Journal of Construction Engineering, Management & Innovation
2024 7(2):157-171
DOI 10.31462/jcemi.2024.02157171

RESEARCH ARTICLE

Mitigating delays and disputes in industrial construction projects: Lessons from a thermal power plant project in Turkey

Selin Alp Yağcı, Merve Çapraz, Gürkan Emre Gürcanlı

Istanbul Technical University, Faculty of Civil Engineering, İstanbul, Türkiye

Article History

Received 17 May 2024
Accepted 16 June 2024

Keywords

Industrial plant construction projects
Thermal power plant
Delays
Disputes
Risk Management
Project Management
Contract Management

Abstract

Industrial plant construction projects are inherently complex, often involving numerous stakeholders, detailed technical specifications, and strict deadlines. Delays in these projects can have a significant impact on financial and operational aspects, including budgets, completion timelines, and overall plant efficiency. While previous research has primarily focused on civil and residential projects, there is a critical need to understand the specific factors causing delays and disputes in industrial plant construction. This study addresses this gap by examining a thermal power plant project in Turkey. A detailed case study analysis was conducted to investigate 12 work packages that had been subject to disputes between the Employer and the contractor. The methodology involved a comprehensive delay analysis with the objective of identifying the root causes of these disputes and delays. The study's key findings indicate that the late submission of design documents, project design changes, inadequate planning and poor communication were major contributors to delays. The study offers practical recommendations for improving project management practices, refining contractual agreements, and enhancing risk mitigation strategies. The findings have significant implications for stakeholders in industrial plant construction, offering strategies to mitigate delays and foster better collaboration between employers and contractors. This research contributes to the field by emphasizing the importance of minimizing delays and disputes through proactive risk management and effective communication to achieve project success.

1. Introduction

Although there have been numerous studies on delays and disputes in construction projects and although specialized industrial construction usually involves very large-scale projects with a high degree of technological complexity, research has mostly focused on civil and residential success factors [1]. Thus, it has been recognized that more research is needed to identify the key factors affecting delays and disputes specific to one of the types of construction projects, namely industrial plant projects, and to identify and develop strategies to mitigate them.

Industrial plant construction projects are complex and challenging undertakings, often involving multiple stakeholders, intricate technical specifications, and tight deadlines. a great number of disciplines are involved in industrial construction projects. Depending on the precise for nature of the project, disciplines such as processing, piping,

Correspondence Selin Alp Yağcı alpse@itu.edu.tr

eISSN 2630-5771

product routing and logistics, mechanical-, electrical- and instrumentational engineering and construction will be involved, represented by specialists from within the client organization as well as from machine and installation vendors. Additionally, non-technical disciplines such as finance and personnel will influence the execution of the project [2].

Modern industrial construction projects, such as coal plant workshop, including construction, structure, water supply and drainage, electrical, ventilation, power, technology and fire and many other professional pipelines and various professional equipment [3].

The industrial construction process is a large-scale project with several supply chains involved including drafting, material supply, shop fabrication and module assembly and site construction [4].

Takim and Akintoye (2022), evaluated the key performance indicators of construction projects and identified time, quality, and cost as the most important factors to assess the success of these projects [5]. Delays in industrial plant construction projects can have significant financial and operational consequences, including the impact on project budgets, completion dates, and the overall efficiency of the industrial plant. Both contractors and project owners are adversely affected by the complications that arise from delays [6]. It is of the utmost importance to understand the causes of delays and to develop effective mitigation strategies in order to ensure the successful completion of these projects. Industrial firms who pay close attention to the peculiar characteristics of the industrial construction industry and its changing operating environment will be able to take advantage of favorable conditions and to avoid pitfalls [1].

According to the review by Wepari et al. (2024), underestimation of time for completion of projects by contractors, poor site management (Fugar and Agyakwah-Baah (2010). Ghana), incompetent site management and supervision, too many change orders by clients, and lack of proper planning and scheduling (Yap et al. (2021). Malaysia), lack of interest in timetables and updating them constantly, variations, errors relating to quantities and design, poor coordination (Alsuliman (2019). Saudi Arabia), poor communication, lack of coordination and conflicts between stakeholders, ineffective or improper planning (Durdyev and Hosseini (2020) are compiled as causal factors of construction project delays [7 ,8 ,9, 10, 11].

In order to substantiate these findings, a case study will be conducted, utilizing other sources within the existing literature to identify the specific reasons that apply to industrial plant projects.

Since the objective of this research is to identify the key factors influencing delays and disputes in industrial plant projects, where there is a paucity of existing literature on the subject; a thermal power plant project in Turkey was employed as a case study to address this issue, as it represents a project that falls within the scope of this research.

