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Original Article

Critical Delay Factors in Construction Projects and Their Proposed Solutions from the Perspective of Total Quality Management

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Abstract - *Construction frequently encounters delays, which are a prevalent challenge. Any point in time during the project's development might see a delay, either on its own or in combination with others. This study identifies the main causes, their effects, and ways to reduce delays in a construction project. This study used a literature review, workshops with contractors, clients, consultants, and a questionnaire. It was concluded that poor contract documents, escalation in material prices, poor focus on customers, delay in releasing the payments by clients, disputes, and design errors are the major delay factors of construction projects.*

Keywords - *Saudi construction projects, Delay factors, Total Quality Management, Construction delay.*

1. Introduction

The construction industry is one of the most significant economic sectors that play a crucial role in economic development in all countries. This is especially true in Egypt and Saudi Arabia. However, many projects have suffered delays exceeding contracted time and cost estimates. It is known that the construction industry in Egypt and Saudi Arabia is growing very quickly. There are many major projects currently in progress. Of these, a few have been completed on time, the rest have suffered delays, and some have not yet been completed (Al-Momani 2013).In recent years, the city of Makkah has benefited from massive public investment in infrastructure projects. As a result, most of these projects ran behind schedule. Delays in public construction projects have been recognized by the Saudi Ministry of Transportation (MOT) and the Ministry of Municipal and Rural Affairs (MOMRA). According to their claims, they had gone about 75% beyond their allocated time. (MOMRA 2017). Various factors primarily induce these construction project delays, including, but not limited to, improper planning or expecting different scenarios from reality during the planning and actual implementation of the project.

Moreover, the engineer might not be aware of all the potential problems that could arise with the project; for example, a scenario on the job site might be anticipated by site management in a different way than what is anticipated by the designer or planner. Moreover, it is reported that delays and cost overruns have significant negative economic impacts. Delays in these projects limit the economy's growth potential. Reviewing many studies on the construction industry, the researcher found a large group of theoretical and experimental research on this lingering issue of delayed projects. However, by definition, construction delays can be divided into different classifications. These categories of delays can be seen in these four major categories (Abdelalim and Eldesouky, Amer 2017).

1.1. Critical Delays and Non-Critical Delays

Critical delays hinder the contractor from achieving the agreed-upon completion date stated in the contract. This notion is based on the Critical Path Method (CPM), which assists in identifying crucial tasks in construction projects and other types of projects where critical activities exist universally.

1.2. Justified and Unjustified Delays

Justified delays are delays resulting from an unforeseen event, such as a force majeure that is beyond the control of the subcontractor or the client. Normally, it depends on the contract terms. In contrast, unjustified delays are events within the contractor's control or could be foreseen.

1.3. Compensable or Non-Compensable Delays

Contractors are entitled to additional time and compensation when they have compensable delays. However, delays that are not compensable mean that the contractor will not get any further payment. These holdups are often considered the contractor's fault because of their behaviour or negligent conduct.

1.4. Concurrent Delays

Experts use a multitude of factors when defining concurrent delays. The Association for the Advancement of Cost Engineering (AACE) has a Recommended Practice (RP) 10S-90 titled Cost Engineering Terminology that is often mentioned in delay claims. However, RP 10S-90 provides no uniform concept of concurrent delays. Here are three of these definitions:

