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Mitigation Matrix for Improving Material Management Sustainability Within Construction in the Middle East

Abdulla Subhi Ruzieh

Logistics Management Department, Faculty of Business and Economics, Palestine Technical University—Kadoorie, Tulkarm 00970, Palestine; abdallah.rozieh@ptuk.edu.ps

Abstract: The construction industry in the Middle East faces significant challenges, including low productivity, substantial material waste, and inefficient deliveries, with limited research addressing the relationship between these challenges and critical success factors (CSFs). This study explored mitigation strategies to enhance productivity, competitiveness, and sustainability in the construction sector of the region. Using data from 92 questionnaires collected from industry stakeholders, descriptive and bivariate analyses were employed to identify correlations between variables using SPSS and Excel. The findings map out the challenges affecting material management and their correlation with CSFs, offering innovative solutions to address these issues. For example, this study highlights how poor communication leads to problems, such as change orders and inaccurate drawings, which can be mitigated by improving coordination and collaboration and adopting appropriate ICT tools. The practical mitigation matrix presented in this work provides actionable strategies for effectively overcoming challenges and implementing CSFs. While contextualised for the Middle East, the findings have broader relevance for global construction practices, with careful consideration required for application in different contexts. Importantly, this study advances sustainability by promoting resource efficiency, minimising waste, and fostering effective practices to support sustainable construction across the region.

Keywords: construction management; material management; material management challenges; critical success factors for material management

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1. Introduction

The construction industry constitutes a fundamental component of economic development, driven by the increasing demand for infrastructure and building projects owing to rapid population growth [1]. This escalating demand has resulted in the proliferation of construction organisations, intensifying competition to achieve cost efficiency, high-quality outcomes, and profitability [2,3]. However, the industry's fragmented nature, involving multiple stakeholders and interdependent activities, presents significant challenges for coordination, communication, and resource management [4]. Addressing these challenges is crucial for enhancing performance by eliminating waste, improving productivity, and ensuring the timely delivery of high-value projects [5]. Material management is particularly pivotal in construction, as materials account for more than 60% of total project costs [6,7]. Effective material management ensures the timely availability of appropriate materials of the correct quantity and quality at competitive prices [8]. Conversely, suboptimal practices lead to significant inefficiencies, including material waste, cost overruns, productivity losses, and project delays [9,10]. In the Middle East, these challenges are further exacerbated by region-specific issues, such as high reliance on international funding, resource constraints,

and market saturation, rendering effective material management an essential component of construction success [11,12].

While previous research has explored various material management challenges and critical success factors (CSFs), few studies have examined their interconnections or provided actionable frameworks to holistically address these challenges. This study builds upon existing knowledge by investigating the correlations between specific material management challenges and CSFs in the Middle East's construction industry, offering a novel empirical mitigation matrix. By incorporating insights from 92 industry stakeholders, this study not only identifies key challenges but also provides targeted strategies to mitigate them, focusing on improving communication, collaboration, and adoption of advanced technologies. This study distinguishes itself by contextualising these findings to the unique dynamics of the Middle East construction sector while also emphasising the role of material management in promoting sustainability. It highlights how effective material management can reduce waste, optimise resource utilisation, and enhance project efficiency, contributing to the broader goals of sustainable construction. By addressing these gaps, this study provides a robust framework for improving material management practices, ultimately advancing the industry's productivity, competitiveness, and sustainability. Therefore, this study aims to investigate material management challenges within construction and how they can be mitigated by introducing an empirical mitigation matrix to improve material management, including challenges and CSFs. Consequently, this may lead to the elimination of challenges, improvement in quality, and reduction in costs.

2. Literature Review

Material and information flow management are key priorities for successful construction companies [4,13]. However, proper management practices for these areas may contribute to significant benefits, such as improving the quality of services and performance [14,15]. The material management process in the construction industry is considered a complex interconnected process, as it is composed of multiple actors and activities, as described in Figure 1 [16].

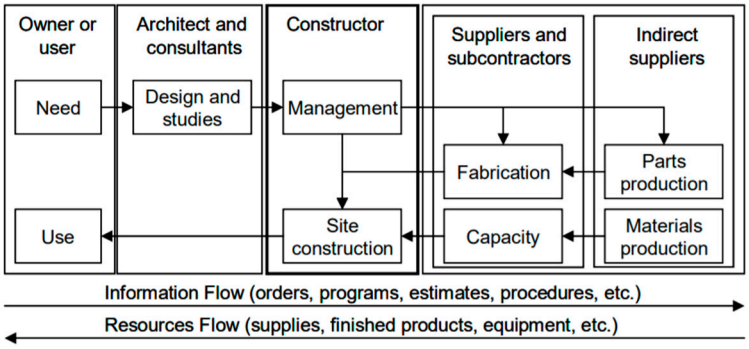


Figure 1. Material management actors in the construction industry [16].

In addition, several authors have stated that supply chain management (SCM) principles could be very useful in this regard, which may allow proper management for these activities [8,16–20]. SCM in construction can be defined as managing all construction processes, including all stakeholders, suppliers, vendors, and clients, to achieve strategic goals [21]. In addition, this can be achieved by linking the client's requirements with the required material and information [19,22].

Several authors have stated that numerous benefits of SCM can be achieved in the construction industry. These benefits include cost reduction, productivity improvement, effective working, and better relations between actors [5,8,16,18,19,23]. However, these

benefits may be attained through the integration of the four main factors [1]. These factors are strategic planning, focus on the client, information integration, and collaboration and coordination.

- Strategic planning involves objectives and goals, strategy and action planning, and the establishment of an organizational structure.
- Focus on the client emphasizes management commitment, process improvement, requirements analysis, and implementation of a pull production system.
- Information integration highlights the use of information technology to streamline SCM processes.
- Collaboration and coordination focus on outsourcing, communication, training and education, and fostering teamwork.

2.1. Material Management Definition and Interaction with Sustainability

Materials are physical substances procured or produced to create semi-finished or finished products [14]. Material management encompasses a range of activities and tasks aimed at delivering the required materials of appropriate quality at the right time and at a competitive price [23]. In the construction industry, materials are typically expensive, voluminous, and delivered in bulk. For instance, construction materials account for approximately 60% of the total cost of construction projects [10]. Effective material management is critical in construction, as it minimises waste, enhances productivity, reduces costs, and fosters competitive advantages [17]. It also significantly contributes to sustainability by reducing material waste, optimising resource utilisation, and promoting environmentally friendly practices. Recent advancements in technology have expanded the variety of available construction materials [11], necessitating robust management systems to mitigate risks and ensure sustainability throughout the project lifecycles. Conversely, inadequate material management leads to material shortages, excessive waste, and productivity losses. For example, poor practices can result in up to 40% of workers' time being spent searching for materials [24]. Conversely, proper material management can enhance efficiency and productivity by over 30% [25]. Effective material management strategies are essential to ensure timely and accurate delivery of materials [26]. These strategies include planning and scheduling requirements, evaluating and selecting suppliers, purchasing, delivering materials, managing distributions, and controlling inventories [20]. Moreover, integrating material management into all project phases—from the design phase through execution—not only supports cost and time efficiency but also promotes sustainable practices by reducing environmental impact and conserving resources [13,27]. Proper material management, therefore, is not only a key driver of project success but also a cornerstone of sustainability in construction

2.2. Material Management Challenges Within Construction

Understanding how materials are managed and dealt with will assist in providing a clear vision of the potential challenges that may face material management activities in construction projects [11,28]. Therefore, identifying material management procedures assists in clarifying the following challenges.

2.2.1. Planning

Scholars have asserted that planning is a crucial component of material management. It includes material identification, estimation, scheduling, and inventory planning. This process serves as a guide for construction activities and schedules [8]. Numerous challenges may affect the planning process, such as incomplete or erroneous drawings and specifications, ambiguous scope of work, and inadequate communication and information

sharing [25]. Furthermore, a deficiency in employee skills may contribute to significant challenges in this process, resulting in issues such as incorrect purchase orders [29]. Consequently, inadequate or insufficient planning frequently leads to project cost overruns and potential delays [25,30,31].

2.2.2. Vendor Evaluation and Selection

This activity involves the evaluation and selection of vendors or suppliers based on technical and financial proposals. For instance, a case study demonstrated that utilising a structured vendor evaluation framework reduced procurement costs by 15% in a major infrastructure project [32]. This process encompasses the assessment of proposals against the project's specific requirements as well as the evaluation of the accuracy and completeness of the content. Incomplete proposals, insufficient information, and unreliable suppliers are common challenges at this stage, frequently resulting in project delays [25]. For example, incomplete supplier proposals led to a 10% increase in lead times for material delivery in high-rise construction projects, ultimately delaying critical project milestones [33]. Furthermore, a paucity of essential information can result in the rejection of proposals and necessitate the issuance of a new request for quotation (RFQ), further contributing to productivity losses and potential project delays. A real-world example of this is the Middle East metro project, where a revised RFQ process caused a two-month delay but, when streamlined, resulted in 20% less material waste owing to more accurate vendor alignment [34].

2.2.3. Procurement

Procurement or purchasing activities encompass multiple functions, including the acquisition of equipment and materials, recruitment of labour, and procurement of other essential services for production [8]. An effective procurement process significantly contributes to a competitive advantage for a construction company, as the costs and quantities of construction materials are typically substantial [35]. Therefore, adopting an appropriate procurement approach enhances a project's performance in terms of productivity and quality. This approach mitigates potential issues, such as significant fluctuations in material prices, delayed deliveries, uncontrolled inventory, and multiple handling instances [36]. However, [37] asserted that paper-based methods and inexperienced personnel are the primary challenges in this process, as they may lead to several issues, including redundancy and suboptimal or erroneous transactions. Consequently, these factors may contribute to cost overruns and potential delays [38].

2.2.4. Expediting and Delivery

The expediting function is vital for monitoring the status of material orders. For instance, an expeditor should review all the elements of purchasing orders, such as requirements and delivery [39]. This process is essential to ensure that vendors comprehend all aspects and address potential corrections in advance, thereby preventing unfavourable events [40]. Some organisations rely solely on unreliable and unskilled employees for expediting and material tracking, while others do not adopt any material tracking system [41]. However, the lack of supplier collaboration adversely affects the performance of construction projects in terms of delivering appropriate materials at a designated time [31]. Furthermore, transportation activities are considered part of this process, as they relate to material movement from warehouses or suppliers to the production site. Consequently, transportation routes should be carefully considered in the planning phase regarding regulations, alternatives, and possible incidents [42,43]. Moreover, for experienced drivers, suitable vehicles influence the effectiveness of the transportation process [44]. Conversely, transport difficulties often contribute to late deliveries, potentially damaging certain mate-

rials. For instance, inadequate planning of transportation activities may result in potential congestion [45]. Generally, construction materials are delivered in bulk to a site. As a result, poor layouts and improper coordination and communication between actors may lead to simultaneous collisions between deliveries [46].

2.2.5. Receiving, Inspection, and Handling

This step is integrated with the previous process (expediting and delivery). However, it encompasses several activities, including receiving material from the appropriate source at the designated time, verifying quantities and qualities, and transferring material to the workplace using suitable handling equipment or tools [47]. Coordination and information sharing are highly recommended in this process, along with assigning an experienced employee to ensure the correct material is delivered according to the required quality and time [48]. However, the activities involved in this process are highly integrated. For example, the ordering of handling equipment is linked to the receiving time [49]. Several challenges may arise during this process, such as receiving incorrect or damaged materials and improper handling practices [41]. However, [50] stated that unclear handling instructions, inadequate quality checks, and lack of experience are potential causes of low productivity and potential project delays [8].

2.2.6. Inventory Control

The availability of materials at a required time is a critical factor that influences productivity and project performance [23]. In certain instances, construction firms procure materials in large quantities for various reasons, including obtaining more favourable pricing, reducing transportation expenses, and mitigating uncertainties [8,23,34]. Inventory control encompasses procedures for sorting, recording, and safeguarding materials as well as reordering when inventory levels fall below a specified threshold [51]. Several challenges may impact inventory management, such as premature material delivery, theft, potential damage, and inadequate tracking and recording systems [52]. Furthermore, [53] posited that coordination between execution rate and material ordering is highly advisable to prevent potential additional costs associated with inventory accumulation [31].

2.2.7. Distribution

Material distribution is categorised into two types: distribution to working areas and distribution to other stakeholders or companies for additional processes or adaptation requirements [23]. Distribution necessitates careful consideration in terms of routes, personnel, and equipment planning, as material loss may occur at this stage owing to inappropriate or unreliable handling practices [31]. Moreover, material losses may be exacerbated by multiple movements and insufficient instructions regarding handling and movement, potentially contributing to cost overruns [34].

2.2.8. Waste Control

A substantial amount of waste may be generated owing to construction activities [54]. In particular, construction material waste presents a significant challenge for construction projects [55]. Various factors can contribute to the generation of waste in construction, including improper handling, unreliable practices, inadequate monitoring and planning, and insufficient worker experience [8]. Consequently, waste control plans are strongly recommended for any material management [56]. For example, poor planning, inefficient transportation, and improper equipment utilisation can increase the amount of waste, potentially leading to increased material costs and project cost overruns [23,57]. However, according to numerous authors, Table 1 summarises the main challenges facing material management in the construction industry regarding each process.