In this context, this paper undertakes an in-depth examination of 12 work packages that were the subject of disputes between the Employer and the Contractor within the scope of thermal power plant project in Turkey, shedding light on the specific risks encountered and their potential consequences. Through a comprehensive delay analysis, this study identifies the root causes of disputes between the Employer and the Contractor, and project delays providing valuable insights into the intricacies of industrial construction projects.

Furthermore, this research draws upon the findings of the delay analysis to offer practical recommendations aimed at mitigating the characteristic risks associated with industrial construction projects. By addressing key areas such as project management practices, contractual agreements, and risk mitigation strategies, these recommendations seek to foster greater collaboration and efficiency between employers and contractors. This, in turn, should enhance the likelihood of project success.

In essence, this paper serves as a valuable resource for stakeholders involved in industrial construction projects, offering actionable insights and best practices to navigate the challenges posed by such endeavors and achieve favorable outcomes.

2. Literature Review

A comprehensive literature review was conducted to investigate the key factors contributing to delays and disputes in industrial plant construction projects. This approach allowed for the identification of gaps in the current research, the rationale behind the development of specific research methodologies and the findings and solutions derived from these methodologies.

A review of the literature revealed several key factors that contribute to delays and disputes.

A number of studies have sought to identify the root causes of time delays, with particular focus on developing countries. The primary underlying construction delay factors were identified by utilizing the Relative Importance Index (RII) method in Turkey. This was achieved by administering a survey to a total of 64 construction professionals, who were asked to respond to questions pertaining to 83-time delay factors. The results indicated that inadequate experience of contractors, ineffective project scheduling and planning, and poor site management and control were the three most significant factors contributing to time delays [12].

According to the analysis made by Fallahnejad (2013) based on his research on Iranian gas pipeline projects and a survey of industry experts, unrealistic project timelines and change orders have played an important role in delaying projects [13, 14].

A study by Doloi et al. (2012) on construction projects in India found that lack of commitment, inefficient site management, poor site coordination, inappropriate planning, lack of clarity in project scope, lack of communication and substandard contracting all played a significant role in delaying construction projects [14, 15].

Similarly, the research conducted by Assaf and Al-hejji (2006) on the causes of delays in major projects concluded that changes represent a significant contributing factor to such delays [14, 16].

According to these approaches, one of key factors causing delay is inadequate planning and monitoring. In Industrial Construction projects, not only the construction stage is where the success of the project is achieved. Therefore, although the construction stage has been the focus of many studies, the first stages are decisive for the success on the whole project [1]. It has been established that the average impact of the delay factors plays a significant role in the planning and design stages [14]. According to Furcada et al. (2008), if planning is not undertaken during the design stage the client cannot monitor and control the activities. On the other hand, the control mechanism such as the evaluation methods is defined as very important [1].

According to Alemu and Thakur (2021), in general, the primary causes of construction delays during the planning and design phase are significant contributors to overall project delays. Therefore, it is crucial to identify and address the underlying causes of these delays in order to ensure the timely completion of projects [14].

As Tıratacı and Yaman (2023) mentioned, the planning and programming of projects at the tender phase is of significant importance in order to accurately estimate the duration of construction and to prevent delays. Construction projects should be scheduled in a clear and logical manner, with the order and sequence of work being explicitly delineated [17].

It can be demonstrated that effective planning and programming during the tender phase leads to success in the construction phase [18, 19]. The most significant factors influencing the time, cost, and quality of construction projects are inadequate planning and programming [20, 21].

As stated by Saini et al. (2017), the utilization of project management software, such as Microsoft Project and Primavera, can assist in identifying the causes of delays by recording, monitoring, controlling, and reporting their progress [22].

The other key factor causing delay is determined as poor communication and coordination. As it has been mentioned before, the construction industry is a dynamic and complex business, with numerous shareholders pursuing diverse objectives. According to Akintelu et al. [23], the failure of construction projects is frequently attributed to poor communication, which is perceived as a significant obstacle in the industry.

Gamil and Rahman [25] stated that inadequate communication has a multitude of consequences in the construction industry, including time overruns, disputes, and ultimately, project failure. A delay resulting from inadequate communication can a priori be attributed to a number of factors, including a slow information flow, the use of inappropriate communication channels, an erroneous design, an incorrect interpretation, reworks, and so forth [24-28].

As survey research conducted by Akintelu et. al. [23] examines the effects of project communication management on project success and the findings showed that it can be concluded that the implementation of a comprehensive communication plan, coupled with the utilization of an effective and efficient communication medium, will result in an enhanced probability of timely project delivery.

