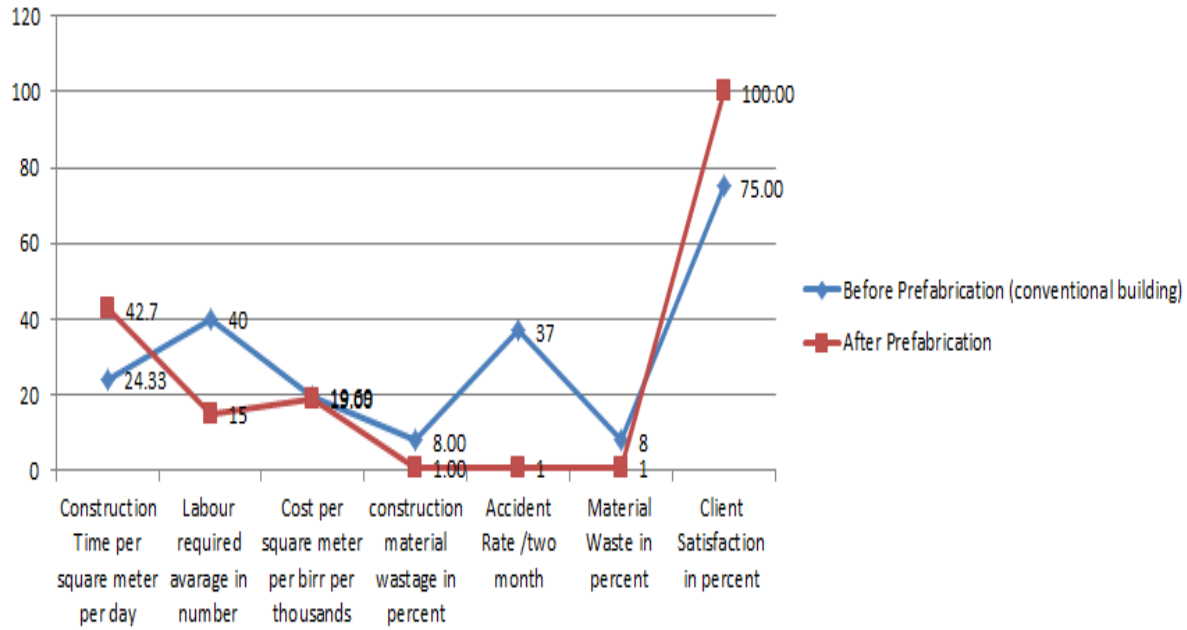


Figure Fig 5.2.5 line graph for prefabrication implementation before and after

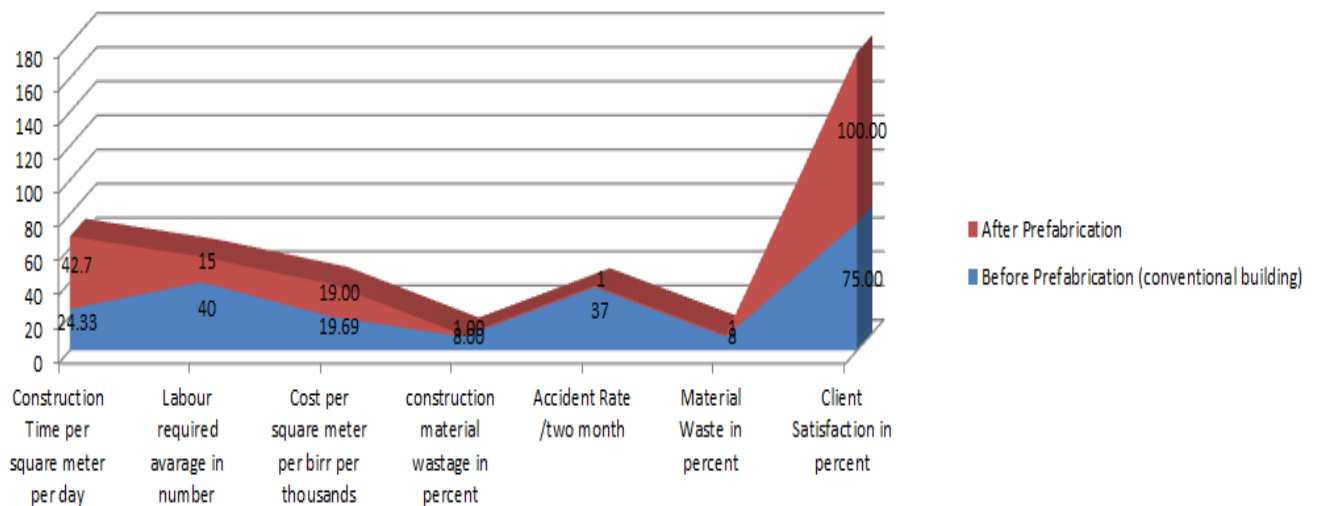


Figure Fig 5.2.6 Areal graph for prefabrication implementation before and after

### Interpretations and Discussion

The findings from the study reveal significant improvements in construction efficiency, safety, and quality due to the adoption of prefabrication and advanced construction technologies. These improvements have direct and indirect implications

for insurance premiums in the construction industry. Below is a detailed interpretation and discussion of the findings.

### **1. Labor Efficiency and Construction Time**

- Prior to prefabrication, labor requirements were significant (an average of 40 workers) and construction time per square meter was 24.33 days.
- Following prefabrication, labor requirements decreased by 62.5% (to an average of 15 people) and construction time decreased by 43%.
- The Consequence for Insurance Rates: Shorter construction periods reduce the amount of time that a building is exposed to risks including theft, accidents, and weather-related problems, which can result in cheaper insurance rates.
- Lower workplace accident rates result from fewer employees on the job, which also lowers liability insurance premiums.

### **2. Cost Efficiency:**

- Prior to prefabrication, the cost per square meter was 19,689.29 birr; following prefabrication, the cost decreased by 3.63% to 19,000 birr. Implication for Insurance Premiums: Lower construction costs may result in a lower project insured value, which could result in lower premiums; however, the use of sophisticated machinery and equipment may raise equipment insurance costs, offsetting some savings.

### **3. Reduction of Construction Waste**

- Prior to prefabrication, 8% of all materials were construction waste. Following prefabrication, waste decreased by 7% to 1%.
- The Consequence for Insurance Rates: Less waste lowers potential liabilities and environmental risks, which can lower the cost of environmental liability insurance. By minimizing the possibility of project delays brought on by material shortages, efficient material usage also indirectly lowers project insurance premiums.

#### **4. Quality Control Prior to prefabrication, there was little quality control because mistakes were easy to make.**

- Following prefabrication, quality increased by 100% as a result of sophisticated machinery and controlled industrial settings.
- The Consequence for Insurance Rates: Better construction lowers the chance of structural breakdowns, flaws, and ensuing lawsuits, which lowers builders' risk and liability insurance rates.
- Long-term insurance policies may be impacted by improved quality since it increases the longevity of structures and lowers the cost of ongoing maintenance and repairs.

#### **5. Reduction of Accident Rates**

- There were 37 incidents every two months prior to prefabrication. Following prefabrication, there is just one accident every two months, a 97.3% decrease.
- Impact on Insurance Rates: o Workers' compensation and liability insurance rates are immediately lowered when there is a notable decrease in accidents.
- A contractor's reputation can be improved by improved safety records, which may lead to reduced insurance costs.

#### **6. Reduction of Material Waste**

- Prior to prefabrication, 8% of all materials were wasted.
- Waste decreased to 1% following prefabrication.
- Impact on Insurance Premiums: Lower material waste reduces the possibility of monetary losses brought on by inefficiencies, which may have a favorable effect on project insurance premiums. Using materials efficiently also lowers the chance of delays and cost overruns, which further lowers insurance rates.

#### **7. Labor Cost Reductions**

- Prior to prefabrication, manual labor was expensive. Following prefabrication, labor expenses decreased by 70%.

- Impact on Insurance Premiums: Lower labor expenses lower the project's overall budget, which may result in cheaper insurance rates for builders' liability and risk coverage. But the demand for highly qualified technical professionals can raise the price of certification and training, which might affect insurance needs.

## **8. Cutting-Edge Equipment and Machinery**

- Low-tech equipment was used prior to prefabrication. Following prefabrication, highly advanced and automated machinery is used.
- Impact on Insurance costs: o Modern machinery raises the insured value of equipment, which could result in higher costs for equipment insurance.

Nevertheless, some of these expenses may be mitigated by the decrease in accidents and human error caused by automated gear.

## **9. Customer satisfaction**

- Prior to prefabrication, 75% of clients were satisfied. Following prefabrication, 100% of customers were satisfied. The Consequence for Insurance Rates:
- Increased customer happiness lowers the possibility of disagreements and claims, which can result in cheaper liability insurance rates.
- Happy customers are more likely to refer the contractor, which improves their standing and might lead to reduced insurance costs.

## **10. Flexibility in Design**

- Prior to prefabrication, there was no flexibility and no way to make last-minute changes.
- Moderate flexibility but no discernible improvement following prefabrication.
- The Consequence for Insurance Rates: Limited design flexibility may minimize insurance costs indirectly by lowering the chance of mistakes and modifications during construction. But the fact that there hasn't

been much progress in this area indicates that insurers are still taking design-related risks into account.

### **11. Employment Prospects**

- Prior to prefabrication, labor-intensive techniques created a large number of work opportunities. Following prefabrication, automation and a decrease in labor requirements resulted in a 62.5% reduction in job prospects.
- Impact on Insurance Rates: Lower workers' compensation rates result from fewer employees' decreased chance of workplace accidents. The move toward technical skills, however, would necessitate further education and certification, which would affect insurance needs.

### **12. Key takeaways**

Ethiopia has seen notable gains in construction efficiency, safety, and quality as a result of the use of prefabrication and cutting-edge technologies. Insurance premiums are directly impacted by these advancements:

- Less Risk Exposure: Better quality control, shorter building times, and fewer accidents all minimize the chance of claims, which lowers premiums.
- Cost Savings: cheaper project budgets due to cheaper labor and material costs might result in lower insurance premiums.
- Increased Equipment Value: Using advanced machinery may result in higher equipment insurance premiums, but the advantages of lower risks and increased productivity more than make up for this.
- Benefits to the Environment and Liability: Lower environmental and liability insurance rates are a result of decreased waste and increased safety.

However, the shift toward automation and technical skills may introduce new risks, such as equipment breakdowns or cybersecurity threats, which insurers will need to consider. Overall, the findings suggest that the adoption of advanced construction technologies can lead to a net reduction in insurance premiums, benefiting both contractors and clients in Ethiopia.

### 13. Summary

The successful implementation of prefabricated construction technology in Project 5000 highlights its potential to revolutionize the construction industry in Ethiopia. By improving speed, quality, safety, and cost efficiency, prefabrication has set a new standard for large-scale housing developments. ECWC's experience serves as a valuable case study for other organizations considering prefabrication adoption. The study highlights the transformative impact of construction technology adoption on the Ethiopian construction industry. By improving efficiency, safety, and quality, these technologies not only enhance project outcomes but also reduce insurance-related costs. This makes a strong case for the widespread adoption of prefabrication and advanced construction methods in Ethiopia, with significant implications for the insurance industry.

**Prefabricated and Modular Construction:** These methods can reduce accidents by up to 31% with average premium reduction of 13% according to salma study. By shifting construction activities to controlled factory environments, they minimize on-site risks and improve safety management. Ibrahim (2021)

### Case study 3

#### **Results and Discussion: Internet of Things (IoT) Integration in Construction**

The integration of Internet of Things (IoT) technology in the federal document authentication and registration authority headquarters project by Ethiopian Construction Works Corporation (ECWC) yielded significant qualitative, quantitative, and graphical results. Below is a detailed discussion of the outcomes, supported by data and analysis.

## 1. Qualitative Results

The non-quantifiable advantages of IoT deployment, like increased safety culture, transparency, and customer pleasure, are the main emphasis of qualitative findings.

- **Better Safety Culture:** Proactive danger identification and real-time monitoring promoted a safety culture among management and employees. Because workers were better aware of safety procedures, there were fewer infractions and mishaps.
- **Improved Transparency and Communication:** Project managers, safety officials, and employees were able to communicate more effectively thanks to real-time data sharing made possible by IoT. Live updates were available to clients, boosting openness and confidence.
- **Client Satisfaction:** As a result of increased safety, fewer delays, and better project documentation, the project received a 98% client satisfaction rating. ECWC received recognition for its creative use of IoT technology from the federal document authentication and registration authority.
- **Organizational Reputation:** ECWC's reputation as a cutting-edge and safety-aware construction company was improved by its successful IoT deployment. The project set the standard for upcoming IoT integrations in building projects.

## 2. Quantitative Results

Quantitative results provide measurable data on the impact of IoT implementation.