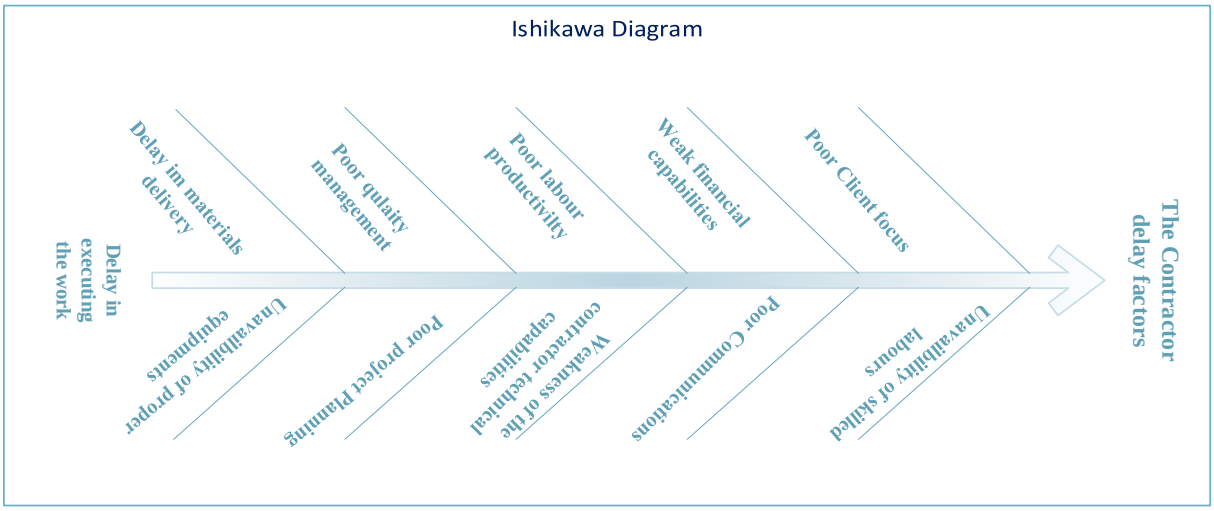

Fig. 1 An example of an Ishikawa diagram for the contractor delay factors

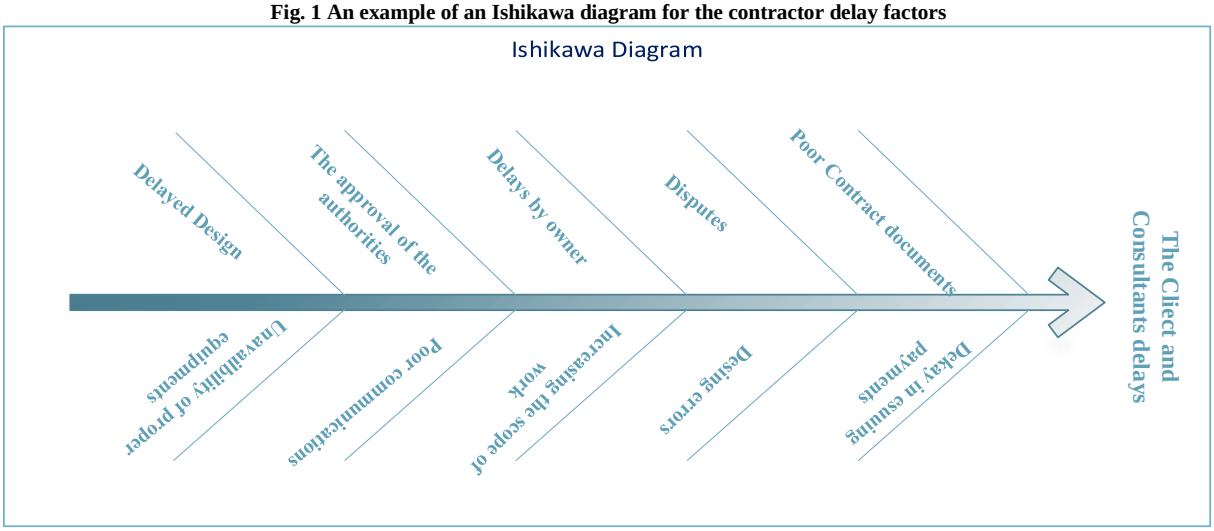

Fig. 2 An example of an Ishikawa diagram for the client and consultant's delay factors

- Two or more delays occur or overlap during the same period, affecting the project delivery date.
- When several separate sources of delay occur at the same time. The occurrence of two or more events that cause delays, when one of these occurrences is caused by the employer and has negative effects on the project, while the contractor causes the other and has the same effect.

1.5. Research Objectives

This study aims to identify the critical delay factors that cause delays in construction project delivery in Egypt and Saudi Arabia. In order to propose solutions to overcome delay causes or mitigate their effects from the perspective of Total Quality Management (TQM).

1.6. Research Problem

It was common for construction projects to encounter many challenges, including delays in completing contracts according to schedule. Therefore, the researcher studied the delay factors and methods of addressing them to mitigate or overcome their impact and put the necessary plans to avoid delay, as delay often leads to disputes, which in turn also require time to settle disputes, which results in many negative effects that affect the relationship between the owner and the contractor. It also causes cost and time overruns, resulting in contract parties' losses.