Table 1. Main challenges facing material management in the construction industry regarding each process according to numerous authors.

Process	Challenges	Authors
Planning	Lack of communication and information sharing	[2,25,40,41,45,50,58,59]
	Lack of skills and knowledge	[2,31,60,61]
	Incomplete drawings	[4,8,23,34,58]
	Poor planning	[4,59]
	Improper specification	[23,37,42,50,62–64]
	Differences between specifications and drawings	[23,25]
	Ordering materials without complying with the production needs on-site [No integration between the activity schedule and material schedule]	[2,65]
	Knowing materials waste percentage.	[2,4,40,66]
	Lack of a proper work plan	[42,62–64,67]
	Work change orders	[40,58]
	Forgetting to order materials or the wrong RFQ	[41,68]
	Slowness in making decisions	[4,40,58]
Vendor selection	Time spent investigating non-qualified suppliers	[23,25,34,40,69]
	Incomplete proposal	[23,25,34,40,70]
	Unreliable suppliers	[2,34,59,61]
	Lack of necessary information about suppliers	[2,58]
Procurement	Fluctuation of material prices	[8,23,31,71–73]
	Over-ordering of materials	[8,23,63,74,75]
	Ordering materials without coordinating with the execution rate	[4,65,76]
	Excessive paperwork	[2,42,62–64,67]
	Lack of skills and knowledge	[2,31,60,61]
Expediting, delivery, receiving, handling, and inspection	Material tracking	[2,8,31,41]
	Delay or inappropriate in the delivery of materials	[8,23,34,41,59,64,77–79]
	Bulk delivery of construction materials	[8,31,80]
	Poor coordination and communication between actors	[2,4,45,58]
	Improper site layout	[2,4,31,81]
	Inefficient planning and scheduling	[34,82]
	Damage to materials due to transport	[2,8,83,84]
	Transport difficulties	[31,37,42,58,62–64]
	Wrong quantity or materials that do not match the purchase order	[31,41,68]
	Inadequate unloading and handling facilities, which contribute to high proportions of waste	[8,31,61]
	Improper site layout with inadequate temporary loading areas	[4,8,31]
Inventory control	Theft or loss of material	[23,31,34,50,68]
	Poor management of surplus materials	[34,41]
	Improper storage and protection facilities (conditions, spaces)	[8,41,61,85–87]
	Ordering material in a huge amount	[2,4,10,31,82]

Table 1. *Cont.*

Process	Challenges	Authors
Distribution	Frequent movement of materials due to improper site layout	[31,81]
	Excessive material handling	[8,40,61]
	Damage to materials due to unreliable practices	[2,31,34,59]
	Improper handling tools	[31,63,64,68,88]
Waste control	Huge waste due to poor control	[41,54,64,89,90]
	Poor monitoring and control	[2,4,8,59,65]

2.3. Critical Success Factors (CSFs) for Material Management in Construction

Several authors, including [40,50,91,92], have recommended several initiatives to effectively deal with material management challenges. These issues include improving coordination and collaboration, using technology, recruiting the right and experienced staff, and adopting appropriate monitoring and control plans. According to numerous authors, Table 2 presents several CSFs for material management in the construction industry.

Table 2. CSFs for material management in the construction industry, according to numerous authors.

CSFs	Authors
Materials scheduling to increase the efficiency of materials handling with deliveries' coordination	[1,40,88,93,94]
Planning of accesses and routing of materials within the construction site	[65,66,95]
Optimum forecasting of material movement	[93,96]
Selection of material handling equipment is an important function	[47,92,96]
Integration between material scheduling and production rate, including updated schedules	[5,17,83,88]
Stock control to ensure that materials are available when required	[1,10,57,83]
Planning of the storage space, such as the timing of the initial buy, and historical information and experience	[69,83,93]
Using the last planner system	[82,97]
Reducing waste through careful consideration of the need for minimisation and better reuse of materials in both the design and construction phase	[1,8,57,66]
Employing a logistics coordinator	[1,8,83,87,98]
Use technology, such as RFID and barcoding, for materials tracking and monitoring	[1,8,17,74,99–101]
Utilising technological solutions, such as BIM and CAD	[1,17,74,99,100,102]
Implementation of ICT [electronic machine, computer program system such as Excel, or telephone]	[8,9,41,64,66,103]
Implement a consolidation centre [big warehousing]	[1,8]
Just-in-time (JIT) principle for material ordering	[8,82,97]
Regular collaboration and coordination meetings, including all actors with information sharing	[45,50,69,74,82,83,98,100]
Adopting best practice sequences in purchasing practices	[8,61,104–106]
Creating a database for materials categories, suppliers, and materials cost	[8,25,40,107]
Continuous monitoring of suppliers to confirm on-time deliveries	[1,40,45]
Work should be done by experienced people	[45,50,69,74,82,83,98,100,102]
Quality control system, including quality officers	[17,47,50,58,96]
Increasing in production reliability	[97,108–110]
Materials scheduling to increase the efficiency of materials handling	[40,88,96]
Centralised material team coordination between the site and the organization so effective material management strategies can be applied and monitored	[1,8,31,111]

2.4. Conceptual Theoretical Matrix

This framework integrates key success factors (CSFs) with material management challenges, emphasising their interactions and contributions to improving project performance, sustainability, and efficiency. It draws on the principles of SCM, sustainability in construction, and resource-based theories to explain how CSFs mitigate challenges and enhance material management.

Core Components

- Material Management Challenges: Identified challenges (e.g., poor communication, delays, material wastage, and improper handling) hinder efficiency and sustainability in construction projects.
- Critical Success Factors (CSFs): Factors such as proper planning, communication, skilled workforce, adoption of technology, and sustainability practices act as enablers for overcoming challenges.
- Sustainability Goals: The overarching goal is to achieve sustainable construction practices by minimising material waste, optimising resources, and improving overall efficiency.

Relationships and Interactions

- CSFs directly address specific material management challenges. (For example, proper planning reduces delays, and effective communication mitigates poor coordination.)
- CSFs are interdependent. (For example, technological adoption improves communication, which in turn enhances planning and execution.)
- The mitigation of challenges contributes to improved project outcomes and aligns with the sustainability goals.

Proposed Model (Visualized Framework)

- The following diagram outlines in Figure 2 the relationships among CSFs, material management challenges, and sustainability outcomes.

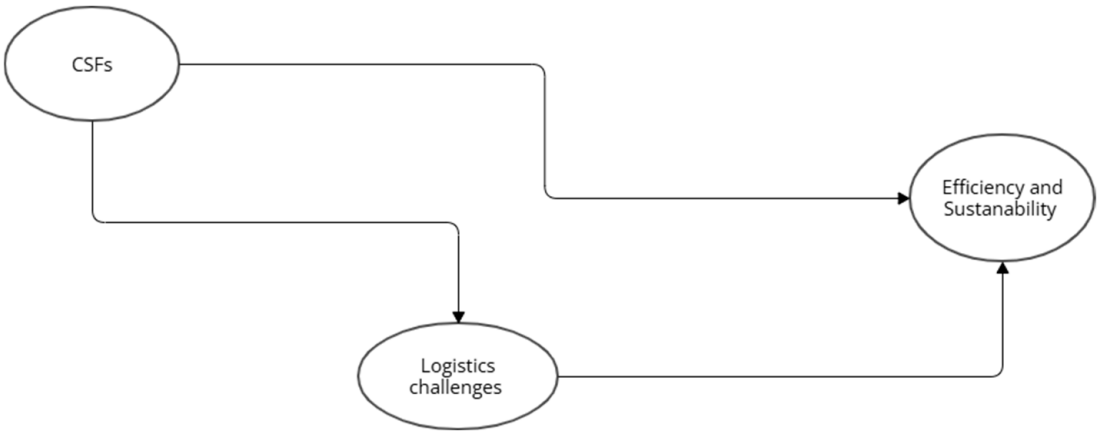


Figure 2. The proposed research model.

However, the matrix illustrated in Table 3 will help in formulating hypotheses that could assist in validating the available literature in the construction industry in the Middle East to improve the performance of material management by eliminating challenges. These hypotheses are as follows:

1. Are the challenges identified in the literature relevant to the Middle East's construction industry?
2. Are the CSFs identified in the literature relevant to Middle East construction industries?
3. What challenges could be considered significant for any project type?

4. How could CSC and Fs be used to address the challenges in each stage of the material management steps?

Table 3. Material management challenges versus CSFs.

Challenges	Critical Success Factors [CSFs]
• Lack of communication and information sharing • Lack of skills and knowledge • Incomplete drawings • Poor planning • Not proper specification • Differences between specifications and drawings • Ordering materials without complying with the production needs on-site (no integration between activity schedule and material schedule) • Knowing material waste percentage • Work change orders • Forgetting to order materials or the wrong RFQ • Slowness in decision-making	• Regular collaboration and coordination meetings. including all actors with information sharing • Work should be performed by experienced people • Implementation of technological solutions, such as BIM and CAD, to improve visibility and information sharing using the Last Planner system • Increase production reliability • Joint team to create coordination between sites and offices
• Time spent investigating non-qualified suppliers • Incomplete proposal • Unreliable suppliers • Lack of necessary information about suppliers	• Best practice sequences in purchasing practices • Work should be performed by experienced people
• Fluctuation of material prices • Materials shortage • Ordering materials without coordinating with the execution rate • Over-ordering of materials • Excessive paperwork • Lack of skills and knowledge	• Implement a consolidation centre (big warehousing) • Best practice sequences in purchasing practices • Creating a database for materials categories, suppliers, and materials cost • Work should be performed by experienced people • Logistics coordinator • Implementation of technological solutions, such as BIM and CAD, to improve visibility and information sharing team to create coordination between the site and offices
• Materials tracking • Delay or inappropriate delivery of materials • Poor coordination and communication between actors • Inefficient planning and scheduling • Damaged materials due to transport • Transport difficulties	• Logistics coordinator • Use technology, such as RFID and barcoding, for materials tracking and monitoring • Implementation of technological solutions, such as BIM and CAD, to improve visibility and information sharing • Regular collaboration and coordination meetings, including all actors with information sharing • Continuous monitoring of suppliers to confirm on-time deliveries • Work should be performed by experienced people • Defining handling requirements, methods, and procedures.

Table 3. *Cont.*

Challenges	Critical Success Factors [CSFs]
• Wrong quantity or materials that do not match the purchase order • Inadequate unloading and handling facilities, which contribute to a high proportion of wastage • Improper site layout • Inadequate unloading of temporary areas	• Planning of access and routing of materials within a construction site • Selection of the material handling equipment is an important issue • Quality control system, including quality officers • Materials scheduling to increase the efficiency of materials handling • Continuous monitoring of suppliers to confirm the right products • Work should be performed by experienced people
• Theft or loss of items • Management of surplus materials • Bulk delivery of the construction materials • Improper storage and protection facilities (conditions, spaces) • Ordering material in a huge amount	• Quality control system, including quality officers • JIT principle for materials ordering • Implement a consolidation centre (big warehousing) • Stock control to ensure that materials are available when required • Use technology, such as RFID and barcoding, for materials tracking and monitoring • Planning of the storage space, such as the timing of the initial buy, and historical information and experience
• Frequent movement of materials due to improper site layout • Excessive material handling • Damaged materials • Improper handling during site activities	• Planning of access and routing of materials within a construction site • Optimum forecasting of materials movement • Selection of the material handling equipment is an important function • Work should be performed by experienced people • Defining handling requirements, methods, and procedure
• Huge waste due to poor control • Waste of materials during storage • Poor monitoring and control	• Adopting proper plans to minimise material waste as well as considering material reuse in some construction activities • Work should be performed by experienced people • Quality control system, including quality officers

3. Methodology

Based on this research aim, epistemology philosophy is employed to facilitate the acquisition of knowledge through questioning in the discipline of material management [112]. However, as this philosophy encompasses two approaches, the positivist approach appears to be more suitable for achieving the research aim and objectives. For instance, the positivist approach examines and investigates a phenomenon by applying existing theory [94]. Through this approach, material management procedures and activities were developed based on a literature review and subsequently adapted to the construction industry environment in the Middle East. Additionally, the deduction approach is utilised, as it pertains to hypothesis development based on existing concepts, followed by the formulation and adaptation of the existing concept to a particular situation [5]. Consequently, the existing material management challenges and CSFs were identified based on the literature and subsequently validated in the construction industry environment and conditions in the Middle East. Furthermore, the quantitative method is adopted, as it involves the collection of numerical information to study and analyse the relationships within the phenomenon and how these issues align with existing theories. This quantitative approach facilitates the elucidation of the relationships between the measured variables using mathematical techniques. Therefore, a quantitative approach using a mono-method was adopted for

several reasons. First, the research aim necessitates a wide range of population coverage to enable adaptation of material management propositions for construction in the Middle East and, second, because of time constraints, particularly for respondents. Third, existing theories are applicable to material management in construction. Fourth, it is compatible with the positivist philosophy adopted in this study.

