ADDIS COLLEGE

DEPARTMENT OF CONSTRUCTION TECHNOLOGY and MANAGEMENT

MASTER's OF CONSTRUCTION TECHNOLOGY & MANAGEMENT

Assessment of the Role and Challenges of Using Prefabricated Technology on Building Construction Projects in Addis Ababa: The Case of Tsehay Real Estate

By

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Abstract

In recent years, the high urbanization rate and rising housing demand have led to numerous housing projects in the country. Although housing projects are a good idea they always end up with high budgets and overruns not to add a high maintenance cost with a minimal recovered value.

This study assesses the role and challenges of using prefabricated technology in construction projects in Addis Ababa, focusing on Tsehay Real Estate. The research population comprised 157 professionals, with a sample size of 110 selected using purposive and simple random sampling techniques. The study utilized the Relative Importance Index (RII) to evaluate the benefits and challenges of prefabricated construction (PC). The research also covers the usage level of PC in the Tsehay real-estate development projects which turned out to be very low and what is the main reason for this low level of implementation in the construction industry, for a better understanding of the alternative construction method this research shows why using prefabricated construction is very advantages over conventional construction for cost efficiency of buildings in real-estate development projects in Addis Abeba.

The findings showed that there is a low level of awareness and practices of prefabricated construction among professionals, using prefabricated construction is full of cost and time advantages with a better quality than conventional construction. The findings indicate that PC offers significant advantages in terms of cost, time efficiency, safety, and health benefits. However, its implementation remains low due to poor perceptions among professionals. By training the professionals, Promote the use of advanced tools and technologies, such as Building Information Modeling (BIM), to enhance the planning and execution of prefabricated construction projects., Advocate for policies that support the use of prefabricated construction, such as streamlined approval processes and building codes. Develop a regulatory framework that encourages the adoption of prefabricated construction by setting standards and guidelines. By implementing these strategies, professionals can be encouraged to embrace prefabricated construction, leading to greater adoption and realization of its benefits in the construction industry. The study recommends various strategies and tools to enhance the adoption of prefabricated construction in real estate developments in Addis Ababa

Keywords: Prefabrication construction; strategy; real-estate development, Addis Abeba.

Table of Contents

List of Tables

List of Figures

List of Acronyms and Abbreviation

AU	African Union
BC	Building Contractor
BIM	Building Information Model
DfMA	Design for Manufacturing and Assembly
EBCS	Ethiopian Building Code of Standards
EU	European Union
FDRE	Federal Democratic Republic of Ethiopia
GC	General Contractor
MoCUD	Ministry of Construction and Urban Development
MoFED	Ministry of Finance and Economic Development
MMC	Modern Method of Construction
OSC	Offsite Construction
PC	Prefabricated Construction
QC	Quality Control
RC	Reinforced Concrete
Rebar	Reinforcement Bar
SCM	Supply Chain Management
SPSS	Statistical Package for the Social Sciences
TQM	Total Quality Management
UN	United Nation

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

The concept of prefabrication or prefab has been conceptualized in diverse ways by various scholars. For instance, Panjehpour and Abang Ali (2013) viewed it as any manufacturing process in a controlled environment and as a dwelling made of manufactured off-site components. This view is in line with the US Department of Commerce's view of prefab homes as being those made up of components such as walls, floors, roofs, panels, etc. that have been fabricated in a factory before erection on site (Johnson, 2006). The prefab housing methodology has revolutionized the built environment over the years not only because of its flexibility in meeting the financial needs of both low-income and high-income homeowners (Tam, 2013); but also, because thanks to the prefab system of housing delivery, the human wishes of having an easily built house, fast and at an affordable price can become a reality (Panjehpour and Abang Ali, 2013). Yet, the built environment stakeholders, among whom are developers, have not tapped into the adoption of this system for housing delivery. Therefore, to actualize this building methodology in Addis Abeba, Ethiopia, in line with the marketing concept, there is a need to seek the support of developers who are the major builders of houses in Addis Abeba, Ethiopia.

Prefabrication construction is a construction method by which construction elements are produced fully or partially with special emphasis off-site in a factory and assembled at site construction. Prefabrication construction has become one of the major mechanisms in the modern construction industry and the majority of building construction consumes prefabricated elements. According to Alireza and Omid (2016), there are several advantages connected with developing and utilizing prefabricated elements which include less time and reliance on site labor, easier site inspection, as well as greatly improved design details and quality control. Generally, the method can have any kind of effect on different countries construction industries in monetary, social, and ecological terms (Alireza and Omid, 2016).

For the current fast-growing population, it is essential to have more residential with lesser cost and time. There are several ways by which cost and time reduction is made in the current construction industry. One such way is using prefabricated structural elements which reduce the

overall cost of construction and greatly reduce the construction time.

Addis Ababa is one of the cities with a fast-growing population and needs more residential housing of low cost and time-saving technology. According to Samson (2017), a huge gap remains in the housing market, and the needs of the middle-income urban population in Addis Ababa. Furthermore, he argued that real estate developers should go in line with technological advancement they should learn from foreigners and come up with something new. Accordingly adopting the latest and advantageous construction method is essential for the growing real estate construction sector of Addis Ababa. As prefabricated elements are produced under controlled quality with standard and its construction method needs limited time and lesser cost it is advantageous to address the demand of the middle-income population.

This research work aims to investigate the application status of prefabricated concrete structural elements in the Addis Ababa real estate construction industry and its potential application.
Tsehay Real Estate is one of the real estates in Addis Ababa run by a Chinese-affiliated company. The company uses prefabricated elements in its real estate development. The prefabricated elements grow with their development. Some of the prefabricated elements that are used by Tsehay real estate include partition walls, lintel beams, doors, and blocks.

1.2. Statements the of Problem

Nowadays, in the construction sector using prefabricated elements for real estate construction has been growing. According to David (2014), prefabricated construction is preferred in the real estate sector for the reason that benefits occur right across the value chain to the home buyer, the builder, and the manufacturer.

Real estate development is becoming a very critical and growing sector in Ethiopia specifically in Addis Ababa city. Even though it has become a critical sector currently there are so many problems in the real construction industry developed in Addis Ababa. Samson (2017) states that delays in the construction of real estate projects are common in Addis Ababa and its price is not affordable by the majority of the population. As time is one of the main factors in the construction industry, time overrun affects the overall cost of the project by additional overhead cost, change of material price because of additional time, and inflation. As construction method plays an important role in eliminating those problems and satisfying the growing demand for residence in the city. Adopting prefabricated concrete structural elements is one of the best methods to minimize the quality problems that occur due to poor workmanship and low-quality

materials, minimize the problems that cause construction delays, and minimize the cost of construction.

In Ethiopia, there has been an increase in the number of construction methods used for work execution during the past 20 years. However, the adoption of prefabricated construction techniques in Ethiopia's infrastructure projects has been limited. Indeed, those organizations that employ this technique in the nation's construction projects have exhibited a relatively slow pace in their undertakings in comparison with the developed economies. The potential benefits of prefabricated construction techniques are still considering the relatively long duration of construction project delivery in Ethiopia (Ayalewe,2022).

Several studies focus on the plant and the management of overall precast works and its advantages relative to cost and time. Some also focus on the existing organizational structure and its history. However, no research had been done specifically on the contribution of prefabrication technology for Tsehay real estate construction.

The provision of adequate and affordable housing for Nigerians has been a daunting problem over the years despite the government and private sector's efforts at ameliorating this situation. The MoUDC (2009) report identifies the following five housing-related issues as critical to solving before Ethiopia can provide an adequate supply of housing: building materials; appropriate design and technology; skill and capacity building; housing finance; land administration; and legal and regulatory framework. Accordingly, switching from conventional brick and mortar to modern construction methodology will greatly boost the availability of houses. Prefab building is one of these contemporary methods, offering benefits including labor and cost savings, economies of scale, improved quality control, and safer construction sites (Kassa B, 2013; Belay, 2021; Ayalew, 2016; Tirunhe 2019, Adebayo A.K., 2017). Health was enhanced by (Panjehpour and Abang Ali, 2013) (Taylor, 2019).

This paper, therefore; will aim to fill the existing gap by investigating the contribution of prefabricated technology on building construction projects in Tsehay real estate, Addis Ababa.

1.3. Research Questions

- What is the awareness level about prefabricated construction in the Tsehay real estate construction industry?
- What are the benefits of prefabricated construction in the Tsehay real estate construction

industry?

- What are the challenges that affect prefabricated construction in Tsehay real estate?
- What are the strategies to implement prefabricated construction for Tsehay real estate?

1.4. Objectives

1.4.1. General Objective

- To assess the role of and challenges of prefabricated technology on building construction projects in Addis Ababa focusing on Tsehay real estate.

1.4.2. Specific Objectives

- To assess the practices of using prefabrication technology on building construction projects
- To assess the benefits of prefabricated building elements over the on-site casting construction systems.
- To identify the challenges that affect prefabricated construction utilization in real-estate construction projects.
- To develop strategies to improve the adoption of prefabrication in real-estate projects.

1.5. Significance of the Study

This study is significant to Real estate developers, designers, and other participants of real estate construction in Tsehay real estate and for other real estate in Addis Ababa to look for the existing potential to use prefabrication construction method. Government and other investors show the need and shortage of prefabricated structural elements as an investment area. Also, it will initiate to review practices of the existing plant to improve its supply capacity. The study identifies areas for further research, such as exploring the long-term impacts of prefabricated construction and its adoption in different regions. This can guide future academic endeavors and contribute to the continuous advancement of the field.

By addressing both practical and academic aspects, this study not only aims to improve the real estate construction industry in Addis Ababa but also enriches the academic discourse on prefabricated construction.

1.6. Scope of the Study

This study focused on the current application of prefabricated construction in Tsehay real estate in Addis Ababa and its potential to be applied, the preference of real estate developers, and involved professionals to use the method. In addition, this research focused on the acceptance of prefabrication technology in Tsehay real estate construction and the plans of the companies to improve the technology. Geographically the research focused on Tsehay real estate construction in Addis Ababa city.

The empirical part of the study is conducted over a three-month period, from April to June 2024. This time frame allows for comprehensive data collection and analysis.

1.7. Organization of the document

This study is organized into five chapters. The first chapter is about the introduction of the study, chapter two reviews of relevant literature for the selected research topic, chapter three is about the research methodology applied in this research, and Chapter four is about the data analysis and presentation. Finally, chapter five is about the findings, conclusion, and recommendation of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1. History of Preconstruction

Ancient Romans have a practice of pouring concrete into molds to build aqueducts, culverts, and tunnels beginning around 100 B.C. (Mikhailov and Susnikov, 1995). In the 1500s, the timber components of the house were crafted and painted in Holland, then assembled in London. Later, the method was widely adopted in Eastern Europe and Scandinavia (Arieff and Burkhart, 2002).

The Crystal Palace (Giant glass-and-iron exhibition hall in Hyde Park, London) was one of the first prefabrication constructions in Britain during the great exhibition of 1851. The Crystal Palace was constructed in a few months and assembled using a series of prefabricated elements. United States went into the market in the 1900s however mass fabrication was first introduced in World War II when easy-to-assemble mass accommodation was required for soldiers (Mikhailov and Susnikov, 1995).

This skill was later utilized by the Europeans and Japanese to quickly rebuild war-devastated areas. In the 1960s and 1970s high rise concrete prefabricated construction was introduced (Velamati**,** 2012). Velamati also stated that the Hilton Palacio Del Rio Hotel was among the first concrete high-rise prefabricated buildings in the world. The project was during the Texas World's Exposition of 1968; the 500-room hotel was designed, completed, and occupied in an unpredictable period of 202 working days.

