Operational Research in Engineering Sciences: Theory and Applications
Vol. 6, Issue 3, 2023, pp. 220-245
ISSN: 2620-1607
eISSN: 2620-1747
DOI: https://doi.org/10.31181/oresta/060311

INTEGRATED TIME SCHEDULE DELAYS FORECASTING MODEL IN EGYPTIAN CONSTRUCTION SITES

Yasser Mahmoud Ragb Aboelmagd[1,2], Remon Fayek Aziz Eskander[3,4]

[1]Head of Civil Engineering Department, College of Engineering, University of Business & Technology (UBT), Jeddah, Saudi Arabia.
[2]Mathematics and Physics Engineering Department, Faculty of Engineering, Alexandria University, Egypt.
[3]Engineering Programs Director, Field of Engineering, Alamein International University (AIU), New Al-Alamein City, Matrouh - Egypt.
[4]Structural Engineering Department, Faculty of Engineering, Alexandria University, Egypt.

Received: 29 May 2023
Accepted: 26 October2023
First Online: 23 November2023

Research Paper

***Abstract**: The primary issue in construction projects is the occurrence of time delays, which has detrimental impacts on both the construction site and its stakeholders. These delays pose risks, leading to exceeding time and cost constraints, sparking litigation, disputes, and even the abandonment of projects. Therefore, it is imperative to conduct a thorough analysis and research to identify the major causes of delays in construction sites. This paper aims to investigate all delay factors in construction, drawing insights from various construction types documented in the literature, across different periods, and considering diverse delay factors and groups observed in different countries. Through numerous brainstorming interviews and questionnaires, this research endeavours to compile a comprehensive list of seventy delay factors. Questionnaires were administered to gather insights from construction participants, such as site/design engineers, contractors, consultants, and owners, prioritizing the most likely delays occurring during the construction phase of Egyptian projects. The collected responses were then used to perform pairwise comparisons among construction delay factors. Statistical tools, specifically the Statistical Package for Social Sciences (SPSS) and Analytic Hierarchy Process (AHP) were employed to rank the likelihood of delay occurrences and uncertainty estimates normalize. Subsequently, a proposed software application model was developed to predict construction project delays before implementation, utilizing several case studies of completed and delayed construction projects in Egypt. The proposed software serves two primary purposes: firstly, it predicts the time delay of a given project based on the analysis of a questionnaire survey utilizing the "SPSS & AHP" methods. Secondly, it analyses the factors contributing to construction project delays to ascertain the anticipated new actual duration of the project under study. Case studies were meticulously examined and compared, aligning the actual delay with the actual causes against the corresponding outcomes derived from the software* *model's analysis. The findings indicate that the lack of owner experience on construction sites holds the highest rank in terms of the most likely occurrence likelihood for construction projects. Subsequently, the key factors contributing to these delays include the contractor's inadequate experience leading to work errors, not enough skills in the staff of consultancy on sites of construction, and also problems in the cash flows in construction process by the contractor.*

Keywords: *Construction Sites, Questionnaire, Consultants, Model Software, Egypt.*

Introduction

Construction projects entail executing defined work within a set timeframe, with time intricately tied to financial considerations. Delays impact temporal and monetary dimensions, crucial for any nation's economy. Contractors, consultants, and project owners feel distinct impacts. Construction managers prioritize delay variables, identifying essential factors and evaluating alternative solutions. This process aids in navigating complexities*, enabling stakeholders to adopt preferable alternatives* (Alwi & Hampson, 2003). Ng, Skitmore, Lam, and Poon (2004) has identified a negative relationship between project value and the loss of construction time, shown the inverse association among project size and in the time loss. Each construction site possesses distinct characteristics, varying in size, type, location, site conditions, inputs, and outputs.

This uniqueness renders every project a singular product, and the standardization of the construction process becomes notably challenging and precarious. Moreover, construction projects are marked by a multitude of uncertainties and risks, stemming from the involvement of numerous parties such as suppliers, subcontractors, contractors, designers, consultants, and owners. These complex characteristics contribute to the intricate nature of major construction projects **(**El-Sayegh, 2008**)**. Hence, it is imperative to exercise careful consideration in managing and controlling both the construction budget and duration (Prateapusanond, 2003). Various studies have reached conclusions highlighting numerous factors and groups, such as project location and country, as contributors to delays. Studies like (Aziz & Abdel-Hakam, 2016; Kanan, 2020; Kanan et al., 2022), assert that the root causes cannot be generalized. Other studies have identified delay root causes as conditions or situations that deviate from primary principles. These causes are characterized by specific details that warrant proactive intervention (Ellis & Thomas, 2003).

Construction Industry and Delays

The business industry is a critical economic sector encompassing design, planning, construction, operations, maintenance, and the transformation of constructed facilities (Al-Rawashdeh, Jawabreh, & Ali, 2023; Alhaj et al., 2023; Alkhodary et al., 2022; Hatamlah et al., 2023). The primary goal of development in any country is to achieve economic growth. The construction industry significantly contributes to the national income and the overall economy of a nation (Jahmani et al., 2023; Jawabreh et al., 2023; Shniekat, AL_Abdallat, Al-Hussein, & Ali, 2022). In the realm of construction, "delay" is a relative concept denoting the extension of time beyond the originally scheduled completion date stipulated in the contractual agreement among the involved parties. This extension can apply specific project component delivery or the entire project itself (Al-Ghafly, 1995) (Bin Yusof, Binti Mohammad, & Bin Mat Derus, 2007; Kaliba, Muya, & Mumba, 2009; Prateapusanond, 2003). Moreover, construction site delays encompass activities that are completed later than specified in planned schedule of the projects (Fugar & Agyakwah-Baah, 2010; Majid, 2006).

The ramifications of exceeding time limits are consistently severe and challenging to rectify. Non-compliance with contractual deadlines not only results in financial losses but also frequently impairs the profitability of the construction site for all parties involved (Kelleher, 2003). Nevertheless, a comprehensive assessment of all causes of construction delays can aid in mitigating issues and play a role in minimizing both delays and their associated impacts constructed a model for short-term forecasting of building energy usage utilizing Artificial Neural Networks (ANN) and explored parameters like time delay and the quantity of hidden neurons (Bin Yusof, Binti Mohammad, & Bin Mat Derus, 2007; Chae, Horesh, Hwang, & Lee, 2016; Majid, 2006; Tumi, Omran, & Pakir, 2009). Zhang and Wen (2019) formulated a systematic forecasting model for delays by employing feature selection to address high dimensionality and enhance the interpretability of the model. Omar and Nehdi (2016) explored various technologies for automated construction data collection, emphasizing that automatic progress tracking can lead to the timely identification of potential time delays and construction discrepancies. This, in turn, directly facilitates informed decision-making in project control.

Durdyev and Hosseini (2020) conducted a comprehensive review of studies on time delays in Construction Project Development (CPD) spanning the period from 1985 to 2019. Santoso and Soeng (2016) examined the factors contributing to delays in road construction projects in Cambodia and assessed their impacts on project time, cost, and quality. Al-Hazim, Salem, and Ahmad (2017) explored the primary factors that could potentially lead to delays in the scheduled time, resource allocation, and planned cost overruns in infrastructure engineering projects within Jordan. Famiyeh, Amoatey, Adaku, and Agbenohevi (2017) identified key factors contributing to time and cost overruns in educational projects in Ghana with the aim of developing practical solutions. Johnson and Babu (2020) implemented a concurrent mixed-methods strategy, incorporating both a questionnaire and interviews with construction professionals in the UAE, to scrutinize the predominant factors contributing to subpar performance in terms of time and cost.

Rao et al. (2022) conducted an exhaustive examination of recent research concerning the real-time monitoring of construction projects, with a specific emphasis on sensor technologies utilized for real-time mapping, scene comprehension, positioning, and tracking of construction activities in both indoor and outdoor environments. Lindhard et al. (2022) explored factors related to resources under the control of site managers. The study involved the examination of three case studies, accompanied by a survey that included 36 participants. Maqsoom, Choudhry, Umer, and Mehmood (2021) investigated how firm size and industry experience influence factors indicative of time delays in Pakistani construction contracting firms with diverse sizes and varied industrial experiences. Tariq and Gardezi (2023) assessed and ranked potential causes of Design and Construct (D&C) issues from a global perspective, delving into the exploration of concealed relationships among these factors. Memon, Memon, Khahro, and Javed (2023) explored the primary challenges influencing the punctual completion of construction projects and subsequently observed the interrelationships among these challenges utilizing Partial Least Squares Structural Equation Modelling (PLS-SEM).

Salami, Ajayi, and Oyegoke (2023) investigated the strategies implemented by construction enterprises to alleviate the risks of litigation linked to potential contract breaches resulting from the impact of COVID-19. Aravindhan et al. (2023) concentrated on examining the crucial factors contributing to delays and analysed day-to-day records to minimize these delays. The data, documented in MS Project, differentiate between tasks and critical activities, providing insights into the delays incurred along with their underlying reasons. Naimi and Alobadi (2023) sought to identify and examine the fundamental causes of project delays. A preliminary literature review delved into the most prevalent reasons for delays in building projects, conducting a critical examination of frameworks and delay causes, with a comprehensive analysis. Sobieraj and Metelski (2022) introduced a construction process model comprising 16 stages and eight phases. The study scrutinized the impact of effectively scheduling construction processes on mitigating the risk of extending individual phases and the entire project. This analysis employed a combined approach involving Monte Carlo simulation and the Time-at-Risk (TaR) methodology, which originates from the financial domain. Gondia, Siam, El-Dakhakhni, and Nassar (2020) recognized and created machine learning models to enhance precise analysis and prediction of project delay risks by leveraging objective data sources.

Construction Delay Types

Delays on construction sites fall into different categories depending on who's responsible, like compensable and excusable delays, as well as non-compensable and non-excusable ones. Sometimes delays happen concurrently or the independently, affecting project schedules. These schedule impacts can be grouped as critical or the non-critical delays, each with its own ramifications, as shown in the Figure 1 (Al-Ghafly, 1995; Falqi, 2004) (Afshari et al., 2010; Bin Yusof, Binti Mohammad, & Bin Mat Derus, 2007; Majid, 2006; Prateapusanond, 2003).

