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Research Article

Proactive prevention model to manage construction time delays in developing countries

Ibrahim Salwan Majeed CHENENA[1], Gökhan KAZAR[2] *

[1] Istanbul Gedik University, Engineering Management Graduate Program, eng.salwan.79@gmail.com, Orcid No: 0000-0002-2088-8794
[2] Istanbul Gedik University, Civil Engineering Department, gokhan.kazar@gedik.edu.tr, Orcid No 0000-0002-8616-799X

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* Corresponding author

ABSTRACT

Due to the complex structure of construction activities, schedule overruns are inevitable in the construction industry. Particularly, construction projects play a key role in the economic conditions of developing countries. Although several studies have mainly focused on the time delay factors in the construction projects, a study does not exist on providing reliable and applicable solutions based on the eye of expert view. Thus, this study attempts not only to identify the major delay factors but also to introduce a proactive prevention model including long-term strategies and immediate practical solutions to be implemented in the construction industry of developing countries. For this purpose, a survey was conducted with 140 experts in the construction sector of a developing country, Iraq. Importance Index (Imp. I) based on the frequency and severity value of each time delay attribute and Relative Importance Index (RII) for suggestions and proactive steps were calculated according to survey results. After identifying major causal factors, strategies, and practical implementations, we developed a proactive prevention model to be utilized in the construction industry. The proposed model includes different practical implementations ongoing construction projects such as developing an Artificial Intelligence (AI)-based predictive model, using Time Series Analysis (TSA) approach, urgent practical applications, and long term strategies for construction companies to reduce time overruns in construction projects. To realize this kind of proactive prevention model in the construction industry, a data collection and sharing system including all related information recorded in diverse construction projects is highly recommended.

Introduction

Construction projects play an important role especially in the economics of developing and underdeveloped countries. One of the critical success factors for these construction works is delivering the project within the time as well as the commitment with allocated budget and high quality [1]. However, time delays in the construction industry are still a great issue and have become the nature of the construction projects. It is highlighted that time overruns in construction projects could cause multiple issues such as loss in productivity and quality, cost increase, disputes between stakeholders, and termination in contracts [2]. It is also stated that such time overruns influence the investment decisions for construction projects [3]. In general, project performance and value of the construction projects have weakened because of the time delays. Although the time delays have been seriously taken into consideration in the construction industry, it is still not possible to avoid extending the project deadlines. The government of Iraq which is one of the developing countries after the 2003 war has allocated 21.1% of the total budget for infrastructure investments [4]. However, the construction projects in Iraq have also extensively suffered from schedule and cost overruns. Since most construction projects have been usually extended in Iraq, a number of studies have focused on understanding the root cause factors of time delays [5–7]. Diverse contributing factors related to schedule overruns such as contractor failure, bureaucracy, security issues, lack of experience, delays in payments, and changes in political and economic conditions and, changes in laws consistently were found the main reasons behind the deadline extensions in Iraqi construction projects [6]. Most of these studies have also suggested general and theoretical measurements for time-delay issues in construction projects. However, a study does not exist that provides a practical solution including urgent proactive steps and long-term strategies against these factors to prevent or reduce time delay issues in the eye of experts. Therefore, the main objective of this study is not only to identify the main causal factors regarding schedule overruns but also to introduce a proactive prevention model including immediate practical implementations and long-term suggestions for the construction industry of developing countries based on the expert opinions.

Background

Time Delay Factors in Construction

Because the construction industry plays a dynamic role in economic growth, the project performances in construction directly influence the financial conditions of countries. Moreover, the quality of physical assets such as infrastructure and residential ones are highly related to project performance during the construction process [8]. Takim and Akintoye (2002) assessed the key performance indicators of construction projects and identified time, quality, and cost as the most important triangle factors to evaluate the success degree of these projects. Also, it is highlighted that there is a strong interaction between those factors and it is not possible to separate them from each other during the construction phases [10]. Time overrun is one of the most commonly observed issues during construction projects, which is defined as a situation when the project is completed beyond the planned time [7].

Such schedule delays are the primary problems encountered in construction projects all over the world. However, construction projects have gained great importance due to providing a huge amount of financial circulation in developing countries compared to developed ones [11]. In this sense, several studies attempted to identify root causes of time delays particularly in developing countries such as in Africa (e.g., Burkina Faso [12], Nigeria [13], Ghana [14]) and in Asia (e.g., United Arab Emirates [15], Turkey [16], Iran [17], Saudi Arabia [18, 19], Malaysia [20], and India [21]).

