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Identification and prioritization of influential criteria in the failure of construction industry projects during the operation phase from a project management perspective

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Abstract

The present study aims to identify and prioritize the influential criteria contributing to the failure of construction industry projects during the operation phase from a project management perspective. Since the long-term performance of buildings during their operational period determines the true success of the project, and studies indicate the gap in local frameworks in this area, this research employed a qualitative content analysis-based grounded theory approach. Data were collected through two principal channels: a systematic review of 23 reputable domestic and international scientific articles, and semi-structured interviews with 20 experts and specialists in project management and the construction industry, from which 15 responses were selected for final analysis using purposive sampling. The collected data were analyzed using MAXQDA software, resulting in the extraction of 59 conceptual codes categorized into eight principal components for failure factors, as well as 45 conceptual codes categorized into eight principal components for optimization and prevention strategies during the operation phase. The findings indicate that deficiencies in primary design and engineering, the absence of comprehensive maintenance and repair programs, inefficient human resource management, stakeholder misalignment, and the deliberate neglect of tacit and experiential knowledge held by local operators constitute the most critical reasons for project failure, despite apparent success in the traditional triangle of time, cost, and quality. Conversely, strategies such as implementing asset lifecycle management, employing life-cycle costing analysis, empowering operation teams, and establishing intelligent monitoring systems can significantly contribute to enhancing the long-term sustainability of project performance. The comprehensive model proposed in this research provides an operational framework for project managers, employers, and construction industry policymakers, enabling them to adopt a preventive and systematic approach to avert costly failures during the operational phase.

Keywords

Construction Project Failure Criteria
Construction Project Management
Failure Prevention Strategies during the Operation Phase
Identification and Prioritization

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1. Introduction

Construction project management is a complex and multifaceted domain encompassing planning, design, execution, and supervision of construction projects. This process requires collaboration among a broad spectrum of stakeholders, including architects, engineers, contractors, and suppliers, each playing a fundamental role in ensuring the project's successful completion. Despite meticulous efforts to achieve the primary objectives of time, cost, and quality, numerous projects continue to encounter failure, which may stem from operational inefficiencies, managerial weaknesses, or unforeseen challenges. These failures are frequently identified through lessons learned from prior projects, revealing underlying factors that might not be readily apparent in conventional performance metrics (Akinradewo et al., 2022).

Operation is the phase of the project life cycle that commences upon the completion of the design and construction phases, encompassing the management, maintenance, and utilization of infrastructure to deliver services to end-users (Zeinalian & Maghareh Abed, 2022). Projects have not consistently concluded successfully during the operation phase, and on occasion, certain projects have experienced failure at this stage. Such failures have sometimes incurred substantial costs or, in some cases, jeopardized the organization's credibility. However, behind every failure lies a valuable lesson and experience that can guide us in our future projects. According to published reports in certain industries, the number of failed projects even exceeds that of successful ones. For instance, based on available statistics in the information technology sector, 68% of projects defined in this domain fail. Of course, not all such failures equate to financial ruin or bankruptcy; rather, the mere inability of a project to be executed according to the stipulated budget and schedule, or its abandonment midway, signifies actual failure (Rahimi Salkuyeh et al., 2020). Today, the necessity of effective planning to accurately estimate the time, cost, and quality of project execution, as well as the resources required, is evident. This directly impacts the proper implementation, administration, and operation of the project. In recent years, the complexity of project execution, the competitive business environment, and the resource constraints of organizations have accentuated the need to focus on project management in achieving project objectives (Najafzadeh Rahaghi & Aghaei, 2019).

Broadly speaking, project failure refers to the inability to achieve the goals or expected outcomes established at the project's inception. The definition of failure may vary depending on the specific criteria employed to measure success. According to Muler and Terner (2007), different types of projects possess distinct characteristics; consequently, the criteria for evaluating their success or failure may also differ. Moreover, the role of effective communication and stakeholder participation in ensuring post-delivery project success is of paramount importance (Latiffi & Zulkiffli, 2022). For instance, one may refer to the Sydney Cross City Tunnel project, in which a 2.1 km toll tunnel was constructed in Sydney to connect the west to the east. Despite its numerous advantages in terms of traffic reduction, environmental improvement, and alleviating traffic congestion, the project unfortunately encountered a lack of public acceptance, leading to its failure. This project failed as it could not anticipate unforeseen risks after the operation phase (Chan et al., 2008).

There are various perspectives on the failure of construction projects. For example, contracting organizations typically deem projects that have failed to achieve their primary cost and time objectives as unsuccessful, whereas financial sponsors, clients, partners, and end-users may base their assessments on the ultimate operational outcomes of these projects. This suggests that the perception of project success and failure varies significantly among stakeholders depending on their roles and expectations, and may also evolve throughout the project life cycle. Consequently, distinguishing between project outputs, outcomes, and impacts is crucial for a comprehensive understanding of project failure. Reliance should not be confined solely to the triple constraint criteria (time, cost, quality, and scope) within the project triangle. Examining project failures in the construction domain from the perspectives of project management and construction management, and through a systematic review of scientific literature, reveals that in the project management literature, poor quality, delays, and cost overruns are recognized as the most prominent forms of failure. In contrast, the construction management literature considers failure in project outcomes and their impacts, as well as business failures such as bankruptcy, financial instability, and fiscal difficulties, as the most significant forms of failure. Compared to the project management literature, the construction management literature has identified various types of failures (defects, delays, and costs). As expected, cost and time overruns are frequently emphasized as a common type of failure in both project management and construction management domains. The reported effects of these failures include customer dissatisfaction, damage to company reputation, and poor safety performance, which can be observed in both the project management and construction management literature. Overall, articles related to project management tend to focus more on internal factors, project management practices, and intra-project dynamics. Conversely, construction management articles emphasize external issues and specific challenges of the supply chain and the overall project environment. The results indicate that adopting a comprehensive approach, incorporating lessons learned from past failures, is essential for improving the outcomes of future projects (Amović et al., 2020).

Furthermore, the effective role of project planning cannot be overlooked. Weak strategic project planning has been identified as a significant factor affecting project success (Akande et al., 2018). Inadequate planning can lead to unrealistic expectations, scope changes, and misallocation of resources, all of which can jeopardize project outcomes. A well-defined project plan encompassing clear objectives, stakeholder engagement strategies, and risk management protocols is indispensable for ensuring that the project not only achieves its immediate goals but also delivers long-term value (Akande et al., 2018).

