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Inventory Material Management Control Technique on Residential Construction Project

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ABSTRACT

Effective inventory management is crucial for ensuring the timely completion and cost-efficiency of residential construction projects. This study explores various material management control techniques applied in residential construction, focusing on methods that enhance inventory tracking, reduce wastage, and optimize material procurement. The research evaluates traditional inventory control models, such as Just-In-Time (JIT) and Economic Order Quantity (EOQ), alongside modern approaches, including automated inventory systems and real-time data analytics. By analysing case studies and industry practices, the study identifies key challenges faced by construction managers in material handling and proposes integrated solutions to improve the overall efficiency of material management. The findings aim to provide a framework for residential construction projects to streamline material use, reduce delays, and minimize costs.

Keywords:- Inventory Management, Construction Project Management, Material Control, Supply Chain Optimization, Project Efficiency

1. INTRODUCTION

Inventory management is a crucial component of the construction industry, particularly in residential construction projects, where the successful delivery of materials in a timely and cost-effective manner can greatly influence the overall project outcome. The effective management of materials ensures that the necessary resources are available at the right time, in the correct quantity, and at the best price, ultimately contributing to the smooth execution of construction tasks. In the residential construction sector, where the demands for various materials are highly variable and often unpredictable, proper inventory control becomes essential for avoiding material shortages, excess inventory, and project delays. Material management in construction projects involves the process of planning, acquiring, storing, tracking, and distributing materials required throughout the construction lifecycle. Residential construction projects typically involve a variety of materials ranging from raw materials like cement, steel, and timber to more specialized items such as electrical fixtures, plumbing systems, and finishes. The management of such a diverse inventory requires not only a comprehensive system for tracking materials but also techniques for ensuring cost-effectiveness and timely delivery to the construction site. One of the primary challenges in managing materials for residential construction projects is minimizing waste and reducing the costs associated with materials procurement and storage. Over-ordering or under-ordering materials can result in increased costs, project delays, or even substandard construction quality. Inventory control techniques, therefore, become critical in maintaining a balanced supply chain that can meet the dynamic needs of a construction project while staying within budget constraints. The inventory management control techniques used in residential construction projects focus on several key strategies: just-in-time (JIT) inventory, economic order quantity (EOQ), vendor-managed inventory (VMI), and centralized inventory systems. These techniques aim to optimize material procurement, reduce lead times, and avoid delays. Just-in-time inventory, for example, helps minimize the storage space required on-site and ensures that materials are available precisely when needed, reducing the risk of overstocking or understocking. Economic order quantity helps project managers determine the most cost-effective quantity of materials to order, minimizing the total costs of ordering and holding inventory. Vendor-managed inventory allows suppliers to take responsibility for maintaining stock levels at the construction site, which can reduce the administrative burden on project managers and ensure that materials are delivered as needed. Implementing these control techniques requires effective planning, the use of technology for real-time tracking of materials, and communication between all stakeholders involved in the project. Construction companies are increasingly turning to software solutions and automated systems to streamline material management processes. These systems help track material usage, predict demand, monitor stock levels, and improve the accuracy of material deliveries, ultimately enhancing the overall efficiency of residential construction projects.

