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A Smart Construction System for Automated Attendance, Material, and Cost Management

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Abstract

The construction industry faces significant challenges in managing workforce attendance, material usage, project costs, and daily site reporting due to manual documentation and disconnected management systems. These issues often lead to delayed decision-making, inaccurate reporting, and increased operational costs. This research proposes a Project-Centric Smart Construction Management System that integrates daily site reporting with automated attendance tracking, material inventory management, labour cost calculation, and project monitoring through a unified mobile platform. The proposed system adopts a mobile-first architecture where site engineers submit structured daily reports containing labour attendance, completed tasks, material usage, and site photographs. The application is developed using Flutter, with NestJS for backend services and Supabase for secure cloud storage, authentication, and Row-Level Security (RLS). GPS-based geofencing and Role-Based Access Control (RBAC) ensure accurate attendance verification and secure project data management. The system automatically updates attendance records, material inventory, labour costs, and project dashboards in real time, reducing manual effort and improving reporting accuracy, transparency, and operational efficiency. The novelty of this research lies in using the daily work report as a single operational data source to automate multiple construction management functions, providing an integrated workflow that supports efficient and data-driven project management.

Keywords

Construction Management System, GPS Geofencing, Mobile Computing, Project Management, Smart Construction

Introduction

The construction industry is one of the most resource-intensive sectors, requiring effective coordination of labour, materials, equipment, financial resources, and project stakeholders.

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Despite rapid digital advancements, many construction projects still depend on manual documentation and disconnected software systems for managing daily site activities. This often leads to fragmented information, duplicate data entry, delayed reporting, and inefficient communication, making it difficult for project managers to monitor workforce productivity, material usage, project costs, and overall progress.

Recent studies have introduced technologies such as GPS-based attendance systems, Internet of Things (IoT) monitoring, Enterprise Resource Planning (ERP) systems, and mobile reporting applications. However, these solutions mainly address individual tasks and lack an integrated workflow that connects field activities with project management. As a result, construction organizations continue to face challenges such as fragmented workflows, limited data integration, and delayed decision-making.

To overcome these limitations, this research proposes a **Project-Centric Smart Construction Management System**, where the daily work report serves as the central source of operational information. Site engineers submit reports containing attendance, completed work, material usage, and site photographs through a mobile application. The system automatically updates attendance records, material inventory, labour costs, project progress, and real-time dashboards using a secure cloud platform with GPS-based geofencing and Role-Based Access Control (RBAC). This integrated approach eliminates repetitive data entry, improves data consistency, and enhances operational transparency.

The proposed system integrates daily site reporting with attendance tracking, material management, labour cost calculation, and project progress monitoring through a unified workflow. By providing secure cloud-based data management and real-time dashboards, it improves operational efficiency and supports faster, data-driven decision-making. Its key contribution is a centralized mobile-first platform that streamlines multiple construction management activities using a single source of project data.

Methodology

This section describes the research methodology adopted for designing and implementing the proposed Smart Construction Management System. The methodology consists of three phases: system design, system implementation, and system evaluation. An extensive review of existing construction management practices and digital solutions was conducted to identify limitations such as fragmented reporting, duplicate data entry, and delayed decision-making. Based on these findings, a workflow was designed in which a **single daily work report** serves as the primary source of operational information for attendance management, material inventory, labour cost calculation, and project progress monitoring.

The proposed system begins with user authentication and project allocation, followed by the submission of daily work reports containing labour attendance, completed tasks, material usage, and site photographs through a mobile application. The submitted data are processed by the backend, where validation and business logic automatically update attendance records, material inventory, labour costs, and project dashboards. Finally, all processed information is securely

stored in the cloud database and displayed through real-time dashboards to provide project managers with accurate and up-to-date project information.

