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Research Article

Experience System to Solve Problems in Emergency Reconstruction Projects

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ABSTRACT

Introduction: This study aims to create an expert system questionnaire and assess the potential impact of delays and project cost changes after disasters. These are important considerations for achieving sustainable development goals and restoring normalcy to communities affected by natural disasters like earthquakes, floods, and fires, environmental crises such as the Covid-19 pandemic, or man-made disasters like wars.

Objectives: The study focuses on construction projects in Iraq after the 2003 war. This hypothesis of this paper came to suggest that utilizing an experience-based system, such as a knowledge-sharing or decision-support system, will help address the challenges faced during the rebuilding process after a disaster, and these challenges extend to include time constraints and limited resources, besides the necessity of faster decision making. There might be no effectiveness in traditional construction projects as in an emergency reconstruction projects scenario; therefore, innovative methodology such as experience system could be crucial.

Methods: The expert system questionnaire was developed based on input from Iraqi experts and consultants in the construction industry. It includes 80 potential causes of delay, categorized into major and secondary factors. This methodology is being applied for the first time in project management in Iraq.

Results: The results revealed that the main contributors to project delays are contractors, owners, external factors, consulting teams, and systems and instructions, with contribution ratios of 30, 20, 15, 10, and 7.5, respectively. The analysis also showed that secondary factors have a higher linear correlation value than primary factors.

Conclusions: The study found that contractors and external factors, such as those seen in the Covid-19 pandemic, have the most significant impact on project delays, while other factors play a lesser role in project implementation delays.

Keywords: Post-Disaster Reconstruction, Project Delay Factors, Experience System, Resilience, Sustainability, Stability.

INTRODUCTION

For post-disaster and emergency reconstruction programs to be successful, construction organizations must be more flexible and capable of recovering from emergencies and dire events. Resilient construction projects must be responsive, adaptable, and able to operate in emergencies, according to [1]. In addition to maintaining the sustainability of construction projects and resilience in unusual circumstances, the primary goal of responding to emergencies is to always preserve and save lives, which is one of the most important objectives for achieving sustainable development by providing security and safety for all societies [2]. To effectively deal with emergencies and achieve the best results, it is crucial to have solid and adaptable leadership, teamwork, clear thinking, and access to resources, good communication skills, situational awareness, backups, and safety measures in place. It's important to regularly review the emergency plan, especially after emergencies have occurred, and make necessary changes when weaknesses in the plan become evident. Natural or technical disasters can lead to project failures, increased costs, and the potential cancellation of construction due to severe damage or natural disasters at the site. The article discussed potential disasters in construction projects, alternative terms for dealing with damage, and various disaster management approaches, models, and frameworks, while also evaluating expert perspectives for effective emergency response. Another study examined contractors' involvement in disaster management planning to ensure more efficient post-disaster reconstruction management. Australia is actively working to become a more resilient nation by better understanding the role that Australian building contractors can play in planning for disasters. There is an emphasis on developing the construction industry in disaster management and enhancing knowledge of the relationship between good planning, design, construction, and disaster prevention and management. It's important to consider that wars and civil conflicts are among the main man-made factors that can lead to disasters. Additionally, internal conflicts resulting from terrorism and sectarianism, such as is the case in civil wars, can exacerbate the situation.

Furthermore, a study has been conducted to examine the issues and challenges surrounding successful emergency projects. The critical success factors that influence project outcomes were identified, aiming to improve post-disaster project management in both the public and private sectors, as well as for international and local NGOs involved in post-disaster reconstruction. The study also presents a model that can be used as a platform for other researchers in this evolving field. Table 1 lists the projects included in this study. All of these projects were implemented in Iraq after the 2003 war. The first 30 projects were implemented under the supervision of local administration project construction bodies, while the last five projects were established under the supervision of international project construction bodies and organizations under the framework of oil for reconstruction, as well as from grants donated by donor countries for emergency reconstruction and implemented with post-disaster project management considerations. For the last five projects, there has been no delay in the project completion time and no change in the planned contract cost and the actual cost of the project. On the other hand, we note that the first 30 projects witnessed these changes in time and cost. In [10], a model was created that can be used throughout a project and gives an impression of what the implementation process might take. This model was built according to the research field study and it touches on the reality of construction projects, gives practical solutions, and reveals the causes of delay.

