

**T.C.
ISTANBUL GEDİK NIVERSITY
INSTITUTE OF GRADUATE STUDIES**



**CREATING AN EXPERT SYSTEM TO MANAGE CONSTRUCTION
PROJECT CHALLENGES (CASE STUDY ON COST MANAGEMENT IN
IRAQ)**

MASTER'S THESIS

Alhasan Abdulkareem Abd Ali AL-LAMI

Civil Engineering Department

Master in Civil Engineering English Program

JULY 2023

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LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

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DECLARATION

I, Alhasan Abdulkareem Abd Ali AL-LAMI, declare that this thesis titled “Creating an Expert System to Manage Construction Project Challenges (Case Study on Cost Management in Iraq)” is original work I did for the award of the master’s degree in Civil Engineering. I also declare that this thesis or any part of it has not been submitted and presented for any other degree or research paper in any other university or institution. (27/07/2023)

Alhasan Abdulkareem Abd Ali AL-LAMI



DEDICATION

I'd want to dedicate this dissertation to my father (Abdulkareem Abd ALI), my mother (Kifah Akram LAMEEL), MY Brother (Ali ABDULKAREEM), and my sister (Shahad Abdulkareem Abd ALI), who have been my biggest supporters throughout my academic journey. Their unwavering love and encouragement have helped me to achieve this significant milestone.

I'd also want to show my appreciation to my supervisor, Assist Prof. Dr. Hasan Bozkurt NAZİLLİ, for their guidance, patience, and support throughout my research. Their expert advice has been invaluable, and I couldn't have completed this thesis without their assistance.

Finally, I'd want to thank all my friends and family for their encouragement and support during my academic journey. Your support and affection have been a continual source of motivation for me, and I am fortunate to have you in my life.

Alhasan Abdulkareem Abd Ali AL-LAMI

PREFACE

This thesis reflects the result of my two-year research work. My past studies and personal interests in the subject of (Construction Project Challenges) sparked the concept for this research project. My main aim was to investigate the possible influence of (Creating An Expert System) On (Manage Construction Project Challenges).

I'd like to thank (Asist Prof. Dr. Hasan Bozkurt NAZILLI) for their constant support, advice, and mentorship throughout the entire process. Their knowledge, critical input, and support were invaluable in crafting this thesis.

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I'd want to express my heartfelt gratitude to my family and friends for their unending support, encouragement, and understanding during the difficult and gratifying path of finishing my thesis.

Lastly, I hope that my thesis will make an important contribution to the field of construction management and stimulate more research in this area.

July 2023

Alhasan Abdulkareem Abd Ali AL-LAMI

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CREATING AN EXPERT SYSTEM TO MANAGE CONSTRUCTION PROJECT CHALLENGES (CASE STUDY ON COST MANAGEMENT IN IRAO)

ABSTRACT

The inability to manage costs effectively can lead to project delays, overruns, and ultimately project failure. Therefore, there is a need for a systematic approach to cost management in construction projects.

This research focuses on developing an expert system to manage construction project challenges, with a specific emphasis on cost management. Based on the hypothesis, the absence of cost and time control which lead to insufficient projects performance

The research methodology involves a case study approach, which includes interviews with construction professionals and a review of literature on expert systems and cost management. The development of the expert system will be based on the knowledge and experiences of the construction professionals interviewed and the literature review.

The expected outcomes of this research are the development of an expert system that provides a comprehensive approach to cost management in construction projects. The expert system will be designed to provide real-time insights and solutions to cost-related challenges encountered during a construction project.

The evaluation of the research's success will be based on the achievement of its intended results. Overall, this research aims to contribute to the improvement of cost management in construction projects and provide a valuable tool to construction professionals to effectively manage cost-related challenges.

Keywords: *Construction projects, Cost management in construction, System development in construction*

YAPI PROJERİNDEKİ ZORLUKLARI YÖNETMEK İÇİN UZMAN SİSTEM OLUŞTURULMASI (IRAKTA MALİYET YÖNETİMİ İLE İLGİLİ VAKA ANALİZİ)

ÖZET

Etkin maliyet yönetimini gerçekleştirilememesi, proje gecikmelerine, aşmalarına ve sonunda proje başarısızlığına yol açabilir. Bu nedenle, inşaat projelerinde maliyet yönetimine sistemli bir yaklaşım gereklidir.

Bu araştırma, inşaat proje zorluklarını yönetmek için bir uzman sistem geliştirmeye odaklanmaktadır, özellikle maliyet yönetimine vurgu yaparak.

Araştırma metodolojisi, inşaat profesyonelleri ile yapılan görüşmeleri ve uzman sistemler ve maliyet yönetimi konularındaki literatürün gözden geçirilmesini içeren bir vaka çalışması yaklaşımını içerir. Uzman sistemin geliştirilmesi, görüşülen inşaat profesyonellerinin bilgi ve deneyimlerine ve literatür taramasına dayanacaktır.

Bu araştırmanın beklenen sonuçları, inşaat projelerinde maliyet yönetimine kapsamlı bir yaklaşım sunan bir uzman sistemin geliştirilmesidir. Uzman sistem, inşaat projesi sırasında karşılaşılan maliyetle ilgili zorluklara anlık görüşler ve çözümler sağlamak üzere tasarlanacaktır.

Araştırmanın başarısının değerlendirilmesi, amaçlanan sonuçların gerçekleştirilmesine dayalı olacaktır. Genel olarak, bu araştırma, inşaat projelerinde maliyet yönetiminin iyileştirilmesine katkı sağlamayı ve inşaat profesyonellerine maliyetle ilgili zorlukları etkili bir şekilde yönetmek için değerli bir araç sunmayı amaçlamaktadır.

Anahtar Kelimeler: *İnşaat projeleri, İnşaat maliyet yönetimi, İnşaat sistem geliştirme*

1. INTRODUCTION

1.1 Introduction

This study aims to provide a concise overview of construction projects, examining the challenges they pose and their impact on both project timelines and costs. Additionally, a comprehensive questionnaire will be designed to identify the factors influencing construction projects and how they affect building outcomes. Furthermore, a computer program will be developed to facilitate effective project management.

In the construction industry, it is crucial to effectively manage project costs to ensure that construction expenses remain within the allocated budget. Therefore, project cost management plays a vital role in maintaining project budget adherence. As stated by the Project Management Institute (2004: 14), project management entails the utilization of knowledge, skills, tools, and methodologies to fulfill project requirements. As a project becomes larger and more intricate, it necessitates a more systematic and structured approach. This is primarily because the project must incorporate and synchronize human efforts alongside specific physical elements while operating under the four fundamental constraints of scope, cost, time, and quality (Ali, 2010).

For the past decade or so, construction owners and contractors have been exploring alternative dispute resolution techniques to efficiently and cost-effectively resolve contract claims and disputes. They have experimented with methods that are more objective, convenient, and confidential, such as arbitration, mediation, and the newer "turbo-mediation." An investigation has been conducted to address the need for an expert system based on knowledge, specifically for claim management.

Chapter three deals with the methodology used in this research. This methodology was chosen to achieve the aim of the research as well as its objectives. The chapter includes a Field study, Design of the questionnaire, Pilot study, Statistics reliability, Questionnaire distribution, and Results of the questionnaire (N. Abbas 2017).

This chapter will include, the field study and aspects related to the questionnaire and that by collecting and analyzing the result of the questionnaire, The first section of the questionnaire includes a group of engineering professionals, managers, and university academics (H. Ali 2012).

Chapter four, a proposed solution is presented for effectively managing issues that arise in construction projects. The solution involves utilizing expert systems and AI technology to provide an optimal method for design.

Chapter five presents a synthesis of the researcher's theoretical and field study, along with an examination of the outcomes derived from the closed questionnaire. Both qualitative and quantitative methodologies were employed in analyzing risks and selecting appropriate risk responses. Based on these findings, several suggestions for future research are proposed.

1.2 Study Topic

As most projects in Iraq are being built in an environment that is unstable in terms of cost and timeline, Project management needs to catch up to the expectations of the owner and contractor, which causes the need to develop a system capable of resolving these issues. Therefore, the following is an explanation of the research's justification:

1. Because of the magnitude and complexity of building projects, an integrated system is required.
2. Because building projects are unpredictable, a system that can make decisions swiftly and inexpensively is required.
3. Because determining the appropriate solution to problems in building projects is costly, an integrated system is required.

1.3 Purpose/Importance

The objective of the research is to develop an expert system that effectively addresses time and cost-related challenges in construction projects. To achieve this overarching goal, the following specific objectives need to be accomplished:

1. Researching and identifying the issues with construction projects.

2. Figuring out how these issues affect construction projects' costs and timeliness.
3. Developing an expert system capable of addressing these problems can be achieved by implementing optimization techniques such as particle swarm optimization and genetic algorithms.

1.4 Literature Review

Governments in developing nations, which represent approximately 85.4% of the global population, establish Medium- and Large-scale Construction Projects (MCPs) as part of their efforts to achieve social and economic sustainable development goals (Ezzat, 2013). The construction sector holds significant importance in a country's economic growth, contributing around 18% to the global GDP. However, due to uncertainties in technology, finances, and development processes, the construction sector is known for its dynamic nature. To carry out construction operations successfully, a sufficient workforce, skillsets, dedication, and effective workforce management are essential. Traditionally, the performance evaluation of construction projects is based on three criteria: time, cost, and quality. Some research suggests that safety is also considered as an additional factor in project performance (Alameri, 2021). The construction sector undertakes the creation of various infrastructure, industrial, educational, cultural, transportation, medical, and residential projects to meet the demands and expectations of societies. MCPs commissioned by governments often involve complex, hazardous, and time-consuming projects. On one hand, these MCPs require advanced design knowledge, technical expertise, skilled human resources, professional managerial capabilities, and significant investments due to their unique nature and characteristics. On the other hand, developing nations face challenges in terms of accessing crucial information, acquiring necessary skills and capacities, and securing adequate funding, which hinder their progress in handling MCPs (Ezzat, 2013).

The rapid advancements in information technology (IT) and information systems have generated a highly competitive landscape across various industries, including the construction sector. As a result of this condition, construction companies must apply various advancements to support their business environment, as well as new management ideas such as concurrent engineering (CE) (Dahmas, 2019).

The construction sector is sure to confront several issues which today's construction management must address. Some are new to the industry, while others have been there for decades. The construction industry often exhibits limited cohesion, efficiency, and a slower pace in adopting new information technologies and products. In comparison to other industries, it tends to allocate fewer resources to research and development (R&D) efforts. In recent years, investors and project owners have increasingly demanded higher quality, lower costs, and faster project delivery times. However, construction projects are complex and require careful management to meet the owner's quality, cost, schedule, scope, and safety criteria. Construction managers must anticipate and address potential threats to project success through project planning, organization, scheduling, implementation, management, monitoring, regulation, and tracking. Ultimately, the success of a construction project depends on achieving its goals and objectives by allocating resources in a way that meets the project's requirements for cost, schedule, quality, safety, and scope (Ugochukwu, 2015).

The construction sector plays a crucial role in economic development by providing essential elements such as infrastructure, significant job opportunities, and fostering entrepreneurial growth. Among the various construction activities, road construction has encountered numerous challenges. Issues related to road construction have been recognized as recurring problems within the construction sector. Many of these challenges persist over time, and new complexities have emerged in the sector due to technological advancements and other influences. Consequently, there is a growing need within the industry to address and effectively manage these specific difficulties (Ugochukwu, 2015).

Many challenges with significance for the building sector have been considered primarily in the context of developed nations. However, it is commonly assumed that these issues still need to impact underdeveloped countries. This study tackles and analyzes some of these challenges from the perspective of developing countries. It begins with the growth of the building sector, which is typically viewed as a requirement exclusively for developing nations, although it is also relevant to developed ones (Ofori, 2000).

1.4.1 Overview and characteristics of developing countries

The classification of countries into "developed" and "developing" categories has long been a subject of ongoing debate and contention. Typically, a country's classification as "developed" or "developing" takes into consideration various factors, including:

1. Economic development.
2. Access to education and training.
3. Political stability, technological progress, infrastructure, and production capacity.
4. Healthcare standards, life expectancy, and population growth rate.
5. Societal challenges often tied to demographics and culture. In 2012, the World Bank introduced a classification system based on a country's Gross National Product (GNP) per capita, which groups nations into low-income, lower-middle-income, upper-middle-income, and high-income categories. All countries falling within these income ranges are generally considered "developing" nations. Here are the income ranges for each category:
 - Low-income countries: GNI \leq US\$1,025 per capita.
 - Lower-middle-income countries: GNI per capita ranging from \$1,026 to \$4,035 USD.
 - Upper-middle-income countries: GNI per capita ranging from \$4,036 to \$12,475 USD.
 - High-income countries: GNI per capita of \$12,476 or above.

To assess a nation's level of human development, the United Nations has introduced the Human Development Index (HDI). The HDI takes into account three key aspects of human development: "long and healthy life," "knowledge," and "decent standard of living." By incorporating these factors, the HDI offers a comprehensive measure of a country's development level. The HDI is categorized as follows:

- Low human development: HDI less than 0.500.
- Medium human development: HDI ranging from 0.500 to 0.799.
- High human development: HDI ranging from 0.800 to 0.899.

- Very high human development: HDI of 0.90 or higher.

These classifications provide a framework for understanding and assessing the level of development across nations, considering various economic, social, and human development factors.

Approximately 52% of the global population resides in countries classified as "middle-income," while 18% of the population lives in "low-income" countries. Furthermore, around 30% of the world's population falls within the spectrum of "high" to "very high" human development levels (Ezzat, 2013).

In a study conducted by Ezzat (2013), the aim was to explore the barriers hindering the expansion of megaprojects (MCPs) in developing countries. The research faced challenges in selecting a representative and unbiased sample of MCPs due to the relatively new nature of the research field and limited knowledge regarding the challenges faced by MCPs in developing countries. To address this, the researchers compiled a list of 348 MCPs from published literature and relevant sources, excluding non-construction projects. They then filtered out MCPs that were completed, in progress, on hold, or canceled in developing countries, resulting in a sample of 100 projects. Despite the difficulties encountered in acquiring information, the researchers obtained and reviewed 36 case studies, which represented approximately 36% of MCP programs in economically disadvantaged countries. Detailed information about the projects, including their type, location, cost, duration, and issues, was extracted from various nations with varying scopes, rules, client organizations, costs, and lengths. This approach improved the dependability and validity of the identified challenges, highlighting the need to address various issues in megaproject management in developing countries. The scholarly community has shown increasing interest in this research area, as indicated by the recent publication of special editions on megaproject management in prestigious journals such as the *International Journal of Project Management* and the *International Journal of Organization, Technology, and Management in Construction* (Ezzat, 2013).

1.4.2 Management of construction projects

As stated by Ugochukwu (2015), construction management services encompass a wide range of tasks and responsibilities related to building design, documentation, procurement, and construction. The scope and approach of construction management

are significantly influenced by the contractual agreement between the construction management company and the client. Project management, on the other hand, involves a variety of duties and responsibilities, including:

- Identifying project requirements.
- Establishing clear and attainable objectives.
- Balancing the competing demands of quality, scope, time, and cost.
- Adapting specifications, plans, and approaches to address the diverse concerns and expectations of different stakeholders.

Given the complex and distinctive characteristics of the construction industry, including factors such as a mobile workforce, ingrained culture, challenging working conditions, project-based structure, diverse subcontractors and suppliers, as well as regulatory bodies and shifting government policies throughout the production process, managing construction projects can be inherently challenging. These issues significantly impact the efficiency of the construction site management team and often contribute to project failures.

1.4.3 Management challenges in construction practice

The increasing need for innovative construction management has highlighted the complexity and challenges of overseeing building projects from conception to disposal. Construction managers manage time, finances, equipment, technology, personnel, and materials throughout the project lifecycle. The construction manager coordinates and utilizes resources effectively, organizing them into activities and establishing a logical sequence to ensure timely delivery of the project while meeting the specified budget and quality standards. In addition, they oversee the construction process, accommodating customer requirements within the boundaries of legal, financial, schedule, quality, and environmental constraints. Moreover, the construction manager assumes responsibility for the entire building lifecycle, from conception to the end of its economic lifespan. This includes managing procurement, construction, design, property management, recycling, and disposal of the building, while also navigating the often-competing interests of clients, users, and the community (Ugochukwu, 2015).

1.4.4 Skills required of construction manager

The role of construction project managers is multifaceted, demanding, and encompasses a diverse range of responsibilities. According to Ugochukwu (2015), while possessing traditional project management skills is crucial for project success, effective communication among team members and the broader network is vital to establish a shared understanding of the project and its objectives. Therefore, proficiently managing construction projects requires a combination of various abilities, including interpersonal skills, technical expertise, cognitive aptitude, and the ability to analyze situations and individuals, while dynamically adapting appropriate leadership behaviors (both soft and hard skills). Ugochukwu (2015) categorizes these abilities into six main areas: communication, organization, team building, leadership, coping, and technical competence (Ugochukwu, 2015).

1.5 Hypothesis

The thesis hypothesis encompasses the following statements:

H0: poor cost and time management performance prevent a construction project from being completed on time and within budget.

H1: Implementing a comprehensive management plan specifically tailored to cost management can lead to better project outcomes and cost control in construction projects.

2. CONSTRUCTION PROJECTS

2.1 Construction Projects

The construction industry is acknowledged for its complexity, primarily due to the involvement of numerous parties, such as clients, contractors, consultants, stakeholders, and regulators. Nonetheless, the industry is vital in society's progress and attaining objectives. As one of the most extensive sectors, it accounts for approximately 10% of developed nations' gross national product (GNP) (Enshassi, 2009).

Project management is defined as the "utilization of knowledge, skills, tools, and methodologies to effectively carry out project operations and meet project requirements." As a project becomes more intricate, it necessitates a more scientific and systematic approach. The project involves the integration and coordination of human contributions along with certain physical elements, all while adhering to the fundamental constraints of scope, cost, time, and quality (Ali, 2010).

In the realm of manufacturing, a building project can be described as a unique production or a one-off endeavor. Consequently, project management in the construction industry faces specific and distinct challenges that are not encountered in other sectors:

- 1- The construction team comprises numerous individuals located at different sites.
- 2- The construction industry operates on short-term, project-based supply networks.
- 3- Various project management and costing approaches, such as "design-bid-build," "construction manager," and "design-build," are employed, each with different product delivery systems.
- 4- Managing the associated legal contracts and related documentation, such as change orders, entails specific requirements.

- 5- The scope of construction projects extends beyond the completion of the physical structure, encompassing the life-cycle operation and maintenance management of the final product as well as the architect-design-construction process (Shen, 2008).

Management in the building industry requires making a few decisions. The final answers will affect the process of construction as well as the ultimate shape of an edifice or structure, and the implications of the decisions will frequently be felt many years later when the built structure is used. Dilemmas can arise at any step of a new construction project, from picking the location to developing plans and designs, selecting technologies, materials, and structures, to project management, project quality, or risk concerns. Any further understanding of this subject necessitates the definition of the term "choice" (Szafranko, 2017).

Construction businesses operate within a dynamic commercial environment that undergoes constant change on a global scale. It is crucial for organizations to adapt and respond to the complexities of this evolving landscape, as failure to do so increases the risk of business failure. With growing customer demands, environmental considerations, and limited resources on one side, and intense competition in the construction industry marketplace on the other, contractors must possess the ability to consistently enhance their performance (Enshassi, 2009).

Modifications and alterations to projects are inevitable, as they are a reality throughout all phases of design and construction. According to research conducted by the Engineering and Physical Sciences Research Council (EPSRC) in the United Kingdom, more than a third of major clients express dissatisfaction with contractors' performance in adhering to agreed-upon prices and schedules, resolving issues, and delivering the expected level of quality in the final product. Change orders that arise during construction projects are often to blame for this dissatisfaction among clients. The management of change orders places significant strain on project management and is a challenging aspect that industry professionals would prefer to avoid. Furthermore, construction changes give rise to ethical concerns and disagreements that can have serious implications (Shen, 2008).

