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A STUDY ON FACTORS INFLUENCING ADOPTION OF AN INVENTORY MANAGEMENT SYSTEM IN CONSTRUCTION PROJECTS.

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A B S T R A C T :

Construction materials account for a significant portion of a project's overall budget, typically ranging between 50% and 60% of total expenditure. As a result, efficient materials management is critical to the success of construction projects. Various challenges, such as material shortages, delivery delays, fluctuating prices, damage, wastage, and storage constraints, complicate the management process. To maintain productivity and minimize costs, effective inventory management becomes essential. Inventory management in construction encompasses multiple aspects, including procurement, storage, identification, retrieval, transportation, and integration with construction processes. A well-structured Inventory Management System (IMS) helps streamline these operations, ensuring better resource allocation and reducing inefficiencies. However, the adoption of IMS faces obstacles due to technological limitations, organizational challenges, and external market factors. This study aims to analyze the factors influencing the implementation of IMS in construction projects. A survey involving 109 industry professionals was conducted, and the collected data was evaluated using the Relative Importance Index (RII) method. The analysis provides valuable insights into the key determinants that affect IMS adoption, ultimately contributing to improved project efficiency and cost control. Understanding these factors can help construction firms develop better strategies for managing materials, reducing waste, and ensuring smooth project execute

Keywords: Construction materials, Inventory Management, Relative Importance Index (RII), Project Efficiency, Cost Control

1. Introduction

. Inventory refers to the goods, raw materials, and components that a company uses for production and sales. It also includes auxiliary items that support the production process, ensuring smooth and uninterrupted operations. Inventory plays a crucial role in a firm's financial planning, as nearly 60% of the total budget in a project is often allocated to it. Being a vital component of current assets, effective inventory management is essential for maintaining the seamless functioning of production and sales activities. Without proper inventory control, a firm may face disruptions, shortages, or excess stock, all of which can negatively impact profitability and efficiency.

Inventory management is a crucial aspect of current asset management, aimed at maintaining an optimal level of inventory while implementing efficient control mechanisms to minimize total inventory costs. It involves tracking stock levels, predicting demand, and ensuring that inventory investment does not exceed the required limit. Excess inventory can lead to higher holding costs, wastage, and obsolescence, while inadequate inventory can result in production delays and lost sales opportunities. Therefore, striking the right balance is essential for operational efficiency and cost-effectiveness.

Closely related to inventory management is materials management, which encompasses planning, procurement, storage, and the timely distribution of materials in the right quantity and quality. Proper coordination ensures that materials are available when needed, reducing delays and enhancing production efficiency. This systematic approach helps an organization streamline its production activities, minimize waste, and optimize resource utilization.

Inventory management also involves managing the supply chain to ensure the smooth movement of materials from suppliers to warehouses and production units, and ultimately to customers. It is a strategic process that influences an organization's ability to meet customer demands while controlling costs. Traditionally, inventory has been considered an asset, but modern approaches view it as a cost-incurring factor rather than a value-adding component. Excessive inventory ties up capital, increases storage expenses, and leads to potential wastage.

One of the widely adopted strategies to optimize inventory management is the Just-in-Time (JIT) approach. JIT is a production strategy that aims to improve a company’s return on investment by reducing in-process inventory and minimizing carrying costs. This approach ensures that inventory is procured and replenished only when needed, reducing the need for large storage spaces and minimizing waste. By implementing JIT, organizations can enhance their operational efficiency, reduce costs, and maintain a lean supply chain. However, it requires precise coordination with suppliers, accurate demand forecasting, and a well-structured production schedule.