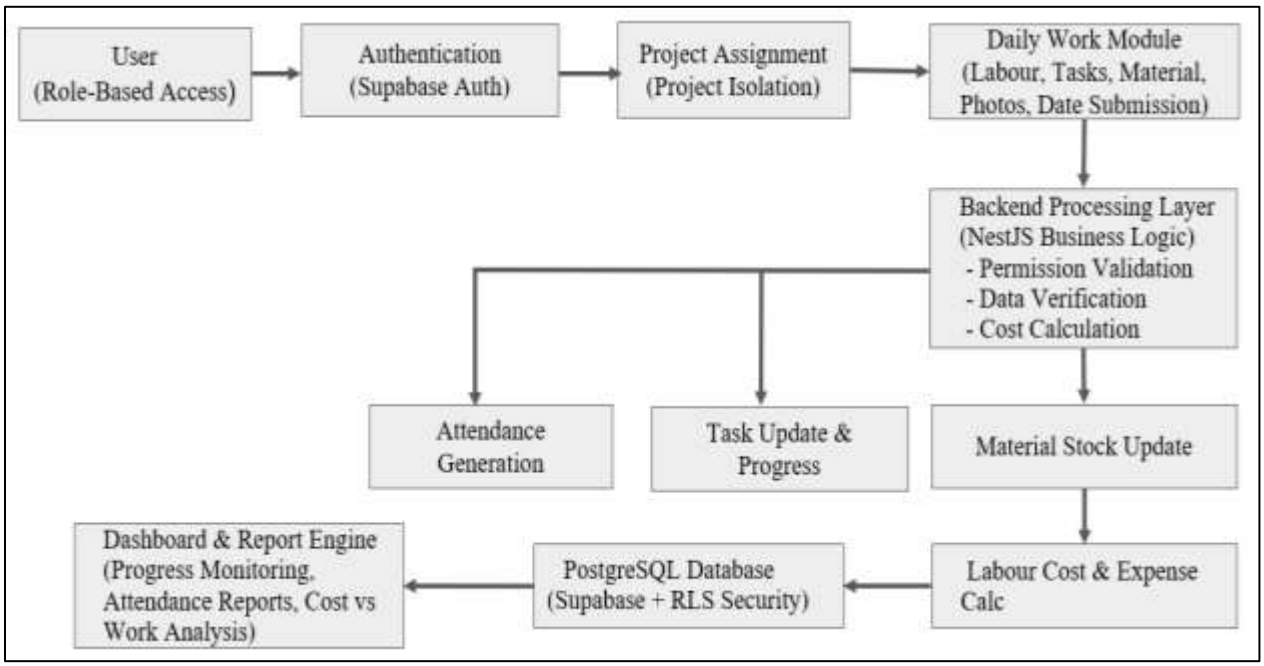

Figure 1. Workflow of the proposed construction management system

2.1 System Design

The proposed construction management system follows a three-layer architecture consisting of the mobile application, backend service, and cloud database layers. This architecture enables efficient communication between field engineers and project managers while ensuring secure data management.

The mobile application layer enables site engineers to record daily construction activities, including labour attendance, work progress, material usage, and photographic evidence. GPS-based geofencing is incorporated to verify that attendance is recorded only when workers are physically present at the construction site.

The backend service layer is implemented using the NestJS framework and is responsible for validating incoming data, executing business logic, calculating labour costs, updating project progress, and synchronizing project information across different modules. Secure REST APIs facilitate communication between the mobile application and the cloud database.

The cloud database is implemented using Supabase PostgreSQL, providing scalable storage, authentication, and Row-Level Security (RLS). Role-Based Access Control (RBAC) ensures that users can access only the projects assigned to them, thereby maintaining data privacy and secure management of multiple construction projects.