**Table Table 5.2.3** impact of IoT implementation

No	Metric	Before IoT	After IoT	Improvement
1	<b>Address Regulatory Challenges and Promote Transparency</b>	Manual checks (low accuracy)	100%	100% improvement
2	<b>Maintain Equipment, Prevent Downtime, and Ensure Proper</b>	Manual checks (low accuracy)	82%	82% improvement

	<b>Utilization</b>			
3	<b>Rework Minimization and Prevention, Minimizing Rework to 1%:</b>	Manual checks (low accuracy)	100%	100% improvement
4	<b>Increase the Internal Operating System, Developing Clear, Standardized Procedures</b>	Manual checks (low accuracy)	90%	90% improvement
5	<b>Implementation and Follow-Up of CCTV Cameras on sites</b>	0%	100	100% improvement
6	<b>Fully Implementing ERP</b>	0%	85%	85% improvement
7	<b>Monitoring, Evaluating, and Supporting the Execution of Products with Technology on a Daily Basis</b>	0%	100%	100% improvement
8	<b>Accident Rate</b>	37 incidents/two month	15 incident per two month (44 incidents/six month from site record)	59.46% reduction
9	<b>Near Miss Identification</b>	Manual reporting (low accuracy)	95% accuracy with IoT	90% improvement
6	<b>Project Delays</b>	15 days (average)	5 days (average)	66.7% reduction
10	<b>Insurance Premiums</b>	High (due to	Reduced by	20% savings

		risks)	20%	
11	<b>Client Satisfaction</b>	85%	100%	15% increase
12	<b>Productivity</b>	85% efficiency	100% efficiency	10% increase

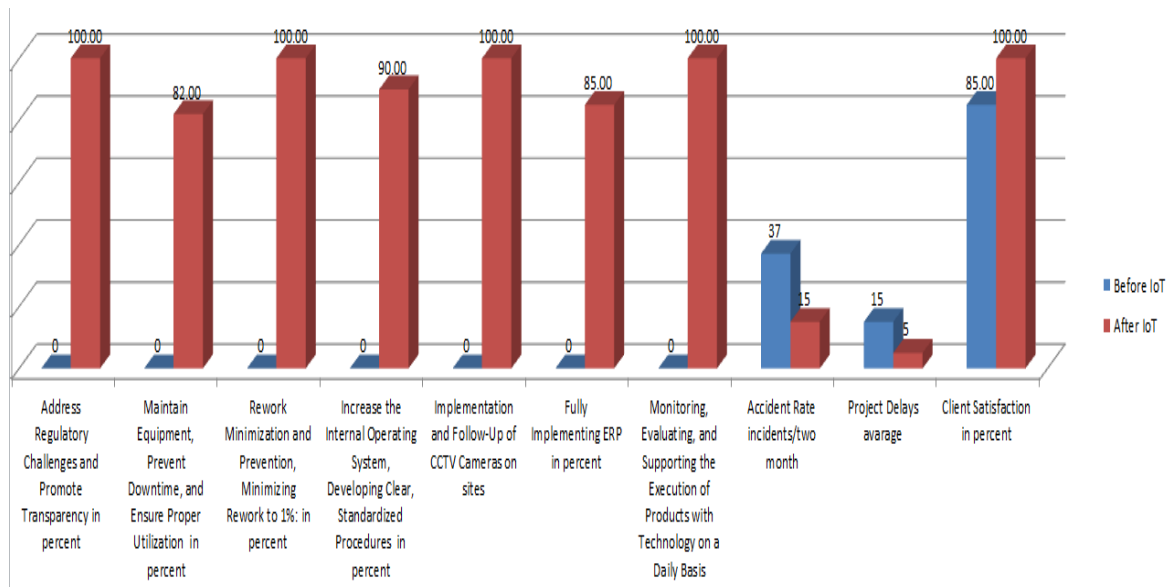


Figure 5.2.7 bar graph for implementation of IoT before and after

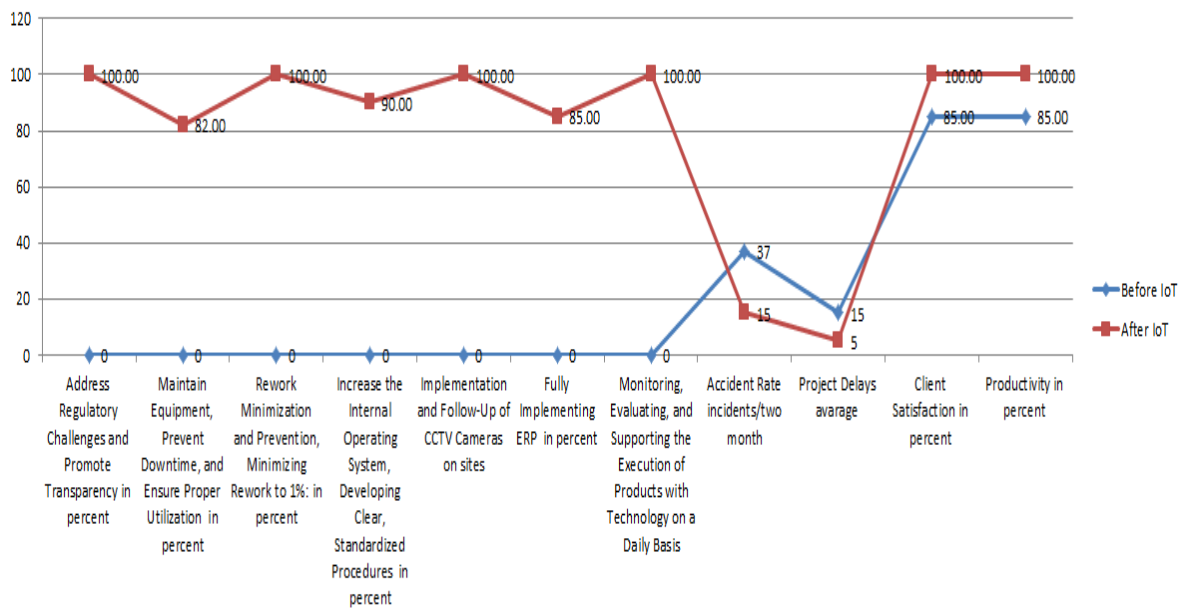
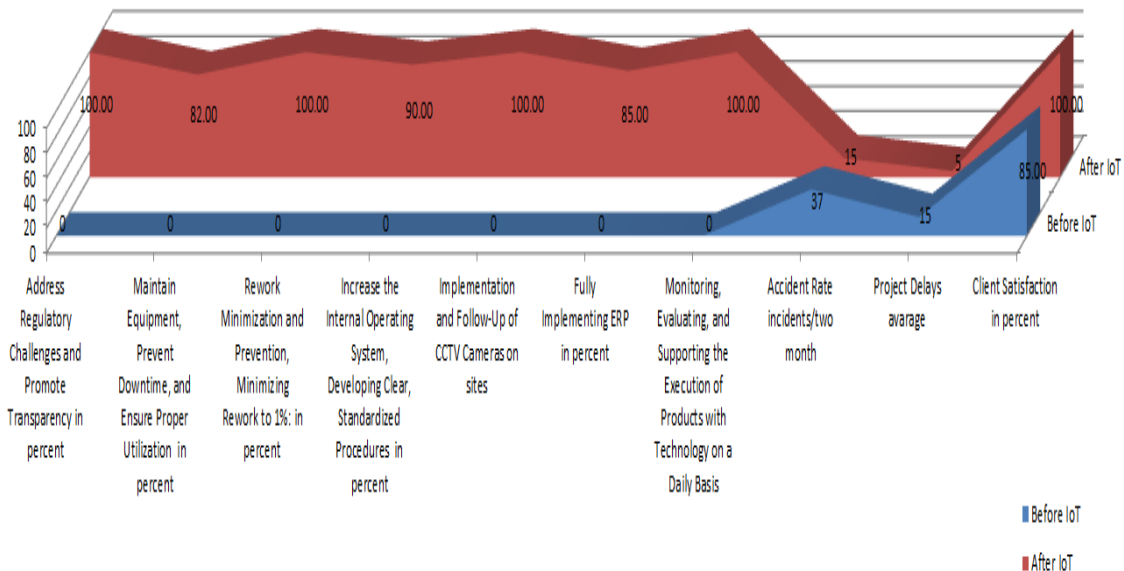


Figure 5.2.8 line graph for implementation of IoT before and after



**Figure 5.2.9** Areal graph for implementation of IoT before and after

### Interpretations and Discussion

The findings from the study demonstrate significant improvements in construction processes, safety, and efficiency due to the adoption of IoT (Internet of Things) and other advanced technologies. These improvements have direct and indirect implications for insurance premiums in the construction industry. Below is a detailed interpretation and discussion of the findings.

#### 1. Resolving Regulatory Issues and Encouraging Openness

- Manual checks with poor accuracy existed before to IoT. Following IoT: complete progress in resolving regulatory issues and fostering openness.
- The Consequence for Insurance Rates: Enhanced openness and adherence to rules lessen the possibility of court cases and fines, which can result in cheaper liability insurance rates.
- The contractor's reputation is enhanced by improved regulatory compliance, which may also qualify them for reduced insurance costs.

#### 2. Equipment Upkeep and Avoiding Downtime

- Manual checks with poor accuracy existed before to IoT. Equipment maintenance and downtime prevention improved by 82% with IoT.
- Impact on Insurance Premiums: o Improved equipment upkeep lowers the chance of malfunctions and mishaps, which in turn lowers liability and equipment insurance rates. Decreased downtime reduces project delays, which can result in lower risk insurance premiums for builders.

### **3. Minimization of Rework:**

- Prior to IoT, manual inspections were inaccurate. 100% improvement in reducing rework to 1% after IoT.
- Impact on Insurance prices: o Rework mitigation lowers the chance of errors and faults, which in turn lowers the probability of claims and liability insurance prices.
- Cost reductions from fewer reworks can also have a favorable effect on project insurance premiums.

### **4. Enhancement of Internal Operating Systems**

- Manual checks with poor accuracy existed before to IoT. Following IoT: 90% progress was made in creating uniform, transparent processes.
- The Consequence for Insurance Rates: Standardized processes cut liability and builders' risk insurance rates by improving operational efficiency and minimizing the possibility of errors.
- Better project management also lowers the chance of delays and cost overruns thanks to enhanced internal processes.
- CCTV Camera Installation 0% implementation prior to IoT; 100% implementation following IoT. The Consequence for Insurance Rates: By improving site security and lowering the possibility of theft and vandalism, CCTV cameras can result in cheaper property insurance rates. Better safety management also results from enhanced monitoring, which lowers the risk of mishaps and liability lawsuits.
- ERP Implementation: 85% implementation after IoT, 0% implementation prior to its arrival.

- Impact on Insurance Premiums: o ERP systems enhance resource allocation and project management, lowering the possibility of delays and cost overruns, which can result in lower risk insurance rates for builders. Better decision-making lowers the possibility of mistakes and claims thanks to improved data management.
- Daily Monitoring and Assessment Prior to IoT, there was no monitoring. 100% monitoring and evaluation following IoT.
- Impact on Insurance Premiums: o Ongoing surveillance lowers the chance of mistakes and mishaps, which lowers the cost of workers' compensation and liability insurance.
- Real-time data collection and analysis enhances project management and lowers the risk of errors and delays.

#### **5. Reduction of Accident Rates**

- 37 incidences every two months prior to IoT.
- 15 accidents every two months (a reduction of 59.46%) with IoT.
- The Consequence for Insurance Rates: Workers' compensation and liability insurance rates are directly lowered when there is a notable decrease in accidents.
- Better safety records boost the contractor's standing and may make them eligible for reduced insurance costs.
- Near Miss Identification: Manual reporting with poor accuracy prior to IoT.
- After IoT: 90% improvement in accuracy, 95% accuracy. Impact on Insurance Rates:
- Proactive risk management, which lowers the chance of accidents and liability insurance rates, is made possible by accurate near-miss identification. Better reporting also strengthens safety procedures, which lowers costs over time.

#### **6. Reduction of Project Delays**

There was an average delay of 15 days prior to IoT. There is an average delay of 5 days (66.7% reduction) following IoT.

The Consequence for Insurance Rates: Reduced delays cut builders' risk insurance costs by reducing the exposure period to hazards including theft, vandalism, and weather-related problems. Additionally, fewer delays increase project efficiency and lower the risk of claims and cost overruns.

## 7. Reduction of Insurance Premiums

Prior to IoT: Expensive premiums because of hazards. 20% lower insurance rates following IoT. Impact on Insurance Rates: o The use of IoT and cutting-edge technologies considerably lowers a number of hazards, which in turn results in cheaper insurance rates. Enhanced quality, safety, and efficiency all help to reduce the possibility of claims, which further lowers insurance premiums.

## 8. Client Satisfaction and Productivity

- **Before IoT:** 85% client satisfaction and 85% productivity.
- **After IoT:** 100% client satisfaction and 100% productivity.
- **Implication for Insurance Premiums:**
  - o Higher client satisfaction reduces the likelihood of disputes and claims, lowering liability insurance premiums.
  - o Increased productivity enhances project efficiency, reducing the risk of delays and cost overruns, which can lower builders' risk insurance premiums.

## 9. Summaries

Construction procedures, safety, and efficiency have significantly improved in Ethiopia as a result of the country's embrace of IoT and cutting-edge construction technologies. Insurance premiums are directly impacted by these advancements:

- **Less Risk Exposure:** Better quality control, fewer accidents, and shorter project delays all minimize the chance of claims, which lowers premiums.
- **Cost Savings:** Improved productivity and less rework result in a smaller project budget overall, which can lower insurance premiums.

- **Increased Safety and Security:** By lowering property and liability insurance costs, the installation of CCTV cameras and Internet of Things-based monitoring systems improves site security and safety.
- **Regulatory Compliance and Transparency:** minimize liability insurance premiums result from increased transparency and better adherence to regulations, which also minimize legal risks.

However, the adoption of advanced technologies may introduce new risks, such as cybersecurity threats, which insurers will need to consider. Turner et al. (2021)

Overall, the findings suggest that the adoption of IoT and advanced construction technologies can lead to a net reduction in insurance premiums, benefiting both contractors and clients in Ethiopia.