In the construction industry, delay can be defined as exceeding the schedule either after the completion date specified in the contract or after the date agreed upon by the parties to deliver the project. The project that suffers from delay is behind the planned contractual schedule. This problem is a common problem in construction projects. For the owner, this delay means lost revenue. For the contractor, this delay means an increase in overhead costs due to a longer work period, higher material costs, and an increased cost of labor and equipment. In general, projects completed on time indicate efficiency. However, the construction process has many unexpected variables that create challenges, as given in Fig.1-2.

In light of previous research from different countries, this research primarily held workshops in October 2022 at the Ministry of Housing Campus, Jeddah, Saudi Arabia, in December 2022 in Egypt, and in January 2023 again in Saudi Arabia, with project managers, consulting officers, and those interested in the construction industry. The

researcher discusses the reasons for construction delays in Egypt and Saudi construction projects.

Are they due to reasons related to the owner or the contractor, the contractor alone, or the surrounding risks and weather conditions? It was found that the most common causes of delay in construction projects are mainly material availability, the lack of skilled labour, unavailability of appropriate equipment, delayed design, poor contract documents, changes in scope, delay in executing the works by the contractor, weaknesses in the contractor's technical capabilities, weakness in contractor's financial capabilities, delays by the landlord, stakeholders, delays in obtaining the necessary permits and approvals, poor quality management, increasing materials prices, disputes, delayed monthly payments, miscommunication between project stakeholders, poor project planning, changing laws and legislation, poor customer focus, poor labor productivity, and poor design offices cause design errors.

2. Literature Review

Many studies have been conducted to determine the causes of delays in construction projects. Tafazzoli (2017) studied the most significant causes of delays in the construction industry in the United States using the relative importance index method (Tafazzoli and Shrestha 2017). The study showed that 30 factors affect delays. The most important results showed that many change orders, time, decision-making processes, and time consumption by the owners are the main delay factors.

Hussain et al. (2018) evaluated Annual Development Programme public sector construction infrastructure project delays through a relative importance index (Hussain, Zhu, et al. 2018). A comprehensive literature review classified 52 factors that cause delays into eight groups. Fifteen professional constructors participated in the pilot study. Experts in public works construction evaluated each survey item. In all, 102 persons were surveyed. The top eight critical delaying factors were inadequate contractor experience, improper project feasibility studies, land usage disputes, extreme weather, improper contractor financing, improper progress payments, and improper project surveys.

Results from Spearman's rank correlation tests demonstrated agreement between contractors and owners. The findings of this research were supported by a comparison of the top five reasons for delay with eight other building sectors in Asia. Marzouk and El Rasas (2014) studied the causes of construction project delays in Egypt. According to their analysis, the main causes of delays were the project owner, consultants, developers, materials supply, workers, machinery, and related external delay factors (Marzouk and El-Rasas, 2014).

Doloi et al. (2012) analyzed the factors contributing to delays in Indian construction undertakings. Their investigation identified the primary causes of delays in the construction industry in India (Doloi, Sawhney et al. 2012). Their research established the relationship between critical attributes to create prediction models for determining the effects of these factors on delays. Their research was based on questionnaires and in-person interviews. The significance of delay factors was determined using factor analysis and regression modelling. The findings from factor analysis determined that lack of commitment is the most significant factor in delaying construction projects, followed by ineffectual site management and poor site coordination. Assaf and Hajji (2006) surveyed several kinds of Saudi Arabian building projects to assess their efficiency (Assaf and Al-Hejji 2006). Developers, consultants, and contractors were surveyed to ascertain their perspectives on the reasons for delays and the severity of those problems.

Twenty-three builders, nineteen advisors, and fifteen builders participated in the field research. A total of seventy-three factors contributing to project delays were found throughout the study. According to the statistics, most contractors (76%) and consultants (56%) estimate a time overrun of 10% and 30%, respectively. All three parties agreed that "change orders" were the primary cause of delays.

In addition, the poll found that 70% of projects had overrun and that 46% of the 76 projects analysed were running late. While Chalabi and Camp (1984) examined the factors contributing to delays in both the pre-planning and construction stages of construction projects, specifically in developing countries, their research targeted developing nations with relatively skilled and capable labor forces (Chalabi and Camp 1984). The researchers stressed the need for preliminary planning to reduce the frequency and magnitude of the delays and cost overruns that impact most developing nations. Al-Momani (2000) studied the causes of delays in 130 Jordanian public works initiatives. Design issues, changes in ownership, adverse weather conditions, site conditions, delivery delays, economic conditions, and increasing scope of work were identified as the primary causes of delays (Al-Momani 2000). The study emphasized the significance of exhaustively analyzing delay factors and taking action to resolve them, as doing so can aid construction industry stakeholders in reducing disputes.