Any development effort must include a certain degree of risk. As a result, the project manager was required to execute a risk management role to identify and mitigate the

risks associated with the specific project. Risk management aims to reduce any risk that might lead to failure to achieve project requirements (Ali, 2010).

For contractors, consultants, and clients, it is essential to ensure that they have a competent team equipped with the necessary skills to effectively manage their projects. Ideally, the construction manager should possess expertise and certifications in project or construction management. This ensures that the projects are executed efficiently and with the appropriate level of expertise (Ali, 2010).

Efficient management is crucial in achieving a productive and cost-effective construction site. However, inadequate planning and feasibility studies can lead to changes in project scope. To effectively oversee the project, the project manager must adhere to the schedule to minimize excessive costs and ensure timely occupancy of the building. The literature review conducted revealed potential solutions for addressing cost overrun issues. Based on the findings of the literature review, the researchers propose eleven variables that can help overcome or mitigate the challenges of cost overruns in construction projects. It is important to identify and implement an appropriate strategy to reduce the challenges associated with cost overruns in building projects in Malaysia (Ali, 2010).

2.1.1 Construction projects problems

The construction sector needs to understand better conflict resolution management; several elements influence the development of dispute resolution. First, relationships between parties involved in building processes have deteriorated recently. Several research on the definitions, nature, parties, categorization, causes, and settlement of construction conflicts have been evaluated. A dispute can be described as a situation where there is a specific disagreement between parties regarding a matter of fact, law, or policy. It occurs when one party makes a claim or assertion that is met with refusal, counter-claim, or denial by another party. In the context of construction, a dispute refers to any contractual question or controversy that needs to be resolved outside the purview of the job site management staff. It arises as a difference between the parties involved, even after internal procedures for resolution have been exhausted. It is worth noting that conflicts are common in the construction industry and can divert resources that could otherwise be utilized more productively. It is

important to recognize that a disagreement typically emerges once a claim has been put forward and subsequently rejected (Elziny, 2015).

The commercial environment in which construction enterprises operate is quickly changing worldwide. Companies that are unable to adjust and effectively address the challenges presented by their evolving environment are at a higher risk of failure. Furthermore, contractors must continuously enhance their performance to meet the growing demands of customers, heightened environmental awareness, and resource limitations. This is particularly crucial given the intense competition prevailing in the construction industry market. By adapting and striving for consistent improvement, contractors can increase their chances of success in this dynamic business landscape (Enshassi, 2009).

It is well known that the construction industry is prone to conflict. Negotiation, litigation, arbitration, mediation, or any other alternative conflict resolution procedure may be used to address this scenario. Each of these choices requires both time and money. Reducing the amount of wasted time and money necessitates significant effort.

In cases where there is a conflict between the contractor and the project owner, the project may experience setbacks, resulting in delayed progress. In addition, the project's cost rises owing to legal fees and the overall disruption created by the conflict. When disagreements make the front pages of trade journals and newspapers, construction businesses, property developers, governmental agencies, and owners' reputations suffer (Arditi, 1989).

Effective project management and timely project completion within the allocated budget require proper handling of project schedules and cost risks. Risk management plays a crucial role in this process, encompassing activities such as identifying potential risks, analyzing their impact, implementing risk reduction strategies, and continuously monitoring risks throughout the project execution phase. By actively managing risks, project managers can enhance the chances of successful project delivery while minimizing schedule delays and cost overruns (Kuulinas, 2020).

"Several studies have explored the factors that affect project performance in developing countries, highlighting construction delays as a key issue. Factors contributing to these delays include a shortage of skilled labor, inadequate site

management and supervision, ineffective leadership, insufficient equipment, and other related factors" (Enshassi, 2009).

The construction industry plays a crucial role in the development of a country, but it faces persistent challenges that hinder its progress. Issues such as inadequate schedule and cost performance, construction waste, low productivity, and dependence on foreign labor are prevalent in the sector. Of these challenges, the poor time and cost performance are particularly concerning and require attention to improve the overall efficiency and effectiveness of construction projects (Memon, 2012).

Changes are a frequent occurrence in construction projects, arising from various sources and factors at any stage of the project. These changes can have a substantial adverse impact on crucial aspects such as costs and schedule adherence. A single significant change has the potential to cause project delays, necessitate a reassessment of the work scope, and lead to additional requirements for equipment, materials, manpower, and overtime work (Shen, 2008).

The globalization and internationalization of the construction industry have brought both advantages and challenges to developing economies. The volume, complexity, and demands of construction projects have significantly escalated over time. However, developing nations face additional socioeconomic and political challenges exacerbated by the scarcity of construction materials and skilled labor, putting further strain on the construction industry. Despite having sufficient financial resources, companies need help to meet project deadlines due to the heavy workload, parallel deadlines, and a shortage of human resources. As developing countries experience a construction boom, clients are placing greater emphasis on time constraints, leading to the adoption of prime contractor ships to transfer time-related risks to contractors. Additionally, heavy liquidated damages for late completion are being imposed to ensure timely project delivery (Toor, 2008).

The use of outdated and inappropriate equipment and methods hinders the pace of construction projects. Consequently, certain countries attempt to import or introduce modern technology to their regions. Unfortunately, this approach often falls short due to a shortage of skilled individuals capable of operating the advanced technology effectively (Ali, 2010).

It has been observed that the true conditions of a construction site are often revealed after excavation has begun. It is possible that the initial assessment overlooked site conditions or that conditions have changed due to weather or subsoil variations. Unforeseen subsurface conditions may necessitate a significant reassessment of costly projects. Moreover, alterations in site conditions create challenges for the movement of machinery and materials in and out of the site, leading to additional costs (Ali, 2010).

Design errors or inadequate design can be attributed to the incompetence of the designer. The process of approving designs or drawings, particularly in government-funded projects, can compromise quality and efficiency. Unrealistic designs that are discovered after the start of construction projects often require modifications, leading to cost overruns (Ali, 2010).

According to reports, project delays were accompanied by cost escalations to cover expenses incurred during construction. As a result, it is essential for owners to secure sufficient funding for the project and ensure timely payments to the contractor as outlined in the contract (Ali, 2010).

As observed, numerous contractors in developing countries have established their own businesses. They possess expertise in cost control as they have a deep understanding of financial management. They tend to offer lower wages, submit competitive bids, and require improved contract planning and coordination skills. However, they often deviate from the contract terms (Ali, 2010).

Another issue identified in the market context is the high cost of machinery. The construction industry is predominantly influenced by market dynamics, and current market trends significantly impact it. For instance, if the price of oil, which is essential for operating machinery, increases, it also leads to a rise in machinery rental costs (Ali, 2010).

2.1.1.1 Time problems

Time overrun refers to the completion of work later than the initially anticipated or contractually agreed timetable. It occurs when the progress of a contract falls behind its projected timeline, and can be caused by any party involved, resulting from one or multiple factors. The consequences of contract delays are detrimental to both the owner and the contractor, leading to lost revenue or additional expenses. Moreover,

delay accountability is a contentious issue that often leads to disputes and, in some cases, legal proceedings (Memon, 2012).

Construction delays can be defined as exceeding the completion date specified in the contract or the agreed-upon delivery date set by the parties involved. It signifies a project falling behind schedule, which is a common challenge in construction projects. For the owner, these delays result in revenue losses due to reduced production, unrented space, or increased reliance on existing facilities. Additionally, the contractor may face higher overhead costs, inflated material expenses, and increased labor costs due to the extended duration of work (Assaf, 2004).

The overall duration of a project is a crucial indicator of effective resource management, ensuring the timely completion of deliverables while maintaining acceptable quality standards. However, in practical terms, the project's baseline schedule is susceptible to uncertainties regarding the durations and costs of actual activities. Therefore, accurate duration prediction plays a vital role in establishing the baseline schedule and developing updated interim baseline schedules during project execution (Koulinas, 2020).

Timely completion of projects is a measure of efficiency. However, the construction process is susceptible to uncertainties and unforeseen circumstances arising from various sources. These sources include the performance of involved parties, resource availability, environmental factors, engagement of external parties, and contractual relationships. It is uncommon, however, for projects to be completed within the initially stated timeframe (Assaf, 2004).

"Studies conducted in developed and developing countries indicate that building delays are a common and persistent challenge in construction projects. Such delays can lead to cost overruns, substandard quality, disputes among parties, project abandonment, and prolonged litigation. Furthermore, the delay in the availability of products and other commercial facilities can result in a loss of revenue for the project owner. Additionally, contractors may experience increased overhead, material, and labor costs. Prior research has identified various factors that typically contribute to project delays. In the past decade, research in developing nations has consistently highlighted challenges resulting in construction delays and cost overruns across various building projects.

Construction projects commonly encounter a range of prevalent issues, including insufficient procurement systems, inadequate resource allocation, discrepancies between design and construction phases, deficient project management practices, frequent change orders, breakdowns in communication, cultural differences, and conflicting interests among stakeholders. These challenges often pose significant obstacles to the successful execution of construction projects.

The globalization and internationalization of the construction industry have brought both benefits and challenges to emerging nations. The volume, complexity, and requirements of construction projects have increased significantly over time. However, these developments have been accompanied by the scarcity of building materials and skilled labor, which exacerbate the existing socioeconomic and political challenges faced by emerging countries. As a result, construction companies struggle to meet project deadlines not due to financial constraints but due to the immense pressure of managing multiple projects with limited human resources.

In response to the growing construction boom in developing nations, customers are becoming increasingly concerned about meeting project timelines. They are placing more reliance on prime contractors to assume time-related risks and imposing high liquidated damages for delays in project completion. This places additional pressure on contractors to efficiently manage their resources and deliver projects on time (Toor, 2010).

Project performance can be assessed and evaluated using a diverse range of performance indicators, which can be categorized into various dimensions or groups. These dimensions include time, cost, quality, client satisfaction, client changes, business performance, and health and safety. These indicators provide valuable insights into different aspects of project performance and help stakeholders gauge the overall success and effectiveness of a project. However, the three most crucial performance evaluation factors are time, cost, and quality. Another intriguing method of assessing project effectiveness is using two standard metrics sets. The first set concerns the owner, users, stakeholders, and the general public; these individuals will examine project success from a macro perspective. The second group consists of the developer and the contractor, who will examine project performance from a micro perspective (Enshassi, 2009).

In a study conducted on construction projects in Hong Kong, a survey of 83 potential delay issues identified five significant factors: inadequate risk management and supervision, unforeseen site conditions, slow decision-making, client-initiated changes, and job variations (Assaf, 2004).

Another study focusing on 31 high-rise projects in Indonesia found that cost overruns are more frequent and of greater concern than time overruns. The key factors contributing to cost overruns were identified as material cost increases due to inflation, inaccurate material estimation, and the level of project complexity. Time overruns, on the other hand, were attributed to design changes, low worker productivity, inadequate planning, and resource limitations (Assaf, 2004).

Research on highway construction delays in Thailand revealed that all project parties could contribute to delays, but the primary causes were identified as inadequate subcontractors, insufficient organizational resources, incomplete and unclear drawings, and discrepancies between consultants and contractors. The study suggested that effective communication leading to better understanding could help mitigate delays (Assaf, 2004).

In a comprehensive analysis of 130 major projects in Jordan, the authorities identified several causes of delays, including the designer, user modifications, weather conditions, site conditions, late delivery, economic factors, and quantity changes. The report emphasized the importance of addressing these issues to reduce contract conflicts and highlighted the significant correlation between delays, contractor failure, and inefficient performance (Assaf, 2004).

Contractor performance was identified as a fundamental cause of delays, with 13 key measures considered in relation to the contractor's resources and skills. Through interviews with 68 contractors, the primary causes of failure in the Saudi construction industry were explored, revealing factors such as lack of experience, poor estimating techniques, inadequate judgment in managing firm policies, and the impact of a national economic recession (Assaf, 2004).

Poor time and cost performance pose significant concerns in construction, as evidenced by the low percentage of projects completed within budget and on time in Malaysia. For instance, only 46.8% of public sector projects and 37.2% of private sector projects were finished within budget, while only 20.5% of public projects and

33.35% of private sector projects were completed on time. These challenges prompted further investigation into cost considerations and schedule performance in Malaysian building projects, although the study focused on development projects in the southern and central parts of Peninsular Malaysia (Memon, 2012).

Project control in the construction industry aims to ensure projects are completed on schedule, within budget, and achieve other project objectives. Successful projects meet technical objectives, adhere to timelines, and stay within budgetary constraints. Effective project management tools and procedures are crucial for achieving project success. Time and cost performance are vital concerns in project management and are widely recognized as essential metrics for project success. Poor performance in these areas can lead to significant time and cost overruns, which is a global issue (Memon, 2012).

Cost overrun refers to the difference between a project's actual cost and its predefined limit. It occurs when a project's cost exceeds the set cost limitations. The cost limit represents the maximum investment the client is willing to make in the completed project, while the cost target refers to the recommended expenditure for each project element. Uncontrolled construction costs create financial pressure, escalate project expenses, impact investment decision-making, and waste national resources, potentially leading to corruption or illicit activities (Memon, 2012).

Multiple studies have brought attention to the persistent problem of poor time and cost performance in construction projects on a global scale. Among these studies, one particular research examining 8,000 projects revealed that only 16% of them managed to meet the widely recognized performance criteria of timely completion, staying within budget, and achieving high-quality standards. Furthermore, a comprehensive international study focusing on cost overrun issues in transportation infrastructure projects encompassed 258 projects across 20 countries, revealing that 9 out of 10 projects experienced cost overruns. These findings emphasize the widespread prevalence of time and cost overruns in construction projects worldwide.

The Malaysian building industry is not exempt from these challenges. An investigation into delay practices in the Malaysian construction sector found that a significant 87% of respondents reported experiencing project delays, with time overruns ranging from 10% to 40% of the contract duration. Similarly, a separate

study conducted on large MARA projects concluded that these construction endeavors faced a considerable overrun of 23.74% of the contract duration. Reports indicate that cost overruns are also prevalent in Malaysian building projects, underscoring the severity of the issues faced by the industry in the country (Memon, 2012).

A pioneering study examining the causes of delays in building projects shed light on 17 factors commonly attributed to project delays in the United States. These factors encompassed a wide range of aspects, including weather conditions, availability of labor, subcontractors, design revisions, shop drawings, foundation conditions, material shortages, manufactured products, sample approvals, jurisdictional conflicts, equipment failures, contracts, construction errors, inspections, financing, permits, and building codes. Moreover, construction delays could also be triggered by labor-management relations, strikes, inadequate organization, scheduling and coordination challenges, declining craftsmanship quality, productivity issues, skill deficiencies in artisans, inadequate training quality, delivery delays, and high financing costs. Another study focusing on delays in public projects in Turkey identified material shortages, difficulties in securing funds from agencies, contractor issues, and the organizational characteristics of contracting companies and public agencies as the primary reasons behind project delays (Toor, 2010).

To identify the factors contributing to construction delays, research studies have primarily relied on questionnaires, while interviews have been less commonly utilized. The findings from these studies not only enable comparisons across different geographical regions but also underscore the importance of collaborative approaches, sustained involvement throughout project development, and increased utilization of value engineering to address issues leading to construction delays. Moreover, these studies emphasize the significance of thorough planning, realistic scheduling, and continuous monitoring as essential measures to mitigate construction delays. They highlight the need to consider factors such as skill levels, resource availability, and the potential for unforeseen events, work efficiency, as well as potential errors and misunderstandings that may arise at various project stages. Incorporating these considerations into construction planning, scheduling, and project management is crucial. Early forecasting and comprehensive problem diagnostics can help minimize construction delays, ensuring timely project

completion within budgetary constraints and meeting the desired quality standards (Toor, 2010).

2.1.1.2 Cost problems

Cost is an essential consideration throughout the project management life cycle and is often considered a key determinant of project success. Cost performance is recognized as a vital aspect of effective project management and is widely acknowledged in both literature and industry. The Earned Value Analysis (EVA) method is commonly employed to evaluate the cost performance of diverse projects. Cost control, estimation, and budgeting are three interrelated activities within the realm of cost management that interact with other aspects of construction projects (Ali, 2010).

Cost overrun refers to the disparity between the actual cost of a project and its predetermined limit. It transpires when the project's cost objective exceeds the defined budgetary constraints. The cost limit represents the maximum expenditure that the client is willing to allocate for the completion of the construction project, while the cost target indicates the recommended expenditure for each project element. Uncontrolled escalation of construction costs places additional financial strain drives up overall project expenses, impacts investment decision-making, and can result in the wastage of national resources, potentially creating an environment conducive to corruption or illicit activities (Memon, 2012).

Cost management in the construction sector is often less effective compared to time management. Project cost management encompasses various categories such as project resource planning, cost budgeting, cost control, and cost estimation. Key elements of effective cost control include managing cash flow and implementing project accounting practices. It is crucial to establish accurate estimates for the projected final cost and also consider future cost forecasts for aspects like scope, time, and quality. By incorporating these measures, the construction industry can enhance its ability to manage costs effectively (Ali, 2010).

Cost overruns are a significant challenge frequently encountered in construction projects. It is not uncommon for the estimated budget to exceed the actual costs, leading to budgetary discrepancies and ultimately surpassing the allocated budget. Such uncontrolled construction costs impose additional financial strain, inflate

overall construction expenses, impact investment decision-making, and potentially result in the misuse of national resources, potentially leading to corruption or criminal activities. Therefore, it is crucial to identify the underlying factors contributing to cost overruns in order to effectively minimize and mitigate these challenges (Ali, 2010).

The trade-off between time and cost is a crucial consideration in project management, especially in the context of project completion. Project scheduling literature extensively discusses the trade-off between project duration and total cost, as both are essential objectives in construction project management. When the project duration is shortened, it is widely recognized that it will require more labor, more efficient equipment, stricter procurement and construction management, and consequently, the cost will increase. Time-cost optimization is a methodology that identifies feasible construction activities for acceleration and determines the potential time and cost savings. However, due to the inherent trade-off relationship between project time and cost, it can be challenging to predict whether the overall cost, including direct and indirect expenses, will increase or decrease as a result of schedule compression. Moreover, since there are numerous combinations of activity durations and costs associated with a project, the difficulty lies in identifying the most optimal set of combinations. The goal of time-cost optimization is to determine the most favorable combinations (Abbasnia, 2008).

Additionally, it was noted that cost performance analysis utilizes four metrics to assess project cost performance. These metrics are employed to evaluate whether the project is progressing within the estimated cost or if it is exceeding the actual cost. The four cost-related measures utilized are TBC (total budgeted cost), CBC (cumulative budgeted cost), CAC (cumulative actual cost), and CEV (cumulative earned value) (Ali, 2010).

Cost estimating is a common practice conducted prior to the initiation of a project, aimed at ensuring effective cost control throughout its duration. The complexity of a project determines whether it necessitates the involvement of multiple individuals and multiple cost estimating iterations over its lifecycle. Project cost management can range from being straightforward to highly intricate. In project management, it is essential to consider the requirements and expectations of project stakeholders and incorporate them into the project cost planning process (Ali, 2010).

Further research is warranted on construction costs, as it was found that conducting more comprehensive studies on building expenses is essential. Cost studies in construction involve applying economic methodologies and expertise to construction projects. These studies aim to optimize resource utilization and enhance the efficiency of construction activity expansion (Ali, 2010).

Cost overruns are typical in the construction business, affecting most projects. Cost overrun happens when the project's final cost or spending exceeds the original predicted cost. It was stated that cost overruns are a significant issue in the building business. Both emerging and wealthy countries may be affected by this issue. This is a severe problem; further research is needed to solve it (Ali, 2010).

An erroneous calculation of the initial project cost is the primary factor leading to budget overruns. This is often a result of challenges in accurately estimating project expenses and the need for additional project information during the early stages (Ali, 2010).