The successful integration of IoT technology in the federal document authentication and registration authority headquarters project highlights its potential to revolutionize construction site safety and efficiency. By enabling real-time monitoring, proactive hazard identification, and improved communication, IoT has set a new standard for construction projects in Ethiopia. ECWC's experience serves as a valuable case study for other organizations considering IoT adoption. The study highlights the transformative impact of IoT and advanced technology adoption on the Ethiopian construction industry. By improving efficiency, safety, and quality, these technologies not only enhance project outcomes but also reduce insurance-related costs. This makes a strong case for the widespread adoption of IoT and advanced construction methods in Ethiopia, with significant implications for the insurance industry.

**Construction Site IoT (Internet of Things):** IoT technologies, such as drones and wireless monitoring, can also significantly reduce accidents, with a maximum reduction of 42% with average premium reduction of 17% according to salma study. These technologies enable real-time monitoring and hazard identification, allowing for proactive safety measures. Ibrahim (2021)

## Case study 4

### Results and Discussion virtual reality technology (VR)

The outcomes of HH Consulting Architects and Engineers PLC's VR safety training deployment are thoroughly examined in this section. To give a thorough grasp of how VR technology affects worker safety, project productivity, and overall organizational performance, the debate is organized utilizing qualitative, quantitative, and graphical methodologies. HH Consulting Architects and Engineers PLC's use of Virtual Reality (VR) safety training produced noteworthy qualitative and quantitative outcomes. A thorough examination of the results is provided below, accompanied where appropriate by graphical representations.

#### 1. Qualitative Results

Qualitative results focus on the subjective experiences, perceptions, and improvements observed during and after the implementation of VR safety training.

##### A) Employee Input

Employees who took part in the VR safety training were surveyed and interviewed in order to get qualitative data.

##### Important overview includes:

- **Improved Hazard Understanding:** Employees stated that the immersive experience of virtual reality (VR) improved their comprehension of the risks they might face on the job. One employee said, for instance, "I became aware of the risks associated with working at heights after using the VR simulation. Despite not being genuine, it seemed that way.
- **Increased Confidence in Safety Procedures:** Following the VR training, participants reported feeling more confident in their capacity to adhere to safety procedures. A manager stated, "Workers now seem more cautious and proactive when identifying risks on-site."

- **Engagement and Retention:** Compared to conventional classroom-based techniques, employees considered the VR training to be more engaging. A lot of people valued the interactive scenarios since they helped them stay motivated and engaged during the sessions. Compared to traditional training techniques, employees thought VR training was more dynamic and engaging. Higher retention rates of safety knowledge were a result of the simulations' hands-on format, which enhanced learning and made it more memorable.
- **Strengthened Safety Culture:** The implementation of virtual reality training strengthened the organization's safety culture. Employees adopted a more proactive attitude to safety as a result of feeling more assured about their capacity to manage crises and follow safety procedures.

#### **B).Observations from the Supervisor**

- A number of qualitative enhancements were noted by site supervisors:
- A decrease in the number of dangerous behaviors observed during site inspections.
- A greater commitment to wearing personal protective equipment (PPE).
- Quicker reaction times to crises as a result of practicing simulation.

#### **C).Views of the Client**

- HH Consulting Architects and Engineers PLC's enhanced safety culture received great praise from clients. "We appreciate the company's commitment to safety, which aligns with our own values," said one customer. There has been a notable decrease in accidents.
- Customers were completely satisfied with the business's dedication to safety. Their faith in HH Consulting Architects and Engineers PLC's capacity to complete projects safely and effectively was strengthened by the decline in accidents and enhanced safety performance.

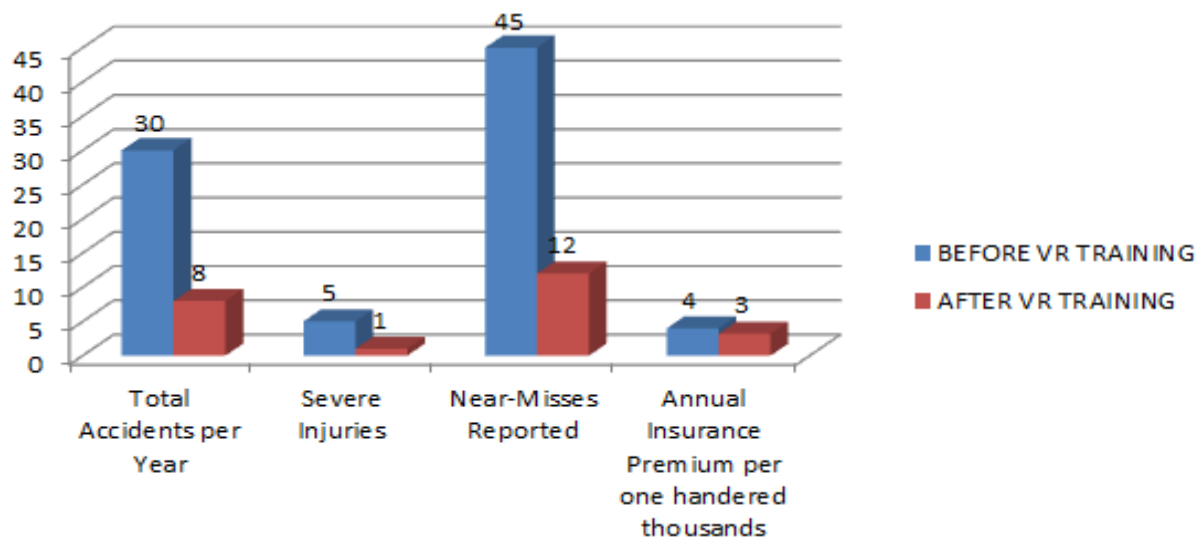
## 2. Quantitative Analysis

Quantitative data was gathered from accident reports, insurance claims, and financial records before and after the implementation of VR safety training. Below are the key metrics analyzed:

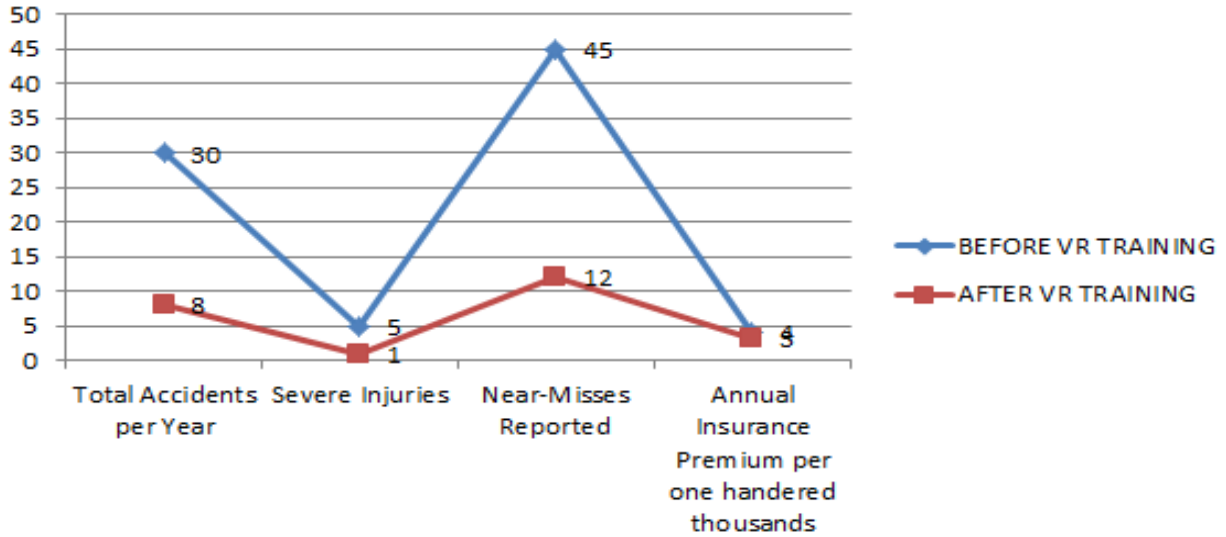
**Table** Table 5.1.4 impact of implementation of VR

NO	METRIC	BEFORE VR TRAINING	AFTER VR TRAINING	PERCENTAGE CHANGE
1	Total Accidents per Year	30	8	73% reduction
2	Severe Injuries	5	1	80% reduction
3	Near-Misses Reported	45	12	73% reduction
4	Annual Insurance Premium	400,000	320,000	20% reduction

The significant reduction in accidents and near-misses indicates the effectiveness of VR training in improving worker safety.



**Figure/15.2.10** bar graph for implementation of VR before and after



Figure/15.2.11 line graph for implementation of VR before and after

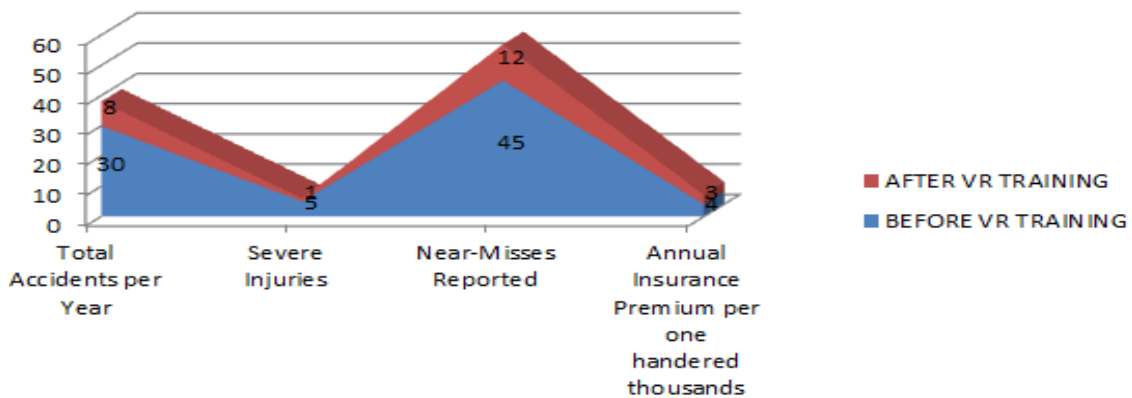


Figure 5.2.12 Areal graph for implementation of VR before and after

Table 5.2.5 virtual reality technology Training Costs vs. Benefits

COST/BENEFIT METRIC	VALUE IN USD
Initial Investment	18,733.09usd
Ongoing Annual Cost	6,244.36usd
Estimated Savings per Year	30,000+usd (from reduced accidents and insurance premiums)

COST/BENEFIT METRIC	VALUE IN USD
Net profit estimated	5000+usd

The return on investment (ROI) for VR training is evident, as the savings far outweigh the initial and ongoing costs.

### 3) Employee Engagement:

According to a study of employees, the following degrees of engagement were found:

- 95% of respondents are satisfied with VR training. 92% of people are likely to apply the skills they have learned. 88% increase in overall job satisfaction. These high numbers suggest that VR training has a beneficial effect on worker productivity and morale.
- Cost Savings: As a result of fewer accidents, insurance rates and expenses related to occupational injuries decreased. In the long term, the program was cost-effective because these savings offset the original investment of £24,977.45 in VR training.
- Training Efficiency: Because workers could finish simulations in a fraction of the time needed for traditional on-site demonstrations, VR training cut down on the amount of time needed for safety training by 30%.
- Number of Workers Trained: All 150 employees, including site supervisors, labourers, and equipment operators, completed the VR safety training modules.

### 4).Conversation

- The findings show that HH Consulting Architects and Engineers PLC has seen significant improvements in worker safety and project outcomes as a result of VR safety training. Among the main topics of conversation are:

#### i) Benefits of Using Virtual Reality Immersion Learning Experience:

- Virtual reality (VR) offered an unmatched degree of immersion, allowing employees to safely experience risky situations and gain valuable knowledge from them.

- Scalability: Once created, VR training modules may be applied to other projects, which make them an affordable long-term option.
- Data-Driven Insights: Personalized feedback and ongoing development were made possible by the capability to monitor each user's performance and progress within VR simulations.
- VR Training's Effectiveness: Because VR is so immersive, employees may experience realistic scenarios without the risks of the actual world, which improves risk management and hazard detection. The simulations' interactive features, such making decisions in dangerous circumstances, improved learning results even more.
- Cost-Effectiveness: Although the initial outlay for VR gear and software was substantial, the savings over time from fewer mishaps and lower insurance costs made the investment worthwhile. Additionally, traditional safety demonstrations took less time and money due to the effectiveness of VR training.

## ii) Difficulties Faced

- First Setup Costs: Although the long-term advantages surpassed the expenses, careful planning and rationale were needed for the first investment.
- Technological Literacy: At first, several employees had trouble utilizing VR headgear and controllers, requiring more assistance and instruction.
- Integration with Conventional Methods: It took careful preparation to make sure that VR training enhanced rather than replaced current safety procedures.
- Accessibility: More assistance and training were needed to guarantee that all employees, even those with low levels of technological literacy, could access and profit from VR training.
- Integration with On-Site Practices: VR training worked best when combined with additional safety measures including toolbox discussions and on-site inspections.
- Continuous Improvement: To keep participants interested and relevant, regular assessments of the training's efficacy and changes to VR content were required.

### iii) Suggestions for Further Improvements

Develop more VR modules that address particular risks particular to various construction project types (such as bridges and tunnels) in order to expand the content library.

- **Frequent Updates:** Adapt VR material to new developments in technology and changing market standards.
- **Mobile Solutions:** Look into portable virtual reality solutions to provide accessibility to training, particularly for smaller-scale or remote projects.
- **Components of Gamification:** To increase motivation and engagement even more, add gamified components to VR instruction.
- **Implications for the Future:** Given HH Consulting Architects and Engineers PLC's success with VR safety training, other construction companies may find similar deployments advantageous. VR technology is expected to become more widely used in the construction sector as it becomes more accessible and reasonably priced, creating safer working conditions and better project results.