Bagaya and Song (2016) carried out a study to investigate major time delay factors observed in the construction industry of Burkina Faso. The authors [12] conducted a survey with 140 construction experts and found the low financial capacity of contractors and owners, delays in cash flows and, lack of equipment are the most common reasons for time delays in construction. In another study [14], it was attempted to evaluate the causes and effects of schedule overruns in housing construction projects in Ghana based on expert opinions. The results of this study show that the critical delay factors are delays in payments, unstable financial conditions in the country, and change orders requested by clients. Egwim *et al.* (2021) explored the most contributing construction delay factors in Nigeria by carrying out a questionnaire with 120 construction experts. The findings demonstrate that deficiencies in quality control, site accidents, financial disabilities of contractors and owners, fluctuations in material prices, and late procurement delivery are the most prevailing causal factors in construction time overruns.

Along with the African countries, time delays are also widely observed in the construction industry of developing Asian countries. For example, the primary underlying construction delay factors were identified by using the Relative Importance Index (RII) method in Turkey [16]. For this purpose, a total of 64 construction professionals responded to the survey questions including 83-time delay factors. Inadequate experience of contractors, ineffective project scheduling and planning, and poor site management and control were found top three major factors relevant to time delays. Besides, contractor-related factors have the most adverse effect on project completion time among the group factors. Assaf and Al-Hejji (2006) examined the main root causes of construction delays in Saudi Arabia and 73 diverse factors were defined in large construction projects by surveying with 23 contractors, 19 consultants, and 15 owners. Change orders are highlighted as the most important factor in the construction project delays according to all three expert groups. In addition, the results of this study show that the planned completion time of large construction projects extended between 10% and 30% on average in Saudi Arabia. A previous study [21] conducted a questionnaire with 77 construction stakeholders to extract the most significant attributes in the construction delays in India. The results of this study indicate that client-related factors have strong influences on the time delays in construction projects.

Construction Time Delays in Iraq

Among the Asian countries, time delays are also widely seen in construction projects carried out in Iraq which is another developing country. For example, one previous study [7] explored the most critical factors causing time delays observed in public projects in Iraq. A total of 65 delay causes were extracted from the literature and integrated into a survey conducted with 134 construction professionals. The author calculated the frequency, severity, and importance index of each causal factor related to schedule overruns. Security issues, changes in regulations, and official and non-official holidays were found the most important reasons for time overruns in the construction industry of Iraq. Waheeb and Andersen (2022) investigated the underlying causal factors leading to construction schedule overruns in Iraq via a questionnaire. For this purpose, time and schedule overruns of each construction project were analyzed to find time delay factors. The results of this study show that contractor failure, change orders and, selection of low-bid prices are the top three factors triggering cost and time variances in construction projects. Significant time delay factors in Iraqi construction projects also were explored in another previous study conducted by Khaleel (2017). To rank the attributes related to schedule overruns, the mean value of each delay factor included in the survey was considered. It is indicated that contractor-related factors such as low financial capability, lack of skilled human resources lead to postponing the deadline of the construction projects. Al Hadithi (2018) collected qualitative data from 47 respondents including the owner, contractor, and consultant, and used a frequency index to rank delay causes. Delays in material delivery, financial and political conditions of Iraq and, cash flow issues were stated as the most significant factors regarding time overruns.

Research Statement

As one can understand from the literature, there is a wide investigation on the time delay factors observed in the construction industry of different developing countries and

Iraq. Although most of these studies explored and introduced the most significant factors related to schedule overruns in construction based on diverse perspectives, few of them [20] provide proactive steps and suggestions in the eye of experts. For example, Abdul-Rahman *et al*. (2006) did not only focus on understanding time delay factors but also provide practical solutions for the Malaysian construction industry by using an expert opinion approach. On the other hand, the studies [5–7], [23, 24] mainly focused on understanding the root causes of the time overruns in the construction industry of Iraq. In one study [24] conducted in Iraq, it was attempted to define delay causes in construction projects and suggested implementing project management methodology. However, the provided suggestion is mainly relied on a theoretical body of knowledge rather than real practical applications because of only refer to the Project Management Body of Knowledge (PMBoK). Since construction experts encounter difficulties in time extensions during construction projects, their suggestions are reliable and essential to reduce and prevent such schedule overruns. Therefore, one of the purposes of this study is not only to identify time delay factors in construction but also to enable long-term strategies for construction companies and immediate proactive steps to mitigate schedule delays by integrating expert opinions.