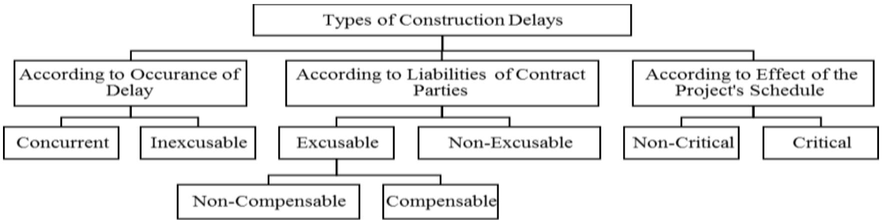


Figure 1: The Construction Delays projects (Al-Ghafly, 1995; Falqi, 2004).

Causes of Delay Classification

Therefore, our study will comprehensively investigate the categorization of delay causes in major countries, encompassing both developing and developed regions. In Ghana, Fugar and Agyakwah-Baah (2010) explored construction project delays, identifying thirty-two triggers across nine major groups. Primary influencers included financial aspects, followed by material-related factors, and control and scheduling issues. In Malaysia, Majid and McCaffer (1998) conducted an extensive study on non-excusable delay factors, categorizing them into twelve groups based on their sources. Likewise Sambasivan and Soon (2007) examined 28 delay causes in the construction industry.

Meanwhile, studies in Hong Kong by Chan and Kumaraswamy (1997) revealed 83 delay contributors across eight main groups, and in Indonesia, Alwi and Hampson (2003) identified 31 causes categorized into six major groups. Majid (2006) investigated delays in Aceh city, identifying 57 causes spread across eight main groups, while in Vietnam, Long, Ogunlana, Quang, and Lam (2004) and Le-Hoai, Lee, and Lee (2008) examined 21 delay causes categorized into six groups. These studies used diverse categorization approaches but converged on common issues like poor site management, design changes, and financial difficulties impacting construction timelines.

Additionally, research in Egypt between 2005 and 2014 highlighted multiple studies. Abdel-Gawad, M., and M. (2005) recognised 44 risks in joint ventures, while Abd El-Razek, Bassioni, and Mobarak (2008) focused on stonework projects, finding 32 delay causes grouped into nine categories. Ammar, Elsamdony, and Rabie (2009) studied barrage construction, identifying 40 risks in five major categories. Aziz (2013) examined post-revolution delay causes, categorizing approximately a hundred factors into nine groups. Marzouk and El-Rasas (2014) conducted interviews and surveys, pinpointing 43 delay causes categorized into seven groups, conducting statistical analysis for validation. These studies employed various methodologies to uncover delay triggers in the Egyptian construction landscape, aiding in understanding prevalent issues and their impacts.

Methodology

Figure 2 illustrates the methodology employed in this research. The study commenced with an initial data collection phase, which involved engaging in discussions with experts specializing in construction sites and conducting a thorough literature review. Subsequently, a comprehensive questionnaire was developed, encompassing 70 delay causes categorized into seven groups. The primary objective of the questionnaire survey was to elicit expert opinions on the likelihood of occurrence of delay factors. This survey was disseminated to a substantial number of engineers within construction companies, with the principal aim of gathering insights into the priorities assigned by experts to construction delays in Egyptian construction projects. The collected data, consisting of the seventy identified construction delay factors, underwent detailed study and analysis. The survey questionnaire comprised three pages and was distributed to a diverse audience, including contracting engineers, consultants, and owner's representatives. The questionnaire, crafted in both English and Arabic, featured a comprehensive set of 70 delay factors derived from a synthesis of literature and expert insights. These factors were subsequently organized into seven main groups. Table 1 provides a detailed listing and summary of the causes of delays in construction projects as outlined in the questionnaire.

The study focused on a selected population comprising five companies, namely Tabarak Engineering and Contracting, City Light for Reconstruction and Development, The Arab Contractors, and Hassan Allam Sons, Gamma Contracting . The study sample encompassed a total of 175 engineers and administrative professionals. Initial engagement with the study sample involved personal meetings and emails to reach out to 150 engineers, out of which 131 responded. Subsequently, through the sorting process, 11 questionnaires were excluded due to non-completion.

Table 1: Delay cause of Construction Projects.

Causes of Delay	Category Title
1. Owners lacking experience in construction site management.	
2. Inadequate selection of subsequent consultants.	
3 Frequent change orders initiated by the owner during construction.	
4 Vague or incomplete project scope definition.	
5 Owners causing project delays or suspensions.	Owner to related. OWRC
6 Slow decision-making processes by the owner.	
7 Delays by the owner in supplying materials.	
8 Owners delaying progress payments to the contractors.	
9 Inaccurate or flawed cost estimations by the owner.	
10 Skilled staff turnover is high at the owner's end.	
1. Contractors with insufficient experience leading to work errors.	
2. Unrealistic or impractical initial project plans.	
3. Lack of effective work software.	
4. Reliance on unreliable subcontractors.	
5. Incorrect cost estimation by contractors.	
6. High staff turnover among contractors' skilled workforce.	Contractor to related CRCDD
7. Frequent changes in subcontractors.	
8. Cash flow problems faced by contractors during construction.	
9. Issues with construction methodologies.	
10. Need for rework due to construction errors.	
11. Contractors' limited capability in material provision.	
12. Resource managment is pooor by contractors”.	
1. Consultants less experienced in the projects of construction.	
2. Delays in design submission by consultants.	
3. Slow invoices approvals by consultants.	
4. Consultants are inflexible.	Consultant to related CSRD
5. Inspection delays due to consultants' slow testing and inspections.	
6. Delays by consultants in approving major work scope changes.	
7. Reiteration: Consultants lacking experience in construction projects.	
1. Errors in design due to the strangeness in the local conditions.	
2. Delayed design work.	
3. Imposition of impractical project timelines.	
4. Complexities in design of the projects.	
5. Incompleteness in design specifications.	Design to related DRCD
6. Buildability issues in designs.	
7. Inadequate use of advanced design software.	
8. Designers' lack of experience.	
9. Frequent design change orders due to deficiencies.	
10. Rework due to design changes or deviations.	
1. Errors in soil investigation.	
2. Restricted site access.	
3. Geological issues at the site.	
4. Accidents due to insufficient safety measures.	Site to related SRCD
5. Delays in providing essential utilities services.	
6. Shortage of available utilities on site.	
7. Ineffective site layout.	
8. Poor quality of soil.	
1. Poor management of contract.	
2. Conflicts between the consultant and the contractor.	
3. Impractical contract pricing.	
4. Difficulties in coordinating various project activities.	
5. Contract suitability concerning project timelines.	
6. Owner interference in the project.	Contractual Relationship to related RRCR
7. Impact of the owner's past working relationships.	
8. Legal disputes at the construction site.	
9. Conflicts in joint ownership.	
10. Inadequate documentation management.	

1.	Changes in banking policies.	External to related EXRD
2.	Escalation of labor wages and material costs.	
3.	Financial market instability.	
4.	Impact of natural disasters (earthquakes, floods, etc.).	
5.	Delays in obtaining government permits.	
6.	Adverse weather conditions.	
7.	Political uncertainties.	
8.	Challenges in obtaining labor permits.	
9.	Effects of revolution, war, riots, or public unrest.	
10.	Stakeholder issues in obtaining approvals or permissions.	
11.	Market monopolies.	
12.	Corruption, kickbacks, and personal interests influencing decisions.	
13.	Issues related to nepotism.	

Data Analysis

The data is analyzed using two software tools: SPSS and the Analytic Hierarchy Process (AHP). The proposed software, designed to predict delays in construction projects before implementation, is based on assessing and meticulously considering delay possibilities. It also involves formulating responses to mitigate the impact of potential delays.

Comparison Between Two Methods Results

The table and figure presented depict a comparative analysis of results obtained through two distinct methodologies, namely SPSS and AHP.

The First Level Result

The delineation of the primary level prioritization and its associated weights, as discerned from the analysis, is exhaustively explicated in Table 1 and graphically depicted in Figure 3. The organizational coherence is maintained throughout, barring a noteworthy exception noted within the "owner" and "external" groups, where a discernible divergence becomes evident.

According to" AHP " (CRCDD, OWRC, EXRD, DRCD, RRCR, CSRD)
According to "SPSS" (CRCDD, EXRD, OWRC, DRCD, RRCR, CSRD)

Table 2: SPSS and AHP Groups Comparison.

Group		
AHP	SPSS	Codd of Group
15.82%	15.23%	Owner – OWRC
31.30%	17.83%	Contractor- CRCDD
3.89%	9.67%	Consultant- CSRD
10.73%	14.52%	Design – DRCD
5.60%	10.94%	Site-SRCD
8.25%	13.88%	Contractual Relationship RRCR
25.27%	17.70%	External -EXRD

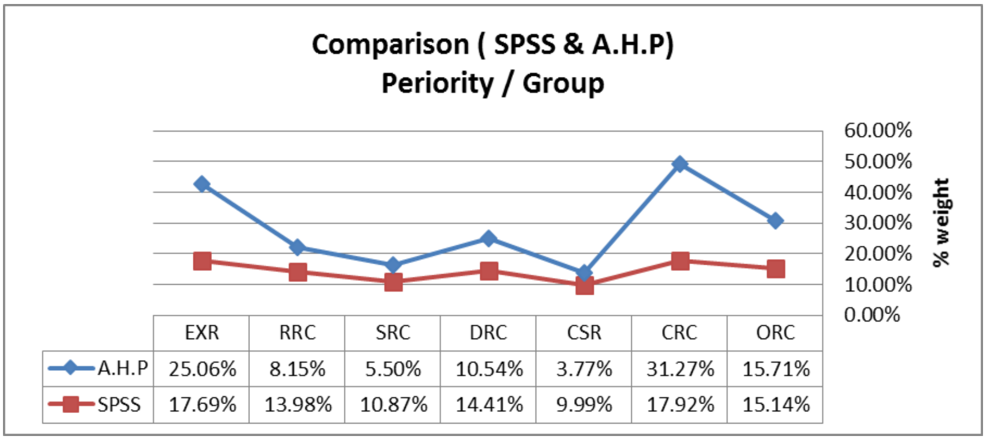


Figure 3: SPSS and AHP Groups Comparison.

Overall Results Analysis

The analyses of the significance directories were calculated through 70 delay causes, and the outcomes are deliberated in Table 3 using both the SPSS and AHP methods.

Table 3: Causes of delay Ranking from SPSS and AHP.