As William [29] argues, the most effective method for avoiding disputes during and after a construction project is to ensure transparent communication between project stakeholders and team members. This allows for the resolution of conflicts in a timely manner, preventing them from escalating into costly arbitrations or litigation.

Another key factor causing delay is changes. Change orders are a practical reality of the construction industry, regardless of the size, type or nature of the project. It has been stated by Hanna and Gunduz [30] that change orders can have a negative impact on the overall performance of a project. According to Clough and Sears [31], re-work and demolition in construction projects are frequent occurrences due to the inherent variations in the nature of such projects. This scenario leads to delayed project completion dates and increased project costs. Again, as stated by Al-Nuaimi et al. [32], the most significant effects of change orders on the project were identified as schedule delays and disputes.

Therefore, it is imperative to implement an effective framework for change order management in construction projects to avoid schedule delays and thus ensure that project objectives are achieved. For this, it is recommended to freeze the design as much as possible before the construction phase and avoid late design changes as much as possible, as stated by Gunduz and Khan [33].

According to the investigation by Alaryan et al. [34], one of the five most common effects of change order is delaying in completion schedule and the six most common control measures are as follows: firstly, it is necessary to check and review the contract documents; secondly, the design must be reviewed before change approval; thirdly, the change order must be negotiated by knowledgeable persons; fourthly, the scope of change orders must be clearly defined; fifthly, appropriate approval in writing must be handed; and finally, the best tools to control the occurrence of change must be employed, including the areas of concern in monthly reports and meetings.

A summary table has been prepared from the literature review on the causes of delays and disputes. The table is presented in Table 1.

The literature review emphasizes the necessity of adopting a comprehensive approach to the prevention and mitigation of delays and disputes in industrial construction projects. This approach should encompass proactive risk management, effective communication and coordination, scope management, project planning and monitoring, and effective contract management throughout the project lifecycle. The implementation of these strategies will enhance the probability of the timely completion of industrial construction projects within the allocated budget and with a minimal number of disputes.

3. Methodology

A case study is a method of investigation that focuses on a single entity, such as a company, a program, an individual or an event. This targeted focus allows for an in-depth investigation of the selected unit, enabling a comprehensive understanding of the phenomenon under study.

Table 1. The key factors causing delays and disputes and mitigation strategies

Key Factors	Definition	Impact on Delays and Disputes	Mitigation Strategies	References
Poor Communication and Coordination	Inadequate communication and coordination between project stakeholders	Misaligned expectations, delays in approvals, unresolved conflicts	Implementation of a comprehensive communication plan Utilization of an effective and efficient communication medium Ensure transparent communication between project stakeholders and team members	[7], [8], [9], [10], [11], [12], [13], [14], [15], [25], [26], [27], [28], [29], [30], [31]
Changes	Changes in project scope and design specifications, including alterations and unforeseen requirements	Need for rework, disruption of project timelines, cost increases and conflicts over responsibilities and extra charges	Develop a robust change management process to assess, document, and implement changes effectively. Implement a proactive design review process to identify potential issues early.	[7], [9], [10], [13], [14], [15], [16], [32], [33], [34], [35], [36]
Inadequate Planning and Monitoring	Poorly structured or inadequately followed project plans, failure to track progress effectively, and failure to reflect delays in the project schedule	Missed deadlines, resource shortages, unanticipated delays, disputes over responsibilities and project timelines	Develop comprehensive project plans with clear milestones and deadlines. Utilize project management software for real-time tracking and monitoring of progress.	[7], [8], [9], [10], [12], [13], [14], [15], [17], [18], [19], [20], [21], [22], [24], [24]

Furthermore, case studies are primarily based on qualitative data, such as observations, documents, and the aim is to understand the 'why' and 'how' behind a phenomenon, rather than merely to measure its occurrence. The inductive approach is employed in case study research. Theories or explanations are developed based on observations and data collected during the research process.

The objective of this research is to examine the causes of delays and disputes specific to industrial plant construction projects. To this end, a thermal power plant project has been selected as a case study, given that it falls within the aforementioned category and has claims and disputes related to delays. In this case study, an in-depth investigation of the delay claims and disputes was carried out through qualitative data obtained within the scope of the project. The aim was to discover the root causes, and a deductive approach was followed from these results. The methodology employed to analyze the delays in the case study is presented in Fig. 1.

3.1. Project description

The thermal power plant project under investigation is a coal-fired power project located in Turkey. The project has a capacity of 290MW and is expected to generate 2,210,000 MWh of electricity when completed. It is involved the construction of various facilities, including a coal crushing building, electrostatic precipitators (ESPs), cooling water pipes, and an administration building. The project was divided into two phases, with the work packages analysed in this study belonging to both phases.