In Iran, construction projects account for a massive portion of national capital. Unfortunately, due to the absence of comprehensive and scientific management, most of these projects, considering the three principles of time, quality, and cost, encounter execution failure and, in some cases, post-operation failure (Behboudi & Fili, 2024). The construction industry plays a significant role in generating investment opportunities and wealth in the economies of many countries, including Iran. The importance of the construction industry's position in the country's economy is evident from the close linkage between construction and its upstream and downstream sectors, such as basic metals, non-metallic minerals, and real estate services. Today, in developing countries, over thirty-five percent of employment opportunities are directly or indirectly dependent on the construction industry. The construction industry's share of the gross domestic product (GDP) alone stands at 5.7%, and including its sub-sectors, it accounted for approximately 23.5% of the GDP in the year 2019 (1398 Persian calendar). The construction industry plays a significant role in generating employment and is a vital contributor to GDP. Due to its GDP share, surpassing many other industries, including agriculture and mining, it has become one of the largest investment domains. Hence, by focusing on the value network, value creation criteria can be identified, leading to improvements in construction methods, reduced energy consumption, and industrialization. In accordance with numerous upstream documents, including the National Building Regulations, resolutions on the resistance economy, knowledge-based economy, and other strategic directives, success in the construction industry is a necessity and imperative for the country (Tajik, 2020).

In developing countries, the construction industry is recognized as a viable opportunity for economic investment, and its importance is underscored by its close association with national economic development and its substantial contribution to GDP. However, despite the high significance of the construction industry, particularly from a developmental perspective, project success is realized only when project management is effectively executed from the conceptual stage through to the final operational phase. In this regard, the application of knowledge, skills, tools, and techniques in fulfilling project responsibilities is essential to address its requirements sufficiently. Generally, it is believed that the primary parameters influencing a project include time, quality, and cost, while attention to project scope, as well as stakeholder satisfaction and needs, is of particular importance (Jeevan et al., 2021).

Since the successful execution of construction projects does not guarantee successful outcomes, the interplay of stakeholder management, risk management, alignment with organizational objectives, and effective planning is the vital factor that influences post-delivery project success or failure. Understanding these dynamics is essential both for project managers and stakeholders, as it enables them to navigate the complexities of construction projects and ensure that they are not only delivered on time and within budget but also fulfill the long-term needs and expectations of all stakeholders involved. Consequently, projects have not always been successfully concluded, and various factors contribute to post-operation project failure. Sometimes these failures incur high costs or, in some cases, compromise the organization's credibility. Nevertheless, we are all aware that behind every failure lies a valuable lesson and experience that can guide us in future projects. In this research, we aim to identify and prioritize the influential criteria that lead to the failure of construction industry projects during the operation phase, notwithstanding their apparent success from a project management perspective. This study examines factors that may lead to project failure despite the project's success and achievement of its main objectives. Reviews of various articles concerning the identification and prioritization of influential criteria for the failure of construction industry projects during the operation phase, despite project success from a project management standpoint, provided notable findings that underscore the critical importance of identifying these factors. The phenomenon whereby construction projects are deemed successful from a project management perspective yet fail in terms of post-delivery outcomes is a complex issue that has been investigated in various studies. A successful construction project is often characterized by adherence to time, budget, and scope, which are traditional criteria of project management success. However, these criteria do not necessarily correlate with the long-term effectiveness or sustainability of project outcomes. In general, various factors and processes contribute to project failure, and given the high importance of identifying these factors, it is possible to significantly prevent project failures. In this research, we investigate the factors contributing to project failure through interviews, the application of the analytical hierarchy process (AHP) technique, and an analysis of the conducted interviews. In the following, we address the research objectives and questions. Objectives are: 1) Identification and prioritization of influential criteria in the failure of construction industry projects during the operation phase from a project management perspective; and 2) Identification of necessary strategies to prevent the failure of construction projects during the operation phase from a project management perspective. The research questions are: 1) What factors contribute to the failure to achieve success in construction projects during the operation phase? And 2) What strategies exist to optimize and prevent project failure during the operation phase?

2. Literature review and theoretical background

2.1.Project success

Project success is a pivotal concept in project management literature that has evolved over recent decades from a unidimensional view to a multidimensional and strategic approach. According to the Project Management Institute (PMI, 2021), in the traditional approach, project success is primarily assessed based on the fulfillment of the triple constraints of time, cost, and scope (quality), commonly referred to as the "iron triangle." Project success is not confined merely to on-time and within-budget delivery; rather, the extent to which expected value is realized and alignment with the organization's strategic objectives constitutes fundamental criteria, encompassing four principal dimensions:

1. Project efficiency (achievement of time and cost targets)
2. Impact on the customer
3. Business and commercial success
4. Future readiness and development of strategic capabilities

Therefore, in this research, project success is conceptually defined as follows: the degree to which the operational and strategic objectives of the project are achieved within the framework of execution constraints, accompanied by the creation of sustainable value and satisfaction of key stakeholders (PMI, 2021).

2.2. Project failure

Project failure is not considered the antithesis of success; rather, it denotes the non-fulfillment of one or more dimensions of the project's functional or strategic aspects. According to the PMI (2021), a project is considered unsuccessful when it fails to meet the objectives established in the baseline plan or fails to generate the expected value for the organization and stakeholders. Some researchers contend that even if a project is completed within the time and cost parameters, if it fails to generate commercial benefits or customer satisfaction, it is considered a strategic failure. On this basis, project failure is defined in this research as follows: a state in which the project fails to achieve operational objectives, economic benefits, strategic value, or stakeholder satisfaction, even if some of its execution indicators have been realized (PMI, 2021).

2.3. Project operation and commissioning

The operation of civil engineering projects constitutes a phase of the project life cycle that begins after the completion of the design and construction phases, encompassing the management, maintenance, and utilization of infrastructure to deliver services to end-users. The following explores this concept based on scientific research. The interests and benefits of numerous natural and legal persons are affected by the implementation of a project for various reasons. Consequently, they may strive to influence the project's fate and sometimes its failure. Managing the interests, benefits, perspectives, and viewpoints of project stakeholders in a manner that maximizes facilitation toward project success and minimizes obstacles to its implementation is referred to in project management literature as the stakeholder management process and is considered one of the project manager's duties. This article, to introduce this topic in the country, studies the project stakeholder management literature to provide a theoretical framework for stakeholder management. This theoretical framework can serve as a basis for stakeholder management and evaluating its implementation in the country's civil projects, which typically encounter numerous organizations and different individuals (Ghorbani et al., 2021).