As stated above, most previous studies related to time delay causes focused on descriptive statistics and identifying the root cause factors of the schedule overruns in construction [3, 12, 19, 25]. However, this kind of information received from these studies or previous construction projects may not be actively used and integrated into the projects during planning and construction phases. Accordingly, a preventive model is highly required to represent how previous knowledge or data recorded in previous construction projects can be returned a value while ongoing construction projects, which is called a proactive system or framework in the literature [26–28]. For example, Park *et al.* (2013) developed a proactive model for defect management in construction via using Building Information Management (BIM) and Augmented Reality (AR). In addition, a previous study [28] proposed a proactive management framework to identify material and design issues that occurred during the modular construction process. Thus, the main objective of this study is to introduce a proactive prevention model including diverse immediate practices to be implemented in construction projects and long-term suggestions for construction companies according to the responses received from the construction professionals. Accordingly, it will be possible to reduce or prevent time delays while ongoing construction projects especially in developing countries.

Research Methodology

Survey Design and Data Collection

Initially, we conducted a survey with construction professionals to identify root causes of the time delays, long-term suggestions, and immediate proactive steps to be integrated into the proactive prevention model. Before the data collection process, a questionnaire was prepared mainly based on the existing literature related to time delay causes and feedback received from the construction professionals (Appendix A). In the current study, since we aimed to uncontrollable processes during construction phases (Table 1). Here, controllable factors represent the attributes that can be interfered with by construction stakeholders, uncontrollable ones are related to outside the contractors, clients, and consultant.

Table 1 Construction Time Delays in Iraq

	ID	Time Delay Causes	[7]	[23]	[6]	[5]	[24]	[22]
Uncontrollable	**U-DC1**	The economic conditions of the country	X			X		
	U-DC2	Frequent official and unofficial holidays	X				X	X
	U-DC3	Government change of regulations and bureaucracy	X			X		
	U-DC4	Financial difficulties of the contractors		X	X	X	X	
	U-DC5	Selection of low-bid prices	X		X			X
Controllable	**C-DC6**	Delay in progress payments	X	X		X		
	C-DC7	Contracting with incompetent contractor		X	X		X	
	C-DC8	Poor project management planning		X		X	X	
	C-DC9	Design changes	X	X	X			
	C-DC10	Insufficient and incomplete feasibility studies				X		X
	C-DC11	Disputes between stakeholders			X			X
	C-DC12	Mistakes in estimating project duration			X		X	
	C-DC13	Unskilled workers	X		X			
	C-DC14	Using traditional paperwork rather than digital platforms					X	

The questionnaire was divided into four different sections; i) background and demographic information about the respondents, ii) time delay causes iii) strategies, and iv) proactive steps. In the second part, a total of 14-time delay causes stated above were included in the questionnaire. The frequency of each time delay cause was asked to participants in a 4-Likert Scale Form (1= never occurred, 2= occasionally 3= frequently, 4= always). Also, the severity of each delay cause was similarly responded to in the same questions via a 4-point Likert Scale (1= low, 2= fairly, 3= high, 4= very high). In addition to time delay causes, we asked the importance of each strategy and necessity of each proactive implementation by using a four-point Likert scale in the third and fourth parts respectively (1= low, 2= fairly, 3= high, 4= very high). Such strategies and practical applications included in the survey were mainly taken from the previous studies conducted in different countries rather than only in Iraq and feedback from the construction experts. The last three sections were prepared to integrate results achieved from the respondents into the proactive prevention models introduced in the current study. After preparing the final version of the questionnaire, it was sent out to 167 construction professionals (e.g., contractors, consultants, and clients) who are working on different construction projects in different regions in Iraq.

Data Analysis

Initially, the reliability of the collected dataset was checked via Cronbach's alpha (α), which was used in different studies using questionnaire data for similar purposes [12], [13]. The Cronbach's alpha (α) shows the internal consistency of the data as a coefficient, which provides information about the reliability level of collected data in a survey. The alpha (α) value is calculated as the following formula:

$$\alpha = n/(n-1)\left(1-\frac{\sum Vi}{Vtest}\right) \quad (1)$$

Where n demonstrates the total number of items, V_i shows the variance score of each item and V_{test} represents the total variance score of the entire data in Eq. (1). To rank 14-time delay causes according to their importance level, we employed the Importance Index (Imp. I) computed by using the Relative Importance Index of Frequency (RII-F) and Severity (RII-S) of each item given by the respondents, which was introduced by [29] and used by [19].

$$\text{RII}-\text{F} = \frac{\sum W}{A*N} \text{ and } \text{RII}-\text{S} = \frac{\sum W}{A*N} \quad (2)$$

$$\text{Imp. I} = \text{RII}-\text{F x RII}-\text{S} \quad (3)$$

Here, W represents the weighting value of each item (ranging from 1 to 4), either in frequency or severity, A shows the highest weight (4 in this case), and N illustrates the total number of respondents in Eq. 2. The RII value ranges between 0 (not inclusive) and 1 and the importance of the item increases when RII goes from 0 to 1. On the other hand, since the frequency and severity of each item in these questions were not measured, the necessity of each proactive step and the importance of each strategy were ranked according to the calculated RII value. By following a previous study [12], Spearman's correlation test was also conducted to check agreement degree between different construction stakeholders (e.g., clients, contractors, and consultants) on proactive steps and strategies received from the participants.