Project cost inflation is a key driver of cost escalation. Within a country or across different countries, there can be regional variations in material, equipment, and labor costs, and subcontractors may have different agreements with suppliers regarding inflation protection. Moreover, as inflation leads to higher interest rates, project costs are likely to increase as well (Ali, 2010).

Poor planning and managerial experience limitations drove failures to employ technology. As a result, product production methods get slower, and the project takes longer to finish (Ali, 2010).

In most situations, price fluctuations generate cost overruns since it is challenging to forecast cost-effectively because it is objective. For example, this occurs because of significant price inflation in emerging nations or supplier speculation (Ali, 2010).

Inadequate site supervision and project management support are significant factors contributing to cost overruns in construction projects. Insufficient site management highlights the shortcomings and lack of competence on the part of contractors. Enhancing site management requires the presence of skilled and experienced personnel to ensure effective project oversight (Ali, 2010).

Most of the contractors needed more experience, particularly in financial management. In addition, the cost allocation of projects needs to be adequately planned. As a result, the budgeted expenses may be exceeded (Ali, 2010).

Some parties have contemplated minimizing the price of their project to obtain project clearance. Unfortunately, the scenario developed on several projects was terrible (Ali, 2010).

Noted that timetable delays may arise because of payment delays caused by complicated financial processes in customer companies. Delays in payment would generate financial issues for contractors, delaying the timeline for completing the tasks on site. In addition, interest might be assessed on late payments, causing project cost overruns (Ali, 2010).

One of the client's needs for the building project is an estimate of its cost. Therefore, proper cost management is critical because it reflects the overall trend toward increased cost-effectiveness and guarantees that building expenses are considered not just in terms of initial costs but also life-cycle costs or total cost assessment (Ali, 2010).

The initial cost estimates should strive for maximum accuracy. Precise cost estimation allows clients to evaluate and allocate the necessary funds for timely project execution (Ali, 2010).

2.2 Expert system

Expert systems (ES) are a specialized field within applied artificial intelligence (AI) that originated in the mid-1960s. The fundamental concept of ES is to transfer expertise or a vast repository of task-specific knowledge from humans to machines. This knowledge is then stored in the computer system, allowing users to seek guidance and assistance whenever needed. The computer system can analyze information, draw conclusions, and generate recommendations, much like a human consultant. Additionally, it can provide explanations behind its recommendations if necessary. ES offers a robust and flexible approach to addressing a wide range of complex problems that may be challenging for traditional methods. Consequently, the use of ES is expanding across various domains, playing a crucial role in decision-

making and problem-solving processes in both social and technical contexts (Liao, 2005).

Knowledge-based expert systems (KBES) are interactive computer programs that leverage expert knowledge, experience, rules of thumb, intuition, and other expertise to provide intelligent advice for a wide range of tasks. These systems are purpose-built to tackle complex real-world problems that necessitate expert interpretation. They achieve this by employing a computer model that emulates the reasoning process of a human expert, delivering comparable outcomes to those of a human expert when confronted with similar problems. KBES enable effective problem-solving and decision-making by harnessing the power of expert knowledge and providing valuable insights in various domains (Liao, 2005) (Arditi, 1989).

The primary attributes of an expert system can be described as follows: (Arditi, 1989):

- Expert systems are knowledge-intensive, which means that subject matter experts' expertise is integrated into the system. To comprehend the findings, you'll also need an experienced user. All expert systems must comply with this criteria.
- Developing an expert system requires the formulation of a set of rules that govern the logic of the specific domain the system is designed for. These rules, commonly constructed using if-then statements and heuristics, are typically based on expert knowledge.
- The inference engine, a component of the program that analyzes data, reinforces the rules of a knowledge base.
- Expert systems feature a user interface that is both intelligent and user-friendly, facilitating highly interactive experiences.
- Expert systems emulate the decision-making and reasoning abilities of human experts to a certain degree. They have the capability to provide guidance and respond to queries, while also being able to justify their decisions.
- Expert systems are capable of incremental development, which means they can learn from instances (Arditi, 1989).

2.2.1 Expert system compounds

A rule-based expert system (ES) is a data structure that incorporates knowledge gathered from a human expert and represents that information in the form of rules, such as IF-THEN statements. These rules then perform data operations to generate appropriate conclusions. These inferences essentially function as computer programs that enable reasoning based on the information in a rule or knowledge base, leading to conclusions (Liao, 2005).

LISP and PROLOG are widely used programming languages in the field of artificial intelligence for developing expert systems. These languages offer interactivity and facilitate easy modification and correction of code. Alternatively, an expert system shell can be employed to build an expert system. The construction industry has witnessed the development of various expert system shells, and a comprehensive evaluation of these shells has been conducted by Loughborough University of Technology (Arditi, 1989).

Furthermore, to be effective in construction claim management, an expert system should efficiently gather relevant facts, seamlessly integrate with the project monitoring system, offer a user-friendly natural language interface, require minimal human involvement to operate the inference engine, provide clear explanations of its decisions and the steps taken to reach them and be capable of learning from experience. The following phase is to create a theoretical framework in which the essential components of the expert system and their interrelationships are explicitly described. The 'knowledge base' is a crucial component of an expert system. A dispute resolution system needs judging expertise; heuristic rules are required to correlate evidence to reach a decision. As a result, a knowledge engineer must gather information from professional mediators, attorneys, and construction managers, collect and analyze case studies, and consult published literature to design acceptable if-then rules. The expert system incorporates a crucial component called the "short-term memory," which stores the most recent analytical data and aids in determining the responsibility for delays and/or expenses between the owner and/or contractor. The data management unit, which also includes the short-term memory, manages user interface activities. The "inference engine" controls the execution of the system by modifying the rules in the "knowledge base," the information in the short-term memory, and the decisions made by the "claim identification module." It consists of

various submodules, each performing a specific function during operation. For example, the "change monitor" detects changes in the short-term memory and notifies the "pattern matcher." The "pattern matcher" compares the most recent data in the short-term memory with the if-then rules obtained from the knowledge base. The "consistency enforcer" ensures a consistent representation of the results by comparing them with previous cases. The "network analyzer" and "delay forecaster" utilize forensic scheduling methods through commercially available project management software to examine time-related conflicts. The knowledge base is continuously updated and evaluated by the "knowledge modifier." In this scenario, the inference engine employs forward chaining to recognize and execute active rules based on available facts.

The knowledge manager comprises two modules: the knowledge base, which consists of a set of if-then rules, and the knowledge acquisition, which incorporates newly acquired knowledge into the knowledge base. The knowledge acquisition module learns from the interactions between the human expert and the program. Finally, the output generator presents the results and provides an explanation of how they were obtained. The justifier outlines the procedural rules and generates a descriptive statement that outlines the penalties each party will face if the resolution is not adhered to. A claim analysis expert system operates methodically and sequentially, similar to a mediator. It gathers project-related information and thoroughly examines the project, displaying any necessary documents and facts. The system produces a report that includes the project completion date, the amount owed to the contractor, and the contractor's obligation (Arditi, 1989).

2.2.2 Expert system in construction projects

The functionalities of an expert system can differ depending on the industry it serves. For construction applications, the most important characteristic of an expert system is its capacity to manage the inherent uncertainties related to construction tasks. Construction projects often involve modifying contract terms, and each site presents distinct conditions. Therefore, the expert system must manage uncertainty when responding to user queries and establishing links between different components of the knowledge base (Arditi, 1989).

The expert system employed in construction applications can handle large quantities of data and update it frequently, particularly for variables such as equipment rental rates that may change frequently. This is the second key feature of such a system.

Lastly, the system must integrate with other programs, such as scheduling analysis software and economic analysis packages, for efficient data exchange and informed decision-making (Arditi, 1989).

Some newly developed expert systems concentrate on specific aspects of construction management". PLATFORM III, for example, makes project feasibility choices in the face of uncertainty. MASON creates masonry construction time estimates. TIME forecasts construction time and expense at the initial design phase. PLATFORM employs network-based project management system features as real-time control tools. PROPICK simulates an owner's decision-making process while determining which contract type to utilize. Under the varying site circumstances provision, DSCAS determines eligibility. SAFEQUAL and HOW SAFE let users conduct reliable and consistent contractor safety evaluations. CPO-ES streamlines the planning process for construction project management firms (Arditi, 1989).

Emphasizing the importance of resolving disputes through peaceful means before resorting to legal or international arbitration processes, it is crucial for project stakeholders to proactively address the root causes of conflicts and prevent them from arising at the initial stages of the project. Swift and efficient handling of claims, coupled with timely decision-making, can provide a robust solution to the issue of construction conflicts. To achieve this, the development of an expert system that effectively reduces the likelihood of construction disputes is paramount. The suggested approach produces a credible prediction of the likely sources of disagreements for every future project. Looked at how arguments happen and then took proactive actions to avoid them. Effective communication, the pursuit of objective solutions, and the avoidance of confrontation may all help. Once the project is underway, good communication, seeking objective answers, and avoiding confrontation may all assist (Elziny, 2015).

A financially based resolution, whether through discussion or mediation, is increasingly widely adopted in the construction sector. Using a mediator or another ADR mechanism to resolve conflicts can save time and money. If all of this fails,

there are always arbitration and lawsuit options. While they are sometimes necessary, they are better avoided if feasible (Elziny, 2015).



3. FIELD STUDY

The fieldwork is divided into two phases. The first is by preparing a questionnaire to identify the challenges in construction projects. The questionnaire was distributed to managers, university professors, and other parts of the projects in the following ministries. The Ministry of Higher Education and Scientific Research, as well as the entities responsible for Construction and Housing, collaborate in gathering and examining the outcomes to identify effective resolutions for these difficulties.

3.1 Design of Questionnaire

Following an extensive examination of existing research, comprehensive data essential for accomplishing the study's objectives was collected, structured, examined, and assessed. Subsequently, a questionnaire was created through multiple iterations of meetings, discussions, and revisions. The questionnaire was structured into five sections, as illustrated in Figure 3.1, and was formulated in the Arabic language (see Appendix 3-A). Furthermore, the questionnaire included a cover page containing the research title, objectives, and a concise explanation. It also contained a statement emphasizing the confidentiality of respondents' responses to foster a higher participation rate. Each section of the questionnaire will be comprehensively explained.

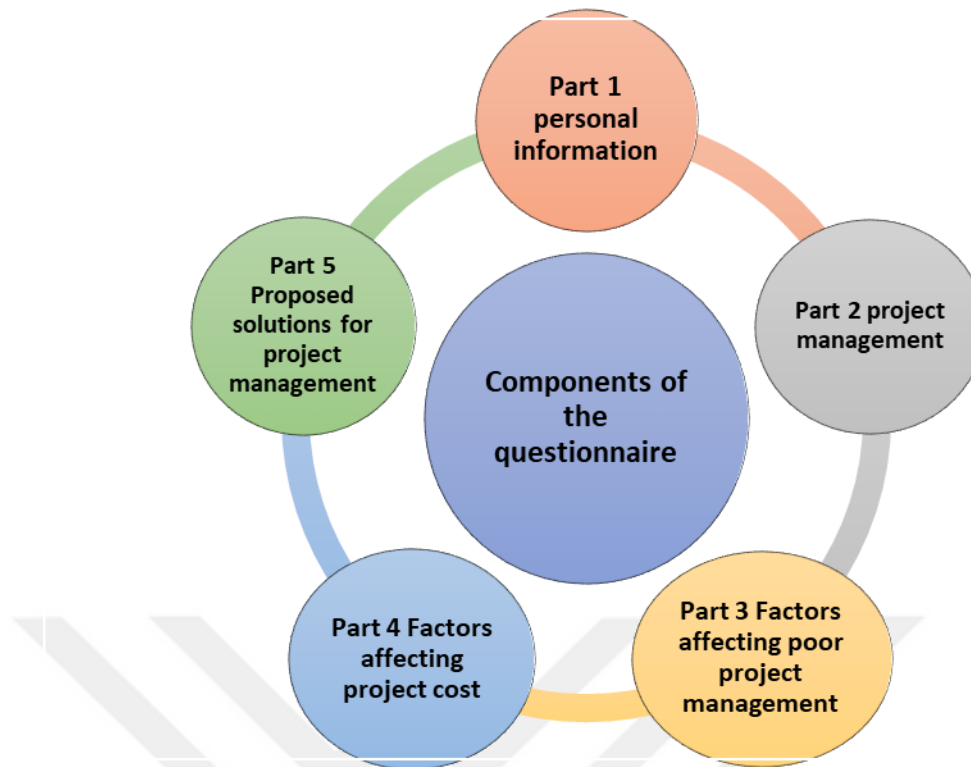


Figure 3.1: Components of the Questionnaire (Researcher)

3.1.1 Part I (personal information)

This section contains general information about the responder. (Work sector, age, gender). In addition to educational qualifications, expertise, professional position, and work experience.

3.1.2 Part II (project management)

This part was used to describe knowledge in project management, the level of knowledge of the standard specifications for projects, the percentage within the work sector, and to assess the perception of construction projects.

3.1.3 Part III: Factors affecting poor project management

This part was used to describe the factors that lead to the mismanagement of projects, such as (the cost of construction, the cost of design, the optimal use of land, the cost of energy consumption, maintaining high and stable levels of economic growth, the cost of transferring services, the efficiency of the energy system, Etc.).

3.1.4 Part IV: Factors affecting project cost

This part described the factors that affect the project's cost by asking a question (What is your assessment of the main reason that led to a significant increase in the cost of construction projects?), and then presenting several factors that affect the cost of the project. This section consists of (23) closed-ended questions designed using a five-point Likert scale. The scale ranges from (1: Very weak) to (5: Very strong) to assess the strength of each response. Each responder was asked to assign a level of importance to each topic based on his beliefs about the construction industry.

3.1.5 Part V: Proposed solutions for project management

This section encompasses the suggested remedies for project management. It comprises five closed-ended questions formulated using a Likert scale of five points. The scale ranges from 1 (Very weak) to 5 (Very strong).

3.2 Pilot Study

According to (N. Abbas 2017), a pilot study refers to an initial and concise research or trial conducted on respondents who share similar characteristics with the original sample. The main objective of conducting a pilot study, as highlighted by (N. Abbas 2017), is to identify challenges and questions that may be more perplexing compared to others. This enables the researcher to take corrective actions to enhance the research process.

The researcher determined a sample size of 64, which was gathered and prepared to process the statistical tests.

3.3 Statistics Reliability

One of the main conditions for obtaining acceptable findings in any research is using precision measuring devices. (N. Abbas 2017) mentioned that one of the researcher's primary objectives is to construct his research instrument and make it distinct in three ways (be meaningful, accurate, and efficient).

As a result, the data obtained from the pilot study underwent reliability tests. Figure 3.2 provides an overview of the specific tests conducted as part of the pilot study.

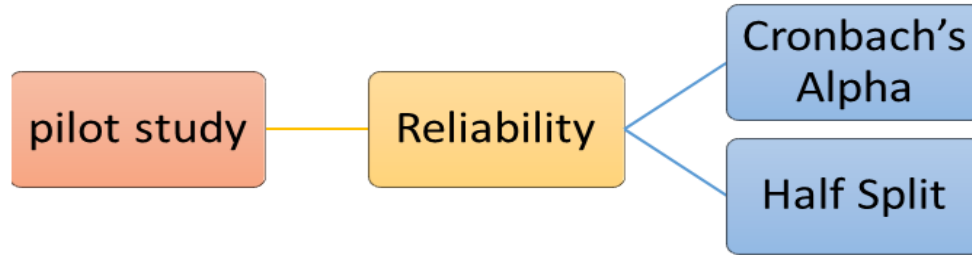


Figure 3.2: Pilot Study Statistical Tests (Researcher)

3.4 Questionnaire distribution

3.4.1 Sample size response rate

By utilizing the electronic questionnaire, the researcher successfully gathered (64) samples, indicating a satisfactory response rate.

3.4.2 Questionnaire distribution administration

Online questionnaires are a viable approach for distributing surveys. Electronic questionnaires, typically hosted on a website, provide a swift means of presenting information to respondents and swiftly collecting their responses. Compared to traditional methods, where participants are required to make an effort to return the completed questionnaire to the owner, online questionnaires facilitate a faster and more convenient process of data collection (N. Abbas 2017).

Table 3.1: Value of Alpha Cronbach for Questionnaire's Parts

Items	Value of α	Degree of Reliability
project management	0.940	Excellent
Factors affecting poor project management	0.916	Excellent
Factors affecting project cost	0.824	Good
Proposed solutions for project management	0.934	Excellent

3.4.3 Sample description

The following diagrams depict the attributes and traits of the survey's target sample: Figure 3.3 provides the gender percentage of respondents, where the percentage of males is equal to 51%, and the percentage of females is equal to 49%.

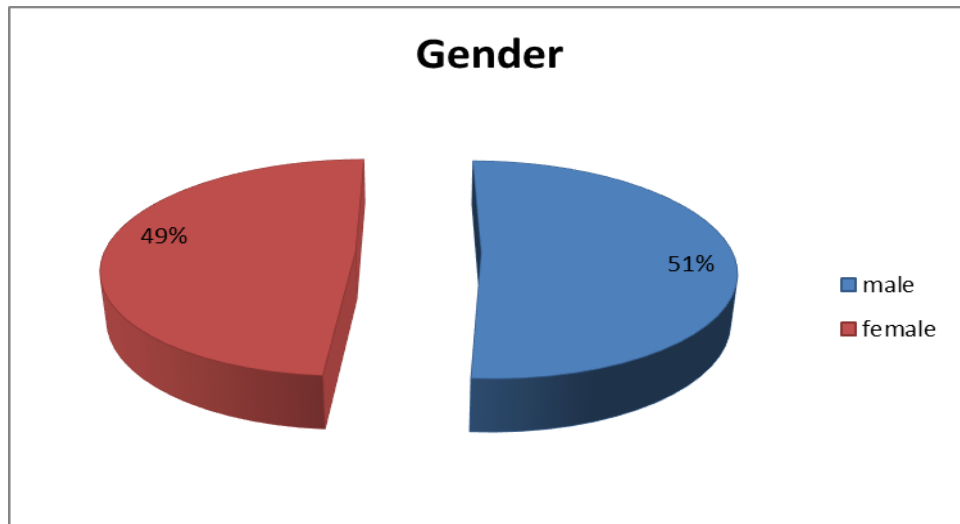


Figure 3.3: Male and Female Percentages of Respondents

Figure 3.4 presents the distribution of respondent ages, indicating that 21% fall within the 18-25 age range, 28% within the 26-30 age range, 7% within the 31-35 age range, 21% within the 36-40 age range, and 23% are above 41 years of age.

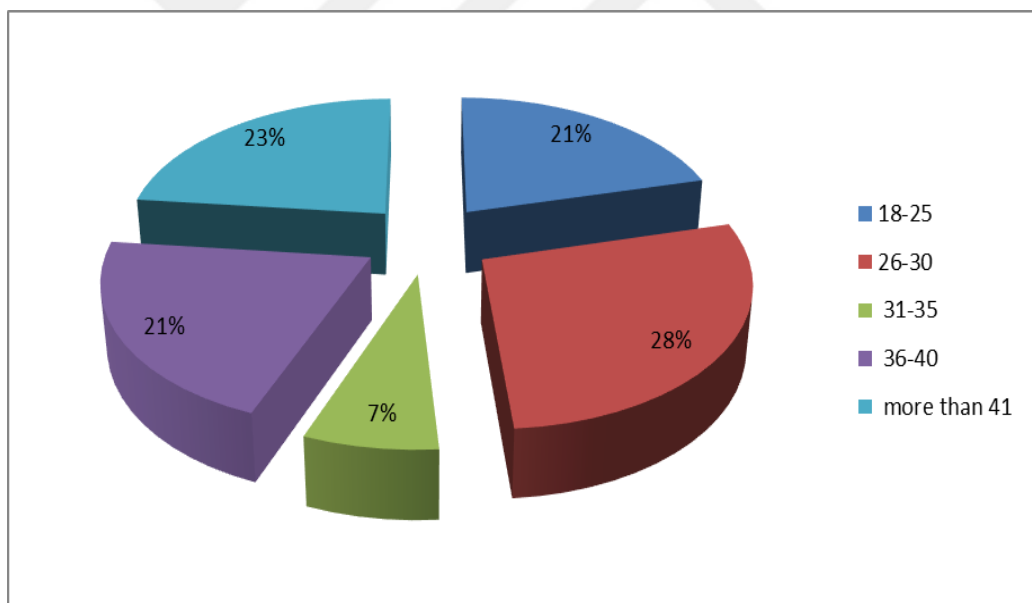


Figure 3.4: Illustrates the Percentage Distribution of Respondents by Age

Figure 3.5 shows the academic qualification of respondents where the percentage of diploma (5%), Bachelor (33%), Master (29%), Ph.D. (26%), and other (7%).