The contract established between the Employer and the Contractor outlines the obligations of both parties.

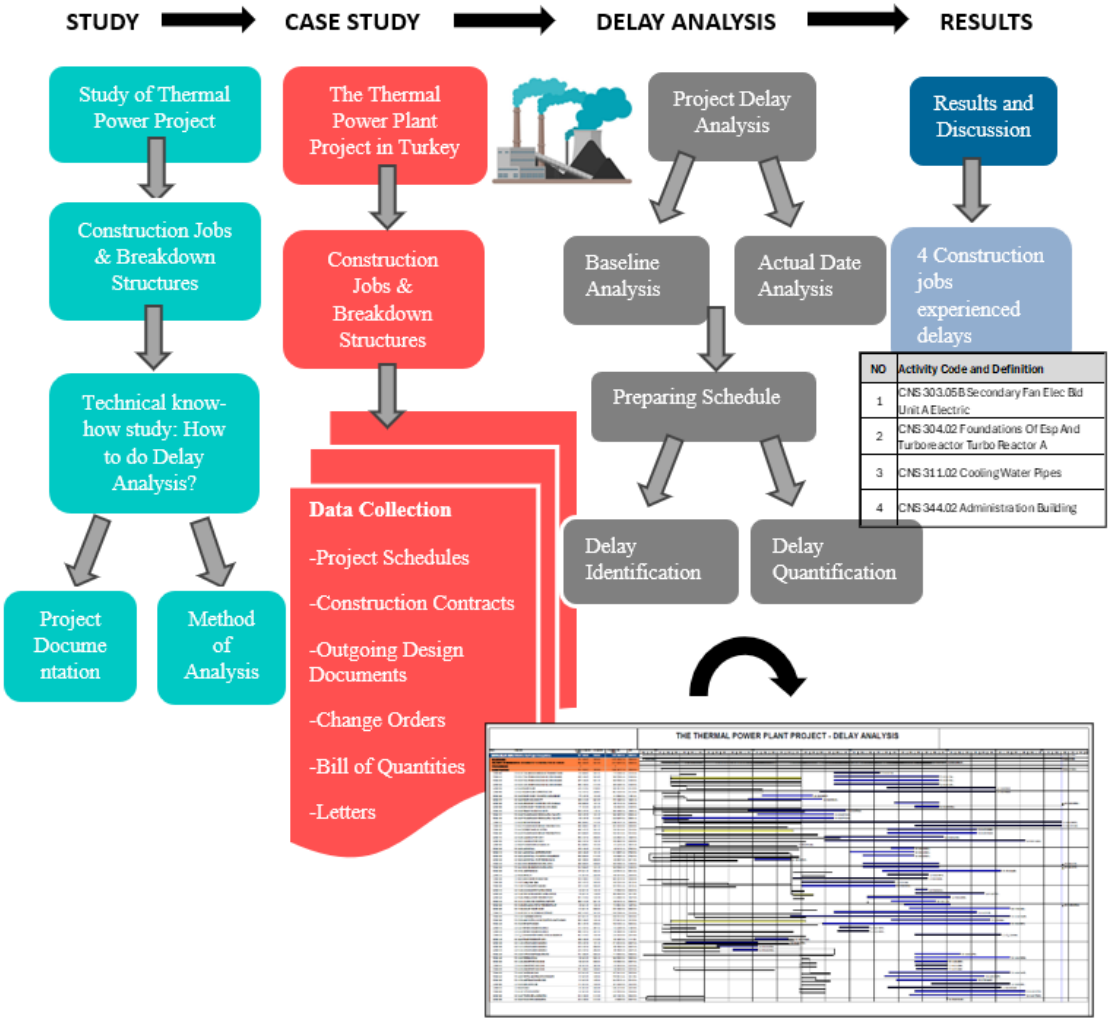

Fig. 1. Methodology used to analyze delays in the case study

The Contractor is responsible for executing the works specified in the contract, while the Employer is obliged to pay the Contractor for the timely completion of the works.

The contract price is determined as a fixed lump-sum price and it may only be changed in accordance with the stipulations set out in the contract conditions.

At the stage of proposal and contract signature, the Contractor is privy to only the basic design of the project and the detailed design, which will fully define the scope of the works in accordance with the requirements of the Employer. The detailed design may vary from the basic design, and the Employer will provide this to the Contractor at a later stage. The Contractor is aware of this at the stage of proposal and contract signature.

