

Digital Material Procurement and Inventory Management System for Construction Projects

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ABSTRACT

Efficient material procurement and inventory control are critical to project time, cost, and site productivity in construction. However, many construction projects in Malaysia still rely heavily on manual practices such as paper-based requisition forms, WhatsApp communication, and basic spreadsheet records. Despite the availability of digital technologies, these fragmented and informal methods remain common. As a result, material-related information is often inaccurate, delayed, or inconsistent, leading to poor coordination among project teams. These weaknesses frequently cause material duplication, wastage, stock shortages, and avoidable construction delays. This study critically examines the limitations of manual material management practices and their impact on overall project performance. Through system analysis and process re-engineering, existing procurement and inventory workflows were analyzed to identify operational inefficiencies and gaps in information flow. The findings reveal that the absence of an integrated system is a key contributor to poor data visibility and weak decision-making. In response, this study proposes a digital Material Procurement and Inventory Management System tailored to the needs of construction projects. The system integrates material requests, approval processes, purchase orders, delivery tracking, and real-time inventory updates within a single platform. Developed using web-based technologies and supported by a cloud database, the system aims to improve transparency, reduce human error, and support timely decision-making. The results demonstrate that adopting a digital material management system can significantly improve operational efficiency, enhance data accuracy, and reduce material-related delays and waste, thereby supporting the Malaysian construction industry's digital transformation efforts.

Keywords: Material Management, Procurement System, Construction Industry, Inventory Tracking, Digitalisation, Manual Workflow, Real-time Visibility

INTRODUCTION

The construction industry is a key sector for the country's growth. Although the construction industry in Malaysia is growing, it still faces many challenges, including material management. According to the study by Mohamed Yusuf Wayrah et al. (2021), many construction project deliveries still face issues in various forms, and most construction projects fail due to poor material management. The situation may cause late deliveries, inefficient resource utilization, and site disruptions in the construction project. Other than that, when procurement activities are delayed due to poor material tracking and coordination, the overall construction workflow is directly affected, leading to schedule overruns and reduced project efficiency.

Despite the availability of advanced technologies, material management in most construction projects still relies on manual methods, such as paper and spreadsheets, to handle and record construction material inventory (Kasim, 2015). This type of material management practice is very ineffective because it cannot provide real-time updates on inventory levels and delivery status. Other than that, due to its manual nature, material

management practices are also prone to human error and fragment material information. As a result, the project teams are often unable to forecast material requirements accurately and cannot respond promptly to supply issues. This situation will lead to procurement delays, disrupting construction schedules and increasing the project's cost due to idle labour, extended preliminaries, and urgent material purchases. In addition, manual material management will lead to inaccurate material records, contributing to over-ordering and improper storage. The condition will result in on-site material waste. According to a CIDB report, 70% of 300 capital project owners and contractor construction professionals worldwide experience supply chain delays and disruptions.

Most previous studies have highlighted the limitations of traditional material-tracking practices in construction projects. According to Kereri's (2018) study, construction materials are often received on site without proper identification and systematic records. This situation makes it difficult to track and locate construction materials, especially on large construction sites. Similarly, another study by Kasim, Kusumaningtias, and Sarpin (2019) found that paper-based and manual material management practices are time-consuming and contribute to poor material handling, storage inefficiencies, and loss of control over materials. These studies highlight the shortcomings of traditional material management methods, but they remain mainly descriptive and focus more on problem identification than on offering integrated or immediate solutions. Specifically, prior studies have not sufficiently examined the systematic ways in which fragmented, non-digital material-tracking systems contribute to project delays, cost overruns, and material waste (Ngor et al., 2019). This indicates a research gap in the development and evaluation of more efficient material-tracking strategies that facilitate prompt decision-making and enhance overall project performance.

Although previous studies have highlighted the weaknesses of manual, paper-based material-tracking practices in construction projects, existing research has largely focused on identifying operational problems rather than proposing integrated system-level solutions. There is a lack of research on centralized, real-time digital material-tracking systems that integrate procurement, inventory control, and on-site material use within a single platform. This situation shows that the absence of such integrated systems limits project teams' ability to monitor material flow accurately, respond promptly to supply disruptions, and minimize delays and cost overruns. Due to the situation above, there is a clear research gap in the development and evaluation of a digital material management system that supports real-time information sharing and decision-making throughout the project lifecycle. This study aims to fill this gap by proposing an integrated digital material procurement and inventory management system for construction projects, addressing the limitations of existing manual practices and improving project performance.

Furthermore, although digital material management technologies have been proposed in previous studies, limited research has provided empirical evaluation of their actual performance in real construction environments. Many studies focus primarily on conceptual system design or technological capabilities without systematically assessing their impact on project efficiency, cost control, and material tracking accuracy. This lack of performance validation limits the practical adoption of digital material management solutions in the construction industry. Based on this research gap, the present study aims to develop and evaluate an integrated digital system for material procurement and inventory management in construction projects. This system is designed to minimize human errors in material management and reduce the reliance on manual, paper-based tracking practices. In the same time, this system will also improve overall efficiency in material procurement and inventory control.

PROBLEM STATEMENT

Material requisitioning and inventory are handled manually via paper requisitioning, WhatsApp, and spreadsheets in many construction projects. This unorganized and improper method always leads to discrepancies in documentation, delays in updating stock, and a lack of visibility into material status. Construction project stakeholders often lack up-to-date information on material requisitioning and inventory, thereby weakening the reliability of the data and hindering the evidence-based decision-making process.