Results

Descriptive Statistics

A total number of 140 construction professionals including 59 clients, 38 consultants, and 43 contractors responded to the survey (Table 2). While 53.6% of the participants have working experience in public and private sectors, 12.9% and 33.6% of them only worked for private or public construction companies respectively.

Table 2 Descriptive Statistics of the Respondents

Parameter	Category	Resp. (N)	Freq. (%)
Sector	Private	18	12.9
	Public	47	33.6
	Both	75	53.6
Experience	Less than 10 years	30	21.4
	10-15 years	21	15
	15-20 years	48	34.3
	More than 20 years	41	29.3
Firm Type	Client	59	42.1
	Consultant	38	27.1
	Contractor	43	30.7
Field of Expert	Buildings	54	38.5
	Infrastructure	34	24.4
	Mechanical and Electrical	27	19.2
	Other	25	17.9
Contractual Type	Traditional	42	30
	Management Contractor	18	12.9
	Design-Build	33	23.6
	Construction Management	47	33.6
Average Project Delay	Less than 10%	18	12.9
	Between 10% and 30%	48	34.2
	Between 30% and 50%	63	45
	More than 50%	11	7.9

The majority of these respondents (78.6%) have more than 10 years of experience in construction sites. In addition, the participants worked in different types of projects such as buildings (38.5%), infrastructures (24.4%), and mechanical- electrical ones (19.2%). Also, they took place in projects conducted via different kinds of contract types such as traditional (30%),

management contractor (12.9%), design-build (23.6%), and construction management (33.6%). Besides, most of them (87.1%) stated that they experienced more than 10% time overruns in construction projects.

Survey Results

Initially, we considered the Cronbach's alpha (α) value of each scaled item to present the reliability of the collected survey data (Table 3). Cronbach's alpha (α) of collected items for frequency (α=0.827) and severity (α=0.898) of the time delay causes is greater than 0.7, which is accepted as a limit value for validation of the survey data [30] and used in a previous study [12]. Also, the collected data related to strategies (α=0.788) and proactive steps (α=0.843) is reliable.

Table 3 Reliability Test Results

	Time Delay Causes		Remedies	Proactive Steps
	Frequency	Severity		
Cronbach's Alpha (α)	0.827	0.898	0.788	0.843

The results of survey analysis show that the most important time delay factor is "Contracting with the incompetent contractor" according to clients (Imp. I = 0.595, Rank=1) and contractors (Imp. I = 0.605, Rank=1). In addition, "Delay in payment progress" (is ranked as the second significant critical factor leading to time overruns in construction projects according to the overall result (Imp. I= 0.549, Rank =2). "Financial difficulties of the contractors" (overall; Imp. I = 0.531, Rank=3) and "Selection of low-bid prices" (overall; Imp. I=0.508, Rank=4) are another major delay causes in the construction industry of Iraq. On the other hand, "Using traditional paperwork rather than digital platforms" (overall; Imp. I=0.333, Rank=13) and "Frequent official and unofficial holidays" (overall; Imp. I= 0.271, Rank=14) are the least contributing factor in construction schedule overruns for all three groups (Table 4). In addition, Spearmen's correlation analysis results (Table 7) show that there is a significant agreement on the time delay causes between all three groups such as clients-contractors (ρ=0.616, p=0.019), clients-consultants (ρ=0.684, p=0.007), and contractors-consultants (ρ=0.88, p<0.001).

According to the results, one of the most two important long-term strategies given by the respondents are "Adopting novel PM methods" (RII=0.793) and "Risk management system" (RII=0.657, Rank=2). "Site supervision and control mechanism" is also highlighted as a long-term strategy to prevent or reduce time overruns in construction projects by consultants (RII=0.628, Rank=3) and contractors (RII=0.621, Rank=3). However, "Offering bonus for early completion" is thought as the least effective strategy to be considered in the construction industry (overall; RII= 0.554, Rank=6) (Table 5). In addition, an agreement does not exist between clients-consultants (ρ=0.086, p=0.872) and clients-contractors (ρ=0.314, p=0.544), but contractors-consultants (ρ=0.771, p=0.072) have agreement on the provided strategies (Table 7).

