EVALUATING POTENTIAL BENEFITS OF PRECAST CONCRETE TECHNOLOGY IN CITIES: THE CASE OF GSES (GEDA SPECIAL ECONOMIC ZONE)

ERMIYAS G/ALIF W/MIHRET

A Thesis Submitted To The Department Of Architecture

School Of Civil Engineering And Architecture

Presented In Partial Fulfillment Of The Requirement For The Degree Of Master's In Urban Planning And Design

Office Of Graduate Studies

Adama Science and Technology University

June, 2024

Adama; Ethiopia

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Declaration

I hereby declare that this Master Thesis entitled Evaluating Potential Benefits Of Precast Concrete Technology In cities: the case of GSEZ (Geda Special Economic zone) is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Ermiyas G/Alif W/mihiret	________________________	________________
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I, the major advisor of this research thesis, hereby certify that I have closely advised/supervised the student while developing this thesis and read the draft thesis entitled Evaluating Potential Benefits Of Precast Concrete Technology In cities: the case of GSEZ (Geda Special Economic zone) prepared under my guidance by Ermiyas G/Alif W/mihiret. Therefore, I recommend the submission of the thesis to the department for further review and evaluation.

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Approval Page Thesis Proposal

I/we hereby certify that the recommendation and suggestion given by the thesis review the committee are appropriately incorporated into the final thesis/dissertation entitled Evaluating Potential Benefits Of Precast Concrete Technology In cities: the case of GSEZ (Geda Special Economic zone) by Ermiyas G/Alif

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Co-advisor/ Co-supervisor Signature Date

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We, the undersigned, members of the Board of Reviewers of the thesis open defense by Ermiyas G/Alif W/mihiret have read and evaluated the thesis/dissertation entitled Evaluating Potential Benefits Of Precast Concrete Technology In cities: the case of GSEZ (Geda Special Economic zone) and assessed the understanding of the candidate about the research. This is, therefore, to certify that the thesis/dissertation is accepted and we recommend the implementation of the research.

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LIST OF ACRONYMS

GSEZ	Geda Special Economic Zone
PCT	Precast Concrete Technology
CAD	Computer Aided Design

ABSTRACT

The 21st century's urbanization trend has led to the emergence of cities, where precast concrete is crucial for cost-effective and resilient construction. The Geda Special Economic Zone (GSEZ) project in Ethiopia exemplifies this, aiming to create a sustainable industrial hub leveraging existing infrastructure and innovative land use planning across 23,656.51 hectares..this research aims to Explore the strengths and weaknesses of precast concrete application and integration in the Geda Special Economic Zone (GSEZ), aiming to provide valuable insights that can guide decision-making processes. Also the research employs applied, descriptive, and exploratory approaches, combining qualitative and quantitative methods to assess precast concrete technology's impact on GSEZ's infrastructure. Sampling techniques involve stratified and random sampling, with questionnaires, interviews, and field observations as data collection tools. Data reliability is ensured through questionnaire pre-testing, while validity is maintained by aligning instruments with research objectives. Analysis includes statistical tools like frequency tables and the Relative Importance Index (RII) for Likert scale data, along with qualitative methods for supplier interviews.In addition the study analyzes survey data on precast concrete technology in Addis Ababa's construction projects. The analysis result shows that application of precast concrete for industrial warehouses and residential structures in the Geda Special Economic Zone (GSEZ), aiming to boost efficiency and attract foreign investment. Precast concrete offers advantages like efficiency, quality control, durability, customization, and sustainability, contributing to New city development and import substitution for steel structures. Challenges include supply shortages, lack of information, skilled labor, and design considerations. It recommends placing precast concrete plants strategically within the zone to avoid future problems. It also suggests investing in research to improve how precast concrete is made, making it more efficient and affordable. Financial incentives like tax breaks can encourage developers and builders to use precast concrete. Collaboration among different groups is also important for sharing ideas and innovations. Lastly, following specific building codes ensures that precast concrete is used correctly, leading to economic growth and sustainability in cities..

Key words:- Precast Concrete technology, Geda Special Economic Zone (GSEZ), Import Substitution

CHAPTER ONE

1. Introduction

1.1 Background

In the 21st century, a notable surge in urbanization is evident as individuals increasingly migrate to cities in pursuit of enhanced opportunities and a superior quality of life. In response to the challenges posed by this rapid urban growth, the notion of cities has emerged. cities strategically utilize technology and inventive approaches to elevate the efficiency, sustainability, and overall livability of urban spaces.

The use of precast concrete in New city development is a promising approach, as it offers numerous advantages such as cost-effectiveness, resilience to natural and man-made disasters, and sustainability (Wang, 2021; Fleischman, 2016). The application of precast concrete in cities can be further enhanced through the use of intelligent concrete, which can sense environmental changes and respond accordingly, optimizing the reliability and sustainability of structures (Wang, 2017). Additionally, the use of precast alkali-activated concrete can contribute to the development of durable and eco-efficient materials, further supporting the sustainable construction of cities (Ferreira, 2014).

The use of precast concrete technology in cities is a key factor in promoting sustainability and green solutions (Nicolay, 2023). This technology is being enhanced by the implementation of digital technologies such as CAD and BIM (Kurakina, 2020). In the context of cities, precast concrete pavements are particularly beneficial for rapid repair and rehabilitation of existing roadways (Tayabji, 2013). Looking ahead, precast concrete structures are expected to play a significant role in the construction of tall buildings, modern factories, and large-scale infrastructure (Lu, 2014).

Within the realm of modern urban development, the construction industry plays a pivotal role, tasked with creating infrastructures aligned with the principles of cities. Traditional construction methods, often marked by time-consuming processes and environmental concerns, are progressively giving way to more innovative approaches. Precast concrete technology has emerged as a transformative force in construction, offering advantages in terms of speed, cost-effectiveness, and sustainability.

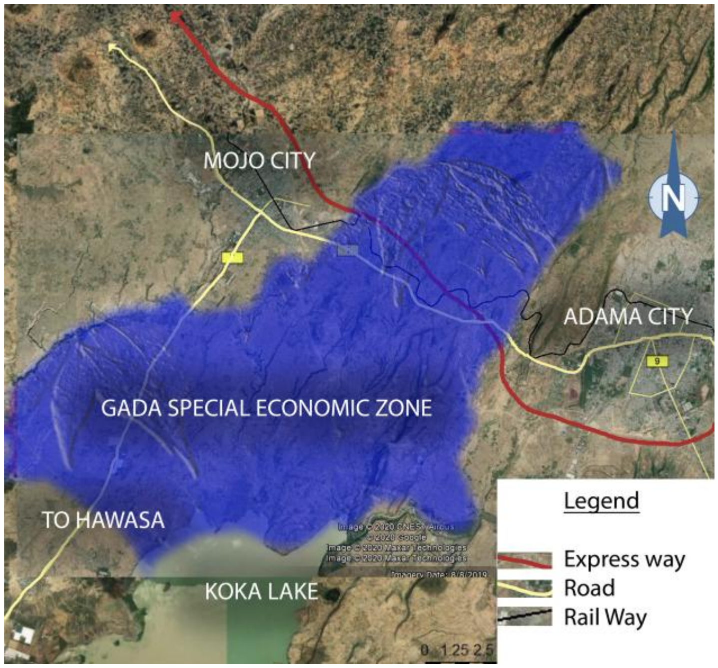

Figure 1 GSEZ PROPOSED MAP

Source: GSEZ Feasibility document

Zooming into a specific context, the Geda Special Economic Zone (GSEZ) project is situated at a key trade junction and serves as the crossroads for existing infrastructure, including railways, expressways, and highways. Positioned to the southeast of Finfinne, the project is strategically located between 8° 27'00" - 8° 37'00" N and 39° 01'00" - 39° 15' 30" E. The project aims to create job opportunities, attract foreign investment, boost exports, and foster regional and national development.

Notably, GSEZ is unaffected by the expansion of nearby towns or cities, providing ample space for future expansion. Encompassing a total area of 23,656.51 hectares between Adama and Mojo city, the land is mostly characterized by gullies erosion and currently used for farming, horticulture, rural settlement, open space, environmental sensitive areas, industries, water bodies, and gorges.

Against this backdrop, the unique attributes of precast concrete, such as its modular nature and off-site production capability, position it as a key player in the evolution of cities. However, the specific impact of precast concrete technology on New city development, especially within the context of urban centers like Geda Special Economic Zone City, remains an area requiring comprehensive exploration. This research seeks to bridge this gap by focusing on exploring the strength, weakness, and opportunity of precast concrete in GSEZ (Geda Special Economic Zone) as a case study, offering insights into the dynamic interplay between precast concrete technology and the evolution of cities.

1.2 Statement of the Problem

The increasing demand for rapid urban development poses significant challenges to traditional construction methods, which rely heavily on manual labor and often result in inefficiencies, high costs, and environmental concerns. In Ethiopia's industrial zones, such as the Geda Special Economic Zone (GSEZ), the reliance on imported steel structures further exacerbates issues of foreign currency outflow and inhibits the achievement of economic objectives. With industrial development heavily dependent on imported materials like steel, there is a pressing need to explore alternative construction methods that align with the country's economic goals, including job creation, foreign investment attraction, and export promotion. Precast concrete technology presents a promising solution, offering potential benefits such as import substitution, job creation, and environmental sustainability. However, the extent of its impact on the economic and infrastructural objectives of industrial zones like GSEZ remains largely unexplored. Therefore, the problem at hand is to investigate the viability and potential benefits of adopting precast concrete technology as an alternative to traditional construction methods, particularly in the context of industrial zones, to address the challenges of foreign currency outflow, job creation, and economic sustainability. This research aims to inform decision-making processes within the construction industry and government agencies, ultimately guiding the adoption of more efficient and sustainable construction practices in support of Ethiopia's economic growth and development objectives.

The objectives of industrial zones in Ethiopia are multifaceted and aim to contribute to the country's economic growth and development. Here are some key objectives:

Job Creation: Industrial zones are designed to generate employment opportunities for the local population. By attracting both domestic and foreign investors, these zones create jobs across various sectors.

Foreign Investment Attraction: The Ethiopian government seeks to attract foreign direct investment (FDI) through industrial zones. These zones provide incentives and infrastructure to encourage international companies to set up manufacturing facilities within the country.

Export Promotion: Industrial zones play a crucial role in boosting exports. By facilitating production and export-oriented activities, these zones contribute to foreign exchange earnings and enhance Ethiopia's trade balance.

Economic Diversification: The establishment of industrial zones contributes to diversifying the economy beyond traditional agriculture. Sectors such as textiles, leather processing, agro-processing, metallurgy, and pharmaceutical manufacturing are prioritized within these zones.

Infrastructure Development: Industrial zones require robust infrastructure, including roads, utilities, and communication networks. Developing and maintaining this infrastructure benefits not only the zones themselves but also the surrounding areas.

Technology Transfer: Collaboration with foreign investors allows for knowledge and technology transfer. Local companies can learn from established international firms, leading to skill development and technological advancements.

Inter-Industry Linkages: Industrial zones encourage linkages between different industries. For instance, a textile factory might supply materials to a garment manufacturer within the same zone, creating a symbiotic relationship.

Environmental Considerations: While promoting industrial growth, the government aims to minimize negative environmental impacts. Sustainable practices and responsible resource management are emphasized.

As cities grow and evolve, the demand for efficient and sustainable construction methods becomes paramount. Traditional construction practices often fall short in meeting the speed, cost-effectiveness, and environmental considerations required for modern urban development. Traditional construction methods fail to meet the government's objectives, particularly in the context of industrial zones that predominantly rely on imported steel structures like I-beams and H-beams, which incur high costs. This heavy reliance on costly imported materials strains both government and private investment, leading to significant outflows of foreign currency. Investigating the potential of precast concrete could reveal more cost-effective, locally sourced, and sustainable construction alternatives, ultimately supporting the economic and infrastructural goals of cities and special economic zones like Geda.

Thus this importing of steel structure comply with attraction of foreign direct investment (FDI) when they build they invest around 50% of their hard currency (USD) from this 25% is building material cost so if they use imported steel members for their sheds we loose 25% of USD, therefore in our country supply-chain concrete and reinforcement materials are available and urgently need to change this thinking to get that hard currency also if this imported material changed to precast concrete technology and manufactured here: Import substitution, Job creation, Additional Collection of foreign investment, Inter industry linkage, Environmental friendly all this goals are can be beated especialy for GSEZ who is under starting point.

Figure 2: Shades constructed by imported Steel Members

Source: https://www.baofengwarehouse.com/ethiopia_nc7

1.3 Objectives of the Study

1.3.1 General Objective

- .To evaluate the strengths and weaknesses of precast concrete application and adoption in the Geda Special Economic Zone (GSEZ), aiming to provide valuable insights that can guide decision-making processes.

1.3.2 Specific Objective

- To examine the principles and benefits of precast concrete technology in the context of New city development.
- To assess the specific applications of precast concrete technology in the construction projects within Geda Special Economic Zone City.
- To identify challenges and opportunities associated with the integration of precast concrete technology in New city projects or GSEZ.

1.4. Significance of the Study

This research holds paramount significance in the realm of urban development and construction innovation. As the 21st century witnesses an unprecedented surge in urbanization and the emergence of cities as a response to rapid urban growth, understanding the transformative impact of precast concrete technology becomes crucial. The study's significance lies in its potential to inform urban planners, policymakers, architects, engineers, and researchers about the specific implications of precast concrete technology in the development of cities, with a focus on the case study of Geda Special Economic Zone City. By comprehensively examining the application and integration of precast concrete in a real-world urban context, the research aims to contribute valuable insights that can guide decision-making processes, precast concrete plant location selection, enhance the efficiency and sustainability of construction practices, and ultimately shape the methodology of construction with import substitution building material within Geda Special Economic Zone. Moreover, the findings are anticipated to fill a critical gap in the current knowledge base, paving the way for more informed and effective approaches to urban development in the face of rapid global urbanization.

1.5. Research Questions

1. How does precast concrete technology contribute to the development of cities?
2. What are the specific applications of precast concrete technology in the construction projects within Geda Special Economic Zone City?
3. What challenges and opportunities are associated with the integration of precast concrete technology in New city projects?