Table 1 Delayed projects and their contract and actual cost and time

Project no.	**Project Name**	**Contract Project time**	**Actual Project time**	**Contract Project cost**	**Actual Project cost**
		Months		$ US	
1	22 Presidential Houses.	6.0	24.3	45.0560 00	55.296.0 00
2	Emigration office.	15.2	18.2	1.424.40 0	1.568400
3	Housing complex.	36.5	39.5	76.000.0 00	84.000.0 00
4	Service office building.	12.2	19.2	200.000	240.000
5	Karkh Traffic office.	18.2	24.2	720.000	880.000
6	Ibn Sina hospital.	3.0	27.0	7.200.00 0	11.200.0 00
7	Headquarters of the construction and housing department.	12.2	14.2	1.011.984	1.040.00 0
8	Preparation of Ziggurat building.	15.0	17.0	19.002.7 7	19.179.2
9	Department of burns at Yarmouk hospital.	12.2	15.2	3.200.00 0	4.000.00 0
10	Temporary workshops.	6.0	8.0	90.515.2	92.000
11	Additional buildings, College of Law, Mustansiriya University.	23.2	29.2	2.383.69 0	2.800.00 0
12	Installation of complete washing machines in Baghdad Factory of Textiles.	4.0	8.0	336.000	353.600
13	Rehabilitation of treatment station(zonal development plan.	6.0	20.0	805.457. 2	1.264.20 8
14	The complementary phase of the classrooms project.	3.0	8.0	224.000	224.000
15	Auditorium for College of education for women.	2.5	2.7	96.000	96.000
16	College of Arts, university of Baghdad.	24.0	32.0		

				2.864.000	3.160.000
17	Construction of space and communications building.	4.0	9.2	1.060.925	1.192.000
18	The new headquarters building of the Ministry of Science and Technology.	12.2	17.2	2.800.000	3.000.000
19	Engineering affairs building.	18.0	27.0	1.555.048	1.921.001
20	Civil Defense Building.	8.0	14.0	480.000	494.215.5
21	Gate of Baghdad – Hilla project.	18.0	55.0	4.856.668	5.196.634
22	Gate of Baghdad – baquba project.	18.0	46.0	4.985.209	5.982.250
23	Gate of Baghdad – Kut project.	18.0	45.0	5.224.811	6.269.773
24	12 classrooms School in a Al-rashidiya project.	4.0	28.0	567.455.2	576.000
25	Construction of the Mesopotamia building in Mahmudiya.	6.0	42.4	630.696.8	674.844.8
26	Gate of Baghdad – Mosul project.	18.0	55.0	5.551.249	5.939.836
27	Restoration and reinforcement of classrooms in Sumaya elementary school.	4.0	12.2	157.600	168.000
28	Building a model 18 classrooms school complex in husseiniya.	5.0	5.7	837.344	837.344
29	Building a model school complex in Basmayah, Nahrawan area.	8.0	8.0	1.487.200	1.487.200
30	Building a model 12 classrooms school complex in Mahmudiya.	12.2	12.2	2.400.000	2.400.000
31	emergency project Baghdad.	2.0	2.0	5.120.000	5.120.000
32	emergency project Erbil.	2.0	2.0	5.120.000	5.120.000
33	emergency project Duhock.	2.0	2.0	5.120.000	5.120.000
34	emergency project Sulaimaniya.	2.0	2.0	5.120.000	5.120.000
35	emergency project karbala.	2.0	2.0	5.120.000	5.120.000

OBJECTIVES

The importance of the study lies in finding innovative ways to improve work performance in the field of reconstruction in emergency and post-disaster situations as well as in traditional, normal situations.

By creating mathematical models and methods using artificial intelligence and statistical analysis to improve performance in the field of construction industry and achieve stability and sustainable development for communities that may be exposed to natural or environmental disasters or due to wars.

The most important problems of the study facing the construction and building sector are the delays that may occur in projects for many reasons and various problems related to the nature of construction and building, and the most important goal of our study is to work on finding solutions to those problems facing the construction and building sector by analyzing risks and finding innovative ways in the labor market to reduce them in upcoming projects that contribute to supporting the economy and sustainable development of the country.

This study is considered an expert system for solving problems facing construction projects in traditional, normal and emergency situations, one of the most important systems that countries need in general and projects in particular, especially since its positive impact provides direct support to the global and local economy and helps in achieving sustainable development goals.

Since improving the economy plays a major role in the urban development of countries, a comprehensive risk analysis must be conducted before starting projects and evaluating potential challenges. Feasibility studies also contribute to the success of the project and its benefits. Based on these analyses, appropriate strategies can be developed to deal with risks and challenges, which in turn reduces the chances of problems occurring and increases the likelihood of project success. Feasibility studies also make an important contribution to identifying the steps and stages necessary to ensure the successful implementation of the project. Also, good and successful project planning is half the success of the project. Commitment to preparing specific timetables and accurate cost estimates for the project contributes to its success and benefiting from it within the specified time and planned cost, as time is money and not the other way around. This in turn helps project teams organize their efforts and complete their tasks in the right way and within the project timetable and the specific planned cost, which contributes to not stopping the project. Motivations for choosing the study problem:

The project management sector may face challenges that prevent it from achieving consistent performance that advances the organization, the most important of which is the lack of appreciation for the crucial role played by the Project Management Office (PMO) as a representative of the organization with the best standards and best practices in the organization, as it now has access to well-targeted tools and strategies, which is necessary to achieve the right visions, efficiency and productivity in terms of cooperation between team members and the remote work environment. The most important objectives of this study are to focus on the challenges faced by project managers and how to manage projects and manage risks and provide recommended solutions to deal with them and improve the efficiency and performance of project management.