#	Factor ID	SPSS Rank	AHP Rank	SPSS Weight	AHP Weight
1.	OWRC01	1	2	0.017	0.0425
2.	OWRC02	16	35	0.015	0.0125
3.	OWRC03	42	59	0.014	0.0051
4.	OWRC04	20	45	0.016	0.0089
5.	OWRC05	9	11	0.017	0.0277
6.	OWRC06	12	25	0.018	0.0169
7.	OWRC07	52	68	0.015	0.0033
8.	OWRC08	9	19	0.017	0.0227
9.	OWRC09	34	54	0.015	0.0070
10.	OWRC10	49	69	0.016	0.0040
11.	CRCDD01	2	5	0.019	0.037
12.	CRCDD02	54	68	0.015	0.003
13.	CRCDD03	17	36	0.017	0.010
14.	CRCDD04	22	40	0.016	0.008
15.	CRCDD05	21	39	0.017	0.009
16.	CRCDD06	35	49	0.015	0.007
17.	CRCDD07	10	19	0.017	0.018
18.	CRCDD08	5	11	0.018	0.027
19.	CRCDD09	64	70	0.015	0.002
20.	CRCDD10	39	52	0.014	0.005
21.	CRCDD11	44	57	0.015	0.004
22.	CRCDD12	13	31	0.017	0.013
23.	CSRD01	62	55	0.013	0.005
24.	CSRD02	23	7	0.015	0.034
25.	CSRD03	36	24	0.014	0.015
26.	CSRD04	59	47	0.013	0.007
27.	CSRD05	46	37	0.013	0.010
28.	CSRD06	28	15	0.014	0.023
29.	CSRD07	3	1	0.018	0.050

30.	DRCD01	26	33	0.014	0.012
31.	DRCD02	55	61	0.013	0.003
32.	DRCD03	16	14	0.016	0.023
33.	DRCD04	11	8	0.016	0.033
34.	DRCD05	49	60	0.013	0.003
35.	DRCD06	25	22	0.015	0.016
36.	DRCD07	53	62	0.013	0.003
37.	DRCD08	40	51	0.014	0.005
38.	DRCD09	30	43	0.014	0.008
39.	DRCD10	9	6	0.016	0.035
40.	SRCD01	4	3	0.018	0.041
41.	SRCD02	67	41	0.012	0.008
42.	SRCD03	57	28	0.013	0.015
43.	SRCD04	58	29	0.013	0.015
44.	SRCD05	45	27	0.013	0.015
45	SRCD06	70	42	0.012	0.008
46	SRCD07	34	12	0.014	0.026
47	SRCD08	60	30	0.013	0.015
48	RRCR01	52	58	0.013	0.004
49	RRCR02	37	35	0.014	0.011
50	RRCR03	50	48	0.013	0.007
51	RRCR04	31	21	0.014	0.017
52	RRCR05	56	56	0.013	0.004
53	RRCR06	47	46	0.013	0.007
54	RRCR07	41	32	0.014	0.012
55	RRCR08	6	4	0.016	0.038
56	RRCR09	29	20	0.014	0.017
57	RRCR10	18	13	0.016	0.025
58	EXRD01	27	25	0.014	0.015
59	EXRD02	43	45	0.013	0.007
60	EXRD03	61	53	0.013	0.005
61	EXRD04	38	38	0.014	0.009
62	EXRD05	32	26	0.014	0.015
63	EXRD06	14	9	0.016	0.031
64	EXRD07	24	17	0.015	0.022
65	EXRD08	65	63	0.013	0.003
66	EXRD09	19	16	0.016	0.022
67	EXRD10	63	54	0.013	0.005
68	EXRD11	66	64	0.013	0.003
69	EXRD12	68	65	0.012	0.003
70	EXRD13	69	66	0.012	0.003

Projected Software

The projected software, named "Expected Time Delays Prediction for Construction Projects," aims to predict project duration delays by analysing a questionnaire survey through two different software SPSS and AHP. Subsequent sub-sections provide fundamental descriptions of the projected software.

The Welcome Page

The primary interface is denoted as the welcome page. This page, presented upon opening the software, introduces the software's name, designer, and supervisors. Users are prompted to select their preferred language—either Arabic or English—and enter the delay prediction software for initiating the application, as illustrated in Figure 4.

Figure 4: Proposed Software Welcome.

The Workspace

Figure 5 delineates the components of the fundamental elements in the main wizard. The main wizard encompasses several functions, including "Help wizard, File wizard, List of projects, Setting wizard, and Summary of last projects."

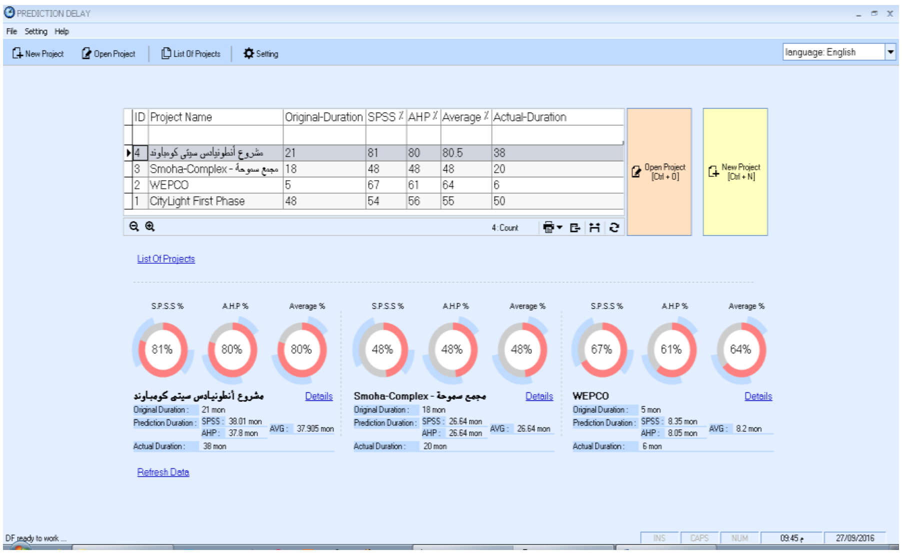
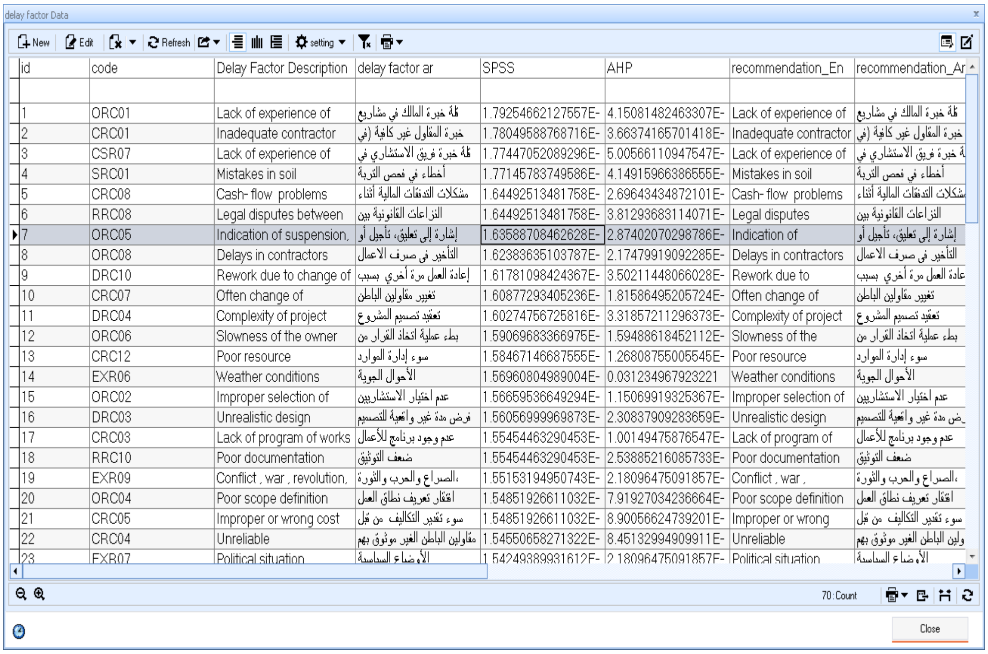


Figure 5: Workspace Show.

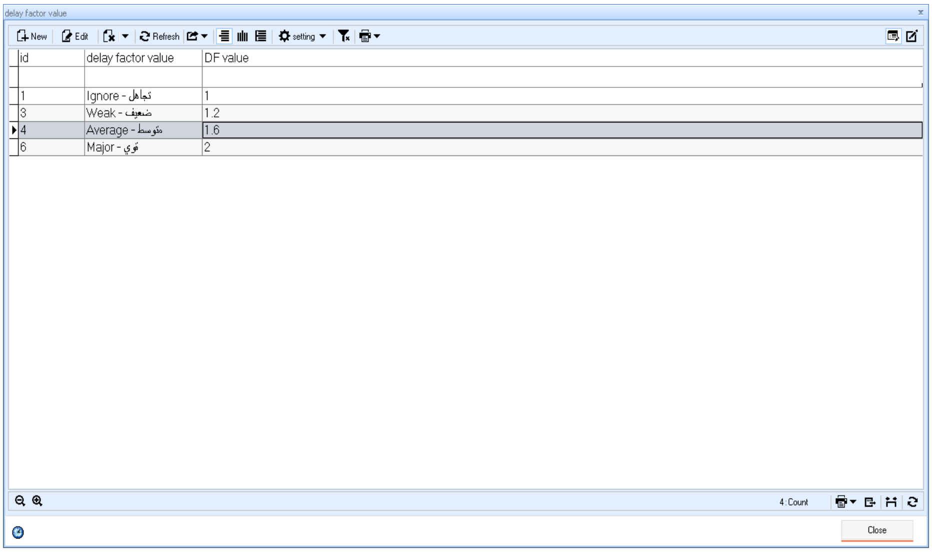
Wizard of Setting

The wizard displays essential data on delay factors, including factor details such as ID, code, and descriptions in both English and Arabic. It provides weights assigned to each factor based on SPSS and AHP analyses, along with recommendations in both languages. Figures 6 and 7 illustrate the delay value and the degree of occurrence.