1.6. Scope of the Study

The research focuses specifically on Geda Special Economic Zone, situated geographically between Adama and Modjo cities in Ethiopia. It examines the application of precast concrete technology within the infrastructure and construction projects taking place within this zone.

The study encompasses from now means at the beginning of the project typically at the installation of precast concrete Plant within Geda Special Economic Zone to the future GSEZ.

This time frame allows for an analysis of the evolution, adoption, and impact of precast concrete technology over this construction stage.

The thematic focus of the research centers on the transformative role of precast concrete technology in the development of Geda Special Economic Zone, with a special emphasis on import substitution of steel structures. Key themes include technological innovation, economic implications, environmental sustainability, construction efficiency, and the promotion of local industries through import substitution strategies. Additionally, the study may explore challenges, opportunities, and best practices associated with the adoption of precast concrete technology within the context of the Geda special economic zone.

1.7. Organization of the thesis

research paper comprises five chapters. The introductory chapter encompasses the background, problem statement, study objectives, significance, scope, and structure of the paper. The second chapter focuses on reviewing relevant literature, incorporating both theoretical and empirical works. The methodology of the study is outlined in the third chapter. Analysis and interpretation are presented in the fourth chapter, while the fifth chapter concludes with findings and recommendations.

1.8. Operational Definitions

The following operational definitions provide clear and precise meanings for key terms, establishing a foundation for consistent interpretation and measurement throughout the research. Here are operational definitions for key terms in your research:

i. Precast Concrete Technology: Operational Definition: In this study, "precast concrete technology" refers to the construction method that involves casting concrete elements, such as walls, slabs, and columns, in a controlled environment away from the construction site. These precast components are then transported and assembled on-site to form the structure, showcasing characteristics of modularity, off-site production, and standardized design.

ii. cities: Operational Definition: For the purposes of this research, "cities" are defined as urban environments that leverage technology and data-driven solutions to enhance the efficiency, sustainability, and quality of life for their residents. This includes the integration of advanced infrastructure, information and communication technologies, and innovative approaches to urban planning.

iii. Geda Special Economic Zone City (GSEZ): Operational Definition: Within the scope of this study, "Geda Special Economic Zone City (GSEZ)" refers to the designated economic zone located at the main trade route, specifically between 8° 27'00" - 8° 37'00" N and 39° 01'00" - 39° 15' 30" E. The GSEZ is intended to attract foreign investment, create job opportunities, and promote regional and national development, as articulated in its planned objectives.

iv. Urban Development: Operational Definition: In the context of this research, "urban development" encompasses the planning, construction, and improvement of physical, economic, and social aspects of urban areas. It specifically includes activities related to the growth and enhancement of Geda Special Economic Zone City, focusing on infrastructure, job creation, foreign investment, and export promotion.

v. Sustainability in Construction: Operational Definition: "Sustainability in construction" for this study is operationally defined as the extent to which construction practices, particularly those involving precast concrete technology in GSEZ, consider and balance environmental, economic, and social factors. This includes measures such as resource efficiency, carbon footprint reduction, and positive community impact.

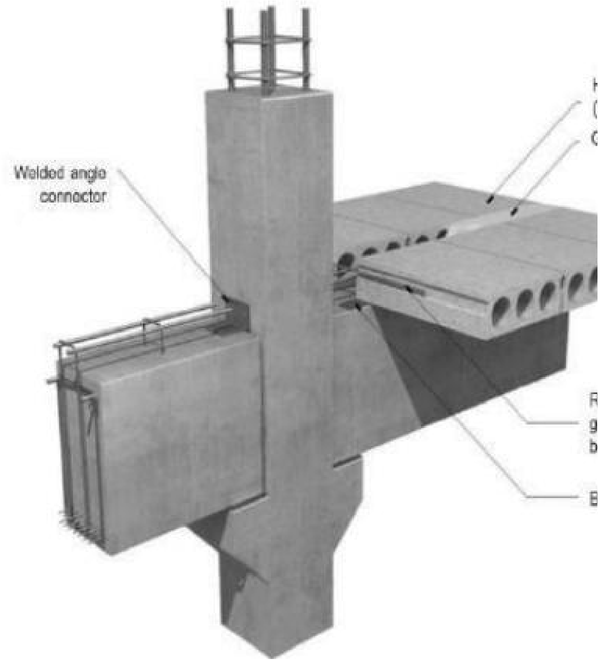

Figure 3 PRECAST COLUMN BEAM AND SLAB

Figure 4 STAIR CASE

Source: [Pin by Ardit Nexhipi on Tekno 3 | Prefabricated structures, Prefabricated architecture, Precast concrete panels (pinterest.com)]

CHAPTER TWO

LITERATURE REVIEW

2.1. Pre-Cast Concrete Construction

Kariuki (2010) describes Precast as the method of fabricating structural elements in a factory or other manufacturing facility and then transporting complete assemblies or sub-assemblies to the construction site for installation. Dineshkumar and Kathirvel (2015) concur with this definition, emphasizing that Precast distinguishes itself from traditional construction practices, which involve transporting raw materials to the construction site.

The primary aim of Precast technology is to manufacture building components efficiently within specialized environments, thereby reducing costs and construction time while improving quality and consistency (Anderson and Anderson, 2007). The widespread adoption of Precast, coupled with increased standardization and mechanization, has significantly transformed the construction industry worldwide, facilitating the construction of large-scale and high-rise buildings (Venkateswara and Sarath, 2013).

Furthermore, Ali and Rahinah (2017) reference Kamar's (2001) work to define Precast technology as an innovative construction process that employs mass-production principles to create industrialized systems either in a factory or on-site under controlled conditions. This process encompasses logistical and assembly aspects, requiring meticulous planning and integration.

2.2. Pre-cast Elements

Prefabricated concrete elements represent a significant advancement in concrete structure construction, characterized by their production through standardized casting methods and subsequent curing to attain strength before transportation to the construction site for assembly (Venkateswara and Sarath, 2013). Bahamon and Bill (2002) describe prefabricated concrete structural elements as a construction system wherein essential structural components are delivered to the site where the final structure will be erected, either partially or fully assembled, requiring only connection and anchoring upon arrival.

Prefabricated concrete offers advantages of efficient and cost-effective construction regardless of weather conditions, facilitating the creation of long spans and open spaces. These elements are manufactured, cast, and cured in specialized facilities under consistent supervision. Moreover, prefabricated concrete is favored in building construction, allowing the fabrication of walls while on-site foundations are under construction, leading to significant time savings and enabling early occupancy (Venkateswara and Sarath, 2013).

2.3. History of Per-cast

Around 100 B.C., the ancient Romans pioneered the practice of pouring concrete into molds for constructing aqueducts, culverts, and tunnels (Mikhailov and Susnikov, 1995). In the 1500s, a similar approach emerged as timber components of houses were intricately crafted and painted in Holland before being transported and assembled in London. This method gained popularity in Eastern Europe and Scandinavia in subsequent years (Arieff and Burkhart, 2002).

The Crystal Palace, a monumental glass-and-iron exhibition hall in Hyde Park, London, stands as one of Britain's earliest examples of prefabricated construction, showcased during the Great Exhibition of 1851. This remarkable structure was erected within a few months, utilizing a series of prefabricated elements. The United States entered the Precast market in the 1900s, with mass fabrication gaining prominence during World War II to swiftly assemble accommodation for soldiers (Mikhailov and Susnikov, 1995).

Subsequently, Europeans and Japanese leveraged this technique to rapidly reconstruct war-devastated areas. In the 1960s and 1970s, the advent of high-rise concrete prefabricated construction marked another milestone (Velamati, 2012). Velamati also notes the Hilton Palacio Del Rio Hotel as one of the world's earliest concrete high-rise prefabricated buildings.

Completed during the Texas World's Exposition of 1968, this 500-room hotel was designed, built, and occupied within an unprecedented timeframe of 202 working days.

Figure 5 Hilton Palacio Del Rio Hotel constructed by precast

Source: Hilton Palacio del Rio - Wikipedia

2.4. History of precast construction in Ethiopia

In 1978 E.C., Ethiopia saw the establishment of its inaugural Precast plant, aided by the former socialist country Yugoslavia. Known as the Precast Building Parts Production Enterprise (PBPPE), this facility stands as Ethiopia's sole Precast factory to date. The initiative, as outlined by Gutema (1998), aimed to swiftly address the escalating demand for housing, alleviate accommodation shortages, prepare for future needs, and reduce reliance on timber for formwork, thus promoting natural forest conservation. Specializing in Precast, PBPPE has been instrumental in producing structural elements for a range of constructions including office buildings, apartments, hotels, and residential structures for both public and private sectors. The building depicted in Figure 2.2 is one such example, as confirmed by PBPPE's records.

Figure 6 ECWC's 5000 Homes Project Using Precast Frames

Source:https://www.ecwc.gov.et/ProjectDetails.php?id=12

The housing deficit in Ethiopia during the early 1980s was staggering, surpassing the collective efforts of both the government and citizens. In response, precast concrete technology was introduced as a means to bolster the construction sector and address the housing shortfall. The primary goals of this initiative, outlined by Gutema (1998), were to advance the building industry through the mass production of precast concrete components, mitigate housing shortages, and curtail construction expenses. The establishment of PBPPE in Addis Ababa heralded the introduction of innovative construction techniques, aiming to serve as a solution to the immense housing demand prevalent at that time.

2.5. Advantages of Precast concrete Technology

Numerous studies and scholars have highlighted the multitude of advantages offered by prefabricated construction methods compared to conventional approaches, particularly in terms of safety, quality, efficiency, and cost-effectiveness. Tanya Trainee (2010) underscores the primary benefits of utilizing prefabricated concrete structural elements, emphasizing lower construction costs, accelerated construction timelines, and enhanced precision in workmanship.

Nadim (2009) posits that prefabrication technology represents a strategic shift in the construction industry, transforming traditional practices into a more streamlined manufacturing and assembly process through the integration of advanced technologies and stakeholder engagement. Furthermore, Nadim (2012) elaborates on the advantages of prefabrication, including enhanced business efficiency, product quality, environmental performance, sustainability, customer satisfaction, and predictability of project timelines. These benefits are achievable within a controlled production environment, minimizing waste, ensuring a safer work environment, and fostering long-term economic viability.

2.6. Advantages of precast concrete technology with respect to quality

Precast concrete elements, according to Jaillon and Poon (2007), are manufactured within controlled factory environments, ensuring superior quality control. By employing a combination of precast and cast in-situ elements tailored to specific design requirements, projects can achieve both higher quality and cost-effectiveness. This blend enables enhanced productivity levels compared to relying solely on cast in-situ construction, as highlighted by Dineshkumar (2015). The standardized production process in factory settings minimizes quality issues stemming from factors such as poor workmanship or subpar material quality.

Moreover, architects emphasize that the integration of precast facades and lost form panels facilitates uniform quality across building elevations, promoting visual consistency and aesthetic coherence, as noted by Jaillon and Poon (2007).

2.7. Advantages of Precast With respect to Time

Numerous technologies globally support the use of precast construction methods, with a common aim of reducing costs and construction time. Prefabrication offers designers the opportunity to assemble structures rapidly, providing several potential advantages in delivery and development, as noted by Alireza and Omid (2016). One significant advantage lies in the substantial time savings achievable. Factory efficiencies enable swift completion of building components, unaffected by weather delays. With all necessary personnel onsite, the factory can efficiently handle diverse building requirements, often eliminating the need for multiple subcontractors. Consequently, precast construction proves advantageous for property owners requiring expedited construction, properties with strict occupancy deadlines, and regions where seasonal weather poses construction challenges, as highlighted by Velamati (2012).

As the industry increasingly focuses on minimizing labor and shortening construction duration, precast concrete structures emerges as a practical alternative to traditional construction methods.

2.8. Advantages of Precast With respect to cost

Other significant advantages of employing precast elements encompass increased financial gains resulting from reduced construction interest expenses and time savings derived from a condensed construction timeline. Additionally, there's potential for decreased hard costs due to the implementation of repeatable and more efficient construction methods, modernized construction processes, diminished material waste, and enhanced construction quality (Velamati, 2012).

2.9. Advantages of Precast With respect to safety

Precast construction not only slashes construction costs but also fosters a more robust and equitably compensated construction sector, characterized by enhanced safety standards and working conditions, increased investment in research, amplified design innovation, and product advancement (Anderson and Anderson, 2007). Furthermore, the predominant use of precast concrete elements significantly diminishes on-site activities, thereby creating a safer working environment (Dineshkumar and Kathirvel, 2015). This underscores the substantial potential of precast concrete elements in mitigating workplace hazards by minimizing on-site operations and ensuring safer working conditions.

2.10. Advantages of Precast With respect to Environment

However, it's crucial to grasp its distinct management approach compared to conventional construction methods. Mere integration of precast into the traditional design and construction processes won't fully unlock its benefits. Successful implementation hinges on meticulous planning and a deep comprehension of the inter-connectedness among design, construction, detailing, execution, and the manufacturing of precast concrete components (Dineshkumar and Kathirvel, 2015). In essence, effective cooperation among the architect, engineer, builder, and producer is indispensable. This collaborative effort not only reduces energy and material consumption but also enhances the availability of finely crafted, reduces traffic disruption, high-quality built environments (Anderson and Anderson, 2007).

The adoption of precast construction depends largely on various factors including labor scarcity, labor expenses, housing demand, construction process efficiency, weather conditions, and the reduction of waste materials and energy consumption. Precast construction inherently offers economic, environmental, and social benefits (Khaled and Farid, 2015).

2.11. Challenges of Precast concrete technology

The seamless transfer of prefabrication technology hasn't occurred as readily as with other technologies due to its foundation in production knowledge rather than consumption or product-oriented principles. This necessitates early decision-making in the design phase, as precast elements are manufactured prior to site assembly, constraining architects' ability to make late alterations or respond to client requests for modifications during construction.

Khaled and Farid (2015) identify several barriers hindering the adoption of precast concrete technology, including insufficient research, higher initial construction costs, limited site space, aesthetic uniformity, lack of industry experience, absence of demand for precast, and inflexibility regarding design changes. Additional factors impacting the integration of prefabrication include industry practices, supply chain management, logistics, professional standards, and construction market risks.