Figure 2.1.Hilton Palacio Del Rio Hotel (Velamati**,** 2012), USA, Texas.

For the first-time prefabrication plant was established in Ethiopia in 1978 E.C with the help of the former socialist country Yugoslavia. The company is called Prefabricated Building Parts Production Enterprise (PBPPE) and it is the only prefabrication factory in Ethiopia till know. According to Gutema (1998), the aim was to accommodate the ever-increasing demands of housing within the shortest possible time, to overcome the shortage of accommodation and meet future demands, and to minimize the pressing need for timber for formwork and consequently conserve the natural forest. The Factory primarily in charge of prefabrication - Prefabricated Building Parts Production Enterprise (PBPPE)- has produced structural elements for the construction of office buildings, apartments, hotels, and residential buildings for the public and private sectors. According to the information from PBPPE, the building shown in the following figure 2.2 is one of those buildings.

Figure 2.2. Mixed-Use Building by Prefabricated Construction in Addis Ababa (Helena Building around Lideta) Addis Ababa, Ethiopia.

The backlog of housing units in Ethiopia was so vast that all efforts made by the Government and inhabitants could not wipe out the shortage of housing in the early 1980s. To promote the building industry and to alleviate the housing shortage prefabrication technology was introduced. The objectives of the enterprise are to promote the building

industry through mass production of prefabricated concrete elements, to alleviate the shortage of housing, and to reduce construction costs (Gutema, 1998).

As indicated above establishment of PBPPE in Addis Ababa has brought new techniques for the construction industry and it was supposed to provide the solution for the vast housing needs at the time.

Figure 2.3. Apartment Building by Prefabricated Construction. (Bole Apartments) Addis Ababa, Ethiopia.

2.2. Prefabrication Construction

Kariuki (2010) defines prefabrication is the practice of assembling elements of a structure in a factory or other manufacturing site and transporting complete assemblies or sub-assemblies to the construction location where the structure is to be placed. Dineshkumar and Kathirvel (2015) also agreed that the term prefabrication is used to distinguish the process from the more conventional construction method of transporting the basic materials to the site where the construction is taking place.

The primary purpose of prefabrication technology is to produce building components in an efficient work environment with access to specialized skills and equipment to reduce cost and time expenses on the site which enhances quality and consistency (Anderson and Anderson, 2007). Prefabrication together with the increasing use of standardization and mechanization has brought a rapid change in the development of the construction field throughout the world. Prefabrication techniques lead to increases large- scale and high-rise constructions (Venkateswara, and Sarath, 2013).

Additionally, Ali and Rahinah (2017) cited the work of Kamar (2001) and defined prefabrication technology as an innovative process of construction using the concept of mass-production of industrialized systems, produced at the factory or onsite within controlled environments, it includes the logistic and assembly aspect of it, done in proper coordination with thorough planning and integration.

2.3. Prefabricated Concrete Structural Element

Prefabricated concrete elements are one of the most remarkable developments in the construction of concrete structures. They are stated to signify that cast in a standardized method and given time to harden and acquire strength before being taken to the actual construction site for erection (Venkateswara and Sarath, 2013). According to Bahamon and Bill (2002) using prefabricated concrete structural elements is a construction system by in which the essential pieces of structure are sent to the site on which the finished edifice will be constructed partially or completely assembled. Once there, it is necessary only to join and anchor the parts.

Prefabricated concrete allows efficient, economical construction in all weather conditions and provides the long clear spans and open spaces needed. They are prepared, cast, and cured at specially equipped plants with a permanent location under standard supervision. Prefabricated concrete is also a popular material for constructing buildings. The walls of the building can be manufactured while the on-site foundations are being built, providing significant time savings and resulting in early occupancy (Venkateswara and Sarath, 2013).

2.4. Advantages of Prefabrication Construction

Various literature and researchers have revealed that using prefabrication construction methods has many advantages over conventional methods relative to safety, quality, time, and cost. Tanya Trainee (2010) specifies the main benefits of using prefabricated concrete structural elements – the lower construction cost, the speed of construction, and the precision of work.

Nadim (2009) also stated that prefabrication technology can be considered as a business strategy that transforms the traditional construction process into a manufacturing and assembly process by embracing new and advanced technologies, engaging people, and translating clients' needs into building requirements. Additionally, Nadim (2012) stated that the advantages of the prefabrication method are as follows, improving the overall business efficiency, quality of product, environmental performance, sustainability, customer satisfaction, and predictability of timescales. These can be achieved within a controlled production environment, with minimum waste, in a safer work environment, and with better investment in the long-term economy.

Many scholars and industry practitioners have severally identified certain benefits of prefabricated construction methods. According to Li (2011), the benefits include reduced time and cost of construction, improved productivity, and the quality of construction processes. Also, Tam, Tam, Zeng, and William (2007) identified early-stage frozen design, improved supervision, reduced construction cost, minimum construction time, better environmental performance, waste minimization, building design and construction integrity, and better aesthetic appeal as advantages of prefabricated construction. Additionally, Chen Okodan and Riley (2010) noted shortened construction time, improved quality, enhanced occupational health and safety, less construction site waste, less environmental emissions, and reduction of energy and water consumption as some other benefits of prefabricated construction. Arif and Egbu (2010), Taylor (2010), and Jaillon and Poon (2010) identified further benefits of prefabricated construction such as less impact on surroundings, fewer defects, low wastage in manufacturing, easy transportation, and efficiency of material and labor resources. It is important to state that most of the benefits of prefabricated construction have turned out to be the drivers themselves. Typical drivers include easy accessibility to prefabricated materials, decentralization of the supply of raw and finished building materials, and the availability of technical assistance in the production and assembly of prefab elements (Stallen, Chabannes & Steinberg, 1994). Additionally, identified drivers of prefabricated construction include reduced on-site work, less coordination of multiple trades, reduced waste, improved building quality, and improved building performance and sustainability (Stallen et al., 1994).

2.4.1. Advantage of Prefabricated Elements Relative to Quality

Prefabricated elements were manufactured in a factory environment with better quality control (Jaillon and Poon, 2007). Different mixes of prefabricated and cast in-situ elements are used to meet different design requirements for better quality and cost-effectiveness. Such a combination enables their projects to achieve a higher level of productivity than is possible with solely cast in-situ construction (Dineshkumar, 2015). As prefabricated elements were produced in a factory under standard control, quality problems occurred by poor workman problems, and low material quality was reduced.

In addition, Architect express that with the use of both prefabricated facades and lost form panels, uniform quality was achieved in the building elevations, hence promoting continuity

in visual quality and aesthetics (Jaillon and Poon, 2007).

2.4.2. Advantage of Prefabricated Elements Relative to Time

There are various technologies available worldwide for using prefabricated construction methods, almost all technologies try to reduce costs and time, prefabrication method gives the possibility to the designers for assembling their structures in a short period. There are numerous potential advantages related when delivering and developing buildings by prefabrication (Alireza and Omid, 2016). One of the greatest benefits is the ability to dramatically reduce the time needed for construction. Factory efficiencies allow building components to be completed quickly and without weather delays. The factory has all of the key players onsite to handle multiple building requirements and multiple subcontractors are not always required. This makes prefabrication construction suitable for owners who need buildings quickly, properties with hard dates for occupancy, and areas where seasonal weather restricts or even halts construction (Velamati**,** 2012).

As the industry strategies itself to build with less labor and shorter construction time, prefabrication of concrete structures has become a viable alternative to the traditional way of construction.

2.4.3. Advantage of Prefabricated Elements Relative to Cost

The other main benefits of using prefabricated elements include higher financial return due to less construction interest carry and related time savings through a shortened construction schedule and potentially reduced hard cost from repeatable and higher efficiency construction methods, modernized construction process, reduced material waste and higher construction quality (Velamati**,**2012).

2.4.4. Advantage of Prefabricated Elements Relative to Safety

Prefabricated construction does not only reduce construction costs, but it also produces a more stable and fairly rewarded construction industry with improved safety and working conditions, and greater investment in research, design creativity, and product development (Anderson and Anderson 2007). Additionally, by using prefabricated concrete elements mainly, on-site operations are considerably reduced, providing a safer working environment (Dineshkumar and Kathirvel, 2015). This shows that using prefabricated concrete elements has helped minimize workplace hazards by minimizing on-site operation and providing

safer working conditions.

2.4.5. Advantage of Prefabricated Elements to Work Environment

However, it is important to have a good appreciation of its difference in management from the conventional construction. The benefits of using prefabrication would not be fully realized by simply adapting the traditional way of design and construction process. The keys to successful implementation lie in the planning and understanding of the close relationships between the design, construction, detailing, execution, and manufacturing of precast concrete Components (Dineshkumar and Kathirvel, 2015). In other words, it is vital to have good cooperation between the architect, the engineer, the builder, and the producer. It also reduces the consumption of energy and material and generally increases the availability of better-designed and high-quality environments (Anderson and Anderson, 2007).

The adaptation of prefabricated buildings mainly depends on factors such as labor shortage, labor cost, housing demand, building process efficiency, weather, as well as reduction of waste material and energy consumption. Prefabricated building has relatively inherent economic, environmental, and social benefits (Khaled and Farid, 2015).

2.5. Major Factors of Using Prefabrication

Prefabrication technology has not transferred as easily when compared with other technologies because it is a production technology knowledge-based and not a consumption technology or product-based (Ryan and Shilpa, 2002). It needs early design decisions were required in the building process as precast elements were manufactured before being delivered to the site for assembly. For architects also, the possibility of a late change in the design was limited, and client instruction to modify the design even during construction (Jaillon and Poon, 2007).

Khaled and Farid (2015) also state that the possible barriers to using prefabricated elements as lack of research information, higher initial construction cost, limited site space, monotone in aesthetics, lack of experience, no demand for prefabrication, inflexible for design changes. Industry practices and techniques, supply chain management and logistics, professionalism of the industry, and construction market risks.

Prefabrication technology has not shifted as easily when compared with other

technologies because it is a production technology or knowledge-based and not a consumption technology or product-based. Adapting prefabricated buildings in these countries is mainly influenced by labor shortage, labor cost, housing demand, building process efficiency, weather, as well as reduction of waste material and energy consumption. Prefabricated building has a relatively low uptake in construction industries worldwide despite its inherent economic, environmental, and social benefits.

This situation is attributed to prevailing local conditions that vary from country to country. Although motivations for using prefabricated buildings help determine its use as an option, the decision to implement such technology is influenced by the balance between potential benefits and impediments. The possible barriers to prefabricated building adoption are industry practices and techniques, supply chain management and logistics, professionalism of the industry, and construction market risks.

Further studies should be conducted to investigate the measurement strategies for the application and evolution of prefabricated buildings. However, addressing prevalent issues in many countries, benefitting from them in enhancing prefabricated building adoption, and avoiding perceived barriers require a more extensive approach. The similarities and differences among countries should also be considered. Meanwhile, many other aspects involved in adopting this technology require attention. Transforming the use of prefabricated buildings into economic rewards requires training, organizational changes, and procurement arrangements in the construction industry.

There are several indications of the potential positive benefits of financial and social incentives, as well as revised national policies and regulations by the government for prefabricated building uptake. Thus, implementing prefabricated building technology requires a complete restructuring of the construction industry. The government should encourage and motivate the private sector to participate in developing such structures (Khaled and Farid, 2015).