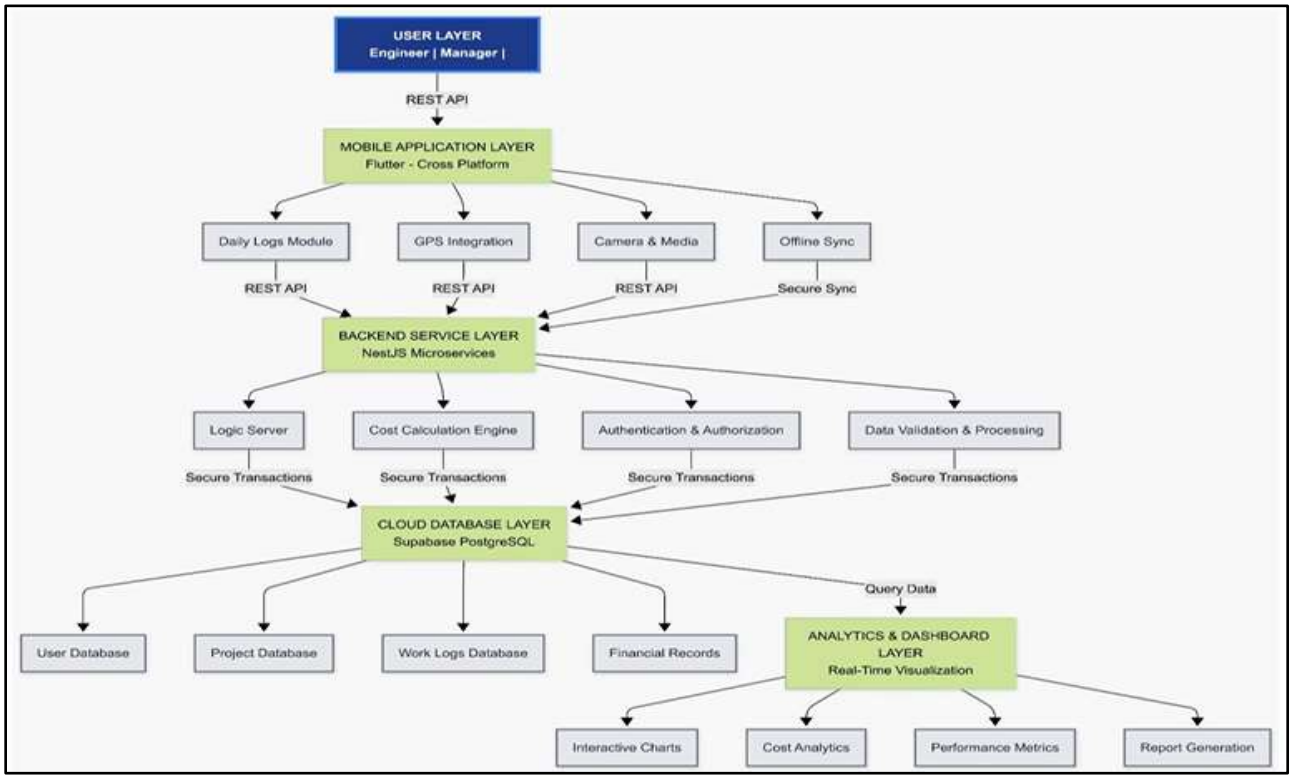

Figure 2. Architecture of the construction management system

2.2 System Implementation

The mobile application was developed using **Flutter** to support cross-platform deployment on Android and iOS devices. It enables site engineers to submit daily reports containing attendance, completed work, material usage, and site photographs, while GPS integration verifies worker locations for accurate attendance tracking. The backend was implemented using **NestJS** to manage business logic, validate data, and automatically update attendance records, material inventory, labour costs, project progress, and site photographs upon report submission. **Supabase** provides secure cloud storage, authentication, and **Row-Level Security (RLS)** for managing multiple construction projects based on user roles.

After a report is submitted, the automated workflow processes the data in real time, updating operational records and generating dashboards that provide project managers with insights into workforce productivity, material usage, project progress, and project costs.

2.3 System Evaluation

After system development, functional testing was conducted to evaluate the reliability and effectiveness of the proposed construction management system. The evaluation focused on validating user authentication, attendance verification, material inventory updates, dashboard generation, and automated project management workflows. The testing confirmed that all modules operated correctly and that information collected through the mobile application was successfully synchronized with the backend and cloud database.

The evaluation also demonstrated the feasibility of integrating field-level data collection with automated construction management processes. The developed system effectively reduced

manual reporting activities while improving the availability of real-time project information for project managers and other stakeholders.

Results and Discussion

Functional testing showed that the proposed system can process daily site reports and synchronize information across attendance, material, cost, and progress modules in real time. The automated workflow reduces manual data entry while improving data accuracy and transparency. GPS-based attendance verification, secure cloud synchronization, and real-time dashboards also help project managers monitor workforce performance, material usage, project progress, and project costs more effectively.