Finally, Figure 3 briefly summarises the adopted research methodology.

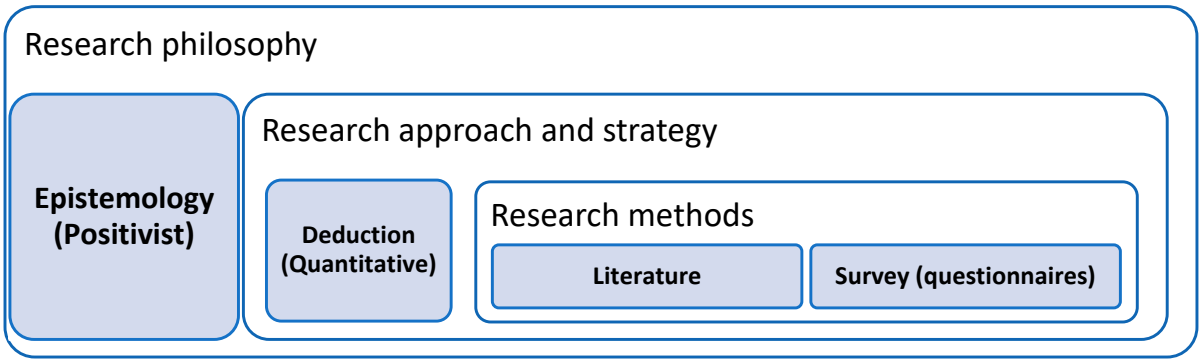


Figure 3. Research methodology.

For this research, the proposed questionnaire is built on close-ended and open-ended questions to gather any extra information that may be important to adapt the existing knowledge to the Middle East construction industry environment and to overcome any pitfalls in these two types of questions [113].

3.1. Sample Selection and Size

A representative sample was selected from the population for survey purposes. Furthermore, the sample was considered a subset of the population to administer a questionnaire [114]. Moreover, respondents were regarded as a subset of the sample who completed and returned the questionnaire [87]. Sample selection can be conducted using various approaches, including probability and nonprobability methods [115]. Social science relies on nonprobability approaches for several reasons. First, constructing a sampling frame for the proposed respondents may be challenging, as some individuals might be unavailable due to specific organisational constraints. Second, researchers may lack a clear understanding of the most relevant stakeholders to include in questionnaires [113]. Consequently, this research adopts a nonprobability purposive method, as the main contractors' actors in the construction industry in the Middle East comprise foremen, junior engineers, senior engineers, project managers, and contractor representatives [14]. Additionally, in the Middle East, the role of material management may vary depending on project scale and typology [14]. Conversely, [116] argued that the nature of the research, the variability of a population, and the analysis type determine the length and sample size of a questionnaire. However, [117] stated that there are no book-specific guidelines that could be followed by researchers. Furthermore, [1] argued that it is recommended that a researcher seek advice from consultants and experts while determining the questionnaire's length and sample size. Nevertheless, [87] defined some rules of thumb that could be utilised for research projects to obtain sufficient information and high responses considering time constraints as follows:

- Approximately 100 answered and returned questionnaires are sufficient.
- A two-sided A4 questionnaire is recommended.

3.2. Bias Avoiding

Avoiding or minimising bias in data collection is an essential issue in research questionnaires to obtain reliable and real representative data [118]. Several types of biases have

been identified. However, Table 4 depicts some of them and how they are mitigated in this study, according to [118]. However, these tips were considered while formulating a questionnaire for this research.

Table 4. Bias types and how they are mitigated.

Bias Type	Clarification	Mitigation Plan
Asking wrong questions	Every question should be clear and in simple words to be understandable by the possible respondents.	• Considering several previous related questionnaires and studies • Considering the literature review • Conducting pilot test • Asking one question in the question • Avoiding inherent answer questions • Avoiding sensitive questions, such as the age
Choosing wrong people	Choosing the right sample is an essential issue, as the research results depend on them.	• Selecting a sample based on the literature review • Defining respondents' characteristics based on research objectives • Considering the features of the industry
Bad formatting and structuring of the questionnaire	Poor structuring of the questionnaire, such as long questionnaires and difficult questions, has a high impact on the response rate and data quality.	• Questions not leading to answers • Questionnaire could be completed in a reasonable time (10–15 min) • Anonymous questionnaire • Grouping of the survey topics • Keeping questionnaire short • Using interval questions instead of yes or no questions • Using clear and simple language.
Providing a single option	Respondents may feel frustrated or may give bad or irresponsible responses if they feel there are not enough options or spaces for answers.	• Providing multiple-answer options • Building the survey flexibly by providing several types of questions, including close-ended and open-ended questions • Providing options, such as "others or neither," if a respondent does not want to answer a specific question
Administration issues	Distribution and data collection should be conducted in the right way to improve the response rate.	• Arranging an appointment with the respondents before • Giving the respondents as much time to answer • Clarifying any questions if anyone needs them

3.3. Data Collection

The maximisation of response rates is a priority of researchers. This can be enhanced by selecting the most appropriate method for data collection, including the distribution of questionnaires [1]. Several methods can be utilised for data collection, such as mail, email, internet, telephone, and face-to-face approaches [1]. The primary consideration in determining the optimal method is to account for the respondents' time, experience, and field of work [113]. Consequently, a face-to-face method was adopted in this study, as respondents may require clarification. In addition, this approach may increase the response rate. Furthermore, an in-person distribution method is being considered. Indeed, this

method is regarded as the most effective for researchers to achieve a higher response rate than others [113].

3.4. Pilot Test

It is recommended that the questionnaire be tested on a small group of experienced people before starting data collection [119]. However, this will help the researcher to know if there are any errors, ambiguities, or unsuitable words and to test the difficulty. Moreover, this may help in defining any missing information that is required for the data analysis later [115].

3.5. Data Analysis

Analysing the questionnaires' data included several steps and could be done through Excel, SPSS26, and Survey Monkey 2022. However, SPSS26 appears to be the most specialised software for academic research [120]. However, the data analysis involved the following steps:

1. Checking the completion of the questionnaires: This stage involved checking every questionnaire to ensure that each question was answered properly. However, incomplete questionnaires or unreliable answers were rejected, as this indicated that the respondent did not pay attention to completing the questionnaire carefully. However, missing some data in a questionnaire does not mean rejection of a questionnaire if most questionnaire questions have been answered and considered carefully [87].
2. Data entry into software: Data were then entered into analytical software such as SPSS to ease the understanding and analysis of the data. This step involves coding the data using appropriate numbers for a specific word to facilitate working with data, such as assigning numbers to Likert-scale questions [121].
    - Understanding the nature of data: A questionnaire generally involves multiple types of questions that require different analysis techniques and procedures [87]. However, these types include first interval or continuous questions regarding employees' number, experience, and income [19]. Second, ordinal questions and Likert questions for questions about the construction project size [basic less than $1 million; complex, between $1–10 million; large, between $10–100 million; and megaproject, above $100 million [122]. Third, nominal or categorical questions regarding gender or speciality were nominal [87].
3. Data Analysis
    - Descriptive statistics or univariate analyses: This analysis was used to profile the respondents' replies as each variable over time, depending on the questions, for instance, staff experience questions or project types [123]. This analysis included measuring means, medians, modes, frequencies, and standard deviations. The outcomes may include charts, frequency tables, cross-tabulation tables, and diagrams. However, this analysis helps to understand some useful issues, such as percentages and frequencies [124]. Conversely, this analysis lacks recognition of the relationships between variables to draw and form patterns [87].
    - Bivariate analysis: This type of analysis emphasises the relationship between the variables. However, variables may come in different types, such as nominal, interval, and ordinal [125]. This affects the analytical techniques and types that can be applied. However, some of these techniques are as follows:
      Contingency tables or cross-tabulation: This technique was applied to investigate the relationship between the two ordinal variables [87].
      Correlation: Correlation tests are used to study the strongest relationship between two variables using a mathematical equation as in Equation (1), as to how

one group could affect the other [126]. For example, it would be useful to examine whether a specific challenge correlates with other challenges or opportunities. However, the correlation coefficient value varies between positive 1 and negative 1. A value of ±1 indicates a perfect degree of association between the two groups. Conversely, if the coefficient values approach or are equal to 0, this indicates that the relationship is weak or does not exist. Several tests could be performed to investigate the correlation, including Pearson's P-test, which is applied to the interval or ordinal variable questions [127]. Moreover, a significant coefficient was used to measure the significance of the results [127].

$$\gamma = \frac{N\sum xy - \sum(x)(y)}{\sqrt{\left[N\sum x^2 - \sum(x^2)\right]\left[N\sum y^2 - \sum\left(y^2\right)\right]}} \quad (1)$$

γ = Pearson correlation coefficient
N = number of observations
Σxy = sum of the products of paired scores
Σx = sum of x scores
Σy = sum of y scores
Σx^2 = sum of squared x scores
Σy^2 = sum of squared y scores.

ANOVA test: The ANOVA test was used to check the significance of the questionnaire results. This test helps determine the need to reject or accept the null hypothesis using the mathematical formula as in Equation (2). This can be done by calculating the significant factor F to identify any differences between them. If the F-value is less than 0.05, then the relationship is significant [128].

$$f = \sqrt{\frac{\sum_{i-1}^{k} p_i * (\mu_i - \mu)^2}{\sigma^2}} \quad (2)$$

where:

$\sum_{i-1}^{k}$ = summation of overall categories (or groups) from i = 1 to k
$p_i = n_i/N$
n_i = number of observations in group i
N = total number of observations
μ_i = grand mean
σ^2 = error variance with groups

Cronbach's alpha or alpha coefficient: The coefficient was developed in 1951 by Lee et al. It measures the reliability or internal consistency of the questionnaire using the mathematical formula as in Equation (3). For instance, reliability is related to how well a test identifies or measures what it should be [129]. For instance, this research aimed to study the relationship between challenges and CSFs. Therefore, high reliability means the results can be used by decision-makers [130]. However, Table 5 depicts the Cronbach's alpha coefficients along with the reliability of the results.

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}} \quad (3)$$

where:

N = the number of items.
$\bar{c}$ = average covariance between item-pairs.
$\bar{v}$ = average variance.

Table 5. Cronbach's alpha coefficient [130].

CRONBACH'S ALPHA	RESULT RELIABILITY
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

The data analysis process is illustrated in Figure 4.

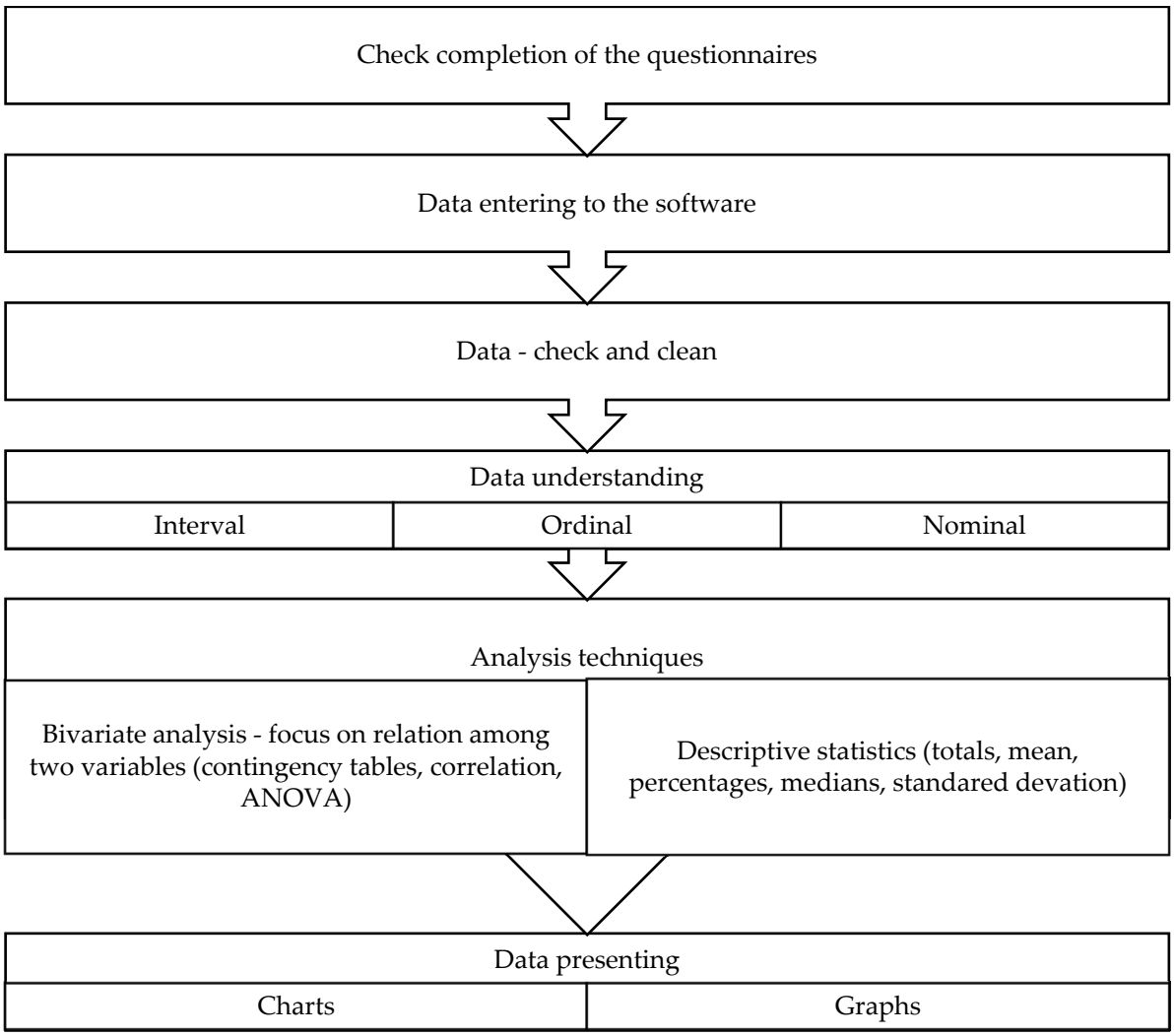


Figure 4. Data analysis procedures.

