Journal of Information Systems Engineering and Management
2025, 10(12s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Review of Delay Factors in Construction Projects of Riyadh; A Case Study to Enhance Project Performance with Sustainability

Muhammad Wajidullah Khan[1*], Muhammad Farid Bin Shaari [2], Nour Al Saud[3]
[1*]*PhD Scholar, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM), Johor, 86400 Malaysia, engr.wajid25@yahoo.com*
[2]*Professor. Dr. Muhammad Farid Bin Shaari, Faculty of Engineering Technology Universiti Tun Hussein Onn Malaysia (UTHM), Johor, 86400 Malaysia, mdfarid@uthm.edu.my*
[3]*Architect, Parsons Saudi Arabia, Riyadh, Saudi Arabia, nour_mosaab@hotmail.com*

ARTICLE INFO

Received: 18 Nov 2024

Revised: 30 Dec 2024

Accepted: 18 Jan 2025

ABSTRACT

The construction project delays can be defined as an extension of time beyond the contractual time agreed during the tender stage, in past decade almost 70% of mega construction projects experienced time overruns. The construction professionals have specified that they have been facing average time delay of 10 to 30% from the original duration of the project. In modern building projects delays during MEP (Mechanical, Electrical and Plumbing) system installation phase are exceeding due to complexity and mechanized application of services in building projects. This study investigates the key challenges affecting the timely completion of construction projects and causing delays. As a case study chosen two mega ongoing construction projects in Riyadh, Saudi Arabia to investigate delays and their impact on project performance and sustainable development in construction. The challenges were discovered from the literature and investigated to analyze their significance towards project performance improvement and sustainable construction development. Data collection was administered through structured questionnaire survey performed among 291 construction professionals according to the sample size to find the objectives using 5-point Likert-scale. The impacts were grouped into main Kep Performance Indicator (KPI's) of project i.e. quality, cost and time. The outcome reported various critical challenges contributed to project delays; poor communication, non-compliance with specifications, design approvals and monthly payments related factors being the most important challenge in the construction industry. The top strategies such as smooth coordination, approved design before execution, mock-ups, prototypes and timely payments of claims could significantly control project delays and enhance performance with sustainability. Finally, the study findings will contribute to the body of knowledge to mitigate delays and will help the construction professionals to enhance performance with sustainability for upcoming construction projects in Saudi Arabia.

Keywords: Delays, Construction Projects, Sustainability, Project Performance, Saudi Arabia

1. INTRODUCTION

Construction is the oldest and one of the largest industries in the world with its market size of about ten trillion US dollars per annum [1]. The global construction market reached USD 15.46 trillion in 2023 and if increased with the same compound annual growth the market is expected to reach USD 19.52 trillion in 2027 [2]. The construction industry plays a vital role in any nations economics growth and enhancement hence the significance of construction projects to any nation or society cannot be over emphasized [3]. The modern buildings are becoming increasingly complex and the complexities continue to increase year after year more than ever before in the history of man. A building can now be built to a height more than one thousand meters with floors exceeding two hundred [4]. New technologies implemented in buildings projects which have mechanized building services in shape of MEP (Mechanical, Electrical and Plumbing) systems. The MEP systems is a huge challenge for many construction projects such as high raised buildings, towers, metro stations and other technical projects [5].

Construction industry is a dynamic industry which occupies internal and external factors as a result the performance management has become demanding due to dynamic nature and unpredicted circumstances and uniqueness of services and applications. Majority of projects could not achieve as plans and such delays have an adverse impact on project's reputation [6]. Completing projects on time is an indicator of efficiency and success ranking of a construction project is determined by how quickly it is completed, how much it costs, how well it is completed, and whether there are major deviations. Therefore, time and cost are increasingly being used as key metrics for defining project success [7].

The era of free market that has grown so vast and rapidly that further encourages the process of sustainability and global economy [8]. The technological advancement has made the construction management more complex; sophisticated approach is necessary to deal with initiating, planning, financing, designing, approving, implementing, and completing a project on time. Accurate construction planning is also key determinant to ensure the delivery of a project on schedule and within the budget [9]. Globally the construction projects are rarely completed as scheduled and the mega infrastructure projects are no exception despite the use of developed project management tools and resources [10].

Construction project is commonly acknowledged as successful when it has been completed on time, within the budget, according to the specifications and meets the sponsors satisfaction [11]. Consequently, time and cost are used as key metrics for determining project performance and success. A construction project is commonly admitted as successful when it complete on time, within budget, according the specifications, and client satisfaction [11]. Therefore, completing projects on time is an indicator of efficiency, but the construction process is subject to many variables and unpredictable factors, which result from many sources [12].

Unfortunately, the construction industry is facing many significant problems on project delivery, poor financial performance and inability to adding value on time as per client satisfaction. As a result the industry has been criticised for poor performance and delays in accomplishment [13]. A research conducted by the Construction Industry Institute (CII 2005) discovered the direct cost escalation as a result of delays and rework on an average of 5% of the total construction cost [15]. Saudi Arabian construction industry is experiencing a rapid growth in all infrastructure fields, including both urban and rural areas. The government is progressively allocating large amounts of resources to develop advance infrastructure in capital city of Riyadh to support the vision 2030 and to conduct FIFA world cup in the Kingdom in 2034 [14]. Therefore, meeting deadlines for construction projects is a fundamental constraint to achieve the vision of Kingdom also to support the sustainable development.

2. LITERATURE REVIEW

Construction industry accounts for a large proportion of global resource consumption and environmental pollution. In line with statistics construction industry consumes 40% of the total energy generation and responsible for 30% of the global greenhouse gas emissions. Collectively, the building sector is responsible for one-third of resource consumption, including 12% of all fresh-water use, and produce up to 40% of our solid waste [16]. Mechanical, electrical, plumbing and related systems (MEP systems) have become one of the bigger contributors to the building construction delays and cost overruns [17]. In production of MEP system material, the annual use of pipes, cables and ducts are limitless in construction projects. The coordination of building services systems is a main challenge for complex building if pre action are not taken delays will immerse in projects [18].

Delays are serious epidemic that have been impacting the construction sector all over the world. The primary cause is the lack of information on its occurrence, which makes it extremely challenging to develop a business case against it. The requirement to reduce delays can have significant sustainable benefits to the construction industry [19]. Sustainable development is one of the leading civilization idea and this term means a development that satisfies the present needs without a limitation of the possibility of satisfying the needs in the future [21]. In spite of the significance of the construction industry, it faced problems of poor financial performance, high cost of project delivery, poor quality and material waste and failures [22]. It has been observed that this industry is suffering worldwide from sustainable solutions during project design and execution stage [23].

Sustainable construction projects provides several key points i.e., cost-efficient design, using minimum energy in construction and producing least pollution, preserving the nature and enhancing the biodiversity, preserving water resources, providing comfort to people by respecting the climate [20]. The Figure 1.1 the United Nations (UN)

sustainable development goals where the Sustainable Development Goal 9 (SDG-9) is directing the "industry, innovation and infrastructure" related to construction industry.