2.12. Challenges of Precast concrete technology in Developing country

The adoption of precast concrete technology is further influenced by labor scarcity, labor expenses, housing demand, construction efficiency, weather conditions, and the imperative to reduce waste and energy consumption. Despite its evident economic, environmental, and social advantages, precast construction has yet to gain widespread traction in the global construction sector.

The variability of prevailing local conditions across countries contributes to the diverse adoption rates of precast concrete technologies. While motivations for using precast play a role in its consideration, the decision to incorporate this technology is shaped by weighing its potential advantages against existing challenges. These challenges encompass industry practices, supply chain management, logistics, professional standards, and risks within the construction market.

Further research is needed to explore effective measurement strategies for assessing the application and progression of prefabricated building techniques. However, addressing common challenges present in many countries, leveraging their potential benefits to boost precast building adoption, and mitigating perceived barriers necessitate a comprehensive approach. This approach should account for both similarities and disparities among nations. Moreover, various aspects of technology adoption, including training, organizational adjustments, and procurement methods within the construction sector, require attention to transition towards reaping economic benefits from precast.

Indicators point to potential positive outcomes through financial and social incentives, as well as revised governmental policies and regulations aimed at promoting precast concrete technology adoption. Consequently, the implementation of precast technology entails a significant overhaul of the construction industry. Governments should play a proactive role in incentivizing private sector involvement in the development of such structures, as advocated by Khaled and Farid (2015).

2.13. Current Application of Precast concrete technology

Precast concrete technology have gained widespread adoption in the modern construction industry globally. With their versatility, complete precast concrete technology have emerged as a popular choice for various construction projects. These prefabricated elements come in a range of shapes and sizes, encompassing both structural components and non-reinforced pieces. The precast sector serves as a vital catalyst for innovation within the construction industry of any given country. Across sectors, including manufacturing and services, there is a universal demand for factory buildings, residential structures, and industrial warehouses.

The utilization of precast concrete has become a preferred method in contemporary construction due to its numerous advantages. Presently, various precast technologies are employed in both developed and developing countries, although with differing degrees of adoption. Panel systems represent the predominant construction method in precast buildings within developed countries, as noted by Baghchesaraei (2015).

2.14. Current Application of Precast concrete technology in Ethiopia

Currently, precast concrete technology has been minimally utilized within the construction industry of Ethiopia. There exists only one prefabrication facility in the country, the Prefabricated Building Parts Production Enterprise (PBPE), which was established three decades ago and has undergone no significant updates since its inception. Kibirt (2017) notes that despite its 30 years of operation, PBPE has shown limited progress as an organization. It continues to rely on outdated equipment such as batching plants, crane systems, and molds, all of which were installed during its establishment.

Kibirt (2017) highlights the issue that over the years since PBPE began operating, significant advancements have occurred globally in construction technology. What was considered acceptable three decades ago may no longer meet contemporary standards. Furthermore, the majority of the equipment, forms, design, and production manuals used by the plant remain unchanged since its inception, with physical copies showing signs of aging and deterioration.

While the enterprise was theoretically designed to achieve a capacity of 50,000 square meters of built-up floor area per year, its maximum attained capacity to date is only 33,000 square meters. PBPE was intended to produce three categories of buildings: residential buildings up to 5 storeys, and public buildings up to 10 storeys (Gutema, 1998). The structural elements manufactured by the factory encompass columns, slabs, footings, girder beams, beams, cantilevers, shear walls, stair flights, and landings.

However, in Addis Ababa, the majority of buildings constructed using precast methods are public and commercial structures, with only a small number being residential apartments. Inadequate efforts have been made to thoroughly assess the advantages and disadvantages of prefabrication, highlighting its effectiveness and efficiency compared to conventional construction methods. To further promote prefabrication construction in Ethiopia, significant future endeavors are necessary in marketing and disseminating information (Gutema, 1998).

2.15. Current construction Method in Ethiopia

The construction sector in Ethiopia, akin to its counterparts in other developing nations, encounters numerous hurdles in its operations. These challenges encompass project delays, substandard quality, inadequate procurement systems, and a deficiency in meeting project specifications and adopting optimal methodologies (Tadesse, Zakaria, and Zoubeir, 2016).

In Ethiopia, the structural components of most buildings primarily consist of reinforced concrete. As discussed by Kibirt (2017), it is customary to construct all structural elements using in-situ construction methods, wherein concrete is mixed and poured manually on-site, often by untrained laborers. An emerging alternative observed at various construction sites involves the utilization of ready-mix trucks for concrete mixing and pouring. Moreover, Kibirt (2017) notes that prefabricated concrete structural elements are more prevalent in government building projects than in private ones.

Implementing strategies to minimize formwork and scaffolding usage is crucial in Ethiopia, aiming to reduce both costs and excessive timber consumption. These strategies, alongside other appropriate building technologies, could complement a multifaceted approach to improving vernacular construction techniques. A prevalent issue in the Ethiopian construction sector is the dearth of knowledge and experience among workers, significantly impeding industry progress (Zegeye and Helawi, 2012).

2.16. New city concept

"A city can be defined as "New: when investments in human and social capital and traditional (transport) and modern (ICT) Communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement." (Caragliu and Nijkamp - 2009). A New city not only possesses ICT technology in particular areas, but has also implemented this technology in a manner that impacts the local community and environment positively. Regional competitiveness, transport and Information and Communication Technologies economics, natural resources, human and social capital, quality of life, and participation of citizens in the governance of cities (Giffinger et al. -2007).

One of the primary functions of cities is to house citizens as well as to provide the right environment, supported by efficient and affordable services and infrastructures. A New city is built upon New systems such as New energy (electricity, gas), New mobility (public transportation, train), New infrastructure (buildings, homes, offices, schools, facilities) water, waste, New public services (healthcare, education, police), and information and communication infrastructure (International Electro-technical Commission, 2014).

New infrastructure and New buildings are components of a New city. Their development is critical to defining the level of progress of a city. The availability and sustainability of New infrastructure and buildings is an impetus to providing housing for masses, good food, learning, health, assured electricity supply, access safe water, enhanced safety and security (Kumar & RamaKrisha, 2016).

2.17. Experiences of cities on precast concrete technology

As such the concept of a New construction method, which is a shift from conventional construction method to IBS to meet up with the rise in construction of New infrastructure demand within a short time frame as well as having accurate and standard construction products are non negotiable. As evidence has shown that applicability of IBS techniques is wholly maximized in the construction of fundamental facilities and infrastructures like housing facilities, health infrastructures, road infrastructures, water supply, educational facilities, organized settlement, New agriculture, bridges, drainage and sewer systems, and power infrastructure (Babatunde, 2018; Ogundari & Otuyemi, 2019)in Lagos and across other parts of the country. This system affords the city with speedy project delivery, the safety of construction workers, creating an eco-friendly environment, and reducing the use of natural resources like timber, largely consumable in the conventional in-situ construction process for temporary staging, bracing, forming (Rahimian, Goulding, Akintoye & Kolo (2017). Notwithstanding, construction sites exploring the IBS (Industrialized Building System) techniques have shown to be New, tidier, weather friendly and better organized as compared to the traditional construction sites which are often wet and untidy.

The National Development Planning Agency announced in 2019 that the advancement of Nusantara would introduce the concept of a New and Highly Sustainable City (Ministry of National Development Planning, 2019). The infrastructure development in Nusantara necessitates adherence to international standards and criteria. Formulating a cities framework involves harmonizing strategic elements (management procedures and implementations), operational processes (interoperability considerations), and technical components (advancing digital infrastructures) (Heaton, 2020).

2.18. Current Experience of Precast Concrete Technology in Ethiopia

Currently, in Addis Ababa's real estate construction, there is a lack of experience and utilization of prefabricated concrete structural elements. No professionals have experience with these elements, and no companies are presently employing them. The only supplier, PBPPE, has no customers among real estate developers. Consequently, there is no application of prefabricated concrete structural elements in the city's real estate construction. Major challenges include a shortage of supply, limited information about potential, insufficient skilled manpower, oversight of existing dimensions during design, and designers' reluctance to adapt their work to accommodate prefabricated elements.(Kidist Dendir, 2018)

2.19. The Gap Identified and Lessons Learned:

Several Literature Discussed about Precast and prefabricated structures offer significant advantages in speed, sustainability, and innovation for New city development. Careful planning and collaboration are crucial to overcome logistical challenges and ensure successful integration with existing infrastructure.

While there has been some research on the cost analysis of precast technology in Ethiopian construction, there remains a significant gap in the literature regarding the impact of utilizing precast in Ethiopian cities. Despite the existing body of work on the cost aspects, there's a notable absence of studies examining how precast technology application influences the development and functionality of cities in Ethiopia. Therefore, this research aims to address this gap by analyzing the impact of precast concrete utilization specifically within the context of GSEZ, thereby contributing valuable insights to the field.

Researches	**Key benefits Listed on the studies**	**Gap identified**
Anderson 2007	• Reduce Cost • Minimize project Time • Quality Product • Consistency product	Not on the context of Ethiopia
Trainee 2010	• Reduce Cost • Minimize project Time • Precision on measurement	Not on the context of Ethiopia
Nardin 2009	• Enviromental Performance • Minimize project Time • Quality Product	Not on the context of Ethiopia

	• Predictable time line • Sustainable	
Jaillon & poon 2007	• Quality Product	Not on the context of Ethiopia
Dineshkumar 2015	• Quality Product	Not on the context of Ethiopia
Alireia & Omid 2016	• Reduce Cost • Minimize project Time	Not on the context of Ethiopia
Kidist dendir 2018	• Precast use in real estates are not applicable	Proved Not in use also not for project like GSEZ

Table 1 Summary Table to show the gap

CHAPTER THREE

3. RESEARCH METHODOLOGY

The methodology serves as a strategic blueprint outlining the investigation process, detailing the data collection methods, analysis procedures, and the path to drawing conclusions and formulating recommendations. Sequential steps depicted in the accompanying figure were adhered to in pursuit of the research paper's objectives.

3.1 Description of the study Area

Ethiopia has a vision to become a middle-income country and carbon free economy by 2025. Within this framework, the Oromia Regional State has envisioned to establish new Gada special economic zone (GSEZ). The aim of the project is creating sustainable industrial city that can be accessed by everyone & boosting economic development.

GSEZ project is located at the main trade root of the country as well as the node at which existing infrastructure (Railways, Expressway, and High way) are crossing.

There is also a Mojo Dry port at the immediate boundary of the project site that is the development potential of SEZ. Selection of the project site is of crucial importance to the development of SEZ.

-The project is located to the southeast of Finfinne

The boundary which stretches from 8°27' 00" - 8° 37'00" N and 39° 01'00" - 39° 15' 30" E.

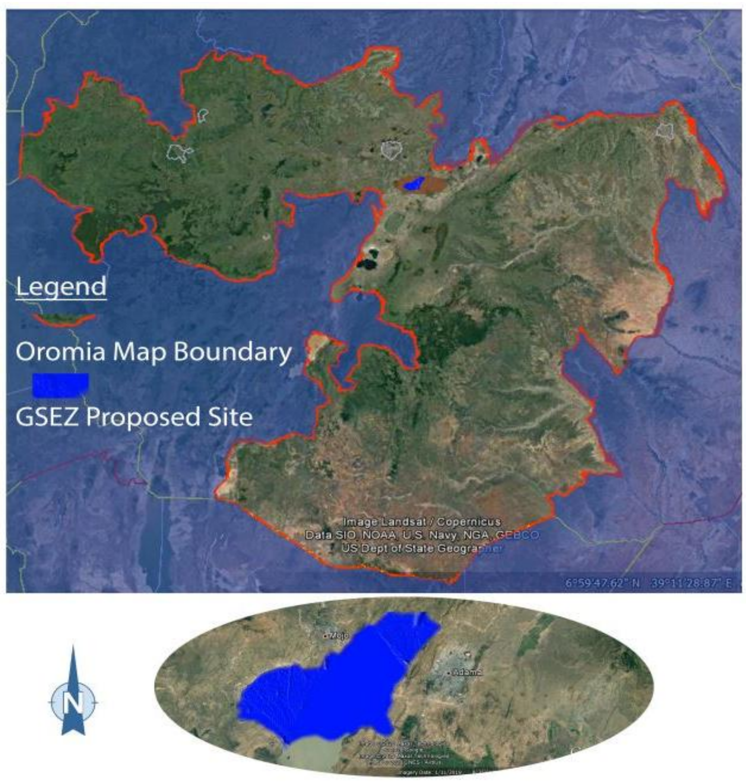

Figure 7 GSEZ PROPOSED SITE

Source: GSEZ feasibility Document

It is Planned to create job opportunities, enhance foreign investment, increase exports and promote regional as well as national development.

GSEZ is free from the impact of the expansion of the nearby existing town/city and there is also enough space for the expansion of the SEZ for the future expansion.

The total area of the project 23,656.51hectare. It is found between Adama and Mojo city. Most of the land is developable And characterized by gullies erosion.