2.6. Prefabrication Plant

The product of construction projects has certain requirements assigned to it. These requirements may be imposed by national standards or industrial standards, or they could

be agreed upon and stated on contract documents. Quality simply means that the project meets these requirements set for it. The accurate meaning of quality for manufactured products for construction is the product satisfies the requirements set for it (Halvorsen, 1993).

Quality control is a set of actions taken to ensure that products meet the requirements set by purchasers or specify. QC involves inspection and testing, record-keeping, and being ready to deal with nonconformance in concrete production quality.

Standards help the prefabrication plant to have a minimum level of quality that the products must meet. As a purchaser of materials, the prefabrication should be a user standard. As a manufacturer, the prefabrication should be a producer of products to the requirements of standards or project specifications (Ali and Rahinah, 2017).

Quality control professionals could use standards as a measure against which they check whether or not products conform to them. In the case of nonconformance, they can change an input or improve an activity and prevent the below-standard product from being delivered to clients. Testing and inspection don't add quality to a product. They evaluate a product against established standards and provide the opportunity to correct nonconforming work and to adjust materials or production before nonconforming products are fabricated‖ (Halvorsen, 1993)

2.7. Processes of Prefabricated Building Element Implementation

As it is one of the construction methods construction by using prefabrication elements has its recognizable sequential flow. According to Richard (2006) in the initial stage, the prefabricated components are designed according to technical specifications and modular coordination concepts that promote flexibility. Indeed, this flexibility is very important to allow geometrical variations that respond to different needs over space and time.

Subsequently, the components are prefabricated at a factory according to specified dimensions. During this stage, the product or components will be produced repetitively to maximize the output of the factory. The huge number of components produced will provide economies of scale and reduce the operation and investment costs (Riduan, 2012).

The prefabricated components are transported to the site from the factory for the assembly

and construction process. At the construction sites, the prefabricated Components are installed with the assistance of lifting equipment. Once installation is completed, the components are ready to be used, even to act as a platform, to support further construction (Bribian, 2009).

Generally, the processes of prefabricated Building element implementation start with design, manufacture, construction, maintenance, and finally demolition activities (Riduan, 2012).

2.8. Current Application of Prefabricated Elements in Construction

Prefabricate concrete structural building elements are widely used in the modern construction industry over worldwide. Being its wide applicability, total prefabricated concrete building systems are becoming a popular choice for many constructions. Prefabricated concrete elements are available in many shapes, and sizes, including structural elements and unreinforced pieces. The prefabrication industry is the backbone for the development of new ideas in the construction business of any country. Factory buildings, residential buildings, and industrial townships are needed practically by all sectors, either to support the manufacturing or services of any industry (Dineshkumarand Kathirvel, 2015). Because of its several advantages using prefabricated elements is become a preferable method in the current construction industry.

Nowadays, different systems of prefabrication technologies are utilized in both developed and developing countries; however, the usage of systems is not the same. In developed countries, panel systems are the most commonly used construction system in prefabricated buildings (Baghchesaraei and Baghchesaraei, 2015).

Currently, prefabrication technology is applied to a limited extent in the construction industry of Ethiopia. There is only one prefabrication plant in Ethiopia, Prefabricated Building Parts Production Enterprise (PBPE), which was established 30 years ago without any modification. Kibirt (2017) states that within its 30 years of operation, the Prefabricated Building Parts Production Enterprise has not shown much progress as an organization. It still uses the same outdated batching plant, crane system, and even molds that had been installed during its.

According to Kibirt (2017), the problem here is that with the number of years that have passed since PBPPE started operation; a lot has changed worldwide in construction

technology. What was acceptable 30 years ago may not be up to par currently. Moreover, almost all equipment, forms design, and production manuals that the plant utilizes are the same ones that were put in place during its start almost three decades ago, and all their pages have parched and turned brown. They are very delicately handled as they have not yet been converted and filed into a soft copy format.

The theoretical design capacity of the enterprise was estimated to reach 50,000-meter square of built-up floor area per year, but the maximum attained capacity to date is 33,000-meter square. The production output of the enterprise was designed to build three categories of buildings: residential buildings up to 5 stories, and public buildings up to 10 stories (Gutema, 1998). The types of structural elements produced by the factory include columns, slabs, footings, girder beams, beams, cantilevers, shear walls, stair-flights, and landings.

However, the majority of the buildings constructed by the prefabrication method in Addis Ababa are public and business buildings, and there are a small number of apartments. The Apartment

Adequate efforts were not carried out to show the merits and demerits of recasting emphasizing the effectiveness and efficiency of pre-fabrication technology as compared to other conventional construction methods. Much has to be done in the future in marketing, and dissemination of information to promote the prefabrication construction in Ethiopia (Gutema, 1998).

2.9. Challenges of Prefabricated Construction System

Despite several identified benefits prefabricated construction system has over the traditional method, it also poses challenges such as a higher initial cost, inadequate communication in the supply chain, and difficulties in altering the design at various stages of construction (Lei, Zhongfu, Long & Yunli, 2018). Other identified challenges include design problems, production problems, transportation problems, installation process problems, and lack of experience regarding prefabricated construction techniques (Blismas, Pendlebury, Gibb & Pasquire, 2005). Since the components are produced by several parties, they are often prone to design errors and installation difficulties. Another major setback of this method is that the components are quite difficult to correct in the event of mistakes and this often results in rework, time, and cost overruns.

Reduced formwork and scaffolding strategies are critical in Ethiopia, to reduce both cost

and excess timber consumption. The other methods may be considered ―appropriate building technologies‖ in Ethiopia and may complement a multi-faceted approach to the enhancement of vernacular construction techniques. A general problem in the Ethiopian construction industry is the low level of knowledge and experience among workers. This contextual condition has a significant negative impact on the industry (Zegeye and Helawi, 2012).

According to Graaskamp (1981) the history of real estate dates back to the evolution of man and his first sedentary shelters. Perhaps it can be called the first attempt to create an enclosed space, which is detached from the surroundings, apparently to protect his family from coldness and attacking animals. Shelter formation enhanced the livelihood of men in terms of protection and gave them longer stability to regularize their surroundings creatively. Miles (2007) also defines the term real estate can as, the private ownership of a limited parcel of land, which includes the right of the air above it and the ground below it, and any buildings or structures attached to the ground.

Miles (2007) and Graaskamp (1981) are agreed on that, real estate can exist in the form of business and/or residential properties, which can be sold either by a relator or directly by the individual who owns the property. Ownership of land is considered as real property that has a sale or transfer right granted by law. Yet, the principle of sale or transfer follows the land policy regulated by the government of a specific country.

Abraham (2007) defines residential real estate as, residential real estate is a type of property, containing either a single-family or multifamily structure that is available for occupation for non-business purposes. Residences can be classified by, if, and how they are connected to neighboring residences and land. Different types of housing tenure can be used for the same physical type. Connected residents might be owned by a single entity and leased out or owned separately with an agreement covering the relationship between units and common areas and concerns.

The city of Addis is developing and transforming but still faces a huge backlog in its housing stock that it has to overcome and cope with in the coming few years. The rate of supply and demand does not match. This increasing growth and development in Addis Ababa represent an ideal situation where the urban phenomena of growth, expansion, and densification can be experienced and investigated. The high demand is creating tension in the construction

sector. The city predominantly uses concrete frames and cast-in-situ constructions (Helawi, 2015).

At this time, private real estate development has been growing in Addis Ababa city. Even though there is a significant increase in the production of small family houses year after year the housing price also increases. However; in a developing country like Ethiopia, the increasing cost of living and the earning capacity of the population makes homeownership extremely difficult which makes the basic one most luxurious item for the low-income population (Negash, 2010).

2.10. Use of Prefabricated Elements in Real Estate Construction

Prefabricated elements play an important role in the modern world construction of major real estate development today. To meet the high demand, some builders experimented new housing market by creating their designs and specifications to help build more and faster. Some builders made off-site building components and then delivered them to other builders or home buyers rather than building everything at the site. Many were shipped from the factories, and the result of big benefits has attracted many new investors (Arieff and Burkhart, 2002).

Today, many American homes are made through prefabricated construction methods. Prefabricated construction helps facilitate the American dream of home ownership by offering affordable prices to buyers. ―The term prefabricated brings to mind a building system in which the essential pieces of structure are sent to the site on which the finished edifice will be constructed partially or completely assembled. Once there, it is necessary only to join and anchor the parts‖ (Bahamon and Bill, 2002).

By using prefabricated concrete structural elements, benefits occur right across the value chain. The home buyer benefits through reduced build time, increased time, and cost certainty through improved value for money and fewer defects. The builder, large or small, benefits through fewer weather disruptions, and when demand for building services is high, can complete more projects per year. The manufacturer increases the opportunities to add more value and increase profits on-site (David, 2014). Today, prefabricated construction attracts real estate developers for the same reasons. During the prefabrication method, the speed at which buildings can be constructed has reduced costs and facilitated higher volumes of construction (Tanya and Trainee, 2010). These benefits have particular

relevance to countries that have a high demand for residences and are currently facing a shortage in the supply of homes such as Ethiopia especially in Addis Ababa.

2.11. CONCEPTUAL FRAMEWORK

Based on the related literature review, it can be summarized that prefab Techs have different contributions to building construction projects, especially in real-estate development. Prefab Tech's contributions are evaluated by quality improvement, relative safety in the work environment, time saving, cost reduction, and reduction in waste generation. Based on this understanding, the conceptual framework is set in such a way that the five dimensions of Prefab Techs contributions are considered independent variables, while Prefab Techs as the dependent variable. As depicted in Figure 2.1, Prefab Techs have an overall contribution to improving construction project performance.

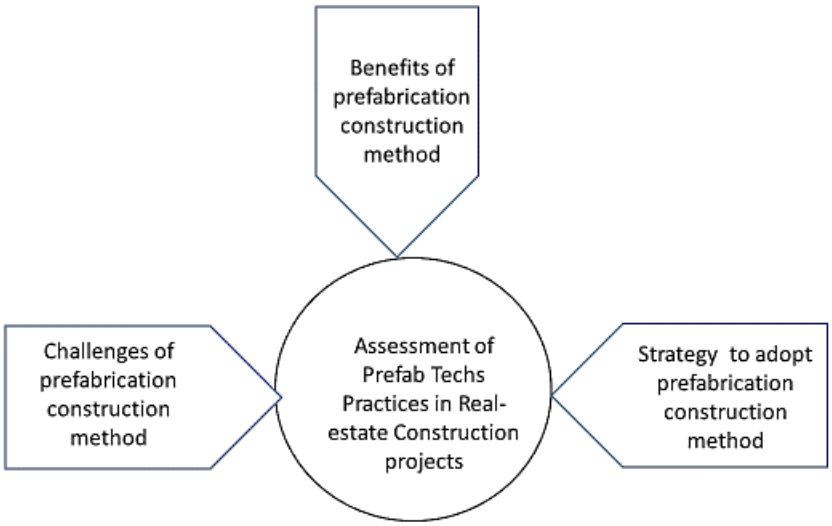

Fig.2.4. Conceptual framework of the study (source: own survey, 2024)

In recent years, research has focused on PC's impact on sustainability, cost, quality, and schedule, making it a valuable area for further exploration. Additionally, innovations in prefab technology emphasize open communication, modeling technologies, and dynamic processes, revolutionizing the construction industry. Prefab construction is particularly suitable for time-sensitive projects, such as healthcare facilities and multi-unit residential buildings, due to its efficiency and sustainability.