Figure 2.1: UN sustainable development goals (Goal 9 industry innovation)

2.1 Construction Project Classification

Construction has been basically considered as a common traditional industry in past century while in present era it become technological advanced, mechanized and complex industry [1]. The unique aspects of construction project it is especially challenging to classify the wide range of possible projects [24]. Construction projects play an important role for the future economic productivity. A construction project is a unique development on a particular site under circumstances that will never be repeated. It is a complex endeavor that requires the coordination of people and the availability of material, and it usually begins despite there being many unknown factors such as design issues, uncertain site conditions or unreliable threats and opportunities [25]. The common five divisions of construction projects are:

i. Residential Construction Projects
ii. Commercial Construction Projects
iii. Institutional Construction Projects
iv. Infrastructure and Mega Construction Projects
v. Industrial Construction Projects

2.2 Delay factors in construction projects

The construction delay is time consumption that is beyond completion date stated in a contract which the parties had agreed upon to deliver the project [27]. So, in construction, the word "delay" refers to something happening later than planned, or which is not expected [26]. Delays and cost overruns can occur during both preconstruction and construction phases. The advancement of auxiliary businesses (engineering, procurement, industrial and information technology) has led to a great demand for the shortening of the construction project duration. But this demand ultimately increases project complexity, leading to an increase in the number of challenges for stakeholders during the execution phase [28].

Efficiently managing construction projects is crucial for project success and to prevent failure and delays. A common perception that construction, in contrast to other industry sectors, has not improved its use of strategies and advance techniques and its overall productivity as much as other sectors in recent decades hence as a consequence its outputs are becoming relatively more expensive [29]. There are many factors that contribute to causes of delays in construction projects. Delays occur in every construction project and the magnitude of these delays varies considerably from project to project [30]. When a defined time period overrun, then the stipulated completion time is pushed forward, the project is said to have experienced schedule overrun [31]. The conceptual framework related

to delay factors associated with construction projects is highlighted in Figure 2.6 with input process and output for mitigation in early stages.

Design errors during construction can be incredibly expensive and disruptive. Every project is carefully planned to ensure smooth execution and timely completion. However, unexpected issues can mess up even the best-laid plans. Picture a busy construction site where progress is stopped abruptly due to a design error discovered halfway through the building process. Workers stand idle, machines are unused, and costs skyrocket as the project is put on hold. Common delay factors highlighted by the literature impacting on project from design, delivery, installation, testing stage of MEP system and architectural applications [32].

MEP systems often have complex designs that need to be coordinated with the building's structure and architectural elements. If there are any errors or discrepancies in the design, it can cause delays while revisions are made. Further, researchers identified coordination problems in construction and miscommunication between contractors, designers, and the project site team can lead to scheduling conflicts causing delays [23]. Procurement delays as the materials and equipment required for MEP systems, such as HVAC units, piping, wiring, electrical panels, or Architecture ceilings may be delayed due to supply chain issues or long lead times, causing overall project delays. Unexpected issues, like hidden structural elements or underground obstacles, may require modifications to the MEP design or installation plan, leading to additional time and costs. Lack of skilled labor for MEP installation can also contribute to delays, especially if the workforce isn't large enough to meet the demands of the schedule [33]. Changes to the MEP systems (such as upgrades or adjustments) after work has begun can cause delays as they require re-designing, reordering materials, and rescheduling tasks. Some common delay factors highlighted by the literature impacting on project during the delivery and application stage of Architecture in construction project execution [34] are high cost of machinery and its maintenance, financial difficulties faced by contractors, the delays in contractor's payments to subcontractors and not approved design application at construction sites etc.

2.3 Investigation of delays in construction projects of Saudi Arabia

The construction industry in Saudi Arabia had been developing rapidly [32]. The construction industry contributed 30% to 40% toward Saudi Arabia economy and government is investing more in this industry [3]. Delay is frequently caused by an occurrence that must be controlled by effective strategy to reduce its effects. Systematic delay management ensures that the source of the delay is recognized and documented as soon as feasible throughout building projects. Delays in building projects can occur for a variety of reasons. The components rely on innovation and its management, as well as those from the physical, social, and financial environments [14]. The Kingdom of Saudi Arabia (KSA) is suffering major delays in construction projects. Because the construction business in Saudi Arabia has changed dramatically over the last three decades, it is crucial to conduct a thorough study into the reasons for delays and to get industry experts on the same page [25].

Since, the construction industry ranks as the second largest industry in Saudi Arabia, the challenges and problem associated with it are enormous [35]. To respond to the increased complexity, it is essential to provide a comprehensive understanding of it and the factors that are affecting its levels [6]. Over the course of the last decade, the Kingdom of Saudi Arabia (KSA) has conveyed its commitment to the United Nations (UN) 2030 Agenda for Sustainable Development (2030 Agenda) and its 17 Sustainable Development Goals (SDGs) by bolstering national capacities to institutionalize the SDGs. In terms of both targets and goals, the KSA's Saudi Vision 2030 aligns with the 2030 Agenda and the KSA has been making significant progress towards their joint realization [36].

The influence of sustainability, efficiency, and innovation for social transformation is at the core of practically all smart city programs and Saudi Arabia is developing Riyadh, according to the vision 2030 and upcoming mega events. The Kingdom of Saudi Arabia (KSA) is suffering major delays in construction projects and the construction business in Saudi Arabia has changed dramatically over the last three decades due to advance implementation of MEP systems and central building management systems [14].

2.3.1 Case Study 1 RMP (Riyadh Metro Project)

The Metro Project is the backbone of the public transport network in Riyadh, capable of transporting 3.6 million passengers per day in initial phase the project is open for public partially. With six lines at a total length of 176 km and 85 metro stations, the metro network will cover most of the densely populated areas, public facilities, and the educational, commercial, and medical institutions [37]. The network will be connected to King Khalid International

Airport and King Abdullah Financial District, the main universities, downtown Riyadh, and the public transport center[38]. The brief of project cost and start times and delays duration are as:

Project Started: March 2014

Completion plan: 2014-2019

Completed (partly) 2025- Delay 5 years

Plan Cost: 23 billion USD

Actual Cost: 27 billion USD

Qasr Al-Hukm District Station | Western Metro Station

KAFD Station | STC Station

Figure 2.2: Riyadh metro project main stations

2.3.2 Case Study 2 KAFD (King Abdullah Financial District)

The project consists of 95 buildings, including 61 towers, and combines residential solutions, work and entertainment over a space of more than 1.6 million square meters. It will provide more than 3 million square meters of space for various uses, 62,000 parking spaces and accommodation for 12,000 residents. In 2011, it was the largest project in the world seeking green building accreditation [39]. The detail of KAFD project according to official sites is listed as:

Project Started: March 2007

Completion plan: 2014-2019

Completed (partly) 2025- Delay 6 years

Plan Cost: 7.8 billion USD

Revised Cost: 28 billion USD (on completion)

Figure 2.3: Under construction of KAFD project in Riyadh

2.4 Impact of delays on project performance

Over the past few decades, the gradually complicated and global business environment and rising competitiveness have emphasized the significance of construction project performance. Before taking steps to improve project performance, it is essential to accurately and integrally measure the performance requirements. Through critically reviewing literature regarding performance the impact of delays on project are globally accepted [40]. Project performance had an inverse and significant correlation with the schedule delays of project. The most common delays that influencing project performance parameters are impact on time, quality and cost of the project [25].