4. Findings

Several statistical tests have been conducted to investigate the existing challenges and potential CSFs for material management within the construction industry in the Middle East. The collected data were carefully coded and analysed. Statistical analysis was

conducted using the SPSS software. Finally, the results are presented in the tables, figures, and bar charts.

4.1. Result Profile

A total of 98 questionnaires were distributed, and 92 questionnaires were completed and retained. However, 78 were fully completed, and 14 were partially completed, as presented in Table 6.

Table 6. Summary of questionnaire numbers.

Case Processing Summary		
Case	**Number**	**Per cent (%)**
Valid	78	84.8
Not fully answered	14	15.2
Total	92	100

A reliability test was conducted using SPSS software, and Table 7 illustrates the result.

Table 7. Cronbach's alpha for the findings.

Reliability Test	
Cronbach's Alpha	Number of collected questionnaires
0.775	92

4.2. Responses Profiles

Figure 5 shows the percentage of respondents in a bar chart. Junior engineers, project managers, and senior engineers had the highest percentages.

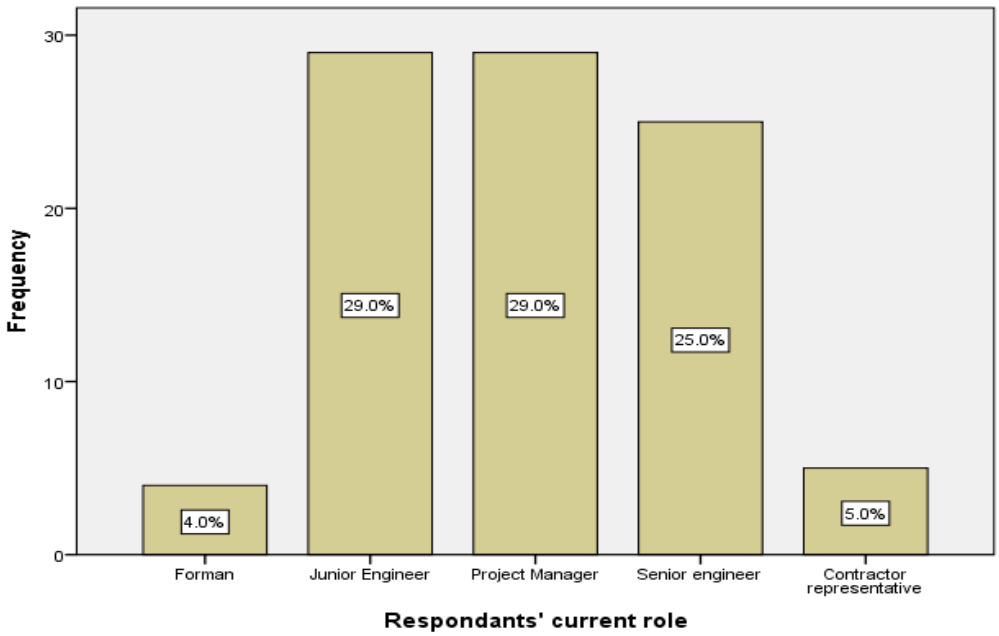


Figure 5. Respondents' current role.

Figure 6 presents respondents' years of experience and other related aspects. However, stakeholders with six or more years of experience are the dominant respondents, with around 50 per cent.

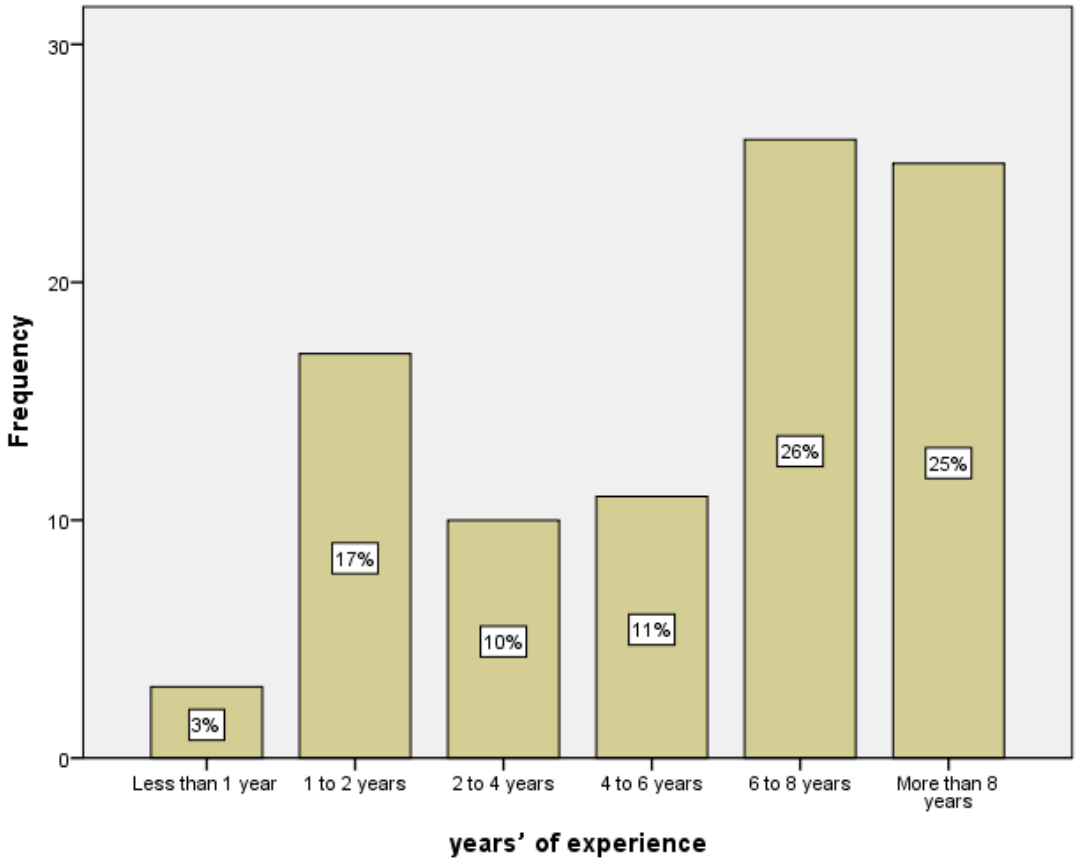


Figure 6. Respondents' years of experience.

Finally, Figure 7 shows the sizes of the construction projects in the Middle East according to the respondents' viewpoints and the related percentages. However, it seems that basic and normal projects are the most frequent in the Middle East, with 44.

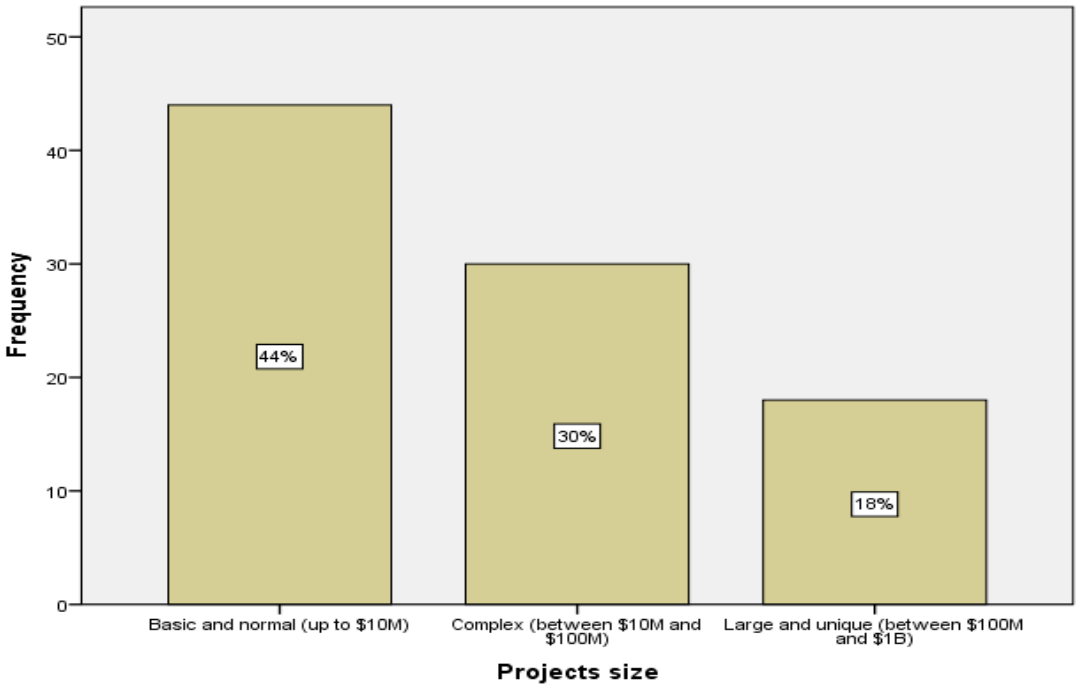


Figure 7. Summary of project sizes.

A stacked bar chart analysis (Figure 8) is used to link two variables to ensure consistency and sufficiency and reliability of the collected data by considering the relationship between them [23]. For example, junior engineers normally have a few years of experience [19]. Figure 8 depicts the respondents' roles and their related years of experience.

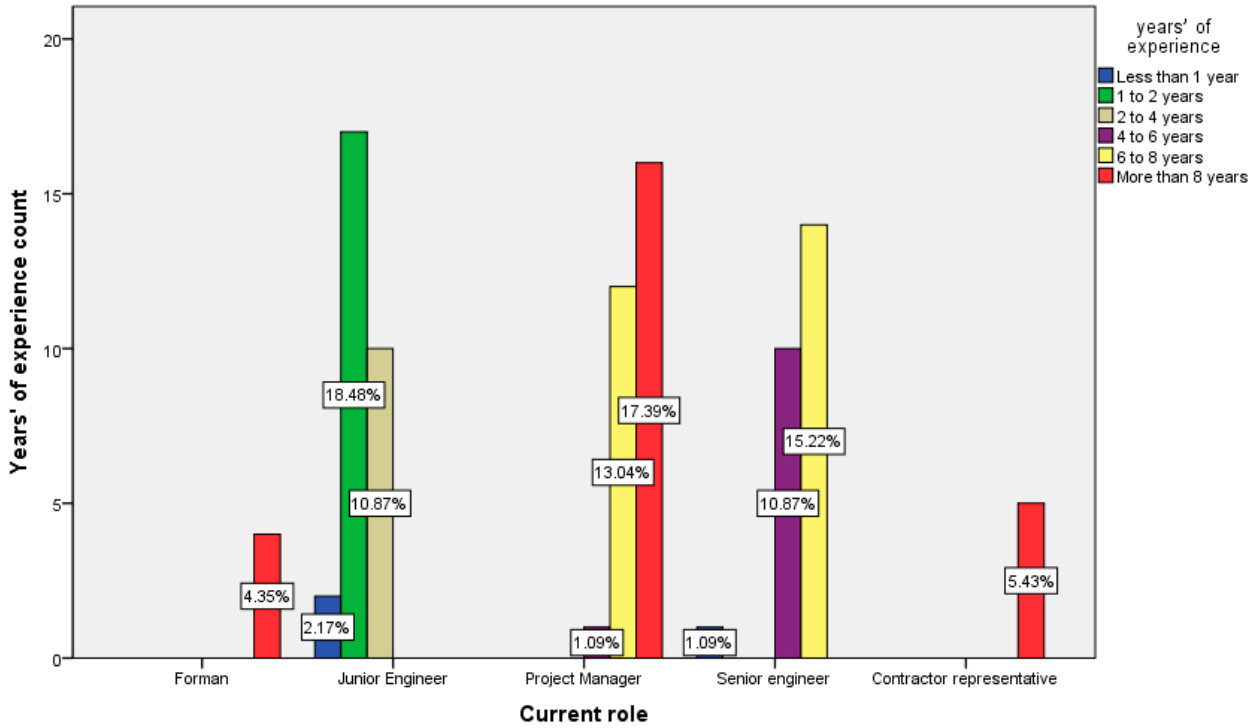


Figure 8. Respondents' roles with their related years of experience.