2.12. RESEARCH GAP

The literature review conducted from 1998 to 2008 shows a positive attitude towards using prefabricated elements. That is, there is an awareness of prefabricated building technology's potential and positive effect on sustainability and efficiency within the residential development sector. Goodier and Gibb (2007) and Pan, Gibb, and Dainty's (2007; 2008) research show take-up in prefabricated technology on the rise and a large demand for external walls, timber frames, and roofs with many studies showing increased efficiency and sustainability achieved (Kamali and Hewage, 2016). However, research conducted from 2010 to 2014 shows developers as more aware of the barriers to using offsite manufacturing techniques, and greater collaboration between manufacturers and developers is identified by several studies as crucial for improving (Elnaas, et al, 2016). However, according to Nadim and Goulding (2015), numerous users believed offsite manufacturing was the future of the construction industry and the lack of uptake and demand can be attributed to many factors, including the Global Financial Crisis which caused the decline of small house building developers (HBF, 2017; Panjehpour, 2014; Ali, and Voo, 2016). Research from 2016 onwards recognizes a need for change in housing delivery and highlights a lack of skilled workers, reduced health and safety risks, quicker completion, and lower costs as its reasoning. Several studies conclude that increased uptake in offsite manufacturing can have a significant impact on increasing housing output, although it cannot be the only solution (Belcher, et al, 2018; BSA, 2016).

The previous literature provides a comprehensive and in-depth analysis of the drivers and barriers to the implementation of prefabricated building methods and suggests they can have meaningful impacts on the delivery of affordable housing (RICS, 2018). According to Kamali and Hewage (2016), previous research concludes that the prefabricated building method outperforms traditional methods of construction but Thuesen and Hvam (2011) found inconsistencies between the study's conclusions and comparisons of the methods (Thuesen, et al., 2015). There appears to be a large belief prefabricated building method has a role to play moving forward for manufacturers, policymakers, and contractors. However, there appears to be a lack of take-up from developers and although this view seems to be changing for larger developers, the role of small house building developers still requires consideration as the Ministry of Infrastructure, Construction and Urban Development

(2019) shows low levels of prefabricated building technology applications by developers (Nadim,2010).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

The methodology is a plan of action that shows how the problems are investigated, what information is collected using which methods, and how this information is analyzed to arrive the conclusions and to develop recommendations. To obtain its objective, this research paper will follow sequential steps illustrated in Figure 3.1.

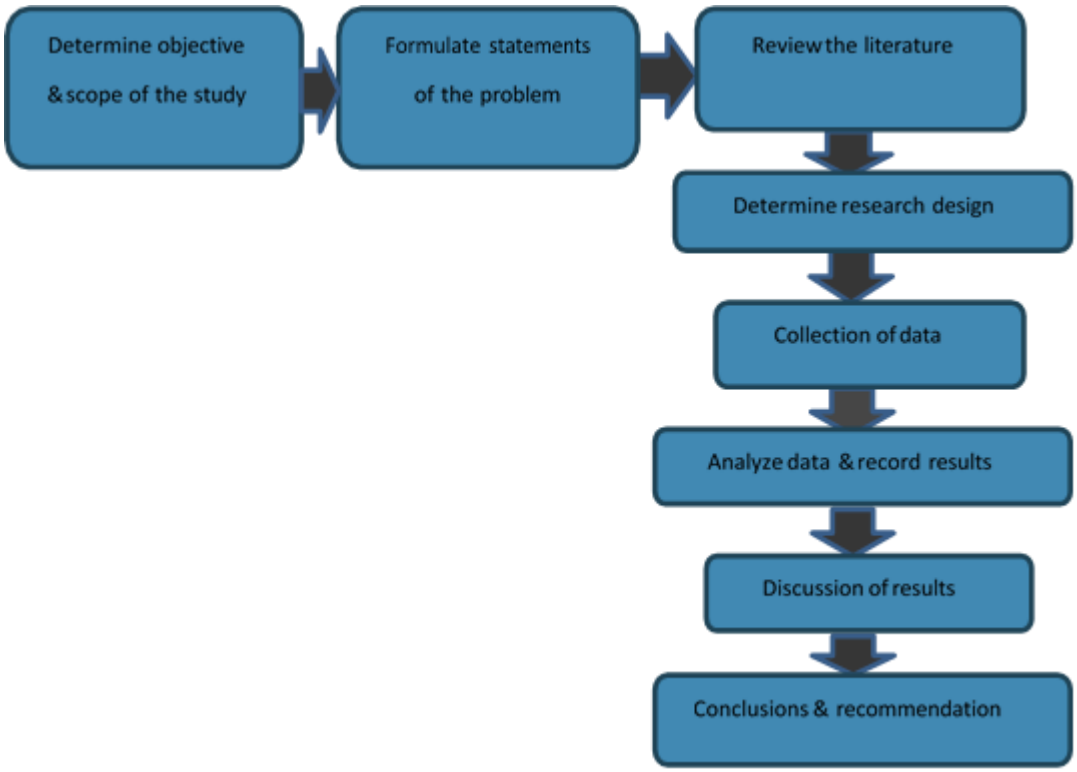

Figure 3.1. Design of the research

3.2. Location of Study

Addis Ababa's administration is structured into sub-cities and Woredas, the construction industry is growing, and significant housing projects are underway to address the city's housing needs. Addis Ababa is divided into eleven sub-cities, which oversee a total of 38 lower-level Woredas. These woredas are further subdivided into 328 neighborhood units (Wereda) that handle local planning and social services. Tsehay real-estate, construction project has faced challenges typical

of the Ethiopian real estate market, such as delays and pricing issues1. Studying these can offer lessons on overcoming common obstacles in the sector. The success of Tsehay Real Estate can serve as a model for future developments, emphasizing the need for innovation and efficient project management. By focusing on these aspects, my research can provide valuable insights into the building material innovations and challenges in housing construction in Addis Ababa, using Tsehay Real Estate as a case study.

3.3. Research Design

The qualitative and quantitative research approaches were applied. Thus, the research is a descriptive and mixed research approach aimed at increasing the reliability of information, thereby making qualitative complement the quantitative information. The data was collected from primary and secondary data sources by using a combination of closed-ended and open-ended questionnaires. In addition, a review was conducted from published documents and an exploration of the reports to study the current state of infrastructure project management practice and the associated challenges.

3.4. Source of Data

Both primary and secondary data were collected to undertake this research. The primary data was collected through key informant interviews, survey questionnaires, and field observation. Secondary data was analyzed from Google, office documents, and secondary data used through a literature review, the contributions of prefabricated building technology in real-estate projects in Addis Abeba in the case of Tsehaye Real-estate. Structured and semi-structured questions were developed to answer the research questions regarding the contributions of prefabricated building technology in real-estate projects in Addis Ababa. A semi-structured question catalog was presented for the sampled professional and outputs were summarized qualitatively.

3.5. Sample design

3.3.1. Sample population

The population of the study consisted of Tsehay real estate developers in Addis Ababa. The total population of the study was estimated at 152 professionals who work at Tsehaye real-estate development projects.

3.3.2. Sample size

This research used random sampling which is the purest form of probability sampling for data analyzed by the quantitate method and Purposive sampling for data analyzed by the qualitative method. Probability sampling was applied to quantitative-based studies (Saunders, Lewis, and Thornhill, 2009). They also state that, in probability sampling, each member of the population has an equal chance of being selected it is a major issue before a researcher heads to the collection of data. The size of the sample should neither be excessively large nor too small, it should be optimum. An optimum sample fulfills the requirements of efficiency, representativeness, reliability, and flexibility. While deciding the size of the sample, the researcher must determine the desired precision as well as an acceptable confidence level for the estimate. The sample size was calculated as the following equation for 95% confidence level (Assaf, 2001).

$$Na= N/ [1+ (N) (e)^{2}]$$

Where Na= the adjusted sample size, e= error, and N = population size. Population elements and V is a standard error of sampling population. (Usually e = 0.05).

- Tsehay Real estate developer sample calculation

$$\mathbf{Na= N/ [1+ (N)(e)^2]}$$

$$\mathbf{N_a= 152 /(1+ 152(.0025)}$$

$$\mathbf{=110}$$

To increase the precision and quality of data collected all professionals who participated in the selected project were allowed to participate in the questionnaire survey which included professionals with the position of skilled labor and above.

3.3.3. Sampling Technique

A combination of purposive and stratified sampling techniques was employed to ensure representation across different roles and levels of involvement in real-estate projects. Purposive sampling was used to select key informants who possess relevant expertise and experience in prefabrication building technology & construction methods. Stratified sampling was then applied to ensure a proportional representation of groups, such as project managers, engineers, and contractors actively working on real estate development projects in Addis Abeba.

3.6. Method of Data Collection

The selection of the data collection method depends on different factors such as the nature and scope of investigation, availability of funds, time needed, and precision required. The type of research and data needed to dictate what type of data collection methods to be used (Saunders, Lewis, and Thornhill, 2009). According to Denscombe (2007), a questionnaire allows large populations to be surveyed more efficiently than other instruments. Accordingly, for this research paper questionnaire survey will be used to collect data from professionals in Tsehay real estate construction because of that it is a relatively large population.

3.6.1 Semi-Structured Interview

Semi-structured interviews were used to obtain detailed research-relevant information. It explored issues related to the practice of using prefab Techs in real-estate development projects. It also provides much more detailed information than what was expected through other data collection methods, such as it was mainly made up of a list of questions surveys. An interview protocol i.e. the rules that guide the administration and implementation of the interviews was developed and followed while conducting the interviews.

3.6.2 Questionnaire

It is planned to use a tool for collecting and recording information about a particular issue of interest but also will include clear instructions and space for answers. The questionnaires were closed and semi-closed questionnaires that were adopted in such a way as to have quantitative data that related to the objectives of the research, since the research is a mixed research approach.

3.7. Method of Data Analysis

The collected data was subjected to both qualitative and quantitative analysis using descriptive statistics by using Excel and Statistical Package software (SPSS) (v.26). The collected data and reviewed documents were presented by using, tables, graphs, and descriptive texts. The professionals and developers project managers, engineers, contractors, and consultants were analyzed using a survey questionnaire. The collected data from key informants and Tsehaye real estate was triangulated with the documents and

ground observation for data validation and analysis. The findings were presented in the form of tables and charts to help understand easily. The Likert scale data was analyzed using the relative importance index (RII) method. The RII method was used herein to arrange variables in terms of importance and agreement to determine professionals 'perceptions of the relative importance of the identified application factor. According to (Cheung and Suen, 2004) the RII was computed as: -

$$RII = \frac{\sum W}{(N*A)}$$

Where:
W -is the weight given to each factor by the respondents and ranges from 1 to 5;
A – The highest weight = 5 in this case;
N – The total number of respondents.

3.8. Method of Data Presentation

The analyzed data was presented using statistical tools such as Tables, graphs, and charts. The study employs both qualitative and quantitative data collection methods. Interviews and surveys are conducted to gather insights from professionals about their experiences and perceptions of prefabricated technology. The collected data is analyzed using the Relative Importance Index (RII) to quantify the benefits and challenges of prefabricated technology. Statistical tools such as SPSS are used to perform descriptive and inferential analyses

3.9. Data Reliability

Saunders, Lewis, and Thornhill (2009) defined reliability as an instrument of the degree of consistency that measures the attribute it is supposed to measure. The lesser the variation an instrument produces in repeated measurements of an attribute, the higher its reliability. Reliability can be equated with a measuring tool's stability, consistency, or dependability. The reliability of the data was ensured by testing the questionnaires before distribution to the planned respondents.

