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The Study of Schedule-Oriented Planning for Efficient Construction Project Management

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Abstract

The global and Malaysian construction industries are experiencing a transformation driven by rapid urbanisation, sustainability demands, and digitalisation, while also facing challenges such as rising material costs, labour shortages, and growing project complexity. This study aims to identify key challenges in schedule-oriented planning, determine effective strategies, and analyse their relationship using a quantitative approach. The respondents were project managers from G7 contractor companies in Klang, Selangor. There were a total of 33 valid responses were analysed using descriptive and Spearman's correlation analyses in SPSS. The findings found that environmental disruptions, inadequate project management tools, and resource constraints are the most significant challenges affecting project schedules. The findings found that environmental disruptions, inadequate project management tools, and resource constraints are the most significant challenges affecting project schedules. In contrast, leadership development, advanced planning and scheduling systems, and labour management strategies are identified as the most effective strategies. The analysis further indicates that the relationships between challenges and strategies are generally weak to moderate, with the strongest relationships being those between mismatched tools and training in communication skills. The results confirm a significant relationship between scheduling challenges and the strategies used to address them, highlighting the importance of proactive planning and effective management in improving construction project performance.

1. Introduction

Schedule-oriented planning involves construction project planning and scheduling. Efficient project planning and scheduling have become a focal point for both the global and Malaysian construction industries, aiming to define project objectives, schedule activities, allocate resources, and manage risks to ensure timely and cost-effective project delivery. Planning and scheduling provide a structural methodology for managing global and Malaysian construction projects by optimising resources and ensuring the achievement of project milestones. Planning provides a strategic framework for decision-making, while scheduling translates the framework into a sequence of time-bound activities to achieve the milestones. Digital project management systems and methods, such as

Critical Path Method (CPM), Gantt Charts, and Program Evaluation and Review Technique (PERT), are widely used in the global construction industry to enhance planning accuracy and collaboration. However, adoption of digital project management in Malaysia is progressively increasing, especially in large-scale infrastructure and urban development projects. Planning and scheduling are a must in construction project management to ensure adherence to timelines, budgets, and quality standards, thereby reducing misunderstandings and enhancing project communication (Yahya *et al*., 2024).

Project schedule delays remain a critical issue in construction project management, arising from interconnected challenges related to time and resource constraints, ineffective communication, limited production control, and inadequate planning tools, all of which undermine schedule-oriented planning and increase the risk of delays or project failure (Bhosale, Shastri, & Khandare, 2017; Hai Nguyen, 2020; Zheng *et al*., 2016; Dave *et al*., 2016; Dasović, Galić, & Kansek, 2020). These internal challenges are further compounded by external factors such as extreme weather conditions, labour shortages, productivity variability, and frequent design changes, which disrupt scheduling, complicate resource allocation and levelling, and necessitate repeated rescheduling that escalates costs and reduces productivity (Schuldt *et al.,* 2021; Nasirzadeh *et al*., 2020; Ma *et al.,* 2019). Existing schedule-oriented planning solutions often fail to address these issues effectively due to rigid and poorly integrated tools that lack real-time adaptability and on-site data integration, resulting in persistent schedule overruns and cost escalation (Markou, Koulinas, & Vavatsikos, 2017; Shah, Bhatti, & Ahmed, 2023). Consequently, scholars increasingly emphasise the need for adaptive, data-driven planning approaches that better manage resource–activity interdependencies, enhance decision-making, and improve stakeholder coordination to support timely project delivery (Tejus & Satish, 2023; Chaudhary & Meshram, 2025). However, despite extensive identification of scheduling challenges and proposed strategies, empirical evidence linking specific challenges to the effectiveness of corresponding solutions remains limited, creating a critical research gap that constrains the development of targeted, high-impact interventions for improving scheduling efficiency and overall project performance in the construction industry (Nejatyan *et al.,* 2023; Al Nasseri & Aulin, 2016; Irfan *et al.,* 2021; Barani, Flanagan, & Kabiri, 2025; Abdullahi & Tembo, 2023; Menon, 2024).

This study aims to identify key challenges and propose solutions for schedule-oriented planning in construction project management, as delays can lead to cost overruns, disputes, and client dissatisfaction. Emphasising the findings of Barani and Abdel-Hakam (2016), this highlights the importance of effective planning and control to ensure timely delivery and optimal resource use, ultimately enhancing project productivity. This study was focused on Klang, Selangor, because the highest total number of delayed projects occurred by January 2025 (Lembaga Perumahan dan Hartanah Selangor (LPHS), 2025). This makes Klang, Selangor, a representative and relevant area for studying challenges in construction project management, especially in scheduling. The respondents in this study for data collection are project managers from the Grade 7 (G7) contractor company in Klang, Selangor. The project managers are selected as respondents because they are directly involved in overseeing and managing the construction project, including the scheduling process and overall project coordination (Gasemagha & Kowang, 2021). To achieve the research objectives weightage of the key challenges in schedule-oriented planning for efficient construction project management is identified. Moreover, the main strategies for addressing the key challenges are determined. Consequently, the relationship between the key challenges and their corresponding strategies in schedule-oriented planning for efficient construction project management is analysed.

2. Literature Review

2.1 Definition

2.1.1 Schedule-oriented planning

Schedule-oriented planning in construction is a strategic approach that outlines the early development and continuous management of a project schedule to ensure the timely completion of construction activities. The PMBOK® Guide characterises schedule-oriented planning as a project management approach that involves developing a comprehensive, detailed project timeline (Senapathy, 2023). According to Launi (2011) and The Chartered Institute of Building (2021), Schedule-Oriented Planning, also known as Schedule-Oriented Project Planning (SOPP), requires the project team to optimise the planning process by drafting a comprehensive project schedule early.

2.1.2 Efficient construction project management

Efficient construction project management is measured by the successful delivery of projects within the specified time frame, budget, and quality standards. According to the Project Management Institute (PMI, 2021), effective construction project management involves applying knowledge, skills, tools, and techniques to project activities in order to successfully meet project requirements. PMI (2021) and the Project Management Academy (2024) also mentioned that performance domains, such as project planning, execution, and delivery, are the leading factors in achieving efficiency throughout the project lifecycle.

2.2 Concept

2.2.1 Schedule-oriented planning

Duggi & Sivakumar (2019) state that schedule-oriented planning in construction projects is an approach that focuses on the efficient organisation and execution of tasks to ensure timely completion, optimal resource utilisation, and cost control. Besides, Watt, Barron, and Barron (2014) confirmed that time-oriented planning involves the sequencing and duration of activities to meet project deadlines. In the context of construction project management, Hendrickson, Haas and Au (2024) highlight that the schedule-oriented approach is related to time-oriented (Critical Path Method) and resource-oriented (Job Schop Schedule) (refer to Figure 1).

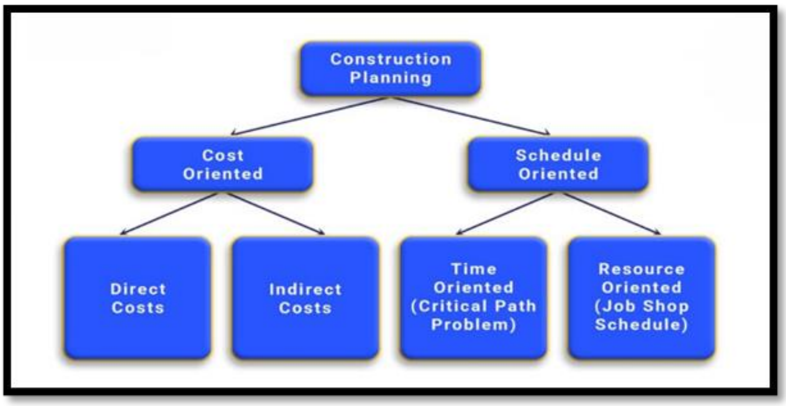

Figure 1 *Alternative Emphases in Construction Planning (Hendrickson, Hass & Au, 2024)*

2.2.2 Efficient construction project management

Efficient construction project management is the strategic coordination and control of a construction project's activities to deliver high-quality outcomes while optimising available resources, including time, cost, labour, and materials (Misnan, Ismail & Tan, 2024). The concept of efficient construction project management revolves around achieving project goals within predefined constraints while enhancing value for stakeholders and clients. According to Kaufmann and Kock (2022) and Menon (2024), efficient project management also includes implementing best practices in planning, scheduling, budgeting, risk mitigation, and performance monitoring. These practices will help to control the project's direction and ensure successful execution.

2.2.3 Importance of schedule-oriented planning in construction project management

In construction, scheduling is the process of setting the time and sequence of various stages that link one activity to another. Thus, the concept of schedule-oriented planning must be applied in construction project management to illustrate the relationships among project activities and to provide realistic cost and time estimates for each associated activity (Hendrickson, 2008). Schedule-oriented planning, as a management approach, is utilised to reduce construction durations, enhance resource coordination, and motivate the team to complete work within the timeline (Ciric *et al.,* 2022). According to Araszkiewicz (2017), schedule-oriented planning is important because it establishes a time framework for the effective execution of construction projects, delivering projects on time and managing overall project success.