id	code	Delay Factor Description	delay factor ar	SPSS	AHP	recommendation_En	recommendation_Ar
1	ORC01	Lack of experience of	قلة خبرة المالك في مشاريع	1.79254662127557E-	4.15081482463307E-	Lack of experience of	قلة خبرة المالك في مشاريع
2	CRC01	Inadequate contractor	خبرة المقاول غير كافية (في	1.78049588768716E-	3.66374165701418E-	Inadequate contractor	خبرة المقاول غير كافية (في
3	CSR07	Lack of experience of	قلة خبرة فريق الاستشاري في	1.77447052089296E-	5.00566110947547E-	Lack of experience of	ة خبرة فريق الاستشاري في
4	SRC01	Mistakes in soil	أخطاء في فحص التربة	1.77145783749586E-	4.14915966386555E-	Mistakes in soil	أخطاء في فحص التربة
5	CRC08	Cash- flow problems	مشكلات التدفقات المالية أثناء	1.64492513481758E-	2.69643434872101E-	Cash- flow problems	مشكلات التدفقات المالية أثناء
6	RRC08	Legal disputes between	النزاعات القانونية بين	1.64492513481758E-	3.81293683114071E-	Legal disputes	النزاعات القانونية بين
7	ORC05	Indication of suspension,	إشارة إلى تعليق، تأجيل أو	1.63588708462628E-	2.87402070298786E-	Indication of	إشارة إلى تعليق، تأجيل أو
8	ORC08	Delays in contractors	التأخير فى صرف الاعمال	1.62383635103787E-	2.17479919092285E-	Delays in contractors	التأخير فى صرف الاعمال
9	DRC10	Rework due to change of	إعادة العمل مرة أخري بسبب	1.61781098424367E-	3.50211448066028E-	Rework due to	عادة العمل مرة أخري بسبب
10	CRC07	Often change of	تغيير مقاولين الباطن	1.60877293405236E-	1.81586495205724E-	Often change of	تغيير مقاولين الباطن
11	DRC04	Complexity of project	تعقيد تصميم المشروع	1.60274756725816E-	3.31857211296373E-	Complexity of project	تعقيد تصميم المشروع
12	ORC06	Slowness of the owner	بطء عملية اتخاذ القرار من	1.59069683366975E-	1.59488618452112E-	Slowness of the	بطء عملية اتخاذ القرار من
13	CRC12	Poor resource	سوء إدارة الموارد	1.58467146687555E-	1.26808755005545E-	Poor resource	سوء إدارة الموارد
14	EXR06	Weather conditions	الأحوال الجوية	1.56960804989004E-	0.031234967923221	Weather conditions	الأحوال الجوية
15	ORC02	Improper selection of	عدم اختيار الاستشاريين	1.56659536649294E-	1.15069919325367E-	Improper selection of	عدم اختيار الاستشاريين
16	DRC03	Unrealistic design	فرض مدة غير واقعية للتصميم	1.56056999969873E-	2.30837909283659E-	Unrealistic design	ض مدة غير واقعية للتصميم
17	CRC03	Lack of program of works	عدم وجود برنامج للأعمال	1.55454463290453E-	1.00149475876547E-	Lack of program of	عدم وجود برنامج للأعمال
18	RRC10	Poor documentation	ضعف التوثيق	1.55454463290453E-	2.53885216085733E-	Poor documentation	ضعف التوثيق
19	EXR09	Conflict , war , revolution,	الصراع والحرب والثورة،	1.55153194950743E-	2.18096475091857E-	Conflict , war ,	الصراع والحرب والثورة،
20	ORC04	Poor scope definition	افتقار تعريف نطاق العمل	1.54851926611032E-	7.91927034236664E-	Poor scope definition	افتقار تعريف نطاق العمل
21	CRC05	Improper or wrong cost	سوء تقدير التكاليف من قبل	1.54851926611032E-	8.90056624739201E-	Improper or wrong	سوء تقدير التكاليف من قبل
22	CRC04	Unreliable	مقاولين الباطن الغير موثوق بهم	1.54550658271322E-	8.45132994909911E-	Unreliable	ولين الباطن الغير موثوق بهم
23	EXR07	Political situation	الأوضاع السياسية	1.54249389931612E-	2.18096475091857E-	Political situation	الأوضاع السياسية

Figure 6: Wizards of First Setting.



id	delay factor value	DF value
1	Ignore - تجاهل	1
3	Weak - ضعيف	1.2
4	Average - متوسط	1.6
6	Major - قوي	2

Figure 7: Wizard of Second Setting.

New Project Creation

This wizard oversees the input of comprehensive project information, including the project identifier, project appellation, initial time frame, realized time frame, and, in instances of finalized projects (exemplified as case studies), particulars pertaining to the project. Please consult Figure 8 for a graphical representation.

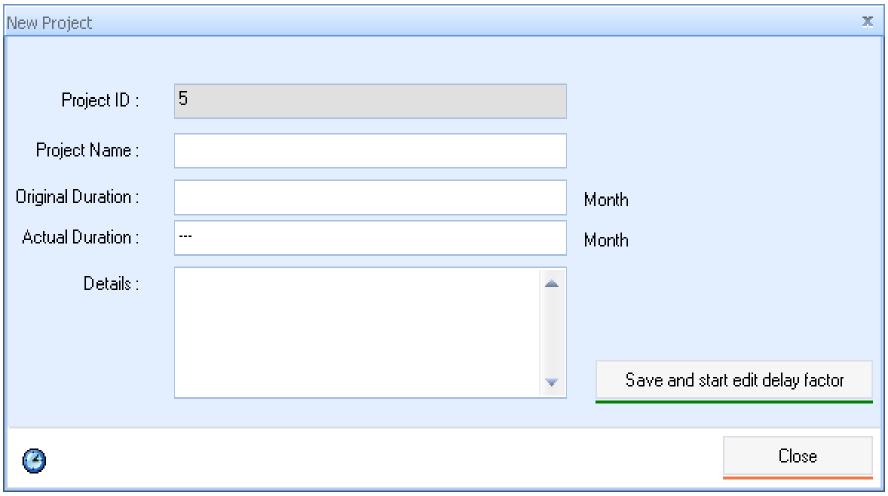


Figure 8: New Project Wizard.

Wizard of Projects

This adept practitioner evaluates factors contributing to project delays by considering the likelihood of occurrences and project-specific details. The expeditious outcomes are generated through the application of both "SPSS" and "AHP" methodologies. The results encompass details on delay factors, recommendations for the top 20 factors, final paper recommendations, and results based on the SPSS and AHP methods, as depicted in Figure 9.

Figure 9: Project Wizard.

Details of Delay Factors Wizard

This wizard displays the ranking results of delay factors, presenting each factor along with its corresponding weight. The outcomes and analyses are depicted using both the "SPSS" and "AHP" methods, as illustrated in Figure 10.

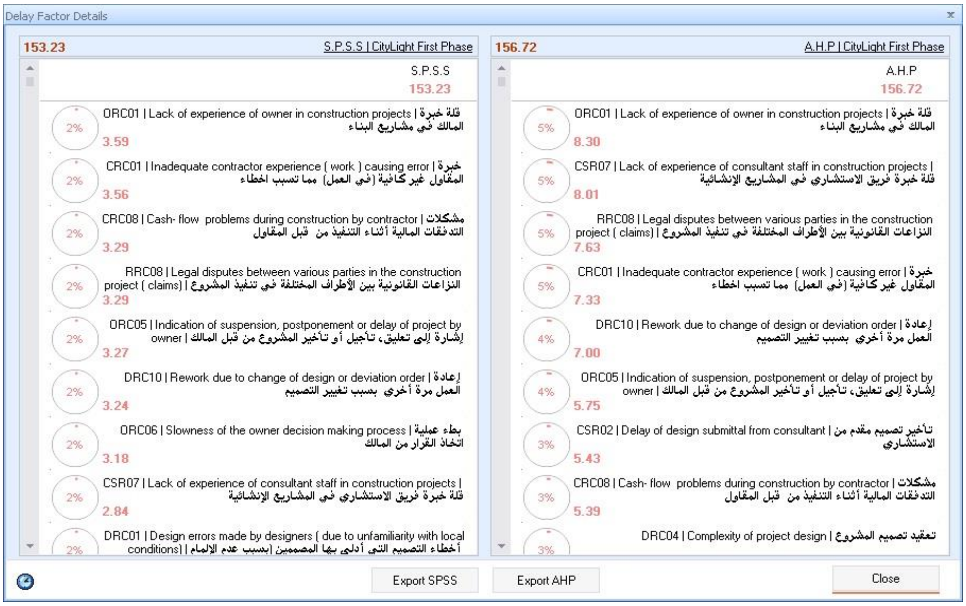


Figure.10: Factors of Delays Wizard.

Top 20 Delayed Factors Recommendations

This wizard reveals the top 20 factors that are causing delays and impacting project timelines. These delays are assessed through both the SPSS and AHP methods, as depicted in Figures 11 and 12, respectively.

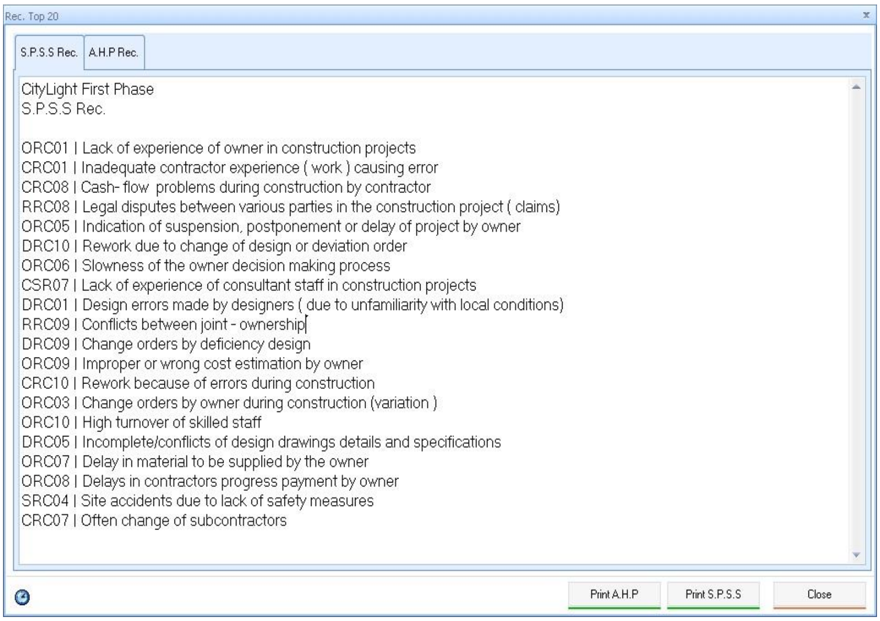


Figure 11: TOP 20 Factors Recommendations in Using SPSS.