Figure 9 explains the respondents' role in construction projects regarding their sizes in the Middle East. However, it appears that all project sizes were included in the data collection, including several respondents. However, project managers of basic and normal projects had the highest respondent participation rate, at 22.

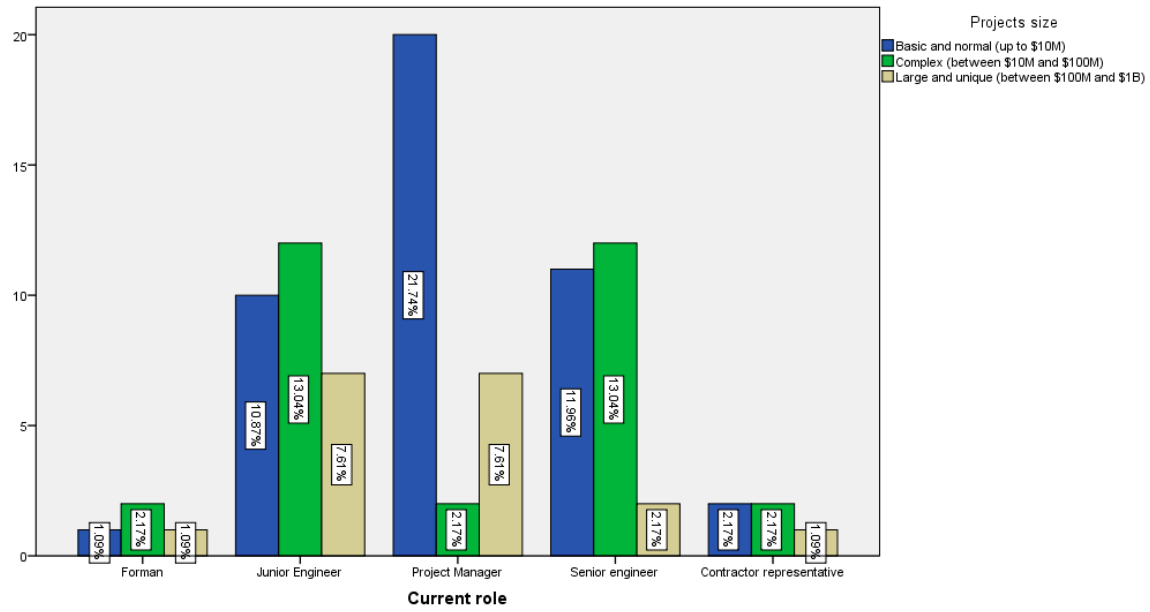


Figure 9. Respondents' role with construction project size.

4.3. Material Management Challenges Within Construction in the Middle East

Material management challenges in the Middle East were identified using the second question of the survey. However, these challenges were identified, and the means were calculated for each challenge. Table 8 presents these challenges and their related means.

Table 8. Material management challenges in the Middle East.

Challenges		Min	Max	Mean	S.d
1.	Transport difficulties due to bad planning for routing	1.00	4.00	1.2065	0.58438
2.	Incompatible specifications	1.00	3.00	1.2717	0.49399
3.	Time spent investigating non-qualified suppliers	1.00	4.00	1.2935	0.62085
4.	Redundancy and errors caused by excessive paperwork	1.00	4.00	1.2935	0.52494
5.	Incomplete supplier proposals	1.00	4.00	1.3043	0.62440
6.	Delay or inappropriate delivery of material	1.00	2.00	1.3152	0.46715
7.	Material damage due to bad handling and unloading	1.00	4.00	1.3152	0.53307
8.	Lack of communication and information sharing	1.00	2.00	1.3370	0.47526
9.	Material damage due to bad handling and unloading	1.00	4.00	1.4130	0.61398
10.	Several change orders due to lack of work's scope	1.00	3.00	1.4891	0.54460
11.	Ordering materials without complying with the site's execution rate	1.00	2.00	1.5109	0.50262
12.	No consistency between specifications and drawings	1.00	3.00	1.5326	0.54372
13.	Knowing the material waste percentage	1.00	2.00	1.5326	0.50167
14.	Theft or loss of material due to improper storage and protection facilities	1.00	4.00	1.5435	0.56282
15.	Frequent movement of materials due to improper site layouts	1.00	2.00	1.5652	0.49844
16.	Slowness in making decisions	1.00	4.00	1.5679	0.56873
17.	Undetailed and inappropriate design drawings	1.00	3.00	1.5761	0.55931
18.	Excessive material handling due to bad schedules	1.00	4.00	1.5870	0.66551
19.	Shortage of skills and knowledge	1.00	2.00	1.5978	0.49302
20.	Over-ordering of materials	1.00	2.00	1.6044	0.49169
21.	Poor material tracking and monitoring	1.00	4.00	1.6413	0.54635
22.	The fluctuation of material prices	1.00	4.00	1.6739	0.59501
23.	Poor plans and practices for the management of surplus material	1.00	4.00	1.7065	0.83255

Finally, an ANOVA test was conducted to check whether the same challenges influenced construction projects in terms of their size. However, Table 9 shows that the significance of some challenges may differ, leading to different consequences. These chal-

lenges were identified using yellow colour to represent the most significant challenges related to the project size (where the Sig coefficient was less than 0.05).

Table 9. ANOVA test for material management challenges in the Middle East.

Project Size-Related Challenges	Sum of Squares	Mean Square	Sig
Lack of communication and information sharing	1.042	0.521	0.099
Shortage of skills and knowledge	0.767	0.383	0.208
Undetailed and inappropriate design drawings	0.912	0.456	0.235
Incompatible specifications	0.070	0.035	0.870
No consistency between specifications and drawings	0.280	0.140	0.627
Ordering materials without complying with the site's execution rate	9.117	4.559	0.000
Knowing the material waste percentage	4.946	2.473	0.000
Several change orders due to lack of work's scope	2.792	1.396	0.008
Slowness in making decisions	0.645	0.323	0.374
Time spent investigating non-qualified suppliers	1.279	0.639	0.192
Incomplete supplier proposals	2.150	1.075	0.062
The fluctuation of material prices	0.361	0.180	0.606
Over-ordering of materials	0.944	0.472	0.142
Redundancy and errors caused by excessive paperwork	1.279	0.639	0.097
Poor materials tracking and monitoring	1.426	0.713	0.091
Delay or inappropriate delivery of material	4.450	2.225	0.000
Transport difficulties due to bad planning for routing	0.816	0.408	0.306
Delivering the wrong material	10.454	5.227	0.000
Theft or loss of material due to improper storage and protection facilities	3.120	1.560	0.105
Poor plans and practices for the management of surplus material	11.560	5.780	0.000
Frequent movement of materials due to improper site layouts	2.151	1.075	0.087
Excessive material handling due to bad schedules	0.211	0.106	0.759
Material damage due to bad handling and unloading	2.569	1.284	0.010

Based on the data obtained from Table 9, a stacked bar chart (Figure 10) was used to clarify the relationship between project size types and potentially significant challenges. For instance, considering the mean among the project size groups, delivering the wrong material is considered a significant challenge in basic and large projects, and it is not a significant challenge in complex projects.

4.4. Material Management Critical Success Factors for Construction in the Middle East

Several CSFs are identified using the third question in the questionnaire. However, these CSFs were identified, and the mean was calculated for each challenge. Table 10 presents the CSFs and their related means.

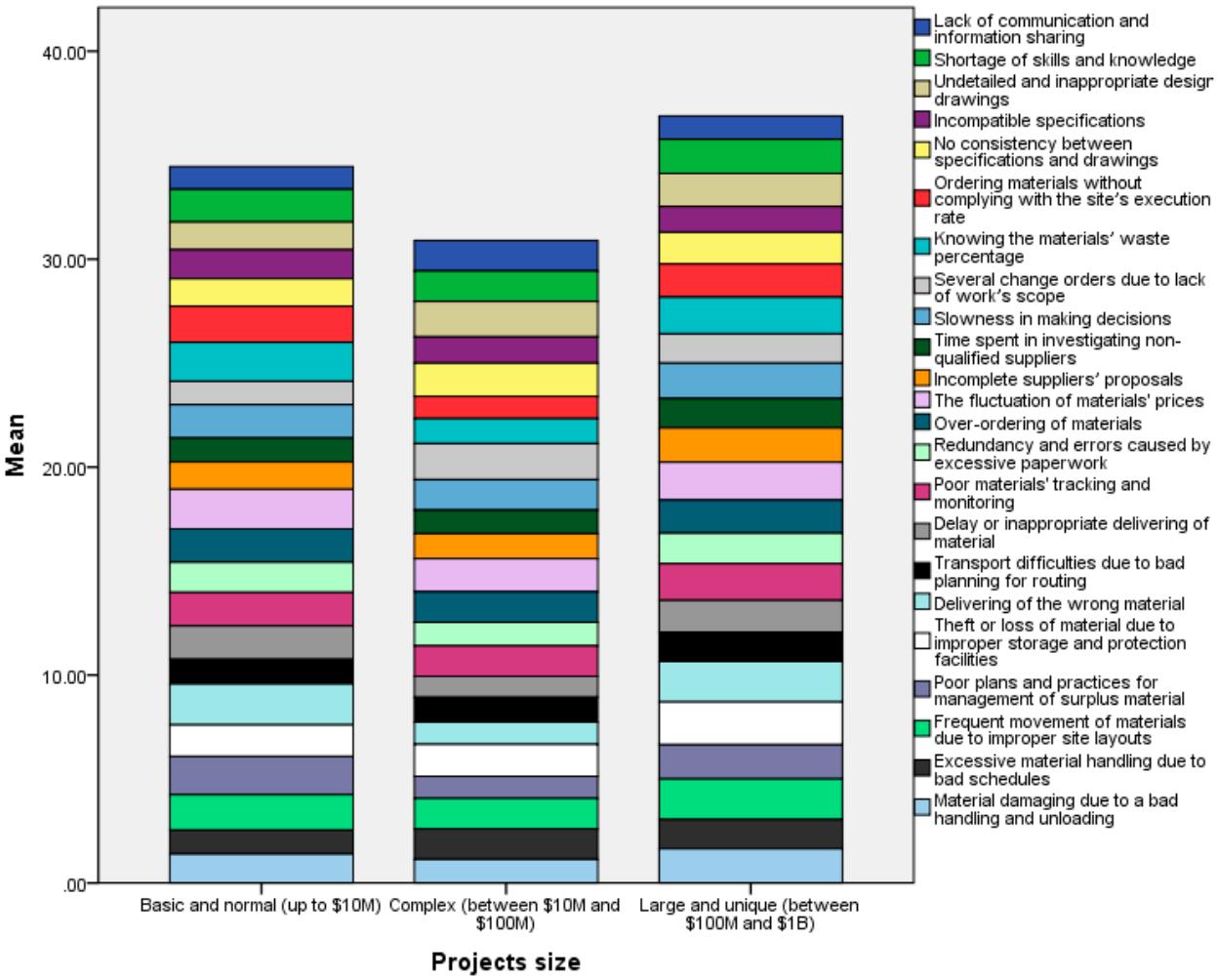


Figure 10. Relationship between project size and potential challenges.

Table 10. CSFs for material management in the Middle East.

	Critical Success Factor (CSF)	Mini	Max	Mean	S.d
1.	Continuous updating of project schedules	1.00	2.00	1.1978	0.40055
2.	Work should be performed by experienced and skilled people	1.00	2.00	1.2283	0.42201
3.	Implementation of proper execution plans and schedules	1.00	2.00	1.3152	0.46715
4.	Proper planning for storage spaces	1.00	2.00	1.3370	0.47526
5.	Adopting proper plans and practices to minimise material waste as well as considering material reuse in some construction activities	1.00	2.00	1.3370	0.47526
6.	Regular collaboration and coordination meetings, including all stakeholders	1.00	3.00	1.3696	0.50747
7.	Implementation of the quality control system, including quality officers	1.00	4.00	1.3736	0.55072
8.	Creating a database for material categories, suppliers, and cost	1.00	2.00	1.4239	0.49688

Table 10. *Cont.*

	Critical Success Factor (CSF)	Mini	Max	Mean	S.d
9.	Defining handling and distribution requirements, methods, and procedures.	1.00	2.00	1.4674	0.50167
10.	Implementation of technological solutions, such as BIM and CAD, to improve visibility and information sharing	1.00	2.00	1.5000	0.50274
11.	Planning of accesses and routing of materials within and outside the construction site	1.00	2.00	1.5870	0.49508
12.	Clear criteria for vendor evaluation and selection	1.00	2.00	1.6304	0.48533
13.	Adopting best practice sequences in purchasing, including just-in-time principle for material ordering	1.00	3.00	1.6630	0.51945
14.	Employing a logistics coordinator for material management monitoring	1.00	4.00	1.8152	1.05798
15.	Use technology, such as RFID and barcoding, for material tracking and monitoring	1.00	5.00	2.0217	1.14813
16.	Implementation of consolidation centre (big warehousing)	1.00	5.00	2.3587	1.25428

4.5. Challenges, Critical Success Factors Correlations in the Middle East

Linking and identifying the relations between challenges and CSFs is performed by conducting a correlation test. Pearson correlation coefficients (P) were measured using SPSS to build correlations between challenges and CSFs, as illustrated in Table 11. However, yellow cells indicate a significant correlation between a specific challenge and a certain CSF, as P is not equal to 0.