3.10. Data Validity

Validity refers to the degree to which an instrument measures what it is supposed to measure (Pilot & Hungler, 1997). Validity has some different aspects and assessment approaches.

Statistical validity will be used to evaluate instrument validity, which includes criterion-related validity and construct.

3.11. Ethical Consideration

The participants of this research were given their consent to fill in the data collection tool, i.e. questionnaire. For confidentiality, the personnel who handed over some confidential documents were also not acknowledged in their names based on the agreements made. The respondents were asked to fill out the questionnaire and they were assured that the information would be confidential and only for research purposes.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1. Response Rate

The response rate is one of the important aspects that indicates the quality of the survey (Croswell, 2012). With regards to respondents' responses in this survey, a total of 260 out of the 299 distributed questionnaires were returned which accounted for a response rate of 87.0%.

Table 4.1. Results of the Response Rate

Questionnaires	**Frequency**	**Percentage (%)**
Total distributed	110	100.0%
Returned questionnaires	80	88.0%
Unreturned questionnaires	30	11.7%
Response errors	10	9.09%
Total valid and usable	70	63.63%

Source: Own Survey, 2024

According to Saunders (2010), surveys with higher response rates (near 60% or 70%) have more accurate measurements than those with lower response rates. Thus, higher response rates are always preferable compared to lower ones. The returned questionnaires were checked further for errors and as a result, 10(9.09%) incomplete questionnaires (missing data) were identified and discarded. Finally, a total of 70 valid and usable responses were used for the final analysis.

4.2. Demographic variables and respondent's profiles

A. Respondents Information

Socio-demographic factors are fundamental indicators of performance in any organization and the basis for research questionnaire turnout. Accordingly, the following demographic characteristics and general information about the respondents were summarized and described in Figure 4.1 below.

With regards to the first demographic distribution of gender of the respondents,51 (73%) of them were male and 19(27%) of them were female. This shows that most respondents were male employees, which is expected more male staff in a labour-intensive company like building construction companies.

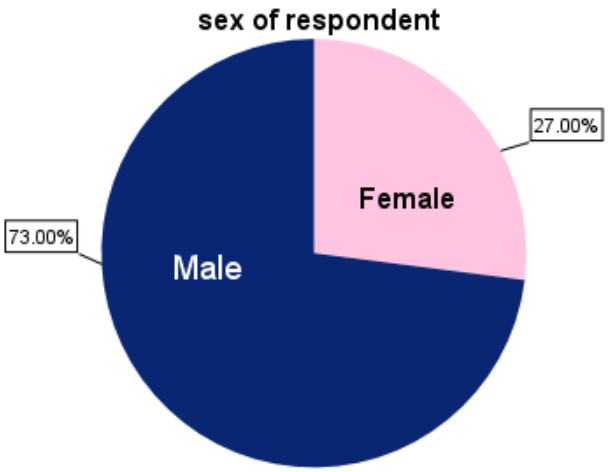

Fig.4.1. Gender of respondents

B. Position of respondents in the organization

Positions of respondents in the organizations were represented in the survey. Considering the current positions in their construction industry, 22(43%), were site engineers, 14(27%) office engineers, 3(6%) were project managers, 6(12%) were supervisors, 6(12%) were other civil engineer professionals.

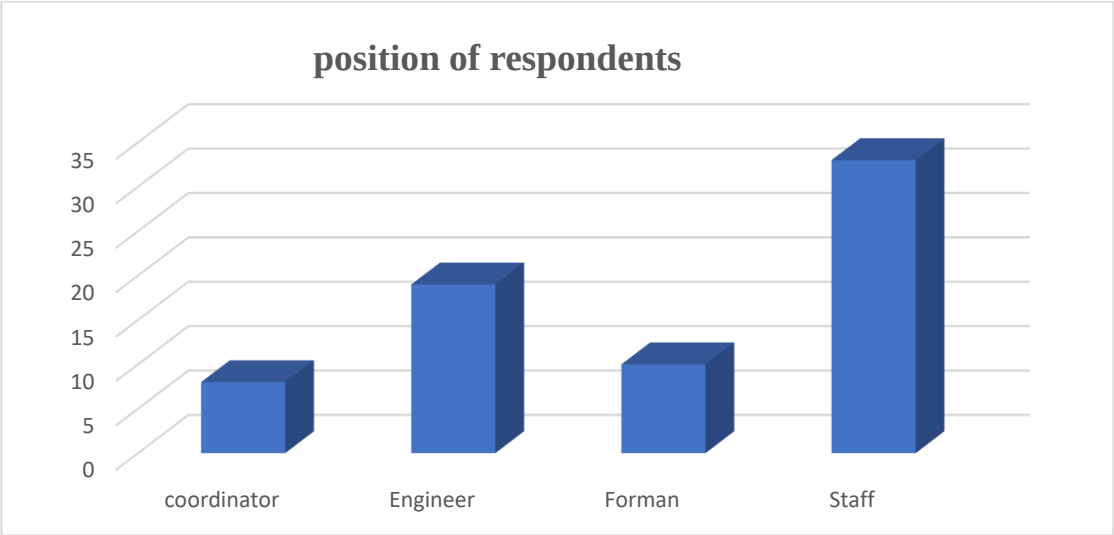

Figure 4.2. Position of respondents in the organization

C. Academic Qualification of Respondents

Concerning the professional backgrounds of respondents, Figure 4.3, shows that, the academic qualifications of respondents comprised of TVET (44%), Diploma (16%), bachelor's degree (23%), and master's degree (10%) and there were no qualifications below degree or above master's degree.

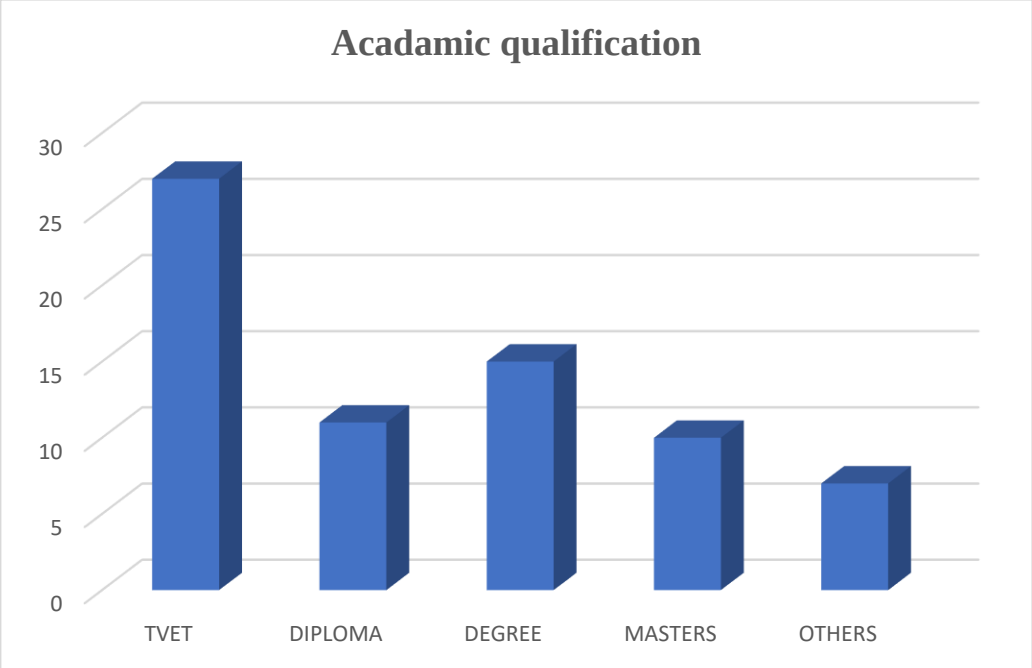

Figure 4.3 Academic Qualifications of Respondents

D. Experience of respondents

Regarding the working experience of the respondents surveyed Figure 4.4 shows that 17(24%) of respondents had worked in the construction industry less than 5 years, 35(50%) between 6 to 10 years, 10(13%) between 11-15 years and 9(12%) more than 15 years.

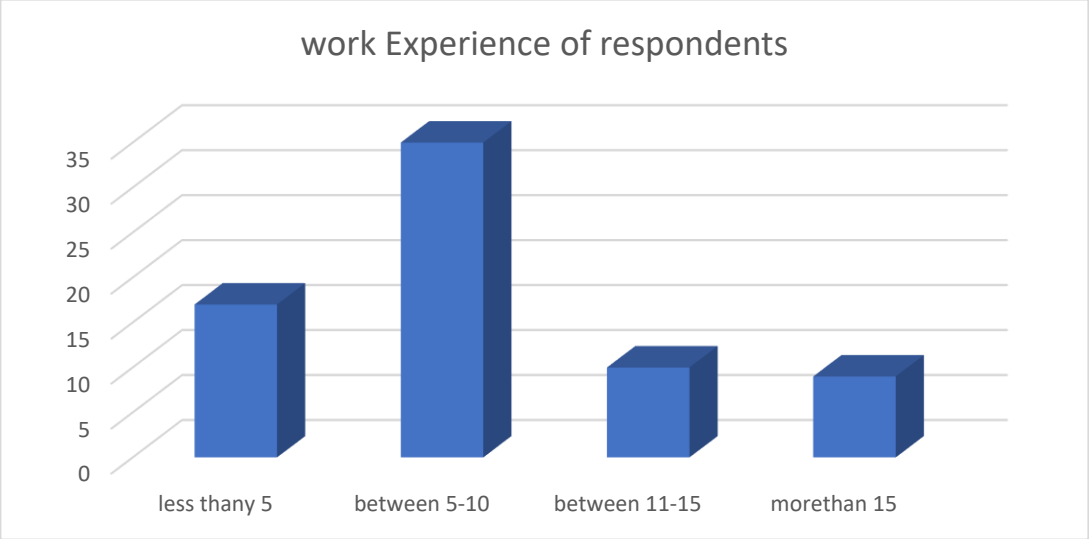

Figure 4.4 Experience of Respondents.

E. Age of Respondents

As the results are shown in Figure 4.5, when it comes to the age of the respondents,14 (20%) of them were between 20-29 years old, followed by42(60%) and 14(20%) within 30-39 years and 40-49 years old respectively. This implies that, despite about 80% of the respondents who participated in this survey being below 40 years old, the survey constituted customers from all age groups which can be taken as an opportunity to get different perceptions from different age groups.