Literature Review

The studies present research work on inventory and materials management across various industries. Hemishkumar Patel et al. emphasized improved communication, advanced design practices, and skilled personnel to achieve cost reduction and productivity improvements by optimizing material and inventory management in construction. Shiau Wei Chan et al. made an exploratory investigation on the issues faced by Malaysian manufacturing SMEs and encouraged developing planning, employee skills, and better funding allocation on the possible grounds of increasing operational efficiency. According to Hari Bahadur Bhandari's study on Janapriya Multiple Campus, Nepal, record keeping, staff skills, and financial resources are some of the critical factors through which efficient management of inventories can be achieved. Research done in Kenya by Kambura Ngatuni has shed light on how information technology, supplier partnership, and employee competence influence the effectiveness of inventory control and hence the necessity for proper systems and qualified personnel. The research by Lenah Mong'ina Ondari and Willy Muturi in Kisii Town is in line with the same elements as stated above, concerning improving better inventory efficiency by reducing bureaucracy, documentation, funding, and skill development among the employees. Mandar Sugiarto's research work focused on PT Dai Nippon Printing Indonesia, where he proposed solutions to mismatches in logistics warehouse inventory through training, improved equipment, and stricter material recording methods. Mohammed Ali Saeed devised an automated Warehouse Management System (WMS) to streamline work in inventory processes, preventing manual errors and improving efficiency. Vatsal Patel and Dr. Jayeshkumar Pitroda have presented an overview of material management practices within the construction industry. They suggest the inclusion of technology such as RFID and better procurement practices in reducing delays and cost overruns. S.S. Islam twined with other researchers to analyze the mismanagement of inventory in an SME dealing particularly in heavy equipment spare parts. They later loaned such improvements as an integrated information system and employee development programs for the improvement of inventories in the firm. Last but not least, Sura Said Alharthy surveyed the issues facing the retail logistics industry in Vietnam, revealing that heavy dependency on reliable partners, the advanced infrastructure for logistics, and innovative practices are keys to optimizing costs and customer satisfaction. As evidenced by these studies, efficient systems, skilled personnel, and technological integration invariably enhance inventory management and operational performance across all sectors The literature survey provides an overview of various techniques employed in inventory management systems within construction companies.

Methodology

3.1. Methods Used

The image presents a flowchart illustrating the process of developing an inventory management system. The process starts with a *general study* of inventory management systems, followed by a *literature review* to understand existing research. Next, it involves *analyzing factors* influencing inventory management and *identifying critical factors* for improvement. A *questionnaire* is prepared for data collection, and the gathered data is analyzed using *SPSS*. Based on insights, a *web application* is developed to optimize inventory management. Finally, the project concludes with *results and suggestions* for implementation and further enhancements. This structured approach ensures a data-driven and effective solution.