2.3 Challenges in Schedule-Oriented Planning

2.3.1 Resource constraints

Limited resources, such as labour, equipment, and materials, disrupt logical task sequencing, causing deviations from the baseline schedule and leading to stakeholder disputes (Kim, 2020). Resource limitations and uncertainties significantly reduce scheduling reliability, particularly in complex projects, resulting in cumulative delays and increased project risk (Hartmann, Lahmer, & Smarsly, 2017). Lack of skilled labour, poor material quality, and inadequate resource availability will lead to schedule delays and cost overruns (Sohu *et al.,* 2024).

2.3.2 Communication issues

Inefficient communication between stakeholders may result in unclear instructions and information delivered to site workers, leading to unproductive project execution and time overruns (Notoatmodjo & Handoko, 2024). According to Daripa (2022), ineffective communication during construction, especially regarding owner-initiated change orders, is a major cause of schedule disruption. Poorly communicated design modifications or unclear instructions can cause the contractor confusion, leading to a delay in construction progress.

2.3.3 Lack of real-time production control

A lack of real-time control limits project teams' ability to detect and respond to performance issues (Lin & Golparvar-Fard, 2021). Without continuous visibility into construction activities, decision-making processes will become reactive, and oversight often results in fragmented workflows, reduced coordination, and poor schedule performance. According to Hai Nguyen (2020), a lack of real-time production control always leads to timely intervention, allowing minor execution issues to escalate into significant disruptions.

2.3.4 Inadequate project management tools

Limited application utilisation leads to inconsistencies in project tracking, affecting stakeholder coordination and control (Kuang Lee *et al.,* 2019). Unreliable tools used in schedule-oriented planning may lead to time overruns and poor inter-team alignment (Almutairi & AlMunifi, 2020). Unstructured, manual scheduling methods lead to duplication, miscommunication, and inefficiencies in schedule execution (Sudarshan & George, 2021).

2.3.5 Environmental disruptions

According to Latif (2023), environmental and regulatory disruptions, such as inclement weather and policy changes, cause site operations to halt and extend project durations. Misalignment between seasonal weather conditions and planning may lead to work stoppages (Gashahun, 2020). External disruptions affect resource flows and construction efficiency, leading to variance between planned and actual progress (Zarghami, 2022).

2.3.6 Labour shortages

Labour storage, including low productivity, also leads to project delays. A shortage of skilled labour reduces operational efficiency and disrupts the execution of sequential tasks, leading to extended timelines (Mbala, Aigbavboa, & Aliu, 2019). In large-scale projects, a skilled labour shortage is a major cause of overruns, due to impediments to work sequencing and to inaccurate forecasting (Chowdhury & Mondal, 2025).

2.3.7 Design change

Unplanned modifications and repeated design iterations compromise schedule stability. Frequent design changes during the design phase may disrupt the construction process and delay overall project timelines (Cao, Truong & Truong, 2024). Design changes often lead to recurring modifications, weak quality management practices, and rework that disrupts the planned sequence of activities and delays the project schedule (Yap & Tan, 2021).

2.3.8 Project location

According to Latif (2023), this study identifies unforeseen environmental and geological conditions, such as unstable soil, high water tables, or environmentally sensitive zones, as primary contributors to schedule disruptions. The project location also introduces regulatory and logistical risks that impact the schedule. Complications in land acquisition, right-of-way clearances, and utility relocation are prevalent in infrastructure projects, especially in highway developments (Sharma, Gupta & Khitoliya, 2020). These location-specific administrative hurdles result in delays that are beyond the direct control of contractors and consultants.

2.3.9 Weak leadership

Weak leadership or poor project management in a project team will lead to failures in planning, resource allocation, and coordination (Latif, 2023). In schedule-oriented planning, the absence of clear leadership undermines timely decision-making and disrupts project timelines. Ineffective communication, often a symptom of poor leadership, leads to misinterpretation of tasks, delayed information flow, and unclear responsibilities (Rehan, Thorpe, & Heravi, 2024).

2.4 Strategies to Address Schedule-Oriented Planning Challenges

2.4.1 Advanced Planning and Scheduling (APS) systems

The Enhanced Planning and Scheduling (EPS) approach evaluates milestone, phase, and production schedules, significantly improving project performance by optimising durations and enhancing schedule reliability (Amarkhil & Elwakil, 2023). Besides, Genetic Algorithms (GA) are used to generate optimal project timelines. It is used to address resource limitations, project duration, and financial constraints, offering a strategy that optimises traditional scheduling techniques in terms of feasibility and adaptability (Moharram, Essawy & Hosny, 2023). Advantages of APS systems in scheduling include the ability to support data-driven decision-making, enabling project managers to detect potential scheduling conflicts early and implement corrective measures proactively (Egbebi, 2024).

2.4.2 Weather-responsive scheduling tools

Weather-responsive scheduling tools leverage real-time and historical weather data, helping mitigate risks associated with adverse weather conditions and ultimately leading to more reliable, efficient construction schedules. According to Senouci & Mubarak (2016), weather-responsive scheduling enables the adjustment of activity durations and resource allocations based on the severity of forecasted weather conditions.

2.4.3 Labour management strategies

Applying linear programming models in labour scheduling optimises labour costs, assigns shifts, and plans rest periods (Al-Rawi & Mukherjee, 2019). Integrating labour management systems in the construction industry will benefit from workload tracking and record management, reducing labour disputes and enhancing operational transparency (Kou & Wang, 2017). The system enables real-time decision-making and facilitates efficient schedule execution. Besides, Differential Evolution (DE) algorithms evaluate multiple mutation strategies to minimise labour demand variability, integrated with Target-to-Best and hybrid approaches (Hoang, Nguyen, & Pham, 2015).

2.4.4 Design change management tools

The Critical Chain Design Structure Matrix (CCDSM) is an innovative method that mitigates rework-induced delays by integrating design dependencies and resource constraints, producing more resilient project schedules (Ma *et al.*, 2019). Additionally, using Building Information Modelling (BIM) tools, such as Revit, and project scheduling software, such as Primavera, integrated within the Autodesk Construction Cloud ecosystem streamlines the change management process (Hiba & Lama, 2025). This methodology supports real-time collaboration and coordination across multidisciplinary teams, enabling quick analysis and tracking of design changes.

2.4.5 Leadership and project culture development

Rehan, Thorpe, and Heravi (2024) identified effective communication, relationship management, and leading by example as core leadership practices that contribute to establishing a positive project culture. This culture enhances labour management strategies by promoting accountability, cooperation, and coordination among project stakeholders, mitigating delays and supporting adherence to project schedules. Leaders who prefer emotional intelligence, relationship building, and clear communication will perform well in resolving interpersonal conflicts and sustaining team motivation under schedule pressure (Adham & Sukkar, 2024).

2.4.6 Integrated Risk Management Systems (IRMS)

The Probability Impact Matrix (PIM) and Precedence Diagramming Method (PDM) within IRMS will help identify, analyse, and mitigate risks that impact project timelines (Mardiani, 2018). Besides, the Risk-Based Method (RBM) will help to control construction defects and improve safety performance in industrial plant projects (Song, 2024). According to Isah and Kim (2021), an integrated schedule risk analysis is employed alongside a stochastic multiskilled resource scheduling model to address uncertainties in resource-constrained project environments. This approach simulates various risk scenarios, evaluates their impacts on scheduling, and reallocates resources effectively based on real-time project conditions.

2.4.7 Real-time progress monitoring systems

According to Lin, Petzold, and Ma (2019), a real-time 4D augmented reality (AR) system using Building Information Modelling (BIM) provides real-time site data to visualise discrepancies between the designed and built conditions. The AR interface improves stakeholder communication and facilitates on-site decision-making, thereby enhancing control over construction schedules in modular projects. Engineer-to-order (ETO) with the "pitching" concept will help generate production activities into short, manageable timeframes, continuously synchronised with field conditions (Dallasega, Rauch, & Frosolini, 2018). Besides, a real-time object detection system using the YOLO (You Only Look Once) algorithm is helpful for continuously monitoring construction site images to detect and classify objects, enabling timely updates on project status (Yang *et al.,* 2023)

2.4.8 Lean construction principles for workflow optimisation

According to Bragadin and Kahkonen (2020) state that methods such as the Location-Based Management System (LBMS) and REPNET facilitate more effective takt time planning and activity sequencing. These methods align spatial and temporal planning elements, enabling synchronised task execution across defined project zones. Additionally, the Last Planner System (BIM–LPS) and LBMS incorporate look-ahead planning mechanisms that promote collaborative planning and significantly improve scheduling accuracy and transparency (Sheikhkhoshkar *et al.*, 2023). Other operational techniques, such as Just-in-Time (JIT), help minimise the risk of material congestion and reduce delays caused by untimely deliveries, thereby optimising the use of site space and resources (Akanbi *et al.*, 2019).