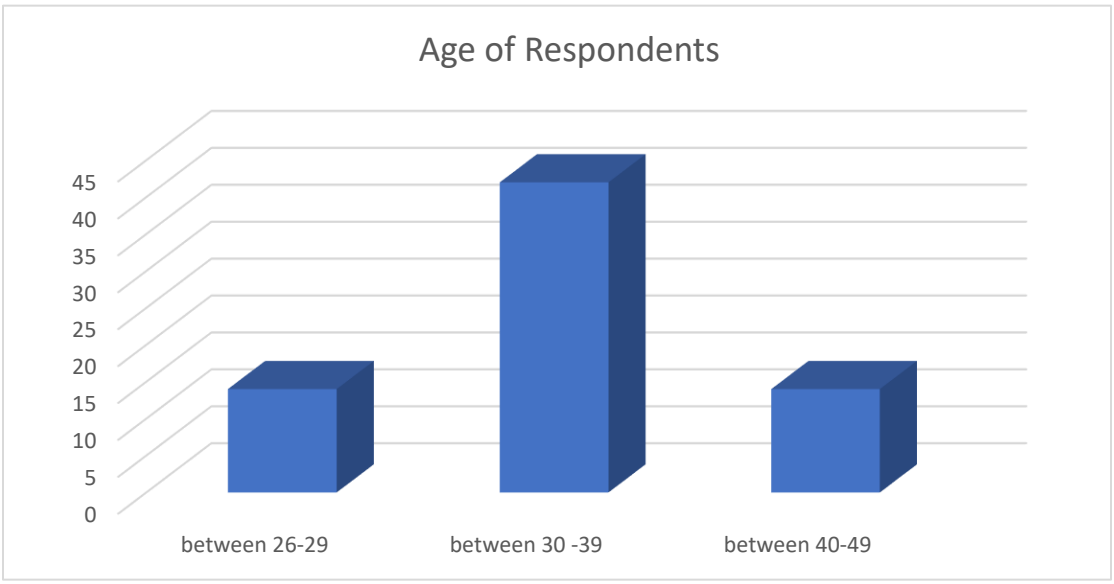

Figure 4.5: Age of the Respondents

4.3. Reliability Check - Cronbach's Alpha

Table 4.2. Cronbach's Alpha for Questionnaires

No	Factors to be evaluated	No of items	Cronbach's Alpha
1	Assess the awareness & practice of PMC	10	0.808
2	Benefit of prefabrication	6	0.881
3	Challenges of prefabricated construction	10	0.938
4	Strategies for Prefabricated Construction Adoption	11	0.785
5	Overall items	37	0.876

As indicated in Table 4.2. above, $\alpha = 0.808$ assess the awareness and practices of prefabricated construction dimensions, $\alpha = 0.881$ for the benefits of PMC, and $\alpha = 0.938$ for challenges related to PMC contribution dimensions, $\alpha = 0.785$ for strategies of PMC adoption. This shows the questions are reliable and have high internal consistency. Moreover, the overall reliability test (Cronbach's alpha) for the items is 0.876. This implies that the items were reliable, clear, and easily understandable by the respondents.

4.4. Prefabrication Construction practices

Based on the responses obtained from the respondents the results and corresponding discussions of the study are presented in the following sections in line with the specific objectives

4.4.1 Practices of Prefabrication Construction Methods in Real-estate Construction Project Sites.

This part investigates prefabrication practices in real-estate construction projects. The results are presented in Table 4.3 using the RII.

The summary of the 10 Prefabrication construction awareness and practices on Real-estate Construction Project sites was identified and ranked in Table 4.3. The Relative importance index (RII) ratings on the identified problems were calculated based on a scale of 1-5 (from "Strongly Disagree" to "Strongly Agree").

Accordingly, using PMC enhances coordination (0.840), supports adoption & application of prefabricated construction (0.823), and standardization with construction code (0.797) were the top three prefabrication construction Practices on real-estate construction projects ranked by respondents based on their RII values.

Table 4.3. Prefabrication Construction practice on Real-estate Construction Project sites

S/NO_	Prefabrication Awareness & Practices on real-estate construction projects		
	Awareness & practices	RII	Rank
1	There is awareness of Prefabrication and its benefits	0.400	9
2	There is awareness about prefabrication adoption and application	0.674	6
3	Aware of the transportation & handling of prefab materials	0.217	10
4	Prefabrication often requires specific tools and machinery for installation.	0.523	8
5	perceive prefabrication as reliable and durable	0.557	7
6	support the adoption and use of Prefabricated Construction in construction industry projects	0.823	2
7	There is Design components integration and flexibility	0.749	4
8	Using prefabricated construction enhances logistics processes coordination/Supply chain coordination	0.840	1
9	Standardization done to ensure consistency and smooth construction workflows	0.797	3
10	Regular inspections are done to ensure high-quality prefabricated elements	0.780	4

By considering awareness of PMC in real-estate construction project sites; the study revealed that respondent's awareness about PMC practice we have about 10 activities. This is an indication that almost all of the respondents had variations in the rating of their awareness of the PMC. From Table 4.3 it was observed that the respondents' level of awareness of PMC was relatively low especially, prefabrication and its benefits (RII=0.400), awareness of 'prefabrication handling & transportation methods' (RII = 0.217), prefabrication requirements (RII=0.820), and perception of prefabricated construction (RII=0.812), while the awareness was relatively low 'specific requirements of machinery & tools' by PMC with (RII = 0.523). From the ongoing, the awareness of practices of PMC like prefabrication and handling methods and its use and benefit should be improved.

From the interview, real-estate construction projects apply prefabrication construction method as currently trained not only for the prefabrication construction method but also to

record as a whole this involves paper-based techniques and is problematic with many human errors which hurt construction project progress.

The construction industry remains an important economic sector vital in ensuring economic development in a country's economy. Developing Towns like Addis Abeba should use the prefabrication construction practice seriously according to the data from the interview there is a lot to do with this useful asset. There is a very high variability of prefabrication construction technology familiarity from site to site. Furthermore, similar sites might present different levels of prefabrication technology for the same material. This indicates that a considerable portion of cost variability, delays, and other related problems can be avoided if we take this seriously. It is very vital to assess construction professionals' skills in prefabrication practice before we pass to the next level. Based on the findings presented above, highly occurring problems associated with prefabrication construction practices in the Tsehaye real estate appear quite low. Due to this (professionals' skills in PMC awareness and practices) must be investigated.

Several professionals are involved in prefabrication construction technology practices. Each of them takes on different roles in construction projects with very different objectives. PMC is a shared responsibility between all parties of the supply chain, from the client down to the contractor. Effective management of building-related technology requires the coordinated action of government, business, supplier, professional groups, and their activities.

For the successful completion of one construction project, it is mandatory to have strategic planning for the construction company and the supplier. And must be full of skilled and competent manpower to have strategic use of construction technology like PMC.

It is one of the most common problems that occurs in construction companies is to have old employees who are assigned to areas that require extra energy and effort. Continuous staff training on how to prefabrication construction is very essential for the company.

According to Tessera (2020), there are challenges and opportunities related to prefabrication in building construction. Prefabricated Method of Construction (PMC) is a prior method of construction in the world. Especially after WW II, many European countries used PMC to solve their housing demand. This technology was also introduced in Ethiopia thirty years

ago. Nevertheless, the development and expansion are limited due to a lack of awareness and practices of prefabricated construction.

4.4.2. Benefits of prefabrication construction methods

This part examined the awareness of prefabrication construction method practices in real-estate construction projects. Table 4.4. provides a level of awareness of prefabrication construction method practice on building construction sites and the RII of the respondents. RII was calculated based on a scale of 1-5 (from “strongly disagree” to “strongly agree”).

The findings are below in Table 4.4. Further, confirmed that most of the respondents have very good Knowledge benefits of prefabricated methodology for housing delivery productivity in reducing labour work ranked 1st (RII=0.834), cost-saving (direct & indirect) 2nd (RII=0.822), minimize wastage generation ranked 3rd (RII=0.811) but not many of them have used it in their line of the profession even though they are aware that the prefab methodology for housing delivery has been benefitted for the real-estate housing projects completion in shorten the time, and is appropriate for housing delivery and is marketable in Addis Abeba.

Table 4.4. Benefits of Prefabricated Construction

S/NO_	Investigating advantages of prefabricated construction on real-estate construction projects		
	Benefits: -	RII	Rank
1	Reduced construction time	0.714	5
2	Cost savings	0.822	2
3	Improved quality control	0.700	6
4	Minimize waste generation	0.811	3
5	Enhance Safety &Health	0.765	4
6	Productivity	0.834	1

Construction industry players need to promote benefits such as prefabrication eliminating wet trades on site, speed to construction, construction without weather barriers, etc. (Dainty & Brooke,2019). Prefabrication can improve productivity while reducing on-site time, thus avoiding vandalism to the materials. By having prefabricated residentials, all components are guaranteed their precision and quality as they have been checked and precisely produced through automation (Bildsten, 2017). Research by Johnsson & Meiling (2020) proves that in Sweden, prefabricated house construction has lower defects compared to the in-situ conventional method.

Turner & Vaughan (2016) added that by implementing prefabricated residential, developers can reduce 25% of labour cost and save on materials as the load and strength become more optimum.

This can be widely adopted and commonly used in public housing development projects. Also, this method has already been applied with success in the production of public housing blocks and projects. Indications are that cost has been cut, quality improved and construction time dramatically reduced.

Prefabricated construction techniques give better quality installations in buildings, improve sound control, higher living comfort, and increase efficiencies in overall construction and installation costs.

The prefabricated construction is capable of providing improved environmental performance over conventional construction methods. Prefabrication offers many benefits, but it requires technical expertise like any construction method. To implement prefabrication successfully, construction administration services from a qualified engineering firm are strongly recommended.

The study conducted by (Isaac et al, 2022) also revealed that Concrete in-situ construction generates numerous construction wastes during building, and transportation of waste tends to incur high building resource consumption, low building efficiency, and frequent accidents, which results in relatively serious environmental pollution pressure Prefabrication may be defined as the production of the entire building, or substantial building constituents‟ offsite, in a factory location before fitting or assembly on site (Bellis, 2011; Li 2014). It is an emerging new technology in the architecture, engineering, and construction industry (WEF 2016). Prefabricated construction is a state-of-the-art

construction technology with both socio-economic and environmental benefits, but sometimes, it is not welcome due to its high cost (Baoquan et al.,2020). To meet with time and budget requirements of construction projects, contractors are utilizing prefabricated construction methods to accelerate the construction process. Prefabricated construction methods require an adequate schedule and understanding by the contractors and constructors to be successful.

4.4.3 Challenges Associated with Prefabrication on Real-estate Construction Projects.

This section analyzed identifying factors associated with prefabrication on building construction projects in the case of Tsehaye real estate.

This objective was examined through the research question indicated below using Likert Scaling like objective one as discussed above.

The Challenges Associated with the prefabrication construction method on Building Construction project sites in the Tsehaye real estate were analyzed using the relative importance index method as indicated above. The RII ratings on the factor associated were also calculated based on a scale of 1-5 (from “strongly disagree” to “strongly agree”).

Based on the responses of the respondents, the top three challenges associated with prefabricated construction for housing delivery by developers in Tsehaye real estate were identified. Accordingly, Lack of awareness (RII=0.897), design flexibility (RII=0.897), Standard & Code Compliance (RII=0.837), and Architectural limitation (RII=0.667) were the top three factors that affect PMC practice.

While, transport restriction, site adaptation, and quality control do not cause many challenges to utilization of prefabricated construction in real-estate projects.

As it has been observed on the site and based on the interview the study found out that Capturing the full cost and productivity benefits of prefabricated construction is not a straightforward proposition. It requires carefully optimizing the choice of materials; finding the right mix of 2-D panels, 3-D modules, and hybrid designs; and mastering challenges in design, manufacturing, technology, logistics, and assembly. It also depends on whether builders operate in a market where they can achieve scale and repeatability.

Lessing et al., (2005) identified that the most common challenges that arise in prefabricated residential is delay in delivery due to inefficient supply-chain relationships. To avoid this problem, all parties must practice direct and effective communication, especially in the early design stage (Nawi et al.,2018; Roy et al., 2003). Besides, the whole parties should practice on-time payment, detailed contractual procedures, and an efficient delivery system where precise planning is applied (Goodier & Gibb, 2007; Nadim & Goulding, 2010). For better coordination, the developer can practice integrated partnership because the prefabricated manufacturers are seeking long-term business partnerships with any client and other stakeholders not only for current projects but also for other future projects (Bildsten, 2011; Blismas et al, 2005).