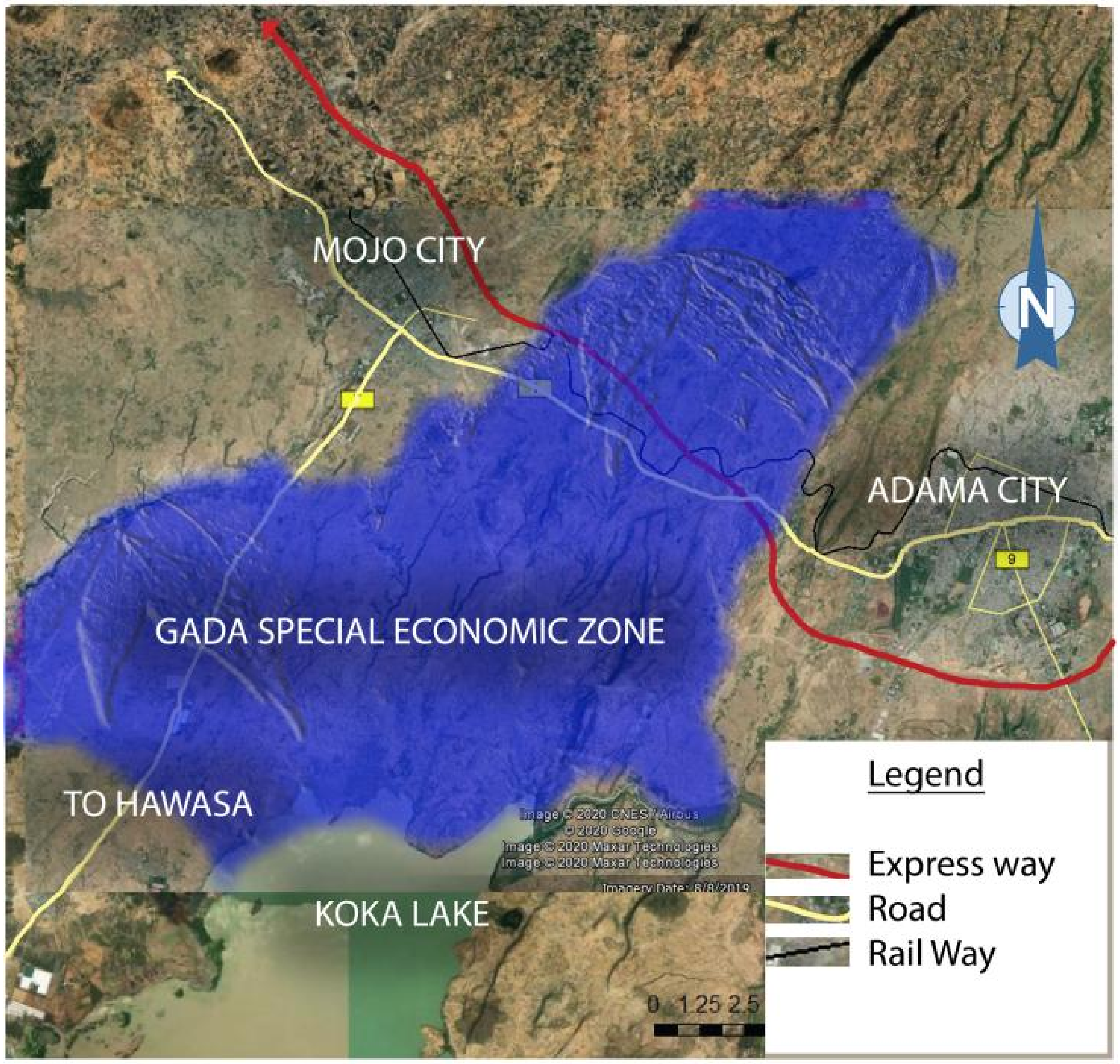

Figure 8 GSEZ Site

Source: GSEZ feasibility Document

•The major current land use of the site are farm lands, horticulture, rural settlement, open space, environmental sensitive area, industries, water bodies, and gorges.

3.2.Study design (Research Design)

According to the research goal, this study falls under applied research since its findings are intended for practical use rather than just expanding knowledge. In terms of research objectives, it's both descriptive and exploratory because it provides detailed descriptions where needed and explores various topics critically.

Regarding the research approach, it combines qualitative and quantitative methods. It uses qualitative approaches for non-numeric data and adopts quantitative methods for analyzing numeric data. In terms of research design, it's non-experimental as it doesn't involve any experiments in data collection or analysis.

Based on the type of data, it's secondary research, also known as a desk study, as it doesn't involve any experimental work. One of the specific objectives of the research is to demonstrate that a modern precast plant could be competitive and profitable in the Ethiopian construction industry.

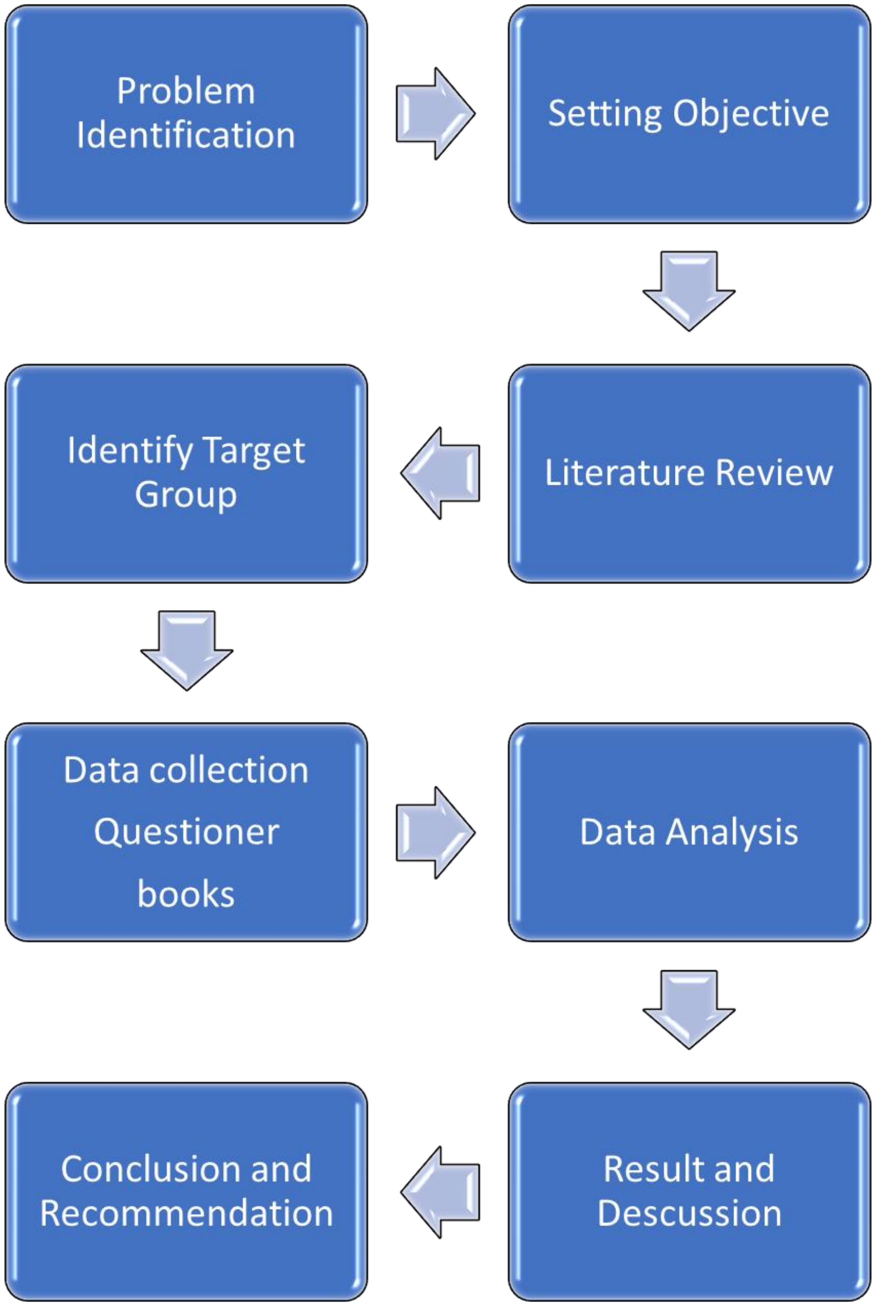

Figure 9: Schematic Diagram for Research Methodology

3.3.Study approaches

Johnson and Harris (2002) delineated that research methodologies fall broadly into two categories: quantitative and qualitative. Quantitative research is characterized by its objectivity, typically involving respondents recording their attitudes, opinions, or beliefs on numerical scales (Krosnick & Presser, 2010). Conversely, qualitative research is subjective, focusing on observing individuals in their natural settings, engaging them in their own language and context (Naoum, 2007).

Creswell (2009) defines a research approach that integrates both qualitative and quantitative methods as a "mixed-methods" approach. Furthermore, Creswell (2009) highlights that employing mixed methods capitalizes on the strengths of each approach while mitigating their respective weaknesses, thus offering a more comprehensive understanding of the research problem compared to using either qualitative or quantitative methods in isolation. Consequently, this research adopts both qualitative and quantitative approaches: employing a qualitative approach for analyzing interview data and a quantitative approach for analyzing questionnaire data.

3.4.Study Population

Research population consists of various members of the construction industry. From above 3500 construction company Specifically, for data related to the in-situ construction method, the primary population comprises ten general construction companies and building construction companies randomly graded from 1 to 5. This selection is based on their capacity in terms of facilities, equipment, and manpower to execute construction tasks efficiently, which aligns with the requirements of the precast construction method.

For data concerning the precast construction method, the study population includes only the PBPPE precast plant, as it is the sole precast plant in the country. Initially, a questionnaire was distributed to randomly chosen contractors to gauge their familiarity with the precast method. The findings from this data strongly supported the decision to proceed with the research.

Evaluation of PBPPE's adherence to international quality control standards relied on information gathered from both formal and informal interviews with key staff members of PBPPE.

3.5.Sampling Technique and Sample Size Determination

For this study, random sampling, regarded as the purest form of probability sampling, was utilized for data analyzed through quantitative methods, while purposive sampling was employed for data analyzed using qualitative methods. Probability sampling, as described by Saunders, Lewis, and Thornhill (2009), ensures that each member of the population has an equal chance of selection, constituting a critical consideration for researchers embarking on data collection.

Saunders, Lewis, and Thornhill (2009) emphasize that determining an appropriate sample size is crucial, balancing between excessive largeness and inadequacy. An optimal sample size meets the criteria of efficiency, representativeness, reliability, and flexibility. In determining sample size, researchers must specify the desired precision and an acceptable confidence level for the estimate. The sample size can be calculated using the following equation for a 96% confidence level, as outlined by Assaf (2001):

$$n_o = [px(1-p)]/v^2 \text{ ....Equation 3.1}$$

$$n = n_o/[1+(n_o/N)] \text{ .... Equation 3.2}$$

Where:

n_o: First estimate of sample size

P: The proportion of the characteristic being measured in the target population

V: Maximum standard error allowed

N: population size

n: Sample size

(Usually S:0.4 and V: 0.06)

3.5.1. Sample Size.

Sample size determination involves selecting the number of observations or replicates to be included in a statistical sample, which is crucial for making accurate inferences about a population. Each sector's means Contractors,ECWC, and GSEZ the sample size from the total sampling frame was chosen to ensure an adequate number of representatives.

This method ensures that the gathered data is more representative and reliable. In this study, each stakeholder in the sample frame was represented, following a sampling design formula outlined by Kothari (2004).

Random sampling, the purest form of probability sampling, was used for data analyzed quantitatively, while purposive sampling was employed for qualitative analysis. Probability sampling ensures that each member of the population has an equal chance of selection, a critical consideration in data collection.

It's essential to strike a balance with sample size; it should neither be excessively large nor too small but optimal. An optimal sample meets criteria such as efficiency, representativeness, reliability, and flexibility. Determining the desired precision and confidence level is crucial in calculating the sample size, often represented by equations such as the one outlined by Assaf (2001) for a 96% confidence level.

$$na = nr / [1 + (nr/N)]$$

Where na= the adjusted sample size, nr= the original required sample size and

N = population size. S Population elements and V is a standard error of sampling population. (Usually S = 0.4 and V = 0.06).

1. ECWC/PRECAST MANUFACTURER/ sample calculation

$$na = nr / [1 + (nr/N)]$$

$$na = S^2/V^2 = (0.4)2/ (0.06)2 = 44.44$$

Population (N) = 21 ECWC/PRECASTER/ nr= 44.44/ [1+ (44.44 / 21)] = 14

This implies the questionnaire should be distributed to 14 professionals above foreman ECWC/PRECASTER/ in order to achieve 96% confidence level.

2. Professionals sample

We first figured out how many companies we wanted to include in our study, and then we chose some active ones on purpose. Each chosen company had one person from their main office and one from their busiest location. We counted all the engineers involved in the projects we picked. To make sure we got accurate and good quality information, we let all the professionals working on those projects take part in our survey, as long as they were site engineers or higher. The table below shows how many professionals were in each project we selected.

Table 2. Number of questionnaire distributed with respect to each respondent group

Organization	ECWC/PRECASTER/	GSEZ/CLIEN T/	Contractor	Total
Questioner distributed	14	11	16	41

3.6.Study instruments (Data collection tools)

Choosing how to collect data depends on a few things like what we're investigating, how much money and time we have, and how accurate we need the information to be. The type of study we're doing and the kind of data we need help us decide which methods to use (Saunders, Lewis, and Thornhill, 2009). Denscombe (2007) says that questionnaires are good for surveying large groups of people quickly compared to other methods.

The main reason we collect data is to gather evidence that helps us understand our findings better and make important decisions (Alex, Julus, and Vian, 2016). Before we used questionnaires and structured interviews to collect data, we looked at existing information in books and articles. Based on what we found, we made a questionnaire. This helped us make sure our questions were good quality and clear for everyone taking part.

Here are the methods we used:

1. Questionnaires/Surveys: We made structured questionnaires to ask people like respondents, local authorities, or community members about precast concrete technology, its speed, sustainability, uses, and how to improve development goals. We also asked about challenges and opportunities. We did surveys through face-to-face interviews, phone calls, or online, depending on what worked best.

2. Interviews: We talked to key professionals and experts in semi-structured or in-depth interviews. This gave us important insights into the challenges, opportunities, and how to meet the development plan of GSEZ.

3. Field Observations: We went out to see and document the physical features of the 5000 Houses development project (which includes fully precast framed G+5 buildings) and the GSEZ site. These observations gave us visual evidence and context to help understand the other data we collected.

3.7. Data Reliability

Saunders, Lewis, and Thornhill (2009) said reliability means how consistent something measures what it's supposed to. If something gives similar results each time, it's more reliable. Think of reliability like stability or consistency in a measuring tool. To make sure the data was reliable, we tested the questionnaires before giving them to the people we planned to ask.

3.8. Data Validity

Validity means how well an instrument measures what it's supposed to measure (Pilot & Hungler, 1997). There are different ways to look at validity, and we can assess it in various ways. Statistical validity helps us judge the validity of an instrument, and it includes things like criterion-related validity and construct validity.

The research's validity pertains to how accurately it gauges its intended focus, while the questionnaire's validity relies heavily on respondents' willingness and ability to provide requested information. The questionnaire used in this study was crafted by drawing from existing literature and similar instruments, tailored to fit the research context. Additionally, it underwent pilot testing by advisors, field professionals, and experts for validation. Overall, the researchers aimed to enhance the study's validity through appropriate measures, controlling for variables, and ensuring generalizability. The study was meticulously designed to address its research question accurately. The instrument's alignment with other challenges for using Precast concrete technology, thorough literature reviews, advisor and instructor feedback, and subsequent Advantages of Precast concrete technology in addressing research questions ensured that the study's approach and measurement instrument met the standards for construct, face, and content validity.