Table 4 Importance Index and Rank of Time Delay Causes

		Client		Consultant		Contractor		Overall	
ID	**Time Delay Causes**	**Imp. I**	**Rank**	**Imp. I**	**Rank**	**Imp. I**	**Rank**	**Imp. I**	**Rank**
C-DC7	Contracting with incompetent contractor	0.595	1	0.623	2	0.601	1	0.605	1
C-DC6	Delay in payments progress	0.46	3	0.637	1	0.601	2	0.549	2
U-DC4	Financial difficulties of the contractors	0.503	2	0.543	4	0.561	4	0.531	3
U-DC5	Selection of low-bid prices	0.414	7	0.583	3	0.578	3	0.508	4
C-DC8	Poor project management planning	0.427	5	0.507	6	0.517	5	0.476	5
U-DC3	Government change of regulations and bureaucracy	0.434	4	0.513	5	0.486	6	0.472	6
C-DC9	Design changes	0.425	6	0.485	9	0.437	10	0.445	7
C-DC10	Insufficient and incomplete feasibility studies	0.407	8	0.463	10	0.47	8	0.441	8
C-DC11	Disputes between stakeholders	0.377	11	0.496	7	0.471	7	0.436	9
C-DC12	Mistakes in estimating project duration	0.405	9	0.448	11	0.443	9	0.426	10
C-DC13	Unskilled workers	0.399	10	0.486	8	0.382	12	0.416	11
U-DC1	The economic condition of country	0.373	12	0.417	12	0.436	11	0.404	12
C-DC14	Using traditional paperwork rather than digital platforms	0.294	13	0.382	13	0.344	13	0.333	13
U-DC2	Frequent official and unofficial holidays	0.248	14	0.284	14	0.292	14	0.271	14

Table 5 Relative Importance Index (RII) of the Remedies

ID	Strategies	Client		Consultant		Contractor		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
R1	Adopting novel PM methods	0.746	1	0.796	1	0.855	1	0.793	1
R2	Risk management system	0.61	2	0.671	2	0.709	2	0.657	2
R3	Site supervision and control mechanism	0.593	4	0.658	3	0.628	3	0.621	3
R4	Handover of project in stages	0.602	3	0.546	6	0.593	4	0.584	4
R5	Last planner system	0.572	5	0.592	4	0.558	6	0.573	5
R6	Offering bonus for early completion	0.508	6	0.586	5	0.587	5	0.554	6

Table 6 Relative Importance Index (RII) of the Proactive Steps

ID	Immediate proactive steps	Client		Consultant		Contractor		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
P1	Criteria for contractor or subcontractor selection	0.771	1	0.816	1	0.907	1	0.825	1
P2	BIM usage for project management	0.72	2	0.744	3	0.808	3	0.754	2
P3	VR/AR-based staff training	0.695	3	0.737	4	0.849	2	0.754	3
P4	Hiring qualified planning/site engineer	0.674	4	0.757	2	0.773	4	0.727	4
P5	Blockchain for smart contracts	0.64	5	0.671	5	0.738	5	0.679	5
P6	VR/AR-based meeting system	0.602	6	0.658	6	0.686	6	0.643	6

The results also indicate that all three groups point out "Distinct criteria for contractor selection" to be practiced among the proactive steps (overall; RII= 0.825, Rank1). "BIM usage for project management" is ranked as the second required immediate proactive step to be implemented in the construction industry to avoid extending construction project deadlines (overall; RII=0.754, Rank=2). On the other hand, one proactive step "VR/AR-based meeting system" is not suggested as an important practical solution to mitigate construction time delays (overall, RII=0.643, Rank=6) (Table 6). According to Spearman's correlation analysis results (Table 7), while there is a significant agreement on the proactive steps between contractors and consultants responded to the survey (ρ=0.771, p=0.072), clients and contractors (ρ=0.6, p=0.208), and clients and consultants (ρ=0.714, p=0.111), do not have agreement on the practical implementations.