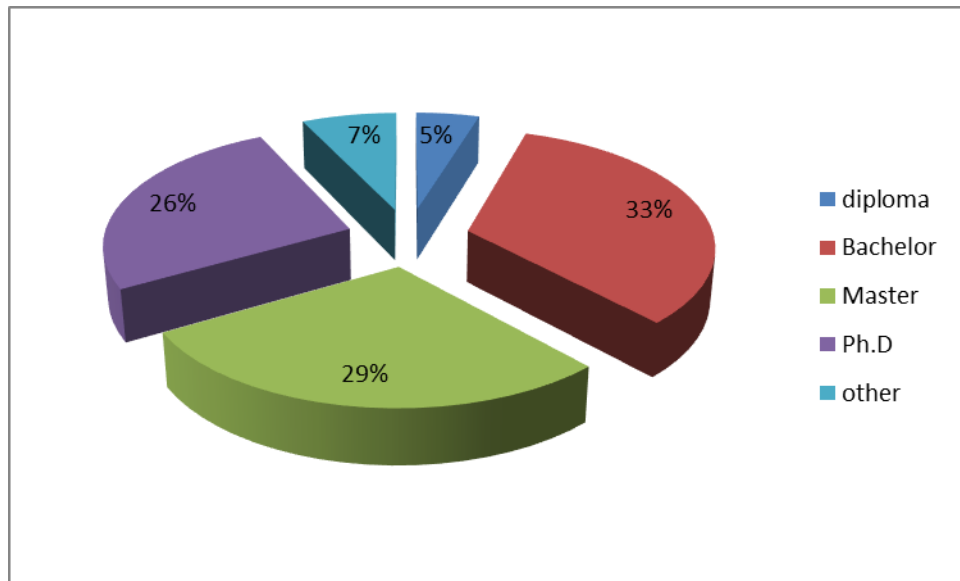


Figure 3.5: Displays the Educational Level of the Respondents

Figure 3.6 explains the group to which the respondents belong where the percentage of Technical (2%), Engineer (50%), Senior Engineer (14%), Assistant Station Chief (17%), and Station manager (17%).

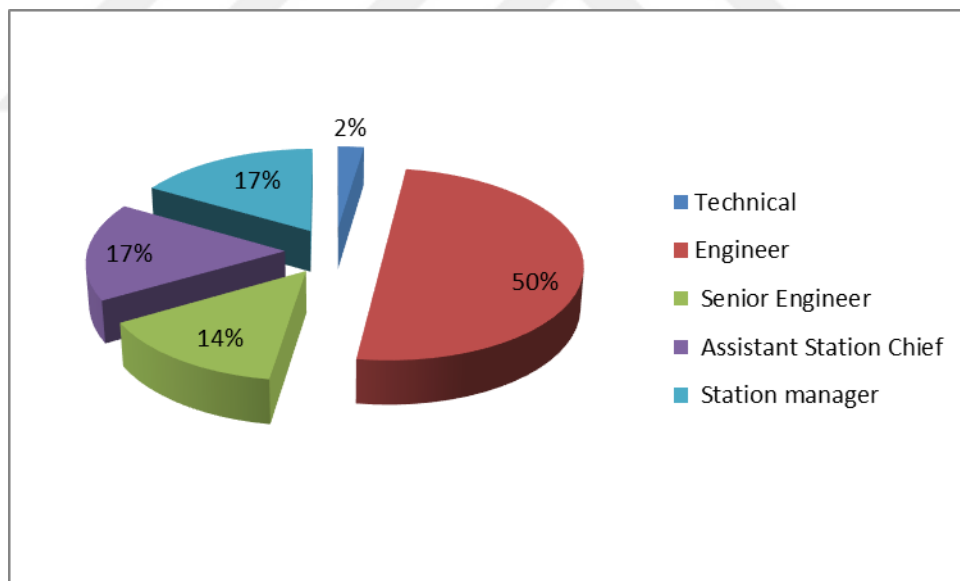


Figure 3.6: The Group to which the Respondents Belong

Figure 3.6 gives an idea about the practical experience of respondents. The percentages as follow: less than 3 years (36%), 3-7 years (20%), 7-10 years (25%), and more than 10 years (19%).

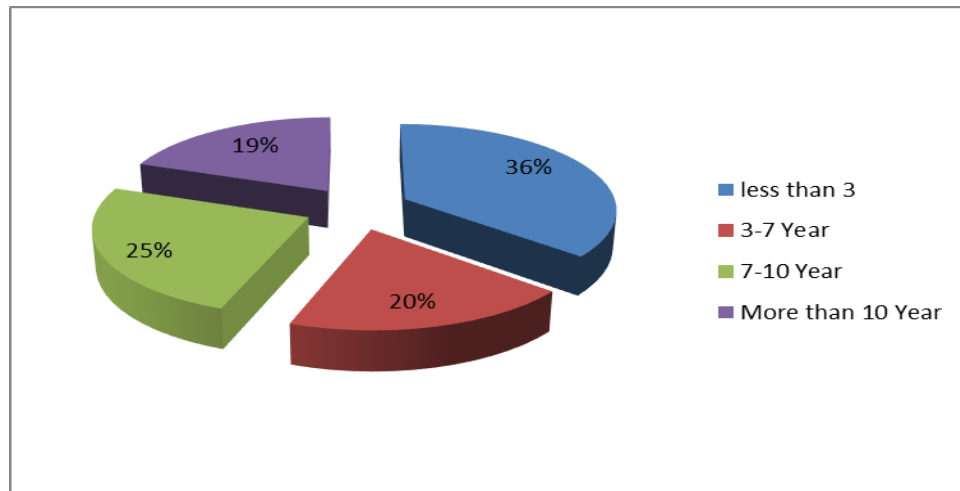


Figure 3.7: The Practical Experience of Respondents

3.5 Results of Questionnaire

The questionnaire underwent quantitative analysis utilizing the Statistical Package for Social Sciences (SPSS). The collected data was analyzed to evaluate the extent of factors contributing to contractor defaults in building projects.

3.5.1 Project management

This study included a series of inquiries concerning the participants' employment within either the government agency or private sector. Additionally, there were questions aimed at gaining insights into the participants' perceptions of construction projects. The evaluation of participants' perceptions of construction projects, as depicted in Figure 3-7, yielded the following outcomes: Existence of outgrown buildings on government lands (3.38), You do not meet the mandatory requirements (3.27), Energy consumption considerations do not exist (3.09), There are no standards for proper construction (2.91), Difficulties in balancing environmental, social and economic issues (2.84), Life cycle assessment of building materials is important (2.91).

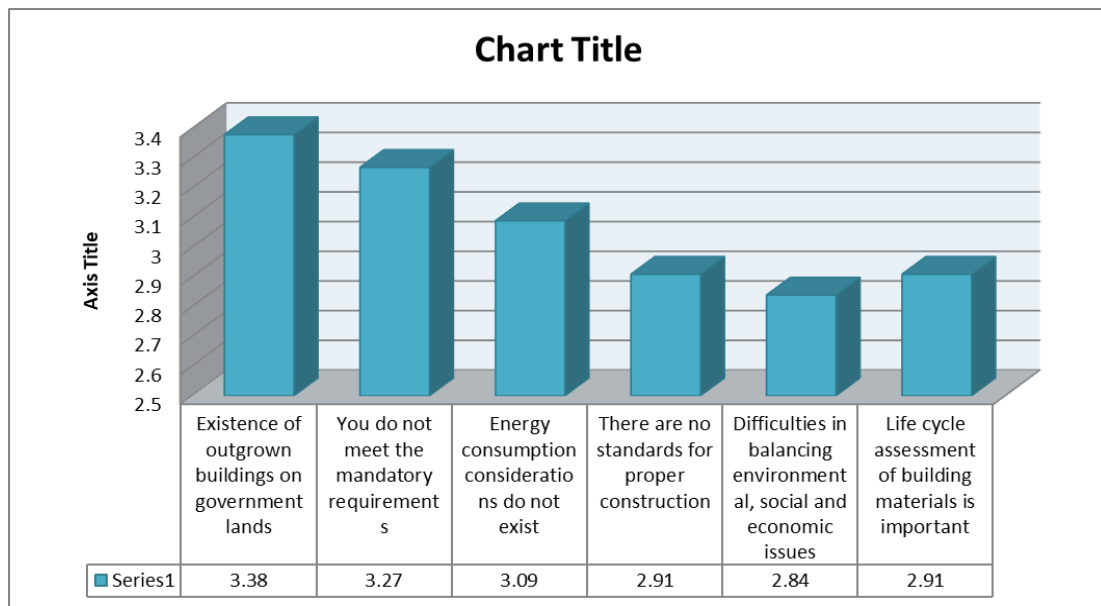


Figure 3.8: Evaluation of Participants' Perception of Construction Projects

- **Descriptive Statistics**

Table 3.2: Participants' Perception of Construction Projects

	N	Mean	Std. Deviation
How would you rate your knowledge of the term project management?	64	2.75	1.613
What is your level of familiarity with standard project specifications?	64	3.70	0.971
What percentage within the sector of work have you carried out	64	3.44	1.233
Existence of outgrown buildings on government lands	64	3.38	1.464
You do not meet the mandatory requirements	64	3.27	0.980
Energy consumption considerations do not exist	64	3.09	1.080
There are no standards for proper construction	64	2.91	1.205
Difficulties in balancing environmental, social, and economic issues	64	2.84	1.130
Life cycle assessment of building materials is important	64	2.91	1.137

The highest cause is the Existence of outgrown buildings on government lands as it is one of the most common reasons in Iraq, which leads to the failure of projects or delays in the implementation of the planned schedule, which leads to a high cost of construction projects, and this may cause a halt or inability to implement projects.

While (You do not meet the mandatory requirements, Energy consumption considerations do not exist) contain almost the same result. Where failure to meet the

mandatory requirements, such as non-compliance with the quality required by the customer, the schedule, or the main objective of the project, may lead to mismanagement and poor quality, as for Energy consumption considerations do not exist. Because the energy problems in Iraq such as the lack of continuous provision of electricity, this leads to non-compliance and meeting the requirements at the required time.

The causes (There are no standards for proper construction, Life cycle assessment of building materials is important) also have the same result. In contrast, these two factors are linked to each other, as the lack of a suitable standard for construction, for example, defining fixed specifications before starting the implementation of the project through which we select the appropriate building materials for the implementation of the project with the required specifications and quality, which may lead to poor management of the project.

3.5.2 Factors that lead to poor project management

This study explored various factors contributing to inadequate project management through a series of questions. This section comprises closed-ended questions formulated using a five-point Likert scale. The scale ranges from 1 (Very weak) to 5 (Very strong).

Evaluating the participants' perception of the factors that lead to poor project management in Figures (3-8) and (3-9). The results are as follows: Design cost (2.88), Optimal use of the land (2.88), cost of energy consumption (3.09), Maintaining high and stable levels of economic growth (3.44), Transportation cost to services (3.33), Efficiency of the energy system in housing (3.05), construction life (3.06), The cost of housing in the long term (3.02), The cost of equipment and machinery used in the stages (manufacturing, implementation, and use) (3.42), The possibility of providing water and other facilities at a lower cost (3.23).

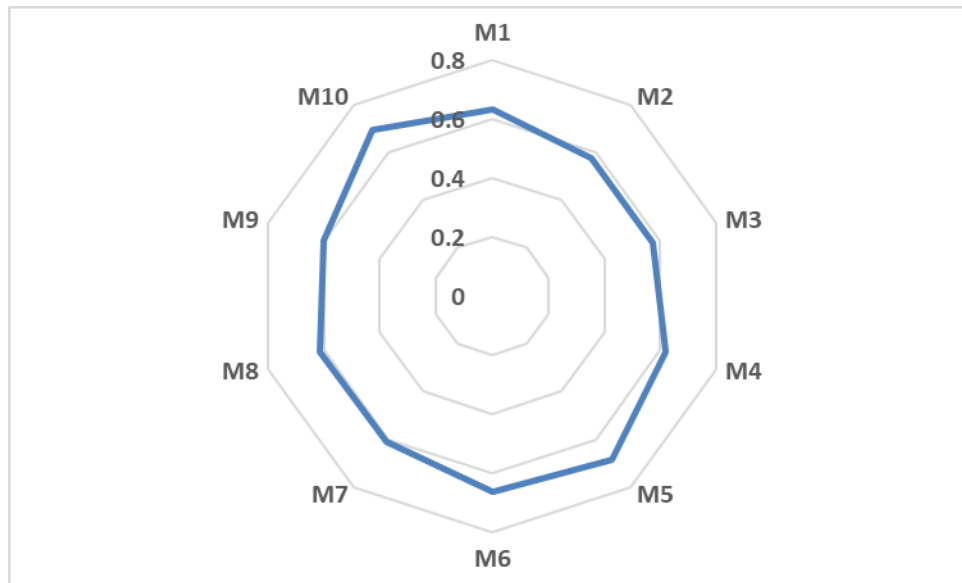


Figure 3.9: Factors That Lead To Poor Project Management

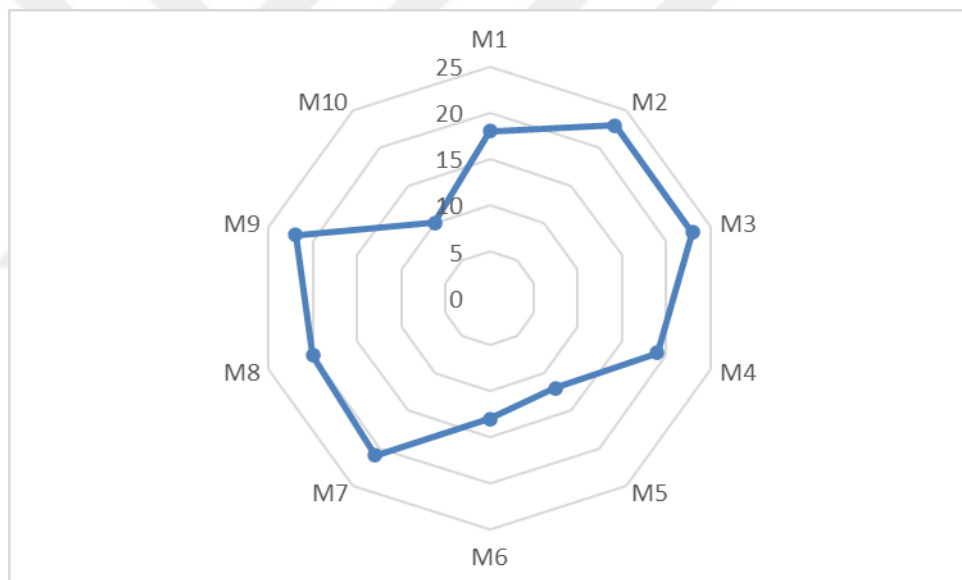


Figure 3.10: Factors That Lead To Poor Project Management

As shown in figure (3,9) , the relative importance index of the factors which that M1 have the highest importance index and also as shown in figure (3.10) that show the rank of the factors which also show that M1 have the highest rank.

- **Descriptive Statistics**

Table 3.3: The Results of the Influence of Factors on Project Management

		N	Mean	Std. Deviation		
Construction cost		64	3.16	1.348		
Design cost	M1	64	2.88	1.397	0.63125	18
Optimal use of the land	M2	64	2.88	1.279	0.575	23
cost of energy consumption	M3	64	3.09	0.955	0.575	23
Maintaining high and stable levels of economic growth	M4	64	3.44	1.006	0.61875	19
Transportation cost to services	M5	64	3.33	1.113	0.6875	12
Efficiency of the energy system in housing	M6	64	3.05	0.983	0.665625	13
construction life	M7	64	3.06	0.753	0.609375	21
The cost of housing in the long term	M8	64	3.02	0.951	0.6125	20
The cost of equipment and machinery used in the stages (manufacturing, implementation, and use)	M9	64	3.42	1.006	0.603125	22
The possibility of providing water and other facilities at a lower cost	M10	64	3.23	1.065	0.69375	10

The highest cause is (Maintaining high and stable levels of economic growth, and the cost of equipment and machinery used in the stages (manufacturing, implementation, and use)) Investment in construction projects plays an important role in economic growth. It is an important part of the transition to a more sustainable and resilient world. However, to achieve these results, the public and private sectors and the communities they serve need to rethink how construction projects are delivered.

When it comes to the expenses associated with equipment and machinery throughout the stages of manufacturing, implementation, and utilization, effective management of personnel, materials, and equipment is essential in construction project management. Emphasizing labor productivity is of utmost importance for those tasked with cost management in facility development. Material management, including procurement, inventory control, shop fabrication, and field maintenance, requires specific attention to achieve cost savings. In recent years, significant advancements in building technologies have been made possible through innovative

procedures and the adoption of new technologies. Construction organizations that fail to comprehend the impact of these advancements and adapt to changing environments find themselves being phased out of the industry.

Regarding the factors of energy consumption cost and the efficiency of the energy system in housing, the results indicate a similar pattern. Both aspects emphasize the significance of energy management within project management operations. Project managers should recognize the importance of energy management and incorporate it as an integral component of their overall responsibilities. High energy costs reduce energy consumption in construction projects and buildings. Therefore, understanding energy use in construction projects and managing it efficiently and effectively is critical in mitigating risks in reducing project operating costs. One way to reduce energy costs is to become more energy efficient by optimizing existing resources and planning appropriate investments in new technologies.

As for construction life, A construction project goes through five primary stages: planning, implementation, performance, monitoring, and closing. Planning, for example, is the key to managing a single site or a multi-site project. A lack of knowledge of any of the five phases can lead to poor implementation and management of construction projects. At this stage of the construction life cycle, the scope of work and the project's road plan must be decided, including determining the resources required and the strategy for their creation.

The cost of design and optimal use of the land was the minor factors affecting the mismanagement of projects, as they are interconnected with each other because the optimal design cost for project management includes the optimal use of land, for example, as a society and the economy have evolved fast, distinct land demands have emerged at various phases of development. Furthermore, land-use practices and the magnitude of consequences have shifted. The population density in metropolitan areas is growing, as is the need for land, resulting in the continual occupancy of cultivated land. Construction and land development can add to landfill garbage; not all materials are ecologically benign. A heat island effect can arise in densely populated and built-up metropolitan or urban regions.

3.5.3 Factors affecting project cost

In this study, multiple inquiries were made regarding the factors influencing project costs. This section comprises closed-ended questions designed on a Likert scale of five points. The scale ranges from 1 (Very weak) to 5 (Very strong).

Where the evaluation of the participants on the main reason that led to a significant increase in the cost of construction projects came in Figures (3-9) and (3-10). The results were as follows: Absence of state law (3.81), The type of labor required, the type & number of supervision and labor required (3.19), Not developing any plans by the competent authorities (3.69), project stakeholders (3.44), The financial ability of the client (3.5), Clarity of work and specifications (3.59), The original price estimated by the customer (3.56), Cost reasons (3.77), Lack of controls for urban planning (4.27),. The ability to do work (3.56), Availability of qualified human resources (3.66), The level of reliability of subcontractors (3.69), Familiarity with the condition of the site (3.61), The study examined various factors related to project costs. These factors include the availability of equipment and materials, availability of the necessary equipment, the specific type of equipment required (rated at 3.66), the quality and availability of labor (rated at 3.5), insufficient data provided for the project (rated at 3.19), unclear and incomplete graphics and specifications (rated at 3.61), uncooperative managers and slow decision-making (rated at 3.87), strained relationships between consultants and contractors (rated at 3.63), as well as inadequate identification and representation of needs and requirements during the development process (rated at 3.81), Misunderstanding & misinterpretation of the client's needs & requirements (3.81), Lack of documentation regarding changes, & feedback (3.69), It is difficult to define requirements (3.30).