2.5 The Relationship between Identified Key Challenges and Their Corresponding Main Strategies in Schedule-Oriented Planning for Efficient Construction Project Management

The strong relationship between challenges and strategies is crucial for achieving an effective project outcome. To address resource constraints, resource optimisation techniques and automated scheduling tools can be used to better align resource availability with task execution timelines (Moharram, Essawy, & Hosny, 2023). Labour shortages and productivity inefficiencies can be addressed using linear programming and multi-skilled labour assignment models to optimise labour deployment schedules and maintain compliance with deadlines (Al-Rawi & Mukherjee, 2019). Communication-related challenges are addressed by implementing leadership-driven project cultures. Rehan, Thorpe, and Heravi (2024) identified that leadership practices, including effective communication and stakeholder engagement, mitigate schedule risks by aligning team objectives and enhancing coordination. By closely aligning the nature of each challenge with its corresponding strategy, project managers can foster a more resilient planning framework.

3. Research Methodology

3.1 Research Design

This study adopted a quantitative approach, utilising a structured questionnaire to address all three research objectives. It aims to identify key challenges in schedule-oriented planning, determine effective strategies to overcome them, and analyse the relationships between the challenges and their corresponding strategies to enhance efficiency in construction project management. Besides, the Statistical Package for the Social Sciences (SPSS) software was used to analyse the data.

3.2 Procedure of Research

Questionnaires were used as the primary quantitative method because they enable objective and systematic measurement of variables, thereby reducing bias and enhancing the reliability of results, which is essential for hypothesis testing. This study utilised both primary data, obtained directly from respondents, and secondary data sourced from journals, books, and academic publications. The overall research process is illustrated in the research flow chart provided in the Appendix.

3.3 Population and Sampling

The target population comprises the project managers from G7 contractors registered with the Construction Industry Development Board (CIDB) in the Klang district, Selangor. This study was focused on the Klang district in Selangor because the highest total of delayed projects occurs there (Lembaga Perumahan dan Hartanah Selangor (LPHS), 2025). This study used the Krejcie and Morgan (1970) sampling methodology to determine the appropriate sample size. Based on their population–sample size table, a population of approximately 42 (≈45) requires a minimum sample of 40 respondents. Accordingly, this study involved 40 project managers from G7 contractor companies operating in the Klang district, Selangor.

Research in Management of Technology and Business Vol. 7 No. 1 (2026) p. 459-477

3.4 Data Collection

3.4.1 Questionnaire Form

This study employed a quantitative research approach, utilising a structured questionnaire to collect primary data directly from respondents. The questionnaire was designed to simplify data collection and consisted of four sections: Section A covered respondents' demographic and professional backgrounds; Section B examined current practices and perceptions of schedule-oriented planning in construction project management; Section C identified the main challenges faced in implementing schedule-oriented planning; and Section D focused on strategies used to address these challenges. Responses were measured using a five-point Likert Scale, ranging from "Strongly Disagree" (1) to "Strongly Agree" (5), which allows for the systematic quantification of respondents' attitudes and perceptions. The use of this scale is supported by Allen and Seaman (2007), who highlighted its reliability and effectiveness in capturing varying levels of agreement.

3.4.2 Pilot Study

The pilot study is a preliminary assessment to refine the data collection tools and ensure the validity and reliability of data collection procedures (Edwin & Hundley, 2001). According to In (2017), a minimum of 10 respondents is required in a pilot study to capture sufficient variability for functional data analysis. This study collected data from 10 project managers, and the feedback indicated agreement with the questionnaire's content and structure, confirming its relevance and clarity. Cronbach's Alpha for the pilot test achieved 0.904, based on a total of 119 questions, indicating an excellent level of reliability.

3.5 Data Analysis

Data for this study were analysed using the Statistical Package for the Social Sciences (SPSS), which supports efficient data management, statistical testing, and clear presentation through tables and charts. Descriptive analyses, including frequency and mean analysis, were applied to summarise respondents' profiles, current practices, challenges, and strategies related to schedule-oriented planning. Frequency analysis helped describe the distribution of responses across Sections A to D of the questionnaire, while mean analysis was used to address the first and second research objectives by interpreting responses within established mean score ranges, thereby identifying prevailing perceptions and priority issues among respondents. According to Ibrahim (2013), mean scores were classified into three levels based on prior research: low (1.00-2.33), medium (2.34-3.67), and high (3.68-5.00).

To achieve the third research objective, correlation analysis was conducted to examine the relationships between key challenges and corresponding strategies in schedule-oriented planning. A normality test using the Shapiro–Wilk method indicated that the data were not normally distributed ($p = 0.001, < 0.05$), justifying the use of Spearman's Rho correlation. This nonparametric technique assessed the strength and direction of relationships between independent variables (challenges and strategies) and the dependent variable (schedule-oriented planning). To test the hypothesis levels in H1 and H0, the significance level, known as the p-value, can be used to determine whether a significant relationship (H1) occurs when ($p < 0.05$) or a non-significant relationship (H0) occurs when ($p > 0.05$). The strength of the relationship was classified into five levels based on correlation analysis: very weak ($r < 0.00$), weak ($0.01 < r < 0.30$), moderate ($0.31 < r < 0.50$), strong ($0.51 < r < 0.70$), and high ($0.71 < r < 1.00$).

The correlation results provided empirical insights into how specific strategies align with particular challenges, supporting more informed decision-making and strategic planning in construction project management. This study examines schedule-oriented planning as the dependent variable, representing the outcome of interest, while challenges and strategies are treated as independent variables expected to influence it.

4. Results and Discussion

A total of 40 structured questionnaires were distributed to G7 contractor companies in the Klang district, Selangor, and 33 complete responses were obtained, yielding a high response rate of 82.5%, which is considered excellent and indicative of strong data validity and reliability (Booker, Austin, & Balasubramanian, 2021; Holtom, Baruch, & Aguinis, 2022). The respondents comprised 33 project managers, and their demographic profiles were collected to ensure the sample accurately represents industry practitioners and supports meaningful interpretation of the findings (Field, 2018; Pallant, 2020). Additionally, the sample size exceeds the minimum threshold of 30 respondents, satisfying the central limit theorem and enabling reliable statistical analysis and greater confidence in the generalisation of results (Gujarati & Porter, 2009).

4.1 Demographic Analysis

Table 1 shows the demographic details from 33 respondents. The number of male respondents is 22 (66.67%), exceeding the number of female respondents at 11 (33.33%). The majority of respondents are between 30 and 49 years old, with 26 respondents (78.80%), while there are no respondents (0%) between 50 and 59 years old, and none (0%) 60 years old and above. Among the race groups, 25 respondents are Malay, 7 respondents are Chinese, and 1 respondent is Indian. Bachelor's Degree holders comprise the majority, with 24 respondents (72.73%), while respondents with a Master's or PhD are the lowest at 12.12% (4 respondents). For service years, 20 respondents (60.60%) have 6 to 10 years' experience, 10 respondents (30.30%) have 1 to 5 years, 2 respondents (6.10%) have 11 to 20 years, and 1 respondent (3.00%) has 21 years and above experience.

Table 1 *Demographic Information of Respondents*

Demographic	Detail	Frequency	Percentage (%)
Gender	Male	22	66.67
	Female	11	33.33
Age	18-29	7	21.20
	30-49	26	78.80
	50-59	0	0
	60 and above	0	0
Race	Malay	25	75.80
	Chinese	7	21.20
	Indians	1	3.00
	Others	0	0
Education Level	Primary/Secondary	0	0
	Certificate	1	3.03
	Diploma	4	12.12
	Bachelor	24	72.73
	Master/PhD	4	12.12
	Other	0	0
Service Years	1-5	10	30.30
	6-10	20	60.60
	11-20	2	6.10
	21 and above	1	3.00

4.2 Descriptive Analysis for Key Challenges in Schedule-Oriented Planning

Table 2 summarises the main challenges faced by the project manager in implementing schedule-oriented planning. Based on Table 4.3, there are 9 rankings of challenges in this summary, including the mean, agreement level, and ranking. The highest ranking is 'Environmental disruption' with a mean of 4.473, indicating a 'high' level of agreement. 2nd in ranking is 'Inadequate project management tools' with a mean of 4.472 and a 'high' agreement level. Next, ranking for 3rd is 'Resource constraints' with a mean of 4.465 and an agreement level of 'high'. 4th in ranking is 'Labour shortage' with a mean of 4.439, and 5th in ranking is 'Design change' with a mean of 4.388. Next, 'Project location' ranks 6th with a mean of 4.388. 7th in ranking is 'Weak leadership' with a mean of 4.388, and 8th in ranking is 'Communication issues' with a mean of 4.279. The lowest ranking is 'Lack of real-time production control' with a mean of 3.667. The agreement level from 1st to 9th is 'high'.