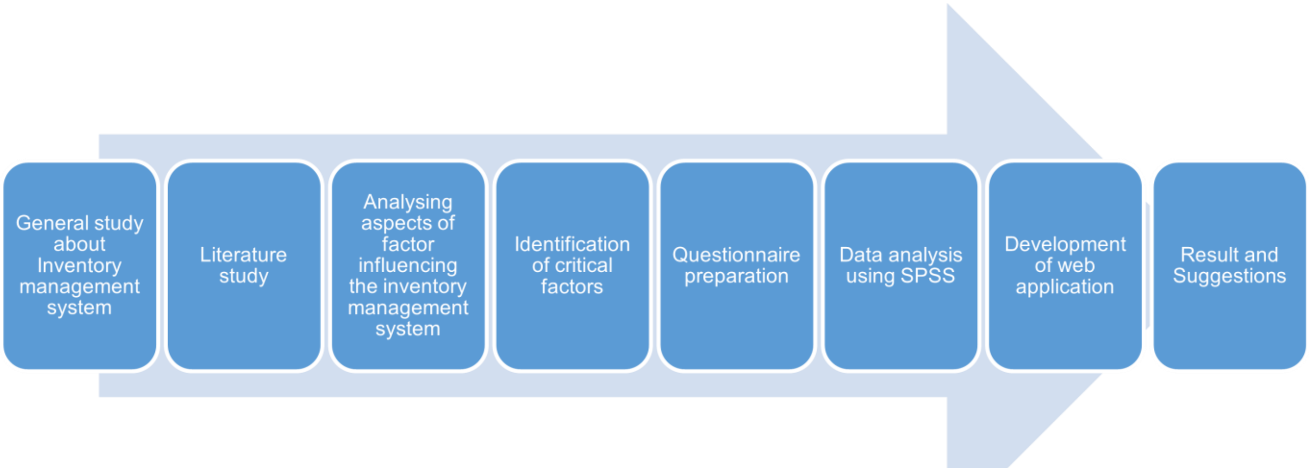

Fig. 1–Methodology chart

4.Identification of factors with literatures

4.1 Factors with literature

S NO	FACTORS	AUTHOR
1	Changing material costs affect the purchasing plan	Subramani (2017);Vidalakis(2011)
2	Transportation cost	Jaskowski(2018);Subramani(2017);Tanskanen(2009)
3	Material planning needs optimization	Jaskowski(2018);Subramani(2017);Tanskanen(2009)
4	Limited time available for advance planning and ordering of small items.	Al-Aidrous(2021);Hsu(2018);subramani(2017)
5	Delays in progress disrupt material planning	Al-Aidrous(2021);Hsu(2018);subramani(2017)
6	Disruption due to labor	Al-Aidrous(2021);Hsu(2018);subramani(2017)
7	Weather conditions greatly impact construction activities	Al-Aidrous(2021);Hsu(2018);subramani(2017)
8	Manager's leadership skills are crucial for clients.	Hsu(2018);Vidalakis(2011b)
9	Reducing overall construction material waste	Ajayi(2017);chen(2021)
10	Enhancing communication between suppliers and clients	Hadidi(2017);Hsu(2018);Vidalakis (2011a)
11	Limited on-site storage capacity	Lu et al(2018);Sari(2007);Tanskanen(2009)
12	Unforeseen transportation issue	Lu et al(2018);Sari(2007);Tanskanen(2009)
13	Frequent changes in production locations.	Lu et al(2018);Sari(2007);Tanskanen(2009)
14	Lack of systematic restocking	Lu et al(2018);Sari(2007);Tanskanen(2009)
15	Unpredictability in construction materials demand.	Lu et al(2018);Sari(2007);Tanskanen(2009)
16	Planning for materials management and delivery	Lu et al(2018);Sari(2007);Tanskanen(2009)
17	Design engineer's misinterpretation of the owner's requirements	Hemishkumar Patel ,Prof.Jayeshkumar Pitroda , and Prof.J.J.Bhavsar (2015)
18	Insufficient and unclear details in the drawings.	Hemishkumar Patel ,Prof.Jayeshkumar Pitroda , and Prof.J.J.Bhavsar (2015)
19	Absence of a plan for material and time waste management	Hemishkumar Patel ,Prof.Jayeshkumar Pitroda , and Prof.J.J.Bhavsar (2015)
20	Delayed responses from the consultant team to contractor inquiries	Hemishkumar Patel ,Prof.Jayeshkumar Pitroda , and Prof.J.J.Bhavsar (2015)
21	Insufficient qualifications of the contractor's technical staff assigned to the project.	Hemishkumar Patel ,Prof.Jayeshkumar Pitroda , and Prof.J.J.Bhavsar (2015)
22	Weak supervision control and delays in issuing instructions.	Hemishkumar Patel ,Prof.Jayeshkumar Pitroda , and Prof.J.J.Bhavsar (2015)
23	Unable to order small quantities of materials	Hemishkumar Patel ,Prof.Jayeshkumar Pitroda , and Prof.J.J.Bhavsar (2015)

Table 1-factors with literature

The table presents key factors affecting inventory management, categorized under various challenges encountered in procurement, planning, logistics, and project execution. It lists *23 factors*, including *cost fluctuations of materials, transportation costs, insufficient planning, delays, labor disruptions, and leadership issues*, all of which influence inventory efficiency. Additionally, *weather conditions, storage capacity limitations, unexpected transportation incidents, and constantly changing production locations* create further complexities.