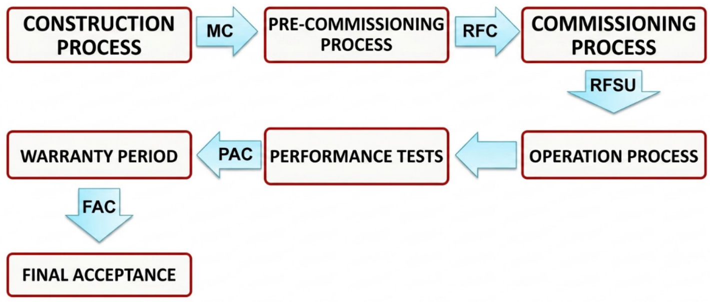

Figure 1. The project's executive and supervisory processes from the construction phase to final delivery

The operation phase is typically considered a separate project involving operations management, maintenance, and infrastructure productivity improvement. This phase is crucial for ensuring the optimal functioning of civil projects. Operation plays a key role in evaluating the performance of transportation projects. This phase can directly impact the final costs and efficiency of the project (Soleimani & Mahmoudi Sari, 2021). The involvement of maintenance contractors in the early stages of the project can mitigate operational issues and ensure the sustainability of project performance. This case study was conducted on road construction projects. The commissioning and productivity of projects is a process that examines the correct functioning of systems and plans to ensure compliance with design specifications, drawings, and engineering principles, so that they are prepared for operation in an orderly and phased manner. This process begins after the completion of operations, including the supply of building materials, bartering, and sales engineering, and comprises two sections in commissioning (Soleimani & Mahmoudi Sari, 2021).

The primary objective of construction management is to execute successful projects in line with predetermined goals. Civil projects are considered fundamental pillars of sustainable development and the productive economy of any country, directly and indirectly involving numerous individuals, organizations, and institutions. Nevertheless, many developing countries, such as Turkey, Nigeria, Saudi Arabia, Malaysia, etc., face significant challenges in the performance of civil projects. Today, despite the progress made in the construction sector in the country, attention to the post-construction stage, the operation or maintenance period, and the status of constructed asset management, especially from a safety perspective, has been relatively neglected. Given the multitude of diverse constructions in the country and the issue of the short useful life of built assets, the challenges of proper operation, safety problems and safety measures, as well as preserving the functions of national assets, the application of constructed asset management knowledge, as a relatively new concept and emerging profession, especially for efficient safety management in building constructions, is an important and essential matter (Fathi et al., 2025). The most important operational activities of any project are as follows:

- Start-up
- Performance testing
- Handover to the operator and commencement of the warranty period
- Warranty
- Maintenance and repairs

Barriers to operation or factors leading to failure: the interests and benefits of numerous natural and legal persons are affected by the implementation of a project for various reasons. As a result, they strive to influence the project's fate and sometimes its failure. Managing the interests, benefits, perspectives, and viewpoints of project stakeholders in a way that maximizes facilitation toward project success and minimizes obstacles to its implementation (Soleimani & Mahmoudi Sari, 2021).

Operation applies throughout all phases of a project; but, the greatest benefits are derived during the initial planning and design stages, where the employer's and designer's flexibility is greater, changes are easier to implement, the impact of changes on project scheduling is less, and costs are lower. According to the International Building Council standard, operation begins at the preliminary information stage of the project, before the main design and development resources are finalized. For this reason, this phase is the best time to utilize operation, as the main function of the project has not yet been established, allowing alternative methods to be identified and considered (Galanis et al., 2021).

To maximize benefits and gain a competitive advantage, rapid and continuous operation design is essential – understanding which parts are vulnerable, which are defensible, which alliances are strategically important, and which threats are dangerous. The environment has become more turbulent than in the past, and only through flexibility can firms manage this increasing complexity (Bhatnagar & Teo, 2009). Operational flexibility can be categorized as primary flexibility/capability and secondary flexibility/competency. The flexibility of a project directly relates to its degree of innovation and depends on its network affiliation. Companies with a project structure are better able to leverage their internal innovative capabilities and create value. The foundation of a value-creating operation relies on three core concepts: superior customer value, core competencies, and core relationships. Different types of strategic networks require different management skills, and it is useful to describe the differences through a value system perspective, based on the idea that each product or service demands a set of values. Furthermore, new details exist regarding the nature and classification of operational networks: vertical value, horizontal value, and multidimensional value. Networks enhance relationships and increase value for those who join them (Ricciotti, 2019).

If operation studies are properly targeted and project stakeholders have sufficient information about them, from the start of preliminary studies to the approval of change proposals, approximately one month is required. Considering the project life cycle and the potential achievements of operation, this period is negligible in most cases, and concerns that operation may slow down the project process are unfounded. The successful implementation of the operation and achieving its executive objectives requires attention to the principles and work plan of the operation, which vary from project to project because interpretations differ. However, all experts agree on the importance of observing certain principles and steps.

2.4. Causes of failure of civil projects during the operation phase

Civil projects fail during the operation phase typically due to multiple factors, including weaknesses in planning, financial problems, technical issues, and a lack of coordination among stakeholders. Various studies have examined this issue, some of which are introduced below.

1. Weakness in initial planning: studies demonstrated that inattention to the project planning process and its ineffective management constitutes one of the primary factors contributing to project failure during the operation phase. Research by Nguyen et al. (2020) emphasized that inadequate planning and a lack of stakeholder coordination lead to execution problems in the final phases of civil projects.

2. Technical and design issues: inappropriate design and the use of substandard materials can cause technical defects and premature deterioration of civil projects. A study by Eldukair (1990) investigated recent failures in US construction projects. It demonstrated that failure to adhere to engineering standards is a primary cause of project failure during the operation phase.

3. Impact of financial issues and tendering processes: financial problems and weaknesses in the tendering process can also lead to project failure. Research by Shahhoseini et al. (2018) suggested that shortcomings in project pricing and insufficient funding for operation represent significant factors in project failure.

4. Stakeholder coordination issues: inadequate cooperation between contractors and project stakeholders is another problem affecting the operation of civil projects. A study by Do et al. (2022) demonstrated that poor stakeholder communication severely reduces project performance.

5. Strategic approaches to reducing failure during the operation phase: research by Mills (2020) suggested that adopting strategic approaches to quality

management and operational processes can reduce the likelihood of failure of civil projects. This study emphasized the importance of improving transition processes between different project phases.