Without digital data entry, the company faces problems such as loss, duplication, and delayed approval. Manual stock data can be vulnerable to inaccuracies, lost documents, and out-of-date data, which can reduce data validity

(Kasim et al., 2015). Inaccurate stock inventories can lead to unnecessary spending and waste, thereby increasing the project's cost and reducing operational efficiency. These shortcomings disrupt project schedules, require additional manpower, and delay site work. Evidence indicates that improper management of construction materials leads to delays and cost overruns in projects (Mohamed Yusuf Wayrah et al., 2021). Therefore, the continued reliance on manual material management systems limits decision accuracy, reduces productivity, and highlights the need for a digital, integrated procurement and inventory management solution, especially one that supports real-time data integration and performance monitoring mechanisms.

OVERVIEW OF THE EXISTING MATERIAL MANAGEMENT PROCESS

In the construction industry, material procurement and inventory management are manual and decentralized. Participants involve the site supervisor and storekeeper in purchasing materials, using methods such as paper MRFs, WhatsApp, Google Sheets, and Excel, which results in fragmented information flow across the different platforms.

MATERIAL REQUISITION FORM		No. 93						
Name of Site: MHC PROJECT - Umy, Malindi, P. Utd			Date: 2/3/20					
Sl. No.	Particulars	Stock No.	Present Stock	Required Qty	Qty to be Procured	Unit	Value	Remarks
1	20' x 10' x 1/2" (1/2" thick) - 2000			200	200	No		2000
2	11' x 11' x 1/2" (1/2" thick) - 2000			200	200	No		2000
3	11' x 11' x 1/2" (1/2" thick) - 2000			200	200	No		2000
4	Profile Sheet (2.5m) - 200			200	200	No		2000
5	Profile Sheet (2.5m) - 200			200	200	No		2000
Note: previous shipment for new shade is cancelled.								
6	Plastic cover sheet 100' x 7' - 200			200	200	No		2000
7	Plastic cover sheet 100' x 7' - 200			200	200	No		2000

Project Manager: [Signature] Store Keeper: [Signature] Site-in-Charge: [Signature]

Figure 1: The paper of the Material Requisition Form (MRF)

ITEM	DESCRIPTION	UNIT	PRICE	AMOUNT
1	Concrete Block	1000	1.00	1000.00
2	Concrete Block	1000	1.00	1000.00
3	Concrete Block	1000	1.00	1000.00
4	Concrete Block	1000	1.00	1000.00
5	Concrete Block	1000	1.00	1000.00
6	Concrete Block	1000	1.00	1000.00
7	Concrete Block	1000	1.00	1000.00
8	Concrete Block	1000	1.00	1000.00
9	Concrete Block	1000	1.00	1000.00
10	Concrete Block	1000	1.00	1000.00
11	Concrete Block	1000	1.00	1000.00
12	Concrete Block	1000	1.00	1000.00
13	Concrete Block	1000	1.00	1000.00
14	Concrete Block	1000	1.00	1000.00
15	Concrete Block	1000	1.00	1000.00
16	Concrete Block	1000	1.00	1000.00
17	Concrete Block	1000	1.00	1000.00
18	Concrete Block	1000	1.00	1000.00
19	Concrete Block	1000	1.00	1000.00
20	Concrete Block	1000	1.00	1000.00
21	Concrete Block	1000	1.00	1000.00
22	Concrete Block	1000	1.00	1000.00
23	Concrete Block	1000	1.00	1000.00
24	Concrete Block	1000	1.00	1000.00
25	Concrete Block	1000	1.00	1000.00
26	Concrete Block	1000	1.00	1000.00
27	Concrete Block	1000	1.00	1000.00
28	Concrete Block	1000	1.00	1000.00
29	Concrete Block	1000	1.00	1000.00
30	Concrete Block	1000	1.00	1000.00