Table 2 *Section C Data Analysis Summary*

Challenge		Mean	Level	Ranking
A) Resource Constraints		**4.465**	**High**	**3**
1.	Shortages of materials interrupt the planned order.	4.64	High	1
2.	Shortages of equipment interrupt the planned order.	4.61	High	2
3.	Shortages of skilled labour cause schedule delays.	4.39	High	4
4.	Misallocation of resources causes delays.	4.48	High	3
5.	Failures in just-in-time (JIT) delivery cause delays.	4.27	High	6
6.	Poor material quality causes delays.	4.39	High	5
B) Communication Issues		**4.279**	**High**	**8**

1. Miscommunication between stakeholders.	4.27	High	3
2. Late design updates cause extra work.	4.33	High	2
3. Lack of consistent updates on critical changes.	4.27	High	4
4. Poor project team coordination causes gaps.	4.39	High	1
5. No shared goals slow decisions down.	4.12	High	5
C) Lack of Real-Time Production Control	**3.667**	**Moderate**	**9**
1. No real-time feedback delays error detection.	4.42	High	2
2. Ignoring inefficiencies lets minor issues escalate.	4.36	High	3
3. Inability to track resource utilisation.	4.30	High	5
4. Delays hinder proactive scheduling adjustments.	4.55	High	1
5. Limited field visibility hinders performance control.	4.36	High	4
D) Inadequate Project Management Tools	**4.472**	**High**	**2**
1. Outdated tools cause planning inefficiencies.	4.67	High	1
2. Manual tools cause planning inefficiencies.	4.39	High	6
3. Inconsistent tracking due to non-standard systems.	4.42	High	4
4. Underused digital tools hinder teamwork.	4.42	High	5
5. Mismatched tools cause fragmented scheduling.	4.55	High	2
6. Inaccurate data for timely decisions.	4.52	High	3
7. Missing data for timely decision-making.	4.33	High	7
E) Environmental Disruption	**4.473**	**High**	**1**
1. Delay disrupts site operations due to weather.	4.52	High	2
2. Changes require government regulation re-approval.	4.58	High	1
3. Inaccessibility of the site due to logistics delays in activities.	4.45	High	3
4. Degradation restricts resource allocation.	4.45	High	4
5. Disruptions to socio-economic resource disposal.	4.36	High	5
F) Labour Shortage	**4.439**	**High**	**4**
1. Skilled shortages extend task durations.	4.42	High	3
2. High turnover causes frequent retraining.	4.45	High	4
3. High turnover causes planning gaps.	4.55	High	1
4. Poor deployment.	4.36	High	5
5. Inaccurate forecasting.	4.33	High	6
6. Lack of multiskilled labour.	4.52	High	2
G) Design Change	**4.388**	**High**	**5**
1. Overlooked flaw.	4.24	High	5
2. Late approvals delay dependent tasks.	4.61	High	1
3. Unclear client requirements.	4.30	High	3
4. Poor documentation of changes.	4.27	High	4
5. Improper validation escalates project risks.	4.52	High	2
H) Project Location	**4.388**	**High**	**6**
1. Difficult to access sites delays material delivery.	4.39	High	2
2. Delay in site permits postpones construction start.	4.42	High	1
3. Unexpected geological conditions.	4.39	High	3
4. Conflict priorities hinder the local authority.	4.36	High	4
5. Limited transit due to transportation issues.	4.36	High	5
I) Weak Leadership	**4.388**	**High**	**7**
1. Hesitation delays the decision by project manager.	4.42	High	1

2.	Lack of leadership.	4.42	High	2
3.	Absence of stakeholder alignment.	4.39	High	4
4.	Weak supervision on-site project.	4.27	High	5
5.	Poor project culture in the team.	4.42	High	3

The findings indicate that project managers face several significant challenges in implementing schedule-oriented planning, with environmental disruptions emerging as the most critical issue, particularly weather-related delays, regulatory requirements, and logistical constraints that are largely uncontrollable and require continuous adaptation (Latif, 2023; Gashahun, 2020). The second major challenge concerns the inadequacy of project management tools, as reliance on outdated, non-integrated systems leads to fragmented workflows, delayed decision-making, and limited real-time visibility into site activities, thereby undermining effective scheduling and coordination (Dasović, Galić, & Klanšek, 2020; Kuang et al., 2019). Resource constraints constitute the third key challenge, with shortages of materials, equipment, and skilled labour disrupting planned work sequences and exacerbated by misallocation of resources, ultimately affecting schedule reliability and project performance (Hartmann, Lahmer, & Smarsly, 2017). Collectively, these findings highlight that schedule-oriented planning is constrained by a combination of external environmental uncertainties and internal limitations related to tools, resources, and planning systems, which is consistent with prior studies emphasising the difficulty of managing dynamic interactions between resource constraints and activity dependencies in construction projects (Chaudhary & Meshram, 2025).

4.3 Descriptive Analysis for Main Strategy to Address Schedule-Oriented Planning Challenges

Based on Table 3, eight strategies were ranked by their mean scores and levels of agreement, all of which showed high levels of agreement among respondents. Leadership development achieved the highest ranking, with a mean score of 4.485, followed by Advanced Planning and Scheduling (APS) systems, with a mean score of 4.449, and Labour Management Strategies,2 with a mean score of 4.424. These were followed by weather-responsive scheduling tools with a mean score of 4.341, design change management tools with a mean score of 4.333, lean construction principles for workflow optimisation with a mean score of 4.212, and real-time progress monitoring systems with a mean score of 4.143, while the Integrated Risk Management System (IRMS) ranked lowest with a mean score of 4.052, despite still achieving a high agreement level.

Table 3 *Section D Data Analysis Summary*

Strategy		Mean	Level	Ranking
A) Advanced Planning and Scheduling (APS) Systems		**4.449**	**High**	**2**
1.	Milestone-based breakdowns for the long term.	4.48	High	3
2.	Enhanced Planning & Scheduling (EPS) for time.	4.39	High	5
3.	Use Genetic Algorithm (GA) to allocate resources.	4.45	High	4
4.	Incorporate real-time feedback.	4.52	High	2
5.	Scheduling the conflicts.	4.58	High	1
6.	Integrate APS with project dashboards.	4.27	High	6
B) Weather-Responsive Scheduling Tools		**4.341**	**High**	**4**
1.	Integrate real-time weather forecast data.	4.36	High	2
2.	Predicted extreme weather events.	4.27	High	4
3.	Develop a long-term model for seasonal weather.	4.30	High	3
4.	Adjust resource delivery on-site.	4.42	High	1
C) Labour Management Strategies		**4.424**	**High**	**3**
1.	Shift scheduling.	4.33	High	6
2.	Allocation of multiskilled workers.	4.30	High	7
3.	Optimisation of labour cost.	4.48	High	2
4.	Tracking of labour workforce.	4.61	High	1
5.	Coordinate labour-task dependencies.	4.39	High	4

6.	Inclusion of labour in complex tasks.	4.45	High	3
7.	Movement time for labour.	4.39	High	5
D) Design Change Management Tools		**4.333**	**High**	**5**
1.	Reschedule using Critical Chain Design Structure Matrix (CCDSM).	4.12	High	6
2.	Coordinate real-time design using BIM.	4.39	High	2
3.	Track with cloud-based tools.	4.36	High	3
4.	Simulate time-cost impact.	4.36	High	4
5.	Establish a formal design change.	4.45	High	1
6.	Predict design change impacts historically.	4.30	High	5
E) Leadership Development		**4.485**	**High**	**1**
1.	Train project managers in communication skills.	4.61	High	1
2.	Establish a clear project vision.	4.48	High	3
3.	Promote teamwork among project teams.	4.39	High	7
4.	Foster accountability among stakeholders.	4.45	High	5
5.	Empower leadership with emotional intelligence.	4.55	High	2
6.	Support leadership with regular feedback.	4.48	High	4
7.	Support leadership with resolution meetings.	4.42	High	6
F) Integrated Risk Management System (IRMS)		**4.052**	**High**	**8**
1.	Identify risk with Probability Impact Matrix (PIM).	4.03	High	4
2.	Identify the critical path with the Precedence Diagramming Method (PDM).	4.00	High	5
3.	Forecast progress by Risk-Based Method (RBM).	3.91	High	6
4.	Simulate techniques for uncertainty risk analysis.	4.15	High	2
5.	Integrate schedule risk assessments.	4.27	High	1
6.	Periodic risk reassessment.	4.09	High	3
7.	Create re-baselining.	3.91	High	7
G) Real-Time Progress Monitoring Systems		**4.143**	**High**	**7**
1.	Visual planned vs actual progress through 4D BIM.	4.18	High	2
2.	Integrate Augmented Reality (AR) for site progress.	4.09	High	4
3.	Track real-time using IoT.	4.18	High	3
4.	Track real-time using FID sensors.	3.91	High	7
5.	Use YOLO to automate visual inspections.	4.09	High	5
6.	Update daily with digital.	4.06	High	6
7.	Alert real-time progress dashboards.	4.48	High	1
H) Lean Construction Principles for Workflow Optisation		**4.212**	**High**	**6**
1.	Plan short-term with the Last Planner System (LPS).	4.27	High	3
2.	Sequence task via Location-Based Management System (LBMS).	4.06	High	5
3.	Optimise crew flow using Takt-time.	3.97	High	6
4.	Deliver site congestion with Just-In-Time (JIT).	4.18	High	4
5.	Improve by daily stand-up meetings continuously.	4.42	High	1
6.	Collaborative teamwork with visual boards.	4.36	High	2

The findings indicate that project managers widely adopt and regard several scheduling strategies as effective, with weekly project meetings emerging as the most frequently used approach due to their role in strengthening coordination, communication, and continuous progress monitoring, which in turn supports timely decision-making and scheduling accuracy (Abdul-Samad, Mokhtar, & Salleh, 2023). In addition, project managers rely heavily on real-time updates and established techniques, such as the Critical Path Method (CPM), to identify critical activities, anticipate delays, and optimise task sequencing, thereby reinforcing a more systematic and responsive scheduling process (Egbebi, 2024). The increasing use of digital planning and monitoring tools, including Microsoft Project, further enhances schedule visibility, information integration, and cross-team communication, reflecting growing acceptance of digitalisation among large-scale contractors (Chin & Hamid, 2015). Overall, these practices demonstrate a shift towards data-driven, structured, and digitally supported scheduling approaches that improve adaptability, coordination, and overall project efficiency, particularly in complex construction projects (Abdullahi *et al*., 2023).