Discussion

Different studies have attempted to explore time delay causes in the construction industry and identified diverse contributing factors in various countries. In the current study, we do not only investigate the root causes of time delays in construction but also provide long-term strategies for construction companies and immediate practical applications in the eye of experts who took place in Iraqi construction projects. The findings of this study show that the top two-time delay factors such as "Contracting with the incompetent contractor" and "Delay in payments progress" are controllable and can be prevented through following the right strategies and implementing exact proactive steps. These two factors are mainly related to contractors and clients in the construction industry [16]. This result is also consistent with previous studies conducted in Iraq (e.g., Aljamee and Naeem (2020), ; Khaleel and Hadi (2017); Mohammed and Jasim 2017) and other developing countries such as Turkey [16], Pakistan [31], Saudi Arabia [18], and Qatar [25]. The low experience of Iraqi construction companies in conducting especially mega-infrastructure and residential projects causes an invitation of foreign construction companies, which leads to transferring financial sources to outside. [4]. This situation also interrupts financial circulation and deteriorates the economic growth of these countries. Other two important causal factors leading to time overruns in a construction project (e.g., "Financial difficulties of the contractors" and "Selection of low-bid prices" are more related to the economic conditions of Iraq, which is also found in other studies [5, 6, 24]. Most Iraqi contractors have difficulties in finding letters of guarantee during the bidding process and financial sources after starting a construction project. Accordingly, the local companies have to stop construction without completion, which is another reason for coming foreign construction companiesto

Table 7 Spearmen's Correlation Analysis Results

Groups	Delay Causes		Remedies		Proactive Steps	
	Spearmen's Correlation Coefficient (ρ)	Sig. Value (p)	Spearmen's Correlation Coefficient (ρ)	Sig. Value (p)	Spearmen's Correlation Coefficient (ρ)	Sig. Value (p)
Clients-Contractors	0.616	0.019	0.314	0.544	0.714	0.111
Clients-Consultants	0.684	0.007	0.086	0.872	0.6	0.208
Contractors-Consultants	0.88	0.000	0.771	0.072	0.771	0.072

Iraq. This situation is also related to the selection of low bid prices. Iraq government institutions only consider the low bid prices rather than experience in megaprojects, which require huge amounts of money and experience. As one can understand from here that controllable and uncontrollable delay causes in construction projects influence each other and create a vicious cycle for the economic condition of the country.

According to expert opinions, we also introduce the most important strategies for the construction industry and urgent proactive steps during a construction project. Here, while strategies refer to suggestions to be integrated by construction companies for the long term, proactive steps represent the actions that can be immediately practiced in projects while planning or construction phases. The first ranked suggestion "Adopting novel PM methods" shows that it is highly required to adopt new methodologies in project management instead of following traditional construction techniques in Iraq. It is widely indicated that the main challenge in construction projects carried out in developing countries is not open to new techniques and innovative solutions [32]. Besides, second "Risk management system" and third "Site supervision and control mechanism" important recommendations stated by the construction experts are highly relevant to tracking each project performance item (e.g., time, cost, and quality) and risk management of projects during construction phases. However, such professional Project Management (PM) approaches are still lacking in the construction industry of Iraq and other developing countries [33]. Therefore, the application of new PM methods should start with public projects by the government. By following this strategy, it is believed to positively influence all stakeholders in the construction industry. Also, knowledge from foreign professional construction companies can be transferred to local construction companies via subcontracting them in huge projects.

Since there is a significant match between time delay factors and practical applications stated by the construction professionals, proactive steps have great potential to prevent the contributing factors for schedule overruns observed in Iraq. For example, whereas the most important causal factor in time delay is the incompetence of contractor and subcontractors, distinct criteria for contractor selection is identified as the most effective solution for construction time delays. All three groups point out the necessity of a distinct criteria list for the selection of contractors and subcontractors while planning and construction phases are carried out. Particularly, disputes between client-contractors and contractors- subcontractors lead to schedule overruns in construction projects [19]. It is a well-known fact that the circulation of subcontractors during the construction phase has adverse effects on project performance. Thus, each contractor or client should have their criteria list to be used during the selection of contractor or subcontractor according to project type. The second important proactive step provided by the participants is the usage of Building Information Modeling (BIM). The benefits of BIM such as improving project performance and reducing conflicts, schedules, and cost overruns have been widely proven in several studies [34 ,35]. The lack of high-skilled workers and engineers is another common problem in the construction industry of Iraq [7] as well as in other developing countries such as Nigeria [15] and Pakistan [31]. Investments in digital technologies such as VR/AR systems should be done to improve the skills of the labor force in carrying out special construction tasks and awareness of occupational safety risks, which is highly suggested in previous studies [36-37]. Also, software training sessions could be provided for engineers on schedule planning and budget estimation to increase their capability on these fundamental PM aspects while planning and construction stages of the projects.