Figure 2 The material on site using Excel

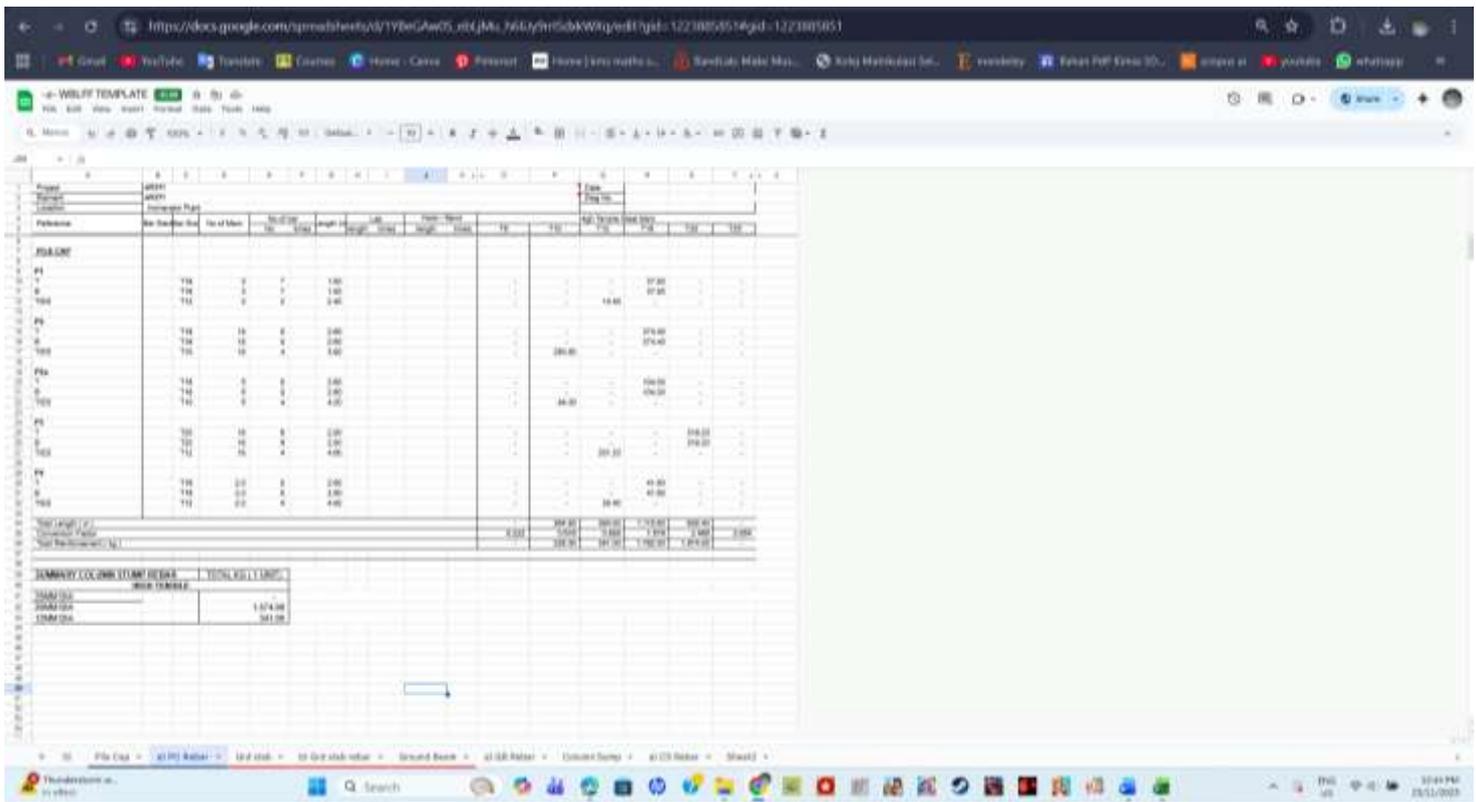


Figure 3: The tools that use Google Sheets

It begins with the site manager's paper requisition. Stock checking will be done manually either by record checks or by the storekeeper. When stock is short, orders are placed via email or WhatsApp. This method does not involve system integration or automatic updates, making the tracking process reactive rather than proactive. Data passes through various channels, especially when the project requires the use of materials with high turnover and tight time management and scheduling requirements. There are delays, duplicates and discrepancies. Manual processes are ineffective for coordination and decision-making (Kasim et al., 2015).

Manual Records Flowchart Process

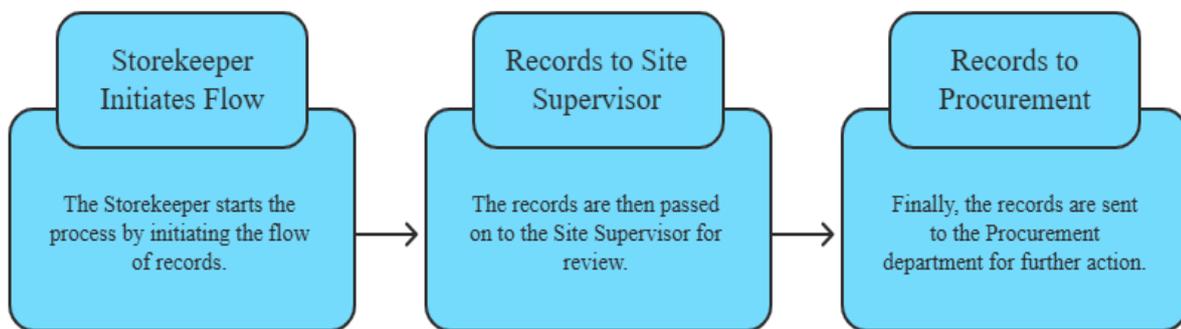


Figure 4: The manual record in the site

Weaknesses and Inefficiencies of the Existing System

Weaknesses in paper and spreadsheets lead to data loss, outdated information, and poor real-time visibility. The stock information does not update automatically, which creates problems in stock availability checks, leading to duplicated orders and inventory inaccuracies (Kereri, 2018), thus increasing the chances of cost overruns and schedule disruptions.