3.1 Comparative Analysis

A comparison was conducted between the proposed system and recent construction management solutions based on key features such as attendance monitoring, material management, cost estimation, project integration, and real-time reporting. As shown in **Table 1**, existing solutions mainly focus on individual functions, such as GPS-based attendance, ERP, or material tracking, requiring multiple systems to manage different project activities.

In contrast, the proposed system brings these functions together in a single workflow, allowing information from daily site activities to be used across attendance, inventory, cost, and progress modules. This integration reduces duplicate data entry, improves data consistency, and gives project managers a clearer view of ongoing project activities.

Table 1. Comparative Analysis of Existing Systems and Proposed System

No.	Paper Title	Year	Tools/Techniques Used	Review
1	Exploring Causes of Ineffective Material Management in Civil Engineering Projects	2026	Survey Analysis, Statistical Evaluation, Material Management Assessment Framework	Identifies causes of poor material management, analytical study, no automated tracking
2	Web-Based Employee Attendance with Gamification & GPS	2025	Web App, GPS, Gamification, Real-time System	Focuses on attendance discipline no cost/ material automation
3	GeoTagging Based Attendance System using Google Maps API Advancements, Features, and Applications	2024	GPS, GeoTagging, Google Maps API, Mobile App	GPS attendance, not integrated with project or ERP systems

(Table 1, continued)

4	Utilizing Industry 4.0 on the Construction Site: Challenges and Opportunities	2021	IoT, AI, Cyber Physical Systems, Wearables, Industrial Internet	No practical implementation
5	Data-driven Material Tracking and Control in Construction Projects	2020	Real-time Data Analytics, Material Tracking System, Database Integration	real-time material monitoring to prevent shortages and over-ordering
6	On-site construction management using mobile computing technology	2013	Smartphone app + Web server + Wireless internet	Mobile reporting only, no cost/material automation

From a sustainability perspective, the proposed system supports more efficient use of construction resources by improving material tracking, reducing unnecessary material usage, and minimizing paper-based documentation. Real-time monitoring of labour, materials, costs, and project progress can also help reduce resource wastage and improve operational efficiency. These benefits are aligned with sustainable construction practices and contribute to broader goals related to sustainable infrastructure, responsible resource use, and efficient project management.

3.2 System Evaluation

Functional evaluation demonstrated that the developed system successfully synchronized field data with backend services and cloud storage, enabling automatic updates across attendance, inventory, labour cost, and project monitoring modules. The integrated dashboards allow project managers to identify material shortages, workflow delays, and resource utilization issues, supporting timely corrective actions.

A practical limitation of the current system is its dependence on network connectivity for real-time synchronization. Construction sites may experience unstable or limited internet access, which can affect immediate data submission and dashboard updates. Future development will therefore focus on a stronger offline mode that allows site engineers to record attendance and daily reports without an active connection and automatically synchronize the stored data when connectivity is restored.

Security and privacy are also important considerations because the system handles worker location information and project-related data. The use of authentication, Role-Based Access Control (RBAC), and Row-Level Security (RLS) helps restrict access to authorized users and assigned projects. Future improvements should further strengthen privacy controls by minimizing unnecessary location collection, protecting sensitive project information, and applying secure data handling practices.

Although the developed system demonstrates significant improvements over conventional construction management practices, its effectiveness depends on the timely submission of accurate

field reports by site engineers. Future enhancements may incorporate Internet of Things (IoT) sensors, Building Information Modeling (BIM), and Artificial Intelligence (AI)-based predictive analytics to further automate data collection, improve project forecasting, and enhance decision support capabilities.

Conclusion

This research presented a **Smart Construction Management System** that integrates daily site reporting, workforce attendance, material inventory, labour cost calculation, and project monitoring into a single mobile-based platform. By automating these processes, the system reduces manual effort, improves data accuracy, and provides real-time project insights for effective decision-making. The integration of GPS-based attendance, secure cloud storage, and automated dashboards enhances transparency and operational efficiency in construction projects. Future work may include integrating Artificial Intelligence (AI), Building Information Modeling (BIM), and IoT technologies to further improve automation and predictive project management.

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