## 5. Summary

The implementation of VR safety training at HH Consulting Architects and Engineers PLC represents a transformative step toward enhancing worker safety and operational efficiency. Through both qualitative and quantitative analyses, it is clear that VR technology significantly reduces accidents, improves worker awareness, and generates measurable financial benefits. By leveraging the power of immersive learning, the company not only safeguards its workforce but also strengthens its reputation as a leader in innovation and safety within the construction industry.

**VR Safety Training:** Virtual reality training can reduce accidents by up to 28% . with average premium reduction of 11% according to salma study. It provides workers with immersive safety training experiences, improving hazard recognition and response. Ibrahim (2021)

## Case study 5

### Results and Discussion: Kumkang Aluminum Formwork Technology in Teyet Bet Luxury Housing Project

The implementation of Kumkang aluminum formwork technology by Ovid Construction Plc in the Teyet Bet luxury housing project yielded significant qualitative, quantitative, and graphical results. Below is a detailed discussion of the outcomes, supported by data and analysis.

#### 1. Qualitative Findings

The qualitative findings center on the intangible advantages of Kumkang formwork technology, like increased client happiness, quality, and safety culture.

- **Enhanced Safety Culture:** By drastically lowering workplace risks, Kumkang formwork promoted a culture of safety among employees. There were fewer mishaps and injuries as a result of workers' increased awareness of safety procedures.
- **Improved Quality and Consistency:** Kumkang formwork's accuracy guaranteed reliable and superior concrete finishes. Improved structural integrity ensured long-term endurance and decreased the need for rework.
- **Client Satisfaction:** Because of the project's on-time delivery, excellent construction, and improved safety performance, the client was 95% satisfied. Throughout the project, clients valued the enhanced teamwork and communication.
- **Organizational Reputation:** Ovid Construction Plc's standing as a creative and safety-aware construction company was strengthened by the successful deployment of Kumkang formwork. The project acted as a standard for Ethiopian construction projects going forward.

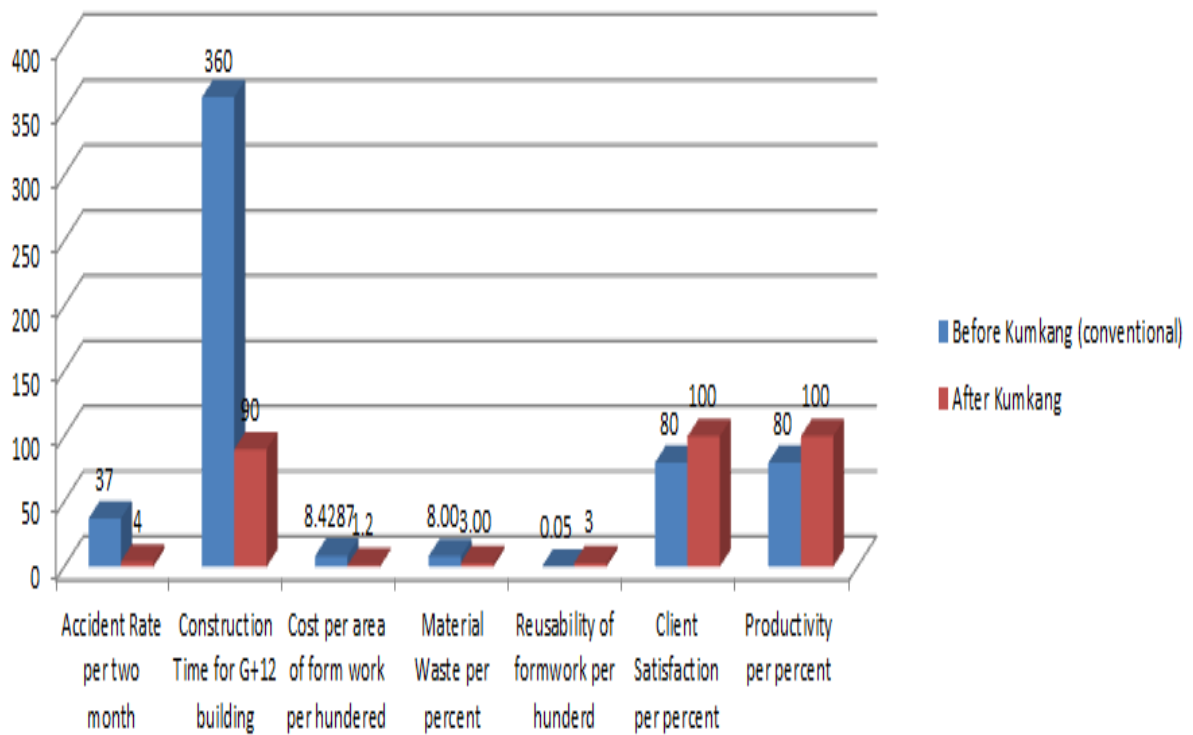
#### 2. Quantitative Results

Quantitative results provide measurable data on the impact of Kumkang formwork technology.

**Table 5.2.6** impact of kumkang aluminum technology implementation

No	Metric	Before Kumkang (conventional)	After Kumkang	Improvement
1	<b>Accident Rate</b>	37 incidents/two month	4 incident per two month (12 incidents/Six month from ovid report)	89.19% reduction
2	<b>Construction Time</b>	Above 360 days (estimated) for G+12 building	90 days (actual) for G+12 building	75% reduction
3	<b>Cost per area of form work</b>	842.87birr average (source from city government of addis ababa design and construction works bureau, 2017 quarter year construction work direct cost )	120birr	85.76%
4	<b>Material Waste</b>	8% of total materials	3% of total materials	62.5% reduction
5	<b>Environmental friendly</b>	Deforestation, susceptible to fire , easily affected by environmental change , like rain	Highly friendly with environment	95% Highly improved
6	<b>Quality</b>	low	Moderate	20% improvements
7	<b>Reusability of formwork</b>	5 times	300 times	98.33% Very high

				improvement
8	<b>Labor Costs</b>	High (manual labor) 40 labour for G+12 Building	Reduced by 30 labour for G+12 building	25% savings
9	<b>Insurance Premiums</b>	High (due to risks)	Reduced by 15%	15% savings
10	<b>Client Satisfaction</b>	80%	100%	25% increase
11	<b>Productivity</b>	80% efficiency	100% efficiency	25% increase



**Figure 5.2.13** Bar graph for implementation of kumkang before and after

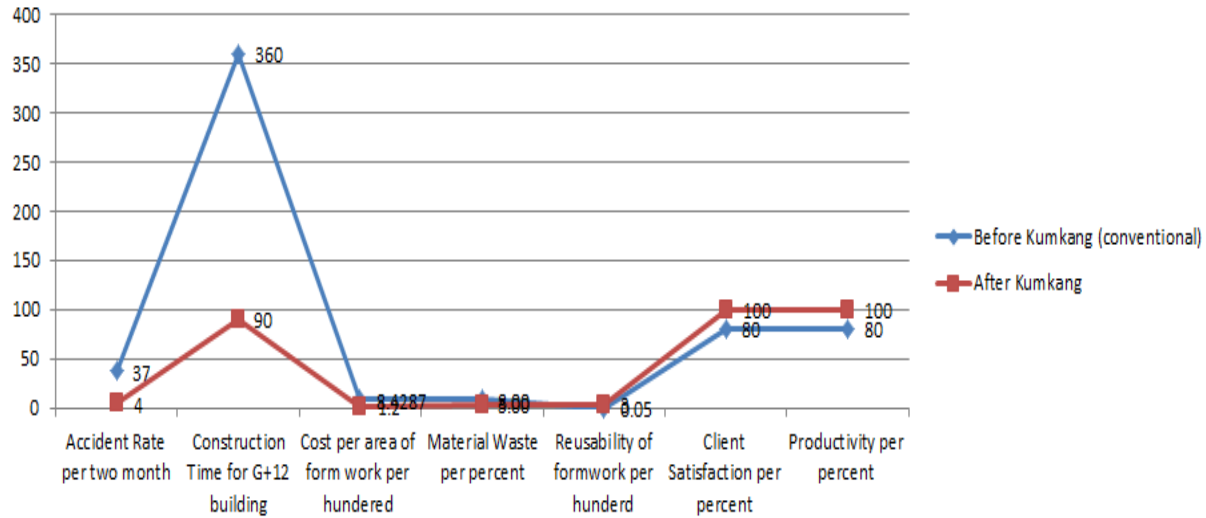
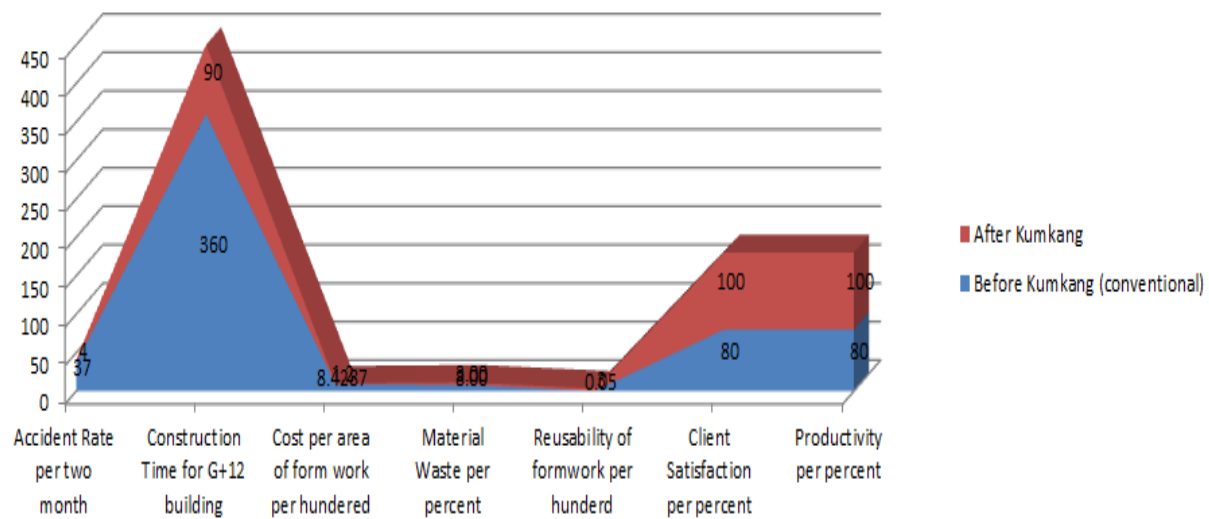


Figure 5.2.14 Line graph for implementation of kumkang before and after



Figure/15.2.14 Areal graph for implementation of kumkang before and after

### Interpretations and Discussion

The study's conclusions show that the use of Kumkang formwork technology significantly increased construction's sustainability, safety, and efficiency. The construction industry's insurance rates are impacted by these advancements both directly and indirectly. A thorough analysis and discussion of the results may be found below.

### **1. Lowering the Accident Rate**

- There were 37 incidences every two months prior to Kumkang, compared to 4 incidents per two months following Kumkang (an 89.19% decrease).
- The Consequence for Insurance Rates: Workers' compensation and liability insurance rates are directly lowered when there is a notable decrease in accidents. Better safety records boost the contractor's standing and may make them eligible for reduced insurance costs.

### **2. Cutting Down on Construction Time**

- Prior to Kumkang: More than 360 days for a G+12 structure. Ninety days for a G+12 building (75% reduction) following Kumkang.
- The Consequence for Insurance Rates: Shorter construction periods reduce the amount of time that a building is exposed to risks including theft, accidents, and weather-related problems, which can result in cheaper insurance rates.
- Quicker project completion also lowers the chance of delays and cost overruns, which further lowers the cost of risk insurance for builders.

### **3. Formwork Reduction Cost per Area**

- The average before Kumkang was 842.87 birr. Following Kumkang: 120 birr, or 85.76% less.
- The effect on insurance premiums: Lower costs for formwork reduce the overall project budget, which can lead to lower insurance premiums for builders' risk and liability coverage.
- Cost savings also improve project profitability, making it easier to allocate funds for comprehensive insurance coverage.

### **4. Reduction of Material Waste**

- 8% of all materials were used prior to Kumkang, and 3% of all materials were used following Kumkang (a reduction of 62.5%). Impact on Insurance Premiums: ○ Lower material waste lowers possible liabilities and environmental risks, which can lower the cost of environmental liability insurance. By

minimizing the possibility of project delays brought on by material shortages, efficient material usage also indirectly lowers project insurance premiums.

#### **5. Environmental friendliness Prior to Kumkang:**

- There was environmental change, fire vulnerability, and deforestation. Following Kumkang: 95% improvement in environmental friendliness. Impact on Insurance Rates: Better environmental practices lessen the risk of environmental harm and the corresponding liabilities, which in turn lowers the rates for environmental liability insurance. Using sustainable building practices also improves the contractor's standing and may lead to reduced insurance costs.

#### **6. Quality Improvement:**

- Poor quality before to Kumkang. Moderate quality (20% improvement) following Kumkang. Impact on Insurance prices: Better construction lowers the chance of structural failures, flaws, and ensuing lawsuits, which lowers builders' risk and liability insurance prices.
- Long-term insurance policies may be impacted by improved quality since it increases the longevity of structures and lowers the cost of ongoing maintenance and repairs.