2.4.1 Impact of delays on quality

Poor quality issues occurs in more than 80% of building projects [41]. Project quality significantly increases project performance and helps in project completion on time and within budget, which is inversely related to rework on the job site. The quality of construction is a key component of perceived value to the project client. As reported by the International Federation of Consulting Engineers (IFCE), a lack of quality in construction is presented due to poor or non-sustainable workmanship, which creates delays and reworks in the project. Researchers asserted that to improve quality, there is a need to understand the root causes of delays, the basic reason for their existence, or the set of conditions that stimulate their occurrence in a process [42].

2.4.2 Impact of delays on cost

A study revealed that delays costs are a major contributor to the cost of building construction projects. In construction the cost reduction mostly involved from design stage prior to construction execution. There is significant relationship between the cost of rework and the project cost and there are also substantial relationships between the costs of delays and project completion time [45]. According to the Construction Industry Institute (CII) project delay costs reached up to 20% of project contract costs. A study revealed that the cost of delays in industrial, residential, and commercial buildings ranges from 2-6% of the contract value [43]. A study about the impact of delays on cost explored that cost overruns are regular events associated with every construction project, so the major factors contributing in project cost overruns is delays [44].

2.4.3 Impact of delays on time

Delay in construction is an old issue that downfall the image of whole industry [46]. An extension of time is an event where extra time is requested to complete the project. It has been realized that one of the main factors in cost and time overruns is rework. Research revealed that in construction delay can also directly or indirectly affect project performance. Delays leads to a significant delay in project time. Considering the projects executed in the last 20 years, most of them were delivered late, which means schedule delays occurred commonly in all construction projects [47]. Moreover, delays has been identified as the primary factor contributing to project cost overruns [47]. According to research published in the International Journal of Sustainable Construction Engineering and Technology (IJSCET)

Malaysia, the time and cost overruns are intimately linked with delays causing cost overrun in most circumstances [48]. Time delays directly impact the project's success in terms of cost and quality and indirectly results in client discontent and loss of profit.

2.4.4 Impact of delays on sustainability

Construction enterprises will contribute to the achievement of sustainable development goals by completing associated small and big projects. Successful execution of these initiatives will result in strong organizations and economies, which will help cities and communities' growth. The success of Vision 2030 projects to meet the SDGs as outlined in Figure 2.1 will depend in large part on construction enterprises [36].

Four years after the adoption of the 2030 Agenda the world of construction is off-track to achieve Sustainable Development Goals (SDGs). Most organizations have failed to turn the transformational vision of the 2030 Agenda into real transformational policies to achieve the SDG-9 related to construction industry [49]. and the world begins to count down the final six years of the United Nations' Agenda 2030, our shared vision of decisive progress towards sustainable development everywhere stands at a precipice. Construction industry required new practices, policies and development of new material respectively that will reduce our planetary footprint, while improving quality of life for all humans [50].

Each project is unique in nature and has some fundamental issues for completing it within the project budget and time. One of the obstacles to success is delays which is an endemic problem in construction projects, although it has been given little attention in terms of research. Identifying the root cause of delays is the first step in delay management, followed by a mitigation approach or reducing and preventing strategy [51]. According to study delay is primary cause of project time and cost overruns [47]. The relationship between delays and sustainability is highlighted in below Figure 2.4.

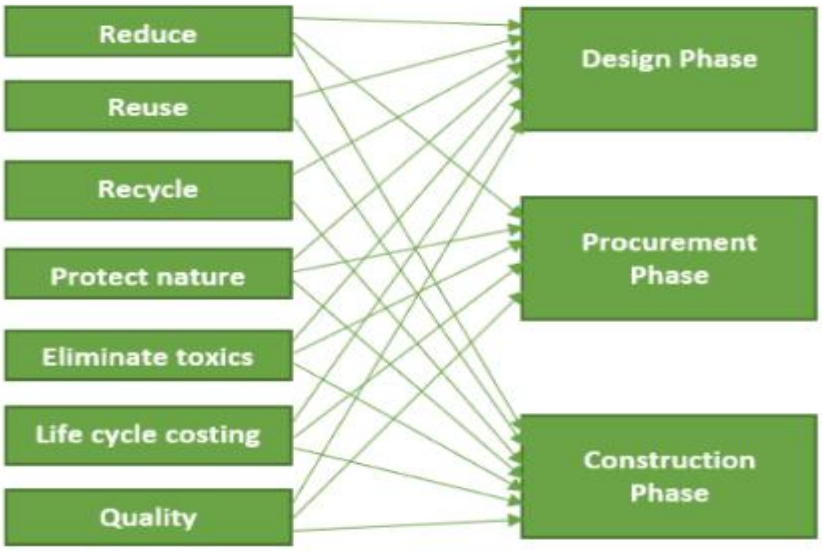


Figure 2.4:Relationship between sustainability and construction phases [52]

Therefore, a comprehensive appreciation of the mechanisms that cause delays will only enable project performance improvements to be made [53] and to achieve the sustainability goals. The entire problematic situation requires a thorough investigation to find the linked causes of project delays and implement appropriate remedial measures. This research conducted as quantitative study of construction projects in Riyadh, Saudi Arabia to investigate the potential causes of delays during construction stage of CSA (Civil, Structure & Architecture) and MEP (Mechanical, Electrical and Plumbing) system installations to elaborate mitigation measures for improving overall performance and enhance sustainable development in future projects. The Figure 2.5 the percentage of gross delays in construction projects in Saudi Arabia.

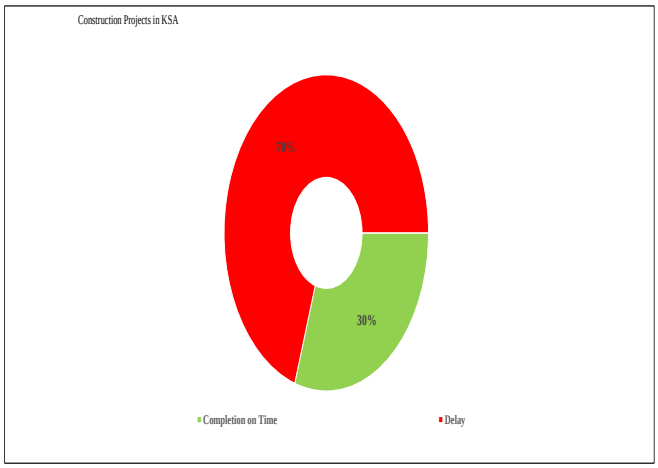


Figure 2.5: Delays in construction project of KSA [35]

Henceforth, five years left to achieve SDG 9 to build resilient infrastructure, promote sustainable industrialization and foster innovation. Studying the correlation between both the critical success and the critical delay factors, examining the effect of the identified critical success factors on each of the critical delay factors directly would shed some light on which factors are most influential upon one another, and aid contract parties and investors in deciding which factors deserve the most attention. Based on research gap and to address the problem statement and to achieve the aim of this research the objectives are set for this study as "To investigate delay factors challenged by construction projects in Riyadh, Saudi Arabia", "To evaluate impact of MEP (Mechanical, Electrical & Plumbing) related delay factors on project performance and sustainability" and "To mitigate delays and improve project performance with sustainability for future endeavors of construction industry.