3.2. Data collection

The process commenced with the collection of data. At this stage, the contract documents outlining the scope of work, responsibilities of the parties, and contractual terms, the work schedule (baseline schedules and revised schedules outlining the planned start and finish dates for each work package) annexed to the contract, any subsequent revisions and contractual change orders, bills of quantities (Documents listing the quantities of materials, labour, and other resources required for

each work package), planned and actual delivery dates of the design documents (including drawings, specifications and technical details) to be submitted by the Employer to the Contractor, correspondence between the Employer and the Contractor (including notifications, requests, and approvals), invoices issued by the Contractor for completed work and completion certificates issued within the project, and expert reports were collected as data.

3.3. Data analysis

In the subsequent phase, the collected data were subjected to analysis.

There are several methods for delay analysis. The "As-Planned Versus As-Built" method was used in this case study. This entails a comparison of the original intention of the program with the as-built program to enable an assessment of where delays occurred at any particular period of time [35]. It considers both the as-planned and as-built schedules to evaluate delay impacts and identifies and quantifies both Employer and Contractor delays [36]. This method evaluates the overall effect of all delays collectively, rather than examining each delay event independently [37]. This method is well-suited for projects where it is simple to pinpoint the primary causes of delays, such as through a detailed comparison of scheduled versus completed tasks using a high-level Gantt chart [35].

The Baseline Start Date (BLS) was determined for each work package by analysing the timetable attached to the contract signed between the Contractor and the Employer and the revisions made thereon. The Baseline Finish Date (BLF) is taken from the contractually agreed completion dates of the work packages. The duration between BLF and BLS indicates how long it will take to complete the work package according to the contract (Baseline Duration).

By utilising the dates of submission of design documents by the Employer to the Contractor in accordance with the 'outgoing document list' kept by the project consultant firm and bills of quantities, invoices, correspondence and completion documents, "the Actual Start (AS) and Actual Finish (AF) dates of the relevant construction activities" were determined. The duration between AF and AS indicates how long it will actually take to complete the work (At Completion Duration).

Furthermore, change order documents, correspondence and expert reports were analysed, and "the relationships between the activities" were determined by taking into account the engineering principles regarding the commencement of any construction activity.

In the following phase, the baseline schedule was generated and the critical path determined through the Primavera Project Planner software, utilising the specified dates and the relationships between the activities derived from the data collated and analysed as previously described. The CPM method was applied to the baseline schedule to identify the critical path and determine the expected duration of each work package. The critical path is defined as the set of tasks that require the least amount of time to complete a project.

In the final stage of the analysis, the Actual Start and Actual Finish dates of the relevant construction activities obtained from the data analysed in the previous section were compared with the baseline schedule (Baseline Start Date (BLS) and Baseline Finish Date (BLF)) using Primavera Project Planner software in order to determine whether there was a delay.

If these tasks are delayed, the overall completion time of the project is also delayed. In other words, if At Completion Duration is less than the baseline duration, it means that there is no delay, and if it is more, it means that there is a delay in the work package.

In order to identify the root causes of the delays, an analysis was conducted to determine at which points and for what reasons the deviations occurred in comparison to the baseline schedule and the responsibility for the delay was assigned to the Employer, Contractor, or both, based on the analysis of the supporting documentation.

3.4. Results and discussion

As a result of delay analysis, it was found that 8 of the 12 work packages had been completed by the Contractor earlier than the completion date specified in the baseline schedule. Therefore, it was clarified that there was no delay in 8 work packages. As a result of the investigation, it was established that there were delays in the remaining 4 work packages. One of these delays was entirely caused by the Contractor and the other three delays were caused by both the Contractor and the Employer. These determinations were made according to the delivery dates of change orders and design documents.

For disputed work packages that delay was detected, the responsible parties for the delay, the main cause of the delay are addressed in Table 2.

In Table 3, justifications are also provided for work packages which no delay is detected.

As a discussion of the study, it was concluded that the main reasons for potential delays that may occur in an industrial plant construction project in Turkey are as follows; poor communication and coordination, design changes, inadequate planning and monitoring. In the study conducted by Alemu and Thakur, it was mentioned that these and similar factors were also effective in construction projects in Malaysia, Egypt, United Arab Emirates, Hong Kong, and Jordan [14].

Similar to the findings of the case study, Fallahnejad [13] also found that unrealistic project duration and change orders were among the main factors for delays in Iran's gas pipeline project, which was classified as an industrial plant project.

Based on this study, even though no delay was detected, the following points should still be considered; Acceptance of change orders without Extension of Time, commencing the construction without annotation that completed projects and specifications have not been submitted, not checking the scope of work in detail during the contract period (to prevent lost time), submitting the construction activity without annotation that completed parts are major and remaining parts do not encumber to utilization, lack of documentation and archives for start and finish dates of work packages.