LITERATURE REVIEW

[11] confirmed. However, disaster rehabilitation operations may involve a range of stakeholders, private and non-profit organizations (NPO) and community groups and individuals. Stakeholders may undertake many different activities and must ensure that their decisions and actions are appropriate in a turbulent environment. This is why project management plays an important role in the management of many post-disaster relief and humanitarian rehabilitation project. When looking into previous status of countries that faced war disasters and sectarianism conflicts, we can conclude that the most important point in the process of rebuilding and resettlement is peace building instead of war in these countries. The first step after rehabilitating minds and transforming them to peace is starting reconstruction projects that need facilities such as bridges, municipality services, health centers and more over educational institutions and markets. And that what [12], referred to when studied rehabilitation and reintegration of post war peace building in Sri Lanka in a program that aimed to rehabilitate people by changing their intentions from conflicts to peace, also the study aimed to evaluate the success of the regime's long-term plan of peace throughout using the primary and secondary data. Reconstruction process is divided into two main parts, the first is the construction of housing units and the second is the restoration or construction of infrastructure: roads, bridges, water and sewage networks, electricity, railways, ports, and infrastructure for all life utilities. Housing projects are the first in most post-disaster reconstruction in many countries, which disaster victims need and become the first government's priority. In developing and poor countries disaster victims do not have home insurance or financial Disaster victims do not have home insurance or the financial ability to rebuild in poor and developing countries, so their responsible governments must permanently provide relief homes for displaced disaster victims in emergency situations. [13], investigated the allocation of funding to housing after disasters, revealing that housing is the preferred expenditure at 30-50% of the financial allocation. There are also two common ways to purchase a residential project. First, because a housing project requires relatively less construction skills, equipment, and simple construction methods than an infrastructure project, disaster victims or post-disaster communities may be able to build their own homes. As for the second approach, the government must be appointed as a private contractor to build houses, [14], [15] studied the main steps for setting a project budget and stated that the construction project schedule is an important document in the construction industry, as project planning contributes to

the success of the project if it is prepared correctly. Participants in the construction project, such as the contractor and owner, use the construction schedule to plan, monitor and control project work to complete the project within budget and time and give satisfaction to all parties of the project. In recent years, the construction schedule has been increasingly used as a legal document in resolving disputes and verifying claims between project participants. The reconstruction process may begin when sufficient funds are available to finance it. Funding for reconstruction projects comes mostly from insurance coverage in developed countries and from grants or donor assistance in developing countries. Insured homeowners may quickly be able to build their homes and the reconstruction process will begin immediately. Conversely, insurance coverage may not be available or unaffordable to homeowners in developing countries, so reconstruction efforts will not begin without outside assistance [16]. It is imperative for governments to look at the success of the project from a holistic point of view, the success of the reconstruction project is due to the affected community back to the living conditions before the disaster, and the facilities established are resilient to subsequent disasters. Project management plays a prominent role in ensuring successful completion of reconstruction projects [16], [17], show how dynamic changes can affect the project management system. They also found that the most important factor was the need to understand how certain dynamics could impede the performance of the project management system. [18], previously demonstrated that integration could manage the complexity of a project as he considered the construction process to be a complex task in any industry. It is important to mention construction risks in the project management system. Risk management is essential for construction activities, to reduce losses and enhance profitability, as emphasized by [19].[20] studied the issues, challenges and problems facing projects, investigated the success factors of emergency projects, and identified the critical success factors that are most influential in avoiding the failure of a particular project and improving the practice of post-disaster project management for the public and private sectors and for international and local non-governmental organizations that participate in the reconstruction phase. After the disasters, it created a model that may be a platform for other researchers to launch in the field of benefiting from the technological revolution and artificial intelligence to reduce losses in time and effort in projects, as time is money. [20], [21] also studied the importance of preparing for any collapses that may occur in concrete structures as a result of natural disasters, especially earthquakes, poor implementation, or other disasters resulting from other disasters, as happens in wars and natural disasters such as earthquakes or malfunctions that may occur as a result of a specific malfunction of equipment and mechanisms. And the elements, or faulty designs, and old buildings, through the development of work on creating earthquake-resistant buildings, and their study revealed the possibility of using joints, and treating these joints and sections in reinforced or unreinforced concrete structures. This is to maintain the safety of people and buildings from sudden disasters and reduce those risks that may pose a threat to safe communities, and to intensify control of the quality of production and defect-free concrete joints and parts to the maximum extent in production factories. As happens in the human spine, we find that cartilage helps maintain the stability of the vertebrae when they bend or are exposed to bruises, shocks, and vibrations when driving a car or walking through a hole in the road or bumps.