4.4 Correlation Analysis for the Relationship Between Key Challenges and Their Corresponding Strategies

For the correlation analysis, only the top three ranked challenges and strategies were selected to reduce redundancy and enhance analytical clarity, in line with Haq *et al.* (2019). As summarised in Appendix C, a total of 81 challenge–strategy pairs were analysed using Spearman correlation. The correlation analysis indicates that most relationships are not statistically significant ($p > 0.05$), thereby supporting H_0, reflecting generally weak associations between project challenges and the proposed strategies. However, several key relationships are statistically significant ($p < 0.05$), supporting H_1.

The strongest positive relationship was observed between “Mismatched tools cause fragmented scheduling” and “Train project managers in communication skills,” with a correlation coefficient of $r = 0.510$ (Rank 1), indicating a moderate and statistically significant relationship that supports H_1. This was followed by the relationships between “Outdated tools cause planning inefficiencies” and “Train project managers in communication skills” ($r = 0.494$, Rank 2), and between “Inaccessibility of site to logistics delays in activities” and the same strategy ($r = 0.430$, Rank 3). Other notable moderate correlations include “Shortages of materials interrupt the planned order” with “Train project managers in communication skills” ($r = 0.422$, Rank 4), “Outdated tools cause planning inefficiencies” with “Establish a clear project vision” ($r = 0.418$, Rank 5), and “Misallocation of resources causes delays” with “Scheduling the conflicts” ($r = 0.411$, Rank 6). These are followed by “Misallocation of resources causes delays” with “Inclusion of labour in complex tasks” ($r = 0.408$, Rank 7), “Misallocation of resources causes delays” with “Incorporate real-time feedback” ($r = 0.406$, Rank 8), “Inaccessibility of site to logistics delays in activities” with “Establish a clear project vision” ($r = 0.405$, Rank 9), and “Delay disrupts site operations due to weather” with “Empower leadership with emotional intelligence” ($r = 0.403$, Rank 10). Collectively, these results suggest that communication capability, leadership quality, and clarity of vision are moderately associated with mitigating technical, logistical, and resource-related scheduling challenges.

In contrast, the weakest relationships show negative, non-significant correlations, supporting H_0 and indicating misalignment between certain strategies and challenges. The lowest correlation was observed between “Delay disrupts site operations due to weather” and “Optimisation of labour workforce” with $r = -0.427$, suggesting that labour optimisation is ineffective in addressing weather-related disruptions. This is followed by “Mismatched tools cause fragmented scheduling” and “Scheduling the conflicts” with $r = -0.291$, and “Delay disrupts site operations due to weather” with “Incorporate real-time feedback”, yielding $r = -0.233$, both indicating weak and inverse relationships. Overall, the correlation analysis shows that most relationships fall within the moderate to weak range. The heatmap, further illustrated in Figure 2, confirms that while some strategies align meaningfully with specific challenges, others exhibit limited or negative associations. These findings emphasise that effective schedule-oriented planning depends on strategically matching mitigation strategies to the nature of the challenges, rather than applying uniform solutions to all scheduling issues.

The analysis of challenge–strategy pairings revealed predominantly weak to moderate positive relationships, indicating that while several strategies are relevant, their effectiveness depends strongly on the specific nature of the challenge. Notably, communication and leadership-related strategies showed the strongest alignment with tool- and logistics-related challenges, highlighting the critical role of managerial competencies in mitigating scheduling risks, consistent with Rehan, Thorpe, and Heravi (2024). Conversely, weak or negative correlations, particularly those involving weather-related disruptions and labour optimisation, demonstrated that some strategies are poorly aligned with certain challenges, reinforcing the need for context-specific interventions (Abdullahi & Tembo, 2023). The heatmap further supported these findings by visually illustrating varying degrees of alignment, underscoring the importance of adaptive, data-driven strategic planning to improve scheduling efficiency and overall project performance (Tejus & Satish, 2023).

			Strategies in Schedule-Oriented Planning								
			Leadership Development			Advanced Planning and Scheduling (APS) Systems			Labour Management Strategies		
			DE1	DE5	DE2	DA5	DA4	DA1	DC4	DC3	DC6
Challenges in Schedule-Oriented Planning	Environmental Disruption	CE2	0.015	0.037	0.339	0.087	-0.011	0.046	0.088	0.167	0.202
		CE1	0.045	0.403	0.235	0.107	-0.004	0.164	-0.011	0.055	-0.051
		CE3	0.430	0.182	0.405	0.128	0.351	0.392	0.248	0.159	0.051
	Inadequate Project Management Tools	CD1	0.494	-0.427	0.418	0.120	0.045	0.096	0.197	0.184	0.300
		CD5	0.510	0.267	0.250	-0.291	0.089	0.117	0.260	-0.145	-0.022
		CD6	0.086	0.210	0.249	0.394	0.151	0.174	0.086	0.083	0.399
	Resource Constraints	CA1	0.422	0.196	0.368	0.243	0.149	0.302	0.035	0.195	-0.069
		CA2	0.186	-0.152	0.172	0.138	0.167	-0.015	-0.233	0.001	0.030
		CA4	0.119	0.058	-0.052	0.411	0.406	0.083	0.178	0.213	0.408

INSTRUCTIONS	
Very strong	(0.71 - 1.00)
Strong	(0.51 - 0.70)
Moderate	(0.31 - 0.50)
Weak	(0.01 - 0.30)
Very weak	(0.00 and below)

Note:

Code	Description
CE	**Environmental Disruption**
CE2	Changes require government regulation re-approval
CE1	Delay disrupts site opearations due to weather
CE3	Inaccessibility of site to logistics delays to weather
CD	**Inadequate Project Management Tools**
CD1	Outdated tools cause planning efficiences
CD5	Mismatched tools cause fragmented scheduling
CD6	Inaccurate data for timely decisions
CA	**Resource Constraints**
CA1	Shortages of materials interrupt the planned order
CA2	Shortages of equipment interrupt the planned order
CA4	Misallocation of resources causes delays
DE	**Leadership Development**
DE1	Train project manager in communication skill
DE5	Empower leadership with emotional intelligence
DE2	Establish a clear project vision
DA	**Advanced Planning and Scheduling (APS) Systems**
DA5	Scheduling the conflicts
DA4	Incorporate real-time feedback
DA1	Milestone-based breakdowns for the long-term
DC	**Labour Management Strategies**
DC4	Tracking of labour workforce
DC3	Optimisation of labour workforce
DC6	Inclusion of labour in complex tasks

Figure 2 *Heatmap of Challenges and Strategies in Schedule-Oriented Planning*

5. Conclusion

Overall, the results show that the effectiveness of schedule-oriented planning among G7 contractors is strongly influenced by experience, project scale, and organisational practices. Environmental disruption, inadequacy of project management tools, and resource constraints emerged as the most critical challenges affecting scheduling accuracy and project timelines. In addressing these issues, leadership development, advanced planning and scheduling systems, and labour management strategies were identified as the most effective strategies, showing the importance of strong communication and efficient workforce management. The analysis further indicates that the relationships between challenges and strategies are generally weak to moderate, with the strongest relationships being those between mismatched tools and communication skills training. These suggest that while certain strategies are helpful, their effectiveness depends on how well they are aligned with specific challenges. Overall, the findings confirm that the study objectives were achieved and emphasise the need for improved digitalisation, proactive risk management, and strengthened leadership to enhance scheduling efficiency and project delivery performance in the construction industry.