3. METHODOLOGY

Research without a design plan is like an ocean voyage without Mariner's compass, hence a research design is the conceptual blueprint within which study is conducted [54]. The quantitative research approach is applied in this study, that is comprised of several stages to explore the research objective. The RMD is outlined in Figure 3.1, and the entire flow chart is divided into six main consecutive stages. In this study, a self-created questionnaire-based field survey was conducted to investigate and evaluate common causes of delays and their impact on project performance using the opinions of construction experts involved in the RMP and KAFD projects. The details of each step are explained in step 1 to 6 as per design of research.

In the first stage, in-depth literature review conducted to identify the research gap by reviewing the delay factors in construction projects. Furthermore, the important causes of delay during the installation of MEP system installation in building projects focused from delivery of material to testing of related systems and their impact on project performance and sustainability. In the second stage, the research methodology design furnished by declaring the quantitative approach and questionnaires were developed as per objectives of the research to achieve the research objectives. In the third stage, a pilot test carried out to check the feasibility and clarity of the questionnaire by offering open suggestions from experts in field of construction management prior to the final field survey. The questionnaire corrected through the process unless it will be succeeded value of Cronbach Alpha in SPSS for continue with further survey.

In the fourth stage, a field survey conducted for data collection using final questionnaires. Besides, in the fourth stage, delays categorized into three sub-groups, the impact of delays on project performance (Quality, Schedule, Cost), the strategies for improving the sustainability development were ranked out. The final data analyzed in SPSS v-26 (Statistical Product and Service Solution). In the fifth stage, research objectives were revealed as results and findings from this study. The outcome emphasized the causes of delays and their impact on project performance and recommended mitigation measures for potential causes involved during the execution of project in terms of major disciplines involved. Finally, in the sixth stage, research findings conclude, and directed to construction professionals, researchers and engineers involved in building projects to enhance performance of upcoming projects by mitigating the delays and improve sustainable development in construction.

3.1 Pilot testing

The pilot testing ensured the questionnaires develop are valid, reliable, effective, and free from problems or errors [55]. In this research the pilot testing aims to improve questionnaire and simplify it, omit redundant factors and eliminate ambiguity in research surveys. In other words, a pilot survey is an early feasibility check to determine the practicality of the questionnaire and to ensure that the applied method can achieve the desired objective of research. The test improved the quality of questionnaire and omitted the redundant factors [56]. In this study a pilot testing submitted to fifteen (20) highly experts and qualified professionals involved in construction management at RMP and KAFD Project. The respondents were requested to review the design and structure of the pilot survey critically as per the research objective. The response rate percentage received more than 65% an acceptable percentage to proceeding the questionnaires for further research [57].

3.2 Questionnaire design for data collection

The questionnaire survey is the most efficient data collection tool which help in testing the hypotheses and answer the research objectives [58]. The most important tool in this section was the questionnaire designed to collect information as per research objective. The feedback provided by the field experts in the pilot study helped in designing a realistic questionnaire to achieve the research objective. The final design of questionnaire prepared in accordance with the main objectives of the research. The questionnaire design composed of four main parts as:

Part I: Demographics of the respondents

Part II: Impact of delays on project performance and sustainability

Part III: Development of mitigation strategies

Part-I intended to collect general information about the respondents, including their qualification level, field of specialization, the nature of their company, project subsection, and work experience. The Part II includes causes of delays during construction in projects chosen as case study for this research. The closed-ended questions used and the respondents were asked to choose answer from any of the multiple-choice based on the five-point Likert scale as shown in Table 3.1. Part-III included the strategies for delay mitigation during the construction execution by using a similar five-point scale (1 – very low rate; 2 – low rate; 3 – medium rate; 4 – high rate; and 5 – very high rate). The purpose of the fourth part of the questionnaire provided a solid and practical recommendation to construction professional.

Table 3.1: Five Point Likert scale [45]

Likert Scale	Response Category (Scale)
1	Very Low Impact
2	Low Impact
3	Medium Impact
4	High Impact
5	Very High Impact

3.3 Reliability test of questionnaire

Before submission of data survey, an internal reliability test was performed on Likert-scaled type questions using Cronbach's alpha. The alpha coefficient ranges in value from 0 to 1, where higher alpha values are more desirable, as shown in Table 3.2. The questionnaires were rectified unless desired value of alpha (α) was not achieved. The value of α achieved greater than 0.70 hence, research considered a reliable measure prior to real survey [59].

Table 3.2: Cronbach's alpha (α) scale

Cronbach's alpha (α) Value	**Level of Reliability**
>0.9	Excellent
>0.8	Good
>0.7	Acceptable
>0.6	Questionable

>0.5	Poor
<0.5	Unacceptable

Note: Cronbach's alpha (α) scale > 0.7 is generally acceptable.

3.4 Population and sampling

The selected number of cases in a population is referred to as sample [60]. The sampling is the process of choosing a trial from a population and this technique is mostly appropriate for quantitative research approach. In research sampling is a experimental way of obtaining information about the whole population by observing some part of it which represent the whole population [61]. The population size in this research will be the overall or total population of construction professionals in both projects from the case study of KAFD & RMP project. The population considered from the list of bodies, i.e., clients, consultants, contractors and subcontractors. As per the company's organization chart the official population of construction professionals in execution stage at KAFD are 500 and in RMP in existing stage are 700 in average and gross population in both is 1200 respondents. By implementing probability sampling and a random sample approach the sample size for this study is calculated as 291 (sample size) which has been derived by using area population and taking 95% of the confidence level verified from Margon's table of sample size considering 95% confidence level and margin of error 5% for population [62] the values of sample are reflected in Table 3.3.