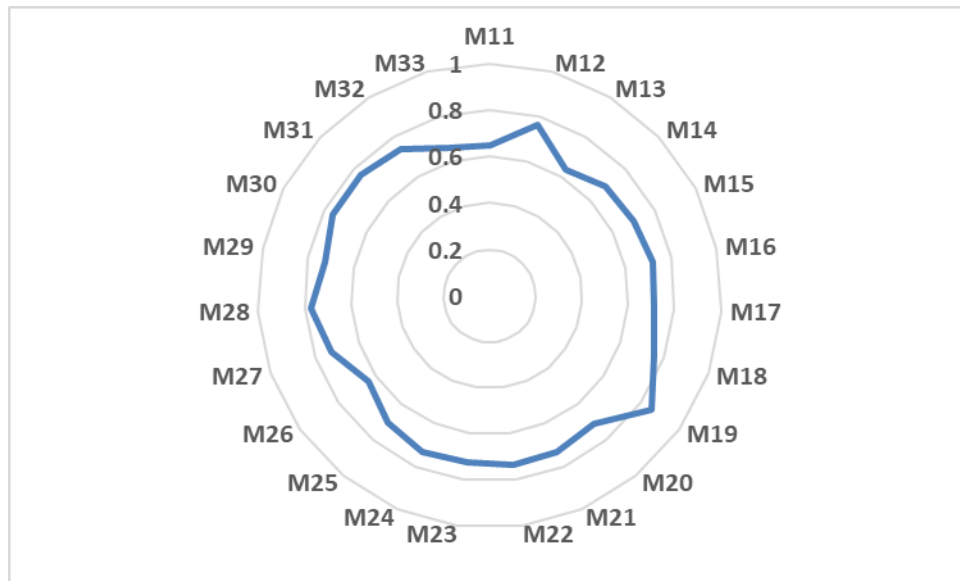


Figure 3.11: Factors Affecting Project Cost

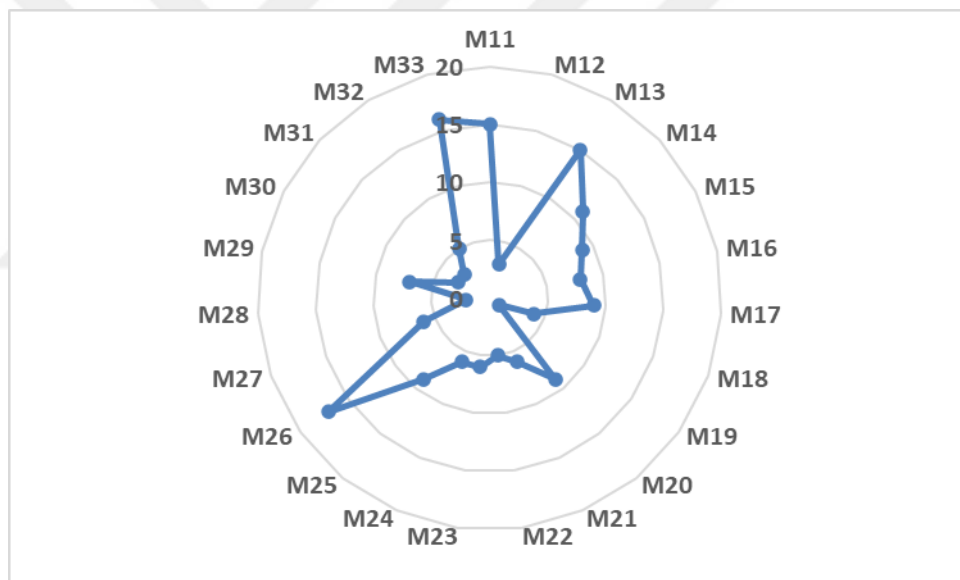


Figure 3.12: Factors Affecting Project Cost

- **Descriptive Statistics**

Table 3.4: The results Factors Affecting Project Cost

		N	Mean	Std. Deviation		
Absence of state law	M11	64	3.81	1.562	0.646875	15
The type of labor required, the type & number of supervision and labor required	M12	64	3.19	1.082	0.7625	3
Not developing any plans by the competent authorities	M13	64	3.69	1.246	0.6375	15

Table 3.4: (Cont.) The results Factors Affecting Project Cost

		N	Mean	Std. Deviation		
Project stakeholders	M14	64	3.44	1.283	0.6875	11
The financial ability of the client	M15	64	3.5	1.234	0.7	9
Clarity of work and specifications	M16	64	3.59	0.729	0.71875	8
The original price estimated by the customer	M17	64	3.56	0.941	0.7125	9
Cost reasons	M18	64	3.77	0.831	0.753125	4
Lack of controls for urban planning	M19	64	4.27	0.877	0.853125	1
The ability to do work	M20	64	3.56	1.067	0.7125	9
Availability of qualified human resources	M21	64	3.66	0.912	0.73125	6
The level of reliability of subcontractors	M22	64	3.69	0.710	0.7375	5
Familiarity with the condition of the site	M23	64	3.61	0.953	0.721875	6
Availability of equipment & materials, Availability of required equipment, Type of equipment required	M24	64	3.66	0.996	0.73125	6
Quality of labor available. Labor availability	M25	64	3.5	1.008	0.7	9
Lack of data provided for in the project	M26	64	3.19	1.296	0.6375	17
Vague and incomplete graphics and specifications	M27	64	3.61	1.136	0.721875	6
Uncooperative managers and slow decision making	M28	64	3.87	1	0.775	2
Litigation relationship between the consultant and the contractor	M29	64	3.63	0.864	0.725	7
Identification & inadequate representation of needs & requirements during the development process	M30	64	3.81	0.889	0.7625	3
Misunderstanding and misinterpretation of the client's needs and requirements	M31	64	3.81	0.957	0.7625	3
Lack of documentation regarding changes, and feedback	M32	64	3.69	0.852	0.7375	5
It is difficult to define requirements	M33	64	3.3	1.064	0.659375	16

The highest cause is (Lack of controls for urban planning), Given that urban planning is a systematic and sequential study to reach the goal or goals of the existing one at the lowest cost and highest return, for example, to obtain the lands needed for reconstruction, whether, through expropriation or preferential purchase, this requires

the provision of sources. There are sufficient financial resources to purchase land, but the difficulty is the high price of land in developed regions, which results in additional expenditures.

In the context of uncooperative managers and slow decision-making, the decision-making process in project management significantly impacts how individuals and teams perceive their roles and can either foster smooth workflow and effective collaboration or lead to various challenges and interpersonal misunderstandings. Decision-making holds critical importance in project management for several reasons:

Minimizing Project Delays: Effective decision-making reduces the likelihood of project delays or, in extreme cases, incomplete deliverables. By considering potential obstacles and ensuring ongoing project progress, it helps avoid costly errors resulting from repeated failures. All these factors have an impact on the project's overall cost.

Meanwhile, in relation to the absence of state law, identification and inadequate representation of needs and requirements during the development process, and misunderstandings and misinterpretations of the client's needs and requirements, these factors yield similar outcomes.

(Absence of state law), because some laws and regulations impose direct or indirect costs on the project. The government procurement system, for example, recommends the lowest price offer, increasing the intensity of competition and making it difficult to win business for professional contractors, who incur costs to raise their work level to non-existent levels. However, the beginner contractor receives what the professional does not because of rules. Furthermore, one of the most significant reasons for our country's construction industry's weakness is the Lack of regulations and laws governing construction projects, defining responsibilities and relationships among the parties involved, and dealing with supervision, contracts, classification, qualification, and technical cadres.

As for (Identification and inadequate representation of needs and requirements during the development process, and misunderstanding and misinterpretation of the client's needs and requirements), as these two factors are linked to each other, There is no question that in the project work environment, a misunderstanding between the project manager and the client may occur, which means that it is possible to breach

mutual understanding with the loss of crucial requirements that would assist define the context in the project. Furthermore, this increases project expenses if there is a misunderstanding of the requirements, which may increase the project paragraphs.

As for (Cost reasons), most clients want to develop their structures at a reduced cost. This, however, may jeopardize the structure's quality. Insufficient funds can lead to a finance-driven project approach, where cost-effective solutions are prioritized over more sustainable alternatives.

Some clients have a predetermined budget, which compels contractors to keep expenses under strict control to guarantee the project is completed within the stated budget. However, designing on a tight budget limits the introduction of valuable features, which may result in high operating and maintenance expenses.

We have three factors that have the same value: (Not developing any plans by the competent authorities, The level of reliability of subcontractors, Lack of documentation regarding changes, and feedback).

As for (Not developing any plans by the competent authorities), A lack of proper planning exposes a project to unforeseen risks and challenges. Insufficient design and careless planning can result in cost overruns in construction projects, leading to wasted time as the team scrambles to address these issues. As time is a valuable resource, project funding ends up being utilized to resolve problems arising from inadequate planning. Consequently, the project is prone to failure. Such errors may require last-minute revisions, causing significant delays and incurring substantial costs, potentially amounting to thousands of dollars.

As for (The level of reliability of subcontractors), The subcontractor can contribute to various factors that lead to an increase in project costs. These factors include work delays, non-compliance with instructions from the main contractor, absence of subcontractors from the site, engaging another subcontractor without approval from the main contractor, inadequate equipment, subcontractor insolvency, poor adherence to health and safety standards by subcontractors, limited communication between subcontractors and the main contractor, failure to report problems to the main contractor in a timely manner, inadequate construction quality, involvement of subcontractors in multiple projects simultaneously, shortage of skilled labor, poor cash flow management, and neglect or mishandling of materials.

As for (Lack of documentation regarding changes, and feedback), Change orders are a common occurrence in the construction industry, but they can catch some organizations unprepared. When insufficient resources, including time, are allocated to accommodate these modifications, it often leads to cost overruns in building projects. The situation worsens when a construction company lacks appropriate software to efficiently communicate and distribute change orders to the relevant parties. In such cases, even minor alterations to the original order can have significant and far-reaching consequences, disrupting the project's financial balance.

Effective project planning methodologies and systems encompass the capability to model different types of scope modifications during the preconstruction phase. By adopting this proactive approach, businesses can mitigate the potential consequences of cost overruns and better manage project expenses.

While (Availability of qualified human resources, Availability of Equipment & materials, Availability of required Equipment, and Type of Equipment required) these two factors are linked. Regarding the availability of competent human resources, a lack of qualified personnel can present itself in various ways. For starters, having the incorrect employees around can lead to inefficiencies on the project site and subpar performance, leading to cost overruns. Construction firms are also increasingly impacted by labor shortages, which have made people in specific trades difficult (and hence expensive) to obtain.

As for (Availability of Equipment & materials, Availability of required Equipment, Type of Equipment required), In terms of production planning, equipment availability stands as a crucial factor. It plays a key role in determining capacities, delivery timelines, and anticipated breakdowns. For instance, the total cost of the equipment, including associated expenses such as freight, installation, taxes, as well as additional capitalizable costs like legal fees, financing charges, and other necessary expenditures, are outlined in the relevant Equipment Schedule for each lease. These considerations ensure a comprehensive assessment of the overall costs required for proper equipment utilization.

3.5.4 Proposed solutions for project management

This study encompassed multiple inquiries regarding the project management solutions suggested by the participants. This section comprises closed-ended

questions designed on a Likert scale with five response options, ranging from 1 (Very weak) to 5 (Very strong).

Where the results of the participants for the proposed solutions for project management were as follows: To what extent do you believe in activating a role that lies in solving a problem (2.56), Work on completing residential projects under implementation (3.94), Work to reduce the spatial disparity in the housing deficit between the regions of the province (3.69), Encouraging investors to participate in the implementation of new city projects (3.94), Cooperation between ministries and bodies responsible for land administration (3.95), Work on the establishment of housing in plots of land at prices (4).

- **Descriptive Statistics**

Table 3.5: The Results Proposed Solutions For Project Management

	N	Mean	Std. Deviation
To what extent do you believe in activating a role that lies in solving a problem	64	2.56	0.614
Work on completing residential projects under implementation	64	3.94	0.833
Work to reduce the spatial disparity in the housing deficit between the regions of the province	64	3.69	0.990
Encouraging investors to participate in the implementation of new city projects	64	3.94	1.153
Cooperation between ministries and bodies responsible for land administration	64	3.95	1.290
Work on the establishment of housing in plots of land at prices	64	4	1.234

Highest suggestion (Work on the establishment of housing in plots of land at prices), Land regulators have challenging problems in effectively governing residential development and housing markets. Excessive land limitations, in principle, limit the availability of buildable land, shifting buildings toward lower density and more prominent, more expensive dwellings. Conflicting interests between local autonomy and regional needs often arise, requiring policymakers to make careful compromises. When affluent individuals hold influence over the political processes governing municipal planning and zoning decisions, housing affordability may suffer as prices increase. Density restrictions and other limitations on the number and size of new housing units can hinder housing assistance programs targeted at low-income

families. The existing empirical literature on the impact of regulations on housing prices varies in terms of methodological rigor and strength of findings. However, several credible studies support theoretical expectations. When local regulators effectively restrict the availability of buildable land through zoning, growth management, or other regulations, both the land itself and the resulting properties can become more expensive.

While (Cooperation between ministries and bodies responsible for land administration), Land administration refers to the implementation and enforcement of regulations governing land tenure. It encompasses a wide range of systems and procedures, both formal and informal, aimed at managing land-related activities. These processes include the transfer of land rights through various means such as sales, leases, loans, gifts, and inheritance. Additionally, land administration involves resolving disputes concerning land ownership and usage. The functions of land administration can be categorized into four main areas: judicial, regulatory, fiscal, and information management. These activities are typically carried out by specialized agencies responsible for surveying and mapping, land registration, land valuation, and land revenue generation. The introductory remarks provided here offer an overview of the objectives and scope of this knowledge domain:

The purpose of these Guidelines is to outline the effective management of land and land-related information. They primarily target senior government officials and policymakers involved in land management. The objective is to emphasize the importance of establishing a robust and reliable land information system. Furthermore, the Guidelines highlight key considerations for designing laws, organizations, databases, and maps, as well as the financial strategies necessary for the implementation and long-term sustainability of an efficient land administration system (J.M.Quigley, L.A.Rosenthal 2005).

While (Work on completing residential projects under implementation, Encouraging investors to participate in the implementation of new city projects) contain the same result.

As for Work on completing residential projects under implementation, Projects under implementation are long-term projects that have not been completed during the financial period and are extended for more than a period until the occurrence of

revenue that requires the financial management to show its value in the projects under implementation account in the budget. As for Encouraging investors to participate in the implementation of new city projects, with global population increase predominantly occurring in cities over the next three decades, reaching the Sustainable Development Goals will rely heavily on meeting them in urban areas.

By building pipelines of bankable projects, preparing, and delivering financial packages and incentives, encouraging commercial links, and supporting sustainability norms, city governments and their investment promotion and economic development agencies may advertise and promote investment. City authorities should deliberate investment promotion in sustainable city development and provide appropriate institutional frameworks to attract and facilitate SDG-related initiatives. Partnerships are crucial for overcoming resource limits, acquiring expertise, overcoming barriers between municipal, regional, and national agencies, and establishing the dynamics frequently required to mobilize investment for Goal-related initiatives (UN 2019).

3.5.5 TURF heat parameters

TURF (Total- Unduplicated- Reach- and- Frequency) is a technology developed primarily in market research whose objective is to evaluate several combinations of multiple products to determine which combinations are most requested by the consumer (N. Abbas 2017). Figure 3.13 illustrates the idea of turf analysis.

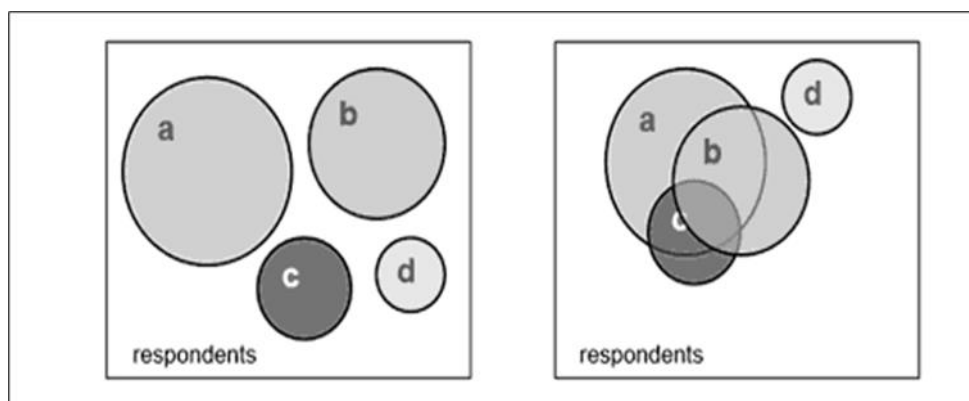


Figure 3.13: Illustrates the Idea of TURF Analysis

The researcher used the Turf technique for the purpose of analyzing multiple-choice software usage questions to evaluate the combinations of each option with the other options.

- **TURF Heat parameters**

	Number of Input Variables	Heat Size	Number to Advance	Final Run Size
Settings	34	15	2	6

Cycle: 0

Table 3.6: Heat: 3. Maximum Group Size: 2. Reach and Frequency

Variables	Statistics			
	Reach	Pct of Cases	Frequency	Pct of Responses
Life of the building , The cost of housing in the long term	8	12.5	8	100.0
The cost of housing in the long term	4	6.3	4	50.0

Assumes no variables are forced.