3.8.1. Reliability of Questionnaire

The reliability of a questionnaire means it gives the same results consistently. A reliable questionnaire will give the same answers when given to the same people at different times or by different researchers. To make sure a questionnaire is reliable, it's important to use standard questions, clear instructions, and a consistent layout. Testing the questionnaire on a small group first can help find any problems before using it with a larger group. Having a reliable questionnaire is crucial for getting accurate and trustworthy data for research.

Cronbach's alpha coefficient is a way to check how consistent a questionnaire is. It shows how well a group of questions are related and if they measure the same thing. A high Cronbach's alpha coefficient (usually above 0.7) means the questionnaire is reliable and consistent in measuring what it's supposed to. But remember, reliability is just one part of a questionnaire's quality. Other things like content and construct validity are also important.

The reliability of data collected from a questionnaire can be affected by things like the respondent's personal characteristics and the conditions they're in when they take the test. Different sampling methods, like stratified, random, or snowball sampling, can affect how reliable the data is, especially with key informants who provide a lot of the data. This is an important consideration for making sure the data is good quality.

The data collected from the **precast concrete technology impact that contribute to the development of New city** of the questionnaires, internal consistency reliability is also tested by Cronbach's alpha coefficient in rated on a five point likert the response scale which included Strongly Agree (SA)= 5, Agree (A)= 4, Neither Agree nor Disagree (A/D)= 3, Disagree (D)= 2, Strongly Disagree (SD)= 1. The data collected from the **Specific applications of precast concrete technology in cities encompass a wide range of infrastructure and building components designed to enhance efficiency, sustainability, and resilience** of the questionnaires, internal consistency reliability is also tested by Cronbach's alpha coefficient in rated on a five point likert the response scale which included: 1 = Not Effective (NE), 2 = Slightly Effective (SE), 3 = Moderately Effective (ME), 4 = Effective (E) and 5 = Extremely Effective (EE). The data collected from the **Precast concrete technology has a significant impact on various aspects of New city development, including speed, cost-effectiveness,**

efficiency, sustainability, and resilience of the questionnaires, internal consistency reliability is also tested by Cronbach's alpha coefficient in rated on a five point likert the response scale which included 1 = Very low impact, 2 = Low impact, 3 = Medium impact, 4 = High impact and 5 = Very high impact. The data collected from the **integration of precast concrete technology into New city development presents both challenges and opportunities** of the questionnaires, internal consistency reliability is also tested by Cronbach's alpha coefficient in rated on a five point likert the response scale which included 1 = Very low impact, 2 = Low impact, 3 = Medium impact, 4 = High impact and 5 = Very high impact. The data collected from the **Advantages of substituting steel frames with precast concrete frames for warehouse construction as an import substitution strategy** of the questionnaires, internal consistency reliability is also tested by Cronbach's alpha coefficient in rated on a five point likert the response scale which included Strongly Agree (SA)= 5, Agree (A)= 4, Neither Agree nor Disagree (A/D)= 3, Disagree (D)= 2, Strongly Disagree (SD)= 1.

Reliability tested using Cronbach‘s alpha values for the items in each construct. Cronbach's alpha requires only a single test administration to provide a unique estimate of the reliability.

The test of reliability, the equation 3.2 is used to determine the Cronbach's alpha as shown below (Namdeo & Rout, 2016):

$$\alpha = \left(\frac{k}{k-1}\right)\left(\frac{S_T{}^2 - \sum S_i{}^2}{S_T{}^2}\right) \quad \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \quad 3.3$$

Where; α is the cronbach alpha coefficient, K is the number of items, S_r^2 is the variance of Total score and S_i^2 is the sum of item variance.

The interpretation of Cronbach's alpha is the range of Cronbach's alpha normally is between 0 and 1. Guide line provided by them to assess the reliability of any data as shown in Table 3.2.

Table 3 Guideline for assessing reliability results

S. No	Range	Reliability
1	0.9 and above	Excellent
2	0.7 – 0.9	High
3	0.5 - 0.7	Moderate
4	0.5 and below	Low

Source: (Perry R. Hinton & Brownlow, 2014)

Results of Reliability Analysis

Before we analyzed the questionnaire results, we checked how consistent the questions were internally using a five-point Likert scale with Cronbach analysis. The Cronbach Alpha test helps determine the reliability of the questionnaire, and we got the results from this reliability test How precast concrete technology transforming cities in case of GSEZ.

part	Reliability Statistics	Cronbach's Alpha	No of items
1	precast concrete technology impact that contribute to the development of New city	0.856	10
2	Specific applications of precast concrete technology in cities encompass a wide range of infrastructure and building components designed to enhance efficiency, sustainability, and resilience	0.795	10
3	Precast concrete technology has a significant impact on various aspects of New city development, including speed, cost-effectiveness, efficiency, sustainability, and resilience	0.882	5
4	Integration of precast concrete technology into New city development presents both challenges and opportunities	0.775	10
5	Advantages of substituting steel frames with precast concrete frames for warehouse construction as an import substitution strategy	0.865	5
	Overall	0.825	

Source: Own survey data analysis

Table 4 : Reliability test of the Questioner

The findings suggest a correlation among the 5 elements comprising How precast concrete technology transforming cities in case of GSEZ. These items exhibit internal coherence. Given that the data was gathered using five-point Likert scales, the reliability of the research was assessed using Cronbach's Alpha method, revealing consistently high values nearing 1 across all components. Specifically, the overall Cronbach Alpha coefficient for the **five** items reached **0.825**, indicating a robust reliability of the data. Consequently, the researchers assert the reliability of both the test and the inquiries posed.

3.9. Data Analysis

I analyzed the data collected from the questionnaire survey using Microsoft Excel. We created frequency tables and descriptive statistics to show the results for each question regarding general information and application factors.

Percentages were used to make the findings easier to understand, showing them as a proportion of the whole. I presented the results in tables and charts for better clarity.

For the Likert scale data, I used the Relative Importance Index (RII) method. This method helps rank variables in terms of importance and agreement, showing how professionals perceive the relative importance of the identified application factors. According to Cheung and Suen (2004), the RII was calculated as follows:

.RII = $\sum W$ 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

The data collected from supplier, ECWC - Prefabricated Building Parts Production Enterprise by interview was analyzed by qualitative method. It concerns the current supply status of prefabricated concrete structural elements.

CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter focus on analyzing and interpreting the result gathered from the respondents through questionnaire and interview. Our target respondents are the subject matter experts who has experience on precast concrete manufacturing, the experts who install the product in various project such as the Addis ababa 5000 housing projects, and the construction engineer experts in GSEZ. Based on the gathered data from the respondent‘s current status of Precast concrete technology Usage on structural Frames in Addis Ababa 5000 Houses project construction and its potential application were analyzed . The result was interpreted based on information from Visual Observation, personal interview with the respondents and questionnaire survey data.

4.1.1. Profile of respondent’s

The research aimed to acquire gender information from the surveyed participants, with 78 percent identified as male and 22 percent as female, as indicated in the findings.

GENDER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	32	78.0	78.0	78.0
	Female	9	22.0	22.0	100.0
	Total	41	100.0	100.0	

The research revealed that among the 84 respondents, 32 (78%) were male, while females comprised 9 (22%). This suggests a relatively Fair participation of both genders in the study, albeit with a predominance of male respondents. This skewed distribution can be attributed to the higher prevalence of male respondents encountered during the data collection phase.

4.2. Precast concrete technology contributes significantly to the development of cities in various ways

4.2.1. Faster construction time or speed

Faster construction time or speed

	Frequency	Percent
Agree	8	19.5
Strongly Agree	33	80.5
Total	41	100.0

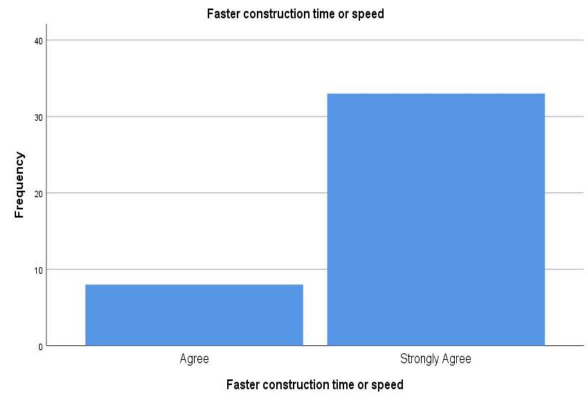

Table 5: Faster Construction Time or Speed

Figure 10 Chart for Faster Construction Time

- 19.5% of respondents agreed that faster construction time or speed is a benefit.
- 80.5% of respondents strongly agreed that faster construction time or speed is a benefit.

This indicates a strong consensus among the respondents that faster construction time or speed is indeed advantageous.

4.2.2. Reduced Traffic Disruption

Reduced Traffic Disruption

	Frequency	Percent
Moderately Agree	8	19.5
Agree	4	9.8
Strongly Agree	29	70.7
Total	41	100.0

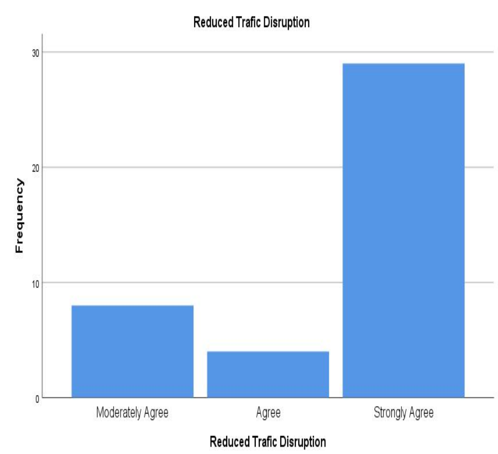

Table 6 Reduced Trafic Disruption

Figure 11 Graph of Reduced Traffic Disruption

- 19.5% of respondents moderately agree that precast concrete technology reduces traffic disruption.

- 9.8% of respondents agree that precast concrete technology reduces traffic disruption.
- 70.7% of respondents strongly agree that precast concrete technology reduces traffic disruption.

The overwhelming majority of respondents (70.7%) strongly agree that precast concrete technology reduces traffic disruption. This indicates a widespread perception among respondents that precast concrete technology contributes significantly to minimizing traffic disruption during construction activities. The combined percentage of those who agree (moderately and strongly) further reinforces the consensus on this aspect.

4.2.3. Quality control

Quality control

		Frequency	Percent
Valid	Agree	3	7.3
	Strongly Agree	38	92.7
	Total	41	100.0

Table 7 Quality Control

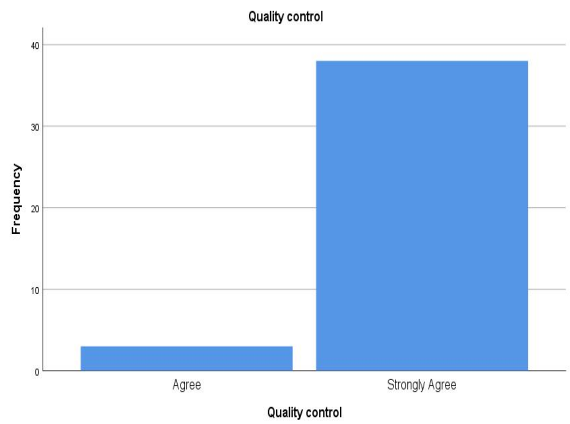

Figure 12 Graph of Quality Control

The result shows that there's a strong consensus among respondents that precast concrete technology plays a significant role in quality control. With 92.7% strongly agreeing and 7.3% agreeing, it suggests that this method is widely perceived as effective in ensuring quality standards. The precise and controlled environment of precast concrete manufacturing likely contributes to this perception, minimizing variables that can affect quality compared to traditional on-site casting.

4.2.4. Modularity and Flexibility

Modularity and Flexibility

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Agree	41	100.0	100.0	100.0

Table 8 Modularity and Flexibility

It appears that all respondents strongly agree that modularity and flexibility are important aspects of precast concrete technology. This overwhelming consensus suggests that precast concrete's ability to be easily customized, assembled, and modified according to project needs is highly valued. This modularity and flexibility likely contribute to the efficiency and versatility of precast concrete construction methods.

4.2.5. Energy Efficiency

Energy Efficiency

	Frequency	Percent
Moderately Agree	2	4.9
Agree	2	4.9
Strongly Agree	37	90.2
Total	41	100.0

Table 9 Energy Efficiency

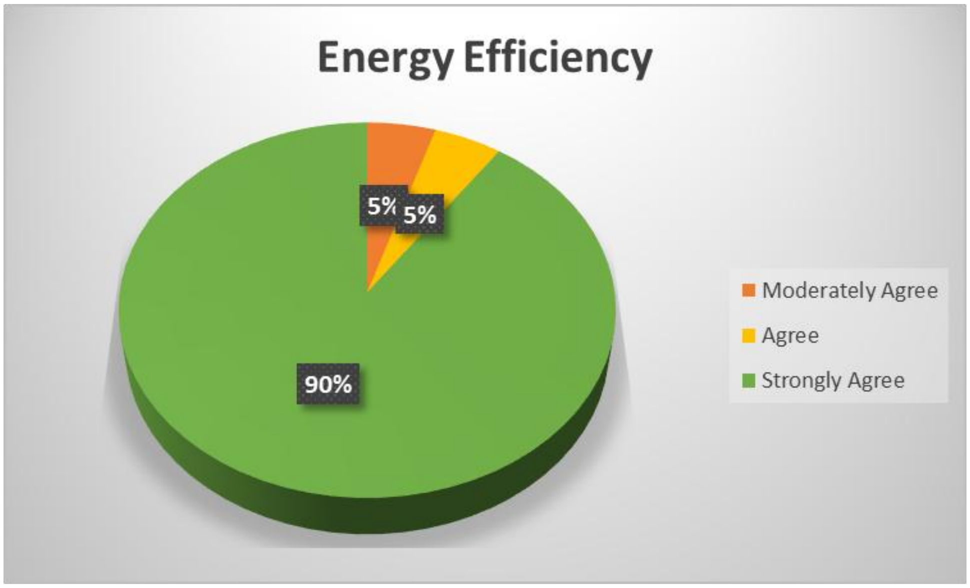

Figure 13: Energy Efficiency chart

The data indicates that the majority of respondents strongly agree that precast concrete technology contributes to energy efficiency, with 90.2% expressing this sentiment. Additionally, 4.9% moderately agree, and another 4.9% agree, further supporting the notion that precast concrete is seen as beneficial for energy efficiency. This perception could be attributed to factors such as the thermal mass properties of concrete, which can help regulate indoor temperatures and reduce the need for heating and cooling, as well as the potential for incorporating energy-efficient designs and materials into precast components.