Workflow Diagram

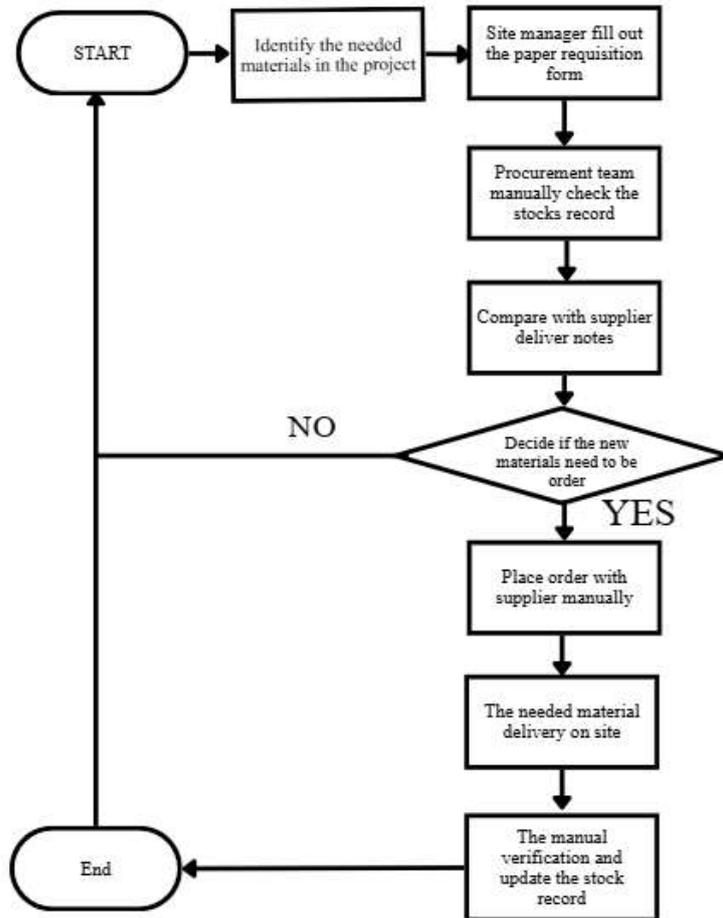


Figure 5: The workflow diagram of the existing system

The lack of a centralized platform leads to poor coordination, multiple data versions, and miscommunication, which weaken accountability and traceability throughout the procurement process. Procurement decisions are delayed because approvals and verifications must be performed manually across multiple parties, slowing the overall workflow and hindering responsiveness to emergency site requirements.

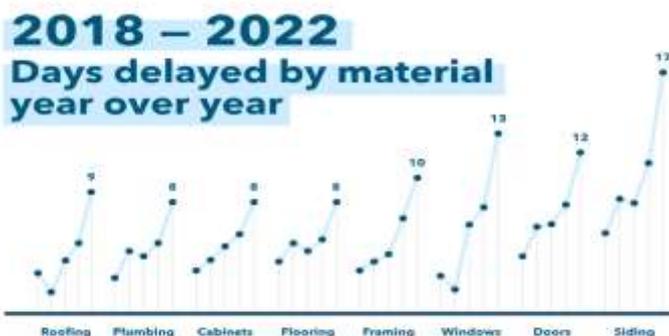


Figure 6: The project was delayed because of the material

Manual data entry increases the risk of miscalculation, illegible writing, lost data, and miscommunication of inventory updates. Human error has been identified in existing research as contributing to waste generation and inefficiency (Kasim et al., 2019). In general, these weaknesses can lead to increased costs and inefficiencies, underscoring the structural limitations of non-integrated material management systems.

Impact on Project Performance

Industry findings show that manual material tracking contributes to up to 50% of project delays due to slow procurement and miscommunication between departments, showing a direct correlation between material visibility and project schedule performance. Studies also found that 38% of construction material costs are affected by inefficiencies in material management, showing the financial impacts of fragmented tracking systems. It directly impacts project execution due to procurement delay caused by poor visibility of materials (Mohamed Yusuf Wayrah et al., 2021). In turn, impacts labour productivity and equipment utilization rates. It results in unnecessary material purchases and increased inventory holding costs. In Malaysia, the Construction Industry Development Board (CIDB) estimates that material waste accounts for approximately 5-10% of total project costs due to poor tracking (Adlina, 2023). Thus, emphasizing the need for systemic digital intervention. Redundant purchasing will increase the cost. It also creates difficulties in storing and managing inventory.

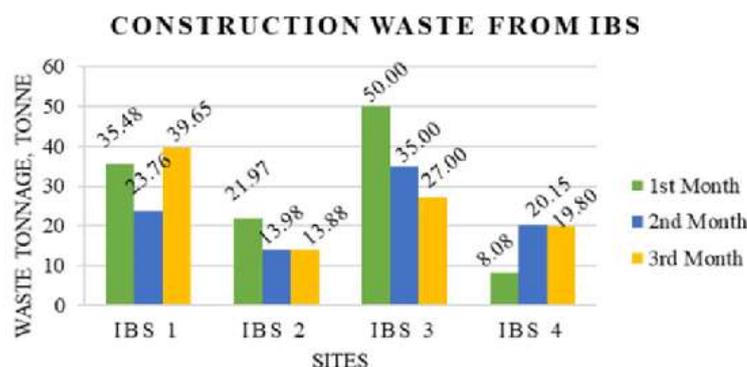


Figure 7: Construction waste from CCM sites

Meeting the site requirements is difficult due to the lack of real-time data. This is due to labour and equipment waste and low productivity, which weaken project performance indicators such as cost variance and schedule performance. The paper-based method is insufficient, as it requires an automated inventory procurement and management system with measurable performance monitoring systems.