Table 2. Disputed work packages that delay were detected

No	Activity Code and Definition	Delay	Responsible for Delay	Root Cause(s) of Delay
1	CNS 303.05B Secondary Fan Elec Bld Unit A Electric	Yes	Contractor	-The construction activity was completed 13 days later than the stipulated duration. The Contractor is fully responsible for this delay.
2	CNS 304.02 Foundations Of Esp And Turboreactor Turbo Reactor A	Yes	Shared (Employer and Contractor)	-The need for additional coordination with other contractors working on site. -Change of Design: -Late completion of the work by the Contractor
3	CNS 311.02 Cooling Water Pipes	Yes	Shared (Employer and Contractor)	-Change of Design: For the foundation of the cooling water pipes, which required additional excavation work. -Late completion of the work by the Contractor
4	CNS 344.02 Administration Building	Yes	Shared (Employer and Contractor)	-Late submission of design documents by the Employer -Late completion of the work by the Contractor -Additional excavation work.

Table 3. Disputed work packages that no delay were detected

No	Activity Code and Definition	Delay	Delay Analysis Result
1	CNS 302.02 Coal Crushing Building	No	*Claim:* Delay in Construction Activity *Counter Claim:* Completed project drawings and specifications were not submitted *Justification for the Counter Claim:* As a general rule, it is advisable to have completed project drawings and specifications before beginning the construction of plants. Owing to the interdependency of elements in the structure, a holistic view is necessary for industrial plant construction, which distinguishes it from ordinary building construction. If we focus on the construction of a coal-crushing plant, it should be underlined that without proper Means of Egress and Passive Fire Protection would be highly unsafe and inadvisable. Commencing the construction of a coal-crushing plant without proper means of egress and passive fire protection detailed drawings and specifications pose significant risks. Without detailed drawings specifying safe exit routes, workers and visitors may not have clear paths to evacuate during emergencies. (Reference: Fernando, R. (2004). Current design and construction of coal-fired power plant. IEA Coal Research) *Failure of the Contractor:* 1. Acceptance of change orders without Extension of Time 2. Commencing the construction without annotation that completed projects and specifications have not been submitted
2	CNS 304.03 Sorbent Hand System	No	*Claim:* Delay in Construction Activity *Counter claim:* 90% of the electrical system installation was completed and taken over by the Employer and remaining parts are minor for the system. *Justification for the Counter Claim:* If 90% of the electrical system installation has been completed in a Sorbent Handling System, it is a significant milestone. Of course, the full utilization of the sorbent handling system is subject to several factors. Ensuring that the remaining 10% of the electrical system installation does not compromise any critical components or functionalities is vital. In our case, these components constitute minor parts of the overall system. It is crucial to ensure that the installed system meets safety standards and regulations to prevent potential risks. Furthermore, it is essential to take into account how the sorbent handling system integrates with other components and the remaining electrical work does not include critical connections or interfaces, there is no claim about the remaining part of the electrical work. *Failure of the Contractor:* 1. Acceptance of change orders without Extension of Time 2. Submitting the construction activity without annotation that completed parts are major and remaining parts do not encumber to utilization
3	CNS 306.5 A Civil Readin. For Installation	No	*Claim:* Delay in Construction Activity *Counter claim:* Waiting time for the Employer to complete predecessor activities. *Justification for the Counter Claim:* It was recorded that change order 167 had the effect of delaying the work by approximately 2 weeks. This change order includes the supply and erection of a cable within electrical works and upon the Contractor's refusal to perform the works because they were not within the scope of the Contract, the supply and installation were carried out by the Employer and the cost was deducted from the Contractor. *Failure of the Contractor:* 1. Not checking the scope of work in detail during the contract period (To prevent lost time)