Table 11. Challenges and CSF correlations in the Middle East.

Challenges/CSFs		Lack of Communication and Information Sharing	Shortage of Skills and Knowledge	Undetailed and Inappropriate Design Drawings	Incompatible Specifications	No Consistency between Specifications and Drawings	Ordering Materials without Complying with the Site's Execution Rate
Regular collaboration and coordination meetings, including all stakeholders	*p*	0.253 *	−0.190	−0.023	0.428 **	0.155	0.544 **
Work should be performed by experienced and skilled people	*p*	−0.059	−0.452 **	−0.284 **	0.595 **	−0.296 **	0.377 **
Implementation of technological solutions, such as BIM and CAD, to improve visibility and information sharing	*p*	−0.069	0.022	−0.293 **	−0.332 **	0.141	−0.239 *
Implementation of proper execution plans and schedules	*p*	0.160	−0.112	−0.366 **	−0.137	0.111	0.009
Continuous updating of project schedules	*p*	−0.172	0.120	−0.163	0.059	−0.188	0.270 **
Clear criteria for vendor evaluation and selection	*p*	−0.121	0.199	0.024	0.194	0.046	0.557 **

Table 11. *Cont.*

Implementation of consolidation centre (big warehousing)	*p*	0.293 **	0.342 **	0.313 **	−0.372 **	0.474 **	−0.032
Adopting best practice sequences in purchasing, including just-in-time principle, for material ordering	*p*	0.331 **	−0.406 **	−0.421 **	0.147	0.059	0.540 **
Creating a database for material categories, suppliers, and cost	*p*	−0.472 **	0.031	−0.414 **	0.108	−0.316 **	0.223 *
Employing a logistics coordinator for material management monitoring	*p*	−0.006	0.109	0.330 **	−0.218 *	0.517 **	−0.358 **
Using technology, such as RFID and barcoding, for material tracking and monitoring	*p*	0.248 *	−0.004	0.323 **	0.183	0.386 **	0.323 **
Defining handling and distribution requirements, methods, and procedures.	*p*	0.070	−0.076	−0.226 *	0.324 **	−0.238 *	0.612 **
Planning of accesses and routing of materials within and outside the construction site	*p*	−0.196	0.212 *	−0.044	0.060	−0.113	0.504 **
Implementation of quality control system, including quality officers	*p*	−0.406 **	−0.252 *	−0.375 **	0.312 **	−0.405 **	0.514 **
Proper planning for storage spaces	*p*	0.270 **	0.303 **	0.543 **	−0.113	0.574 **	−0.039
Adopting proper plans and practices to minimise material waste, as well as considering material reuse in some construction activities	*p*	0.173	0.256 *	0.006	−0.160	−0.022	0.560 **
Challenges/CSFs		Knowing the Material Waste Percentage	Several Change Orders Due to Lack of Work's Scope	Slowness in Making Decisions	Time Spent Investigating Non-Qualified Suppliers	Incomplete Supplier Proposals	Fluctuation of Material Prices
Regular collaboration and coordination meetings, including all stakeholders	*p*	−0.005	−0.144	0.180	0.245 *	−0.255 *	−0.252 *
Work should be performed by experienced and skilled people	*p*	0.354 **	−0.300 **	0.103	−0.049	−0.100	0.212 *
Implementation of technological solutions, such as BIM and CAD, to improve visibility and information sharing	*p*	0.240 *	−0.301 **	−0.358 **	−0.370 **	0.000	0.331 **
Implementation of proper execution plans and schedules	*p*	0.120	0.122	−0.614 **	0.094	0.496 **	0.216 *
Continuous updating of project schedules	*p*	0.415 **	−0.189	−0.336 **	0.262 *	0.684 **	0.090
Clear criteria for vendor evaluation and selection	*p*	0.501 **	−0.431 **	0.146	0.327 **	0.158	0.073

Table 11. *Cont.*

Implementation of consolidation centre (big warehousing)	*p*	0.042	−0.034	−0.023	0.188	−0.057	−0.018
Adopting best practice sequences in purchasing, including just-in-time principle, for material ordering	*p*	0.022	0.045	−0.343 **	0.242 *	0.286 **	0.103
Creating a database for material categories, suppliers, and cost	*p*	0.671 **	−0.653 **	0.212	−0.372 **	0.005	0.398 **
Employing a logistics coordinator for material management monitoring	*p*	0.022	−0.185	0.208	−0.101	−0.280 **	0.078
Use technology, such as RFID and barcoding, for material tracking and monitoring	*p*	−0.078	−0.017	0.195	0.500 **	−0.025	−0.199
Defining handling and distribution requirements, methods, and procedures	*p*	0.310 **	−0.283 **	−0.186	0.155	0.243 *	0.038
Planning of accesses and routing of materials within and outside the construction site	*p*	0.542 **	−0.424 **	0.200	0.113	0.198	0.358 **
Implementation of quality control system, including quality officers	*p*	0.364 **	−0.465 **	−0.012	−0.144	0.240 *	0.176
Proper planning for storage spaces	*p*	−0.024	−0.007	0.083	0.369 **	−0.201	−0.190
Adopting proper plans and practices to minimise material waste, as well as considering material reuse in some construction activities	*p*	−0.162	−0.092	−0.271 *	0.257 *	0.095	−0.229 *
Challenges/CSFs		Over-Ordering of Materials	Redundancy and Errors Caused by Excessive Paperwork	Poor Material Tracking and Monitoring	Delay or Inappropriate Delivery of Material	Transport Difficulties Due to Bad Planning for Routing	Delivering the Wrong Material
Regular collaboration and coordination meetings, including all stakeholders	*p*	0.242 *	−0.123	−0.151	0.152	0.110	−0.095
Work should be performed by experienced and skilled people	*p*	0.123	−0.157	−0.404 **	0.467 **	0.030	0.258 *
Implementation of technological solutions, such as BIM and CAD, to improve visibility and information sharing	*p*	−0.054	0.271 **	0.540 **	−0.117	−0.019	0.078
Implementation of proper execution plans and schedules	*p*	−0.267 *	−0.023	0.362 **	0.295 **	0.202	0.010
Continuous updating of project schedules	*p*	−0.430 **	−0.061	0.271 **	0.430 **	0.106	0.202
Clear criteria for vendor evaluation and selection	*p*	0.231 *	0.215 *	0.116	0.471 **	−0.038	0.542 **

Table 11. *Cont.*

Implementation of consolidation centre (big warehousing)	*p*	0.367 **	0.206 *	0.543 **	−0.401 **	−0.102	−0.030
Adopting best practice sequences in purchasing, including just-in-time principle, for material ordering	*p*	0.205	−0.278 **	0.189	0.397 **	0.159	0.145
Creating a database for material categories, suppliers, and cost	*p*	0.047	0.108	0.161	0.507 **	−0.116	0.660 **
Employing a logistics coordinator for material management monitoring	*p*	0.526 **	0.514 **	0.283 **	−0.459 **	−0.115	0.152
Use technology, such as RFID and barcoding, for material tracking and monitoring	*p*	0.387 **	0.080	0.223 *	−0.259 *	0.173	−0.121
Defining handling and distribution requirements, methods, and procedures	*p*	0.028	−0.401 **	0.097	0.490 **	−0.033	0.180
Planning of accesses and routing of materials within and outside the construction site	*p*	0.337 **	0.049	0.096	0.379 **	−0.272 **	0.460 **
Implementation of quality control system, including quality officers	*p*	−0.033	−0.003	−0.246 *	0.632 **	−0.025	0.383 **
Proper planning for storage spaces	*p*	0.297 **	0.480 **	0.344 **	−0.335 **	0.142	0.088
Adopting proper plans and practices to minimise material waste, as well as considering material reuse in some construction activities	*p*	−0.130	−0.092	0.301 **	0.110	−0.055	0.006

Challenges/CSFs		Theft or Loss of Material Due to Improper Storage and Protection Facilities	Poor Plans and Practices for the Management of Surplus Material	Frequent Movement of Materials Due to Improper Site Layouts	Excessive Material Handling Due to Bad Schedules	Material Damage Due to Bad Handling and Unloading
Regular collaboration and coordination meetings, including all stakeholders	*p*	0.103	0.164	0.001	0.034	−0.151
Work should be performed by experienced and skilled people	*p*	−0.151	0.059	0.261 *	−0.241 *	−0.030
Implementation of technological solutions, such as BIM and CAD, to improve visibility and information sharing	*p*	0.223 *	−0.044	0.000	−0.036	0.349 **
Implementation of proper execution plans and schedules	*p*	−0.042	−0.160	0.388 **	0.116	0.259 *
Continuous updating of project schedules	*p*	−0.188	0.096	0.221 *	−0.158	0.494 **
Clear criteria for vendor evaluation and selection	*p*	−0.081	0.691 **	0.067	−0.183	0.030

Table 11. *Cont.*

Implementation of consolidation centre (big warehousing)	*p*	0.481 **	0.287 **	−0.255 *	0.305 **	0.125
Adopting best practice sequences in purchasing, including just-in-time principles, for material ordering	*p*	0.023	0.192	0.547 **	0.407 **	0.110
Creating a database for material categories, suppliers, and cost	*p*	−0.094	0.619 **	0.203	−0.436 **	0.195
Employing a logistics coordinator for material management monitoring	*p*	0.250 *	0.159	−0.375 **	0.085	−0.227 *
Use technology, such as RFID and barcoding, for material tracking and monitoring	*p*	0.225 *	0.286 **	−0.204	0.377 **	−0.029
Defining handling and distribution requirements, methods, and procedures	*p*	−0.247 *	0.558 **	0.288 **	0.044	0.183
Planning of accesses and routing of materials within and outside the construction site	*p*	−0.164	0.823 **	−0.090	−0.228 *	−0.084
Implementation of quality control system, including quality officers	*p*	−0.233 *	0.226 *	0.308 **	−0.191	0.210 *
Proper planning for storage spaces	*p*	0.308 **	0.393 **	−0.181	0.233 *	−0.120
Adopting proper plans and practices to minimise material waste, as well as considering material reuse in some construction activities	*p*	0.058	0.301 **	0.063	0.271 **	0.444 **

Note: * indicates that the result is statistically significant at the 0.05 level ($p < 0.05$), ** indicates that the result is highly significant at the 0.01 level ($p < 0.01$).

5. Discussion

This section aims to identify the relationships between the results obtained from this research and the literature review and to adapt the existing hypotheses to align with the construction industry environment in the Middle East. This objective can be achieved by determining the significance of the results and establishing correlations among various variables [8]. Several comparisons have been made to assist in refining, modifying, and adapting the conceptual hypothesis, thereby facilitating the development of empirical mitigation strategies. This mitigation matrix can be applied to the construction industry in the Middle East.

5.1. Result Validity and Reliability

Evaluating the reliability of a questionnaire is an essential component of the research. Reliability pertains to the efficacy of the test in identifying or measuring challenges and potential CSFs. This assessment can be conducted by calculating Cronbach's alpha coefficient [130]. Cronbach's alpha coefficient was determined using SPSS, yielding a value of 0.78. According to Table 7, this value indicates that the test is acceptable. Furthermore, a sample size of approximately 92 was considered adequate for establishing meaningful comparisons when necessary. These results can be used to determine the appropriate

actions [87]. An additional test was conducted to ensure the respondents' experiences were aligned with the general requirements of the construction industry. For example, project managers typically possess extensive experience compared with junior engineers with limited experience [19]. This distinction is evident in this study, with most project managers having more than six years of experience, while the majority of junior engineers have between one and two years of experience. Moreover, the involvement of all stakeholders in material management is crucial for obtaining reliable results and generalising the findings [118]. All construction contractors involved in material management processes were identified, including foremen, junior engineers, senior engineers, project managers, and contractors [19]. However, the primary stakeholders directly associated with the construction industry in the Middle East are project managers, junior engineers, and senior engineers. This is attributed to the fact that contractors employ engineers to perform multiple tasks to reduce costs. Conversely, the employment of engineers is often a prerequisite for project owners [40]. The majority of construction projects in the Middle East are categorised as basic, normal, or complex, as a significant proportion of these projects are proposed and funded by international organisations. Additionally, international organisations endeavour to distribute funds across multiple projects to encompass various locations and benefit a larger population [67].