Table 3.3: Morgan table for sample size [63]

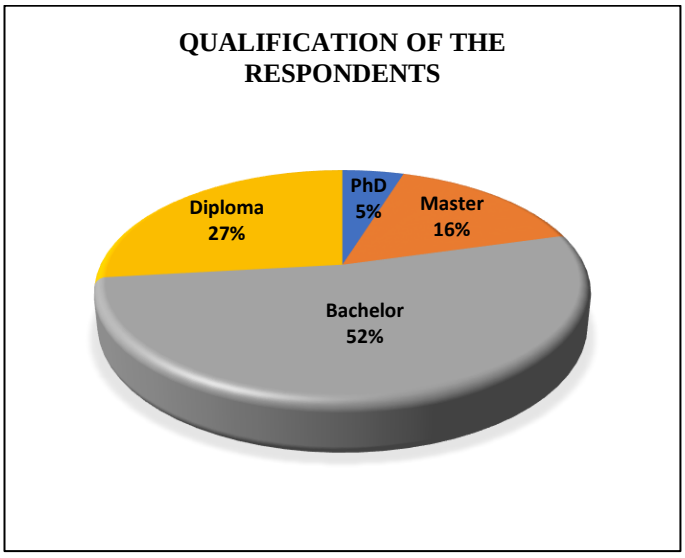
N	S	N	S	N	S
10	10	130	97	1000	278
30	28	150	108	1100	285
40	36	170	118	1200	291
50	44	190	123	1300	297
60	52	200	132	1400	302

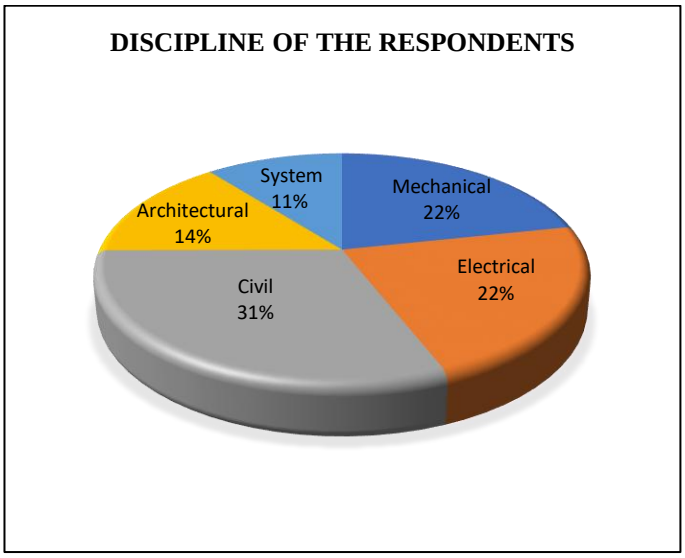
N is population size and S is sample size

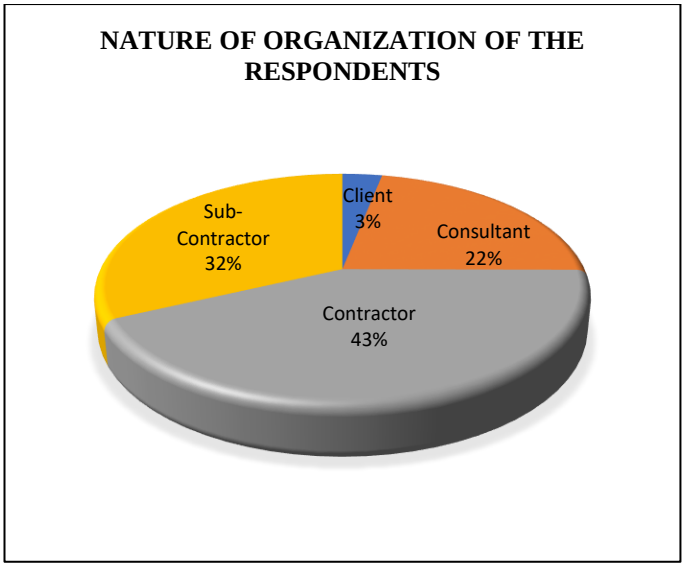
4. DATA ANALYSIS AND RESULTS

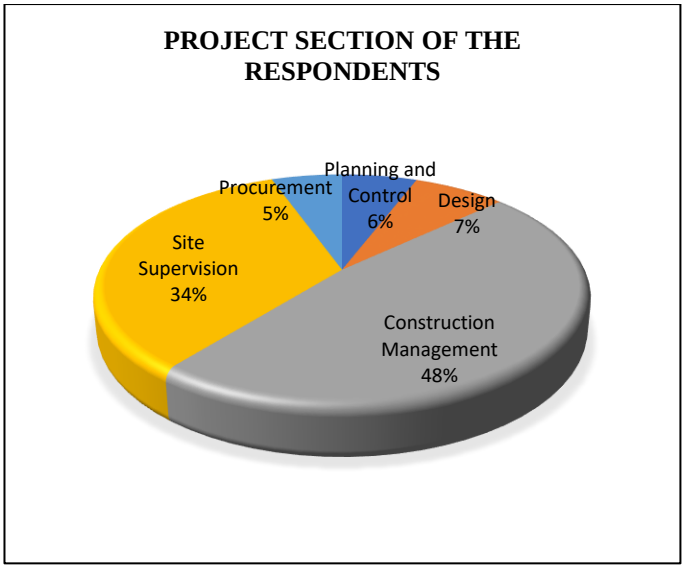
4.1 Demographic of respondents

The data was collected from construction professionals working as organization from client, contractors, consulting and sub-contractors in RMP and KAFD project sequentially. The participants in this study having work experience from 5 to 35 years and above, the demographic details of respondents analysed as indicated in Figures below.









4.2 Delay impact on project quality

This section is composed of 13 delay factors investigation that influence cost performance during the construction observed by the respondents in RMP and KAFD project. Delays had several effects to construction projects performance but the respondents rank these effects by using 5-point scale. The results of delay impact on project quality are revealed in Table 4.1.

Table 4.1: Identification of delay factors impact on Project Quality

Sr. No	Investigation of Delays in RMP and KAFD	Index	Standard Deviation	Impact Level
1.	Non-compliance with specifications and standards in execution	4.10	.762	High
2.	Poor coordination between the design and construction teams	4.04	.810	High
3.	Lack of knowledge and experience of project staff	4.02	.592	High
4.	Disregarding the sequence of construction	3.94	.830	Medium
5.	Poor communication among different project stakeholders	3.91	.860	Medium
6.	Lack of collaboration between manufacturer and design	3.79	.655	Medium
7.	Work resume prior to the approved drawings	3.78	.923	Medium
8.	Fast-tracking and crushing of activities due to limited time	3.71	.617	Medium
9.	Negligence in clearance from Civil/ Arch prior MEP installation	3.68	1.02	Medium
10.	Delays in submission of inspection requests for work approval	3.94	.830	Medium
11.	Improper project feasibility study	3.58	.927	Medium
12.	Insufficient details in contract documents	3.51	.954	Medium
13.	Over-designing results in quality issues	3.48	.857	Medium

Results revealed that delay identifications impacting on quality such as non-compliance with specifications, poor coordination between the design and construction, lack of knowledge and experience and delays in submission of inspections etc. Similar delay identifications were proposed in research by [56], [64], [65] and [59] about construction projects.

4.3 Delay impact on projects cost

This section is composed of delay factors those influence cost performance during the construction in RMP and KAFD project. The results of delay impact on project cost are demonstrated in Table 4.2.