The table also highlights *management-related issues* such as *misunderstanding owner requirements, inadequate details in drawings, poor material waste management, slow consultant responses, and low contractor staff qualifications*. Furthermore, problems like *lack of systematic replenishment, uncertainty in material demand, and supervision delays* are also critical.

Various authors, including *Subramani, Jaskowski, Al-Aurous, Hsu, Lu et al., and Patel*, have contributed research to these factors, providing valuable insights into improving inventory management practices, particularly in construction and logistics industries. Addressing these challenges can enhance efficiency and reduce project risks.

4.2 Factors used for questionnaire survey

ID	FACTORS
IM1	Changing material costs affect the purchasing plan
IM2	Material planning needs optimization
IM3	Limited time available for advance planning and ordering of small items.
IM4	Delays in progress disrupt material planning
IM5	Weather conditions greatly impact construction activities
IM6	Manager's leadership skills are crucial for clients.
IM7	Reducing overall construction material waste
IM8	Enhancing communication between suppliers and clients
IM9	Limited on-site storage capacity

IM10	Unforeseen transportation issue
IM11	Frequent changes in production locations.
IM12	Lack of systematic restocking
IM13	Unpredictability in construction materials demand.
IM14	Planning for materials management and delivery
IM15	Design engineer's misinterpretation of the owner's requirements
IM16	Insufficient and unclear details in the drawings.
IM17	Absence of a plan for material and time waste management
IM18	Delayed responses from the consultant team to contractor inquiries
IM19	Insufficient qualifications of the contractor's technical staff assigned to the project.
IM20	Weak supervision control and delays in issuing instructions.
IM21	Unable to order small quantities of materials

Table 2- Factors for survey

The compressive and tensile strength of hardened concrete samples were evaluated. After the curing for 14 and 28 days, the specimens were taken out from curing tank and allowed to dry. A Universal Testing Machine (UTM) is used to determine compressive strength and tensile strength of the concrete samples. These tests were performed to study the effects of WFS and GF in concrete. Both tests involved controlled loading through the UTM to examine the mechanical properties of the concrete.

5.Data analysis

5.1. Cronbach's alpha

Cronbach's Alpha	N of Items
0.773	21

Table 3 -Reliability statistics

Cronbach's alpha	Interpretation
$\alpha > 0.9$	Excellent
$\alpha > 0.8$	Good
$\alpha > 0.7$	Acceptable
$\alpha > 0.6$	Questionable
$\alpha > 0.5$	Poor

Table 4-Nominal Value

The first image shows the reliability statistics of a scale, reporting a Cronbach's Alpha of 0.773 for 21 items. The second image provides an interpretation scale for Cronbach's Alpha values. Cronbach's Alpha measures internal consistency, indicating how closely related a set of items are in a test or questionnaire. According to the interpretation table, a value of 0.773 falls in the "Acceptable" range ($0.7 < \alpha \leq 0.8$). This suggests that the test has a reasonable level of reliability, meaning the items within the scale are measuring the same construct with consistency. However, while acceptable, a higher value (above 0.8) would indicate even better reliability. If needed, improvements could be made by refining items or removing poorly correlated questions. Overall, the scale used in the analysis is sufficiently reliable for research or practical purposes but could benefit from further refinement for stronger consistency.