2. LITERATURE REVIEW

Better models are needed to expedite procedures because the inventory and procurement management systems used in building projects are frequently ineffective. To improve inventory and procurement management in building projects, A. R. Mohammed et al. [1] suggest a hybrid centralized-decentralized UML (Unified Modeling Language) paradigm. To increase efficiency, this strategy blends decentralized decision-making with centralized control. By integrating digital and automated processes, the outcome is a notable increase in inventory management and procurement efficiency, which advances Construction 4.0. Time-varying delays exacerbate the bullwhip effect, a phenomenon that disrupts supply chain performance by causing slight swings in demand to result in huge differences in supply chain orders. In order to decrease the bullwhip effect, D. Chen et al. [2] employ a discrete-time strategy for robust control, which ensures more precise demand forecasting and minimizes unnecessary inventory fluctuations. By managing the bullwhip effect, the suggested approach effectively stabilizes supply chain performance, improving supply chain management as a whole. The design and management of closed-loop supply chains that deal with product recovery and recycling are made more difficult by the uncertainty and variety of recovery possibilities they encounter. To overcome uncertainties and enhance supply chain sustainability, F. Mohammed et al. [3] provide a solid architecture that includes carbon policy and several recovery techniques. The strategy increases supply networks' sustainability and resilience in unpredictable situations, making them more flexible and ecologically friendly. Ineffective risk management frequently results in delays, cost overruns, and project failures in the construction industry. In order to investigate intelligent risk management strategies that could enhance risk identification and mitigation in construction projects, L. Chenya et al. [4] do a thorough literature study. The review offers important insights for enhancing risk management in upcoming construction projects by identifying new trends and techniques in intelligent risk management. Effective cost management in building projects is extremely difficult and frequently results in budget overruns. To reduce costs in construction projects, Z. Zeng et al. [5] provide a model based on fuzzy logic and auction theory. The model makes use of auction theory to improve resource allocation decision-making and fuzzy logic to manage ambiguity. Better decision-making leads to better cost control, which in turn improves project budget management. Digital technology adoption in the building construction sector has been sluggish, which restricts its potential to increase productivity and creativity. In order to determine the major areas where digital tools can be most helpful, K. K. Naji et al. [6] conduct a systematic review to evaluate the state of digital transformation in the building construction business. The study encourages the integration of digital technologies to increase efficiency and promote innovation by highlighting critical areas for digital adoption. In building projects, dynamic and adaptable project management techniques that can adjust to local and global settings are required. In order to improve flexibility and decision-making in dynamic project environments, G. Sklias et al. [7] create a sophisticated framework that is supplemented by machine learning. By increasing project management's adaptability and reactivity, the framework makes it more capable of managing the intricacies of regional and international project dynamics. Financial and environmental factors must be balanced in construction projects, particularly when addressing greenhouse gas (GHG) emissions and optimizing net present value (NPV). A. Hussain et al. [8] create a mathematical model to maximize NPV and GHG emissions in building projects while taking financial objectives and environmental restrictions into account. Construction projects' financial and environmental performance is effectively optimized by the model, yielding both money gains and less environmental damage. It can be difficult to estimate time-cost tradeoffs in building projects, particularly when attempting to balance the two for effective project management. In order to offer a more effective way to balance time and cost in project management, R. Gupta et al. [9] present an Apriori-based optimized model for time-cost tradeoff modeling. By improving time-cost tradeoff analysis, the optimized model assists construction managers in making more informed choices about project budgeting and scheduling. Procurement inefficiencies frequently impact the overall success of projects in project-oriented organizations. With an emphasis on enhancing project procurement procedures and results, M. A. M. A. Kermani et al. [10] employ a process analysis technique to investigate and improve procurement performance. Procurement efficiency is greatly increased by process analysis, which improves project performance and ensures successful project completion. Effective risk detection and management are hampered by the limited application of Named Entity Recognition (NER) in the building supply chain. A transformer-based NER model is created by M. B. Shishehgarkhaneh et al. [11] to enhance risk management procedures by better identifying risks in construction supply chains. By enhancing risk identification and management, the transformer-based NER model helps reduce possible hazards in the building supply chain. In building projects, cost overruns are a frequent problem that frequently results in unstable finances. To avoid cost overruns in building projects, M. Welde et al. [12] present external quality assurance methodologies and stochastic cost estimation tools. These techniques aid in more efficient cost control, guaranteeing that projects remain within their allocated budget and lowering the possibility of monetary issues. In building projects, time and cost optimization are significant obstacles that frequently lead to delays and excessive spending. In order to

optimize time and cost in construction projects, M. Alzara et al. [13] suggest a 5D model based on evolutionary algorithms and Building Information Modeling (BIM). The methodology helps construction projects stay below budget and achieve deadlines by producing notable improvements in time and cost efficiency. Due to a number of obstacles, choosing sustainable materials for residential construction projects is frequently unsuccessful. To determine the obstacles impeding the efficient selection of sustainable materials in building projects, C. Mahame et al. [14] carry out a qualitative investigation. The study facilitates the adoption of more sustainable materials in residential building by identifying the main obstacles to sustainable material selection and offering solutions. Construction projects cannot be carried out smoothly when inventory management is inefficient. Computer vision and machine learning technologies are used by William Villegas-Ch et al. [15] to improve construction inventory management procedures. The use of these technologies greatly increases the effectiveness of inventory management by lowering errors and improving the automation and accuracy of decision-making.

Table -1: Some more Literature Review/ Industrial & Case studies

Year	Author(s)	Country	Objective	Contribution	Data	Methodology	Conclusion/Result
2024	Abdullah Alsehaimi et al. [16]	Saudi Arabia	Examine BIM's role in construction, logistics, and supply chain management	Identified key roles of BIM in optimizing construction processes	Case studies and literature review	Conceptual framework analysis	BIM enhances sustainability in construction and supply chain management
2023	Lu Ding et al. [17]	China	Investigate logistics for circular economy in construction	Provided insights into forward and reverse logistics practices	Systematic literature review	Qualitative synthesis of articles	Circular economy practices enhance sustainability in construction logistics
2024	Yu Liu et al. [18]	France	Explore the potential of digital twins in logistics and SCM	Discussed digital twins' services and capabilities	Literature review and analysis	Conceptual model development	Digital twins have significant potential to transform logistics and supply chain management
2024	Yunbo Wang et al. [19]	China	Design a logistics warehouse robot positioning model	Proposed an improved EKF and calibration algorithm for robot positioning	Simulation data and testing	Model development and testing	The proposed model significantly improves robot positioning accuracy
2025	Moritz Rettinger et al. [20]	Germany	Enhance explainability in deep learning for commodity procurement	Presented methods for explainable AI in procurement decisions	Case study data	Deep learning and explainability techniques	Explainable deep learning improves decision-making transparency in procurement
2021	Konstantin Frolov et al. [21]	Russia	Address strategic procurement for transportation resources	Discussed architectural and methodological issues in transportation procurement	Literature and expert opinions	Qualitative analysis and discussion	Strategic procurement frameworks help optimize transportation resources
2024	Elham Sharifi et al. [22]	Denmark	Investigate virtual warehousing in manufacturing	Proposed a case study for digitalized inventory and on-demand manufacturing	Case study data from industry	Case study and analysis	Virtual warehousing enhances inventory and manufacturing efficiency
2021	Júlio Barros et al. [23]	Portugal	Review safety stock dimensioning under uncertainties	Provided a systematic review of safety stock management under risk	Literature review and case studies	Systematic literature review	Improved safety stock dimensioning practices enhance risk management