It was discovered that delays have a substantial effect on the effectiveness and overall performance of contractors. Through the researcher's review of the previous studies above, the most important factors that cause delays in construction projects are poor communication between stakeholders (concerned), force majeure, site condition, slow decision-making, improper planning, lack of materials, increased scope of work, poor design and the weakness of the contract and financing documents. Moreover, some researchers also report that the contract's language is difficult to understand and is a major source of disputes.

Construction projects in Egypt and Saudi Arabia (Jeddah) are also considered global phenomena, especially the big ones. However, research also reveals that the underlying causes and treatments differ from country to country and from time to time. Case studies are very useful in explaining specific cases. However, they have a limited

ability to fully diagnose the fundamental problems that impede the handover of large projects, including housing and infrastructure projects, on time and at the planned cost. In short, the main reasons behind delays, time, and cost overruns in construction projects in Egypt and Saudi Arabia still need more studies and research (Al-Ghafly 2019, Ahmed Mohammed Abdelalim Rizk Elimam A. Youni 2022).

3. Research Methodology

It is survey-based research conducted with people working in the industry and managing construction projects, especially large ones, Ministry of Housing projects, and medium and large-scale projects in the Jeddah area and Cairo. For more accuracy of the results, some workshops were conducted with consultant offices and contracting companies before survey distribution. Then, additional interviews were conducted with the managers of large projects and their supporting teams in each part of the project to identify factors that caused project delays. To prioritize the most significant outcomes and delay factors, workshops were held with 15 engineers, six from Saudi Arabia and nine from Egypt, including project managers and experienced project specialists.

Table 1. Survey responses

Sl. No	Factor	Strongly Agree (5)	Agree (4)	Satisfactory (3)	Disagree (2)	Strongly Disagree (1)
1	Material availability	63	45	17	16	5
2	Unavailability of skilled labour	70	37	31	2	6
3	Unavailability of appropriate equipment	27	21	45	39	14
4	Delay of Designing the Project	54	54	6	27	5
5	Poor contract documents	108	30	8	0	0
6	Changes in scope	108	17	12	6	3
7	Delay in executing the works	28	24	9	57	28
8	Weakness of the contractor's technical capabilities	57	33	24	21	11
9	Weakness of the contractor's financial capabilities	90	36	15	5	0
10	Delays by the owner	93	36	17	0	0
11	Stakeholders	80	46	17	3	0
12	Delays in obtaining necessary permits and approvals	96	27	23	0	0
13	Poor quality management	81	30	21	8	6
14	Escalating of Materials price	96	48	1	1	0
15	Disputes	102	27	17	0	0
16	Delayed issuance of payments	99	39	6	1	1
17	Miscommunication between project stakeholders	57	42	27	12	8
18	Poor Project Planning	45	43	30	20	8
19	Changing laws and legislation (the Saudi authorities have begun localizing some professions for Saudis)	46	45	23	20	12
20	Poor customer focus	100	35	11	0	0
21	Poor labour productivity	95	21	20	10	0
22	Design errors as a result of poor-quality design offices	102	26	15	3	0