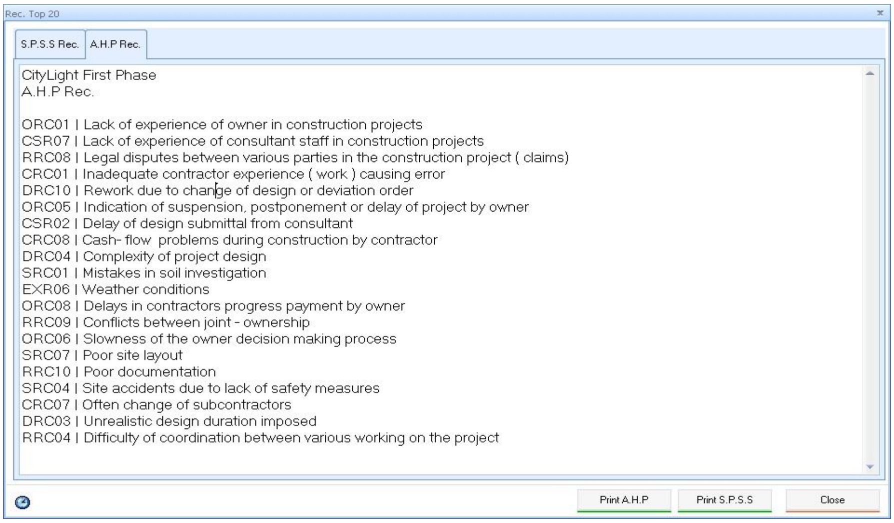


Figure12: Top 20 Factors Recommendations Using AHP.

Projects List

This wizard displays a list of projects, featuring Project ID, Project name, Project details, actual duration, and delay percentage using both SPSS and AHP methods, as illustrated in Figure 13.

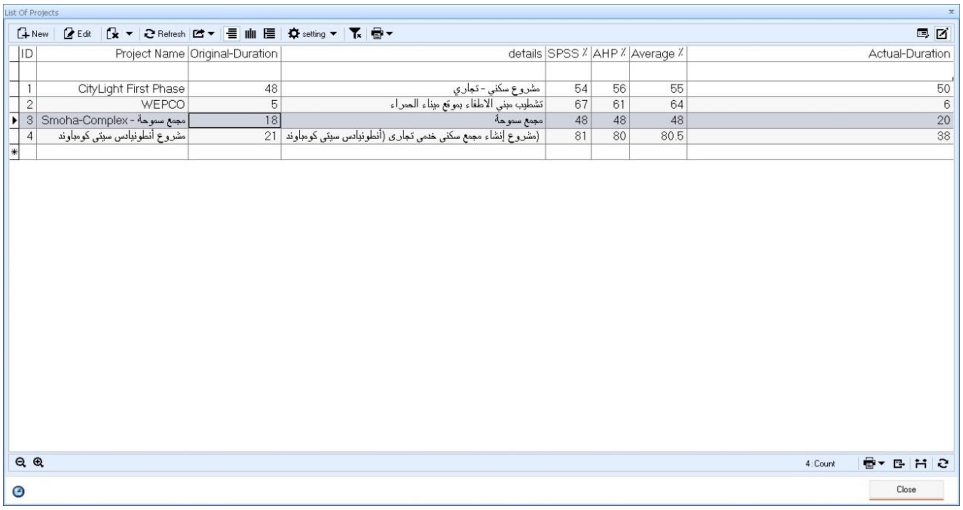


Figure 13: Projects Wizards List.

Conclusion of Report Wizard

The wizard presents a conclusive report delineating the ten foremost delay factors impacting projects, derived from the integration of both SPSS and AHP methodologies. Accompanying the report are pertinent recommendations, elucidated in Figure 14.

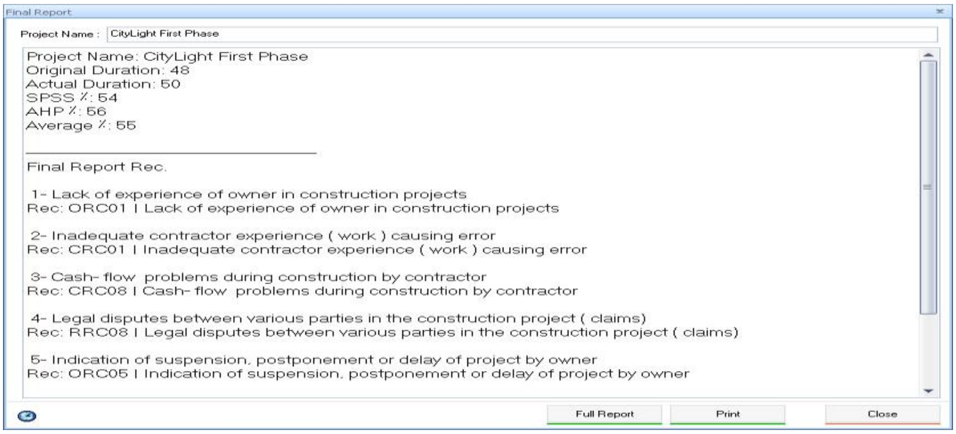


Figure 14: Report wizard Conclusion.

Final Report

The concluded document, prepared for printing and spanning six pages, presents an exhaustive summary encapsulating Figures 15 to 18. It incorporates essential project information such as the project appellation, envisaged delay percentages determined through SPSS and AHP methodologies, and various timeframes encompassing original schedules, SPSS and AHP prognosticated durations, mean duration, and actual duration. Furthermore, the report expounds upon the categorization of Delay Factor Classification based on project manager preferences, classifying factors as either ignored, weak, average, or significant contributors to project delays. A visual representation through Bar Charts facilitates a lucid comprehension of these durations, while recommendations derived from analytical insights are furnished. Additionally, the report includes export functionalities, facilitating seamless sharing in PDF and HTML formats.

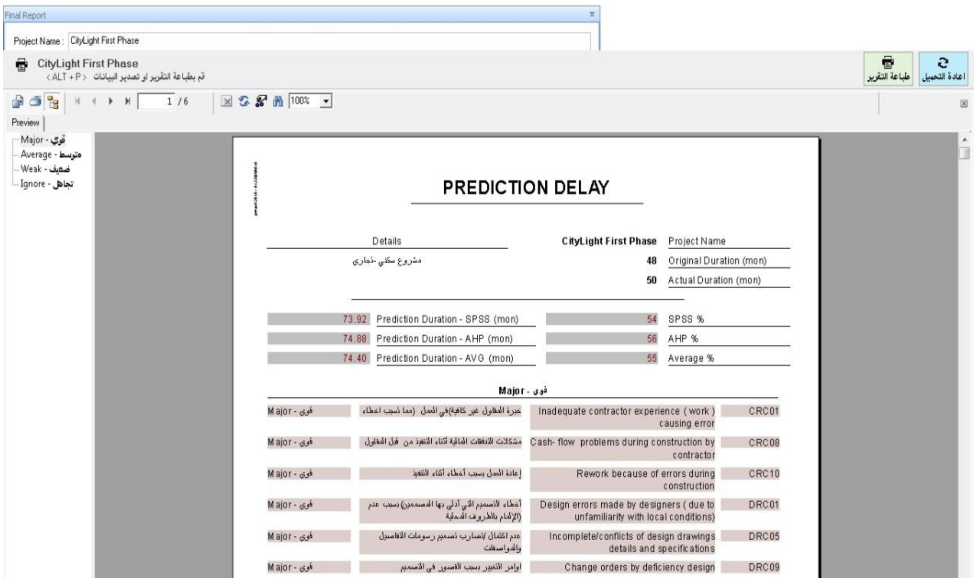


Figure 15: First wizard Reports Final.

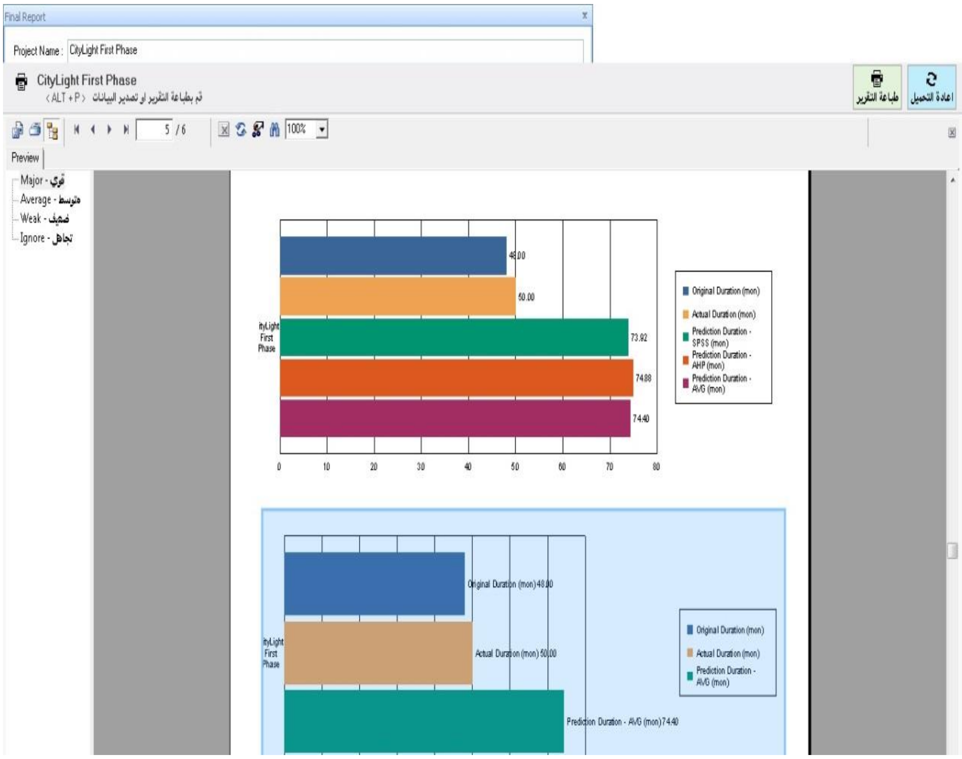


Figure 16: Second Wizard Report Final.