Therefore, the most significant obstacles to the failure of civil projects during the operation phase are as follows:

- Lack of belief, awareness, and acceptance among project stakeholders, particularly the employer.
- Misconceptions about achieving improvements and reducing costs due to incorrect design and inadequate design consultant studies.
- Resistance from the designer and consultant to accepting design reviews with the assistance of operators, due to perceived insult to their professional standing.
- Lack of conviction among project stakeholders, especially the contractor or manufacturer, regarding the operation methodology due to unsuccessful experiences with other cost-reduction and improvement methods.
- Insufficient motivation among project personnel to strive for project improvement.

2.5. History of failure of civil projects in Iran during the operation phase

1. Failure of urban projects in Tehran: A study by Nasiri Sagharli (2023) examined the factors contributing to the failure of civil projects of the Tehran Municipality. This study indicated that issues such as budget deficits, weaknesses in construction management, and a lack of coordination among executive bodies directly affect the failure of these projects during the operation phase.

2. Delays and issues in gas pipeline projects: Fallahnejad (2013) investigated delays in Iran's gas pipeline projects and demonstrated that these delays during the operation phase also result in problems such as cost increases and reduced efficiency.

3. Tehran Metro projects and risk issues: Pourehashemi et al. (2020), in their investigation of underground projects in Tehran, identified issues such as poor geological risk analysis and lack of detailed examination of site history as the main causes of project failure. These factors led to structural instabilities and additional costs during the operation phase.

4. Challenges of managing South Pars projects: Daneshkhah and Younesi (2023), in a study on the massive South Pars projects, identified the lack of effective management in collecting initial information and the lack of proper understanding of operational requirements as the most important factors contributing to project failure in this region.

5. Risk analysis in Iranian bridge projects: Naderpour and Kheyruddin (2019) utilized the Monte Carlo simulation technique for risk analysis in bridge construction projects and demonstrated that failure to consider risk assessment in the early stages leads to significant operational problems.

6. Failure of commercial and recreational projects: Khosravi et al. (2020) demonstrated that the construction of commercial and recreational centers in Iran has faced numerous problems during the operation phase, mainly due to weaknesses in initial estimates and sudden changes in economic conditions.

2.6. Empirical background

International background

Zhang et al. (2024), in a study examining the operational problems of Beijing Daxing International Airport, concluded that a composite framework exists for designing the transition to operations in large inter-organizational projects, involving organizational design strategy, structures, processes, and people management in transition. This framework offers a set of considerations for designing organizational boundaries that emphasize communication coordination and achieve continuity between projects and operations. This study contributes to linking operations management, project management, and organizational design of large inter-organizational projects.

Komurlu et al. (2024), in a study exploring the barriers to green building production in Turkey and possible solutions, concluded that the most significant problems encountered in Turkey include a lack of government subsidies, the absence of green building regulations, public indifference to green building technologies, and educational and technological deficiencies. According to respondents, possible solutions include government incentives, adoption of national standards and best practices, public and design/construction professional education on green buildings, and development of new green building technologies. The results suggested that sustainability in the building design/construction industry has gained importance due to increasing energy demand, widespread use of non-renewable resources, and consequent environmental damage caused by traditional building design and construction.

Zoufa (2017), in a study titled “Appraising sustainability drivers for value creation among construction project stakeholders,” evaluated the effectiveness of sustainability drivers for value creation among stakeholders in civil projects. The success or failure of investment in civil projects often depends on stakeholders’ ability to manage the dynamics between economic, environmental, and social factors. Furthermore, it has been acknowledged that one of the proposed values of civil projects in emerging economies includes value creation through project sustainability, operational effectiveness, and stakeholder participation, rather than relying on highly focused financial methods.

Domestic background

Behboudi and Fili (2024), in a study identifying the problems of the claims management process in civil projects and the factors affecting it, and ranking these factors based on the DANP technique, concluded that the execution of civil projects requires time, cost, and other resources from relevant project parties. The expenditure of these resources itself creates rights and claims for the parties. Consequently, the success of civil projects is highly dependent on the effective resolution of claims.

Sheikhzadegan Khiavi et al. (2023), in a study identifying and evaluating project stakeholders to assess their capability in claim initiation using stakeholder communication network analysis in a case study, concluded that the role of stakeholders in each claim varies based on centrality measures, and using communication network analysis among stakeholders in common claims, the effectiveness of each stakeholder can be identified and necessary measures for claims management can be considered. The findings of this research can help managers better understand the key factors influencing project performance and, consequently, claim management and dispute prevention.

2.7 Comparative analysis of international and domestic cases

The failure of civil projects during the operation phase is one of the most neglected areas of project management. Contrary to the common perception that failure is solely associated with delays or cost overruns during execution, real failure in many projects lies in the failure to achieve expected benefits throughout the operational life cycle. Gorog (2016) emphasizes that a project may be evaluated as successful from the perspective of the traditional “iron triangle” (time, cost, quality) criteria; however, during the operation phase, due to operational inefficiencies, stakeholder dissatisfaction, and non-alignment with actual societal needs, it effectively fails.

In Iran, there are semi-completed projects that have reached the brink of operation but are left abandoned, particularly airport and shopping center projects in major cities. In some projects, the initial design is incompatible with actual user needs or environmental conditions in the long term. This leads to suboptimal utilization and ultimately reduced efficiency. Furthermore, many civil projects lack a codified and operational program for maintenance, preventive repairs, and updates. This neglect leads to the accelerated deterioration of facilities and a reduction in the project’s useful life.

Numerous studies have demonstrated that civil projects in Iran often fail due to factors such as inaccurate initial estimates, weaknesses in project and contractor management, and budget shortages (Mohammadi & Saghaghi, 2021).

International case study: Sydney Cross City tunnel project

The Sydney Cross City tunnel, a 2.1 km toll tunnel, was opened in 2005 to reduce surface traffic and improve the environmental situation. Although the project was delivered relatively successfully from a technical perspective and within time and cost constraints, it encountered complete failure during the operation phase. A root cause analysis of this failure by Chan et al. (2008) identified the most significant causes as:

- Overly optimistic traffic demand forecasting: the initial estimate of the number of vehicles using the tunnel was more than double the actual figure. This egregious error did not stem from deficiencies in simulation software but from the oversight of “native travel patterns” and “Sydney drivers’ habits.” The tacit knowledge embedded in the behavior of local citizens was not incorporated into decision-making models (Chan et al., 2008).
- Inaccurate positioning of access points and poor coordination with the existing road network: the tunnel’s entrances and exits were designed in an unnatural and inconvenient form for many local drivers. Indigenous transportation experts and experienced public transport drivers could have reminded this deficiency before construction, but there was no mechanism for their participation in the design process.