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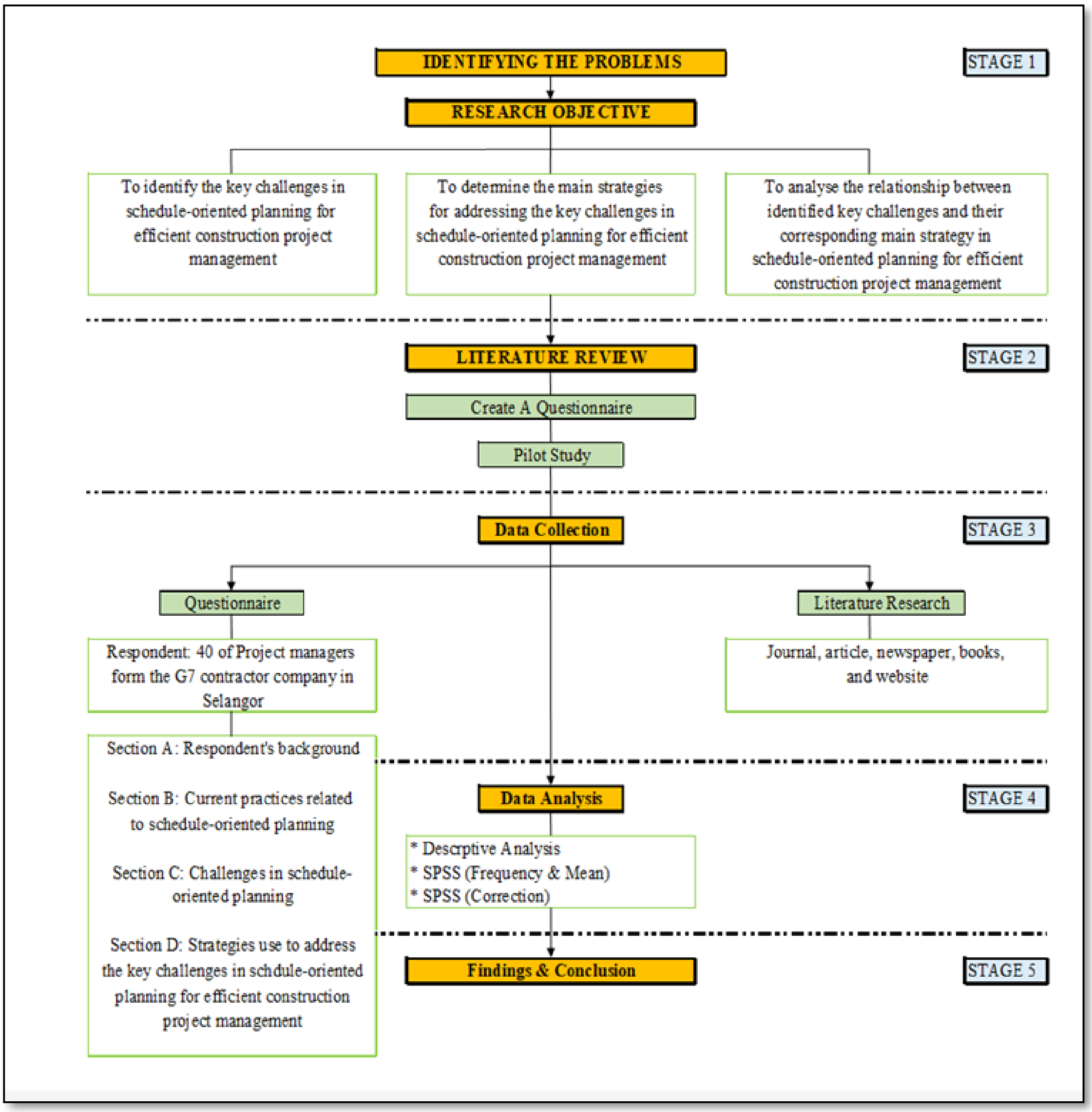
Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Yong Yin Yin, Rozlin Zainal; data collection: Yong Yin Yin;* ***analysis and interpretation of results:*** *Yong Yin Yin, Rozlin Zainal;* ***draft manuscript preparation:*** *Yong Yin Yin, Rozlin Zainal, Narimah Kasim. All authors reviewed the results and approved the final version of the manuscript.*

Appendix: Research Flow Chart



References

Abdullahi, C. M., & Tembo, M. (2023). Improving the efficiency and effectiveness of construction project planning and scheduling using lean principles. *International Journal of Construction Engineering and Management, 12*(3), pp.75–80. Retrieved April 13, 2025, from https://doi.org/10.5923/j.ijcem.20231203.01

Abdul-Samad, Z., Mokhtar, F. R., & Salleh, H. (2023). Project Meeting and Guidelines: The Impact on Time Performance of Construction Projects in Malaysia *Jurnal Pengurusan*, *68*(2023). Retrieved May 28, 2025, from https://doi.org/10.17576/pengurusan-2023-68-15

Adham, I., & Sukkar, A. (2024). Effective Management of Construction Project Team: Identifying Leadership Qualities and Responsibilities. *Scholars Journal of Economics, Business and Management*, *11*(02), pp.63–

73. Retrieved April 28, 2025, from https://doi.org/10.36347/sjebm.2024.v11i02.003

Akanbi, O. A., Oyedolapo, O., & Steven, G. J. (2019). Lean Principles in Construction. *Sustainable Construction Technologies*, pp.317–348. Science Direct. Retrieved April 26, 2025, from https://doi.org/10.1016/b978-0- 12-811749-1.00010-9

Al Nasseri, H., & Aulin, R. (2016). Enablers and barriers to project planning and scheduling based on construction projects in Oman. *Journal of Construction in Developing Countries, 21*(2), pp.1–20. Retrieved April 18, 2025, fromhttps://doi.org/10.21315/jcdc2016.21.2.1

Almutairi, S., & AlMunifi, A. (2020). THE EFFECTS OF POOR MANAGEMENT PRACTICES ON PROJECTS PERFORMANCE. *Proceedings of International Structural Engineering and Construction*, *7*(1). Retrieved May 5, 2025, from https://doi.org/10.14455/isec.res.2020.7(1).cpm-02

Al-Rawi, O. Y. M., & Mukherjee, T. (2019). Application of Linear Programming in Optimizing Labour Scheduling. *Journal of Mathematical Finance*, *09*(03), pp. 272–285. Retrieved May 8, 2025, from https://doi.org/10.4236/jmf.2019.93016

Al-Rawi, O. Y. M., & Mukherjee, T. (2019). Application of Linear Programming in Optimizing Labour Scheduling. *Journal of Mathematical Finance*, *09*(03), 272–285. Retrieved April 8, 2025, from https://doi.org/10.4236/jmf.2019.93016

Amarkhil, Q., & Elwakil, E. (2023). Enhanced planning and scheduling in building construction projects: an innovative approach to overcome scheduling challenges. *International Journal of Construction Management*, *24*(16), pp. 1–11. Retrieved April 29, 2025, from https://doi.org/10.1080/15623599.2023.2286888

Araszkiewicz, K. (2017). Application of Critical Chain Management in Construction Projects Schedules in a Multi-Project Environment: A Case Study. *Procedia Engineering*, *182*(2017), pp. 33–41. Retrieved May 15, 2025, fromhttps://doi.org/10.1016/j.proeng.2017.03.108

Aziz, R. F., & Abdel-Hakam, A. A. (2016). Exploring delay causes of road construction projects in Egypt. *Alexandria Engineering Journal*, *55*(2), pp. 1515–1539. Retrieved April 18, 2025, from https://doi.org/10.1016/j.aej.2016.03.006

Barani S., M., Flanagan, R., & Kabiri, S. (2025). Understanding complexity at the pre-construction stage of project planning for construction projects. *American Journal of Operations Research, 15*(1), Article 151001. Retrieved April 18, 2025, from https://doi.org/10.4236/ajor.2025.151001

Bhosale, V., Shastri, S., & Khandare, A. (2017). A Review of Genetic Algorithm used for optimizing scheduling of Resource Constraint construction projects. In *International Research Journal of Engineering and Technology*. Retrieved May 20, 2025, from https://www.irjet.net/archives/V4/i5/IRJET-V4I5720.pdf

Booker, Q. S., Austin, J. D., & Balasubramanian, B. A. (2021). Survey Strategies to Increase Participant Response Rates in Primary Care Research Studies. *Family Practice*, *38*(5), 699–702. Retrieved on October 31, 2025, from https://doi.org/10.1093/fampra/cmab070

Bragadin, M. A., & Kahkonen, K. (2020). Workflow Optimisation with Construction Scheduling under a Lean Perspective. *Proceedings of the Creative Construction E-Conference 2020*, *048*(2020). Retrieved May 16, 2025, from https://doi.org/10.3311/ccc2020-048

Cao, V. T., Truong, M. P., & Dang, N. L. (2024). Rework in civil construction projects at design phase: Influencing factors and suggested solutions. *CTU Journal of Innovation and Sustainable Development*, *16*(3), pp. 33–43. Retrieved May 28, 2025, from https://doi.org/10.22144/ctujoisd.2024.304

Chaudhary, A., & Meshram, S. (2025). Comparison of various techniques for project scheduling under resource constraints. *International Journal of Engineering Trends and Technology, 73*(2), pp. 57–72. Retrieved April 25, 2025, from https://doi.org/10.14445/22315381/IJETT-V73I2P106

Chin, L. S., & Hamid, A. R. A. (2015). The Practice of Time Management on Construction Project. *Procedia Engineering*, *125*(1), 32–39. Sciencedirect. Retrieved May 26, 2025, from https://doi.org/10.1016/j.proeng.2015.11.006

Chowdhury, M. R., & Mondal, D. (2025, January 7). *Critical Factors and Consequences of Delay in Construction Practices of Bangladesh: Analytical Review*. ResearchGate. Retrieved May 13, 2025, from https://doi.org/10.46610/JOCCE.2025.v011i01.001

Ciric, D., Lalić, B., Delić, M., Gračanin, D., & Stefanović, D. (2022). How project management approach impacts project success: From traditional to agile. *International Journal of Managing Projects in Business, 15*(3), 494–521. Retrieved May 11, 2025, from https://doi.org/10.1108/IJMPB-04-2021-0108