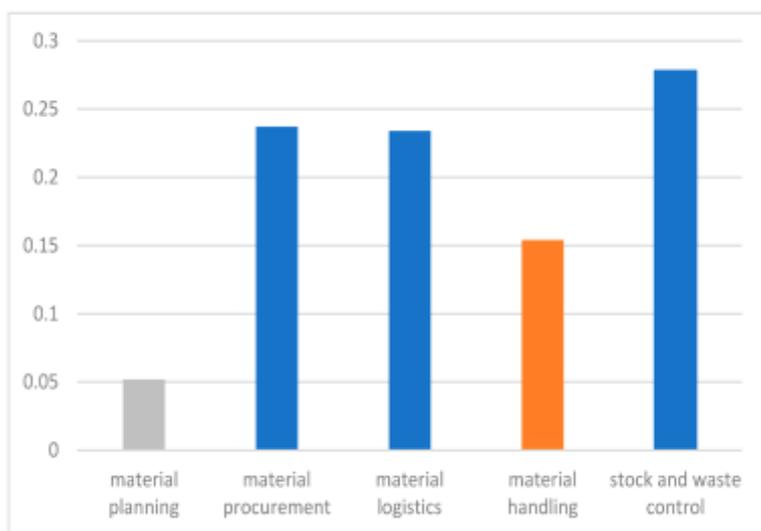


Figure 8: Project performance in the construction industry

Technological Solutions and Available Tools

In construction projects, material and inventory management systems play an essential role in preventing errors caused by manual material handling, as many projects in Malaysia still rely on manual processes such as paper

forms, WhatsApp messaging, and Excel sheets. Such ways of doing things lead to several issues, such as errors, inconsistencies, and inefficiency. As a result, a new material management system was created on digital platforms. This section explains the system's design, the technologies reviewed, and how the final tools were selected, demonstrating how this system will further improve workflow, communication, and accuracy at construction sites.

System Design Approach

This new system design was developed to address the problems caused by the manual system, specifically. These methods cause several problems, including delays, material loss, and errors in stock tracking (Navon & Berkovich, 2006; Tsai, Lin, & Yang, 2008). Hence, this study planned the solution based on the problems. We have implemented a process called process re-engineering. This means analyzing the entire process from start to finish to optimize it by going fully digital. Our process replaces the manual process found in the previous system with an automated, digital platform that provides real-time updates on material requests, approvals, orders, and deliveries. The key features of the system design include:

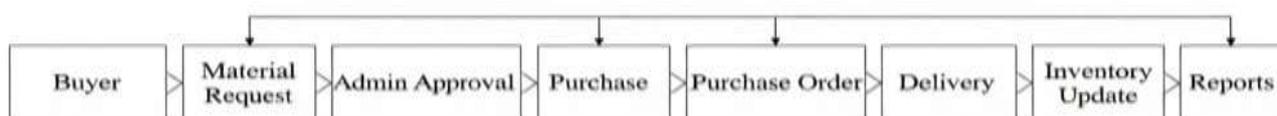


Figure 9: Process new system

This new system also addresses common problems on construction sites, including misplaced materials, duplicate orders, and slower decision-making. For instance, with real-time updates and automated inventory tracking, there are fewer chances of duplicate or missing orders, and this also enables faster decision-making, thereby accelerating the construction process (Kasim, Shamsuddin, Zainal, & Kamarudin, 2012; Kasim, Kusumaningtias, & Sarpin, 2019).

Table 1: Continuous automated process

Workflow Step	Main Function
Buyer	Submit material request
Material Request	Record the type and quantity of materials.
Admin Approval	Review and approve requests.
Purchase Order	Automatically generate purchase orders.
Delivery	Track delivery and update stock
Inventory Update	Real-time inventory updates
Reports	Generate reports for management decisions.

Hence, the information was obtained through observation of current systems on construction sites and the digital systems adopted on Malaysian construction sites. Then, the prevailing challenges noted within current construction site systems, such as delays and mistakes (Mustapa et al., 2012; Nawi et al., 2014; Olanrewaju et al., 2017; Musarat et al., 2024), should be taken into account in the design of the new system.

TECHNOLOGY REVIEW

Several technologies were selected for review to determine which one performed best in a construction setting. Some of the areas reviewed include cloud databases, mobile and web apps, and dashboard/reporting tools. Table

2 below explains some pros and cons of each:

Table 2: Advantages and limitations of each technology

Technology Component	Comparison Rationale / Advantages
Firestore Database	Provides real-time updates Supports multi-user access Seamlessly integrates with mobile/web apps
MySQL Database	Well-established and supports complex queries Reliable for structured data management in the office
Application Platform	Offers universal accessibility Integrates easily with office systems Useful for reporting and administration
Material Tracking	Inexpensive during initial use Can later be upgraded to barcode/QR code tracking for automation
Dashboard / Reporting Tools	Centralizes data, makes it visual Facilitates decision-making and improves coordination

Firestore Database is the most appropriate choice for this system, especially in a construction sites environment, because it provides real-time updates and supports multiple users accessing the information simultaneously. This is particularly useful in construction projects, where delays in data updates can lead to serious issues, including material shortages, duplicate orders, or misplaced materials.

The primary objective of the system was to improve efficiency, accuracy, and control in material management processes that are traditionally fragmented and error-prone. Firestore Database, integrated with mobile and web-based applications, was adopted for its real-time data synchronization, enabling all project stakeholders to access the same up-to-date information simultaneously. This directly addresses common site-level problems such as delayed updates, duplicate material orders, and unrecorded material usage. In addition, using a centralized database eliminates information fragmentation caused by paper-based records and isolated spreadsheets, ensuring that everyone, from site personnel to project managers, has consistent access to material data.