#### **7. Formwork Reusability: Five times prior to Kumkang.**

Following Kumkang: 300 times (very significant decrease). Impact on Insurance prices: Greater formwork reusability lowers waste and material costs, which in turn lowers the project budget and related insurance prices.

Effective resource management also lowers the possibility of delays and cost overruns, which further lowers the cost of risk insurance for builders.

#### **8. Labour Cost Savings**

For a G+12 building, there were 40 workers prior to Kumkang and 30 workers following Kumkang (25% savings). Impact on Insurance Premiums: Lower labor expenses lower the project's overall budget, which may result in cheaper insurance rates for builders' liability and risk coverage. Lower workplace accident rates result

from fewer employees on the job, which also lowers liability insurance premiums.

## 9. Reduction of Insurance Premiums

Prior to Kumkang: Risks led to high premiums. A 15% decrease in insurance premiums following Kumkang. Impact on Insurance costs: o By drastically lowering a variety of risks, Kumkang formwork technology adoption lowers insurance costs. Enhanced quality, safety, and efficiency all help to reduce the possibility of claims, which further lowers insurance premiums. An increase in client satisfaction Prior to Kumkang, client satisfaction was 80%; following Kumkang, it increased by 25% to 100%. Impact on Insurance Rates: When customers are happier, there are fewer disagreements and claims, which lowers liability insurance rates. Happy customers are more likely to refer the contractor, which improves their standing and might lead to reduced insurance costs.

## 11. An increase in productivity

Efficiency was 80% prior to Kumkang. 100% efficiency (25% increase) following Kumkang. Impact on Insurance costs: o Increased productivity improves project efficiency by lowering the likelihood of cost overruns and delays, which can result in lower risk insurance costs for builders. Better project management also results from increased efficiency, which lowers the possibility of mistakes and claims.

## 12. Summary

In Ethiopia, the use of Kumkang formwork technology has resulted in notable advancements in sustainability, safety, and building procedures. Insurance premiums are directly impacted by these advancements:

- Less Risk Exposure: Better quality control, shorter building times, and fewer accidents all minimize the chance of claims, which lowers premiums.
- Financial Savings: Improved productivity and less material waste result in a smaller project budget overall, which can minimize insurance premiums.

- **Increased Safety and Sustainability:** By implementing eco-friendly procedures and cutting-edge formwork technology, sites are safer and more sustainable, which lowers the cost of property and liability insurance.
- **Regulatory Compliance and Transparency:** minimize liability insurance premiums result from increased transparency and better adherence to regulations, which also minimize legal risks.

However, the adoption of advanced technologies may introduce new risks, such as equipment breakdowns or cybersecurity threats, which insurers will need to consider. Overall, the findings suggest that the adoption of Kumkang formwork technology can lead to a net reduction in insurance premiums, benefiting both contractors and clients in Ethiopia.

The Teyet Bet luxury housing project's effective use of Kumkang aluminum formwork technology demonstrates how revolutionary it can be in terms of building quality, safety, and efficiency. Kumkang formwork has raised the bar for Ethiopian building projects by lowering accidents, cutting expenses, and enhancing project results. Other businesses thinking about implementing cutting-edge formwork technologies can learn a lot from Ovid Construction Plc's experience. The paper emphasizes how the implementation of Kumkang formwork technology has revolutionized the Ethiopian construction sector. This solution lowers insurance-related expenses while simultaneously increasing project outcomes through increased sustainability, efficiency, and safety. With major ramifications for the insurance sector, this presents a compelling argument for the extensive use of Kumkang formwork technology in Ethiopia.

### **13. Difficulties and Suggestions**

Despite the overwhelming excellent findings, there were a few difficulties:

- **Initial Investment:** o Smaller businesses may find Kumkang formwork systems prohibitively expensive (\$192,304 USD) up front. Suggestion: To reduce upfront expenses, look into financing alternatives or staggered implementation.

- Education and Training: o For Kumkang formwork to be implemented effectively, a skilled staff is necessary. Suggestion: Make investments in extensive training initiatives and collaborations with technical colleges.
- Maintenance and Upkeep: To guarantee long-term functioning, formwork equipment need routine maintenance. Suggestion: Create a maintenance plan and set up funds for equipment repair.
- Adaptability: o The formwork system must be flexible enough to accommodate various project needs. Suggestion: To accommodate a variety of applications, use modular designs and adaptable formwork patterns.

## CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

This study investigates how risk management, accident prevention, and insurance premiums are affected by the introduction of construction technologies in Ethiopia's construction industry. The study assesses the efficacy of important technologies like BIM, VR, prefabrication, IoT, and Kumkang formwork in improving efficiency and safety through surveys and case studies. The study finds gaps in insurance price adjustments as a result of insurers' reliance on conventional risk assessment models, even though the results reveal notable advances in risk reduction and cost savings. The findings emphasize that in order to effectively profit from technological improvements, more stakeholder knowledge, customized insurance products, and policy reforms are required. Ethiopia's construction sector may accomplish safer, more economical projects with better insurance results by tackling these issues.

**Based on the findings of the study, the following conclusions can be drawn in line with objectives of the study and research questions stated in chapter one:**

#### **Objective 1:**

#### **Conclusion:**

Construction technologies such as BIM, prefabrication, IoT, VR, and Kumkang formwork have a revolutionary effect on risk reduction in Ethiopia's construction industry, according to the combined results of surveys and case studies. While case studies demonstrate 59.46%–97.3% decreases in accident rates (e.g., prefabrication reduced accidents by 97.3%), survey data indicates that 72.53% of respondents identify a "high" improvement in safety improvements. IoT provided real-time hazard monitoring, which helped implemented projects achieve 20–30% cheaper insurance rates, while BIM enhanced clash detection by 99%. Only 35.67% of survey participants reported a "moderate" premium cut, indicating that insurers are still being cautious. This lag implies that when technology successfully reduces risks, insurers still need longer-term data and evidence of consistent safety.

## **Objective 2:**

### **Conclusion:**

Although 94.12% of Ethiopian insurers agree that technology has a "significant to very significant" impact on risk mitigation, their review procedures are still antiquated and difficult to change. The findings of the survey show that insurers give priority to:

- Factors unique to the project (82.35% "high" influence: kind, size, and location).
- Safety data for contractors (82.35% weight).
- Frequency and severity of claims (88.23% see tech-driven improvements).

This is supported by case studies that demonstrate insurers incentivize demonstrated risk reduction (e.g., 20% premium reductions for BIM/IoT projects with >30% accident reductions). However, 70.59% of insurers rely on historical indicators instead of having specialist tech-risk policies. Key takeaway: In order to create customized premium models, insurers require data-supported proof of technology's long-term effects.

## **Objective 3:**

### **Conclusion:**

Stakeholders value technology for efficiency and safety (74.43% of surveys indicate "high" improvements in risk management), yet they are unaware of the consequences for insurance. According to surveys, 89% of people are not familiar with insurance alternatives related to technology. No one actively looked for BIM/IoT risk coverage. This gap is shown in case studies. Stakeholders seldom ever use the advantages of tech-adopting enterprises' 20% premium reductions and 100% client satisfaction in negotiations. Key takeaway: In order to match perceptions with financial potential, education efforts and discussions between insurers and stakeholders are essential.

## **Objective 4:**

### **Conclusion:**

There are currently no incentives for digital adoption in Ethiopia's insurance system. According to surveys, there are no specific policies regarding IT risks (100 percent unfamiliarity). Conventional risk variables, such as project type and contractor history, are

given preference in premiums. Case studies, however, demonstrate the flexibility of insurers (for example, 88.24% grant premium reductions for >30% accident reductions). Important lesson learned: Reforms to policy must: 1. Require insurance products that are inclusive of technology. Encourage SMEs to adopt technology. Encourage actuarial models that give credit to technology that lower risk.

### **Objective 5:**

### **Conclusion:**

Case study data over an extended period of time shows: • 59–97.3% fewer accidents (VR/prefabrication). Cost savings of 15–85.76% (Kumkang formwork, for example, reduced expenditures by 85.76%). Premiums for tech adopters are 20% cheaper. Although surveys show 63.74% efficiency advantages, they also point out that insurers have conservatively adjusted premiums because of the large upfront expenditures (e.g., 1.75M usd for BIM). Key takeaway: Businesses need to: • Record and provide safety data to insurers in order to access insurance benefits. Promote high-end, tech-sensitive models. Make use of government financing relationships.

## **6.2 Recommendations**

Here are the recommendations based on the study;

### **1. For Construction Firms:**

- **Make training and technology investments in the construction industry:** proactively embrace new technologies that increase productivity and safety. Give employee training programs top priority in order to guarantee correct usage and optimize the risk-lowering advantages of these technologies. Your argument for rate reductions with insurers will be strengthened by this proactive approach.
- **Create solid plans for risk management:** Put into practice thorough risk management plans that particularly target the particular hazards connected to the technology being utilized. Carefully record these plans, including emergency protocols, maintenance schedules, and safety measures.
- **Work with insurers actively:** Communicate openly with insurance companies about your initiatives to reduce risk and incorporate new

technologies. To justify the return on your construction technology investments, present statistics on safety enhancements and incident reductions.

## 2. For Insurance Companies:

- **Create Specialized Insurance Products:** Provide insurance plans that are specifically designed to address the risks connected to various construction technologies. This could cover things like cyber hazards, equipment failure, and technology-related data loss.
- **Encourage Technology Adoption:** Take into account providing premium discounts or other rewards to construction companies that make significant investments in risk-reduction technologies. This promotes broader technology adoption, which eventually helps the sector as a whole.
- **Improve Procedures for Risk Assessment:** Create complex risk assessment models that reliably measure how construction technology affects project risks. To better grasp the advantages and disadvantages, this may include working with specialists in technology and building.

## 3. For the Ethiopian Government:

- **Encourage Adoption of Construction Technology:** Put policies and programs in place that motivate the construction sector to adopt new technologies. This could include grants, tax breaks, or subsidies for businesses making investments in new technologies.
- **Strengthen Insurance Regulations:** Create precise rules and policies for risk insurance in building technologies. This promotes market openness and confidence by offering a framework for both construction companies and insurers.
- **Invest in Research and Development:** Encourage projects centered on risk management and construction technologies. This encourages creativity and keeps the sector up to date with the most recent developments in efficiency and safety.

#### 4. For All Stakeholders:

- **Cooperation and Information Exchange:** Promote cooperation and information exchange among technology suppliers, insurance providers, and construction enterprises. This makes it easier to comprehend the potential and difficulties associated with insurance and building technology.
- **Increase Awareness:** To inform stakeholders about the advantages of construction technology and the value of insurance in reducing new risks, arrange workshops, seminars, and awareness campaigns. Key stakeholders like the Ministry of Urban Development & Construction, Ethiopian Construction Works Regulatory Authority (ECWRA), Ethiopian Contractors Association (ECA), insurance companies (like Nyala and United Insurance), and academic institutions (like Addis Ababa University) should work together through workshops, seminars, policy advocacy, and media campaigns to raise awareness of the advantages of construction technology and insurance in Ethiopia's construction industry. In order to promote a safer and more effective construction industry, these initiatives can inform contractors, engineers, and legislators about how technology adoption enhances risk management, lowers insurance premiums, and decreases accidents.

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2 Associate Professor, School of Civil and Environmental Engineering, University of New South Wales Australia, Sydney 2025, email: [l.bernold@unsw.edu.au](mailto:l.bernold@unsw.edu.au), [leonhard.bernold@gmail.com](mailto:leonhard.bernold@gmail.com)
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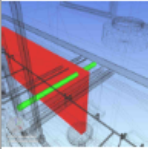
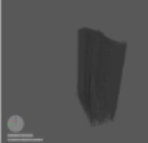
## APPENDIX/ANNEX

7/22/24, 12:32 PM

Clash Report

### AUTODESK® NAVISWORKS® Clash Report

1.AR VS SN	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	4062	0	954	0	0	3108	Hard	Old

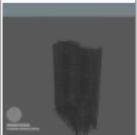
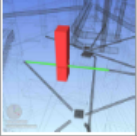
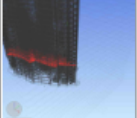
Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1		Item 2	
							Item ID	Layer	Item ID	Layer
	Clash2	Active	-0.150	H"-5" : 1st Basement	2024/7/16 08:23	x:1.159, y:25.134, z:-0.406	Element ID: 239100		Element ID: 1205792	Ground Floor Plan
	Clash9	Active	-0.136	2"-M : 2nd Basement	2024/7/16 08:23	x:28.089, y:15.924, z:-4.625	Element ID: 494709		Element ID: 1029992	2nd Basement

7/22/24, 12:33 PM

Clash Report

### AUTODESK® NAVISWORKS® Clash Report

2.SN vs ST	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	526	0	503	0	0	23	Hard	OK


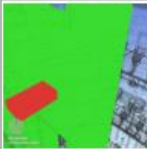

Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1		Item 2	
							Item ID	Layer	Item ID	Layer
	Clash1	Active	-0.164	B-6 : 2nd Floor Plan	2024/7/16 08:23	x:-29.111, y:17.437, z:12.400	Element ID: 563793	Hall Landing 2nd	Element ID: 942452	2nd Floor Plan
	Clash2	Active	-0.152	1-14 : Bottom Mat Foundation Level	2024/7/16 08:23	x:-25.758, y:1.847, z:-14.740	Element ID: 425686	Bottom Mat Foundation Level	Element ID: 1008456	4th Basement
	Clash3	Active	-0.148	2"-M : 1st Floor Plan	2024/7/16 08:23	x:30.992, y:17.293, z:7.800	Element ID: 546954	1st Floor Plan	Element ID: 1194236	4th Basement