5.2. Construction Material Management Challenges in the Middle East

The findings revealed that challenges in the material management process within construction in the Middle East are consistent with those identified in the literature review. Existing literature emphasises the prevalence of these challenges, particularly in the construction industry in the Middle East. However, this study aimed to extend the analysis by establishing relationships between these challenges to explore potential correlations. For instance, lack of communication and information sharing is correlated with delays and inappropriate deliveries. Furthermore, poor communication leads to a lack of understanding of requirements, which subsequently results in inappropriate deliveries. To investigate these relationships, a correlation test was conducted using the SPSS software. A relationship is considered to exist if the Pearson correlation coefficient (P) is between 1 and −1 (not equal to 0) and the significant coefficient is equal to or less than 0.05 [87]. Establishing these relationships may prove beneficial, as addressing certain challenges may contribute to mitigating other challenges in subsequent stages [127]. Table 11 demonstrates that most of the challenges are interconnected and significantly influence one another. For example, lack of communication and information sharing is correlated with 12 other challenges. This deficiency in communication and information sharing contributes to a shortage of skills. For instance, stakeholders may fail to employ suitable personnel if the requirements are not communicated effectively during the hiring process [31]. This may also lead to inconsistencies between the specifications and drawings. For example, some engineering specifications have been developed collaboratively by multiple engineers and contractor staff. Additionally, requirements may vary depending on site characteristics, or tender specifications may not be suitable for a particular project location [23]. Moreover, without proper specifications, communication, and information sharing among stakeholders, identifying the approximate quantity of materials and waste percentages is challenging. This issue is crucial for planning and procurement departments to determine the appropriate quantities of materials to be ordered and avoid incorrect or inappropriate deliveries [2].

Nevertheless, several orders of change in construction may occur because of an unclear scope of work or the identification of feasible alternatives. Furthermore, this may present a challenge for contractors, particularly when they order materials based on the original contract. For instance, stakeholders may need to return materials and procure new materials.

Updated information is beneficial for contractors by providing them with more options and assisting them in making better decisions regarding materials, thereby reducing potential waste [40]. Delays in decision-making are also correlated with inadequate communication and information sharing. For example, decision making is generally predicated on available information [58]. Moreover, the evaluation of suppliers and vendors is contingent upon proper communication and information sharing. Without this selection of suitable suppliers, it is challenging to effectively address potential problems. Insufficient communication and information sharing are associated with poor material monitoring and tracking. For example, the inability to provide accurate and sufficient data may result in unsuccessful material monitoring. This may lead to delayed and inappropriate deliveries [41]. Finally, inadequate communication among stakeholders may result in unreliable and impractical planning. This may lead to decreased productivity and cost overruns [31].

Considering the shortage of skills and knowledge, unskilled and inexperienced personnel are associated with producing inadequate drawings and specifications, which may contribute to unrealistic estimations of materials. This issue is exacerbated by poor material handling and practice. Furthermore, incomplete or inappropriate drawings can result in the delivery of unsuitable materials. For instance, the utilisation of traditional methods, such as paper-based approaches, by unskilled staff members is correlated with the creation of substandard and insufficient drawings. Consequently, inappropriate design drawings can also affect project execution and material ordering processes. As execution plans are generally based on design drawings, this may disrupt the material ordering and work execution rates. Incomplete drawings are associated with difficulties in identifying suitable suppliers. This may lead to numerous change orders, and suppliers may experience frustration because of the insufficient engineering details required to calculate their prices. These factors may also result in fluctuations in material prices and inappropriate deliveries owing to the addition or removal of certain items from the material [72]. Additionally, incomplete drawings may affect site activities by necessitating site workers to execute multiple activities owing to insufficient technical information and specifications. This may require additional handling activities [31].

Incompatible specifications are correlated with several work change orders. For instance, some project owners have attempted to construct a new project based on previous tender documents. However, construction projects differ in size, specifications, and environments [68]. Consequently, this may result in multiple change orders, owing to the inadequacy of the specifications. This may also affect the site's activities and inventory management. For example, ordering materials based solely on specifications may be inadvisable, as design drawings may differ and change over time or throughout the project lifecycle. This may lead to inventory accumulation and material waste as it remains unused. Furthermore, unused materials may result in some stakeholders becoming negligent and unaware of the situation [68]. In certain construction projects, contractors attempt to purchase materials in large quantities to obtain favourable prices, mitigate unexpected events, or overcome transport difficulties [8]. However, the ordered quantities can be estimated based on previous experience or tender documents. This may result in inappropriate deliveries and multiple handling of some materials, in addition to poor inventory monitoring and management.

However, delays in decision-making are associated with insufficient information. However, limited experience, incomplete supplier proposals, numerous change orders, and material price fluctuations significantly contribute to diminishing decision-making capabilities. For instance, the selection of reliable suppliers can be a challenging task because substandard suppliers may affect productivity by providing incorrect or low-quality materials, leading to increased handling and material waste. Some suppliers attempt to

submit incomplete proposals because of various reasons. First, they may lack sufficient and detailed information regarding exact specifications and quantities. Second, suppliers occasionally avoid providing price offers because they recognise that fluctuations in prices can confer competitive advantages. Third, in the construction industry, some companies have attempted to attribute material waste to suppliers. Consequently, suppliers endeavour to mitigate this issue by offering companies different prices throughout the project's lifecycle. Furthermore, this may occur when trust levels are low between stakeholders [34]. In such instances, fluctuations in material prices typically occur for several reasons, including lack of skills and insufficient project specifications. For example, some suppliers may increase prices if the specifications are unclear, thereby protecting themselves against potential risks such as changes in material quantities [71]. Second, some suppliers attempt to offer different prices based on their perceptions and experience with the contractor [72]. Third, fluctuations in material prices are associated with supplier availability. For instance, in a highly competitive environment, there are numerous vendors, and prices change rapidly over time or when additional amendments are made. However, some suppliers may offer a competitive price without considering service quality, which may result in potential delays or suboptimal delivery quality [73].

Delays and inappropriate material deliveries are associated with multiple challenges in the Middle East. The primary factors appear to be inaccurate information and unreliable practice. This issue can lead to several problems, such as reduced productivity and material damage owing to multiple and unreliable handling processes [34]. In such instances, late deliveries are often attributed to transportation or movement restrictions. However, these restrictions are frequently associated with inadequate planning and dependence on unreliable suppliers. Consequently, this also correlates with incorrect deliveries and multiple unnecessary handling processes. [41] asserted that incorrect deliveries have several consequences, as they may result in material damage due to inappropriate and unreliable handling and may increase the likelihood of theft. In the Middle East, theft or loss of materials at construction sites is associated with several issues. The presence of unnecessary materials at construction sites is linked to an increased possibility of theft. Furthermore, inadequate material monitoring, tracking, and control contribute to theft. Additionally, the poor management of surplus material may lead to theft. For instance, some individuals may attempt to acquire unused material [34]. Conversely, inadequate plans for surplus material can increase the incidence of theft. These plans should be developed using comprehensive information related to material quantities, waste percentages, and activity schedules, including all stakeholders [41]. Moreover, these plans should incorporate best practices for material handling to minimise waste and improve material utilisation efficiency.

5.3. Project Type-Based Challenges

Challenges in the construction industry appear to be generalised. There is a paucity of research that attempts to identify challenges based on construction project types. Consequently, this study employed ANOVA to identify significant challenges for each project type. Considering their typology, the identified challenges may have a substantial impact on the performance of construction projects. Conversely, other challenges exist, but the impact of these challenges may become significant if stakeholders do not consider them judiciously. Table 12 summarises the various challenges affecting different project sizes.

Table 12. Significant challenges for construction projects based on their types.

Significant Challenges for Basic and Normal Projects	Significant Challenges for Complex Projects	Significant Challenges for Large and Unique Projects
• Ordering materials without complying with the site's execution rate	• Several change orders due to lack of work's scope	• Ordering materials without complying with the site's execution rate
• Knowing the material waste percentage		• Knowing the material waste percentage
• Poor plans and practices for management of surplus material		• Incomplete supplier proposals
• Delay or inappropriate delivery of material		• Poor plans and practices for management of surplus material
• Delivering the wrong material		• Delay or inappropriate delivery of material
		• Delivering the wrong material
		• Material damage due to bad handling and unloading

5.4. Construction Material Management—CSFs in the Middle East

Success factors for material management in the Middle East were identified based on a literature review and questionnaire surveys. A statistical correlation test was conducted to establish relationships between the identified CSFs. These factors can be integrated to improve the process and overcome challenges. To achieve this, a correlation test was conducted using SPSS to establish the relationship between them. For instance, a relationship will be considered if Pearson correlation coefficient (P) is between 1 and −1 (not equal to 0) and the significant coefficient is equal to or less than 0.05 [127]. First, it improves coordination and communication between all actors. This can be accomplished using appropriate methods, such as telephones or emails. Furthermore, it should be based on proper working plans and schedules implemented by experienced personnel to create reliable communication methods. Additionally, material quantities, qualities, handling and distribution requirements, methods, and procedures should be carried out appropriately. However, the findings revealed that handling and distribution procedures should be clarified for all construction activities, including storage, execution, and distribution, to increase efficiency and decrease waste. Moreover, proper planning for routings is essential to select the most appropriate ways and ensure all materials can be delivered within their designated time and regulations. In addition, this should be performed by considering the material types and schedules. Proper communication with material suppliers is based on clear criteria for increasing efficiency and reducing time. However, without transparency, communication, and coordination, project objectives cannot be achieved successfully. Therefore, a system for material monitoring and tracking is vital for effectively accomplishing project tasks. This system may enhance quality and reduce potential waste and theft. Communication should also be extended to all workers, together with identifying the proposed schedules and working procedures.

The construction industry generally produces costly outputs, and its activities are interconnected and correlated. However, construction activities rely heavily on human resources [131]. Therefore, the selection of appropriate personnel is a significant factor in improving the construction process. For instance, it is recommended that experienced staff, including logistics coordinators, be chosen. Moreover, the findings indicate that selecting skilled individuals is correlated with several CSFs. Conversely, the selection of appropriate personnel can be achieved through proper communication and coordination with the most

suitable individuals who are qualified to perform tasks. Additionally, this process may be facilitated using information and communication technology (ICT) tools. Furthermore, these tools should be available in all areas of construction storage and supply to establish effective communication methods. ICT tools in the construction environment appear to be crucial, as several construction activities depend on them to proceed with and execute other tasks. Moreover, these tools are essential for facilitating construction processes, such as introducing procedures, investigating suppliers, and creating and updating plans [8]. However, adopting proper execution plans can be achieved through appropriate communication with experienced staff using appropriate methods. Furthermore, they should be based on accurate and precise information from warehouses, suppliers, and workers. RFID technology can facilitate these processes by improving the monitoring and control of materials. Subsequently, continuous updating of the activity schedule is recommended to monitor progress against the baseline and to implement appropriate mitigation measures when necessary. This can be accomplished through regular collaboration and communication with reliable information sources, such as logistics coordinators and quality officers. However, these plans may contribute to waste minimisation by implementing proper scheduling of activities and optimal utilisation of materials [57].

Conversely, implementing optimal procurement sequences, including explicit criteria for vendor evaluation and selection as well as the just-in-time principle for material ordering, appears to be a critical task. For instance, construction materials should be delivered at a specific time, with the required quantities and qualities, at competitive prices [104]. Several factors may contribute to the successful completion of this task. First, effective communication with potential suppliers is achieved by providing accurate information about the required materials and project specifications. Second, the material prices and potential providers can be predefined by experienced staff in the initial stages of the project to reduce the duration of investigations [25]. Furthermore, the implementation of a consolidation centre can enhance the process. However, the findings from this study indicate that implementation should incorporate sufficient communication and coordination with all skilled actors to optimally estimate material quantities and define suitable handling and storage conditions. Moreover, the material management process can be monitored and controlled by integrating a logistics coordinator and quality officers [23]. However, the findings demonstrate that several factors could be utilised to support these employees' activities toward optimal outcomes. First, appropriate communication and coordination should be adopted, with access to accurate and precise information. Second, they should possess the authority to control and monitor construction activities, including on-site and off-site operations. Third, utilising technology, such as RFID, in material tracking and monitoring could be beneficial, but it has some limitations. For instance, it requires a specialised system to implement, and it requires reliable actors to operate it [74]. Nevertheless, the findings reveal that this technology could improve warehousing and storage processes and provide accurate and reliable data that could enhance transparency and decision-making. Finally, a construction project is considered successful if it is completed within the allocated time and budget and meets the required quality standards [14]. Therefore, the role of quality systems appears to be significant. However, this role can be successfully fulfilled by integrating several elements, such as appropriate communication and adopting suitable plans and schedules. Additionally, this could lead to the proper execution of work, appropriate handling, and efficient warehousing activities.

5.5. Empirical Mitigation Matrix for Improving Material Management in the Middle East

This section establishes a correlation between challenges and CSFs while considering material management activities. This mitigation matrix could potentially be utilised to

enhance material management in the Middle East. It is evident that the challenges are correlated with several CSFs and the CSFs are interrelated. Thus, comprehending the internal relations between challenges and CSFs becomes crucial, specifically how one challenge may contribute to another and how CSFs should be integrated to achieve optimal results. However, addressing logistics challenges in construction material management necessitates a robust integration of CSFs to ensure that inefficiencies are mitigated and performance is optimised. A critical issue frequently encountered is the lack of communication and information sharing, which creates disconnections among stakeholders and leads to errors, delays, and inefficiencies. To overcome this, regular collaboration and coordination meetings involving all project actors are essential for improving the information flow and ensuring alignment among all parties. Additionally, implementing technological solutions such as building information modelling (BIM) and computer-aided design (CAD) enhances visibility across project phases, facilitates real-time updates, and ensures that accurate information is shared between sites and offices. These technologies enable the creation of a centralised platform where stakeholders can access updated schedules, material quantities, and specifications, thereby reducing the likelihood of miscommunication. Complementing this, a joint team for site and office coordination can streamline communication, ensuring consistent information exchange and bridging gaps between planning and execution teams. Closely linked to communication is a lack of skills and knowledge, which arises when untrained personnel are tasked with managing materials, leading to errors in handling, ordering, and tracking. Ensuring that work is conducted by experienced individuals is critical for addressing this challenge, as skilled personnel provide the expertise needed for material estimation, planning, and execution. To support this, assigning logistics coordinators can provide specialised oversight, ensuring that material processes are well-managed and aligned with project requirements. Moreover, providing clear handling requirements, methods, and procedures offers a structured approach for staff to follow, minimising mistakes caused by inexperience. Training programs and workshops further reinforce skill development, equipping the workforce with the necessary knowledge to manage materials efficiently and adopt emerging technologies.