Cycle: 0

Table 3.7: Heat: Final. Maximum Group Size: 1. Reach and Frequency

Variables	Statistics			
	Reach	Pct of Cases	Frequency	Pct of Responses
Design cost	18	28.1	18	29.0
Optimal use of the land	16	25.0	16	25.8
Absence of state law.	12	18.8	12	19.4

Table 3.8: Heat: Final. Maximum Group Size: 2. Reach and Frequency

Variables	Statistics			
	Reach	Pct of Cases	Frequency	Pct of Responses
Design cost Optimal use of the land	25	39.1	34	54.8
Design cost, Efficiency of the energy system in housing	25	39.1	26	41.9
Optimal use of the land, Absence of state law.	24	37.5	28	45.2

Table 3.9: Best Reach and Frequency by Group Size

Variables	Statistics				
	Group Size	Reach	Pct of Cases	Frequency	Pct of Responses
ADDED: Design cost	1	18	28.1	18	29.0
ADDED: Optimal use of the land KEPT: Design cost	2	25	39.1	34	54.8

Assumes no variables are forced;

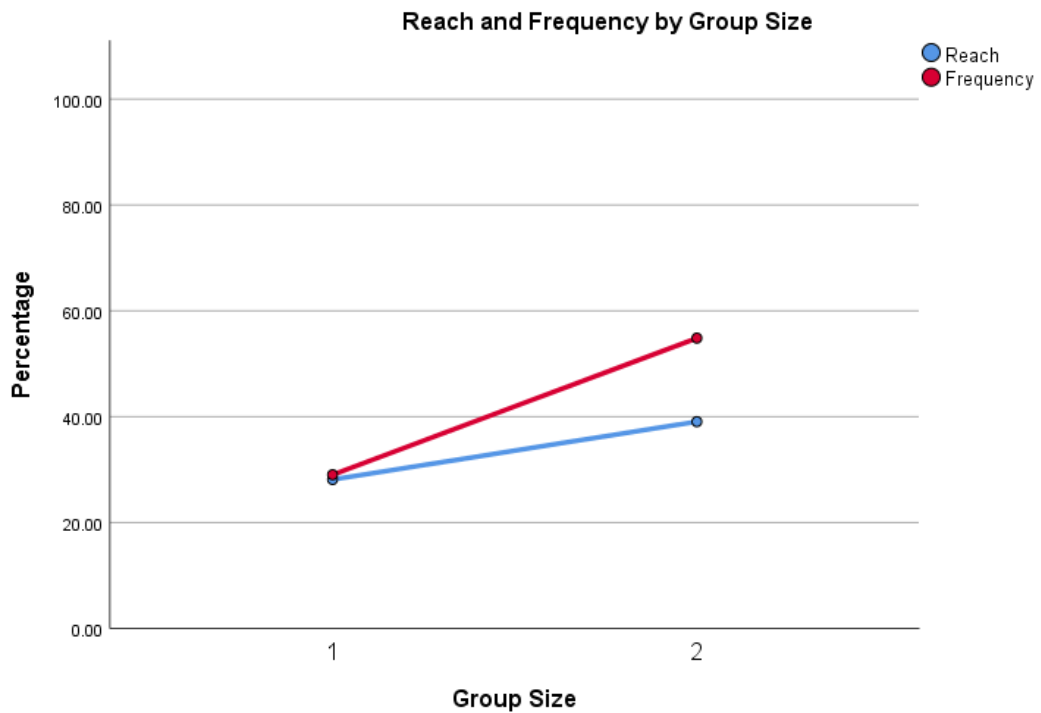


Figure 3.14: Reach and Frequency by Group Size

4. THE PROPOSED EXPERT SYSTEM

4.1 The Proposed Expert System

The proposed system comprises multiple stages, commencing from project definition and extending to problem-solving. The initial stage provides a comprehensive overview, including project details such as the project name, beneficiary, funding agency, and other relevant information. The flowchart of the proposed system is illustrated in Figure (4.1), visualizing the sequential process flow.

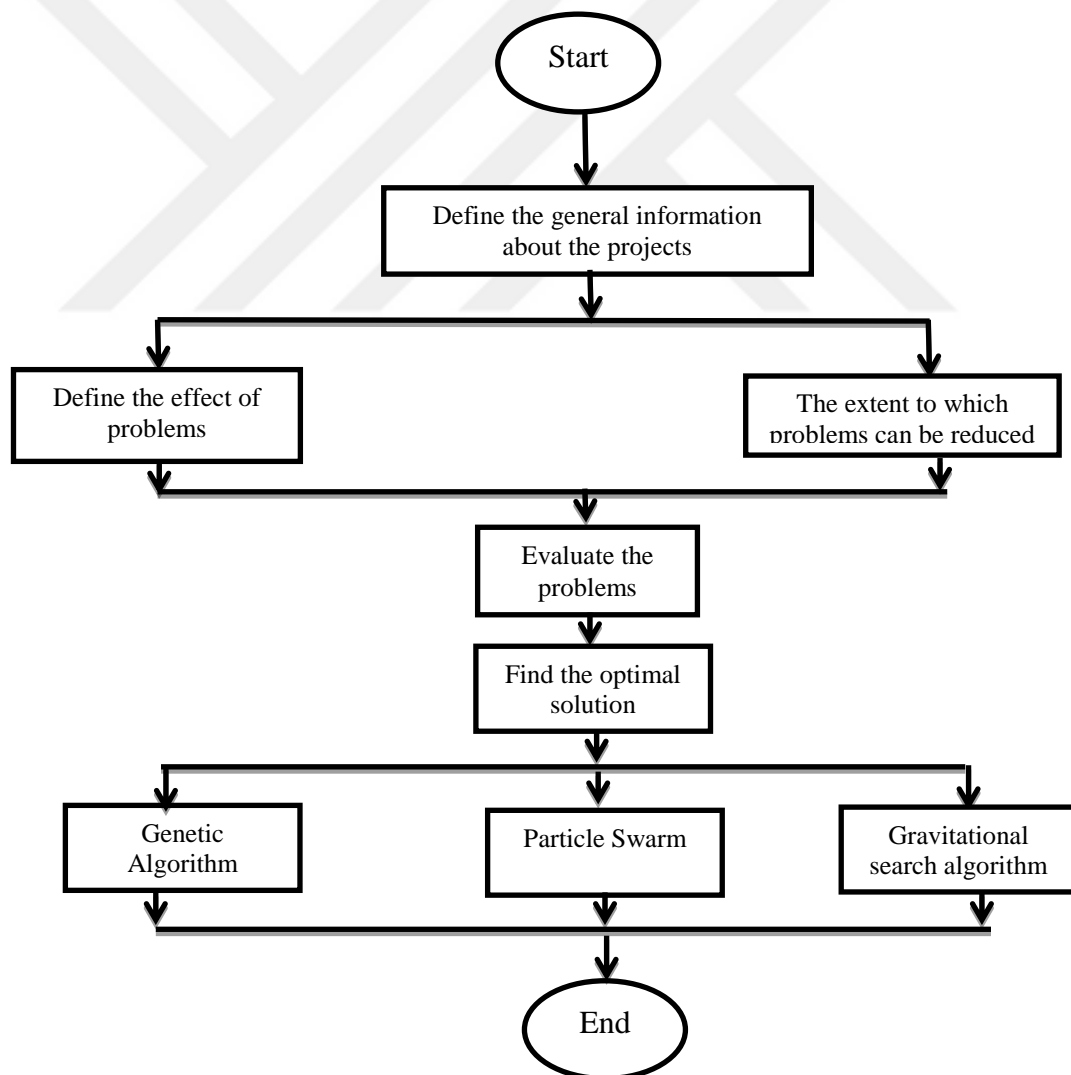


Figure 4.1: Proposed Expert System

First, the system consists of user interface for the user name and password that enter to the system as in figure (4.2):

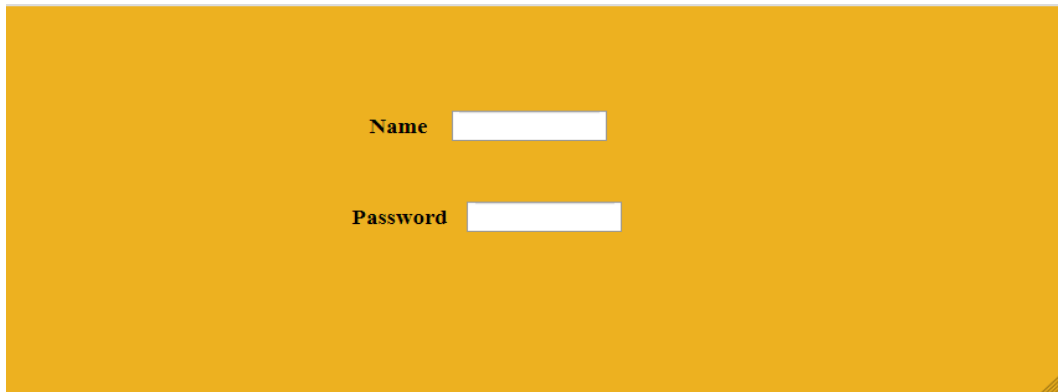


Figure 4.2: Welcoming User Interface

The system consists of several stages as follow

A. Stage one:

Presented in Figure (4.3), the system offers a comprehensive overview that serves as a general introduction.

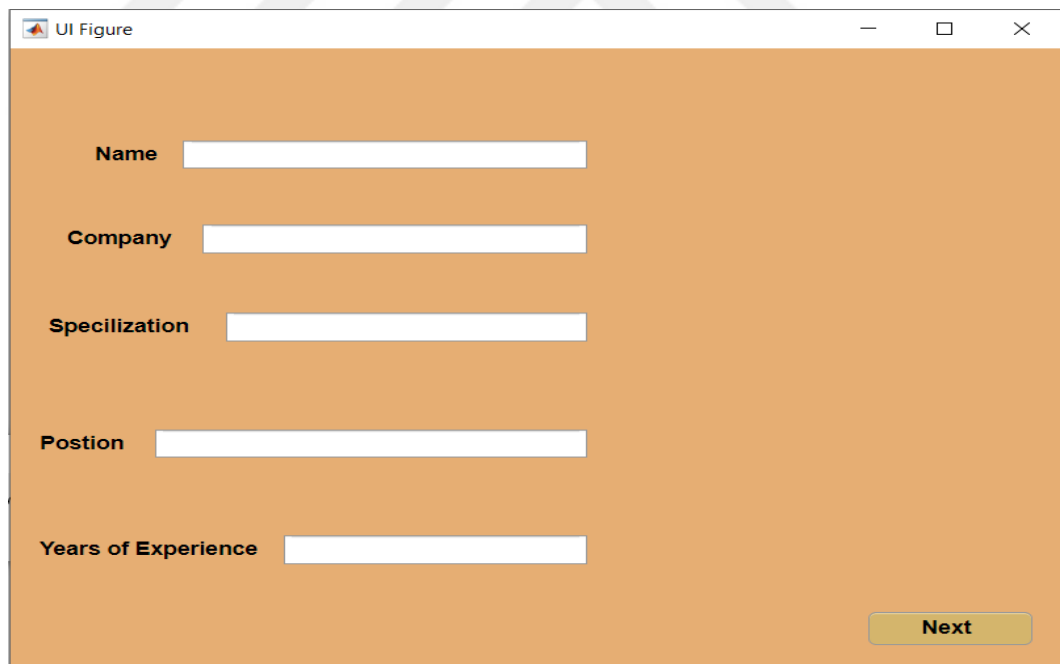


Figure 4.3: General System

B. Stage two:

In this stage enter the effect of recycled material

In this stage, the user accesses the system and initiates the problem, progressing to the next stage in the process. For a visual representation of the contract system, please refer to Figure (4.4).

Figure 4.4: Problems Evaluation

At this stage, the problems will be evaluated according to bound decided by the user.

C. Stage three:

In this stage, the extent to which problems can be reduced is shown in Figure (4.5).

Figure 4.5: Extent to Which Problems can be Reduced

D. Stage four:

In this stage, every identified problem undergoes evaluation and is accompanied by an optimal solution. Refer to Figure (4.6) for a depiction of the treatment stage.

Figure 4.6: Evaluation Stage

- E. Stage five: This stage includes selecting the optimal solution for each problem in the sustainability and traditional building with using of a genetic algorithm. (GA), particle swarm and gravitational search algorithm.

The model of the genetic algorithm as follow:

Genetic Algorithm (GA) is a dynamic technology that aims to achieve global optimization by simulating the natural evolutionary process described by Darwin's principle of "survival of the fittest." The algorithm initially works on a population of individuals, which undergoes natural selection, resulting in the evolution of the fittest individuals with a higher chance of survival. The algorithm's fundamental principles are selection and crossover, as illustrated in the diagram, and mutation Figure (4.7).

The genetic algorithm employs an iterative process to assess the fitness or quality of each individual within a population, utilizing a fitness function. Individuals with higher fitness scores have a greater chance of being selected for reproduction, passing on their genetic information to the next generation. As successive generations progress, the population evolves as individuals with superior fitness are favored and their characteristics are combined through genetic operators.

Genetic algorithms are known for their ability to explore large solution spaces and find near-optimal or satisfactory solutions in complex problems. They have been

applied to a wide range of domains, including optimization, machine learning, scheduling, robotics, and many others.

It's worth noting that the term "GA Algorithm" is not a commonly used or widely recognized term, but it is often used as a shorthand for genetic algorithms.

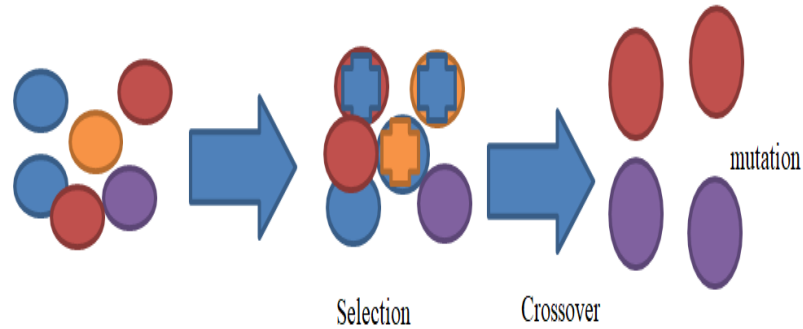


Figure 4.7: The Step for Implantation of the Algorithm is Explained in Table (4-1)

Table 4.1: The Algorithm of Applying Genetic

Algorithm: Find the Solutions Using GA
Input: Data set of the entire projects
Output: find the optimal solution
Begin
Step (1): Input the GA parameters
Step (2): Define the file name
Step (3): Define the range of the data
Step (4): Define the mathematical model:
Effectiveness = Weight of the solution * x_{ij}
$C_m = C_{ij} * \max(x_{ij})$
$S_{mij}(i, j) = s_j(j) - s_{ij}(j) * x_{ij}(i, j);$
$CM > 0.2 B$
$S_m > 0.1 T$
T time of the problem
C_{ij} cost of the solution
B the total cost for the project
$s_j(j)$ time delay caused by current problem
$s_{ij}(j)$ duration of implementation for each solution.
Step (5): Define upper and lower limit for X_{ij} from 0-1

Table 4.1: (Cont.) The Algorithm of Applying Genetic

```
1
Step (6): SelectParents Fcn (Cost, SelectionNum,
SelMethod) PopSize = size (Cost,1);
switch SelMethod case 1
    R = randperm (PopSize); ParIndexes =
R(1:SelectionNum); Step (7):cross over
witch Cross Method case 1
    Beta1 = rand; Beta2 = rand;

    Off1 = Beta1*Par1 + (1-Beta1)*Par2; Off2 =
Beta2*Par1 + (1-Beta2)*Par2;
case 2
    Step (7): Calculate the objective function Max  $y = q * x_{ij}$ 
    Step (8): Update the population by repeating the step
5 to 7
    Step (8): Optimize the projects optimize the projects
by finding the best solution for each problem
according to step 5
END
```

The GSA optimization algorithm is utilized to solve various problems and is based on Newton's laws, specifically the principles of mass and velocity.

The acronym GSA represents the Gravitational Search Algorithm, which is a metaheuristic optimization algorithm inspired by the principles of gravity and the movement of celestial bodies.

In GSA, a set of agents, each representing a potential solution to the problem, move around in a search space according to the law of gravity and the mass of other agents. The agents are attracted to each other by a gravitational force that is proportional to their masses and inversely proportional to the distance between them. The algorithm seeks to minimize the objective function by iteratively updating the position and mass of each agent based on its fitness and the fitness of its neighbors.

The GSA algorithm is versatile and applicable to various optimization problems, encompassing both continuous and discrete optimization scenarios, as well as single-objective and multi-objective optimization settings, and constrained and unconstrained optimization. It has been successfully used in many fields, such as engineering, finance, and data science, among others.

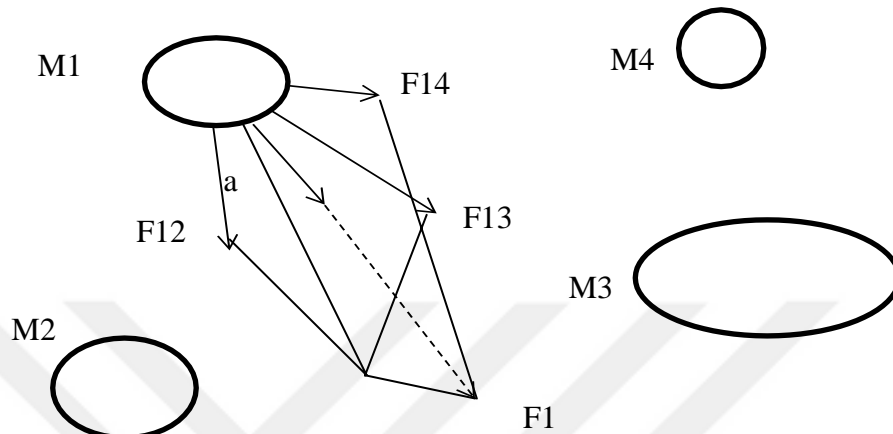


Figure 4.8: GSA Diagram

The forthcoming section will delve into the application of the case study.

4.2 Application of the Case Study

In order to determine the most suitable solutions for each case, a series of case studies were conducted. To assess their impact on project performance, the challenges encountered during the field survey were examined across various ministries. Figure (4.9) offers a visual summary of the application process.

After inputting each treatment, the genetic algorithm will determine the optimal solution for each problem by considering its individual impact, as illustrated in Table (4.2).

Table 4.2: Problems treatments with its Effects

Items	Responsive	Effectiveness
The type of labor required, the type & number of supervision & labor required Absence of state law	Cooperation	0.77
	Precise Implementation of Power and Subtle Application of Influence	0.84
	Mitigating External Factors	0.9

Table 4.2: (Cont.) Problems treatments with its Effects

Items	Responsive	Effectiveness
Absence of state law	Cooperation	0.77
	Disciplined Use of Force and Subtle Use of Influence	0.94
	Controlling for Outside Influences	0.8
Not developing any plans by the the competent authorities	Adjusting the current instructions.	0.77
	Modifying the existing SBD	0.84
	Cooperation	0.8
The financial ability of the client	Disciplined Use of Force and Subtle Use of Influence	
	Embrace Automated Reporting Systems	0.98
	Create a Flow of Communication	0.79

Figure 4.9: Problems Evaluation (Case study)

This part include entering the items that include the effect of problems on the project. The definition of each part as follow:

► Name
Name 1

→ This section focuses on the process of transitioning between various challenges encountered within the projects.

Name ▼

Recommendation

Name ▼

Recommendation

→ This section offers a summary of the information pertaining to the issues faced during the projects.

→ This section emphasizes the evaluation of issues within the projects.

→ This section highlights the process of reporting and transitioning the problems to the next stage.

► treat1
▼ treat2
cost of treat
time delay
time for treatment
project cost
project time

→ This section illustrates the process of transitioning between different treatment approaches within the projects.

Column 1	Column 2	Column 3	Column 4

→ This section provides information about the treatment approaches employed in the projects.

Problem n...	Problem A...	ci	sj
0.1			
0.1			

→ This section highlights the available options for treating the problems.

After inputting each treatment, the genetic algorithm will analyze the impact of each problem and identify the optimal solution, as outlined in Table (4-2). These problems, along with their respective treatments, were incorporated into the project to identify the optimal solution and assess its project weight.

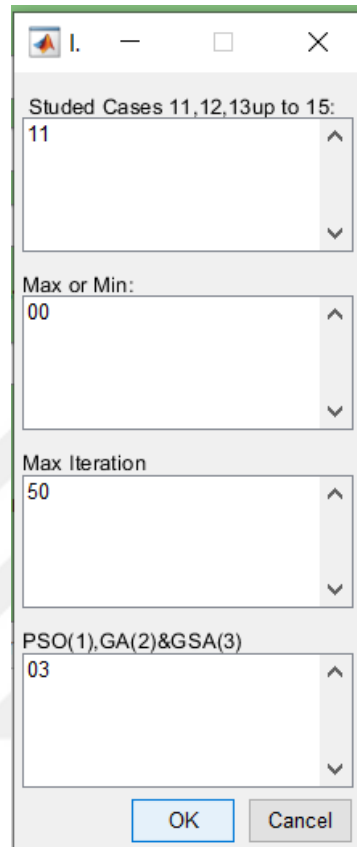


Figure 4.10: Problems Selection with Finding Optimal Solution

Once the problem has been selected and the maximum iteration has been determined, the algorithm will commence the search for the optimal solution to each problem. The weights assigned to the various components of the problem are determined based on expert opinion and fall within the range of 0 to 1.