From a feasibility perspective, Firestore offers a cost-effective solution that requires no complex or expensive infrastructure, making it particularly suitable for small- and medium-sized construction firms that dominate the Malaysian construction industry. The system is also designed to be construction-friendly, with a simple user interface and the ability to function under limited internet connectivity, a persistent challenge on many construction sites. Furthermore, built-in authentication and authorization mechanisms enhance transparency and accountability by restricting system modifications to authorized users and enabling the systematic tracking of approvals and material transactions. Collectively, these features address key weaknesses of manual material management practices and support more reliable, transparent, and controlled procurement and inventory operations.

Overall, Firestore Database technology is most suited for construction sites, as it addresses the main problems associated with manual materials management, which makes it faster, more accurate, and cost-saving

(Musarat, Alaloul, Zainuddin, et al. 2024; Mansor & Cing, 2025; Mustapa, Mustapa, Misnan, & Mahmud, 2012; Nawi, Haron, Hamid, & Baharuddin, 2014).

Proposed New System Development

The development of the Material Procurement and Inventory Management System was undertaken using a structured Software Development Life Cycle to address inefficiencies identified within the Malaysian construction industry. The system was developed using the full-stack approach with the SERN stack (SQLite, Express, React, Node.js). This architecture was specifically chosen for its adaptability. While SQLite is used in the current prototype to ensure rapid validation, the modular backend allows for seamless migration to scalable cloud-based SQL databases (such as PostgreSQL or MySQL) for future enterprise-level integration.

The phases involved included:

1. **Requirement Analysis:** Identifying the critical failure points within the manual process workflow.
2. **Database Design and Architecture:** Designing a relational database schema utilizing SQLite for handling complex relationships among users, requests, orders, and inventory.
3. **Implementation:** Building a RESTful API with Node.js/Express and a dynamic front-end with React 18 that is coupled with secure JWT authentication.
4. **Testing:** Verification of critical business logic and data integrity constraints. This included validating the automated inventory synchronization triggers and enforcing referential integrity rules, such as preventing the deletion of Suppliers who have active items in 'In Transit' status to preserve supply chain history.

System Status: The system has been fully developed as a functional prototype. This includes a full database initialization script, role-related dashboards, and automated inventory logic.

Complete Material Request Lifecycle

The proposed system introduces a structured, fully digital workflow that replaces fragmented manual processes with an integrated material management process. As illustrated in **Figure 10**, the complete material request lifecycle begins when site personnel submit a request through the system. The request is then routed through predefined approval levels to ensure that only verified and authorized orders proceed to procurement. Once approved, the system automatically supports purchase order generation, delivery scheduling, and inventory updates. This end-to-end workflow ensures that every material transaction is traceable, systematically recorded, and visible to relevant stakeholders, thereby reducing the risk of duplicate requests, missing records, and uncontrolled material usage.

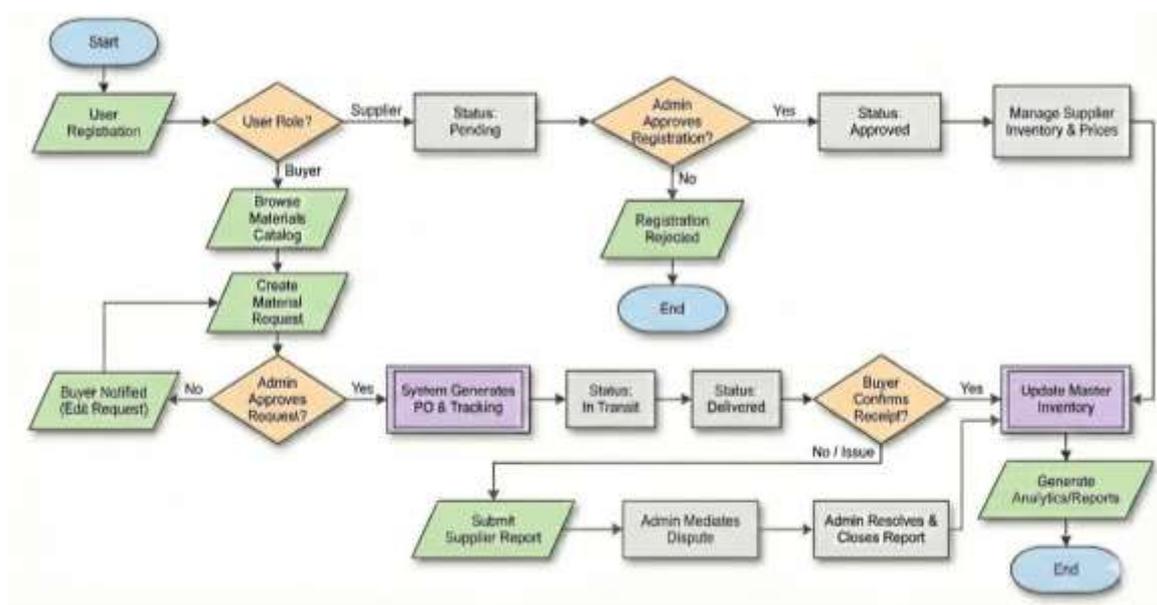


Figure 10: Inventory management system

Delivery Status Progression

The delivery status progression, shown in **Figure 11**, provides real-time tracking of materials from order confirmation to on-site receipt. Each delivery moves through clearly defined status stages, such as ordered, in transit, delivered, and verified, allowing project teams to monitor progress and identify delays at an early stage. This structured progression improves coordination between suppliers, site teams, and management by replacing informal follow-ups and verbal confirmations with verifiable system records. As a result, uncertainties surrounding delivery timing and material availability are significantly reduced.