The presence of incomplete drawings and discrepancies between specifications and drawings frequently impede material procurement and planning processes, resulting in delays and rework. These issues can be mitigated by implementing BIM and CAD technologies, which provide accurate and comprehensive representations of project drawings and specifications. By utilising these tools, stakeholders can align specifications with construction drawings in a single digital model, facilitating real-time updates and reducing inconsistencies. Regular collaboration and coordination meetings further ensure that discrepancies are promptly identified and addressed, whereas quality control systems, including quality officers, can verify the accuracy and completeness of all drawings prior to implementation. Quality officers play a crucial role in ensuring that specifications meet project requirements, thereby reducing the risk of mismatches and subsequent work disruption. Effective planning is another significant challenge, with inadequate scheduling and integration between activities frequently resulting in material shortages, overordering, or delays. To address this, material scheduling to enhance the efficiency of material handling is essential to align procurement with project execution. By integrating activity schedules with material delivery plans, stakeholders can ensure that materials arrive on-site at the appropriate time, thus minimising idle time and resource wastage. Complementing this, the optimum forecasting of material movement enables improved anticipation of material requirements and reduces uncertainties in planning. A logistics coordinator can further oversee these processes, ensuring that planning aligns with site activities and addresses potential scheduling bottlenecks. Additionally, the continuous monitoring of suppliers to

confirm timely deliveries ensures adherence to schedules and prevents disruptions caused by delays.

The challenge of ordering materials without adhering to on-site production requirements arises from the lack of integration between procurement schedules and construction progress. Implementing just-in-time (JIT) principles for material ordering addresses this issue by ensuring that materials are ordered and delivered only as required, thereby reducing storage needs and material waste. This approach functions in conjunction with material scheduling and the planning of access and routing of materials within the construction site, which ensures efficient movement and minimises interference with construction activities. A consolidation centre (large-scale warehousing) can further optimise procurement and storage, allowing materials to be centrally managed and delivered to the site as needed. The issue of waste generation, whether due to improper handling, frequent material movement, or poor control, necessitates a multifaceted approach. Adopting appropriate plans to minimise material waste, including strategies for material reuse, helps to mitigate unnecessary resource consumption. Implementing quality control systems, including quality officers, ensures that material handling, storage, and usage are monitored for compliance with established standards, thereby reducing waste caused by errors or inefficiencies. Additionally, defining handling requirements, methods, and procedures for each project phase provides clear guidelines for material movement and storage, whereas the use of RFID and barcoding for material tracking ensures real-time visibility and reduces losses and theft. Proper stock control systems further assist in managing the material inventory and preventing overstocking or understocking, both of which contribute to waste. Another challenge is the fluctuation of material prices, which has significant financial implications. This can be managed through the utilisation of JIT principles to minimise bulk purchases during periods of price volatility. Implementing a consolidation centre provides an opportunity for centralising orders, reducing procurement costs through bulk negotiations while ensuring that materials are available when required. Additionally, creating a database for material categories, suppliers, and costs allows stakeholders to monitor price trends and make informed procurement decisions, thereby reducing their exposure to market volatility. Similarly, the time-consuming process of investigating non-qualified suppliers and addressing incomplete or unreliable proposals can be improved by maintaining this centralised supplier database, which streamlines evaluations and ensures that only qualified vendors are involved.

Logistics challenges, such as material delays, transport difficulties, and damaged materials owing to improper handling, can be addressed through effective planning and coordination. The planning of the access and routing of materials within a construction site ensures that delivery paths are optimised to minimise delays and congestion. A logistics coordinator can oversee these routes and address unexpected disruptions, whereas the selection of appropriate material handling equipment reduces the damage caused by inefficient tools and practices. Additionally, implementing RFID and barcoding systems for material tracking allows stakeholders to monitor delivery timelines and identify issues in real time. These systems also improve transparency, reducing the likelihood of theft or loss during transportation and storage. Frequent material handling and improper site layouts exacerbate inefficiencies, increasing costs and resource waste. Addressing these issues requires careful planning of storage spaces to ensure that materials are stored in designated areas with sufficient access for movement and handling. Defining handling methods and procedures reduces unnecessary movement and ensures that materials are protected during site activities. The role of logistics coordinators becomes critical in this context, as they can optimise site layouts, coordinate material flows, and reduce disruptions. Excessive material handling can also be reduced through material scheduling and optimum

forecasting, ensuring that materials are delivered directly to where they are needed, thus minimising unnecessary movement.

The challenge of inadequate monitoring and control can be addressed by integrating quality control systems into the material management processes. Quality officers monitor material utilisation, handling, and storage to ensure adherence to project standards and timelines. RFID and barcoding technologies enhance real-time monitoring and control, improve accuracy, and reduce material loss. Continuous monitoring of suppliers further ensures timely delivery and compliance with quality requirements, thereby enhancing the overall project performance. By systematically addressing these logistics challenges through the aforementioned CSFs, construction projects can achieve greater efficiency, sustainability, and cost savings. The integration of technology, experienced personnel, and structured planning processes provides a robust solution for mitigating inefficiency and delivering successful outcomes. The synergy between these success factors creates a well-coordinated and streamlined approach to material management, ultimately improving the project performance. The detailed mitigation matrices are presented in Figure 11.

Challenges / CSFS	Regular collaboration and coordination meetings including all stakeholders	Work should be done by experienced and skilled people	Implementation of technological solutions Such as BIM and CAD to improve visibility and information sharing	Implementation of proper execution plans and schedules	Continuous updating of project schedules	Clear criteria for vendors evaluations and selections	Implementation of consolidation centre [big warehousing]	Adopting best practice sequences in purchasing including just in time principle for material ordering	Creating a database for materials categories, suppliers, and cost.	Employing a logistics coordinator for material management monitoring	Use technology such as RFID and bar-coding for materials' tracking and monitoring	Defining of handling and distributions requirements, methods, and procedures.	Planning of accesses and routing of materials within and outside the construction site	Implementation of a quality control system including quality officers	Proper planning for storage spaces	Adopting proper plans and practices to minimise material waste as well as considering material reuse in some construction activities
Lack of communication and information sharing	√						√	√	√		√			√	√	
Shortage of skills and knowledge		√					√	√						√	√	√
Undetailed and inappropriate design drawings		√	√	√			√	√	√	√	√	√		√	√	
Incompatible specifications	√	√	√				√			√		√		√		
No consistency between specifications and drawings		√					√		√	√	√	√		√	√	
Ordering materials without complying with the site's execution rate	√	√	√		√	√		√	√	√	√	√	√	√		√
Knowing the materials' waste percentage		√	√		√	√			√			√	√	√		
Several change orders due to lack of work's scope		√	√			√			√			√	√	√		
Slowness in making decisions			√	√	√			√								√
Time spent in investigating non-qualified suppliers	√		√		√	√		√	√		√				√	√
Incomplete suppliers' proposals	√			√	√			√		√		√		√		
The fluctuation of materials' prices	√	√	√	√					√				√			√
Over-ordering of materials	√			√	√	√	√			√	√		√		√	
Redundancy and errors caused by excessive paperwork			√			√	√	√		√		√			√	
Poor materials' tracking and monitoring		√	√	√	√		√			√	√			√	√	√
Delay or inappropriate delivery of material		√		√	√	√	√	√	√	√	√	√	√	√	√	
Transport difficulties due to bad planning for routing													√			
Delivering the wrong material		√				√			√				√	√		
Theft or loss of material due to improper storage and protection facilities			√				√			√	√	√		√	√	
Poor plans and practices for management of surplus material						√	√		√		√	√	√	√	√	√
Frequent movement of materials due to improper site layouts		√		√	√		√	√		√		√		√		
Excessive material handling due to bad schedules		√					√	√	√		√		√		√	√
Material damaging due to bad handling and unloading			√	√	√					√						√

Figure 11. Construction material management challenges–CSF correlations in the Middle East.

6. Conclusions and Recommendations

The construction industry is characterised by complexity owing to its multi-fragmented activities involving numerous stakeholders. Furthermore, construction activities are executed through the integration of several factors, primarily labour, equipment, and materials. Enhancing efficiency in the construction industry necessitates the elimination of waste and challenges, as well as the reduction of costs. This research aims to improve the performance of the construction industry in the Middle East with a focus on material management. Contractors in the Middle East face various challenges and problems arising from lack of experience, intense competition, and a recent decrease in funded construction projects. However, there is a dearth of research addressing this issue comprehensively, considering all aspects, including potential challenges and CSFs. Therefore, this study encompasses all the possible aspects of material management in the construction industry as a foundation for this research. A methodology based on epistemology-positivist philosophy and a deductive approach was adopted. A quantitative method was selected, using a questionnaire for data collection. A total of 92 questionnaires were designed, distributed, and collected from diverse stakeholders across the various project types. Data analysis was conducted using the SPSS software. The material management process in the Middle East was improved through the identification of potential challenges and the proposal of integration between CSFs. This research establishes relationships that provide a comprehensive understanding of the situation, including correlations between CSFs and challenges and CSFs. ANOVA tests were conducted to identify the most significant challenges for each project type. The findings revealed that several challenges are interrelated; thus, addressing one challenge can mitigate multiple issues. For instance, addressing the lack of communication and information sharing could potentially reduce work-change orders, poor drawings, and delivery of incorrect materials. Conversely, several CSFs were identified, and correlations between them were established. This may facilitate a more effective approach to address these challenges. For example, improving coordination, collaboration, and communication can address the lack of communication and information sharing. This can be achieved by considering various factors, such as adopting appropriate ICT tools, conducting regular collaboration and coordination meetings, and implementing a robust quality control system. All relationships are presented in Table 11. Finally, the following recommendations were proposed for the construction industry in the Middle East:

- Several challenges have a great impact on the construction industry, and many of these challenges can be addressed and eliminated.
- The proposed CSF approach must be implemented to achieve effective outcomes.
- Material management in the Middle East can be improved by adopting the proposed practical model, as illustrated in Figure 11.
- Material management is one of the core elements of construction supply chains. Thus, proper material management leads to robust strategic planning, client satisfaction, good information sharing and integration, and improved coordination and collaboration across the supply chain.

However, the proposed matrix is versatile and can be tailored to suit both small- and large-scale projects as well as varying regional contexts.

- Small-Scale Projects

In small-scale projects where budgets and resources are often limited, the matrix can be simplified by prioritising a few high-impact CSFs and challenges. For instance, adopting basic ICT tools such as shared spreadsheets or communication platforms (e.g., Microsoft Teams or WhatsApp) can address issues related to communication and coordination without significant costs. Regular informal meetings among stakeholders can substitute for

more formalized coordination mechanisms. The focus on small-scale projects may also lean heavily on addressing labour-related challenges, as these are typically more prominent in smaller operations.

- Large-Scale Projects

For large-scale projects, the matrix can incorporate advanced and comprehensive solutions. This may include deploying sophisticated building information modelling (BIM) systems, conducting detailed risk assessments, and leveraging real-time data analytics to proactively monitor and address challenges. Large projects also benefit from establishing dedicated teams for quality control, communication, and logistics to ensure smooth coordination across all levels.

- Regional Adaptations

In regions with limited infrastructure or underdeveloped markets, the matrix emphasises the importance of building local supplier capacity, ensuring compliance with regulatory standards, and mitigating risks related to unreliable supply chains. Conversely, in more developed regions, the focus can shift toward optimizing advanced technologies, such as automated material tracking systems and lean construction practices.

Research Limitations and Future Work

This study aimed to explore and improve the material management process within construction to improve the performance of the construction industry in the Middle East. However, some limitations were identified, which should be carefully considered when adopting the research findings. The limitations of this study are as follows:

- Adopting the results for other environments should be carefully considered.
- One primary data collection method was used owing to the time and cost constraints. However, using more methods, such as semi-structured interviews, is also useful for identifying the causes of these challenges.
- Finally, the majority of the research data was collected from small and complex projects because of the nature of construction projects in the Middle East. Therefore, these findings may not be significant for large projects.

Therefore, owing to these limitations, it is recommended to extend the study and conduct further research.

- Research has focused on particular project sizes, such as small or large construction projects.
- Using extra methods for data collection could supplement the research results and may lead to additional mitigation and significant in-depth understanding.

Research focusing on linking the effects of bad material management to time, cost, and quality is also recommended.

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