4.2.6. Durability and Resilience

Durability and Resilience

		Frequency	Percent
Valid	Moderately Agree	2	4.9
	Agree	3	7.3
	Strongly Agree	36	87.8
	Total	41	100.0

Table 10 Durability and Resilience

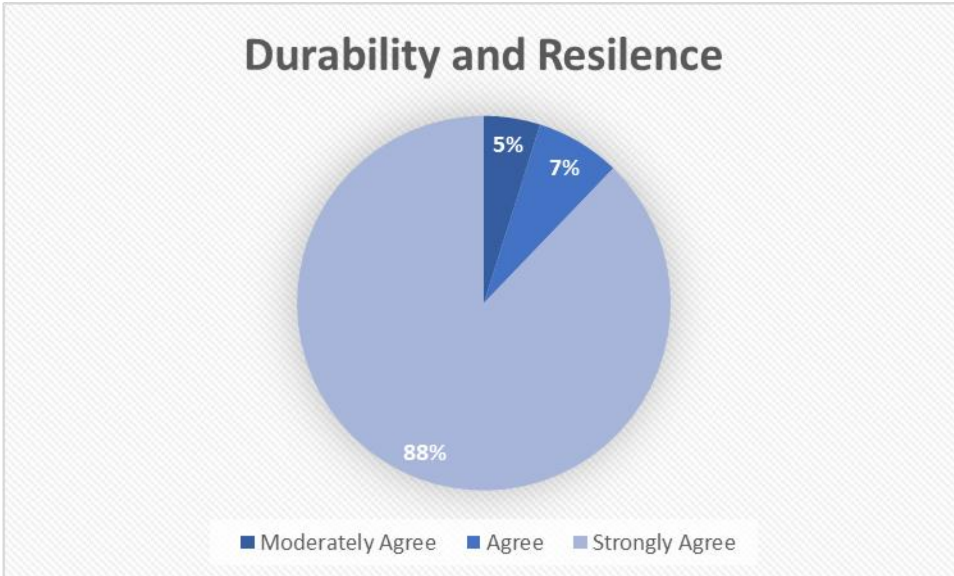

Figure 14: Durability and Resilience graph

The data shows a strong consensus among respondents regarding the durability and resilience of precast concrete technology. Specifically, 87.8% strongly agree, while 7.3% agree moderately, and 4.9% agree. This indicates that the majority of respondents believe precast concrete structures possess high durability and resilience. This perception is likely influenced by the inherent strength and robustness of concrete as a material, as well as the controlled manufacturing processes that can ensure consistent quality and resistance to various environmental factors.

4.2.7. Integration with New Grids

Integration with New Grids

		Frequency	Percent
Valid	Agree	5	12.2
	Strongly Agree	36	87.8
	Total	41	100.0

Table 11 Integration with New Grids

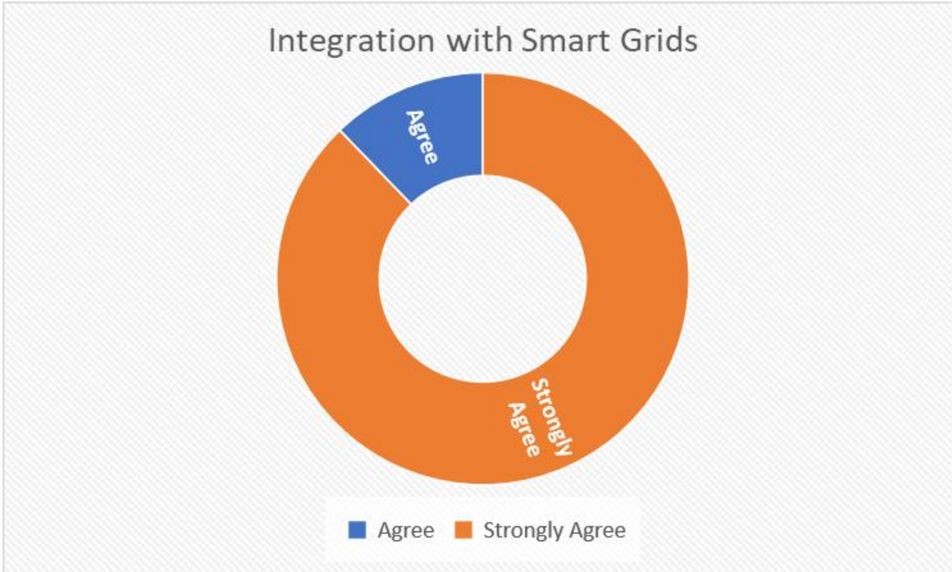

Figure 15: integration with New grids chart

The data suggests a strong agreement among respondents regarding the integration of precast concrete technology with New grids. Specifically, 87.8% strongly agree, while 12.2% agree. This indicates that the majority of respondents perceive precast concrete structures as being well-suited for integration with New grid systems. This integration could involve various aspects such as incorporating sensors and communication technologies into precast components to enhance energy efficiency and optimize resource usage within the context of New grid networks.

4.2.8. Waste reduction

Waste reduction

		Frequency	Percent
Valid	Agree	4	9.8
	Strongly Agree	37	90.2
	Total	41	100.0

Table 12 Waste Reduction

Figure 16: Waste Reduction Graph

The data indicates a strong consensus among respondents regarding waste reduction in precast concrete technology. Specifically, 90.2% strongly agree, while 9.8% agree. This suggests that the majority of respondents perceive precast concrete as an effective means of reducing waste in construction processes. This perception could s-tem from the controlled manufacturing environment of precast concrete, which allows for precise material usage and minimization of on-site waste generation compared to traditional construction methods.

4.2.9. Affordable Housing

Affordable Housing

		Frequency	Percent
Valid	Moderately Agree	3	7.3
	Agree	7	17.1
	Strongly Agree	31	75.6
	Total	41	100.0

Table 13 Affordable Housing

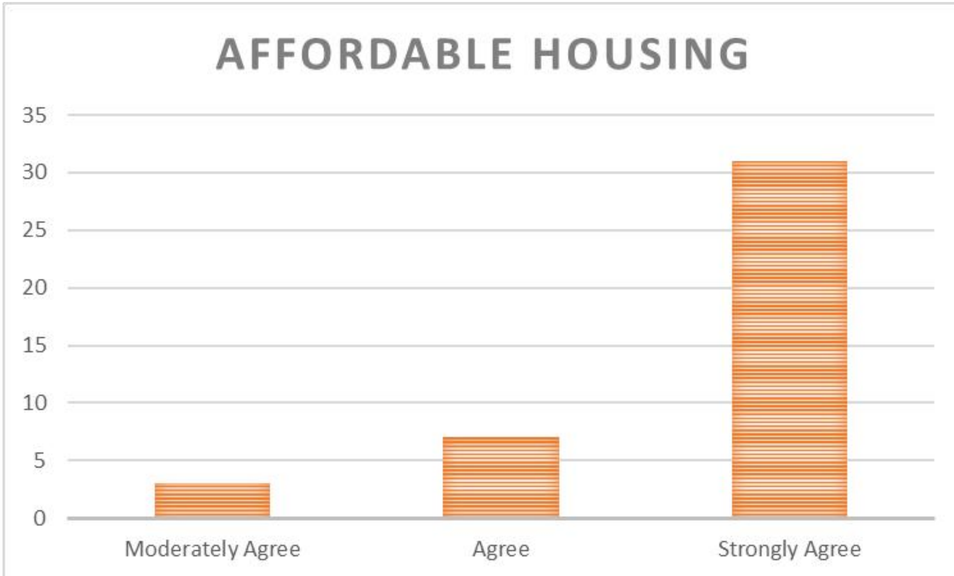

Figure 17: Affordable Housing graph

The data illustrates a strong consensus among respondents regarding precast concrete technology's role in affordable housing. Specifically, 75.6% strongly agree, 17.1% agree, and 7.3% moderately agree. This indicates that the majority perceive precast concrete as an effective solution for facilitating affordable housing. Precast concrete's potential to reduce construction time and labor costs, as well as its durability and resilience, likely contribute to this perception, making it a favorable option for affordable housing projects.

4.2.10. New Transportation Infrastructure

New Transportation Infrastructure

		Frequency	Percent
Valid	Agree	5	12.2
	Strongly Agree	36	87.8
	Total	41	100.0

Table 14 New Transportation

The data illustrates a strong consensus among respondents regarding precast concrete technology's role in affordable housing. Specifically, 75.6% strongly agree, 17.1% agree, and 7.3% moderately agree. This indicates that the majority perceive precast concrete as an effective solution for facilitating affordable housing. Precast concrete's potential to reduce construction time and labor costs, as well as its durability and resilience, likely contribute to this perception, making it a favorable option for affordable housing projects.

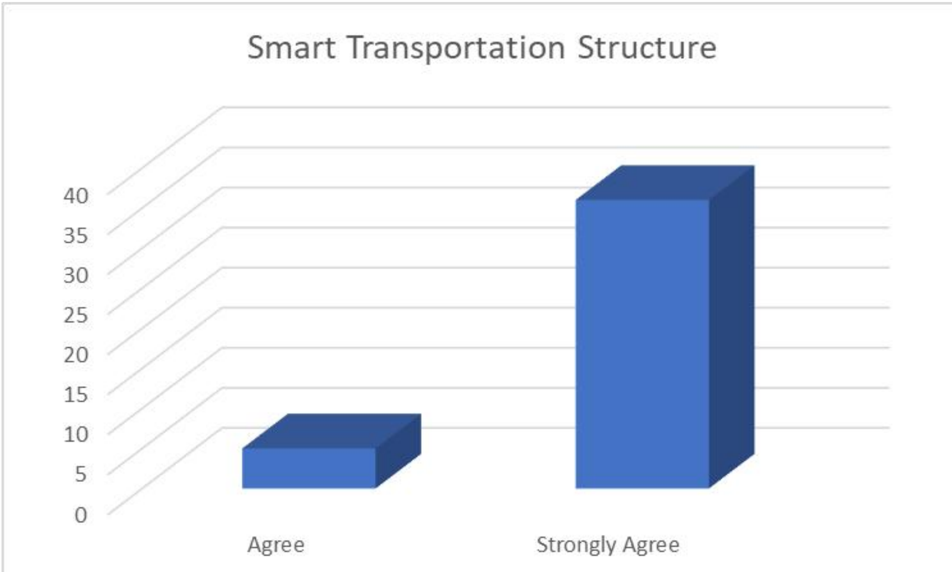

Figure 18: New Transportation infrastructure

4.3. What are the specific applications of precast concrete technology in the construction projects within Geda Special Economic Zone City?

	Strongly Agree	Agree	Neutral	DisAgree	Strongly Disagree	total
New Housing Module	16	25				41
New Parking Structure	30	5	6			41
New Street Furniture	5	15	6	15		41
New Bus Shelter	7	5	5	24		41
New Utility Vault	32	9				41
New Bridge Components	41					41

New Waste Management System	29	3	1	8		41
New Water Infrustracture	22	5	9	5		41
New Transportation Hub	36	5				41
New Green Spaces			16	25		41
Speed	36	5				41
Cost Effectiveness	41					41
Efficiency	33	8				41
Sustainability	41					41

4.4. The integration of precast concrete technology into New city development presents both challenges and opportunities:

	Strongly Agree	Agree	Neutral	Dis Agree	Strongly Agree	
Challenges						
Initial Investment	41					41
Transportation and Logistics	41					41
Design Complexity	23	9	3	6		41
Standardization and Compatibility	41					41
Maintenance and Upkeep	37	4				41
Opportunity						
Innovation and Customization	41					41
Sustainable Solution	41					41
New Integration	41					41
Streamlined Construction Process	41					41
Resilient Infrastructure	41					41

Table 15 Challenge and Opportunity

4.5. precast concrete technology contribute to foreign direct investment theory

precast concrete technology contribute to foreign direct investment theory	Strongly Agree	Agree	Neutral	Dis Agree
Reduced Dependency	7	27	7	
Promotion of Local Industry	35	6		
Foreign Currency Savings	41			
Fire Resistance	25	16		
Job Opportunity	16	25		

Table 16: precast concrete technology contribute to foreign direct investment theory

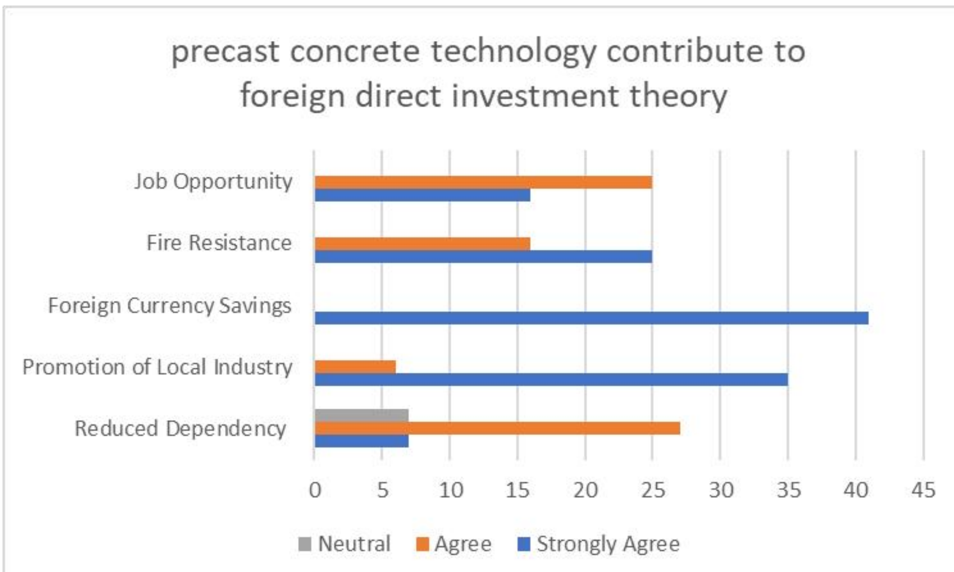

Figure 19:precast concrete technology contribute to foreign direct investment theory

Respondents were asked to indicate their level of agreement with various statements about precast concrete technology and its impact on FDI theory. The table shows the number of respondents who strongly agree, agree, are neutral, or disagree with each statement. For example, 7 respondents strongly agree that precast concrete technology reduces dependency, while 27 respondents simply agree with this statement. Additionally, 35 respondents strongly agree that precast concrete technology promotes local industry, while 6 respondents agree with this statement. The table provides insight into perceptions about how precast concrete technology influences foreign direct investment theory across different factors such as reducing dependency, promoting local industry, foreign currency savings, fire resistance, and job opportunities.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

The main objective of this research was to evaluate the application of prefabricated concrete structural elements rather than Steel Structured Frame for industrial warehouse and precast residence and Utilities structures for Geda Special Economic Zone. In order to accomplish that objective, it was necessary to initiate precast plant at appropriate place inside Geda special economic zone. The research has shown how precast concrete technology effective on the development of Geda special economic zone at this stage also to foreign investment policy.