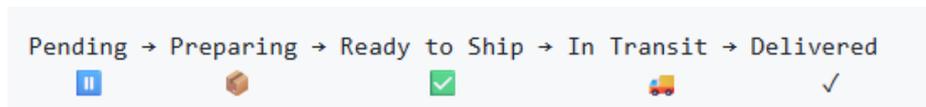


Figure 11: Delivery status progression

Supplier Report Workflow

In addition, the supplier report workflow presented in Figure 12 enhances oversight and performance monitoring of suppliers. The system automatically records supplier-related data, including order history, delivery performance, and compliance with agreed timelines. These records are compiled into structured reports that support objective evaluation of supplier reliability and responsiveness. By formalizing supplier reporting within the system, the workflow strengthens accountability, supports informed procurement decisions, and reduces dependency on subjective assessments or incomplete manual records.



Figure 12: Supplier Report Workflow

Limitations of Conventional Material Management and System Improvements

Prior to implementing the proposed system, material management practices were largely reactive and prone to operational breakdowns. Materials delivered to the site were often not systematically recorded, resulting in frequent misplacement, unverified stock levels, and material losses that went unnoticed until work was disrupted. Inventory records were commonly outdated, leading to duplicate orders for materials that were already available on site. Procurement approvals relied heavily on paper-based forms and informal communication platforms such as WhatsApp, slowing decision-making and reducing traceability. These manual processes also introduced significant human error, including illegible handwriting, miscalculations, and missing documents.

Furthermore, once materials were ordered, there was little to no visibility over delivery progress, creating uncertainty in work planning. Supplier performance was rarely monitored in a structured manner, making it difficult to identify unreliable vendors. In addition, physical records and loosely controlled digital files exposed procurement data to loss and unauthorized access, raising concerns over data integrity and accountability.

The new system directly addresses these weaknesses through an integrated and controlled digital workflow, as illustrated in **Figures 13 to 15**.