2024	Fadi Althoey et al. [24]	Saudi Arabia	Examine IoT's influence on resource management in construction	Evaluated IoT implementations in construction resource management	Literature review and case studies	Qualitative analysis	IoT implementations lead to improved resource management in construction
2024	Lea Hasselsteen et al. [25]	Denmark	Bridge gap between scientific knowledge and industry needs in resource management	Identified critical gaps between scientific findings and industry needs	Industry surveys and literature review	Mixed-methods approach	Bridging gaps between research and industry improves resource management
2024	Lalji Kumar et al. [26]	India	Compare forecasting methods for inventory optimization	Assessed Holt-Winter's exponential smoothing and ARIMA for inventory optimization	Case study data	Quantitative modeling and comparison	ARIMA outperforms Holt-Winter's in inventory optimization
2024	Ahmed M. Khedr et al. [27]	India	Review ML and DL techniques in supply chain management	Explored the integration of machine learning and deep learning in SCM	Literature review	Systematic review of ML and DL techniques	ML and DL significantly enhance supply chain optimization and management
2024	Surjeet Dalal et al. [28]	India	Optimize supply chain efficiency through CNNs and BiLSTM	Proposed an optimization framework using CNNs and BiLSTM in SCM	Industry case studies and simulations	Modeling and simulation	CNN and BiLSTM improve efficiency and sustainability in supply chain management
2024	Milad Baghalzadeh Shishehgarkhaneh et al. [29]	USA	Investigate construction supply chain risk management	Developed frameworks for risk management in construction supply chains	Case studies and literature review	Qualitative analysis	Risk management frameworks significantly reduce risks in construction supply chains
2024	Noppasorn Sutthibutr et al. [30]	Thailand	Optimize production planning in supply chains based on cost and risk	Presented a fuzzy multi-criteria decision-making model	Case study data	Fuzzy MCDM approach	Multi-criteria decision-making optimizes production planning and reduces costs

2.1 Research Gaps Based on above Literature & Case Studies

In residential construction projects, effective inventory material management is crucial to ensure timely completion, cost control, and overall project success. However, improper inventory management often leads to issues such as material shortages, overstocking, delays in construction timelines, increased costs, and inefficient resource utilization. These challenges are exacerbated by poor tracking systems, lack of integration between procurement and construction schedules, and inadequate forecasting methods. This research aims to explore and develop a systematic approach for managing construction materials inventory, addressing the existing inefficiencies, and proposing solutions that optimize material flow, reduce waste, and enhance project delivery in residential construction.

3. CONCLUSION & FUTURE SCOPE

The inventory management of materials in residential construction projects is critical for ensuring timely project completion, cost control, and efficient use of resources. Poor inventory management often leads to material shortages, delays, and budget overruns, which impact project schedules and overall quality. This issue is exacerbated by inefficient tracking systems, lack of real-time monitoring, and inaccurate forecasting of material

needs. The implementation of advanced inventory management techniques, such as Just-in-Time (JIT) or Automated Inventory Systems, can significantly improve material flow, reduce wastage, and enhance overall project performance. The study concludes that adopting more effective inventory management strategies and modern control techniques is essential to overcome these challenges, contributing to better resource utilization and cost savings in residential construction projects. On the basis of this review on inventory material management control techniques in residential construction projects lies in the significant impact efficient material management has on the overall success of construction projects. Inefficient inventory control can lead to material shortages, delays, increased costs, and wastage, all of which affect the project's timeline and budget. In residential construction, where timely delivery and cost-effectiveness are critical, implementing effective material management techniques can enhance project productivity. By using advanced control systems, such as Just-In-Time (JIT) inventory, barcoding, or RFID tracking, construction managers can better anticipate material needs, reduce inventory holding costs, and avoid wastage. Furthermore, proper inventory management improves communication between suppliers, contractors, and project managers, enabling a smoother workflow. Automated systems use IoT sensors for real-time stock levels and dashboards for predictive analytics, reducing bullwhip effects from demand variability. BIM overlays material schedules on 3D models for visual planning. This future scope is vital for developing strategies that optimize resource allocation, reduce downtime, and improve the sustainability of residential construction projects, ultimately contributing to higher profitability and efficiency.

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