Table 4.2: Identification of delay factors impact on Project Cost

Sr. No	Investigation of Delays in RMP and KAFD	Index	Standard Deviation	Impact Level
1.	Lack of clear understanding of contract documents	4.09	.346	High
2.	Change in design on client request after work completion	4.03	1.03	High
3.	Incomplete design during installation works at the site	4.01	.744	High
4.	Change in design due to clashing with MEP services installation	3.80	.986	Medium
5.	Reworks; concrete demolishing for equipment adjustment	3.60	.610	Medium
6.	Material costs escalated in the market	3.52	.762	Medium
7.	Repair of damage caused by another subcontractor	3.50	1.01	Medium
8.	Unfeasible site condition for installation of MEP system	3.46	1.02	Medium
9.	Cost variation requested by the contractor due to Site limitation	3.45	.732	Medium
10.	Changes asked by the Engineer for quality control	3.43	.730	Medium
11.	Overdesign due to lack of construction experience	3.15	1.04	Medium
12.	Weather conditions, such as rains and summer work bans	3.11	.958	Medium
13.	Fast-tracking of activities for schedule compression	2.65	.965	Low

Results revealed that delay identifications impacting on cost such as lack of clear understanding of contract documents, Change in design, Incomplete design at site, reworks, concrete demolishing etc. Similar delay identifications were identified in research by [7], [59], [56], [64], and [65] in construction projects in various areas.

4.4 Delay impact on project time

The results revealed 13 delay factors that influence time performance of construction in RMP and KAFD project. The results of delay impact on project are demonstrated in Table 4.3. Based on the field experience of construction professionals the delay factors impacted on project time are demonstrated by index value, standard deviation and impact level of each factor.

Table 4.3: Identification of delay factors impact on Project Time

Sr. No	Investigation of Delays in RMP and KAFD	Index	Standard Deviation	Impact Level
1.	Issues in monthly progress claims by contractor	4.08	.968	High
2.	Delay in submission of construction drawings for approval	4.01	.977	High
3.	Delay in delivery of the materials by supplier	3.95	.572	Medium
4.	Effect of uncontrolled causes such as pandemic conditions	3.82	.585	Medium
5.	Inefficient selection of contractor and subcontractors	3.78	.723	Medium
6.	Prolong procedure for change requests and approvals	3.77	.961	Medium
7.	Poor site conditions, such as water, electricity and food	3.64	.688	Medium
8.	Lack of using updated technologies during installation	3.59	.914	Medium
9.	Shortage of skilled labor required to complete tasks	3.55	.731	Medium
10.	Logical dependencies in phase of construction	3.44	.856	Medium
11.	Area not released by Civil/ Arch for MEP installation	3.39	1.27	Medium
12.	Policy and commitment of government and local regulatory	3.11	.887	Medium
13.	Ineffective project planning and scheduling Improper	2.92	.683	Low

The respondents agreed on two top causes of delays impact on time due to payment issues or delays in monthly invoices, delivery of the materials by supplier, contractor and subcontractors experience and change requests length has highest impact value on project time. As per research by [5], [56], [64], and [85] about construction projects similar delay identifications were proposed with higher impact on project time.

4.5 Mitigation measures for enhancing performance with sustainability

This section comprises mitigation strategies to avoid delay in construction. The respondents were asked to rate the factor according to their experience in KAFD and RMP during the construction stage. The construction professionals rated the top ten strategies as of high importance to avoid delays in building construction. The resulting averages were ranked in descending order according to the highest average in the group response and the topmost ranks are presented in Table 4.4.

Table 4.4: Top 10 strategies for delay mitigation in building construction

Sr. No	Mitigation Measures to enhance project performance and sustainability	N*	Mean	Ranking
1.	Implement smooth coordination among disciplines to avoid delays in construction	291	4.55	1st
2.	Engage engineers from early stage of project to improve collaboration to avoid delays which will lead to enhance sustainable development	291	4.42	2nd
3.	Submit on-time inspection requests to quality control section to avoid additional comments and reworks which lead to delay during execution	291	4.41	3rd
4.	Pay monthly claims on time to the contractor, because it debilitates the contractor capability to finance the work	291	4.16	4th
5.	Verify manufacturer recommendations before installation of equipment of MEP system in building construction	291	4.00	5th
6.	Provide mock-ups and prototypes for consultant engineers approval prior to installation of critical system	291	3.97	6th
7.	Submit shop drawings and change request for review/approval of design engineer prior to installation	291	3.75	7th
8.	Introduce monthly or quarterly basis rewards and recognition at construction site for team motivation	291	3.71	8th
9.	Provide approved and updated combined services drawings for early clashes identification by construction team	291	3.64	9th
10.	Use of modern information technology tools such as BIM, Revit, Aconex etc. in project to enhance team visualization	291	3.60	10th

*N is final number of respondents considered in SPSS for data analysis (that was N= 291 respondents from population)

The analysis of the survey revealed the high degree of agreement among the respondents shows that there is a significant difference in impact of delay in construction process. As a result, the topmost important causes of delay in the construction project identified from overall to mitigate the delays are sequentially ranked as coordination among disciplines, on-time inspection requests to quality control, monthly claims on time, follow manufacturer recommendations before installation of equipment in technical rooms and application modern information technology tools such as BIM could help to avoid delays in upcoming projects.

5. CONCLUSION

Numerous challenges and obstacles have hampered the construction industry worldwide. The construction industry has been struggling with the problem of persistent delay. The focus of this paper is to give a general understanding of the construction sector and then provide basic information about the issue of delays faced by construction projects in Riyadh, Saudi Arabia as a confluence for sustainability and enhancement of projects performance. To meet these new demands, construction firms working on the cities of the future are currently undergoing a metamorphosis. The current change in the building industry is dominated by smart architectural, infrastructure and MEP systems to facilitate the building occupants. However, cities like Riyadh are fundamentally altering into newly envisaged high-

tech connected urban places, so the need is to build projects in time by avoiding delays to meet the client expactations. Consequently, the effective operation of the construction sector is critical for the development of sustainable smart cities. The analysis conducted indicates that time overruns and delays are the most prevalent issues affecting construction projects in Riyadh, Saudi Arabia.

Additionally, several strategies can mitigate construction delays by establishing clear communication channels and regulations among all parties is crucial. Construction professionals must prioritize improved team communication, ensuring contracts are clear, well-defined, and signed by all stakeholders to avoid issues stemming from poor contact management. Effective resource management, including hiring experienced and qualified construction managers and professional engineers, skilled workers is also essential factor to address delys. This research, focused on identifying the causes and effects of construction project delays in Riyadh, can be expanded in the future to other cities or countries using different research methodologies.

REFRENCES

[1] M. Size, L. Quality, and S. Hazards, “Overview of construction,” 2018.

[2] Aecom, *Property & Construction Handbook*. 2024.

[3] A. Alzanati, “Project Management : An Analysis of Causes and Effects of Rework on Construction Project,” p. 94, 2014.

[4] B. Olusegun Adewale, “a Framework for the Process of Effective Coordination of Building Services During the Design Development and Review Stages,” no. May, 2016.

[5] Khanzode,Fischer and Reed, “Benefits and lessons learned of implementing building virtual design and construction (VDC) technologies for coordination of mechanical, electrical, and plumbing,” *Build. Res. Inf.*, vol. 24, no. 3, pp. 152–159, 2008.

[6] Z. Lafhaj, S. Rebai, W. AlBalkhy, O. Hamdi, A. Mossman, and A. Alves Da Costa, “Complexity in Construction Projects: A Literature Review,” *Buildings*, vol. 14, no. 3, 2024, doi: 10.3390/buildings14030680.