5.1. Conclusions

Precast concrete technology plays a vital role in the development of cities due to its numerous advantages such as efficiency, sustainability, and resilience. Here's how precast concrete technology contributes to New city development and its relation to import substitution for steel structure industrial warehouse frames:

Efficiency in Construction: Precast concrete components are manufactured off-site in controlled environments, allowing for simultaneous on-site preparation. This reduces construction time significantly compared to traditional methods. In the context of GSEZ, where rapid development is essential, this efficiency is crucial for meeting the government plan shorten deadlines and minimizing disruptions to urban life.

Quality Control and Standardization: Precast concrete elements are produced under strict quality control measures, ensuring consistency and high quality. This reliability is essential for New city projects where adherence to standards is paramount. Moreover, standardized components facilitate interoperability and compatibility with New technologies, streamlining the integration process.

Durability and Resilience: Precast concrete structures offer superior durability and resilience against natural disasters, vandalism, and other threats. In cities, where sustainability and long-term viability are priorities, the use of durable materials like precast concrete ensures infrastructure longevity and minimizes maintenance costs.

Customization and Design Flexibility: Despite being manufactured off-site, precast concrete allows for a high degree of customization and design flexibility. This versatility is beneficial for GSEZ projects that require tailored solutions to address specific urban challenges, such as traffic management, waste management, and energy efficiency.

Sustainability: Precast concrete technology promotes sustainability through reduced material wastage, energy efficiency in production, and the use of eco-friendly materials. In the context of GSEZ, which aim to minimize environmental impact and enhance residents' quality of life, sustainable construction practices are crucial for achieving long-term success.

In relation to import substitution for steel structure industrial warehouse frames, precast concrete technology offers several advantages:

The main Objective of GSEZ project is to attract foreign investment for hard currency and minimizing unemployment by creating job opportunity so by this sense the attracted foreigner comes in Ethiopia and starts building his industry 50% of his budget is for construction from this 25% comes with imported building materials like I-beam steel frame, thus when we substitute this imported steel frame with precast concrete frame we get the hard currency and it saves the importing process time and transportation cost also:

Cost-Effectiveness: makes precast concrete an attractive alternative to steel structures for industrial warehouses, especially in regions where steel imports are expensive or subject to trade restrictions.

Reduced Dependency on Imports: By utilizing precast concrete technology, countries can reduce their dependency on imported steel for construction purposes. This not only strengthens domestic industries but also enhances national security by mitigating supply chain vulnerabilities associated with reliance on foreign materials.

Job Creation and Economic Growth: The adoption of precast concrete technology stimulates local manufacturing and construction sectors, creating employment opportunities and fostering economic growth. Moreover, the development of a robust precast concrete industry contributes to export potential, further boosting the economy.

Improved Structural Performance: Precast concrete structures offer comparable or superior structural performance to steel frames, particularly in terms of fire resistance, thermal insulation, and soundproofing. This ensures the safety and functionality of industrial warehouse facilities while minimizing maintenance requirements over their lifecycle.

Overall, the use of precast concrete technology in New city development and import substitution for steel structure industrial warehouse frames offers a synergistic approach to achieving sustainable, resilient, and cost-effective urban infrastructure solutions.

The major challenges to use precast concrete technology are: - shortage of supply of prefabrication elements, lack of information about the existing potential, shortage of skilled man power on the area, lack of consideration of the existing dimension during design and low motivation of designers to adjust their work with it.

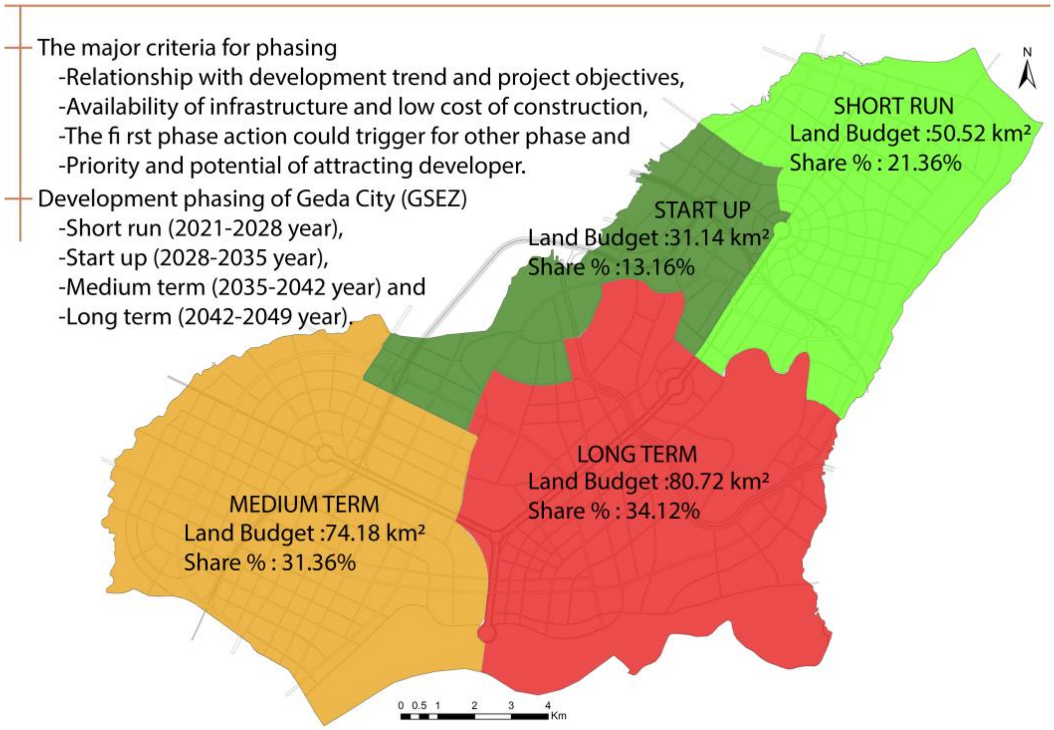

Figure 20 GSEZ planned Project phases

Source: GSEZ feasibility Document

General Land use Categories	Area (Ha)	Percentage%
-Administration	287.95	1.22
-Commerce, Business, & Trade	687.4	2.91
-Free Trade Zone	168.09	0.71
-Industry	4813.02	20.34
-Logistic Service	166.76	0.7
-Port	70.49	0.3
-Recreational, Green area & Environmental Sensitive	8431.62	35.65
-Residence	4630.82	19.57
-Service	773.8	3.27
-Transports and Utility	2252.14	9.29
-Urban Agriculture	244.98	1.04
-Water Body	1183.12	5
Grand Total	**23,656.51**	**100**

Figure 21 GSEZ's Planned land uses

5.2. Recommendations

Based on the findings of the study and the discussions above a summary of some general recommendations are offered to support the improvement of application of precast concrete technology around GSEZ and to recommend some area for further investigation. These are listed below:

As an Urban planner I recommend

1. GSEZ is a 40 years project plan so precast concrete plant industries are the first and the most industries that urgently needed, Government should have to compete and give them different policy appreciation to attract them and select the best location for future expansion of the GSEZ's phases, better to be center for all phases to minimize future urban disruption.

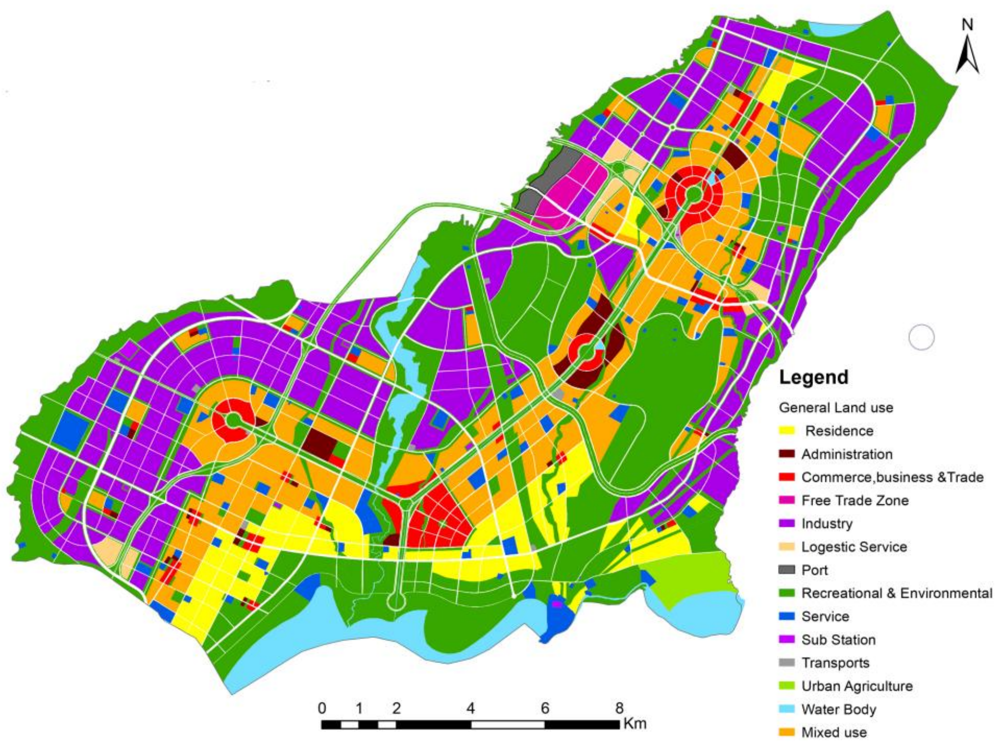

Figure 22 Phase 1 General Land Use

Source: GSEZ feasibility Document

For GSEZ administration who is in need of precast concrete technology and promote import substitution for steel structures in industrial construction, here are some recommendations:

2. Invest in Research and Development: Allocate resources towards research and development initiatives aimed at enhancing precast concrete technology. This includes innovations in manufacturing processes, material composition, and design techniques to improve the efficiency, sustainability, and affordability of precast concrete components.

3. Provide Incentives and Support: Offer financial incentives, tax breaks, and subsidies to encourage the adoption of precast concrete technology by developers, contractors, and manufacturers. This could include grants for research and development projects, subsidies for purchasing precast concrete components, or tax incentives for companies investing in precast concrete production facilities.

4. Promote Collaboration and Knowledge Sharing: Facilitate collaboration between government agencies, industry stakeholders, research institutions, and academia to exchange knowledge, share best practices, and foster innovation in precast concrete technology. This could involve organizing workshops, seminars, and conferences, as well as establishing public-private partnerships to drive research and development initiatives.

5. Implement Building Codes and Standards: Develop and enforce building codes and standards that encourage the use of precast concrete technology in construction projects. This includes incorporating provisions for precast concrete components in building codes, providing guidelines for their design, fabrication, and installation, and ensuring compliance through regular inspections and quality assurance measures.

6. Support Local Manufacturing: Encourage the establishment and expansion of local precast concrete manufacturing facilities to promote import substitution and create jobs in the domestic market. This could involve providing grants or low-interest loans for companies investing in

R. Bhushan, K. Mogadala, and C. Rajasekaran, “Study on Methods of Prec
Indian Construction Industry,” Vol. 9, no. 4, pp. 137–141, 2018.

precast concrete production, as well as streamlining regulatory processes to facilitate the establishment of new manufacturing plants.

7. Demonstrate Leadership through Pilot Projects: Initiate pilot projects showcasing the benefits of precast concrete technology in New city development and industrial construction. This could include constructing residential buildings, commercial complexes, infrastructure projects, and industrial facilities using precast concrete components to demonstrate their efficiency, sustainability, and cost-effectiveness.

By implementing these recommendations, governments can effectively leverage precast concrete technology to drive the development of GSEZ and promote import substitution for steel structures in industrial warehouse construction, thereby fostering economic growth, sustainability, and resilience in urban environments.

5.3. Recommendations for further study

1. Precast element Connection
2. Pre tension and post tension characteristics related to precast

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APPENDIX A

Survey Questionnaire

Adama Science and Technology University School of Civil Engineering and Architecture
Department of Urban Planning and Design

Questionnaire: Survey for a Thesis Paper on HOW PRECAST CONCRETE TECHNOLOGY IS TRANSFORMING cities: In Case of GEDA SPECIAL ECONOMIC ZONE

Dear/Sir;

The purpose of this questionnaire is to collect data for the research study entitled "BUILDING THE FUTURE: HOW PRECAST CONCRETE TECHNOLOGY IS TRANSFORMING cities: In Case of GEDA SPECIAL ECONOMIC ZONE " as a fulfillment of the requirement for the degree of Master of Science in the department of Urban planning and Design.

Genuine, professional opinions and timely responses are vital in Determining the success of this study. Please note that the provided information is intended for academic purposes only, and confidentiality will be upheld.

Honest and responsible completion of the questionnaires is greatly appreciated as it contributes to future recommendations for similar works. Thank you for your participation! Your responses will provide valuable insights into the role of precast concrete technology in New city development.