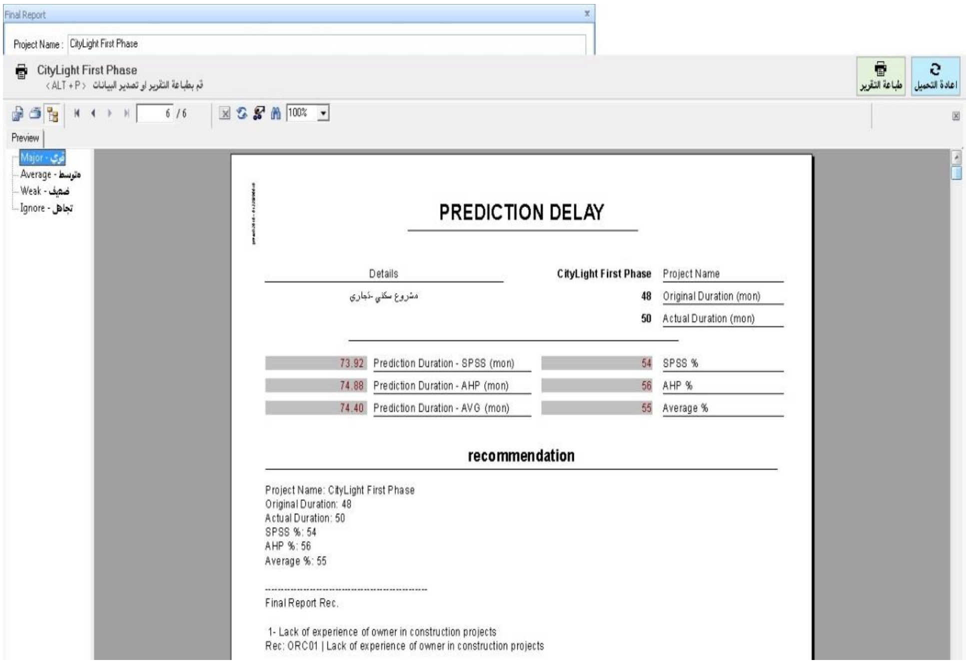


Figure17: Third Wizard Report Final.

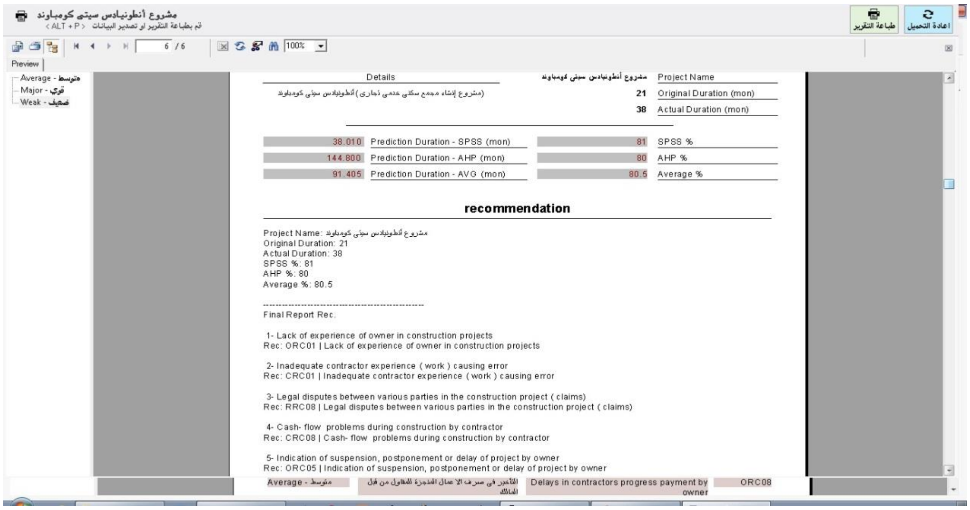


Figure18: Forth Wizard Report Final.

Findings Of Case Study

Introduction

This case study seeks to analyse the root causes of delays in a comprehensive construction project in Alexandria, encompassing commercial, administrative, and residential components within a structural integrated complex. The project spans an area of 23,000 m2. The objective is to identify responsible parties, determine the percentage of delays, and provide recommendations to prevent future delays.

Steps of Analysis

Interviews were conducted with key stakeholders, including the general manager, construction project manager, and consultant, to identify factors contributing to project delays. The reasons collected encompass: A) Conflicts among partners. B) Unstable project income sources and financial volatility. C) Owner's lack of experience in conceptualizing the complete project timeline, and D) External factors such as revolutions, recessions, inflation, and Dollar price instability. E) The owner's challenge in establishing a clear initial and final project vision, compounded by a high volume of variation orders. F) Insufficient expertise across diverse domains. G) Legal infringements and subsequent removals. H) Ramifications arising from removals. I) Absence of a legal and administrative framework for all project stakeholders, lacking clear scopes for each party. J) Involvement of family business dynamics. K) Administrative weakness, resolution volatility, and delays in adopting suitable resolutions. These factors have resulted in a project delay of 52%, exceeding the original 4-year duration (48 months) to an actual duration of 73 months.

The delays have several consequential experiences, leading to escalated project expenses and difficulties in meeting client delivery deadlines. The process of integrating the time delay prediction software involved specific phases: firstly, completing a tailored questionnaire designed for the case; subsequently, inputting the gathered data into the developed software. Subsequently, the application of SPSS and AHP methodologies within the software is undertaken to analyze and prioritize the causes of delays. Conclusively, an elaborate report is generated, delineating delay percentages and providing recommendations for the prospective mitigation of delays in projects. Noteworthy is the utilization of both methodologies in this case study, resulting in comparable outcomes. The ranking of the top 20 factors demonstrates a rational and acceptable level of disparity between the employed methodologies.

Discussion and Implications

Construction projects play a crucial role in societal development by delivering vital infrastructure, homes, and facilities. They also contribute to economic growth through job creation and investment opportunities. However, delays in construction projects pose significant challenges, leading to adverse consequences for stakeholders and project outcomes. This research endeavours to investigate the causes of delays in Egyptian construction projects, employing a comprehensive methodology that includes expert consultations, literature review, and a detailed questionnaire survey. The study encompasses an extensive range of delay factors, classifying them into seven groups: Owner-related, Contractor-related, Consultant-related, Design-related, Site-related, Contractual Relationship-related, and External-related. The analysis, conducted through SPSS and AHP, provides valuable insights into the prioritization and weighting of these delay factors. The research findings are consistent with the prevailing literature on construction project delays. Assaf and Al-Hejji (2006), Al-Momani (2000) and Al-Momani (2000) highlighting the importance of factors such as insufficient planning, financial challenges, and ineffective project management as key contributors to delays.

The prioritization of delay factors in this research resonates with the findings of Assaf, Hussein, Abdelkhalek, and Zayed (2023), who recognized owner-related challenges, contractor-related issues, and external factors as pivotal influences on project delays within the construction industry. This alignment underscores the credibility and applicability of the employed methods, affirming their ability to reveal crucial insights that resonate with broader industry dynamics. Moreover, the comparison of the SPSS and AHP methods in prioritizing delay factors across various levels (Owner, Contractor, Consultant, Design, Site, Contractual Relationship, and External) highlights certain differences. Although both methods generally concur on the ranking of groups, exceptions are evident, particularly for the Owner and External categories. Despite these disparities, the comprehensive analysis consistently indicates alignment in the prioritization of delay factors between the two methods.

The in-depth scrutiny of the top 20 delay factors using both SPSS and AHP methods unveils intriguing nuances. As an example, elements like "Owner suspension indication," "Contractor cash flow problems," and "Consultant delay in approving work scope main changes" consistently stand out as pivotal factors influencing project delays. The research assigns weightings to each delay factor, providing a quantitative measure of their impact on project timelines (Mustafa et al., 2023). Consequently, employing methodological triangulation enhances the validity of the study's findings, underscoring the intricate nature of delay factors in construction projects. Conversely, the proposed software aimed at predicting construction project delays integrates insights derived from the questionnaire survey. It enables the input of project-specific data, facilitating an analysis of delay factors and generating recommendations based on evaluations conducted using both SPSS and AHP methodologies.

The software's comprehensive approach, amalgamating expert opinions and analytical methodologies, establishes a sturdy foundation for predicting and alleviating delays in construction projects. The utilization of both SPSS and AHP methods in the analysis enhances the robustness of the research. Similar methodological dualism has been employed in studies by Mustafa et al. (2023) and Le-Hoai, Lee, and Lee (2008) highlighting the importance of triangulating research findings for enhanced reliability. Additionally, the proposed software aligns with the digital advancements in construction project management advocated by Desbiens (2020) showcasing a proactive approach to address delays through technology. This positioning of the software establishes it at the forefront of modern project management methodologies, underscoring its relevance and practical utility in effectively addressing the intricate challenges associated with construction project delays.

In the particular context of the case study focused on the structural integrated complex in Alexandria, the identified reasons for project delays closely parallel the broader trends observed in extensive research within the construction industry. The case study, exposing a significant 52% delay, attributes this setback to a comprehensive range of issues, including conflicts among project partners, financial volatility, and the owner's insufficient expertise in project timetabling. Notably, the incorporation of the proposed time delay prediction software in this case study serves as a tangible manifestation of its practical usefulness, efficiently evaluating delays and furnishing customized recommendations. The resonance between the case study's outcomes and the seminal works of Latif, Saleem, and Cheema (2023) affirms the persistent theme observed in various studies, highlighting the significant influence of partner conflicts, financial instability, and owner-related issues on project delays. This alignment not only validates the effective implementation of the proposed software but also strengthens the broader research methodology's applicability in addressing real-world complexities within construction projects (Budiwan, Wongwatcharapaiboon, Thienthaworn, & Tapracharoen, 2023). Therefore, the extensive analysis reaffirms the widespread relevance of the identified delay factors and the proposed software, adding to a more holistic comprehension of effective project management in the construction domain. These findings suggest that companies should prioritize project management strategies to enhance efficiency, specifically by addressing and minimizing delays in their projects.