In 2005, [22] stated that each disaster recovery project is different, and the context can vary greatly, which makes it difficult to ensure ongoing improvement. Also, [23] stated this statement in 2007 to explain the challenges in such projects. In post disaster construction projects challenges vary in a different way than traditional projects, where decision making considers a controlling factor because of the need of conducting these projects as soon as possible (Afkhamiaghda). Thus solution that goes upon an experience system can provide decision-makers with immediate access to relevant solutions or methods based on past experiences, helping them to make informed choices quickly [24]. In 2003, [25], stated that there should be an availability of resources such as construction materials, well trained labors, and adequate equipment to start the project in disaster cases, which they tend to be unavailable in most cases. And the solution certainly should be consulting experience system that can help in managing resources effectively [26], [27]. Another challenge may appear in post disaster projects, namely the collaboration and coordination, which involve multiple teams, agencies, and organizations to lead the communication breakdown and inefficiency [28], and here the experience system comes to facilitate better collaboration by connecting and sharing knowledge and offering solutions to common issues to ensure consistent goals (Fong, 2003).

To avoid such disasters, there should be safe precautions followed, and the best solution to do so is to adopt an approach for more secured society

There must be proper management of disasters, whether natural or man-made, especially in recent years, where many earthquakes have struck some countries. Major and minor causes of delay and their weights due to expert system have been obtained during pandemic.

METHODS

Form 1 was a filling out questionnaires of consultants and employees "experience system' filled by consultants of different institutions and offices. Thirty questionnaire forms have identified the most essential points that consultants might face in construction sector. This kind of questionnaire has been standing on the 80 grounds of delay reasons that may hinder the progress of projects construction. They were answered by consultants and experience system. Each country has its own circumstances, which play different role on delay factors. It is well known that the construction projects industry in Iraq had faced a major difference between the periods before and after the 2003 war. [21], found unique insights into factors that need to be considered in projects construction evaluation for post disaster emergency reconstruction in areas impacted by wars and terrorism. According to these outcomes the following questionnaire is designed. Also, [30], has developed an indoor environment assessment tool for residential buildings using the opinion of experts in a questionnaire form in computerized application where their method was appropriate to obtain the needed data. And to solve the tradeoff problem in term of time and cost in construction project management, [31], have used the fuzzy mathematical model building to facilitate achieving the optimum solutions and reducing the efforts and time plus cost compared to the traditional methods in forecasting delay factors affecting reconstruction projects implementation. In her study, [32], the most common major delay factors found were contractor failure causing schedule overruns, redesigns, poor planning, frequent change orders, security reasons, low bids, weather factors, and owner failure. [33] studied the most influential factor in the stumbling and failure of government projects and found that cost overruns, time overruns, delays, and scope creep are those factors. We find that many studies have examined the factors causing delays and cost overruns, but few have examined projects in conditions such as those that have dominated Iraq over the past two decades. she also indicated in her study that epidemics and pandemics are external factors that increase the stumbling of projects in this way.

3.1. Proposed questionnaire form

"Iraq as a Case Study: Identification of Causes of Delay in Emergency Reconstruction Post-disaster Projects, and Factors Impacting Time and Quality Cost.

This questionnaire is intended for experts employed by state institutions, such as directors, deputies, heads of engineering departments or their representatives, advisors, designers, consultant engineers, contractors, professionals in the construction industry, project managers, or their deputies. The following are the details required from the individuals filling out the questionnaire:"

Please provide the following details related to your experience and specialization:
1. Experience and Specialization
1.1 Institution or entity
1.2 occupation
1.3 The sector that you work in
1.4 years of experience
1.5 specialization
Subsequently, please provide the project-related information:

2. Projects that you have been involved in
2.1 Number of projects you have contributed to
2.2 Types of projects you have worked on
2.3 Have any of your projects been delayed?
2.4 If not, proceed to 2.9
2.5 How many projects have been delayed?
2.6 The types of delayed projects
2.7 List the common types of delayed projects in your opinion
2.8 What is the ratio of delay (delay time and change in cost) to complete the project and hand it over to the beneficiary: Less than 10%, 10-30%, 30-50%, 51-100%, or more than.
2.9 Who do you think is responsible for the delay: The contractor, the employer, the supervising engineer, or the designer
2.10 Note the list of delay reasons in section (2.3) and rank the most important reasons from your point of view (type the identification number of reason only) 1..., 2..., 3..., 4..., 5...

3. Delay causes (forms)

3.1 The following table represents the frequency of time delay in three-degree levels:

Degree	Importance	%100
1	Little effect	
2	Moderately effect	
3	Strongly effect	

Degree	frequency	%100
1	Rarely happens	
2	Occur	
3	common occurrence	

3.2. The following table represents the degree of the effect of the delay cause, where divided into three levels
Note: Please check off the box of the direct reason of delay. You can choose more than one reason.