[7] J. Y. Altarawneh, V. Thiruchelvam, and B. Samadi, “Determining Critical Success Factors that Contribute to the Delay of Water Infrastructure Construction Projects in the Abu Dhabi Emirtae: A Conceptual Framework,” *Int. Bus. Res.*, vol. 10, no. 12, p. 139, 2017, doi: 10.5539/ibr.v10n12p139.

[8] I. Fatima and D. Wibisono, “Main Performance Indicators for a Construction Company in Indonesia,” *Asia Pacific J. Adv. Bus. Soc. Stud.*, vol. 3, no. 2, 2017, doi: 10.25275/apjabssv3i2bus8.

[9] F. Ahmed Soomro *et al.*, “Causes of Time Overrun in Construction of Building Projects in Pakistan,” *Technol. Appl. Sci. Res.*, vol. 9, no. 1, pp. 3762–3764, 2019.

[10] K. F. Rafat and R. Ahmed, “SSRN-id3884720,” vol. 11, no. 1, pp. 166–174, 2017.

[11] T. Gebrehiwet and H. Luo, “Analysis of Delay Impact on Construction Project Based on RII and Correlation Coefficient: Empirical Study,” *Procedia Eng.*, vol. 196, no. June, pp. 366–374, 2017, doi: 10.1016/j.proeng.2017.07.212.

[12] S. A. Assaf and S. Al-Hejji, “Causes of delay in large construction projects,” *Int. J. Proj. Manag.*, vol. 24, no. 4, pp. 349–357, 2006, doi: 10.1016/j.ijproman.2005.11.010.

[13] D. B. ROSMAN, “INFLUENCE OF REWORK ON THE PROJECT PERFORMANCE,” 2020.

[14] A. M. Alajmi and Z. Ahmed Memon, “A Review on Significant Factors Causing Delays in Saudi Arabia Construction Projects,” *Smart Cities*, vol. 5, no. 4, pp. 1465–1487, 2022, doi: 10.3390/smartcities5040075.

[15] P. By, A. Alzanati, and A. Bajracharya, “Project Management: An Analysis of Causes and Effects of Rework on Construction Project,” 2014.

[16] UNEP, “Action COMMON PLATFORM,” 2010, [Online]. Available: www.unep.org/sbci/resources/Tools.asp

[17] R. Palomera-Arias and R. Liu, “Mechanical, electrical and plumbing systems in construction management: A literature review of existing MEP textbooks,” *ASEE Annu. Conf. Expo. Conf. Proc.*, vol. 122nd ASEE, no. 122nd ASEE Annual Conference and Exposition: Making Value for Society, 2015, doi: 10.18260/p.24480.

[18] V. Motiejunas, “Improving the MEP coordination using BIM technologies-A case study based on observations and interviews,” 2016.

[19] A. AL JANABI, “An empirical study of the impact of knowledge management strategies on waste and rework reduction in construction projects during post-contract award stage in UAE,” no. November, 2018, [Online]. Available: https://bspace.buid.ac.ae/handle/1234/1318

[20] L. Czarnecki and M. Kapron, “Sustainable construction as a research area,” *Int. J. Soc. Mater. Eng. Resour.*, vol. 17, no. 2, pp. 99–106, 2010, doi: 10.5188/ijsmer.17.99.

[21] L. Czarnecki, “Sustainable Construction as a Research Area,” pp. 1–8, 2010.
[22] I. Saidu and W. Shakantu, “The contributions of construction material waste to project cost overruns in Abuja, Nigeria,” *Acta Structilia*, vol. 23, no. 1, 2016, doi: 10.18820/24150487/as23i1.4.
[23] A. H. Memon, A. Q. Memon, S. H. Khahro, and Y. Javed, “Investigation of Project Delays: Towards a Sustainable Construction Industry,” *Sustain.*, vol. 15, no. 2, pp. 1–17, 2023, doi: 10.3390/su15021457.
[24] M. Safa *et al.*, “Classification of Construction Projects,” *Int. J. Civil, Environ. Struct. Constr. Archit. Eng.*, vol. 9, no. 6, 2015.
[25] E. Viles, N. C. Rudeli, and A. Santilli, “Causes of delay in construction projects: a quantitative analysis,” *Eng. Constr. Archit. Manag.*, vol. 27, no. 4, pp. 917–935, 2020, doi: 10.1108/ECAM-01-2019-0024.
[26] G. Kikwasi, “Causes and Effects of Delays and Disruptions in Construction Projects in Tanzania,” *Australas. J. Constr. Econ. Build. - Conf. Ser.*, vol. 1, no. 2, p. 52, 2013, doi: 10.5130/ajceb-cs.v1i2.3166.
[27] M. Mukuka, C. Aigbavboa, and W. Thwala, “Effects of Construction Projects Schedule Overruns: A Case of the Gauteng Province, South Africa,” *Procedia Manuf.*, vol. 3, no. Ahfe, pp. 1690–1695, 2015, doi: 10.1016/j.promfg.2015.07.989.
[28] S. Idrees and M. T. Shafiq, “Factors for Time and Cost Overrun in Public Projects,” *J. Eng. Proj. Prod. Manag.*, vol. 11, no. 3, pp. 243–254, 2021, doi: 10.2478/jeppm-2021-0023.
[29] R. Milford, “Construction Industry Development in Developing Countries ; Lessons and Opportunities,” *3rd Int. Conf. Concr. Dev.*, no. September, pp. 59–70, 1998.
[30] W. Kenny and V. Vanissorn, “A study of the factors affecting construction time in Western Australia,” *Sci. Res. Essays*, vol. 7, no. 40, pp. 3390–3398, 2012, doi: 10.5897/sre12.138.
[31] Jacob, “PROJECT DEL LAYS IN THE NIGER R DELTA REGION, N NIGERIA,” *Экономика Региона*, p. 32, 2012.
[32] T. M. Abduljawwad and A. Almaktoom, “Factors Behind Construction Delays in Saudi Arabia,” *J. Archaeol. Egypt/Egyptology*, vol. 18, no. 15, pp. 184–194, 2021.
[33] A. M. Odeh and H. T. Battaineh, “Causes of construction delay: Traditional contracts,” *Int. J. Proj. Manag.*, vol. 20, no. 1, pp. 67–73, 2002, doi: 10.1016/S0263-7863(00)00037-5.
[34] J. M. Assbeihat, “Factors affecting delays on private construction projects,” *Int. J. Civ. Eng. Technol.*, vol. 7, no. 2, pp. 22–33, 2016.
[35] A. Alshehri, “Addressing the Challenges in Construction Project Management: The Case of Saudi Arabia,” *J. Eng. Appl. Sci.*, vol. 6, no. 1, pp. 1–9, 2019, doi: 10.5455/jeas.2019050101.
[36] A. Reema, K. Abby, and A. Ibrahim, *The Role of Saudi Universities in Advancing the SDGs and Saudi Vision 2030*, no. June. 2022.
[37] M. Stadler Robert Hagen Ron Reck Rainer Mutschler Stefan Vesligaj-Klose Andrea Mandic and I. Al Eid Abdulaziz Al Thunaian Yazeed Al Thenyan, “Riyadh Public Transport Program,” no. February, 2024.
[38] Asiva Noor Rachmayani, *Riyadh City*. 2019.
[39] S. Public Investment fund, “KAFD Dialogue Report, Saudi Arabia’s Journey to Becoming A Global hub,” 2023, [Online]. Available: https://www.kafd.sa/en/kafd-dialogue
[40] K. Meng and P. Fenn, “PERFORMANCE MEASUREMENT FOR CONSTRUCTION PROJECTS,” pp. 89–103, 2019.
[41] A. Lateef, “Investigation of the poor-quality practices on building construction sites in Malaysia,” *Organ. Technol. Manag. Constr.*, vol. 14, no. 1, pp. 2583–2600, 2022, doi: 10.2478/otmcj-2022-0008.
[42] E. K. Simpeh, “An Analysis of the Causes and Impact of Rework in Constructioc Projects: A dissertation presented to the Higher Degrees Committee of the Cape Peninsula University of Technology in fulfilment of the requirements for the degree of Master,” *A Thesis Submitt. Cape Penins. Univ. Technol. South Africa*, no. June, pp. i–142, 2012.
[43] R. Attia, “Rework Prediction on a Construction Site through BIM \& ANN Integration,” 2022.
[44] P. E. D. Love, D. J. Edwards, J. Smith, and D. H. T. Walker, “Divergence or Congruence? A Path Model of Rework for Building and Civil Engineering Projects,” *J. Perform. Constr. Facil.*, vol. 23, no. 6, pp. 480–488, 2009, doi: 10.1061/(asce)cf.1943-5509.0000054.
[45] E. Chidiebere Eze and J. E. Idiake, “Analysis of Cost of Rework on Time and Cost Performance of Building Construction Projects in Abuja, Nigeria,” *Int. J. Built Environ. Sustain.*, vol. 5, no. 1, pp. 56–67, 2018, doi: 10.11113/ijbes.v5.n1.246.
[46] A. Albogamy, D. Scott, and N. Dawood, “Dilemma of Saudi Arabian Construction Industry,” *J. Constr. Eng.*