Table 4.5. Challenges of Prefabrication Construction Method

S/NO_	Section IV: Challenges Prefabrication Construction Utilization on Real-estate Construction Projects.		
	challenges	RII	Rank
1	Initial High Building Costs	0.809	6
2	Lack of Awareness	0.897	1
3	Technical and Installation skills	0.811	5
4	Local Availability of material	0.789	8
5	Site Adaptation	0.760	9
6	Transport Restrictions	0.574	11
7	Quality Control	0.757	10
8	Design Flexibility	0.823	4
9	Architectural Limitation	0.831	3
10	Standard & Code Compliance	0.843	2
11	Supply chain Risks	0.794	7

4.4.4. Strategies for Prefabrication Construction Method on Construction Projects

This section presents data analysis and findings from the questionnaire survey. It begins with a descriptive analysis of the general demographic variables of respondents. This is followed by an analysis of Strategies for prefabrication on real-estate construction Projects.

In this section, 10 strategies for prefabricated construction methods on real-estate construction project sites were mentioned and our respondents were asked to choose the appropriate prefabricated construction adoption and application strategies for their organization. From those strategies, our respondents preferred to implement Quality control (77%), Development strategy and policy support (77%), using a Building information model (BIM) (74%), design for manufacturing (73%), standardized component design (70%), coordinate system early (69%), raise awareness (68%), optimize layout and planning (65%), Tripartite evolution

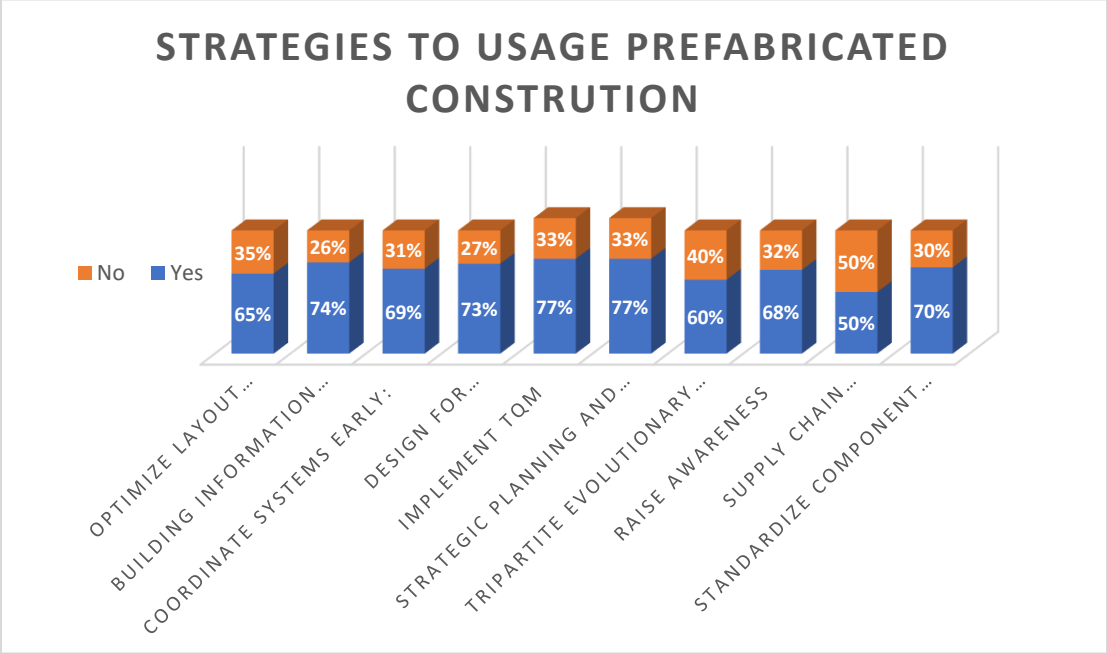

Figure 4.6 Strategies for Inventory Control on Construction Projects

(60%), supply chain management (50%) respectively. The study concludes that implementing quality control and development and policy support are the most used prefabricated construction adoption strategies in respondents' organizations. The most common answer received is that the respondent's company is currently applying a prefabricated construction method.

From the interview results, almost all construction projects use the traditional construction method, which has several limitations. Which is; labor intensive, inaccurate, and subjected to error-prone which further leads to waste and surplus of materials, schedule delays, decrease in productivity, and the lack of up-to-date information regarding the status of construction (much more take-offs). Thus, the traditional construction method is labor

intensive and not reliable as they are dependent on workers' motivations and skills to track the materials also the companies do not use any software /technology to alert the user when inventory levels are below or above certain levels.

Prefabricated construction strategies are an indispensable function in construction companies, well-managed prefabricated construction improves site installation more smoothly and in turn, gains better profitability. Ideally, the right material should be supplied at the right place, at the right time, and in the right quantity to have speedy installation and minimize the cost of craft labor time of the project it is mandatory to have a well-organized prefabricated system. There is a very high variability of prefabricated adoption strategies that are different from site to site on quality control systems but all of them were arguing to achieve the fundamental objective of a good quality control system that can determine the construction time, cost, quality, and overall productivity and performance the above result not knowing these fundamental prefabricated usage objectives which can cause project delays and cost overruns.

In a construction process called the "conventional" or also "on-site" method, or even "site-built", a building is built on the site for which it was designed. The prefabrication method is rather an industrialized process based on the production and pre-assembly of off-site components and elements which will subsequently be transported to the site to be assembled, in the form of an open or closed system. An open system, it can be said that it is the one that allow for the integration of construction materials from different manufacturers, while in a closed system, all components are defined by the system itself or the manufacturer, not allowing for the integration of others. Different types of prefabrication are also considered: the manufacture and sub-assembly of components (e.g., doors), non-volumetric pre-assembly (e.g., wall panels or wooden structures), volumetric pre-assembly (e.g., bathrooms), and modular construction (e.g., complete units or modules that make up a building) (Kamali et al,2019). One of the particularities of this system is that substantially, as the level of prefabrication increases, both the use of materials and the energy and greenhouse gas emissions tend to decrease (Kamali et al,2019). Prefabrication has been approached as an alternative to conventional construction mainly for residential buildings, but its implementation is still not very expressive (Xue et al.,2023) despite growing interest, mainly in the business sector, as it is seen as an opportunity to reduce costs and, above all, environmental and energy impacts.

Overall, most of the existing research addressing comparative studies between conventional construction and prefabrication concluded that prefabricated construction methods are more beneficial, as they have more positive impacts on the environment, the economy, and society. One of the highlights of the literature is its contribution to the sustainable development of this type of system, as it ensures better cost-effectiveness, better control of construction quality, greater worker safety, and consequent labour productivity (Wasim, 2020; Moon,2014).

4.5. Summary of major findings

Prefabrication construction could be a ground-breaking movement, unfortunately, within the Ethiopian context, and amongst private developers, though they are very aware of the existence of the technology and its benefits, how best a user perceives its relevance to his/her performance output directly affects the technologies usage. The study examined perceived usefulness without investigating its relationship with perceived ease of use, attitude towards using the system, and actual usage amongst Tsehaye real-estate members who are private developers. All relationships with other variables within Tsehay Real Estate are not within the scope of this study but rather investigated and analyzed in further studies. Many engineers believe that the key barrier to user acceptance is the lack of user-friendliness of current systems and that adding user interfaces that increase usability is the key to success (Branscomb & Thomas, 1985). The present results indicate that the usefulness of a system is very important, and should not be overlooked. Users may be willing to tolerate a difficult interface to access functionality that helps them increase productivity, in this case, increased housing supply, while no amount of ease of use can compensate for a system that does not do a useful task. The conclusion can therefore be made that factors that motivate individual users in different societies to accept technology should be considered before introducing the technology. These studies could enable organizations to determine the factors that are likely to lead to high outcomes rather than simply copying what has worked elsewhere; due to the differences in settings and perceptions.

In this study, mainly investigated awareness and practices, the contributions of PCM, the challenges to utilizing PCM, and strategies needed to apply PCM in the case of Tsehaye real-estate construction projects. Based on the data analyses, the major findings of the results are summarized as follows:

Accordingly, using PMC enhances coordination (0.840), supports adoption & application of prefabricated construction (0.823), and standardization with construction code (0.797) were the top three prefabrication construction Practices on real-estate construction projects ranked by respondents based on their RII values.

By considering awareness of PMC in real-estate construction project sites; the study revealed that respondent's awareness about PMC practice we have about 10 activities. From this study it was observed that the respondents' level of awareness of PMC was relatively low especially, prefabrication and its benefits (RII=0.400), awareness of prefabrication handling & transportation methods (RII = 0.217), prefabrication requirements (RII=0.820), and perception of prefabricated construction (RII=0.812) higher importance, while the awareness was relatively low on; transportation and handling material 'and 'specific requirement for machinery and tools' (RII=0.217, RII = 0.523). From the ongoing, the awareness and practices of PMC like prefabrication and handling methods and its use and benefit should be improved.

Findings in Figure 1 further confirm that most of the respondents have a very good Knowledge benefits of prefabricated methodology for housing delivery productivity in reducing labour work ranked 1st (RII=0.834), cost-saving (direct & indirect) 2nd (RII=0.822), minimize wastage generation 3rd (RII=0.811) but not many of them have used it in their line of profession even though they are aware that the prefab methodology for housing delivery has been benefitted for the real-estate housing projects completion in shorten time, and is appropriate for housing delivery and is marketable in Addis Abeba.

Based on the responses of the respondents, the top three challenges associated with prefabricated construction for housing delivery by developers in Addis Ababa were identified. Accordingly, technical & installation skills (RII=0.698), code compliance (RII=0.694), and Architectural limitation (RII=0.667) were the top three factors that affect PMC practice.

While, transport restriction, site adaptation, and quality control do not cause many challenges in utilizing prefabricated construction in Tsehaye real estate.

In this section, 10 strategies for prefabricated construction methods in the case of Tsehaye real-estate construction project sites were mentioned and our respondents were asked to choose the appropriate prefabricated construction utilization strategies for their organization. From those strategies, our respondents preferred to implement Total Quality Management (TQM) (77%), strategic planning and support (77%), using a Building

information model (BIM) (74%), design for manufacturing (73%), standardized component design (70%), coordinate system early (69%), raise awareness (68%), optimize layout and planning (65%), Tripartite evolution (60%), supply chain management (50%) respectively. The study concludes that implementing TQM, strategic planning and support, and BIM is the most used prefabricated construction adoption in respondents' organizations real-estate. There is a conflict between architects' desire to generate unique designs and the technical limitations of using standardized, prefabricated materials (Madigan, 2012). There is the additional 'chicken-and-egg' complication in establishing prefabrication building in that, unlike traditional building components, there is not an existing catalog of components to use in designs, so designs are not made calling for the use of these components (Bertelsen, 2005). Proving the technical merits and appropriateness of prefabrication against existing standards and regulations is a potentially complicating factor (Gann & Senker, 1993).

Although it could be argued that prefabricated materials and transportable houses address issues of repeated travel to sites for contractors, the logistics of transporting heavy or large materials to sites should also be considered (Daly, 2009).