3.2 delay causes form

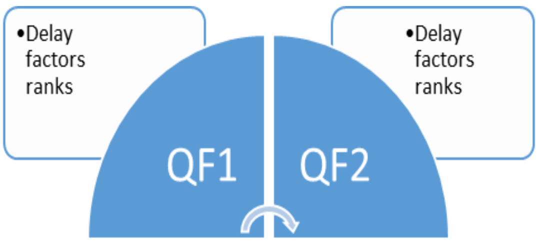
	direct delay cause	Frequency cause			importance		
contractor							
materials		1	2	3	1	2	3
1	Lack of materials						
2	Change in materials prices						
3	Change in materials specifications						
4	materials supplying delays						
5	laboratory tests delays						
equipment							
5	Inefficient work equipment						
6	large number of working equipment failure						
7	Import delayed work equipment (difficulty shipping or other)						
8	Lack of working equipment						
Labor							
8	shortage of skilled and unskilled labor						
9	High labor prices						
10	Lack of skilled manpower (lack of experience)						
Contractor project management							
10	Lack of technical competence of the contractor staff.						
11	Inefficient contractor management						
12	Contractor Poor planning						
13	Inefficient method of execution used						
14	lack of contractor quality control						
15	Contractor weak control of subcontractors						
16	Contractor Miscalculation of time and cost of the project						
17	The lack of work progress schedule of project or time scheduling						
18	Lack of commitment to work project schedule progress						
19	Change requests Delay (change issues)						
20	delay Site Survey						
21	Lack of coordination of project team with random related organizations and differing in point of views						
Financial issues							
22	Contract Sale for more than a subcontractor						
23	Inefficient financial Contractor						
24	The multiplicity of contractor financial obligations						
25	Difficulties in the project financing						
26	Lack of the contractor cash flow						
27	Financial problems with sub-contractors on the financial advances						
Employer							
28	Delays in the delivery of the work site to the contractor.						
29	Allocated to the completion of the work is already insufficient duration						
30	Lack in cash flow						
31	Pause action by the owner.						
32	Delays in issuing change orders.						
33	Decision-making delay by the staff of the employer.						
34	employer delay of Contractor financial payment						
35	The employer acts inconsistent with the contract works.						
36	The large number of change orders in the project.						

37	Non-delivery of the contractor plans required redesign plans by the consultant after the assignment and the contract is signed
38	Number of committees overseeing the receipt and change of many engineers, project leaders, and especially recent graduates and lack of experience in the construction industry.
39	Quantitative and technical errors in the BOQ by the Advisory Group
40	existence of vague clauses in the BOQ without the prior knowledge
41	lack of clarity in the plans
42	Employer interference in the modus operandi that contractor followed by
employer (the supervising engineer)	
43	Lack of technical and managerial experience (recent graduate)
44	Slow response to requests
45	Applying specifications pointedly.
46	was not on a permanent basis at the site
47	Diligence in interpreting plans and specifications (by mistake)
48	Questioning ended in the work done
49	follows the traditional style in addressing the project team
50	Inadequate competence with the task assigned to him for example a chemist is placed in the management of construction project or a mechanics in the .management of chemical project. Emphasize the right person is the right place
designer	
51	the lack of expertise of project designer staff (project designer)
52	Preparation delay of the required detailed plans
53	Responding delays to the contractor requests and inquiries.
54	weak collaboration with the project team
55	Delay in Preparation and alternatives evaluation and tests results
56	Disagreement with the proposed alternatives which have the same specifications and non-application of value engineering (VE)
Consultant team (the initial planning and design)	
57	already inadequate of the period allocated of the implementation
58	Quite different from what is documented site conditions Tender.
59	Imprecision and lack of uniformity and large number of errors in the design and specifications.
60	Circulating in the sample project sites and other provinces
61	Over a long period of guessing the actual implementation of the project (difference in prices between the two periods ,labor, materials and equipment)
62	Wrong Speculation in project cost
Official regulations and instructions	
63	Delay penalties ineffective
64	The difficulty in obtaining construction permit
65	Changes in laws and building regulations
66	Refer the realization of the lower bids in state enterprises and without access to the actual ability of the contractor to complete the work and similar or condoned with inefficient contractor financial.
67	Administrative law in the state construction contracts.
68	Lack of a uniform approved standards in projects
69	Establishing a new taxes during the implementation
External factors	
70	Bad weather at the site
71	Unforeseen circumstances soil site (groundwater, Rocks, etc.)
72	Site selections and the difficulty of transport and entry mechanisms.
73	Social and cultural considerations in the project area
74	Unusual raise in the price of materials or labors or equipment.
75	Work among several contractors overlap with most of work site and work opening of more than a contractor within the project.
76	Security conditions and the disruption of roads.(curfew)
77	Enter certain parties which is not responsible for the work.
78	Strikes and riots among workers and the lack of commitment to the ethics and rules of good conduct

79	Declare a state of emergency or a declaration of war in the country.
80	Administrative poor management and lack of performance factors that may cause delay.