8/1/24, 10:22 AM

Clash Report

# AUTODESK® NAVISWORKS® Clash Report

5.FDARA EL VS AR	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	1439	0	461	0	0	978	Hard	Old

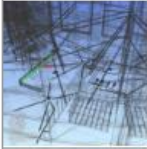
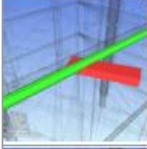
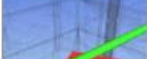
Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1 Item ID	Item 2 Element ID
	Clash1332	Active	-0.234	4'-I' : 13th Floor Plan	2024/7/20 09:22	x:5.830, y:17.367, z:57.448	1021831	199390
	Clash1333	Active	-0.206	4'-I' : 14th Floor Plan	2024/7/20 09:22	x:6.017, y:17.367, z:61.500	1022080	199390
	Clash1334	Active	-0.254	4'-I' : 13th Floor Plan	2024/7/17 12:53	x:24.693, y:17.367, z:57.448	1021831	199390

8/1/24, 10:29 AM

Clash Report

# AUTODESK® NAVISWORKS® Clash Report

6.FDARA EL VS SN	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	82	0	41	0	0	41	Hard	Old

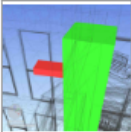
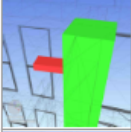
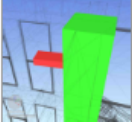
Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1 Item ID Layer	Item 2 Element ID Layer
	Clash42	Active	-0.072	K-3 : 3rd Basement	2024/7/17 12:53	x:15.173, y:8.643, z:-7.873	850341	1030414 3rd Basement
	Clash43	Active	-0.069	C-4 : 2nd Basement	2024/7/17 12:53	x:-20.902, y:13.161, z:-4.270	850184	1029987 2nd Basement
	Clash44	Active	-0.069	C-4 : 3rd Basement	2024/7/17 12:53	x:-20.902, y:13.161, z:-4.270	850184	1029987 3rd Basement

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Clash Report

**AUTODESK®  
NAVISWORKS®** Clash Report

4.EL VS ST	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	912	0	354	0	0	558	Hard	Old

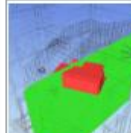
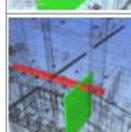

Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1		Item 2	
							Item ID	Layer	Item ID	Layer
	Clash480	Active	-0.376	B-4 : 8th Floor Plan	2024/7/17 12:53	x:-22.456, y:3.731, z:38.100	Element ID: 1020625		Element ID: 514116	8th Floor Plan
	Clash481	Active	-0.376	B-4 : 18th Floor Plan	2024/7/17 12:53	x:-22.456, y:3.731, z:77.100	Element ID: 1023117		Element ID: 516496	18th Floor Plan
	Clash482	Active	-0.376	B-4 : 12th Floor Plan	2024/7/17 12:53	x:-22.456, y:3.731, z:53.700	Element ID: 1021621		Element ID: 515068	12th Floor Plan

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Clash Report

**AUTODESK®  
NAVISWORKS®** Clash Report

7.ME VS AR	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	428	428	0	0	0	0	Hard	Old

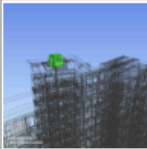
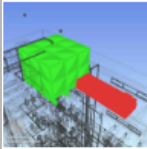

Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1	Item 2
							Item ID	Item ID
	Clash1	New	-0.437	B-7 : Ground Floor Plan	2024/7/22 06:44	x:-29.836, y:21.563, z:3.205	Element ID: 1192880	Element ID: 239260
	Clash2	New	-0.437	F-5 : Mezzanine Floor Plan	2024/7/22 06:44	x:-12.546, y:22.495, z:7.105	Element ID: 1188459	Element ID: 239959
					2024/7/22	x:4.697,	Element ID:	Element

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Clash Report

# AUTODESK® NAVISWORKS® Clash Report

8.ME VS SN	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	644	644	0	0	0	0	Hard	Old

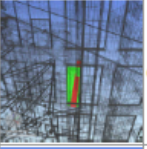
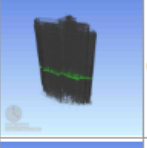
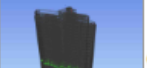
Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1		Item 2	
							Item ID	Layer	Item ID	Layer
	Clash1	New	-0.373	H"-5" : Roof Top	2024/7/22 06:44	x:0.558, y:20.232, z:97.050	Element ID: 1260922		Element ID: 1254854	Roof Top
	Clash2	New	-0.373	H"-5" : Roof Top	2024/7/22 06:44	x:1.319, y:20.901, z:97.050	Element ID: 1260881		Element ID: 1254854	Roof Top
				H"-5" :	2024/7/22	x:0.558,	Element		Element	

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Clash Report

# AUTODESK® NAVISWORKS® Clash Report

9.ME VS ST	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	3014	3014	0	0	0	0	Hard	Old

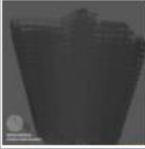
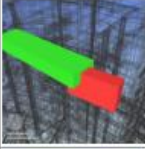

Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1		Item 2	
							Item ID	Layer	Item ID	Layer
	Clash1	New	-0.385	2"-M : Ground Floor Plan	2024/7/22 06:45	x:29.942, y:17.610, z:3.288	Element ID: 1219211		Element ID: 466327	Ground Floor Plan
	Clash2	New	-0.380	H'-5" : 6th Floor Plan	2024/7/22 06:45	x:-0.575, y:23.185, z:31.010	Element ID: 1240293		Element ID: 713283	7th Floor Plan
	Clash3	New	-0.380	H'-5" : 5th Floor Plan	2024/7/22 06:45	x:-0.575, y:23.202,	Element ID:		Element ID:	6th Floor Plan

8/2/24, 5:02 PM

Clash Report

**AUTODESK®  
NAVISWORKS®** Clash Report

10.FDARA ME VS EL	Tolerance	Clashes	New	Active	Reviewed	Approved	Resolved	Type	Status
	0.005m	89	89	0	0	0	0	Hard	Old

Image	Clash Name	Status	Distance	Grid Location	Date Found	Clash Point	Item 1 Item ID	Item 2 Item ID
	Clash1	New	-0.134	4'-L : 6th Floor Plan	2024/7/22 06:45	x:22.737, y:20.258, z:30.790	Element ID: 1111033	Element ID: 971335
	Clash2	New	-0.112	H-1 : 6th Floor Plan	2024/7/22 06:45	x:1.435, y:-0.940, z:30.790	Element ID: 1111362	Element ID: 971224
				4'-L : 6th Floor	2024/7/22	x:21.550,	Element ID:	Element ID:

**CONTRACT AGREEMENT FOR THE  
DESIGN AND BUILD OF HOUSING DEVELOPMENT  
PROJECTS IN AKAKI KALITY SUB-CITY 'WEREDA 05'**

This Contract agreement is made on the .....<sup>15<sup>th</sup></sup>..... day of the month of June, 2022

**BETWEEN**

**ADDIS ABABA CITY GOVERNMENT** and having its principal place located at: Addis Ababa, P.O. Box .....Tel.....), (hereinafter called the "Employer"), in one hand

**AND**

**ETHIOPIAN CONSTRUCTION WORKS CORPORATION**, incorporated under the laws of FDRE and having its principal place of business at Addis Ababa, P.O. Box: 21952/1000 Tel: (+251)11-667-5473 or (+251)11-646-1138, Fax: (+251)11-667-6090 (hereinafter called the "Contractor"), in the other hand

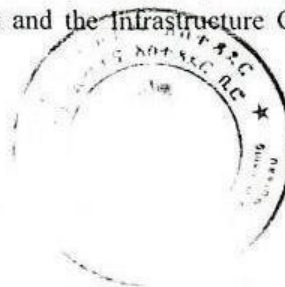
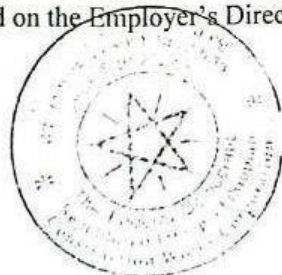
**WHEREAS:** The Employer has initiated the execution of the said works as clearly defined in the duly prepared Drawing, Specification and Bill of Quantity (here after called the "Works"), and has accepted a bid by the Contractor for the provision of those Works at Design Build of Housing Development Projects of 'Akaki' Kality Sub-City 'Wereda 05 Site', with Birr 19,000.00 (Nineteen Thousand Birr and 00/100 Cents) before VAT per Square Meter of the Building.

**WHEREAS:** The Employer desires that the works shown known as the **Design of Mass Houses along with all Infrastructures and Construction of Apartment Buildings of Seventy - G+4** (herein after called "LOT-1") with a Contract Amount of Birr 4,259,724,000.00 (Four Billion Two Hundred Fifty Nine Million Seven Hundred Twenty Four Thousand Birr and 00/100 Cents) excluding of VAT.

and

**Construction of Apartment Buildings of Twenty - G+9** (herein after called "LOT-2") with a Contract Amount of Birr 3,217,878,000.00 (Three Billion Two Hundred Seventeen Million Eight hundred Seventy Eight Thousand and 00/100 Cents) excluding of VAT in the Project at Akaki Kality Sub-City "Wereda 05" Site should be executed by the Contractor, and has accepted the proposal by the Contractor for the execution and completion of these works and the remedying of any defects therein,

**WHEREAS:** the Construction of LOT-2 would be started upon decision made on the Methodology of Constructing the G+9 Buildings and the Infrastructure Construction would be implemented based on the Employer's Direction.



**WHEREAS:** The Contract Price of the project shall be **Birr 8,599,242,300.00 (Eight Billion Five Hundred Ninety Nine Million Two Hundred Forty Two Thousand Three Hundred Birr and 00/100 Cents) only including VAT**, (hereinafter called "the Contract Price") in the manner and on the terms described herein.

**WHEREAS:** The Contractor having represented to the Employer that it has the required skills, personnel and technical resources, has agreed to carry out the Works on the terms and conditions set forth in this Contract;

**NOW THEREFORE** the parties hereto hereby agree as follows:

**1. The Agreement**

In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Conditions of Contract referred to.

The following documents shall constitute the Contract between the Employer and the Contractor, and each shall be read and construed as an integral part of the Contract:

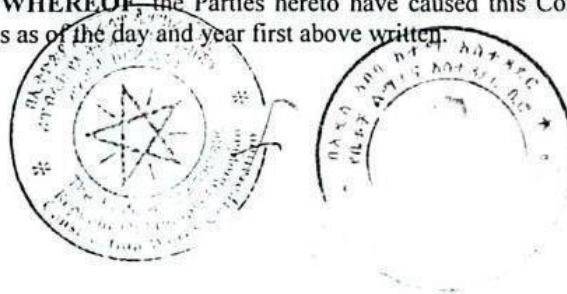
1. The Contract Agreement;
2. Minutes of Pre-contract signing discussion meetings;
3. The Letter of Acceptance;
4. Particular Conditions of Contract;
5. General conditions of Contract; Part II; (CONDITIONS OF CONTRACT for PLANT AND DESIGN-BUILD first edition 1999 FIDIC yellow book);
6. The Technical Proposal;
7. Employer's Requirement;
8. The Schedule;

This Contract shall prevail over all other Contract documents. In the event of any discrepancy or inconsistency within the Contract documents, then the documents shall prevail in the order listed above.

In consideration of the payments to be made by the Employer to the Contractor as hereinafter mentioned, the Contractor hereby covenants with the Employer to carry out the Works and to remedy defects therein in conformity in all respects with the provisions of the Contract.

The Employer hereby covenants to pay the Contractor in consideration of the provision of the Works and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract.

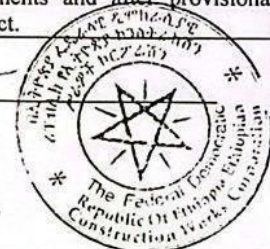
**IN WITNESS WHEREOF** the Parties hereto have caused this Contract to be signed in their respective names as of the day and year first above written.