Proactive prevention model

Along with identifying the time delay causes, strategies, and proactive steps, we introduce a proactive prevention model to mitigate or prevent time delays in the construction industry of the developing countries and Iraq (Fig. 1). The proposed model is divided into three main stages such as planning, construction, and operation. At the planning phase of a new construction project, daily data recorded in previous internal and external construction projects (historical time data) should be used to generate an AI-based predictive model according to project type. Such a predictive model can be initially used to estimate the completion time of a new project based on construction activities

that will be carried out in that project. Then, the predictive model can be fed with new daily schedule data during the construction phase of the project. After feeding the predictive model with daily time data, it is possible to conduct Time Series Analysis (TSA) to check schedule variance. In this sense, a comparison can be done between the New Predicted Completion Time (NPCT) and original Predicted Completion Time (PCT) at the end of each month (M_i) to check the project progress whether it is behind or ahead of the original project deadline. If NPCT is equal to or less than PTC, it can be understood that the project performance is at the desired level. In this scenario, project administration should look at the right strategies they followed to pursue such practices during the rest of the project stage. If NPCT is greater than PCT at month M_i, it can be said that the project is behind the planned schedule. In this step, the project administration should initially find the time delay reasons in the current construction project. According to time delay causes (if controllable), proactive steps can be immediately realized in the current project, or general suggestions could be considered as future or long-term strategies by the construction company. By following these steps, it is possible to prevent or reduce time delays in construction projects. Such preventive models have been proved to provide major opportunities for practitioners to monitor and take action according to the situation while the ongoing construction process [26, 28].

Identifying risk management strategies should not be only based on the previous projects and descriptive statistics, but also information gathered during the construction phase should be actively utilized. Accordingly, project administrators could have a chance to show reactions and implement immediate proactive actions while ongoing projects. Although recording information during construction projects has gained importance for last years, there is a still lack of data collection and sharing systems in the construction industry. Therefore, data collection and open access systems are highly essential to realize this kind of proactive model. The main contribution of this study is to provide a proactive model to be utilized in construction projects during planning and construction stages. Since the proposed model consists of different long-term strategies and urgent proactive applications taken from the construction experts, it could be more reliable and applicable. Besides, such a preventive model can be also implemented not only in construction projects carried out in Iraq but also in other developing countries. Along with the practical contribution, this study could open a new door to develop an AI-based time predictive model to be used in construction projects and provide diverse proactive steps and recommendations with the help of construction professionals. These points could be theoretical contributions of this study. Apart from the contributions, the current study has some limitations. This kind of model also can be developed for cost overruns observed in construction projects. Besides, empirical data related to time delays received from a previous construction project can be tested by using TSA without any AI-based predictive model. All mentioned limitations could be addressed in future studies..