5.2. Relative importance index

The *Relative Importance Index (RII)* is a widely used statistical method to assess the significance of different factors, particularly in research related **to** *BIM (Building Information Modelling) adoption* at various project lifecycle stages. It helps prioritize factors based on their perceived importance among respondents

$$RII = \frac{5\,n5 + 4\,n4 + 3\,n3 + 2\,n2 + 1n1}{A*N}$$

Where

n5 = Number of respondents for Strongly Agree

n4 = Number of respondents for Agree

n3 = Number of respondents for Neutral

n2 = Number of respondents for Disagree

n1 = Number of respondents for Strongly Disagree

A (Highest Weight) = 5

N (Total number of respondents) = 109

5.3. Ranking factors

FACTOR ID	SA	A	N	D	SD	TOTAL	RII	A*N	RII	RANK
IM 16	29	35	27	13	5	109	397	545	0.72844	1
IM 18	27	32	30	16	4	109	389	545	0.71376	2
IM 20	22	41	24	20	2	109	388	545	0.71193	3
IM 17	24	39	23	19	4	109	387	545	0.71009	4
IM 7	19	41	31	13	5	109	383	545	0.70275	5
IM 5	19	43	28	11	8	109	381	545	0.69908	6
IM 10	25	32	28	17	7	109	378	545	0.69358	7
IM 6	23	34	23	24	5	109	373	545	0.6844	8
IM 13	22	30	34	17	6	109	372	545	0.68257	9
IM 8	21	37	26	15	10	109	371	545	0.68073	10
IM 19	21	35	30	13	10	109	371	545	0.68073	11
IM 2	13	43	30	20	3	109	370	545	0.6789	12
IM 9	22	37	23	16	11	109	370	545	0.6789	13
IM 15	17	38	30	19	5	109	370	545	0.6789	14
IM 3	22	36	24	16	11	109	369	545	0.67706	15
IM 14	15	41	30	14	9	109	366	545	0.67156	16
IM 4	20	30	31	22	6	109	363	545	0.66606	17
IM 21	20	31	32	16	10	109	362	545	0.66422	18
IM 11	21	28	27	20	13	109	351	545	0.64404	19
IM 1	13	35	27	19	15	109	339	545	0.62202	20
IM 12	15	29	28	26	11	109	338	545	0.62018	21

Table 5-Ranking of factors

The table presents the *Relative Importance Index (RII) rankings* for different factors **(***FACTOR ID*) based on survey responses. The *SA (Strongly Agree), A (Agree), N (Neutral), D (Disagree), and SD (Strongly Disagree)* columns show how many respondents selected each response category. The total number of respondents **(***N***)** is *109***.**Where A = 5 (highest weight) and N = 109 (total responses). The A*N column represents the maximum possible score (545). The RII column shows the computed importance score, ranging from 0 to 1, with higher values indicating greater significance.

The RANK column orders the factors from highest to lowest based on their RII values. IM 16 ranks highest (0.7284), making it the most critical factor, while IM 12 ranks lowest (0.6202), indicating lower importance.

This analysis helps identify the most influential factors affecting BIM adoption in various project lifecycle stages, providing valuable insights for decision-makers to focus on the most significant areas for improvement.

5.4. Factors and Relative importance index of top 10 factors

ID	Factor	RII
IM1	Unclear drawings lead to misinterpretation of material requirements	0.728
IM2	Delayed consultant response to contractor inquiries	0.714
IM3	Weak supervision and delays in instruction issuance	0.712
IM4	Lack of a material waste management plan	0.71
IM5	Need to reduce overall construction material waste	0.703
IM6	Weather affecting material storage	0.699
IM7	Unforeseen transportation issues	0.694
IM8	Managers unaware of available resources	0.684
IM9	Unpredictable demand for construction materials	0.683
IM10	Duplicate: Reducing material waste	0.681