Section V: Particular (Special) Conditions of Contract (FIDIC CONDITIONS OF CONTRACT for PLANT and DESIGN and BUILD CONTRACT First edition, 1999)

CLAUSE	DEFINITION							
14.2	No.	Description	TOTAL AREA per BLOCK (M <sup>2</sup> )	RATE (ETB)	No. of House per Block	NO. OF BLOCKS	NO. OF HOUSES	AMOUNT (ETB)
	1	G+4 Apartment	3,202.80	19,000.0	40	70	2,800 including 140 Communals	4,259,724,000.00
	2	G+9 Apartment	8,468.10	19,000.0	72	20	1,580 including 140 Rentals	3,217,878,000.00
	TOTAL SUM					90	4,380	7,477,602,000.00
	15% VAT							1,121,640,300.00
	TOTAL SUM INCLUDING 15% VAT							8,599,242,300.00
14.2	<ul style="list-style-type: none"> <li>Add at the beginning of the first paragraph, "The advance payment payable to the Contractor no later than 30 days after signing the Contract for mobilization and design shall be 30% of the Contract Price of LOT-1(G+4 Buildings construction)and the Contractor furnishing of an equivalent advance payment bond from reputable Bank or Insurance Company. The advance payment of a Lot-1 Construction should be made by instalments, which means 40.83% up on contract sign, and the remaining 59.17% should be released after Two months of the first advance payment installed.</li> <li>"The advance payment payable to the Contractor no later than 30 days after decision is made on the Work Methodology of Constructing of LOT-2 by the Client and shall be 30% of the Contract Price of LOT-2 (G+9 Buildings construction)and the Contractor furnishing of an equivalent advance payment bond from reputable Bank or Insurance Company."</li> <li>Replace (b) by "deduction for the advance payment shall be made from the amount of each payment certificate at the amortisation rate calculated as such the total advance taken to be repaid at the time when the project reaches 100% of completion.</li> </ul>							
14.4	<p>Replace the first paragraph by "The Contractor shall submit a statement in six copies to the Engineer as per sub clause 14.4, showing in detail the amounts to which the contractor consider himself to be entitled, together with supporting documents which shall include the relevant report on progress in accordance with sub clause 4.21";</p> <ul style="list-style-type: none"> <li>Change statement in (a) the contract value of the Works executed and the Contractor's Documents produced (excluding items described in sub-paragraphs (b) to (g) below);"</li> <li>The amount to be deducted for retention is 5% of each payment request. 2.5% shall be released after provisional acceptance and the remaining 2.5% shall be released after final acceptance.</li> <li>The Contractor shall collect the retention within interim payments and after provisional acceptance when it faces cash flow shortage for executing the project.</li> </ul>							

Design and Build of Housing Redevelopment Projects



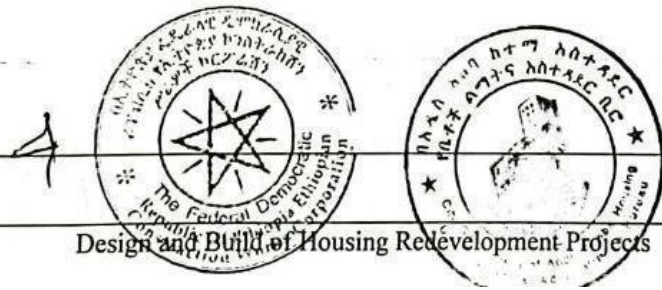
Section V. Particular (Special) Conditions of Contract (FIDIC CONDITIONS OF CONTRACT for PLANT and DESIGN and BUILD CONTRACT First edition, 1999)

CLAUSE	DEFINITION
4.4	At the end of sub-clause 4.4 add: "Subcontracting shall be confined to portions and values of the works as required by the Main Contractor."
4.5	Not Applicable
4.7	Except the first paragraph delete all paragraph;
4.13	All Right of Way issues and related Costs shall be resolved by the Employer;
4.19	Amend the Text of this Sub clause to read: The Contractor shall use electricity and water services as may be available on the Site for the project services.
4.20	Not Applicable
Clause 5	<b>5. DESIGN</b>
5.7	Not Applicable
Clause 7:	<b>7. PLANT, MATERIALS and WORKMANSHIP</b>
7.4	Substitute sub-clause 7.4  The Employer's Engineer and the Contractor shall carryout all the necessary tests at every stage of the construction. Whenever it is deemed necessary that the tests shall be executed outside the project; the Employer's Engineer shall fix the place and the time of execution of the tests.
Clause 8:	<b>8- COMMECEMENT, DELAYS and SUSPENSION</b>
8.1	Substitute sub-clause 8.1 The start date shall be within 15 days after issuance of advance payment and upon official site hand over.
8.2	Intended Completion date 550 Calendar Days from the issuance of advance payment and upon official site hand over.
Clause 9:	Not applicable
	<b>10. EMPLOYER'S TAKING OVER</b>
Clause 10:	Substitute Clause 10 <b>Provisional Acceptance</b> <ul style="list-style-type: none"> <li>• The works shall be taken over by the Employer when they have satisfactorily passed the tests on completion and a certificate of provisional acceptance has been issued or is deemed to have been issued.</li> <li>• The Contractor may apply, by notice to the Engineer, for a certificate of provisional acceptance not earlier than 15 days before the works, in the Contractor's opinion, are complete and ready for provisional acceptance. The Engineer shall within 30 days after the receipt of the Contractor's application either:                             <ul style="list-style-type: none"> <li>✓ issue the certificate of provisional acceptance to the Contractor with a copy to the Employer stating, where appropriate, his reservations, and, inter alia, the date on which, in his opinion, the works were completed in accordance with the Contract and ready for provisional acceptance; or</li> </ul> </li> <li>• If the Engineer fails either to issue the certificate of provisional acceptance or to reject the Contractor's application within the period of 30 days, he shall be deemed to have issued the certificate on the last day of that period. The certificate of provisional acceptance shall not be</li> </ul>

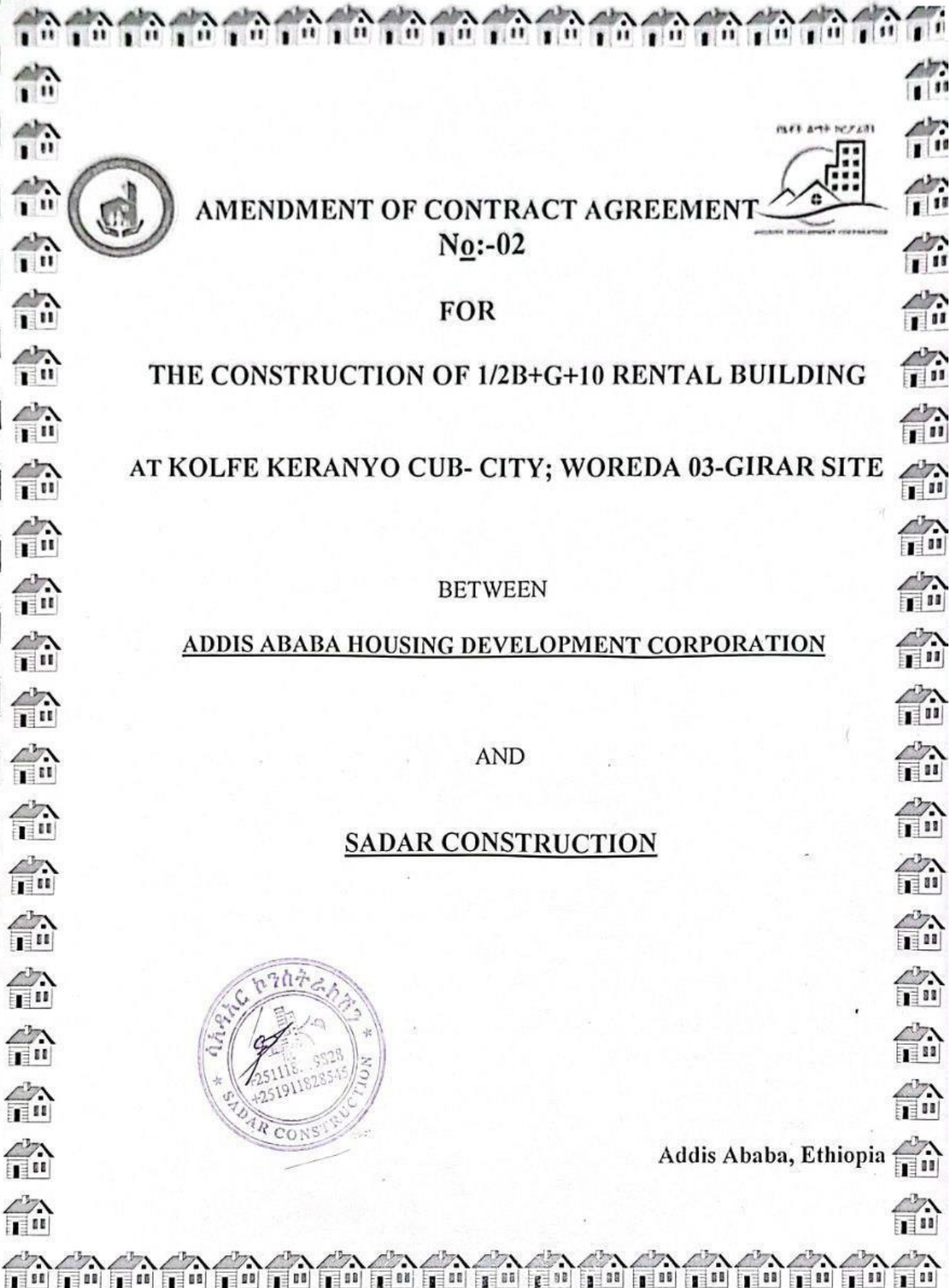
Design and Build of Housing Development Projects

Section V Particular (Special) Conditions of Contract (FIDIC CONDITIONS OF CONTRACT for PLANT and DESIGN and BUILD CONTRACT First edition, 1999)

CLAUSE	DEFINITION
	<p>deemed to be an admission that the works have been completed in every respect. If the works are divided by the contract into sections, the Contractor shall be entitled to apply for separate certificates for each of the sections.</p> <ul style="list-style-type: none"> <li>Immediately after provisional acceptance, the Employer may make use of all the works as completed.</li> </ul>
	<p><b>Final Acceptance</b></p> <ul style="list-style-type: none"> <li>Upon the expiry of the Defects Liability Period, or where there is more than one such period, upon the expiry of the latest period, and when all defects or damage have been rectified, the Engineer shall issue to the Contractor a Final Acceptance Certificate and a copy thereof to the Employer stating the date on which the Contractor completed his obligations under the Contract to the Engineer's satisfaction. The Final Acceptance Certificate shall be given by the Engineer within 30 days after the expiration of the above stated period, or as soon as any works ordered have been completed to the satisfaction of the Engineer.</li> <li>The works shall not be considered as completed until the Final Acceptance Certificate has been signed by the Engineer and delivered to the Employer, with a copy to the Contractor.</li> <li>Notwithstanding the issue of the Final Acceptance Certificate, the Contractor and the Employer shall remain liable for the fulfilment of any obligation incurred under the contract prior to the issue of the Final Acceptance Certificate, which remains unperformed at the time such Final Acceptance Certificate is issued. The nature and extent of any such obligation shall be determined by reference to the provisions of the contract.</li> </ul>
<p><b>Clause 11:</b></p>	<p><b>11. DEFECT LIABILITY</b></p>
<p><b>11.8</b></p>	<p>The Contractor shall, if required by the Engineer, search for the cause of any defect, under the direction of the Engineer. Unless the defect is to be remedied at the cost of the Contractor under Sub-Clause 11.2 [Cost of Remedying Defects], the Cost of the search plus reasonable profit shall be agreed or determined by the Engineer in accordance with Sub-Clause 3.5 and all costs are included in the Contract Price.</p>
<p><b>Add Clause</b></p>	<p>The defect liability period is 365 working days starting from the date of work Completion and issuance of certificate of provisional acceptance by the engineer.</p>
<p><b>Clause 12</b></p>	<p>Not Applicable</p>
<p><b>Clause 13:</b></p>	<p><b>13. VARIATION and ADJUSTMENT</b></p>
<p><b>13.8</b></p>	<ul style="list-style-type: none"> <li>Applicable, based on the submittal of Base Price attached herein the Contract Document, and Adjustments for Changes in Cost and/or in quantity shall be done with negotiation.</li> </ul>
<p><b>Clause 14:</b></p>	<p><b>14. CONTRACT PRICE</b></p>
<p><b>14.1(a)</b></p>	<ul style="list-style-type: none"> <li>Replace by                             <ol style="list-style-type: none"> <li>The Contract Price shall be: - Birr 8,599,242,300.00 (Eight Billion Five Hundred Ninety Nine Million Two Hundred Forty Two Thousand Three Hundred Birr and 00/100 Cents) only including VAT,(hereinafter called "the Contract Price) in the manner and on the terms described herein.</li> </ol> </li> </ul>



Design and Build of Housing Redevelopment Projects



**AMENDMENT OF CONTRACT AGREEMENT**

**No:-02**

**FOR**

**THE CONSTRUCTION OF 1/2B+G+10 RENTAL BUILDING**

**AT KOLFE KERANYO CUB- CITY; WOREDA 03-GIRAR SITE**

**BETWEEN**

**ADDIS ABABA HOUSING DEVELOPMENT CORPORATION**

**AND**

**SADAR CONSTRUCTION**



**Addis Ababa, Ethiopia**

## Part I. Conditions of Contract Agreement

### A. AMENDMENT CONTRACT AGREEMENT No:-02

Principal main contract agreement made on the dated 22/10/2012 E.C and amendment contract agreement no.01 made on February 08/ 2016 E.C for Construction Works of 1/2B+G+10 Rental Building at Addis Ababa Kolfe Keranyo sub-city/woreda 03-girar/ site Total main contract amount was Ethiopian Birr Birr 89,542,642.8 (Eighty Nine Million Five Hundred Forty Two Thousand Six Hundred Forty Two and 8/100Cents) Only including 15% VAT, (Herein after called "The Old Contract Price.")

BETWEEN City Government of Addis Ababa Housing Development Corporation, (hereinafter called "Public Body" ) of the one part and whose address is:-  
City Government of Addis Ababa Housing Development Corporation

Tel:-+251- 15583869.

Fax: -----

P.O.Box:-----

Addis Ababa

And

#### SADAR CONSTRUCTION

(Hereinafter called "The Contractor") of the other part whose address is:

P.O. Box-- -----

Tele. No. +2510911828545

#### WHEREAS

- (a) The Public Body invited interested contractors for Construction Works of 1/2B+G+10 Rental Building (hereinafter called the "Works"), and has accepted a contract price by the Contractor for the stipulation of those Works in the sum of Birr 214,393,672.8 (Two Hundred Fourteen Million Three Hundred Ninety Three Thousand Six Hundred Seventy Two and 8/100 Cents) Only including 15% VAT. (Hereinafter called "The amended Contract No.01 Price") in the manner and on the terms described herein.
- (b) The Contractor having represented to the Public Body that it has the required skills, personnel and technical resources, has agreed to carry out the Works on the terms and



conditions set forth in this Contract.