This questionnaire was developed by researchers based on the issues observed in previous project samples. Fifty copies of the questionnaire were distributed to 50 experts working in various Iraqi organizations involved in project construction. All necessary permissions were obtained from these organizations with the approval of the Iraqi engineer's syndicate. Thirty completed questionnaires were returned to the researchers. The response data from these questionnaires constitutes Sample Form 1. After reviewing the collected forms and data, we observed that the sample included various types of construction projects such as infrastructure, roads, and multi-purpose buildings. The construction sector in our country is characterized by the unique nature of each project, necessitating efforts to address the challenges and difficulties in this industry. This includes the need to rebalance and overcome bottlenecks, especially in the most challenging types of engineering projects. "The chosen methodology is to build a delay prediction model using a traditional statistical model. It is well known that the estimated cost of a project is not usually exact, but it is an estimate (33). According to research by (34), the accuracy and reliability of the cost estimate may depend entirely on the extent to which the project scope is defined and the time and effort expended in preparing the estimate. Many qualitative and quantitative factors may affect the cost of the contract, as indicated by previous related studies. However, most previous construction models used only a small number of these factors due to the lack of some information in the early stages of the project. Additionally, (34) found that there are many methods used to predict future construction costs. Some of these models describe construction cost as a function of factors thought to influence construction cost, and the relationship between construction cost and these factors has been determined from previous construction cost records." Models created using this approach are typically used to estimate the cost of individual contracts. These models, with their relational structure, are expected to provide reliable long-term estimates. In her study [35], she developed an application for digitally managing project risk during emergencies, sudden circumstances, pandemics, and post-disaster situations. She also created an application for managing digital risks and mitigating the negative impact of epidemics by enhancing information technology and the Internet of Things. Her study also included an overview of the reasons for cost changes and overruns in a selected group of thirty government projects in Iraq over time and cost control. In their study of risk management strategies resulting from the Covid-19 pandemic, [36] identified solutions to scheduling problems that may arise in thirty-six engineering projects of various types and sizes, including those in Middle Eastern countries, particularly Iraq. They developed a theoretical and practical concept for managing project risks, addressing both global and local issues that could negatively impact time and cost. Another study, [37], confirmed that disasters, like the Covid-19 pandemic, can paralyze community activities, leading to increased efforts in disaster management and the search for innovative solutions to mitigate risks, such as remote work and digital planning. The focus of their research was on the use of artificial intelligence (AI) as a solution to problems that arise in projects, highlighting the importance of adapting to advancements in the information technology sector. "Creativity is driven by needs." This paper compares the methodology and results of a study collected through a questionnaire (QF1) with the findings of [10], which also used a similar methodology and obtained promising results (QF2). The methodology used by [10] aims to avoid delays and cost changes in emergency reconstruction projects, especially in post-disaster conditions, by identifying factors affecting the actual construction period and project cost versus estimated construction duration. The study involved thirty construction projects in different regions of Iraq. Participants provided project data through a survey form, and mathematical data analysis was used to predict changes in time and cost of projects from the initial construction stages. The study used artificial intelligence and neural networks for analysis and identified factors such as contractor failure, redesigns, change orders, security issues, selection of low-priced bids, weather factors, owner failure, and other external factors like COVID-19 conditions as the most important contributors to schedule delays and cost increases. [38] concluded that using an artificial neural network model is an effective way to model this complex phenomenon. Both methodologies identified the most important factors causing time delays and cost changes, albeit in different ways.

Comparison Methods flowchart



RESULTS & DISCUSSION

A questionnaire called the "experience system" was created to identify the most common causes of delays in the construction industry, according to experts in various engineering fields such as civil, electrical, mechanical, architectural, environmental, surveying, and production engineering. The questionnaire was distributed to 30 experts working in both governmental and private sectors within the construction industry. Their opinions were collected regarding the factors contributing to delays.

The form contains 80 possible causes of delay, which are classified under different main categories. Each category represents a group of delay causes that could be clustered under the same category. The main categories deal with the people who run the project, such as the contractor, the owner, the consultant team, as well as instructions, rules, and some external factors.

In Table 2, the main causes of delay and the secondary causes are presented. Each cause was weighted by consultants and experts in the field of construction using an experience system. According to the experience system, the rate of delay in construction projects is ranked as follows: Contractor>Owner>External factors>Consultant team>System and instructions at 30>20>15>10>7.5, respectively.

The experience system has rated the failure in construction projects, with 30% of the delay being blamed on contractors and related issues, and 20% being blamed on the owner and issues related to them. External factors account for 15% of the delay, consultant team delay was 10%, while instructions and system issues that change frequently contribute to 7.5% of the delay in construction projects.

The main causes of delay each have different secondary factors, as indicated in table 2, and they were weighted. Analysis of variance revealed a significant difference ($P<0.05$) among the main causes, while the secondary causes did not show significant differences. Additionally, there was a high linear association among the secondary factors (Eta2=0.997), indicating a strong relationship among them, while the linear association among the main factors was much less (Eta2=0.581). The measure of association (Eta2) defines the strength of the linear relationship in terms of the degree of monotonicity [37]. The secondary factors showed high association, demonstrating a symmetrical type of causal direction, indicating their relation to each other within each main factor category. On the other hand, the main factors showed an asymmetrical type of causal direction, suggesting that they might not be related to each other.