Table 6-Relative importance index

Results and Discussions

4.1Flowchart for IMS

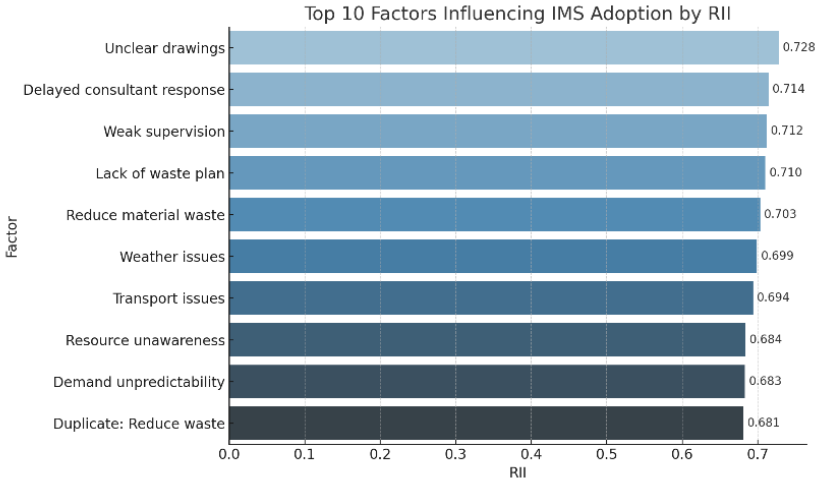

Figure 2-Flowchart for Ims

This flowchart represents the end-to-end flow of inventory processes in a construction project—from material requirement identification to feedback and continuous improvement. The loop ensures that lessons learned from project performance feed back into planning, enhancing efficiency and reducing material-related delays.

This bar chart visually depicts the Relative Importance Index (RII) scores for the top 10 ranked factors influencing the adoption of IMS. Higher RII values reflect more critical factors, with 'Unclear drawings' and 'Delayed consultant response' leading in importance.

4.2. Limitations of the Study

While this study presents meaningful insights into the adoption of Inventory Management Systems in construction, it has limitations:

- The survey sample is limited to 109 professionals, primarily from a regional pool, which may limit the generalizability.
- The responses are based on subjective perceptions which might carry individual biases.
- The study focuses on material inventory and does not explore equipment or labor inventory management.

4.3. Future studies consider

- Development of a predictive IMS model integrated with AI and real-time tracking.
- Evaluation of IMS implementation cost versus return on investment.
- Case studies on successful IMS deployment in mega-projects.

Conclusion

Project time overruns are a significant issue in construction and infrastructure projects, primarily caused by mismanagement, inefficient planning, and delays in resource allocation. These problems often arise during the pre-construction and execution stages, leading to disruptions in project timelines, increased costs, and compromised technical performance. Addressing these challenges requires a comprehensive approach that ensures better project planning, coordination, and execution. One of the key solutions is accelerating the study phase to prevent unnecessary delays in feasibility assessments and technical evaluations. A streamlined study process with clear deadlines and structured methodologies can help in identifying potential risks early, allowing for smoother execution. Additionally, adopting a participatory approach in project preparation is crucial. Engaging stakeholders, including government agencies, contractors, investors, and local communities—from the outset ensures that all perspectives are considered, reducing the likelihood of conflicts and regulatory issues. This collaborative approach leads to better project acceptability and efficiency. Another major cause of project delays is the slow approval of agreements due to bureaucratic inefficiencies. To counter this, governments must pass legislation that facilitates faster ratification of contracts and agreements. By reducing bureaucratic red tape and ensuring quicker approvals, project timelines can be significantly improved. Additionally, ensuring the timely disbursement of funds is critical. Many projects suffer from financial interruptions due to delays in funding, which leads to halted work and extended project timelines. A well-organized financial management system that ensures funds are available as per the project's needs can prevent these disruptions and keep the project moving forward without unnecessary breaks. Proper planning for the bidding process and contractor selection is also essential to avoid project delays. Executing agencies should launch bidding processes well in advance to ensure that competent contractors and auditing firms are recruited on time. The selection of contractors should not be based solely on cost but also on experience, technical expertise, and a proven track record of timely project completion. Awarding work to the most capable bidder enhances efficiency, reduces risks associated with poor-quality work, and ensures that the project progresses according to schedule.

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