If you need further explanation, you can contact me at the address indicated below:

ERMIYAS G/ALIF,Mobile Number: +2519-23-677845 Email: ermi.g.gtalk@gmail.com

PART ONE

General Information Questionnaire:

1. Age: ________

2. Gender: [ ] Male [ ] Female

3. Occupation/Profession: ____

4. Organization/Institution (if applicable): ________________________

5. Position/Role: ____

6. Highest Level of Education:

[ ] Bachelor's Degree [ ] Master's Degree [ ] Doctorate

7. On a scale of 1 to 5, how familiar are you with precast concrete technology? (1 = Not familiar at all, 5 = Very familiar) [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

13. Please check the box that best describes your level of expertise in New city development:

[ ] Beginner [ ] Intermediate [ ] Advanced [ ] Expert

14. What aspects of New city development are you most interested in? (Check all that apply)

[ ] Urban Infrastructure [ ] Transportation [ ] Energy [ ] Sustainability [ ] Technology and Innovation [ ] Governance and Policy [ ] Social Inclusion and Equity [ ] Other (Please specify: ________________________)

18. Would you be interested in participating in follow-up interviews or discussions regarding New city development? [ ] Yes [ ] No

19. Is there anything else you would like to share or any feedback you have about this questionnaire?

Thank you for taking the time to complete this questionnaire!

PART TWO

Precast concrete technology contributes significantly to the development of cities in various ways. Here's a list of cases illustrating its impact:

To what Extent do you agree with the following listed **precast concrete technology impact that contribute to the development of New city?** Please indicate by making tick to the appropriate box using the following scale: Strongly Agree (SA)= 5, Agree (A)= 4, Neither Agree nor Disagree (A/D)= 3, Disagree (D)= 2, Strongly Disagree (SD)= 1.

S/N	List of Impact	Impact Level				
		SA =5	A= 4	A/D =3	D =2	SD =1
1	Faster Construction: Precast concrete elements are manufactured off-site, allowing for faster construction compared to traditional methods. This speed is crucial in the development of cities where rapid infrastructure deployment is necessary to keep pace with urban growth.					
2	Reduced Traffic Disruption: By manufacturing components off-site, on-site construction time is minimized, leading to reduced traffic congestion and disruption. This aspect is vital in cities where minimizing disruptions to transportation networks is a priority.					
3	Quality Control: Precast concrete manufacturing allows for stringent quality control measures in a controlled environment. This results in higher quality and more durable infrastructure, which is essential for the long-term sustainability of cities.					
4	Modularity and Flexibility: Precast concrete elements offer modularity and flexibility in design, allowing for easier integration of New technologies such as sensors, communication devices, and energy-efficient systems. This adaptability is crucial for the dynamic nature of New city infrastructure.					

5	Energy Efficiency: Precast concrete can incorporate insulation materials within its structure, improving energy efficiency in buildings and infrastructure. This contributes to the overall sustainability goals of cities by reducing energy consumption and carbon emissions.					
6	Durability and Resilience: Precast concrete structures are known for their durability and resilience, making them suitable for withstanding natural disasters and extreme weather events. In cities, where resilience to climate change is paramount, the use of precast concrete can enhance the overall robustness of infrastructure.					
7	Integration with New Grids: Precast concrete elements can be designed to accommodate infrastructure for New grids, including underground conduits for power and data cables. This integration facilitates the deployment of New energy management systems, optimizing energy distribution and consumption within the city.					
8	Waste Reduction: Precast concrete technology often results in less material wastage compared to traditional construction methods. This reduction in waste aligns with the sustainable development goals of cities, promoting efficient resource utilization and minimizing environmental impact.					
9	Affordable Housing: Prefabricated concrete panels and modules can be used for rapid construction of affordable housing units in cities facing housing shortages. This addresses the pressing need for inclusive urban development and ensures that residents have access to safe and affordable housing options.					
10	New Transportation Infrastructure: Precast concrete is used in the construction of various transportation infrastructure components such as bridges, tunnels, and roadways. These structures can be designed to integrate New transportation technologies, including traffic management systems, vehicle charging stations, and intelligent signage, enhancing mobility and connectivity within the city.					
11	Overall, precast concrete technology plays a crucial role in the development of cities by offering efficient, sustainable, and resilient solutions for urban infrastructure development.					

PART THREE

Specific applications of precast concrete technology in cities encompass a wide range of infrastructure and building components designed to enhance efficiency, sustainability, and resilience. Here are some specific examples:Please indicate the most effective strategies by making on the appropriate box using the following a 5-point likert scale: 1 = Not Effective (NE), 2 = Slightly Effective (SE), 3 = Moderately Effective (ME), 4 = Effective (E) and 5 = Extremely Effective (EE).

These specific applications demonstrate how precast concrete technology can be seamlessly integrated into various aspects of New city development, offering innovative solutions for enhancing urban infrastructure and quality of life.

S/N	List of Impact	Impact Level				
		EE=5	E=4	ME=3	SE=2	NE=1
1	New Housing Modules: Precast concrete modules can be used in the construction of New housing units. These modules can incorporate pre-installed wiring and conduits for New home devices, energy-efficient appliances, and home automation systems, facilitating easy integration of New technologies into residential buildings.					
2	New Parking Structures: Precast concrete elements are commonly used in the construction of parking garages and structures. These structures can be equipped with sensors and automated systems for real-time monitoring of parking space availability, optimizing traffic flow, and reducing congestion in urban areas.					
3	New Street Furniture: Precast concrete is used to manufacture various street furniture elements such as benches, bollards, and streetlights. These elements can be designed to integrate sensors for monitoring environmental conditions, pedestrian traffic, and air quality, providing valuable data for urban planning and management.					

4	New Bus Shelters: Bus shelters constructed using precast concrete can be equipped with digital displays, Wi-Fi connectivity, and USB charging ports for commuters. Additionally, these shelters can incorporate solar panels for powering lighting and digital signage, promoting sustainability and energy efficiency.					
5	New Utility Vaults: Precast concrete utility vaults house critical infrastructure components such as electrical transformers, water meters, and telecommunications equipment. These vaults can be designed with built-in sensors and communication systems for remote monitoring and management, improving the reliability and efficiency of urban utilities.					
6	New Bridge Components: Precast concrete is used in the construction of bridge components such as beams, columns, and deck panels. These components can be designed to accommodate sensors for structural health monitoring, traffic flow analysis, and bridge condition assessment, ensuring the safety and longevity of urban bridges.					
7	New Waste Management Systems: Precast concrete containers and enclosures are used for waste collection and recycling stations in urban areas. These containers can be equipped with sensors for monitoring fill levels, optimizing waste collection routes, and reducing operational costs for municipal waste management services.					
8	New Water Infrastructure: Precast concrete pipes, manholes, and storm water management systems are essential components of urban water infrastructure. These elements can be designed with integrated sensors for monitoring water quality, flow rates, and infrastructure condition, enabling proactive maintenance and management of water resources.					

9	<u>New Transportation Hubs:</u> Precast concrete components are used in the construction of transportation hubs such as bus terminals, train stations, and airports. These hubs can be equipped with digital signage, way finding systems, and real-time passenger information displays, enhancing the overall passenger experience and accessibility of public transportation services.					
10	<u>New Green Spaces:</u> Precast concrete elements are used in the construction of urban green spaces, including retaining walls, seating areas, and decorative features. These elements can be designed to incorporate irrigation systems, LED lighting, and soil moisture sensors, promoting sustainable landscaping practices and enhancing the aesthetic appeal of public parks and gardens.					

PART FOUR

Precast concrete technology has a significant <u>impact on various aspects of New city development</u>, including speed, cost-effectiveness, efficiency, sustainability, and resilience:Please indicate the influence impact by making on the appropriate box using the following a 5-point likert scale: 1 = Very low impact, 2 = Low impact, 3 = Medium impact, 4 = High impact and 5 = Very high impact.

S/N	List of Impact	Impact Level				
		VH =5	H=4	M =3	L=2	VL =1
1	Speed: Precast concrete components are manufactured off-site in controlled environments, allowing for parallel construction activities at the site. This results in faster construction timelines compared to traditional cast-in-place methods. The accelerated construction process enables rapid deployment of infrastructure and buildings, crucial for keeping pace with urban growth and development in cities.					

2	Cost Effectiveness: While the initial investment in precast concrete technology may be higher than traditional methods, the overall cost-effectiveness becomes evident over the project's life cycle. The reduced construction time, lower labor costs, and minimal on-site waste generation contribute to significant cost savings. Additionally, the durability and longevity of precast concrete structures result in lower maintenance and operational costs over time.					
3	Efficiency: Precast concrete technology improves construction efficiency by standardizing manufacturing processes and minimizing on-site labor requirements. The precise manufacturing tolerances of precast components ensure consistency in quality and dimensions, reducing construction errors and rework. The modular nature of precast elements also facilitates efficient assembly and integration, streamlining construction workflows and project delivery.					
4	Sustainability: Precast concrete technology aligns with sustainability goals by promoting resource efficiency and reducing environmental impact. The manufacturing process generates less waste and consumes fewer raw materials compared to traditional construction methods. Additionally, precast concrete structures can incorporate recycled materials and contribute to energy efficiency through thermal mass properties and insulation features. The durability and long lifespan of precast concrete also promote sustainable development by reducing the need for frequent replacements and renovations.					
5	Resilience: Precast concrete structures are inherently resilient and capable of withstanding various environmental hazards and extreme weather events. The robustness of precast components enhances the resilience of New city infrastructure against seismic activity, floods, hurricanes, and other natural disasters. Additionally, precast concrete technology allows for the integration of advanced reinforcement techniques and structural enhancements, further enhancing resilience and ensuring the safety and functionality of critical infrastructure in cities.					
6	Overall, precast concrete technology plays a vital role in advancing the speed, cost-effectiveness, efficiency, sustainability, and resilience of New city development. By leveraging the benefits of precast concrete technology, urban planners and developers can create more resilient, sustainable, and livable cities capable of meeting the challenges of the 21st century.					

The integration of precast concrete technology into New city development presents both challenges and opportunities:3.Please indicate the influence impact by making on the appropriate box using the following a 5-point likert scale: 1 = Very low impact, 2 = Low impact, 3 = Medium impact, 4 = High impact and 5 = Very high impact.

S/N	List of Challenges	Impact Level				
		VH=5	H=4	M=3	L=2	VL=1
	Challenges:					
1	initial Investment: The initial capital investment required for implementing precast concrete technology can be substantial, including the setup of manufacturing facilities and equipment. This initial cost may pose a barrier for some municipalities or developers, especially in regions with limited financial resources.					
2	Transportation and Logistics: Transporting precast concrete components from manufacturing facilities to construction sites can present logistical challenges, particularly for large and heavy elements. Issues such as transportation costs, route planning, and coordination with local authorities need to be addressed to ensure timely delivery and minimize disruptions					
3	Design Complexity: Designing precast concrete elements to integrate seamlessly with New city infrastructure can be complex. Architects and engineers need to consider factors such as structural requirements, integration of sensors and communication systems, and aesthetic considerations while ensuring compatibility with existing infrastructure and regulations.					
4	Standardization and Compatibility: Achieving standardization and compatibility of precast concrete components across different projects and locations can be challenging. Variations in design specifications, manufacturing processes, and local					

	building codes may hinder interoperability and scalability, requiring coordination and collaboration among stakeholders.					
5	Maintenance and Upkeep: While precast concrete structures are known for their durability, they still require regular maintenance to ensure long-term performance and functionality. Developing proactive maintenance strategies and protocols for precast elements integrated with New city infrastructure is essential to maximize their lifespan and resilience.					
	Opportunities:					
6	Innovation and Customization: Precast concrete technology offers opportunities for innovation and customization in New city development. Advanced manufacturing techniques such as 3D printing and robotic assembly enable the production of complex geometries and customized components tailored to specific project requirements.					
7	Sustainable Solutions: Precast concrete technology aligns with the sustainability goals of cities by promoting resource efficiency, waste reduction, and energy savings. Opportunities exist to further enhance sustainability through the use of recycled materials, carbon-neutral production processes, and innovative design strategies.					
8	New Integration: Integrating precast concrete components with New city infrastructure presents opportunities to enhance functionality and performance. Sensors, actuators, and communication devices can be embedded within precast elements to enable real-time monitoring, data collection, and adaptive control, contributing to improved efficiency, safety, and user experience.					
9	Streamlined Construction Processes: Prefabrication and modular construction techniques associated with precast concrete technology streamline construction processes and reduce on-site labor requirements. This efficiency translates into faster					

	project delivery, cost savings, and minimized disruptions to surrounding communities, benefiting both developers and residents.					
10	Resilient Infrastructure: Precast concrete structures inherently offer resilience against various hazards, including seismic activity, extreme weather, and environmental degradation. By integrating precast elements into New city infrastructure, municipalities can enhance resilience and ensure the long-term viability of critical assets and services.					
	Advantages of substituting steel frames with precast concrete frames for warehouse construction as an import substitution strategy:Please indicate by making tick to the appropriate box using the following scale: Strongly Agree (SA)= 5, Agree (A)= 4, Neither Agree nor Disagree (A/D)= 3, Disagree (D)= 2, Strongly Disagree (SD)= 1.					
		(SA)= 5	(A)= 4	(A/D) = 3	(D)= 2	(SD) = 1
11	Reduced Dependency on Imported Materials (import substitution): By substituting steel frames with precast concrete frames, the project reduces reliance on imported steel, contributing to import substitution goals and promoting local manufacturing.					
12	Promotion of Local Industry: The use of precast concrete frames encourages the growth of the local precast concrete industry, creating jobs and supporting economic development in the region.					
13	Foreign Currency Savings: Precast concrete frames may offer foreign currency savings over steel frames in certain situations, particularly if locally sourced materials and labor are utilized, reducing transportation and import costs.					
14	Fire Resistance: Concrete is inherently fire-resistant, offering greater protection against fire hazards compared to steel, which can deform and lose strength at high temperatures.					

15	Job Opportunity: creates better local job opportunity when the precast plant function in the industry area					

Overall, while challenges exist in the integration of precast concrete technology into New city development, the opportunities for innovation, sustainability, efficiency, and resilience are substantial. By addressing these challenges and leveraging the opportunities, cities can harness the full potential of precast concrete technology to create Newer, more resilient, and sustainable urban environments.