This Amended Contract Agreement No.02 is made on the date -----

**Amendment Considerations;**

**All other terms and condition of the principle contract except those expressly amended/ altered shall remain intact.**

**NOW THEREFORE :**

The Amendment agreement No.02 is made according to letter from Addis Ababa Housing Development Corporation Project 09 Branch Office With Reference Number:- T/09/ጥ/ጽ/ቤ.ጎ/46/1026/2016 and Dated on 29/02/2016 E.C and .

The total cost of the project according to the Amended contract Agreement Number 01 is changed to Birr 275,008,984.53 (Two Hundred Seventy Five Million Eight Thousand Nine Hundred Eighty Four and 53/100 Cents) Including 15% VAT, As per; Amendment BOQ.

**NOW THEREFORE** the parties hereto hereby agree as follows:

**1. The Agreement**

- 1.1 In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Conditions of Contract referred to.
- 1.2 The following documents shall constitute the Contract between the Public Body and the Contractor, and each shall be read and construed as an integral part of the Contract:
  - a. Contract Agreement, including all appendices;
  - b. Letter of Acceptance by the Public Body to the Contractor;
  - c. The Special Conditions of Contract;
  - d. The General Conditions of Contract for construction works project, FPPA August 2011;
  - e. Technical Proposal with technical specifications;
  - f. The design documentation (Prints of drawings as per the attached list);  
For Unit-price contracts: The Bill of Quantities and Price Schedule (after
  - g correction of arithmetical errors);



correction of arithmetical errors);

h. Standard technical specifications and method of measurement 1991 and other related to the works

- 1.3 This Contract shall prevail over all other Contract documents. In the event of any discrepancy or inconsistency within the Contract documents, then the documents shall prevail in the order listed above.
- 1.4 In consideration of the payments to be made by the Public Body to the Contractor as hereinafter mentioned, the Contractor hereby covenants with the Public Body to carry out the Works and to remedy defects therein in conformity in all respects with the provisions of the Contract.
- 1.5 The Public Body hereby covenants to pay the Contractor in consideration of the provision of the Works and the remedying of defects therein, the Contract Price or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract.

IN WITNESS WHEREOF, the Parties hereto have caused this Contract to be signed in their respective names and their respective common seals to be here unto affixed on the day and year mentioned first above written.

For the Public Body

\_\_\_\_\_  
Name & Title

\_\_\_\_\_  
Authorized signature

\_\_\_\_\_  
Date

For the Contractor

\_\_\_\_\_  
Name & Title

\_\_\_\_\_  
Authorized signature

\_\_\_\_\_  
Date



WITNESS

- |    | <u>Name</u>                        | <u>Signature &amp; Date</u> |
|----|------------------------------------|-----------------------------|
| 1. | _____ (Public Body)                | _____                       |
| 2. | _____ (Public Body)                | _____                       |
| 3. | <u>Zelalem Semale</u> (Contractor) | <u>[Signature]</u>          |
| 4. | <u>Sesay Asetta</u> (Contractor)   | <u>[Signature]</u>          |

Project: -Construction of 1/2B+G+10 Rental Apartment Building  
 Client:- Addis Ababa Housing Development Corporation  
 Location:- Kofe Keranyo sub-city (woreda- 03 /Girar site)  
 Consultant:- Addis Abeba City Adm. Construction Design & Consultancy office  
 Contractor: -SADAR CONSTRUCTION  
 Block No. 2

SUMMARY OF BOQ

No	DESCRIPTION	CURRENCY	1st Amended Contract Amount	2nd Amended Contract Amount
	SUB-STRUCTURE (A)			
1	EXCAVATION & EARTH WORK	ETB	10,984,233.84	8,489,632.79
2	CONCRETE WORK	ETB	20,720,749.14	17,364,386.60
3	BLOCK WORK	ETB	1,030,942.61	363,958.88
4	WATER PROOFING & DAMP PROOFING WORK	ETB	697,623.40	442,294.91
5	CARPENTARY AND JOINERY WORK	ETB	201,417.93	59,945.81
6	ALUMINIUM AND METAL WORK	ETB	1,130,451.54	825,508.97
7	FINISHING WORK	ETB	5,114,655.63	2,326,502.26
8	PAINTING WORK	ETB	442,034.58	511,710.41
9	GLAZING	ETB	128,684.59	97,867.74
10	MASONRY WORK	ETB	354,875.45	1,296,548.61
	TOTAL(A)	ETB	40,805,668.71	31,778,356.98
	SUPER-STRUCTURE (B)			
1	CONCRETE WORK	ETB	64,882,290.31	88,302,175.14
2	BLOCK WORK	ETB	8,267,535.52	7,282,077.71
3	ROOFING	ETB	2,700,393.18	2,258,294.97
4	CARPENTARY AND JOINERY WORK	ETB	1,392,665.18	5,672,051.01
5	ALUMINIUM AND METAL WORK	ETB	9,246,482.07	21,939,613.03
6	STRUCTURAL & STEEL WORK	ETB	1,257,215.38	2,376,749.71
7	FINISHING WORK	ETB	19,649,278.62	36,465,006.26
8	PAINTING WORK	ETB	3,912,159.67	8,859,871.74
9	GLAZING	ETB	1,267,648.14	805,102.25
10	LANDSCAPING	ETB		
11	Civil works around the building	ETB		351,004.65
12	SANITARY INSTALLATION	ETB	8,778,441.23	8,778,441.23
13	ELECTRICAL INSTALLATION	ETB	24,269,502.71	24,269,502.71
	TOTAL (B)	ETB	145,623,612.01	207,359,890.43
	TOTAL (A+B)	ETB	186,429,280.72	239,138,247.42
	VAT (15%)	ETB	27,964,392.11	35,870,737.11
	GRAND TOTAL WITH VAT 15%	ETB	214,393,672.83	275,008,984.53



## Questioners

### For contractors consultants and clients

#### This questioners is prepared for academic purpose only

- **Name**.....
- **Recent working institution**.....
- **Company Position (high level manager)...(medium level manager).....(expert).....(other).....**
- **Educational proportionality (under graduate).....(graduate)..... (MSc/MA).....(PhD).....**
- **Work Experience (2-4)..... (5-7)..... (Above 8).....**

1. How has the adoption of construction technology affected the safety measures implemented on construction sites? On a degree of very low to very high, how would you rate the improvement in safety measures on construction sites due to the adoption of technology?

Insignificant (very  low moderate  high very hig

2 Has the use of technology resulted in a decrease in accidents and property damage during construction projects? Can you provide the scale decrease in accidents and property damage since the adoption of construction technology?

Insignificant (very l low moderate  high very hig

3. What specific technological advancements have been adopted by your company..... and how have they improved overall project efficiency? How much scale increase in project efficiency have you observed due to the adoption of specific technological advancements in your company?

Insignificant (very l low moderate  high very hig

4. Have you observed any changes in insurance premiums for construction projects since the implementation of technology? How much scale change have you noticed in insurance premiums for construction projects post-implementation of construction technology?

Insignificant (very l low moderate  high very hig

5. How has the adoption of construction technology influenced your risk management strategies? On a scale below, how much has the adoption of construction technology influenced your risk management strategies?

Insignificant (very l low moderate  high very hig

6. Are you familiar with insurance options for construction technology risks like BIM, kumkang, prefabrication, IoT, robotics, and automation etc.? (Yes/No) If yes, please briefly describe.
7. Have you actively sought specialized insurance coverage or specific clauses in your policies to address construction technology risks? (Yes/No) If yes, please briefly describe.
8. Are you familiar with construction technology below?

<b>No</b>	<b>CONSTRUCTION TECHNOLOGY</b>	<b>YES</b>	<b>NO</b>	<b>remark</b>
1	Building information modeling (BIM)			
2	Virtual reality safety training (VR)			
3	Kumkang formwork technology			
4	Prefabricated and modular construction			
5	Construction site internet of things (IOT)			

**9. Impact of Construction Technologies in construction hazard identification, risk assessment and mitigation, accidents Reduction and overall safety in the construction industries.**

<b>No</b>	<b>CONSTRUCTION TECHNOLOGY</b>	<b>Impact of Construction Technologies in construction hazard identification, risk assessment and mitigation, accidents Reduction overall safety in the construction industries.</b>					<b>Remark</b>
		<b>Very low (insignificant)</b>	<b>low</b>	<b>Moderate</b>	<b>high</b>	<b>Very high</b>	
1	Building information modeling (BIM)						
2	Virtual reality safety training (VR)						
3	Kumkang formwork technology						
4	Prefabricated and modular construction						
5	Internet of things (IOT)						

**For insurance company**

**This questioners is prepared for academic purpose only**

- Name.....
- Recent working institution.....
- Company Position (high level manager)...(medium level manager).....(expert).....(other).....
- Educational proportionality (under graduate) ....(graduate)... (MSc/MA)... (PhD).....
- Work Experience (2-4)..... (5-7).....(above 8).....

**Insurance Company Questionnaire:**

1 How has the adoption of construction technology affected the overall risk landscape in the construction industry? On a scale, how much has the adoption of construction technology changed the overall risk landscape in the construction industry?

Insignificant (very low  low  moderate  high  very high

2 Have you observed any changes in the frequency and severity of insurance claims related to construction projects before and after construction technology adoption? (yes/no) if yes, to what degree?

Insignificant (very low  low  moderate  high  very high

3. Have you developed specific insurance products or coverage options tailored to address the risks associated with construction technology? (Yes/No), if yes, how many specific insurance products or coverage options have you developed to address risks associated with construction technology? Describe?

4. How do you stay updated on the latest advancements in construction technology to accurately assess associated risks? On a scale, how effective are your mechanisms for staying updated on the latest advancements in construction technology to assess associated risks?

Insignificant (very low  low  moderate  high  very high

5. Are you familiar with insurance options for construction technology risks like BIM, kumkang, prefabrication, IoT, robotics, and automation? (Yes/No) If yes, please briefly describe.

6. Have you actively sought specialized insurance coverage or specific clauses in your policies to address construction technology risks? (Yes/No) If yes, please briefly describe.

- **Factors Affecting Insurance Premiums**

- Relative impact of insurance premium indicating factors and categories.(for insurance company)

Category	Safety Factors	Factor Impact on (or correlation with) Premium (The numbers represent the % of responses)				
		No	low	Moderate	High	Very high
Project factors	1. Project type/ nature					
	2. Project size					
	3. Project Contract price					
	4. Project location and surrounding environment					
	5. Project weather conditions					
	6. Project duration					
	7. Drawings, Specifications, Construction time schedule & BOQ					
	8. Project financial structure/ lenders					
	9. Project procurement method (traditional, design-build, ...)					
	10. Number of contractors on-site					
	11. Number of insured participants					
	12. Project sum insured					
	13. Building materials for use					
	14. Unique project complexities					
	15. Construction contract terms and conditions					
	16. Insurance coverage limits and deductibles					
Parties'	1. Contractor's size					

factors	2. Contractor's experience in similar projects/ method statement					
	3. Contractor's construction technology and building techniques					
	4. Contractor's method statements for severe jobs					
	5. Contractor's Safety Claim history					
	6. Contractor's Sub-Contract Management					
	7. Contractor's Safety Policies/ Hazard Management Policies					
	8. Contractor's Safety technology					
	9. Contractor's Safety Training					
	10. Contractor's Labor Experience					
	11. Contractor's Labor Level of Education					
	12. Owner/ Engineer influence on committing to safety standards					
	Insurer factors	1. Insurer's Direct Cost: Reinsurance cost and insurance broker commission				
2. Insurer's Indirect Cost: Insurance company overhead cost						
3. Insurer's Strategy of Profit Generation and Potential Future Business						
4. Volume of business in insurance market						
Market factors	1. Market Competition					
	2. volume of business in the market					

• **Expected insurance premium cost for construction projects by insurers**

- ❖ What is the average percent (%) of premium afforded by your company from the total construction project cost (you can put the average percent (%) that your company negotiated with construction companies recently)?

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No	Insurance policies	average percent (%) of premium (from total project cost)	Deductable (for each and every occurrence)	Remark
1	Professional Indemnity Insurance (PI)			
2	Contractor's All Risks Policy			
3	Contractors Third Party Liability Policy			
4	Contractors Employers Liability Policy			
5	Worker's Compensation Insurance			
6	Vehicle Insurance			
7	Erection all risks (EAR)			
8	Major Medical Insurance			
9	Wrap up liability insurance			
10	Others			

No	Parameters	Very low	Low	Moderate	high	Very high
		(0-10)%	(11-30)%	(31-50)%	(51-70)%	(71-100)%
1	<b>Expected average <u>Losses</u></b> which is the Money paid out for claims. In your company from <b>construction projects</b> from total premium calculated by underwriter or valuator.					
2	<b>Expected average <u>Expenses</u></b> which is Administrative costs, marketing, etc. In your company from <b>construction</b>					

<p><b>projects</b> from total premium calculated by underwriter or valuator.</p>					
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✓ **"How much flexibility does your company offer in negotiating insurance premium reductions based on the decrease in incidents through the use of construction technology?"**

No	Construction technology reduction of accident in percent (%)	"How much flexibility does your company offer in negotiating insurance premium reductions based on the decrease in incidents through the use of construction technology?"					
		0%	1%-10%	11%-20%	21%-30%	31%-40%	41%-50%
1	≤5%						
2	6%-15%						
3	16%-30%						
4	31%-45%						
5	46%-60%						