Table 3. Cont'd

4	CNS 306.5 B Civil Readin. For Installation	No	*Claim:* Delay in Construction Activity *Counter claim:* Waiting time for the Employer to complete predecessor activities. *Justification for the Counter Claim:* It was recorded that change order 167 had the effect of delaying the work by approximately 2 weeks. This change order includes the supply and erection of a cable within electrical works and upon the Contractor's refusal to perform the works because they were not within the scope of the Contract, the supply and installation were carried out by the Employer and the cost was deducted from the Contractor. *Failure of the Contractor:* 1. Not checking the scope of work in detail during the contract period (To prevent lost time)
5	CNS 315.02 Arch.Civil Elect. Parts of Chem Water Treatm Plant	No	*Claim:* Delay in Construction Activity *Counter claim:* Despite the additional work, the work package was completed before the stipulated date. *Justification for the Counter Claim:* Actual submission of the documents especially bills of quantities is very crucial for plants. BOQ provides detailed information about quantities, specifications, and estimated costs for each item. It serves as a critical document for project planning, procurement, and cost control during the construction and operation of the water treatment plant. This work package cannot be started until the BOQ is delivered. Additionally, extra works were done within the scope according to the change order. *Failure of the Contractor:* 1. Acceptance of change orders without Extension of Time
6	CNS 322/2 Main Control, I&C And Electrical SG	No	*Claim:* Delay in Construction Activity *Counter claim:* Despite the additional work, the work package was completed before the stipulated date. *Justification for the Counter Claim:* If we go further into the change order, it is stated those holes were omitted in the detailed design and the drilling of holes was required by electrical and plumbing supervisors. In fact, they should be regarded as a delay component for this activity but the impact on the schedule is accepted as omissible due to early completion. *Failure of the Contractor:* 1. Acceptance of change orders without Extension of Time
7	CNS 341/01 Outdoor Cable Channels	No	*Claim:* Delay in Construction Activity *Counter claim:* Despite the additional work, the work package was completed before the stipulated date. *Justification for the Counter Claim:* To commence this work, it is imperative that all design details and associated method statements, as outlined in the technical specification, are submitted. As the worksite is shared with other contractors, there may be coordination problems, access issues, and overlapping work areas to contend with. The technical reasons for these issues have been thoroughly analyzed through scheduling and delay analysis as part of the construction management. According to the change order, which mentions additional excavation work, may directly affect the completion dates of 341/01 and 341/02. However, per our analysis, the submission of the works other than this change order mentioned above did not affect the duration of the activities. Additionally, the completion date of the activity in accordance with the documents should be discussed. The analysis was performed by accepting one of two possible completion dates. *Failure of the Contractor:* 1. Acceptance of change orders without Extension of Time 2. Lack of documentation and archives for start and finish dates of work package.

Table 3. Cont'd

8	CNS 341/02 Outdoor Cable Channels	No	*Claim:* Delay in Construction Activity *Counter claim:* Despite the additional work, the work package was completed before the stipulated date. *Justification for the Counter Claim:* To commence this work, it is imperative that all design details and associated method statements, as outlined in the technical specification, are submitted. As the worksite is shared with other contractors, there may be coordination problems, access issues, and overlapping work areas to contend with. The technical reasons for these issues have been thoroughly analyzed through scheduling and delay analysis as part of the construction management. According to the change order, which mentions additional excavation work, may directly affect the completion dates of 341/01 and 341/02. However, per our analysis, the submission of the works other than this change order mentioned above did not affect the duration of the activities. Additionally, the completion date of the activity in accordance with the documents should be discussed. The analysis was performed by accepting one of two possible completion dates. *Failure of the Contractor:* 1. Acceptance of change orders without Extension of Time 2. Lack of documentation and archives for start and finish dates of work package.

4. Reccommendations

Delays and disputes represent significant challenges in industrial construction projects, frequently resulting in cost overruns, time extensions and project failures. By understanding the key factors contributing to these issues and implementing recommended mitigation strategies, project stakeholders can significantly reduce the likelihood of delays and disputes and improve project outcomes. The case study presented in this paper offers valuable insights into the root causes of delays and disputes in industrial construction projects and underscores the importance of proactive risk management, effective communication, and collaboration among all project stakeholders.

Based on the findings of the case study and the literature review, the following recommendations are provided to minimize delays and disputes in industrial construction projects:

- *Establish and Maintain Effective Communication and Coordination Channels:*

It is advisable for project managers to conduct regular meetings with all relevant stakeholders, including the client, contractor, subcontractors, designers and consultants. These meetings should be held at regular intervals, such as weekly or fortnightly, to discuss project progress, identify potential issues and address concerns promptly.

It is recommended that a centralized document management system be established in order to ensure that all project stakeholders have access to up-to-date information, including drawings, specifications, meeting minutes and progress reports. The system should be accessible online and allow for the simple retrieval and sharing of documents.

It is essential to appoint a dedicated project communication coordinator, whose role will be to facilitate communication between all project stakeholders. The responsibility of this individual to prepare and distribute meeting agendas and minutes, maintain the document management system, and ensure that all stakeholders are kept informed of project developments.

- *Implement a Robust Change Management Process:*

It is necessary to develop a clear and documented change management process that outlines the steps involved in proposing, evaluating, approving, and implementing project scope changes and design alterations. It is essential that this process delineates the roles and responsibilities of each stage of the change management process.

It is recommended that a change management committee be established, comprising representatives from the employer, contractor, and other relevant stakeholders. The committee is responsible for reviewing and evaluating proposed changes, assessing their impact on the project, and making recommendations for approval or rejection.