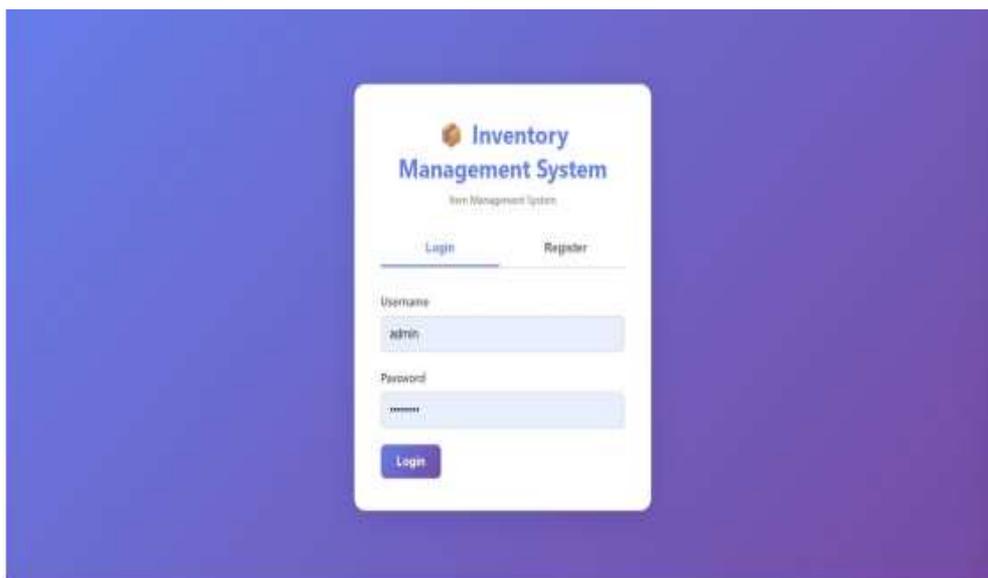


Figure 13: Interface registration and authentication

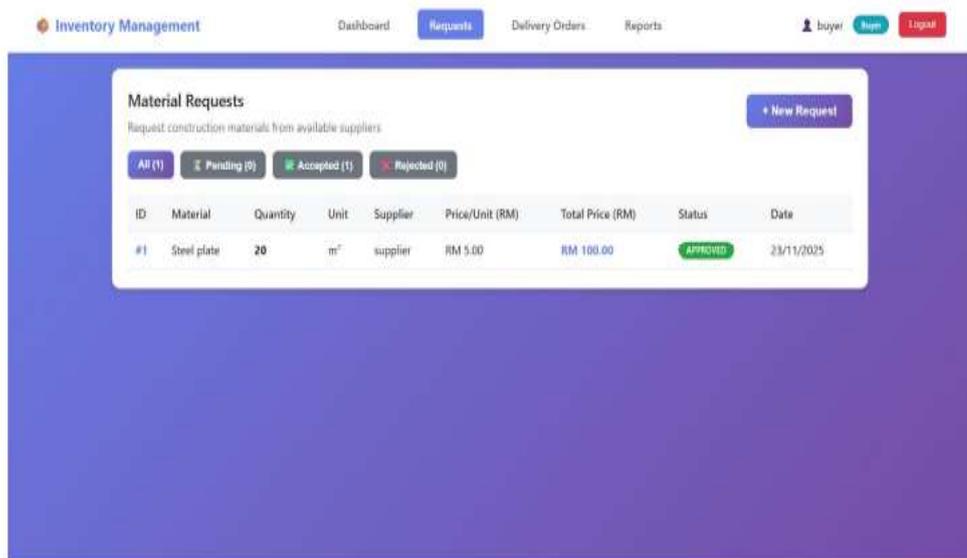


Figure 14: Interface material request

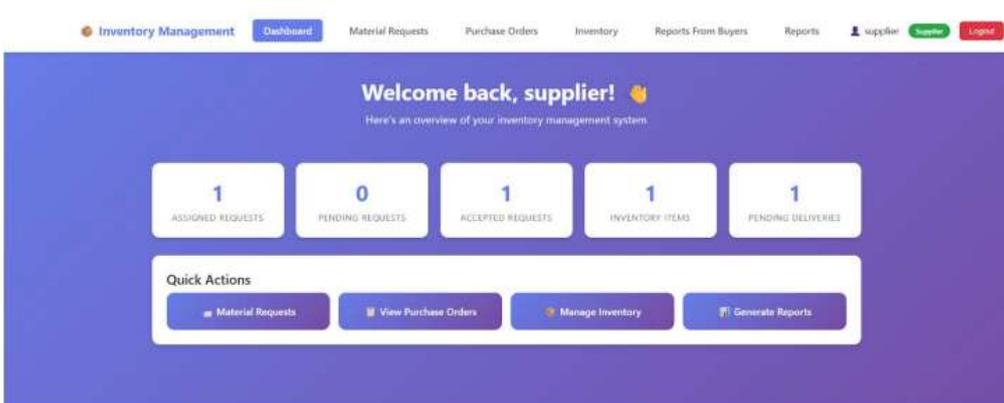


Figure 15: Interface supplier inventory management

A dynamic inventory module automatically updates stock levels once materials are marked as delivered, ensuring that on-site quantities are consistently accurate. A centralized dashboard provides real-time inventory visibility to all authorized users, reducing unnecessary reordering and improving planning accuracy. Procurement approvals are streamlined through an automated digital workflow that allows administrators and suppliers to approve or reject requests with minimal delay, while maintaining a clear audit trail. Standardized digital data entry with field validation significantly reduces human error by enforcing consistency in material types, quantities, and units. Delivery tracking is enhanced through multi-stage status updates, enabling project teams to monitor material movement from preparation to transit. Supplier accountability is strengthened through a reporting mechanism that flags underperforming suppliers based on repeated issues, supporting more informed procurement decisions. Finally, system security is reinforced through authentication controls and session timeouts, reducing the risk of unauthorized access and protecting sensitive procurement data, summary of comparison as per Table 3.

Table 3: Improvement Achieved

PROBLEM (BEFORE)	HOW THE NEW SYSTEM SOLVES IT
Material Misplacement & Loss: Materials stored on-site are not systematically recorded.	Dynamic Inventory Module: Marking an item as "delivered" in the backend triggers an automatic update to stock levels.
Duplicate Orders: Frequent reordering of available stock due to outdated records.	Centralized Dashboard: Provides real-time visibility of current inventory levels to all users before they request new materials.
Slow Procurement Approvals: Manual paper forms and WhatsApp messages slow down decision-making.	Automated Approval Workflow: Requests are digitally routed to Admins/Suppliers who can approve or reject with one click
Inaccurate Data/Human Error: Errors from miscalculations, illegible handwriting, or lost documents.	Standardized Digital Entry: Forced field validation for material types, quantities, and units within the digital form.
Lack of Delivery Tracking: No real-time visibility on material status after ordering.	Multi-stage Status Updates: Tracks items through "Pending," "Preparing," "Ready to Ship," and "In Transit" statuses.
Poor Supplier Oversight: Difficulty in identifying problematic or unreliable vendors.	Supplier Report System: Buyers can submit reports against suppliers; systems flag "problematic" status after 2+ reports.
Session Insecurity: Physical records are often misplaced or accessible by unauthorized staff	JWT Authentication & Timeout: Secure login with a 1-hour inactivity timeout to protect sensitive procurement data.

CONCLUSION

This research identifies persistent challenges in construction projects that continue to rely on manual, disjointed methods for managing material procurement and inventory. The results indicate that the use of paper-based documentation, spreadsheet tracking, and informal communication platforms contributes to operational inefficiencies that negatively influence project timelines, cost management, and material control. In particular, the absence of centralized data and real-time monitoring leads to slow approval processes, unreliable inventory records, excessive material waste, and interruptions to site activities.

Through a detailed evaluation of existing material management processes, this study identifies critical weaknesses that underscore the need for a more integrated, systematic digital approach. To address these shortcomings, a digital Material Procurement and Inventory Management System was conceptualized and developed using contemporary web-based technologies supported by cloud infrastructure. The system unifies material requisition, approval workflows, purchase order creation, delivery tracking, and real-time stock updates within a single centralized platform, facilitating accurate data sharing and stronger coordination among project participants.

The findings show that the implemented system offers notable improvements over conventional manual practices by increasing transparency, minimizing reliance on human intervention, and enhancing the reliability of procurement and inventory information. The use of automated processes and centralized reporting enables quicker decision-making and more effective resource planning, leading to improved overall project outcomes. In conclusion, the study demonstrates that adopting a digital material management solution provides a viable and scalable means of overcoming material-related inefficiencies and contributes meaningfully to the ongoing digital transformation of the Malaysian construction industry.

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