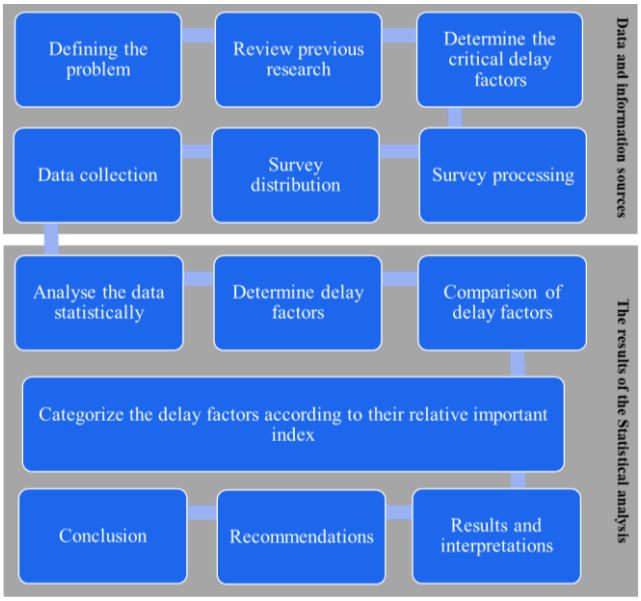

Fig. 3 Research Methodology

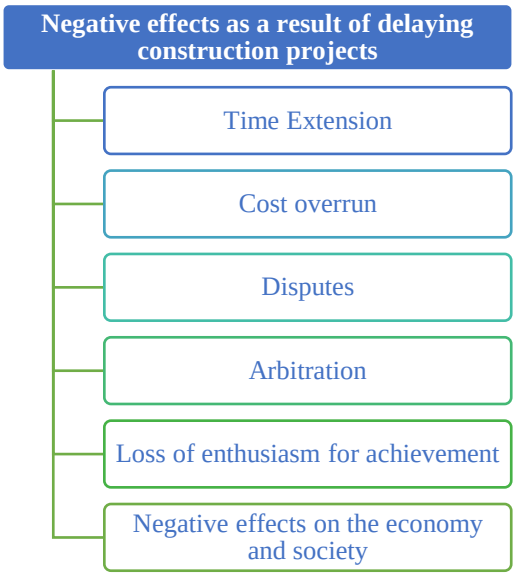

Fig. 4 Negative effect of the delay in construction projects

These workshops were held for discussion and analysis. As a result of the interviews, a comprehensive list of project delay factors was collected. Of 340 responses, 146 were received; 50 were from Saudi Arabia, and 96 were from Egypt. Firstly, the questionnaire was sent via Google Forms to get approval to conduct the survey. Then, interviews were carried out with available respondents (about 60% of the total); the remaining respondents were discussed through Zoom meetings to collect their responses. The data was collected in six months. All participants had significant prior experience, and many had advanced degrees (either a master's or a doctorate) (Table 1).

A five-point Likert scale with interval levels ranging from 1 (strongly disagree) to 5 (strongly agree) was used to evaluate the survey. A 5-point Likert scale is considered appropriate for the multivariate analysis technique used in the current study (Hair 2009). The survey was carefully designed to allow respondents to provide the importance and causes of delays in construction projects based on their experience.

Finally, additional interviews were conducted in Saudi Arabia in February 2023 for approximately two hours per meeting in two separate meetings to assess the results. Four highly experienced project managers in Ministry of Health (MOH) projects who did not participate in the workshop were asked to propose factors for delaying a large project. This was done according to their preferences. These were also compared with the survey results and were highly consistent with the findings (Fig. 3).

3.1. Data Analysis

For Data analysis, the Author used SPSS software. The Relative Importance Index (RII) ranking method was applied to rank the different causes of delays in order of importance, whereby the most significant delay factors in the construction industry can be identified. A five-component Likert scale was converted into RII for each factor as follows:

$$\text{RII}=\frac{\Sigma W}{AN}=\frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \quad (1)$$

Where:

W = Weight is given to each factor (ranging from 1 to 5)
N = Total number of respondents

The higher the RII value indicates, the more important the delay factor for the construction industry.

4. Results and Discussion

The causes within each category are ranked according to the RII measurement per Eq. (1). In Table 2-3, a concise discussion of the ranking of the factors is given in detail. The significance of the statistical analyses gives the result as follows. The weakness of the contract documents is considered one of the most important causes of critical delay in large construction projects in Egypt and Saudi Arabia, as per 91.2% of the survey sample. The increase in materials prices is the second cause of critical delay in large construction projects, as per 90.27% of the survey correspondent, followed by poor customer focus (89.73%), the delay in issuing the payments (89.60%), represents disputes (89.20%), design errors as a result of the presence of low-level design offices (88.67%), delays by the owner (88%), the changes in the scope of work (87.87%), the delays in obtaining necessary permits and approvals (87.60%), the weakness of the contractor's financial capabilities (86.53%), the stakeholders (85.47%), poor labour productivity (85.20%), poor quality (81.33%), the unavailability of skilled labour (80.13%), material availability (77.73%), miscommunication between project stakeholders (75.47%), the delay in designing projects (75.07%), the weakness of the contractor's technical capabilities (72.27%), poor project planning (71.33%), hanging laws, procedures, and legislation, for example the start of the Saudi competent authorities' policy of settling some professions with Saudis (70.80%), the lack of appropriate equipment (59.47%), and the delay in the implementation of the works (54%). This finding is consistent with many researchers conducted in Egypt, Saudi Arabia, and other countries who have reached the same conclusion (Abd El-Hamid, Al-Sulaihi, Al-Hammad 2010, El-Sayegh 2016, Abou-El-Makarem 2018).