All approved changes must be documented, including their description, rationale, impact on the project schedule and budget, and responsibilities for implementation. It is recommended that this documentation be maintained in the project management system and made accessible to all project stakeholders.

- *Develop a Comprehensive and Realistic Project Plan:*

It is recommended that all relevant project stakeholders be engaged in the development of the project plan, including the employer, contractor, subcontractors, designers, and consultants. This collaborative approach ensures that all parties have input into the plan and are committed to its implementation.

The project should be divided into smaller, more manageable work packages, with clear deliverables, milestones, and timelines. This will facilitate more effective monitoring of the project's progress and the identification of potential delays.

It is advisable to consider using project management software to develop and manage the project schedule. Such software can assist in the identification and resolution of scheduling conflicts, the tracking of progress, and the generation of reports.

It is essential to conduct regular reviews and updates of the project plan in order to reflect any changes in the project scope, schedule, and budget. This will ensure that the plan remains both realistic and achievable.

- *Ensure Clarity and Fairness in Contractual Agreements:*

It is recommended that legal counsel with expertise in construction law be engaged to assist in the drafting and review of the project contract. This will ensure that the contract is clear, comprehensive, and legally sound.

It is of the utmost importance to clearly define the roles and responsibilities of each party involved in the project, including the employer, contractor, subcontractors, designers, and consultants. This will help to avoid any subsequent misunderstandings or disputes.

It is also necessary to outline a detailed dispute resolution process in the contract, including steps for negotiation, mediation, and arbitration. This will provide a clear framework for the resolution of disputes in a timely and efficient manner.

It is also advisable to include provisions for addressing unforeseen circumstances and changes to the project scope. This will help to minimize the likelihood of disputes arising from unexpected events.

- *Foster a Collaborative and Proactive Approach to Risk Management:*

It is advisable that a risk management team be established, comprising representatives from the employer, contractor, and other relevant stakeholders. It is the responsibility of this team to identify, assess, and prioritize potential risks to the project.

It is necessary to develop strategies for the mitigation of each identified risk, including contingency plans for the management of high-impact risks. It is imperative that these strategies be documented and communicated to all project stakeholders.

It is of the utmost importance to monitor and update the risk assessment on a regular basis throughout the project lifecycle, in order to account for any changes in project conditions and the emergence of new risks.

It is essential to foster a culture of open communication and collaboration among all project stakeholders, which will encourage the sharing of risk information and the development of effective mitigation strategies.

The implementation of these recommendations will result in a significant reduction in the likelihood of delays and disputes in industrial construction projects, thereby leading to improved project outcomes, reduced costs, and enhanced stakeholder satisfaction.

5. Limitations

This study has some limitations. Namely, due to page limitations and the need to protect the confidentiality of the case study documents, the methodology of the delay analysis could be explained in general terms and the results of the study could be included. In order to anonymize the project, the activity code numbering has been changed.

6. Conclusion

In conclusion, this paper presents a comprehensive analysis of delays and disputes in industrial construction projects, with a particular focus on a thermal power plant project in Turkey. A detailed examination of 12 construction activities enabled the root causes of disputes between the employer and the contractor to be identified. This shed light on the specific risks encountered and their potential consequences.

A set of practical recommendations has been provided, based on insights from both literature reviews and delay analyses, with the aim of mitigating prevalent causes of delays and fostering enhanced project execution. The recommendations emphasize the importance of enhanced communication and collaboration, clear and comprehensive contractual agreements, effective risk management and change control, proactive planning and time management, as well as strategic supply chain and resource management.

The implementation of these recommendations enables industrial construction projects to proactively address common causes of delay, minimize project disruptions and ultimately achieve successful project outcomes. This paper serves as a valuable resource for stakeholders involved in industrial construction projects, offering actionable insights and best practices to navigate challenges and achieve favorable outcomes in similar endeavors.

In essence, the prioritization of the adoption of these recommendations allows project stakeholders to optimize project performance, enhance collaboration between employers and contractors, and ensure the successful completion of industrial construction projects.

Declaration

Funding

This research received no external funding.

Author Contributions

S. Alp Yağcı: Writing-Original draft, Writing - Review & Editing, Methodology, Investigation, Visualization; M. Çapraz: Writing-Original draft, Writing - Review & Editing, Methodology, Investigation, Visualization; G. E. Gürcanlı: Conceptualization, Methodology, Investigation, Writing - Review & Editing, Supervision, Project administration.

Acknowledgments

Not applicable.

Data Availability Statement

No new data were created or analysed in this study.

Ethics Committee Permission

Not applicable.

Conflict of Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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