Table 2 Main and Secondary Causes(factors) of delay and their weights due to expert system

Delay %	**30**		**20**		**10**		**7.5**		**15**	
Main caus	Contractor	weight	Owner	weight	Consultant team	weight	System and instruction	weight	External factors	weight
secondary causes	Material	5.0	work's start up delay	1.0	lack of experience	2	inactive delay penalties	1.5	Bad weather conditions	1
	Equipment and machinery	2.5	insufficient Period	1.0	Detailed technical sketches delay.	2	Building permission difficulty	0.5	unexpected soil conditions	1
	Human resources	2.5	lack of cash flow	1.0	delay of response to contractor demands	2	changing rules and systems of construction	0.5	Site limitation. transportation difficulties and equipment translocation	1
	Contractor projects management	10	Temporary work halting	1.0	Weak team spirit	2	Low price assignment	0.5	Social and cultural considerations	0.5
	Financial problems	10	Changing orders delay	1.0	Delay of presenting alternatives and after laboratory tests	1.5	Administrative rules arbitration of governmental contracting system	3	Increase of manpower and materials cost	1

		Decision making delay	1.0	Rejecting suggested alternatives	0.5	Unconsolidated specification depended in construction projects	0.5	contractor work's interaction	2
		In due Payment's delay	2.0	Insufficient executive paragraph	1	Developing new taxes throughout implementation	0.5	Violence actions and ways blockage	2.5
		Contradictory works	1.0	Different conditions of work site	1	Interaction between contractors works	1	Interruption of unrelated directions	1
		many changing orders	2.0	Unprecise designs and mistakes abundance	2			Turbulence and disorders	1
		Sketches off submission	1.0	project generalization to different locations	1			Emergency status declaration	2.5
		Multiplicity of supervising and delivering committees	1.0	Shifting between planned and actual time of implementation	1.5			Weak project management	1.5
		Wrong bill of quantities B.O.Q	2.0	Wrong of project planned cost	1				
		Unknown items in B.O.Q	1.0						
		Incomplete sketches and plans	1.0						
		Owner / contractor work interruption	1.0						
		Lack of experience of project management	2.0						
		Weak response	1.0						
		Strict application of Specification	1.0						
		Frequent absence in field	1.0						
		Wrong interpretation of plans	1.0						

	Continues Suspecting of performance	1.0
	Convectional team language with no invention	1.0
	Incompatible specialization missionary	2.0

The data was extracted from questionnaires distributed to experts and specialists in the engineering industry. Table 3 displays the percentages of delays attributed to various factors as rated by the experts and specialists. It also includes information on their years of experience and the number of projects they have been involved in. The table indicates that most of the specialists attribute the highest percentage of delays to the contractor. Figure 1 illustrates the specialists' ratings of the main delay factors presented in Table 3. Other data is extracted from the experience system forms of questionnaires that were distributed to experts and specialists in the field of engineering industry. Table 3 shows causes of delay percentages rated according to the opinion of experts and specialists; it also shows their years of experience, project participation, and number of projects they witnessed delay throughout their service life. From this table, we can see that most specialists have given the highest rating of delay upon the contractor as a main factor. Figure 1 shows the specialist's rating of the main delay factors that are shown in Table 3.

Table 3 opinion of experts, specialists, and weightings main delay factors

No.	**Specialists in Engineering industry**	**Years of experience**	**Cause of Delay weights Percentages (%)**					**time & cost delay %**	**Projects number took part in**	**Projects number witnessed delay**
			Contractor	Owner	Consultant	Systems instructions	External factors			
1	Civil	21	45	20	10	5	25	10	100	10
2	Civil	15	35	15	25	10	15	5	25	2
3	Civil	15	32	30	12	6	24	12	17	4
4	Electrical	15	55	8	37	0	12	30	25	3
5	Civil	15	30	15	17	0	13	30	100	12
6	Civil	15	90	5	2	0	8	10	30	2
7	Architect	17	80	5	0	0	15	30	15	3
8	Civil	20	30	4	60	0	7	10	30	7
9	Mechanical	19	12	3	18	0	15	15	18	5
10	Civil	15	50	20	17		15	30	20	6
11	Civil	16	60	18	12	5	14	30	30	3
12	Civil	25	70	8	15	0	12	50	20	4
13	Environment	15	40	25	8	3	7	30	16	7
14	Production	15	75	8	0	0	12	50	50	10
15	Electrical	17	28	17	0	0	45	10	100	15
16	Civil	16	48	16	14	0	27	10	400	15
17	Civil	17	30	12	0	0	60	30	18	4
18	Architectural	30	45	28	8	0	25	50	500	100
19	Civil	20	35	32	12	0	20	50	30	7
20	Civil	16	48	30	8	7	10	50	25	5
21	Electrical	45	35	28	22	0	17	50	55	15
22	Civil	18	32	25	14	8	17	50	30	10
23	Civil	17	25	30	32	0	9	50	120	30
24	Civil	35	34	28	32	0	15	50	60	15