Dallasega, P., Rauch, E., & Frosolini, M. (2018). A Lean Approach for Real-Time Planning and Monitoring in Engineer-to-Order Construction Projects. *Buildings*, *8*(3), pp. 38. Retrieved May 28, 2025, from https://doi.org/10.3390/buildings8030038

Daripa, J. (2022). Impacts of Delays in Project Completion in Terms of Time and Cost. *International Journal for Research in Applied Science and Engineering Technology*, *10*(7), pp. 3512–3515. Retrieved May 10, 2025,

from https://doi.org/10.22214/ijraset.2022.45788
Dasović, B., Galić, M., & Klanšek, U. (2020). A Survey on Integration of Optimization and Project Management Tools for Sustainable Construction Scheduling. *Sustainability*, *12*(8), pp. 3405. MDPI. Retrieved April 14, 2025, from https://doi.org/10.3390/su12083405
Dave, B., Kubler, S., Främling, K., & Koskela, L. (2016). Opportunities for enhanced lean construction management using Internet of Things standards. *Automation in Construction*, *61*, pp. 86–97. Retrieved April 14, 2025, from https://doi.org/10.1016/j.autcon.2015.10.009
Duggi, S., & Sivakumar, A. (2019). Impact of schedule management plan on project management effectiveness. *International Journal of Engineering and Advanced Technology, 9*(1), pp. 3350–3355. Retrieved April 28, 2025, from https://doi.org/10.35940/ijeat.A1515.109119
Edwin, van T., & Hundley, V. (2001). *Social Research Update 35: The importance of pilot studies*. Sru.soc.surrey.ac.uk; University of Surrey. Retrieved May 14, 2025, from https://sru.soc.surrey.ac.uk/SRU35.hmtl
Egbebi A. O. (2024). Best Practices for Efficient Project Planning and Scheduling in Construction. *International Journal of Research Publication and Reviews*, *5*(7), 440–449. Retrieved April 17, 2025, from https://doi.org/10.55248/genpi.5.0724.1614
Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). Sage.
Gasemagha, A. A., & Kowang, T. O. (2021). Project Manager Role in Project Management Success. *International Journal of Academic Research in Business and Social Sciences*, *11*(3), pp. 1345–1355. Retrieved May 13, 2025, from https://doi.org/10.6007/IJARBSS/v11-i3/9230
Gashahun, A. D. (2020). Causes and Effects of Delay on African Construction Projects: A State of the Art Review. *Civil and Environmental Research*, *12*(5). Retrieved May 10, pp. 2025, from https://doi.org/10.7176/cer/12- 5-04
Gujarati, D. N., & Porter, D. C. (2009). *Basic econometrics* (5th ed.). McGraw-Hill.
Hai Nguyen, L. (2020). Empirical Analysis of a Management Function's Failures in Construction Project Delay. *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(2), 26. Retrieved April 24, 2025, from https://doi.org/10.3390/joitmc6020026
Haq, A. U., Zhang, D., Peng, H., & Rahman, S. U. (2019). Combining Multiple Feature-Ranking Techniques and Clustering of Variables for Feature Selection. *IEEE Access*, *7*, 151482–151492. Retrieved October 10, 2025, from https://doi.org/10.1109/access.2019.2947701
Hartmann, V., Lahmer, T., & Smarsly, K. (2017). Project scheduling under uncertainty and resource constraints.*PAMM*, *17*(1), 839–840. Retrieved May 26, 2025, from https://doi.org/10.1002/pamm.201710387
Hendrickson, C. (2008). *Construction planning*. In *Project management for construction* (Version 2.2). Carnegie Mellon University. Retrieved May 2, 2025, from https://www.cmu.edu/cee/projects/PMbook/09_Construction_Planning.html
Hendrickson, C., Haas, C., & Au, T. (2024). Project Management for Construction (and Deconstruction) - Fundamental Concepts for Owners, Engineers, Architects and Builders. In *ecampusontario.pressbooks.pub*. Carl Thomas Michael Haas. Retrieved May 2, 2025, from https://ecampusontario.pressbooks.pub/projectmanagementforconstructionanddeconstruction/
Hiba, R., & Lama, S. (2025). Design Change Management using BIM and Autodesk Construction Cloud. *International Journal of BIM and Engineering Science*, *10*(1), 35–42. Retrieved May 24, 2025, from https://doi.org/10.54216/ijbes.100105
Hoang, N.-D., Nguyen, Q.-L., & Pham, Q.-N. (2015). Optimizing Construction Project Labor Utilization Using Differential Evolution: A Comparative Study of Mutation Strategies. *Advances in Civil Engineering*, *2015*(1), pp. 1–8. Retrieved May 8, 2025, from https://doi.org/10.1155/2015/108780
Holtom, B. C., Baruch, Y., & Aguinis, H. (2022). Survey response rates: Trends and a validity assessment framework. *Human Relations, 75*(5), 1560–1584. Retrieved June 10, 2025, from https://doi.org/10.1177/00187267211070769
Huang, J. (2023). Research on Optimization of Water Conservancy Project Construction Schedule Control Based on Multi-objective Genetic Algorithm. *Automation in Construction*, pp. 1076–1081. Retrieved May 22, 2025, from https://doi.org/10.1109/peeec63877.2024.00199
In, J. (2017). Introduction of a Pilot Study. *Korean Journal of Anesthesiology*, *70*(6), 601–605. Retrieved May 8, 2025, from https://doi.org/10.4097/kjae.2017.70.6.601
Isah, M. A., & Kim, B.-S. (2021). Integrating Schedule Risk Analysis with Multi-Skilled Resource Scheduling to Improve Resource-Constrained Project Scheduling Problems. *Applied Sciences*, *11*(2), pp. 650. Retrieved May 8, 2025, from https://doi.org/10.3390/app11020650
Kaufmann, C., & Kock, A. (2022). Does project management matter? The relationship between project management effort, complexity, and profitability. *International Journal of Project Management, 40*(6), pp.

624–633. Retrieved April 16, 2025, from https://doi.org/10.1016/j.ijproman.2022.05.007

Kim, K. (2020). Generalized Resource-Constrained Critical Path Method to Improve Sustainability in Construction Project Scheduling. *Sustainability*, *12*(21), pp. 8918. Retrieved May 14, 2025, from https://doi.org/10.3390/su12218918

Kou, Y., & Wang, Y. (2017, February 22). *Labor management system for building industry and use method of system*. SciSpace - Paper. Retrieved May 14, 2025, from https://scispace.com/papers/labor-management-system-for-building-industry-and-use-method-35j1t6aq0x

Krejcie, R. V., & Morgan, D. W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, *30*(3), pp. 607–610. Retrieved May 23, 2025, from https://doi.org/10.1177/001316447003000308

Kuang Lee, C., Wing Yiu, T., Xin Lim, W., Qudus Adeleke, A., & Choon Toh, T. (2019). Status and Barriers Impeding Utilization of Project Management Tools: Epidemic for Tripartite Construction Parties in Malaysia. *KnE Social Sciences*, *3*(22), pp. 289–312. Retrieved May 13, 2025, from https://doi.org/10.18502/kss.v3i22.5057

Latif, M. Z. (2023). Analyzing the Key Factors Contributing to Project Delays in the Construction Industry: A Comprehensive Study. *Journal of Development and Social Sciences*, *4*(III). Retrieved May 8, 2025, from https://doi.org/10.47205/jdss.2023(4-iii)85

Launi, J. D. (2011). *Schedule-Oriented Project Planning (SOPP)*. Project Management Institute. Retrieved May 1, 2025, from https://www.projectmanagement.com/articles/284097/schedule-oriented-project-planning-- sopp-

Lembaga Perumahan dan Hartanah Selangor (LPHS). (2025). *Portal Rasmi - Lembaga Perumahan dan Hartanah Selangor*. Www.lphs.gov.my. Retrieved May 22, 2025, from https://lphs.gov.my/page/view/5

Lin, J. J., & Golparvar-Fard, M. (2021). Visual and Virtual Production Management System for Proactive Project Controls. *Journal of Construction Engineering and Management*, *147*(7), 04021058. Retrieved May 6, 2025, from https://doi.org/10.1061/(asce)co.1943-7862.0002045

Long, L. D. (2024). A non-unit repetitive construction project scheduling with uncertainties. *Automation in Construction*, *164*, pp. 105428. Retrieved May 22, 2025, from https://doi.org/10.1016/j.autcon.2024.105428

Ma, G., Jiang, S., Zhu, T., & Jia, J. (2019). A Novel Method of Developing Construction Projects Schedule under Rework Scenarios. *Sustainability*, *11*(20), pp. 5710. Retrieved April 21, 2025, from https://doi.org/10.3390/su11205710

Mardiani, G. T. (2018). Construction industry project planning information system. *IOP Conference Series: Materials Science and Engineering*, *407*(1). Retrieved May 8, 2025, from https://doi.org/10.1088/1757-899x/407/1/012093

Markou, Ch., Koulinas, G. K., & Vavatsikos, A. P. (2017). Project resources scheduling and leveling using Multi-Attribute Decision Models: Models implementation and case study. *Expert Systems with Applications*, *77*, 160–169. Retrieved April 20, 2025, from https://doi.org/10.1016/j.eswa.2017.01.035