Moreover, Fig. 4 shows negative effects due to delaying construction projects. Therefore, those in charge of the project, whether the owner, consultant, contractor, or subcontractors, work together and face the challenges and causes of delay with proper planning. These stakeholders should look properly at factors such as duration, supply of materials, risks, and scope, extensive study, review, and coordination of drawings to ensure they are at the proper level required, predict changes since the project began, and alert them. Also, the contract documents should be carefully reviewed, and their comments should be raised for rectification at the beginning of the contract. This study employed a broader strategy than prior research concentrating on certain aspects of construction delay. A more thorough investigation of the intricate network of factors causing delays was made possible by using TQM principles. A well-constructed questionnaire, workshops with key stakeholders, including contractors, clients, and consultants, and an extensive literature review all helped to provide a firm foundation for the study. The essential insights gained from these many sources aided in the complete identification of delay reasons and their linked nature in building projects. Using TQM principles as a foundation, the proposed solutions evolved into realistic and situationally relevant strategies for reducing delays. This study stands out as a valuable contribution to the field because of its thorough approach and the new perspectives it incorporates. It helps to comprehend critical delay factors better and encourages the development of TQM-driven solutions for construction project management.

According to the above results and by applying the principles of TQM, project managers can increase the probability of handing over the project with specifications that meet the client's requirements and specifications on time and within budget, ultimately reducing delays and disputes.

Table 2. Categorizing the results as per Relative Importance Index

Factor	Rank	Relative Importance Index
Poor contract documents	1	91.2
Escalating of Materials price	2	90.27
Poor customer focus	3	89.73
Delayed issuance of payments	4	89.6
Disputes	5	89.2
Design errors as a result of poor-quality design offices	6	88.67
Delays by the owner	7	88
Changes in scope.	8	87.87
Delays in obtaining necessary permits and approvals	9	87.6
The weakness of the contractor's financial capabilities	10	86.53
Stakeholders	11	85.47
Poor labour productivity	12	85.2
Poor quality management.	13	81.33
Unavailability of skilled labour	14	80.13
Material availability	15	77.73
Miscommunication between project stakeholders.	16	75.47
Delay of Designing the Project	17	75.07
Weakness of the contractor's technical capabilities	18	72.27
Poor Project planning	19	71.33
Changing laws and legislation (the Saudi authorities have begun localizing some professions for Saudis).	20	70.8
Unavailability of appropriate equipment	21	59.47
Delay in executing the works	22	54

Table 3. Statistical analyses of the survey data

S.No	Factor	Mean	Standard Deviation	T-test	Sample Orientation	Rank	RII
1	Material availability	3.89	1.46	7.33	Agree	15	77.73
2	Unavailability of skilled labour	4.01	1.41	8.61	Agree	14	80.13
3	Unavailability of appropriate equipment	2.97	1.42	-0.23	Satisfactory	21	59.47
4	Delay in Designing the Project	3.75	1.49	6.11	Agree	17	75.07
5	Poor contract documents	4.56	1.22	15.49	Strongly agree	1	91.2
6	Changes in scope	4.39	1.41	11.96	Strongly agree	8	87.87
7	Delay in executing the works by the contractor	2.7	1.56	-2.32	Satisfactory	22	54
8	Weakness of the contractor's technical capabilities	3.61	1.57	4.73	Agree	18	72.27
9	Weak financial capabilities of the contractor	4.33	1.3	12.3	Strongly agree	10	86.53
10	Delays by the owner	4.40	1.25	13.55	Strongly agree	7	88
11	Stakeholders	4.27	1.27	12.13	Strongly agree	11	85.47
12	Delays in obtaining necessary permits and approvals	4.38	1.28	13.05	Strongly agree	9	87.6
13	Poor quality management	4.07	1.47	8.74	Agree	13	81.33
14	Escalating of Materials price	4.51	1.19	15.35	Strongly agree	2	90.27
15	Disputes	4.46	1.26	14.03	Strongly agree	5	89.2
16	Delayed issuance of payments	4.48	1.25	14.32	Strongly agree	4	89.6
17	Miscommunication between project stakeholders	3.77	1.47	6.34	Agree	16	75.47
18	Poor project planning	3.57	1.47	4.67	Agree	19	71.33
19	Changing laws and legislation (the Saudi authorities have begun localizing some professions for Saudis)	3.54	1.52	4.28	Agree	20	70.8
20	Poor customer focus	4.49	1.23	14.63	Strongly agree	3	89.73
21	Poor labour productivity	4.26	1.39	10.96	Strongly agree	12	85.2
22	Design errors as a result of poor-quality design offices	4.43	1.29	13.41	Strongly agree	6	88.67