From the interview results, addressing negative perceptions requires a concerted effort to showcase the quality and reliability of prefabricated construction through real-world examples and pilot projects. Investing in local manufacturing facilities and improving logistics can mitigate technical and logistical challenges. Advocacy for supportive policies and regulatory frameworks is essential to create an enabling environment for prefabricated construction. Encouraging industry leaders to champion prefabricated construction can create a ripple effect, influencing others to follow suit. Implementing comprehensive training programs and certification courses can enhance the competency of professionals and foster a culture of innovation and continuous improvement. Educational initiatives should be prioritized to build a knowledgeable and skilled workforce capable of leveraging prefabricated construction methods. Collaborative efforts can lead to the development of innovative solutions and the establishment of best practices, driving the industry forward.

The interviews provided valuable insights into the use, challenges, and role of professionals in adopting prefabricated construction methods and materials. While there are significant benefits to be gained, overcoming the challenges requires a multifaceted approach involving education, advocacy, and collaboration. By addressing these issues, the construction industry in Addis Ababa can fully realize the potential of prefabricated construction, leading to more efficient, cost-effective, and high-quality building projects.

To provide a comprehensive understanding of the use, challenges, and role of professionals in adopting prefabricated construction methods and materials, we triangulate the findings from interviews with the responses from questionnaires completed by professionals and top management. Both data sources consistently highlight the need for increased awareness and education about prefabricated construction methods to improve adoption rates. The challenges identified in both interviews and questionnaires are consistent, emphasizing the need for targeted interventions to address perceptions, technical issues, and regulatory barriers. Both interviews and questionnaires underscore the importance of leadership and training in promoting prefabricated construction. This highlights the need for initiatives that empower industry leaders and provide continuous professional development. The alignment between interview findings and questionnaire responses reinforces the need for educational initiatives and collaborative efforts to enhance the adoption of prefabricated construction.

The triangulation of interview results with questionnaire responses provides a robust understanding of the current state of prefabricated construction in Addis Ababa. Both data sources consistently highlight the low awareness and adoption rates, the challenges faced, and the critical role of professionals in promoting prefabricated construction. The findings suggest that targeted educational programs, supportive policies, and collaborative efforts are essential to overcome the barriers and maximize the benefits of prefabricated construction in real estate development projects.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

In this chapter conclusions and possible recommendations are presented.

5.1. Conclusions

Based on the findings of the study the following conclusions are drawn.

Prefabrication offers a range of contributions that make it an attractive option for modern construction projects. Prefabrication offers cost benefits compared to traditional construction methods. By manufacturing building components in a factory offsite, the cost of materials can be reduced because the process is faster and more efficient, resulting in lower labor costs. Additionally, the materials used for Prefabrication are often more durable, meaning the building will last longer and require fewer repairs over time. Prefabrication also offers time savings compared to traditional construction methods. The components of the structure are built offsite, which means that all of the components can be delivered to the site in a single shipment. This eliminates the need for multiple shipments, thus reducing the overall time needed to complete the project. Furthermore, the construction process is much faster, as the components are assembled before arriving at the job site. Prefabrication also offers increased safety compared to traditional construction methods. The components are built offsite in a controlled environment, meaning they can be tested and inspected before being delivered to the job site. This ensures a high-quality product that meets all of the necessary safety standards. Additionally, the components are designed to be self-supporting and easy to assemble, which reduces the risk of injury on the job site.

Prefabrication has its challenges. Prefabricated components are often highly customized and require skilled labor for their assembly. This requires the building site to be well-equipped with experienced workers familiar with the modular components and the construction process. As a result, finding the necessary labor for prefabrication projects can be difficult, and experienced workers can be expensive. Overall, Prefabrication can be a complex process. While its advantages are many, there are certain challenges to be aware of. Experienced workers are needed to assemble the components, and there can be difficulties in modifying the components once they are delivered. Additionally, the transportation of the components

can be complicated and expensive. However, these challenges can be managed with the right supplier and the right training. Additionally, prefabricated components are only sometimes easy to modify. It can be difficult to change the size of the components or add new features without specialist tools. This can lead to time delays and increased costs if the design is modified during construction.

5.2. Recommendations

The following points are recommended based on the findings of the study.

- The developer should engage a prefab company early in the design process, but not allow the manufacturer to drive the design process for the progress of the method. Further, it's important to understand the differences between a traditional contractor and a prefabricated construction manufacturer, as both debt and equity partners will require more assurances, financial considerations, and explanations before allowing its use.
- The road to the full implementation of prefab construction has to start with educating the stakeholders of the construction sector, this has to be done step by step from the construction minister to financial institutions and then to small-level contractors but teaching these parties by itself is not enough since the one who will use the method are the clients which mean this knowledge sharing have to extend to all citizens which are potential clients, even though some prefabricated construction companies are doing the part on educating the people the government have to have the initiation and lead the country on helping in educating the country and attracting new investors on the field since it won't be an easy task for the private sector only.
- It's also important for the growth of prefabricated construction that the government incorporate the rules and regulations of the construction and design specification of the method into EBCS and any other construction rules.
- Lawmakers like their developed countries counterparts could play a major role in the growth of the prefabricated construction market by giving a tax break for those companies which import the materials and by giving low taxation for the clients and contractors who use the technology.
- Despite the technological progress in the current construction market, if a developer in this case Tsehaye Real-Estate has successfully navigated this path, especially for housing

projects, there are clear financial benefits to offsite prefabricated construction even without the highly needed help from the governments and it's highly recommended.

- Three main strategic measures appear to be required for real-estate developers to successfully obtain an offsite capability and implement prefabricated construction.to increase profitability and productivity in the real-estate business prefabricated construction is a competitive advantage and should be given strategic planning and support from the top management, and implement TQM and BIM tools and techniques to utilize prefabricated construction to deliver housing at the required cost, time, quality standards.

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APPENDIX I: QUESTIONNAIRE

ADDIS COLLEGE SCHOOL OF POSTGRADUATE STUDIES
DEPARTMENT OF CONSTRUCTION TECHNOLOGY & MANAGEMENT

INVESTIGATING CONTRIBUTION OF PREFABRICATED TECHNOLOGY ON BUILDING CONSTRUCTION PROJECTS IN ADDIS ABABA
(Questionnaire)

Dear Sir/Madam,

You have been selected to participate in this study because you have invaluable information and knowledge related to the study due to your position. The information sought is required only for academic purposes. Participation is entirely out of your own volition; and necessary for the success of this work. I request you to respond with truthfulness and honesty for the success of the research. Remember that the information you provide will be confidential and will not be passed to a third party.

Sincerely,

……

TWELDE TEKA G/MISKEL

Address:-

Mobile: +251937070789

Email: tekatewelde@gmail.com

Section (A): Background Information

Tick or write where necessary in the space provided the alternative of your choice.

1. Gender

Male ☐ Female ☐

2. Age

20 – 29 ☐ 30 – 39 ☐

40 – 49 ☐ ☐ Over 50

3.Level of Education

TVET ☐ Diploma ☐

Degree ☐ Master Degree ☐

3.Designation in the company

Project Manager ☐ coordinator ☐

Engineer ☐ Forman ☐ Other ☐

4.Relevant Work Experience (Years)

Less than 5 ☐ 6 – 10 ☐

11 – 15 ☐ more than 15 ☐

Section (B): Awareness and practices of prefabricated construction in real-estate construction projects

In the table below, awareness and practices of prefabricated construction are listed. Is there awareness, good practices, and perception adoption and application of prefabricated construction in real-estate projects? Please indicate your response by ticking (√) in the box.

Level of Agreement				
~~Strongly Disagree~~	~~Disagree~~	~~Undecided (Neutral)~~	~~Agree~~	~~Strongly Agree~~
1	2	3	4	5

Awareness & Practices	Level of Agreement				
	1	2	3	4	5
1. There is awareness of Prefabrication and its benefits					
2. There is awareness about prefabrication adoption and application					
3. Aware of the transportation & handling of prefab materials					
4. Prefabrication often requires specific tools and machinery for installation.					
5. perceive prefabrication as reliable and durable					
6. support the adoption and use of Prefabricated Construction in construction industry projects					
7. There is Design components integration and flexibility					
8. Using prefabricated construction enhances logistics processes coordination/Supply chain coordination					
9. Standardization done to ensure consistency and smooth construction workflows					
10. Regular inspections are done to ensure high-quality prefabricated elements					
If you have any other stakeholder skill statements please specify. .	Please tick (√) on the box se tick				
	1	2	3	4	5

Instruction: Give your response by ticking (□□) once beside each choice.

Section (B): Prefabricated Construction Benefits in Real-estate Projects

Instruction: Rate the subsequent prefabricated construction benefits on your project and kindly specify the level of your agreement with the statement below once as per the scales provided.

Level of Agreement				
Strongly Disagree	Disagree	Undecided (Neutral)	Agree	Strongly Agree
1	2	3	4	5

In the table below, prefabricated construction benefits are listed. According to your experience, to what extent do you agree with the following statements? Please indicate your level of agreement throughout the questionnaire by ticking (√) in the appropriate box.

Questions related to prefabricated construction benefits on real-estate construction projects					
Benefits: -	Level of Agreement				
	1	2	3		5
1. Reduced construction time					
2.. Cost savings					
3. Improved quality control					
4. Minimize waste generation.					
5. Enhance Safety &Health					
6. Productivity					
If you have any other stakeholder skill statements please specify. . .	Please tick (√) on the box se tick				
	1	2	3	4	5

Instruction: Give your response by ticking (□□) once beside each choice.

Section (C): Challenges associated with prefabricated construction on Real-estate construction projects.

In the table below, there are commonly identified challenges that affect prefabricated construction in real estate construction projects. Based on your experience, please specify your level of agreement on the factors by ticking (√) on the box.

Strongly disagree = 1, disagree =2, neutral =3, agree =4 and **strongly agree = 5**

Problems	Level of agreement				
	1	2	3	4	5
Initial High Building Costs					
Lack of Awareness					
Technical and Installation skills					
Local Availability of material					
Site Adaptation					
Transport Restrictions					
Quality Control					
Design Flexibility					
Architectural Limitation					
Code Compliance					
Supply chain Risks					
If you have any other stakeholder skill statements please specify. . .	Please tick (√) on the box se tick				

Instruction: Give your response by ticking (□□) once beside each choice.

Section (D): Strategies for prefabricated Construction adoption in Real-estate Projects

In the table below strategies for the adoption of prefabricated construction are listed. Please choose YES/NO in the strategies that are best for construction projects.

STATEMENTS	YES 1	NO 2
1. Optimize Layout Planning (OLP)		
2. Building Information Modelling (BIM)		
3. Coordinate Systems Early		
4. Design for Manufacturing and Assembly (DfMA)		
5. Implement Total Quality Management (TQM)		
6. Strategic Planning and Support		
7. Tripartite Evolutionary Game Model (TEGM)		
8. Raise awareness		
9. Supply Chain Management (SCM):		
10. Standardize component design		
If you have any other strategies, please specify. . .		

APPENDIX-II

RESEARCH INTERVIEW QUESTIONS

1. What is the design service life of prefab tech building elements?

2. What are the main problems not to using prefab techs in building construction?

3. What are the relevant advantages and disadvantages of the prefabricated construction process?

4. Why combined forms of prefab and cast in-situ are preferable?

5. What is the role of Prefab techs in achieving green building goals?

6. What is your perception of prefab techs and their time, cost, and quality-related advantages?

7. How can one decide on which form of construction method is effective prefab or cast in-situ?

8. What is your perception of an “ideal project”?

Thanks for your cooperation!!!