Mbala, M., Aigbavboa, C., & Aliu, J. (2019). Causes of Delay in Various Construction Projects: A Literature Review. *Advances in Human Factors, Sustainable Urban Planning and Infrastructure*, *788*, pp. 489–495. Retrieved May 10, 2025, from https://doi.org/10.1007/978-3-319-94199-8_47

Menon, S. (2024). Best practices and implementation challenges in effective project management. *International Business Research,* *17*(2), pp. 66–73. Retrieved April 24, 2025, from https://doi.org/10.5539/ibr.v17n2p66

Misnan, M. S., Ismail, Z., & Tan, J. Y. (2024). Construction project management issues and development in current for future construction project: Challenges and prospects in sustainable project management. *International Journal of Research and Innovation in Social Science, 8*(2), pp. 1997–2011. Retrieved May 3, 2025, from https://doi.org/10.47772/IJRISS.2024.802141

Moharram, R. M., Essawy, Y. A. S., & Hosny, O. S. (2023). Automated Resource Scheduling for Construction Projects Using Genetic Algorithm. *Lecture Notes in Civil Engineering*, *363*(2022), pp. 513–522. Retrieved May 11, 2025, from https://doi.org/10.1007/978-3-031-34593-7_32

Moharram, R. M., Essawy, Y. A. S., & Hosny, O. S. (2023). Automated Resource Scheduling for Construction Projects Using Genetic Algorithm. *Lecture Notes in Civil Engineering*, *363*(2022), 513–522. Retrieved May 22, 2025, from https://doi.org/10.1007/978-3- 031-34593-7_32

Nasirzadeh, F., Rostamnezhad, M., Carmichael, D. G., Khosravi, A., & Aisbett, B. (2020). Labour productivity in Australian building construction projects: a roadmap for improvement. *International Journal of Construction Management*, pp. 1–10. Retrieved April 16, 2025, from https://doi.org/10.1080/15623599.2020.1765286

Nejatyan, E., Sarvari, H., Hosseini, S. A., & Javanshir, H. (2023). Determining the factors influencing construction project management performance improvement through earned value-based value engineering strategy: A Delphi-based survey. *Buildings, 13*(8), pp. 1964. Retrieved April 21, 2025, from https://doi.org/10.3390/buildings13081964

Notoatmodjo, B., & Handoko, J. (2024). DELAY RED FLAG CONSTRUCTION COMPANY: CONTROL ANALYSIS WITH FOUR LEVER OF CONTROL. *Riset*, *6*(2), 102–116. Retrieved May 14, 2025, from https://doi.org/10.37641/riset.v6i2.2118

Pallant, J. (2020). *SPSS survival manual* (7th ed.). McGraw-Hill Education.

PMI, Project Management Institute. (2021). *A Guide to the Project Management Body of Knowledge: (PMBOK guide)* (7th ed.). Project Management Institute.

Pregina, K., & Kannan, M. R. (2024). Fuzzy-Graphical evaluation and review technique for scheduling construction projects. *KSCE Journal of Civil Engineering*, *28*(7), pp. 2573–2587. Retrieved April 20, 2025, from https://doi.org/10.1007/s12205-024-0904-z

Project Management Academy. (2024). *Project domains*. Retrieved May 1, 2025, from https://projectmgmtacademy.com/2024/09/25/project-domains/

Rehan, A., Thorpe, D., & Heravi, A. (2024). Project manager's leadership behavioural practices – A systematic literature review. *Asia Pacific Management Review, 29*(2), pp. 165–178. Retrieved May 3, 2025, from https://doi.org/10.1016/j.apmrv.2023.12.005

Rehan, A., Thorpe, D., & Heravi, A. (2024). Project manager's leadership behavioural practices – A systematic literature review. *Asia Pacific Management Review, 29*(2), 165–178. Retrieved May 18, 2025, from https://doi.org/10.1016/j.apmrv.2023.12.005

Schuldt, S. J., Nicholson, M. R., Adams, Y. A., & Delorit, J. D. (2021). Weather-Related Construction Delays in a Changing Climate: A Systematic State-of-the-Art Review. *Sustainability*, *13*(5), pp. 2861. mdpi. Retrieved May 20, 2025, from https://www.mdpi.com/2071-1050/13/5/2861

Senapathy, Y. (2023, October). *What is the project schedule in PMP?* Project Management Training Institute. Retrieved May 8, 2025, from https://www.4pmti.com/learn/project-schedule-pmp/#:~:text=The%20project%20schedule%20acts%20as,on%20its%20goals%20and%20objectives.

Senouci, A. B., & Mubarak, S. A. (2016). Multiobjective Optimization Model for Scheduling of Construction Projects Under Extreme Weather. *Journal of Civil Engineering and Management*, *22*(3), pp. 373–381. Retrieved May 2, 2025, from https://Doi.Org/10.3846/13923730.2014.897968

Shah, F. A., Bhatti, O. S., & Ahmed, S. (2023). A Review of the Effects of Project Management Practices on Cost Overrun in Construction Projects. *Engineering Proceedings*, *44*(1). MDPI. Retrieved May 9, 2025, from https://doi.org/10.3390/engproc2023044001

Sharma, V. K., Gupta, P. K., & Khitoliya, R. K. (2020). Analysis of Highway Construction Project Time Overruns Using Survey Approach. *Arabian Journal for Science and Engineering*, *46*(5), pp. 4353–4367. Retrieved May 2, 2025, from https://doi.org/10.1007/s13369-020-04934-4

Sheikhkhoshkar, M., El-Haouzi, H. B., Aubry, A., Hamzeh, F., & Poshdar, M. (2023). Analysing the Lean Principles in Integrated Planning and Scheduling Methods. *Annual Conference of the International Group for Lean Construction*. Retrieved May 16, 2025, from https://doi.org/10.24928/2023/0159

Sohu, S., Kassim, T. R. B. M., Mustafa, A., Arshad, M. U., & Nagapan, S. (2024). Assessing the Causes and Effects of Delay and Disruption in Construction Projects in Malaysia. *Journal of Applied Engineering Sciences*, *14*(2), pp. 336–341. Retrieved May 7, 2025, from https://doi.org/10.2478/jaes-2024-0041

Song, K. (2024). Development of an Enhanced Risk Management System for Construction Defect Control in Industrial Plants. *KCI Accredited Journals*, *23*(4). Retrieved May 6, 2025, from https://doi.org/10.6106/ICCEPM.2024.1313

Sudarshan, S., & George, G. (2021). A Comparison of Project Planning and Scheduling Software's Primavera and Microsoft Project Used in The Construction Industry. International Journal of Engineering Technologies and Management Research, 8(9), pp. 78–87. Retrieved May 8, 2025, from https://doi.org/10.29121/ijetmr.v8.i9.2021.103

Tejus, R. K., & Satish, S. V. (2023). Optimizing Construction Project Scheduling Using Advanced Planning and Scheduling Tools. *© 2023 IJNRD |*, *8*, pp. 2456–4184. Retrieved May 7, 2025, from https://www.ijnrd.org/papers/IJNRD2312146.pdf

The Chartered Institute of Building. (2021). *CIOB launches 'CIOB Planning Protocol 2021'*. Retrieved May 9, 2025, from https://www.ciob.org/news/ciob-launches-ciob-planning-protocol-2021

Watt, A., Barron, M., & Barron, A. (2014). The project life cycle (phases). In *Project management – 2nd edition*. BCcampus. Retrieved May 13, 2025, from https://opentextbc.ca/projectmanagement/chapter/chapter-3-the- project-life-cycle-phases-project-management/

Yahya, M. Y., Abdullahi Abba, W., Md Yassin, A., Omar, R., Sarpin, N., & Orbintang, R. (2024). Innovative Strategies for Enhancing Construction Project Performance. *Journal of Technology Management and Business*, *11*(1).

Retrieved May 14, 2025, from https://doi.org/10.30880/jtmb.2024.11.01.002

Yang, J., Wilde, A., Menzel, K., Sheikh, M. Z., & Kuznetsov, B. (2023). *Computer Vision for Construction Progress Monitoring: A Real-Time Object Detection Approach*. ArXiv.org. Retrieved May 8, 2025, from https://doi.org/10.48550/arXiv.2305.15097

Yap, J. B. H., & Tan, S. M. (2021). Investigating Rework: Insights from the Malaysian Construction Industry. *ASM Science Journal*, *14*(2021), pp. 1–9. Retrieved May 8, 2025, from https://doi.org/10.32802/asmscj.2020.636

Zarghami, S. A. (2022). Forecasting Project Duration in the Face of Disruptive Events: A Resource-Based Approach. *Journal of Construction Engineering and Management*, *148*(5). Retrieved May 9, 2025, from https://doi.org/10.1061/(asce)co.1943-7862.0002257

Zheng, X., Le, Y., Chan, A. P. C., Hu, Y., & Li, Y. (2016). Review of the application of social network analysis (SNA) in construction project management research. *International Journal of Project Management*, *34*(7),pp. 1214–1225.Retrieved April 20, 2025, from https://doi.org/10.1016/j.ijproman.2016.06.005