- Lack of a knowledge transfer mechanism from local operators to designers: the tunnel was designed without the involvement of road operators, traffic police, and existing tunnel maintenance teams. Consequently, problems such as blind spots, inappropriate sign placement, and deficiencies in the emergency ventilation system emerged within the first months of operation.
- Imbalanced risk distribution: the government placed the demand risk entirely on the private consortium, without providing any instrument to adjust forecasts based on field data or local experiences. Chan et al. (2008) argue that unpredictable conditions and inaccurate government estimates can make project management difficult or even impossible for the private sector. In such situations, the government must intervene, share responsibilities, and overcome the problems.

Consequences included a significant decline in toll revenue, bankruptcy of the operating consortium, withdrawal of investors, and a net loss exceeding AUD 500 million for the government. The main lesson from this failure was that success during the operation phase depends not only on precise engineering calculations but also on integrating technical knowledge with the tacit and experiential knowledge of local operators.

Comparison with a similar project in Iran: A case study of the Niayesh tunnel, Tehran

The Niayesh tunnel project in Tehran (approximately 6 km in length, located in District 1 of the municipality) was selected as a comparable example in terms of application (urban tunnel) and benchmarked against the Sydney tunnel. The Niayesh tunnel is a twin road tunnel constructed in the Tehran alluvium, with a total length of 10 km, connecting the Sadr Highway to the Niayesh Highway, utilizing the New Austrian Tunneling Method (NATM) (Motavakel Khosroshahi et al., 2013). The site of this tunnel is a sedimentary environment where the influence of groundwater presence and fluctuations on tunnel stability and durability is of paramount importance (Ghorbani et al., 2012).

The required data were collected through interviews with experts and published technical reports. Table 1 summarizes this systematic comparison.

Table 1. Comparison of Sydney Cross City tunnel and Tehran Niayesh tunnel in terms of failure factors during the operation phase

Comparison criterion	Sydney Cross City tunnel (Chan et al., 2008)	Tehran niayesh tunnel (Ghorbani et al., 2012)
Demand and usage pattern forecasting	Very optimistic, without attention to local habits	Inbound traffic estimate lower than reality, failure to correctly analyze hourly and daily patterns based on Tehran drivers' experience
Local operator participation in design	None	Very limited
Neglect of tacit knowledge	Design without consultation with local drivers and maintenance teams	Failure to utilize the accumulated experience from the operation teams of the older Tehran tunnels
Tangible problems during operation	Lack of uptake, revenue decline, and bankruptcy	Inadequate ventilation in some sections (Rafiei & Sturm, 2018), seasonal water ingress, and problems due to groundwater level fluctuations (Motavakel Khosroshahi et al., 2013)
Key failure factor from a project management perspective	Weakness in predicting user behavior and neglecting indigenous knowledge, along with imbalanced risk distribution	Weakness in transferring experiential knowledge from maintenance teams of previously constructed tunnels to the design and execution phase of the Niayesh tunnel

The comparison reveals that in both projects, the neglect of "tacit knowledge" of local agents and field operators was the most significant common gap.

Ghorbani et al. (2012) demonstrated in their study that tunnelling in urban areas possesses specific characteristics and limitations compared to rural areas, which must be considered in the design and construction of such infrastructures. An extensive monitoring system utilizing geotechnical, geodetic, and structural instruments was designed for the Niayesh project. Based on the monitoring results, potential warnings, countermeasures, and numerous design optimizations were provided. However, operational phase problems persisted.

Rafiei and Sturm (2018) conducted a case study of the Niayesh Tunnel, examining the environmental issues resulting from the discharge of polluted air from tunnels into the surrounding areas, with a particular focus on residential neighborhoods. The simulation of carbon monoxide dispersion near tunnel portals indicated that pollutant management in urban tunnels is a major challenge, and preventive measures afre required inside and outside the tunnel. This issue highlights the weakness in ventilation system design and insufficient attention to the environmental impacts of the operation phase during the design stage.

The Role of neglect of local experience and tacit knowledge as one of the main reasons for project management failure in some projects in Iran

In this research, a systematic review of 23 articles and interviews with 15 project management experts in Iran revealed that "failure to utilize experiential and tacit knowledge of local experts, operators, and maintenance teams during the design and planning stages" is one of the six main categories of failure factors during the operation phase. One expert with over 18 years of consulting experience in Iranian construction projects stated in this regard: "weakness in initial design and engineering, lack of coordination between construction and operation units, extensive changes during the project without assessing long-term effects, failure to predict maintenance and repairs during the design phase, weakness in quality management during execution, financing problems and payment delays, and lack of real operational data for decision-making are among the most important factors."

The same expert, describing a concrete example of operational phase failure despite construction success, stated: "In one hospital project, everything progressed according to plan during construction, but the following problems arose after operation: the mechanical facilities system did not match the actual type of operation; due to non-standard equipment selection, maintenance costs multiplied; delivered drawings and documents were incomplete; and the operation team did not have access to necessary data." He also pointed to the role of training and knowledge handover: "lack of adequate training for operation personnel and incomplete handover of documents and records are the main challenges. Lack of knowledge and experience in the operation team is one of the primary reasons for failure. Many projects are delivered without any training program."

Another expert with 15 years of experience as a project manager in power plant projects mentioned a wastewater treatment plant project: "equipment was purchased and installed exactly based on European catalogs, but local operators who had worked with old treatment plants for years repeatedly stated that these sensors are not compatible with our power quality and voltage fluctuations."

In some civil projects in Iran, failure occurs not because of a "lack of engineering knowledge," but due to the neglect of the experiential knowledge of those who are supposed to "keep the project alive." As long as the experience of the local expert and field operator does not enjoy institutional credibility equivalent to that of software calculations, and the project knowledge management system lacks mandatory mechanisms for recording, transferring, and applying this tacit knowledge (Jafari & Love, 2013), these costly failures in the operation phase will be repeated.