Proj. Manag., vol. 3, no. 4, pp. 35–40, 2013, doi: 10.6106/jcepm.2013.3.4.035.
[47] P. E. D. Love, Z. Irani, and D. J. Edwards, "A rework reduction model for construction projects," *IEEE Trans. Eng. Manag.*, vol. 51, no. 4, pp. 426–440, 2004, doi: 10.1109/TEM.2004.835092.
[48] A. Alameri, I. A. Rahman, and N. A. N. Nasaruddin, "Ranking of factors causing construction project changes in uae mega construction projects," *Int. J. Sustain. Constr. Eng. Technol.*, vol. 11, no. 1, pp. 1–6, 2020, doi: 10.30880/ijscet.2020.11.01.001.
[49] The One Earth editorial team, "Governance for sustainability," *One Earth*, vol. 5, no. 6, pp. 575–576, 2022, doi: 10.1016/j.oneear.2022.06.001.
[50] P. E. D. Love, J. Matthews, M. C. P. Sing, S. R. Porter, and W. Fang, "State of Science: Why Does Rework Occur in Construction? What Are Its Consequences? And What Can be Done to Mitigate Its Occurrence?," *Engineering*, vol. 18, pp. 246–258, 2022, doi: 10.1016/j.eng.2022.05.010.
[51] R. Asadi, J. O. B. Rotimi, and S. Wilkinson, "Classification of rework root causes in the design stage of projects for contract assessment," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1101, no. 4, 2022, doi: 10.1088/1755-1315/1101/4/042033.
[52] O. E. Ogunmakinde, T. Egbelakin, and W. Sher, "Contributions of the circular economy to the UN sustainable development goals through sustainable construction," *Resour. Conserv. Recycl.*, vol. 178, no. October 2021, p. 106023, 2022, doi: 10.1016/j.resconrec.2021.106023.
[53] P. Love and D. J. Edwards, "Forensic project management: The underlying causes of rework in construction projects," *Civ. Eng. Environ. Syst.*, vol. 21, no. 3, pp. 207–228, 2004, doi: 10.1080/10286600412331295955.
[54] S. A. Deeba, "The research design," *J. Crit. Rev.*, vol. 12, no. 2, pp. 35–41, 2023, doi: 10.1097/00005110-198202000-00007.
[55] N. I. A. Gani, M. Rathakrishnan, and H. N. Krishnasamy, "A pilot test for establishing validity and reliability of qualitative interview in the blended learning English proficiency course," *J. Crit. Rev.*, vol. 7, no. 5, pp. 140–143, 2020, doi: 10.31838/jcr.07.05.23.
[56] A. M. Al-Janabi, M. S. Abdel-Monem, and K. M. El-Dash, "Factors causing rework and their impact on projects' performance in Egypt," *J. Civ. Eng. Manag.*, vol. 26, no. 7, pp. 666–689, 2020, doi: 10.3846/jcem.2020.12916.
[57] H. Dzwigol, "Pilot study in the research procedure," vol. 2, no. 50, pp. 0–2, 2020, doi: 10.29119/1899-6116.2020.50.1.
[58] H. O. W. T. O. Plan, "Questionnaire design: how to plan, structure, and write survey material for effective market research," *Choice Rev. Online*, vol. 51, no. 02, pp. 51-0965-51–0965, 2013, doi: 10.5860/choice.51-0965.
[59] A. Enshassi, M. Sundermeier, and M. A. Zeiter, "Factors Contributing to Rework and their Impact on Construction Projects Performance," *Int. J. Sustain. Constr. Eng. Technol.*, vol. 8, no. 1, pp. 2180–3242, 2017, [Online]. Available: http://penerbit.uthm.edu.my/ojs/index.php/IJSCET
[60] F. Luis and G. Moncayo, *Research Design*. 2017.
[61] S. Shukla, "Concept of Population and Sample," *How to Write a Res. Pap.*, no. June, pp. 1–6, 2020.
[62] M. Hennink and B. N. Kaiser, "Sample sizes for saturation in qualitative research: A systematic review of empirical tests," *Soc. Sci. Med.*, vol. 292, p. 114523, 2022, doi: 10.1016/j.socscimed.2021.114523.
[63] B. Abdul, "Sample Size Determination Using Krejcie and Morgan Table. 10.13140/RG. 2.2. 11445.19687," no. February, 2021, doi: 10.13140/RG.2.2.11445.19687.
[64] N. Forcada, M. Gangolells, M. Casals, and M. Macarulla, "Factors Affecting Rework Costs in Construction," *J. Constr. Eng. Manag.*, vol. 143, no. 8, 2017, doi: 10.1061/(asce)co.1943-7862.0001324.
[65] X. Yang, M. Huang, and F. Lin, "Research Strategies on New Prefabricated Technology for Underground Metro Stations," *Urban Rail Transit*, vol. 5, no. 3, pp. 145–154, 2019, doi: 10.1007/s40864-019-0106-z.