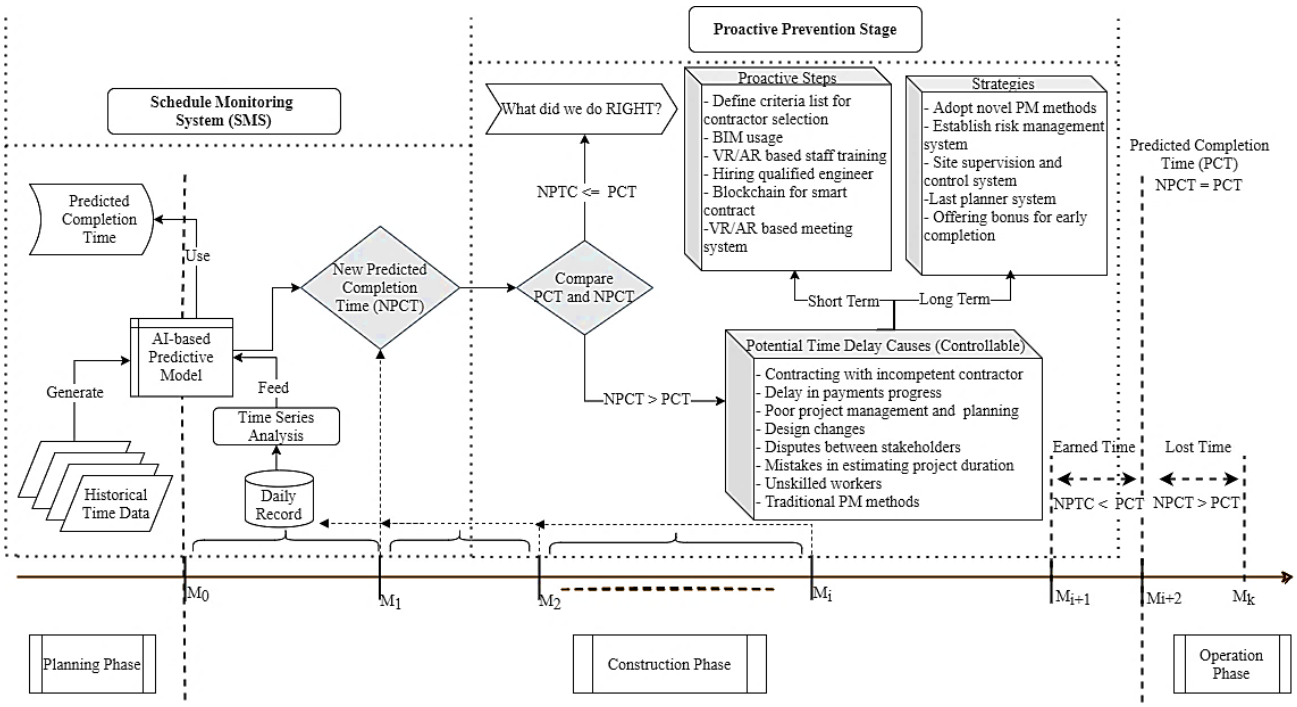

Figure 1 Proactive prevention model for time delays in construction

Conclusion

In the current study, we attempted to introduce a proactive prevention model to reduce or prevent schedule overruns in construction projects carried out in developing countries. For this purpose, a survey was conducted to identify the root cause factors of the time delays and explore long-term strategies and proactive steps on such schedule overrun issues in the eye of construction experts. The collected survey data was integrated into the developed proactive prevention model which involves a number of steps to be practiced during planning and construction phases.

Since such construction professionals encounter real issues related to project performance criteria such as time, cost, and quality, their opinions should be initially considered. Therefore, identifying proactive steps and general suggestions with the help of construction experts rather than just relying on the theoretical body of knowledge is important to achieve more reliable consequences. Accordingly, the introduced proactive prevention model could be more applicable and feasible for the construction industry of developing countries since construction performance issues are similar in those countries. Also, even though a case study was carried out for Iraqi construction projects, the steps included in the proactive prevention model can be easily adapted by other developing countries. Following these preventive steps will provide great opportunities to practitioners in improving the performance of construction projects and preventing disputes between stakeholders. The most important point of this kind of proactive model is to return information recorded in previous and ongoing projects to value by using AI-based algorithms. It should be here noted that data collection and open access systems are considerably required to realize such proactive prevention models in construction projects. In addition, identifying time delay causes and following the right practical implementations during ongoing projects will have vital roles in saving time in construction projects.

Data Availability Statement

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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Ethics committee permission

The authors acquired ethics committee permission for surveys implemented in this paper from the Istanbul Gedik University Ethics Commission (Date: 28/03/2022; No: E-56365223-050.01.04-2022.137548.71-336).

Declaration of conflicting interests

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

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Appendix A (Survey)

Part 1: Demographic Information

1	Sector	Public	
		Private	
		Both	

2	Academic Degree	Bachelor	Master	Ph.D.

3	Expert Field	Building	Infrastructure	Mechanical	Electrical	Other

4	Firm Type	Contractor	Client	Consultant

5	Contractual Type	Traditional	Management	Contractor	Design-Build	Construction Management

6	Average Project Delay	Less than 10%	Between 10%-30%	Between 30%-50% years	More than 50%

7	Job Experience	Less than 5 years	Between 5-15 years	Between 15-25 years	More than 25 years

Part 2

Please rank the major delay factors observed in construction projects based on their occurrence frequency and severity from 1 to 4 as shown in the table below.

scale	frequently	severity
1	Never	Not effect
2	occasionally	Fairly sever
3	frequently	Severe
4	always	Very severe

NO	Major delay factor	Frequency				Severity			
		1	2	3	4	1	2	3	4
1	Design changes								
2	Financial difficulty from the contractors								
3	Poor project management planning								
4	Mistakes in estimating project duration								
5	Contracting with incompetent contractor								
6	The economic crisis of the country								
7	Using traditional paperwork more than software programs								
8	Delay in progress payments by the owner								
9	Frequent official and unofficial holidays								
10	Government change of regulations and bureaucracy								
11	Insufficient and incomplete feasibility studies								
12	Political decisions and political realities								
13	Inadequate the financial allocations								
14	Unskilled workers								

Part 3 Strategies

Please rank each item based on the importance for construction projects as a strategy.

NO	Proactive steps	Importance			
		1	2	3	4
1	Adopting novel PM methods				
2	Risk management system				
3	Site supervision and control mechanism				
4	Handover of project in stages				
5	Last planner system				
6	Offering bonus for early completion				

Part 4 Immediate proactive steps

Please rank each item based on the importance for construction projects as an urgent proactive step.

NO		Importance			
		1	2	3	4
1	Criteria for contractor or subcontractor selection				
2	BIM usage for project management				
3	VR/AR-based staff training				
4	Hiring qualified planning/site engineer				
5	Blockchain for smart contracts				
6	VR/AR-based meeting system				