3. Research methodology

The primary objective of this research is to identify and prioritize the influential criteria in the failure of construction industry projects during the operation phase, despite the project's success from a project management perspective. The research is developmental in nature and descriptive in approach, employing the qualitative research method. Qualitative research methods represent a research strategy or methodology for gathering, analyzing, and synthesizing information from previous articles and expert interviews to understand research problems during the conduct of a study. The research method was also a combination of data triangulation, enabling the researcher to provide a comprehensive analysis of civil projects and the operation phase by combining qualitative and quantitative data. The statistical population of the research in the qualitative phase comprised two groups: 1) selected articles from domestic databases (Magiran, Civilica, Noor Journals) and international databases (Elsevier and Emerald) based on a systematic review method and predetermined criteria; 2) several academic experts (management professors) and project management specialists who possessed the necessary knowledge in this area. The interviews were conducted with 20 individuals, though the responses of 15 were suitable for further analysis. The collected data were examined through content analysis, and the resulting codes were finally reviewed using MAXQDA software, where duplicate items were merged, and the final model was drawn.

4. Discussion and conclusion

Initially, to identify and prioritize the influential criteria in the failure of construction industry projects during the operation phase from a project management perspective, as well as effective strategies, we need to identify the main factors through literature review and interviews. To achieve the research objectives, 23 effective articles were identified through a systematic review, and 15 experts were interviewed (15 experts, including the active professionals with various job ranks, were selected using purposive convenience sampling). The criteria for selecting experts included three items: a) having the necessary expertise in project management, b) having more than five years of work experience in project management, and c) holding a master's or doctoral degree in project management.)

After each section of the interview, a summary of the interviewees' statements was prepared, and the key points extracted by the interviewer were returned to them for confirmation/rejection, or further discussion. This process contributed to the validity of the interviews. All interviews were completed in a single session.

Table 2. The characteristics of the interviewed experts

Age	Experience (years)	Education	Gender	Number
Over 50	More than 30	PhD	Male	In1
Over 50	More than 30	PhD	Male	In2
40-50	10-20	MSc	Male	In3
40-50	10-20	MSc	Male	In4
Over 50	20-30	MSc	Male	In5
30-40	10-20	MSc	Male	In6
30-40	10-20	MSc	Male	In7
Over 50	More than 30	MSc	Male	In8
40-50	10-20	MSc	Male	In9
40-50	10-20	MSc	Female	In10
30-40	20-30	MSc	Male	In11
40-50	20-30	MSc	Male	In12
Over 50	20-30	PhD	Male	In13
40-50	20-30	MSc	Female	In14
30-40	10-20	MSc	Male	In15

Ultimately, 59 indicators within 8 main categories were identified as influential criteria on the failure of construction industry projects during the operation phase, and 45 indicators within 8 main categories were identified as strategies for optimizing and preventing project failure during the operation phase, represented in Tables 3 and 4. These indicators were confirmed through content analysis, and their diagrams were plotted using MAXQDA software, as seen in Figures 1 and 2. Previous research on identifying and prioritizing influential criteria in the failure of construction industry projects during the operation phase from a project management perspective and providing effective strategies has largely focused on specific or limited aspects of this concept, and the models presented have sometimes lacked the comprehensiveness to cover all contributing factors. In this research, a comprehensive and integrated model was presented for identifying influential criteria in the failure of construction industry projects during the operation phase from a project management perspective, providing effective strategies that encompass all key dimensions, including organizational performance management. This model can serve as a novel framework in scientific and practical literature for analyzing and enhancing the success of construction industry projects during the operation phase in other sensitive and complex construction projects.

Table 3. Categorization of codes for influential criteria in the failure of construction industry projects during the operation phase

Open code	Component
Failure to consider the real needs of operators during design and execution	Weakness in primary design and engineering
Low construction quality and materials, increasing operation costs	
Uneconomic and unsustainable project design	
Inappropriate selection of technology or equipment	
Low construction quality and materials in the project construction	
Failure to consider humidity and corrosion from the weather during construction	
Lack of specialized training for the operation team personnel	Factors related to human resource management in maintenance
Shortage of specialized personnel with relevant work experience and technical knowledge	
Absence of clear job and legal guidelines	
Weakness in communication and teamwork within operation team	
Continuous turnover of key managers during the project	
Lack of management team skills and experience	
Inadequate training of operation personnel	
Loss of specialized operation team personnel for various reasons	
Lack of a continuous training system for the operation team	
Frequent changes in owner or operator and use of non-specialized individuals	Weakness in operation management knowledge
Lack of risk and knowledge management system	
Absence of a specialized manager in the operation phase	
Failure to conduct a separate performance evaluation by the supervision team	
Over-reliance on external contractors rather than strengthening the maintenance team	
Inconsistency in project information recording (e.g., warranty, technical, and usage information)	
Misalignment between managers and stakeholders	Stakeholder-related factors
Lack of a knowledge transfer program between the construction and operation phases	
Weakness in horizontal and vertical project communication	
Strategy for managing stakeholder expectations	
Conflicts of interest among project stakeholders	
Misalignment between the employer, contractor, consultant, and operator	
Inefficiency of financial and legal contracts	
Inaccurate estimation of costs and cash flow	Financial and economic problems
Lack of a sustainable revenue model in operation (charges, rent, advertising, etc.)	
Lack of financial resources in the operation and maintenance phase	
Inefficiency of financing through government loans and banks, considering inflation	
Cultural incompatibility with operational financing models, such as service charges	
Costly post-operation modifications to meet standards	
Inefficiency of financing through pre-sale and partnership contracts in the private sector	

Open code	Component
Change in building and equipment usage and increased costs	Unpredictable changes in environmental and social factors
Macro-political and managerial changes and upstream decisions in the country	
Failure to consider changing societal needs and lifestyles	
Macro-political factors affecting the housing market trend	
Social or cultural resistance to project acceptance	
Lack of alignment with climate and environmental sustainability	
Political pressures or environmental regulations	
Cultural and social incompatibility with the project location	
Inaccurate site selection	
Failure to consider the cultural and economic context of society	
Political and economic instability	
Lack of alternative scenarios and operational risk analysis	
Lack of comprehensive project environment analysis	Lack of a strategic plan and operational guidelines
Absence of a long-term operation and maintenance plan	
Failure to designate a specific organization or responsible party for operation and maintenance	
Budget and cost risk management considering increasing inflation and exchange rate fluctuations	
Lack of equipment identification and preventive maintenance information	
Review and update of risk management in design principles and macro project objectives	
Weakness in strategic decision-making and policy-making	
Lack of maintenance and repair standards in the organization	Failure to implement safety and standard guidelines
Inconsistency of mechanical and electrical systems	
Failure to properly execute safety plans and strategies by the operation team	
Failure to maintain continuous documentation using modern control tools (BIM, QMS)	
Lack of safety and standard guidelines for risk management and project knowledge	