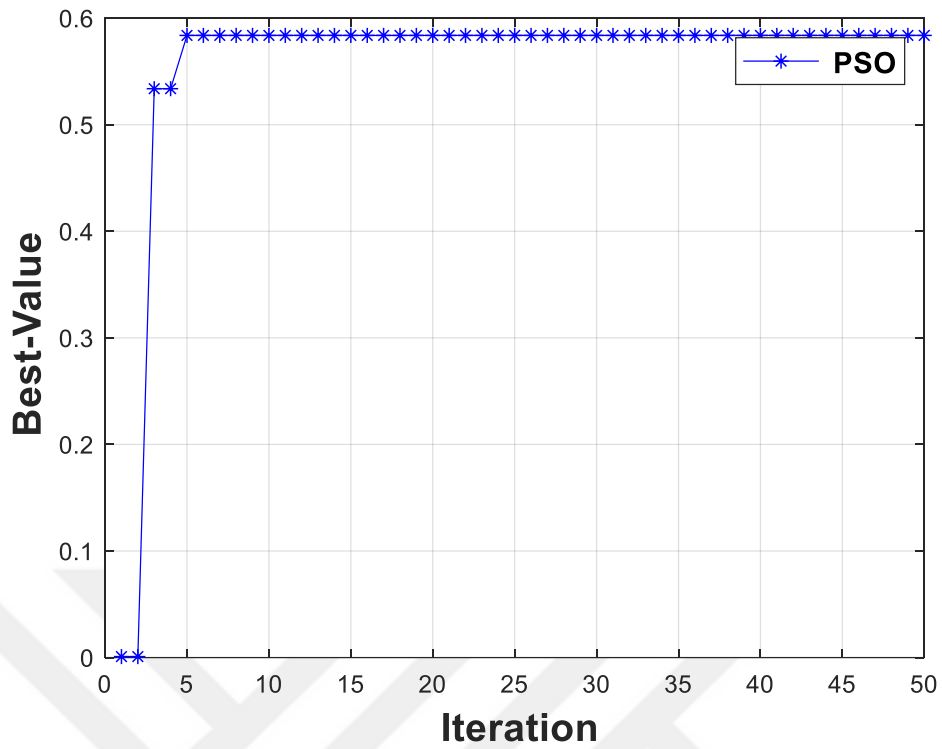


Figure 4.11: Project Number One with its Treatment Using PSO

Figure (4.11) demonstrates the treatment approach taken for the initial project, indicating that neglecting the materials led to a solution effectiveness of approximately 0.7.

Each project has three solutions, either ignoring the materials, reuse in other works or recycled for the roads projects.

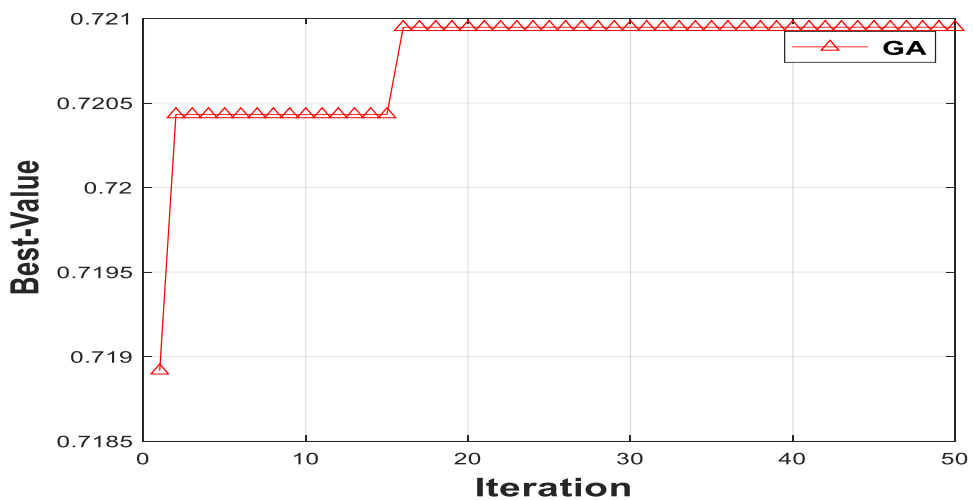


Figure 4.12: Project Number One with its Treatment Using GA

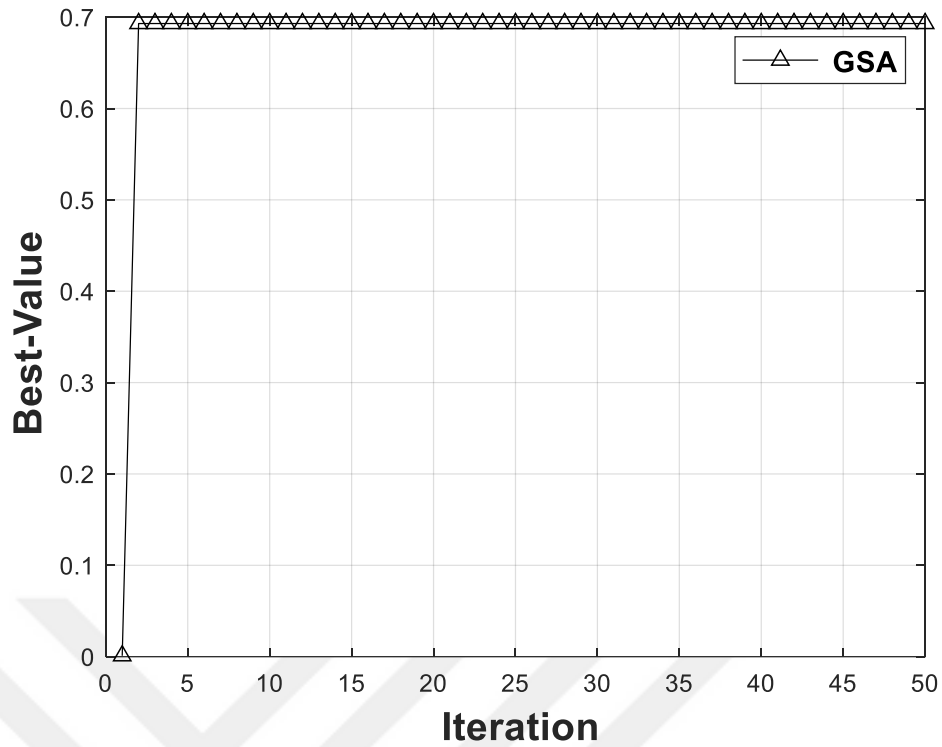


Figure 4.13: Project Number One with its Treatment Using GSA

Upon the selection, the process will proceed to the subsequent stages following the same procedure. The summary of the results can be observed in table (4-3), which provides the definition for each outcome as follows:

X_{ij} = define risk factor between 0-1

C_i = cost for each solution

S_i = delay cause by the problem

S_{ij} = time treatment provided by each solution

e = effectiveness of the solution

Table 4.3: Problems Treatments with its Effects Using PSO

Projects	xij	ci	si	sij	time	cost	e	Solution pso
1	0.99	0.000001	0.000337	0.00337	3056503150	337	0.7	Controlling for Outside Influences
2	0.99	589000000	13.2	60	1542486400	120	0.95	Disciplined Use of Force and Subtle Use of Influence
3	0.99	2750000000	80.52	366	4584262000	732	0.93	Modifying the existing SBD
4	0.99	1663200000	47.3	47.3	33386500000	430	0.85	Embrace Automated Reporting Systems