Building upon prior research, this study holds both theoretical and practical significance. Theoretical implications stem from its contribution to the existing knowledge base on construction project delays. The comprehensive methodology, integrating expert consultations, literature review, and dual-method analysis, deepens the understanding of delay factors and their hierarchical significance. The consistency between findings and established literature reinforces the research's robustness and applicability. The study's insights into the top 20 delay factors, quantifying their impact through SPSS and AHP, advance theoretical frameworks for evaluating and alleviating project delays. The incorporation of expert opinions and analytical methodologies into the proposed software constitutes a theoretical innovation, presenting a proactive and technology-driven method for predicting delays in construction projects. Additionally, this expanded framework could serve as a valuable resource for other researchers exploring new avenues in their future research endeavours. On a practical level, the research findings and the proposed software carry direct implications for construction project management not only in Egypt but also globally. The software's provision of prioritized delay factors and quantitative measures offers practical guidance for project stakeholders to identify and address potential delays effectively. The incorporation of SPSS and AHP methods into the software enhances its reliability and practical applicability. Project managers can utilize the research insights to formulate more efficient delay mitigation strategies, with a particular focus on critical factors like owner-related issues, contractor cash flow problems, and consultant-related delays. The software's successful application in the case study underscores its practical relevance, illustrating its effectiveness in real-world scenarios. In essence, the research provides practical tools and insights that can inform decision-making and enhance the overall management of construction projects, aligning with the industry's continual efforts to improve efficiency and reduce delays.

Despite making significant contributions, the study has inherent limitations that could be addressed in future research. Primarily, the focus on Egyptian construction projects may hinder the generalizability of findings to other contexts. Additionally, the reliance on a questionnaire survey introduces potential response bias, and the exclusion of qualitative data may limit the depth of understanding. The practical implementation of the proposed software may encounter challenges related to user adoption and integration into existing project management systems. To mitigate these limitations, future research could expand the study to diverse geographic contexts, incorporate qualitative methodologies, and conduct usability testing for the software. Furthermore, exploring the long-term effectiveness of the proposed delay mitigation strategies and continuously refining the software's predictive capabilities would enhance the study's practical impact and contribute to the field.

Conclusions

This paper introduces a delay prediction software, named "Expected Time Delays Prediction for Construction Projects." It utilizes a comprehensive analysis of a questionnaire survey through two methods, "SPSS" and "AHP", to predict project duration delays. These techniques rank delay factors using assigned weights, determined by their importance in construction sites. The proposed software incorporates these weights, with each factor having two weights from both SPSS and AHP methods. Three case studies were conducted using the SPSS and AHP methods to analyse and rank delay factors, identifying the most significant contributors to construction project delays. For projects under 6 months, AHP proved more accurate in predicting delay percentages, while SPSS was deemed impractical for projects of this size. For projects exceeding 18 months, both methods were applied and yielded comparable results.

Recommendations

Several factors have been considered in recommending strategies for mitigating and managing construction delays on sites by stakeholders, as outlined below:

1) It is crucial to consider any financial challenges faced by the owner, emphasizing the importance of disbursing each contractor's payments promptly according to the

agreed schedule to prevent delays in the contractor's work. 2) Clearly delineate contracts among project stakeholders, ensuring thorough review by contract management to articulate the rights and responsibilities of each party and avert potential legal disputes or claims in construction. 3) Consider the contractor's financial challenges, placing emphasis on obtaining a financial guarantee letter and banking documents to secure the contractor's commitment to fulfilling the agreed-upon work. 4) Clearly define the scope of work. 5) Address the owner's lack of construction site experience by engaging a specialized project management company to provide training and foster experience for upcoming projects. 6) Address delays in the owner's decision-making process by selecting highly experienced advisors to expedite and facilitate efficient decision-making. 7) Consider potential errors from designers unfamiliar with the environment or local conditions. It is crucial to engage experienced designers capable of adapting designs to specific conditions.

The study offers recommendations based on a case study.

1) Legal Disputes (Claims): Recommendation: Ensure contracts are clear and reviewed, outlining the rights and duties of each party (Rec: RRCR08). 2) Cash Flow Issues for Contractors: Recommendation: Emphasize banking guarantees and documents to ensure the contractor's ability to complete the work (Rec: CRCDD08). 3) Owner Decision-Making Delays: Recommendation: opt for experienced advisors to streamline the owner's decision-making process (Rec: OWRC06). 4) Poor Documentation: Recommendation: Seek legal advisory offices with adequate experience (Rec: RRCR10). 5) Consultant Design Submittal Delays: Recommendation: Conduct regular meetings to discuss and address delays during implementation (Rec: CSRD02). 6) Consultant Lack of Construction Experience: Recommendation: Owner to approve the consultant group's CV to ensure sufficient experience (Rec: CSRD07). 7) Owner Lack of Construction Site Experience: Recommendation: Utilize specialized project management companies for training and project experience (Rec: OWRC01). 8) Inexperienced Contractor Causing Errors: Recommendation: Focus on selecting contractors with a proven track record, experience, and sound administrative and technical structures (Rec: CRCDD01).

References

Abd El-Razek, M., Bassioni, H., & Mobarak, A. (2008). Causes of delay in building construction projects in Egypt. Journal of Construction Engineering and Management, 134(11), 831-841. https://doi.org/10.1061/(ASCE)0733-9364(2008)134:11(831)

Abdel-Gawad, M., M., G., & M., I. (2005). Sources of Project Risks under Joint Ventures in Egypt. In Proceedings of the Eleventh International Colloquium on Structural and Geotechnical Engineering, ICSGE. Cairo, Egypt.

Afshari, H., Khosravi, S., Ghorbanali, A., Borzabadi, M., & Valipour, M. (2010). Identification of causes of non-excusable delays of construction projects. In International conference on e-business management and economics (Vol. 42). IACSIT Press, Hong Kong. https://www.semanticscholar.org/paper/6296fc651d561b0445f1fd600652425d7083a7d9

Al Ghafly, M. A. A. (1995). *Delay in the construction of public utility projects in Saudi Arabia.* King Fahd University of Petroleum and Minerals (Saudi Arabia),

Al-Hazim, N., Salem, Z. A., & Ahmad, H. (2017). Delay and cost overrun in infrastructure projects in Jordan. Procedia Engineering, 182, 18-24. https://doi.org/10.1016/j.proeng.2017.03.105

Al-Momani, A. H. (2000). Construction delay: a quantitative analysis. International Journal of Project Management, 18(1), 51-59. https://doi.org/10.1016/S0263-7863(98)00060-X

Al-Rawashdeh, O. M., Jawabreh, O., & Ali, B. (2023). Supply Chain Management and Organizational Performance: The Moderating Effect of Supply Chain Complexity. Information Sciences Letters, 12(3), 1673-1684. http://dx.doi.org/10.18576/isl/120351

Alhaj, A., Zanoon, N., Alrabea, A., Alnatsheh, H., Jawabreh, O., Abu-Faraj, M., & Ali, B. J. (2023). Improving the Smart Cities Traffic Management Systems using VANETs and IoT Features. Journal of Statistics Applications & Probability, 12(2), 405-414. http://dx.doi.org/10.18576/jsap/120207

Alkhodary, D., Abu-AlSondos, I. A., Ali, B., Shehadeh, M., & Salhab, H. A. (2022). Visitor Management System Design and Implementation during the Covid-19 Pandemic. Information Sciences Letters, 11(04), 1059-1067. http://dx.doi.org/10.18576/isl/110406

Alwi, S., & Hampson, K. D. (2003). Identifying the important causes of delays in bulding construction projects. In The 9th East Asia-Pacific Conference on Structural Engineering and Construction (pp. 12-18). Queensland University of Technology. https://eprints.qut.edu.au/4156/

Ammar, M. A., Elsamdony, A. A., & Rabie, A. A. (2009). Risk Allocation and Mitigation in the Egyptian Barrage Projects. In Proceedings of the 13th International Conference on Structural and Geotechnical Engineering, December 27 (Vol. 29, pp. 180-190). Environmental Science, Engineering. https://www.semanticscholar.org/paper/3472a0aad61075253e847df85c53ce5a9a1c93dc

Aravindhan, C., Santhoshkumar, R., Bonny, K., Vidhya, K., Manishankar, S., & Dhamodharam, P. (2023). Delay analysis in construction project using Primavera & SPSS. Materials Today: Proceedings, 80, 3171-3177. https://doi.org/10.1016/j.matpr.2021.07.186

Assaf, M., Hussein, M., Abdelkhalek, S., & Zayed, T. (2023). A Multi-Criteria Decision-Making Model for Selecting the Best Project Delivery Systems for Offsite Construction Projects. Buildings, 13(2), 571. https://doi.org/10.3390/buildings13020571

Assaf, S. A., & Al-Hejji, S. (2006). Causes of delay in large construction projects. International Journal of Project Management, 24(4), 349-357. https://doi.org/10.1016/j.ijproman.2005.11.010

Aziz, R. F. (2013). Ranking of delay factors in construction projects after Egyptian revolution. Alexandria Engineering Journal, 52(3), 387-406. https://doi.org/10.1016/j.aej.2013.03.002

Aziz, R. F., & Abdel-Hakam, A. A. (2016). Exploring delay causes of road construction projects in Egypt. Alexandria Engineering Journal, 55(2), 1515-1539. https://doi.org/10.1016/j.aej.2016.03.006

Bin Yusof, M. A., Binti Mohammad, N., & Bin Mat Derus, Z. (2007). Excusable and Compensable Delays in the Construction of Building Project–a Study in the States of Selangor and Wilayah Persekutuan Kuala Lumpur, Malaysia. Journal - The Institution of Engineers, Malaysia, 68(4), 21-26. http://dspace.unimap.edu.my/handle/123456789/13579

Budiwan, A. P., Wongwatcharapaiboon, J., Thienthaworn, A., & Tapracharoen, K. (2023). Key Factors to Design Omnichannel Communication Platform for B2b Thai Construction E-commerce Business. In 14th Built Environment Research Associates Conference (pp. 807-816). BERAC2023At: Bangkok, Thailand. https://www.researchgate.net/publication/373708778

Chae, Y. T., Horesh, R., Hwang, Y., & Lee, Y. M. (2016). Artificial neural network model for forecasting sub-hourly electricity usage in commercial buildings. Energy and Buildings, 111, 184-194. https://doi.org/10.1016/j.enbuild.2015.11.045

Chan, D. W., & Kumaraswamy, M. M. (1997). A comparative study of causes of time overruns in Hong Kong construction projects. International Journal of Project Management, 15(1), 55-63. https://doi.org/10.1016/S0263-7863(96)00039-7

Desbiens, F. (2020). Conception d'un système de mesure et de suivi de la performance pour une entreprise intégrée du domaine de l'immobilier et de la construction (Doctoral Dissertation, Université Laval). https://library-archives.canada.ca/eng/services/services-libraries/theses/Pages/item.aspx?idNumber=1201506862

Durdyev, S., & Hosseini, M. R. (2020). Causes of delays on construction projects: a comprehensive list. International Journal of Managing Projects in Business, 13(1), 20-46. https://doi.org/10.1108/IJMPB-09-2018-0178

El-Sayegh, S. M. (2008). Risk assessment and allocation in the UAE construction industry. International Journal of Project Management, 26(4), 431-438. https://doi.org/10.1016/j.ijproman.2007.07.004

Ellis, R. D., & Thomas, H. R. (2003). The root causes of delays in highway construction. In Presentation at the 82nd Annual Meeting of the Transportation Research Board (pp. 1-16). Citeseer.