Table 4. Categorization of codes for strategies to optimize and prevent project failure during the operation phase

Open code	Component
Creating a database of failure history and utilizing it in predictive analysis	Maintenance and repair management as the foundation of project efficiency
Inspection-based risk (RBI) planning for high-risk equipment	
Implementing sensor-based monitoring for critical machinery	
Designing a maintenance plan based on criticality analysis	
Establishing a permit-to-work system for controlling repair activities	
Standardizing PM processes according to RCM2 or PMO2000	

Open code	Component
Creating a detailed asset register, including all assets with standard coding	Asset management and the role of standards in operational success
Calculating the total cost of ownership (TCO) for better financial planning	
Utilizing life cycle costing (LCC) models	
Determining different strategies for managing assets	
Synchronizing the asset system with the organization's ERP	
Conducting periodic compliance audits with ISO 55000	
Holding practical training courses alongside theoretical training	Knowledge transfer and compliance with legal requirements
Preparing customized operational checklists for each piece of equipment	
Conducting pre-startup safety review (PSSR) tests	
Creating a digital documentation bank and regularly updating it	
Recording symptoms for tracking until complete resolution	
Developing operational checklist programs in accordance with PMBOK standards	
Developing a safety system to reduce human error	Safety, health, and environmental management and reduction of operational risks
Conducting HAZOP and HIRA for operational processes	
Establishing a trained emergency team	
Conducting fire and crisis drills	
Environmental monitoring: control of noise pollution, effluents, waste, and emissions	
Peak load management and intelligent control	Energy optimization and development of sustainable operation
Implementing AI-based energy consumption forecasting models	
Monitoring the productivity of large equipment (boilers, chillers, and compressors)	
Analyzing maintenance costs by asset/area/contractor	
Determining Min/Max stock for consumable items	Spare parts and warehouse management
ABC and VED analysis for inventory prioritization	
Using RFID or barcode systems for tracking	
Establishing vendor-managed inventory (VMI) contracts with suppliers	
Developing an inventory depletion warning system	
Maintaining suitable environmental conditions for sensitive parts	
Annual technical-financial evaluation of contractors	Contractor and service contract management
Developing HSE and quality criteria for contractors	
Establishing a scoring and annual evaluation system	
Mandating digital reporting and information recording in specific registers	
Maintaining service level agreements (SLAs) between internal units	
Conducting internal audits to prepare for official inspections	
Managing legal documents and certificates with software	
Creating a budget forecasting model	Capital planning and user/operator management
Prioritizing investments	
Designing a five-year asset improvement roadmap	
ROI analysis of energy and predictive maintenance projects	
Establishing a financial reserve fund for major failures (owner charges)	

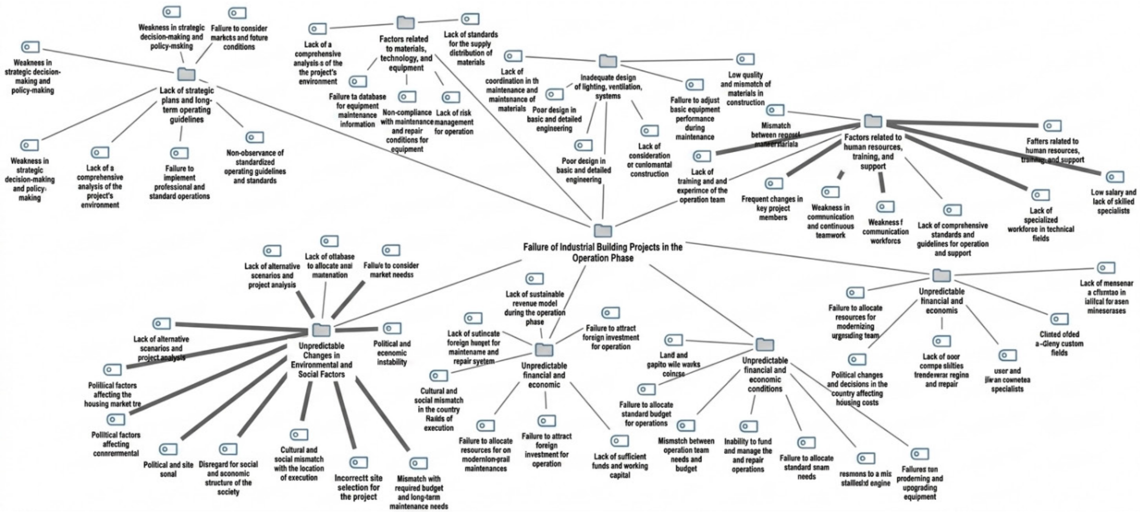

Figure 1. Categorization of main codes and influential criteria in the failure of construction industry projects during the operation phase

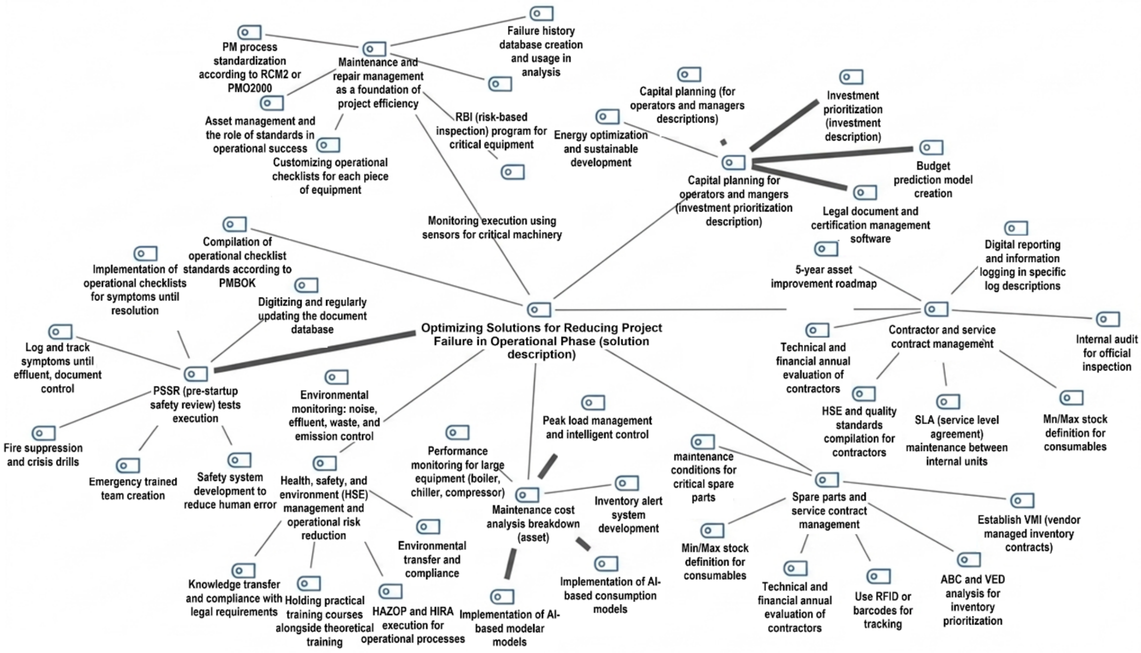

Figure 2. Categorization of main codes and influential criteria for strategies to optimize and prevent project failure during the operation phase