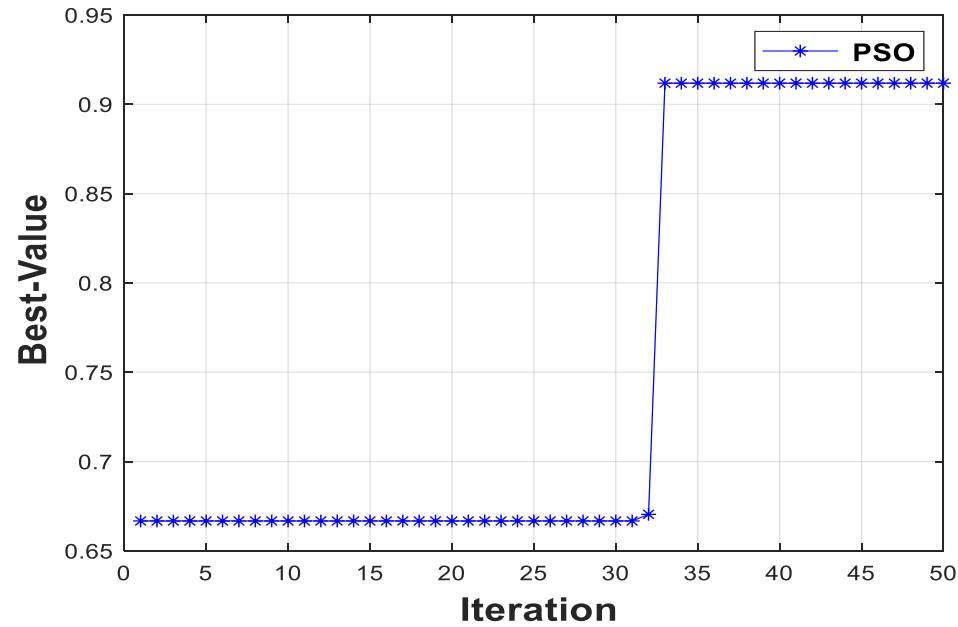


Figure 4.14: Project 2 with its Treatment Using PSO

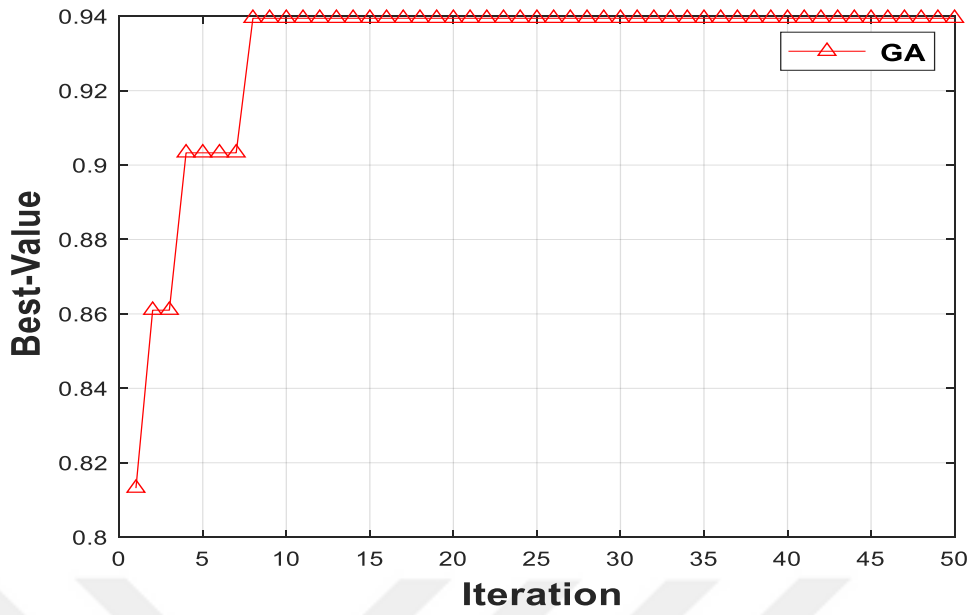


Figure 4.15: Project 2 with its Treatment Using GA

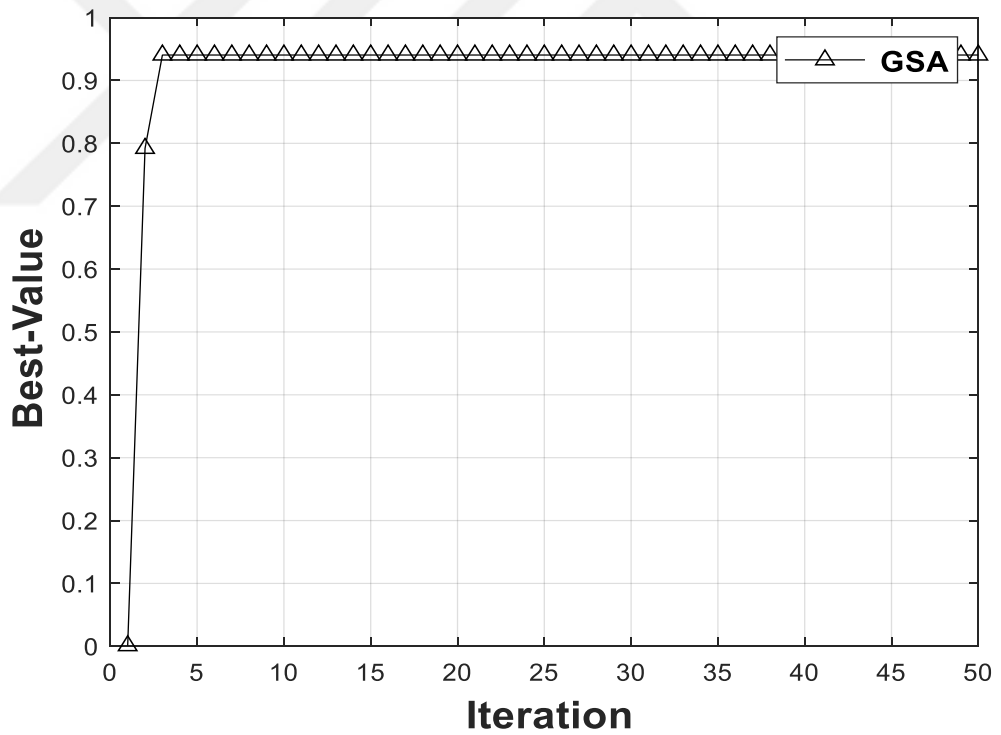


Figure 4.16: Project 2 with its Treatment Using GSA

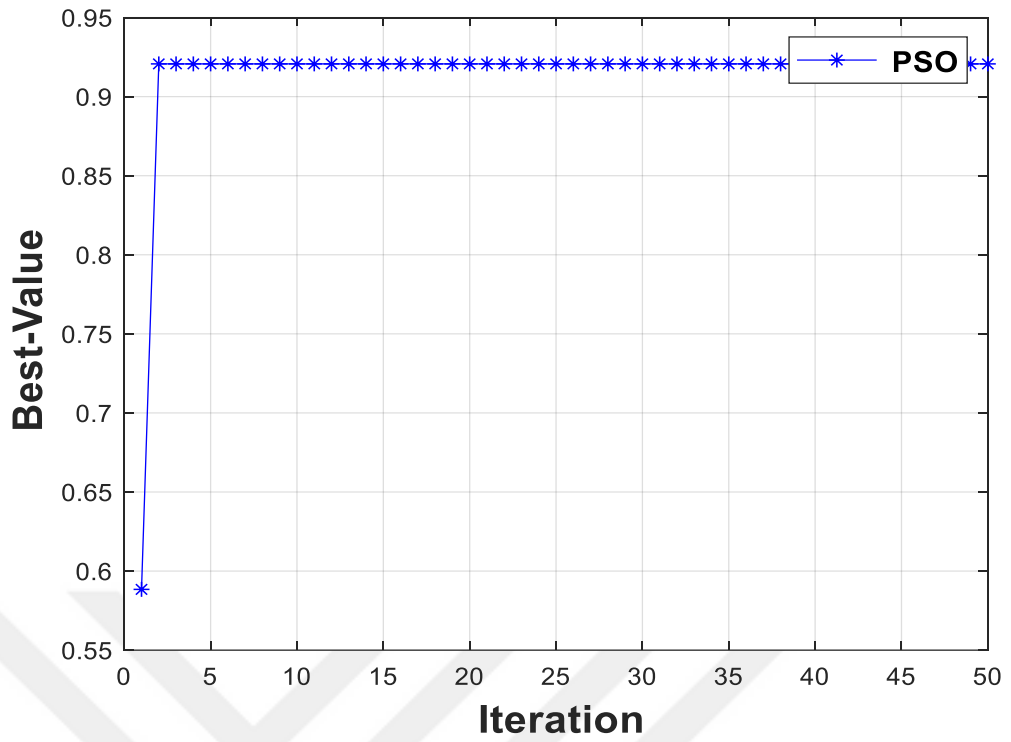


Figure 4.17: Project 3 with its Treatment using PSO

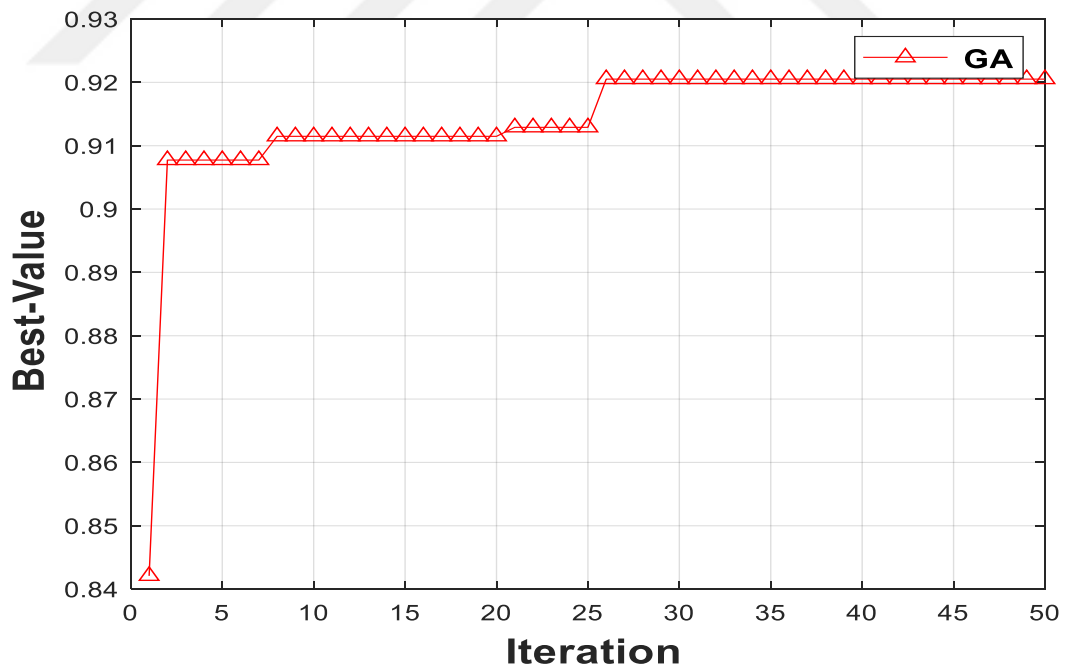


Figure 4.18: Project 3 with its Treatment using GA

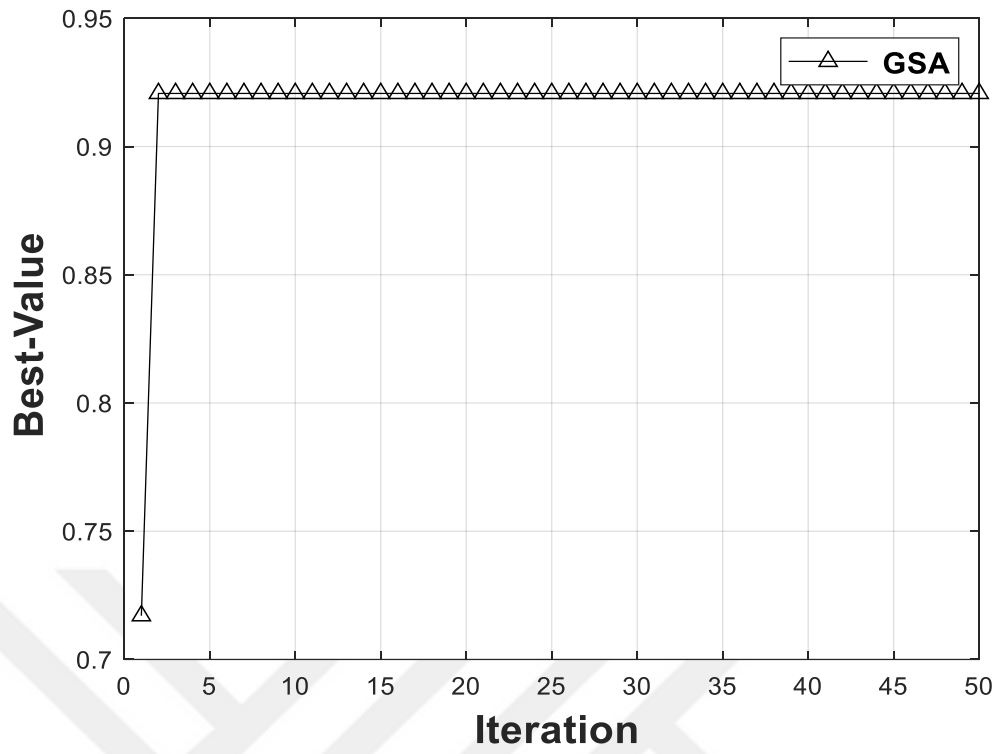


Figure 4.19: Project 3 with its Treatment using GSA

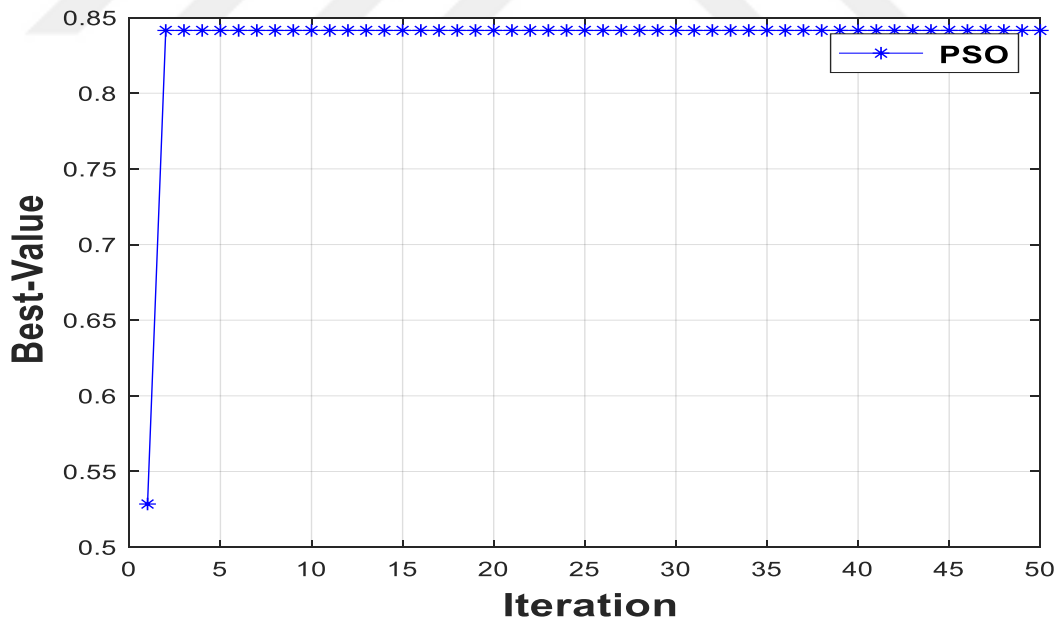


Figure 4.20: Project 4 with its Treatment using PSO

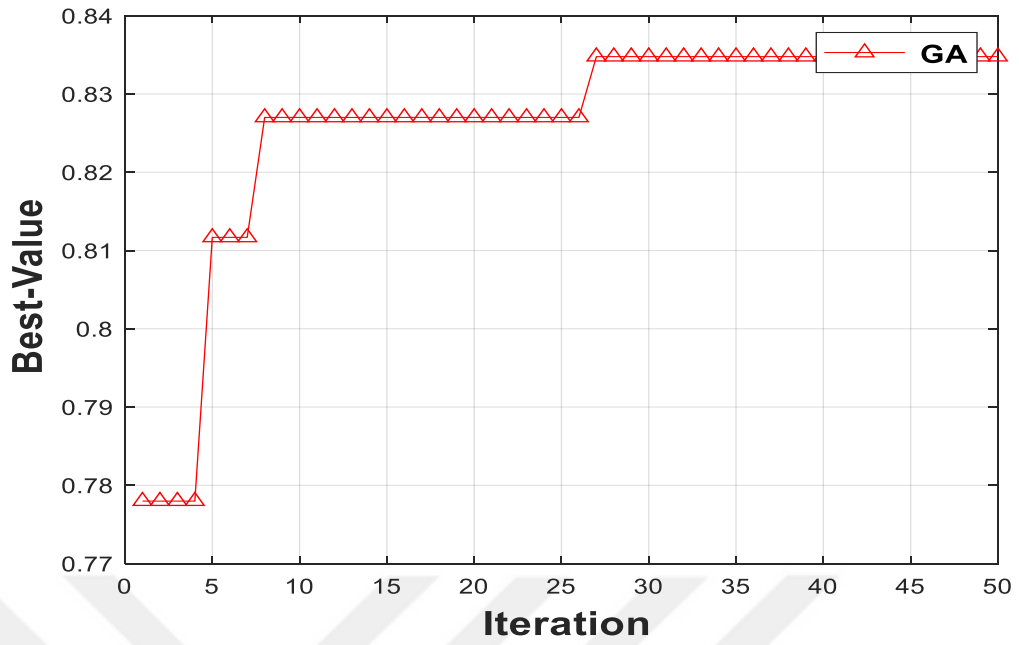


Figure 4.21: Project 4 with its Treatment using GA

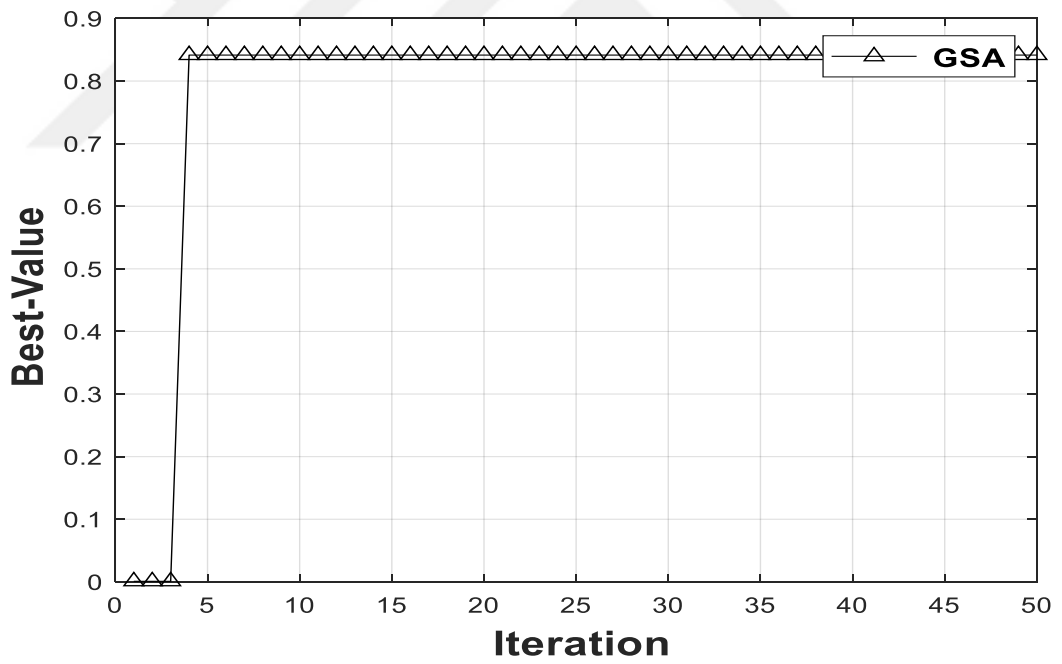


Figure 4.22: Project 4 with its Treatment using GSA

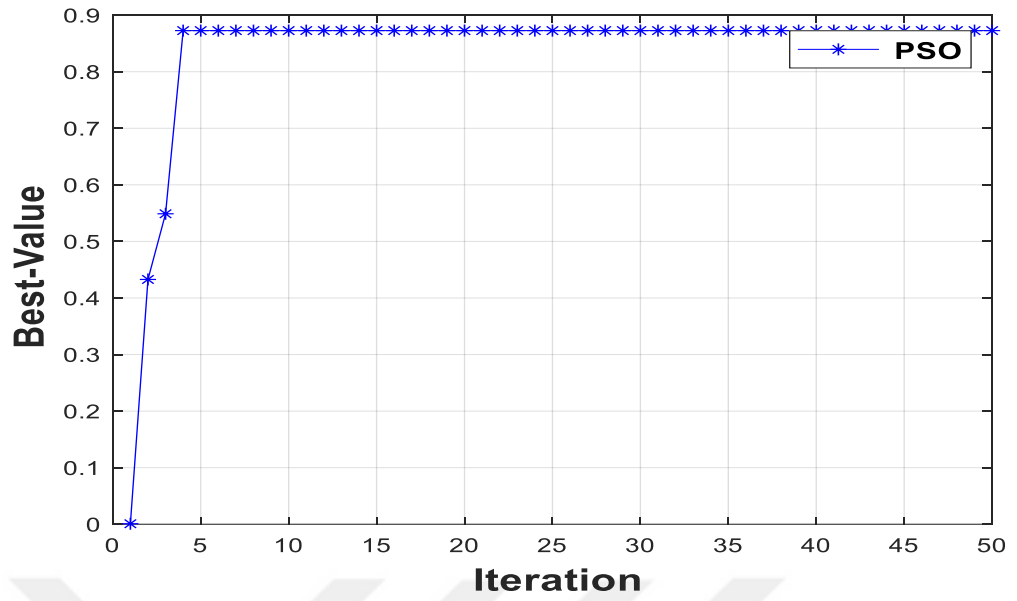


Figure 4.23: Project 5 with its Treatment using PSO

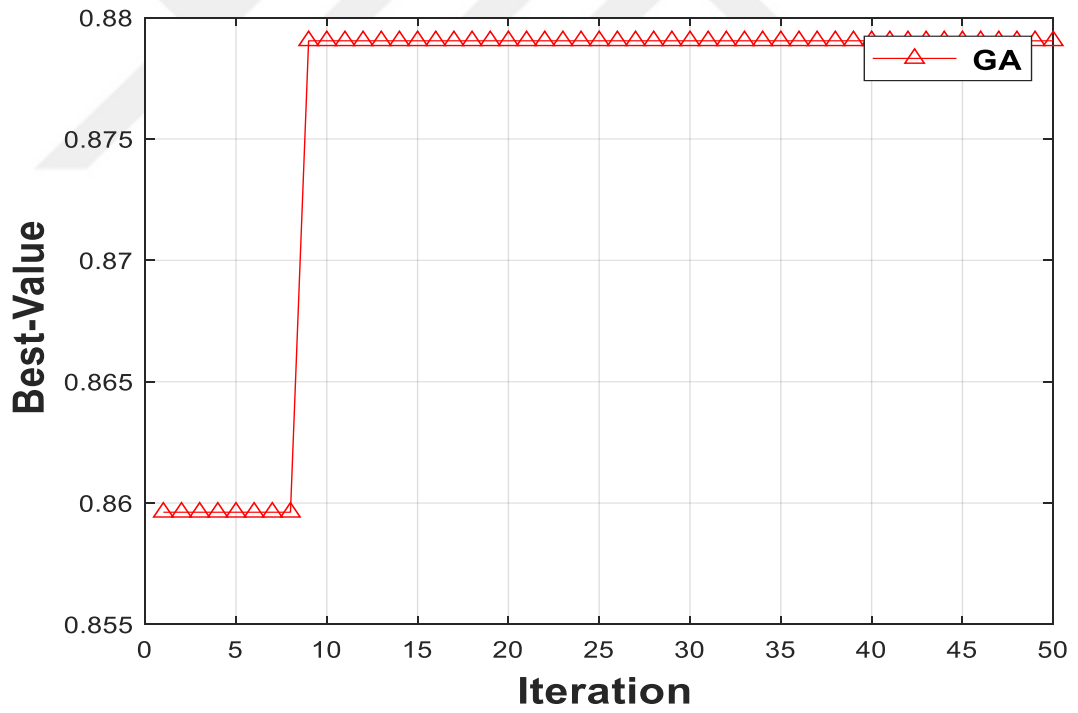


Figure 4.24: Project 5 with its Treatment using GA

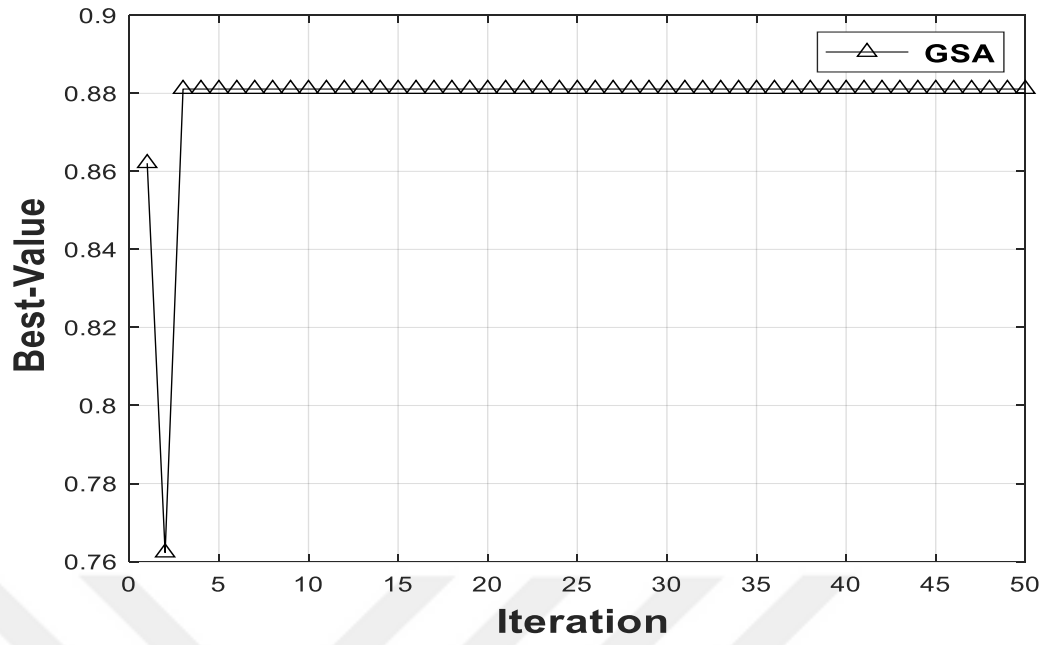


Figure 4.25: Project 5 with its Treatment using GSA

5. RECOMMENDATIONS AND CONCLUSIONS

5.1 Conclusions

Ultimately, this research has successfully designed and created an expert system to address construction project challenges. The developed system provides construction professionals with real-time decision assistance, enabling them to make informed decisions that help minimize and manage various difficulties that may arise during the project lifecycle.

The development of the expert system involved identifying major challenges in construction projects, creating a comprehensive knowledge base, and implementing an inference engine to generate recommendations based on input data. Through testing and assessment on actual construction projects, the system has demonstrated its ability to effectively assist project managers in their decision-making processes.

The suggested expert system holds significant potential to significantly enhance construction projects by improving project management practices, increasing efficiency, and reducing costs. However, further research is needed to enhance the system's efficiency, integrate it with existing project management systems, and enhance its user-friendliness and accessibility.

Key findings from this research include:

1. Expert systems can serve as valuable tools for addressing construction project issues. By automating specific processes and providing decision assistance, expert systems can aid project managers in making better decisions and reducing the likelihood of errors.
2. Developing an efficient expert system requires a thorough understanding of the specific problem, available data, and best practices.
3. Based on hypothesis H0, the low control of cost and time will lead to misleading in the projects and subsequent, low performance as shown in the

effect of poor projects management leading to low construction life and Lack of controls for urban planning as the factor that leads to poor cost control.

4. Based on hypothesis H1, the implementation of a meticulously crafted management plan, specifically designed for cost management, has been demonstrated to significantly contribute to the enhancement of project outcomes and the effective control of costs in the context of construction projects.
5. While expert systems can be beneficial, they should not be considered a one-size-fits-all solution. Project managers should continue to rely on their experience and judgment, using expert systems as one tool among many in their project management toolbox.

Furthermore, it is proposed that the construction risk analysis be incorporated at the beginning of the project. This proactive approach to risk management can significantly contribute to project success in terms of cost and time. By analyzing and mitigating potential risks early on, construction professionals can better anticipate challenges and allocate resources effectively.

The research outcomes have tangible benefits for various stakeholders:

- **Construction Project Managers:** The expert system provides valuable support to project managers by offering a systematic approach to identify, analyze, and mitigate project challenges. This enhances their decision-making process and improves overall project outcomes.
- **Construction Professionals:** The research benefits architects, engineers, contractors, and other construction professionals by providing a tool to effectively address and manage common challenges in construction projects. It serves as a knowledge base and reference to overcome hurdles efficiently.
- **Construction Companies:** Construction companies can adopt the expert system to enhance their project management practices. Leveraging the capabilities of the system enables companies to handle challenges, mitigate risks, increase efficiency, and successfully deliver projects within budget and schedule.

In summary, the concrete contribution of this master's thesis is the development of an expert system tailored to managing construction project challenges. This system benefits construction project managers, professionals, companies, the academic community, and paves the way for further advancements in the field.

Overall, this research demonstrates the viability and promise of employing expert systems to manage construction project issues. The proposed method serves as a valuable tool for construction professionals to enhance project outcomes and advance the construction sector.

5.2 Recommendations

1. **Expand the scope:** While your thesis focuses on cost management, consider the potential to expand the expert system's capabilities to address other critical areas of construction project management. For example, you could include modules for schedule management, risk assessment, quality control, or resource optimization. This expansion would make the system more comprehensive and valuable to construction professionals.
2. **Consider real-time data integration:** Explore the possibility of integrating real-time data sources into the expert system. This could include incorporating data from construction management software, financial systems, or IoT devices on construction sites. Real-time data integration would enhance the accuracy and timeliness of cost management recommendations, allowing for more informed decision-making.
3. **Incorporate machine learning algorithms:** Investigate the integration of machine learning algorithms into the expert system. Machine learning techniques can help improve the accuracy of cost estimation models, identify patterns in historical data, and generate predictive insights. By leveraging machine learning, the expert system can continuously learn and adapt to evolving construction project challenges.
4. **Validate the expert system:** Conduct rigorous testing and validation of the expert system using a diverse range of construction project scenarios. Evaluate the system's performance against established industry standards and compare its results with human experts or existing cost management

methodologies. Validation will provide evidence of the system's effectiveness and build confidence in its practical application.

5. User feedback and iterative improvement: Gather feedback from construction professionals who use the expert system in real-world projects. Incorporate their suggestions and experiences to iteratively improve the system's usability, functionality, and effectiveness. This feedback-driven approach will enhance user satisfaction and increase the system's adoption rate within the construction industry.
6. Collaborate with industry stakeholders: Establish collaborations with construction companies, industry associations, and research organizations to facilitate the implementation and adoption of the expert system. Engage with stakeholders throughout the development process to understand their specific needs, challenges, and requirements. Collaboration will increase the system's relevance and enhance its practical applicability.
7. Document best practices: As you develop the expert system, document the best practices and lessons learned throughout the process. Create guidelines, manuals, or training materials that provide step-by-step instructions on using the system effectively. These resources will support future users in implementing and maximizing the benefits of the expert system in cost management.
8. Share your findings: Disseminate your research findings through academic conferences, journals, or industry publications. Present your expert system as a valuable innovation in cost management for construction projects. Sharing your work will contribute to the knowledge base in the field of construction project management and potentially inspire further research and development in related areas.

Remember to consider the feasibility and practicality of implementing these recommendations within the scope of your research. Adapt them based on the resources and constraints you have for your master's thesis.

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RESUME

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- MCE from Istanbul Gedik University
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COURSES:

- Conversation Course (Speak Now Book)
- OSHA Construction
- Preparing a site engineer

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- Microsoft Windows and Microsoft Office
- AutoCAD
- Staad pro