Famiyeh, S., Amoatey, C. T., Adaku, E., & Agbenohevi, C. S. (2017). Major causes of construction time and cost overruns: A case of selected educational sector projects in Ghana. Journal of Engineering, Design and Technology, 15(2), 181-198. https://doi.org/10.1108/JEDT-11-2015-0075

Falqi, I. (2004). Delays in project completion: a comparative study of construction delay factors in Saudi Arabia and the United Kingdom. *Unpublished MSc. Thesis, School of the Built Environment, Heriot-Watt University*.

Fugar, F. D. K., & Agyakwah-Baah, A. B. (2010). Delays in building construction projects in Ghana. Australasian Journal of Construction Economics and Building, The, 10(1/2), 128-141. https://doi.org/10.5130/AJCEB.v10i1-2.1592

Gondia, A., Siam, A., El-Dakhakhni, W., & Nassar, A. H. (2020). Machine learning algorithms for construction projects delay risk prediction. Journal of Construction Engineering and Management, 146(1), 04019085. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001736

Hatamlah, H., Allahham, M., Abu-AlSondos, I., Mushtaha, A., Al-Anati, G., Al-Shaikh, M., & Ali, B. (2023). Assessing the moderating effect of innovation on the relationship between information technology and supply chain management: an empirical examination. Applied Mathematics & Information Sciences, 17(5), 889-895. http://dx.doi.org/10.18576/amis/170515

Jahmani, A., Jawabreh, O., Fahmawee, E., Almasarweh, M., & Ali, B. J. (2023). The Impact of Employee Management on Organizational Performance in Dubai's Five-Star Hotel Sector. Journal of Statistics Applications & Probability, 12(2), 395-404. http://dx.doi.org/10.18576/jsap/120206

Jawabreh, O., Baadhem, A. M., Ali, B., Atta, A. A. B., Ali, A., Al-Hosaini, F. F., & Allahham, M. (2023). The Influence of Supply Chain Management Strategies on Organizational Performance in Hospitality Industry. Appl. Math, 17(5), 851-858. http://dx.doi.org/10.18576/amis/170511

Johnson, R. M., & Babu, R. I. I. (2020). Time and cost overruns in the UAE construction industry: a critical analysis. International Journal of Construction Management, 20(5), 402-411. https://doi.org/10.1080/15623599.2018.1484864

Kaliba, C., Muya, M., & Mumba, K. (2009). Cost escalation and schedule delays in road construction projects in Zambia. International Journal of Project Management, 27(5), 522-531. https://doi.org/10.1016/j.ijproman.2008.07.003

Kanan, M. (2020). Assessment of the COPQ due to Poor Maintenance Practices in Saudi Industry. SSRG International Journal of Engineering Trends and Technology, 68(11), 163-172. https://doi,org/10.14445/22315381/IJETT-V68I11P222

Kanan, M., Wannassi, B., Barham, A. S., Ben Hassen, M., & Assaf, R. (2022). The Quality of Blended Cotton and Denim Waste Fibres: The Effect of Blend Ratio and Waste Category. Fibers, 10(9), 76. https://doi.org/10.3390/fib10090076

Kelleher, A. H. (2003). An investigation of the expanding role of the critical path method by ENR's top 400 contractors (Masters Theses, Virginia Tech). https://vtechworks.lib.vt.edu/handle/10919/9889

Latif, M., Saleem, M., & Cheema, S. M. (2023). Analyzing the Key Factors Contributing to Project Delays in the Construction Industry: A Comprehensive Study. Journal of Development and Social Sciences, 4(3), 936-944. https://doi.org/10.47205/jdss.2023(4-III)85

Le-Hoai, L., Lee, Y. D., & Lee, J. Y. (2008). Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries. Ksce Journal of Civil Engineering, 12(6), 367-377. https://doi.org/10.1007/s12205-008-0367-7

Lindhard, S. M., Neve, H., Terje Kalsaas, B., Møller, D. E., & Wandahl, S. (2022). Ranking and comparing key factors causing time-overruns in on-site construction. International Journal of Construction Management, 22(14), 2724-2730. https://doi.org/10.1080/15623599.2020.1820659

Long, N. D., Ogunlana, S., Quang, T., & Lam, K. C. (2004). Large construction projects in developing countries: a case study from Vietnam. International Journal of Project Management, 22(7), 553-561. https://doi.org/10.1016/j.ijproman.2004.03.004

Majid, I. (2006). Causes and Effects of Delays in Aceh Construction Industry (MSc. Thesis, University Technology Malaysia, Skudai, Johor Bahru, Malaysia).

Majid, M. A., & McCaffer, R. (1998). Factors of non-excusable delays that influence contractors' performance. Journal of Management in Engineering, 14(3), 42-49. https://doi.org/10.1061/(ASCE)0742-597X(1998)14:3(42)

Maqsoom, A., Choudhry, R. M., Umer, M., & Mehmood, T. (2021). Influencing factors indicating time delay in construction projects: Impact of firm size and experience. International Journal of Construction Management, 21(12), 1251-1262. https://doi.org/10.1080/15623599.2019.1613206

Marzouk, M. M., & El-Rasas, T. I. (2014). Analyzing delay causes in Egyptian construction projects. Journal of Advanced Research, 5(1), 49-55. https://doi.org/10.1016/j.jare.2012.11.005

Memon, A. H., Memon, A. Q., Khahro, S. H., & Javed, Y. (2023). Investigation of Project Delays: Towards a Sustainable Construction Industry. Sustainability, 15(2), 1457. https://doi.org/10.3390/su15021457

Mustafa, A., Syah, R., Paena, M., Sugama, K., Kontara, E. K., Muliawan, I., Suwoyo, H. S., Asaad, A. I. J., Asaf, R., & Ratnawati, E. (2023). Strategy for Developing Whiteleg Shrimp (Litopenaeus vannamei) Culture Using Intensive/Super-Intensive Technology in Indonesia. Sustainability, 15(3), 1753. https://doi.org/10.3390/su15031753

Naimi, H. A., & Alobadi, S. (2023). A Study of Construction Delays. International Journal on “Technical and Physical Problems of Engineering”(IJTPE), 15(54), 296-308. https://www.researchgate.net/profile/Sepanta-Naimi-2/publication/371289605

Ng, S. T., Skitmore, R. M., Lam, K. C., & Poon, A. W. (2004). Demotivating factors influencing the productivity of civil engineering projects. International Journal of Project Management, 22(2), 139-146. https://doi.org/10.1016/S0263-7863(03)00061-9

Omar, T., & Nehdi, M. L. (2016). Data acquisition technologies for construction progress tracking. Automation in Construction, 70, 143-155. https://doi.org/10.1016/j.autcon.2016.06.016

Prateapusanond, A. (2003). A comprehensive practice of total float pre-allocation and management for the application of a CPM-based construction contract

(Doctoral Dissertations, Virginia Tech). https://vtechworks.lib.vt.edu/handle/10919/11094

Rao, A. S., Radanovic, M., Liu, Y., Hu, S., Fang, Y., Khoshelham, K., Palaniswami, M., & Ngo, T. (2022). Real-time monitoring of construction sites: Sensors, methods, and applications. Automation in Construction, 136, 104099. https://doi.org/10.1016/j.autcon.2021.104099

Salami, B. A., Ajayi, S. O., & Oyegoke, A. S. (2023). Tackling the impacts of COVID-19 on construction projects: An exploration of contractual dispute avoidance measures adopted by construction firms. International Journal of Construction Management, 23(7), 1196-1204. https://doi.org/10.1080/15623599.2021.1963561

Sambasivan, M., & Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry. International Journal of Project Management, 25(5), 517-526. https://doi.org/10.1016/j.ijproman.2006.11.007

Santoso, D. S., & Soeng, S. (2016). Analyzing delays of road construction projects in Cambodia: Causes and effects. Journal of Management in Engineering, 32(6), 05016020. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000467

Shniekat, N., AL_Abdallat, W., Al-Hussein, M., & Ali, B. (2022). Influence of Management Information System Dimensions on Institutional Performance. Information Sciences Letters, 11(5), 435-1443. http://dx.doi.org/10.18576/isl/110512

Sobieraj, J., & Metelski, D. (2022). Project Risk in the Context of Construction Schedules—Combined Monte Carlo Simulation and Time at Risk (TaR) Approach: Insights from the Fort Bema Housing Estate Complex. Applied Sciences, 12(3), 1044. https://doi.org/10.3390/app12031044

Tariq, J., & Gardezi, S. S. S. (2023). Study the delays and conflicts for construction projects and their mutual relationship: A review. Ain Shams Engineering Journal, 14(1), 101815. https://doi.org/10.1016/j.asej.2022.101815

Tumi, S. A. H., Omran, A., & Pakir, A. H. K. (2009). Causes of delay in construction industry in Libya. In The International Conference on Economics and Administration (pp. 265-272). Citeseer. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=6e71f468aadf9697a4d0dc3ff5b9b29e0253ee3d

Zhang, L., & Wen, J. (2019). A systematic feature selection procedure for short-term data-driven building energy forecasting model development. Energy and Buildings, 183, 428-442. https://doi.org/10.1016/j.enbuild.2018.11.010