5. Discussion

Based on the first research question, "What factors contribute to the failure to achieve success in construction projects during the operation phase?", we identified 59 influential indicators, all of which demonstrate appropriate validity. A review of the research literature revealed several categories of key factors that are the most significant root causes of failure during the operation phase:

1. Weak planning and management in the initial phases
2. Inappropriate design, design errors, or frequent design changes
3. Deficiencies in resource allocation and management: human resources, skilled labor, materials, and equipment
4. Deficiencies in supervision, quality control, and site management during execution
5. Weakness in communication and coordination among project stakeholders (employer, contractor, consultant, supervisor, etc.)
6. Short-term focus on delivery of construction rather

than a long-term perspective on operation and maintenance

7. Environmental risks and external factors, including material price fluctuations, unfavorable economic or political conditions, and the financial status of the contractor or employer

The findings of this research align with those of studies by Behboudi and Fili (2024), Zeinalian et al. (2022), Zhang et al. (2024), and Komurlu et al. (2024). To clarify this result, construction projects are generally divided into three main phases: design, construction, and operation. The operation phase lasts the longest within the project life cycle, and the long-term performance of the building, including structural durability, physical quality, quality of life or operation, maintenance costs, and stakeholder satisfaction, is primarily determined during this phase. Therefore, the true success of a construction project should not be limited to delivery time, cost, or construction progress; rather, the durability, efficiency, and sustainability of the building's performance during the operation period must also be considered. However, research indicates that many construction projects encounter numerous problems after delivery, specifically during the operation phase: low-quality structures or facilities, frequent repairs or modifications, high maintenance costs, or user dissatisfaction with the building's condition. This "failure in the operation phase" often reflects deficiencies from earlier stages – such as design, management, execution, or supervision – and analyzing the factors contributing to this failure is essential to prevent it in future projects. Current studies in the construction industry show that project failure occurs not only during the construction phase but also in the long-term performance of the building, with causes ranging from weak management, design changes, and inaccurate initial estimates to poor execution quality and insufficient supervision. Therefore, the project must be managed as a continuous chain from design through to operation and maintenance, with success criteria extending beyond the physical delivery of the building. If such risks are overlooked during planning or if risk management is weak, the project may fail to sustain the required level of sustainability after completion.

Based on the second research question, "What strategies exist for optimizing and preventing project failure during the operation phase?", we determined 45 influential indicators, all possessing appropriate validity. A review of the research literature revealed several categories of key strategies for optimizing and preventing project failure during the operation phase:

1. Senior management commitment and organizational support
2. Precise quality monitoring and quality assurance during construction and delivery
3. Development and implementation of maintenance and operation plans
4. Empowerment and skill enhancement of the operation/maintenance team and technical knowledge transfer
5. Defining success indicators beyond construction, focusing on operational performance (performance, stakeholder satisfaction, durability, and sustainability)
6. Utilizing modern management methods, planning, and technology (including BIM and digitization) to improve operational and building maintenance
7. Effective interaction and coordination among stakeholders (owner, contractor, consultant, operator, and maintenance team) and transparency in contracts and post-delivery commitments

This research's findings are consistent with those of studies by Sheikhzadegan Khiavi et al. (2023), Rahimi Salkuyeh et al. (2020), and Zoufa (2017). It can be explained that, upon completing the construction phase and physically delivering the project, the building enters the operation stage. This period is especially critical because the long-term performance, including structural durability, facility quality, operator satisfaction, maintenance costs, and sustainability, is shaped during this stage. Achieving true project success involves not only effective execution and delivery but also ensuring efficiency, reliability, and stakeholder satisfaction during the operation phase. Many issues in the operation phase stem from weaknesses during construction and the lack of quality supervision during implementation. Research shows that implementing a quality control and assurance system during construction can significantly improve operational performance. Therefore, to ensure project success during operation, it's vital to incorporate a comprehensive "project life cycle" framework from the early stages of planning, design, execution, and delivery. In other words, project success should not be measured solely at the time of building delivery; rather, efficiency, durability, and operator satisfaction throughout the operational life should also be considered as success indicators. Furthermore, recent studies have shown that attention to these factors, including management, quality, design, technical team capability, and operational support, increases the probability of project success during operation.

5.1. Recommendations

- Employers and contractors should develop a formal program before project delivery, including equipment operation guidelines, periodic inspection schedules, spare parts lists, and troubleshooting procedures. This action can prevent premature failures and reduce long-term maintenance costs.
- Lack of coordination among design, construction, and operation teams leads to a mismatch between project performance and actual operator needs. Life cycle studies emphasize that operator participation in the early stages of design and construction reduces operational problems. Regular meetings among these teams should be held, and key decisions should be made considering the operation phase requirements.
- Research has identified the choice of inexperienced and technically unqualified contractors and consultants as a key factor in project failure. To avoid operational issues, it is recommended that the selection process be based on qualitative criteria, performance history, technical competence, and standard certifications.
- Selection of low-cost, low-durability equipment is a major factor in increasing operation and maintenance costs. Employing life cycle cost analysis can lead to the selection of higher-quality and more suitable equipment for operation. It is recommended that employers and designers use this method as a decision-making tool.
- At all project stages, from feasibility and design through construction and operation, a comprehensive and future-oriented approach should be adopted. Attention to stakeholder analysis, detailed maintenance and repair planning, and the establishment of flexible and efficient management structures are fundamental steps toward ensuring the long-term success of civil projects.

Authors' Contributions

The authors contributed equally to this research.

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Conflict of Interest

The authors declared no conflict of interest regarding the conduct of this research.

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