Therefore, the researcher recommends taking care of the comprehensive planning of the project from the beginning of the project (design phase) until the final close of the project as follows:

4.1. For the Client and the Consultant

- There is a need to speed up the approval of design drawings and materials for the project.
- The need to complete the issuance of the necessary licenses for the project on time.
- The commitment to site studies, soil tests, and technical analyses.
- Identify potential risks and develop a management plan to avoid/mitigate them.
- Scope of the work management plan and change management plan to be carried out from the design phase to close out.
- Accuracy of cost estimation by the entity that owns the project in a way that helps to set financial appropriations so that the budget is closer to reality.
- Quality Assurance (QA) and Quality Control (QC) are required for design quality and preparing contract documents with high accuracy to avoid future issues and changes that negatively affect the project.
- Ensure the project site is ready and free from any obstacles to start project execution without delay under the contracted program.
- Setting the necessary criteria for evaluating and qualifying contractors to ensure contractor ability to implement projects and comply with contractual obligations.
- Attention to comprehensive quality, conducting periodic quality inspections, and monitoring construction work to ensure it conforms to project specifications and expectations.
- Ensure that the contractor is technically and administratively capable by studying and evaluating the technical and financial offer. Projects must be awarded according to the financial and technical offer.
- Payment must be promptly certified on time to avoid delaying the project or any claims.
- Carry out the work assigned to the sub-contractors appointed by the owner on the specified dates.
- The consultant fulfills his contractual duties, including supervising the work, following up on the progress of the work and taking the necessary measures to ensure the implementation of the principles of total quality in the project**.**
- Applying the principles of TQM regarding the continuous technical and administrative improvement of the project by all parties.

4.2. For the Contractor

- It is necessary to give the work team sufficient time to ensure accuracy and quality in presenting financial and technical project proposals by studying documents and drawings.
- There is a need to take prior measures regarding leasing or purchasing equipment for the project.
- Develop a comprehensive and detailed project plan with a realistic program and resource plan.
- Identify potential risks and develop a management plan to avoid/mitigate them.
- It is necessary to prepare the scope management plan and project change management plan from the start date to the date of closing out the project.
- Develop cash flow and cash flow out plans for every project.
- Managing security and safety in the project in a way that maintains security and safety for workers, the project, and stakeholders.
- Establish clear communication and coordination between all project stakeholders, including contractors, subcontractors, suppliers, and customers.
- Focusing on the owner's satisfaction and stakeholders in general.
- Pay attention to total quality, conduct periodic quality inspections, and monitor construction work to ensure it conforms to project specifications and expectations.
- Use TQM tools, such as continuous improvement processes, to quickly identify and correct quality issues.
- Encourage feedback and collaboration among all stakeholders to identify potential issues as early as possible.
- Create strategic partnerships with suppliers and subcontractors to ensure the supply of materials and completion of work on time according to the project schedule.
- Studying and coordinating the drawings and studying the project's technical specifications when developing those specifications, not only copying previously used specifications.
- Speed up the approval of the work and project materials programs, especially long lead items.
- Periodic follow-up of the contractor's contract management and ensuring it does what is required.
- Pay attention to employing skilled workers who know project security and safety procedures.

5. Conclusion

Egypt and Saudi Arabia are developing countries, and their population is increasing, especially in Egypt. Population growth increases pressure on infrastructure and construction. So, there are many projects in both countries. Since the construction sector is one of the tributaries of the national economy in both countries, the government and private sectors are working hard to achieve such development. Many private organizations are also working towards the same goal, but delays have caused a significant impact on many of the projects. So, we recommend more research into delay factors in construction projects. This will enable us to identify the critical factors that cause delays and find appropriate solutions. Through this research, we advise proper planning for each major project separately. We advise studying the problems from previous experiences and what may emerge from them. This will enable us to plan to overcome or mitigate adverse economic effects.

Declarations and Statements

Data Availability Statement

Data is available and will be provided at the editor's request.

Author Contributions

The authors have contributed to writing, designing, compiling, and editing the final manuscript.

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