25	Civil	20	25	18	28	5	20	30	30	6
26	Mechanical	18	32	20	30	0	10	50	20	4
27	Surveyor	20	40	28	20	5	15	30	30	6
28	Mechanical	30	25	18	17	10	30	50	50	7
29	Architect	25	32	38	22	0	15	50	500	70
30	Civil	30	15	38	22	0	30	50	1000	160

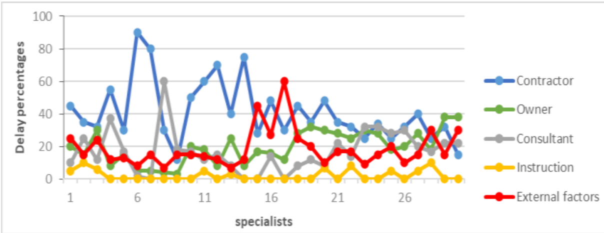


Fig 1. Main Delay Factors Percentages due to Experience System Specialist Opinion.

The experts' responses were analyzed using the chi-square test to determine if the responses were influenced by the main delay factor defined by the experience system or if they were influenced by the relationship among different factors. The results indicated that the responses were indeed influenced by the relationship among the factors, as the null hypothesis was rejected with a test P-value of less than 0.05. This suggests that rating one factor will affect the rating of other factors. Discriminant analysis confirmed the importance of each factor in relation to the others. Figure 2 illustrates that the contractor and external factors have a significant impact on project delays, while the other factors have a lesser effect. In simpler terms, an increase in the rating of the contractor factor will also affect the ratings of the other factors.

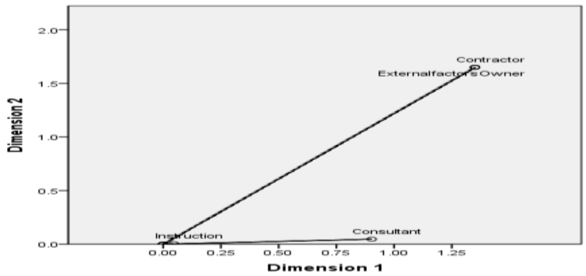


Fig 2. Discrimination Analysis of Main Delay Factors due to Experience System Weighting

CONCLUSIONS

A system of experience has the potential to significantly improve the efficiency and effectiveness of post-disaster construction projects by offering rapid access to critical knowledge, improving decision-making, better managing resources, and ensuring that teams can collaborate effectively. While implementing these systems presents challenges, the benefits (especially in high-pressure recovery scenarios) can be substantial.

The current analysis leads to the following conclusions:

1. The factors contributing to project delays, ranked by their percentage contribution from highest to lowest, are as follows: Contractor (30%), Owner (20%), External factors (15%), Consultant team (10%), and System and instructions (7.5%).
2. Analysis of variance indicates a significant difference ($P<0.05$) among the main causes, while the secondary causes do not show significant differences.

3. The measure of association indicates a high linear association among the secondary factors ($Eta2=0.997$) and a less linear association among the main factors ($Eta2=0.581$). This suggests a strong symmetrical causal direction of the secondary factors, indicating a relationship between these factors in each category of the main factors. The main factors show an asymmetrical causal direction, possibly because they are not related to each other.
4. The percentage scores for the high-rate cause are 73.33% for contractors, 6.67% for owners, 13.33% for consultants, 0% for system instructions, and 10% for external factors.

5. The chi-square test results demonstrate that the rating of one factor affects the rating of the other factors, indicating a relation between them.

6. Discriminant analysis confirms the importance of each factor in relation to the others. The contractor and external factors are found to play an active role as delay factors, while the other factors have a lesser impact on delays in construction projects.

Comparison of QF1 and QF2 results:

- QF1 results show the factors affecting project delays as follows: Contractor>Owner>External factors>Consultant team>System and instructions with percentages of 30>20>15>10>7.5, respectively.

- QF2 results show contractor failure > Re-design > Security status > Low price > Weather factor > Owner failure > Change site position > Laboratory test delay > Holidays delay > Consultant failure > Delay project preparing > External Factor, with percentages of 100.00%, 95.50%, 68.20%, 67.20%, 55.60%, 47.40%, 44.50%, 38.90%, 34.60%, 34.20%, 18.10%, 16.30%, respectively.

RECOMMENDATION

It is important to find innovative ways and modern technological techniques to improve environmentally friendly building materials in the construction industry. This can be achieved by introducing environmentally friendly materials and recycling to work on sustainable development. This technology can be used to improve sustainable development and green buildings, making it a popular choice in construction engineering.

DECLARATION

I hereby declare that all the information given above is true and correct and that the authors have no competing interests as defined by Springer, or other interests that might be perceived to influence the results and/or discussion reported in this paper. I also declare that the results/data/figures in this manuscript have not been published elsewhere, nor are they under consideration (from you or one of your Contributing Authors) by another publisher. I also declare that there is no fund for this research paper.

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